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of the International TEAM Society

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CONTENT

1. INTEGRITY AND LIFE OF WHEELS REPAIRED BY WELDING
D. Tanasković, U. Tatić, S. Sedmak, B. Djordjević, J. Lozanović, A.Sedmak 1

2. POST HOC ANALYSIS IN BIOMETRICS
Mario Fröhlich, Tamara Dumančić, Vesna Gantner-Kuterovac and Zoran Škrtić…………………………..7

3. THE QUALITY OF TABLE EGGS IN RELATION TO THE AGE OF LAYING HENS
Pavičić Nera, Hell-Kurevija Ana, Fr□hlich Mario, Kralik Zlata and Škrtić Zoran……………………………11

4. FORMING OF CAR BODY STRUCTURE ELEMENTS BY ELASTIC MEDIUM
József Danyi, Ferenc Végvári and Gábor Béres……………………………………………………………16

5. HIGH TEMPERATURE WETTING PHENOMENA BETWEEN MOLTEN BRAZING LIQUIDS AND MULTICOMPONENT (DUAL-PHASE) STRUCTURAL STEELS
Zoltan Weltsch……………………………………………………………………………………………..20

6. ENERGY DEMAND AND SUPPLY IN 21ST CENTURY
Miroslav Trifunović…………………………………………………………………………………………23

7. THE INFLUENCE OF QUENCHING/COOLING MEDIA ON HARDNESS AND MICROSTRUCTURE OF DUCTILE IRON
Vladimir Pecić and Štefanija Klarić……………………………………………………………………….. 28

8. MICROSTRUCTURE AND MECHANICAL PROPERTIES INVESTIGATION OF DIFFUSION WELD JOINTS
J. Urminský, M. Jáňa, M. Marônek…………………………………………………………………………32

9. STRUCTURAL TRANSITION IN CULTURAL POLICY: A POST-SOCIALIST PERSPECTIVE
Tóth, Ákos……………………………………………………………………………………………………..38

10. MICROSTRUCTURAL EVOLUTION AND MECHANICAL BEHAVIOR OF WC-Co / AISI 1020 STEEL JOINT OBTAINED BY BRAZING AND GTAW PROCESS
B. Cheniti, D. Miroud and D. Allou…………………………………………………………………………45

11. DEVELOPMENT OF ENERGY SUSTAINABLE CONCEPTUAL VARIANT OF THE TECHNICAL SYSTEM KIOSK
D. Butumović, M. Karakašić, P. Konjatić, Ž. Ivandić and D. Kozak ……………………………………49

12. DESIGN AND EVALUATION OF ROOF STRUCTURES AND FOUNDATION SYSTEMS FOR THE TECHNICAL SYSTEM KIOSK
T. Morvaj, M. Karakašić, P. Konjatić, Ž. Ivandić and D. Kozak………………………………………………55

13. CONCEPTUAL DESIGN FOR MACHINE TO CUT RAW RUBBER TO RIBBONS
Z. Štefek, M. Karakašić, Ž. Ivandić and M. Kljajin…………………………………………………….. 59

14. ANALYSIS OF DUCTILE IRON METALLOGRAPHIC IMAGES GAINED BY LABORATORY AND ON-SITE METALLOGRAPHY METHODS
Štefanija Klarić, Zlatko Pavić, Halima Hadžiahmetović………………………………………………. 64

15. AUTOMATIC EXCHANGE OF GRIPPERS FOR ROBOTIC ARMS IN ASSEMBLY OPERATIONS AS THE BASE FOR FURTHER INDUSTRIAL APPLICATIONS
Radovan Holubek, Nina Vetríková, Roman Ružarovský, Daynier Rolando Delgado Sobrino and Karol Velíšek…………………………………………………………………………………………… 69

16. THE IMPORTANCE OF SOFT SKILLS IN TECHNICAL EDUCATION
Danijela Pezer……………………………………………………………………………………………...75

17. INFLUENCE OF MINERAL FERTILIZATION ON THE GRAPEVINE YIELD (*VITIS VINIFERA* L.)
Mira Sameljak, Teuta Benković-Lačić and Krunoslav Mirosavljević…………………………………………80

18. SIMULATION AND SIMULATION OPTIMIZATION IN THE DESIGN AND ANALYSIS OF THE MATERIAL FLOW AND LAYOUT: THE CASE OF A FLEXIBLE ASSEMBLY CELL
Daynier Rolando Delgado Sobrino, Radovan Holubek, Karol Velíšek, Nina Vetríková, Roman Ružarovský………………………………………………………………………………...............83

19. DETERMINATION OF STRESS THROUGH A STATIC FEM ANALYSIS OF LOCAL RESISTANCE IN THE CENTRAL AREA OF A CHEMICAL TANKER OF 49000 TDW
Anisoara-Gabriela Cristea, Florentina Palade…………………………………………………….......89

20. THE CHANGES OF THE AUTOMATED ASSEMBLY WORKPLACE WITH THE CAMERA CONTROL SYSTEM
Nina Vetríková, Radovan Holubek, Roman Ružarovský, Daynier Rolando Delgado Sobrino, Peter Košťál and Karol Velíšek ………………………………………………………………………... 95

21. STRESS AND BUCKLING ANALYSIS FOR TOWING HOOK AFT AND TOWING BIT AFT
F. Palade, A.G. Cristea……………………………………………………………………………………... 101

22. METHODOLOGY FOR THE COMPUTATION OF CRITICAL BUCKLING FORCE AT STEEL TUBES WITH FLATTENED ENDS
S. Kotšmíd, P. Beňo, D. Kozak and G. Królczyk…………………………………………………………. 107

23. SOME GENERAL INEQUALITIES FOR CONVEX FUNCTIONS
Zlatko Pavić, Maja Čuletić Čondrić and Tomislav Aušić………..……………………………………….. 110

24. A CRACK APPROACHING AN INTERFACE BETWEEN THE TWO ORTHOTROPIC MATERIALS
Jelena Djoković, Ružica Nikolić, Aleksandar Sedmak…………………………………………….…. 115

25. EXAMINATION OF THE DEVELOPMENT OF PEPPER (*CAPSICUM ANNUUM* L.) SEEDLING WITH VIRUS VECTOR ON ROCK COTTON MEDIUM IN GLASSHOUSE
V.J. Vojnich, J. Pető, A. Hüvely…………………………………………………………………………….. 120

26. EVALUATION OF WELD JOINTS PRODUCED BY LASER WELDING OF SUPERDUPLEX STAINLESS STEEL SAF 2507
J. Ertel, J. Bárta, M. Marônek and J. Bílik……………………………………………………………….... 123

27. PROVING EQUALITIES AND INEQUALITIES BY USING THE INTEGRAL METHOD
Zlatko Pavić*, Štefanija Klarić, Magdalena Zovko……………………………………………………………126

29. THE STRUCTURE OF MOTIVATION FOR MECHANICAL ENGINEERING STUDY AT UNIVERSITY OF ZAGREB
Nikša Dubreta, Damir Miloš………………………………………..…………………………………….. 131

29. ANALYSIS OF THE PENSION SYSTEM OF CROATIA AND CORRELATION WITH ECONOMIC DEVELOPMENT
Željko Požega, Marijan Kuprešak and Marko Martinović………………………………………………… 137

30. QUALITATIVE CHANGES IN HUMAN RESOURCES MANAGEMENT IN SLOVAK ORGANIZATIONS – ARE WE COOPING THE CONTEMPORARY TENDENCIES IN EUROPEAN LABOR MARKET?
Zuzana Joniaková, Jana Blštáková…………………………………………………………………….......141

31. APPLICATION OF AHP AND ADDITIVE METHOD IN SUPPLIER SELECTION
Sara Havrlišan, Katica Šimunović, Tomislav Šarić, Goran Šimunović, Danijela Pezer, Ilija Svalina, Ivan Majdančić……………………………………………………………………………………………...149

32. THE ROLE OF PROJECT MANAGEMENT IN THE STRUCTURAL FUNDS OF THE EUROPEAN UNION
M. Cobović, G. Prebeg and M. Vretenar Cobović………………………………………………………...154

33. SAFE HANDLING WITH MACHINES FOR PLANT PROTECTION
Branimir Vujčić, Lejla Safundžić, Siniša Bilić, Jasna Vujčić...159

34. PLANT GENETIC RESOURCES AND GENETIC EROSION
Sonja Marić, Marina Roksandić, Vlado Guberac, Sonja Petrović, Sunčica Guberac, Marija Dundović…………………………………………………………………………………..………….. 163

35. SURVEY ON INTRUSION DETECTION SYSTEMS - keynote lecture
László Göcs[1*], Zsolt Csaba Johanyák………………………………………………………….……….167

36. ANALYSIS OF ACTIVE EMPLOYMENT MEASURES
Vukajlić, M………………………………………………………………………………………….…….171

37. INVEX SETS AND PREINVEX FUNCTIONS
Zlatko Pavić, Vedran Novoselac and Ivan Raguž...175

38. ADAPTIVE CENTER WEIGHTED MEDIAN FILTER
Vedran Novoselac and Zlatko Pavić……………………………………………………………..………180

39. OPTICAL MEASUREMENTS OF SURFACE ROUGHNESS CUT WITH WATERJET
Ivan Nikolić, Miroslav Duspara, Antun Stoić, Ivan Samardžić..183

40. DRAWINGLESS MANUFACTURING IMPLEMENTATION
Peter Košťál, Dávid Tóth, Andrea Mudriková, Marcela Bučányová, D. Delgado Sobrino, Radovan Holubek, Nina Vetríková and Roman Ružarovský……………………………………………..…..189

41. BENCHMARKING AS A STRATEGIC TOOL FOR STRENGTHENING OF THE COMPETITIVENESS
L. Duspara, S. Knežević, A. Bencun………………………………………………………………........…193

42. THE ANALYSIS OF SPORT PRODUCTS IN SLAVONSKI BROD FROM THE STUDENT POPULATION PERSPECTIVE
H. Sivrić, M. Kušljić and A. Katolik Kovačević..197

43. CROSS CULTURAL DIFFERENCES AND THEIR IMPLICATIONS ON CROATIA
S. Knežević, L. Duspara, D. Miljković.. 202

44. SMARTPHONES POSITIONING ON SAMSUNG EXAMPLE
A. Katolik Kovačević, V. Vučemilović and M. Aračić.. 206

45. CONFLICT MANAGEMENT IN THE ORGANIZATION AS ONE OF MANAGERIAL SKILLS
A. Kulaš, R. Ćurak……………………………………………………………………………….….. 210

46. DISTRIBUTION OF THE ELECTRIC FIELD ACCORDING TO THE EVOLUTION OF THE DISCHARGE IN A SYSTEM POINTED PLANE WITH INSULATING BARRIER
S. Benharat, S. Bouazabia.. 214

47. NEW METHODS OF MODELLING AND DESIGN OF AUTOMATED ASSEMBLY SYSTEMS BY USING THE SIMULATION TOOL "VIRTUAL COMMISIONING"
R. Ružarovský, R. Holubek, D. Delgado Sobrino, N. Vetríková, P. Košťál and K. Velíšek............. 217

48. MONITORING OF WELDING PARAMETERS WITH WELDING MACHINE WELBEE P500L
Dejan Marić, Miroslav Duspara, Leon Maglić, Antun Stoić, Ivan Samardžić... 225

49. THE INFLUENCE OF COLD ROLLING ON THE ELECTROCHEMICAL AND MECHANICAL BEHAVIOR OF 316Ti AUSTENITIC STAINLESS STEEL IN ACID SOLUTION H_2SO_4.
Houria Kaddour, Benrabah Imed-Eddine, Taguia Sohaib, Fatah Hellal………..……………………… 229

50. QUALITY ASSURANCE AT B&H UNIVERSITIES AND THEIR INTEGRATION IN THE EUROPEAN HIGHER EDUCATION AREA
H. Bašić, H. Muhić.. 233

51. FRICTION STIR WELDING OF BMG'S: A REVIEW
Ravi Kumar, Somnath Chattopadhyaya, Aniruddha Ghosh, Ratnesh Kumar and Amit Kumar.............. 236

52. MICROSTRUCTURE AND MECHANICAL BEHAVIOR OF TIG BIMETALLIC JOINTS
M.F. Benlamnouar, R. Badji, M. Hadji, A. Boutaghane, N. Bensaid.. 245

53. BUCKLING ANALYSIS OF PERFORATED STRUCTURES MANUFACTURED IN HYBRID COMPOSITE MATERIALS
L. Belgacem, D. Ouinas... 249

54. THE RIGIDITY OF THE WALL OF PISTONS IN RELATION TO THE WALL THICKNESS
Á. Horváth, I. Oldal, G. Kalácska, M. Andó…………………………………………………………... 252

55. INFLUENCE OF UV EXPOSURE ON THE MECHANICAL PROPERTIES OF POLYMERIC FILMS USED IN THE CONSTRUCTION OF GREENHOUSES
Lorand Kun and Alin Constantin Murariu…………………………………………………............... 256

56. THE EFFECT OF BORON ON STEELS
E. Johanyák………………………………………………………………………………………… 260

57. FROM BEGINNING TO MODERN ENGINEERING
Zlatko Pavi, Ivan Raguž 266

58. COMPARISON OF MACROECONOMIC INDICATORS OF CROATIA AND IRELAND
I. Blažević, M. Pelivan and A. Bencun..270

59. ENVIRONMENTAL PROTECTION IN INTERMODAL NETWORKS BY MINIMIZING CO_2 EMISSION
Radoslav Rajkovic, Nenad Zrnic, Đorđe Stakic, Aleksandar Sedmak, Snežana Kirin.......................... 274

60. ACHIEVING SOCIAL OPTIMUM AND USER EQUILIBRIUM TRAFFIC ASSIGNMENT ON SPECIFIC TEST NETWORK
Krisztián Medgyes, Rafael Alvarez Gil, Tamás Kovács.. 279

61. THE COMPLEX MEASURING METHOD (CMM) IN EDUCATION
Iván Devosa, Ágnes Maródi, Tamás Grósz, Zsuzsanna Buzás, János Steklács………………………... 283

62. SPELT (TRITICUM SPELTA L.) - ENERGY PRODUCTION FROM AGRICULTURAL RESIDUES – keynote lecture
N. Jovičić, A. Matin, D. Kiš and S. Kalambura………………………………………………………….. 287

63. A SIMPLE DIGITAL IMAGING METHOD FOR THE ANALYSIS OF THE COLOR OF FOOD SURFACES
Ivana Markovic, Jelena Ilic, Dragan Markovic, Vojislav Simonovic, Sanja Dejanovic, Snezana Golubovic………………………………………………………………………………………….. 292

64. EVALUATING COMPETITIVE POSITION OF AN AIRLINE COMPANY
Bahar Sennaroglu, Egemen Hopali 296

65. USING NEURAL NETWORKS TO PREDICT ALUMINIUM OXIDE LAYER THICKNESS
P. Michal, A. Vagaská, E. Fechová, M.Gombár, K. Monková, P. Monka... 299

66. BUSINESS COMMUNICATION COURSE SYLLABI IN UNDERGRADUATE MANAGEMENT AND TECHNICAL EDUCATION IN CROATIA – A COMPARISON - keynote lecture
I. Bilić, G. Duplančić Rogošić.. 305

67. DETERMINING THE THEORETICAL FAILURE RATE FUNCTION OF THE THERMAL POWER SYSTEM IN POWER PLANT "NIKOLA TESLA, BLOCK B2"
Dragan Kalaba, Milan Đorđević and Snežana Kirin.. 310

68. WEED FLORA OF THE EASTERN LATERAL CHANNEL "JELAS POLJA"
R. Benković*, S. Antunović, K. Mirosavljević……………………………………………………………. 314

69. MACHINING OF MATERIALS BY ABRASIVE WATER JET TURNING WITH THE PROPOSAL OF ON-LINE MONITORING USING ACOUSTIC EMISSION
Ján Cárach, Sergej Hloch 317

70. AISI 304 STAINLESS STEEL DISINTEGRATION USING A WATER JET INTENSIFIED BY MECHANICAL VIBRATIONS WITH FREQUENCY OF 20 kHz
D. Lehocká, J. Klich, J. Foldyna, S. Hloch, J. Cárach... 320

71. THE CHALLENGES OF RISK MANAGEMENT OF CRITICAL INFRASTRUCTURE - keynote lecture
Kirin S., Keković Z Kleinheyer B., Brzaković M, Zlatanovic, D.. 324

72. DOES THE AGRICULTURAL PRODUCERS RECOGNIZE THE IMPORTANCE OF BRANDING THE LOCAL PRODUCTS?
Dubravka Živoder, Josipa Pavičić*, Petra Tudor……………………………………………………......... 328

73. ANIMATION DESIGN IN THE PROCESS OF DEVELOPING A NEW MECHATRONIC PRODUCT
T. Pavlic, M. Miletić, B. Hršak, T. Badrov, S. Golubić, T. Vaško, I. Šegrt, R. Jolić, D. Aleksić…………. 332

74. THE ELECTROCHEMICAL IMPEDANCE SPECTROSCOPY STUDY OF ULTRAFINE-GRAINED TITANIUM IN ARTIFICIAL SALIVA
Dragana Barjaktarević, Ivana Dimić, Ivana Cvijović-Alagić, Jelena Bajat and Marko P. Rakin.............. 336

75. CORPORATE SOCIAL RESPONSIBILITY AS A CHALLENGE OF MODERN SOCIETY
M. Božić, S. Kirin, S.Borović, S. Lakićević.. 340

76. DYNAMIC BEHAVIOR AND STRESS FIELD OF EXCAVATOR SchRs740 BOOM AS CONSEQUENCE OF TECHNOLOGICAL REQUIREMENT FOR THE INCRESING IN BOOM LENGTH
Branko Petrović, Ana Petrović, Dragan Ignjatović and Ines Grozdanović…………………………………345

77. RELATION RESEARCH OF SITE-SPECIFIC TRITICALE YIELD AND COMBINE SPEED
Vojislav Simonovic*, Dragan Markovic, Ivana Markovic, Jovana Šakota Rosić……………….............. 349

78. MAIN ATTRIBUTES OF SME´S INNOVATION ACTIVITY IN SLOVAKIA
Ľ. Lesáková1*, P. Laco 353

79. INFLUENCE OF FRICTION WELDING PARAMETERS ON HARDNESS, MICROSTRUCTURE AND MECHANICAL PROPERTIES OF THE Al-Cu JOINT
Nada Ratković, Dušan Arsić, Vukić Lazić, Ružica Nikolić, Aleksandar Sedmak……………….……….. 359

80. STRESS AND DEFORMATION ANALYSIS OF STRUCTURAL MEMBERS OF ONE MULTIPURPOSE KIOSK
P. Konjatić, J. Kapetan, M. Karakašić, D. Kozak and Ž. Ivandić................................... …………….. 364

81. AGING BEHAVIOR AND RESTORATION BY HEAT TREATMENTS OF 2205 DUPLEX STAINLESS STEEL
N. Ouali[1*], B. Belkessa[1] and M. Bouabdallah... 369

82. SLOVAK AND CZECH FOUNDRIES – BENCHMARKING OF THEIR PROSPECTS IN THE MARKET
M. Pokusová, J. Šujanová and E. Hekelová... 373

83. DUAL TRAINING IN THE LIGHT OF VEHICLE ENGINEERING STUDENT FEEDBACK
Erika Török, Zsuzsanna Kovács.. 377

84. RECENT TRENDS IN WHEY UTILIZATION – PRODUCTION OF BIOACTIVE PEPTIDES
Tanja Krunić, Slavica Arsić, Maja Bulatović, Maja Vukašinović Sekulić, Marica Rakin……………..….. 382

85. STUDY OF SURFACE MORPHOLOGY OF WATER-JET CUT SURFACE OF FRICTION STIR WELDED JOINT
Ratnesh Kumar, Dharmendra Kumar Prasad, Shabbir Ali, Sachindra Shankar, Somnath Chattopadhyaya, Ravi Kumar, Sergej Hloch, Michal Zelenak………………………………………………………….……….. 386

86. IMPLEMENTATION OF FIWARE IN INTERNET OF FIELDS
Nikola Đukić, Branislav Tejić, Srđan Tegeltija, Stevan Stankovski, Dragan Kukolj and Gordana Ostojić………………………………………………………………………………………… 391

87. DRILLING OF CFRP-ALUHAB®-CFRP SANDWICH STRUCTURE
János Líska, Krisztián Kun, Roland Sándor and Norbert Babcsán 397

88. ANALYSIS OF THE STRESS FIELD IN A MODEL OF PIPE BRANCHES
Taško Maneski, Darko Bajić, Nikola Momčilović, Nenad Mitrović, Miloš Milošević, Ana Petrović and Martina Balać... 402

89. PUBLIC PERCEPTION OF AN URBAN PUBLIC SPACE RECONSTRUCTION
Tibor Ferenczy.. 406

90. CRITICAL ANALYSIS OF TIG WELDED JOINT OF TITANIUM G-5 ALLOY SHEET
Deepak Gope, Shubham Yadav, Vipin Kumar, S. Chattopadhyaya, S. Mandal, Sergej Hloch.............. 411

91. THE IMPORTANCE OF NUMERICAL ANALYSIS FOR VSR METHOD APPLICATION – CASE STUDIES
Fuad Hadžikadunić, Nedeljko Vukojević, Safet Isić.. 416

92. ELASTIC-PLASTIC NUMERICAL ANALYSIS OF TENSILE SPECIMENS WITH SURFACE CENTER-CRACKED ASYMMETRIC WELDED X-JOINTS
E. Doncheva, B.Medjo ,G.Adziev, S.Sedmak.. 421

93. MEASURING INTERCULTURALIZM USING FUZZY LOGIC
Janáková Hana.. 426

94. LASER PEENING OF LASER WELDED NICKEL BASED SUPERALLOY SHEETS
S. Petronic, M. Burzic, D. Milovanovic, K. Colic and S. Perkovic………………………………………… 431

95. MECHANICAL BEHAVIOR OF A PIPE SUBJECT TO BUCKLING
H. Chenine, D. Ouinas and Z. Bennaceur………………………………………………………………… 436

96. DEVELOPMENT OF TRAINING PLATFORM FOR POWER PLANT APPLICATION USING VIRTUAL REALITY TOOLS
R. Beleznai, G. Dobos, Sz. Szávai and Z. Bézi……………………………………………………………… 442

97. NUMERICAL SIMULATION OF DISSIMILAR METAL WELDING - keynote lecture
Z. Bézi, Sz. Szávai, C. Ohms…………………………………………………………………………........... 448

98. MECHANICAL BEHAVIOUR OF PIPES STEEL REINFORCED WITH COMPOSITE MATERIALS AND ON STEEL
Z.Bennaceur, D.Ouinas and H.Chenine…………………………………………………………………… 455

99. DEVELOPMENT OF THE SUPPORTING SYSTEM OF AUGMENTED REALITY IN OUTER SPACE FOR THE ENRICHMENT OF TOURIST ATTRACTIONS
Mihael Kukec, Željko Knok and Nenad Breslauer……………………………………………………... 460

100. DETERMINATION OF IMPACT ENERGY BY DYNAMIC EFFECT OF FORCE ON THE COMPOSITE RUBBER BANDS
E. Pirić, Z. Burzić, M. Manjgo, F. Islamović, T. Vuherer……………………………………………........ 466

101. WAYS OF RECEIVING INFORMATION IN THE LOCAL ACTION GROUP (LAG) TERRITORY
I. Mietule, A. Zvaigzne.. 470

102. TEHD CONTACT MODELLING WITH SHELL LIKE LUBRICANT FILM ELEMENT BY FEM
Sz. Szávai………………………………………………………………………………………..................... 475

103. HEALTH AND KINESIOLOGY ACTIVITY AMONG STUDENTS
Nevenka Breslauer, Tomislav Hublin and Marija Zegnal Koretić……………………………………….. 481

104. THERMO-MECHANICAL ANALYSIS OF TANK WAGON FOR TRANSPORTATION OF MOLTEN SULFUR
Vladimir Milovanović, Nikola Jovanović, Jelena Živković, Aleksandar Dišić, Snežana Vulović and Miroslav Živković…………………………………………………………………………….............. 485

105. TOPOLOGY OPTIMIZATION USED TO REDUCE WEIGHT OF FOUR-AXLE BOGIE FREIGHT WAGON – keynote lecture
N. Jovanović, M. Topalović, V. Milovanović, S. Vulović and M. Živković.. 489

106. ROMANIAN EXPERIENCE IN IMPLEMENTING IIW/EWF MANUFACTURER CERTIFICATION SYSTEM
H. Daşcău…………………………………………………………………………………………………….. 493

107. 3D PROFILING OF 12Cr HEAT RESISTANTE STEEL CHARPY V NOCH FRACTURE SURFACES OBTAINED AT DIFFERENT TEMPERATURES
Gordana Bakic, Milos Djukic, Radivoje Mitrovic, Aleksandar Maslarevic, Zarko Miskovic,
Bratislav Rajicic, Vera Sijacki Zeravcic.. 496

108. ANALYTICAL AND NUMERICAL CALCULATION OF THE EQUIVALENT STRESS OF OPEN SECTION THIN-WALLED "U" PROFILE AT CONSTRAINED TORSION
Đ. Đurđević, N. Anđelić, T. Maneski, V. Milošević-Mitić, M. Milovančević, A. Đurđević........................ 502

109. CERTIFICATION AND QUALIFICATION OF NDT PERSONEL, WELDERS AND WELDING INSTRUCTORS IN SERBIA
Goran Sofronić, Dragana Kuzmanović, Davor Gruber, Vladimir Zorić……………………………………. 506

110. USE OF LEARNING OUTCOMES IN ASSESSMENT – NEW PERSPECTIVE BROUGHT BY NATIONAL QUALIFICATIONS FRAMEWORKS IN ENGINEERING HIGHER EDUCATION IN CROATIA – keynote lecture
M. Balković, D. Kozak and S. Grgić.. 509

111. MANAGING INTELLECTUAL CAPITAL: THE CASE OF MONTENEGRO
Ana Radunović-Šebek, Djuro Kutlaca.. 514

112. EIGENVALUE AND EIGENVECTOR SENSITIVITY
Nataša Trišović, Wei Li[2], Ljubica Milović[3] and Ines Grozdanović……………………………….......... 519

113. MACROSTRUCTURES, DEFECTS AND MICROHARDNESS OF FRICTION STIR WELDED T JOINTS OF AA 5052-H32 AND AA 5754-H111
A. Đurđević, A. Sedmak, A. Živković, Đ. Đurđević.. 523

114. INFLUENCE OF INJECTION MOLDING PARAMETERS ON INJECTION MOLDED PART WEIGHT
Pero Raos, Josip Stojšić………………………………………………………………………………………528

115. FRICTION STIR WELDING OF T JOINT – NUMERICAL ANALYSIS
A. Đurđević, S. Tadić, A. Sedmak.. ……………531

116. BONE CEMENT DEMOLITION BY PULSATING LIQUID JETS - keynote lecture
Sergej Hloch, Josef Foldyna, Michal Zeleňák, Jiří Klich, Pavol Hvizdoš ………………………………..535

117. TWO-SPEED TWO-CARRIER PLANETARY GEAR TRAINS
Sanjin Troha, Dimitar Karaivanov and EminaDžindo...538

118. THE INFLUENCE OF THE SIZE DISTRIBUTION AND PARTICLE PROPERTIES ON THE FILTRATION PERFORMANCES IN TECHNICAL WATER
Zorana Golubović, Aleksandar Sedmak, Milan Milosavljević……………………………….................. 543

119. REGULAR ADAPTRONIC PRODUCTS ENHANCED WITH THE FRACTIONAL ORDER CONTROL
Vasilije Vasić, Mihailo Lazarevic……………………………………………………………………………. 547

120. SUBLIMATION OF VARIOUS MODELS RESULTS OF MULTI-CRITERIA ANALYSIS AS A FUNCTION OF IMPROVEMENT OF ALTERNATIVE RANK RELEVANCE
Izet Hot, Nazim Manić, Mladen Pantić, Simon Sedmak and Ramo Bakić………………………………… 552

121. SELECTION OF STEELS FOR VITAL STRUCTURES AND TURBINE COMPONENTS OF THE HYDRO POWER PLANT 'DJERDAP 1'
Miodrag Arsić, Simon Sedmak, Srđan Bošnjak, Mladen Mladenović, Zoran Savić............................... 558

122. TECHNO-MANAGERS IN CAPITALISM AND SOCIALISM: COMPARATIVE ANALYSIS OF THE FORD MOTOR COMPANY AND ZAVODI „CRVENA ZASTAVA"
Milan Stanković, Predrag Markovic.. 565

123. THE ADVANCED MECHATRONIC AGRICULTURE MACHINES - CHALLENGE FOR THE FUTURE -
J. Melchers, V. Vasić……………………………………………………………………………………… 573

124. MOST COMMON PITFALLS WITHIN CREATION OF PROJECT PROPOSALS FOR EU FUNDING
D. Ninković, I. Svetel, G. D. Grkovic, B. Kleinheyer, E. Engh...…………… 576

125. DESIGN OF CYLINDRICAL SHELL STEEL STRUCTURES WITH BILLBOARD TOWER AS THE CASE STUDY
Dorin Radu, Aleksandar Sedmak………………………………………………………………………… 580

126. MICROMECHANICAL STUDY OF DUCTILE FRACTURE INITIATION AND PROPAGATION ON WELDED TENSILE SPECIMEN WITH A SURFACE PRE-CRACK IN (HAZ)
Bashir Younise, Aleksandar Sedmak, Marko Rakin and Bojan Medjo... 585

127. ROLE OF HYDROELECTRIC POWER PLANT IN DEVELOPMENT OF UZICE AND BAJINA BASTA SETTLEMENTS
Ivana Vučetić, Aleksandra Stupar and Aleksandar Sedmak... 589

128. REVITALISATION OF ERs 1000 “VEDRICAR” EXCAVATOR DRIVING WHEEL BY WELDING
Mladen Tošanić, Aleksandar Sedmak, Stefan Tošanić ………………………………………………….. 595

129. INFLUENCE OF MACHINING PARAMETERS ON MACHINE TOOL LOADS AT ROTARY ULTRASONIC MACHINING OF SYNTHETIC DIAMOND
Marcel Kuruc, Jozef Peterka.. 598

130. CERTIFICATION OF PERSONNEL FOR API 510 PRESSURE VESSEL INSPECTOR
Igor Martic, Galip Buyukyildirim, Tamara Golubović, Ramo Bakic... 602

131. STRESS INTENSITY FACTOR ANALYSIS FOR A CRACK EMANATING CIRCULAR NOTCH REPAIRED BY COMPOSITE PATCHING
H.I. Beloufa, D. Ouinas and M. Tarfaoui... 606

132. MODELLING OF A CRACKED ALUMINIUM PLATE REPAIRED WITH COMPOSITE PATCH IN MODE I AND MIXED MODE
H.I. Beloufa, D. Ouinas and M. Tarfaoui... 610

133. DYNAMIC BEHAVIOR OF COMPOSITE PLATES IMPACTED AT LOW VELOCITY
H. Benyahia, M. Tarfaoui and D. Ouinas... 614

134. THE IMPACT OF THE CONTACT LOAD RESISTANCE TO ADHESION WEAR OF THERMAL-CHEMICALLY PROCESSED STEEL MnCr
Ivan Opačak, Dejan Šakić, Vlatko Marušić, Ivan Samardžić... 617

135. THE INFLUENCE OF PARAMETERS OF THERMOCHEMICAL PROCESSING ON PROPERTIES OF STEEL 20MnCr5
Ivan Opačak, Luka Marušić, Vlatko Marušić, Dejan Marić.. 622

136. TRANSPARENT BUILDING ELEMENT EFFECTS ON HEAT ENERGY CONSUMPTION
Arben Ljajić, Ramo Bakić, Nazim Manić and Izet Hot... 626

137. COMBINED SERBIAN AGRICULTURAL MACHINE FOR TILLAGE FERTILIZATION PREPARATION AND STABILIZATION OF SOIL AND SOWING
S.Mandić, U. Tatić, B. Đorđević, M. Radojković Tatić……………………………………………………. 629

138. SOME NOTICES ON TRADITIONAL CHALK AND TALK METHOD VS. CONTEMPORARY E-LEARNING
Dj. Kozić, A. Sedmak……………………………………………………………………………………….632

139 THE PRESMOD LANGUAGE FOR MODELING (2D)
Željko Popović, Ivan Aranđelović... 635

140 FATIGUE BEHAVIOUR OF MODELS USING 3D PRINTING TECHNOLOGY
Jasmina Lozanović Šajić.. 638

141 WELD REPAIR OF A P91 STEAM PIPE WITH OVER 100.000 OPERATING HOURS EXHAUSTED LIFE
C. Delamarian.. 642

142 GEOMETRIC PROGRAMMING FOR OPTIMAL DESIGN OF A WELDED ASSEMBLY: AN ILLUSTRATIVE EXAMPLE
B. Pejović[1], D. Stević[1], I. Hut[2], V. Mićić[3], A. Sedmak... …………………. 646

INTEGRITY AND LIFE OF WHEELS REPAIRED BY WELDING

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Abstract

Presented in this paper are the results of testing of repared crane wheels. Wheels were subjected to load witch resulted with a crack on drift surface. The effects of contact between the rail and wheel were tested in real exploitation condition, as well as by using numerical simulations.

Keywords:

Wheel, rail, wear, welding, crack

1.Introduction

Performing of manufacturing processes with minimal costs related to maintenance and spare parts, along with minimal use of manual work, represents an everyday goal that science and technology should achieve. In case of steel industry, cranes represent the “arms” of operation and without them work would be impossible. Safe and reliable work with cranes is mostly dependant on wheels.

During exploitation, wheels are affected by wear and need to be replaced. Worn, damaged crane wheels can be successfully repaired by welding.

Within the facility for manufacturing and maintenance of spare parts at Železara Smederevo, 20-25 crane wheels are repaired each month, on average. Increased production leads to increased demand for crane wheels.

Demands for crane wheel repair are entirely related to dimensions and surface hardness. Due to wheel/rail wear, the dimensions of the wheel’s drift surface area and rim are reduced. Crane wheels are manufactured by forging of steels C11G1C, C14G1C, C45, C45E, C45G, or by casting steel GS255JRN, GS295JRN, G34CrMo4 along with adequate machine and thermal processing. Hardness of the drift surface of the wheel ranges between 37 and 40 HRC. [10]

Based on their shape, wheels can be divided into following groups: wheels with a single rim (Fig. 1a), wheels with two rims (Fig. 1b) and wheels without rims (Fig. 1c). Drift surface can be conical (Fig. 2a) and cylindrical (Fig. 2b). Wheel diameters range from 350 to 800 mm.

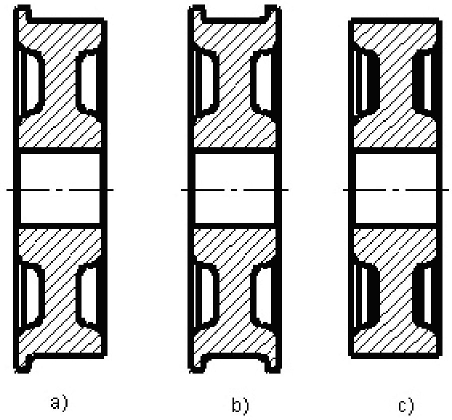

Figure1. Left: Wheel with a single rim; Center: Wheel with two rims; Right: Wheel without a rims

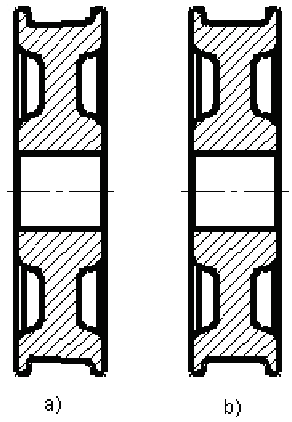

Figure 2. Drift surface shape

Železara Smederevo has 206 cranes - 127 technological and 79 repair cranes. Their load bearing capacity ranges from 0.5 to 170 tons.

Wheels with cylindrical drift surface and two rims, with a diameter of 630 are most frequently used, thus the tests and analysis performed in this paper are related to this type of wheels.

In modern day engineering, the application of CAD/CAM/CAE technologies enables the simulation of exploitation conditions and the analysis of product functionality.

2. Wheel wear

During the recent years, due to increased production in facilities, cranes are used for transporting of maximum loads, which leads to increased wheel/rail strain. It should be mentioned that wheel and rail design has not been changed since the crane was installed (late 60's and early 70's). Increased loads have changed the nature of most wheel damage from wear to fatigue. Unlike the slow process of wear, fatigue causes cracks on contact areas of wheels, along with loss of material.

Almost 40% of all wheel replacements are the result of intense wear of wheel rim and its fracture, Fig. 3. Experiments have proven that an increase in surface hardness improves its wear resistance. However, if this hardness "goes" deeper into the wheel rim, it will actually increase the probability of its failure, leading to wheel damage.

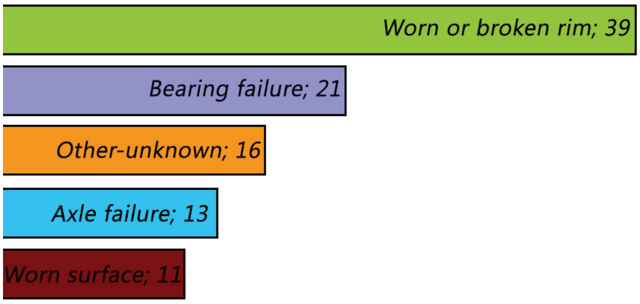

Figure 3. Reasons for replacement in % [12]

Like hardness, core toughness below the hard surface area contributes to chipping of material from the wheel drift surface, Fig. 4, due to the fact that the tough core absorbs the stresses caused by incorrectly leveled rails. These stresses can be transferred to the rim, leading to damage and fracture [1,2].

When rim fracture is the main reason for wheel replacement, Fig. 5, it is of great importance to define surface hardness and core toughness as demands for each new wheel. Thus, it is important for operators to ensure that all replaced wheels have this vital protection - particularly when large distances between rails and significant loads are present during exploitation.

Crane wheels are replaced in case the when rim is narrower than 10 mm or the radius of drift surface is 5 mm less than the nominal measure. Replacement of such a wheel must be performed immediately, or as soon as possible, in case the necessary conditions cannot be achieved at the moment (requirement for continual production process, i.e. crane exploitation, lack of spare parts etc.).

Figure 4. Wheel damage due to drift surface wear

Figure 5. Wheel damage due to rim wear

3. Repair welding of wheel

An established procedure for repairing wheel cranes consists of the following operations:

- Positioning of number plates
- Wheel normalisation
- Mandatory pre-treating of the drift surface diameter. If the rim diameter is within ±5 mm of the nominal measure according to drawings, it should not be treated. In case the rim diameter is more than 5 mm below the nominal measure, it should be pre-treated until the first clean measurement (in 6 mm increments), negative in respect to the nominal value from the drawing, is achieved.
- Pre-treating of the wheel opening to a maximum of 2 mm above the nominal measure.
- Measurinig of the pre-treated wheel according to the sketch.

- Pre-heating of the wheel to a temperature of 200 to 220 degrees. Drift area and rims should be welded using a wire, followed by 3 layers welded using a wire for the wear layer. During welding, temperature should be maintained between 320 and 450 degrees.
- Wheel should be welded in the minus 6 mm opening. The wheel should then be annealed immediately upon welding.
- Wheel annealing. Cooling and heating rate is 50 degrees per hour.
- Drift surface and rim should be treated to match the drawing measures.
- Welded wheel opening should be treated to macth the drawing measures
- Position of groove(s) for the wedge should be denoted.
- Treating of groove(s) for the wedge, according to designations from the drawing.
- Edges should be treated and threads should be cut on both fronts of the wheel. [3,4,9]

It was shown in practice that, even despite the strict control after repair welding, wheels that contain initial flaws (cracks), Fig. 6, can be "released" for exploitation. The origin of these flaws can be mutiple and includes: additional material selection, welding technology selection, worker errors and thermal processing mode. The life of these wheels depends on crack growth during the initial stage. How the crack will develop depends on the fatigue threshold.

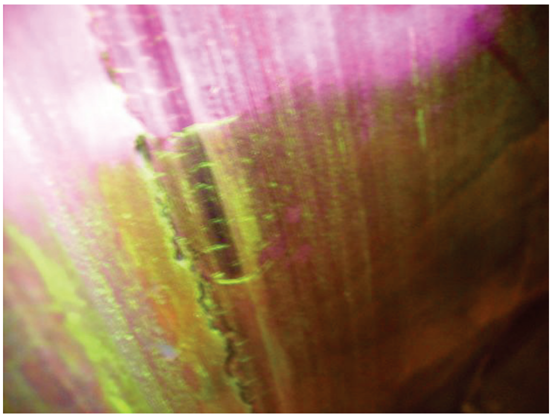

Figure 6. Cracks on welded wheel

Most commonly encountered flaws on repaired wheels include low hardness and occurrence of lateral surface cracks on the rim and drift surface. Wheels with flawed hardness are subjected to repeated thermal processing, whereas wheels with cracks are removed from exploitation. The reason for the removal of cracked wheels is a lack of knowledge and certainty related to their wear resistance.

In case of newly manufactured wheels and repaired wheels without flaws in initial exploitation, cracks during work life occur due to stress concentration and material fatigue. The representative parameter for these wheels is the lifetime until crack initiation.

4. Wheel load

Analyses are performed on wheels with a diameter of 630 mm with a flat drift surface. Maximum allowed load for these wheels, which move along the type S49 wheel is 200 kN [6]. The span of these rails ranges between 21.5 and 32 m.

During the contact between two cylindrical machine parts with parallel generatrices, the contact area is shaped like a narrow rectangle with width of $2e$ and length l. Assuming that the curve radii of these cylinders are ρ_1 and ρ_2, made of a material with a Poisson's ratio of v = 0.33 and elasticity modules of E_1 and E_2, then the contact rectangle width is equal to:

$$2e = 3.04\sqrt{\frac{F \cdot \rho}{E \cdot l}}$$

$$E = \frac{2 \cdot E_1 \cdot E_2}{E_1 + E_2}$$ - Equivalent elasticity module

$$\rho = \frac{\rho_1 \cdot \rho_2}{\rho_1 + \rho_2}$$ - Equivalent curve radius

According to Hertz's theory of contact stresses, contact stress between wheel and rail (flat surface cylinder) is:

$$P_{\max} = \frac{4}{\pi} \times P_{sr} = 0.418 \times \sqrt{\frac{F \times E}{\rho \times l}} \qquad [7]$$

P_{max} = 1082 N/mm^2

In case of sphere contact, i.e. between a cylinder and a flat surface (wheel and the rail), $\rho_2 = \infty$ is adopted in the above relations, resulting in a reduced curve radius, $\rho = \rho_1$.

According to current research, maximum allowed pressure on contact surface with hardness between 35 and 39 HRC is equal to [12].

5. Numerical simulation

Finite element method represents a widely used numerical method based on physical discretization of a model. It represents the process of dividing 3D numerical models into small elements with simpler geometry, and finite dimensions, degrees of freedom as well as mechanical properties. Elements are connected to each other by a finite number of nodes in order to create a mesh. Depending on the factors such as geometry, the nature of the problem analyzed etc., the shape and size of elements is to be defined.

The FEM software uses previously defined mesh to calculate the displacement field for each node, and based on it, determine the strain and stress states within the elements and thereby the whole model [13].

When applying FEM, difficulties can appear in defining the geometry of a realistic physical model, and thereby in some cases approximations are to be used. In a case of rail and wheel geometry is relatively simple, but contact between rail and wheel represents a complex part [14,15] to be modeled individually, because of curvature in surface and different material sections.

In the process of evaluation of the stress strain distribution caused by the contact it was necessary to develop two separate models (Model 1 and Model 2). In the case of a first model it was assumed that a contact was ideal and that a wheel and a rail are symmetrically positioned as it can be seen on Figure 7 on the left. This case was denoted as Model 1.

Second model represents a case in which, because of the distance between two separate wheels on the same axis, as well as loading and sudden move of a lift there is a slight tilt in the angle relative to the direction of the rail. As a consequence of this tilt, the wheel is moved to a side of the rail and initial contact between rail and wheel is reduced only to the side wall of the wheel rim. Gap appears between top surfaces of the wheel and rail (Figure 7).

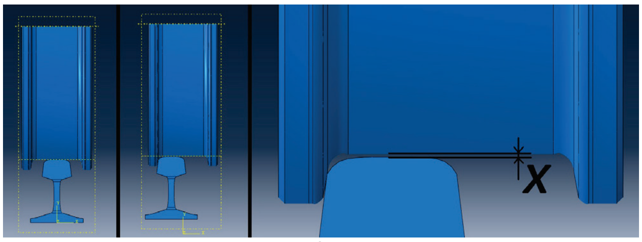

Figure 7. Model 1 on the left, Model 2 in the middle, Contact surface gap on the right

Two separate models, both dealing with sidewall contact, were created. The models were almost identical with only difference that in Model 2a, the initial gap was set to 0.2mm whereas in a case of Model 2b, the initial gap was 1.5mm (Figure 8).

For the creation of the numerical models some approximations were made in order to simplify the model and reduce the number of finite elements.

Model of a wheel was created as a 180° sketch revolution in order to produce half of physical model, since stress strain distribution is expected only in the area between the axis and contact with the rail. Length of the rail was reduced to 250 mm which ensured enough length to provide adequate behavior outside the direct contact area.

In both models, loading was defined as concentrated force. In order to ensure even distribution, two equal forces were used with the combined value of 200 kN. Forces were positioned along the bottom line of an axis opening at a distance of 47.5 mm from the side of the wheel (Figure 8).

In both models, encastre on a bottom side was used to restrict the position of a rail and to simulate working conditions. Additional restriction to lateral movement and rotation was added on to side surfaces of axis opening, as can be seen on figure 8).

In a case of Model 2 (both a and b) additional boundary condition was added to prevent rotation around the direction of the rail and ensure adequate contact distribution.

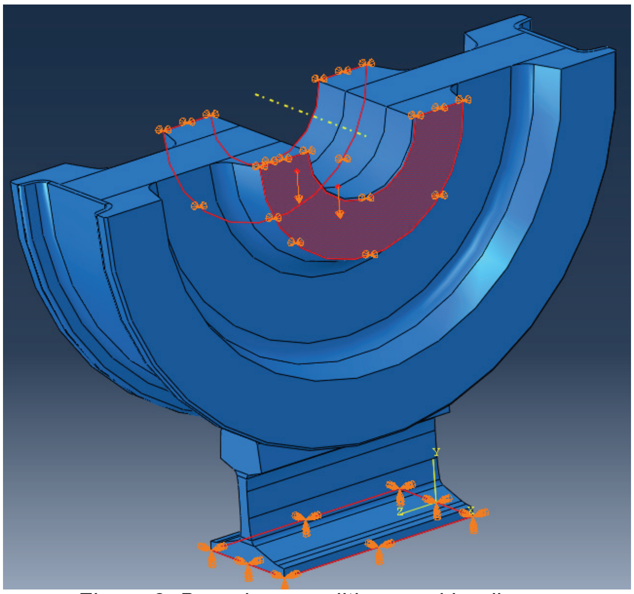

Figure 8. Boundary conditions and loading

During the development of the numerical model, an additional area of 6 mm was added to simulate the welded layer.

Base of the wheel was modeled with G34 CrMo4, while in the drift area WLDC 12 (CORE-WIRE, UK) of thickness 6 mm was modeled. Material properties used in the numerical model can be seen in a table 1 [5, 11, 16,17].

Table 1. Applied material properties

	E [Mpa]	Poisson's coefficient	R_e [Mpa]
G34CrMo4	210 000	0.33	415
WLDC12	216 000	0.33	862

Mesh in a both models was created identically. C3D8R elements, 8-node linear elements with reduced integration were used. Rail was meshed with use of 5780 elements, while the wheel consisted of 24900. Element size was reduced towards a contact area in both wheel and rail (Figure 9).

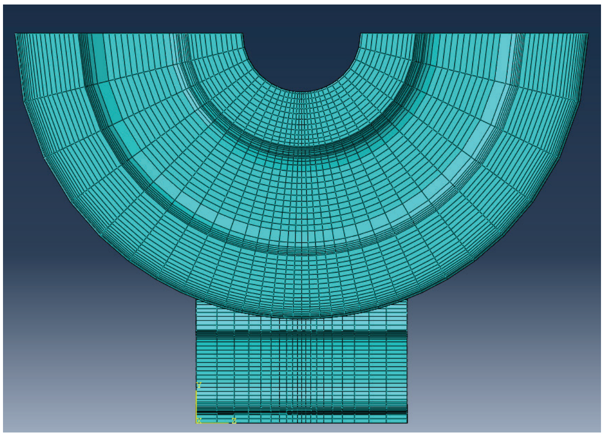

Figure 9. Mesh in assembly

6. Results

Numerical simulation has shown that the stress is concentrated around the contact area, as was expected. In the case of both models, difference can be noticed in the different material sections. Stress values in both models are below the value of yield stress. Stress distribution is symmetric in case of Model 1, as can be seen on the Figure 10.

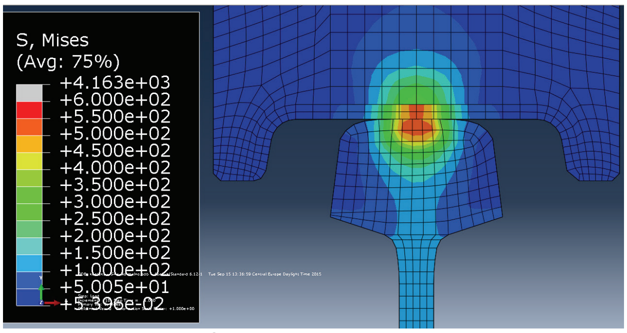

Figure 10. Stress distribution in Model 1

In the case of Model 2, under the influence of loading, slight deformation and displacement of the contact area of wheel occurs. This is followed by the appearance of a new contact area between the top of rail and plain area of the wheel beside the initial contact on the edge. In both cases for Model 2 (a and b) there were no significant differences in the stress strain deformation. Stress field of model 2b can be seen in figure 11.

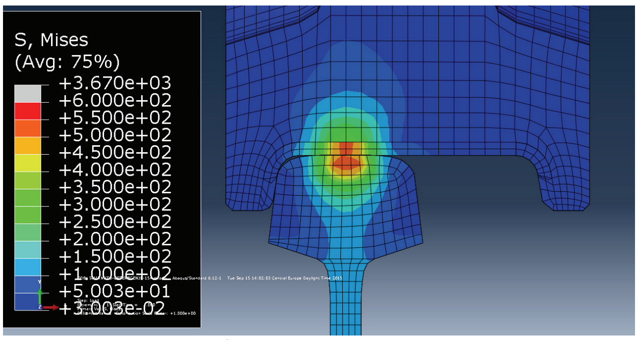

Figure 11. Stress distribution in Model 2b

In the area between plain surface and the edge of rim of the wheel there is an area of increased stress, but its values are 150 - 200 MPa.

7. Conclusion

Presented in this paper are the issues related to repair welded crane wheels, along with repair welding technology, as well as stresses in the contact zone between the wheel and the crane. It can be seen that the contact stress obtained by numerical analysis are within the allowed stress limits, i.e. that the maximum stresses are located in the welded layer zone. Welding of a hard layer with thickness greater than 6 mm is not necessary. This is very important, since applying of thicker layers of hard materials increases the risk of surface cracks occurring.

Life span of repair welded wheels without surface cracks surpasses the life of new wheels whose drift surface was only thermally processed (tempered). In case of these wheels, the rim has low toughness and its fracture frequently occurs before wear (reduction of thickness).

Influence of the surface cracks is not determined in this paper but since they can have major influence on work parameters, and it was determined that they can appear, their influence is still to be evalueted in further analyses.

8. Acknowledgement

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POST HOC ANALYSIS IN BIOMETRICS

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Abstract

In this paper we have conducted comparison of four post-hoc tests (LSD, Bonferroni, Scheffe, Tukey), whom have we used on four data sets. Every one of four biometrics sets contained three groups and every group had equal number of observations. Data sets differed in size (n <30 and n >30) and in the coefficient of variation (CV < 5% and CV > 20%). We have used one-way analysis of variance, calculated by GLM procedure, to perform statistical analysis. Results were further analysed by computer program Statistica v.8.0. (StatSoft, Inc., 2007). Based on results of analysis we have observed that most liberal of all test was LSD test (lowest statistically significant differences between all observations in all data sets). More conservative tests (Bonferroni, Scheffe and Tukey) had higher values of statistically significant differences between all groups of observations (A-B, A-C and B-C). Also, usage of conservative tests in post-hoc can show no statistical significance between observations, what won't be the case if more liberal tests, like LSD test, are used.

Keywords:

Biometrics, post-hoc tests, Statistica

1. Introduction

What type of test to use during statistical analysis can be quite challenging. It is needed to know what type of data will be used (nominal, ordinal, interval) [7], how data is organized, how many groups there are and if groups are dependent or independent. Also, it must be checked if data, collected from population, is following normal distribution or not [10]. In some circumstances testing treatment means is conducted post-hoc using wide range of tests [1]. All these tests determine critical differences treatment means need to cross to be considered statistically important (P<0.05). In many cases diferent post-hoc tests can result in same results [2]. Variations in tests are based both on their ability to cope with data presented and the probability of rejecting assumptions of ANOVA. These tests, also called multiple comparison tests, and their purpose is to determine specific differences between treatment means that are responsible for statistically significant result. In many cases results of all of these tests will show same results, but every one of these tests has its own unique approach to the certain problem. Good way to determine what type of test to use is to take in account what is the purpose of conducted research.

If it is tested for probability of treatment groups to show specific result then it is better to use more liberal tests like Fisher's PLSD test. Fisher's PLSD test is most liberal test of all and has highest probability of resulting in Type 1 error [3]. In this test all pair-wise comparisons are graded and critical values are set using t-test [8]. Critical values are set for every mean pair based on difference between largest and smallest mean [1,5]. If used only on results that will show statistical significance (P < 0,05), critical value will be lowest. In the same time, it is ensured that test is used to it's maximum when it is used to determine difference between means [4].

On the other hand if the purpose of research is to determine if specific treatment is affecting other treatments than it is better to use more conservative tests like Scheffes test. This test is considered one of the most popular tests, the most flexible, and the most conservative. Scheffe's test corrects alpha for all pair-wise or simple comparisons of means, but also for all complex comparisons of means as well. As a result, Scheffe's is also the least statistically powerful procedure [5].

Tests like Tukeys HSD test and SNK test are set between two above mentioned tests. Tukey's test is similar to Fisher's but it's characterized by lower probability of resulting in Type 1 error [1]. It's one of few tests that can be used to determine which means differ from the means group. Similar test is SNK (Student-Newman-Kleus) but also it's stronger test than Tukey's. It is considered stronger because it can complete larger number of pair-wise comparisons which results in higher probability of obtaining statistically significant results. It shows if there is a difference between two or more means, but it does not show what the difference is [9]. Differences between these two tests can also be observed based on their attitude towards alpha value. Tukey test want's to preserve alpha value, while SNK test broadens it so that it could show more statistically significant result [6].
Purpose of this paper is to determine convenience of statistical program Statistica v.8.0. [11] for biometrical researches in whom both ANOVA and post-hoc tests are used to determine statistically significant differences (P<0,05) between groups

2. Method

Data used for analysis in statistical Statistica v.8.0. [11] was collected from results of four conducted researches and they included: (I)pH value in turkey muscles, (II) cholesterol content in turkey pectoral muscle (mg/100 g), (III) turkey weight in 16. fattening week (g) and (IV) chick weight in 35. fattening day (g). Results of said researches are given in Table 1.

Table 1. pH value in turkey muscles, cholesterol content, cholesterol content in turkey pectoral muscle (mg/100g), turkey weight in 16. fattening week (g), chick weight in 35. fattening day (g).

	pH value in turkey muscles			cholesterol content in turkey pectoral muscle (mg/100g)			turkey weight in 16. fattening week (g)			chick weight in 35. fattening day (g)		
Sample no.	Treatment			Treatment			Treatment			Treatment		
	A	B	C	A	B	C	A	B	C	A	B	C
1	5,	5,	5,	10	28	4,9	1010	1035	9920	11	15	13
2	5,	5,	5,	15	30	6	1016	1048	9957	12	16	13
3	5,	5,	5,	24	50	10	1028	1054	1026	12	17	14
4	5,	5,	5,	34	53	11,	1022	1060	1028	13	18	16
5	5,	5,	5,	37	56	22,	1028	1062	1030	13	19	16
6	5,	5,	5,	40	56	22,	1036	1069	1038	14	20	17
7	5,	5,	5,	43	57	23	1036	1084	1040	15	22	18
8	5,	5,	5,	44	58	28,	1040	1089	1054	17	22	19
9	-	-	-	-	-	-	1047	1102	1061	18	25	23
10	-	-	-	-	-	-	1052	1107	1064	21	26	23
11	-	-	-	-	-	-	1056	1131	1068	22	28	24
12	-	-	-	-	-	-	1057	1156	1080	23	29	25

These four data sets differ considering both sample size (n<30 and n>30) and coefficient of variation (low, CV < 5% and high, CV > 20%). Given data were first tested using one-way ANOVA and later tested with post-hoc tests in Statistica v.8.0.

3. Results and Discussion

Table 2 shows results of ANOVA. As it can be seen differences between all observed groups were statistically significant (P < 0.001). F value for pH is 59.4, for cholesterol 16.4, for turkey weight in 16. feeding week 15, 28 and for chick weight 35. feeding week 9.48. Thus, all samples fulfilled requirements needed for further statistical analysis.

Table 3. shows mean values, standard deviation, standard error and number of observations per group.

Table 4 shows results of LSD test conducted on all data sets (ph value, cholesterol content, 16. week weight and 35. day weight). LSD test conducted on data sets for pH value in turkey muscles show statistical significance between all observed groups (P < 0.001). Same results for cholesterol content in turkey pectoral muscle, turkey weight in 16. fattening week and chick weight in 35. fattening day were obtained.

Using Bonferroni post-hoc test on observed data sets statistical significance can be observed (Table 5.)

Table 2. Results of ANOVA.

Effect		SS	Deg. of Freedom	MS	F	p
pH value in turkey muscles	Intercept	749.5073	1	749.5073	264532.0	0.000000
	Observation	0.3364	2	0.1682	59.4	0.000000
	Error	0.0595	21	0.0028	-	-
Cholesterol content in turkey pectoral muscles (mg/100g)	Intercept	24339.77	1	24339.77	178.6765	0.000000
	Observation	4482.87	2	2241.43	16.4542	0.000050
	Error	2860.67	21	136.22	-	-
Turkey weight in 16. fattening week (g)	Intercept	4.017553	1	4.017553	53230.59	0.000000
	Observation	2.307068	2	1.153534	15.28	0.000020
	Error	2.490659	33	7.547451	-	-
Chick weight in 35. fattening day (g)	Intercept	122353095	1	122353095	618.5002	0.000000
	Observation	3752417	2	1876208	9.4843	0.000557
	Error	6528134	33	197822	-	-

Table 3. The mean values, standard deviation, standard error and number of observations per group.

Effect	Observation	n	Mean	Std. Dev	Std. Err.	-95%	+95%
pH value in turkey muscles	Total	24	5.588333	0.131204	0.026782	5.532931	5.643736
	Group A	8	5.590000	0.064365	0.022756	5.536189	5.643811
	Group B	8	5.732500	0.034122	0.012064	5.703974	5.761026
	Group C	8	5.442500	0.056505	0.019978	5.395260	5.489740
Cholesterol content in turkey pectoral muscles (mg/100g)	Total	24	31.84583	17.86853	3.647398	24.30062	39.39105
	Group A	8	31.27500	13.24880	4.684158	20.19873	42.35127
	Group B	8	48.86250	12.53383	4.431379	38.38395	59.34105
	Group C	8	15.40000	8.72009	3.083018	8.10982	22.69018
Turkey weight in 16. fattening week (g)	Total	36	10564.03	370.2403	61.7067	10438.76	10698.3
	Group A	12	10262.08	155.4568	44.8765	10163.31	10360.8
	Group B	12	10881.58	355.2892	102.5632	10655.84	11107.3
	Group C	12	10548.42	275.7286	79.5960	10373.23	10723.6
Chick weight in 35. fattening day (g)	Total	36	1843.556	541.9687	90.3281	1660.180	2026.931
	Group A	12	1443.667	421.3132	121.6226	1175.977	1711.356
	Group B	12	2234.333	472.3790	136.3641	1934.198	2534.469
	Group C	12	1852.667	439.1128	126.7609	1573.668	2131.666

Table 4. Results of LSD post-hoc test.

	Observation	A	B	C
pH value in turkey muscles	A		0.000026	0.000017
	B	0.000026		0.00000
	C	0.000017	0.00000	
Cholesterol content in turkey pectoral muscles (mg/100g)	A		0.006610	0.012819
	B	0.006610		0.000011
	C	0.012819	0.000011	
Turkey weight in 16. fattening week (g)	A		0.000004	0.015490
	B	0.000004		0.005508
	C	0.015490	0.005508	
Chick weight in 35. fattening day (g)	A		0.000122	0.031064
	B	0.000122		0.043272
	C	0.031064	0.043272	

Table 5. Results of LSD post-hoc test.

	Observation	A	B	C
pH value in turkey muscles	A		0.000078	0.000051
	B	0.000078		0.000000
	C	0.000051	0.000000	
Cholesterol content in turkey pectoral muscles (mg/100g)	A		0.019831	0.038456
	B	0.019831		0.000033
	C	0.0038456	0.000033	
Turkey weight in 16. fattening week (g)	A		0.000012	0.046469
	B	0.000012		0.016523
	C	0.046469	0.016523	
Chick weight in 35. fattening day (g)	A		0.000365	0.093193
	B	0.000365		0.129816
	C	0.093193	0.129816	

Only exception are results obtained from chick weight in 35. fattening day. In this data set statistical significance ($P < 0,01$) was observed only between group A and B while other groups show no statistical significance. On the other hand, Bonferroni test results conducted on other tree data sets show statistical significance between all groups within data sets. It should also be observed that obtained results have higher values than those obtained by LSD test conducted on same data sets. This can be explained with the fact that LSD test is more liberal than Bonferroni test.

Scheffe test is more conservative than both Bonferroni and LSD test and thus shows higher result values than both before mentioned tests. Statistical significance between all groups in pH and cholesterol content data sets can be observed. On the other hand, statistical significance for turkey weight in 16. fattening week can only be observed between groups A – B and B – C. Group A – C shows no statistical significance. There are similar results for chick weight in 35. fattening day where statistical significance can only be observed between group A – B (Table 6.).

Table 7. shows results of Tukey test. From all four post-hoc tests, Tukey test was most conservative and values of statistical significance were lowest. Nevertheless, almost all data sets showed statistical significance. Only exception is found in data for chick weight in 35. fattening day where statistical significance can only be observed between group A – B while other groups show no statistical significance.

Table 6. Results of Scheffe post-hoc test.

	Observation	A	B	C
pH value in turkey muscles	A		0.000119	0.000078
	B	0.000119		0.000000
	C	0.000078	0.000000	
Cholesterol content in turkey pectoral muscles (mg/100g)	A		0.022960	0.042019
	B	0.022960		0.000051
	C	0.042019	0.000051	
Turkey weight in 16. fattening week (g)	A		0.000020	0.051099
	B	0.000020		0.020041
	C	0.051099	0.020041	
Chick weight in 35. fattening day (g)	A		0.000558	0.094443
	B	0.000558		0.125781
	C	0.094443	0.125781	

Table 7. Results of Tukey HSD test.

	Observation	A	B	C
pH value in turkey muscles	A		0.000202	0.000178
	B	0.000202		0.000140
	C	0.000178	0.000140	
Cholesterol content in turkey pectoral muscles (mg/100g)	A		0.017506	0.033055
	B	0.017506		0.000163
	C	0.033055	0.000163	
Turkey weight in 16. fattening week (g)	A		0.000135	0.040128
	B	0.000135		0.014915
	C	0.040128	0.014915	
Chick weight in 35. fattening day (g)	A		0.000455	0.077241
	B	0.000455		0.104988
	C	0.077241	0.104988	

4. Conclusion

In this paper we have conducted comparison of four post-hoc tests (LSD, Bonferroni, Scheffe, Tukey), whom have we used on four data sets.

Every one of four biometrics sets contained three groups and every group had equal number of observations. Data sets differed in size (n <30 and n >30) and in the coefficient of variation (CV < 5% and CV > 20%). We have used one-way analysis of variance, calculated by GLM procedure, to perform statistical analysis. Results were further analysed by computer program Statistica v.8.0. (11).

Based on results of analysis we have observed that most liberal of all test was LSD test (lowest statistically significant differences between all observations in all data sets). More conservative tests (Bonferroni, Scheffe and Tukey) had higher values of statistically significant differences between all groups of observations (A-B, A-C and B-C). Also, usage of conservative tests in post-hoc can show no statistical significance between observations, what won't be the case if more liberal tests, like LSD test, are used.

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THE QUALITY OF TABLE EGGS IN RELATION TO THE AGE OF LAYING HENS

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Abstract

In this research, the influence of age and temperature on quality of layer eggs was observed. Parameters included were egg weight, albumen weight, yolk weight and shell weight (g), widht and lenght of eggs (mm), shape index, firmness and thikness of egg shell (mm), pH value of yolk and albumen and yolk color. Number of eggs used was 360, from Lohmann Brown laying hen hybrid. Age of hens were 25. Weeks (young) and 69. Weeks (old). Quality of eggs was determined in fresh eggs, 7 days and 14 days of keeping. Temperature of keeping was room temperature (22°C) and fridge temperature (4°C). Young layers lay lighter, shorter and narrow eggs. Shell weight, albumen and yolk weight is lower in younger layers. Older layer have softer, and younger have thinner egg shell. In fresh eggs yolk is lighter in younger layers. Also they have higher pH of albumen and yolk. Temperature of keeping statistically significant (P<0.05) influence yolk color, pH value of albumen and yolk, as on shell weight and albumen weight. Longer keeping lowers egg quality, which is influenced by temperature in relation to layers age.

Keywords:

Layers, age, temperature, egg quality.

1. Introduction

Poultry production represents one of the main production systems of food industry. It encloses all segments of production including production and breeding of both heavy and light laying chicken hybrids, production of day-old chicks, egg production and rising of chicken, turkey, duckling and goose broilers [2,3]. Also, modern poultry production would not be possible if it weren't for genetics and selection. Selection processes are needed to ensure that only best animals, with best genetic potential, are selected which in return enables final products of best quality. Further more, genetic researches and selection processes enabled breeding of animals who have better resistance to external influences, are less prone to get sick and with faster metabolism [2,3,5].

Main products of poultry production are meat and eggs which are mainly used as food. Secondary products of same production are feces and feathers.

Feces is used as a manure on fields, while feathers are used in textile industry. This, modern, production is based on intensive, indoor broiler breeding conditions. Structures in such production are built from different types of materials and linked one to each other. During construction of such structures it is needed to take in consideration many different aspect such as: (I) location, (II) capacity, (III) material used and (IV) future microclimate. (5). Also, to ensure animal welfare equipment used must be made of high class materials and which equipment to use is based on: (I) holding structure dimensions, (II) animal type and (III) production type (5). Combination of best equipment, highly trained experts and animals in best health will result in highest possible production.

When talking about egg production it is needed to take great care which hybrid to use in production. Today, majority of egg production is carried out by light hybrids. As said before, to ensure best production it is needed to ensure that production conditions are such to ensure maximum production and egg production is no different. Quality of eggs, as well as other food quality, is in high correlation with production conditions and if they are low, so will be quality. Minimal quality requirements eggs need to achieve before going into the market are set by every country individually. Eggs of highest quality are best source of proteins, fat, vitamins and minerals (7) and are considered essential part of nutrition to keep healthy and balanced diet.

In this paper, the influence of holding conditions on egg quality over the course of two weeks will be observed. Purpose of the experiment was to show in which way and in what amount egg quality drops if they are held in room temperature and in refrigerator in 0, 7 and 14 days interval.

2. Material and Methods

This research was based on quality of eggs from Lohmann Brown layers of different age (25. and 69. weeks of age) held in furnished cages. To determine quality 360 eggs were and they were distributed as such:

- 120 fresh laid eggs (60 pcs. from layers of 25. weeks of age and 60 pcs. from layers of 69. weeks of age)
- 120 eggs kept on both room temperature and in freezer for seven days (60 pcs. from layers of 25. weeks of age and 60 pcs. from layers of 69. weeks of age)

- 120 eggs kept on both room temperature and in freezer for fourteen days (60 pcs. from layers of 25. weeks of age and 60 pcs. from layers of 69. weeks of age).

All eggs were collected randomly and all belong to „A“ quality class. Quality indicators observed were divided in two groups: (I) external (which included: egg weight, egg shape index, eggshell firmness, eggshell thickness and weight of eggshell) and (II) internal (which included: yolk color, yolk weight, yolk pH value, albumen weight and albumen pH value). All obtained results were entered in observation list based on day and temperature of measurement.

Egg shape index is displayed as a percentage of egg width and height. Width and height were measured by movable ruler and results were inserted in formula which is:

$$\text{Egg shape index (\%)} = \text{egg width/egg height} * 100 \quad (1)$$

Egg weight is represented by sum of total egg weight, eggshell weight and yolk and albumen weight. All weights were measured by PB 1502-S Mettler Toledo scale and were expressed in grams (g). Eggshell weight is measured in similar way. Eggs were first cracked so that yolk and albumen could be separated after which eggshell weight was taken. On the other hand, measuring weight of albumen and yolk was conducted over several steps. First, yolk and albumen were separated using spoon. After that, scale was calibrated so that it doesn't take in account weight of the cup used for measuring. Only then can either yolk or albumen weight can be measured.

Eggshell firmness represents the force which is needed to crack the eggshell. It is measured, after measurements of egg shape index and total egg weight take place, using Egg Shell Force Gauge MODEL – II (Figures 2 and 3). Device sensor measures applied force on eggshell and stop when enough force to crack the eggshell is applied. Results obtained (in kilograms, kg) are shown on display.

Yolk color is measured eggshell is cracked and its firmness is measured. It can be measured in different ways, but in research Yolk Color Fan was used. Yolk Color Fan consists of different color shades enumerated from 1 to 15. It is held immediately above the egg yolk and both color of the yolk and color on the fan is compared. (Figure 4.).

Albumen pH value is measured after cracking of the eggshell. It represents negative logarithm of the activity of hydrogen ion in albumen and it represents albumen acidity or alkalinity. It is measured by ph meter which is composed from two parts – fixed bedplate and movable measuring instrument with electrode. Before it can be used, device needs to be calibrated to desired pH value at defined temperature using appropriate buffer solution. After calibration, albumen sample is separated from yolk and put in separate cup where is weighted and pH value has been measured. Normal value of pH for albumen is around 7, but it changes based on conditions and duration of storage.

Yolk pH is measured in the same way. Eggshell thickness is measured by electronic micrometer close to the center of the eggshell.

Statistical analysis was conducted using Statistica v.12 [9]. Differences in quality between fresh eggs were determined using one-way ANOVA. Data representing differences in egg quality, storaged for 7 and 14 days, were processed using MANOVA (2x2). Observed factors were layers age (25 and 69 weeks old) and storage temperature (room temperature and refrigerator). Results were considered statistically significant if P-value between observations was less than 0,05 for both ANOVA i MANOVA. Fisher's LSD test was used for post-hoc analysis to determine differences between groups.

3. Results and Discussion

Experiment was conducted on 360 randomly chosen eggs, „A class“, whom were set in different weight classes. Over the fourteen days course freshly laid eggs, eggs stored on room temperature (22˚C) and eggs stored in refrigerator were tested respectively. Freshly laid eggs traits are shown in Table 1.

Based on results statistical difference was observed for egg weight, height, width and egg shape index ($P<0,001$) in relation to layers age. As it was expected eggs from older layers were bigger and heavier than those from younger layers. This was also confirmed by earlier researches conducted by Hosseini et al. (2007) and Akyurek et al. (2009). One of the most important parameters considering egg quality is egg shape index which is used for egg classification. Most optimal egg has egg shape index 74%. It is so because it generates minimal probability of eggshell cracking and other damages while handling. If eggshell value is 72% then egg is considered oblong and if it is 76% it is considered round (4). Based on results, most of the eggs can be considered round, especially those coming from younger layers while those coming from older ones could be considered optimal. Results obtained are similar to those of Nikolova and Kocevski (2012) who have shown that age has statistically significant ($P<0,001$) influence on egg shape.

Table 1. Freshly laid eggs traits considering in relation to different layers age (25 and 29 weeks of age).

Traits	69.week (n)	25.week (n)	69. week $\overline{X} \pm S$	25. week $\overline{X} \pm S$	P - value
Weight (g)	60	60	64,54^a ± 4,64	57,71^b ± 5,05	<0,001
Egg height (mm)	60	60	58,24^a ± 2,03	54,33^b ± 1,67	<0,001
Egg width (mm)	60	60	44,40^a± 1,26	43,43^b ± 1,32	<0,001
Egg shape index	60	60	76,31^b ± 2,88	79,95^a ± 2,04	<0,001
Eggshell firmness	58	60	3,42^b ± 0,87	3,95^a ± 0,76	<0,001
Eggshell thickness	59	60	0,38^a ± 0,03	0,33^b ± 0,04	<0,001
Egshell weight (g)	59	60	8,79^a ± 1,01	7,84^b ± 0,84	<0,001
Albumen weight (g)	58	59	35,51^a ± 4,20	34,63^b ± 3,64	<0,001
Yolk weight (g)	58	59	17,23^a ± 1,65	12,83^b ± 1,34	<0,001
Albumen pH	58	59	8,30^b ± 0,16	8,46^a ± 0,27	<0,001
Yolk pH	58	59	5,85^b ± 0,06	5,95^a ± 0,08	<0,001
Yolk color	59	59	12,27^a ± 0,78	11,90^b ± 0,78	=0,011

$\overline{X}$ – arithmetic mean; s - standard deviation; Numbers marked ^{a,b,c,d} have shown statistical difference (P<0,05).

Measurements conducted after egg destruction have shown that age has statistically significant (P<0,001) influence on eggshell thickness, firmness and weight obtained from freshly laid eggs. Eggshell firmness from younger layers was 3,9a±0,76 kg/cm2 in compared to older ones 3,42±0,87 kg/cm2. Older layers had thicker egg-shell which also resulted in higher weight (8,79±1,01g and 0,38±0,03mm compared to 7,84±0,84g and 0,33±0,04mm). Based on results it can be observed that results for eggshell thickness from older layers is slightly above optimal values while those from younger are near the lower end.

There can be observed statistically significant (P<0.001) influence of layers age on albumen weight and ph-value. Older layers had heavier albumen while younger ones had higher pH values. Statistical significance was also observed in yolk weight and ph-value. Heavier yolks, with lower pH-value, were observed at older layers compared to younger ones (P<0,001). This was also confirmed by researches conducted by Akyurek et al. (2009) whom have shown that layers from 20 to 50 weeks of age show lower ph-values for albumen and yolk, as well as for albumen weight. Darker yolk color was observed in the eggs from older layers (P = 0,011).

Second part of experiment was conducted on 120 eggs stored for seven days on different temperatures (+4˚C and +22˚C) Results are shown in Table 2.

External quality traits for seven days old eggs are in compliance to those observed from freshly laid eggs (older layers have heavier eggs while younger ones have thicker eggshell). Silversides i Scott (2001.) have shown that layer age (25 weeks 52,49g and 59. weeks 61.71g) and storage duration (fresh 57.45 g i 10 days old 57.03 g) have influence on egg weight. Furthermore, it can be observed that temperature also has influence on egg weight, which has been confirmed in experiment by Samil et al. (2005). In their research they have shown that temperature and storage duration significantly influence egg weight and other internal and external traits which has also been observed in this research. Eggshell weight has dropped as temperature rose, which is compatible to results obtained by Samil et al. (2005) and Akyurek et al. (2009). Statistically significant differences (P=0,024) were also observed for albumen weight from older layers whom were kept on different temperatures. This results are no surprise if it is taken in account that evaporation level through pores located on eggshell rises with temperature. Statistical significance was also observed for measured pH-values (P<0,001). pH-values have risen due to albumen buffering ability, but also due to the release of CO2 during storage which results in higher ph-values. As it can be seen from the table, buffering ability and release of CO_2 increases at room temperature. Also, it can be observed that age has influence on pH deviations (6,09±0,07 and 6,05±0,07 : 6,17±0,07 and 6,06±0,04). Age has influence on yolk weight too. Younger layers have lighter yolks than older ones and are also less subjected to temperature influences (16,78±2,02 i 16,78±1,45 : 12,4±0,90 i 13,28±1,82). Same was confirmed in researches conducted by Silversides and Scott (2005) and Samil et al. (2001). They have show that eggs stored for 10 days on room temperature have shown rise in pH-values from 5,75 to 6,08. On the other hand, they have also show that pH-value of eggs,stored on +5˚ C have, has dropped from 5,90 to 5,86. Yolk color is also under influence of temperature. Both layers (younger and older) have darker yolks if eggs are stored in refrigerator compared to those stored on room temperature.

Table 2. Egg quality traits off eggs stored for seven days originating from differently aged layers.

Trait	Older layers			n	P–age	P–temperature	P–interaction
	$\bar{x}$ ± S		$\bar{x}$ ± S				
Weight (g)	63,55^{b}± 6,10	30	67,36^{a} ± 5,80	29	<0,001	=0,002	=0,443
Egg height (mm)	58,17^{a} ± 1,80	30	58,72^{a} ± 2,14	29	<0,001	=0,509	=0,402
Egg width (mm)	44,43^{b} ± 1,97	30	45,34^{a} ± 1,42	29	<0,001	=0,001	=0,969
Egg shape index	76,45^{c} ± 4,00	30	77,27^{bc}±2,72	29	<0,001	=0,030	=0,418
Eggshell firmness	3,25^{b} ± 0,73	30	3,76a ± 0,95	28	=0,003	=0,070	=0,177
Eggshell	0,43^{a} ± 0,04	30	0,32^{b} ± 0,04	29	=0,216	<0,001	=0,255
Egshell weight (g)	8,12^{b} ± 0,96	29	9,08^{a} ± 0,80	29	<0,001	<0,001	=0,299
Albumen	33,64^{b} ± 6,50	29	37,18^{a} ± 6,67	28	=0,386	=0,032	=0,166
Yolk weight (g)	16,78^{a} ± 2,02	28	16,78^{a} ± 1,45	26	<0,001	=0,176	=0,174
Albumen pH	9,36^{a} ± 0,10	29	9,03^{b} ± 0,08	28	=0,650	<0,001	=0,650
Yolk pH	6,09^{b} ± 0,07	28	6,09^{b} ± 0,07	26	<0,001	<0,001	=0,009
Yolk color	11,83^{ab} ±0,70	30	12,14^{a} ±0,80	28	=0,209	=0,090	=0,71
	Younger layers						
	$\bar{x}$ ± S		$\bar{x}$ ± S				
Weight (g)	56,95^{c} ± 4,67	30	59,26^{c} ±4,46	30	<0,001	=0,002	=0,443
Egg height (mm)	55,00^{b} ± 2,29	30	54,93^{b} ± 1,82	30	<0,001	=0,509	=0,402
Egg width (mm)	43,03^{c} ± 1,24	30	43,97^{b} ± 1,43	30	<0,001	=0,001	=0,969
Egg shape index	78,32^{b} ± 2,82	30	80,10^{a} ± 3,12	30	<0,001	=0,030	=0,418
Eggshell firmness	3,95^{a} ± 0,80	30	4,024^{a} ± 0,93	30	=0,003	=0,070	=0,177
Eggshell	0,43^{a} ± 0,04	30	0,34^{b} ± 0,03	30	=0,216	<0,001	=0,255
Egshell weight (g)	7,38^{c} ± 0,79	30	8,01^{b} ± 0,81	30	<0,001	<0,001	=0,299
Albumen	34,16^{b} ±3,90	30	34,93^{ab} ± 3,88	30	=0,386	=0,032	=0,166
Yolk weight (g)	12,46^{c} ± 0,90	30	13,28^{b} ± 1,82	30	<0,001	=0,176	=0,174
Albumen pH	9,37^{a} ± 0,07	30	9,03^{b} ± 0,06	30	=0,650	<0,001	=0,650
Yolk pH	6,17^{a} ± 0,07	30	6,06^{bc} ± 0,04	30	<0,001	<0,001	=0,009
Yolk color	11,70^{b} ± 0,84	30	11,90^{ab} ± 0,88	30	=0,209	=0,090	=0,714

$\bar{X}$ – arithmetic mean; s - standard deviation; Numbers marked ^{a,b,c,d} have shown statistical difference (P<0,05).

Table 3. Egg quality traits off eggs stored for fourteen days originating from differently aged layers.

Trait	69.weeks			n	P– age	P– temperature	P– interaction
	$\bar{x}$ ± S		$\bar{x}$ ± S				
Weight (g)	61,07^{ab}± 5,21	29	62,94^{a} ± 5,04	30	<0,001	=0,117	=0,638
Egg height (mm)	58,07^{a} ± 2,55	29	58,17^{a} ± 1,62	30	<0,001	=0,638	=0,472
Egg width (mm)	44,03^{a} ± 1,45	29	44,17^{a} ± 1,29	30	=0,200	=0,702	=0,899
Egg shape index	75,93^{b} ± 3,31	29	75,95^{b}±1,89	30	<0,001	=0,230	=0,238
Eggshell firmness	3,39^{c} ± 0,71	29	3,60^{bc} ± 0,55	30	<0,001	=0,732	=0,258
Eggshell	0,31^{b} ± 0,04	30	0,32^{b} ± 0,02	30	=0,088	=0,740	<0,001
Egshell weight (g)	7,98^{b} ± 0,93	29	8,66^{a} ± 0,78	30	<0,001	<0,001	=0,169
Albumen	30,59^{b} ± 6,00	29	33,87^{a} ± 4,76	30	=0,085	=0,024	=0,297
Yolk weight (g)	15,87^{a} ± 2,98	26	16,42^{a} ± 1,25	30	<0,001	=0,191	=0,696
Albumen pH	9,42^{b} ± 0,17	29	9,02^{c} ± 0,08	30	=0,552	<0,001	<0,001
Yolk pH	6,15^{b} ± 0,21	26	6,09^{b} ± 0,07	30	<0,001	<0,001	=0,054
Yolk color	11,76^{bc} ±0,83	29	12,03^{ab} ±0,61	30	=0,408	<0,001	=0,120
	25.weeks						
	$\bar{x}$ ± S		$\bar{x}$ ± S				
Weight (g)	57,81^{c} ± 5,05	30	58,82^{bc} ±4,61	30	<0,001	=0,117	=0,638
Egg height (mm)	55,67^{b} ± 2,29	30	55,20^{b} ± 1,97	30	<0,001	=0,638	=0,472
Egg width (mm)	43,73^{a} ± 1,41	30	43,80^{a} ± 1,49	30	=0,200	=0,702	=0,899
Egg shape index	78,64^{a} ± 2,95	30	80,78^{a} ± 8,43	30	<0,001	=0,230	=0,238
Eggshell firmness	4,10^{a} ± 0,68	29	3,98^{ab} ± 1,08	30	<0,001	=0,732	=0,258
Eggshell	0,34^{a} ± 0,03	30	0,31^{b} ± 0,02	30	=0,088	=0,740	<0,001
Egshell weight (g)	7,53^{c} ± 0,70	30	7,81^{bc} ± 0,68	30	<0,001	<0,001	=0,169
Albumen	33,32^{ab} ±6,24	30	34,54^{a} ± 4,14	30	=0,085	=0,024	=0,297
Yolk weight (g)	13,06^{b} ± 1,17	30	13,36^{b} ± 1,19	30	<0,001	=0,191	=0,696
Albumen pH	9,50^{a} ± 0,07	30	8,95^{d} ± 0,03	30	=0,552	<0,001	<0,001
Yolk pH	6,26^{a} ± 0,14	30	6,10^{b} ± 0,06	30	<0,001	<0,001	=0,054
Yolk color	11,67^{c} ± 0,66	30	12,33^{a} ± 0,61	30	=0,408	<0,001	=0,120

$\bar{X}$ – arithmetic mean; s - standard deviation; Numbers marked ^{a,b,c,d} have shown statistical difference (P<0,05).

Third part of experiment was conducted after fourteen days of storage. 120 eggs from both layers (25 weeks and 69 weeks) were stored both on room temperature (+22˚C) and refrigerator (+4˚C) and results are shown in Table 3.

Storage temperature had no statistically significant influence on egg weight, height, width, shape index and eggshell thickness. Age had no statistically significant influence on egg width, eggshell thickness, weight, albumen pH-value and yolk color. It has been observed that eggs from older layers kept on +4˚C are heavier that those kept on +22˚ (61,07ab±5,21:62,94a±5,04). Storage temperature has statistically significant influence on eggshell weight (P<0,001). Heavier albumen was found in eggs kept in refrigerator (P=0,024). Higher values of pH of yolk and albumine were observed in eggs kept on room temperature. Also, eggs kept on room temperature had brighter yolk than those kept in refrigerator (P<0,001).

4. Conclusion

Based on conducted research on influence of age and storage temperature on egg quality it can be concluded that:

- Older layers had heavier, wider and higher (P<0,001) freshly laid eggs. Younger layers laid eggs who had lighter, skinnier and thicker eggshell and lighter yolk and albumin (P<0.001). Higher yolk and albumin pH-levels (P<0,001) were observed for younger layers. Darker yolk color (P=0,011) was observed in freshly laid eggs from heavier layers
- After seven day storage on temperatures of 4° and 22°C it can be observed that pH-values of yolk and albumin have dropped for eggs kept on room temperature. Eggs kept in refrigerator for seven days had darker color compared to those kept on room temperature and those from both younger and older layers.
- After seven day storage on temperatures of 4° and 22°C statistically significant influence of temperature (P<0,001) on eggshell weight, albumin and yolk pH value, yolk color as well as on albumin weight (P=0,024) can be observed.

Older layers lay heavier, wider and higher eggs. Eggshell weight as well as albumin and yolk weight is higher at older layers. Younger layers have firmer, while older have thicker eggshell. Freshly laid eggs from older layers have darker yolk color.

The pH-values of albumin and yolk differ based on age of layers. Storage of eggs on different temperatures results in differences in yolk color, albumin and yolk pH-values and weight of eggshell and albumin. If egg storage is prolonged their quality deteriorates which is more influenced by the temperature than by the layer age.

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FORMING OF CAR BODY STRUCTURE ELEMENTS BY ELASTIC MEDIUM

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Abstract

The aim of automotive materials' developers is to reduce car's weight, and increase the energy absorption at the same time. Possibilities to decrease the weight of car body structures, seems to be using of higher strength steels, and formed tubes as parts of the loaded elements. The manufacturing of tubes, with constantly variable cross-sections along the longitudinal axis requires special technologies, like forming with explosion, with hydroforming, or with elastic medium. These are different forming technologies of modern tube expansion, in which the force-transmitter mediums differ. This report presents the results of the experimental work of tube forming by high inner pressure, with elastic transmitter medium, supported by TÁMOP 4.2.2.A-11/1/KONV-2012-0029 competition, with the leadership of Miklós Tisza, Professor of University of Miskolc

Keywords:

Car body elements, tube forming, weight reduction, elastic medium

1. Introduction

A large number of tubes, manufactured from different materials, diameters and wall thicknesses are applied by the automotive industry. The role of these tubes is significant in the frame structure. The most widely used tube forming processes are:
- hydro-forming
- electro-dynamic (electro-magnetic, and electro-hydraulic) forming
- explosive forming, and
- forming with elastic medium.

Forming with elastic medium is already used by the airplane industry since the early last century. In case of large sheets, the replacement of the female mold with rubber pad was necessary from economic reasons. [1]. Kecskemét College has lots of experience and experimental results in similar topic: deep drawing with elastic medium [2].

Against solid tools, during forming with elastic medium, compressive stress is generated perpendicular to the plane of the sheet, which is an important advantage in terms of ductility. In this way, the literature classifies it between the froming processes which take advantge of stress state. [3]

2. Method

The tubes' material was S235JR and S355J structure steels. The diameter of S235 was Ø30 and wall thickness was 1 mm, in case of the higher strength steel this values were Ø30 and 1,5mm. Samples were prepared from the tube to determine its mechanical properties by Instron 4482 universal material tester. The results are summarized in Table 1. The mediums of the forming were 25 and 46 ShoreD hardness polyurethane pads.

Table 1. Mechanical properties.

	$R_{p0,2}$ [N/mm^2]	R_m [N/mm^2]	A_{80} [%]
S235	270-310	410-430	26-29
S355	350-370	500-530	20-22

3. Calculation of the compressive force

The base of the calculation relies on the boiler formula. In a pressurized tube, stresses are arisen in axial (σa) and tangential (σt) directions (Fig. 1).

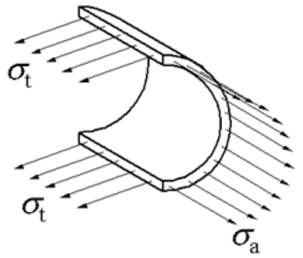

Figure 1. Axial and tangential stresses in a tube loaded by internal pressure

According to the boiler formula, σ_t can be calculated as follows:

$$\sigma_t = \frac{D \cdot p}{2s}\ [MPa] \quad (1)$$

where:
σ_t – tangential tensile stress
D – outer diameter of the tube
p – internal pressure
s – wall thickness of the tube

The maximum permitted tangential stress is equal with the tensile strength (R_m in Table 1). The maximum allowable compressive pressure can be calculated from Eq. 1:

$$p_{max} = \frac{2 \cdot Rm \cdot s}{D} \text{ [MPa]} = 28 \text{ MPa} \qquad (2)$$

According to our measurements and literature data [1,2], the stress distribution in the polyurethane pad does not correspond to a Newtonian fluid. Our results earlier showed that the pressure which acts on the side wall is 0,8-0,9 times smaller than the theoretical tangential stress. Calculation with these values, the pressure of the polyurethane pad:

$$p_0 = \frac{p_{max}}{0{,}8 - 0{,}9} = 31{,}1 - 35 \text{ [MPa]} \qquad (3)$$

In our experiments, tube expanding tests were performed from the initial Ø30 cylindrical shape to diameter Ø33, Ø36, and Ø39, and to a square shape individually. During the forming, the pressures were measured, and the deformations were investigated. The cylindrical formed tubes and the forming tool are shown in Fig. 2. Over and above, more complex expanded tubes were performed by different forming tools of square and cylindrical shapes. The results of the square and complicated expansions are visible in Fig. 3.

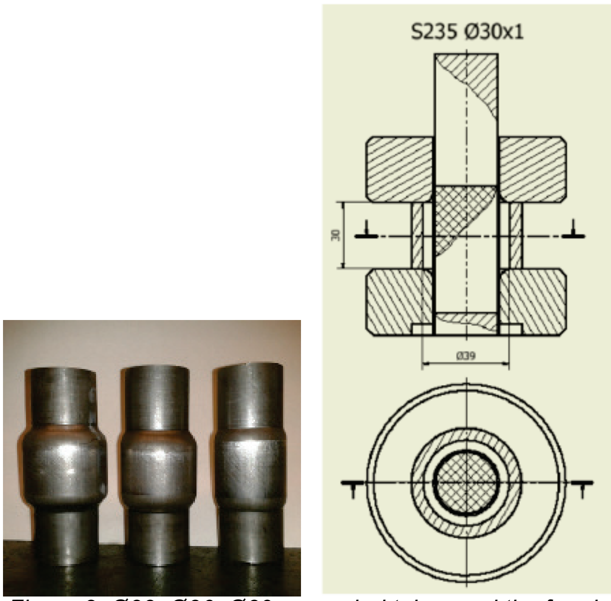

Figure 2. Ø33, Ø36, Ø39 expanded tubes and the forming tool.

During our investigations, compression force has acted to the polyurethane pad only. Some experiments carried out by axial forces acting on the tube wall. Compared to the published data [4], the force-requirement of bulging is 1,4-1,5 times larger than in our case. Slight length reduction of the tube has happened in all cases, but in our study, the friction was responsible for it.

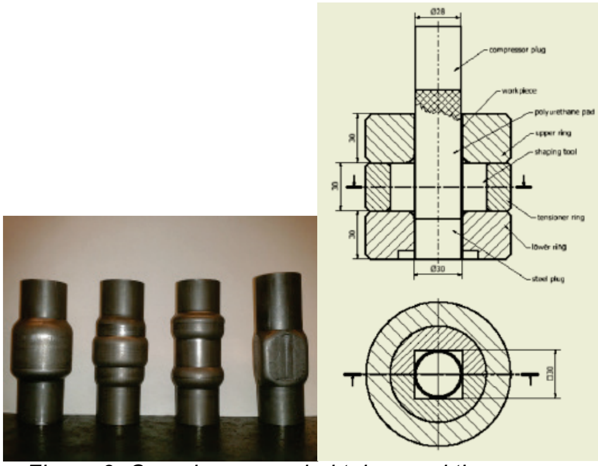

Figure 3. Complex expanded tubes and the square forming tool.

The pressure-displacement diagrams illustrate well the phases of the deformations (Fig. 4). In I phase the elastic deformation happens. It is followed by the strain hardening (phase II), and finally the total filling (III). As it is visible in Fig 5, the changing of the medium's hardness does not change significantly the forming pressure.

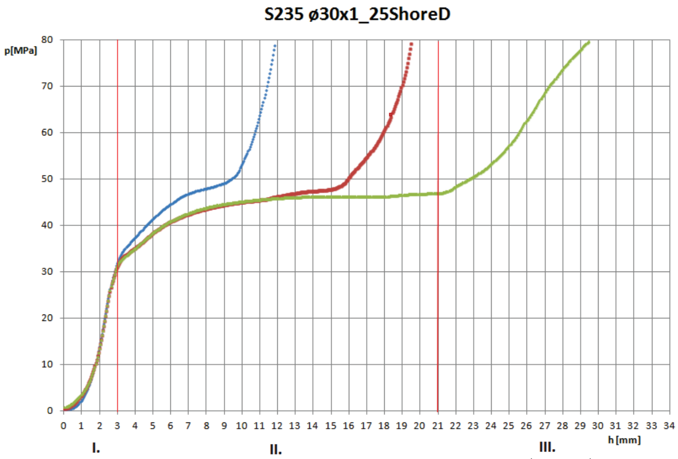

Figure 4. Pressure-displacement diagrams of Ø33, Ø36, Ø39 expanded tubes.

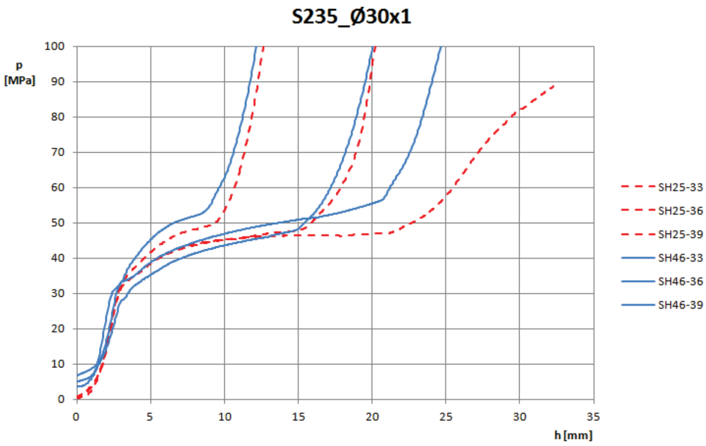

Figure 5. Pressure-displacement diagrams of S235JR tubes acted by 25 ShoreD (interrupted line), and 46 ShoreD (solid line) hard mediums.

The determination of the plastic deformation start point and the investigation of the linear deformation phase can be performed by the return of the load (Fig. 6).

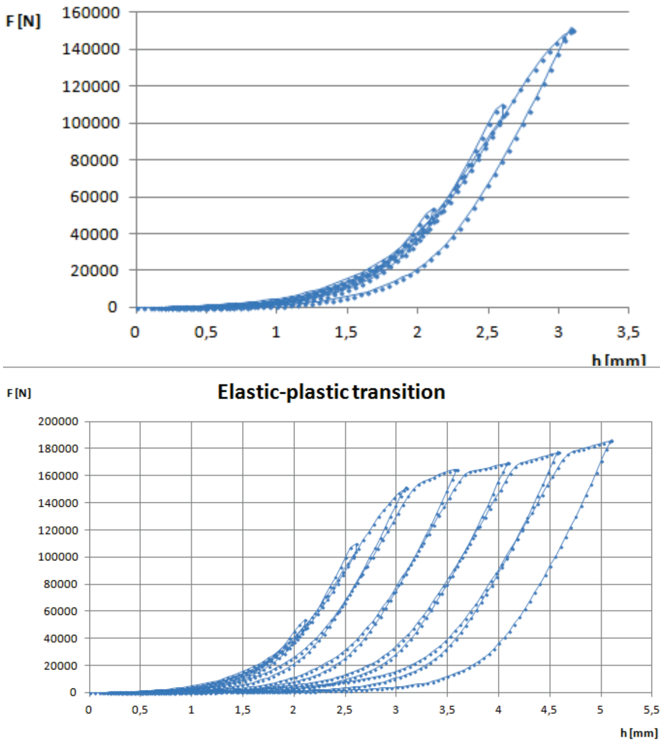

Figure 6. Force-displacement hysteresis curves.

The forming hysteresis curves clearly determine the deformations in the strain hardening phase that match with the results of the biggest diameter measurements which belong to different displacement of the punch (Fig. 7). The increasing of the measured diameters stops when the tube reaches the form's inner wall, thereafter the forming requires higher and higher force.

Examination of the deformation

Few tubes were marked by measuring net. After the forming, the examination of the deformation of each segment was carried out at University of Miskolc. Next to the measuring net analysis, the wall thickness was also measured in the axial cross-section.

The deformation of the cylindrical expansion was investigated at the S235JR steel largest deformed sample: Ø39. The deformation corresponds to 30%. It is well visible in different directions in Fig. 8: φ1 (upper line) indicates the radial, φ2 (middle line) indicates the axial direction along the curve, and φ3 refers to the wall thickness changing. In the diagram, the vertical axis shows the true strain in percentage. During the forming, the length has reduced with 4-5 millimetres. Consequently, the wall thickness had to grow at the ends of the tube (φ3), where the forming was inhibited. The wall thickness growth was about 8%. At the place of the largest diameter growth, the wall thickness thinning has occurred to 16-18%. It is in good agreement with the measured values. (With the compression of the tube wall in axial direction, the authors of literature [4] got 10% wall thinning in the largest deformed cross-section area). The largest deformation has happened in tangential direction φ1, in 26-27% proportion.

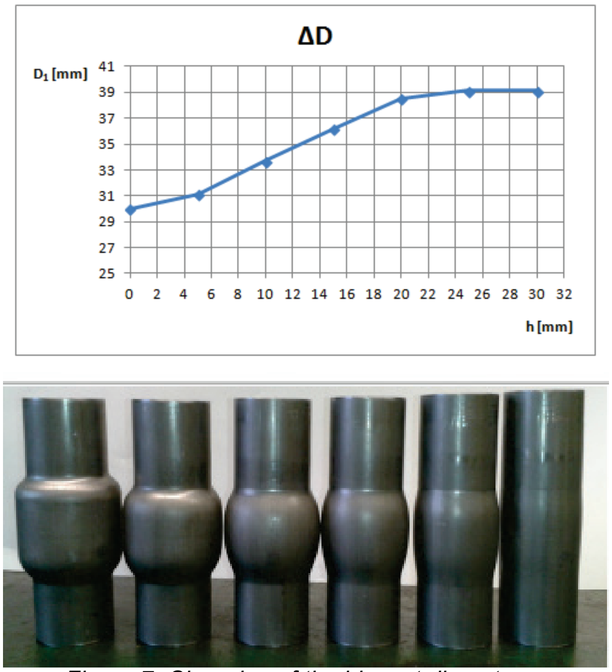

Figure 7. Changing of the biggest diameter.

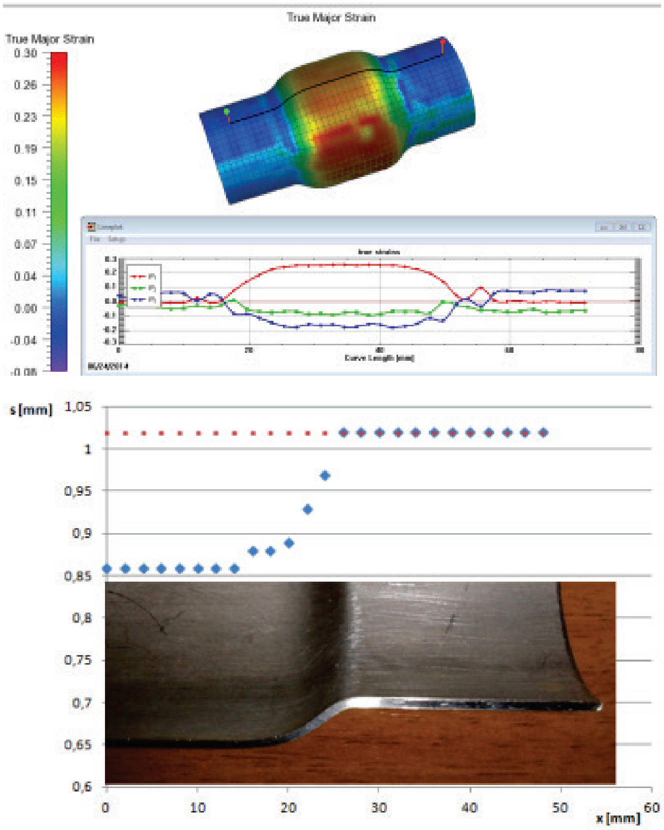

Figure 8. Deformation of the Ø39 expanded work piece and the wall thinning.

The square tube expansion was done from initial cylindrical form (Ø30 mm) to square cross-section □30 mm. The deformation is well visible in different directions in Fig. 9: φ1 (upper line) indicates the radial, φ2 (middle line) indicates the axial direction along the curve, and φ3 refers to the wall thickness changing. In the diagram, the vertical axis shows the true strain in percentage. During the forming, the length has only changed slightly. Consequently, the deformation in axial direction was close to zero. The largest deformation has happened in direction φ1, at the manufacturing of corners. In the middle of square's walls, the tube touches the walls from the beginning of the forming. Consequently, deformation does not extend uniformly throughout the tube.

The deformations at the corners were 30-32%, and the wall thickening was similar, due to the accumulating material from the sides. The results of the measuring net analysis and the measured wall thicknesses are in good agreement also.

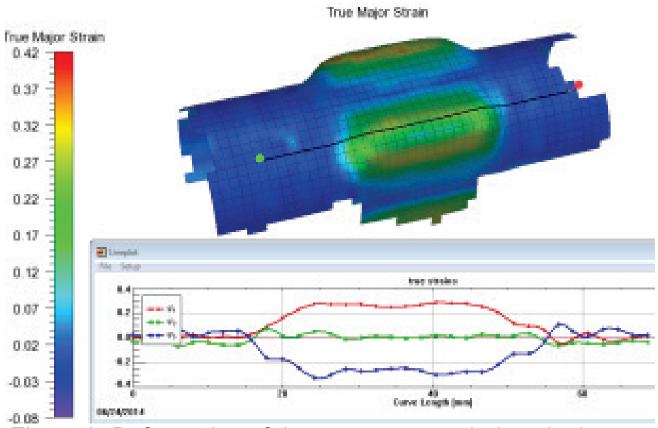

Figure 9. Deformation of the square expanded work piece.

3. Conclusion

The deformation is not depending on the features of the force-transmitter medium during the forming. Also the softer medium (25 ShoreD) is able to perform the forming (Fig. 10). The linear deformation is really equable in all cases, the S355J steel has greater strain hardening as we expected. The technology of forming by elastic medium is easy to take under control, do not require complicated tools and high pressure gaskets. Furthermore the manufacturing of complex forms is resolved.

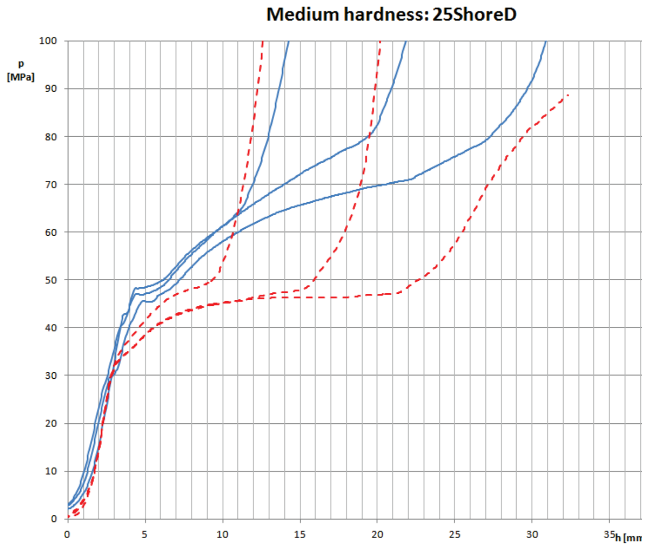

Figure 10. Pressure-displacement diagrams of S235JR (interrupted line) and S355J (solid line) tubes by the same medium hardness.

4. Acknowledgement

Thanks for University of Miskolc for their assistance at the deformation examinations. The researcher work was supported by TÁMOP-4.2.2.A-11/1/KONV-2012-0029 project in the framework of the New Széchenyi Plan.

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HIGH TEMPERATURE WETTING PHENOMENA BETWEEN MOLTEN BRAZING LIQUIDS AND MULTI-COMPONENT (DUAL-PHASE) STRUCTURAL STEELS

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1. Introduction

In earlier study, method and equipment for the observation of the wetting angle (Θ) between non-reactive alloy melts and solid ceramics have been developed, using the sessile drop method. An instrument is designed and built making possible the observation Θ (T) dependence at high temperature range up to -1200°C.

The essential part of equipment is the double wall thermal isolation system, for the elimination of oxygen traces in the surrounding atmosphere, as it is illustrated in Fig.1.

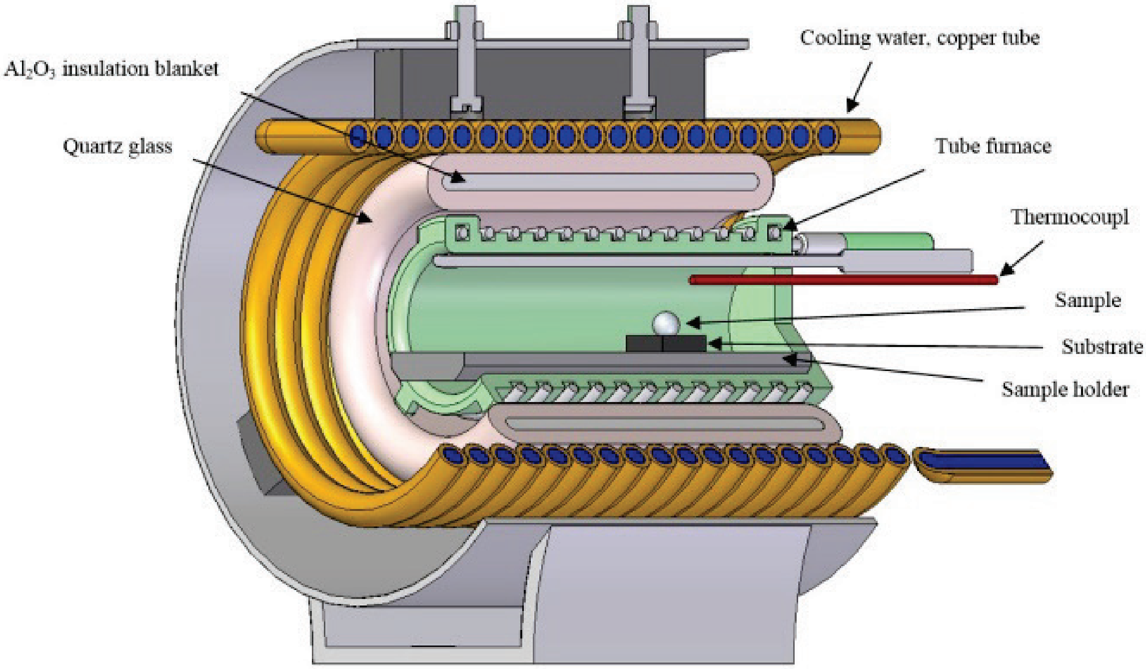

Figure 1. The construction of furnace, developed for the high-temperature wetting measurements [1].

The basic description of wetting phenomena between condensed phases (liquid-liquid, liquid-solid) together with the theoretical background have been elaborated in early nineteen century [3, 4] The wetting is often characterized by the sessile drop method by the measurement of equilibrium contact angle (Θ) according to Fig. 2.

The outlined phenomenon has gained increasing interest in the development of the steel-production and, the non-ferrous metallurgy. The experimental and theoretical activity was simultaneously extended to the study of metal-gas interactions at high temperatures. The central problem was the influence of metal-gas interaction on the surface tension (hence the change of mutual wettability between various solid –liquid and liquid –liquid phases under various atmospheric circumstances (for example: metal-slag reactions) [5].

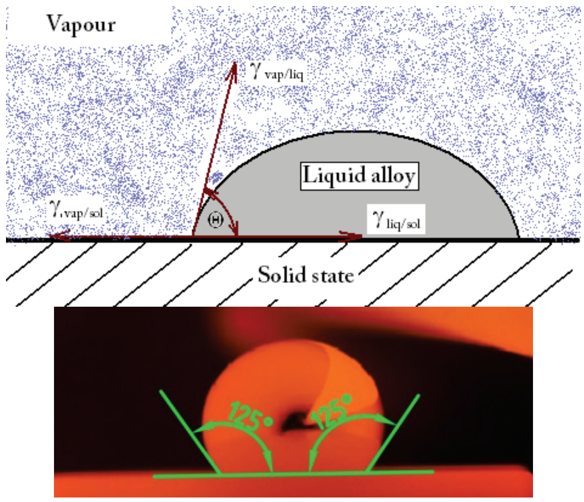

Figure 2. The schematic (up), and real (down) illustration of contact angle for a liquid drop on solids [2].

Recently the knowledge of surfaces and interfaces has of an outstanding significance again due to the intensive progress in material science (the nature of interfaces between the constituent phases in various composites, or, understanding of alloying effects in ultrafine (nano-crystalline) grain assemble [6]. The simultaneous, complex application of high-resolution structural investigations is inevitable in this field. Similar, complex investigation is required in studying the bonding mechanism during the brazing process of in modern (dual phase) steels.

In the present proposal significant thematic extension of the previous investigation is planned. We focus mainly on the study of wetting phenomena between reactive, metallic partners [7], including dual phase steels [8] and some appropriate brazing alloy liquids. Such systems have outstanding technical significance in the modern car-industry (brazing techniques for body elements).

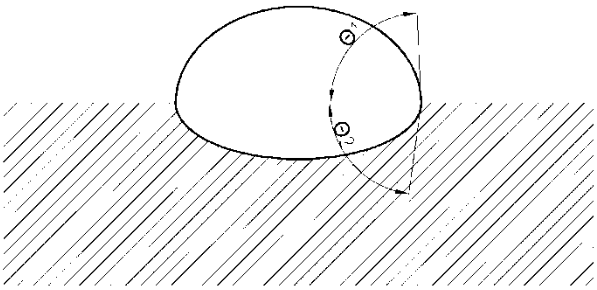

Figure 3. Contact angle between reacting phases [2].

One of the essential requirement for the successful brazing of machine parts is the mutual, perfect wettability between the liquid pool of the brazing alloy, and the solid metallic parts to be joint, which can also be expressed by the wetting angle. However, the actual wettability is strongly influenced by the atmospheric circumstances, therefore the wettability is improved by the flux addition [5]. This is also the case in the material-couples to be investigated in the present proposal. The functions of flux material are:

- dissolution of surface oxide (chemical reaction between the surface oxides and flux)
- protection of melt (brazing) pool against the oxide formation during the brazing process (consequently the melting temperature of flux should be lower, than that for the brazing (filler) alloy.

Hypotheses, key questions, aims

Based on the previous research activity, the aims of the proposed research can be defined as follows:

- Kinetic study of wetting process and bond formation at constant temperature and atmospheric circumstances applying continuous monitoring of Θ(t).
- The study of local structural change in the vicinity of solidified filler alloy (real structure of bond formation) including also the structural consequence of heat affected zone formation, local phase transformations etc.

In the case of non-reactive partners, (i.e. absence of chemical reactions between the partner solid, liquid and gas phases) the change of Θ is not expected (equilibrium state). In contrast, when chemical reaction between the substrate and the shape of melt drop changes, Θ is time-dependent for various reasons, when the partners are reactive.

In the first period – subsequently the melt of flux material, the shape piece of brazing alloy turns to drop-shaped (melted), and the chemical interaction between substrate surface and brazing alloy has started.

In the following period, (presumably the starting chemical interaction between the substrate and melt drop,) the drop shape is altered again (the drop both consumed, and compositionally changes, as shown schematically in Fig. 3.

It is supposed, that drop-profile monitoring can supply information indirectly about the local compositional changes, hence on the time-scale of joint-formation.

In Fig. 4 the T-dependence of Θ for various composition of Cu(Sn) melts are illustrated (measure on graphite substrate). The Θ(T) rapidly changes with the Sn-content of melts, showing the sensitivity of wetting with the concentration. molten phase composition. So, significant wetting angle change can be expected, when the solute content alters in the molten brazing (filler) alloy.

Isothermal monitoring of Θ is planned:

- at various temperature (at fixed steel-brazing alloy couple)
- two kind of atmosphere (Ar and?)

It is expected, that measurements of Θ(t) when T=const and Θ(T), at different superheating, give information about the mechanism of brazing joint formation between a given couple of materials.

Extension of wetting study into multiphase substrate alloys is also planned. Figure 4 also indicates the significance of phase relations in the determination of Θ(T) character in a given alloy system. Therefore, the role of phase relations will be also studied comparing the behaviour of steels with identical composition, but having different thermal history (martensitic and pearlite dual phase steels)

The study of local structural change, as well as the concentration profile in the vicinity of solidified filler alloy-substrate interface, will be studied using scanning electron microscopy (real structure of bond formation), including change in substrate materials (heat affected zone), will be investigated after the brazing process (the extension of depth of diffusion zone) on the cross-sectional micrograph of different joints using:

- traditional metallographic testing
- local thermopower (TEP) measurements

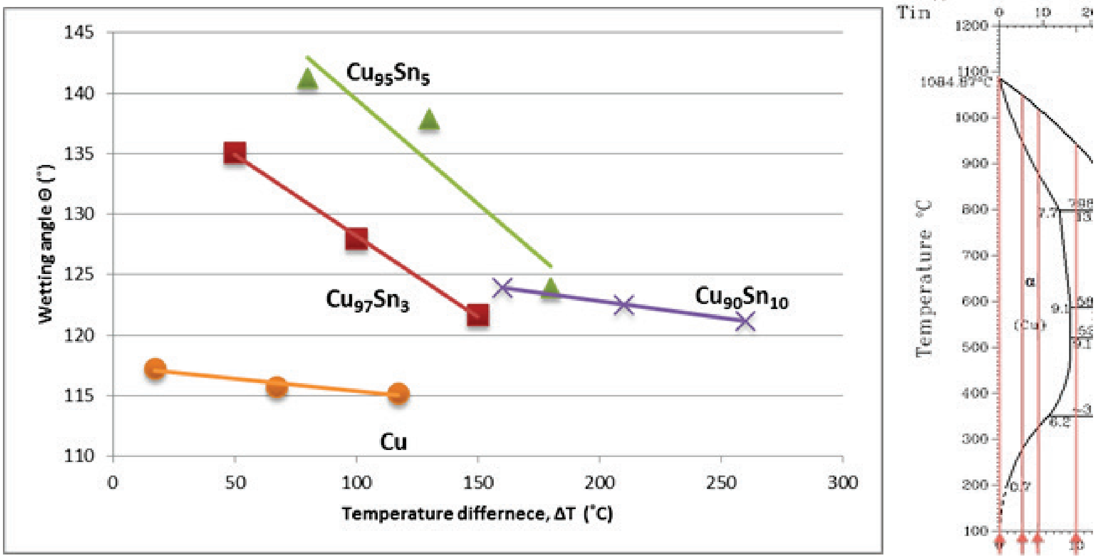

Figure 4. θ(T) for various Cu(Sn) melts on graphite substrate, together with the segments of Cu-Sn phase diagram in the appropriate concentration range [2].

It is demonstrated in Fig. 5. that TEP measurements is sensitive to the detection of phase-transformations in steels. The TEP shifts to negative direction when the structure of carbon steel turns from pearlitic to martensitic structure. The applied instrument with high lateral resolution makes possible the detection of local local change in the phase relation in Fe-based alloy. It is expected, that local, partial transformation martensitic-to pearlitic state) can be detected by measuring of the local TEP in the vicinity of brazing gap.

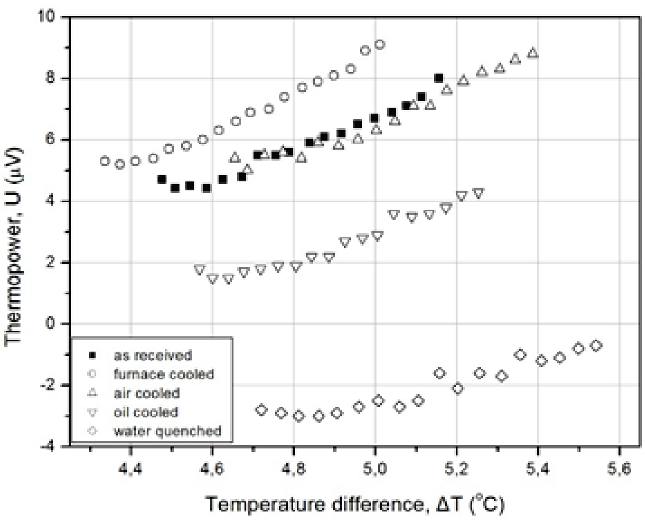

Figure 5. The influence of thermal history on evaluation of thermopower in hypo-eutectoidal carbon steel.

Conclusions

The scientific and technical significance of research work is as follows:

- The extension of knowledge in the field of diffusion mechanism at high temperature across solid-liquid boundary layer.
- Knowledge of correlation between the composition of bulk molten phases and the surface energy. Further research on the connection between the shape of equilibrium phase diagrams and the character of Θ(T) dependence in molten state.
- Further widening of knowledge about the brazing parameters and its relation with real structure of bond, allowing prediction towards the strength and duration of bonds.
- Better understanding of the mechanism of brazing joint formation between the body-elements applied in modern car-industry.

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ENERGY DEMAND AND SUPPLY IN 21ST CENTURY

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Abstract

Energy is one of the four basic resources, necessary for the elementary survival of the human race. The explosion of the population growth together with the continuous increase of the energy consumption per capita are threatening with the depletion of all known non-renewable resources within a couple of centuries. Although the use of the new renewable energy sources has shown some initial results, it is not very likely that they can replace the fossil fuels in a short term. In spite of the fact that the technologies exist, available daily capacity, intermittent character, geographical distribution and investment levels pose major problems for global, large scale installations. The paper summarizes in quantitative terms key issues related to the global energy consumption and available energy sources, aiming to raise awareness on the looming problems related to the sustainable development.

Keywords: Energy Consumption, Energy Resources, Energy Scarcity.

1. Introduction

Already for many decades it has been recognized that the fossil fuel based energy sources are finite. On the other hand, the main discussions about energy consumption and energy sources were initiated by investigations of their role in environmental pollution. The relationship between fossil fuel combustion and consequential CO2 emissions on one side and global warming and climate change on the other has put use of fossil fuels under a severe scrutiny of a variety of stakeholders such as climatologists, industries, NGOs and governments. This paper will not deal with quantitative influence of CO2 on perceived climate changes. Author of this paper believes that the issues of energy deficiency in the light of the ever-increasing demand are more critical and have to take precedence in the deliberations about current and future energy use.

The real race between the energy needs and discovery of the new resources and related technologies started with the industrial revolution. After intensive use of the renewable biomass that has covered most of the needs until second half of the 18th century, industrial revolution has produced a quantum leap in energy demand. Fortunately, such spike in the demand was matched with the discoveries of the coal that has greatly contributed to the fulfilling of the energy needs. Continuous growth of the demand was based on the increased energy consumption per capita as well as with the exponential growth of the global population. It is not difficult to prove correlation and causal relationship between energy consumption and economic development. Figure 1 shows the relation between the power consumption per capita and gross domestic product per capita for the countries around the world (David JC MacKay, 2009). It is obvious that more developed countries use more energy per capita than the non-developed ones. The disparity between the developed and non-developed countries in both measures is huge; rich and developed countries rank 50 times higher than the poorest ones. It has to be noted that countries on the lower levels of the economic development have legitimate aspirations to improve their wellbeing and increase of GDP per capita that will come through substantial increase of the individual energy consumption. Such desire is one of the key drivers of increase in the total global energy needs.

The second driver of exponential increase in energy consumption is global population growth. The rate of growth is not the same in all countries, it is typically higher in the countries which are on the lower level of economic development. In the last 150 years the global population has increased sevenfold, from 1 billion to over 7 billion. The trends are worrying as they do not show any signs of abating or saturation. Uncontrollable increase of the global population results in strain on primary global resources such as water and food, as well as other mineral resources which are finite and non-renewable. Fig. 2 shows the history of the global population growth, it is clear that until the middle of the second millennium, renewable energy sources (mainly wood) were sufficient for the human survival.

Historically, as the energy demands were growing, science and technology were coming with credible energy responses that could cater for the new needs. Coal in 18th and 19th century and petroleum and nuclear in 20th century were key enablers of the economic growth. It must be said that today there are no new energy sources of the same magnitude, ready for exploitation.

The compounded effect of the population growth and growth of the consumption per capita has resulted in the today's energy consumption of 150.000 TWh, which is several orders of magnitude higher than the consumption form not so distant past. As Fig. 3 shows, only in the period 1990 – 2010, the global energy consumption increased by over 50%. It should be noted that in 1992, almost 200 countries have signed up to a Kyoto Protocol, committing to reduce and minimize CO2 emissions. Nevertheless, most of the 50% of the energy consumption increase during the mentioned period is to be attributed to the fossil fuels that are responsible for the anthropogenic CO2 emissions.

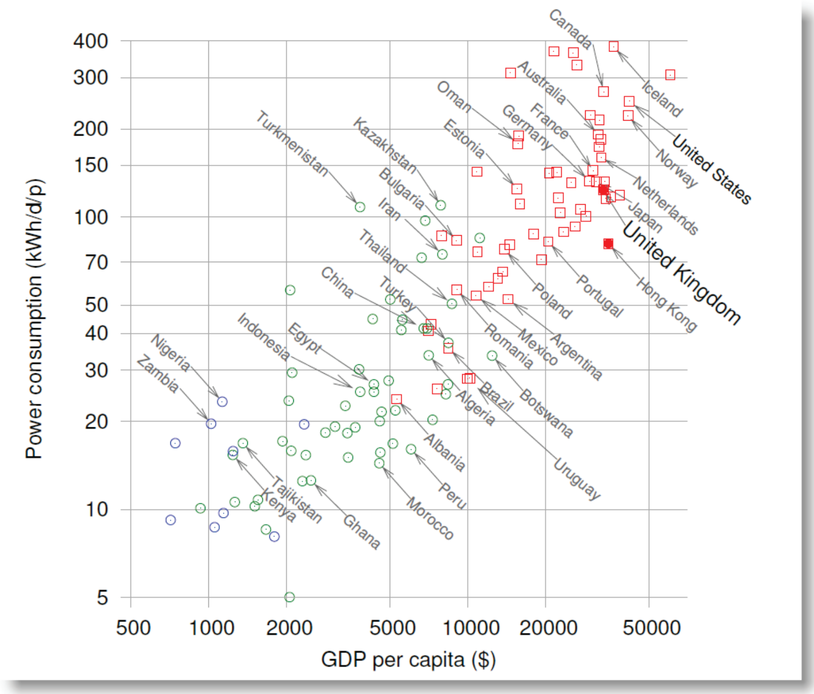

Figure 1. Power consumption per capita vs. GDP per capita http://www.withouthotair.com/c30/page_231.shtml

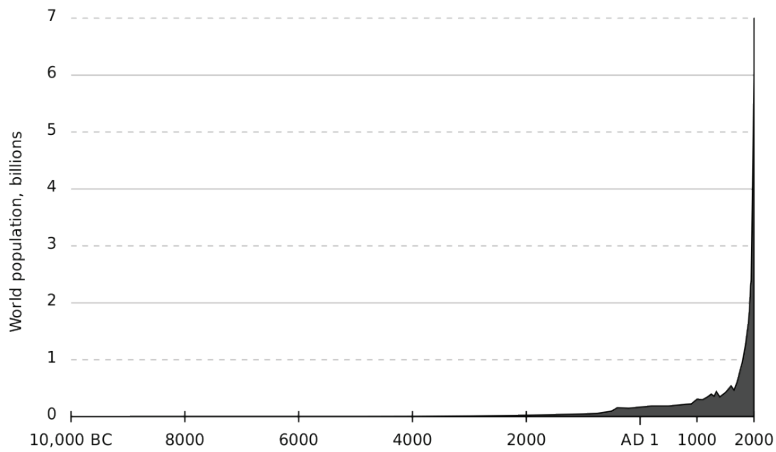

Figure 2. History of world population growth, http://en.wikipedia.org/wiki/File:Population_curve.svg

	Energy Consumption (TWh)				Population (million)				Annual Growth Rate			
									1990-2000		2000-2010	
Region/Country	1990	2000	2010		1990	2000	2010		Energy	Pop.	Energy	Pop.
United States	24924	29257	28664	18,7%	250	282	311	4,6%	1,6%	1,2%	-0,2%	1,0%
China	7913	10654	30656	20,0%	1.148	1.264	1.343	20,0%	3,0%	1,0%	11,1%	0,6%
OECD Europe	20495	22514	23329	15,2%	402	522	550	8,2%	0,9%	2,6%	0,4%	0,5%
Other Non-OECD Asia	3671	6050	9173	6,0%	781	1.014	1.086	16,2%	5,1%	2,6%	4,2%	0,7%
Russia (1)	17871	7977	8763	5,7%	288	147	140	2,1%	-7,7%	-6,5%	0,9%	-0,5%
Central & S. America	4247	6099	8236	5,4%	359	422	462	6,9%	3,7%	1,6%	3,0%	0,9%
Middle East	3288	5083	8089	5,3%	135	173	213	3,2%	4,5%	2,5%	4,8%	2,1%
Japan	5504	6576	6096	4,0%	124	127	127	1,9%	1,8%	0,3%	-0,8%	0,0%
India	2309	3945	6975	4,6%	838	1.006	1.214	18,1%	5,5%	1,8%	5,9%	1,9%
Canada	3218	3828	4191	2,7%	28	31	34	0,5%	1,8%	1,1%	0,9%	0,9%
Oth. Non-OECD Europe	1867	5152	5686	3,7%	154	128	199	3,0%	10,7%	-1,8%	1,0%	4,5%
Africa	2775	3527	5715	3,7%	631	804	1.001	14,9%	2,4%	2,4%	4,9%	2,2%
South Korea	1126	2298	2989	2,0%	43	47	49	0,7%	7,4%	0,9%	2,7%	0,5%
Mexico/Chile (2)	1379	1870	2491	1,6%	85	100	128	1,9%	3,1%	1,6%	2,9%	2,5%
Australia & N. Zealand	1301	1665	2022	1,3%	20	23	26	0,4%	2,5%	1,2%	2,0%	1,3%
Total World	**101887**	**116495**	**153077**	**100%**	**5.287**	**6.089**	**6.701**	**100%**	**1,3%**	**1,4%**	**2,8%**	**1,0%**

Note(s): 1) 1990 Values for Russia approximated by Former USSR. 2) Before 2010, Mexico/Chile category only included Mexico.
Source(s): EIA, International Energy Outlook 2011, Sept. 2011, Table A1, p.157; EIA, Country Profiles http://www.eia.gov/country/index.cfm

Figure 3. Energy consumption and population growth, 1990 – 2010.

During the same period, the global population increased by over 25%. In the developed countries, the population growth is moderate or around zero and the overall energy consumption is stable as well. The most of the energy consumption challenges are coming from the developing countries, both because of their strong population growth and their low level economies. Considering the overall global needs and legitimate aspirations for better life, it is obvious that the existing energy resources will be under tremendous pressure and that the competition for energy sources will be severe. In such situation it is prudent to make even a rough estimate on how much energy is necessary to satisfy reasonable human needs.

Global Energy Demand Estimate. For a variety of reasons, it is difficult to make a firm estimate of global energy demand. The overall population growth, different levels of current energy consumption and influence of politics on energy availability are the main hurdles that prevent exact needs estimate. At this stage it is also necessary to distinguish between needs and aspirations. Although the basic needs can be rather small, the natural aspiration for a specific lifestyle (which is directly related to the energy consumption) is something completely different. In the previous chapter the ever-increasing population growth has already been illustrated and commented on. The growth in global energy demand is even steeper, as it is compounded by the fact that the energy consumption per capita is increasing as well.

The analysis has been carried for countries and regions of the world, taking into account the local average energy consumption per capita. The results are presented of the Fig. 4.

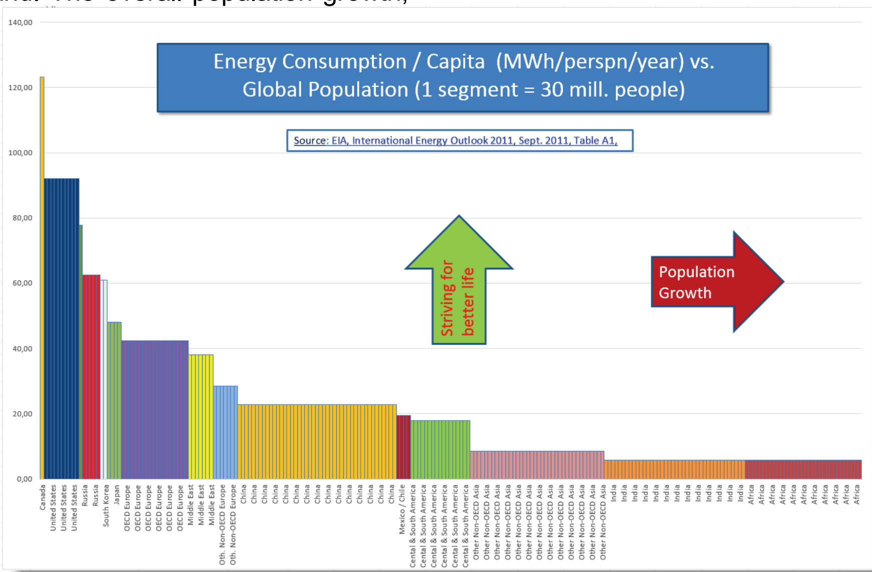

Figure 4. Energy consumption per capita, source data: International Energy Outlook 2011, September 2001, Table 1.

Each small segment on the horizontal axes represents 30 million people; on the vertical axis average energy consumption per capita per person is presented, in MWH/person/year. It is clear that developed parts of the world are using muck more energy per capita than the rest. It is equally clear that countries with large populations (China and India) or other regions (Africa, non-OECD countries show ambitions to develop their economies and consequently to dramatically increase their average energy consumption per capita. To provide all of the global population with the energy per capita consumption on the same level as it is currently in USA, global energy production and consumption would need to be roughly six time higher than today. This estimate it is made under assumption that the average consumption per capita in the referent country (USA) will not further grow. Another assumption that is made in this analysis is that the global population will saturate on around 7 billion, which is not very likely. By 2050 it is expected that the global population will grow for 2.3 billion which equals roughly today's population of China in India. This means that factor six is rather conservative, even if serious energy savings are put in place. Apparently, some of the studies from Stanford University argue that optimal population on Earth would number around 1.5-2 billion people (Gretchen C. Daily et al.July 1994). Although pertinent to this paper, the discussion on this specific topic is not subject to this paper. Nevertheless, it confirms, that at current state of energy technology, today's energy consumption is only 1/6 of what is estimated aspiration of today's population.

Current Global Energy Production. The total energy production today is being estimated by many reputable organizations and institutions. One of the most quoted source is Lawrence Livermore National Laboratory in California (USA); their energy flow is very helpful to understand the supply part of the energy equation (C.A. Smith, et al. 2011).

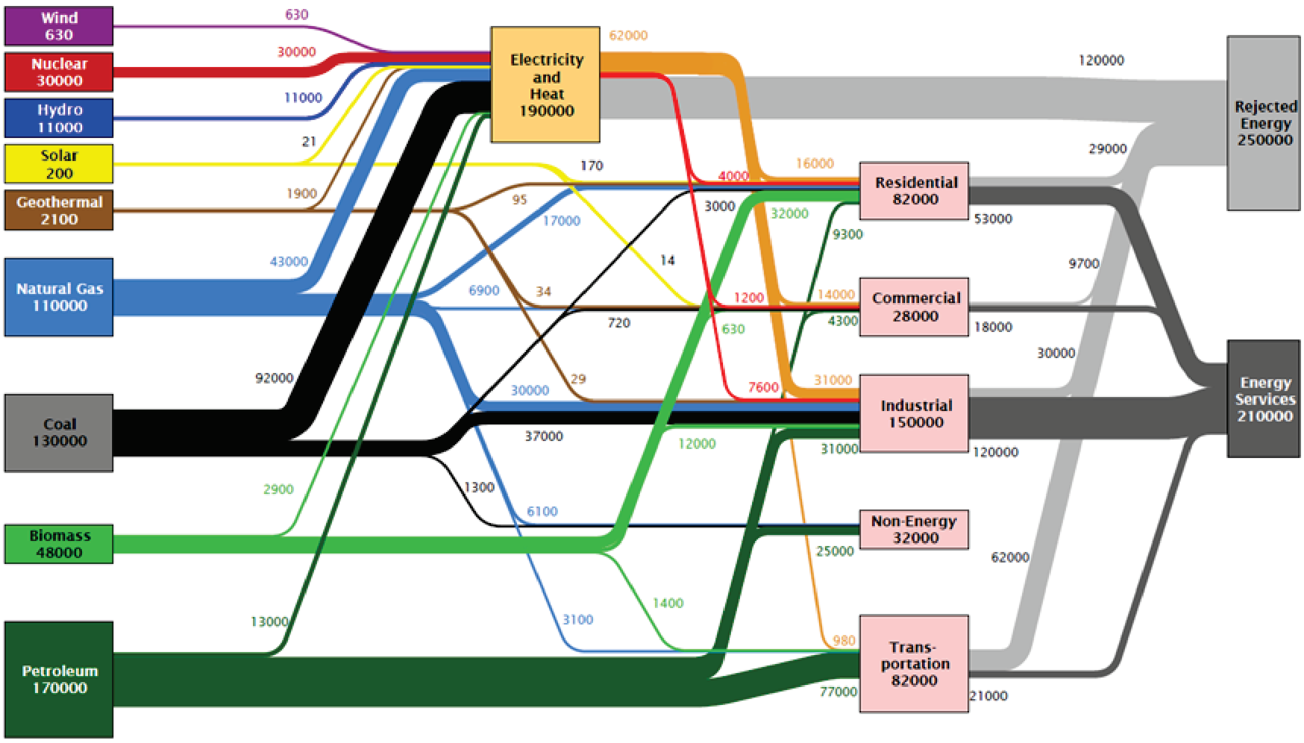

Figure 5. Energy consumption per capita, source data: International Energy Outlook 2011, September 2001, Table 1.

The global picture of energy flows shows the overall status of primary and secondary energy sources and their main consumption sectors. The primary source split shown on the left side confirms that renewable sources play a minor role in the total energy mix. Fossil fuels and uranium constitute almost 88% of total consumption, although over the past two decades, there has been an intensive debate aiming to replace a larger part of fossil fuels with renewable energy sources.

Even within renewable sources, the "traditional" ones (hydro and biomass) compromise the large majority: 95% of total renewable sources. In 2007, solar, wind, geothermal and other renewable sources made up only 5% or 0.6% of the total primary energy use worldwide.

In the last eight years, the use of "non-traditional" renewable sources increased globally and at an impressive rate, particularly in developed countries. In the USA, they quadrupled, becoming 23% of all renewable sources. However, in the total USA energy balance today, they represent just above 2% of the total primary energy consumption which includes both renewable and non-renewable energy sources.

From Fig. 5, it can be seen that almost 40% of all primary energy sources are used to produce electricity and heat, which are the most convenient forms of energy for practical use.

Energy is used primarily in three sectors: around 29% for buildings, 40% for industries and 22% for transportation. These data have approximate values; different sources might give different global percentages. Nevertheless, these three sectors are dominant and require individual attention for more detailed analysis.

Finally, data on the right side of the chart show that more than half of the energy used from the primary sources is lost as "rejected energy". Improving the efficiency of the energy usage could reduce such energy waste in all three sectors. However, these reductions can improve the situation only to a certain degree. At the current level of technology, it is practically impossible to substantially reduce the rejected energy related to the electricity production or use in one of the mentioned sectors.

Individual countries would have rather different values in their energy flow charts, depending on their economies and the availability of indigenous primary energy sources

Energy Resources. Global non-renewable energy resources are finite. They have been in intensive use from the beginning of the 20th century and are being rapidly depleted. The new major discoveries are rather rare, fuels are with lower quality and more difficult to extract and refine. According to some energy analysts the peak oil point (the point of the maximum global oil production) is happening just now and that in the near future the production will gradually decline. Similar scenarios are expected for coal and gas.

Another important fact is that non-renewable resources are owned by the countries if they are found on their sovereign territories. Most of the global oil and gas reserves are found only in three regions: Middle East, Russia and USA. Only five countries (USA, Russia, China, Australia and India) owe 65% of all global coal reserves. Today the countries trade their surpluses, but there is a realistic scenario that energy resources will be used as means for political or economic pressure.

On the other side, although renewable energy sources are inexhaustible, quantitatively, they cannot simply replace the current non-renewables. They have problem of intermittency, geographical distribution and absolute energy quantity available on the daily basis. In addition there are issues of the investment levels needed, raw materials and ERoEI evaluations.

2. Results and Discussion

Considering the globbal energy issues, it is clear that the outlook is not to good. Energy defficiency was not a topic some 120 years ago. However, the fact is that estimated 50% of all non-renewable sources has been used during the period of last 120 years. It took hundreds of millions of years for these fuels to be formed in the Earth core. Currently, there is no technology that could replace oil, gas and coal, even on the current level of energy consumption.

During 21 century the world will have to make serious efforts in several directions: improvement of energy efficiency wherever possible, deployment of the renewable energy resources where economically viable, development of completely new, currently unknown energy technologies and better management of the overall population growth.

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THE INFLUENCE OF QUENCHING/COOLING MEDIA ON HARDNESS AND MICROSTRUCTURE OF DUCTILE IRON

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Abstract

Today ductile iron plays important part in overall production of castings due to its favourable balance of mechanical properties compared to the cost of production. In this paper hardness and microstructure changes due to heat treatment (austenitizing and quenching/cooling in different media) are analysed for two types of ductile iron: EN-GJS-400-15 and EN-GJS-700-2 (EN 1563 : 2011).

Keywords:

ductile iron, heat treatment, hardness, microstructure, quenching/cooling media

1. Introduction

Ductile cast iron is a pseudo binary casting alloy of iron and carbon in which the carbon is expressed mainly in the form of a spherical graphite nodules, which is achieved by inoculation with Mg or Ce [1]. According to EN ISO 945: 2002 nodular graphite is referred to as form IV.

The increase use of ductile iron is a result of its mechanical properties (ductility, elastic modulus, mechanical strength) and corrosion resistance which are between the properties of grey iron and steel casting. [2,3,4]. Besides, ductile iron can be warm formed, machined and even welded (but high content of carbon bust be considered) and it is used for the production of crankshafts, rods, gear housings, gears, parts of carriages, turbines, water pump housings, valves and steering articulations, parts of wind turbine and so on [1,3]

2. Heat treatment of ductile iron

Although ductile iron are used in as-cast condition in order to increase mechanical properties (like toughness, ductility, strength, wear or corrosion resistance) or to change the microstructure the heat treatments like normalizing, hardening, austempering, stress relieving and annealing are used. Also the stabilisation of microstructure, better machinability or lower residual stresses can be achieved by those heat treatments of ductile iron [5,6].

In this paper the influence of different quenching /cooling media (water, oil, air) on hardness and microstructure changes of two ductile cast iron types is analysed.

3. Experimental Procedures

In order to examine the influence of quenching media on properties of ductile cast iron two different types of ductile cast iron are selected: EN-GJS-400-15 (samples 1.1 to 1.4) and EN-GJS-700-2 (samples 2.1 to 2.4). The chemical composition of selected material is given in table 1.

Table 1. Chemical composition of ductile cast iron

Samples	C	Si	Mn	P	S	Cu
1.1-1.4	3,50	2,123	0,144	0,052	0,010	0,057
		Mg	Cr	Ni	Mo	Al
		0,044	0,046	0,053	0,009	0,008
Samples	C	Si	Mn	P	S	Cu
2.1-2.4	3,53	2,074	0,674	0,036	0,009	0,674
		Mg	Cr	Ni	Mo	Al
		0,040	0,056	0,053	0,013	0,011

Chemical composition can also be expressed through the carbon equivalent (CE) and saturation factor (S_c) [4,7]:

$$CE = \%C\ \% + 1/3\ (\%Si\ \% + \%P) \tag{1}$$

$$S_c = \frac{\%C}{4{,}23 - 0{,}31\%Si - 0{,}27\%P} \tag{2}$$

For the selected ductile cast iron types values of CE and Sc are presented in table 2 and it is visible that both ductile iron types are hypoeutectic alloys [3].

Table 2. CE and S_c of ductile cast iron samples

Samples	*CE*	*S_c*
1.1-1.4	4,23	0,98
2.1-2.4	4,23	0,99

Heat treatment of samples was performed in chamber furnace. The cylindrical specimens were 20 mm in diameter and 20 mm in length. Quenching /cooling after austenitization for 1 h at temperatures of 870 °C was carried out in the water, oil and air. In order to achieve maximal hardness after quenching, austenitizing time and temperature were selected according to literature sources [6, 8]. Plan of experiment is presented in table 3.

Table 3. Plan of experiment and heat treatment parameters

Sample	Heat treatment	Analysis type
1.1	No heat treatment	Hardness measurement HB5/750/15 and metallographic analysis
1.2	Quenched in water after austenitization	
1.3	Quenched in oil after austenitization	
1.4	Cooled in air after the austenitization	
2.1	No heat treatment	
2.2	Quenched in water after austenitization	
2.3	Quenched in oil after austenitization	
2.4	Cooled in air after the austenitization	

After the heat treatment according to experiment plan given in table 3, all samples were ground and polished using a standard metallographic technique and Brinell hardness measurement (HB5/750/15) were performed.

For the analysis of microstructure, etching of the test surfaces with the 2% Nital was used. The microstructures of samples were studied using the optical microscopy.

4. Results and discussion

The materials hardness values before and after the heat treatments are presented in Table 4. The shown hardness values present the average of three measurements.

Table 4. Hardness HB5/750/15 of samples at different heat treatment conditions

Sample No	Heat treatment	Hardness HB5/750/15 *(average of 3 measurements)*
1.1	No heat treatment	143
1.2	870°C/1 h, quenched in water	522*
1.3	870°C/1 h, quenched in oil	510
1.4	870°C/1 h, air cooled	302
2.1	No heat treatment	254
2.2	870°C/1 h, quenched in water	535*
2.3	870°C/1 h, quenched in oil	525
2.4	870°C/1 h, air cooled	329

* appearance of cracking in samples

It can be noticed that selected austnitization temperature and time were enough to achieve higher values of hardness after quenching/cooling but as the water is severe cooling media cracking occurred on the samples quenched in water (Figure 1).

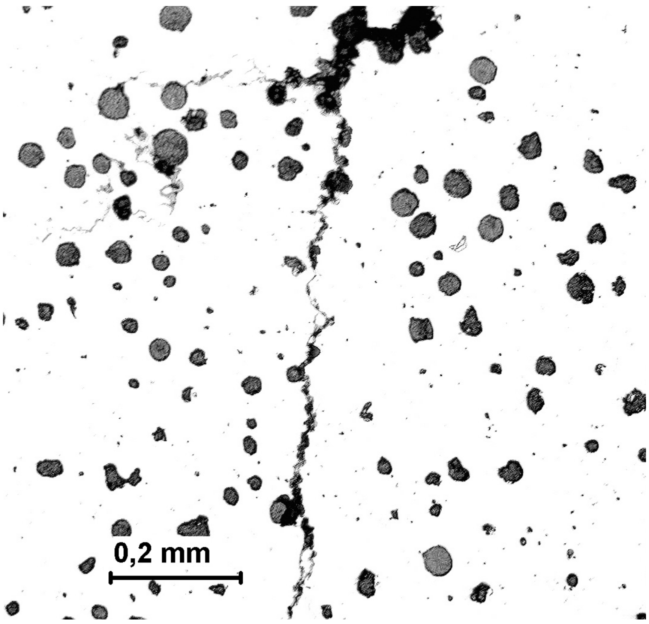


Figure 1. Cracking after the heat treatment (sample 1.2)

Figure 2 shows the microstructure of the samples 1.1 – 1.4 (EN-GJS-400-15).

Microstructure on Figure 2 a) (EN-GJS-400-15 before heat treatment) shows nodular graphite in a ferritic-pearlitic matrix microstructure and appropriately for this level of ferrite/pearlite ratio [9], lower values of hardness are measured (Table 4).

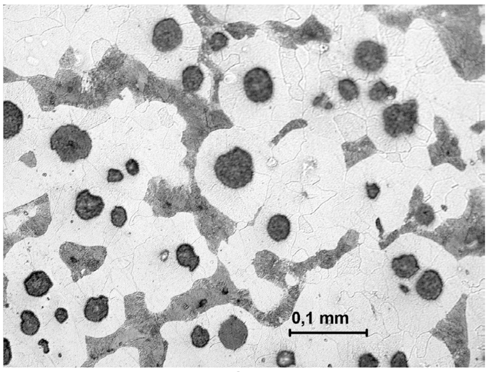
After the quenching in water and oil (microstructures shown in Figures 2 b) and c)) the level of hardness rises considerably due to marteniste formation in matrix during cooling.

Microstructure of the samples 2.1 – 2.4 (EN-GJS-700-2) are shown in figure 3.

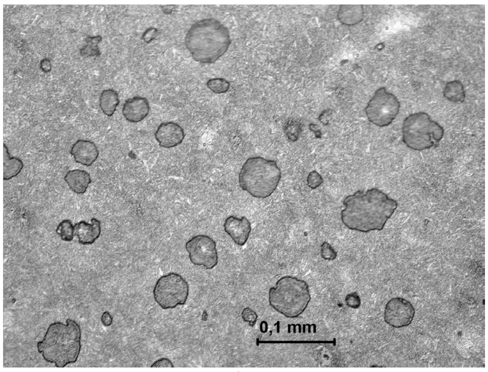
Microstructure of the specimen 2.1 (Figure 3a), EN-GJS-700-2 before the heat treatment, is pearlitic. So as expected [8, 9] the hardness of the specimen 2.1 is higher than the hardness of the specimen 1.1 with ferritic-pearlitic matrix.

The results of hardness measurement after quenching /cooling (specimens 2.2 and 2.3) also shows the increase of results regarding the material EN-GJS-400-15 (specimens 1.2 and 1.3) and martensite structure.

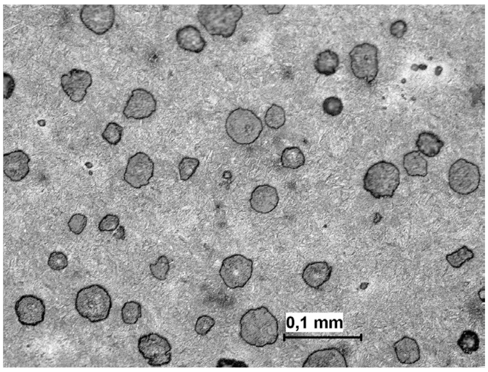
By comparison of the microstructure and hardness values it is evident that cooling speed for specimens 1.4 and 2.4 was not enough to achieve martensitic structure (Figures 2 d and 3 d).



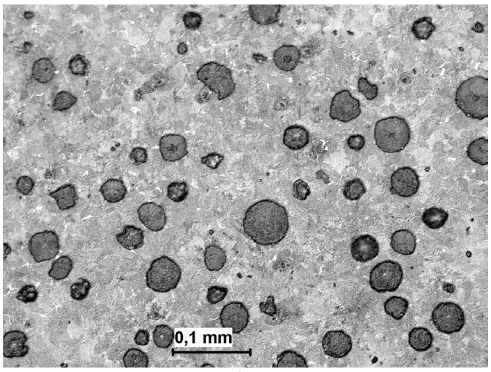
a) Sample 1.1



b) Sample 1.2

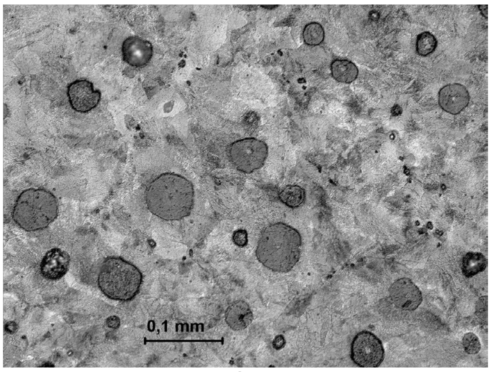


c) Sample 1.3

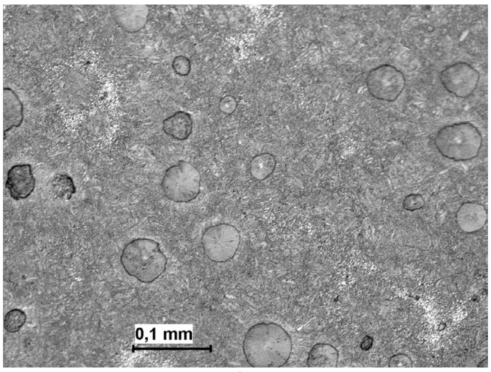


d) Sample 1.4

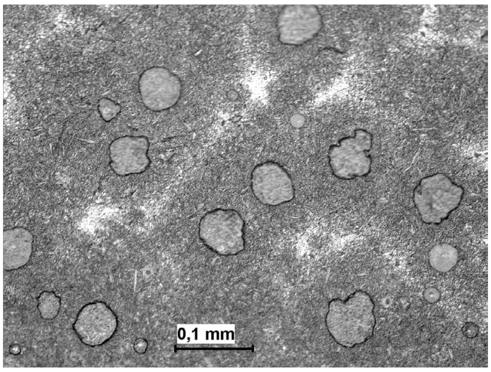
Figure 2. Microstructure of EN-GJS-400-15 before the heat treatment (a); after quenching in water (b); oil (c); air cooled (d)



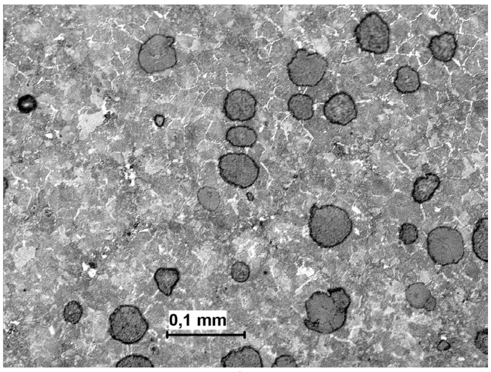
a) Sample 2.1



b) Sample 2.2



c) Sample 2.3



d) Sample 2.4

Figure 3. Microstructure EN-GJS-700-2 before the heat treatment (a) and after the quenching in water (b), oil (c) and air cooled (d)

5. Conclusion

Optimal structure of matrix and mechanical properties of ductile iron for specific application can be achieved after the casting (i.e. by careful selection of alloying elements [9,10]) or/and with application of heat treatment. In this paper the microstructure and hardness of samples quenched/cooled in three different media are analysed.

Besides appropriate selection of heat treatment (austenitizing) time and temperature for successful heat treatment the choice of appropriate coolant is important.

For selected ductile iron casting analysed in this paper oil is more appropriate media if martensitic matrix is desirable than water due to appearance of cracking.

Since at this type of castings, after the quenching the high level of quenching stresses is expected, it isnecessary to implement tempering heat treatment process.

For the continuation of the research, the investigation of tempering influence on hardness level and microstructure on castings quenched with water and oil is planned.

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MICROSTRUCTURE AND MECHANICAL PROPERTIES INVESTIGATION OF DIFFUSION WELD JOINTS

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Abstract

The paper deals with investigation of microstructure and mechanical properties of light alloys diffusion weld joints. The plastic deformation of weld joints originated from welding was assessed by optical 3D scanning. Structural features and phase composition in weld joints were identified by optical microscopy and scanning electron microscopy, respectively. Detailed study of weld joint interface was performed by EDX chemical microanalysis. Mechanical properties of weld joints were evaluated by microhardness measurement and shear strength test.

Keywords: diffusion welding, light alloys, structural stability, interlayer, intermetallic compound

1. Introduction

Energy and fuel saving requirements lead to exploitation of light alloys and their combination with other metals these days. In many cases the light alloys themselves are not capable to provide desired properties and their joining with other materials is required. However, the commonly used conventional methods of fusion welding can't be applied due to limited heat input, residual stress, intermetallic phase formation etc. One of suitable alternative seems to be diffusion bonding [1, 15, 17].

If metallic system can't be bonded by the purely diffusion process, the transient liquid phase (TLP) or the transient liquid phase diffusion (TLPD) bonding should be applied [2, 3, 12, 17]. These bonding processes use an interlayer which is tolerant to surface oxides and geometrical defects on contact surfaces. Throughout heating, the interlayer melts and the interlayer elements diffuse into the substrate materials, causing isothermal solidification. A thin layer of liquid spreads along the interface to form a joint at a lower temperature than the melting point of either of the materials. The form of interlayer material can vary, e.g. thin foil, powder, sprayed thin layer etc.

The Chinese authors [4] investigated the effect of welding heat on microstructure and mechanical properties of AZ31B/Al6061 weld joint. The results showed that thickness of intermetallic compound (IMC) $Al_{12}Mg_{17}$ in diffusion area increased with rising temperature and it affected the progress of microstructure and deterioration of weld joint mechanical properties. Weld joints had highest shear strength (37 MPa) at a temperature of 440 °C. Subsequently, brittle failure of weld joints was observed in $Mg_{17}Al_{12}$ IMC.

At the Chinese technical university authors [5] observed effect of Ag interlayer on microstructure and mechanical properties of Mg – Al weld joint. Interlayer was applied to aluminium alloy by magnetron sputtering. During the welding process, the interlayer participated in creation of IMC precipitated in weld joint interface.

The optimal welding parameters were: T_w = 390 °C, p_w = 5 MPa, t_w = 30 min. The maximal hardness value was 225 HV. The transgranular fracture and plastic deformation occurred in Mg/Ag/Al weld joint interface.

2. Methods

Materials selected for diffusion welding were:

- Aluminium alloy 7075-T651,
- Magnesium alloy AZ31B.

Aluminium 7075-T651 alloy [6, 17] is particularly known for a high strength. The main alloying element is Zn in amount of 1 to 8 wt. %. The presence of Mg can deliver the highest strength properties of all Al alloys, but the corrosion resistance is rather poor. However, the corrosion resistance can be increased by ageing. The chemical composition of Aluminium 7075-T651 alloy and its mechanical properties are given in Tables 1, 2 and 3.

The non-hardenable Magnesium alloy AZ31B in form of rolled sheet, showing good plastic behavior and machine-ability was used for experiments. In case of suitable atmosphere application or using vacuum (GTAW, EBW and LBW), the braze-ability is not limited. High thermal conductivity of Mg alloys may cause excessive grain coarsening during brazing at higher temperatures. This results in formation of residual stresses causing possible distortion of brazed joints [7, 8]. Chemical composition, physical and mechanical properties of used light alloys are given in Tables 1, 2 and 3.

Table 1.Chemical composition of 7075 Al alloy and AZ31BMg alloy [6, 7, 8, 13, 14]

Element (wt. %)	Fe	Cu	Mg	Zn	Mn	Al
Al7075	0.5	1.2–2	2.1–2.9	5.1– 6.1	0.3	Bal.
AZ31B	0.005	0.04	Bal	0.6–1.4	0.2–1	2.5–3.5

Table 2. Physical properties of 7075Al alloy and AZ31BMg alloy [6, 7, 8, 13, 14]

Physical properties	Al7075	AZ31B
Density	2,8 g.cm^{-3}	1,77 g.cm^{-3}
Melting point	477 - 635 °C	605 - 630 °C
Thermal conductivity	130 W.m^{-1}.K^{-1}	96 W.m^{-1}.K^{-1}
Heat capacity	960 J.kg^{-1}.K^{-1}	970 J.kg^{-1}.K^{-1}

Table 3. Mechanical properties of 7075 Al alloy and AZ31B Mg alloy [6, 7, 8, 13, 14]

Mechanical properties	Al 7075	AZ31B
Tensile strength	572 MPa	244 MPa
Yield strength	503 MPa	221 MPa
Shear strength	331 MPa	140 MPa
Fatigue strength	159 MPa	97 MPa
Hardness	191 HK	51.1 HK
Young's modulus	71.7 GPa	45 GPa
Elongation	9 %	15 %

The experiments were performed on welding equipment GLEEBLE 3800 made by US Company Dynamic System. Diffusion welding was performed in vacuum. Temperature measurement and power control for required temperature set-up were provided by a thermostat and K-type thermocouple.

Weld joints were completed with or without pure Zn and Ag interlayer. The main diffusion welding parameters were considered to be welding temperature, pressure and time. Welding temperature allows to thermally activate diffusion processes, while welding pressure delivers the local plastic deformation of welded materials surface [9, 10, 11]. Parameters and conditions of diffusion welding (Fig. 1) for material combination Al7075 / AZ31B were: T_w = 420 to 480 °C, p_w = 0.25 to 10 MPa, t_w = 5 to 45 min.

Parameters and conditions of diffusion welding for material combination Al7075 / Zn / AZ31B and Al7075 / Ag / AZ31B were: T_w = 420 to 440 °C, p_w = 0.25 to 10 MPa, t_w = 5 to 45 min.

Course of welding pressure and thermal expansion during the heating and cooling of welded materials have influence on creation and progress of weld joint internal stresses resulting into weld joint distortions.

The sample surface roughness was Ra = 0.1 μm.

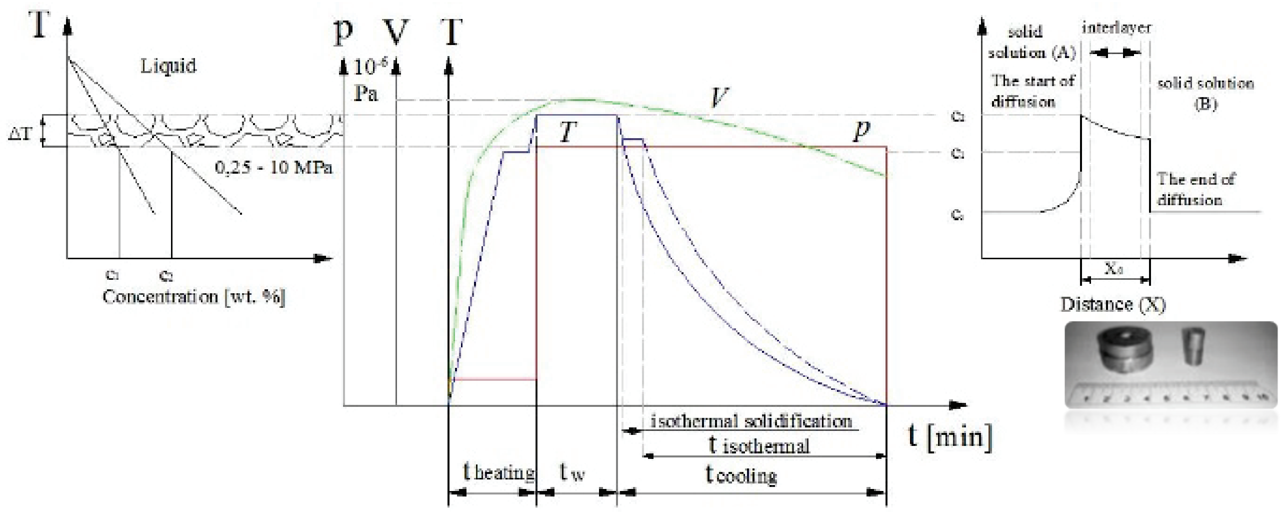

Figure 1. Duty cycle of diffusion welding [17]

The equipment GOM ATOS II TripleScan SO MV320 (Fig. 2) with measuring volume 320 × 240 × 240 mm and camera resolution 5.0 MPix were used for measurement of weld jointsdeformation.

The weld joints interface quality as well weld joints mechanical properties were evaluated by light microscopy, EDXmicroanalysis, micro-hardness measurements and shear strength test.

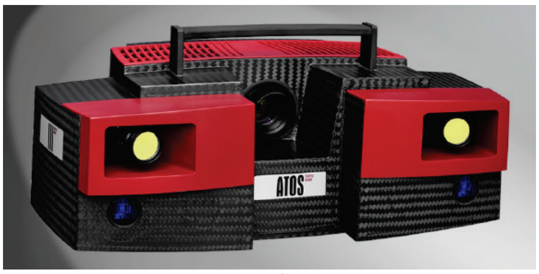

Figure 2. The head of optical 3D scanner GOM ATOS II TripleScan SO MV320 [16]

3. Results

The subject of deformation measurements was to observe shape deviations of weld joints (Fig. 3). There were observed radial and tangential deviations. The major deformations occurred at the edges of weld joints. Various deformation sizes were detected in separate planes of welded joint in perpendicular direction to the vector of pressing force. Tangential deformations along the circumference of the weld joint ranged from -0.27 to +0.22 mm. Partial radial deformations were brought into material during sample preparations by cutting. Further radial deformations were generated during diffusion welding by pressing mandrel of welding equipment.

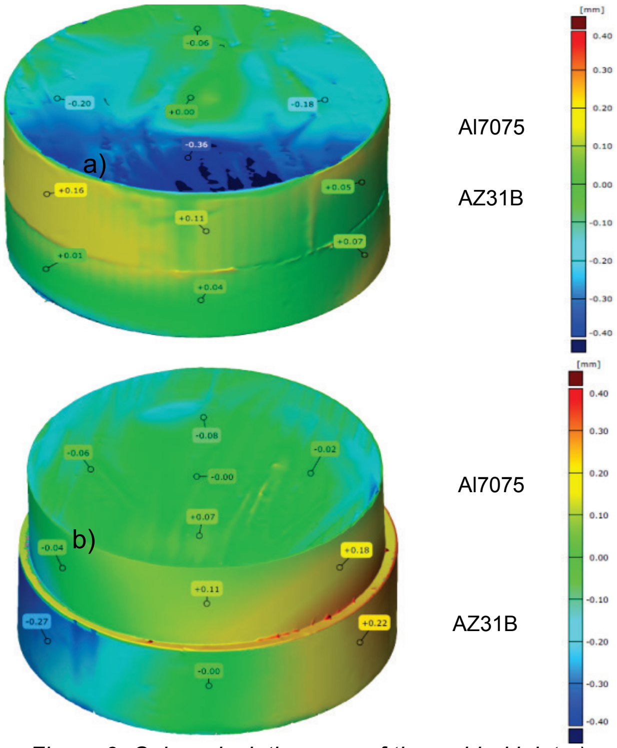

Figure 3. Colour deviation map of the welded joint a) Al7075/AZ31B; b) Al7075/Zn/AZ31B & Al7075/Ag/AZ31B

Macroscopic analysis confirmed integrity of the metallurgical joints. Microscopic analysis of weld joint Al7075 / AZ31B (Fig. 4) revealed, that Mg alloy had lost its polygonal character atthe weld interface. However, the polygonal structure was gradually recovering as the distance from weld joint interface grew. Formation of two IMPs was observed at the weld joint interface at temperatures exceeding 420 °C. Structure of weld joint consisted of solid solution α-Al, δ-Mg (solid solution Al and Zn in Mg) and IMPs Mg_2Al_3 and β-$Mg_{17}Al_{12}$. Both IMPs were created from Mg alloy AZ31B by diffusion of Al at boundaries of interdendritic spaces. Manganese phases of Al_8Mn_5 pattern were observed in Mg alloy structure, participating on formation of β-$Mg_{17}Al_{12}$ phase. Agglomerations of oxides with $MgAl_2O_4$ pattern were observed at the interface of metallurgical joint.

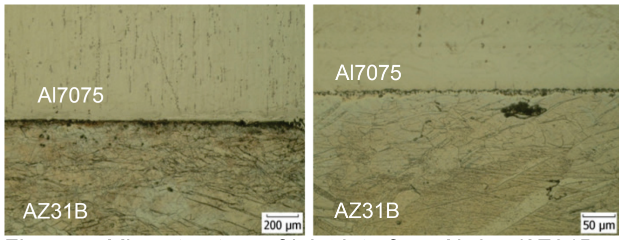

Figure 4. Microstructure of joint interface Al7075/AZ31B

Creation of IMP as reaction with Zn was observed at the interface of the welded joint Al7075/Zn/AZ31B (Fig. 5).The interlayer melted at temperatures over 419,53 °C and during holding time its part diffused into welded materials and formed IMP $MgZn_2$ (Laves phase). In accordance with Al-Mg phase diagram, at first, the phase δ-Mg was created by isomorph transformation. After temperature drop to 430 °C, phase $MgZn_2$ was formed by eutectic reaction.

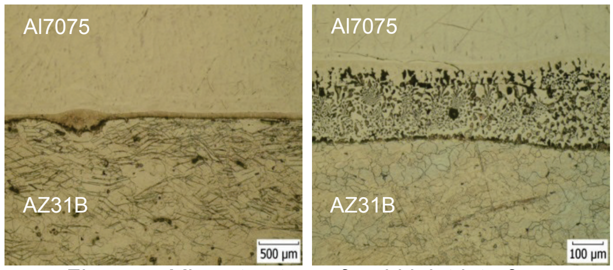

Figure 5. Microstructure of weld joint interface Al7075/Zn/AZ31B

Structure of weld joint interface Al7075 / Ag / AZ31B (Fig. 6) consisted of solid solution α-Al and δ-Mg with precipitates $AgMg_6Al_4$ and two IMPs: Mg_3Ag and MgAg. Phase Mg_3Ag was created at first, followed by MgAg phase.

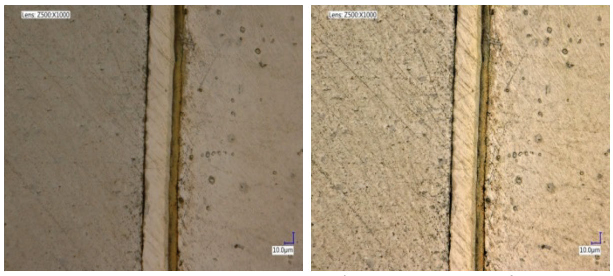

Figure 6. Microstructure of weld joint interface Al7075/Ag/AZ31B

Character, quality and structural stability of weld joints were evaluated by EDX microanalysis. Examined area across weld joint interface Al7075/AZ31B and line profiles of Al and Mg are shown in Fig. 7.

The diffusion area width of Al7075/AZ31B weld joint was approximately 24 μm. Examination of Al7075/ Zn/AZ31B weld joint interface revealed Zn interlayer diffusion of 20 μm into Al alloy and cca 10 μm into Mg alloy. Difusion of Ag within 8 – 10 μm into Mg alloy was observed at weld joint Al7075/Ag/ AZ31B. Measurement areas and line profiles of Al, Mg, Zn and Ag elements are presented in Fig. 8-9.

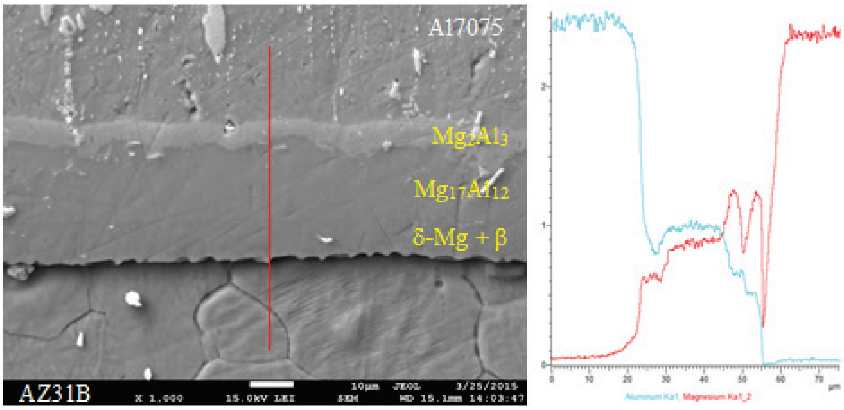

Figure 7. Examined area and concentration change of Al and Mg in welded joint interface Al7075/AZ31B

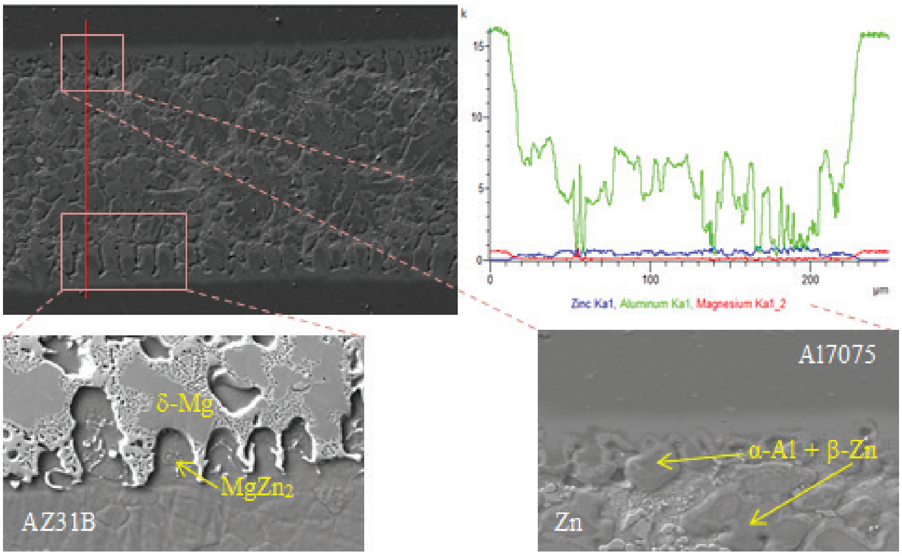

Figure 8. Examined area and concentration change of Al, Mg and Zn in weld joint interface Al7075/Zn/AZ31B

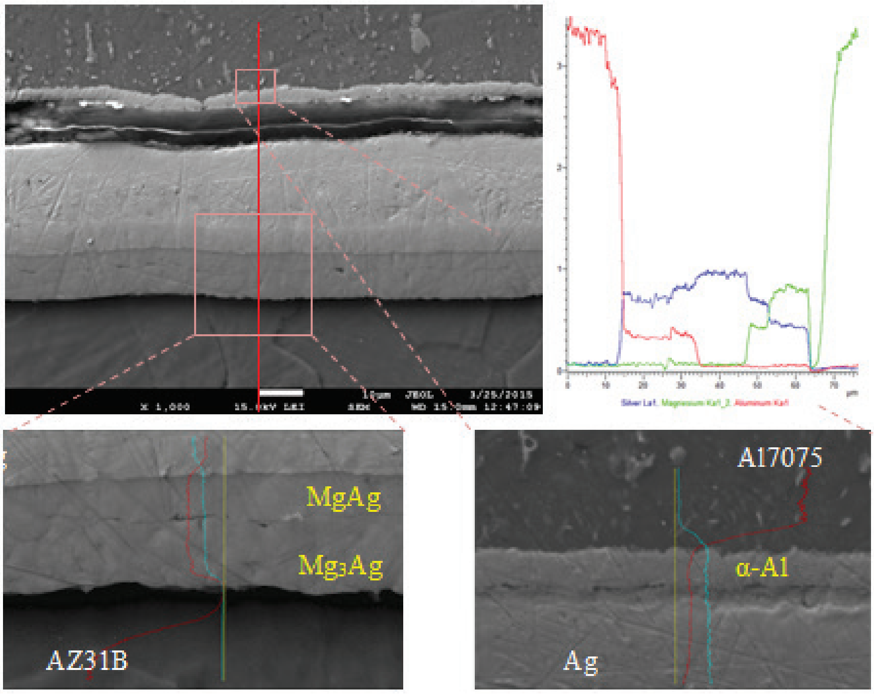

Figure 9. Examined area and concentration change ofAl, Mg and Ag in weld joint interface Al7075/Ag/AZ31B

Hardness measurements across welded joint interface with/without usage of interlayer are documented in Fig. 10, 11 and 12. All IMPs are characterized by significantly higher hardness and brittleness. The hardness increase was caused by strain hardening at joint interface. The hardness decreased in direction from interface into base material.

Mechanical properties of weld joints were verified by shear strength test. Weld joint Al7075 /AZ31B exhibited average value of shear strength of 43 MPa. Engaging the interlayers, the shear strength significantly increased. Zinc interlayer increased the weld joint shear strength twice, Ag interlayer approximately 1.4 times.

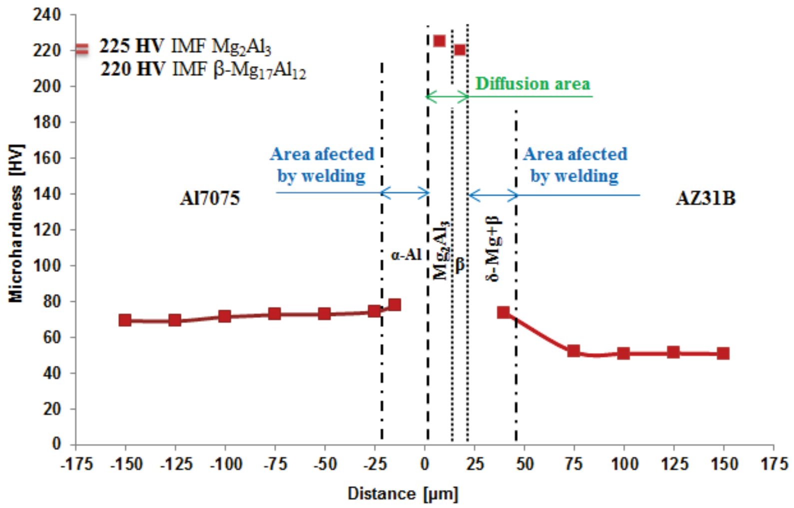

Figure 10. Hardness versus distance from weld joint Al7075 / AZ31B interface

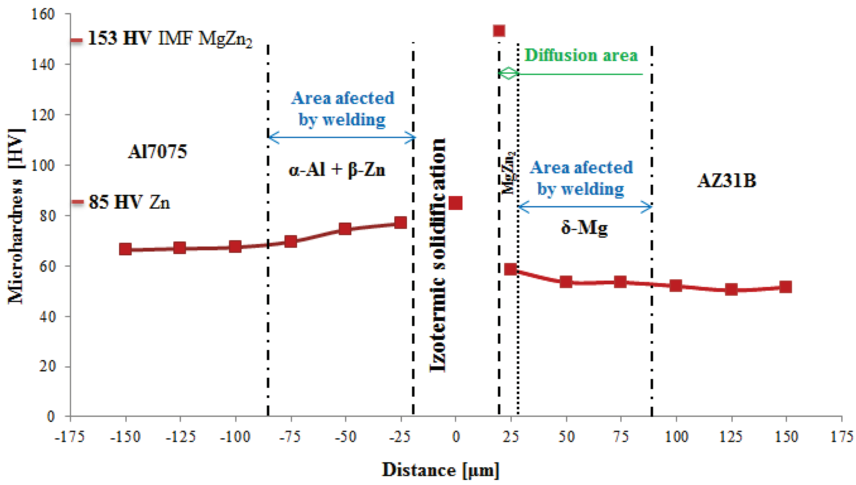

Figure 11. Hardness versus distance from weld jointAl7075 / Zn / AZ31B interface

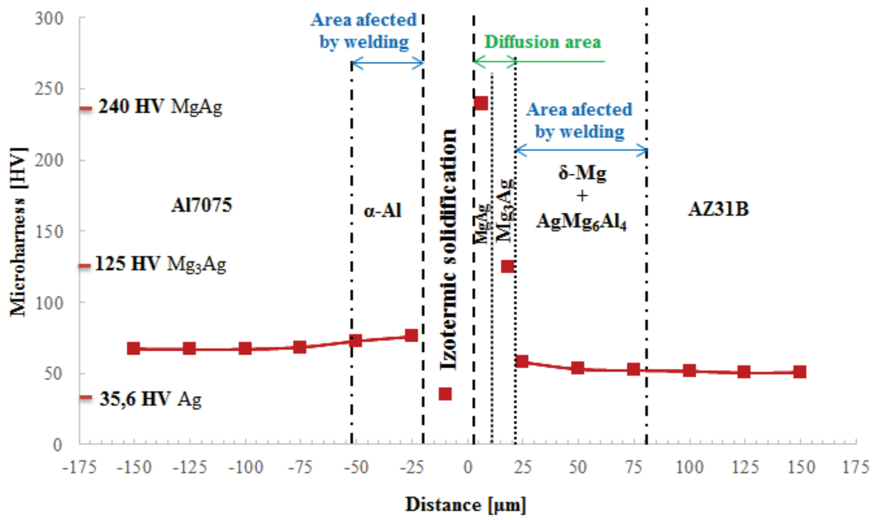

Figure 12. Hardness versus distance from weld joint Al7075 / Ag / AZ31B interface

5. Conclusion

Solid state bonding of light alloys by diffusion welding is widely used in many advanced industrial countries in the world. However, the process parameters, mechanical properties and weld joint microstructure strongly depend on chemical composition of welded materials as well as used interlayer. The paper examines physical-metallurgical aspects of joining two light alloys (Al7075/AZ31B) by diffusion welding. Deformations after welding were measured by optical 3D scanning using GOM ATOS II Triple Scan device. Based on obtained results it can be concluded, that the weld joint shape deviations had radial and tangential character. An important factor was to judge physical-metallurgical aspects in the weld joint area. Weld joints heterogeneity and interface character were evaluated by light microscopy and EDX microanalysis. The analyses confirmed presence of solid solutions, IMPs and precipitation processes. Hardness measurements revealed the strain hardening in the area of weld materials interface. Shear strength test confirmed the importance of correct choice of weld joint interlayers as they can significantly influence the mechanical properties of final weld joints.

6. Acknowledgement

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STRUCTURAL TRANSITION IN CULTURAL POLICY: A POST-SOCIALIST PERSPECTIVE

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Abstract

After the political change in post-socialist countries (Czech Republic, Poland, Slovakia, Slovenia and Hungary), theyhave chosen different strategies to make structural reforms in the cultural policy. Slovakia and Slovenia preferred the centralized model of decision-making and fiscal resource allocation. The Czech Republic and Poland aimed to decentralize both the decision-making and the fiscal resource allocation. In Hungary a hybrid model was created as the decision-making in cultural policy became more and more centralized, while the fiscal resource allocation is decentralized. Different transition strategies in cultural policy raise questions:

- *Does the homogeneity of institutional system (decision-making, fiscal resource allocation) affect the economic performance of the cultural sector?*
- *Which strategy (centralized homogenous, decentralized homogenous or hybrid) is more efficient in economic terms?*

The assumption is that institutions matter. The quality and the form of State intervention has major role in the economic performance of the cultural sector. Direct government support and household expenditure on culture and recreation are necessity, but have no direct influence on the cultural sector value added to GDP.

Keywords: post-socialist transition, comparative cultural policy, European Union

1. Introduction

More than 25 years have passed since the political system changed in the Eastern European countries. The transition was based on different strategies in the countries, not only in the economy but in the cultural policy as well. The various models now have different economic results in the cultural sector. The aim is to analyze which model is more successful in the long run among examined post-socialist countries (Czech Republic, Poland, Slovakia, Slovenia and Hungary). Although all of them used quite similar cultural policy for 45 years, after the political change they used different cultural policy models. The different ways of transition results difference in the economic performance of the cultural sector. The assumptions are the following:

H1: Institutions matter in case of cultural sector value added to GDP. In those countries, in which the structural reforms created a homogenous institutional system in the cultural policy, and the formal institutions are in harmony with the society's beliefs and norms, the economic performance of the cultural sector is better.

H2: The harmony of formal institutions (decision-making and fiscal resource allocation) increases transparency and accountability and as a result it has influence on the economic performance of the cultural sector.

H3: The speed of the transition and the strategy of it have determining role in the success of the transformed cultural policy. The slower, step-by-step and well-planned strategy has positive influence on the economic performance of the cultural sector.

The methodology used here is based on comparative economics, which puts institutions into the focus. In the article the "cross-national" approach is used. In the case of the "cross-national" approach, the comparison is based on the principle of "rationality", which asserts continuity between the phenomena compared "term by term" or "item by item". In the analysis beside the orthodox economic variables, some heterodox economic variables are also implemented. The chosen variables demonstrate the status of the economy and the political institutions. The following variables are compared: Intellectual Property Right (IPR) index, Culture Index, employment of the cultural sector, household expenditure on culture, direct government subsidy on culture, religion and recreation in percentage of GDP, GDP per capita and cultural sector value added to GDP.

2. Structural Transition in Cultural Policy: a Post-socialist Perspective

In 1989 the speed of transition was very fast from the point of the scale of history in Central and Eastern Europe. Beside the speed of the transition it is also remarkable that the change was spontaneous without any major strategy. The result is that the political, societal, economic and cultural sectors did not change at the same time. The speed was also different in the various fields. The transition was the fastest in the economy, followed by the political system, the society and culture. It is important to emphasize that the political change in 1989 was the first in history, when the transition of a system was managed to do in a peaceful way without any casualties and martyrs. The transition of the cultural sector was also peaceful. *Inkei* gives an in-depth analysis of the positive and negative tendencies of the cultural sector in the last two decades after the political change [1]:

Positive Tendencies

- "Culture has lately been increasingly recognized also as a factor of development and welfare, and this has corroborated its political status.
- New values and tastes appear manifested in many contemporary art forms, interdisciplinary projects and festival formats. Overcoming the former isolation, the often forcefully provincial value hierarchies, the local canons can now be set against global cultural references.
- Culture has reinforced its role of local cohesion, identity and pride, a vehicle of self-celebration in rural communities.
- Most of the formerly monopolistic associations of minorities (structures inherited from the previous regime) survived, but the actual scene is more characterized by multiplicity of civil society forms.
- International players have been particularly active in promoting intercultural cooperation.
- After the hardest early years of economic and social transformation, the percentage of cultural spending in the central state budgets regained the share that they had had before. The mechanisms of public support for culture have become more flexible and diverse. Along with direct subsidies given to public institutions, the governments have developed various grant schemes from which independent cultural operations can benefit, too. In addition to the current subsidy covering routine expenses of an organization, grants for experimental programs and projects are available also in the public sector."

Negative Tendencies

- "With the disappearing of the state control and censorship, the change was so fast in the fields of the development of the entertaining businesses and the cultural consumption patterns that the commercially mass products got wider space in the market, causing confusion in peoples' beliefs and norms.
- Cultural institutions and programs exert limited attraction because they very slowly adjust themselves most of them neglect marketing work and audience development adapted to the new patterns of cultural behavior.
- An indirect effect of the fast transition of the media sector is the fact that people watch much more television in the post-communist countries than the European average.
- Culture institutions have largely failed to tackle the problems of the culturally most deprived groups. There is no evidence about major successful targeted outreach programs and audience development projects".

It is noticeable from the positive and negative effects of the transition that more than 25 years after political change there is still confusion in the people's beliefs and norms. It needs more time to accept and get used to the newly created social, economic and political system. Harmony of formal and informal institutions is a key factor how the society behaves and acts.

The rules and laws on culture were fast created with full of improvisation in the post-socialist countries. As already mentioned the examined countries did not restructure their cultural policy system in the same way. Despite the different transition strategies there were common processes as well. The fast created non-profit sector, the Eastern type of privatization of cultural institutions and sectors (book sector, movie "industry") are examples for similarities. In many cases the western best practices were automatically taken over without any customization to the local specialties. Most of the decision-makers and the cultural experts believed in the fast speed of the transition. Now we can see that the expectations were *naïve*. The lack of the well-planned strategy, the use of the eastern-type of privatization and the fast transition led to an inefficient system, in which the economic performance of the cultural sector legs behind the cultural sector contribution to GDP in the western European countries. *Table 1* shows the importance of time in case of cultural policy and how it influences the economic performance of the cultural sector.

The data show that the longer the period of the cultural policy, the higher the cultural sector value added to GDP. The regression analysis also supports this argument on 10 % significance level (*see Table 2*) as the cultural sector value added to GDP's dependence on the number of years of cultural policy injured is moderately robust.

The various strategies used by the post-socialist countries after the transformation – centralization vs. decentralization, the homogeneity vs. heterogeneity of the cultural policy and fiscal allocation – result in the difference in the economic performance of the cultural sector. In the next chapter this assumption is tested with comparative analysis.

3. The Comparative Analysis of the Post-socialist Eastern European Countries

The previously introduced hypotheses are now proved with comparative analysis. Before starting to compare the main variables of the examined post-socialist countries, we examine how the main variables of the EU 13 and post-socialist countries differ from each other. The examined variables are the following (*see Table 3*):

- Intellectual Property Rights Index (2009)
- Culture Index (2009)
- Cultural Sector Employment (2006)
- Cultural Sector Value Added to GDP (2006)
- Household Expenditure on Culture and Recreation (2006)
- GDP per Capita (2006)
- Direct Government Support on Culture, Religion and Recreation in % of GDP (2006)

Table 1. EU Member States Cultural Statistics on Cultural Sector Value Added to GDP and Cultural Policy Injured

Country	Cultural Policy Injured (number of years) [a]	Cultural Sector Value Added to GDP [b]
Denmark	51	3.1
Finland	21	3.1
The Netherlands	41	2.7
Ireland	60	1.7
Great Britain	71	3.0
Sweden	77	2.4
Austria	36	1.8
Belgium	30	2.6
Czech Republic	15	2.3
France	52	3.4
Hungary	21	1.2
Germany	31	2.5
Poland	18	1.2
Italy	40	2.3
Portugal	16	1.4
Spain	25	2.3
Slovakia	18	2.0
Slovenia	31	2.2

Sources:[a]*ERICarts* (2012);[b]*KEA* (2006)

Table 2: Regression on Cultural Sector Value Added to GDP and Cultural Policy Injured (own calculation)

	Cultural Policy Injured (number of years)
Cultural Sector Value Added to GDP	0,433*
Significance level	0,072

*10 % significance level

Table 3: Statistical data on the cultural sectors of the EU 13 and the Central Eastern European countries

Country	IPR Index[a]	Culture Index[b]	Cultural Sector Employment (%)[c]	Cultural Sector Value Added to GDP (%)[c]	Household Expenditure on Culture and Recreation (%)[d]	GDP per Capita (USD)[e]	Direct Government Support on Culture, Religion and Recreation in % of GDP[f]
EU 13 countries							
Austria	7,90	6,64	3.00	1,80	6,60	35695	1,10
Belgium	7,90	3,41	2,70	2,60	4,70	33527	1,30
Denmark	8,10	9,19	3,30	3,10	5,30	35217	1,60
Finland	8,50	7,91	3,70	3,10	5,70	32736	1,10
France	8,10	5,32	2,50	3,40	5,20	31048	1,40
The Netherlands	8,00	9,24	4,20	2,70	4,80	36548	1,70
Ireland	7,60	4,74	3,40	1,70	3,10	40716	0,70
Great Britain	8,20	3,47	3,80	3,00	7,70	32990	1,00
Germany	8,40	5,86	3,20	2,50	5,20	31950	0,80
Italy	6,50	4,80	2,80	2,30	4,10	28866	0,90
Portugal	7,10	3,01	2,30	1,40	4,20	20839	1,10
Spain	6,40	3,73	3,10	2,30	3,30	29382	1,50
Sweden	7,60	10,0	3,60	2,40	5,30	34870	1,10
Average	**7,71**	**5,97**	**3,23**	**2,95**	**5,01**	**32645**	**1,18**
Eastern European Countries							
Czech Republic	5,80	5,00	2,50	2,30	5,90	22009	1,30
Hungary	6,20	4,09	2,60	1,20	4,30	18154	1,60
Poland	5,70	4,26	1,90	1,20	4,00	14541	1,10
Slovakia	6,30	3,72	1,90	2,00	5,00	17585	0,90
Slovenia	5,50	4,19	3,60	2,20	5,50	24837	1,30
Average	**5,9**	**4,25**	**2,5**	**1,78**	**4,94**	**19425**	**1,24**

Source: [a] www.internationalpropertyrightsindex.org; [b] *Williamson* (2009); [c] *KEA* (2006); [d] *OECD* (2009); [e] *OECD* (2008); [f] *Eurostat* (2013);

[b]Culture Index was first published in 2009. Culture Index symbolizes informal institutions, which private constraints are stemming from norms, culture, and customs emerge spontaneously (*Williamson*, 2009:372)

The most robust finding of the comparative test is that the post-socialist countries average of direct government support in % of GDP is higher and the household expenditure on culture and recreation is almost similar to the EU 13 average. So the post-socialist countries and the citizens spend a little bit more in percentage on culture from the given budget than the more developed western ones.

If we compare the data on cultural sector value added to GDP, the result is different, as the EU 13 countries data is 1,17 % higher.

Based on this result the first argument of the research is that direct expenditure of the government and the households on culture and recreation has no real effect on the economic performance of the cultural sector.

If we compare the data of direct government support and the GDP per Capita it is noticeable that it is not automatic that a rich country spends more on culture in % of GDP. The best examples are Austria, Germany and Ireland. Hungary's GDP per Capita is low, however it spends 1,6 % of the GDP on culture.

The data clearly demonstrate that the level of cultural sector employment and cultural sector value added to GDP correlate with each other. The more people work in the cultural sector, the higher the value added to GDP is, as the actors' income in the cultural sector appears in the GDP.

Finally we focus on institutions. Both IPR Index and Culture Index are higher in the EU 13 countries, so the quality of institutions is determining. It means that the enforcement of formal and informal institutions has positive effect on the economic performance of the cultural sector.

The data and the results of the comparative analysis show that more than 25 years after the change the political, economic and social quality of the post-socialist countries is below the EU 13 average. The post-socialist countries are almost reaching the level of the examined Mediterranean countries, but far behind Scandinavian countries, or etatist France, federal Germany or liberal Great Britain.

Now we turn to compare only the post-socialist countries. Although there are some general characteristics of the transition such as the immediate abolishment of censorship after the change, the still existing heavy and inflexible cultural institutions, the fast development of the mass cultural production or the reduction in public subsidies, we argue that the post-communist countries didn't develop in the same way after the political turn. First the change in the direct government support on culture, religion and recreation in percentage of GDP is compared, and then we demonstrate the size of fiscal *centralization* or *decentralization* in the cultural sector. Finally we describe the main structure of the currently used cultural policies.

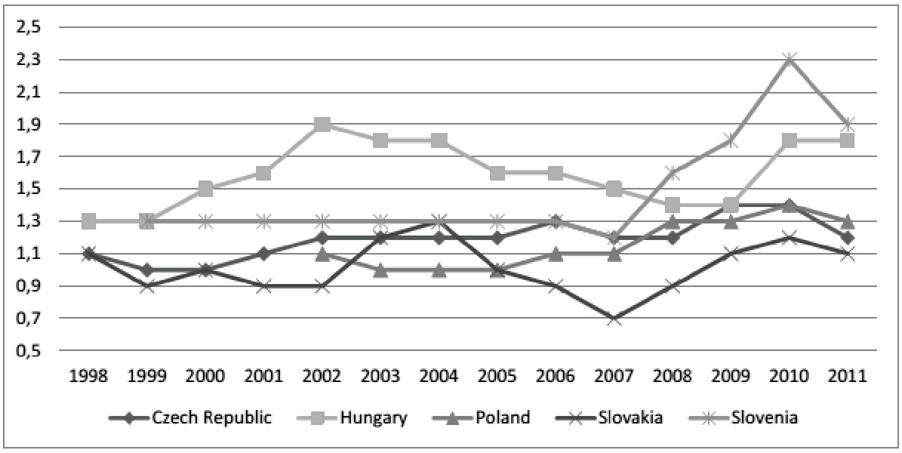

Figure 1. Direct Government Support on Culture in percentage of GDP (1998–2011)Source: Eurostat (2013)

The curves in *Figure 1* show that the most hectic are the Slovakian and the Hungarian government supports on culture in percentage of GDP. These countries did not use a consequent strategy in the examined period. After the change they tried various models to set how much the optimal size of direct government support should be. The Czech Republic, Poland and Slovenia use a consequent strategy as they slightly increase the direct government support on culture in the examined period, no hectic changes can be seen. Based on the data Hungary's average support is the highest followed by Slovenia, the Czech Republic, Poland and Slovakia. It is an important result that the higher government support does not mean automatically that the cultural sector value added to GDP is higher in a country. The value added to GDP is the highest in the Czech Republic, followed by Slovenia and Slovakia. Hungary and Poland produce the lowest level of value added to GDP. The tendency of the household expenditure on culture and recreation is the same as the value added to GDP. Except Poland the crowding out theory is valid in practice as in those countries where the government support is higher the household expenditure is lower and vice versa (*see Figure 1 and Table 3*).

The result of the comparative analysis on the role of the direct government expenditure on culture is the same for the EU 13 and 5 post-socialist countries too. We argue that the size of direct government support on culture is needed, but has no real effect on the cultural sector value added to GDP. However government expenditure can have negative influence household expenditure on culture.

The cultural policies also show some differences, which can have effect on the efficiency of the cultural sector's performance. In the Czech Republic, Poland, Slovakia and Slovenia there are injured cultural strategies. On the formal institutional level the main aims are well determined, although the cultural experts show some dissatisfaction with the system, but comparing to the Hungarian case (*as we show later*), these systems are more transparent, as there is no long-run cultural policy and strategy in Hungary. The lack of strategy has its effects on the economic performance of Hungarian cultural sector as those countries, which have well determined strategy (Czech Republic, Slovakia, Slovenia, Poland) show more efficient economic performance. Centralization vs. decentralization is another determining factor. In Poland the cultural decision-making is decentralized, and the fiscal allocation is directed by the government to the local governments (*see Table 4*).

Table 4: Public Cultural Expenditure in Poland (2011)

Level of government	Total expenditure PLN	% share of total
State	1 422 771 000	17,60
Local	6 654 537 000	82,40
Provinces	1 365 348 000	16,90
Districts	2 400 779 000	29,70
Local	2 888 410 000	35,80
Total (State+Local)	**8 077 308 000**	**100,00**

Source: *ERICarts* (2012)

In *Poland* there is no "*arm length body*" for cultural subsidization. The main aims of the Polish cultural policy [2]:

- "decentralization – shift the competencies from the central administration to the regional level, and from the regional to the local level;
- public financial support for selected cultural institutions and crucial cultural events;
- support for the development of non-public cultural institutions and funding mechanisms which could supplement the public funding of culture."

The Czech Republic is smaller in size and population than Poland, but it uses also a decentralized system. This country has a cultural strategy for the period 2009–2014 with four main objectives [2]:

- "Economic and Social Dimensions: to use the benefits of arts and cultural heritage and associated creativity to increase competitive strength in other areas and activities.
- The Civic Dimension – Personal Development: to emphasize the role of culture in the individual professional and personal development of citizens, especially with regard to creativity, the cultivation of democratic values and individual attitudes and thus increasing the general responsibility for inherited values as well as the newly created ones.
- The Role of the State, Regions and Municipalities in Supporting the Maintenance and Formation of Cultural Values: to provide direct and indirect support to maintain existing cultural values and create new values.
- The Role of the State in Formulating the Rules: to create a transparent and non-discriminating environment for cultural activities and their support at the levels of the state, regions and municipalities."

Culture appears at the State level in the concept materials of other ministries, mainly the Ministry of Education, Youth and Sports, the Ministry of Foreign Affairs and other bodies of state administration, which approach is used in the British system as well. The financing is also decentralized as the public cultural budget is mainly spent by the local authorities (*see Table 5*). Both the decision-making and the fiscal system of the cultural sector is decentralized, the system is homogenous.

In *Slovakia* the decision-making is centralized, but there is an independent committee, the so called "Committee on Culture and Media" with monitoring and controlling rights. The local governments also have decision-making on local, municipal cultural institutions, amateur projects. The Slovakian system is fiscally centralized (*see Table 6*).

They try to implement some "arm length" principle with "advantaged or state-supported credits for investments in the area of culture and the selective reduction of taxes for cultural goods and services" [2]. We can see that this system is less eclectic than the Hungarian one.

Slovenia is running a different model comparing to the previously mentioned two models. The main institutional body is the Ministry for Culture, but the arm length aspect is determinant too as the so called "National Assembly" deals with culture in general level through bills, national four year programs for culture and annual state budgets [2]. Beside these institutions the National Assembly appoints an independent body, the National Council for Culture, which monitors and assesses the impact of cultural policy on cultural development. The whole system can be characterized as being poly-central. Although the State subsidies are relevant, the municipals have also important role in the decision-making and fiscal allocation (*see Table 7*).

Previously we analyzed countries, in which the decision-making and the fiscal resource allocation is in harmony, so the system is homogenous. In the Czech Republic and Poland decentralization is the priority in cultural policy, while in Slovakia and Slovenia, the system is centralized.

Table 5: Public Cultural Expenditure by Level of Government in the Czech Republic (1998–2011)

Year	Central government level (million EUR)	Local government level (million EUR)
1998	241,1	417,2
1999	232,8	355,3
2000	256,9	402,3
2001	318,7	487,8
2002	401,8	652,2
2003	357,8	716,8
2004	380,1	767,6
2005	393,0	861,7
2006	508,2	1 082,8
2007	549,8	1 118,9
2008	664,3	1 252,6
2009	694,4	1 333,4
2010	597,0	1 471,7
2011	582,3	1 384,6

Source: *Eurostat* (2013)

Table 6: Public Cultural Expenditure by Level of Government in Slovakia (1998–2011)

Year	Central government level (million EUR)	Local government level (million EUR)
1998	189,1	55,3
1999	158,1	47,9
2000	205,9	41,0
2001	193,7	46,6
2002	201,2	64,4
2003	272,7	118,1
2004	283,1	170,6
2005	244,3	163,3
2006	410,4	129,6
2007	208,4	205,5
2008	394,5	201,1
2009	398,3	295,8
2010	463,8	330,9
2011	554,6	248,3

Source: *Eurostat* (2013)

Table 7: Public Cultural Expenditure by Level of Government in Slovenia (1998–2011)

Year	Central government level (million EUR)	Local government level (million EUR)
1998	160	136
1999	159,3	140,0
2000	158,6	144,0
2001	175,5	148,0
2002	183,9	174,4
2003	189,6	181,1
2004	199,0	183,1
2005	207,3	197,6
2006	217,2	220,5
2007	224,7	237,0
2008	372,8	272,8
2009	385,7	298,0
2010	414,1	428,6
2011	408,8	315,2

Source: *Eurostat* (2013)

Hungary is an exception with its hybrid system. After the political change the Anglo-Saxon cultural financing was preferred. The fast creation of the non-profit sector, tax reductions and the National Cultural Fund (arm length body) are examples for the liberal way of financing culture. The fiscal system was also decentralized as the local governments take the major role in public expenditure on culture (*see Table 8*). However the political decision-making was and is still centralized.

Table 8: Public Cultural Expenditure by Level of Government in Hungary (2001–2009)

Year	Central government level (million HUF)	Local government level (million HUF)
2001	62 227	69 888
2002	67 911	80 171
2003	64 785	98 600
2004	65 685	104 701
2005	58 515	111 467
2006	52 513	120 854
2007	51 515	121 928
2008	57 593	123 013
2009	57 740	121 484

Source: http://kultstat.emmi.gov.hu/site/kultstat2010/kultstat_kiadvany_2010_1_4.pdf

The results of the comparative analyses focusing on the homogeneity of the formal institutions (*decision-making and fiscal resource allocation*) support our hypothesis that the harmony of institutions has determining role in the economic performance of the cultural sector of a country.

4. Conclusions

The transition of cultural policy of 5 post-socialists countries were examined. In the analyses the institutional perspective was used, to prove our argument that institutions matter in case of economic efficiency of cultural sector. The conclusions are as follows:

- The post-socialist countries have chosen different strategies to transform their cultural policy after the political change.
- The economic performance of the cultural sector in the eastern countries is below the western ones.
- The size of direct government support on culture is needed, but has no real effect on the cultural sector value added to GDP. However government expenditure can negatively influence household expenditure on culture.
- The role of long-run cultural policy strategy is determining in the economic performance of the cultural sector.
- The harmony of informal (Culture Index) and formal institutions (Intellectual Property Right Index) is determining in the cultural sector value added to GDP.
- Those countries' cultural sectors perform better, in which the formal institutions (the political decision-making and the fiscal resource allocation) are in harmony.

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MICROSTRUCTURAL EVOLUTION AND MECHANICAL BEHAVIOR OF WC-Co / AISI 1020 STEEL JOINT OBTAINED BY BRAZING AND GTAW PROCESS

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Abstract

In this work, the microstructural evolution and the mechanical proprties of WC-Co / AISI 1020 steel joint obtained by brazing and Gas Tungsten Arc Welding (GTAW) process are investigated. The maximum peak temperature induced by the GTAW process and the introduction of a shielding gas cause a migration of WC and Co elements from the carbide to the interface and create an inter-diffusion zone. The Energy Dispersive Spectroscopy (EDS) analysis reveals a small diffusion range of Co and Ni across the interface and confirm their presence. The mechanical behaviors are carried out through shear and microhardness tests, they show that the creation of a vulnirable zone which is a Heat Affected Zone (HAZ) in the GTAW jointbeside the hard metal, makesthe brazing joint more stronger then the once obtained by the GTAW process., dispite the existance of the inter-diffusion zone. Further, a special shear test (SST) led to confirm that the joint made by the GTAW process is much less resistant then the brazed once.

Keywords:

Brazing, AISI 1020 steel, GTAW, WC-Co, interface.

1. Introduction

The selection of materials for cutting and drilling tools is crucial; it requires a combination between the toughness and the hardness.For that raison, the employment of WC-Co seems a sensible choice due to their excellent properties including high hardness, good resistance even at high temperature and a low thermal expansion coefficient (TEC)[1]. Recently, the assembly of cermets or hard metalsto steel structures especially for drilling and cutting tools has generated a lot of interest [2].[3] Several authors have studied the influence of temperature on the joint brazing WC-Co and a steel.Mehmet et al found that the formation of an intermediate layer of Fe-Co-Cu during his study on WC-Co /SAE1045 brazed joint using aCuZnNi10 as a filler alloy[4].

Moreover, Hongsheng et al found that the addition of Ni allows the formation inter-diffusion zone, thus improving the mechanical strength of the brazed joint WC-Co / interlayer / 3Cr13 [5].

Won-Bae found a migration of cobalt cermet (WC-Co) to the braze, thus generating a good influence on mechanical properties of the joint. In addition, diffusion of Ni from the braze to the steel [3].

In the present work, the AISI 1020 steel is assembled to WC-Co via two different techniques of assembly the brazing and the GTAW process, using the same-based silver filler alloy. The microstructure analysis is established with EDS analysis while the mechanical properties are assessed by the shear testing and the microhardness profile across the assembled joints.

2. Method

The hard material used in this study is WC-3% Co having a cylindrical shape with 13 mm diameter, 9 mm in thickness and aAISI 1020 steel with 0.17% of carbon, the main compositions of the base materials are shown in table 1.

Before assembling, the samples surfaces were ground and cleaned with acetone. We used two different types of assembly to join WC-Co to AISI 1020 steel. The first is oxyacetylene brazing with Ag based filler alloy witch its composition is given in table 1. The second is a GTAW process with Ar + 1% of N_2 shielding gas using the same type of filler alloy. The parameters of welding are resumed in table 2. Due to the large difference in thermal expansion coefficient (TEC) between WC-Co and the steel, this makes their assembling difficult, for that reason, we used a DCEN mode (direct current electrode negative) assuring a considerable heating of samples witch implies an important penetration, a narrow weld bead and also a significant heat input [6].To get an idea on the temperature range during assembly process, we used an infrared thermometer SCANTEMP 490; it indicated a temperature of 620 to 650 ° C for brazing, whereas for GTAW process it was over 1000 °C.

After brazing and welding operations, metallographic sections transverse to the brazing and welding direction were prepared for optical metallography using standard techniques for mechanical polishing. The samples were then etched with a solution containing: 5ml H2SO4 80 ml H2O and 10g of K2Cr2O7.

Table 1. Chemical compositions of the base and filler materials used in this study

Elements	W	C	Co	Ni	Mn	Ag	Zn	Si	Cu	Fe
WC-Co (wt%)	87	10	3	--	--	--	--	--	--	--
AISI 1020 steel	--	0.17	--	--	0.15	--	--	0.15	--	99.51
Filler alloy (wt%)	--	4.12	--	6.11	8.02	44.39	21.52	--	15.84	--

Microstructural examination of the samples was done using a Nikon ECLIPSE LV100D-U optical microscope and a JEOL JSM 6830 scanning electron microscope. Energy dispersive X-ray spectrometry (EDS) microprobe was used to carry out the chemical compositions of the inter-diffusion zones between the WC-Co / filler alloy. In order to determine the evolution of mechanical properties in all joints, a special shear test were performed at room temperature to evaluate a bonding strength of the brazed and welded joints. Hardness tests were obtained across the cross sections of the brazed and the welded joints, using BUEHLER LTD micro-hardness tester under a load of 300g.

Table 2. Welding parameters during TIG welding:

Current & polarity	DCEN (-)
Filer alloy	Ag21Zn16Cu8Mn5Ni
Ø Electrode (mm)	3.0
Amp.Range (A)	46-50
Volt.Range (V)	9-10
Frequency	2
Gas	99% Ar + 1% N2
Folw Rate (l/min)	8-10

3. Results and discussion

Figure 1 shows a transversal section of the AISI 1020 steel/filler alloy/WC-Co joints obtained by (a: the GTAW process and b: bybrazing) respectively. It is interesting to note that contrary to the brazed joint, the presence of cracks in some regions at the WC-Co/Cu-Ag-Zn interface made by GTAW. This can be explained by the difference in the TEC between the carbide and the filler alloy. Moreover, the different residual stress conditions that are strongly affected by the temperature range of each process and the cooling rate, which may have a direct influence on the mechanical behavior of joint [7], whereas porosities have been detected in the brazed joint.

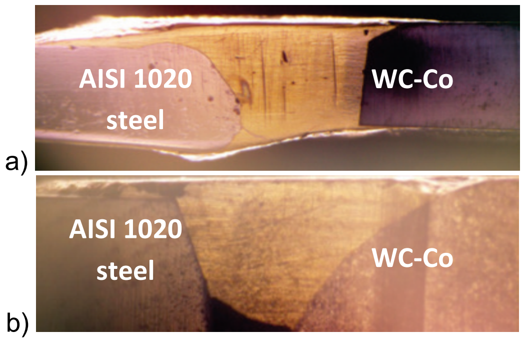

Figure 1. Transversal section of the AISI 1020 steel/filler alloy/WC-Co joints obtained by: a. GTAW; b. brazing

Figure 2-3 exhibit the WC-Co/Cu-Ag-Zn interface obtained by the GTAW process and the one obtainned by brazing respectively. Similar microstructure aspect of the filler alloy was found compared to Khorram, where he obtained eutectic structure of the Ag-Cu Zn filer alloy by brazing Inconel 718 using laser [8].

The main difference, was in the eutectic size, which is finer in the brazed joint because of the low temperature of brazing which decrease the diffusion process and preventing eutectic coarsening, that will have an influence on the mechanical properties of the joint

It can clearly be seen using SEM image of WC-Co/filler alloy interface the creation of new zone of 22-25 μm of thickness in the GTAW process joint. The EDS line scan analysis made on this area shown in Figure 4 exhibits the presence of Cu, Mn and Ni, elements and significant extent of Co migrated towards the interface. Further, the Ni is diffused from the filler alloy to the interface, probably because of the high range of temperature and its affinity with W[9]. Similar result found by J. Nowacki, who he noted that diffusion processes lead to exchange the components of cermets and filler metal [10], in his study on the carbide/Cu-Zn/steel brazing.

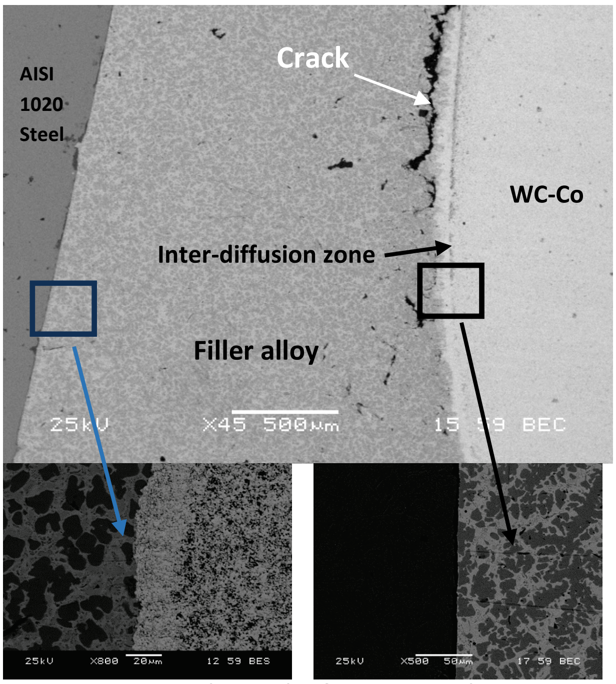

Figure 2. The interfaces of AISI 1020 steel/filler alloyand filler alloy /WC-Co obtained by GTAW

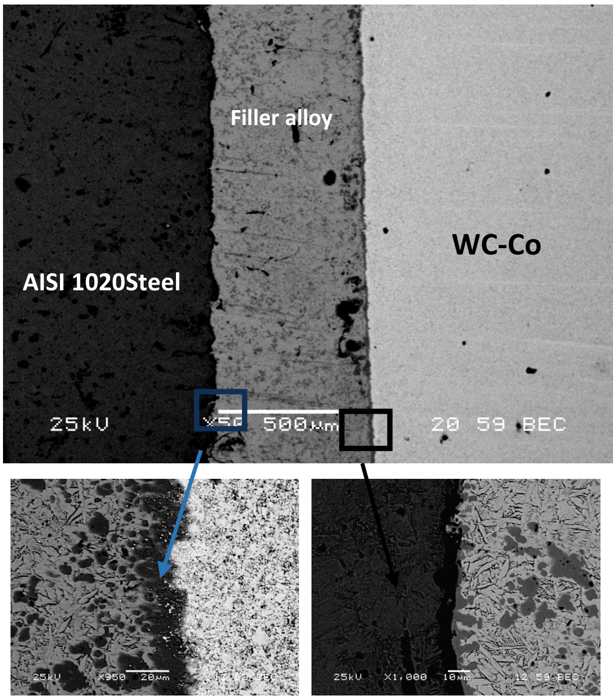

Figure 3. The interfaces of AISI 1020 steel/filler alloy and filler alloy /WC-Co obtained by brazing

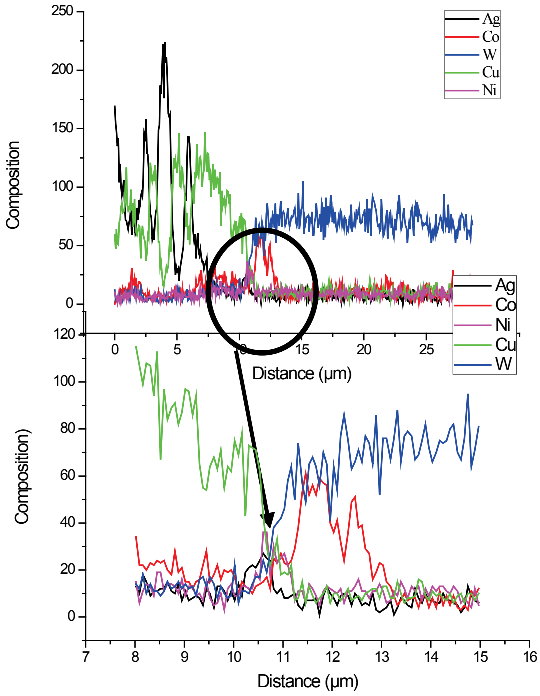

Figure 4. EDS linescane analysis of the interface WC-Co/filler alloy obtained by GTAW process

While in the brazed joint, the EDS analysis (Figure 5) indicate any element diffusion. However, Mehmet Uzkut found a diffusion of Co element, in the SAE 1040/WC-C0 brazed joint when the temperature of work is 775 °C [4]. Although, the EDS linescane analysis done on the interface obtained by the GTAW, reveal the migration of Co and WC to the filler alloy interface and a small diffusion range of Ni towards the carbide. That can be explained by the diffusion of cobalt in metal (filler alloy) is easier than the diffusion of Ni in cermet (WC-Co), which gives a large distance of diffusion on Co in filler alloy and small ones of Ni in WC-Co [11].

Xu relates the migration of WC to the use of shielding gas [12]. Morecver, Przybyłowicz found that, the heat activation involves the dissolution of great amount of carbide[13], however in joint obtained by the GTAW process we noticed the rearrangement of the W beside the filler alloy which is probably caused by the temperature. Furthermore, Buytoz noted that when the energy input decreases the carbide remains undissolved when he applied a melted tungsten carbide powders on the surface of carbon steel, using tungsten inert gas[14].

Therefore, it can be said that the high temperature and the use of shielding gas activate migration of some elements and dissolution of carbides.

Figure 6 shows the microhardness distribution across the joints. The curves exhibit a similar tendency for both procedures, i.e. the higher value of microhardness is recorded in the carbide side with 1510 HV0.3.Then, it decreases until the filler alloy. This difference is due to the ductile nature of elements present in the filler alloy such as Cu, Ni, Zn [3] After that, it increases closer the AISI 1020 steel where it remains nearly constant at 200 HV0.3.

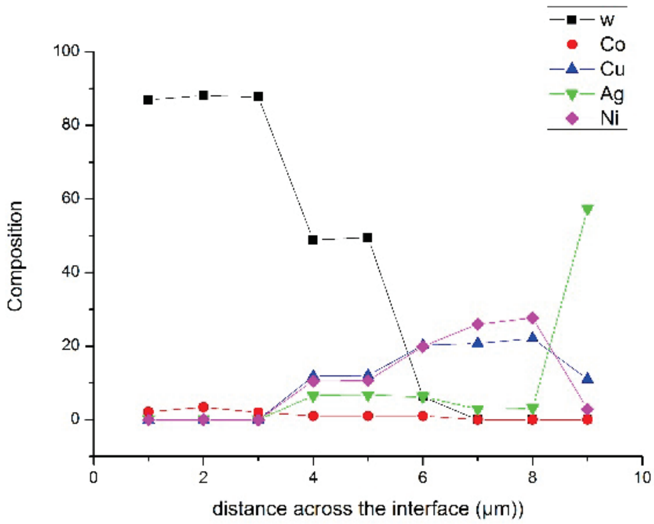

Figure 5. EDS analysis from the WC-Co to the filler alloy obtained by brazing.

In the brazing joint closer the WC-Co, the microhardness achieves 210 HV0.3, increasingly moving away from this interface, the microhardness decreeses and stabilizes at 162 HV0.3. Whereas, for the joint obtained by the GTAW process, the behavior in the hardness shows two different regions at the interface, the first is the inter-diffusion zone where the hardness is intermediate between the WC-Co and the filler alloy ones. The hardness recorded in this zone (530 HV0.3) is relatively similar to the tungsten ones, which its presence was confirmed by the EDS microprobe analysis. The second is the HAZ where the hardness was high and achieves a 1570 HV0.3. Similar results found by Mehmet Uzkut, who referred this value to passage of Co element along the connection line in this region indicating the mobility of this element [4].

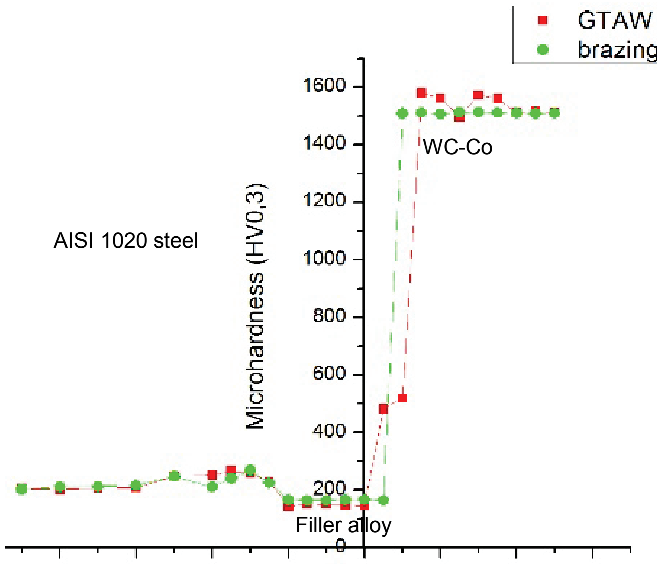

Figure 6. Microhardnes destrubution across the WC-Co/ filler alloy interface.

The higher microhardness of the filler alloy after brazing compared to GTAW (162-140 $HV_{0.3}$) is due to the fast cooling rate caused by the low range of temperature (650°C) which gives finer microstructures then the one obtained by the GTAW process.

The results obtained through shear testing indicate that the maximum value was recorded in the joint obtained by brazing with 260MPa. While the GTAW process once was 168MPa. The reason can be related to the presence of the HAZ and the cracks in the joint. Thereby confirming the measurements of micro-hardness already obtained

4. Conclusion

The comparison of the microstructures and mechanical properties results between those two procedures support the following conclusions:

Based on the EDS microprobe analysis of the GTAW interface, the higher the temperature the greater amount of carbide dissolution is. Further, it activates the rearrangement of the WC beside the interface.

It can be seen that the use of shielding gas and the high range of temperature activate the migration of some elements as well as the Ni and the W. Thus, the inter-diffusion zone formed between the WC-Co and the filler alloy. However, at low temperature the WC remains undissolved.

The special shear test showed that the maximum shear strength value obtained for the joint made by brazing compared to the one obtained by the GTAW process. It is interesting to note that for the both processes, the fracture happened in the filler alloy zone cross the WC-Co side and the presence of the HAZ in the GTAW joint makes this joint weak and fragile.

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DEVELOPMENT OF ENERGY SUSTAINABLE CONCEPTUAL VARIANT OF THE TECHNICAL SYSTEM KIOSK

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Abstract

This paper describes the generation of energy sustainable and multi-functional conceptual variant of the technical system kiosk. From the requirement list, morphological matrix is made. The matrix contains partial functions and principal solutions of these functions. Applying AHP evaluation method, based on selected criteria, the best conceptual variant is selected.

Keywords: Conceptual design, Morphological matrix, functional requirements, AHP method, kiosk

1. Introduction

Market requirements are the basis for defining basic functional requirements, which in turn represent the initial information on a new potential product [1, 2]. At the conceptual phase, functional requirements are usually unarranged and incomplete. By means of structural enlargement of functions, product structure can be presented as a functional structure, which is at the same time the basis for defining the shape of the product [3].

It is obvious that design process must be planned carefully and executed systematically. In particular, an engineering design method must integrate the many different aspects of designing in such a way that the whole process becomes logical and comprehensive [4]. In order to solve a technical problem we need a system with a clear and easily reproduced relationship, between inputs and outputs (Figure 1).

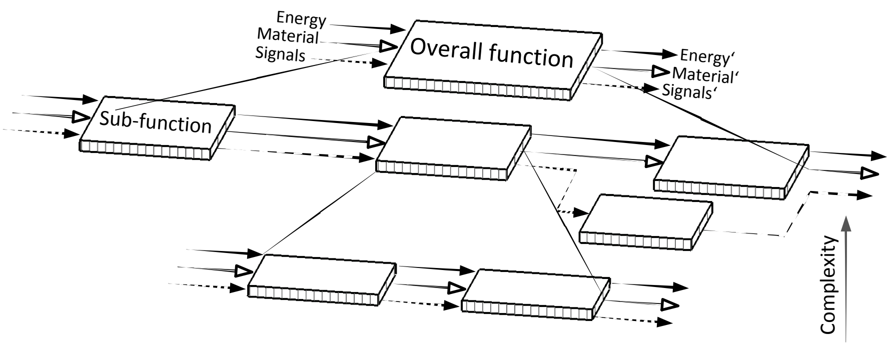


Figure 1. Establishing a function structure by breaking down an overall function into sub - functions

With the purpose of solving technical problems different methods were developed [5]. One of these methods is the morphological matrix [6, 7]. When concepts are defined it is necessary to select the best solution (conceptual variant). For this purpose in this paper is used AHP (*Analytic Hierarchy Process*) method.

Kiosk presented in this paper, is the result of the work of design team from Mechanical Engineering Faculty in Slavonski Brod. Authors of this paper are also members of the team. Technical system kiosk was developed based on the requirements of the J. J. Strossmayer University of Osijek. The aim was to generate multi - functional and energy sustainable system of kiosk, with distinctive architectural elements of the City of Osijek.

2. Requirement list and morphological matrix

Requirements presented in the requirement list can be divided into several categories: design requirements, form requirements, installation requirements and requirements to energy efficiency. Because the number of requests is a large, in table 1 are presented only some of them. A complete list of requirements is presented in [8].

Morphological matrix, presented in table 2, with partial functions is derived from requirement list. Three conceptual variants (V1, V2 and V3) are performed from matrix.

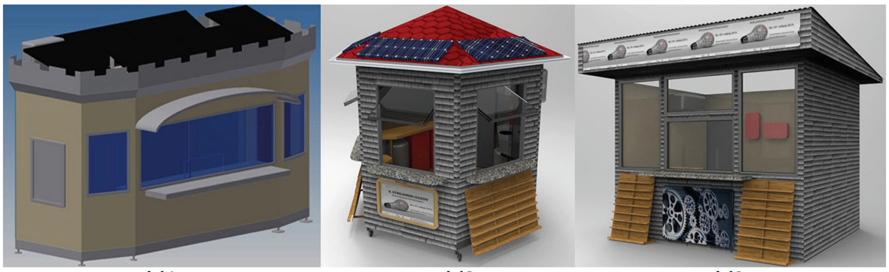
Conceptual variants of kiosk, obtained from morphological matrix, are presented in figure 2. These variants are result of links between the principles of solutions of partial functions

Table 1. Requirement list

Requirement list			
Requirement or wish	**Requirements**	**Requirement or wish**	**Requirements**
R	Gross area max. 15 m^2	R	Economic viability
R	Simple assembly/disassembly	R	The use of recyclable materials
R	Roof angle 2°	R	Design recognition (typically Osijek)
R	To ensure stability of the construction	R	The floor construction must be separated
R	Construction durability min. 15 years	R	Static calculation according to HRN EN (1991, 1993, 1995)
R	Min. weight of construction frame 400kg	R	Calculation on wind and snow
W	Modular design	R	Air condition up to 3 kW
R	The min. load capacity of 150 kg/m^2	R	Renewable energy source
R	Installations for heating and cooling	R	Boiler for water up to 5L

Table 2. Morphological matrix

Morphological matrix			
Partial functions	**Principles of solutions**		
Form cross-section of construction in top view according to modularity requirements	Octagon ●	Hexagon ◆	Rectangle ▲
With profiles perform a kiosk framework	Square profile ▲	I - profile ◆	Ben steel profiles ●
With panel perform below horizontal rock	Three-layer panel (steel, insulation, wood) ● ▲	Double-layer panel (mineral wool, wood) ◆	-
With panels perform vertical rocks	Panel with mineral wool ◆	Panel with polyurethane foam ●	Three-layer panel (tin, insulation, knauf) ▲
With panel performe upper horizontal rock	Panel with polyurethane foam ●	Three-layer panel (tin, insulation, knauf) ▲	Panel with mineral wool ◆
Form roof	Single-eaves ▲	Straight ●	Multi-eaves ◆
Form eaves	Straight ▲	No ◆	Curved ●
Form glass panel	Laminated+insulated glass ▲	Insulated glass ● ◆	-
Construction rely	Adjustable supports ●	Screws for fundament ◆	No ▲
Construction fundament	Belt fundament ●	▲ Reinforced panel ◆	-
Max. power of air condition / kW	2,5 ●	3 ▲	2 ◆
Place the tank	External ▲	Internal ◆ ●	-
Drive off waste water	Tank ▲	◆ Water system ●	-
Transport construction	Individual parts ●	▲ The entire construction ◆	-
Energy gain	Electrical networks ▲	◆ Solar panels ●	-
Design recognition (typically Osijek)	Bastion ●	Tram station	No ▲ ◆
	V1 ●	**V2** ◆	**V3** ▲



V1 V2 V3

Figure 2. Conceptual variants of kiosk

3. Analytic Hierarchy Process evaluation method

Evaluation makes the initial phase of decision – making. In relation to the set goal, the appropriate points are assigned to the variants. In this way, the utility is determined in relation to the goal. The AHP method is used. In table 3 is defined eight criterions, with input data for decision – making model.

Table 3. Kiosk variants with input data

Criterions / variants	V1	V2	V3
Appearance	5	4	3
Price	5	3	4
Functionality	5	4	5
Assembly	5	2	4
Transport	4	5	4
Roof load / kg/m²	580	445	210
Thermal conductivity of wall / W/m²K	0,25	0,82	0,51
Thermal conductivity of roof / W/m²K	0,25	0,41	0,68

Criteria weights (Table 3) are selected on the basis of the assessment of the decision maker. They are expressed as numbers.

The hierarchical model of the decision – making problem is shown in figure 3. The goal is on the top. The criteria and sub – criteria are on lower levels and alternatives are on the bottom of the model.

On each level of the hierarchical structure elements of the structure are compared. The preferences of the decision maker are expressed by the Saaty scale of relative importance [9]. Comparison of alternatives in pairs for each criterion is performed. The priorities of individual alternatives are calculated according to the expression:

$$p_{\mathrm{i}} = \frac{m_{\mathrm{i}}}{\sum_{\mathrm{j}=1}^{\mathrm{q}} m_{\mathrm{j}}} \tag{1}$$

where q is number of rows and m_{i} is geometric mean of row alternatives.

Geometric mean of rows is calculated according to the expression:

$$m_{\mathrm{i}} = \sqrt[\mathrm{q}]{\sum_{\mathrm{i}=1}^{\mathrm{q}} w_{\mathrm{i}}} \tag{2}$$

where w_{i} is relative importance according to Saaty scale.

4. Results and discussion

Using expressions (1) and (2), the geometric mean and the priorities for each alternative within each criterion are calculated. The results are shown in tables 4 to 11. After mutual comparison of alternatives, is performed criteria comparison. The results are shown in table 12.

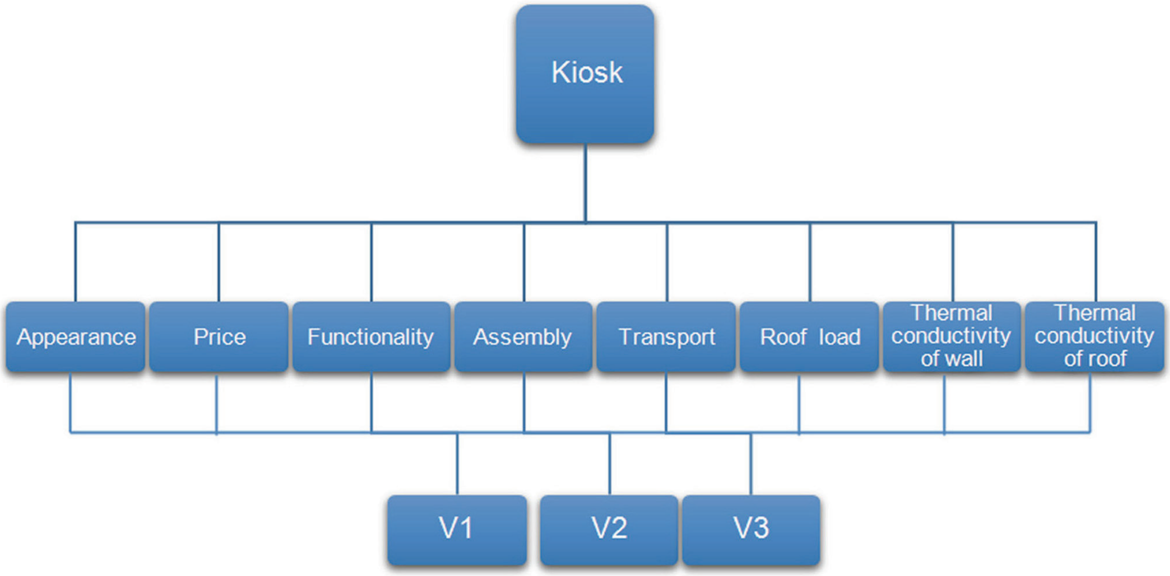


Figure 3. Hierarchical model

Table 4. Priorities of alternatives toward appearance criteria

Appearance	V1	V2	V3	Geometric mean	Priorities
V1	1	3	5	2,4662	0,637
V2	1/3	1	3	1	0,2583
V3	1/5	1/3	1	0,4055	0,1047

Table 5. Priorities of alternatives toward price criteria

Price	V1	V2	V3	Geometric mean	Priorities
V1	1	5	3	2,4662	0,637
V2	1/5	1	1/3	0,4055	0,1047
V3	1/3	3	1	1	0,2583

Table 6. Priorities of alternatives toward functionality criteria

Functionality	V1	V2	V3	Geometric mean	Priorities
V1	1	3	1	1,4422	0,4286
V2	1/3	1	1/3	0,4807	0,1428
V3	1	3	1	1,4422	0,4286

Table 7. Priorities of alternatives toward assembly criteria

Assembly	V1	V2	V3	Geometric mean	Priorities
V1	1	7	3	2,7589	0,6406
V2	1/7	1	1/6	0,2877	0,0668
V3	1/3	6	1	1,2599	0,2926

Table 8. Priorities of alternatives toward transport criteria

Transport	V1	V2	V3	Geometric mean	Priorities
V1	1	1/3	6	1,2599	0,2851
V2	3	1	8	2,8845	0,6527
V3	1/6	1/8	1	0,2752	0,0623

Table 9. Priorities of alternatives toward roof load criteria

Roof load	V1	V2	V3	Geometric mean	Priorities
V1	1	2	7	2,4101	0,6026
V2	1/2	1	4	1,26	0,315
V3	1/7	1/4	1	0,3293	0,0824

Table 10. Priorities of alternatives toward thermal conductivity of wall criteria

Thermal conductivity of wall	V1	V2	V3	Geometric mean	Priorities
V1	1	7	4	3,0366	0,7049
V2	1/7	1	1/3	0,3625	0,0842
V3	1/4	3	1	0,9086	0,2109

Table 11. Priorities of alternatives toward thermal conductivity of roof criteria

Thermal conductivity of roof	V1	V2	V3	Geometric mean	Priorities
V1	1	3	6	2,6207	0,6548
V2	1/3	1	3	1	0,2499
V3	1/6	1/3	1	0,3816	0,0953

Table 12. Priorities of criteria

	Appearance	Price	Functionality	Assembly	Transport	Roof load	Thermal conductivity of wall	Thermal conductivity of roof	Geometric mean	Priorities
Appearance	1	1/2	2	3	3	2	2	2	1,7067	0,1785
Price	2	1	3	3	4	2	3	3	2,4495	0,2562
Functionality	1/2	1/3	1	3	3	2	2	2	1,3643	0,1427
Assembly	1/3	1/3	1/3	1	4	1/5	1/4	1/4	0,4555	0,0477
Transport	1/3	1/4	1/3	1/4	1	1/5	1/4	1/4	0,3107	0,0325
Roof load	1/2	1/2	1/2	5	5	1	2	2	1,3712	0,1434
Thermal conductivity of wall	1/2	1/3	1/2	4	4	1/2	1	1	0,9506	0,1
Thermal conductivity of roof	1/2	1/3	1/2	4	4	1/2	1	1	0,9506	0,1

Based on estimates of the ratio of the priorities contained in the preceding tables, local priorities were calculated. The overall priority is calculated so that each priority of alternative multiplied by the priority of criterion and then multiplies them. According to this, the priorities for each alternative are calculated. Total priorities of alternatives are shown in table 13. From table 13, it is evident that the variant V1 (Fig. 4) is the best solution. Its total priority of alternative is 0,6003.

Table 13. Total priorities of alternatives

	Alternatives		V1	V2	V3
Criteria and their relevant important	Appearance	0,1785	0,637	0,2583	0,1047
	Price	0,2562	0,637	0,1047	0,2583
	Functionality	0,1427	0,4286	0,1428	0,4286
	Assembly	0,0477	0,6406	0,0668	0,2926
	Transport	0,0325	0,2851	0,6527	0,0623
	Roof load	0,1434	0,6026	0,315	0,0824
	Thermal conductivity of wall	0,1	0,7049	0,0842	0,2109
	Thermal conductivity of roof	0,1	0,6548	0,2499	0,0953
	Total priorities of alternatives		0,6003	0,1963	0,2044

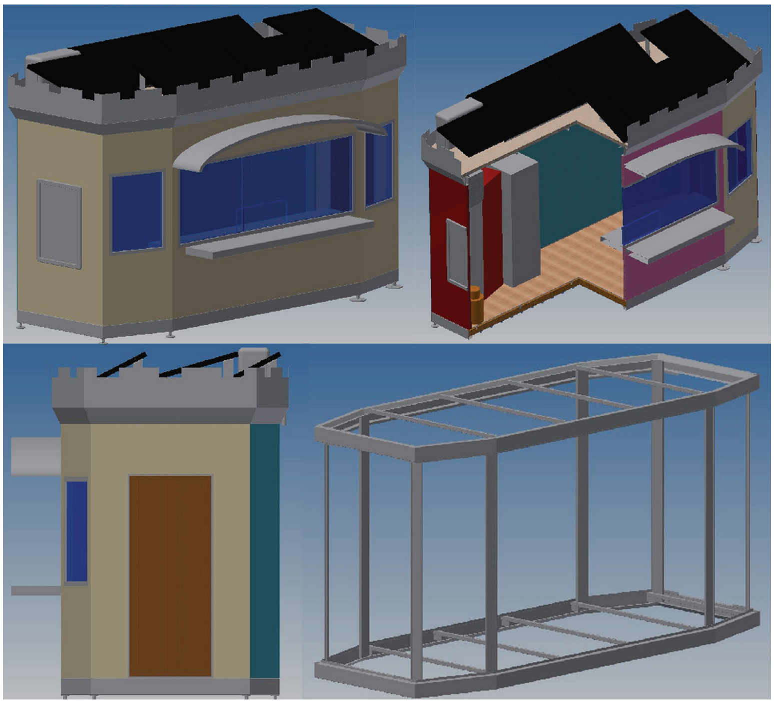


Figure 4. Variant V1 as the selected solution

5. Conclusion

This paper describes the generation of energy sustainable and multi - functional conceptual variant of the technical system kiosk. Customer requirements were the starting point for generation list of requirements. By the list of requirements is designed morphological matrix with partial functions. Each function is described with the principle of solution. From the matrix are generated three conceptual variants: V1, V2 and V3. By the AHP method is selected the best solution of kiosk conceptual variant.

6. Acknowledgement

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DESIGN AND EVALUATION OF ROOF STRUCTURES AND FOUNDATION SYSTEMS FOR THE TECHNICAL SYSTEM KIOSK

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Abstract

Paper describes the process of generating conceptual variants of the roof structure and foundation for energy - independent and multifunctional kiosk technical system. Morphological matrix for roof structure and foundation is based on a list of requirements. Generated variants were evaluated using a ranking technical evaluation method. Based on this method results, best variants are chosen and built into kiosk technical system.

Keywords:

Conceptual design, design process, product functions, morphological matrix, kiosk

1. Introduction

Design process is the synthesis of relatively well-known elements into a unique, previously unknown entity with certain required properties. This synthesis requires a creative work. Important characteristic of design process it that human should have the crucial share in performing required actions [1].

Using scientific methods, process of methodical design was developed. Methodical design is a process in which same procedures can solve different assignments [2]. Methodical design uses tools in the form of procedures to create requirement list, morphological matrix [3], evaluation, and functional decomposition. Same procedure can be applied to any product in order to reach desired solution.

Kiosk technical system has its inner and outer characteristics. Inner characteristics are imposed by design process and they represent its fundamental properties, while outer characteristics represent touch with the environment [1]. Properties arise from requirements which need to be fulfilled by the technical system. Therefore, the emphasis in this paper is on the generation of conceptual variants of the roof structure and foundation which will be implemented in the technical system of kiosk.

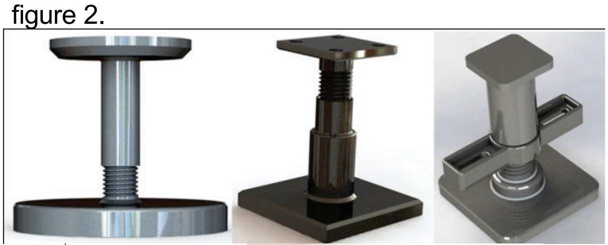
2. Requirement lists and morphological matrix

Requirement list is an internal list of requirements and wishes provided for the development of a product. Neither variant that does not meet the requirements cannot be evaluated [2]. According to [4], requirements and wishes are split into categories: geometry, kinematics, force, energy, materials, ergonomics, signals, production, control, assembly, transport, exploration, service, expenses and deadlines.

Most important requirements for the foundation of the kiosk are: simplicity and stability of the structure, separating the selling stand from ground minimally 80 mm, support the weight of selling stand, ability to adjust height, using standard materials with preferable corrosion resistance and recycling options, also minimum service life should be at min. 15 years. Full requirement list for the foundation of the kiosk is shown in the table 1.

Requirement list is also made for the roof structure with most important features being: recognizable construction form in city Osijek, included rainwater pipe design, space on the roof to enable installation of air conditioning unit and solar panels, construction life span should be 15 years minimum. Full list of requirements is shown in the table 2.

In table 3 morphological matrix for foundation is shown and in table 4 for roof structure of kiosk. Conceptual variants for foundation, derived from table 3, are shown in figure 1. Conceptual variants for foundation, derived from table 3, are shown in figure 2.



V1 V2 V3

Figure 1. Conceptual variants for foundation

3. Ranking method for technical evaluation

In the process of evaluating with the ranking method, variants are classified according to their advantages in relation to the set criteria. Number of positions (ranks) corresponds to the number if variants of solutions that need to be evaluated. Best rank is marked as "I". To get the best variant, ranks "I" are summed and the best variant is the one with most ranks "I". If two variants have same number of "I", best variant is the one with more ranks "II".

Table 1. Requirement list for foundation of the kiosk

Requirement list for foundation			
Requirement or wish	**Requirements**	**Requirement or wish**	**Requirements**
	GEOMETRY		***MATERIALS***
R	Simple and stable structure	R	Use of standard profiles, parts and materials
R	Separating kiosk from ground min. 80mm	W	Use materials resistant to corrosion and atmospheric influences
R	Washer width must be sufficient to provide stability on every surface	R	Recyclable materials use
	FORCES		***ERGONOMICS***
R	Support the weight of kiosk, ~1100kg	R	Easy to use mechanism for height adjustment
	ASSEMBLY AND TRANSPORTATION	R	Easy accessible basis for the adjustment needs
R	Height adjusted must be easy to do		***PRODUCTION AND CONTROL***
	CINEMATICS	R	Construction life span of 15 years minimum
R	Height adjustment option	R	Corrosion and atmospheric influences protection
	COST		
R	Use of standard profiles, materials, parts to minimize production costs		
R	Use simple design form to minimize maintenance cost		

Table 2. Requirement list for roof structure

Requirement list for roof structure			
Requirement or wish	**Requirements**	**Requirement or wish**	**Requirements**
	GEOMETRY		***MATERIALS***
R	Construction should resemble city Osijek	R	Use of recyclable materials
R	Tilted roof structure to enable rainwater to gather towards rainwater pipes	R	Use of standard profiles, parts and materials
W	Include rainwater system	R	Use materials resistant to corrosion and atmospheric influences
W	Guides for mounting solar panels	R	Use different types of materials
R	Guides for mounting air conditioning unit	R	Isolating roof panel
W	Light structure		***PRODUCTION AND CONTROL***
	FORCES	R	Construction life span of 15 years minimum
R	Support weight of possible snow accumulation on the roof	R	Corrosion and atmospheric influences protection
R	Withstand wind speed shocks	R	Fulfill wind and snow calculation requirements
	ASSEMBLY AND TRANSPORTATION		***COST***
R	Enable mounting of air conditioning unit	R	Use of standard profiles, materials, parts to minimize production costs
W	Possibility to mount 200 l water tank	R	Use simple design form to minimize maintenance cost

Summing ranks gives us best, second, and third variant of solution. On that note we cannot know how much is one variant better than the other one. This method can be applied in cases with generally defined criteria and if the number of variants is not too high [2].

In this paper it's not necessary to evaluate entire selling stand design, but two sub-assemblies. These two sub-assemblies have only few criteria so this method is acceptable. Table 5 contains evaluation results for kiosk foundation.

Table 3. Morphological matrix for foundation of the kiosk

Morphological matrix				
Partial functions	**Solution principles**			
	1	**2**	**3**	**4**
Basis type	Fixed	Adjustable	-	-
Height adjustment method	Metric thread	Trapezoidal thread	Inserting pins	-
Connection with selling stand frame	Bolted	Welded	-	-
Ground basis type	Concrete panel	Concrete stripe	Concrete foot	-
Possibility to connect basis foot with ground basis	Bolted	Without connection	-	-
Conceptual variants	**V1**	**V2**	**V3**	**-**

Table 4. Morphological matrix for roof structure

Morphological matrix				
Partial functions	**Solution principles**			
	1	**2**	**3**	**4**
Resemblance	Bastion	HNK building	Barok era rooftops from Osijek fort	-
Suitability for mounting additional appliance	Closed construction type	Open construction type	-	-
Rainwater drain	Externally mounted rainwater system	Rainwater system inside roof structure	Sloped roof guiding rainwater in one corner	-
Solar panel mounts	Yes	No	-	-
Roof structure isolation	Without isolation on the roof structure	Roof panel 80mm thick	Roof panel 60mm thick	-
Air conditioning unit mount	Outer mounts	Mounts inside roof structure	No mounts for air conditioning unit	-
Conceptual variants	**V1**	**V2**	**V3**	**-**

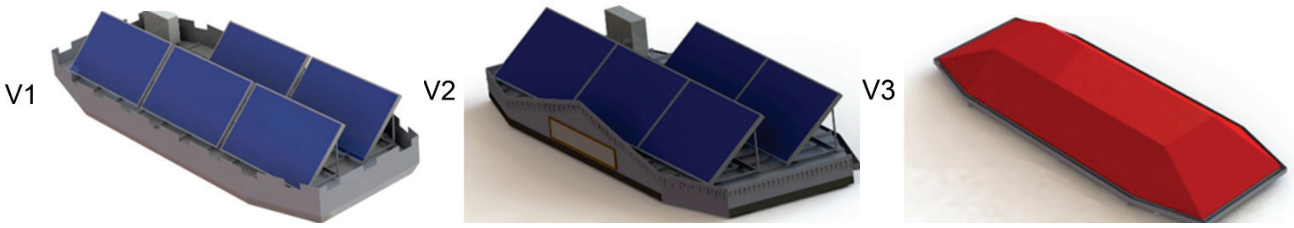


Figure 2. Conceptual variants for roof structure

Table 5. Ranking evaluation method used on a kiosk foundation

CRITERIA	**Variants**		
	V1	**V2**	**V3**
Simple design	I	II	III
Foot basis mass	I	III	II
Standard parts usage	I	II	III
Visual resemblance	III	II	I
Easy operation	I	III	II
Adjustment height	I	II	II
I	5	0	1
II	0	4	3
III	1	2	2

Sum of rank "I" showed that the best variant is variant V1, which got five out of six possible ranks "I". Wining variant is shown in figure 3.

Figure 3. Variant V1 of foundation

Table 6 contains evaluation results for kiosk roof structure.

By summing ranks "I" in the evaluation table, variant V1 of the roof structure proved to be best variant. Variant V1 of roof structure is shown in figure 4.

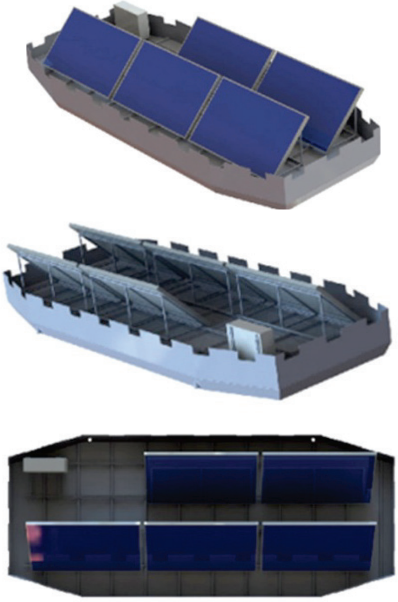


Figure 4. Variant V1 of roof structure

Table 6. Evaluation table for kiosk roof structure

CRITERIA	Variants		
	V1	V2	V3
Visual resemblance	I	II	III
Design simplicity	I	II	III
Weight of structure	II	I	III
Flexibility for mounting solar panels	I	II	III
Flexibility for mounting air conditioning unit	II	I	III
Rainwater pipes effectiveness	II	III	I
Esthetics	II	III	I
I	3	2	2
II	4	3	0

4. Conclusion

This paper presents a general approach to the design process in the case of designing a roof structure and the foundation for the kiosk technical system. The initial requirements and wishes of the competition were basis for the creation of morphological matrix and modeling three solution variants for the kiosk foundation and roof structure. Using the ranking evaluation method, best variants are chosen. Variant V1 foundation kiosk is the simplest and most cost-effective variant of the solution due to its simple construction and low material consumption, while providing sufficient stability and desired adjustability. The selected variant of the roof structure provides a unique look and resemblance of city Osijek. Variant V1 of roof structure best meets the requirements in the way that's providing place for mounting solar panels and air conditioning unit. It also contains good interior isolation and precipitation protection.

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CONCEPTUAL DESIGN FOR MACHINE TO CUT RAW RUBBER TO RIBBONS

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Abstract

The paper presents design process for concept variant for machine cutting raw rubber into ribbons. Using the flow function modelling method transformation of the operands was shown. Function as a part of the total transformation, causes a certain change of characteristics of the operand that is realised by the physical bearer of the function (technical solution). Technical solution is a machine for cutting raw rubber. The machine is constructed to allow reception of raw rubber rolls of various dimensions, as well as cutting into ribbons of various widths. The techno-economic evaluation was carried out and the best solution of the concept variant of the machine was chosen.

Keywords:

Conceptual design, functional decomposition, morphological matrix, rubber

1. Introduction

Vulcanising workshops often use machines for cutting of raw rubber. The raw rubber is a mixture of natural and synthetic rubbers. The manufacturers deliver it as a plate of 0.8 mm to 6 mm thickness, rolled into a roll. The roll is usually of diameter up to 400 mm and wide up to 1000 mm.

Analysis of the market and existing solutions show that it is necessary to conceptually design a machine that will be appropriate for a small workshop, with maximal utilisation of the raw rubber wound in a roll, which means the rubber must be cut cross-wise.

The machine should be capable of receiving rolls of various dimensions and allowing unwinding and cutting the raw rubber into ribbons of specific widths.

To obtain the final solution for the machine for cutting raw rubber, it is necessary to resolve the requirements for the task. For that purpose, a list of requirements was defined. In the concept design phase these requirements are the starting point for definition of the functional structure of the product. The function is property of the technical system that describes its capability to fulfil its purpose, mainly to convert the input values into the required output values, under strictly defined conditions [1]. It could be said that the function provides a relation between inputs and outputs from the system, which's purpose is to perform the given task [2]. Since the total function of the system can be broken down into partial functions, it is necessary to find the solution principles for each of the partial functions. By using the matrix method, such as descriptive morphological matrixes [3], the function and the principle of the solution are brought into a mutual relation. The matrix provides the conceptual variants. The variants are evaluated according to the criteria given in the requirement list [4].

2. Requirement list

The requirements shown in the requirement list (Table 1) can be divided into several categories: requirements related to geometry, kinematics, forces, energy, material, signals, safety, ergonomics, usage, maintenance and costs. Within each of the categories can be found requirements (R) or wishes (W). The requirements and wishes are important because of selection of criteria during the evaluation process. For that reason, just one conceptual variant that does fulfil the requirements cannot be evaluated [5].

3. Function flow modelling method

According to Hubka, the technical artefacts (technical systems) must be observed as the systems related to the environment through their inputs and outputs, that must be clearly defined for solving a technical problem [1]. What belongs to a system is determined by the system boundaries. Input and output values cross the boundaries of the system. Energy, material and signals form input and output values, i.e. the operands [6].

The functional model based on the flow shows changes of characteristics of operand in the operation. Three types of operands are considered (energy, matter and signals), and the flow of each of them is marked with a different type of arrow (Figure 1). Each operand that takes part in a process can be described by its starting and final states. Relations represent direction of changes of states of operands in the function [7].

Table 1. Requirement list

Requirement list			
Requirement or wish	**Requirements**	**Requirement or wish**	**Requirements**
	GEOMETRY		***MATERIALS***
R	Raw rubber role diameter up to Ø 400 mm	R	Use standard steel profiles
R	Role Width up to 1000 mm	R	Use materials resistant to corrosion
R	Working height of the plate 1000 mm		***SIGNALS***
R	Thickness of the raw rubber ribbon from 0,8 to 6 mm	R	Measure and provide for setting the required with of the ribbon to be cut
R	The rotation axis of the role to be unwound must be parallel to the floor	W	The device must be portable
	FORCES		***SAFETY***
R	Force required for cutting is 100 N	R	Parts of the cutting machine must be protected
R	Largest role mass is 150 kg		***ERGONOMICS***
	CINEMATICS	R	The cutting process must be simple and safe
R	Main movement is translational	R	Clamping of the roll must be safe and simple
R	Auxiliary movements are rotational and translational		***USAGE***
	ENERGY	R	Simple and safe handling
R	No special requirements for the power supply	R	Protection of the rotational parts
	COSTS		***MAINTENANCE***
R	Minimal costs	R	Maintenance of the machine must be simple

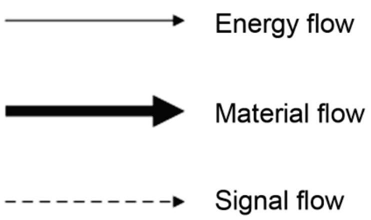

Figure 1. Operands of functional model

From the requirement list, the following partial functions were obtained: accept the roll, clamp the roll, catch the roll, move the ribbon (unwind the roll), determine the ribbon width, cut the ribbon, lead the ribbon, produce the force for moving the ribbon, increase the force for moving ribbon and transfer, produce the force for cutting, increase the force for cutting and transfer and transfer the force to the environment. The function flow model with the partial functions can be set as shown in the figure 2. The figure shows that the partial functions contribute to transformation of operand from their starting state to their final state that performs the main function called: *Provide controlled unwinding of the raw rubber roll and cutting it into ribbons of specific width.*

4. Morphological matrix and concept variants of the solution

In the morphological matrix (Table 2) listed are the partial functions and solution principles for each function. By combining the solution principles according to the system of tolerance, obtained were three concept solution variants: V1, V2 and V3.

Figure 3 shows the conceptual variants obtainned from the morphological matrix.

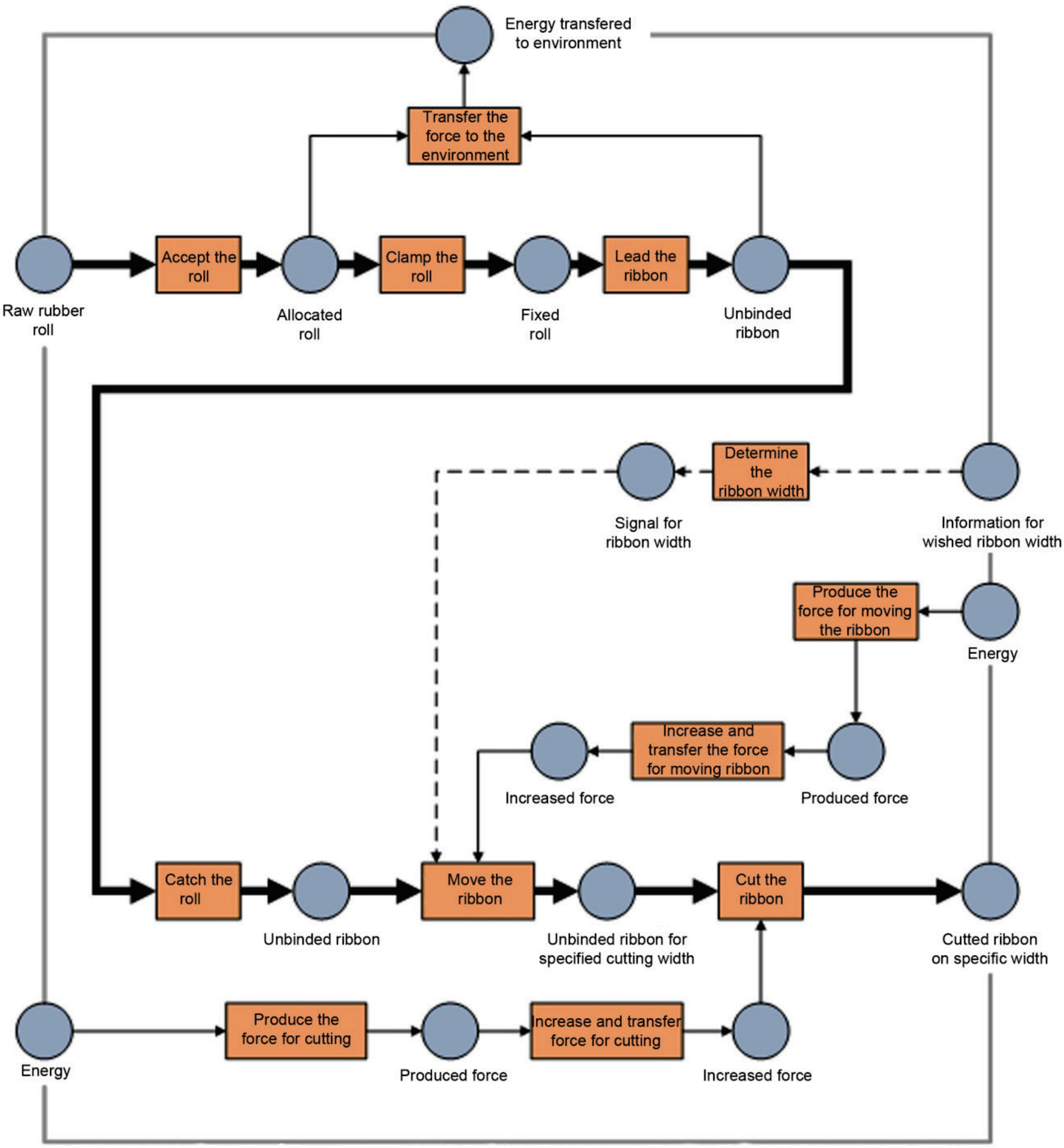

Figure 2. Functional structure of a machine for cutting raw rubber to ribbons

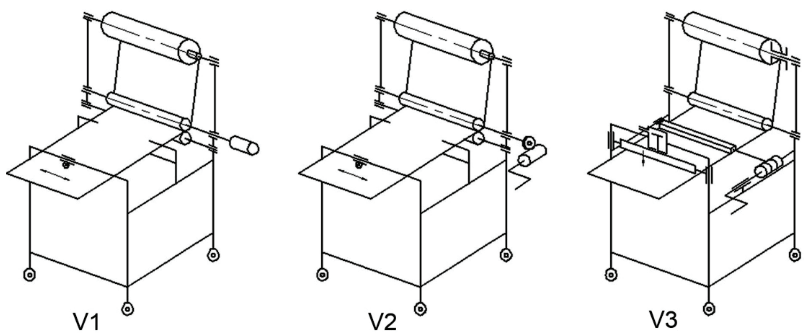

Figure 3. Conceptual variants obtained from the morphological matrix

Table 2. Morphological matrix

Morphological matrix				
Partial functions	**Solution principles**			
	1	**2**	**3**	**4**
Accept the roll	Shaft and roller bearings ▲	◆ Shaft and sliding bearings ●		
Clamp the roll	Distance ring ●	Nut	Ring with threaded screw ▲ ◆	
Catch the roll	Rack and pinion ●	Rack and pinion at end of the ribbon	Rollers ◆ ▲	
Move the roll (unwind the roll)	Translational movement of the rack ●	Rotating roller ▲ ◆		
Determine the ribbon width	Visually, using meter ●	▲ Counting number of turns of the threaded axle	Counting number of turns of the driving cog wheel	Automatic regulation ◆
Cut the ribbon	Transversal translatory movement of the knife	Vertical translatory movement of the knife ●	Round knife ◆ ▲	
Lead the ribbon	▲ ◆ ●			
Produce force for moving the ribbon	Man's energy ▲ ●	Step electromotor ◆	Pneumatic motor	Electromotor
Increase and transfer the force for moving the ribbon	Rack and pinion	● Threaded axle	Pair of cogwheels	Worm gear ▲
Produce force cutting	Man's energy ▲ ●	Electromotor ◆		
Increase and transfer the force for cutting	Manually ▲	Rack and pinion ◆	Pneumatic cylinder ●	
Transfer the force to the environment		● ▲ ◆		
Conceptual variants	**V1** ◆	**V2** ▲	**V3** ●	

5. Evaluation and selection of the final conceptual variant

The concepts are selected based on fulfilment of the criteria selected from the requirements list. Negative (-) means the concept does not fulfil the criterion, or does it poorly. The evaluation (-/+) means that for that criterion has both good and bad aspects. The evaluation (+) means the solution meets the criterion well [4]. In table 3 are presented criterions selected by means of the requirement list.

Table 3. Evaluation table

Criterion	V1	V2	V3
Price	-	+	-
Adjustment without tools	-	-	+
Simple use	+	-/+	-
Easy loading of the machine	-/+	-/+	-
Quick way of using	+	-/+	-
Simple assembly	-	+	-
Reliability	-/+	+	-
Simple setting of the ribbon width	-/+	+	-
Ecologically acceptable machine	-/+	+	-
∑+	6	8	1
∑-	7	4	8
Total evaluation	-1	+4	-7

According to the total evaluation from the evaluation table for further more detailed consideration selected is variant V2. After detailed development of the concept, the final look of the raw rubber cutting machine is shown in the figure 4.

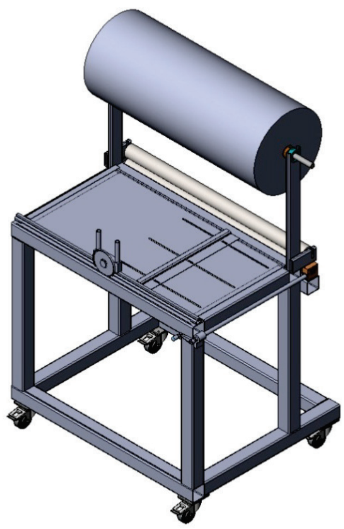

Figure 4. Raw rubber cutting machine

Loading the roll on the load bearing construction is achieved by an axle and rolling bearings, and clamping of the roll is by a ring that if fixed to the axle using a threaded screw. Catching of the ribbon is by two screws, and moving of the ribbon is by turning a roller via worm gear. The ribbon width is determined by counting revolution of the worm gear. The worm gear is powered manually, by turning a handle. Cutting is performed by a circular knife driven by a liner guide and powered by hand.

6. Conclusion

The paper has shown the process of generation of conceptual variants of the machine for cutting raw rubber. The emphasis was on generation of functional structure of the machine, by using the function flow modelling method. So defined functional structure provides insight into the process of transformation of operands (energy, materials and signals) from the input state to the output state. Transformation is performed by activity of the total function called: *Provide controlled unwinding of the raw rubber roll and cutting it into ribbons of specific width*.

By further development obtained were different solution principles for partial functions, which were then related in a morphological matrix to various conceptual solutions. After techno - economic evaluation of the concepts, selected was the best conceptual variant as the solution. It can be concluded that by selecting the variants with manually driven worm drive, there are possibilities for improvements in the field of easier manipulation of the machine. This improvement can be achieved by automating the technological process, but this is not appropriate for operation scope for small workshops.

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ANALYSIS OF DUCTILE IRON METALLOGRAPHIC IMAGES GAINED BY LABORATORY AND ON-SITE METALLOGRAPHY METHODS

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Abstract

Application of ductile iron today is a result of its optimal mechanical properties achievement. Mechanical properties of ductile iron (and castings in generally) are directly related to their microstructure. In this paper the results of laboratory and on-site metallography methods for obtaining metallographic images of ductile iron are compared. In addition, the possibilities of different image analysis methods for recognition of graphite (nodules) on metallographic images obtain by above methods are presented.

Keywords:

ductile iron, image analysis, metallography, microstructure, segmentation

1. Introduction

In order to reveal a microstructure of specimen, usually, laboratory preparation of cast iron samples for microstructure analysis consists of cutting out of samples (mounting, if necessary), grinding, polishing and etching in appropriate reagent.

Regrading to this preparation process during microstructure analysis of iron castings, there are some specifics that should be taken in consideration. First of all, the metallographic analysis of graphite is conducted after the polishing and before the etching. Also the heating of specimen during grinding should be avoided, and there is a possibility of difference between microstructure on the surface and in the middle of the castings.

Graphite, ferrite, pearlite, cementite, martensite or bainite are constituents that usually can be found in unalloyed or low alloyed iron casting microstructure, and these samples can be successfully etched with Nital, [1].

Possibilities of metallographic examination are expanded with development of on-site methods. These methods allow microstructure analysis of parts that are too large for laboratory analysis or even of the parts in plants that are still operating. Although by application of these on-site non destructive methods there is a possibility only of microstructure analysis of the part surface, this methods have some advantages regarding laboratory methods like possibility of microstructure examination of finished parts, good resolution between microstructure constituents, and possibility of application on curved surfaces or to analyse different surface damages [1, 2].

Metallographic replicas are applied on grinded and polished and etched surface of samples. They actually represent the „negative“ of structure of the specimen surface. For the production of replicas there are different materials being used in order to allow simple and quick record of the sample microstructure. For example, sheets of Cellulose Acetate tapes can be softened in acetone, methyl acetate or ethyl acetate and applied on the polished and/or etched surface. After the evaporation of the solvents dry replica is removed from the surface of the sample and it maintains exactly the „negative“ of the sample surface, [3]. Also there are pre-prepared metal-coated plastic foils available for production of replica. These metal coated foils allows efficient light reflection during the replicas examination on optical microscope and provides easier and safer handling of the replica. Replicas today are also made of two-part silicon rubber and provide good analysis of the topographic surface. Application of backing paper allows preparation of very thin replicas that can be observed on optical microscope or prepared for analysis on scanning electron microscope, [2].

Possibilities of microstructure digital image analysis and different methods for cast iron graphite shape or grain boundary automatic characterisation are subject of number of researches [4-9]. The reason is the necessity of automatic estimation of microstructure as the conventional method of analysis is based on visual evaluation and comparison with reference images given in standards.

In this paper, MATLAB image analysis (segmentation) algorithms, [10], are applied for characterisation of ductile iron microstructure images obtained by laboratory and on-site (replicas) metallography techniques.

2. Image segmentation

Image segmentation is part of digital image analysis process that covers different methods for object recognition (classification of an image into distinguish parts of interest and background). Image segmentation methods can be classified into: edge detection, thresholding based, region based, cluster based and graph based methods, [11], and there are used for objects detection or tracking, analysis of images in medicine, mail sorting, missiles guidance, video compression enhancement etc, [12-15].

The image obtain by replicas is somewhat different in quality regarding to metallographic image from laboratory specimens, so in this paper the attention is given to possibility of detection of nodules on images by application of two image analysis methods: thresholding and boundary detection method and texture analysis.

3. Ductile iron graphite characterization

Mechanical properties of ductile iron are related to the structure of its iron matrix (i.e. ferrite and pearlite portions) and shape, distribution and size of graphite. As it is determined by [16] the increase of nodule numbers/mm^2 in ductile iron positively influence on ductility, [16]. Also strength properties decreases as the proportion of non-nodular graphite increase in ductile iron, [17]. Due to above mentioned the characterisation of graphite is important part of ductile iron microstructure characterisation.

Classification of cast iron graphite is based on its shape, morphology and structure. According to ASTM standard cast iron graphite is classified as, [18]: Nodular (spheroidal) graphite, Nodular (spheroidal) graphite - imperfectly formed, Aggregate or temper carbon, Quasi-flake graphite, Crab-form graphite, Irregular or “open” type nodules and Flake graphite (uniform flakes, rosette grouping, superimposed flake size, interdendritic - random orientation, interdendritic - preferred orientation).

4. Laboratory and on-site metallography

In this paper the comparison between microstructure of ductile iron gain by laboratory and replication method is shown. For the image analysis and later classification of graphite the microstructure of polished (not etched) surface is considered.

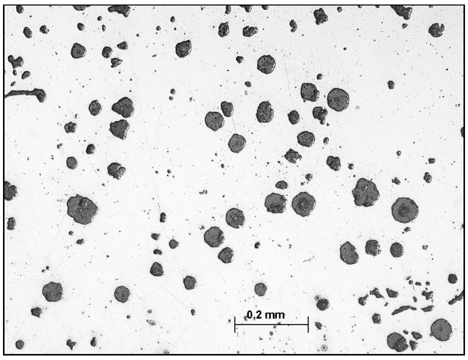
Specimens of Ductile Iron type EN-GJS-500-7 (EN 1563: 2011) are metallographically prepared and microstructure images are recorded directly from sample and from its replica (Transcopy Replica Foil produced by Struers) by optical microscope Leica DM 2500. Chemical composition of analysed ductile iron sample is given in Table 1.

Table 1. Chemical composition of ductile iron sample

C	Mn	Si	Mg	S	P
3,50 %	0,40 %	2,21 %	0,038 %	0,011 %	0,05 %

Figure 1a shows microstructure of ductile iron (laboratory sample) before the etching. The size and shape of nodular (spheroidal) graphite is clearly visible. Microstructure in Figure 1b shows etched surface of the sample and beside nodular graphite surrounded with ferrite (the “bull's-eye structure”) a pearlite in matrix microstructure is visible.

a)



b)

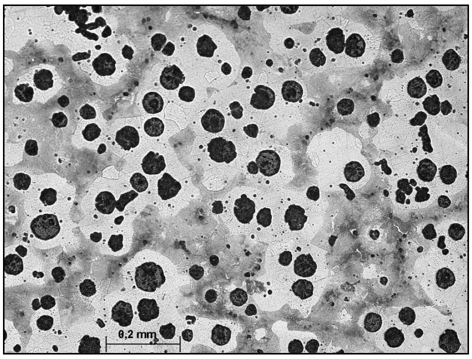


Figure 1. Microstructure of ductile iron after the polishing (a) and etching with the 2% Nital (b)

Microstructure of the polished sample prepared by replication of sample surface is shown in figure 2. Although the quality of image is different from image in figure 1a) the size and shape of graphite is clearly visible.

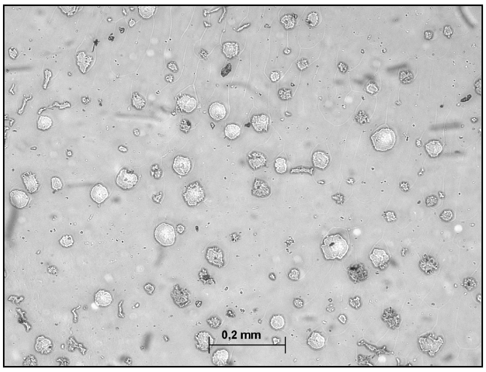


Figure 2. Image of replica surface (polished, not etched)

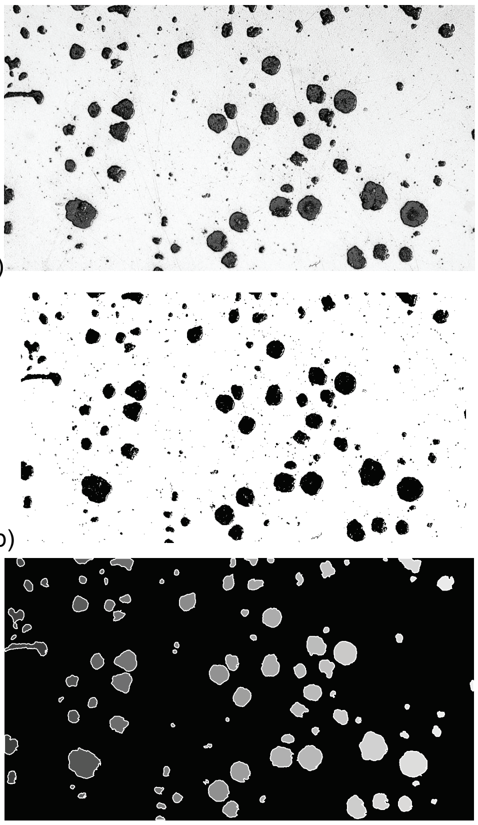
5. Image analysis methods

It is known that there is not a single method of image segmentation that can give desirable results for every application, [11]. Images analysed in this paper are different in brightness, present noise, contrast etc. Two methods are applied in order to identify graphite nodules on images. One is consisted of thresholding and boundary tracing. The similar method was successfully applied for computation of roundness of nodules in the ductile casting samples prepared by laboratory metallography in [5]. The other applied method is based on textural analysis.

6. Thresholding and boundary tracing for object identification

The object identification steps consisted of thresholding the image (using Otsu's method), conversation of image to black and white image and invert the colours of background and objects (pixels with 0 value are considered as background), removing the traces of grinding and polishing and finding the boundaries of image objects, [10].

Figure 3 shows the results of above described image analysis by boundary tracing of the laboratory prepared specimen. The input image is shown in Figure 3a, converted black and white image in figure 3b and results of boundary tracing on figure 3c.



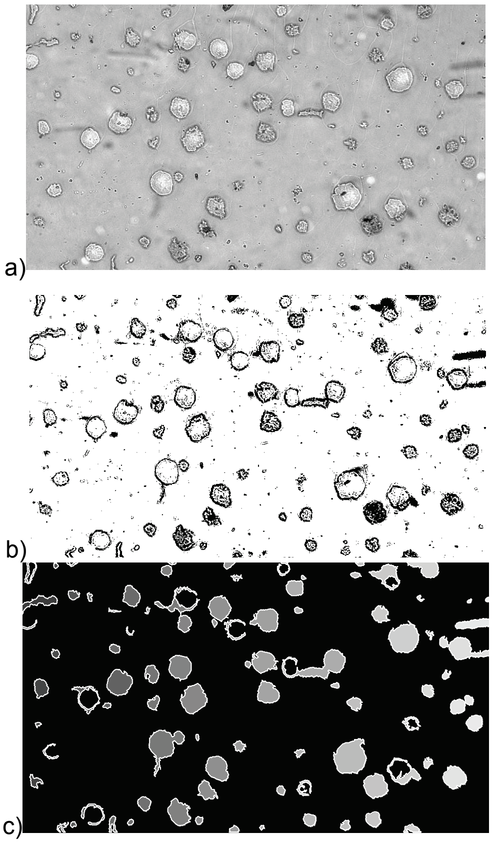
a) b) c)

Figure 3. Boundary tracing applied on laboratory prepared specimen image: input image (a), converted black and white image (b) and detected graphite (c)

The same above mentioned steps are performed on the metallographic image gain by on-site metallography (from replica). The input image (a), black and white image (b) and results of boundary tracing (c) are shown in figure 4.

As shown in figure 3, the application of tresholding and boundary tracing has shown as successful method for detecting the graphite on laboratory prepared polished samples.

The application of the same method on images gain from on-site metallography methods by replication (figure 4) is evidently not as appropriate since some of the graphite nodules are recognised as open curves (figure 4c).



a) b) c)

Figure 4. Boundary tracing applied on image of surface replica: input image (a), converted black and white image (b) and detected graphite (c)

7. Texture analysis

Image textures as complex visual patterns are composed of subpatterns with specific properties like brightness, colour, slope and size. Approaches to texture analysis can be categorised into: structural, statistical, model-based and transform methods, [19]. The detection of nodules in analysed examples are based on standard deviation image filtering.

The segmentation steps in this example are based on standard deviation filtering (determination of standard deviation (σ) in the previously defined local environment around the appropriate input image/pixel, [20]) followed by thresholding the image, conversation of image to black and white, removing the traces of grinding and polishing and finding the boundaries of image objects. Figure 5 shows the results of above described image analysis of the laboratory prepared specimen.

The input image is shown in Figure 5a, filtered image prepared for boundary tracing in Figure 5b and results of boundary tracing in Figure 5c. Results of texture analysis and overall segmentation on the metallographic image gain by on-site metallography are shown in Figure 6.

The application of texture analysis tool before boundary tracing gave more successful results of nodules detection than simple thresholding, especially for image taken from replica (figure 6).

The application of texture analysis tool before boundary tracing gave more successful results of nodules detection than simple thresholding, especially for image taken from replica (figure 6).

a)
b)
c)

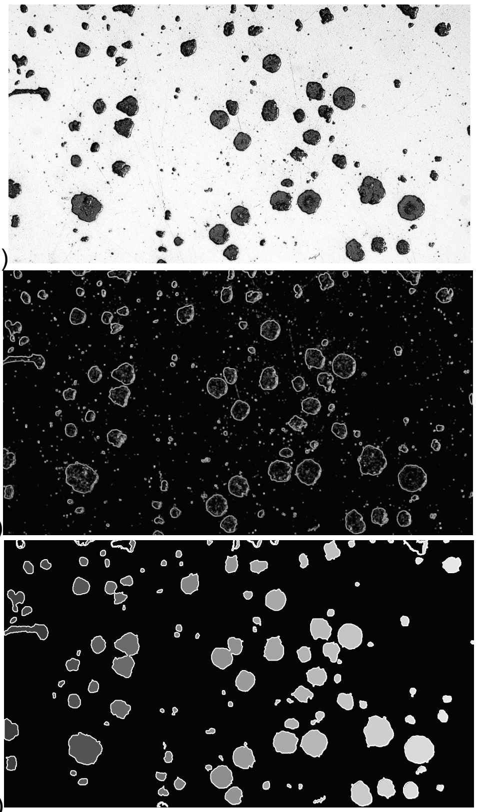


Figure 5. Texture filtering and boundary tracing applied on laboratory prepared specimen image: input image (a), filtered image (b) and detected graphite (c)

8. Conclusion

As the connection between material structure and its mechanical and physical properties is well known and researched, an appropriate image analysis in metallography and correct interpretation of material structure is important issue.

In this paper the application of two segmentation methods for detecting nodules of metallographic images gain from laboratory specimens and replicas are presented. It is noticed that application of simpler method of just the thresholding and boundaries detection gives satisfying results on samples prepared in laboratory. For the images of replicas texture analysis (standard deviation filtering) may be more appropriate.

Image segmentation is only one of the several steps in metallographic image digital analysis and nodulas characterization process. After the first results presented in this paper, the further analysis of different algorithm application for i.e.: separation of connected objects after segmentation, object shape and size analysis, analysis of different shape factors for object detection in images of cast iron microstructures are planned.

a)
b)
c)

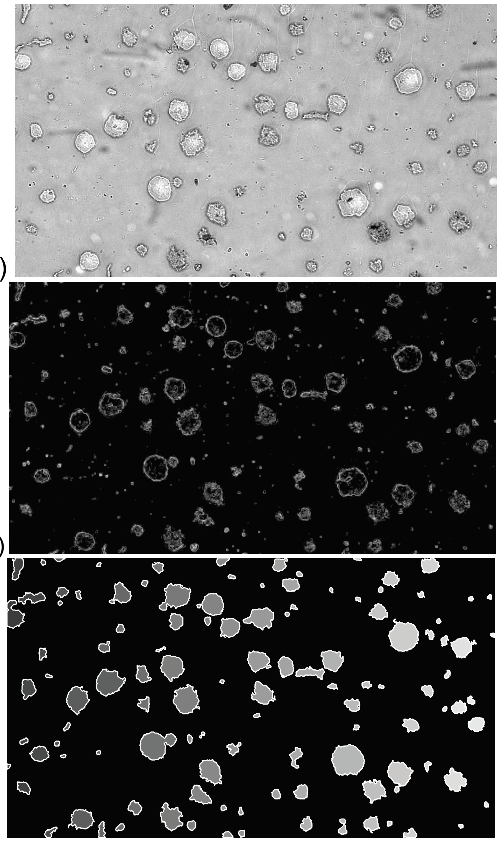


Figure 6. Texture filtering and boundary tracing applied on image of surface replica: input image (a), filtered image (b) and detected graphite (c)

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AUTOMATIC EXCHANGE OF GRIPPERS FOR ROBOTIC ARMS IN ASSEMBLY OPERATIONS AS THE BASE FOR FURTHER INDUSTRIAL APPLICATIONS

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Abstract

Currently, hardware automation of production processes still prevails over the software one. The latest generation of control systems in manufacturing are the systems designed on the basis of artificial intelligence. Such systems entail many improvements within the automated processes, but also bring a lot of pitfalls that must be eliminated to a possible minimum threshold. Deployment of various automation components brings multiple uses and increases the flexibility of the assembly process. This contribution deals with the automated exchange of grippers in the assembly process. There are several reasons for deployment of such elements in the process of assembly, but as the most important we highlight the increase of efficiency in the assembly process, elimination of ancillary times, and not least an increase in productivity of assembly doses. Methods for automatic exchange of grippers and the reasons for deployment in the assembly process will be more appropriately considered in the next part this contribution.

Keywords:

Assembly, jaw, automatic exchange gripper

1. Introduction

Various types of end-effectors adapted to manipulate objects are often used as manipulation effecttors. They are usually quite similar to robotic hands, whose form is based on the shape of a human hand. There are different variations of robotic grippers, each of which is designed for a specific operation. The shape, size and visual aspect of the gripper depends on what kind operation it is designed to. Main steps of the algorithm for the design of grippers solved on the principle of grasping by conventional mechanical grasping elements Figure 1, correspond to the principles of general methodology and also provide a basis for the use of computer support to solve this way designed gripper.

2. Grippers of assembly robots

Assembly robots carry out assembly operations using grippers (end-effectors). Grippers are placed at the end of the kinematic chains of assembly robots and make technical interface between manipulating and technological system [1].

This part of the structure is made of the output of assembly robot, and it directly implements the appropriate assembly and handling operations. Great diversity of grippers is used for the implementation of handling and assembly operations in the assembly processes. They provide gripping of objects, their fixation, precise positioning and orientation, and correction of irregular activities [3]. Several demands are placed on the grippers of assembly robots, such as:

- shape and dimensional adaptability to manipulated objects,
- high gripping accuracy,
- boded movement of active parts,
- simple and rigid structure,
- small size and mass,
- high reliability, easy maintenance.

There is a wide range of grippers used in the assembly process, and they can be classified according to Figure 2.

3. Intelligent assembly cell at the IPT

Intelligent assembly cell at the Institute of Production Technologies (IPT) is an assembly device that incorporates a new approach to determine the structure of the assembly system. The intelligent behavior, which was embedded when designing and implementing the cell, consists in monitoring of important parameters of the work of the system itself and its interaction with the environment on the basis of the data obtained in a flexible response of the system. Use of this type of concept designed as an "intelligent" assembly cell, provides flexible reaction of the system to the changes in production and assembly requirements, as well as changes in surrounding environment. Such a solution provides savings of built-up area, lower investment costs and higher utilization efficiency of the whole device.

The intelligent assembly cell is designed as a device intended for piece production or small series production. It represents an assembly system with a certain degree of intelligence, which handles the semi-finished products and the parts that are ultimately assembled into the finished product [4]. External industrial robot is not used for handling and assembly, making this concept different from traditional assembly systems Figure 3.

The intelligent assembly cell integrates and makes cooperation between the four integrated devices, namely:

- storage of semi-finished and finished products before their expedition,
- transport and handling of semi-finished and finished products,
- the assembly of individual components into a finished product,
- expedition.

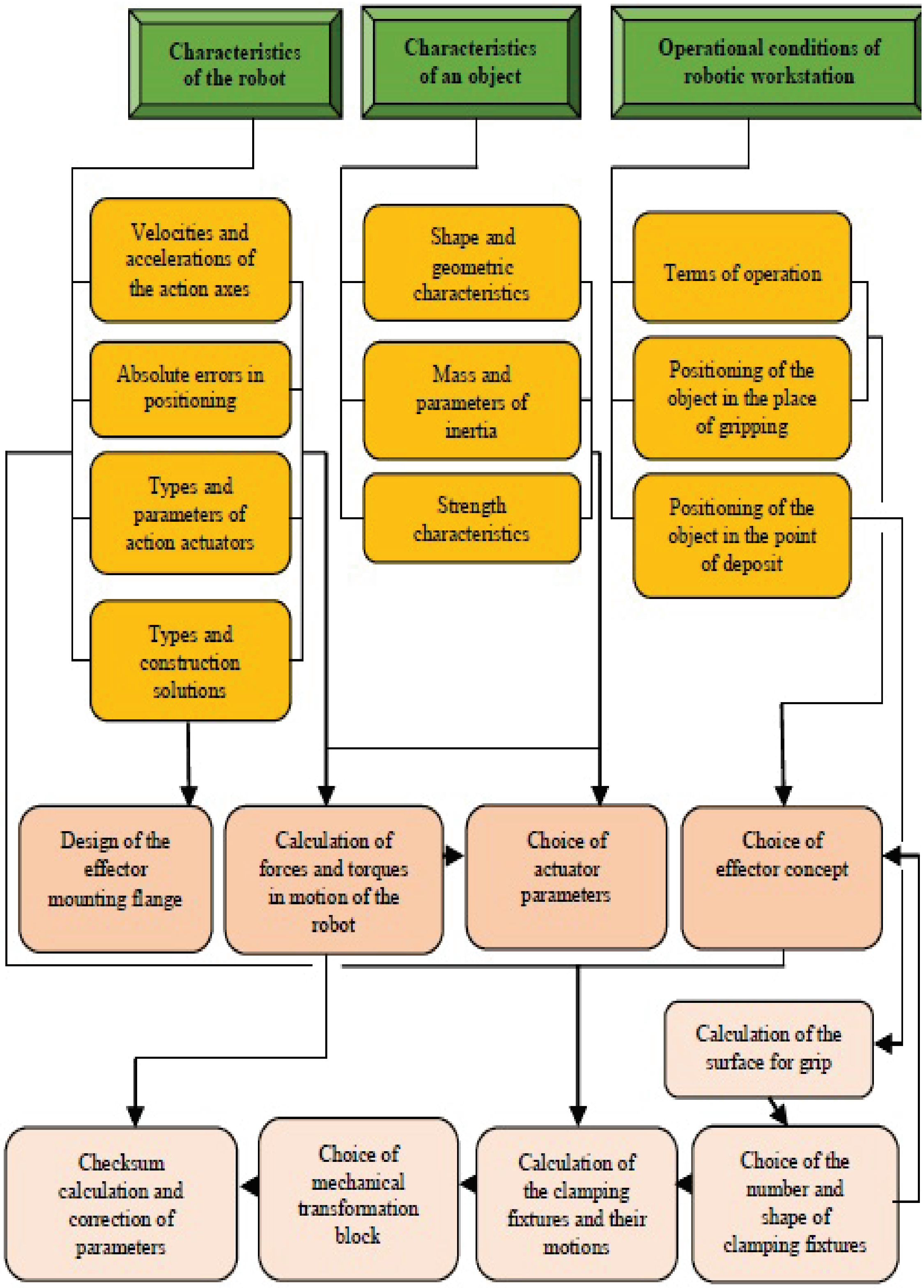

Figure 1. Scheme of the gripping effector design

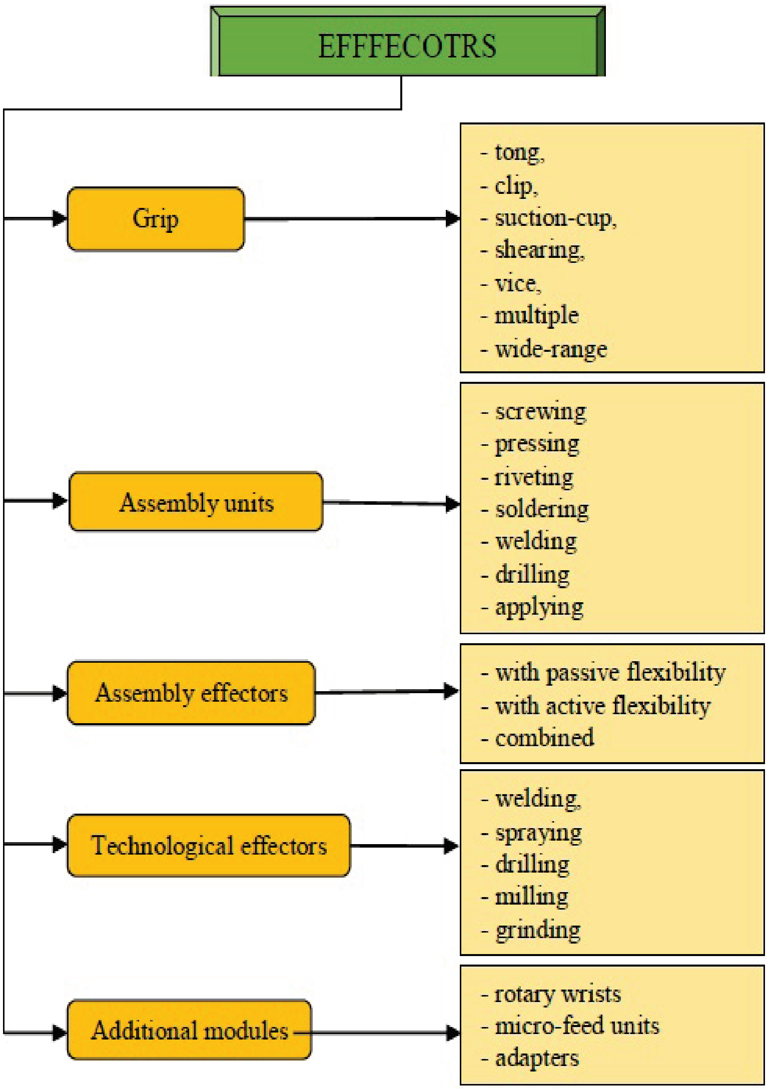

Figure 2. Division of effector units of assembly robots

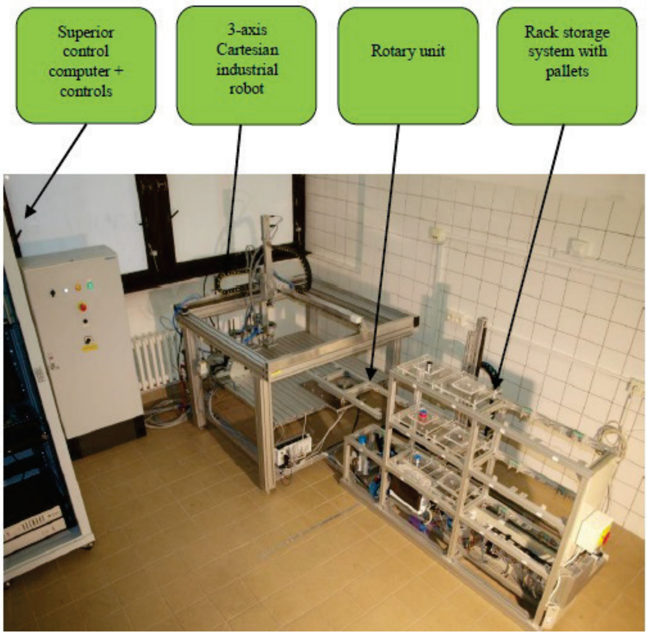

Figure 3. Intelligent assembly cell at the IPT

4. Automated selection process of the automatic exchange of grippers using algorithmization

In view of efficiency and implementation of the automatic exchange of grippers in intelligent assembly cell into comprehensive sequences and algorithms, there is necessary to define and analyze:
- component base of assembled parts,
- assembly procedure of individual parts entering the assembly process,
- identification and selection of a suitable gripper with jaws for the assembly operation,
- temporal analysis of the sequence of the automatic exchange of grippers depending on assembled parts.

After the fulfilment of the above partial objectives, there could be envisaged on algorithmization of the entire process of the selection and automatic exchange of grippers.

In view of the assembly of the finished product in the IAC, a component base of the verification model was chosen, considering the extent of the grippers of the automatic exchange Figure 4. From the material, dimensional and shape analysis, the verification model of assembled parts of rotating shape was designed. The component base of assembled group of products is analyzed in terms of size, shape and material of their type of construction. From the point of view of assembly, it is necessary to focus on their basic external dimensions as well as the internal dimensions because of the proper gripping, positioning, orientation, manipulation and final assembly.

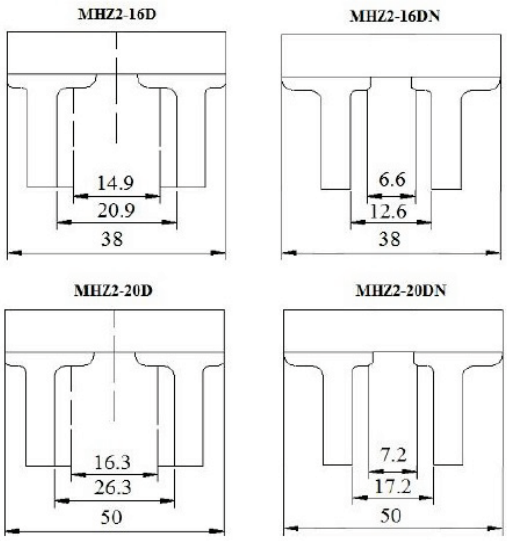

Figure 4. The grippers range of the MHZ type series

On the basis of Figure 5, the progressive assembly of four types of assembled parts is carried out. The assembly base is made up of just two pneumatic cylinder housings of the same size, i.e. the red and silver-plated cylinders into which is mounted a black piston. Into the black cylinder, the silver piston is mounted. The standardized spring and cap are same for all types of cylinders Figure 5.

5. Material flow of assembled parts in IAC

In terms of the input of assembled parts, and output of finished assemblies, it is necessary to define the material flow in the IAC. For the automatic exchange of grippers in the IAC, it is necessary to know, from which place in the working area of the IAC, assembly parts are entering [5].

The pneumatic cylinder housings and the pistons enter the workspace using a rotary unit. The control system calls them from stock racking system, depending on desired amount required by the superior control system. Automatic exchange of grippers select the right type of the gripper in cooperation with the control system on the basis of the part currently located on a pallet of the rotary unit, which is just in the working area of the IAC. It is important to follow the assembly procedure Figure 5, therefore also the procedure of material flow of assembled parts. Figure 6 shows the material flow of entering assembled parts (pneumatic cylinder housing and piston).

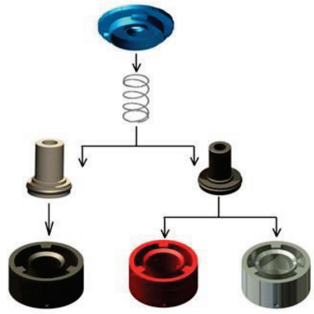

Figure 5. The flow assembly of verification model of rotating component base [2]

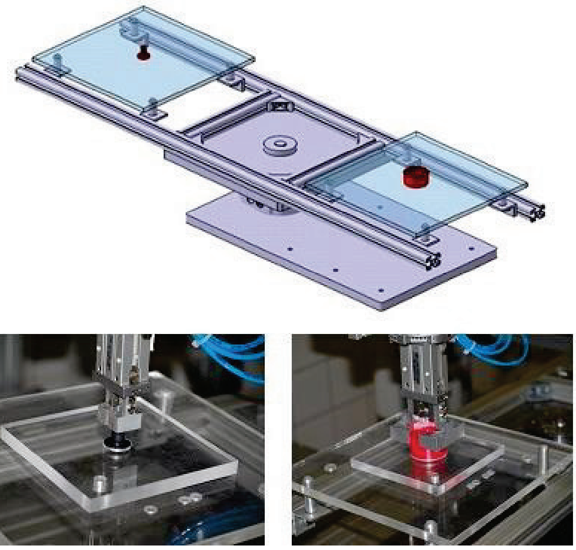

Figure 6. Material flow of entering assembled parts

Magazine of springs of the assembly set of veryfication model is located in the working area of the IAC. Individual springs are stacked in the magazine at each other. The release of the spring from the stack magazine to the unloader place is done by the double acting pneumatic cylinder, Figure 7.

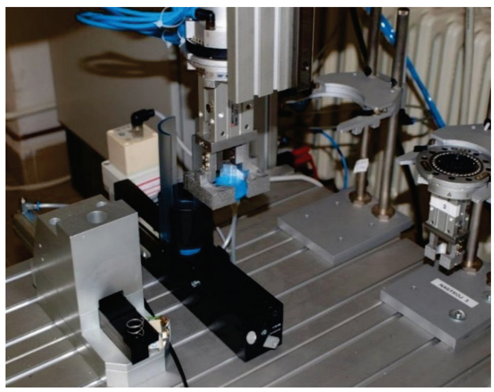

Figure 7. Magazine for springs and caps

An automatic exchange of gripper suitable for handling the spring is selected by means of the control system [6]. Caps are stacked in the magazine on one another. Feeder of the cap is resolved by a double acting pneumatic cylinder.

6. Design of gripper jaws for automatic exchange based on the selected component base

Gripper jaws for automatic exchange are designed in dependence on the selected component base, for rotating assembled parts. On the basis of the selected component base Figure 5, suitable types of prismatic jaws were calculated and designed.

The calculation of the width of prismatic jaws for the gripper MHZ2-16DN for the minimum diameter of the roller Bmin=8mm, with the opening angle α = 90°:

$$\overline{OD} - \overline{O_1 D} = 0$$

$$\frac{\overline{OC}}{\sin\frac{\alpha}{2}} - \frac{A}{2tg\frac{\alpha}{2}} = 0$$

$$\frac{4}{\sin\frac{90}{2}} - \frac{A}{2tg\frac{90}{2}} = 0 \qquad (1)$$

$$\frac{4}{0{,}707} - \frac{A}{2} = 0 \Rightarrow A = \frac{8}{0{,}707} = 11{,}32mm$$

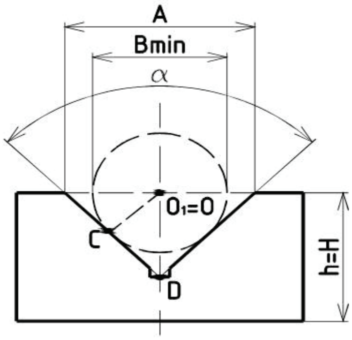

Figure 8. Prism with a minimum diameter roller A - width of the prism, Bmin - minimum diameter of the clamped roller, C - tangent line of the roller with the prism, h - height of the prism, H - distance of the axis of the roller from the base, O - axis of the clamped roller, O1 - centre of the slot width of the prism

Calculation of the maximum diameter of the clamped roller from the width of the prismatic jaw:

$$\sin\frac{\alpha}{2} = \frac{\overline{OC}}{A} \Rightarrow \overline{OC} = \sin\frac{\alpha}{2}\cdot A = 0{,}707\cdot 11{,}32 = 8mm$$

$$B_{\max} = 2\cdot\overline{OC} = 2\cdot 8 = 16mm$$

Maximum diameter of the roller that can be clamped into prismatic jaws with the width of 11.32mm is 16mm. The given prism is suitable for clamping both types of pistons from the set of the component base Fig. 10.

The calculation of the width of prismatic jaws for the gripper MHZ2-16D for the minimum diameter of the roller *Bmin*=10mm, with the opening angle α=90°:

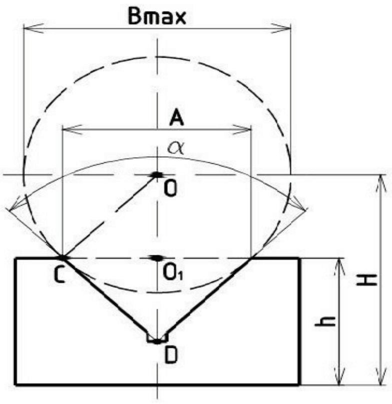

Figure 9. Prism with a maximum diameter roller A - width of the prism, B_{max} - maximum diameter of the clamped roller, C - tangent line of the roller with the prism, h - height of the prism, H - distance of the axis of the roller from the base, O - axis of the clamped roller, O_1 - centre of the slot width of the prism

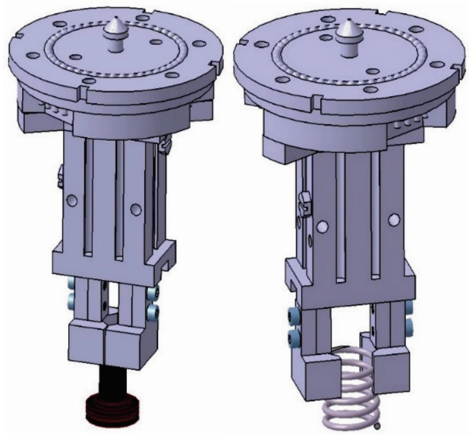

Figure 10. Prismatic jaws for the gripper MHZ2-16DN for piston, prismatic jaws for the gripper MHZ2-16DN for spring,

$$\overline{OD} - \overline{O_1 D} = 0$$

$$\frac{\overline{OC}}{\sin\frac{\alpha}{2}} - \frac{A}{2tg\frac{\alpha}{2}} = 0$$

$$\frac{15}{\sin\frac{90}{2}} - \frac{A}{2tg\frac{90}{2}} = 0$$

$$\frac{5}{0{,}707} - \frac{A}{2} = 0 \Rightarrow A = \frac{10}{0{,}707} = 14{,}14mm \qquad (2)$$

Calculation of the maximum diameter of the clamped roller from the width of the prismatic jaw:

$$\sin\frac{\alpha}{2} = \frac{\overline{OC}}{A} \Rightarrow \overline{OC} = \sin\frac{\alpha}{2}\cdot A = 0{,}707\cdot 14{,}14 = 10mm$$

$$B_{\max} = 2\cdot\overline{OC} = 2\cdot 10 = 20mm$$

Maximum diameter of the roller that can be clamped into prismatic jaws with the width of 14.14 mm is 20 mm. The given prism is suitable for clamping a spring from the set of the component base Fig. 10.

The calculation of the width of prismatic jaws for the gripper MHZ2-20DN for the minimum diameter of the roller *Bmin*=30mm, with the opening angle α=90°:

$$\overline{OD} - \overline{O_1D} = 0$$

$$\frac{\overline{OC}}{\sin\frac{\alpha}{2}} - \frac{A}{2tg\frac{\alpha}{2}} = 0$$

$$\frac{15}{\sin\frac{90}{2}} - \frac{A}{2tg\frac{90}{2}} = 0$$

$$\frac{15}{0{,}707} - \frac{A}{2} = 0 \Rightarrow A = \frac{30}{0{,}707} = 42{,}44mm \quad (3)$$

Calculation of the maximum diameter of the clamped roller from the width of the prismatic jaw:

$$\sin\frac{\alpha}{2} = \frac{\overline{OC}}{A} \Rightarrow \overline{OC} = \sin\frac{\alpha}{2} \cdot A = 0{,}707 \cdot 42{,}44 = 30mm$$

$$B_{max} = 2 \cdot \overline{OC} = 2 \cdot 30 = 60mm$$

Maximum diameter of the roller that can be clamped into prismatic jaws with the width of 42.44mm is 60mm. The given prism is suitable for clamping all the types of the pneumatic cylinder housings and The cap from the set of the component base Figure 11.

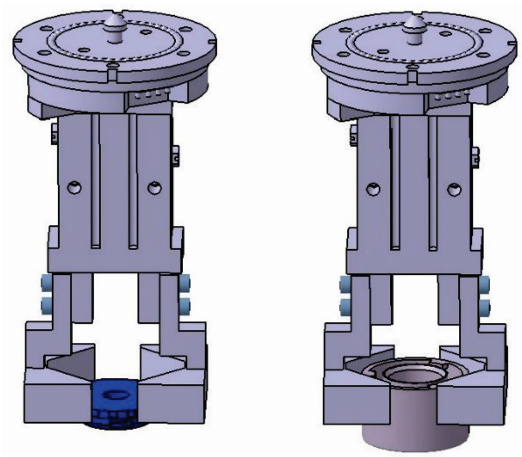

Figure 11. Prismatic jaws for the gripper MHZ2-20DN

7. Conclusion

One of the current trends in the industrial use of automation components and robotics lies on the improvement of the production cycle and the increase of productivity till the phase of assembly of final products. In several assembly operations it is necessary to use different types of jaws and grippers depending on the reach of the gripper and the pieces to manipulate. The former trend of manually removing of the grippers has been proved to be outdated and inefficient in terms of unnecessary side times when finalizing the product.

Instead, using the automatic exchange of such grippers has been also proved to be far better in achieving a better assembly effectiveness if existing the proper feedback to the central control system of an industrial robot [7]. The connection of the parts and the adapter itself, which is fixed to the ending joint of a 3 axis robot is achieved with the help of pneumatics. The flange contains pins for the transmission of electrical signals that help sending back information of the connection itself, from now on: signals of the sensor in the gripper (whether is open or closed, etc.). The proposal of jaws for particular types of pneumatic grippers arose in this paper from the set of components/parts shown in Figure 5. In the frame of practical classes and exercises with the students and with objective of contributing to the solution of the project KEGA 027STU-4/2014 several jaws were designed, developed and later mounted in real grippers. The automatic exchange and the entire assembly process were tested in a real system shown in Figure 3, resulting in few inaccuracies corrected and removed from the assembly process. In terms of verifying the functionality of the proposals, it can be said these proved themselves useful for further applications in industrial operations, especially the automatic exchange of grippers.

8. Acknowledgement

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THE IMPORTANCE OF SOFT SKILLS IN TECHNICAL EDUCATION

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Abstract

Today, the global market requires, besides developed technical skills, development of soft skills, which became a core skills of engineers in the team-based environments. Study programs facing the challenge, how in the most creative and innovative way (with regard to the 21st century), prepare the future mechanical engineers for the labor market. The paper gives a brief overview of the difference between the technical (hard) and non-technical (soft) skills, the importance of emotional intelligence in business, and the development of soft skills in technical environment.

Keywords: Soft skills, hard skills, technical education, emotional intelligence, teamwork

1. Introduction

In order to successfully cope with demands of today's society, from the individual is expected to adopt and develop a wide variety of competences that allow him to rapid adaptation to new social and professional requirements. The rapid development of technology and globalization processes make demands for the development of those competences of individuals that will provide them individual success, but also contribute to the success of society in general. If you want to be recognized in the competitive environment, it is necessary to possess skills that will make you stand out from other candidates. These skills are called soft skills, and are necessary for quality management of our own business and personal development. Exactly these skills, employers estimate as a core skills, and when hiring, these particular skills can be crucial when selecting person who would complement, and well incorporate in their business environment. Employers believe that soft skills are highly desirable qualities of employees for effective business interaction among co-workers, and if you do not possess of these skills (regardless of the acquired professional knowledge), they consider that the presentation of your hard skills may not be adequate. Soft skills creates the new possibilities and opportunities of career improving, because today is necessary rise not only as a specialist but also as a person.

2. Soft skills vs. hard skills

Hard skills are technical procedures which are easy to observe, quantify and measure, while soft skills provides a holistic approach for technical education. Hard skills are skills acquired by learning and through the practical work, while soft skills including interaction with other people. Soft skills is much harder to measure (evaluate) and it is more difficult to acquire, but once acquired, significantly facilitate the application of the hard skills in practice. Soft skills, as opposed to hard skills related to the professional knowledge acquired with education, are developing through the constant self-development and are applicable in various fields of life. For improving the soft skills it is necessary to manage of motivation/self-motivation, develop and improve personal efficiency when performing tasks and achieving the objectives, develop methods and techniques to improve working methods and the effectiveness of the time using, adopt the methods and communicating techniques and presentation skills, understand the importance of stress management, daily and in business life, improve negotiation skills and the basics of teamwork.

Examples of hard skills include [1]:

- proficiency in a foreign language
- a degree or certificate
- typing speed (writing, reading)
- measuring and calculating
- analyzing data
- machine operation
- ability to use software programs (computer programming).

Examples of soft skills include [2]:

- effective written and oral communications
- critical thinking
- information management skill and life-long learning
- problem solving and decision making
- leadership skills
- teamwork skills
- ethical behaviour.

Figure 1, [3], shows a comparison of the hard and soft skills.

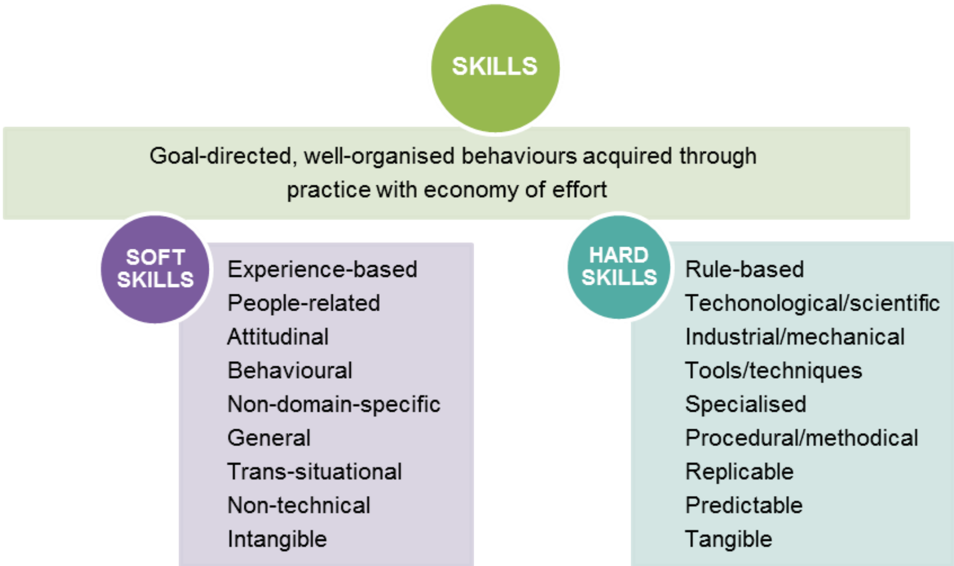

Figure 1. Representation of soft and hard skills

3. Emotional intelligence

Emotional intelligence towards [4], is a set of emotional skills which allow us to choosing the correct manner of use feelings and unconscious instinctive mechanisms to interact with other people as well as the understanding of yourself. This type of intelligence involves knowledge of what you feel and use your own feelings to make good life decisions, and represents the ability of good management moods and the urge control based on the awareness of our own feelings in the moment of events. The basic components of emotional intelligence are:

- recognizing (the ability to recognize your own emotional state),
- using (knowing how to motivate yourself to create your best performance),
- understanding (sense the emotions in others),
- emotion managing (develop productive relationship with other people).

For achieving the business success, ahead of conventional intelligence, priority is given to organizations (companies, institutions) directed to emotional intelligence, while significantly reducing the time required for product development and placing it on the market, if there is a built emotional competence in development teams. It also contributes to increased productivity, better quality innovation and return on investment through new strategies and technologies.

Companies for that reason, require not only a professional and competent people, but also those who have the emotional maturity to successfully cope with the complexities, ambiguities, uncertainties, risks and variety of modern times, and those who know how to motivate and keep the other talented people.

It is important to emphasize that emotional intelligence is a skill that can be developed.

According to [4], emotional intelligence can be divided into four quadrants based on the model with a total of 18 competencies. Studies show that leaders should have a high level of competence in six core areas in order to be effective (Table 1).

The six core areas for leadership and most critical aspects of emotional intelligence are:

- Emotional Self Awareness
- Accurate Self Assessment
- Self Confidence
- Emotional Self Control
- Empathy
- Influencing Others.

4. Soft skills in technical education

Due to the competition of global markets, soft skills no longer just nice to have, but it is necessary to have, and development of the same skills sets more like imperative to engineers, because that skills are contributing to a more successful business. Universities are mostly focused on teaching professional information prior than soft skills such as creativity, problem solving, personal communication, writing and the ability to speak. Students generally learn how to become an engineer, and less focus is on the soft skills.

Without soft skills, each graduate engineer is faced with too many problems in their professional life, because he can't communicate effectively, team work and solve problems – thus, students should acquire soft skills prior that they graduate.

The term, social interaction in heterogeneous groups [5] refers to an individual's ability to cooperate with others and well-managed relationships for personal well-being but also for the establishment of new forms of cooperation. This competence shares common features with the so-called "social competence", "social skills" or "soft skills".

Table 1. Daniel Goleman's 4 quadrant model of emotional intelligence

SELF AWARENESS Emotional Self Awareness Accurate Self Assessment Self Confidence	SOCIAL AWARENESS Empathy Organizational Awareness Service Orientation
SELF MANAGEMENT Emotional Self Control Transparency Adaptability Achievement Orientation Initiative Optimism	RELATIONSHIP MANAGEMENT Influencing others Developing others Inspirational Leadership Conflict Management Teamwork/Collaboration Change Catalyst

The social competence is possible and thus necessary to develop in the framework of education. According to [4], social competence is part of emotional intelligence, and includes knowledge and reflect on their own feelings in making good decisions in life, but also the skills of persuasion and leadership of others, and the ability of non-violent conflict resolution. Although sharing some common features, it is necessary to distinguish the social competence of the social skills.

The skills comprise specific behaviors of individuals (e.g. tolerance, nonviolent conflict resolution, constructive communication), while competence is determined by the way of the individual uses of skills in a social environment. We can say that the individual is socially competent if using social skills in an appropriate manner and at the same time successfully achieving a crucial personal objectives, [5].

Students can acquire soft skills through the extracurricular activities such as sports activities where they learn about being a team responsibility and adapting, volunteer work that helps improve communication skills and work ethic (not work for money), art that develops creativity and teaches the effective use of time and available resources, international and domestic travel that enhance planning skills and so on [6].

Students are the adults, built persons, and as such are, they enrolling the study and come with some embedded behavior patterns, and thus more difficult accept the changes related to their behavior. On the development of soft skills therefore should commence at the earliest age of a child's life, when it is a natural to adopt some certain behavior that is now popularly called soft skills, of course, adapted to the current age, and upgrade the same throughout their schooling. It is very important to every child/person watch as an individual and remain in compliance with its personality.

Soft skills are the skills which can be mastered, and even in later years, but many times it's forget that this is a process that takes time. These are skills that can not be adopted overnight, but should be built gradually and naturally, in real situations, at real problems. How much is a parental effort (and constant repetition) children need to adopt the habits of good behavior and what is most important - to know how to apply it at the right time.

Soft skills will help students in a lot of the situations that will face them in the working environment.

According to [7], there are 29 soft skills which are most frequently cited in scientific papers as crucial:

1. Communication (oral and written)
2. Analytical and problem solving
3. Team player
4. Team work
5. Management skills
6. Interpersonal (presentation, listening, negotiation skills)
7. Innovative and creative
8. Self-learning
9. Open and adaptive
10. Leadership
11. Organizational
12. Planning
13. Ability to work under independently
14. Fast learning
15. Critical thinking
16. Work under pressure
17. Decision making
18. Design above functional level
19. Shared beliefs and trust
20. Emotional intelligence
21. Commitment
22. Research
23. Concern with quality
24. Cross-cultural skills
25. Legal skills
26. Awareness skills
27. Language skills (written communication)
28. Ethical, political, and economical skills
29. Outsourced management skills.

In the top are the communication skills, and problem solving skills as well as teamwork. The term, teamwork, refers to work in a team composed of competent people who possess the knowledge necessary to achieve the defined objective, where each person is responsible for the activities defined by the project, respects the creative ideas of other coworkers without inappropriate behavior, because the ultimate goal should be for all participants the same - a quality job done.

Group/team work should be more present in the process of education of future engineers (must be taken to ensure that the groups/teams are consisting of students with equal competences and personalities that do not happen that individuals who "stand out" must take all the work and responsibility while others are "spared" and equally receive a merits - this is not a healthy working atmosphere and is usually frustrating and demotivating for those who do all the work).

Students, especially at graduate studies, should be more involved in smaller projects (in which they can participate based on already acquired professional knowledge in order to feel useful and with faith that they really up to the task - otherwise it can only lead to a drop in self-esteem and thus to a motivation decrease, and ultimately giving up, as for the labor market can mean the loss of inventive people if they are not handled in the right way - individual) because that is the best way to prepare them for the labor market, which nowadays is really demanding.

Each student should be present at each lecture and participate in discussions (pay special attention to involved those who shy, withdrawn). Teaching jobs, in addition to being pedagogically oriented, is complex because it requires psychologists knowledge and knowing how to access to any of the students at individual manner (prefer to work in smaller groups). In the classroom should be reign friendly atmosphere, not the fear (which does not mean that the interaction between the students and the teacher should be at the level of peers). Students should recognize that the teacher is there for them and their future and the future of all of us that we prosper as a society if we develop young creative people of them, which we will leave the future, not for the reason of intimidation to show the hierarchy or because someone believe that is the way to achieve respect - counterproductive. Teachers, first of all should be consistent (not easy, but it is worth), stick to the agreement, and to be honest with his students, in order to develop mutual trust.

Students should enable presentation of their works, not only through individual courses, presenting in a classroom in front of their generational colleagues, but also through the public tribunes, meetings, conferences (one of the example who has been successfully implemented for 9 years consecutive, at the Mechanical Engineering Faculty in Slavonski Brod, the event, called Mechanical challenge in cooperation with industry, where students have the opportunity to present their work to a wider audience, which is good for the growth of their self-esteem and development of soft skills).

Students ultimately should be referred in what that awaits them in a job interview, appropriate dress manner (dress code), self-presentation, generally a way of communicating in order to understand general rules of business life, on time.

Lifelong learning as the name suggests, never stops, and refers among other things to research the topics of interest, the ability to acquire knowledge and its application, understanding of new materials, learning from personal experience [8]. There can be classified and associations such as the Alumni club, which brings together all the graduates (engineers) of certain institutions with the aim to connect and share experiences and problems, whose members should be include more (through invited lectures, panel discussions) to work with students to create a true picture of the "outside world", and about what awaits them after their graduation, the importance of lifelong learning and to prepare them at professional life.

Students should enable the conditions for the acquisition of soft skills, motivating them and putting in front of challenges, in which they will solve the given problems using the same skills.

The importance of soft skills can be presented to students on the real-world examples that are directly related to their field of study, noting that teams that work well, provide a more effective technical solutions at customer satisfaction.

5. Conclusion

In modern society is increasingly coming to the fore the importance of successful interaction with others and the establishment of high-quality professional and personal relationships. Therefore, when trying to define basic competencies to be developed during obligatory education (not only technical education), social competence is recognized as one of the core.

Activities that promote effective communication soft skills in technical education may not be available to a greater extent in today's programs, but support for these skills is essential in building the labor force of the future. With changes from somewhere need to start, the best of ourselves. The teachers are an example for our students, and when the students hiring, in some way they send out a picture of faculty which are attended and the way how we treated to them in the five years spent together. We wish that our students ultimately be even better (more mature, more responsible, more self-aware, amicable) than when they came to our institution.

Therefore, the primary objective of the curriculum of technical education to prepare engineers for the labor market of the 21st century, where except specific professional knowledge, requires the possession of soft skills in order to be ready for the challenges that await them in a competitive global work environment.

Changes should not be afraid, especially those which lead to improving, success.

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INFLUENCE OF MINERAL FERTILIZATION ON THE GRAPEVINE YIELD (*VITIS VINIFERA* L.)

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Abstract

Fertilization is one of the agro-technical procedures that can ensure the achievement of optimum yield and quality of grapes and for this reason is a necessary intervention in the cultivation of grapes, especially in environmental conditions that are not optimal for its production. It contributes to the creation of the vine's greater vegetative power, which can then be loaded with larger number of buds, and thus achieve the highest yield. The investigation was conducted in year 2012 on Riesling and Slankamenka cultivars. The experiment was set in three treatments and four repetitions as a randomized block design. The effect of different amounts of mineral fertilizers on the grapevine yield is investigated. The treatments in the study were control (KO) - no fertilizer, Treatment 1 (NPK1) - addition of fertilizer in an amount of 0.5 kg/vine NPK and Treatment 2 (NPK2) - addition of fertilizer in an amount of 0.75 kg/vine NPK. Mineral fertilization with 0.75 kg/vine NPK resulted in best grapevine yield.

Keywords: grapevine, mineral fertilization, Riesling, Slankamenka, yield

1. Introduction

Grapevine as highly flexible plant is grown in different environmental conditions, and they can sometimes be limiting factors in achieving optimum yield and quality of grapes. Fertilization is one of the agro-technical procedures that can ensure the achievement of the desired results in terms of yield and complete quality. During the growth and development of vegetative and generative organs, a grapevine must have available plant nutrients in the root system zone. With good soil nutrients supply, grapes feeding can be well balanced, which ensures regular and stable yield as well as a good quality, of course with the best application of agro-technical and other measures in ampelo technological maintenance of vineyards.

Fertilization of vineyards by combination of mineral and organic fertilizers showed the best economic effects [1]. Nitrogen fertilization as agrotechnical procedure in vineyard production may contribute to the growth of the vegetative mass of grapevines, the dynamics of maturation and yield of grapes because it reduces photosynthetic activity and increases respiration which results in metabolism stimulation. Adoption of nitrogen and its impact on growth and productivity of grapevines are essential for a good understanding of the nitrogen fertilizer application. Positive impact of nitrogen mineral fertilization on the growth of one-year gilts was already determined [2]. Symptoms of nitrogen reduction are reflected in a reduced size of leaves and shoots, and there is a yellowing of vegetative organs of grapevines as well as reduced photosynthetic activity. Ough et al. found that fertilization between 0 to 112 kgN/ha gives the best results for quality of wines [3]. Similar results, after twelve years of research, have established Saayman and Lambrechts, who concluded that the optimal fertilization to achieve the growth of shoots and the quality of grapes is around 100 kgN/ha [4]. But such an extensive nitrogen fertilization can have adverse effects and Delas et al. found a significant increase in the infection of gray mold (*Botrytis cinerea*) in the use of 100 kgN/ha in rootstock SO4 [5].

The influence of nitrogen fertilization on vegetative and reproductive capacity of grapevines was studied in an experiment with low nitrogen content conducted in Western Australia. Five treatments of nitrogen fertilizer (0, 50, 100, 200, and 400 gN/vine) were applied in irrigation on cultivar Cabernet Sauvignon in the vineyard 12 years old during three seasons. After the analysis it was found that moderate amounts of nitrogen fertilization can have a positive effect on the productivity of vines, while excessive nitrogen fertilization is not profitable [6]. Mirošević et al. have investigated the influence of fertilization on grapevine yield and quality of grape must of Plavac Mali cultivar. The experiment was set in karst conditions of Blatsko polje at the Korčula island with randomized blocks and five treatments in five repetitions. The treatments were: no fertilization; fertilization with 500 kg/ha of NPK (7:14:21) in the autumn; fertilization with 500 kg/ha of NPK (7:14:21) + 100 kg superphosphate (16%) in the autumn; fertilization with 500 kg/ha of NPK (7:14:21) + 100 kg superphosphate (16%) in the spring; and fertilization with 500 kg/ha of NPK (7:14:21) + 100 kg superphosphate (16%) + 100 kg / ha of KAN (27%) in the spring. During the study (years 1988-1997) the highest average yield per vine was obtained in the final treatment and lowest in the first treatment, without fertilization. With the respect to grapes yield, the best results were obtained with treatments in which fertilization was carried out in the spring [7]. Potassium fertilization contributed significantly on yield increase of Riesling cultivar in both years, compared to the control treatment without fertilization [8].

The aim of this work was to determine how different amounts of mineral fertilizers (NPK (S03) 7:14:21 (24)) affect the vine yield of Riesling and Slankamenka (Plovdina) cultivars.

2. Method

The vineyard where the study was conducted is located on the site of Bili Brig (Nova Kapela) owned by the family farm "Željko Sameljak". In the eastern region of continental Croatia in which the vineyard is situated the mean annual temperature ranges from 10.9 to 11.7 °C, and during the growing season from 17.6 to 18.2 °C. The sum of effective temperatures ranges from 1440 to 1540 °C. The total amount of precipitation is 640-850 mm, and during the growing season from 350 to 430 mm. Insolation during the growing season lasts an average of 1500-1600 hours [9]. The vineyard was planted in 1993, on the basis Kober 5BB, and a grapevine was formed in bilateral cordon training system.

The cultivars in the study were Riesling and Slankamenka. Riesling is probably the most common white grape cultivar in wine-growing assortment of Croatia because of the ability of good and regular fertility and high quality of grapes, must and wine which can be achieved in our agroecological growing conditions. Slankamenka has been planted because of its high birth rate, but because of the low acidity of must and wine, and grape sensitivity to gray mold (*Botrytis cinerea*) it is less frequent in the growing these days [10]. Spacing between the rows is 300 cm and 120 cm within the rows. Vineyard area is 1,212 square meters. The location is on a slightly raised platform, about 150 m above sea level, southern exposure. The experiment in the vineyard is set in three treatments, as randomized block design. Each block consists of 4 vines, making a total of 12 vines of Riesling and 12 vines of Slankamenka cultivar. The treatments were carried out as follows:

1. treatment - without application of fertilizer - KO;
2. treatment - mineral fertilization in an amount of 0.5 kg NPK / vine - NPK1;
3. treatment - mineral fertilization in an amount of 0.75 kg NPK / vine - NPK2.

For mineral fertilization presented in the study a complex NPK fertilizer (the so-called "NPK (SO3) 7-14-21 (24)") of “Petrokemija d.d.” company has been used. In the experimental part of the vineyard (Fig. 1) mineral fertilizer is applied during the growing season in two occasions: the first time on April 11, 2012 and the second time on May 30, 2012.

It should be noted that throughout the vineyard organic fertilization with manure was conducted at the end of the previous growing season of 2011. Manure is incorporated into the soil by plowing. Influence of fertilization on yield of grapevine varieties Riesling and Slankamenka is investigated.

To determine the amount of yield weight of bunches per vine was measured and an average weight was calculated. Vintage and measurement were conducted on September 12, 2012, Fig. 1.

Figure 1. Experimental Vineyard

3. Results and Discussion

Table 1 shows the effect of mineral fertilization on yield of Riesling cultivar in all three treatments performed. The control treatment had the smallest average yield per vine (1.79 kg), while the highest yield was observed in the treatment NPK2 where mineral fertilization was 0.75 kg / vine NPK (2.25 kg). The positive impact on the yield of the fertilization with nitrogen mineral fertilizers were found also by other authors [6,7].

Table 1. Yields in kg for Riesling cultivar

Treat-ment	Vine 1	Vine 2	Vine 3	Vine 4	Average
KO	1.68	1.93	1.75	1.80	1.79
NPK1	1.95	2.10	2.21	2.01	2.07
NPK2	2.03	2.24	2.40	2.30	2.25

Figure 2 shows the average yield of Riesling cultivar based on different treatments and repetitions. It is evident that the yield of grapes in the treatment NPK2 was the largest across all repetitions, while the treatment NPK1 had some lower yields across the various repetitions.

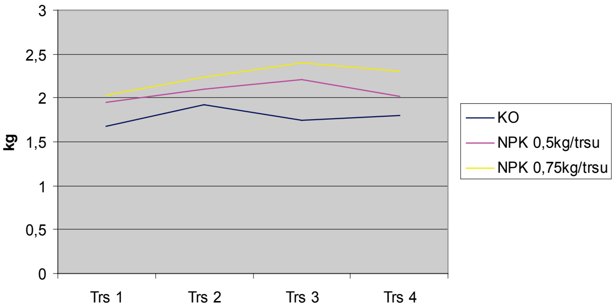

Figure 2. Yields in kg for Riesling cultivar.

Table 2 shows the effect of mineral fertilization on yield of Slankamenka cultivar conducted in all three treatments. The control treatment had the smallest average yield per vine (3.57 kg), while the highest yield was observed in the treatment NPK2 where mineral fertilization was 0.75 kg/vine NPK (3.96 kg).

Table 2. Yields in kg for Slankamenka cultivar.

Treat ment	Vine 1	Vine 2	Vine 3	Vine 4	Average
KO	4.19	3.32	3.77	3,00	3.57
NPK1	3.82	3.70	3.56	3.90	3.75
NPK2	3.80	4.10	4.02	3.98	3.96

Figure 3 shows the average yield of Slankamenka cultivar based on different treatments and repetitions. It is evident that the yield of grapes in the treatment NPK2 was the largest in all three repetitions carried out, while the treatment NPK1 had somewhat lower yields across the various treatments in relation to the treatment NPK2. KO treatment (without the use of mineral fertilizers) had the highest yield in one replication, but the lowest average total yield.

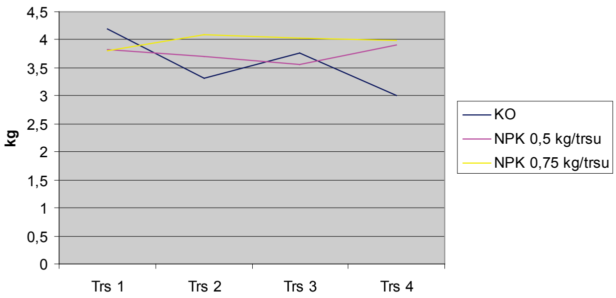

Figure 3. Yields in kg for Slankamenka cultivar.

From the comparison of Graševina and Slankamenka cultivars it is obvious that the mineral nitrogen fertilizers positively affected the yield of both cultivars. It should be noted that the Slankamenka cultivar gave high yields but that the wines of this variety are of inferior quality.

4. Conclusion

During the growth and development of vegetative and generative organs, a grapevine must have available plant nutrients in the root system zone. With good soil nutrients supply, grapes feeding can be well balanced, which ensures regular and stable yield as well as a good quality, of course with the best application of agro-technical and other measures in ampelo technological maintenance of vineyards. Nitrogen fertilization as agro-technical procedure in vineyard production may contribute to the growth of the vegetative mass of grapevines, the dynamics of maturation and yield of grapes.

This is beacuse it reduces photosynthetic activity and increases respiration which results in metabolism stimulation. On the basis of the research performed on family farm "Željko Sameljak" about the impact of nitrogen mineral fertilization on yield of grapevines, it can be concluded that the grape yield in Riesling and Slankamenka cultivars was the highest in the treatment with the addition of 0.75 kg / vine NPK(SO3) 7-14-21(24). From these studies it can be concluded that nitrogen mineral fertilizer positively stimulated increase of the grapevine yield, and as such can be used in the vineyards that have a need for higher productivity.

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SIMULATION AND SIMULATION OPTIMIZATION IN THE DESIGN AND ANALYSIS OF THE MATERIAL FLOW AND LAYOUT: THE CASE OF A FLEXIBLE ASSEMBLY CELL

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Abstract

Over the years, simulation and simulation optimization have become a valuable tool in the design and analysis of manufacturing systems and cells. They have played an outstanding role in the validation of methods, designs and in general changes made to any stage of the manufacturing process. One of their most common applications has taken place in the material flow and layout problems. Because of its practicality, simulation techniques have been broadly included in many study programs so that students may be able to deal with these issues once facing real life situations in manufacturing. The paper aimed at analyzing and improving the design and analysis of the material flow and layout of a flexible assembly cell; such cell serves both for research and academic purposes. The paper also highlights the relevance of simulation and simulation optimization in dealing with the previous aim, for which some simulation software were also mentioned and briefly compared while being Witness highlighted.

Keywords: Simulation optimization, material flow, flexible/intelligent manufacturing/assembly system /cell, Material flow configurations/permutations

1. Introduction

In the last decades, a fast migration from traditional manufacturing systems (MS) to a more flexible manufacturing has been taking place, e.g. flexible/intelligent manufacturing/ system/cell (F/IMS/C). These rather new emerging systems are generally capable of processing different types of products in an arbitrary sequence with insignificant setup delays between operations and are mainly distinguished from other types of MSs by the following characteristics: high degree of functional integration, complex tool management and complex control software. In the case of IMS/Cs other elements like the autonomy/self-control, reconfiguration capabilities and even to soft and hard compatibilities are also key characteristics. All these elements make of these systems, besides it is becoming better over the years, relatively expensive and thus just a few companies can implement them. In this respect there is a growing tendency to develop and use just their smaller versions called F/IMCs [1].

In consonance with all this, The Institute of Production Technologies (IPT) consists of a FAC. This cell is composed of three main subsystems: cartesian robot (CR) and shelf-storage system (SS) and a Palletization Area with Buffers (PAB). Besides what's been done so far in such FAC, at present, it is still subject to further improvements, what is also influenced by the scope of new projects and interests. A major emphasis is made on deeper and further analyses of material flow (MF), that in a way expose its combinatorial nature and complexity and that mainly compare and decide on better MF scenarios, while also covering other MF-related manufacturing decisions, e.g.: the layout, which is offering a few difficulties in the functioning of the cell due to an initial misconception of it. All what needs to be improved also respond to the needs of turning this cell into a more flexible, autonomous, real life-oriented and intelligent one, while at the same time also supports and enhances the teaching process at the institute; the authors of [2] share a similar insight on this last specific topic. This entire situation highlights the needs of methods that help analyzing and validating the efficacy of changes in the existing layout and/or MF which including other possible MF scenarios, in other words, simulation and simulation optimization methods.

To help coping with such needs, a few simulations software will be briefly addressed within this paper; special emphasis will be made on the Witness simulation package while showing its advantages in avoiding unnecessary changes and investments inside the a MS in general. A brief application of Witness will be carried out in the mentioned FAC so as to help improving the design and analysis of the MF and layout.

2. Simulation and simulation optimization: a few important issues on it and software used

When analyzing the states of the art and practice and the MS Design Problem itself, tons of simulation software somehow meet what is needed for the design and/or analysis, control and also optimazation of the material flow and layout, e.g.: Promodel, Plant Simulation, Arena, SIMUL and Witness among many others. Very often, software-based simulations tend to model F/IMS/Cs or single workstations, as a set of interconnected queues, in which a workstation or device of it is represented by a single-stage service facility with an input/output queue. The material handling system is usually considered as a resource for which these workstations compete. The load/unload stations, although depending on the type of layout, are generally at the entrance and exit of the simulation model. In such a network of queues, parts are customers and it is the dispatching rules in the production schedule, which determine how to route them to the next machine. From the viewpoint of flow, a part is simulated as being either in a waiting, transporting, processing or controlling state in the system. Within a FMS/C unlike other MS/Cs, the part might be transported to any capable workstation at some decision points depending on the dispatching rules. In the case of an IMS/Cs, this event could occur similarly but however, some degree of uncertainty could be expected since the system would be supposed to perform operations in a more open and autonomous way.

Regardless of the case, simulation functions as an interface to the physical system trying to capture its current status and thus works as a feedback for continuously improving the performance. Simulation can not only deal with the current states of the system, but also with the future uncertainties by randomly generating the future disturbances according to a probability of future disturbances estimated from the past history. It can also be used to shorten any kind of long term evaluation or testing process, and to validate new designs, technologies or changes regarding the physical elements of the systems based on the model results. This makes the mean time among proposals or designs, their correction and the complete implementation, shorter and less risky. Table 1 shows some simulation advantages/disadvantages in F/IMS/Cs. For further details on simulation and simulation optimization, authors are invited to also see [3-7].

On the other hand, from a deeper analysis on the benefits the many simulation tools offers, several authors like [3,6], have made their comparisons and got to important conclusions.

As they noticed, if also taken into account that the analytical models become hard to be used due to the inner poor flexibility and autonomy of these kind of systems, underline in most of the cases, the vital role of such packages in the design, analysis, control and optimization of production systems and problems like the MF and layout, which are specifically the ones addressed through this paper.

From the previous analyses, among the variety of simulation packages which could be used in the design and/or analysis of the MF, Witness appears as a relevant one. It has the advantages of ease-of-use, flexibility, modeling power, realistic animation capabilities, and good statistical analysis, i.e.: possibilities of analyzing the results by using Minitab, among others as it can be verified in [6-8]. These authors enhanced in their works the supremacy of this software over others, and in the case of the last one, both criteria for the selection of the appropriate software and comparisons among them were offered as well.

Table 1. Use of simulation in F/IMS/Cs

ADVANTAGES	DISADVANTAGES
It explore and analyzes possibilities and answers to what if questions	The construction of the models require some special training
It diagnoses problems	The results could be difficult to interpret
It visualizes plans and prepares for changes	It can be time consuming and expensive
It evaluates and validates before the resources have been acquired or future changes, new designs and theories related to the elements of the system implemented	If used improperly it could imply significant risks. It also often lacks of the flexibility needed when dealing with F/IMSs, thus some assumptions should be made
It helps predicting future disturbances and test different scenarios. It compares alternatives	

Source: Modified based on [3].

The modeling elements of Witness provide fundamental building blocks to represent the physical and logical components of the system being modeled. The operation of a F/IMS/C is always defined freely by the designer, mostly through part flow, operating logic and rules. Witness includes in its menus basic elements and others like: More Parts, More Buffers, More Machines, More Labor, etc; most importantly it offers the possibilities of interacting with other software like Microsoft Visio, AUTOCAD, Microsoft Excel, Minitab and Access among many others.

All what said so far verifies the adequacy and somehow superiority of the Witness simulation package in terms of coping with the already mentioned goals pursued through this paper. Thus, it is no coincidence this is one of the key software students learn to work with at the IPT. Many more details on the Witness simulation package are to be shown in further sections where a real application will take place in the mentioned FAC. Readers are also encourage to see [9] where a nice useful take on simulation optimization appears. In such a paper authors nicely analyze several simulation optimization algorithms and depending mainly on the searching steps and the amplitude of the variables ranges, come to specify the conditions under which each one of such algorithms works the best. The authors also nicely proposed a procedure according to their own experiences and tests that helps dealing with simulation optimization problems when having just a few variables and huge variation ranges. Such procedure has been slightly modified to better fit the case study addressed within this paper.

3. A synthetized description of the MF and layout in the FAC

The MF begins at the PAB, see the Figure 1, where parts wait to be manipulated, i.e.: pistons (P) and cylindrical housings (CH). Inside the area, an ABB robot IRB 120 will select and place the right parts in the right position on the pallets as well as the assembled pieces in the boxes during the reverse flow. In the same PAB there is a shelf consists of 4 positions that will be used either for the direct flow of parts or the reverse flow of the assembled pieces. Once the pallets and their parts are ready, each pallet having one and only one part, these are handled by another smallest AGV (Robotino), which is intended to move between the PAB and the Shelf-Storage (SS). This second storage area consists of 12 positions and an input/output one (I/O) where in a simple and first approximation, all parts must be placed when coming from the PAB, and all pieces or empty pallets when coming either from SS to the PAB or directly from the Rotating Device (RD) to the PAB in case these are not stored in the SS before being transported.

The parts placed by the AGV at the I/O can be either moved into SS having to wait, or directly moved by the M to the RD, for which the M must have stored the previous pallet(s) from the RD into SS first (it could be a pallet with an assembled piece, a piston's pallet or both of them). The selection of 1 of the 2 previous alternatives, has to do with the importance of the order being processed or simply the will of prioritizing the direct flow of parts or the reverse flow of pieces. The combination/permutation of all the time standards of the FAC devices and their variation, e.g.: as a consequence of the different speeds the devices of the cell operate at, may create other MFCs.

The RD either takes parts into the AP or takes the pieces out from it when assembled. Once the parts are in the AP, first the cylindrical housing and then the piston which is also transported by the AGV, different grippers from the 3 existing ones are mounted successively for the realization of the assembly process. The assembly process begins with arrival of the cylindrical housing which is fixed, then the piston is introduced, right after the spring, and finally the cover, the last 2 ones are in buffers located in the same AP. Assembled pieces just like any empty pallet, can either remain in the RD waiting till the incoming part being transported by Robotino from the PAB is stored in the SS, or be directly moved into the SS while the incoming part takes its place in the RD, the course of action decided will lie on the elements explained in the last paragraph. In any of the cases, pieces and empty pallets are placed in the 4 positions shelf when taken by the AGV in its return to the PAB, then; pieces are taken and placed by the same ABB robot into the proper boxes.

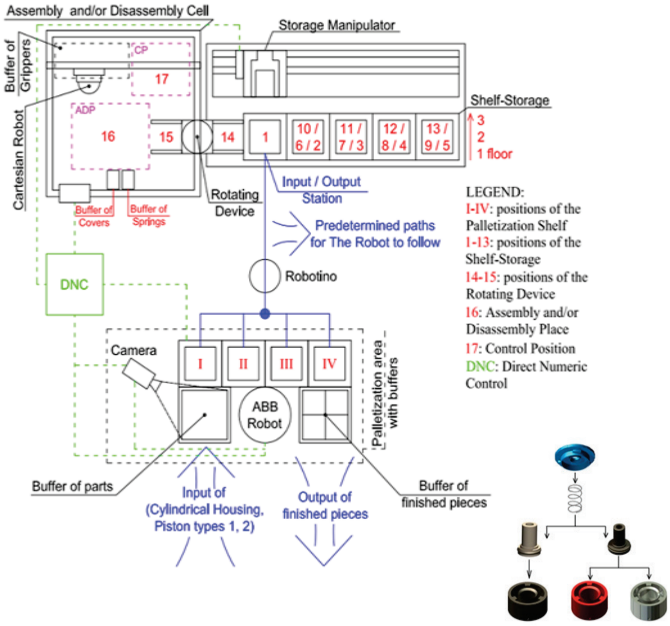

Figure 1. Current layout of the FAC and family of parts. Source: Self-elaboration.

4. Definition and simulation of scenarios

Despite many MF and layout scenarios have been defined and may be simulated so as to improve the existing one, for the sake of not further extending this paper, just 3 out of the 10 already identified will be next mentioned and simulated. Even though, some analyses on the combinatorial nature and complexity of the case study considering the many permutations created from those 10 general/initial scenarios in the FAC have been already done, further research papers will better and more explicitly focus on detailing such issues, herein they are just to be mentioned.

1. The general/initial scenario described above according to its storing and retrieving policies. In this scenario the SS is initially full of CHs pistons and empty pallets while keeping available 3 positions for finished pieces. In each case, in the beginning items are placed/stored in their defined positions. Once the SS continues to be replenished with parts, empty pallets and finished pieces to be stored, this will be done according to the first closer empty position and those predefined orders/positions will not be followed any more.
2. The normal working scenario 1 with the exception that parts, finished pieces and empty pallets would instead be always placed/stored in the first closer position.

3. This is scenario implies a layout redesign i.e.: the repositioning of the PAB and ABB robot so that, possibly using other grippers, such ABB may be even able to manipulate the pallets itself to/from the SS and the PAB, see Figure 2.

Now it is needed to prove the superiority of any of these scenarios over the others, this will hopefully verify the empirical beliefs that the scenario 3 is the best among them, not only in terms of the physical layout, but in terms of the MF as well. Since scenarios 1 and 2 have been somehow described and keep similarities as well, a few more MF details on the scenario 3 will be added.

Again, the main difference of this scenario with respect to 1 and 2 lied in the repositioning of the PAB and with it the ABB robot within the layout of the FAC, this leads to the elimination of the AGV philosophy and implies a few changes both in the MF and layout conceptions. The ABB robot would be now executing another operation what will allow increasing its utilization, i.e.: it will be also placing and taking the pallets to/from the I/O position. There will also be a slight repositioning of the buffers so as to allow a better accessibility of the robot. As for the SS and the other parts of the cell involved, the same routines/rules/ steps explained for the scenario 1 remain, however, it will be assumed within the frame of this paper storing and retrieving policies similar to the ones in scenario 2, i.e.: pieces and parts would be placed in the first closest empty position within the SS. Next some simulation outputs are shown.

Notice that for demonstration purposes, it has been assumed for the simulations a working regime at the FAC of 1 day and 1 single shift of 8 hours, time is expressed in seconds:

$$Available\ working\ time = 8\frac{hours}{day} \times 60\frac{min}{hour} \times 60\frac{sec}{min} = 28\,800\ sec/day \tag{1}$$

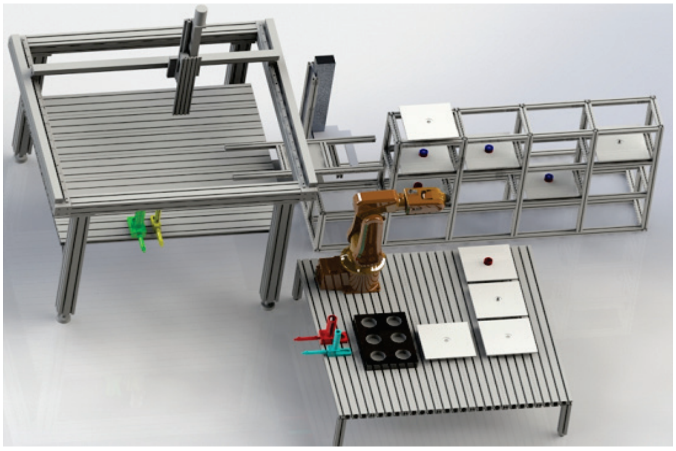

Figure 2. Modification of FAC layout and MF. The one to be simulated and compared. Source: Self-elaboration.

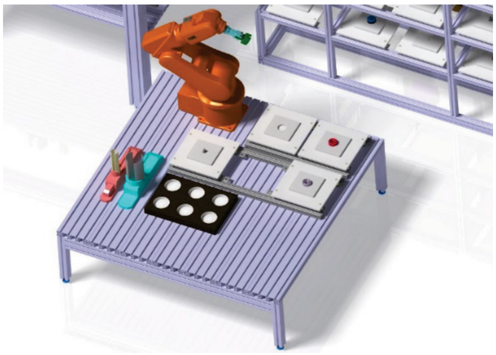

Figure 3. An example of other modifications of FAC layout and MF Source: Self-elaboration.

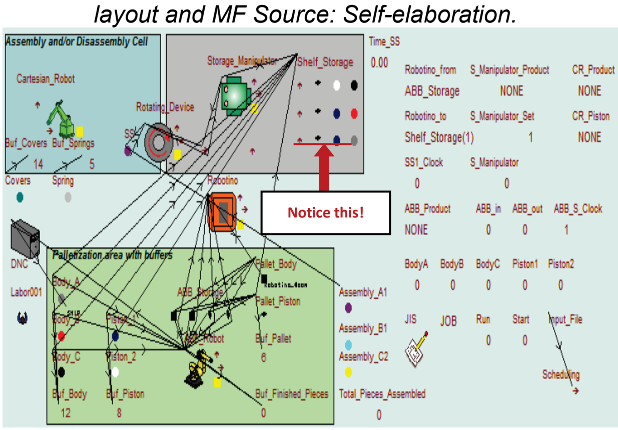

Figure 4. Witness interface-scenario 1. Element flow activated. SS status underlined. Source: Self-elaboration using Witness.

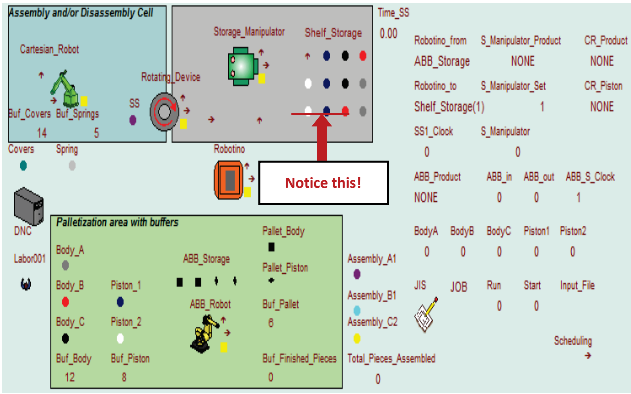

Figure 5. Witness interface-scenario 2. SS status underlined.Source: Self-elaboration using Witness.

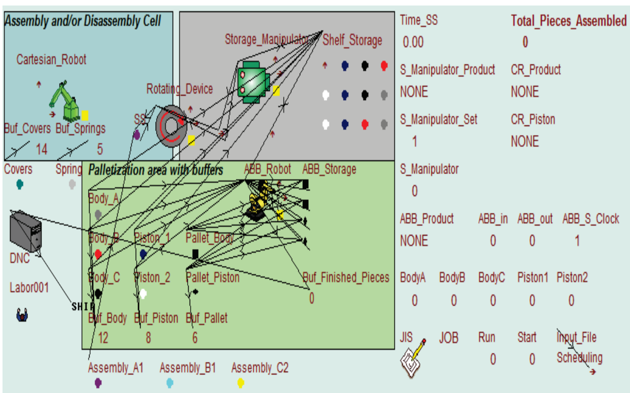

Figure 6. Witness interface-scenario 3.Source: Self-elaboration using Witness.

Figure 7 shows the machine statistics report of the scenarios being analyzed. The results of the simulations reveal herein that a better throughput rate can be achieved in the new scenario 3 while at the same time a better utilization of the ABB robot. For the simulated time, a total of 199 pieces were assembled in the scenario 3 which exceed in 23 and 27 respectively the best results of the other scenarios. Most importantly, it can be seen in the simulation results that less blocked percentage can be achieved what contributes to a smoother MF. Because of all these reasons, the lack of practical meaning of the AGV in the FAC and the feasibility, both mechanical and economical, of the application of such scenario 3, it is clearly concluded this is by far the most convenient general/initial scenario in terms of favoring the MF and the layout within the FAC.

Machine Statistics Report by On Shift Time

Name	% Idle	% Busy	% Filling	% Emptying	% Blocked	% Cycle Wai
Rotating_Device	92.61	7.39	0.00	0.00	0.00	0.00
Storage_Manipulator	17.38	82.62	0.00	0.00	0.00	0.00
ABB_Robot	81.56	18.44	0.00	0.00	0.00	0.00
Cartesian_Robot	53.86	46.14	0.00	0.00	0.00	0.00
Robotino	41.06	41.78	0.00	0.00	17.16	0.00
DNC	99.97	0.03	0.00	0.00	0.00	0.00

Machine Statistics Report by On Shift Time

Name	% Idle	% Busy	% Filling	% Emptying	% Blocked	% Cycle Wai
Rotating_Device	92.61	7.39	0.00	0.00	0.00	0.00
Storage_Manipulator	18.68	81.32	0.00	0.00	0.00	0.00
ABB_Robot	81.91	18.09	0.00	0.00	0.00	0.00
Cartesian_Robot	54.17	45.83	0.00	0.00	0.00	0.00
Robotino	40.07	40.49	0.00	0.00	19.44	0.00
DNC	99.97	0.03	0.00	0.00	0.00	0.00

Name	% Idle	% Busy	% Filling	% Emptying	% Blocked	% Cycle Wai
Rotating_Device	93.70	6.30	0.00	0.00	0.00	0.00
Storage_Manipulator	37.83	61.43	0.00	0.00	0.74	0.00
ABB_Robot	58.40	41.60	0.00	0.00	0.00	0.00
Cartesian_Robot	60.62	39.38	0.00	0.00	0.00	0.00
DNC	99.98	0.02	0.00	0.00	0.00	0.00

Figure 7. Partial results from the simulations of the scenarios 1, 2 and 3.Source: Self-elaboration.

5. A few details on the optimization of results

In this step, the objective function Aflow (part name) will be use. The use of this function and associated elements will offer the average time parts/pieces spend in the FAC, the shorter the time spent is, the less interruptions, waiting times, collisions and of course better throughput would have been achieved. The optimization process will be carried out on the Scenario 2 what by analogy and under further needs can be easily extended to the other ones, i.e.: this has been done just for demonstration purposes. The following figures illustrate in a way how the process of optimization started to look like. The optimization has been carried out by the procedure proposed by [9] to which some modifications have been made, as shown in the correspondent Figure.

The Algorithm in Figure 8 helps reducing the number of MFCs. It has been necessary strategy in order to reduce the time in exploring a huge search area of MFCs or permutations arising from the scale of values of given variables of the devices of the FAC, i.e.: for our case, the speed the devices may operate at. Modifications made to it appear in red color.

Table 2. Estimated evaluations and time of the different Witness optimizer algorithms in evaluating the targeted instance.

Witness optimizer algorithm	Estimated evaluations	Total estimated time
Adaptive Thermostatical SA	1000	00: 35: 35 min
Six Sigma	1000	00: 35: 35 min
All Combinations	4 294 967 295	24 8 55 days (almost 69 years)
Random Solutions	100	00: 03: 33 min
Min/Mid/Max	243	00: 08: 38 min
Hill Climb	100	00: 03: 33 min

Source: Self-elaboration using the Witness optimizer (experimenter).

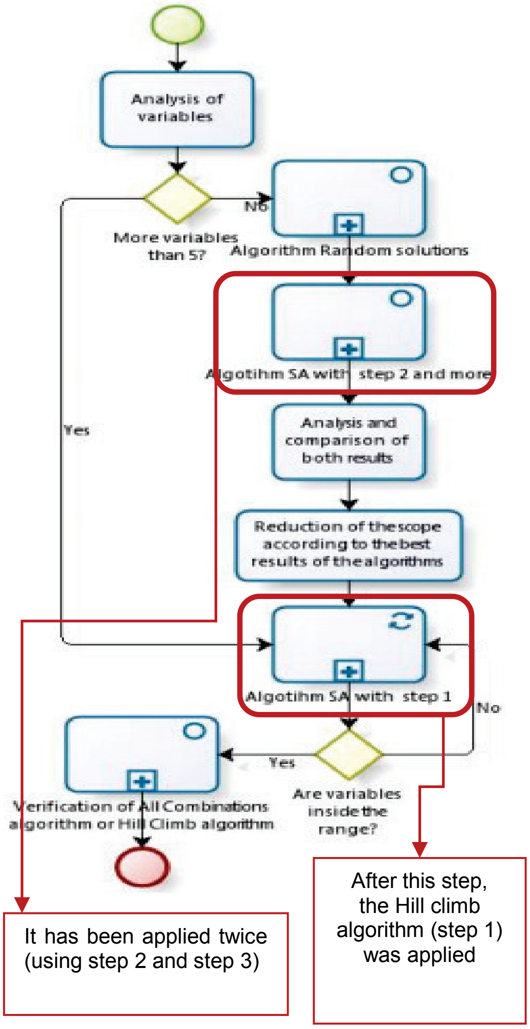

Figure 8. Optimization procedure. Source: Modified based on [9]

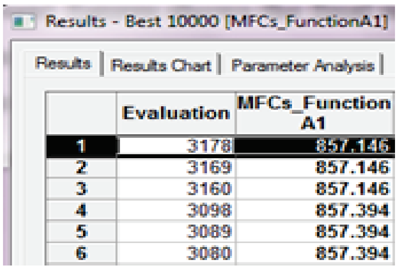

Figure 9. Partial interface of the Witness experimenter once applied the "All combinations" method.Source: Self-elaboration using Witness.

In synthesis, from this optimization process it can be concluded that the shorter throughput times are achieved when the devices ofthe FAC are used in the following speed percent respectively: CR ≈ 312, 33 sec ≈ 35 %; AGV (Robotino) ≈ 29, 33 sec ≈ 44 %; M ≈ 24 sec ≈ 25 %; ABB robot ≈ 12, 42 sec ≈ 30 %; RD ≈ 7, 12 ≈ 26 %.

6. Conclusions and further research issues

The present paper enhanced the use of simulation and simulation optimization in the design and analysis of the MF and layout. The Witness simulation software was enhanced and applied to a FAC where a new MF and layout scenario was simulated and proved to be better than the actual one being at present implemented. Similarly a simulation optimazation application showed how to deal with huge number of MFCs by reducing them and finding the best ones and shown in the above table. Further research issues may lie on extending the analysis made to other scenarios and on more explicitly boarding the whole combinatorial nature of the problem.

Acknowledgment

VEGA 1/0285/12 – Research on the possibilities of „intelligence„ implementation into the assembly process

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DETERMINATION OF STRESS THROUGH A STATIC FEM ANALYSIS OF LOCAL RESISTANCE IN THE CENTRAL AREA OF A CHEMICAL TANKER OF 49000 TDW

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Abstract

The purpose of this paper is to calculate and evaluate the general structural response of a chemical tanker of 49000 tdw, and to propose structural improvements where necessary.

Keywords: stress calculation, hogging, sagging, pressure, mechanical structural.

1. Introduction

The structure of the body took into consideration in the global model is 3D FEM being limited to three cargo holds in the central area of the vessel.

The structural model was initiated using MARS 2000, then it was developed, solved and post processed using the software FEMAP v9.3.1 as modeler and NX Nastran as solver [4].

2. Description and implementation of the model

The vessel considered is a chemical tanker type intended to carry chemical products. The primary concern with regard to the development of finite element analysis, consists in the generation of a model that provides the best possible results of structural strength. Model sizing was made in accordance with the rules of the Classification society Bureau Veritas for OIL TANKER (CSR) in MARS 2000 programme, where the preliminary structural model was made, in accordance with the general and local resistance rules. The cross section through the vessel is shown in Figure 1.

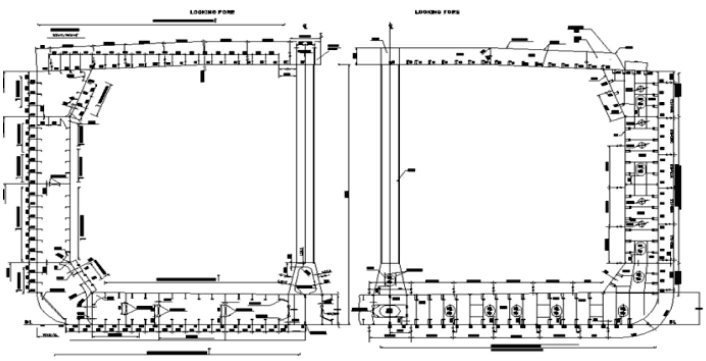

Figure 1. The cross section through the real size ship to the dead flat

For modeling and analysis of tensions around relief cutouts of a framing element, in this case of a floor frame, we have used the finite element software system FEMAP version v9.3.1, [4].

The main characteristics of the vessel are shown in Table 1.

Table 1. Main characteristics of the vessel

Total length of the vessel, LOA	178,5 m
Length between perpendiculars, Lpp	175 m
Width of vessel, B	32.2 m
Full load draft, T	12,6 m
Height of building, D	18 m
Block coefficient	0.807
Maximum speed	14.4 Nd
Displacement	49000 tdw
Intercostal distance in the cargo area	a = 0,8 m
Distance between floor frames	4a = 3200 m

3. Units of measurement, coordinate system

The global coordinate system of the finite element model is:

- X-axis: longitudinally, positive from the aft to bow
- Y-axis: transversely, positive towards port
- Z-axis: vertically, positive upwards

The following units are used for analysis:

- Length: millimeters (mm)
- Pressure: megapascals (N/mm^2)
- Mass: kilogram (kg)
- Stress: N/mm^2 (MPa)

4. Geometry and mesh

Model sizing was designed in agreement with the rules of Classification society Bureau Veritas.

In this calculation we have used a model extended throughout the length of three warehouses in the central area of the ship, so as to avoid end effect and more precisely, we have studied the central warehouse.

Given the complexity of the model and *Cross Mesh* digitization method, details like cutouts of the manholes or relief holes were not observed in terms of their connection radii because this aspect is insignificant in such a meshing.

Cross mesh method [3], [5] used involved the division of plates into plate finite elements with dimensions of 800/800 (Figure 2). Also, cross-sectional elements were designed by the same principle excepting some connection plates (Figure 3). Instead, in order to achieve the longitudinal framing elements (fore and aft, longitudinal double bottom plating, double bottom longitudinal, bridge longitudinal, rolling keel and reinforcing ribs) bar elements were used.(Figure 4).

Registry conditions recommend, for the finite element method analysis of ship structures, taking into consideration two or three cargo holds (cargo tanks) to decrease the influence of boundary conditions, along the pressure distribution in the master section.

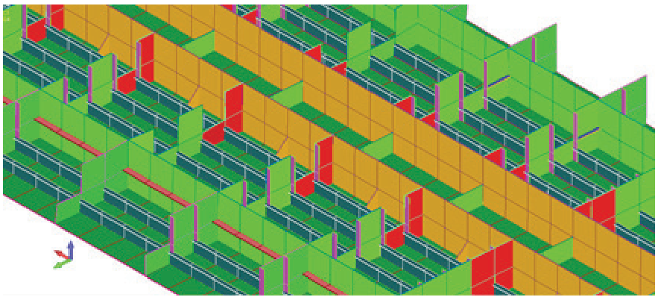

Figure 2. Representation of the bottom floor with composed frvvaming

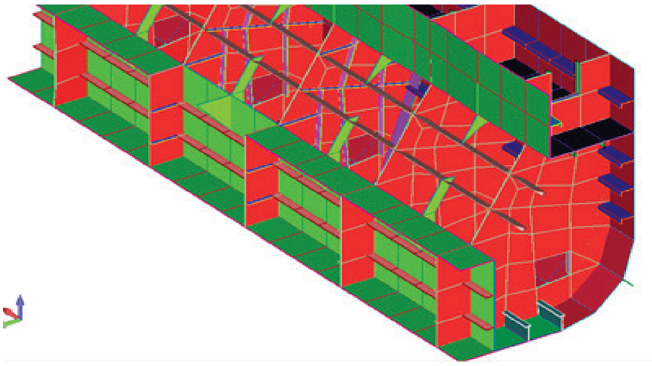

Figure 3. Representation of the bilge area and its components

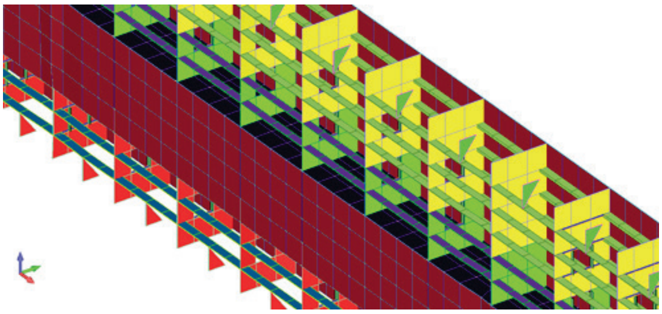

Figure 4. Representation of the double board area and its components

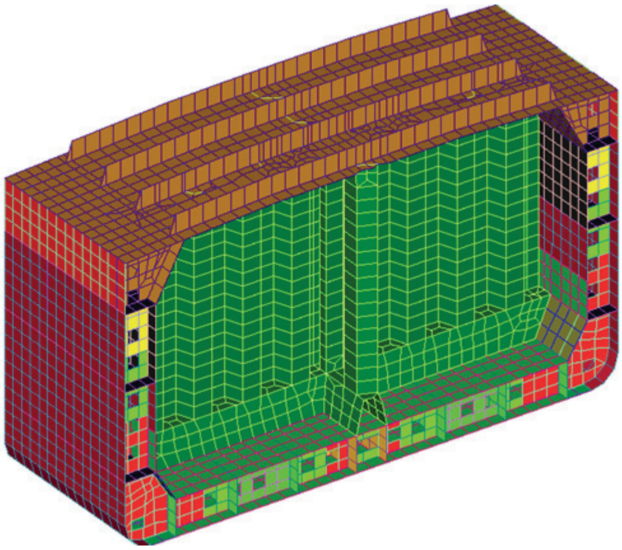

Figure 5. Representation of the longitudinal elements forming the vessel coating with supports, platforms and frilled walls.

All thicknesses of structural elements have been defined according to the sampling both for plate elements and for bar-type elements. In addition, the preparatory phase of this stage was to define the A-type of naval steel with various flow restrictors. R_{eH} = 235 N/mm^2 and R_{eH} = 315 N/mm^2.

Table 2 shows CAD-FEM model characteristics and material characteristics of the vessel.

Table 2. CAD-FEM characteristics of the model

Number of plate and membrane elements PLATE (QUAD)	35127
Number of bar elements	21590
Number of knots	30883
Young's modulus, E	2.1E+5 N/mm^2
Poisson's ratio, ν	0.3
Density of steel, ρ	7,7E-6 kg/mm^3

It should be noted that, in case of meshing the model, triangular elements have been also used where they were necessary to represent stiffeners or if rectangular plate elements could not describe accurately the model. However, their number is much smaller in comparison to that of the rectangular plate elements.

Each structural member was introduced according to its characteristics, and element modeling was performed broadly according to the plane orientation of local stiffeners, taking into consideration the layout of floor frame reinforced at four intervals from the rib together with the layout of the frilled transverse and longitudinal walls (Figure 5).

Figure 6 shows the model extended throughout the length of three warehouses [2], and Figure 7 presents the section in front of the neutral axis.

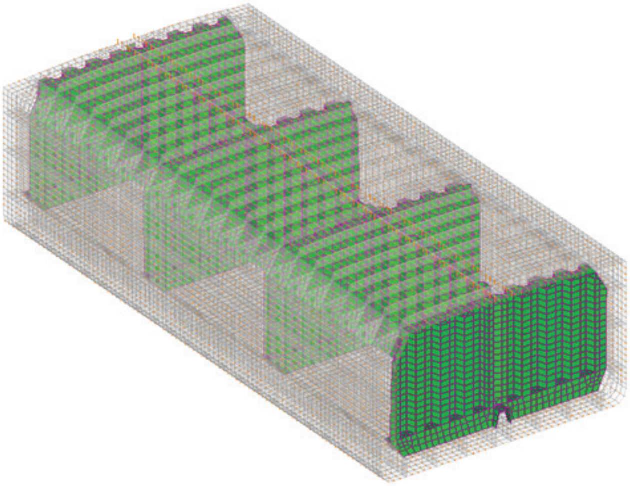

Figure 6. Representation of the frilled walls

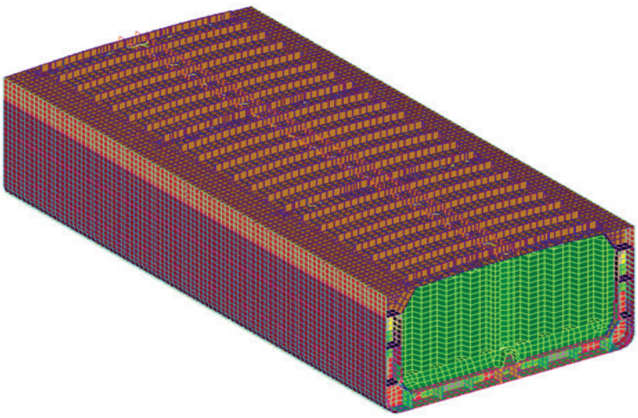

Figure 7. Representation of three warehouses

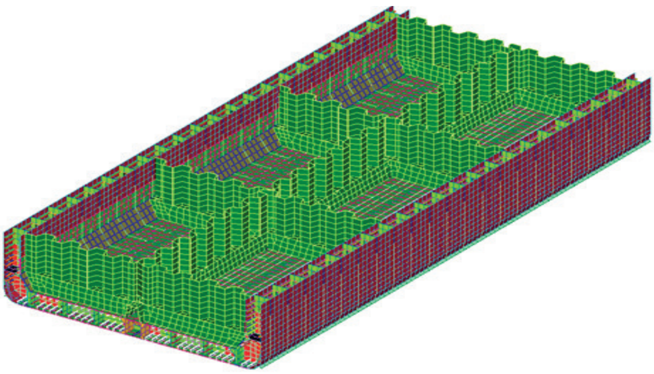

Figure 8. Representation of the section in front of the neutral axis

5. Boundary conditions

To model physical bearing points and the interactions with adjacent structures, it is necessary to predetermine a series of displacements and rotations of the finite element model.

As far as concerns blocking up movements and rotations we must take into account the fact that the supporting points should not affect the area of numerical interest (or be replaced with elastic ties) for a more realistic analysis of the model.

Therefore, the final conditions of this model consist of blocking the movement in the x, y and z directions and rotation around the X axis (Table 3).

Table 3. Conditions edge

Model	Displacements			Rotations		
	Ux	Uy	Uz	Rx	Ry	Rz
	X	**X**	**X**	**X**		

To achieve all these conditions, it was necessary to introduce a rigid knot so as to require the structure to block the displacements and spins mentioned above. The rigid knot is located on the vertical axis in the neutral zone and is positioned in the area of the aft of the structure (Fig. 8).

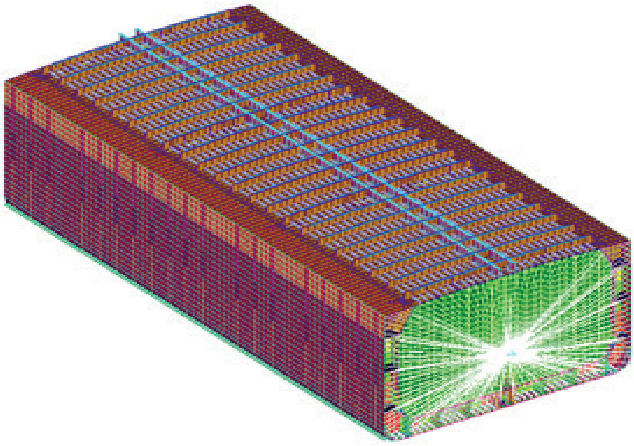

Figure 9. Representation of the boundary conditions in the aft area

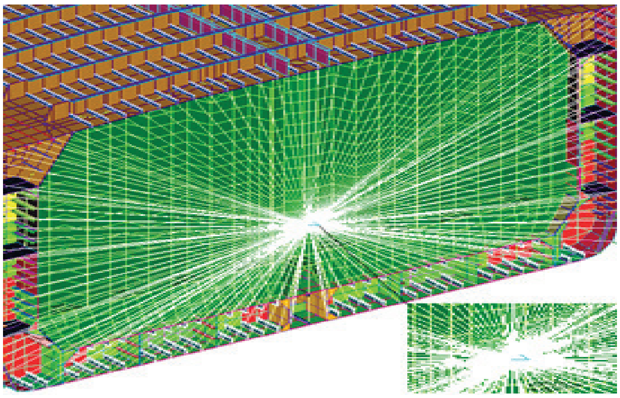

Figure 10. Representation of the rigid knot

6. Load capacity

The loading cases include:
- external pressures (still water and wave);
- internal pressures (hydrostatic, dynamic effect, safety pressure valve, sloshing, heeling);
- self gravity of the model;
- specific balanced boundary loads.

The section was modeled both with the pressure from the merchandise and the pressure on plating due to sea water.

The static pressure of the merchandise, [1], Figure 11, Phys is:

$$P_{hys} = \rho_{sw}\, g(T_{LC} - z\,),\ [kN/m^2] \qquad (1)$$

where:

z - the vertical coordinate of loading point in [m] and it should not be higher than T_{LC} ;

P_{sw} = 1.025 t/m³ - density of sea water

T_{LC} - draft in m;

g = 9.81 m/s², - gravitational acceleration.

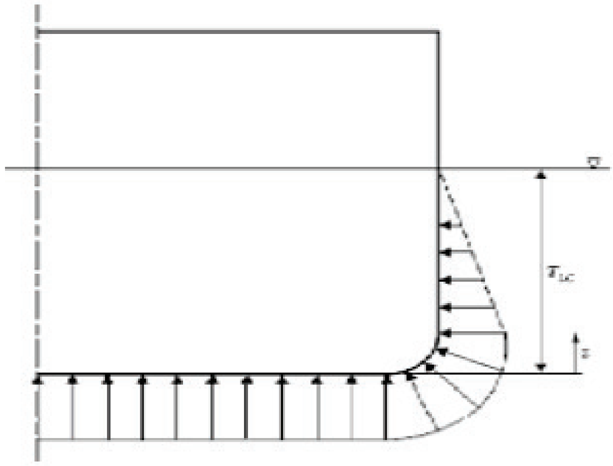

Figure 11. Hydrostatic water pressure distribution [1]

The static pressure of the merchandise, $P_{in\text{-}tk}$, is:

$$P_{in\text{-}tk} = \rho g z_{tk},\ [kN/m^2] \qquad (2)$$

Where (Fig. 12):

z_{tk}, - vertical distance the highest point of the merchandise in the tank, [m];

ρ - density of the merchandise in the tank, [t/m³]

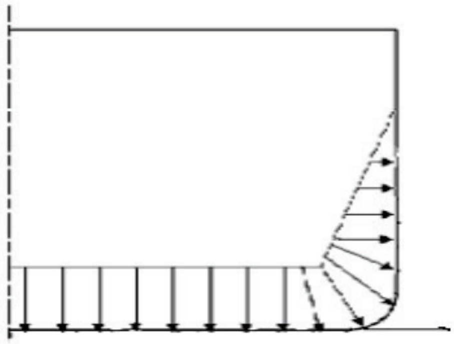

Figure 12. Hydrostatic cargo pressure distribution [1]

For the model in question two cases of loading were considered, namely the ship sitting on the hollow wave (if excess weight is amidships this is counteracted by excessive buoyancy in the bow and the aft- Figure 10),and in the reverse situation it will cause higher sinking of the ship ends, bow and the aft, compared to amidships, in which case wave crest occurs (Figure 11). Most commercial ships tend to have a slightly sagging at full load and hogging when in ballast.

The moments were applied to the ends of structure in order to obtain the maximum torque amidships for the two cases considered. Torque value is calculated under the rules of CSR register *Common Structural Rule*.

As far as concerns the position of the point of torque application, they are applied to the appropriate vertical position of the neutral axis in the diametral plane of the vessel.

L.C.1 – Alternate loading of cargo in holds

Ship on wave crest, maximum hogging bending moment (wave + static) obtained at middle of the structure [1].

The loading conditions for this loading case are:

- external hydrostatic pressures corresponding to Tmax ;
- external pressures due to wave crest
- internal pressures in the holds according to: GL Rules I-1-1, Sec.4, D1 (Figure 13a); - moments were applied at both ends of the structure in order to obtain the maximum bending moment (hogging - wave + static) at the middle of the structure.

For this loading case, significant results are expected for the shell plating, transverse bulk-heads and stools, transverse rings, longitudinal girders.

L.C.2 - Homogeneous cargo in holds

Ship on wave trough, maximum sagging ben-ding moment (wave + static) obtained at middle of the structure from all homogeneous cases.

The pressure calculation for this loading case is similar to loading case 1.

- external hydrostatic pressures corresponding to Tmin;
- internal pressures in the holds according to: GL Rules I-1-1, Sec.4, D1 (Figure 14a);
- moments were applied at both ends of the structure in order to obtain the maximum bending moment (wave + static - hogging) at the middle of the structure;
- the boundary loads were applied so that the model remains in equilibrium.

For this loading case, significant results are expected for the shell plating, transverse rings, longitudinal girders.

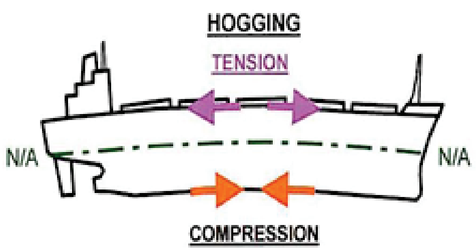

Figure 13a). Schematic representation when the ship is on the crest of wave

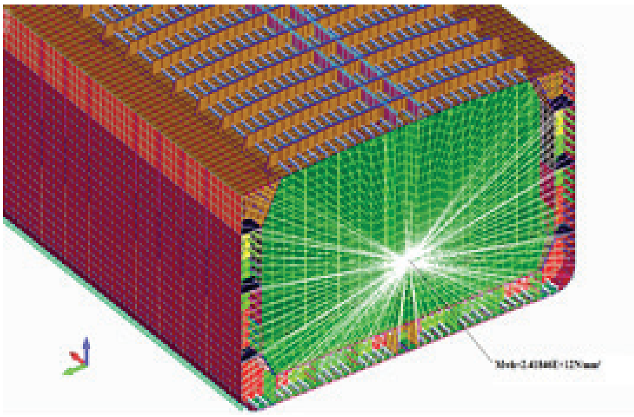

Figure 13b). Torque application when the ship is on the crest of wave

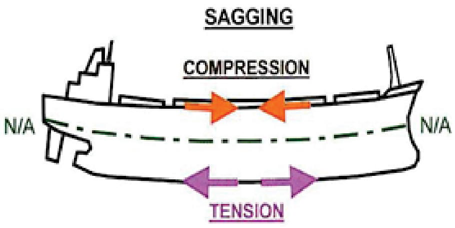

Figure 14a).Schematic representation when the ship is on the crest of wave

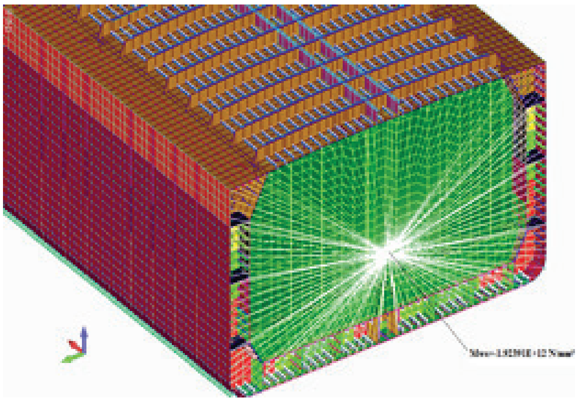

Figure 14b). Torque application when the ship is on the crest of wave

7. Calculation and evaluation of results

We present below the results obtained from the linear static analysis carried out for the ship loaded with goods and still water pressure. These results are generally charts with von Misses stress distribution, with a color scale, corresponding to stress levels plotted for each element of the structure shown. Figures 15-20 presents the distributions of Von Mises stresses for wave crest case and wave hole case. In general, one can say that the boundary conditions were chosen appropriately, which is why there is no noticeable effect on the stress field.

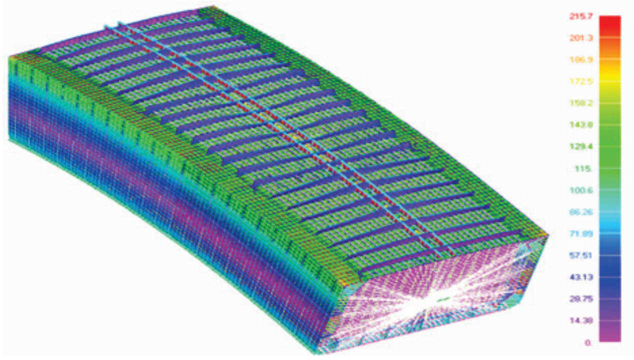

Figure 15. Von Misses stress when the ship is on the crest of wave

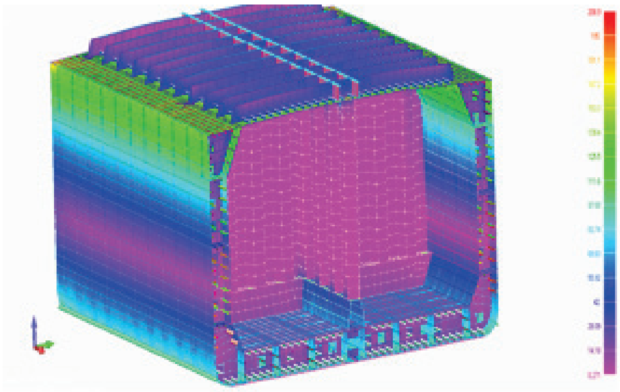

Figure 16. Von Misses stresses occurring in the central warehouse, when the ship is on the crest of wave

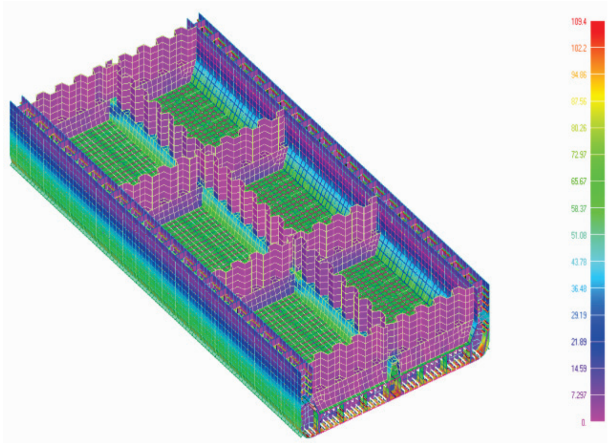

Figure 17. Von Misses stresses that occur in the neutral axis, when the ship is on the crest of wave

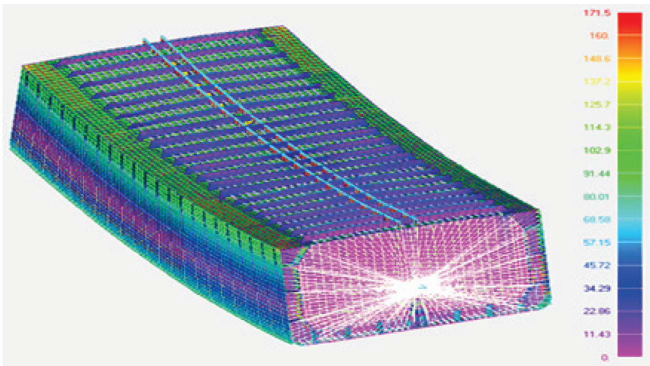

Figure 18. Von Misses stresses when the ship is on the wave hole

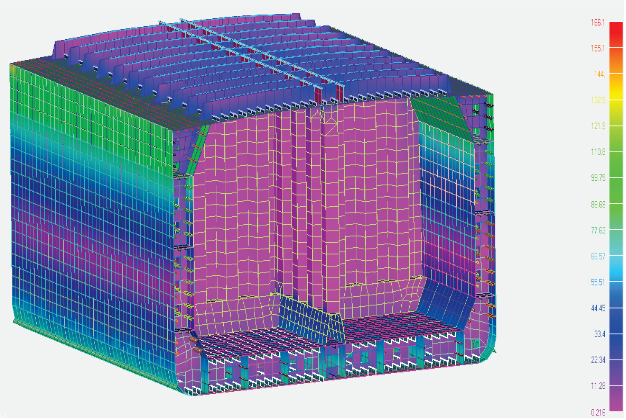

Figure 19. Von Misses stresses occurring in the central warehouse, when the ship is on the wave hole

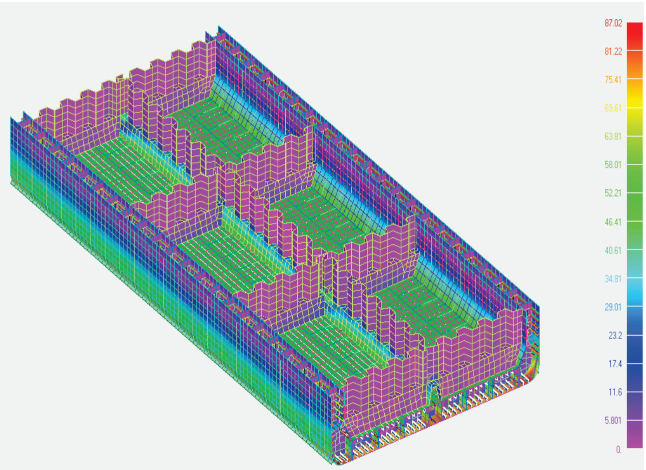

Figure 20. Von Misses stresses that occur in the neutral axis, when the ship is on the wave hole

8. Conclusions

The purpose of the 3D static analysis is to determine the overall structural response of the hull girder, and also to obtain appropriate boundary conditions for use in the 3D fine-mesh analysis of local structures.

Generally, one can say that, the edge conditions were chosen properly, reason for which there are no visible effects on the stress field.

Following the analysis performed it is noticed that the model subject to the torque action characterizing loaded structures on the wave crest and respectively on the wave hole, presents a satisfactory structural integrity. This is due to the elements showing a strong stress however, without exceeding the value of the yield strength of the material Reh=315 N/mm², maximum values being 215.3 N/mm² for the crest of wave and 171.5 N/mm² on the wave hole.

In order to improve the overall strength a solution could be the construction of a *stolen* at the top of the corrugated walls. This solution could improve global resilience of the ship because the adaptation of such constructive solutions allow uniform discharge of tensions that arise at deck level given that the deck registers the highest values of stresses.

Regarding deformations in structures, they fall within the limits imposed and do not represent any danger to the structural integrity of the model analyzed.

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THE CHANGES OF THE AUTOMATED ASSEMBLY WORKPLACE WITH THE CAMERA CONTROL SYSTEM

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Abstract
This contribution focuses on the laboratory of flexible manufacturing systems with robotized operator for environment of drawing-free production, which is located at the Institute of production technologies. The practical education of drawing-free documentation using the software Catia and Autocad special focused on the mentioned laboratories. Students create 3D models of parts and whole machine units according the required tasks using the programs of modeling/design and then it is subsequently generated to 2D drawing and NC program. It is possible to realize the production of specified machine parts, units and also their subsequent assembly on the final workplace with using the CNC machines. All of these laboratory facilities are intended not only to help the educational process and motivate students but also to use them in the bachelor and diploma thesis which are supposed to allow students to virtually create the new conceptual designs realized in the each manufacturing and assembly workplace/station of the system. This contribution focuses on the design of the automated assembly workplace on the base of the new base part what has been designed and produced in our laboratory.

Keywords: part, machining center, model, flexible production system

1. Introduction

With the present trend of automation increasing in the production processes in industry, it is necessary to increase the technological level of elements, which creates these automated systems. An important factor in all the elements of the system is reliability. The proper functioning of the production system, designed in regard to the elimination of product defects is needed to achieve the desired quality. The increasing of the capacity of computing performance also affects areas such as computer/machine vision. Machine vision can be called as the part of data processing, which aims to acquire and process the relevant information of the captured image. In the industry, there is the machine vision used and it interferes to the production process. High labor costs in developed countries are an important factor for the growth of automation. The increase of the machine vision in the application occurs for different reasons. One of the factors is the increasing of this still relatively young technology. Foreign authors describe also research in relatively new area such as machine vision in their articles [1,2,3,4,7].

With an ever-increasing performance of computer technology and data processing, implementation of machine vision tasks became more easily feasible and economically recoverable. We also try to work with the students to realize their proposals, designs of the new base parts in the case of their diploma and bachelor thesis in the mentioned laboratory flexible manufacturing system with robotized operator. Regarding the new base parts it is necessary to implement some changes to the individual workplaces of the flexible manufacturing system where it is necessary also to count with the subsequent implementation of machine vision tasks.

2. The analysis of the current state of the automated assembly workplace

A flexible manufacturing system shown in Figure 1, which is located in the mentioned laboratory is used as a modular, open, flexible, manufacturing and assembly system. The central part of the system is a pallet conveyor system (which works as a conection between the individual workstations of the system). This system consists of the five workplaces such as:

- milling workplace,
- turning workplace,
- automatic storage workplace,
- control workplace,
- assembly workplace.

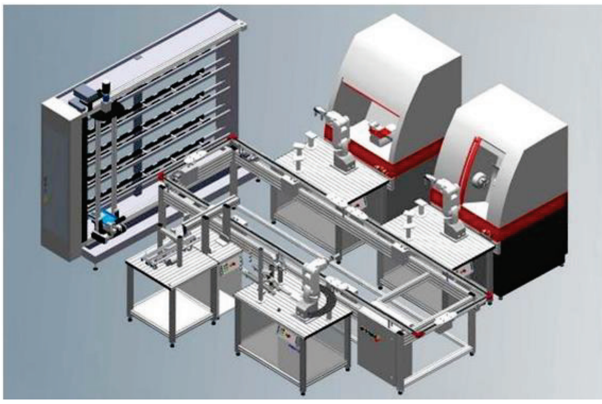

Figure 1. Flexible manufacturing system type

The automatic storage workplace is the main storage for all material used in the iCIM production, raw and semifinished parts as well as the end products. All workpieces are stored on the standard pallets, equipped with the fixtures for each specific workpiece. This storage workplace also provides the intelligent evidence of the production by the superior control system, [5].

The production is provided by two CNC machines (concept turn and concept mill) on the base of the production procedures, which are automatic sent to the production devices from the superior control system. The manipulation with the raw, semifinished parts and end products of the whole system is provided by a few angular industrial robots [2].

One of the most important elements/parts of the system is robotized assembly workplace shown in Figure 2, which provides the final mounting. Assembly workplace consists of several parts.
1. camera,
2. buffer of pens,
3. buffer of hygrometers,
4. buffer of thermometers,
5. RIA-Box,
6. CR1D controller,
7. operating panel,
8. robot RV-3SDB,
9. mounting module,
10. workpiece holder for camera control,
11. system palette

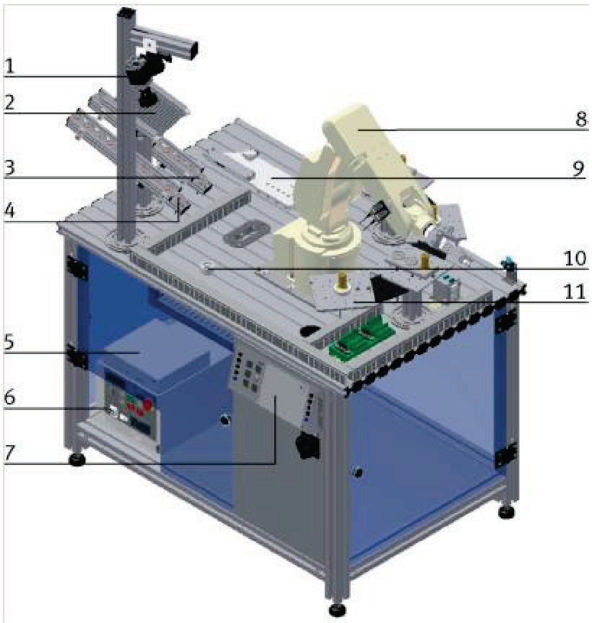

Figure 2 Robotized assembly workplace

The produced composition shown in Figure 3, which is produced and mounted in this system consists of five parts such as: baseplate, penholder, pen, thermometer – device used for temperature measurement, hygrometer – device used for humidity.

After the production of the required penholder and base plate - produced in milling and turning workplace, the parts of the composition are transported by the pallets to the workplace for the final assembly measurement, [8,5,9].

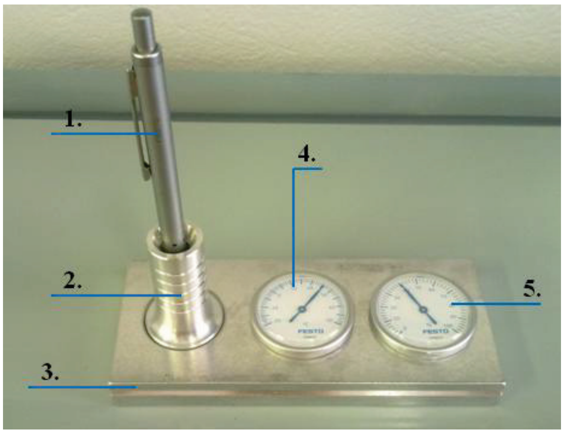

Figure 3. Composition to be initially produced in the system iCIM

3. The design of the new base part

The system ICIM 3000 is a flexible manufacturing system, what means that there will be proposed the change of the production program modification. One of the objectives of the changes made in the laboratory is to propose a new assembly composition which will be assembled at the assembly workplace with the camera control system within the system ICIM 3000.

In the designing of the new assembly composition, it is necessary to take into account many various factors which limit the possibilities of storage, transport and assemble of the components (i.e. limiting of the capacity of the robot in the automated storage system, dimensions, etc.). Individual components of the designed assembly composition are shown in the Figure 4.

Figure 4. Mechanical damper of the bumps

A simple mechanical bump damper/absorber has been elected as the new composition. The damper is designed to absorb the mechanical pulses generated by kinetic energy. Damping elements are two springs which have different diameters with different rigidity in this case. Mounted damper consists of the following components:

1. The outer body covering,
2. The compression spring STN 02 6002 a larger diameter (outer diameter of the spring Φ33,5 and diameter of the wire Φ6)
3. The compression spring STN 02 6002 a smaller diameter (outer diameter of the spring Φ20 and diameter of the wire Φ4),
4. Circular Pad Φ33,5x6,
5. piston of the damper,
6. Plain washers nut M12 STN 02 1702,
7. Hex nut M12 STN 02 1401,
8. pin Φ4x20 STN 02 1781.

The installation procedure is shown in Figure 5.

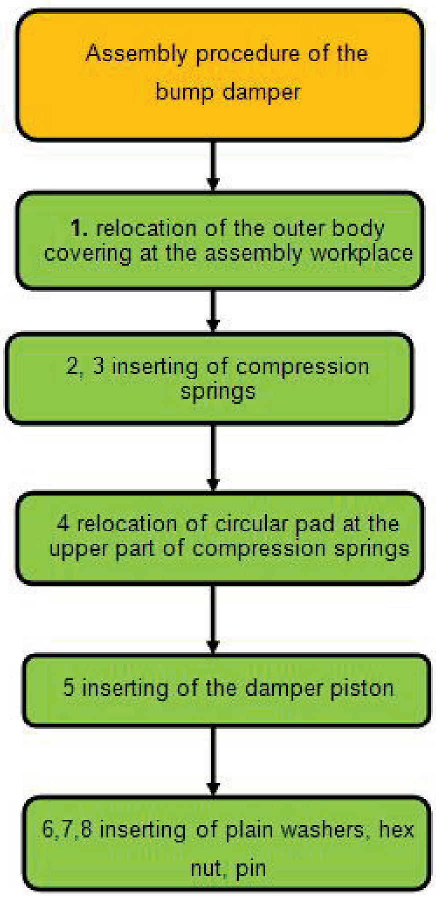

Figure 5. Assembly procedure of the damper

The composition is completed after the securing of the piston position by washers, nuts and cotter pin. Figure 6 shows the assembled composition of the damper.

The introduction of a new damper composition is not necessary to change the system pinch palettes shown in Figure 7. Only a simple change of the stop pins 1 in the palette is sufficient.

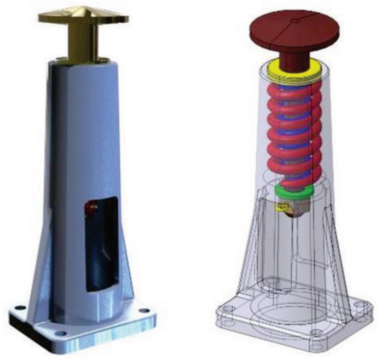

Figure 6. Mounted composition of the damper

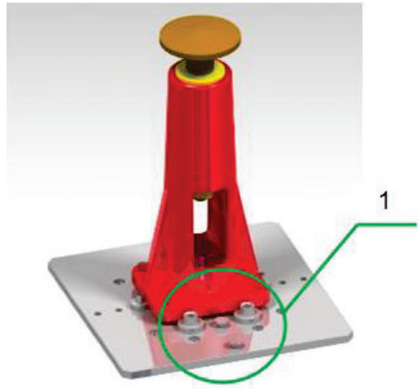

Figure 7. Damper composition on the pinch palette

The composition can be assembled by several types/variants from the different springs of different stiffness and different body. The purpose of camera control which is implemented in the assembly workplace, is the control of the selection of the proper spring. The individual variants are different in the following attributes:

- three types of material used to form the body of the damper (differentiated by various colors of the surface treatment)
- four types of the springs of greater diameter Φ33,5, which differ by the total number of turns, and thus the stiffness (color-coded surface);
- four types of the springs of smaller diameter Φ20, with different numbers of threads and stiffness (also color-coded).

4. Design of the automated assembly workplace with the camera control

The design of the automated workplace based on the arrangement of the elements in the original assembly workplace with the camera control in the manufacturing and assembly system ICIM 3000. After the change of assembly composition, it is necessary to make several changes. Design and model has been implemented in CATIA V5 from Dassault Systèmes.

New assembly workplace consists of several parts, which are shown Figure 8:

1. camera system, 2. preparation for the establishment of the springs in the control, 3. angular

robot Mitsubishi RV-2SD, 4. pallets for storing the finished assembly compositions, 5. NOK box for the sorting of the wrong springs, 6. buffer of the springs Φ33,5, 7. buffer of the springs Φ20, 8. buffer of the spring covers Φ33,5x6, 9. buffer of the damper piston, 10. buffers for the manual assembly of the washers, nuts and cotter pins, 11. assembly module.

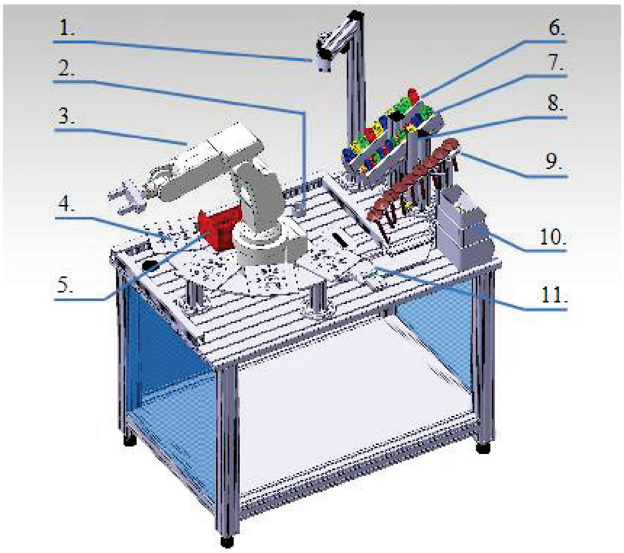

Figure 8. Designed automated assembly workplace

At the beginning of the process operation control system initiates a request to the assembly of the damper composition, and it enters the specific parameters of the required composition. After entering the system requirements for the assembly if the composition in a particular format (elected body type and springs Φ33,5 and Φ20) in automated storage using the cartesian robot displacement of the pallet with the competent body of the damper. Pallet is supplied by the conveyor system to the workplace where the angular robot transfers components from the palette to the assembly module. Assembly module shown in Figure 9 contains of several changes compared to the original solution.

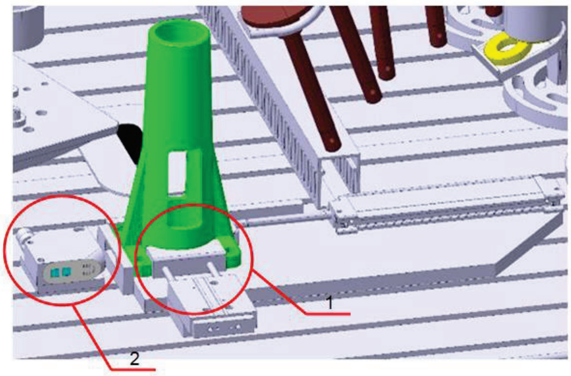

Figure 9. Damper body in the assembly module

After placing the body of the damper to the assembly place, it activates the activity of the rectilinear pneumatic actuators. Jaws 1 on a smaller actuator have been changed. They are designed and centered on the exact shape of the damper body, and provide better support during assembly. It had also been removed inductive sensor that detects the presence of the component. Function of the inductive proximity sensor has been replaced by the color sensor Festo SOEC-RT-Q50 2, which senses the color of an object through a cutout in the wall, which partially eliminates the formation of glare and thus erratic sensor. The sensor is easy to setup using the button called teach-in function. It offers three adjustable channels which are preset to concrete color using a teach-in function. It has its own LED light source and it is shown in Figure 10.

Figure 10. Color sensor Festo SOEC-RT-Q50

The sensor simply detects body color of the damper, closes the respective channel and sends information to the control system. The system evaluates if a captured color corresponds to the selected requirement. If all goes well, the system continues operating procedures. If the color doesn´t match, the damper body is returned to the automated storage, where the new require is also initialized for the proper body damper. After the evaluation of the correct color by the sensor, robot grips the spring (diameter Φ33,5) from the catchment buffer in Figure 11, where the springs are arranged in accordance with the requirements precondition to the order of assembly.

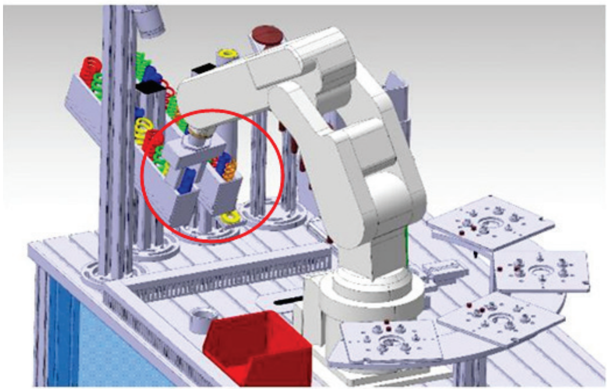

Figure 11. Selection of the spring from the buffer by the robot

To verify the correct type of the spring, the robot places the component to the control workstation. The control workstation has been changed from the original. It has different, customized dimensions and there is located also thorn for better stability of the springs. After the establishment of the component to the control workplace, it follows the camera control. The software system using a camera control evaluates:

- color of the springs - compares comply with the type of chosen spring
- diameter of the springs - software measures the outer and inner diameter of the spring - for elimination of the errors caused by the correct color but the wrong diameter. Upon the detection of the errors is the spring moved into the red NOK box. The service for the filling of the box takes the next process of the grading NOK components. In the case of the successful control, the spring is placed in the body of the damper. The same procedure follows in the assembly of the spring with a diameter Φ20. The next step in the assembly process is the placement of a circular spring cover Φ33,5x6. Components are placed in a free-fall buffer. The robot picks up the cover and moves it on top of the springs in the assembly composition. After this process, it is added a piston of the damper, which is also delivered by the robot to the gravitational axis of the damper buffer shown in Figure 12.

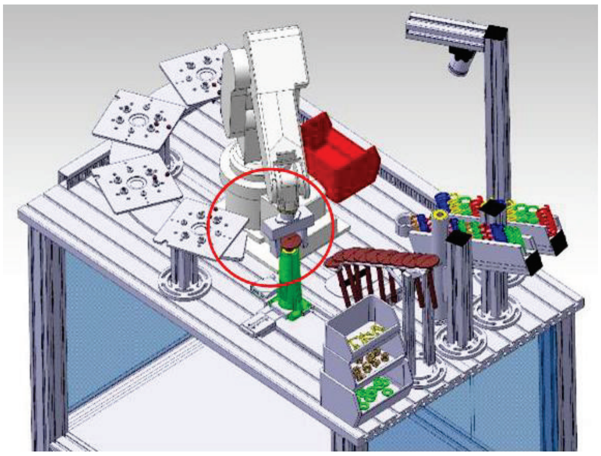

Figure 12. Inserting of the damper piston

The last step in the workflow of the assembly is the application of the three components of the fastener rows: Plain washers nut M12 STN 02 1702, hex nut M12 STN 02 1401, pin Φ4x20 STN 02 1781.

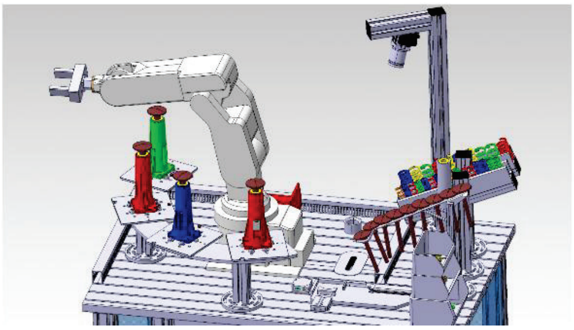

Figure 13. Storage places with the completed compositions

After these operations, the process of assembling is complete and final composition is transferred to one of storage places as is shown in Fig. 13. System organizes the transferring of assembled composition on the palette by conveyor system according to the information about available free palette.

Due to the need for an expanded work area for other active elements that would allow automated assembly of the fasteners, the assembly of the last three components is fitted manually by the service personal. In the future and the future research and proposals made in the system ICIM we do plan not only the mentioned expansions of the workplace of the assembly but also another frameworks of the implementing of more active elements necessary for automated assembly washers, nuts and cotter pins.

5. Conclusion

Given assembly composition has been designed in regard to the possibilities of the system ICIM. It is a prerequisite for further development of a complex system using the given composition. Non-standard components - damper piston and cover springs will be produced directly in the production system within system ICIM 3000 in future. This is related to other changes in the system and change of pallets in an automatic storage. It also creates space for introducing of the mentioned automation for the assembly of plates, nuts and split pins to the suggestion to be assembled manually. Therefore, in the future, we aim to realize and implement further changes to the flexible manufacturing and assembly system, to adapt it to production, assemblage of the new base parts, which will be based on the requirements from the practice. Foreign authors describe also research in relatively new area such as machine vision in their articles [6,7]. The main purpose is intensive linking of the educational process with the practice, what will increase the competitiveness of our graduates in the current labor market in Slovakia and also in the framework of globalization on the pan-European labor market.

6. Acknowledgement

This work was supported by KEGA 027-STU 4/2014: Establishment virtual laboratory of robotics and manipulation techniques

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STRESS AND BUCKLING ANALYSIS FOR TOWING HOOK AFT AND TOWING BIT AFT

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Abstract

The hooks are the basic elements of the towing installation being the main fixtures to the tugboat of the free end of the hauling rope. Calculation on stress for Towing Hook aft and Towing Bit aft is very important to know and determine the strength of tug structure when using the towing equipment.

Keywords: FEM, tug, towing bit, towing hook, winche, stress, buckling.

1. Introduction

A tugboat (tug) is a boat that maneuvers vessels by pushing or towing them. Tugs move vessels that either should not move themselves, such as ships in a crowded harbor or a narrow canal,[1] or those that cannot move by themselves, such as barges, disabled ships, log rafts, or oil platforms. Tugboats are powerful for their size and strongly built, and some are ocean-going. Some tugboats serve as icebreakers or salvage boats. Early tugboats had steam engines, but today most have diesel engines. Many tugboats have firefighting monitors, allowing them to assist in firefighting, especially in harbors, [3].

Figure 1.Example of Tug [4]

The main characteristic of tugs is the towing installation, by means of which hawsers are fixed and handled. For small tugboats, this installation is reduced to the towing hook that is fitted with a strong spring for shock absorption. Regarding big tugboats, with a traction force that reaches 80-100 t, they are equipped with towing winches to modify, as the case may be, the length of the hawsers as well as a series of mechanical devices for their braking [4]. The towing installation provided on a ship that contains symbol "Tug" means all the equipment and facilities of this ship provide the possibility to perform the following operations:

- "in line" towing; in this case the towing equipment is located in the aft.
- escort towing operations which are performed with the towing equipment located in the bow of the ship.[2]

The effective structure of a towing installation is established by the Technical Specification of the vessel as theme of design, containing the following elements:

- hauling ropes;
- towing winches;
- towing hook;
- towing bollards;
- guides / limiters for the hauling rope;
- stern roller guide;
- towing rails;

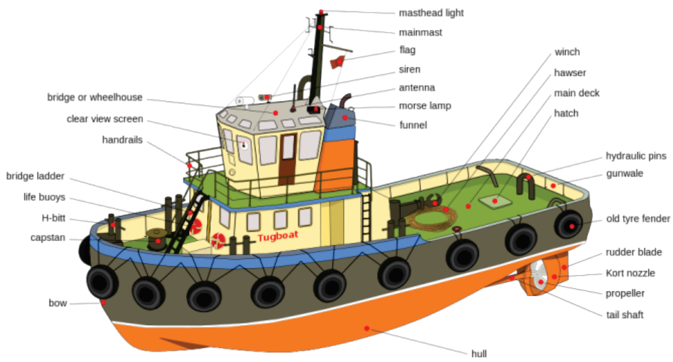

Figure 2.Diagram of components [2]

The towing hookshall be located as far as possible, immediately in in the aft, in the center of gravity of the shipand as low as possible, so as to increase its handling and transverse stability.It can be found directly on the upright frame or on the towing hook, closely linked to the framework rod of the body [5].The hooks are basic elementsof the towing installation, being the main fixtures to the tugboat of the free end of the hauling rope. The towing hooksaccepted for operation are closed, allowing the release of thehauling ropeonly on command. To take over cable shocks, they are provided with axial shock absorbers [6].

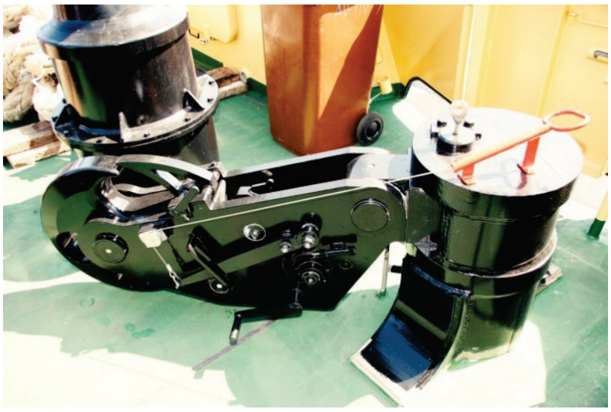

Figure 3.Example of Tug [6]

To execute the towing hook, the following requirements of the rules of Classification Societies shall be considered:
- hook resistance will be provided for a calculated hook force:

$$TC = C \ x \ T \qquad (1)$$

where „C" is un supra-unitary safety coefficient.
- hook construction and its fastening to the ship will ensure its rotation both vertically and horizontally.
- the hook will be provided with a quick release system, able to operate in cases of emergency with the towing hook under load [7].

The dimensions of the towing hook depend on the traction force on the hook that is given bytug power. The tug boat is chosen using the formula:

$$N = \frac{N_{mac}}{\frac{V_{\max}}{V}} \qquad (2)$$

where N is tug power (CP); N_{max} tug power according to its technical book (CP); V_{max} – tug boat speed without trailer (Nd), V – towing speed (Nd)

2. Modeling equipment with Rhinoceros

Rhinoceros is one of the standard 3D modeling programs, providing efficiency in the layout, design and execution program, with high accuracy of three-dimensional objects and beyond.

Rhinoceros program was chosen because it is compatible with other 3D software programs, and its use is very simple (in the case of 2D models, the commands are identical to those in Autocad).

Modeling the towing hook in Rhino is reduced to the use of two distinct types of objects: curves and surfaces. It will be taken into account the fact that any area is a rectangular grid that can be deformed until the overlapping of opposite edges and that any edge of an area is a curve that can be reduced to a point. Moreover, surface properties are also used: closures, singularities, cuts, unions.

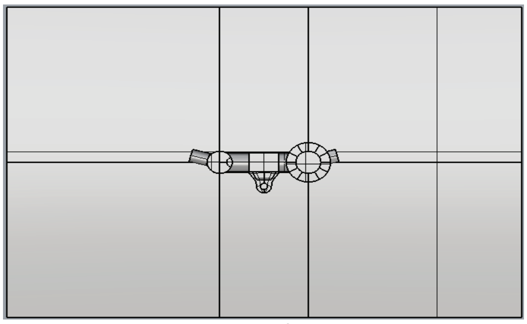

Figure 4.Top View of the towing hook

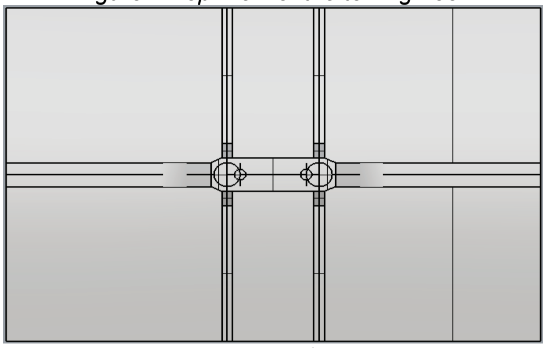

Figure 5.Bottom view of the towing hook

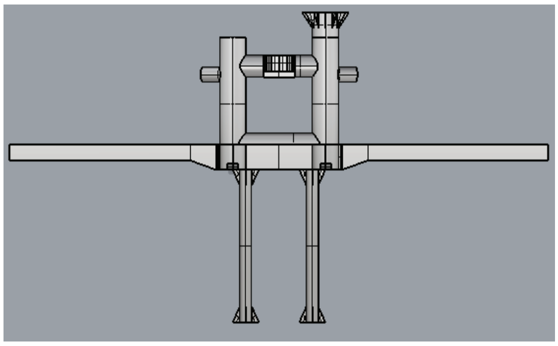

Figure 6.Front view of the towing hook

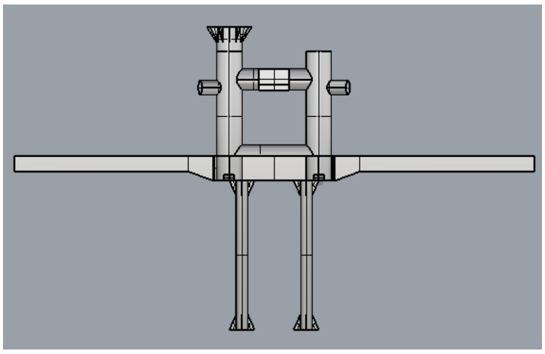

Figure 7.Back view towing hook

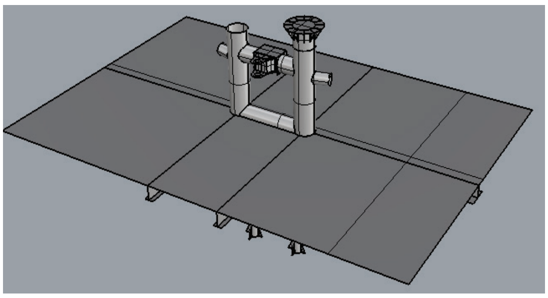

Figure 8.Perspective view of the towing hook

3. FEM analysis of the towing hook

The geometry modeled in the design software Rhinoceros is exported to Femap, program where analysis of stress and buckling of the towing hook will be carried out. These analyses are carried out in order to obtain optimum efficiency and safety in operation.

Femap software developed by Siemens PLM Software is an application of advanced engineering simulation that creates models of finite element analysis of products and complex systems and finally displays the analysis results. Femap can model virtual components, assemblies or systems andcan determine their behavior in aset operating environment.

After importing the model in Femap, material is defined. A-grade steel with the following characteristics are used:

- Young's modulus: E = 210000 N/mm^2
- Poisson coefficient: = 0.3
- Density of steel: ρ = 7.85x10^{-6} kg/mm^3

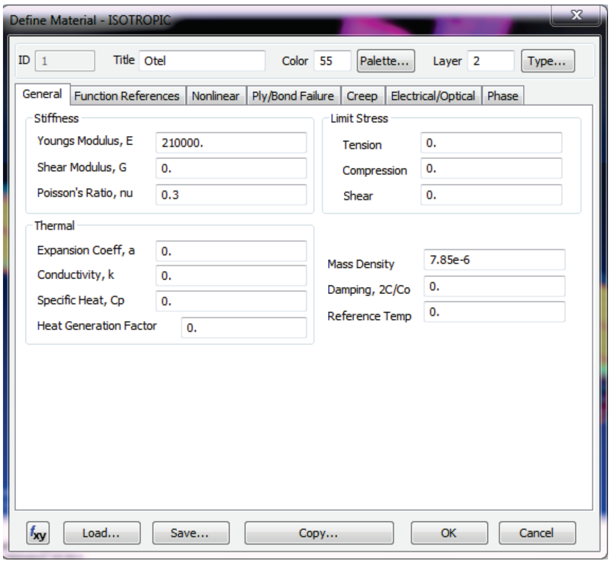

Figure 9.Defining the material

Table 1. Thickness of the structural elements

Structural elements	Thickness	units
Deck	12	mm
Pontill	40	mm
Flatbar	12	mm
Longitudinal elements	40	mm
Towing hook	45	mm
Crane column	40	mm
Columns reinforcements	40	mm

Meshing is generally made to meet practical requirements. In terms of mesh dimension, one was chosen so as to capture a deformation as naturally as possible, without requiring too much the computing system. In making the mesh, flat-type elements and rigid nodes were used that were applied external forces, Figures 10-14.

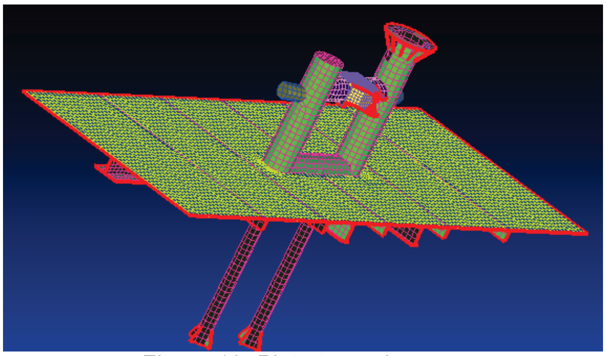
Figure 10. Plate-type elements

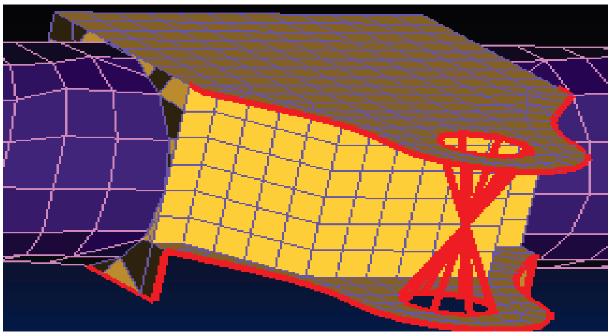
Figure 11. Rigid type element

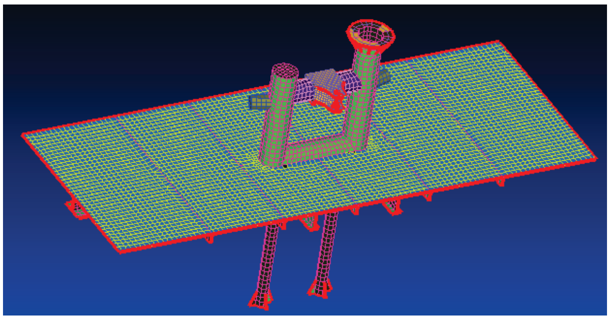
Figure 12. Meshing of the model - top view

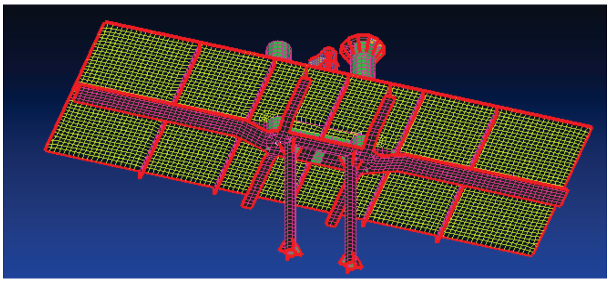
Figure 13. Meshing of the model - bottom view

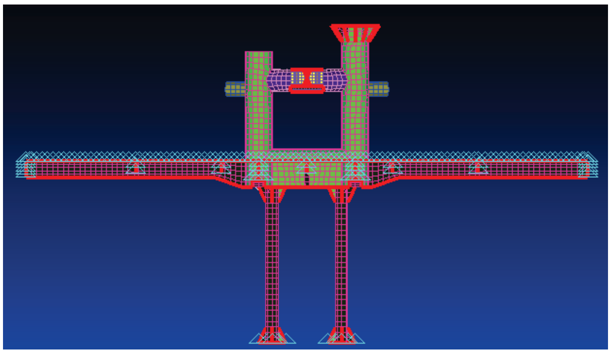
Figure 14. Boundary conditions

In order to achieve the structure plate-type elements (flat) were used, and for buckling analysis, bar type elements (bar) were used for reinforcement.

As far as concerns boundary conditions for this model, embedding is used, preventing any displacement of the element:
- on the edge of the deck
- the ends of the framework elements
- two pontills.

4. Stress analysis - Results

For the towing hook 3 analyses were carried out to verify if the structure is resistant to stress. In all three cases, the maximum stress that the structure can withstand, according to the Register, is 235 MPa. However, a safety factor of 1.2 will be taken into account. Therefore, the values obtained from the analysis should not exceed 195 MPa. Below, the three cases of stress analysis are shown. In the first case a force of -1275300 N is applied in the Y direction, Fig. 15, and the results are shown in Figures 16-18. In the second case the same force is applied, but instead of Y direction, acting at 45^0 Portside (PS), Figures 19-21. Finally, In the third case the same force is applied, acting at 45^0 Starbord (SB), Figures 22-24.

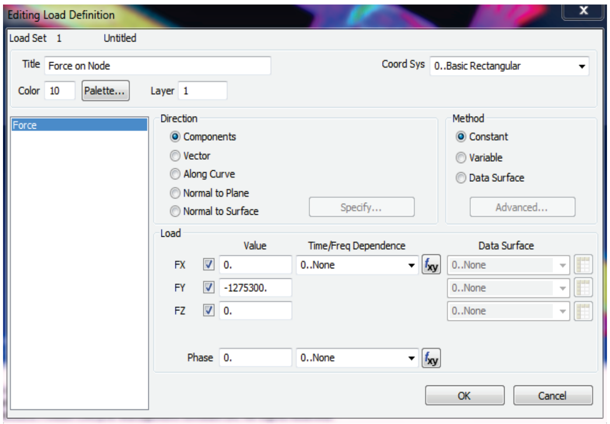

Figure 15. Load case 1 - 0^0 from CL

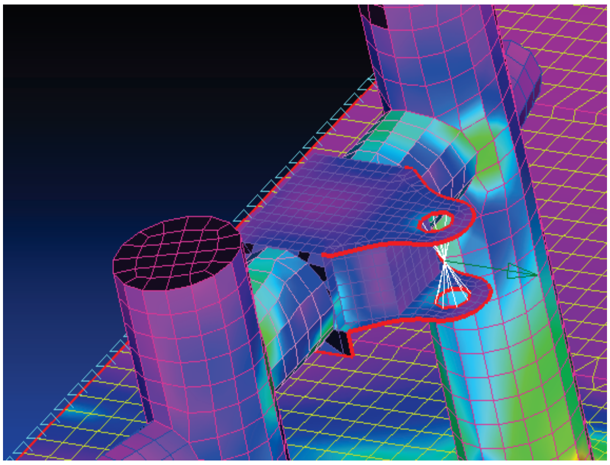

Figure 16. Load case 1 – towing hook 0^0 from CL

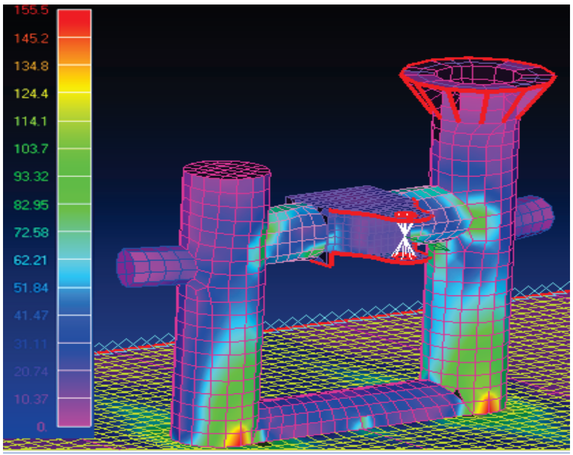

Figure 17. Load case 1 - Von-Mises results

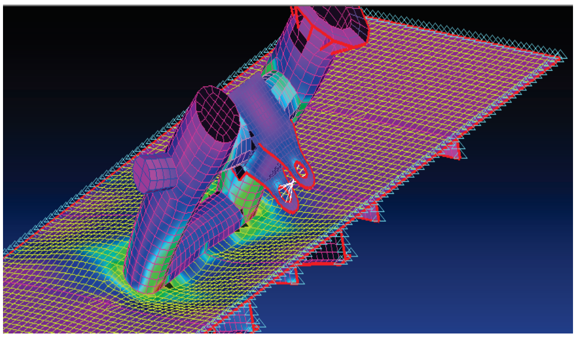

Figure 18. Load case 1 - Deformation

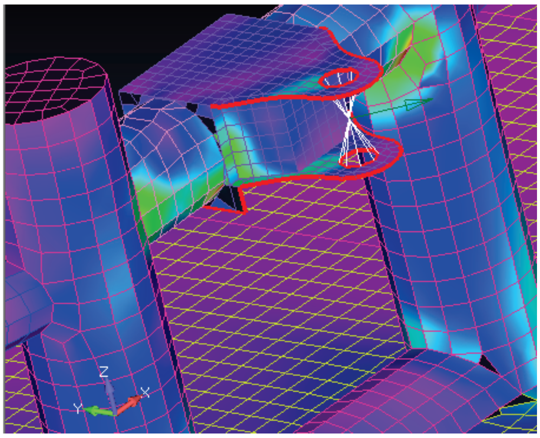

Figure 19. Load case 2 – towing hook 45^0 PS

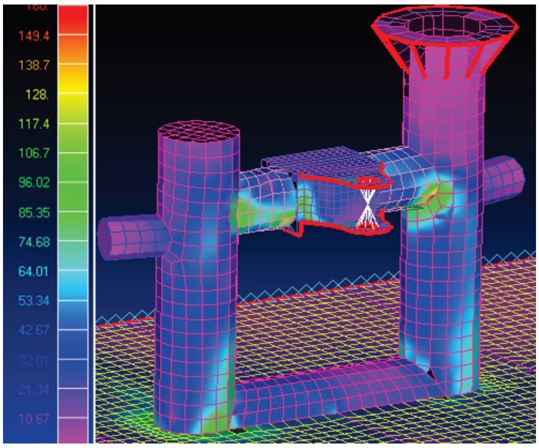

Figure 20. Load case 2 - Von-Mises results

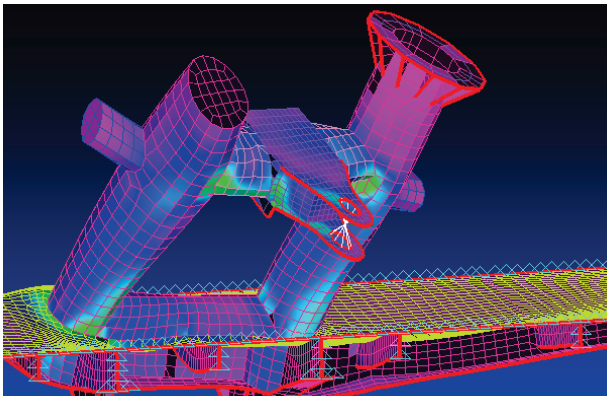

Figure 21. Load case 2 - Deformation

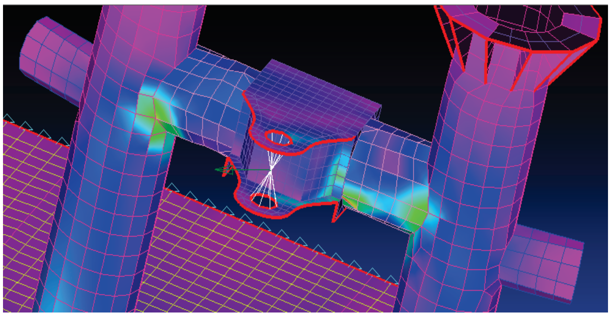

Figure 22. Load case 3 – towing hook 45^0 SB

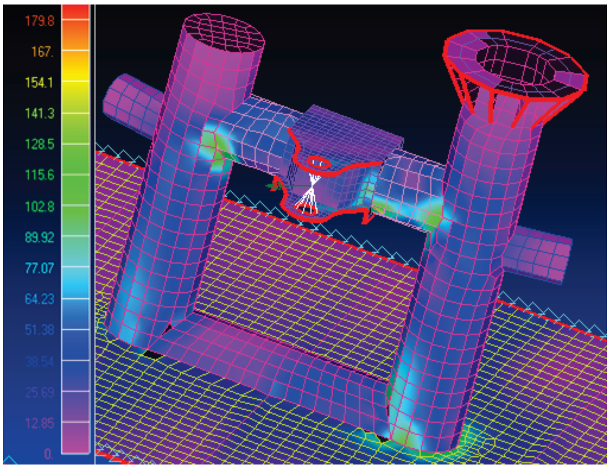

Figure 23. Load case 3 - Von-Mises results

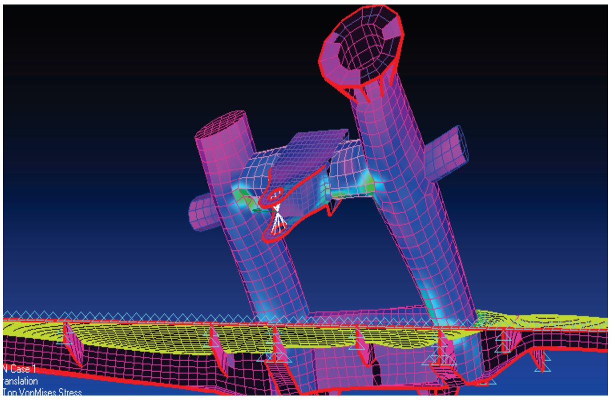

Figure 24. Load case 3 - Deformation

5. Buckling Results

The loss of stability of beam and plate elements may occur as a structural response to membrane forces, acting axially at beam elements and in the median plane of plate elements. Also, stability can be lost when an element or structure converts the internal energy of deformation of the membrane into internal energy of deformation due to bending, without changing the external strain. There is a critical level condition in which buckling occurs. This means that there is the possibility that deformation changes a little so the loss in the energy of deformation of the membrane is numerically equal to the increase in deformation energy at bending. This means that the loss of stability occurs when the membrane compression forces are sufficiently large to reduce the flexural stiffness to zero for certain physical deformation modes achievable. If the membrane forces become tensile forces, then an effective increase in flexural rigidity is found and this effect is called "tension stiffening”.

Buckling factor for case 1 – towing hook 0^0 from CL is 1.89, for case 2 – towing hook 45^0 PS is 1.30, for case 3 – towing hook 45^0 SB is 1.14, in each case smaller than safety factor 2.

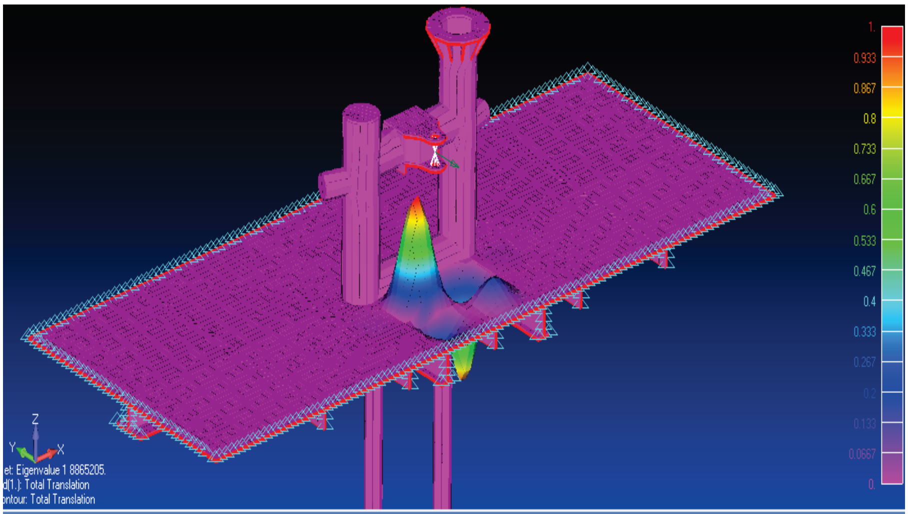

Figure 25. Buckling results, Eigenvalue = 1.886520

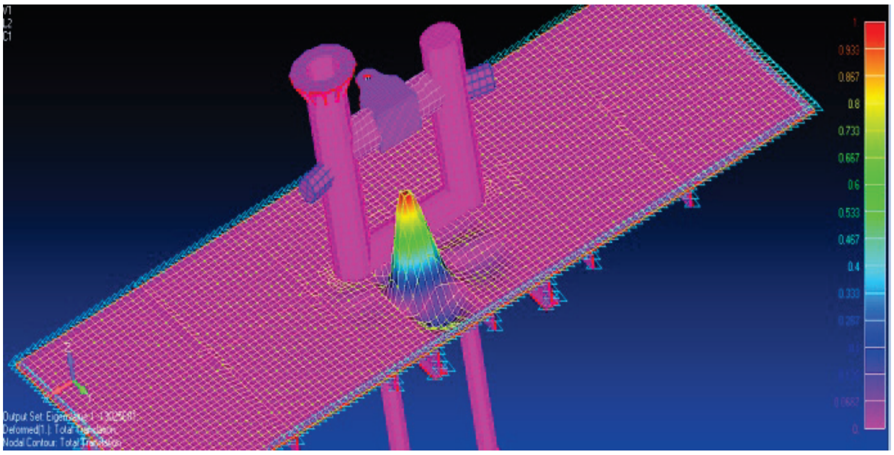

Figure 26. Buckling results, Eigenvalue = 1.302568

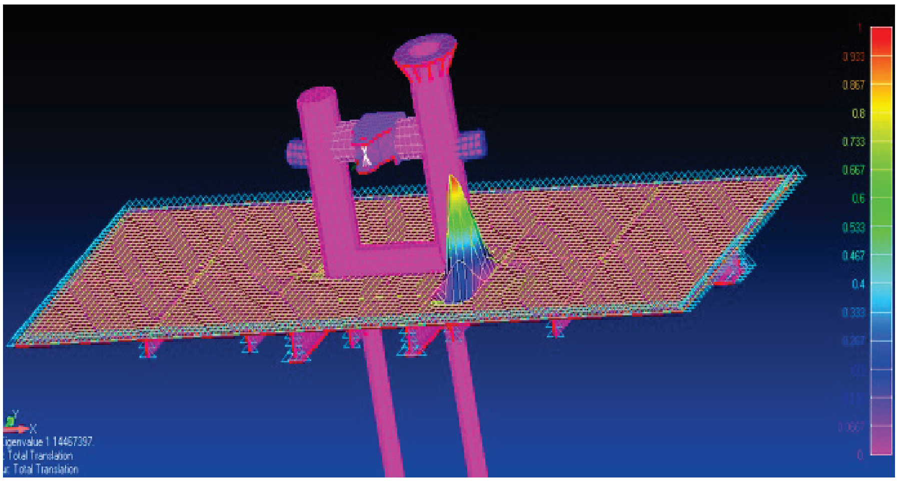

Figure 27. Buckling results, Eigenvalue = 1.144673

6. Conclusion

As far as stress analysis is concerned, as we can see, the resulting values do not exceed the maximum limit of strain in which account has been taken of the safety coefficient of 1.20. The value of this maximum strain is 195 MPa. It can be concluded that the structure designed is secure for future exploitation.

As far as buckling analysis is concerned, this is basically a verification of structural strength. If problems arise, there are solutions, but the wishes of the ship-owner and the costs that could be incurred must be taken into account. One solution that could solve the problem of deck board deformation lies in the application of an insert under the whole structure that also includes the towing hook, and the material used should be a high quality steel.

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METHODOLOGY FOR THE COMPUTATION OF CRITICAL BUCKLING FORCE AT STEEL TUBES WITH FLATTENED ENDS

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Abstract

This contribution deals with a methodology for the computation of critical buckling force at steel tubes of a defined shape. Due to the simple joining on the gusset joint plates, a tube with flattened ends was chosen as a column shape. This contribution brings some information about a performed experiment, where the value of critical buckling force was being found out. Subsequently, it was computed by Rayleigh energy method and by differential equation. While computing the values, some differences were found out in the results which related to the used boundary conditions. The contribution brings some information about these differences and proposes a suitable way for the computation thus defined columns.

Keywords:

Buckling, critical buckling force, flattened ends, steel tubes

1. Introduction

Regarding the stability loss, many computation methods of critical buckling force were described. The first studies about stability loss were brought by Leonard Euler in 18th century. Analytical formulas for the computation of critical buckling force are generally well-known. They were written on the basis of differential equations. Lagrange, Poincaré, von Kármán, Timoshenko and von Mises undoubtedly belong among the other authors, who significantly worked towards a development of this branch [1].

After time, the methods for the computation of critical buckling force for non-uniform columns were also brought. Owing to the difficulties with the computation by differential equation, various energy methods like Rayleigh or Ritz method are being used [2]. Also, Vianello method of successive approximations is being also often used.

This contribution was made as a partial task solving the stability questions for the columns with non-uniform cross-section. In this contribution, non-uniform column means a steel tube with flattened ends which is jointed with gusset joint plates by bolts. An original assumption of deformation evokes a pinned joining. According to the experiment, this joining becomes known as a clamped. The computations with a consideration of clamping convince us, that these boundary conditions are not suitable and it is needed to introduce certain simplifications.

2. Experimental measurements

The experiment for determination of critical buckling forces was performed on steel tubes with flattened ends. Tubes with an external diameter of 12 and 14 mm with a wall thickness of 1 mm were used for the experiment and material S355 according to the Standard EN 10025 was chosen. Lengths of columns are given in Table 1.

Table 1. Computational Lengths

D_{ext} (mm)	Length (mm)					
12	452	498	548	594	640	688
14	534	588	646	704	756	812

These dimensions were chosen in regard to the uniform spacing of slenderness which had the values 116, 128, 140, 152, 164 and 176 for pinned joining. In a case of clamping and recommended buckling coefficient β = 0.65 [3] these values of slenderness are changed to 75, 83, 91, 99, 107 and 115. Due to a limit slenderness of column (β = 78), the experiment was performed in the elastic area. Due to the joining on a fixture, the ends of tubes were modified by a flattening on length of 1.5 multiple of a tube internal diameter with a subsequently drilled hole with diameter of 7 mm. This hole was situated in a column axis in distance of 0.75 multiple of the internal diameter from a border between flattened and transition part of tube (Fig. 1).

The experiment was performed for each chosen variant with five specimens by universal machine Testometric M500-100 CT (Fig. 2) which also contained Gefran displacement sensors (5) for measurement of a column deflection. These sensors were powered by a stabilized power supply (6) and data was recorded by NI USB 6008 (7) and PC (8) by means of LabView and winTest Analysis software. The fixtures (2) in fact simulating the real gusset joint plates were made for joining. They were installed on the machine (1) and the specimen (4) was fixed by bolt (3).

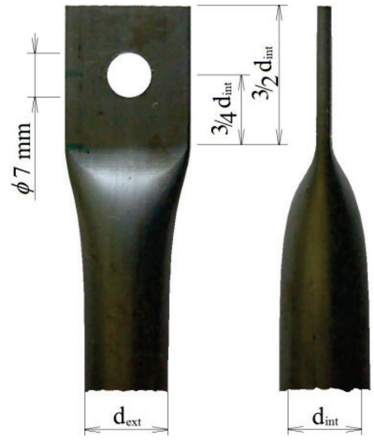

Figure 1. Shape of Steel Tube – broken half

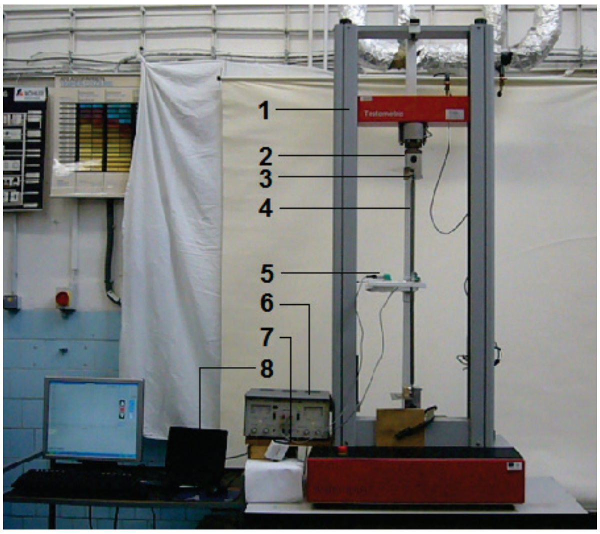

Figure 2. Experimental Measurement

A fact, that tubes were deformed in the plane which is perpendicular on the rotation plane, was noticed from these measurements, [4].

3. Mathematical Modeling

The governing differential equation for the buckling of axial loaded column with variable cross-section can be derived from the equilibrium of moment as:

$$\frac{d^2}{dx^2}\left(EI(x)\frac{d^2}{dx^2}w(x)\right)+N\frac{d^2}{dx^2}w(x)=0 \qquad (1)$$

where *EI(x)* is the flexural rigidity and *N* is the axial force. This equation will be solved numerically by Finite Difference Method. The values of moment of inertia are exactly computed with the step of 1 mm. For a both side fixing, we require to meet the boundary conditions:

$$w(0)=w(l)=w'(0)=w'(l)=0 \qquad (2)$$

Rayleigh energy method is based on the formula (3), which uses the rule of minimum potential energy [5]:

$$N_{crit}=\frac{\int_0^l w'^2(x)dx}{\int_0^l \frac{w^2(x)dx}{EJ}} \qquad (3)$$

The second variant of Rayleigh method is:

$$N_{crit}=\frac{\int_0^l w''^2(x)EJdx}{\int_0^l w'^2(x)dx} \qquad (4)$$

where the function (5) is used.

$$w(x)=\frac{w_0}{2}\cdot\left(1-\cos\frac{2\pi x}{l}\right) \qquad (5)$$

In practice, there are also used the other methods like Ritz or Vianello method, but they are identical with the second variant of Rayleigh method. Also, Euler method with a recommended buckling coefficient β = 0.65 will be used.

4. Results and Discussion

For each variant of diameter and slenderness, the values of critical buckling force were computed and compared with average measured values. A comparison of these values is shown in Fig. 3 and Fig. 4.

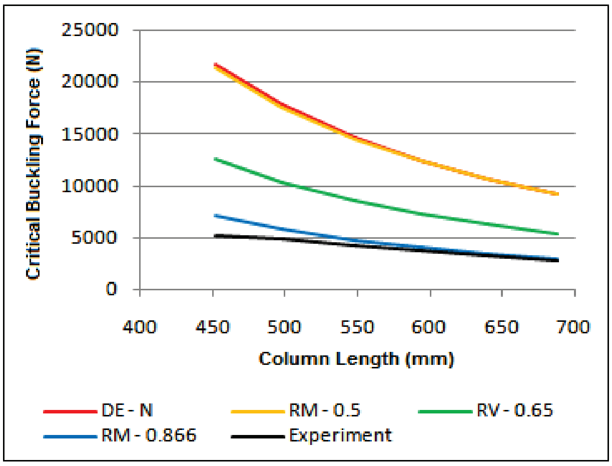

Figure 3. Comparison of experimental and computed values of critical buckling forces for diameter of 12 mm

Legend:

DE – N	*Differential Equation (numerically)*
RM – 0.5	*Rayleigh Method using the buckling coefficient β = 0.5*
RM – 0.866	*Rayleigh Method using the buckling coefficient $\beta \approx$ 0.866*
RV – 0.65	*Euler Method using the buckling coefficient β = 0.65*

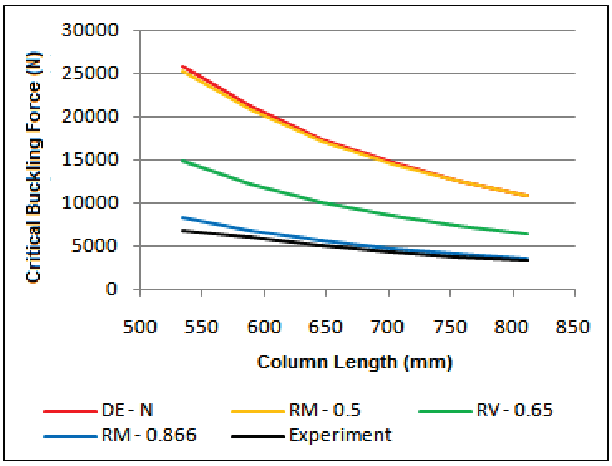

Figure 4. Comparison of experimental and computed values of critical buckling forces for diameter of 14 mm

The computation realized by differential equation provides non-stabile values therefore some simplifications have to be carried out. In comparison with experiment, these values are more than 3 times overestimated in dependence on diameter and slenderness.

Using the Rayleigh energy method and its first variant, differences between tubes with flattened ends and without flattened ends are negligible. The buckling coefficient has the value $\beta \approx 0.866$ by editing on the form of Euler equation. These values are the most closest to the experiment; however they are significantly overestimated in some cases. We will consider the hypothesis that flattening does not have any effect on the value of critical buckling force, which was verified by the other experiments performed in past.

Using the second variant of Rayleigh energy method, the buckling coefficient has the value of 0.5, which is in conformity with Euler method. Also, this value appears using the Ritz and Vianello method [6]. The computation is not carried out in elastic area and so the computation with this coefficient is not correct; however it will be considered in the computation, because at the first time dimensioning perhaps we do not have knowledge of low slenderness value. These values are also more than three times overestimated. Considering the recommended value of buckling coefficient 0.65, the values of critical buckling force are more than two times overestimated.

5. Conclusion

The aim of this contribution was to find out the value of critical buckling force for the column with flattened ends by defined methods. For a comparison of the values, the experiment was performed. We can find out that original assumed pinned joining is not correct and the column is deformed as clamped. Owing to this, the computation was carried out for clamped column.

At the computation, Rayleigh energy method for both variants, Euler method for β = 0.65 and differential equation were used. It was verified, that the flattening does not have any effect on the value of critical buckling force and so there was considered a constant moment of inertia in cases of β = 0.5 and β = 0.65 without a big deviation. The results are not considered as adequate in comparison with the experiment. The most closest is Rayleigh energy method; however these values are significantly higher than measured.

Complications are caused by flattened part, because in the certain time, an axial force achieves the value which does not cause the exceeding of limit state in uniform part of column, but yield stress in a place of flattening is exceeded. The computation does not contain this aspect in the formulas. Deformation of column appears earlier than the theory considers with. We recommend to ignore this area of flattening and put the pinned joining to the place between the flattened and transition area. In past, some computations were carried out, where the computed values are underestimated, because the added bending moment was neglected. This moment is relatively small therefore differences between the experiment and theory are also small and the mathematical model is suitable for the computation.

6. Acknowledgment

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SOME GENERAL INEQUALITIES FOR CONVEX FUNCTIONS

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Abstract

We investigate the fundamental inequalities for convex functions on the bounded closed interval of real numbers. Our aim is to generate the functional forms of inequalities that have a wide application. In the section Inequalities with functionals, we present inequalities which imply the Jensen, Fejér and Hermite-Hadamard inequality.

Keywords: inequality, positive linear functional, convex function

1. Introduction

The preference of the introduction is to recall the basic concepts used in the paper. We are talking about two concepts, convex functions on the bounded closed interval of real numbers, and positive linear functionals on the space of real functions. The basic structure used in the paper is a real linear space $\mathbb{X}$. Let us remind the initial notions of convexity upgrading the signification of the space $\mathbb{X}$.

A **set** $C \subseteq \mathbb{X}$ is said to be **convex** if the inclusion

$$\alpha x + \beta y \in C \tag{1}$$

holds for all points $x, y \in C$ and all coefficients $\alpha, \beta \in [0,1]$ satisfying $\alpha + \beta = 1$. The sum $\alpha x + \beta y$ satisfying the above requirements is called convex combination.
A **function** $f : C \to \mathbb{R}$ is said to be **convex** if the inequality

$$f(\alpha x + \beta y) \le \alpha f(x) + \beta f(y) \tag{2}$$

holds for all convex combinations $\alpha x + \beta y$ of points $x, y \in C$. A bounded closed interval $[a,b] \subset \mathbb{R}$ where $a < b$ is used permanently throughout the paper. Each point $x \in [a,b]$ can be represented by the unique binomial convex combination

$$x = \alpha a + \beta b \tag{3}$$

where

$$\alpha = \frac{b-x}{b-a},\ \beta = \frac{x-a}{b-a}. \tag{4}$$

Assume that we have a convex function $f : [a,b] \to \mathbb{R}$. The secant line of the function f passes through the graph points $(a, f(a))$ and $(b, f(b))$, and its equation is

$$f^{\sec}_{\{a,b\}}(x) = \frac{b-x}{b-a} f(a) + \frac{x-a}{b-a} f(b). \tag{5}$$

Let $c \in (a,b)$ be an interior point. The support lines of the function f pass through the graph point $(c, f(c))$. Each support line is specified by the slope coefficient $\kappa \in [f'(c-), f'(c+)]$, and its equation is

$$f^{\sup}_{\{c\}}(x) = \kappa(x-c) + f(c). \tag{6}$$

The support-secant line inequality

$$f^{\sup}_{\{c\}}(x) \le f(x) \le f^{\sec}_{\{a,b\}}(x) \tag{7}$$

holds for every $x \in [a,b]$.

Let X be a nonempty set, and let $\mathbb{F} = \mathbb{F}(X)$ be a subspace of the linear space of all real functions on the domain X. We assume that the space $\mathbb{F}$ contains the unit function u defined by $u(x) = 1$ for every $x \in X$. Such space $\mathbb{F}$ contains every real constant κ within the meaning of $\kappa = \kappa u$, and also contains every composite function $f(g)$ of an affine function $f : \mathbb{R} \to \mathbb{R}$ and a function $g \in \mathbb{F}$. Namely, using the equation $f(x) = \kappa x + \lambda$ where κ and λ are real constants, it is clear that the composition

$$f(g) = \kappa g + \lambda u \tag{8}$$

belongs to the space $\mathbb{F}$. Let $\mathbb{L} = \mathbb{L}(\mathbb{F}(X))$ be the space of all linear functionals on the space $\mathbb{F}(X)$.

A **functional** $L \in \mathbb{L}$ is said to be **positive** (nonnegative) if the inequality $L(g) \geq 0$ holds for every nonnegative function $g \in \mathbb{F}$. Then it follows that

$$L(g_1) \leq L(g_2) \tag{9}$$

for each pair of functions $g_1, g_2 \in \mathbb{F}$ satisfying $g_1(x) \leq g_2(x)$ for $x \in X$. A functional $L \in \mathbb{L}$ is said to be unital (normalized) if $L(u) = 1$. Such functional has the property $L(\kappa) = \kappa$ for every real constant κ.

2. Inequalities with functionals

We start with two inceptive lemmas. The first lemma ensures a basic inclusion which relates to the image of a space function and a positive unital functional.

Lemma 2.1. ***1*** *Let $g \in \mathbb{F}$ be a function with the image in $[a,b]$. Then a positive unital functional $L \in \mathbb{L}$ satisfies the inclusion*

$$L(g) \in [a,b]. \tag{10}$$

Proof. Acting with the positive and unital functional L to the image assumption

$$au \leq g \leq bu, \tag{11}$$

we get

$$a \leq L(g) \leq b \tag{12}$$

proving the inclusion in (10). □

The second lemma ensures a basic equality which relates to the composition of an affine function and a unital functional.

Lemma 2.2.2 *Let $g \in \mathbb{F}$ be a function, and let $L \in \mathbb{L}$ be a unital functional. Then an affine function $f : \mathbb{R} \to \mathbb{R}$ satisfies the equality*

$$f(L(g)) = L(f(g)). \tag{13}$$

Proof. Using the affine equation $f(x) = \kappa x + \lambda$ where κ and λ are real constants, and the unital property of L, we obtain

$$f(L(g)) = \kappa L(g) + \lambda = L(\kappa g + \lambda u) = L(f(g))$$

proving the equality in formula (13). □

The next theorem introduces continuous convex functions into consideration.

Theorem 2.3. ***3*** *Let $g \in \mathbb{F}$ be a function with the image in $[a,b]$, and let $L \in \mathbb{L}$ be a positive unital functional. Then a continuous convex function $f : [a,b] \to \mathbb{R}$ satisfies the double inequality*

$$f(L(g)) \leq L(f(g)) \leq f^{\sec}_{\{a,b\}}(L(g)) \tag{14}$$

if provided that the composition $f(g)$ is in $\mathbb{F}$.

Proof. The point $l = L(g)$ is in $[a,b]$ by Lemma 2.1. We realize the proof in two steps depending on the position of l. If $l \in (a,b)$, we take a support line $f^{\sup}_{\{l\}}$ of f at l. Including the function g into the support-secant inequality in formula (7), we have

$$f^{\sup}_{\{l\}}(g) \leq f(g) \leq f^{\sec}_{\{a,b\}}(g),$$

and acting with the positive functional L to the above function inequality, we obtain

$$L(f^{\sup}_{\{l\}}(g)) \leq L(f(g)) \leq L(f^{\sec}_{\{a,b\}}(g)).$$

Applying Lemma 2.2 to affine functions $f^{\sup}_{\{l\}}$ and $f^{\sec}_{\{a,b\}}$, the above inequality takes the form

$$f^{\sup}_{\{l\}}(L(g)) \leq L(f(g)) \leq f^{\sec}_{\{a,b\}}(L(g)), \tag{15}$$

where the first term

$$f^{\sup}_{\{l\}}(L(g)) = f(l) = f(L(g)).$$

If $l \in \{a,b\}$, we rely on the continuity of f using a support line at a point of the open interval (a,b) that is close enough to l. Suppose that $l = a$. Given $\varepsilon > 0$, we can find $c > a$ so that

$$f(a) - \varepsilon < f^{\sup}_{\{c\}}(a). \tag{16}$$

Combining the above inequality, and the inequality in formula (15) with c instead of l, we obtain

$$f(a) - \varepsilon < L(f(g)) \leq f(a), \tag{17}$$

and reach the conclusion $L(f(g)) = f(a)$. In this case, the trivial inequality $f(a) \leq f(a) \leq f(a)$ represents the inequality in formula (14). □

The inequality in formula (14) can be expressed in the form suitable for working with means.

Corollary 2.4. ***4*** *Let $g \in \mathbb{F}$ be a function with the image in $[a,b]$, and let $L \in \mathbb{L}$ be a positive unitalfunctional. Then a continuous convex function $f : [a,b] \to \mathbb{R}$ satisfies the double inequality*

$$f(a+b-L(g)) \leq f^{\sec}_{\{a,b\}}(a+b-L(g)) \leq f(a)+f(b)-L(f(g)) \tag{18}$$

if provided that the composition $f(g)$ *is in* $\mathbb{F}$.

Proof. The point $a+b-g(x)$ belongs to $[a,b]$ for every $x \in X$, and so the point $a+b-L(g)$ also belongs to $[a,b]$ by Lemma 2.1. Since $f \leq f^{\sec}_{\{a,b\}}$, the left-hand side of the inequality in formula (??) is valid. Applying the affinity of $f^{\sec}_{\{a,b\}}$, and using the right-hand side of the inequality in formula (14), we get

$$f^{\sec}_{\{a,b\}}(a+b-L(g)) = f(a)+f(b)-f^{\sec}_{\{a,b\}}(L(g)) \leq f(a)+f(b)-L(f(g))$$

proving the right-hand side of the inequality in formula (18). □

A visual representation of the inequalities in formulae (14) and (18) ca be seen in Figure 1. The black dots above the point l represent the terms of the inequality in formula (14), and black dots above the point $a+b-l$ represent the terms of the inequality in formula (18).

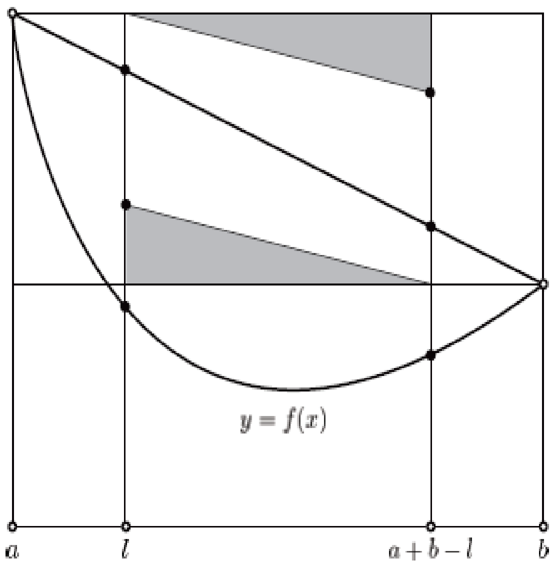

Figure 1. *Geometric presentation of inequalities in formulae (14) and (18)*

Formula (14) can be expressed in the form which includes the convex combination of the interval endpoints a and b. The respective form of Theorem 2.3 is as follows.

Corollary 2.5. 5 *Let* $g \in \mathbb{F}$ *be a function with the image in* $[a,b]$, *and let* $L \in \mathbb{L}$ *be a positive unital functional. Let* $\alpha a+\beta b$ *be the convex combination equal to* $L(g)$. *Then a continuous convex function* $f:[a,b] \to \mathbb{R}$ *satisfies the double inequality*

$$f(\alpha a+\beta b) \leq L(f(g)) \leq \alpha f(a)+\beta f(b) \tag{19}$$

if provided that the composition $f(g)$ *is in* $\mathbb{F}$.

Proof. The corresponding terms of formulae (14) and (20) are the same. As regards the last terms, we have

$$f^{\sec}_{\{a,b\}}(L(g)) = \alpha f^{\sec}_{\{a,b\}}(a)+\beta f^{\sec}_{\{a,b\}}(b) = \alpha f(a)+\beta f(b)$$

because of the affinity of $f^{\sec}_{\{a,b\}}$, and its congruence with f at endpoints. □

As for the coefficients in formula (19), putting $x=L(g)$ in formula (4), we get

$$\alpha = \frac{b-L(g)}{b-a},\ \beta = \frac{L(g)-a}{b-a}. \tag{20}$$

In 1931, Jessen (see [6] and [7]) stated the left-hand side of the inequality in formula (14) for a convex function f on the interval $I \subseteq \mathbb{R}$. In 1988, Ra s a (see [10]) pointed out that I must be closed, otherwise it could happen that $L(g) \notin I$, and that f must be continuous, otherwise it could happen that the left-hand side of the inequality in formula (14) does not apply.

3. Applications to integral inequalities

We utilize Theorem 2.3 to obtain a very general forms of integral and discrete inequalities. In order to shorten the integral expressions which follow, the integrands will be written without the variable x. We have the following extension and generalization of the famous integral form of Jensen's inequality, see [5].

Theorem 3.1. *6* *Let* X *be a measurable set respecting a measure* μ *so that* $\mu(X)$ *is the positive number. Let* $g: X \to \mathbb{R}$ *be a* μ*-integrable function with the image in* $[a,b]$, *and let* $h: X \to \mathbb{R}$ *be a positive* μ*-integrable function. Then a convex function* $f:[a,b] \to \mathbb{R}$ *satisfies the double inequality*

$$f\left(\frac{\int_X ghd\mu}{\int_X hd\mu}\right) \leq \frac{\int_X f(g)hd\mu}{\int_X hd\mu} \leq f^{\sec}_{\{a,b\}}\left(\frac{\int_X ghd\mu}{\int_X hd\mu}\right). \tag{21}$$

Proof. Let $\mathbb{F}$ be the space of all μ-integrable functions over the domain X. The convex function f is bounded on $[a,b]$, and may be discontinued only at endpoints a or b. Therefore, the composition $f(g)$ is measurable and bounded, and as such is μ-integrable over X. Including the given positive function $h \in \mathbb{F}$, the integrating linear functional L defined for functions $q \in \mathbb{F}$ by

$$L(q) = L(q;h) = \frac{\int_X qhdx}{\int_X hdx} \tag{22}$$

is positive and unital. Applying the functional L to the given function $g \in \mathbb{F}$ with the image in $[a,b]$, we get the number

$$l = L(g) = \frac{\int_X ghd\mu}{\int_X hd\mu} \tag{23}$$

belonging to $[a,b]$ by Lemma 2.1. Since the product $f(g)h$ is μ-integrable, we can calculate

$$L(f(g)) = \frac{\int_X f(g)hdx}{\int_X hdx}. \tag{24}$$

Inserting the right-hand sides of equations in formulae (23) and (24) into the inequality in formula (14), we obtain the integral inequality in formula (21) applying to a continuous convex function f. Let us verify that the inequality in formula (21) applies to a convex function which is not continuous at endpoints. We observe the position of the point l. If the point $l = a$, then equation in formula (23) can be rearranged to the integral equation with the nonnegative integrand,

$$\int_X (g-a)hdx = 0, \tag{25}$$

from which follows that $g(x) = a$ almost everywhere in X. The consequence is that $f(g(x)) = f(a)$ almost everywhere in X, and therefore the inequality in formula (21) is reduced to $f(a) \le f(a) \le f(a)$. The same is true if the point $l = b$.

If the point $l \in (a,b)$, then we take the continuous extension $\overline{f}$ of $f/(a,b)$ to $[a,b]$, and use it in formula (21). The first two terms are the same as we use f, and the last term satisfies the inequality

$$\overline{f}^{\sec}_{\{a,b\}}(l) < f^{\sec}_{\{a,b\}}(l). \tag{26}$$

So, formula (21) applies to f in this case also. Respecting all considerations, we may conclude that the inequality in formula (21) applies to any convex function f. □

The inequality in formula (21) is the extended version of Jensen's inequality for the ratio of integrals on the interval $[a,b]$, as well as the generalized form of the Fejér and Hermite-Hadamard inequality. Let us demonstrate the simplifications of the inequality in formula (21) relating to the identity, unit and symmetric function.

Corollary 3.2. 7 *Let $g:[a,b] \to \mathbb{R}$ be an integrable function with the image in $[a,b]$, and let $h:[a,b] \to \mathbb{R}$ be a positive integrable function. Then a convex function $f:[a,b] \to \mathbb{R}$ satisfies the extended integral form of the Jensen inequality (see [5])*

$$\begin{aligned} f\left(\frac{\int_a^b gdx}{b-a}\right) &\le \frac{\int_a^b f(g)dx}{b-a} \\ &\le \frac{\int_a^b (b-g)dx}{(b-a)^2} f(a) + \frac{\int_a^b (g-a)dx}{(b-a)^2} f(b), \end{aligned} \tag{27}$$

the Fejér inequality (see [1])

$$f\left(\frac{a+b}{2}\right) \le \frac{\int_a^b fhdx}{\int_a^b hdx} \le \frac{f(a)+f(b)}{2}, \tag{28}$$

and the Hermite-Hadamard inequality (see [3], [2])

$$f\left(\frac{a+b}{2}\right) \le \frac{\int_a^b f\,dx}{b-a} \le \frac{f(a)+f(b)}{2}. \tag{29}$$

Proof. Using the inequality in formula (21) concerning the interval $X = [a,b]$, we have the following. The inequality in formula (27) follows by using $h(x) = 1$. The inequality in formula (28) follows by using the identity function $g(x) = x$, and a function $h(x)$ satisfying the equation $h(x) = h(a+b-x)$ that represents the symmetry with the center at the midpoint $(a+b)/2$. Namely, as a consequence of the symmetry we have

$$l=\frac{\int_a^b xhdx}{\int_a^b hdx}$$
$$=\frac{\int_a^b (x-\frac{a+b}{2})hdx}{\int_a^b hdx}+\frac{\int_a^b \frac{a+b}{2}hdx}{\int_a^b hdx}$$
$$=\frac{a+b}{2}$$

because

$$\int_a^b (x-\frac{a+b}{2})hdx=0.$$

The inequality in formula (29) follows by using $h(x)=1$ in Fejér's inequality in formula (28). □

We could say a few words about barycenters, respecting the Lebesgue measure or the Riemann integral. The barycenter of the interval $[a,b]$ is defined by

$$\frac{\int_a^b xdx}{b-a}=\frac{a+b}{2}, \qquad (30)$$

and the barycenter of the function h on the interval $[a,b]$ can be defined by

$$\frac{\int_a^b xhdx}{\int_a^b hdx}. \qquad (31)$$

The Hermite-Hadamard inequality involves the barycenter of the interval $[a,b]$, and the Fejér inequality involves the barycenter of the function h on the interval $[a,b]$. In both cases, the set and function barycenter belong to the interval $[a,b]$.

The refinements of the Hermite-Hadamard inequality in formula (29), as well as the refinements of some standard means were obtained in [9].

4. Conclusion

In Theorem 3.1 we have used the integral as the most important positive linear functional. In the next application we could use the sumarizing linear functional, and thus obtain discrete variants of some important inequalities. Individual deriving of all these inequalities would be significantly more difficult. Therefore, in any serious work should try to apply the general theory, if possible. This approach certainly applies to the engineering research, especially in fundamental investigations.

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A CRACK APPROACHING AN INTERFACE BETWEEN THE TWO ORTHOTROPIC MATERIALS

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Abstract

The "competition" between the crack penetrating the interface and crack deflecting into the interface is considered by comparing the energy release rate needed for the crack deflection and the energy release rate needed for the crack penetration of the interface. Results presented in this work enable comparison of the interface fracture toughness to fracture toughness of the material across the interface, in order to determine whether the attacking crack would deflect into the interface or would it continue to propagate across the interface. If the ratio of fracture toughness of the interface and the fracture toughness of the material in which the crack continues to propagate was less than the ratio of the energy release rate for the crack that is deflecting into the interface and the energy release rate for the crack that is crossing the interface, the crack would deflect into the interface. If the opposite was the case, the crack would penetrate the interface and it would continue to propagate in the material across it.

Keywords: Interfacial crack, Orthotropic materials, Crack deflection, Interface penetration.

1. Introduction

Problems of an approaching crack penetrating the interface or deflecting into it were studied in numerous papers. For instance, behavior of a crack, which penetrates the interface between the two different isotropic materials, at the right angle, was subject of interest by Cook and Erdogan in [1] and Erdogan and Biricikoglu in [2]. Further, several problems, which include deflection and penetration for the main crack that attacks the interface at the right angle, were analyzed by Goree and Venezia, [3]. The same problems were treated by Lu and Erdogan in [4]. In addition, he and Hutchinson in [5] have considered behavior of a crack that is approaching interface between the two different elastic materials and the same problem was studied in the paper by Djokovic in [6]. In papers by Suo [7], Suo et al. [8] and Nikolic et al. [9] behavior of a crack at an interface between the two anisotropic materials was investigating. Deflection of a crack into the interface between the two orthotropic materials was studied by Gupta et al. in [10], but without considering the "competition" between crack penetrating the interface and deflecting into it, while Djoković and Nikolić in [11] were considering exactly that problem.

The plane problem, considered in this paper, represents an idealization of the real problem in composites with cylindrical fibers. The degree of anisotropy, which is analyzed, is restricted to the orthotropic level, because the majority of fibers can be modeled in such a way. The problem presented in Figure 1 is a special case of the general problem of a crack that is attacking the interface. Same as in the case of a crack deflecting from an interface between the two isotropic materials, here results, for the crack attacking an interface between the two orthotropic materials at the right angle, are determining the selection of the interface toughness.

The problems considered in this paper, Figure 1, are conditions under which the semi-infinite crack, which is attacking the interface between the two orthotropic materials at the right angle, would penetrate it and continue to propagate across it, or would deflect into the interface and continue to propagate along it. Figure 1(a) presents the crack approaching the interface at the right angle, Figure 1(b) the problem of a crack penetrating the interface, while Figures 1(c) and 1(d) show two possible cases of the deflected crack propagation along the interface.

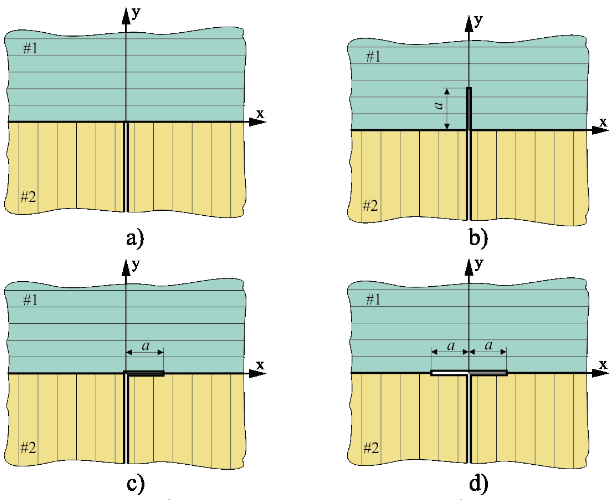

Figure 1. (a) Crack approaching the interface attacks it at the right angle; (b) Crack penetrates the interface and continues to propagate across it; (c) Crack deflects into the interface in a single direction; (d) Crack deflects into the interface in two branches ("double deflection")

Whether the crack is going to deflect single or double sided into the interface depends on the load conditions at the crack tip. The more probable and frequent form is the double sided deflection, which occurs when the load phase angle ψ is < 45°. Single sided crack deflection into the interface occurs in cases when the Mode II load is dominant at the crack tip. In that case, the load phase angle ψ is > 45°.

The "competition" between the crack penetrating or deflecting into the interface is considered by comparing the "driving forces" needed for those cases - energy release rates for crack penetration of the interface G_p to energy release rate for crack deflection into the interface G_d. Those results are then further used for determination of the interface toughness Γ_i and the base material toughness Γ, which ensures that the crack would deflect into the interface.

The crack will deflect into the interface if the following holds:

$$\frac{G_d}{G_p} > \frac{\Gamma_i}{\Gamma}. \tag{1}$$

The crack will cross the interface if inequality (1) is reversed. The objective of this paper is to determine the materials characteristics Γ_i and Γ and the crack diving forces G_d and G_p. The results presented in this paper were obtained by the symbolic programming routine *Mathematica*.

2. Problem formulation

For analyzing the problem of a crack on the interface between the two anisotropic materials, the 3×3 matrix **H** is used, which depends on elastic constants of both materials and which has the modulus of elasticity dimensions. Definition of the **H**-matrix is given in Appendix of [9], following [7] and [8].

For the case of the two different orthotropic materials, with mutually perpendicular principal axes and an interface, which lies along the x-axis, components of the H matrix, are:

$$\begin{aligned}
H_{11} &= \left[2n\sqrt[4]{\lambda}\sqrt{s_{11}s_{22}}\,\right]_1 + \left[2n\sqrt[4]{\lambda}\sqrt{s_{11}s_{22}}\,\right]_2,\\
H_{22} &= \left[2n\frac{1}{\sqrt[4]{\lambda}}\sqrt{s_{11}s_{22}}\right]_1 + \left[2n\frac{1}{\sqrt[4]{\lambda}}\sqrt{s_{11}s_{22}}\right]_2,\\
H_{12} &= \bar{H}_{21} = i\left[\sqrt{s_{11}s_{22}} + s_{12}\right]_1 - \left[\sqrt{s_{11}s_{22}} + s_{12}\right]_2
\end{aligned} \tag{2}$$

where $[\ ]_1$ denotes variables of material 1, while $[\ ]_2$ denotes variables of material 2, and where:

$$s_{11} = \frac{1}{E_1},\ s_{22} = \frac{1}{E_2},\ s_{66} = \frac{1}{G_{12}}, \tag{3}$$

$$s_{12} = -\frac{\nu_{12}}{E_1} = -\frac{\nu_{21}}{E_2},\ \lambda = \frac{s_{11}}{s_{22}} = \frac{E_2}{E_1},$$

$$n = \sqrt{\frac{(1+\rho)}{2}},$$

$$\rho = \frac{2s_{12} + s_{66}}{2\sqrt{s_{11}s_{22}}} = \frac{\sqrt{E_1E_2}}{2G_{12}} - \sqrt{\nu_{12}\nu_{21}}.$$

Here s_{ij} are the compliances, which correspond to the Young's and shear moduli and Poisson's ratio. Parameters λ and ρ measure anisotropy in the sense that for $\lambda = 1$ material has the cubic symmetry and for $\lambda = \rho = 1$ material is isotropic. The Dundurs' [12] parameters are:

$$\alpha = \frac{\Sigma - 1}{\Sigma + 1},\quad \beta = \frac{iH_{12}}{\sqrt{H_{11}H_{22}}}, \tag{4}$$

where: $\Sigma = \left[\sqrt{s_{11}s_{22}}\,\right]_2 \Big/ \left[\sqrt{s_{11}s_{22}}\,\right]_1$.

Stress field in the vicinity of the interfacial crack tip has the oscillatory character, which is measured by the complex stress intensity factor K, defined by Rice [13]:

$$\sigma_{yy} + i\sqrt{\frac{H_{11}}{H_{22}}}\sigma_{xy} = \frac{Kr^{i\varepsilon}}{\sqrt{2\pi r}}, \tag{5}$$

where:

$$\varepsilon = \frac{1}{2\pi}\ln\frac{1-\beta}{1+\beta}. \tag{6}$$

Energy release rate for the crack on the interface is:

$$G = \frac{H_{22}}{4ch^2(\pi\varepsilon)}|K|^2, \tag{7}$$

For the case of the crack deflection into the interface, based on dimensional analysis, one obtains:

$$K_1 + iK_2 = k_l a^{\frac{1}{2}+\gamma}(da^{i\varepsilon} + ea^{-i\varepsilon}). \tag{8}$$

where: d and e are dimensionless complex functions of α, β, λ_1, λ_2, ρ_1 and ρ_2. Factor k_l is proportional to load, while γ is a real variable that depends on α, β, λ_1, λ_2, ρ_1 and ρ_2. For analysis in this paper explicit knowledge of those parameters is not necessary.

By substituting equation (8) into (7), one obtains the energy release rate for the crack that deflects into the interface as:

$$\frac{G_d}{G_p} > \frac{\Gamma_i}{\Gamma}. \tag{9}$$

For the case of the crack crossing the interface, the stress field ahead of the crack tip corresponds to pure Mode I of crack propagation. Based on the dimensional analysis, one obtains the stress intensity factor for this case as:

$$K_I = ck_I a^{\frac{1}{2}+\gamma}, \tag{10}$$

where c is the dimensionless function of α, β, λ_1, λ_2, ρ_1 and ρ_2. Energy release rate for the crack crossing the interface is, [8]:

$$G_p = \frac{(s_{11}n)_1}{\sqrt[4]{\lambda_1}} K_I^2 = \frac{(s_{11}n)_1}{\sqrt[4]{\lambda_1}} c^2 k_I^2 a^{1+2\gamma}. \tag{11}$$

Ratio of energy release rates G_d/G_p depends neither on a nor on k_I, i.e.:

$$\frac{G_d}{G_p} = \frac{H_{22}}{4ch^2(\pi\varepsilon)} \frac{1}{(s_{11}n)_1\sqrt[4]{\lambda_1}} \cdot \cdot \frac{[|d|^2 + |e|^2 + 2\mathrm{Re}(de)]}{c^2}. \tag{12}$$

Relative tendency of the crack to deflect into the interface or to continue to propagate across it can be determined based on equation (12).

Knowing the dimensionless complex functions c, d and e one can determine the ratio G_d/G_p. Solution proposed by [5] for the isotropic materials is here applied to orthotropic materials.

3. Results and discussion

In Figure 2 the variation of the two energy release rates ratio is shown in terms of parameter α and for the three different values of parameter β. The ratio G_d/G_p is shown for two cases: for the crack that is deflecting into the interface in the single direction (solid lines) and for the crack that is deflecting into the interface in two (double) directions (broken lines), for the same crack lengths.

From Figure 2 one can see that the variation of parameter β does not significantly influence the variation of the G_d/G_p ratio, so in the further analysis it was adopted that $\beta = 0$. It can also be seen that values of the G_d/G_p ratio for the double-sided deflected crack are for 3 to 4 % larger than those for the crack that deflects into the interface in the single direction. This is why, in further considerations, only the double-sided deflection was analyzed.

If the values presented in Figure 2 were compared to results presented in [5] and [6], which were obtained for the isotropic materials, the relatively good agreement could be seen, what confirms the correctness of the conducted analysis.

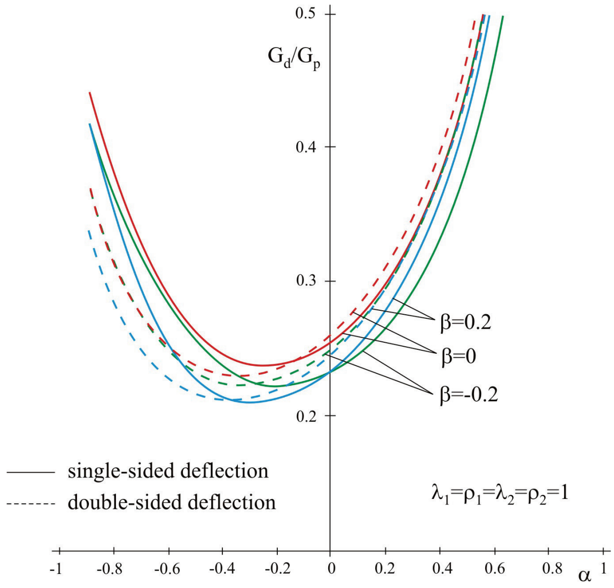

Figure 2. Influence of parameter β on ratio G_d/G_p variation in terms of parameter α.

Due to large number of factors that influence the G_d/G_p ratio variation with α, it is not possible to consider this variation in combination of all the factors simultaneously. This is why is in Figure 3 shown variation of the G_d/G_p ratio as a function of α, for the three different values of the anisotropic parameter ρ_1.

From Figure 3 can be seen that with increase of parameter ρ_1 values, the value of ratio G_d/G_p decreases, what points to the fact that anisotropy that corresponds to factor ρ_1, does not influence favorably the strengthening of the interfacial toughness.

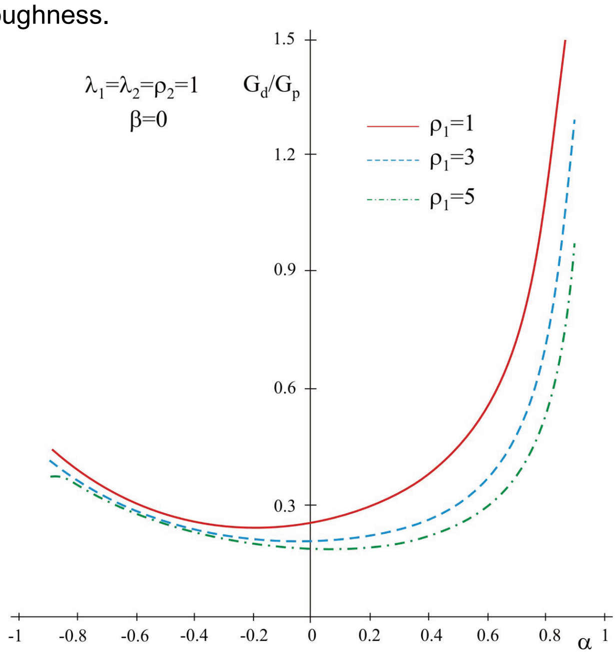

Figure 3. Influence of parameter ρ_1 on ratio G_d/G_p variation in terms of parameter α.

In Figure 4 is shown variation of the G_d/G_p ratio as a function of α, for the three different values of the anisotropic parameter λ_1.

From Figure 4 can be seen that the variation of the G_d/G_p ratio is very sensitive to variation of λ_1. Ratio G_d/G_p increases with increase of λ_1. It can be noticed that the interface toughness is for 3 to 4 times higher than the substrate toughness, for the case of the crack deflecting into the interface.

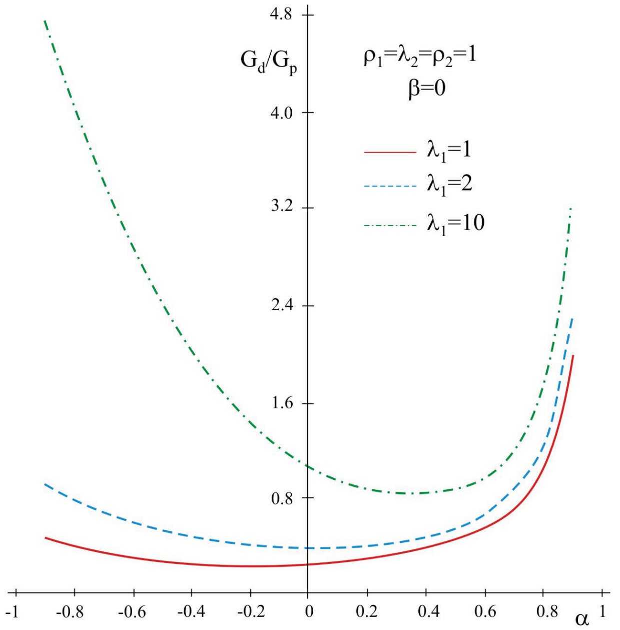

Figure 4. Influence of parameter λ_1 on ratio G_d/G_p dependence on α .

In Figure 5 is shown variation of the G_d/G_p ratio as a function of α, for the three different values of the anisotropic parameter ρ_2.

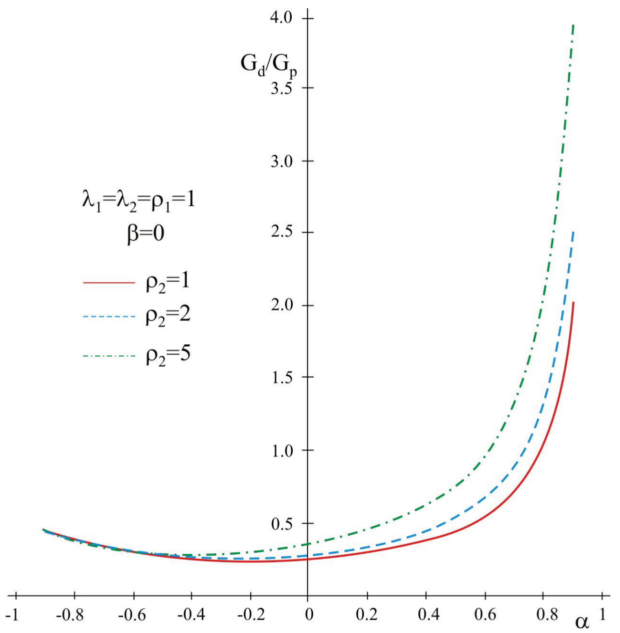

Figure 5. Influence of parameter ρ_2 on ratio G_d/G_p dependence on α .

In Figure 6 is presented variation of the G_d/G_p ratio as a function of α, for the three different values of the anisotropic parameter λ_2,

From Figure 5 can be noticed that ratio G_d/G_p increases with increase of ρ_2 and the same is valid for variation of the ratio G_d/G_p with increase of λ_2, what can be seen from Figure 6.

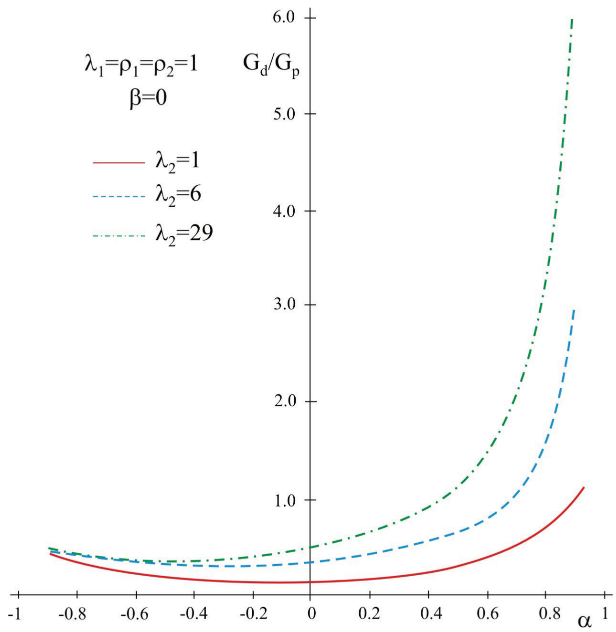

Figure 6. Influence of parameter λ_2 on ratio G_d/G_p dependence on α .

In Figure 7 is presented the variation of the load phase angle ψ in terms of parameter α, for four different values of parameter λ_1.

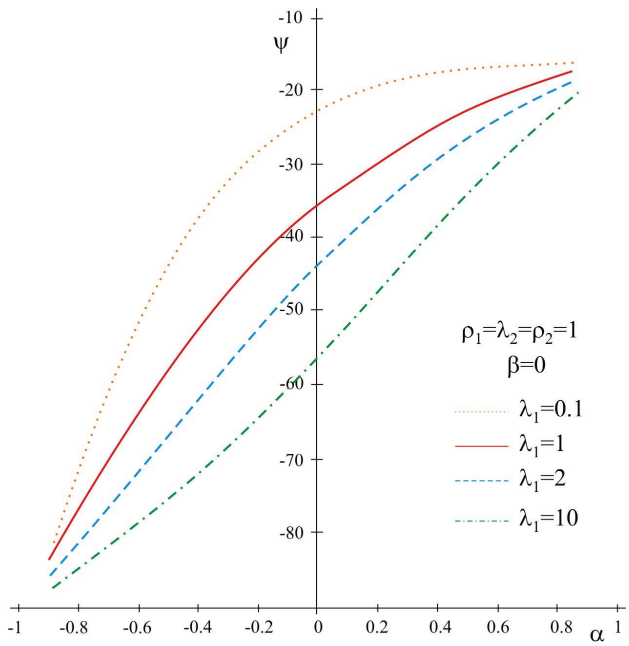

Figure 7. Variation of the load phase angle ψ in terms of α, for different values of λ_1

Considering that the load phase angle measures relative value of the Mode **I** with respect to Mode **II**, one can see from Figure 7 that with variation of parameter λ_1 value of the Mode **II** component changes within interval 40 to 80 % of the Mode **I** component.

4. Conclusion

Based on results presented in Figures 3 to 6, one can conclude that the ratio of energy release rate needed for the crack deflection into the interface G_d and the energy release rate needed for the crack to penetrate the interface G_p depends on variation of the anisotropic parameters λ_1, λ_2, ρ_1 and ρ_2. The G_d/G_p ratio changes within interval 0.2 to 5. When the value of this ratio exceeds 1 that means that crack approaching interface at the right angle will deflect into it even if the interface toughness is higher than the toughness of the base material.

From Figure 7 can be seen that, for the majority of cases, the Mode **II** load component, for the crack that has deflected into the interface (double-sided) varies within range 40 to 80 % of the Mode **I** load component.

Results presented in this paper enable the comparison of the interface toughness to the base material (substrate) toughness, thus concluding whether the incoming crack would deflect into the interface or would it penetrate the interface and continue to propagate in the second material across it.

If the ratio of the interface fracture toughness to fracture toughness of the material into which the crack continues to propagate is less than the ratio of the energy release rate for the crack that deflects into the interface and the energy release rate for the crack that penetrates the interface, the crack will deflect into the interface. If this relation was reversed, the crack will penetrate the interface.

5. Acknowledgement

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EXAMINATION OF THE DEVELOPMENT OF PEPPER (*CAPSICUM ANNUUM* L.) SEEDLING WITH VIRUS VECTOR ON ROCK COTTON MEDIUM IN GLASSHOUSE

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Abstract

Pepper (Capsicum annuum L.) cultivation in Europe and in Hungary is characterized by the fact that its forced cultivation is increasing in parallel with the decrease of open field areas. We can prevent the proliferation of pests in glasshouses and walk-in plastic tunnels by the chemical sterilisation of the soil. In our experiment, we studied how the plants contaminated with virus vector develop in rock cotton and measured their morphological changes regarding the number of leaves, the height of the plants as well as the number of sprouts.

Keywords: Pepper (*Capsicum annuum* L.), seedling, rock cotton, virus vector, glasshouse

1. Introduction

Pepper is native in Central and South America, from where it spread to all over the world. In Hungary, large scale field cultivation started in the first half of the 19th century, first with cultivation centres around Szeged, then Kalocsa [1]. Pepper is one of the most valuable vegetables in Hungary considering its economical significance. It can be processed various ways (it can be consumed pickled, baked or in a salad). In 2013, forced cultivation of pepper was carried out on 1530 hectares, which was 75-80% of the total area of pepper cultivation. The amount of produced pepper was 155 thousand tons in 2013 [2]. The reason for increasing expansion of forced pepper cultivation can be the following: (1) As a result of the optimal or near optimal environmental factors, yield increases significantly, and a 4-5x fruit yield can be reached compared even to intensive open field cultivation; (2) Quality of the force cultivated fruits is better regarding size, shape, cleanliness, although nutritional values are poorer; (3) Crop safety is higher; (4) Considering the potentials of the market, production can be scheduled [3, 4, 5]. There are two basic methods for forced cultivating: in the original soil of the cultivator or in a separate system (with soil or a different growing media, e.g. rock cotton or coir in buckets or containers). Phytotechnology is also important in forced cultivation [6]. Forced cultivated seedlings are endangered by several harmful pests, independently of the time of planting. The most important goal for plant protection is protecting against aphids and thrips that are potential virus vectors [7].

2. Method

A force cultivated pepper seedling experiment was carried out in the autumn of 2014 in the glasshouse of Kecskemét College, Faculty of Horticulture. Glasshouse raising of kapia peppers started with sowing on 4th September. The variety of pepper was Kapirex, the seedlings with cotyledons were transplanted into Grodan Classic Forte 1 (100 cm × 15 cm × 7.5 cm) rock cotton blocks placed in the canal on 1st October 2014. The seedlings were transplanted into rock cotton medium infected by virus vectors. Viral infection was verified during the previous seedling cultivation cycles, when seedlings growing in these medium blocks showed symptoms of viral infections through greenhouse whitefly and thrips vectors. Three treatment types were applied on the rock cotton blocks infected with viral vectors: 1. no treatment with pesticide (control); 2. treatment of the rock cotton blocks with Actara SC insecticide (Syngenta; active substance: thiamethoxam) in pepper seedlings; 3. foliage treatment with Actara SC in pepper seedlings.

The applied concentrations were the following: 0.1-0.2 cm^3 insecticide, 24% per litre [8]. Actara SC was applied every two weeks between 1st October 2014 and 11th December 2014, in a total of 5 treatments. Treatments were repeated three times in a random design, 11 plants were measured in each repetition. The morphology of the seedlings was evaluated on 11th December 2014, by then seedlings finished their development because of lacking of suitable temperature and sunshine hours. The height of the pepper seedlings (cm) was measured, and the number of leaves (pcs) and number of sprouts (pcs) were counted. Evaluation of the morphology data was carried out according to the Tukey-HSD method, the statistical analysis was performed with SPSS v19 software [9]. A difference between two groups was considered significant, if the value was below the 5% confidence level.

3. Results

Damage caused by greenhouse whiteflies (*Trialeurodes vaporariorum*) was seen on the pepper seedlings [10]. Greenhouse whiteflies caused serious damage in untreated seedlings growing on infected rock cotton medium (Figure 1).

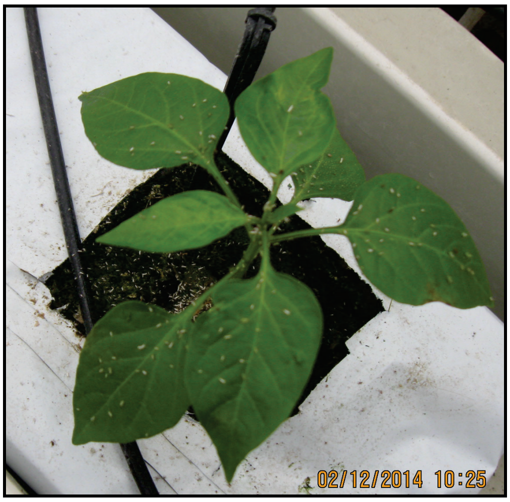

Figure 1. Greenhouse whiteflies (Trialeurodes vaporariorum) on a control pepper seedling.

According to the morphology examination, seedlings growing on infected rock cotton medium sprayed with Actara SC insecticide developed the best and gave the highest result based on plant height (Table 1), number of leaves (Table 2) and number of sprouts (Table 3). Greenhouse whiteflies caused little damage to the foliage of the seedlings growing on infected rock cotton medium.

The plants growing on untreated infected rock cotton medium (Treatment 1, i.e. control, without treatment with a pesticide) were compared to those of treated with Actara SC insecticide (Treatments 2 and 3) with statistical methods. Both insecticide treatment routines resulted in a significant increase in height of the seedlings compared to the control (Table 4). Both Actara SC treatment routines resulted in a significant increase in number of pepper leaves compared to the control (Table 5). A significant increase was observed in pesticide-treated seedlings regarding the number of sprouts analyzed with Tukey-HSD method (Table 6)

Table 1. Average heights of the pepper seedlings growing on treated or untreated, infected rock cotton media (2014).

Treatments	Plant height (cm)	No. of seed-lings	SD	Mini-mum (cm)	Maxi-mum (cm)
1.Infected rock cotton medium without pesticide treatment (control)	8.12	33	2.40	4.5	13.5
2.Rock cotton medium treated with Actara SC insecticide	14.63	33	3.21	4	19.5
3.Foliage treatment with Actara SC insecticide in pepper seedlings	12.30	33	3.36	6.5	18.5

Table 2. Average number of leaves of pepper seedlings growing on treated or untreated, infected rock cotton media (2014).

Treat-ments	No. of leaves (pcs)	No. of seed-lings	SD	Mini-mum (cm)	Maxi-mum (cm)
1.Infected rock cotton medium Without pesticide Treatment (control)	10.30	33	2.13	7	13
2.Rock cotton medium treated with Actara SC insecticide	14.76	33	2.46	8	21
3.Foliage treatment with Actara SC insecticide in pepper seedlings	12.88	33	1.93	9	18

Table 3. Average number of sprouts of pepper seedlings growing on treated or untreated, infected rock cotton media (2014).

Treat-ments	No. of sprouts	No. of seed-lings	SD	Mini-mum (cm)	Maxi-mum (cm)
1.Infected rock cotton medium Without pesticide Treatment (control)	0.06	33	0.24	0	1
2.Rock cotton medium treated with Actara SC insecticide	2.91	33	1.46	0	6
3.Foliage treatment with Actara SC insecticide in pepper seedlings	2.15	33	1.92	0	8

Table 4. Heights of pepper seedlings analyzed with Tukey-HSD method (2014).

Treatment (A)	Treat-ment (B)	Average difference between treatments (A-B)	SD	Signifi cance
1.Infected rock cotton medium without pesticide treatment (control)	2.Rock cotton medium treated with Actara SC insecticide in pepper seedlings	-6.50909*	0.66	0.00
	3.Foliage treatment with Actara SC insecticide in pepper seedlings	-4.18182*	0.66	0.00

*Level of significance: 0.05

Table 5. Number of leaves of pepper seedlings analyzed with Tukey-HSD method (2014).

Treatment (A)	Treatment (B)	Average difference between treatments (A-B)	SD	Significance
1.Infected rock cotton medium without pesticide treatment (control)	2.Rock cotton medium treated with Actara SC insecticide in pepper seedlings	-4.45455*	0.49	0.00
	3.Foliage treatment with Actara SC insecticide in pepper seedlings	-2.57576*	0.49	0.00

*Level of significance: 0.05

Table 6. Number of sprouts of pepper seedlings analyzed with Tukey-HSD method (2014).

Treatment (A)	Treatment (B)	Average difference between treatments (A-B)	SD	Significance
1.Infected rock cotton medium without pesticide treatment (control)	2.Rock cotton medium treated with Actara SC insecticide in pepper seedlings	-2.84848*	0.30	0.00
	3.Foliage treatment with Actara SC insecticide in pepper seedlings	-2.09091*	0.30	0.00

*Level of significance: 0.05

4. Conclusion

We found that better development was achieved in the pepper seedling groups treated with Actara SC insecticide (Treatments 2 and 3). The highest average plant height (14.63 cm) was measured at the seedling group growing on Actara treated rock cotton medium (Treatment 2). The second best result (12.3 cm) was seen in the foliage treated group (Treatment 3), which showed 51% higher results than the untreated group of seedlings (8.12 cm) growing on infected rock cotton (Treatment 1). The average leaf number (pcs) results were the following: 43% higher numbers (14.76 leaves) were seen in the rock cotton treated group (Treatment 2) than in the untreated, infected rock cotton group (Treatment 1).

The foliage treated peppers (Treatment 3) grew 25% more leaves (12.88 leaves) than the control group (Treatment 1). Average sprout number could only be counted in the pesticide treated groups (seedlings in Treatment group 2 had an average of 2.91 sprouts, while seedlings in Treatment group 3 had an average of 2.15 sprouts). All the seedlings growing on untreated, infected rock cotton (Treatment 1) had a total of one sprout. From the results of our experiment, we can conclude that successful protection was achieved against greenhouse whitefly, a common pest affecting forced cultivated plants, with the application of the pesticide Actara SC. The pesticide was proven most effective if it was sprayed on the growing medium.

5. Acknowledgement

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EVALUATION OF WELD JOINTS PRODUCED BY LASER WELDING OF SUPERDUPLEX STAINLESS STEEL SAF 2507

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Abstract

The modernization process and effectiveness increase in production is often connected with implementation of more effective and automated devices, materials change and technological operation sequence change. These processes have to take into account further product application. Paper deals with the microstructural changes caused by material deformation before the welding of SAF 2507 stainless steel. The corrosion resistance in simulated real conditions was realised in order to evaluate the impact of welding process.

Keywords: superduplex stainless steels, duplex stainless steels, deformation, corrosion.

1. Introduction

Nowadays a lot of producers, especially smaller ones do not pay enough attention to material selection for certain application. In order to meet pre-defined requirements of utilizing stainless steels (SS), they choosing cheaper SS with no knowledge of different SS grades. This may result into quicker depletion of operating life caused by abrasion of certain exposed parts, lower corrosion resistance, or low material strength. Speeding up the production times have to take into account the requirements of materials used in production. Certain materials as duplex stainless steels require more time for processing especially in case of welding and forming these materials.

2. Material

Cold rolled superduplex stainless steels (SDSS) SAF 2507 with 2 mm thickness were used for experiment. This material has a good mechanical properties and corrosion resistance. Corrosion resistance and mechanical properties are mostly influenced by phase ration in microstructure of SDSS. The microstructure of SDSS usually consists of 45–65 % austenite and 35–55 % ferrite, Figure 1, [1, 2].

Figure 1 HAZ of weld in SAF 2507

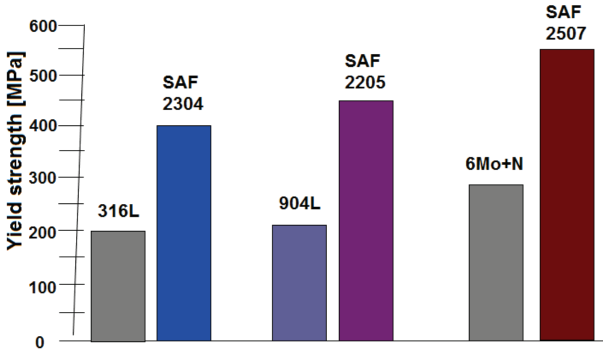


Figure 2. YS - austenitic and duplex stainless steels

3. Methods

The deformation of 10 and 20 % was applied on tested specimens. Specimens were welded by laser beam welding. Laser device used for experiment was TRUMPF TruDisk 4002 with output power of 1.4 kW. Optical cable for laser light distribution had 0.4 mm diameter and was connected to D70 welding head. To get wider weld joint with more fluent transition to base material, the focused spot having 0.4 mm diameter was moved 5 mm above the material surface. Welding head was placed on FANUC M-710iC/50 robotic arm(Figure 4).Microstructure of weld joint and base material was observed by NEOPHOT 32 optical microscope (Figure 5) at 400x magnification. To get the better overview, the test was also realised on standard duplex stainless steel SAF 2205 (Table 1) [3].

Table 1.Deformation of samples

Sample	Material	Rolling direction [˚]	Deformation [%]
P1	2205	90	10
P2	2205	90	20
P3	2205	0	10
P4	2205	0	20
P5	2507	0	10
P6	2507	0	20
P7	2507	90	10
P8	2507	90	20

Second part of this research was to evaluate corrosion resistance of weld joints, where two shielding gases (Ar and N) were compared. By the presumption nitride should promote austenite formation at the surface and root section of the weld joint and it should increase the corrosion resistance. Test was realised on 3 weld joints produced with Ar as a shielding gas and another 3 samples with same welding parameter with nitrogen as shielding gas.

In real condition, the weld joints are attacked by corrosion from top or root part of the joints. Therefore the corrosion chamber, Fig. 5, was chosen for this experiment. Since duplex stainless steels are sensitive to chlorides, 5 % NaCl solution environment was chosen. Test duration was 500 hours [4].

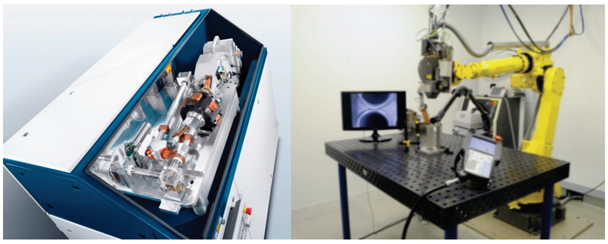


Figure 4. TRUMPF TruDisk 4002 laser device (left), Fanuc M-710iC/50 robotic arm (right)

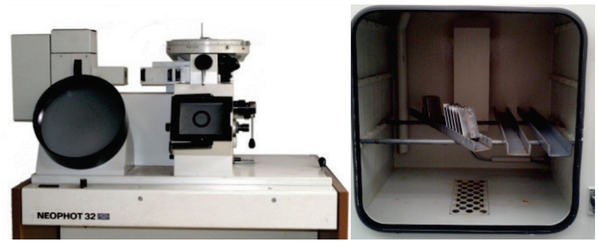


Figure 5.Optical microscope Neophot 32 (left), corrosion chamber (right)

4. Results

Austenite and ferrite ratio was measured after welding process for all samples is provided in Table 2. Samples 4 and 8 show lowest austenite amount. Presented ratio is and average value of 5 measurements. Pre-deformation ensured better phase ratio only in microstructure of heat affected zone. Also, the better ratio and better shape of grains was observed in samples with deformation perpendicular of rolling direction of the material (Table 3).

Table 2.Measured phase ratio

Sample	F/A ratio	Sample	F/A ratio
P1	72,32/26,01	P5	70,26/29,74
P2	77,31/22,69	P6	78,58/21,42
P3	75,65/24,35	P7	71,77/28,23
P4	83,84/16,16	P8	81,35/18,65

Good corrosion results were achieved during corrosion test. Normally the corrosion is evaluated by weight change before and after corrosion test. In this case the weight change was too small to evaluate corrosion resistance. The area of corrosion distortion could be inspected only visually. Some of the results are documented in figures 6-10. The biggest pitting corrosion attack was observed in surface and root section of weld joints. Despite of low weight change after corrosion test, the following can be stated:

- Base material shows lower corrosion due to the better ratio of austenite and ferrite,
- Bigger corrosion attack was observed in samples welded with Ar as a shielding gas.
- Surface of all weld joint showed bigger corrosion attack than root section in case of using Ar and N shielding gases,

Table 3.Microstructure - HAZ of predeformed weld joint

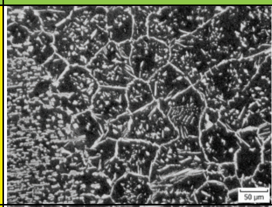
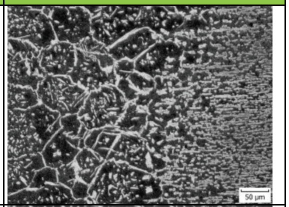
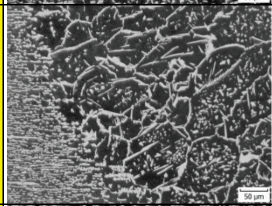
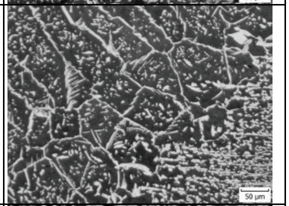
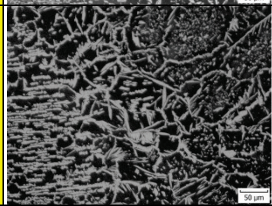
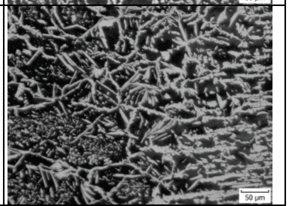
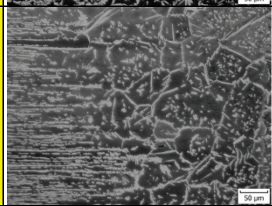
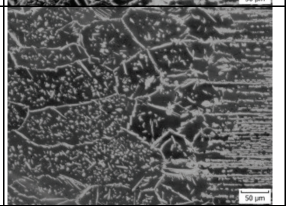
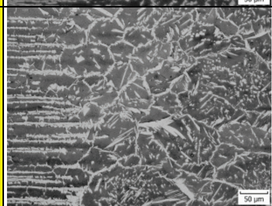
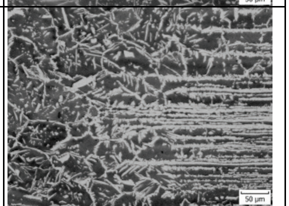
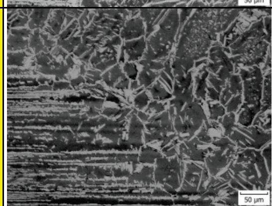
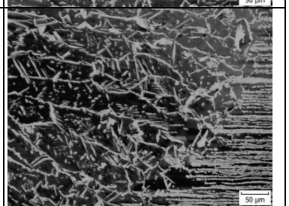
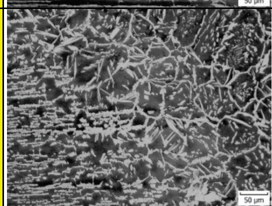
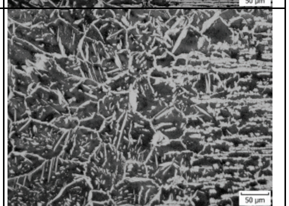
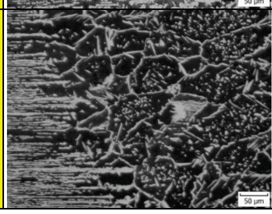
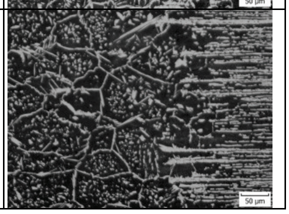
	HAZ 1	HAZ 2
P1		
P2		
P3		
P4		
P5		
P6		
P7		
P8		

Figure 6.Corrosion attack of base material

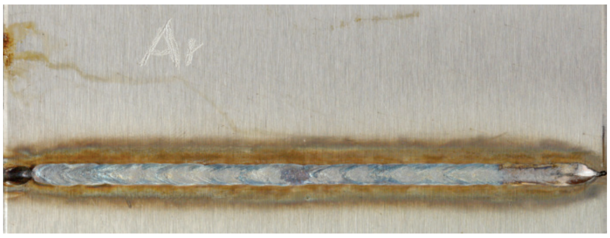


Figure 7.Corrosion attack of sample Ar2 (weld surface)

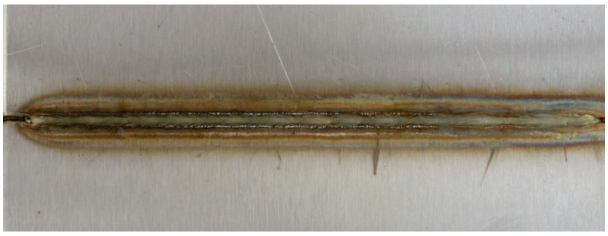


Figure 8.Corrosion attack of sample Ar2 (weld root)

Figure 9.Corrosion attack of sample N1 (weld surface)

Figure 10.Corrosion attack of sample N1 (weld root)

5. Conclusion

The innovation process in manufacturing process cannot be ignored. Paper points out the importance of right selections of materials. Research results showed good mechanical and corrosion properties of superduplex stainless steel SAF 2507. Pre-deformation direction and intensity do not have an effect on grain shape in weld metal microstructure; however it has an influence on size of the grains.

The corrosion test showed that nitrogen as a shielding gas has positive influence on corrosion resistance because of higher austenite amount in surface and root section of the weld joint. Further research will be focused on balancing the phase ratio to get better results in corrosion resistance.

6. Acknowledgement

This research was supported by Slovak Research and Development Agency using financial support No. APVV-0248-12.

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PROVING EQUALITIES AND INEQUALITIES BY USING THE INTEGRAL METHOD

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Abstract

The work presents the application of the integral method in the proof of Young's inequality. In addition to the integral method, considered inequality problems are also studied by using the geometric-arithmetic mean inequality and Jensen's inequality. Results include generalizations of the discrete and integral form of Young's inequality, and particularly refinements of the integral form.

Keywords: integral method, Young's inequality, geometric-arithmetic mean

1. Introduction

Dealing with inequalities we use means. In this paper, we mainly apply the two basic means, arithmetic and geometric. Let $a_1,\dots,a_n \in \mathbb{R}$ be points on the real axis, and let $\alpha_1,\dots,\alpha_n \in \mathbb{R}$ be non-negative coefficients satisfying $\sum_{i=1}^{n}\alpha_i = 1$. The sum

$$c_{AM} = \sum_{i=1}^{n}\alpha_i a_i \tag{1}$$

is called convex combination (generalized or weighted arithmetic mean), and its center c_{AM} belongs to the closed interval $[a_{\min}, a_{\max}]$. Using the notion of convex hull, we usually write $c_{AM} \in \operatorname{conv}\{a_1,\dots,a_n\}$. Assuming that all $a_i \ge 0$ (respectively $a_i > 0$), and that all $\alpha_i > 0$ (respectively $\alpha_i \ge 0$), the product

$$c_{GM} = \prod_{i=1}^{n} a_i^{\alpha_i} \tag{2}$$

is called geometric combination (generalized or weighted geometric mean). By applying the logarithmic and exponential function to the equation in (2), it follows that the point $c_{GM} \in \operatorname{conv}\{a_1,\dots,a_n\}$. According to the theory of quasi-arithmetic means, the geometric center is less than or equal to the arithmetic center, $c_{GM} \le c_{AM}$.

2. Young's inequality

The section presents an overview of the most important results on Young's inequality. The discrete form of Young's inequality

$$ab \le \frac{1}{p}a^p + \frac{1}{q}b^q, \tag{3}$$

where points $a,b \ge 0$ and coefficients $p,q > 1$ satisfy $1/p + 1/q = 1$, is a special case of the generalized geometric-arithmetic mean inequality $c_{GM} \le c_{AM}$.More important is the integral form of Young's inequality. Let $g:[0,\infty) \to [0,\infty)$ be a bijective continuous function (such a function is strictly increasing satisfying $g(0)=0$ and $\lim_{x\to\infty} g(x) = \infty$), and let g^{-1} be its inverse function.

Let a be a non-negative number. Given the integer n, we take the points $x_{ni} = (a/n)i$ assuming that $x_{n0} = 0$, and so we have $x_{ni} - x_{ni-1} = a/n$. As the following calculation demonstrates,

$$\begin{aligned} ag(a) &= \sum_{i=1}^{n}\frac{a}{n}\left[ig(x_{ni}) - (i-1)g(x_{ni-1})\right] \\ &= \sum_{i=1}^{n}\frac{a}{n}g(x_{ni-1}) + \sum_{i=1}^{n}\left[g(x_{ni}) - g(x_{ni-1})\right]\frac{a}{n}i \\ &= \sum_{i=1}^{n}\left[x_{ni} - x_{ni-1}\right]g(x_{ni-1}) \\ &\quad + \sum_{i=1}^{n}\left[g(x_{ni}) - g(x_{ni-1})\right]g^{-1}(g(x_{ni})), \end{aligned} \tag{4}$$

the product $ag(a)$ is presented with the integral sums of the functions g and g^{-1}. Letting n to infinity, we obtain the necessary equality

$$ag(a) = \int_0^a g(x)dx + \int_0^{g(a)} g^{-1}(x)dx. \tag{5}$$

Take another non-negative number b. Using the above, and related equality

$$bg^{-1}(b) = \int_0^b g^{-1}(x)dx + \int_0^{g^{-1}(b)} g(x)dx, \tag{6}$$

we can prove that

$$\int_a^{g^{-1}(b)}(b-g(x))dx=\int_{g(a)}^b(g^{-1}(x)-a)dx. \qquad (7)$$

The following theorem extends the equality in equation (5) to any two non-negative numbers a and b.

Theorem 2.1. 1*Let* $g:[0,\infty)\to[0,\infty)$ *be a bijective continuous function, and let* a *and* b *be non-negative real numbers.Then*

$$\begin{aligned}ab&=\int_0^a g(x)dx+\int_0^b g^{-1}(x)dx\\&\quad-\int_a^{g^{-1}(b)}(b-g(x))dx.\end{aligned} \qquad (8)$$

Proof. Using the basic properties of the integral calculus, and the equality in equation (6), it follows that

$$\begin{aligned}&ab+\int_a^{g^{-1}(b)}(b-g(x))dx\\&=ab+b\int_a^{g^{-1}(b)}dx-\int_a^{g^{-1}(b)}g(x)dx\\&=bg^{-1}(b)-\int_0^{g^{-1}(b)}g(x)dx+\int_0^a g(x)dx\\&=\int_0^a g(x)dx+\int_0^b g^{-1}(x)dx\end{aligned}$$

proving the equality in equation (8). □

The equalities in equations (5), (7) and (8) are equivalent.The integral value $\int_a^{g^{-1}(b)}(b-g(x))dx$ is non-negative, and it is equal to zero if, and only if, $a=g^{-1}(b)$, or equivalently $g(a)=b$. Applying the variable values $x=g^{-1}(b)$ and $x=a$ to the function $g(x)$, we get the estimation

$$\begin{aligned}0&\le\int_a^{g^{-1}(b)}(b-g(x))dx\\&\le(b-g(a))(g^{-1}(b)-a).\end{aligned} \qquad (9)$$

A similar estimation was obtained in [1]. Combining the above inequality and the equality in equation(8), we get the Young inequality extended to the right side, as follows.

Corollary 2.2. 2*Let* $g:[0,\infty)\to[0,\infty)$ *be a bijective continuous function, and let* a *and* b *be non-negative real numbers.Then*

$$\begin{aligned}ab&\le\int_0^a g(x)dx+\int_0^b g^{-1}(x)dx\\&\le ab+(b-g(a))(g^{-1}(b)-a).\end{aligned} \qquad (10)$$

Theorem 2.1 also provides a clear picture of the equality cases. The equalities in equation (10) appear if, and only if, $g(a)=b$. In fact, the inequality in equation (10) is equivalent with the equalities in equations (5), (7) and (8).The left inequality of equation (10) is the well-known integral form of Young's inequality. He proved the inequality using the assumption that the function g is differentiable, see [8].

3. Generalizations

The objective of this section are generalizations of the discrete and integral form of Young's inequality. In the following lemma, we extend the discrete form of Young's inequality, and then demonstrate applications.

Lemma 3.1. 3 *Let* $a_1,\dots,a_n$ *be non-negative points on the real axis, and let* $\alpha_1,\dots,\alpha_n$ *be positive coefficients satisfying* $\sum_{i=1}^n\alpha_i=1$*.Then*

$$\prod_{i=1}^n a_i^{\alpha_i}\le\sum_{i=1}^n\alpha_i a_i\le\sum_{i=1}^n a_i-(n-1)\prod_{i=1}^n a_i^{\frac{1-\alpha_i}{n-1}}. \qquad (11)$$

Proof. We prove the right inequality in equation(11). Applying the geometric-arithmetic mean inequality to the geometric mean

$$\prod_{i=1}^n a_i^{(1-\alpha_i)/(n-1)},$$

we obtain the inequality

$$\prod_{i=1}^n a_i^{\frac{1-\alpha_i}{n-1}}\le\sum_{i=1}^n\frac{1-\alpha_i}{n-1}a_i=\frac{1}{n-1}\left(\sum_{i=1}^n a_i-\sum_{i=1}^n\alpha_i a_i\right),$$

which after rearrangement coincides with the right inequality in equation (11). □

The left term of the inequality in equation (11) is geometric mean, and the middle term is arithmetic mean. Using the concrete examples it can be shown that the right term does not necessarily belong to $\mathrm{conv}\{a_1,\dots,a_n\}$, except in the initial case $n=2$.If $n=2$, then the geometric mean $a_1^{1-\alpha_1}a_2^{1-\alpha_2}$ belongs to the interval $\mathrm{conv}\{a_1,a_2\}$ and thus it is equal to some binomial convex combination $\beta_1a_1+\beta_2a_2$. Therefore,

$$\begin{aligned}a_1+a_2-a_1^{1-\alpha_1}a_2^{1-\alpha_2}&=a_1+a_2-\beta_1a_1-\beta_2a_2\\&=(1-\beta_1)a_1+(1-\beta_2)a_2\end{aligned}$$

belonging to the interval $\mathrm{conv}\{a_1,a_2\}$. Putting $a=a_1^{\alpha_1}$, $b=a_2^{\alpha_2}$, $\alpha_1=1/p$ and $\alpha_2=1/q$ in equation (11) for $n=2$, and using the fact that

$a^p + b^q - a^{p-1}b^{q-1} = ab + (b - a^{p-1})(b^{q-1} - a)$, we get the following extension of the discrete form of Young's inequality.

Corollary 3.2. 4*Let* $a, b \geq 0$ *be points on the real axis, and let* $p, q > 1$ *be coefficients satisfying* $1/p + 1/q = 1$*.Then*

$$ab \leq \frac{1}{p}a^p + \frac{1}{q}b^q \leq ab + (b - a^{p-1})(b^{q-1} - a). \quad (12)$$

The equalities are valid in equation (12) if, and only if, $a^p = b^q$. The equation (12) can be obtained by applying the substitutions $g(x) = x^{p-1}$ and $g^{-1}(x) = x^{q-1}$ to equation (10). As a coincidental consequence of Lemma 3.1, we can expose the extensions of Bernoulli's inequalities.

Corollary 3.3.5*Let* a *be a non-negative real number, and let* r *be a real number.Then the following inequalities are valid and equivalent:*

$$a - 1 \leq \frac{a^{1-r} - 1}{1 - r} \leq a^{-r}(a - 1), \; r < 0 \quad (13)$$

$$a^r - 1 \leq r(a - 1) \leq a^{1-r}(a^r - 1), \; 0 < r < 1 \quad (14)$$

$$a - 1 \leq \frac{a^r - 1}{r} \leq a^{r-1}(a - 1), \; r > 1 \quad (15)$$

Proof. For example, the inequality in equation (14) follows by substitutions $a_1 = 1$, $a_2 = a$, $\alpha_1 = 1 - r$ and $\alpha_2 = r$ to equation (11) with $n = 2$. □

Now, we try to generalize the integral form of Young's inequality.First, we want to apply a non-decreasing convex function to the extended Young's inequality in equation (10). For this purpose, we put

$$c = \int_0^a g(x)dx + \int_0^b g^{-1}(x)dx. \quad (16)$$

The numbers ab, c, and $g(a)g^{-1}(b)$ belong to the interval $\mathrm{conv}\{ag(a), bg^{-1}(b)\}$. Replacing the middle term in equation (10) with the convex combination $c = \alpha ag(a) + \beta bg^{-1}(b)$, and using the fact that

$$\begin{aligned} &ab + (b - g(a))(g^{-1}(b) - a) \\ &= ag(a) + bg^{-1}(b) - g(a)g^{-1}(b), \end{aligned}$$

we get the inequality

$$\begin{aligned} &ab \leq \alpha ag(a) + \beta bg^{-1}(b) \\ &\leq ag(a) + bg^{-1}(b) - g(a)g^{-1}(b), \end{aligned} \quad (17)$$

where $\alpha = \dfrac{bg^{-1}(b) - c}{bg^{-1}(b) - ag(a)}$ $\beta = \dfrac{c - ag(a)}{bg^{-1}(b) - ag(a)}$.

Theorem 3.4. 6*Let* $g : [0, \infty) \to [0, \infty)$ *be a bijective continuous function, and let* a *and* b *be different non-negative real numbers. Let* $f : \mathrm{conv}\{ag(a), bg^{-1}(b)\} \to \mathbb{R}$ *be a non-decreasing convex function.Then*

$$\begin{aligned} &f(ab) \leq \alpha f(ag(a)) + \beta f(bg^{-1}(b)) \\ &\leq f(ag(a)) + f(bg^{-1}(b)) - f(g(a)g^{-1}(b)). \end{aligned} \quad (18)$$

Proof. The left term of the inequality in equation (18) is a direct consequence of the monotonicity and convexity of the function f.To prove the right-hand side of this inequality, we use the function $f_{\{A,B\}}^{\mathrm{line}}$ of the chord line passing through the points $A(ag(a), f(ag(a)))$ and $B(bg^{-1}(b), f(bg^{-1}(b)))$ of the graph of f. By applying the convexity of f, as well as the monotonicity and affinity of $f_{\{A,B\}}^{\mathrm{line}}$, it follows that

$$\begin{aligned} &\alpha f(ag(a)) + \beta f(bg^{-1}(b)) \\ &= f_{\{A,B\}}^{\mathrm{line}}\left(\alpha ag(a) + \beta bg^{-1}(b)\right) = f_{\{A,B\}}^{\mathrm{line}}(c) \\ &\leq f_{\{A,B\}}^{\mathrm{line}}\left(ag(a) + bg^{-1}(b) - g(a)g^{-1}(b)\right) \\ &= f\left(ag(a)\right) + f\left(bg^{-1}(b)\right) - f_{\{A,B\}}^{\mathrm{line}}\left(g(a)g^{-1}(b)\right) \\ &\leq f\left(ag(a)\right) + f\left(bg^{-1}(b)\right) - f\left(g(a)g^{-1}(b)\right), \end{aligned}$$

and the inequality proof is done. □

To generalize the extended Young's inequality in equation (10), we interpolate new points, and thus achieve the main result.

Theorem 3.5. 7*Let* $g : [0, \infty) \to [0, \infty)$ *be a bijective continuous function, and let* a *and* b *be non-negative real numbers. Let* $n \geq 2$ *be an integer, and let* $a = x_1, \ldots, x_n = g^{-1}(b)$ *be either the non-decreasing or non-increasing* n*-tuple.Then*

$$\begin{aligned} &ag(a) + \sum_{i=1}^{n-1}[g(x_{i+1}) - g(x_i)]x_i \\ &\leq \int_0^a g(x)dx + \int_0^b g^{-1}(x)dx \\ &\leq bg^{-1}(b) + \sum_{i=1}^{n-1}[x_i - x_{i+1}]g(x_i). \end{aligned} \quad (19)$$

Proof. Let us prove the inequality in (19) using the induction on the integer $n \geq 2$.The base of induction. Taking $n=2$ the inequality in (19) reduces to the inequality in (10). The step of induction. Suppose that the inequality in equation (19) is true for all corresponding n-tuples of points x_i. Using $n+1$ points x_i where $x_{n+1}=g^{-1}(b)$, and applying the induction premise to the left inequality, we get

$$\begin{aligned}
&ag(a)+\sum_{i=1}^{n}[g(x_{i+1})-g(x_i)]x_i \\
&\le \int_0^a g(x)dx+\int_0^{g(x_n)} g^{-1}(x)dx+\int_{g(x_n)}^{b} x_n\,dx \\
&\le \int_0^a g(x)dx+\int_0^{g(x_n)} g^{-1}(x)dx+\int_{g(x_n)}^{b} g^{-1}(x)dx \\
&= \int_0^a g(x)dx+\int_0^{b} g^{-1}(x)dx,
\end{aligned}$$

proving the left inequality for $n+1$ points. To prove the right inequality we proceed in a similar way. □

The geometric image of the inequality in equation (19), the case $a\le g^{-1}(b)$, can be seen in Figure 1. Expressed by the numeric values, it is as follows.

The numeric value of the middle term is equal to "area of the curvilinear triangle with vertices $O(0,0)$, $A(a,0)$ and $A'(a,g(a))$" plus "area of the curvilinear triangle with vertices $O(0,0)$, $B(0,b)$ and $B'(g^{-1}(b),b)$". The value of the left term is equal to "area of the rectangle with sides a and $g(a)$" plus "areas of the rectangles with sides x_i and $g(x_{i+1})-g(x_i)$". The value of the right term is equal to "area of the rectangle with sides $g^{-1}(b)$ and b" minus "areas of the rectangles with sides $x_{i+1}-x_i$ and $g(x_i)$".

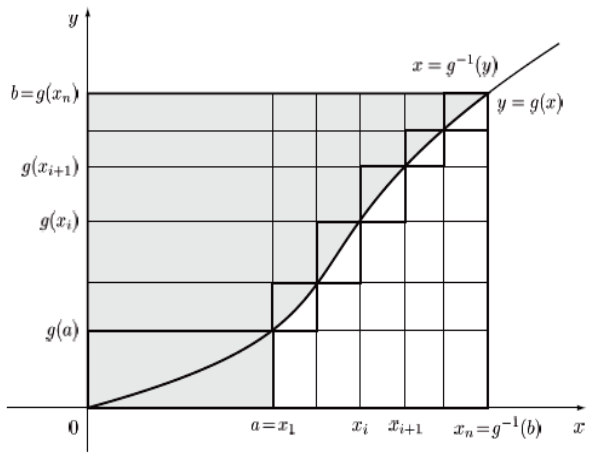

Figure 1. The geometric presentation of theinequality in equation (19)

Remark 3.6.8 *If, for the given integer n, every interval $[x_{ni},x_{ni+1}]$ of the n-tuple of Theorem 3.5 contracts to the point as n approaches infinity, then both the left and right term of equation (19) approaches the middle term. It actually says that the left term approaches*

$$ag(a)+\int_{g(a)}^{b} g^{-1}(x)dx, \tag{20}$$

and the right term approaches

$$bg^{-1}(b)+\int_{g^{-1}(b)}^{a} g(x)dx. \tag{21}$$

The bounds of Young's inequality (1) were discussed in [1] and [4]. Review of the earlier work on Young's inequality and its consequences can be found in books [7] and [5]. At the end, let us show the introduction to the functional approach.

4. A functional approach

Let $\mathcal{X}$ be a non-empty set. Let $\mathbb{X}$ be a subspace of the linear space $\mathbb{R}^{\mathcal{X}}$ of all real functions on the domain $\mathcal{X}$ containing the unit function e_0, defined by $e_0(x)=1$ for every $x\in\mathcal{X}$. A linear functional $L:\mathbb{X}\to\mathbb{R}$ is said to be positive (non-negative) if $L(g)\ge 0$ for every non-negative function $g\in\mathbb{X}$. The positive functional L is called unital or normalized if $n=1$. For any function $g\in\mathbb{X}$, the number $L(g)$ is located in the closed convex hull of the set $\{g(x):x\in\mathcal{X}\}$, that is, in the closed interval of real numbers which contains the image of g .Jessen (see [3]) affirmed the functional form of Jensen's inequality. Functional variants of Jensen's inequality and its applications have been considered in [6].

We take $\mathcal{X}=[0,\infty)$, and assume that $\mathbb{X}$ is the linear space of all continuous real functions on the domain $[0,\infty)$. For every positive number a we can define the unital positive linear functional $L_a:\mathbb{X}\to\mathbb{R}$ by

$$L_a(g)=\frac{1}{a}\int_0^a g(x)dx. \tag{22}$$

According to the left inequality of equation (10), it follows that the inequality

$$ab\le aL_a(g)+bL_b(g^{-1}) \tag{23}$$

holds for all pairs of numbers $a,b>0$ and mutually inverse functions $g,g^{-1}\in\mathbb{X}$.

In what follows, we will use functionals L_a and L_b satisfying the inequality in (23) independently on equation (22). Applying the substitution $b = a$ to the inequality in equation (23), and using the function $h = g + g^{-1}$, we get

$$a \le L_a(h). \tag{24}$$

Summarizing the inequality in equation (23), and the related inequality where g and g^{-1} are replaced, we obtain

$$2ab \le aL_a(h) + bL_b(h). \tag{25}$$

5. Conclusion

The geometrical picture of the equality in equation (5) is very simple. This image appears in Figure1, if we take *n*=1. It took decades before that equality was analytically proven.The first analytical proofs emerged in seventies of the last century. All this points to the complexity of the integral method, especially when it comes to specific applications. On the other hand, without integral we could not scientifically validate a simple geometrical picture. Finally, we could draw the conclusion that in scientific work it is the best to combine geometrical and analytical methods.

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THE STRUCTURE OF MOTIVATION FOR MECHANICAL ENGINEERING STUDY AT UNIVERSITY OF ZAGREB

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Abstract

The paper aims to explore freshmens' reasons to study mechanical engineering at University of Zagreb. These reasons are framed mostly in terms of intrinsic and extrinsic motivation. In addition, the paper examines elements of motivational structure with respect to the selected independent variables of the sample. The obtained results indicate relative significance of some independent variables and slightly more pronounced importance of intrinsic motivation.

Keywords:

Students of mechanical engineering, extrinsic motivation, intrinsic motivation, motivational structure

1. Introduction

Through the last couple of decades, students' interest in engineering study has closely corresponded to fluctuations in socio-economic development of late industrial societies. Up to 2000., this interest was decreasing due mostly to the factors of deindustrialisation and to the rising precarious character of employment with the corresponding uncertainty in terms of individual professional career and individual biography [1]. With the beginning of economic crisis in developed world in 2000s and clearly expressed orientation toward reindustrialisation interest in engineering had start to rise again. However, it unevenly affected different strains in STEM field and corresponding accademic programs [1].

Also, as related research indicates [2], number of long-standing factors inherent to academic engineering curriculum were identified as discouraging with regard to students' interest in engineering study. Predominantly narrow disciplinary focus, excessive abstraction of the studies and difficulties in understanding engineering as a social enterprise are singled out as main potential barriers to attracting the best and the most creative freshmen [3]. However, as Matusovich at al. [4] pointed out, general understanding on students' motivation to enter engineering study was still relatively poor. In other words, just mentioned socio-economic and curriculum factors needed to be upgraded by research of the structure of motivation of future engineering students.

Accordingly, the main objectives of our research are aimed to explore freshmens' reasons to study mechanical engineering at University of Zagreb in terms of intrinsic and extrinsic motivation.

As a matter of empirical and theoretical concern which is thoroughly established in psychology, research on motivation is also frequently used in the field of engineering education, although sometimes with poor conceptual background [5]. While concentrating on structure of students' motivation for engineering study, most of these studies tried to explore students' inclination toward engineering in terms of quasi-conceptual opposition between extrinsic (security, salary or social position) and intrinsic (interest in engineering or work autonomy) motivation. Extrinsic motivation reffered to someone's activity oriented toward different utilitarian aims of relativelly wide spectre - from ascribed importance to utility itself. On the contrary, intrinsic motivation reffered to activity independent on external influence, and which stemmed from interest for activity itself and was related to corresponding enjoyment [6]. However, both types of motivation have been integrated into more sophisticated models raised in expectancy theory, theory of task's importance, and theories in which motivation is associated with cognition and volition [7].

In our research we have partly relied on theoretical approach of Deci et al [6] since they indicated a need to differ between several levels along the continuum of extrinsic motivation including not only it's "pure" type (external regulation), or couple of transitional types (introjected and identified regulation), but also its the most developed type (integrated regulation) where externally regulated activities by their character were integrated into "individuals' coherent sense of self" [6]. Although this last type brings closer to intrinsic motivation, it is identified in terms of extrinsic motivation because the specific interest in an activity is not fully internally induced [6]. This conceptualisation confirms analytical usefulness of so called transitional types which on the scale of extrinsic motivation gradually get closer to intrinsic motivation. On the contrary, possibilities to operationalize intrinsic motivation are reduced to its ideal-type extreme.

2. Sample and Method

The research participants were the first year students of the Faculty of Mechanical Engineering at the University of Zagreb. During the first week of class in autumn 2014, 227 freshmen filled our questionnaire. In proportion with the number of students enrolled (435), the questionnaire comprised students of all majors. In this respect, the sample can be considered as representative.

In this paper we used descriptive and inferential statistical methods.

The descriptive statistical methods were used for describing the sample and the independent variables Besides that, inferential statistical methods were used in accordance with the goal of the research. Series of t-tests and One-way ANOVAs were made.

Independent variables consisted of 186 male students (82%) and 40 female students (18%). With regard to high school, there were 185 gymnasium students (82%) and 40 students who came from technical school (18%). 51 students estimated their family income as above average (28%), while 64 students estimated family income as average (33,%), and finally 74 students estimated family income as bellow average (39%). With regard to parents' education, 89 (41%) students have mothers with high school education contrary to 126 students whose mothers had college degree (59%). Finally, 97 students had fathers with high school (45%), while 118 (55%) students had fathers with college degree.

3. Results

The first variable which represents the extrinsic motivation to study engineering is an aggregate of the next categories: 1) The desirability of high salary (represented with two indicators in the questionnaire: "I joined this study primarily due to possibility to find a well-paid job" and "Above-average salary is the main factor for my choice of this study"); 2) Orientation towards work and career (represented with two indicators: "I started this study primarily due to the possibility of quick employment" and "I started this course primarily due to the possibility of fast career advancement"); 3) The importance of the professional reputation in society (one indicator: "I find this study attractive mostly because of the engineers' professional reputation in society"). Questions asked are sorted by similarity into three meaningful categories. All the questions were presented 1-5 Likert scale where 1 means "Strongly disagree" and 5 "Strongly agree".

The variable which points to levels of intrinsic motivation consists of answers to the following questions: "I started this study because I am primarily interested in the field of science and technology", "I have started this study mostly by being attracted by gaining new technical knowledge", "I have already shown a preference in repairing different devices" "I enjoy solving mathematical problems", "Engineering is the official name for the hobbies I enjoy," "I prefer to deal with things rather than people." Responses were noted in the same manner as in elements of extrinsic motivation. Because of the greater variety of indicators than in the previous case we did not extract them into the common categories.

Table 1 shows that among individual extrinsic motives the possibility of fast career advancement and the possibility of quick employment dominate. Category "Job and Carrer" in which they are summed up consequently shows the highest value. They are followed by a well-paid job and professional reputation in society. The table also shows that individual variables are summed up in corresponding category including their hierarchy. The most important element of extrinsic motivation for our respondents is job and career. Professional reputation is estimated as the next in importance, while potential financial benefits (salary and well paid job) rank last. As it can be seen overall score on a scale of extrinsic motivation is 3.41.

Table 1. Elements of extrinsic motivation.

Individual variable	Mean	SD	Category	Means by category	Overall Mean	SD
Opportunity to get a job quickly	3,53	1,0	Job and career	3,57	3,41	0,80
Possibility to have fast career	3,60	1,01				
Possibility to get well paid job	3,44	1,08	Salary	3,26		
Possibility to have sallary above average	3,08	1,11				
Engineers' reputation in society	3,38	1,14	Reputation	3,38		

When it comes to the issues of intrinsic motivation (Table 2), it is evident that students put the highest scores to issues which indicate the importance of the interest in science and technology and of gaining new technical knowledge. Hierarchically, inclination towards solving mathematical problems follows immediately behind them. Finally, all of them are followed by tendency to repair various devices and the latest two are engineering as a hobby and preference to deal with things rather than people.

Table 2. Elements of intrinsic motivation.

Individual variable	Mean	SD	Overall mean	SD
Primarilly interest in science and technology	4,46	0,67	3,72	0,56
Attracted by new technical knowledge	4,09	0,8		
Inclination to fix devices has always existed	3,56	1,06		
Engineering as career name for own hobbies	3,23	0,97		
Rather being involved in things than in people	3,22	1,14		
Enjoying in solving mathematical problems	3,75	1,05		

It is easy to notice that the total score on the scale of intrinsic motivation (M = 3.72, SD = 0.55) is higher than in the case of extrinsic (M = 3.41, SD = 0.80) and testing of their differences (paired samples) showed a significantly higher intrinsic than extrinsic motivation (t = -4502, df = 226, p = 0.000).

In a few words, students are remarkably more intrinsically than extrinsically motivated. In the first type of motivation interest in science and technology, new technical knowledge, enjoying math and experience in repairing devices dominates while in the second (extrinsic) quick employment, fast career advancement, good salary and professional reputation in society prevail.

We also tested differences in the components of the both types of motivation with regard to independent variables. Independent variables used are: Sex (M/F), High school (technical or gymnasium), monthly income per capita (below average, average or above average), mothers' education (high school or college) and fathers' education (high school or college).

When it comes to extrinsic motivation, it's each component is observed particularly with regard to social groups represented in the independent variables. Table 3 indicates that overall extrinsic motivation rises as the parents' educational level is smaller. In both cases - mother's and father's education - significanrt difference was found. Also, as it is visible in Table 3, father's education is expressed by greater significance. With regard to other independent variables we found no significant differences.

Table 3. Differences in levels of overall extrinsic motivation (EM) with regard to independent variables.

		N	EM Overall Mean	SD	EM Overall Difference sig.
Sex	Male	186	3,35	0,82	n.d.
	Female	40	3,59	0,69	
High school	Gyumasium	185	3,38	0,77	n.d.
	Technical high school	40	3,55	0,93	
Income	Bellow avegage	74	3,50	0,76	n.d.
	Average	64	3,38	0,80	
	Above average	51	3,41	0,86	
Mothers' education	High school	89	3,54	0,79	0,017
	College	126	3,30	0,79	
Fathers' education	High school	97	3,57	0,66	0,003
	College	118	3,25	0,87	

Detailed analysis of specific extrinsic motivation components (Table 4) shows that the element of job and career in extrinsic motivation is more important to female than to male students. Similarly, students who came from technical high schools found professional reputation of engineers more important than the students who came from gymnasium. Among income groups there is no difference in any of the components. On the other side, students with less (high school) educated mothers consider job, career and salary more important than students whose mothers have college diploma. Finally, students with less educated fathers gave more importance to all three components of extrinsic motivation (Job and Career, Salary, Professional reputation) than those students whose fathers have college degree. Finally, It is noticable that salary as the component of extrinsic motivation showed no differences across all independent variables except parents' education. In discussion we shall concentrate on elements which proved to be consistent in both, the overall and the detailed differences in extrinsic motivation.

With regard to the issue of intrinsic motivation the same procedure as in the previous case was repeated. However, because of the variables' diversity they were more difficult to be summed up in a category of higher order so that was not done. Table 5 shows that there are no significant differences in terms of any single independent variables when considering the overall intrinsic motivation. More precisely, it can be said that the difference in overall intrinsic motivation between the sexes doesn't exists. Likewise, there is no difference regarding the high school, family income or level of parental education.

Table 4. Differences in components of extrinsic motivation (EM) with regard to independent variables

		N	Job and career	Job and career sig.	Salary	Salary sig.	Professional Reputation	Professional Reputation sig.
Sex	Male	186	3,51	0,046	3,23	n.d.	3,33	n.d.
	Female	40	3,81		3,38		3,58	
High School	Gymnasium	185	3,58	n.d.	3,24	n.d	3,31	0,048
	Technical school	40	3,58		3,38		3,70	
Income	Bellow average	74	3,60	n.d	3,43	n.d	3,46	n.d.
	Average	64	3,46		3,24		3,42	
	Above average	51	3,67		3,21		3,35	
Mothers' education	High school	89	3,70	0,048	3,42	0,034	3,51	n.d.
	College	126	3,46		3,13		3,29	
Fathers' education	High school	97	3,71	0,02	3,45	0,004	3,55	0,049
	College	118	3,43		3,06		3,25	

Table 5. Differences in levels of overall intrinsic motivation (IM) with regard to independent variables

		N	IM Overall Mean	SD	IMO Difference sig.
Sex	Male Female	186 40	3,71 3,79	0,53 0,64	n.d.
High school	Gyumasium Technical high school	185 40	3,72 3,74	0,56 0,55	n.d.
Income	Bellow avegage Average Above average	74 64 51	3,77 3,72 3,73	0,49 0,56 0,61	n.d.
Mothers' education	High school College	89 126	3,68 3,62	0,59 0,53	n.d.
Fathers' education	High school College	97 118	3,65 3,74	0,55 0,55	n.d.

Detailed analysis of specific intrinsic motivation components (Table 6) shows that the students with more educated fathers show more interest in science and technology than students with less educated fathers. In three variables: “Gaining new technical knowledge", "Experience in repairing devices" and "Dealing with things rather than people” there is no differences between groups of independent variables. Students with below-average family income (M=3,96, SD=0,867) enjoy in mathematics more than students with above-average family income (M=3,47, SD=1,255), and it was confirmed by One-way ANOVA $F(2, 188) = 3,372$, $p=0,027$. Students with more educated mothers prefer engineering as a hobby more than those who have less (high school) educated mothers. Also, contrary to common perception on gendered nature of differences with regard to inclination toward natural sciences' school subjects such as math, physics etc., we found that female students enjoy in solving mathematical tasks and problems much more than their male colleagues.

4. Discussion

Considering the main objectives of this enrolled the study of mechanical engineering and naval architecture at University of Zagreb in 2014, was primarily intrinsically motivated. This finding is confirmed by testing the differences between overall means in extrinsic and intrinsic motivation and it indicates statistically significant higher value of intrinsic motivation indicators.

To some extent, this finding corresponds to results found in similar studies conducted in Croatia. It is consistent with findings in research done by Kesić and Previšić [8] who compared the motives for enrolling into faculties of economics and electrical engineering. Although their two-factor motivational structure corresponded to a simplified matrix of extrinsic and intrinsic motivation, their findings indicated primary importance of intrinsic motives not only in process of study-enrolment decision making, but also in students' images on their own future profession. Also, our finding is relatively consistent with those in Potočnik's research [9]. Despite some differences in sample, methodology and overall results (she researched the students' motives for enrolling at the University of Zagreb and she combined qualitative and quantitative approach), it was determined that the majority of students, including those studying technical sciences, have a prevailing interest in the studies, while independent variables such as gender, age and years of study do not represent relevant factors.

Table 6. Differences in components of intrinsic motivation (IM) with regard to independent variables

		Interest in S&T	Interest in S&T sig.	New technical knowledge	New technical knowledge sig.	Inclination to fix devices	Inclination to fix devices sig.
Sex	Male	4,43	n.d.	4,11	n.d.	3,58	n.d.
	Female	4,60		4,03		3,50	
High School	Gymnasium	4,49	n.d.	4,09	n.d.	3,53	n.d.
	Technical school	4,43		4,10		3,70	
Income	Bellow average	4,47	n.d.	4,11	n.d.	3,74	n.d.
	Average	4,47		4,20		3,44	
	Above average	4,57		4,20		3,43	
Mothers' education	High school	4,39	n.d.	4,13	n.d.	3,63	n.d.
	College	4,50		4,06		3,49	
Fathers' education	High school	4,31	0,005	4,14	n.d.	3,53	n.d.
	College	4,57		4,02		3,57	
		Enjoy in math	Enjoy in math sig.	Things before people	Things before people sig.	Engineering as hobby	Engineering as hobby sig.
Sex	Male	3,65	0,003	3,18	n.d.	3,29	n.d.
	Female	4,20		3,45		2,98	
High School	Gymnasium	3,77	n.d.	3,23	n.d.	3,21	n.d.
	Technical school	3,65		3,20		3,35	
Income	Bellow average	3,96	0,036	3,11	n.d.	3,23	n.d.
	Average	3,77		3,17		3,27	
	Above average	3,47		3,37		3,33	
Mothers' education	High school	3,82	n.d.	3,09	n.d.	3,07	0,041
	College	3,68		3,29		3,34	
Fathers' education	High school	3,73	n.d.	3,08	n.d.	3,12	n.d.
	College	3,73		3,30		3,28	

However, it is necessary to clearly point out that finding on importance of intrinsic motivation should not neglect the importance of extrinsic motivation since some other research emphasized the concurrent importance of extrinsic and intrinsic motivation [10]. Also, our finding should be related to contextual factors of engineering study itself [11]. as well as to the fact that choice of study is of highly contingent character [12].

The structure of each type of motivation (including their particular components) with regard to independent variables allows for discussion of the most consistent results. Level of parents' education - including mothers and fathers - proved to be significant factor with regard to overall extrinsic motivation and with regard with to almost all of its components. Our findings indicate that in both cases students whose parents have high school degree are significantly more extrinsically motivated to enroll engineering study. In other words, it seems that students with less educated parents strive more for good salary, quick employment and career advancement. To some extent, this finding corresponds to approaches in which education is confirmed as potential factor in social mobility, although educational system is also proved to be important vehicle in context of social class reproduction.

At the level of overall intrinsic motivation we found no significant differences with regard to independent variables. However, analysis of particular components of intrinsic motivation indicates couple of significant differences. The most striking is one that stays contrary to the conventional and traditional values on gendered nature of inclinations toward natural and technical sciences. We found that female students enjoy in math more than male students and this finding is indicated as the most significant among all other differences found in context of intrinsic motivation. In corresponding research Jugović [13] indicated that there were no differences between boys and girls when it comes to personal importance and the assessment of their own abilities in the area of science. Although she concentrated on gender differences in the field of physics her findings are of reference for our research results.

5. Conclusion

Our findings are consistent with corresponding research on students' motivation to enroll different - including engineering - academic study programs in Croatia. Although intrinsic motivation is proved to be significantly more important in choosing to enroll engineering study, analytical usefulness of concept of extrinsic motivation in terms of continuum indicated primarily students' need to achieve their professional choice through education. Differences in components of extrinsic and intrinsic motivation are singled out in some details which have to be verified in next researches.

Finally, all results should be considered with regard to the fact that they represent one generation of freshmen at single engineering faculty in Zagreb.

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ANALYSIS OF THE PENSION SYSTEM OF CROATIA AND CORRELATION WITH ECONOMIC DEVELOPMENT

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Abstract

This paper studies the pension system of Croatia by its counties, the structure and number of pensioners and the average amount of pensions according to different bases and types of pensions. An analysis of the state pension and pension trends is given, as well as the comparison by counties and specifically to whether there is a significant, positive or negative, correlation between the average amount of different types of pensions and gross domestic product per capita (GDP p.c.).

Keywords: number of users, types of pensions, pension levels, GDP p.c., economic growth

1. Introduction

Every country that takes a systematic and responsible economic policy must establish pension system in a way that it is sustainable and conductive to the economic development and economic and social developments in the country. In such cases care must be taken of the number of pensioners in relation to the total population, in particular the number of economically active population, then the ratio of employees and pensioners, and, ultimately, on the amount of different types of pensions that reflect fairness, encourage consumption and economic growth, but do not endanger the stability of the system.The hypothesis of this study is that the amount of different types of pensions positively and significantly impact gross domestic product per capita, observed by counties in Croatia.

2. Analysis of the pension system of Croatia

Number of pensioners and the average amounts of different types of pensions by Croatian counties on day 30th of September, 2014. are observed and values are given in Croatian kunas (HRK).

As can be seen in Figure 1, the largest number of pensioners live in City of Zagreb, Zagreb County, Primorje - Gorski Kotar County, Osijek - Baranja County, Split - Dalmatia County and Istria County; whereas the smallest number live in Lika - Senj, Virovitica - Podravina, Pozega - Slavonia and Medjimurje County. This generally reflects the population or geographical position of the largest cities (Zagreb, Split, Rijeka, Osijek, Pula) having the highest number of people receiving a pension of any kind (age, disability and family pensions).

As can be seen in Figure 2, the largest average pension have residents of Primorje - Gorski Kotar County, the County of Istria, Dubrovnik - Neretva County and the City of Zagreb, while the lowest average pensions have residents of Koprivnica - Križevci, Bjelovar - Bilogora, Lika - Senj County, Virovitica - Podravina, Pozega - Slavonia, Brod - Posavina and Međimurje County.

As can be seen in Figure 3, the highest average age pensions have residents of Primorje - Gorski Kotar, Split - Dalmatia County, the County of Istria, Dubrovnik - Neretva County and the City of Zagreb, while the lowest average old-age pension have citizens of Koprivnica - Križevci, Bjelovar - Bilogora,Lika - Senj, Virovitica - Podravina, Pozega - Slavonia and Međimurje County.

As can be seen in Figure 4, the highest average disability pension have residents of the County of Zagreb, Primorje - Gorski Kotar County, the County of Zadar, Split - Dalmatia County, the County of Istria, Dubrovnik - Neretva County and the City of Zagreb, while the lowest average disability pension have residents of Pozega - Slavonia, Brod - Posavina and Međimurje County.

As can be seen in Figure 5, the highest average family pensions have residents of Primorje - Gorski Kotar, Split - Dalmatia County, the County of Istria, Dubrovnik - Neretva County and the City of Zagreb, while the lowest average family pensions have residents of Koprivnica - Križevci, Bjelovar - Bilogora, Lika - Senj, Virovitica - Podravina, Pozega - Slavonia, Brod - Posavina and Međimurje County.

As can be seen in Figure 6. that outlines the average pensions, it is interesting to note that all three curves have the same tendency to move, or to record the lowest level of all types of average pensions to the residents of Koprivnica - Križevci and Bjelovar - Bilogora County, then growth and high average pension by Primorje - Gorski Kotar County, then again drop and low average pension by residents of Lika - Senj, Virovitica - Podravina, Pozega - Slavonia and Brod - Posavina County, and again growth and high average pensions by residents of Split - Dalmatia, Istria and Dubrovnik - Neretva County. This tendency is still continuing with a low level of pensions by residents of Međimurje County, and a very high level of pensions by residents of the City of Zagreb.

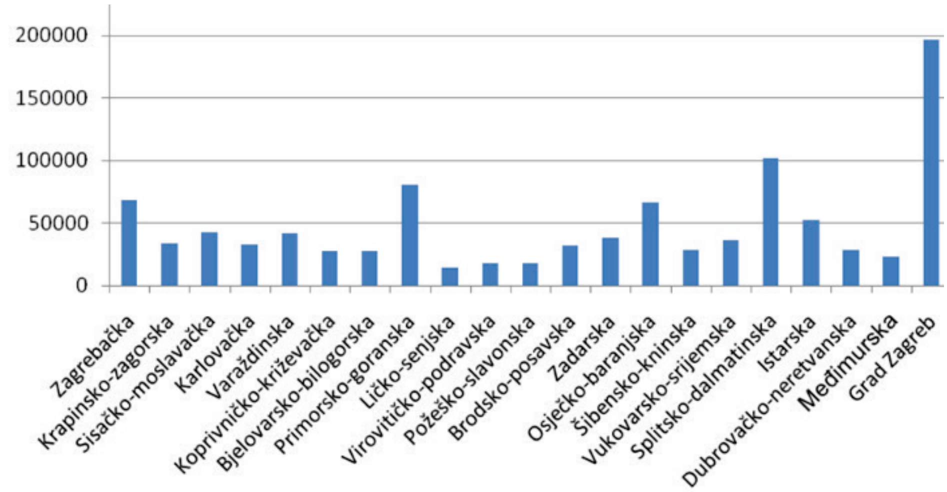

Figure 1. Number of pension beneficiaries by counties (source: made by authors).

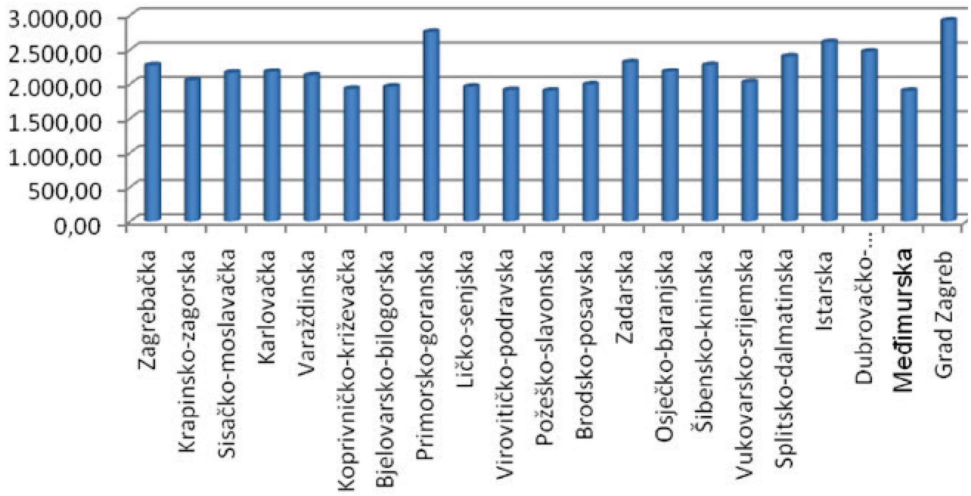

Figure 2. Overall average pension by counties (source: made by authors).

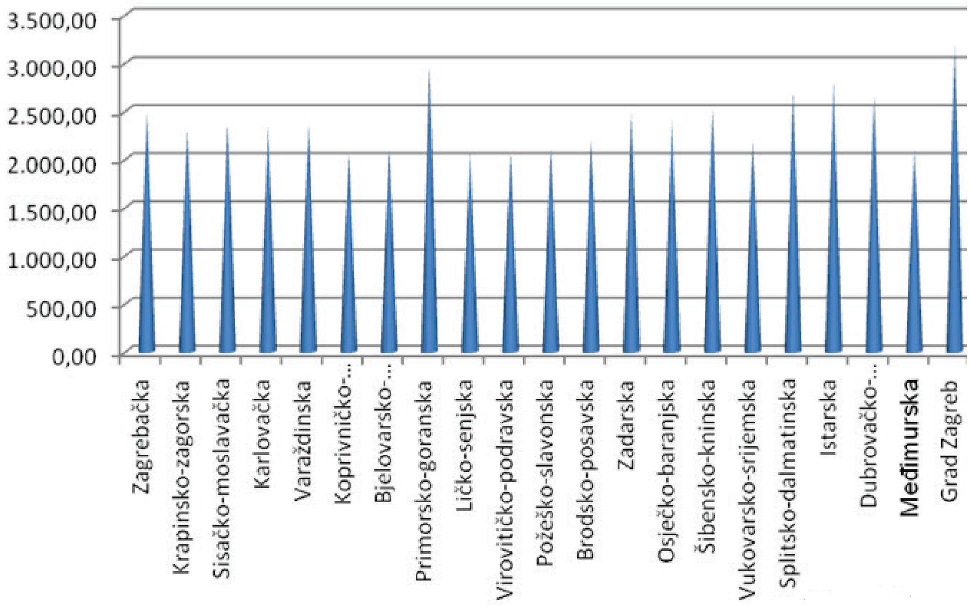

Figure 3. Average old-age pension by counties (source: made by authors).

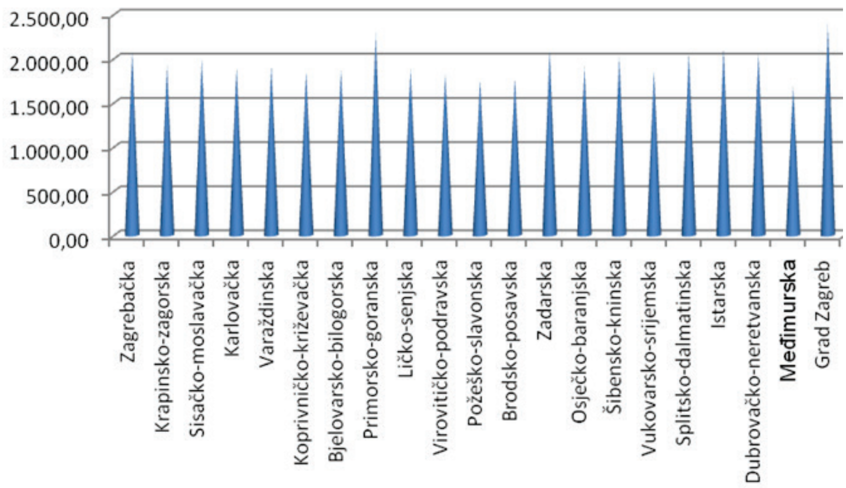

Figure 4. Average disability pension by counties (source: made by authors).

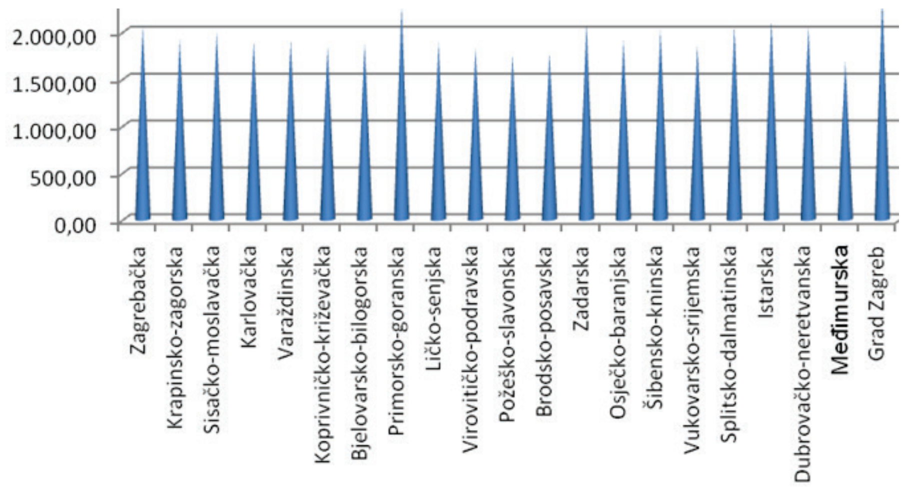

Figure 5. Average family pension by counties (source: made by authors).

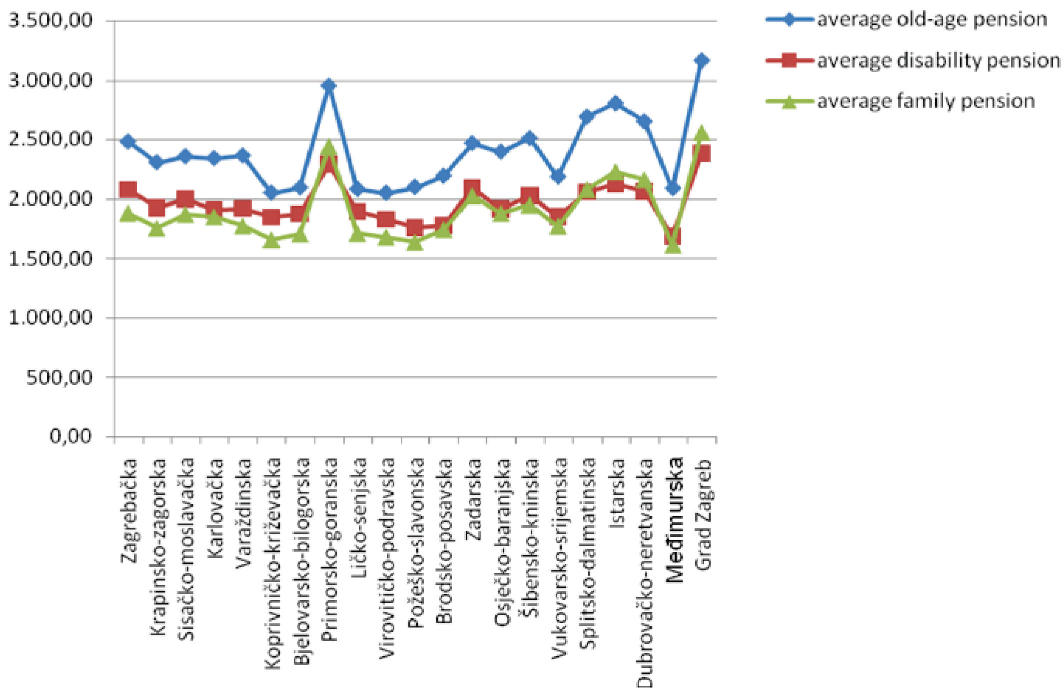

Figure 6. Different types of pensions by counties (source: made by authors).

3. Data collection and research methodology

The collected data relate on all twenty counties and the City of Zagreb and their statistical data on the number of pensioners, the average standard retirement payment, the average preferential retirement and the average veteran's retirement payment on day 30th of September, 2014, as well as GDP per capita by counties in 2014.

The average standard pension payment includes pensioners who are entitled to pension under the Pension Insurance Act (ZOMO) and includes all three types of pensions. The average preferential pension includes pensioners who are entitled to pension under the pension insurance rights of active military personnel, police officers and authorized officials (DVO) and includes all three types of pensions (old age, disability and family pension).

The average veteran's pension includes pensioners who are entitled to pension under the Law on the Rights of Croatian Homeland War Veterans and Members of their Families (ZOPHBDR) and includes all three types of pensions. It is the official, publicly available statistics.

Collected data were processed and analyzed by means of a statistical software package, SPSS, by analyzing both the linear correlation matrix and the multiple linear correlation matrix. Obtained research results are shown and interpreted by means of tables.

The research focused on the mutual influence of variables: average standard of pensions, average privileged pensions, average veteran's pensions and GDP p.c., all of them by counties.

As shown in Table 1, and as analysis of the linear correlation matrix show, the average standard pensions have a positive and very significant effect on the dependent variable, GDP p.c. Average privileged pensions have a positive, but not significant effect on the dependent variable.

Table 1. Matrix of linear correlation.

Matrix of linear correlation				
	average standard of pensions	average privileged pensions	average veteran's pensions	GDP p.c.
average standard of pensions	1	0,15	0,21	0,86
average privileged pensions	0,15	1	0,18	0,12
average veteran's pensions	0,21	0,18	1	-0,5
GDP p.c.	0,86	0,12	-0,5	1

Average veterans pensions have a negative and significant effect on GDP per capita. Mutually, variables the average standard pensions, the average preferential pensions and veterans' pensions average have a positive, but not significant influence on each other.

As shown in Table 2, and as analysis of multiple linear correlation matrix show, the average standard of the average pension and privileged pensions have a positive, but not significant effect on the dependent variable, GDP p.c, while the average veteran's pensions have a negative and significant effect on GDP p.c.

Table 2. Multiple linear correlation matrix.

Multiple linear correlation matrix	
constant:	1 096
squared coefficient:	0,82
standard error of regression:	731
number of observations:	21
degrees of freedom:	29
dependent variable:	GDP p. c.
variable:	coefficient:
average standard of pensions	0,14
average privileged pensions	0,24
average veteran's pensions	-0,57

The hypothesis of this study is that the amount of different types of pensions, whichhas positive and significant impact on gross domestic product per capita, observed by counties, is completely dismissed.

4. Conclusion

The study showed significant differences in the amount of the average pensions by Croatian counties, as old-age pensions, disability and as well as family pensions. There was no evidence of clear and undeniable links, both positive and negative, between amount of average pension and degree of economic development of each county. This paper raised questions for further research that will prove the link between the observed variables.

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QUALITATIVE CHANGES IN HUMAN RESOURCES MANAGEMENT IN SLOVAK ORGANIZATIONS – ARE WE COOPING THE CONTEMPORARY TENDENCIES IN EUROPEAN LABOR MARKET?

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Abstract

The perception of human resources being one of the most important sources of competitiveness in business persists. The ability to attract and retain quality employees, to shape and develop their potential and manage their performance is key activities of human resource management in organizations. Current trends of development of sociological and demographic kind erase challenges to HRM, in the form of changes of a qualitative nature, which affect the fundamental of practices attitudes. The paper deals with necessity of qualitative change of the approach to personnel management in organizations, by the direction in which it is possible to achieve such a change, as well as analyzing the situation in Slovak organizations in terms of readiness for this change.

Keywords:

Human resource management, competitiveness, challenge, change, aging, flexicurity

1. Introduction

Requirements for attitude and roles of personnel management are changing due to changes in the external environment where the organization operates in many aspects. From a closer perspective to identify changes caused by the exponentially increasing of innovation potential in the evolving world of technology, which are accompanied by changes of sociological and demographical kind. Here emerge the important challenges for human resource management, which are personnel specialists now to cope. The paper emphasizes the qualitative change of the attitude of organization to perception of its human resources, as well as the role of HR specialists and their contribution to contribution to competitiveness of business. The labor market is significantly determined by social and demographic change, which must react at flexibly. In this area, the most significant current influence is aging and a fundamental change in social bonds. The number of people in productive working age in Slovakia, as it is defined now, is declining. Since the state extended periods of obligatory work activity, the role of an employee on the labor market will last much longer than in the past. The labor market will include increasing number of aging supply. This contrasts with the current trend, when a talented, efficient and flexible is considered exclusively young employees. The challenge to employers becomes seeking ways to capitalize on the symbiosis of different age categories of employees. One of the issues is to attract and retain young talent, but on the other hand to create policies how to ensure their long-term retention or to create systems of their flexible replacement harmless to the culture of performance.

The aging population brings causes remarkable financial consequences for businesses. But also shows a significant change between "young and old" in general. The decisive change in the age structure of job seekers is expected to be on the One of the comparable markets to Slovakia, relevant to researched field, is the German environment. German labor market shall experience the significant change in the character of job applicants in the years 2017 to 2024, in particular hitting the information and telecommunications technologies. The role of human resources management departments for the changeover is to respond adequately. Responsibility for the adoption and implementation of measures to tackle the impact of demographic impact on enterprises shall by lied on human resources management departments primarily, but solutions are not able to enforce by lack of support. Prerequisite for successful management of outlined problem lies within the departments of human resources management and their business orientation, as well as the ability to understand the process beyond their own area of expertise. The mission of the HRM is not only to propose ideas and solutions, their business is to communicate and enforce them properly. There is necessary to apply an interdisciplinary approach to solving this problem, which is fundament to implementation and efficiency management to any measures.

2. Job revolution boosts the change

The second half of the 20th century brought the world of the work many fundamental changes. Change as a trend also continues and accelerates into the present. Most of these changes have its origins in a combination of technological progress and economic trends [1]. The rapid development of information and communication technologies besides other means that people can work remotely, workstations can be set up flexibly according to the needs of both organizations and employees. The whole world is "shrinking", the relevant market is becoming not only local, regional, or national market, but mostly explicitly global. By finding customers physical distance became irrelevant, but more often cultural distance matters. Entire labor market in Slovakia has become considerably more flexible. Many companies have slimmed down their structures, outsource activities excluding the core business and reduce the number of employees. The trend is also a transfer of business activities from developed countries with high personnel costs in emerging economies, which is also related to a change in the labor market. We recognize enormous pressure on the intensification of work, quality performance, lifelong learning and competence development, along with the willingness and ability to change the type of work in the course of a career is often not only within a single profession. "Safe" jobs so cease to exist. Employees are forced to adapt to a high flexibility of tasks, their working environment and organization as a whole. Flexibility at work is a considerable degree of uncertainty and high requirements for continuous learning of employees. Continuous professional development leads to the employment options and indirectly supports employee freedom, which challenges managements of organizations. Equally important is its alignment with the needs of the labor market. Today significant divergences according to Dvořáková mostly due to not complying with school education at all levels, the absence of effective lifelong learning systems as well as the existence of barriers that prevent the free movement of persons, reducing the profession, sectorial and geographical mobility [2].

As we mentioned above the labor market in Slovakia is also strongly determined by social and demographic changes, which HR specialists must respond flexibly to. But the fact remains that coping with them is difficult for organizations. One of the major phenomenon we recognize is aging, fundamental change in social bonds, decreasing number of people in productivity age, postponing the retirement period, which emerges the gender diversity. As a controversial tendency we recognize where the talented, powerful and flexible are considered preferentially young employees.

According to estimates by researchers in 2030 labor market will miss out 6.5 million candidates, it will be necessary to keep older workers in employment longer [3]. As a result of employing older employees (in studies appears the limit from 65 to 67 years), the age structure at the workplaces will change, which will be compared to contemporary situation, much less homogeneous. Representation of diverse age groups in conjunction with the overall diversity of employees in terms of other criteria (such as gender and cultural diversity) will force companies to adapt the policies of human resources management and this situation will result in the introduction of diversity management into enterprise management system. Employers, who want to use the potential of employees in longer period, will be forced to come up with new models of work that will be attractive to both parties.

Also open labor market is not absolutely borderless, but causes that organizations are confronted with cultural diversity. Changing social bonds is conditioned primarily by atomization of family influence of industrialization and urbanization, causing weakening of the bonds within the wider family, and reduction of intergenerational support and understanding. The reality in Slovakia is also the emancipation and promotion of gender equality, increasing the proportion of women in economic and public life, causing tension between the traditional roles of men and women and in many cases adversely affects the stability of the current family. Women experience a classic problem of reconciling maternal and professional roles, increasing the number of women who delay childbearing, dual career marriages are a reality as well as an increase in the number of single-child families. On the other hand, loss of work due to the high rate of unemployment is a major problem not only for the economy but also for the employees themselves and their families. Performance is a source of job satisfaction and determines the lifestyle of individuals. Determines their status and helps to create identity, expanding their social horizons.

3. Change in the attitude of HRM

Increasing speed of changes in the business environment evokes the need to leave old perceptions and used behavioral formulas, which have been developed, functioning and very useful in the past, but, became insufficient today. Nowadays, it is necessary to perceive human resource management according to its contribution to the success of the business of organization, which is different from the traditional approach where this area of management has been perceived as form of service delivering administrative agenda, mostly concerned rather with its processes and content than outcomes and contribution. Human resource management nowadays needs to obtain strategic character and becomes contributor to value added delivery for all subjects involved – organization, its employees as well as customers.

Readiness of organizations to instant reaction to fast speed of business environment changes is into great extant determined by its ability, which has Ulrich defined as the DNA of competitiveness [4]. Meanwhile the “hard” skills, such as technologies, financial resources, etc. remain quite easy to assess and therefore influence, the problem appears in case of “soft” skills, the change of which is significantly more difficult.

These abilities of organizations depend on their employees’ competencies, therefore the need of their redefinition is obviously an issue for human resource potential management. According to Ulrich, organizations nowadays aim their development aspirations within the area of “soft” skills into four areas, as follows:

- development of organizational credibility, based on trust in management and its decision,
- forthrightness, which expects removing barriers in communication in an organization as well as beyond its borders,
- maximization of flexibility, as the precondition of ability to adopt fast, to react fast to changes and even to be active in creating changes and inventing,
- investments into education and learning process, which would support the ability of fast reaction mentioned above.

Organizational credibility development needs to be perceived not only as part of public relation activity, but also as one of the main tools of employee loyalty enhancement and employee identification with the organization support. The contract of employees to their organization defined as relative force of identification of an individual with an organization consists of three components. One is the will to retain the membership in an organization, the other would be the belief in declared values and their acceptation as own, the consequence of which is the identification with employer’s goals and finally the aim and will to deliver effort in order to these values application [5].

Thus if an employee is devoted to an organization, which he or she works for, honors the opportunity and wishes to retain in the organization, its value system and its goals, also willing and prepared to work for the organization doing his/her best. Some authors even use the expression “citizen” of an organization. The commitment to the organization is supported by positive working experiences and inner factors, such as the level of trust, autonomy, working challenges, which are considered much more incentive compared to the external factors, such as wage and working conditions. The creation of trustfully atmosphere inside of the organization therefore might significantly support the feeling of employee dedication to the organization.

Organizations today are confronted with the concept of business ethics. Many of them have already implemented partial components of applied business ethics into their own business activities. This is happening by force of corporate social responsibility activities, which are very concrete steps towards development of satisfactory, long term, mutually beneficial relationship between organization and its environment. Systemic development of an ethical organization assumes healthy core, based on pillars of trust, freedom and responsibility. For many organizations may these values be still only a challenge, but many declare these values as principles of their business activities publically, or even as reasons and sources of their success in the role of an employer. In any case they remain a tool of organizations’ credibility development influencing any involved partners in business.

The aim of forthrightness assumes to develop such an organization, where there will be all conditions for fluent information flow favorable on the vertical and horizontal line, as well as towards the inner and external environment of an organization. This shall enable the transfer of ideas and solutions without meaningless barriers and support business process in any level. It is possible to develop such skill by effective communication strategies.

Forms of communication in organizations, however, change depending on technical and technological development in the world of information technologies. Not only communication media change, but also the meaning of sharing information succumbs by these circumstances. Into human resource management has entered the concept of knowledge management and the question of delivering employees with high quality knowledge potential. Truneček has ten years ago spoken of moving from managing human resources to managing human knowledge potential [6]. Knowledge management brings many new challenges into personnel management in general. Information technologies has so far remain support tool for HR managers in their administrative agenda, while knowledge management challenges forces them to move on towards the center of data-information-knowledge-wisdom chain[7]. Also external situation forces organizations to optimize their processes, decrease their expenses, which may, for example in the area of information management, be very effectively supported by application of self-service information technologies for personnel management. These technologies delegate maximum of operative activities to employees, which leads to involving them into human resources processes, helping faster and flexible information flow within the organization. All necessary changes meanwhile evoke pressures on human potential quality. Thus the aim of contemporary management becomes the development of organizational system, within which the employee development takes significant place in order to reach quality, effectiveness and competitiveness of an organization [8].

Contemporary perception of an employee and its role within an organization, which has been developed by the concept of knowledge management, moves the core of human resource management towards the top management of an organization. From the position of strategic partner it is possible to work on the concept of personnel strategy, which supports forthrightness, mutual information sharing and enrichment of information sources. On the other hand the encouragement to sharing and open communication might nowadays be accepted only with difficulties, for the great value of quality information sources. The support in working with information shall therefore be also a challenge within corporate culture development, which ought to be perceived as significant tool for corporate strategy implementation. Corporate culture reflects inner consistency, containing employees' attitudes influencing their behavior in order to reaching organizational goals set [9]. In case the strategy is elaborated into reasonable and understandable goals and procedures how to reach the goals, and these are properly communicated to the employees, there has been a premise of its successful implementation and employees' identification created. If this strategy also brings desired and visible results, the way of delivering organizational performance and working behavior becomes the appropriate one and considered as profitable, therefore willingly accepted it becomes content of corporate culture and supports the strategy. The compliance of corporate strategy and corporate culture has become one of the preconditions of long term successfulness of an organization.

The speed of environmental changes contemporary increases and intensifies which is a factor that all organizations need to face. The more successful organizations are able to react instantly by developing an ability to learn from changes, instead of trying to control and master the change. As a consequence of these changes, organizations need to run constant revision of procedures and programs, transformation of processes and changes in corporate culture. This changes any perception of whole organization as well as the self-perception. Human resource managers ought to be the once who are able to support organizational abilities to adapt for all types of changes. Even if all models of change management are theoretically elaborated into details, their practical utilization often doesn't bring expected results. Ulrich stats following most frequent reasons of change failure [10]:

- lack of linkage to the strategy,
- considering changes a fashion issue of fast solution,
- short term perception,
- policy, compromising the change,
- overestimated expectation in contrary to poor results, inflexibility,
- insufficient management of change,
- concerns of unknown,
- inability to mobilize loyalty and engagement for change realization.

Successful realization of changes in an organization is obviously supported by processes of consequent learning and development. It is not only the processes of employee education and development, as they have been perceived by traditional personnel management, but everyday sharing of information and mutual enrichment new knowledge, emerging out of the organization's activities. Because as the primary incentive for changes realization is the organizational external influences, the primary determinants of their successful implementation are people inside the organization [11]. Their ability to learn from experiences in the process of changes application supports the efficiency of whole organization. Learning ability of individuals and whole organizations is conditioned by effective communication, support of individual expression and trust [12]. This further on supports devotion of organization's visions and willingness of its employees to accept and realize decisions, reacting to environmental changes as to an opportunity that it creates. This leads to the essence of linking all above mention areas of building organizational skills, which lead into support of synergic effect of mutual influence.

4. Qualitative changes in HRM practice in Slovakia – research results

The situation in the area of human resource management practice in Slovak organization has been target of monitor at annual basis, realized within the framework of international research collaboration Cranet (The Cranfield Nework - CRANET), and coordinated by the Cranfield School of Management. Permanently gathered information regarding policies and practically applied tools of human resource management in Slovak organizations has become proven track record of collecting powerful, representative data, on a continuing basis; undertaking rigorous analysis and disseminating high quality results. On such platform we are able to evaluate the situation in analyzed area in the practice of Slovak organization and confront these finding with tendencies identified within international concept. The paper publishes outcomes of analysis based on data collections provided on annual basis since 2003 to 2013.

We have used the Ulrich's conception of organizational "soft" skills, i.e. credibility, forthrightness, flexibility and knowledge orientation introduced above, as the basis for analyzing personnel procedures and policies in the context of their implication to competitiveness. Ulrich has identified these organizational competencies and defined them as the core of the DNA of organizational competitiveness, meanwhile their development and utilization is directly dependent on managing human resources. For evaluation of the reaction ability of Slovak organization for contemporary challenges of business environment, examining applied personnel procedures and programs, it is essential to focus on development of above mention distinguished skills.

The analytical part of the paper is based on the survey data output, the context of which has already been explained above, realized at the Department of Management, at the University of Economics in Bratislava. The main aim has been to verify the extent into which organizations in Slovakia choose the personnel management measures and procedures, which would indicate their disposal of distinguished skills or at least potential to develop these skills in the future. The main assumption has been the dependence of choices in "hard" measures on the level of "soft" skills development. As the basis presumption we have chosen to focus on the formalized status of human resource manager within an organization. We have assumed that organizations having their human resource manager present in the body of top management, also formalized within the hierarchy, will be in greater extent displaying their distinguished skills by choice of relevant personnel policies and application of subsistent personnel practices, both oriented towards credibility and forthrightness of their organization. Also we have assumed that these organizations will be aiming to reach high dynamics of their processes, inventive approach and reaction time minimizing need to change application. Among these organizations the flexibility support has been expected by employee education and training concept application with character of learning organization.

Formal increase of the importance of human resource departments in organizations prove the change in perceiving the purport of human potential to organizational competitiveness and introduces an appeal upon the human resources management quality improvement. Creation of opportunities to participate on strategic level of decision-making process within an organization may be considered essential precondition for becoming the strategic partner in business, however the status itself oughtn't to be perceived the goal of HR departments either the guarantee of their performance quality increase.

Thus we assume differences in particular personnel measures and procedures, which develop abilities participating on development of organizational competitiveness, based just on the formalized status of human resource manager in top management. By analyzing formulated challenges for the period of following three years, based in the research results, we need to establish the finding, that organizations, which have their HR managers involved into top managements, tent to articulate their appeal on excellent HR services and to transform this area of management into strategic partnership and business partnership, worthily contributing to reaching strategic goals of their organization. Among these organizations we have more often noticed the requirement of organizational culture transformation, emphasizing values such as politeness, fairness, dignity. They also feel the need to reinforce the participation on decision-making across their organizational structure and also the need to formulate and introduce into utilization ethical codex, which would reflect all above stated intentions. We have also found out, that all organizations which have formalized status of their HR managers in top management bodies would more tend to their future expectation and orientate their management direction into long term perspective, having their upcoming challenges identified more often.

In total, among most frequently stated challenges, which organizations in analyzed sample have mentioned as challenges for upcoming three years, the need of personnel processes quality increase has appeared quite often. Evaluating the issue of challenge setting we have determined following areas, according to challenges identified in human resource management in organizations for upcoming three years:

- employee retention, organizations have identified the need to optimize the structure of their employees, providing their quality, developing their competencies and reliability, quite often also the term core employees has been mentioned,
- creation of complex systems of employee assessment and performance management, where in organizations with HR management participating in top management level, also appears the request of linkage between performance management system and business performance
- complex employee development and education system, where the organizations plan to focus on talent management and its linkage to career growth.

Besides these intentions there is still as a challenge perceived the need to develop and in greater extent utilize the potential of information technologies linked to application supporting other managerial subsystems within an organization. Many organizations have also expressed the need to reevaluate their compensation systems, especially in the area of benefits and intensify their employees' motivation issue.

However, by more detailed analysis of other practical personnel procedures and processes reflecting development of distinguished skills, we have surprisingly found out very little or even irrelevant differences between approaches of both analyzed groups of organizations. Based on this findings, we need to make conclusion, that formalization of the human resource managers' status in the organizations' bodies of top managerial levels, aiming to increase the HRM quality, might be considered foundation, but must not be perceived guarantee of developing organizational competitive skills. By this status created options to participate on the strategic decisions needs to be supported by HR managers and utilized more intensively, but also valorized in favor of quality of their tactical and operative procedures, so that the reason of such status would be valid and proofed. However the formalization and declaration of human potential importance in an organization ought to be, on the contrary, the result of practical application values which declare this meaning. Further on, we have therefore focused on analyzing concrete personnel procedures, which directly support development of credibility, forthrightness, flexibility and learning competencies of organizations, where we have left the selection of analyzed sample according to the status of HR manager in the top management, since the differences between approaches hadn't appeared remarkable.

Credibility of an organization is supported by the way of organization presents itself, and its message to the external environment as well as the attitude towards its employees. One of the ways of sending the message is forming and communication of the values, which an organization find essential and which they stick to by any of their activities. Therefore we have we have examined the credibility development of Slovak organizations by analyzing formulated values within their corporate culture, focusing especially on the way of their declaration, implementation and communication. In analyzed sample of analyzed organizations we have noticed among most frequently declared values responsible approach, efficiency, quality aim and team spirit. These are mostly values emphasizing orientation towards performance; meanwhile with significantly lower frequency organizations declare trust, respect, recognition, safety, integrity, activity and dynamic as their desired values. These are the values characteristic for partnership approach and creation of the atmosphere of trust within the approach to employees. These values still remain underestimated or considered values useless for business competitiveness development, or are meant for more suitable for the NGOs.

Open organizations towards their information flow means to approach to information management in order to maximize the elimination of various barriers and obstructions, enabling, fast and efficient information flow of any direction within an organization as well as towards its environment. The object of interest researching this issue within the sample of organizations have been communication process, their character and used communication tools. The basis for analysis has been examination of the intensity of sharing strategic information regarding corporate culture, financial results and work organization with various categories of employees.

Intensity of communication and the extent of information delivery among all involved employees are slightly higher in the pool of organizations, where human resource manager is involved into top management level, but this difference may be considered irrelevant, since it is only approximately 10%. In case organizations aim to support their employees' identification with its values and goals, they need to be involved and not only information must be easily accessible, but also purposely communicated. In examined areas the most communicated strategic information has been information about work organization towards all categories of employees. Reasonably theses information directly influence employees working performance, but even here we observe the average 80%, naturally expected 100%. Information regarding strategic goals and choices are less shared with employees, significantly dropping by the decrease of the level of managerial responsibilities of employees. Further on employees are provided with the feedback in the form of financial results of an organization, again dependent of the level of their managerial responsibility within organizational hierarchy and appears to be approximately between 30-60%. We consider these results not very favorable, because they prove rather low level of sharing essential information, which doesn't positively influence development of the environment supporting employees' involvement and their identification with corporate goals. Even if not very common, but there are still present communication channels which create barriers, or makes for employees less possible to communicate with top management directly, and might result into gaining the feeling of frustration from ignorance or lack of interest. This disturbs development of a climate favorable to employees' involvement into organizational matters. Direct communication between employees and senior management has been stated as supported only in 12% of organization from the sample. Forms of communication supporting various forms of employees' participation on decision making process, such as system of innovation ideas, remains less applied (13%). We find remarkable that forms of electronic communication are significantly more frequent in top down direction compared to bottom up line, where we've noted only half of the „top-down" intensity. This finding proves that the "one way" form of communication still majors in many organizations, which is controversial feature of communication policy aiming to support positive environment for sharing information, ideas and know-how.

Open communication and continuous education and development are coherent competencies and their development is mutually dependent. We have considered information technologies the "hard" skills of communication flow support in organizations and we have focused on the use of IT in personnel management practice. Since fast, easy and impeccable information and knowledge sharing, might be significantly supported by customized information systems, we have analyzed personnel processes which were actually using this support in organizations. As mentioned above, improvement and integration of personnel information systems with other managerial information systems still remain a challenge for many organizations in Slovakia for upcoming period of three years. This demand we find legitimate, because as the results show, information technologies support is being used in the significant extent for wage agenda (94%). For education and training activities support the information technologies find their utilization only in less than one third of the sample, and only one third use IT to communicate information regarding their human resource process and policies.

Flexibility of organizations and their readiness to react to contemporary changes might be in the area of human resource management supported by HR processes flexibility. However flexibility as the desired competency of competitive organization also reflects in very concrete practical tools, such as work organization. Concretely, we have analyzed various models of flexible work regimes application, which have been relatively little used in comparison to European Union Standards. Based on our research we may note, that traditional work regime, such as shifts, or overtime working hours are quite common. More than a half of organizations have already gotten familiar with flexible regimes application, however the will to involve newer or more progressive forms remains vague. Work regimes, such as job sharing, compressed weeks or tele-work are mentioned by only 10-20% of organizations as applied for less than 5% of their employees.

One of the starting points for addressing these problems in the European labor market is the concept of. flexicurity, which was defined in the context of the Lisbon strategy and integrates the two parts at first sight contradictory principles. Its objective is to enhance labor market flexibility while ensuring security for both employees and employers. Flexibility here is a flexible legislation, flexible systems of work organization, education and reconciliation of work and private life. Certainty does not guarantee job retention for the employee, but an approach to appropriate qualifications and the subsequent possibility of obtaining adequate position. Characteristic sign of flexicurity is that it applies to all workers regardless of their level of qualifications and age limits. It allows obtaining employment and social application throughout the duration of the active life of the worker. This concept should be jointly implemented in all EU countries. Given the different characteristics of each member of the labor markets, however, there is the universal form, and its tune is a matter of policies of individual countries. Flexicurity introduces the principle into practice presupposes providing the flexibility in contractual relations through legislative changes, developing a concept of lifelong learning, particularly for the highest-risk groups in the labor market, implementation of active labor market policies on the part of governments, aligning supply and demand, as well as to build a modern social security systems. As Dvořáková states, flexibility is often seen as a new form of social risk [13]

Above mentioned flexible work regimes are contemporary involved into personnel strategies of organizations abroad to build a concept of reaction to negative crises impact, these organizations report positive experience. Inability to utilize these work regimes within the work design in Slovak organizations indicates difficulties with their flexibility in personnel processes and in other areas as well.

5. Conclusion

The analysis of contemporary situation in Slovak organizations proves the fact, that formalization of the human resource manager status with the top management doesn't automatically guarantee neither increase of quality of personnel processes nor their contribution to organizational competitiveness. The finding, that quality of personnel processes is independent from such status formalization, might on one hand appear shocking on the other hand indicates that managing human resources ought to be no more concentrated into hands of few specialists, but shall be the concern of any active subject of management at any hierarchical level. However, it is quite essential to realize the contribution of quality personnel processes and the advocate and carrier of such idea does not necessary be present only in top management. On the other hand research results have proved the fact that there is certain inability of HR managers to accept and utilize the role of strategic partner, which they in many cases need to handle. Quite often they are not able to take advantage of such status and use this trust and power to co-create the added of their organization. Thus in the role of change agents, HR manager often fail or even become target of disappointment.

What shall be the role of personnel managers by forming key competencies of organizations? To be able to transform employees' individual abilities into abilities of whole organization, which would remain competitive, it is necessary to continuously monitor these skills and to have actual review about what competencies the organization and its employees dispose of. Naturally it is insufficient to be in continuous contact with present situation in organizational predispositions and competencies; they must be predicted, estimated, expected and accepted. Thus it is necessary to identify, define and acquire these competencies in order to be able to harmonize them with corporate strategy and further on to utilize them properly and fully.

The aim is to effectively utilize these developed competencies; otherwise any work with them might become useless personnel management activity. Based on Ulrich, skills are the link between strategy and its realization [14]. Following step would be preparation of human resources management policies and procedures, which would form desired strategic goals into operative actions in various HR functions. Very crucial expectation from personnel managers is their ability to create relevant indicators of organizational skills and competencies monitor. This will enable to examine efficiency and effectiveness of sources used in this area of management as well as to declare its contribution to business activities of the whole organization. The difficulty of this task is proved by the fact that 75% of organizations declare unsuccessful development of new distinguished organizational competencies. Difficulty to develop „soft" organizational skills shall not be a factor discouraging personnel specialists to try hard in this area, on the contrary it ought to be perceived as great challenge leading towards the participation on competitiveness development of their organization.

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APPLICATION OF AHP AND ADDITIVE METHOD IN SUPPLIER SELECTION

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Abstract

With the main aim of selecting the optimal supplier of plastic joinery, in the present study two well-known multiple criteria decision making methods, namely Analytical Hierarchy Process (AHP) methodology and additive method, were applied. Four alternatives, i.e., four suppliers were evaluated according to the suggested criteria: price, delivery time and after-treatment following the installation of joinery. The results obtained by the AHP methodology and additive method were compared, and conclusions on the effect of each criterion weight were adopted.

Keywords: AHP methodology, additive method, supplier selection

1. Introduction

Supplier selection is a process of choosing the right supplier which can provide the right quality of products/services at the right price, in the right quantities and at the right time [1, 2]. The process is complex, primarily because of the involvement of many, sometimes conflicting qualitative and quantitative criteria. Due to the complexity of the process, different decision-making methods have been often used. On the basis of a detailed review of the literature in [3], it is concluded that 26 decision-making methods have been used in suppliers' selection. These methods are divided into 3 groups: multi-criteria decision-making, mathematical programming and artificial intelligence methods. The selection of suppliers is primarily considered as a multi-criteria problem and the most commonly used methods of multiple criteria decision making have been applied as follows: AHP, ANP, ELECTRA, PROMETHEE, TOPSIS, DEMATEL, VIKOR, and SMART [3]. For the purpose of systematic evaluation of suppliers, criteria and multiple criteria AHP model for selecting the best supplier have been proposed in the paper [4]. The model is illustrated by the example of supplier selection to purchase parts for assembly of the agricultural machine. Fuzzy AHP method is used when selecting the most suitable suppliers in the aviation industry and is based on 6 criteria: cost /price, product quality, delivery, financial stability, corporate social responsibility and assortment [5].

In the paper [6], the selection of the best supplier was applied in the automotive industry, where the weight of each criterion is determined by fuzzy ANP method. The authors of the paper [7], investigating also the selection of the most appropriate supplier in the automotive industry, have compared the two methods: Fuzzy AHP and Fuzzy TOPSIS. AHP method and the additive method (the last one also known as simple additive weights-SAW as well as weighted property method-in the field of optimal material selection) are applied and compared for the selection of optimal alternative of stock material [8].

In this paper, AHP methodology [9, 10] and additive method [11] are applied and compared in the selection of supplier of plastic joinery based on the three defined criteria: price, delivery time and offer of after-treatment following the installation of joinery (further the term after-treatment will be used).

2. Description of the used methods

Analytical hierarchy process

Analytical hierarchy process (AHP) methodology is developed by Thomas Saaty [9, 10]. This methodology is based on the decomposition of defined decision problem to the hierarchy structure. The hierarchy structure is a tree-like structure which consists of the main goal at the top of the hierarchy (the first level), followed by the criteria and sub-criteria (also sub-sub-criteria) and finally by the alternatives at the bottom of hierarchy (the last level).

The goal presents the optimum solution of the decision problem. It can be the selection of the best alternative among many feasible alternatives. Also, the ranking of all alternatives can be performed, by obtaining the priorities. Criteria (sometimes called objectives or attributes) are the quantitative or qualitative data (judgments) for evaluating the alternatives. The weights of the criteria present the relative importance of each criterion compared to the goal. Finally, alternatives present the group of feasible solutions of the decision problem. Alternatives are evaluated against the set of criteria.

AHP methodology consists of the following basic steps [9, 10]:

- Decomposition of the defined decision problem to the hierarchic structure - building an AHP model with the overall goal at the top of the hierarchy (the first level), the evaluation criteria and finally the alternatives at the bottom of the hierarchy (the last level).
- Pair wise comparisons of the criteria and alternatives based on the Saaty's scale of numbers from 1 to 9 (Table 1). The value 1 means equal importance of two criteria (or alternatives), while the value 9 stands for extreme importance of one

criterion (or alternative) to another. Pair wise comparisons of the criteria are performed with respect to the goal or criteria at higher level. The weights of the criteria present the ratio of how much more important is one criterion than another, with respect to the goal or criterion at higher level. Pair wise comparisons of the alternatives are performed against each criterion and present the ratio of how much more important is one alternative than another, taking into account each criterion. The local priorities of alternatives are derived. Testing the consistency of subjective judgments is also performed (further explained).

- Synthesizing the results by the calculation of the total priorities of alternatives. The total priority of each alternative is calculated by the multiplication of the local priority of alternative by the weight of corresponding criterion and then summing all the products for each criterion. Example of calculation of total priority of alternative (considering three criteria) is shown by Equation (1).

$$p=a\cdot x+b\cdot y+c\cdot z \tag{1}$$

where:
p – total priority of the alternative
a, b, c – local priorities of the alternative for the first, second and third criterion, respectively
x, y, z, – weights of the first, second and third criterion, respectively.

Sensitivity analysis can be also performed and it gives the response of the alternative priorities to the change of the input data. Furthermore, AHP methodology allows monitoring the consistency of assessments at any time of the pair wise comparison, by the use of consistency index and consistency ratio [9, 10].

Table 1. Saaty's scale for pair wise comparisons

Scale	Description of the importance
1	equal
3	moderate
5	strong
7	very strong
9	extreme
2, 4, 6, 8	intermediate values

Additive method

Additive method [11], also known as simple additive weights - SAW, uses normalized weights (weighting factors) of criteria multiplied by the normalized (or transformed) values of criteria. The alternative with the maximal value of the score will be the best alternative. A term or a version of additive method, called weighted properties (property) method, or weighted properties index method has been often used in the field of optimal material selection.

If we compare the terminology of weighted properties method and AHP methodology and other decision making methods, the term properties is equivalent to the term criteria.

This method is very useful when there are a lot of important criteria (properties) to compare and evaluate. Scaled (normalized, transformed) value of the ith criterion (S_{Vi}) is multiplied by the weighting factor (B_i) (see Equation 2). The sum of multiplied scaled values of criteria and weighting factors represents the performance index of the jth alternative (V_{rj}), see Equation (2).

$$V_{rj}=\sum_{i=1}^{k} B_i\cdot S_{vi}\rightarrow \max. \tag{2}$$

where:

V_{rj} – performance index or overall score
B_i – weighting factor, weight of criterion
S_{Vi} – scaled criterion value
k – number of criteria.

Weighting factor B_i or weight of criterion represents the relative importance of the criteria according to the defined objective. This factor is determined by using the experience, the digital-logic method or some other methods (for instance Fuller triangle or decision makers can introduce arbitrary numbers for the weighting factors). Digital-logic method, which will be applied in the present study, is based on the comparison of criteria, where more important criterion has mark 1, and less important one has mark 0. After that, for every criterion the number of positive decisions is determined. Weighting factor for the criterion is the ratio of the number of positive decisions and the total number of decisions, which is presented by Equation (3).

$$\text{The total number of decisions}=\frac{k(k\text{-}1)}{2} \tag{3}$$

Scaled values of the criteria are applied because of more reliable comparison of the criteria with different units of measurements. Equation (4) represents the dimensionless scaled criterion value for the criteria where a lower value is desirable (for example costs, mass loss, etc.).

$$S_v=\frac{\text{minimum value in the list}}{\text{numerical value of the criterion}} \tag{4}$$

Equation (5) represents the dimensionless scaled criterion value for the criteria where a higher value is desirable (for example hardness, tensile strength, etc.).

$$S_v=\frac{\text{numerical value of the criterion}}{\text{maximum value in the list}} \tag{5}$$

All the criteria data are transformed to the 0 - 1 scale (or 0 – 100, with multiplying by 100). The criterion with the value 1 (or 100) is the best criterion for the particular alternative.

3. Supplier selection

According to the given suppliers' offers, the selection of the best supplier of plastic joinery is performed in this section. The two above-mentioned multi-criteria decision making methods will be applied considering the three criteria shown in Table 2. Referring to Table 2, it is evident that:

- Suppliers 1 and 2 have offered the after-treatment included in the offered price
- Supplier 3 has the shortest delivery
- Supplier 4 has offered the lowest price.

To make decision about the best supplier, AHP and additive methods will be used to assist in objective decision making.

Supplier selection by the use of AHP methodology

The hierarchy model of the supplier selection problem consisting of the main goal at the top of the hierarchy, followed by the three criteria and finally by the four alternatives at the bottom of the hierarchy (the last level) is presented in Figure 1.

Table 2. Suggested criteria and corresponding values for different suppliers

	Supplier 1	Supplier 2	Supplier 3	Supplier 4
Price, €	1957	1433	1230	1140
Delivery term, days	28	30	25	35
After-treatment/grade*	YES/5	YES/5	NO/1	YES, but not included in the price/3

**1 – the worst grade; 5 – the best grade*

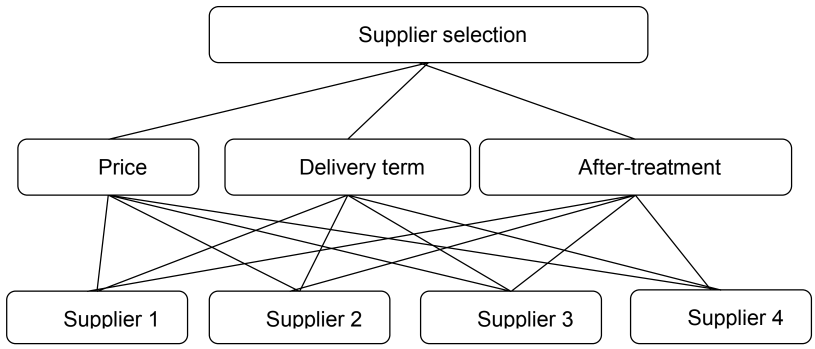

Figure 1. AHP model for supplier selection

After AHP model is defined, the weights of each proposed criterion by the pair wise comparison (Table 3) using Saaty's scale (Table 1) have to be obtained as well as local and total priorities of alternatives (suppliers). Local priorities of suppliers are calculated by pair wise comparisons of alternatives with respect to each criterion, using Saaty's scale. Total priority for every alternative is calculated by Equation (1).

Table 3. Pair wise comparisons of criteria

	Price	Delivery term	After-treatment
Price	1	3	2
Delivery term	1/3	1	1/3
After-treatment	1/2	3	1
∑	11/6	7	10/3

Normalised matrix presented in Table 4 is used for the calculation of the criteria weights according to the methodology described in the previous section. This matrix is obtained by dividing each value from the Table 3 by the sum of the appropriate column. The criterion weight is the average value of the related row in Table 4. It can be seen from Table 4 that the criterion price has the highest weight, while the criterion delivery term has lower weight than the criterion after-treatment.

Table 4. Normalised matrix and criteria weights

	Price	Delivery term	After-treatment	Weight
Price	6/11	3/7	3/5	0.525
Delivery term	6/33	1/7	1/10	0.142
After-treatment	3/11	3/7	3/10	0.333

According to the AHP methodology, the next step is the comparison of the alternatives related to each criterion and the calculation of local priorities, which is shown in Tables 5, 6 and 7. Total priority of each alternative which is shown in Table 8 is calculated on the basis of the Equation 1.

The highest total priority has supplier 2 as well as supplier 3. These suppliers offer the prices which are not the highest and there is a moderate difference between them; delivery terms are not the longest and there is a moderate difference between them. But, there is a strong difference between the grades for the criterion after-treatment. Supplier 2 offers after-treatment, as well as the supplier 1 (but this supplier offers the highest price). Contrary, supplier 3 doesn't offer after-treatment (but this supplier offers low price and the shortest delivery time). On the basis of the results of the digital-logic method the criteria weights are calculated (Table 9).

Table 5. Pair wise comparison of alternatives with respect to the criterion "price"

	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Local priority
Supplier 1	1	1/2	1/3	1/4	0.100
Supplier 2	2	1	1/2	1/2	0.185
Supplier 3	3	2	1	1	0.345
Supplier 4	4	2	1	1	0.370

Table 6. Pair wise comparison of alternatives with respect to the criterion "delivery term"

	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Local priority
Supplier 1	1	1	1	3	0.297
Supplier 2	1	1	1/2	2	0.225
Supplier 3	1	2	1	4	0.377
Supplier 4	1/3	1/2	1/4	1	0.100

Table 7. Pair wise comparison of alternatives with respect to the criterion "after-treatment"

	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Local priority
Supplier 1	1	1	5	3	0.394
Supplier 2	1	1	5	3	0.394
Supplier 3	1/5	1/5	1	1/2	0.075
Supplier 4	1/3	1/3	2	1	0.137

Table 8. Criteria weights, local and total priorities of alternatives

Alternative	Criteria and criteria weights			Total priority
	Price	Delivery term	After-treatment	
	0.525	0.142	0.333	
Supplier 1	0.100	0.297	0.394	0.225
Supplier 2	0.185	0.225	0.394	0.260
Supplier 3	0.345	0.377	0.075	0.260
Supplier 4	0.370	0.100	0.137	0.255

Table 9. Pair wise comparisons of criteria by the use of digital-logic method

Criterion	Comparison of criteria			Total grade	Weight
Price	1	1		2	2/3=0.667
Delivery term	0		0	0	0/3=0
After-treatment		0	1	1	1/3=0.333

Supplier selection by the use of additive method

Criteria scaled values (obtained by Equations (4) and (5)), weights and overall scores calculated by the Equation (2), are presented in Table 10. The highest overall score has supplier 4 as well as supplier 2 (the difference is negligible).

Table 10. Criteria scaled values, weights and overall scores

	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Criterion weight
Price	0.58	0.79	0.93	1	0.667
Delivery term	0.89	0.83	1	0.71	0
After-treatment	1	1	0.20	0.60	0.333
Overall score (V_r)	0.71986	**0.85993**	0.68691	**0.8668**	

4. Discussion

When comparing the selection of the best supplier by the use of these two methods, it is remarkable that they give the same ranking of the criteria weights. The criterion price has the highest weight, while the criterion delivery term has lower weight than the criterion after-treatment. But the values of criteria weights are not the same influencing the final result (ranking of alternatives, i.e. suppliers). Saaty's scale containing 9 numbers for pair wise comparisons has given the following weights for the criteria price, delivery term and after-treatment: 0.525, 0.142 and 0.333, respectively. By the use of digital-logic method containing only 2 numbers (1 and 0), which is actually black and white approach, the weights for the criteria price, delivery term and after-treatment are as follows: 0.667, 0 and 0.333, respectively. In that case, the criterion delivery term had never been more important when comparing with other two criteria (price and after-treatment) and the corresponding weight was zero. As a result, the ranking of suppliers by the use of two applied methods is different. When considering the AHP methodology, suppliers 2 and 3 are the best. However, when applying the additive method supplier 4 was the best. But, here the overall score for supplier 2 (the best alternative obtained by the AHP methodology too) is very close to the overall score of supplier 4.

From that reason, the black and white approach of digital logic method is further overcome by the use of the arbitrary numbers for the weighting factors (five point scale assigned to criteria, where 5 is the best grade, and contrary, 1 is the worst grade). The weight of a particular criterion is obtained by dividing the grade by the sum of the grades for all the criteria, which is shown in Table 11.

Table 11. Using of arbitrary numbers for weights

	Price	Delivery term	After-treatment
Grade	5	2	4
Weight	5/11=0.46	2/11=0.18	4/11=0.36

In this way, by combining these weights with the scaled values from the Table 10, the ranking of alternatives is as follows: supplier 2 (overall score 0.87), supplier 4 (overall score 0.8), supplier 1 (overall score 0.78) and supplier 3 (overall score 0.68). The second approach can be the integration of the criteria weights obtained by the use of AHP methodology and scaled or transformed values of the criteria. The used approaches are shown in Table 12, where overall scores 1, 2 and 3 are obtained by the use of Equation (2).

The weights obtained by the digital-logic method (weight 1), use of arbitrary numbers (weight 2) and by Saaty's scale (weight 3) are multiplied by the scaled values of criteria. The total priorities of the alternatives obtained by the original AHP methodology are presented in the last row of Table 12.

Since the supplier 2 has obtained the highest scores for four times (of four available), the decision can be made that this supplier will be chosen for the cooperation. This supplier offers after-treatment included in the price and the acceptable delivery time. The price is not the lowest, but is considerable lower than the offered price of the supplier 1 and not very different from the suppliers 3 and 4.

Table 12. Comparison of the different approaches

	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Weight 1 Digital-logic	Weight 2 Arbitrary numbers	Weight 3 Saaty's scale
Price	0.58	0.79	0.93	1	0.667	0.46	0.525
Delivery term	0.89	0.83	1	0.71	0	0.18	0.142
After-treatment	1	1	0.2	0.6	0.333	0.36	0.333
Overall score 1	0.71986	0.85993	0.68691	0.8668			
Overall score 2	0.787	0.8728	0.6798	0.8038			
Overall score 3	0.76388	0.86561	0.69685	0.82562			
Original AHP method	0.225	0.260	0.260	0.255			

5. Conclusion

At the present, there are a lot of multiple criteria decision making methods widely applicable over many fields and areas of human endeavour. However, two very important problems can exist: how to determine criteria weights and which criteria have to be taken into account for a particular problem. When considering the problem of the selection of best supplier, many investigations have been done and conclusion can be made that this is a very specific problem depending on the industry or field related to the supplier selection.

In the present paper, the selection of best supplier of plastic joinery based on the three defined criteria, namely price, delivery time and after-treatment is performed. Some additional criteria related to the thermal properties of the used glass or even ecological ones could be included. Furthermore, the sub-criteria associated with the price could be added (e.g. delayed payment, which is very common in Croatia and instalment payments). Regarding criteria weights, it is evident that the application of different methods can give different results. It is obvious that a great experience of decision maker(s) in making judgements is needed. Consequently, many investigators have been applying different methods and integrated approaches to avoid subjectivity and to confirm the best solution as it is done here.

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THE ROLE OF PROJECT MANAGEMENT IN THE STRUCTURAL FUNDS OF THE EUROPEAN UNION

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Abstract

The aim of this paper is to explain major management roles in a process of fund raising for projects financed from structural EU funds, mainly structural EU funds and referring to the procedures for Croatia. It will elaborate the path of how EU policies are conducted from the strategical documents to the project and what is the role of project managers in the process.

Keywords:

Structural funds, projects, management, EU

1. Introduction

During pre-accession period European Commission has ensured EU funding for transition of Croatian economy and its adjustment to the principles and standards of the EU, as well as preparation for the post-accession funds – structural funds and Cohesion Fund. Project management was one of the main functions that took a part in pre-accession process. Project managers from different sectors had to improve their management skills to be able to plan projects, write project proposals, apply for different funds, and conduct projects in a new politico-economic environment. Due to the fact that EU has specific and very rigid procedures, it was necessary for project managers to improve management skills, organisational procedures and culture, in order to meet criteria for gaining EU funds.

After the pre-accession period Croatia has become a member state of the EU, and by accession to the EU, has a possibility for using structural and funds. Even though the project management principles are equal for all EU project, funding from structural funds has its specific requirements. Project managers must therefore learn how to apply for structural funds and how to successfully implement projects. Since grant beneficiaries from structural funds are mostly non-profit organisations and small or medium business, a process of fining appropriate funds to which to apply for, meeting criteria for funding and conduction of a project, is usually a very challenging task that requires specific management skills.

2. Structural funds

One of the most important documents regarding to the EU funds is an EU's ten-year growth strategy "Europe 2020 Strategy". European commission also has number of different policies, and one of the most important for Croatia is a Cohesion policy 2014-2020. In order to ensuring a more strategic and complementary use of different sources of EU funding, a new set of rules and legislation governing the 2014-2020 round of EU investments came into force in December 2013. This legislative package sets down common rules for the 5 "European Structural and Investment Funds" (ESIF) as it is shown on Figure 1. Funds that are available for Croatia are structural funds and Cohesive Fund.

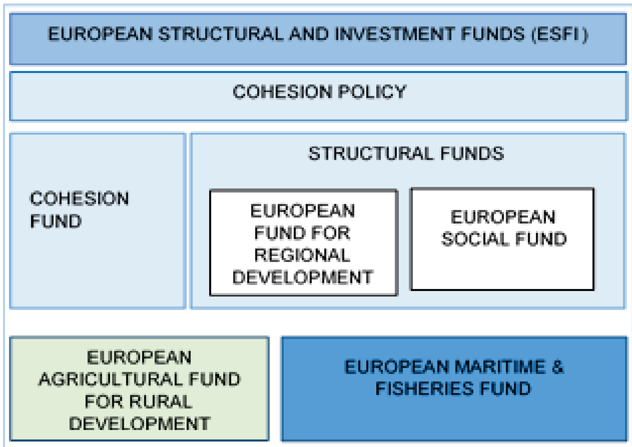

Figure 1. European Structural and Investment Funds [1]

The EU countries administer the funds on a decentralised basis through shared management. Therefore each member country has a Partnership Agreement between European Commission and individual country, which set out national authorities' plans on how to use funding from the European Structural and Investment Funds between 2014 and 2020. They outline each country's strategic goals and investment priorities, linking them to the overall aims of the Europe 2020 Strategy, [2].

A Partnership Agreement between Croatia and European Commission was adopted on October 2014. After the adoption of the partnership agreement national authorities and European Commission agree on National programmes setting out the priorities for each country. "The Commission also works with the Member States as they draw up "Operational Programmes" (OPs) breaking down the investment priorities and objectives of the Partnership Agreements into concrete actions. These

OPs can cover entire Member States and/or regions, or be cooperation programmes involving more than one country. The Commission negotiates with the national and regional authorities on the final content of these investment plans. All levels of governance, including civil society should be consulted and involved in the programming and management of the OPs. The OPs are then implemented by the Member States and their regions. This means selecting, implementing, monitoring and evaluating the individual projects according to the priorities and targets agreed for the programmes with the Commission. This work is organised by 'managing authorities' in each country and/or region according to the principle of shared management and subsidiarity. The new rules require a much stronger focus on results and goals to be measured, monitored and published throughout the period" [3].

Each OPs has number of priorities (priority axis), that can also be divided on different measures.

For the period from 2014 to 2020, Croatia has prepared two operational programs for the implementation of cohesion policy:

Operational Programme "Competitiveness and cohesion" for using the European Regional Development Fund and Cohesion Fund, and Operational program "Effective human resources" for using of the European social Fund.

Institutional framework for management and control of OPs in Croatia is regulated through a system of legal acts and regulations, guidelines (procedures) and the bodies (institutions).

Bodies in the system for each priority axis are:

The Managing Authority (MA) is the authority designated by the Member State to manage assistance of the structural funds. In Croatia it is Ministry of Regional Development and EU Funds. **Intermediate Body level 1 (IM1)** can be Ministries or organizational units within the Central Authority, and are responsible for the coordination of the implementation of the axis or measures of OPs, and therefore plans budgets, and are responsible for the implementation of the measures, providing information and other support to potential applicants, organizing the application and selection procedure, etc**. Intermediate Body level 2 (IM2)** are Ministries or Agencies and can participate in organizing the application and selection procedure, concludes grant with the beneficiary, and are responsible for control of conduction of the projects, decide on the eligibility of costs during the implementation and initiate financial corrections, etc. Some priority axis do not have IM2 body, [4].

All the information about each priority axis are published on the web pages of intermediate body, and therefore it is helpful for project managers to follow pages of IM1 or IM2, according to the area of interest in EU findings.

3. Appling for EU structural funds and project management

EU structural funds are distributed through the system of regulations and organization on two ways, either through open or limited Call for proposals or directly through contracting for strategical projects or technical assistance for each priority axis. The key presumption for using EU funds is that organizations, small and medium businesses, or other entities apply their projects for funding. The process of management of projects financed with EU funds has many stages, and requires number of different project management skills. Therefore a role of a project manager varies during the process, and function of project manager is separated on a number of subspecialty functions, such as planning, writing project proposals, project managers for implementation, and even project managers for implementation on different specialised type of activities (.i.e. public procurement project manager).

Still, the project management of a project funded by the EU is one integral process that is based on a Logical Framework Approach (LFA).

LFA is an analytical process and a set of tools for planning and management of the project. It helps in a process of information analysis, and allows for information to be organised in a structure, in order to open and set up important issues, identify weakness and risks, a provide information for decision making. During 20 years period different government agencies all over the world has developed and modified tools, procedures and terms of LFA, but based on the same principles. European Commission since 1993 demands LFA in the project cycle management (PCM). Therefore it is important to know the principles of LFA and how to apply those principles during project planning, writing project proposal, and later on implementation of the project.

In the process of PCM, LFA is used for:

- During the phase of identification of the project it helps for the analysis of current situation, defining the relevance of the project proposal to the call for proposals, and identifying potential goals and strategies;
- During the phase of formulation of the project it is used for preparation of the action plan for the project, and it defines aims, goals, measurable results and a clear strategy of risks management, as well as division of responsibilities;
- During the phase of project implementation it is use as management tool for contracting (LogFrame), operational planning and monitoring of the project;
- During the phase of evaluation of the project and its final verification it provides information about goals and results that are to be achieved, outputs and indicators for project success measurement and means of verification, [5].

The first step for the management authorities of the organisations that are interested in EU funds

(Structural and Cohesion Fund) is to identify the problem that is to be solved through conduction of the project, and to link it to the relevant Operational Programme (Ops) and its' priority axis. For each priority axis, Implementation body (IM1 or IM2) publishes Call for proposals on its' web pages. In Croatia all Calls for proposals are also published on the web page of Central Finance and Contracting Agency (http://www.safu.hr), and for structural funds on the page on web pages of Ministry of Regional Development and EU Funds (http://www.strukturni-fondovi.hr). Usually IM1, and IM2 publishes Indicative Annual Plan of Calls that is useful for decision maker in order to plan their projects.

Once the relevant Call for proposal is published on different web pages it will consists of number of different relevant documents. Usually it consists of Call for proposals which determines the main purpose of the call, and all relevant terms of the call. It helps project manager to determine whether the project or the organisation is acceptable and relevant for the Call and explains all the terms of the Call. Other very important document is a Guidelines for applicants that explains relevance of the Call and its link to all strategical documents, procedures for the application to the Call and evaluation of application, administrative procedures and request, terms of Agreement and other relevant information for the Call.

After the phase of identification of the project and finding relevant Call for proposal, next phase is formulation of the project. Each Call contains package of forms that are too be filled and prepared according to the Guidelines. Project proposal document must be prepared according to the LFA, although for Call for proposals under Croatia OPs, the document called Logical framework is not always included. Nevertheless, the structure of documents for project proposal must follow the same logic even though the document (table LogFrame) is not requested. Also, in order to achieve goals of the OPs, EU have new regulations that set up measurable indicators for each Call, and every project must contribute not only to the results defined by the project, but also to the indicators of the Call. Each call has different obligatory measurable indicators, and it is important to provide information of quantity and quality achievements of the project through measurable indicators of the Call. Sometimes it is hard to link obligetory indicators with project activities, and therefore LogFrame table is a very useful tool.

Beside the package of the documents for project proposal, part of the application is to be submitted on-line by using SF MIS - Integrated information system for management of Cohesion Fund and structural funds. Namely, Ministry of Regional Development and EU Funds, as Managing body of the OPs in Croatia, has developed ICT system in order to support all the structures involved in managing the Structural and Cohesion Funds of the EU, as well as collecting data and their maintenance and to allow effective monitoring and management of those data, [6].

It can be found on Ministries web pages, as it is shown in Figure 2.

Figure 2. Ministry web pages [7]

The Full application consist of number of documents that the Applicant must provide. It is not only the activities that will be evaluated, but also the organisation, long term sustainability of the action, and other requests of the Call. Project proposal must describe how the action will improve current situation, how is the project relevant for the Call, is the chosen methodology appropriate for the specific project, does the applicant has operational and financial capacities to implement the project according to the EU requirements, is the budget realistic etc. It is not enough to have a good project, but Applicant must also provide all the information that will prove that the project logic is correct, and that there will be no organisational or financial problems during the implementation period, as well as the activities will continue after the implementation period.

During process of preparation of application it is recommended, and very useful to check status of the Call on the web page were it was published. Sometimes IMs can change parts of the Call, deadlines, or even some conditions of the Calls. Also IMs have obligation to answer questions, and therefore it is useful to read FAQs, to ensure that the project proposal will be correct. Detailed information on how to ask questions, and where to find the answers are defined in Guidelines for application. If there were some changes in application forms or even conditions of the Call, and the applicant did not notice the change, application will be rejected.

Submitted applications will be evaluated according to the terms from the Call of the proposal. Each call defines dates and deadlines for each stage of the evaluation of the project proposal. Phases of the evaluation are usually administrative evaluation during which IM1 or IM2 evaluates whether the application is correct, is it relevant for the Call, and is it sent on time and according to the Guidelines etc. After the administration approval of the applications, project proposals are evaluated through one or more cycles of evaluation, in order to grade all applications and approval for contracting the best of submitted project applications. After each stage of the evaluation the Applicants are informed about the results, and possibility for complaint.

If the application is approved the Applicant will be informed when will the action be contracted. Before final contracting of the Action, project manager will in cooperation with IM2 and IM2 check full application, including the budget. Namely, in some project applications there are smaller irregularities that were not significant for the approval of the application, but later on must be corrected. Sometimes during the additional checking there is a possibility that the approved project proposal been rejected by the IM1 or IM2. Therefore, the application and the Action is not fully approved before the signing of the Contract. Once the Contract is signed, the application is officially approved, and the project implementation can start.

It is important to manage contract conduction correctly and it is responsibility of the project manager. Contract usually have Special Conditions (describing the specific context and parameters of the call for proposals, detailing the eligibility of costs, the criteria for eligible activities, as well as duration and location of the project, and information on the two sides in the contract), General Conditions, and Annexes (Description of the project, Budget, contracting procedure, templates of the reports, Expenditure Verification Report, etc.), [8].

Implementation phase of the project is the most challenging phase of the project cycle. Therefore IMs usually organizes one or two days educations for project managers and other staff on the project, in order to inform them about the requests, communication procedures, reporting procedures and other regulations that are to be followed. It is responsibility of the manager to ensure that the project will be conducted according to the Contract and other regulations that are relevant for the Action. Project manager is responsible for the whole Operation and must cooperate with the IM1 and/ IM2. Also, project manager must ensure that the team on project is working properly and according to the action plan, that all the results and goals of the project are achieved, and that all supporting documentation is collected according to the request of IMs. Project manager must take care for the implementation, monitoring, and reporting to the authorities. Also, if there are some changes during the implementation period, project manager must inform IMs about the changes, and if necessary request for the reallocations of budget lines, changes of the projects, and sometimes even changes of the Agreement. It is not unusual that the organizations subcontracts external experts for project management during implementation period of the project, although it sometimes indicates that the organization doesn't have organisational capacities for conduction of the project. Because of that, sometimes evaluators during the phase of approval of the applications give lower grades for such projects, and sometimes it is even the main reason for the rejection of the application.

For easier implementation of the project beneficiary may receive an implementation package of documents, that contains all the reporting forms, guidelines for procurement procedures, different templates of contracts, and other needed documents. Procurement procedures for the projects contracted through Croatian OPs are in accordance by the Croatian Law on Public Procurement. Not all the beneficiaries are under the obligation of this Law and therefore must follow other procedures to ensure transparent process of procurement of goods and services. Those procedures are explained under the Annex 5 - Public procurement procedures for entities that are not liable to the Public Procurement Act. A useful document is a Practical Guide to Contract Procedures for EC External Actions, so called PRAG. It contains detailed description for management of EU funds, and public contracts financed by the EU.

EU also has number of regulations regarding the **visibility of the project**. For the purpose of easier implementation of the visibility actions IMs usually prepares guidelines for the visibility, and although they are not a part of the contract, the beneficiary must follow the procedures, [9]. Other useful document for visibility actions is Communication and Visibility manual for EU External Actions

Last phase is the **project evaluation**. Evaluation of the project can be conducted internally and externally. Internally, project manager monitors the whole operation, according to the internal organisational procedures. External evaluation can be performed by an external independent evaluator, and if it is obligated by the Call, can be sub-contracted on the project. External evaluation can be evaluation of the whole project, or external audit for verification of eligibility of cost. If external audit is in the contract, final reimbursement will not be made before the external auditor submits a Final report on audit. Also IMs also can evaluate the project and the Action. Therefore IMs can review the procurement plan, check requests for reimbursement, check the status of the project, check compliance with the requirements for information and visibility, check the claimed expenses, check the documentation of evidence of payment, check the Request for payment of advance payment, on-spot verification, financial conclusion of the project, conduct Ex - post checks durability of the project, and others. Evaluation of the project are much easier if the LogFrame with Means of verification is prepared, and if internal procedures for documentation flow are adjusted to the project procedures. Therefore it is highly important to collect all required documentation, and to administrate the project. If there are no means of verification, there are no supporting evidence that activity took a part, and that can be a reason for IMs not to accept Interim or Final reports, which than would have impact on a successful closure of the contract.

4. Conclusion

Project management is one of the key functions for development of society, and is of the highest importance for conduction of recent EU policies on any level. EU strategical documents presume that most of the measures will finally be conducted through a number of project implemented by different private or public entities. Therefore it is important to have all needed skills and to successfully apply for EU funds, implement such a project, and improve the society.

A function of a project management for EU projects is wide range of functions that requires different subspecialties. Conservative definition of project is that the project can be any activity that is determined by time, with clearly defined objectives that are common to all those who will carry out a joint activity. The project could be the introduction of new products, development of new software solutions, investment project of construction of the facility, or help in solving community problems. The project manager can be any person within a certain company who has skills necessary for the successful implementation of the project. Sometimes it is the owner himself, sometimes the head of a team, and often the project manager can be a person who is employed for the duration period of the project, and only for the purposes of the implementation of a particular project. [10]

A function of a project manager on EU funds is much more than a conventional project management function. Besides the usual definition of this function, project manager for the EU funds must also be well informed about the policies and the regulations in the EU, most know how to apply for EU funds, have skills and knowledge of implementation of the EU projects according to the EU requirements, have leadership and organisational skills for conduction and administration of the EU projects, and be responsible towards implementing bodies regarding activities conduction, expenses and costs verification, visibility of the project, procurement procedures, monitoring, reporting and evaluation. Selection of project manager primarily depends on the size of the project, the expertise needed to carry it out, if it comes to the technologically demanding projects, and that a possible additional requirements set investors or project funders.

Successful project manager for EU funds is the one who is able to plan the project in accordance with the EU policies, conduct a project according to the requirements, meet the needs and solve the problems that are addressed in project proposals and achieves goals of the organisation.

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SAFE HANDLING WITH MACHINES FOR PLANT PROTECTION

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Abstract

The paper presents testing of machine operator for plant protection in the Brod-Posavina County, based on testing twenty agricultural producers and review of their work equipment and machines for plant protection. According to the Labor law, on safety at work, there are norms and obligations, which the machine operators for plant protection products must comply. We also have prescribed standards, which machinery protection products must meet. During the analysis of collected data on how you operate with machinery for plant protection, it is evident neglect of legal regulations, which will inevitably lead to the injury of the machine operator or even cause death. The prescribed legal norms reduce the injury to a minimum, but also affect the environment. The basic safety rules at work is the Law on Safety at Work, whose purpose is to implement measures for improving the safety and health of workers at work, prevention of work-related injuries, occupational diseases and diseases related to work and the protection of the working environment. Subordinate legislation in the field of occupational health lays down measures to protect health and safety at work related to the means of labor, in our case, machines for plant protection and prevention measures to reduce the risk, identification and strain present in the work performance.

Keywords:

protective equipment, training, proper equipment

1. Introduction

Machines for plant protection belong to the high-risk machinery operators and thus plant protection operators must take into account the mechanical, biological and chemical harmfulness that can cause major health hazard and which are a source of work-related injuries. When handling chemical substances it is important to comply with the security measures to reduce the risk of poisoning.

Individuals must be professionally qualified to carry out such works and familiarize themselves with the dangers when carrying out these works. When working with chemical substances a person may not eat or drink, one must not enjoy tobacco and alcohol products. Prior to the use of chemical substances, one must notify the owners of the surrounding land that there will be chemical treating and specify used chemicals. Set notification of restraining for treated surface and hold it until it is safe. Treatment must not be carried out in strong wind or the opposite direction of the wind. Workers must have personal protective equipment consisting of rubber gloves, protective glasses, washable cotton caps, cotton socks, impermeable work pants and blouse, fastened to the neck, sleeves clamped over the gloves and trousers with leg-coated rubber boots. It is advisable to use white equipment because it is easier to see pollution. Protective clothing and footwear should be washed and changed daily and keep in special cabinets separate from daily clothes. Respiratory protection uses, depending on the operating conditions: respirators with filters to absorb organic vapors and for protection from insecticides in the form of droplets and dust or insulating breathing apparatus with self-contained breathing clean air or oxygen.

2. Materials and methods

The paper analyzed the Eastern Croatia area, more precisely Brod-Posavina County. We collected data from five localities with four respondents. Based on these data we made an analysis, with tabular presentation of absolute and relative terms to see the current situation on the field. Respondents have a working machine with a docking device for the spray distribution. Survey form consists of questions about:

- education on safety protection
- possession of protective equipment
- confirm the device validity.

After the survey, we started with a visual check of the machine to determine the existence of safety and security features, in order to determine their status. Sources of danger in working with plant protection primarily consists of different types of poison, but one must not ignore the risk of rotating equipment parts, which, as in the case of cardan shaft, protect with protective cover. Each towed machine for plant protection, which distributes sprays, has transmissions through the e cardan shaft. Cardan shaft (figure 1) is used for the pump that is integrated on the machine itself, in the position specified by the manufacturer.

Figure 1. Connected cardan shaft

The connection cardan shaft is connected to the rear of the machine and transmits power or the torque until the driveline of plant protection device. This torque transmission is the most common because drivelines are not rigidly attached, or even, their position is relatively changeable.

Protective clothing (figure 2) is personal protective equipment, which protects the human body from the harmful effects.

Figure 2. Protective clothing

Protective clothing must not adversely affect the health of workers. It is made of material, which does not leak substances that are toxic to the human, and is designed to monitor and shape the workers body dimensions in order to cover workers entire body with protective clothing, it is important to be comfortable and flexible with each movement.

Protective clothing must have sewn on visible markings that should include name and trademark, the company designation, a size mark, number of specific standard EN, pictogram indicating a specific threat, clothing design, the protective action and guidance on how to maintain clothes.

Protective coat (figure 3) and protective clothing should be made of good quality material that is lightweight, waterproof, does not leak toxic substances and must bear a visible indication as well as protective clothing.

Figure 3. Protective coat [1]

Protective mask (figure 4) is personal protective equipment for respiratory protection from harmful effects of toxic substances.

Figure 4. Protective mask

Protective mask must meet norms prescribed by the Personal Protective Equipment Ordinance on the use of personal protective equipment [2] and ensure the protection of workers from inhalation of hazardous substances in the workplace. There are masks for entire face, half-masks and quarter-masks. In the application of chemical substances recommended are full-face masks. It is very important that the mask is tight on the face during use, and the area between the mask and the face is as small as possible in order to keep as few of exhaled air. Masks should be made of material that is harmless so they do not irritate the skin, shock resistant and non-combustible.

Protective boots (figure 5) should be made of such materials that are resistant to all weather conditions, resistant to chemicals, waterproof, and with anti-slide soles.

Figure 5. Protective boots

It is also important for boots to be comfortable to perform work-related activities, and to have all the necessary markings such as size, number of specific standard EN.

Protective gloves (figure 6) are personal protective equipment that is very important for the prevention of work-related injuries and occupational diseases.

Figure 6. Protective gloves

When selecting protective gloves, it is important to take into account that the gloves are certified and with CE conformity marking and the appropriate size. It is necessary to keep the manufacturer's instructions on the use, care and storage of gloves and one cannot use gloves that are damaged. Gloves for protection against chemical harmfulness protect the hands from the effects of chemicals and therefore have to be made in accordance with the standard HR EN 374 and be marked with the appropriate pictograms, which shall indicate at least three chemicals code letters. Before using gloves, examine them to determine that they have no damage and tuck the edge in order to prevent the entry of chemicals into the interior of the glove. When you complete work, remove gloves without touching outer surface, hand and dry gloves in airy place but protected from sunlight.

3. Results and discussion

The research was conducted with the machine operators for plant protection in the Brod-Posavina County, during June 2015, by testing twenty (n = 20) of agricultural producers and analysis of their work equipment and machines for plant protection. The aim of the research is the analysis of data collected on how to operate with machinery for plant protection. It is made through four closed questions, to identify the level of knowledge and application of the Labor law on safety at work [2], with regard to the norms and obligations the machine operators for plant protection must comply, but also prescribed standards which machinery for plant protection must meet. The first question relates to education in the field of safety at work. Worryingly, a large number of operators of equipment are without proper training on handling machines for plant protection.

Table 1. Participation in the program of education on work safety

Have you participated in an education program on work safety?	f_i	P_i
Yes	3	15
No	17	85

The second question relates to the possession of protective equipment at work. Even 30% of operators do not have the proper equipment for work protection.

Table 2. Do you own equipment for work protection?

Do you own a complete set of equipment for protection at work?	f_i	P_i
Yes	14	15
No	6	30

Machine operators for plant protection seriously have noted the importance of obtaining a certificate of device safety. Even 90% of operators have a valid certificate of device safety.

Table 3. Do you own a certificate of device safety?

Do you own a certificate of device safety?	f_i	P_i
Yes	18	90
No	2	10

After the survey, we carried out a visual inspection of the equipment and observed a significant share of the equipment with the existing deficiencies that affect the safe operation of the devices.

Table 4. Plant protection equipment condition

The equipment accuracy that affects the work safety	f_i	P_i
Operational	17	85
Identified defects	3	15

According to survey results on the research (figure 7), it is visible that the worst results are seen precisely in education on work safety for operators.

Furthermore, it can be concluded that from inadequate education comes to further mistakes from work safety operators.

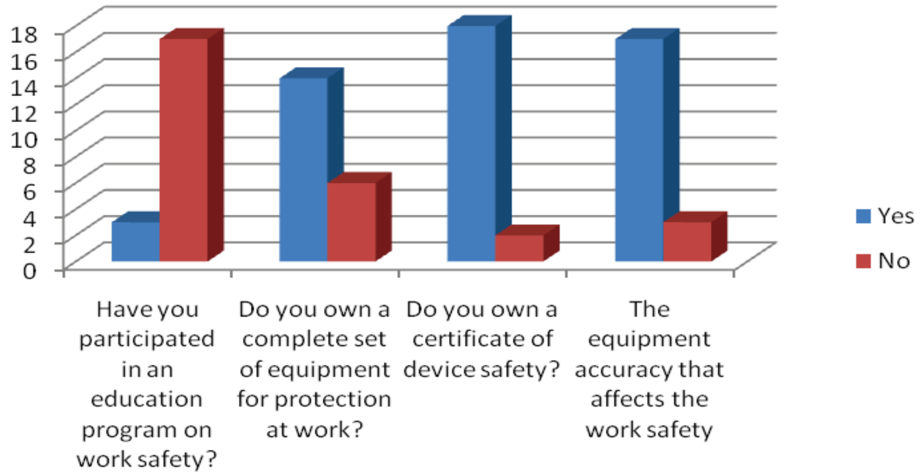

Figure 7. Survey results

4. Conclusion

Given the results, we conclude that the situation in the tested area is extremely negative. All indicators point to major failures, starting from the lack of education, malfunctioning of sprayer distributer's distribution to the non-existence of the equipment for safe operation. All this can result in an injury, even lethal ones. Very often, there is a mild form of poisoning not recorded in the medical records. The reasons, often cited as explanations for these phenomena, are financial difficulties and outdated agricultural machinery. Lack of education comes from faith in operators own experience, while neglecting theoretical knowledge and legislation. On the other hand, by ignoring these rules, operators are endangering the flora and fauna of working and living environment. The toxic asset concentrations in agricultural production are extremely high. We can say that the irresponsible behavior or handling of the same is a crime. It is necessary to wake up the rural population to protect themselves and others. Unfortunately, there is a conventional long-standing practice not to observe the rules, which should be eradicated. There are more and more trainings for farmers and machinery operators but fewer participants. Perhaps, human consciousness is not sufficient to affect changes.

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PLANT GENETIC RESOURCES AND GENETIC EROSION

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Abstract

Main aim of plant breeding is creation of new genotypes with superior agronomic traits. Genetic difference is base for breeding success and it can be find in plant genetic resources (from wild relatives to breeding material). Plant genetic resources are important for agriculture, nutrition, environment protection, sustainable production, preservation of rural areas, lowering level of poverty in rural areas, market stability. Genetic erosion is loss of genetic difference or variability in plant/agricultural species and it has high impact on future improvement of cultivars and food production. For future food production it is essential to determine the level and sources of genetic erosion in plant species and to create plans for preservation and development of new genetic difference.

Keywords:

plant genetic resources, erosion, indicators, genetic difference, genetic vulnerability

1. Introduction

Main aim of plant breeding is creation of new genotypes with superior agronomic traits. Genetic variability or genetic difference is base for breeding success and it can be find in wild relatives, landraces and populations or it can be created by crossing, mutations or genetic engineering [2], [3]. Today, in intensive agriculture production plant cultivars are high yielding but genetically very similar and they are grown in monoculture. Also, for higher food production high inputs in agrotechnics are made [4], [6].

Result of breeding high yielding but genetically similar cultivars is narrowing of genetic variability or genetic erosion [6]. That can have very serious impacts on plant breeding in the future and therefore it is crucial to save existing genetic variability of plant species and to preserve plant genetic resources. First step in their preservation is to determine the level of genetic erosion and its causes [12].

2. Definition and importance of plant genetic resources

It is estimated that 30,000 plant species from 500,000 are edible. Through history around 7,000 plant species were collected and cultivated by humans. Today, only 30 plant species settled 95% of human food demands. Several plant species are staple crops (wheat, corn, rice, potato) [11]. Plant species can be divided on cultivated species, wild species and weeds. Cultivated species are developed by human activities and used in agricultural production. Wild species are plants in nature without anthropogenic influence and they can be used in breeding process as source of important genes. Weeds are plant species that competes with cultivated species for life space, nutritive, water and light. [17], [20].

Plant genetic resources represents plant material that can be used in plant breeding for improvement of existing varieties and breeding material.

Gene pool concept [13] recognize three major gene pools for plant genetic resources differing in possibilities of successful crossings between varieties. More recently fourth gene pool was added [5], [10], [12]. Cultivated plant genetic resources includes modern, high yielding cultivars, traditional cultivars and landraces. Some authors in cultivated plant genetic resources includes subspecies, botanical varieties, breeding populations and old commercial cultivars [25], [28]. Furthermore, plant genetic resources can be defined through certain traits useful for plants that can be described, evaluated and used in agricultural production [9].

Plant genetic resources are important for agriculture, nutrition, environment protection, sustainable production, preservation of rural areas, lowering level of poverty in rural areas, market stability [21]. Local populations and extensive old cultivars provide 15-20% of general food production and they are crucial to insure income for less developed rural areas [12]. Landraces and old cultivars are used for preparation of different traditional meals, in traditional and modern pharmacy, as source of valuable nutritional substances, and as source of genes for improvement of modern cultivars [1], [14], [19], [21]. Old cultivars and wild relatives can be source of genes for tolerance to biotic and abiotic stress (insufficient water supply, high temperature, acid soil). Today, plant genetic resources are research objects in cytogenetics, phylogenetic, evolutionary biology, phytopathology, biochemistry, physiology and ecology. With novel research work their new values for plant breeding and agriculture production and new possible usage can be determined [14], [22], [28].

3. Definition and indicators of genetic difference

Genetic difference represents difference between alleles on one or more gene loci, between plants within one population or between two or more populations. It can be observed at the level of nucleotides, genes, chromosomes and genomes [5], [23]. Allele variability includes differences in nuclear and cytoplasmic DNA and it is base for existence, adaptation, evolution and breeding of plant species [27].

Indicators of genetic difference are numerically representative values aggregated from series of different measures [16]. Indicators are necessary for: (1) evaluation of differences between wild and cultivated genotypes; (2) monitoring of changes and (3) evaluation of the measures for preservation of genetic resources. Indicators can be based on referent values or on monitoring of trends in changes in certain period of time [5]. There are primary and secondary indicators. Good indicators must have scientific value, they should be reliable, simple and useful with low analysis cost. They should be understandable, applicative on different species, sustainable during longer period of time, based on described and recognized methods. They should clearly indicate changes in plant genetic resources.

Number of species, subspecies and ecotypes in protected areas are used in evaluation of genetic differences of wild relatives in natural habitat (*in situ*) especially for rare and endangered species (primary indicator). For wild species in gen banks (*ex situ*) number of species in collection, relations between species developed during evolution and vitality are used as indicators [5]. Recently, molecular methods are also used in determination of genetic difference [23], [24]. They are highly reliable and they determine difference on DNA level excluding subjective evaluation and environmental impact. On the other hand they are more expensive and they demand equipment and specific knowledge.

4. Definition and sources of genetic erosion

Genetic erosion is loss of genetic difference or variability in plant/agricultural species. It can be defined as gradual loss of genetic difference in narrow (loss of certain genes and alleles and their combinations) and broader (loss of cultivars and species) sense [6], [14], [19], [27]. Some authors consider genetic erosion as a loss of genetic difference on certain area in certain period of time and it can be on the level of individual genes, gene combinations and genes in local populations, cultivars and gene collections [18]. As a consequence of natural and anthropogenic processes genetic erosion was determined in wild and cultivated species [12], [19], [27]. Natural causes are natural disasters (flood, fire, drought) and climatic changes without human influence. In wild plant species natural selection and mutations trigger in the same time loss and development of new genetic differences [10], [22], [28]. In today's time genetic erosion is primarily caused by human activities and it is much rapid.

Development of agricultural production is followed by genetic erosion. From domestication to intensive selection loss of genetic differences in plant species is evident. The most endangered species are those lack breeding and production interest. Those species are not grown anymore and usually not preserved in gene banks. Many authors investigated sources of genetic erosion and reported existence of genetic erosion in different species [6], [8], [12], [22], [27].

Increase of world population, urbanization, deforestation, over usage of soil caused loss of natural habitats for wild relatives of agricultural species. Habitats are fragmented which cause development of smaller, isolated populations with different genetic structure [18], [26].

Sources of genetic erosion are also extensive usage of herbicides, uncontrolled pasture, environment pollution, climatic changes, introduction of invasive plant species, human migrations and conflicts [15], [16], [20], [22], [29].

There are many examples of genetic erosion. Genetic erosion of traditional, local cultivars of barley are recorded in Ethiopia [19]. Introduction of modern varieties, replacement of barley with other species (potato, rye, wheat), unfavorable climatic conditions, lack of interest and state support for growing of old cultivars are causes for this erosion.
Genetic erosion of cereal species and cultivars was recorded in Georgia [1], Serbia, Montenegro [8], Tanzania [11].

Genetic erosion threatens world food production. Its result is genetic vulnerability of agricultural crops. There are four kinds of genetic vulnerability: genetic homogeneity, mutational vulnerability, migrational vulnerability and environmental vulnerability [5]. As a result of genetic homogeneity, one cultivar or several very similar cultivars are produced on large areas, and due to the similar traits they are highly susceptible to pathogens. One example for this is production of male sterile corn lines with T type of cytoplasmic sterility in USA in 1970-es. They were susceptible to the southern corn leaf blight and huge losses in production were recorded. Mutational vulnerability is connected with development of new strains of pathogens and their virulence for existing cultivars. Migrational vulnerability consider vulnerability connected with migration of pathogens and pests and appearance of new pathogens due to migrations. Environmental vulnerability is connected with changes in climatic conditions and ability of cultivars to adopt.

5. Indicators of genetic erosion

Genetic erosion can be measured as a proportion of genetic difference that was lost in plant species /population in certain period of time or it is threatened if conservation measures are not applied in near future. It is calculated in relative values [5], [19]. It can be estimated by comparison between number of genotypes (plant species or cultivars of one species) cultivated in the past on certain area with the number of genotypes cultivated during research. Molecular analyses are used for estimation of genetic erosion on the level of alleles. Spreading of modern cultivars not necessarily means genetic erosion. Modern cultivars also introduce new genetic variability. Also, old local cultivars can be used in development of new cultivars and they can pass their genes. Furthermore, they can be preserved in gene banks. In some cases loss of traditional cultivars/genotypes can be substituted with production of local genotypes from neighboring areas. Usually traditional cultivars/genotypes originated from same area are genetically similar and differs in very small amount of traits [7], [18], [27].

According to some authors genetic erosion cannot be defined exactly as a total loss of genotype or allele because it should be considered that new genes or genotypes substitute old ones [27].

Precise indicators should be sensitive enough to indicate important changes in allelic variability (loss of several alleles on one polymorphic loci is not that important as loss of alleles for resistance). Indicators should detect important genes or genotypes in certain areas. Loss of locally specific genes or genes for adaptability that cannot be replaced from another populations mostly contributes to genetic erosion. Therefore, genetic erosion mostly affects local alleles in local genotypes adapted to certain agro ecological conditions [18], [27].

6. Conclusion

Plant genetic resources represents genetic variability required in plant breeding process for the creation of new highly productive and adaptable genotypes. They are source of genes for resistance to biotic and abiotic stress.

Genetic erosion can be at the level of species, genotypes and alleles. There are natural and anthropogenic causes for genetic erosion. Anthropogenic causes prevails today. Most important of them are: modernization of agricultural production (introduction of modern, high yielding cultivars, uniformity of modern cultivars, monoculture, high application of fertilizers and herbicides), urbanization (loss of natural habitats, destruction of environment), climatic changes due to human activities.

Indicators of genetic erosion should be precise, reliable, applicable, understandable and simple. They should detect important components of genetic difference such are alleles for resistance to biotic and abiotic stress.

There are several options for overcoming genetic erosion and its consequences: conservation of plant genotypes *in situ*, conservation of plant genotypes *ex situ* in gene banks, development of divergent genotypes, diversification of agricultural production, sustainable agricultural production, and preservation of traditional ways of agricultural production.

7. References

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SURVEY ON INTRUSION DETECTION SYSTEMS

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Abstract

Intrusion detection systems (IDSs) play an important role in the defense of the companies' IT systems. These systems provide automated protection against a variety of attacks and intrusions. Without them in several cases system administrators are not able to recognize in time high degree attacks and thus effective defense and intervention actions cannot be taken. IDSs use sensors to detect potential attacks and they either inform system administrators or intervene automatically when an attack signature is recognized. In this paper, we do a survey on the main families of IDSs presenting their classification and the advantages and disadvantages of the different approaches.

Keywords: IT security, IDS systems, corporate security, intrusion detection system, data security

1. Introduction

Intrusion-detection systems analyze network traffic and software behavior looking for special events and traces, which could be signs of malicious activities or attacks. When comparing them to firewalls one can state that while a firewall is blocking unconditionally the traffic that is considered unnecessary and is enabling traffic types considered as safe, the task of IDS is to recognize attack traces and in some cases to effectuate counter-actions as well [1].

An IDS consists of the following elements (Fig. 1):

- *Sensors*: monitor and record activities that are processed by the IDS;
- *Analytical Engine*: analyzes the collected data and compares it to the known malicious activity patterns stored in the database;
- *Signature Database*: the collection of known and suspected harmful activities.
- *Report Generator*: alarms system administrators and logs IDS activity [2].

Practice unambiguously shows that creating an automated environment is indispensable for a corporate IT system, where there are many workstations and the communication is multidirectional.

Without its support the administrators would not be able to monitor intrusions and their consequences. The main goal of this paper is to give a comprehensive picture of the IDS families, their key ideas, their advantages and disadvantages.

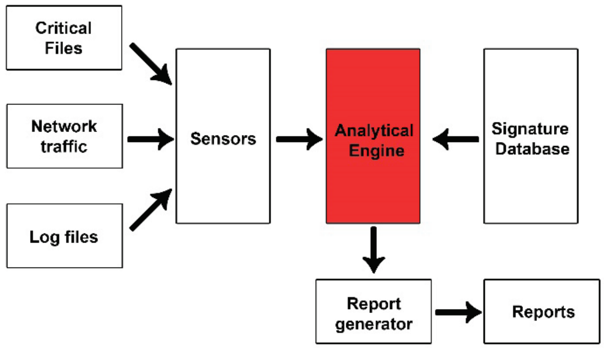

Figure 1. IDS System

2. IDS Categorization

Intrusion detection systems can be categorized in several ways. In this paper, six main aspects are used based on [10] for the definition of main IDS classes (see Fig. 2). They are the applied intrusion detection approach, the type of the protected system, the structure of the IDS, the source of the data used for the analysis, the level of the services offered after the recognition of an attack, as well as the timing of the analysis.

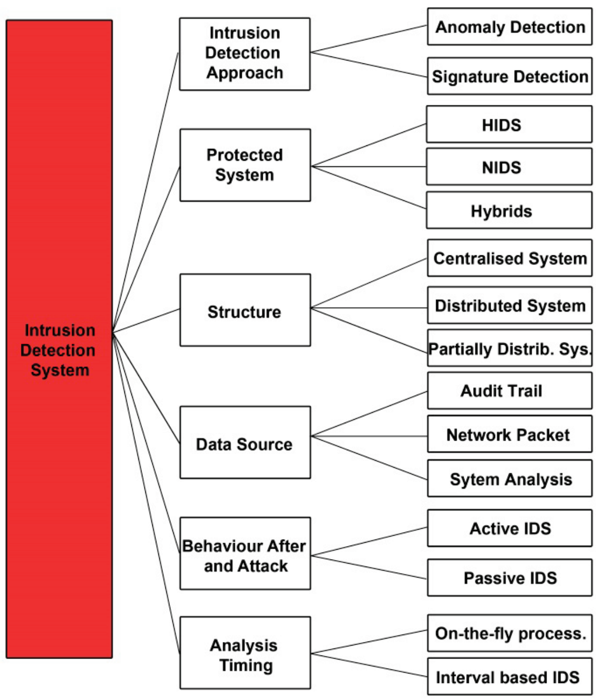

Figure 2. Types of IDS systems [10]

The first aspect we take into consideration for the categorization of IDSs is the applied intrusion detection approach. Conform to it one can identify anomaly detection and signature detection based IDSs [9].

Anomaly detection based IDSs (also called Behavior based IDSs - BIDSs) work on statistical basis. They learn the normal behaviors of both the system and the users. Based on the acquired knowledge they determine whether the analyzed activity is harmful to the system or not. BIDS create statistics for the logon time, the time a user was logged in, the usually accessed files, as well as for the frequency of the modification and movement of these files.

The advantage of the anomaly based approach is its fast and dynamic adaptation capability to unknown attack types. The disadvantage of BIDS is that it alerts the administrator and takes counter measures more often than knowledge-based IDSs due to their high rate of false alarms [9]. Additionally, a BIDS is less efficient in case of systems whose behavior pattern is not static enough for the creation of statistics or in case of systems where user activity is not monotonous, [4]. One has to take extra precautions in course of the learning period to avoid the possibility of “learning” an actual intrusion as a normal behavior.

Signature based IDSs use a database with samples of previous attacks. They are also called Knowledge-based IDSs (KIDS) or misuse detection based IDSs (MIDS). Based on the stored patterns the IDS decides whether the observed activity is a potential attack attempt or not. It is currently the most widely used IDS model. Its advantage is that owing to the stored samples significantly less traffic is blacklisted than in case of BIDS as well as its alarm signals are standardized and easily interpreted by administrators. The disadvantage of KIDSs is that its database requires constant updates and maintenance, as well as it does not recognize new attack types [3], [9]. Thus it may allow access to the system for a new, previously unknown attack types (high rate of false negative decisions) [9]. Moreover, a KIDS could put a new attack type on the white list of activities.

Based on the subject of the protection one can distinguish three kinds of IDSs, the host-based, the network based, and the hybrid systems [2], [7].

The HIDS [19] is used to monitor a stand-alone computer. It has to be installed to and configured for the protected system. A HIDS also requires small testing mechanisms built into it that collect the necessary information for the intrusion attempt recognition from the monitored system's log files. It is able to indicate and prevent threats and physical attacks to the system.

The NIDS usually includes a network monitoring tool, which is supported by a network interface card. This type of IDS is located in a segment of the network or at its borders and examines network traffic. It is able to observe and protect against attacks one or more systems and devices in the network.

Recently it has become a new trend to combine two types of IDSs, the host-based and network-based ones. It is called hybrid intrusion detection system (HYDS). It is more flexible than previous solutions and it increases the level of security. HYDSs combine IDS sensors, reports, and counterattacks to protect a segment or the entire network [4].

3. Structure

Big companies often face the problem it is hard to establish a proper IDS. The biggest challenge is that the individual detection systems can be situated geographically spread at far distances. First, one has to decide about the type of the connection between them and the hierarchical structure to be built. Next, the information and command flow has to be defined, and the final question is whether the IDS infrastructure is controlled centralized, distributed, or a combined approach is chosen.

The structure of an intrusion detection system can also be used as a distinctive characteristic of the categorization. Based on it conform to the above described aspects one can identify centralized, distributed, and partially distributed IDSs.

The IDSs usually utilize agent applications that are installed on some nodes of the computer network. These nodes are called monitor nodes. A monitor node examines the network traffic. It can listen in two modes, i.e. normal and promiscuous. In normal listening mode, the monitor node interprets and forwards data packages that were sent to a given internal subnet after processing (evaluating) them. In promiscuous listening mode, the monitor node examines all messages independently from their destination.

Centralized IDSs (CIDSs) have a central software on a server of the network, which application is responsible for the analysis, detection, classification, and action [5].

The advantage of the centralized approach is the reduced cost compared to the case of a distributed system. Besides, the maintenance and administration costs are also lower. Furthermore, the whole network architecture becomes more simplified and thus the number of vulnerabilities in the security infrastructure of the organization is also reduced. In addition, the managers of CIDSs being able to monitor and evaluate the systems and the networks of the company as a whole unit can easier identify a large scale attack [11].

A Distributed IDS (DIDS) contains several intrusion detection systems. They form a network and communicate with each other or with a central server. This solution has several advantages compared to the centralized one.

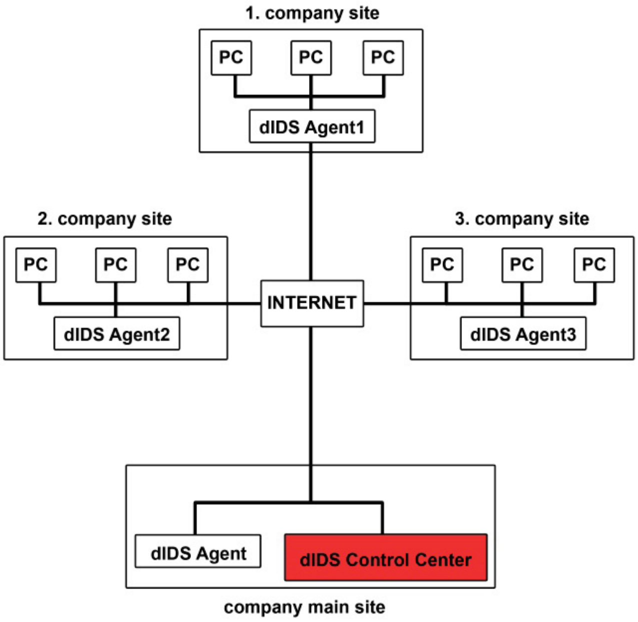

Figure 3. Distributed IDS structure [16]

Firstly, the monitoring, analysis, and processing of attack data is easier. Moreover, a DIDS is able to recognize attack signatures on the whole network of the company where individual segments can be situated geographically far from each other or even in different time zones. DIDS make possible an early intrusion detection that can result in blocking incoming traffic into the whole network from specific IP addresses.

In addition, if a worm gets into the company's network a DIDS can successfully prevent its further propagation. Furthermore, if a threat is identified in one segment it will not be necessary its further analysis on other segments. A DIDS can easily recognize and trace back an internal attack as well using the data logged by DHCP and RADIUS servers [16].

In order to avoid the complexity of using an additional specialized routing protocol (required for a centralized IDS) and limit the overall energy consumption of sensor nodes distributed IDSs consist of agents being able to do the job partially or fully on their own [5].

The partially distributed IDSs combine the centralized and distributed control strategies. The local agents – characteristic to distributed systems – identify locally the hostile activity and take counter actions. Besides, they also send a report to the center. The advantage of the combined approach is that is makes possible the recognition of a coordinated attack that happens at several entry points of the company network at the same time.

Data analysis plays an important role in the protection of IT systems. The data can come from various sources like audit logs, network traffic sniffing, or system analysis. Thus based on the origination of the data they are working with one can define three groups of IDSs being presented in the following subsections.

Audit trails contain information about system activity both by system and application processes as well as data about user activity related to systems and applications. Based on audit trails known intrusion attempts are modelled as sequences of user behavior. These behaviors are then modelled as events in an audit trail. The IDS is responsible for determining how identified user behavior is manifested in an audit trail [6].

A firewall typically does not examine the entire packet and not permitted packet types are simply dropped. Unfortunately this approach cannot stop all malicious packets from getting into the protected system.

An IDS can do a deep examination of packets from the network traffic, and based on the results can permit or prohibit their pass, all of this doing in real-time. Thus all suspicious events/packets are immediately blocked. Therefore the advantage of a network packet based IDS is that owing to the check of the whole package one can block even new attacks against which the original configuration of the firewall would not be able to give protection. Thus network packet based IDS is able to stop attacks that cannot be stopped by the firewall.

A system attack can influence the functioning of the system by deploying malicious software. Therefore the presence of non-desired processes/tasks can also be a sign of hostile activities and thus provide information for IDSs. The limits of this approach are given by the fact that advanced malicious programs are developed to work hidden in the background being difficult to recognize.

Intrusion detection systems also can be categorized based on their behavior after an attack. There are two basic approaches. After recognizing the hostile activity the IDS either creates only a report/alert (passive) or it blocks the attack (active) in order to prevent further malicious activities.

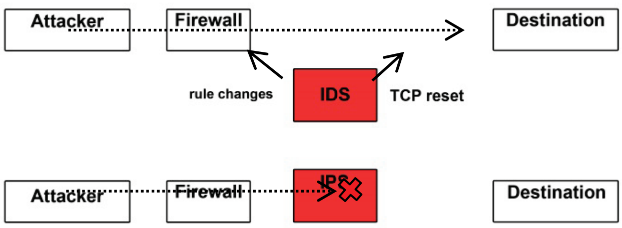

Figure 4. IDS and IPS operation

An active IDS is an intrusion prevention system (IPS). It works without need for human intervention by automatically blocking suspicious system access attempts. The IPS should be placed at the network boundary. However, owing to its position the IPS itself could become vulnerable to attacks. Furthermore, it could even happen that the activities of the IPS are identified as unauthorized access. Its disadvantage is that without proper configuration an IPS often disables users and applications that otherwise would be authorized to use the system.

A passive IDS does not take preventive actions. It runs background scans and in case of potential attacks or suspicious behaviors it alerts the system administrator. The advantage of this approach is that as a passive observer in the network, it does not become the target of attacks, and there is no risk of identifying its own activities as an attack. The disadvantage is that by the time the administrator receives the notice, analyzes it and decides on the proper response, most likely the attack had taken place and the damage is done.

Intrusion detection systems can work continuously while others must be run periodically [18].

Most of the IT systems work continuously around the clock. They need real time protection in order to ensure maximum uptime. Most of the IDSs belonging to this category are based on network traffic analysis. Usually the header of the transport layer packets is monitored, which can include the IP addresses, TCP/IP flags, etc. Another approach analyzes the application layer communication (FTP, HTTP, etc.). Here an important aspect is whether the content of the packets is conform to the protocol.

The advantage of the on-the-fly processing based IDSs is that they can offer a continuous protection and a higher level of availability of the IT system compared to the interval based ones. Their drawback is that they can require huge computational capacity and working memory. Sometimes the applied algorithms are not fast and efficient enough which can result in packet losses.

Interval based IDSs are not working continuously, they are run periodically when a prescribed amount of time is elapsed. There are IT systems that operate only in certain time intervals periodically. They do not need to be monitored and protected continuously. In their case a periodically activated interval based IDSs can provide a proper protection. The advantage of the interval based approach could be that the computational load generated by the IDS is less than in the case of the on-the-fly approach. However, the IDSs belonging to this category can offer only a reduced protection for continuously operating IT systems.

4. Conclusions

IT systems have become part of each section of the everyday life of a company. Their security and availability is a priority for all concerned personnel. Although most likely it is not possible to ensure a full protection but there are several tools that can contribute to the enhanced security when they are properly configured and tuned.

Intrusion detection systems play an important role in the defending mechanism of each professional IT system. They appeared in the late 80s and their evolution continuously followed the growth of IT systems. This paper gives a comprehensive review of the categories of intrusion detection systems showing their advantages and drawbacks as well.

There is no overall optimal solution, one should carefully examine the actual situation, infrastructure available computational power and of course the cost factor which was only implicitly included in this survey.

5. Acknowledgement

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ANALYSIS OF ACTIVE EMPLOYMENT MEASURES

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Abstract

It is very difficult to get employed today. Therefore, there are certain measures that encourage employees and employers to establish a relationship in which young people receive experience and training, and employers do not lose a lot of money. Beside the mentioned measures, university degree helps to get employed university degree. University degree is wanted in good companies that are well established and functioning well, but such is unfortunately very few in Croatia. In addition, it determines the level of salary, which guarantees that it will be at least two times higher than the salaries of secondary education. Companies are now willing to employ highly educated people, but often are not able to pay them. For this reason, measures for employment are very helpful.

Keywords:

Employment, politics, measures;

1. Introduction

The Republic of Croatia, just like other members of the European Union, through its employment services, is investing in active labor market measures. Those measures are designed specifically to unemployed people with difficult access to the labor market. They are used in order to help them to return to work more easily and more quickly. The most disadvantaged in the labor market: namely young people who have just completed their education and lack an experience, people with disabilities, older people and those who are long-term unemployed, women, which is certainly more difficult to find work and other groups; The measures are aimed at those people for a number of reasons. In addition, the measures are designed to the specific characteristics of each group and they are a kind of guarantee that these groups can take advantage at job interview, sometime in the future; they may give preference in employment. Active employment measures mostly support the transition from unemployment into work through education, work experience in the workplace, in public works, support groups of unemployed people and by encouraging self-employment with financial support.

2. The current state of entrepreneurship

According to the National Classification of Activities, a large part of employees in Croatia is employed in the public sector. Moreover, it is said that the number is too large relative to the size of the state's and its needs and often discussed reducing the number of employees in the public sector. "According to Eurostat data, the majority of employees in the public sector are employed in public administration and defense, compulsory social security, followed by education, health and social work and other community, social and personal activities. In addition to that, people who work in the public sector probably know they will work there for a lifetime, without worries; but people working in private sector, regardless of the quantity of their work, know that despite all, their employers often do not earn enough to cover all the costs that the state imposes. Beside the state, many costs are imposed by the local authorities." [1] Data from 2014 suggest that youth unemployment with higher education is concentrated especially in the first year after graduation and to a lesser extent in the next two years. Furthermore, when it comes to employment or unemployment post-secondary education, there is a link between the three-year vocational schools and vocational studies as they are richer in practice and better integrated with the economy, so participants of the schools cope more easily in the labor market.

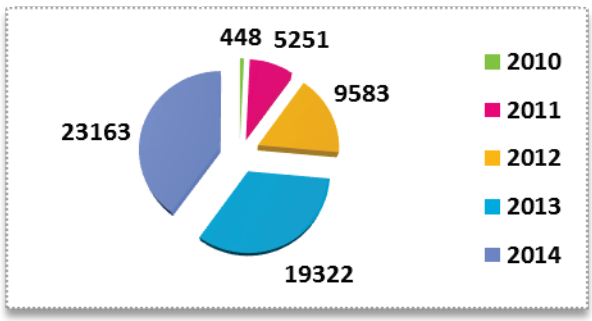

Figure 1. The total number of beneficiaries of professional training for work without employment

Young workers often completely exclude the elderly when it comes to finding a job. Companies in which the majority of employees were older, could be considered as uncompetitive, as the age of the employee is normally associated with inflexibility, lower learning abilities and development, declining skills etc. For companies, it is important to continually develop, which is not possible if there is no young workers or older workers ready for whole life learning. According to contemporary managerial theory, companies that want to be successful, respect potential and performance of both sexes. Therefore, it is considered that the optimum amount of equality 50% - 50%. However, Croatia has not yet adopted this fact, and the ratio in Croatia is around 60% - 40% in favor of men. The average employee in Croatia is in his forties, under-skilled, not mobile and not additionally trained. This makes the way towards greater competitiveness for the company. Youth guarantee model is an employment measurement for young people in the Republic of Croatia officially adopted in 2015. It is a new approach to solving the problem of unemployment of young people- all persons under the age of 25 years, which applies to the EU, and Croatia under the age of 30 years, who are trying as quickly as possible to become active on the labor market. Quick activation of the labor market provides greater motivation for young people looking for work. Great motivation is also upgrading of knowledge and skills that a person has acquired during his often long-time education. This is certainly positive and promising step forward in youth employment. What rapid activation means is getting quality offer within 4 months from the moment of leaving or completing their education or becoming unemployed, regardless of whether the person is registered at the employment office or not.

3. Youth guarantee

Quality offer is part of Youth guarantee program, created with a focus on individual adaptation possibilities and needs.

Table 1. Quality offer of Youth guarantee

Quality offer:
Job offer
Continuing education
Offer of apprenticeship or traineeship and apprenticeship

Youth Guarantee does not guarantee employment, but represents a structural reform that will enable rapid activation of young job seekers as soon as possible, what is not so commendable, however, motivates young people looking for work. "Many young people who are out of college went looking for a job is not even reported to the Department of Employment. The reason for this is the experience of peers that the Bureau has not offered an interview for months for a suitable job, and their application is not necessary to have a right to health insurance, as there are no other benefits." [2] Now, after certain reforms that have been implemented or their implementation is under way, employers can get subsidies for employment of certain categories of young people. At the beginning, this kind of employment was not recognized. As for all the changes, it was necessary for some time. The echo of the measures and quality offers mentioned in the table is particularly visible in the previous year. There is also a problem with those measures which is the difference between private and public sector. In private sector, employers have to employ permanently a person who used a measure after the measure is used. It also applies to a public sector, but it is not happening. In public sector, when the measure is used, people loose job and other people come on their places. Therefore, since it is not allowed in private sector, those measures are losing their purpose.

4. Croatia and European Union together for entrepreneurship, Figure 2

The European Council launched an initiative for youth employment through active measures for employment. The initiative is supported by the European Social Fund in order to implement measures for youth employment and to help with direct aid in the form of money and business. Since most of the educated unemployed youth studied profession for which there is no work in Croatia, part of the funds that Croatia will get for the employment of young people from European Union funds, will be used for the reform of vocational education. Croatian youth employment can count on 66 M euros in the next two years, half of which was from the European Social Fund and the other half from the program Youth guarantee. As more than five and a half million unemployed young people in Europe would not have ended up as a lost generation, the European Commission has devised a program for the Youth Guarantee, which will provide 6 G euros up to 2020.

Figure 2. Croatia and European Union together for entrepreneurship

5. Start-up companies

Entrepreneur who is just starting his business usually thinks he knows what to expect when starting a job. In addition, he does not get too informed about the problems and costs of running a business. Because of desire for a positive beginning, all questions and concerns are left to solve later, which is not good decision. It is common knowledge that good plan is the base of every successful enterprise. Just an idea is not enough for successful entrepreneurship. Idea is an important element, but the plan plus idea are one of the most successful combination. “Over 60% of the Croatian population has a positive attitude towards entrepreneurship, but the percentage is still far below the international average of 75%. Male respondents expressed some less positive attitude (59%) compared to female respondents (64%), but are willing to start their own business than women. The results show that the Croatian respondents motive for entering the enterprise is not only the money. For the 58% of respondents stressed "the independence of the employer" as the most attractive aspect of entrepreneurship“, [1]. As for education, the vast majority of Croatians believe that entrepreneurship can be learned and that we're not born entrepreneurs, but we can become. People who have difficulty finding a job, and have the knowledge and skills needed to revive an idea that could have success in the market, could consider self-employment. Those people who express an interest in self-employment can use the expert assistance of the Institute and get all the relevant information about activities related to the implementation of entrepreneurial ideas. It is positive that all information can be collected in one place, which also gives assistance in developing a business plan, other free education as well as information about other providers and connect all stakeholders in the local labor market. Every financial support that entrepreneurs receive has to be purposefully consumed.

Mentioned financial support can use those who are, for a long time (at least 6 months), registered with the employment office, regardless of length of service and level of education. What is important is that they are willing to be involved in entrepreneurship and to attempt in business. One can open a company, craft or register free profession. In order to help entrepreneurs facilitate the business, institutions have developed a program that facilitates them to obtain loans or guarantees for loans from commercial banks. Ministry of Business and Trade particularly wants to promote entrepreneurship among young people and provide them with more favorable borrowing that is particularly difficult in the beginning. The growing positive attitude towards entrepreneurship in Croatia is very strong among highly educated respondents and younger generations. These are precisely the groups that represent the future growth of Croatian entrepreneurship.

6. Erasmus for entrepreneurs

Erasmus for Entrepreneurs is a cross-border exchange program which gives new or potential entrepreneurs the opportunity to improve their knowledge for its own business with experienced entrepreneurs in the EU. Erasmus is one of advantages entrepreneurs can use. This is one of the reasons that number of users of active employment measures increases with years, Figure 2.

The main goal of the program is to help new and young entrepreneurs to develop their skills, enrich their experience through learning and networking, spending time with experienced entrepreneurs in other EU countries. That would mean a further improvement of internationalization, entrepreneurship and competitiveness of newly established companies. The young entrepreneur has the opportunity to develop their skills and gather enough experience to begin to lead their own business. Erasmus is made in order to help entrepreneurs find themselves in the market and to make some connections between their colleagues. Local entrepreneur also gets the opportunity to find new partners and to discover new markets. This program may include new entrepreneurs in early stage of businesses. This includes companies which are planning or already did create company, but which are old up to 3 years. Then, there are experienced and successful entrepreneurs. This includes persons who are owners of businesses older than 3 years or contractors who are directly involved in the management of small and medium-sized enterprises. However, participants can be also intermediary organizations. These are the organizations responsible for the support and implementation of the program, which may include chambers of commerce, development agencies, business incubators and others.

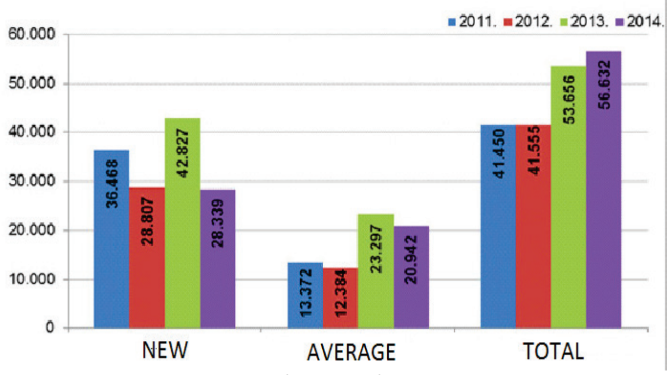

Figure 2. Number of users of active employment measurements, [1]

7. Conclusion

The fact is that the past year through student services throughout Croatia was 75,435 students, nearly 65 percent of the total number of full-time students enrolled in the academic year 2013/2014. The consequence of such high number of employed students is that people permanently employed or for a certain time, or who are unemployed are losing their jobs or future jobs, because a students are much more competitive and more flexible option for each employer. However, to solve this problem, above all others, measures were adopted to help everyone keep their jobs, and those who have not been employed, to be employed. Active employment measures are stimulating employers to hire less educated people, also. This means that every person in labor market can get a chance to be employed. According to the data available on the website of the Croatian Government, in the past year, about 23,000 employers used this measure, which is about 4,000 more than in 2013, and there are nearly 22,500 more users than when the measures were adopted for the first time, back in 2010. Youth employment through such incentives and all financial support to employers, to some extent has a bright future. Unemployment, at least in a group of people under 30, has fallen, what is giving a positive response in the labor market. Therefore, many young people are encouraged and motivated to report to the Croatian Employment Service. The state of entrepreneurship is better than last years and active employment measures give positive results and changes.

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INVEX SETS AND PREINVEX FUNCTIONS

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Abstract

Fundamental inequalities for preinvex functions are studied. The result relating to preinvex functions on the invex set that satisfies condition C shows that such functions are convex on every generated line segment. As a result of such convexity, we provide basic forms of the most important inequalities in order to specifically apply them to preinvex functions.

Keywords: invex set, preinvex function, convex function, inequality

1. Introduction

A notion of preinvex function was introduced in [9] and [8], and came from the notion of invex function. Some prominent properties of preinvex functions can be found in [10]. We briefly present the concept of preinvexity (referring to a preinvex function on the invex set) notifying two definitions and two examples.

Definition 1.1. 1 *A set $K \subseteq \mathbb{R}^k$ is said to be invex respecting a vector function $v: K \times K \to \mathbb{R}^k$ if the inclusion*

$$x + tv(y,x) \in K \tag{1}$$

holds for all points $x, y \in K$ and all $t \in [0,1]$.
The invex set K contains the line segment between points x and $x+v(y,x)$ for every pair of points x and y of K, because

$$x + tv(y,x) = (1-t)x + t(x + v(y,x)). \tag{2}$$

Any subset $K \subseteq \mathbb{R}^k$ is invex respecting the vector function v identically equal to null vector. Besides the term vector function, we will also use the term mapping. Every convex set K is invex respecting the mapping $v(y,x) = y - x$. The next example demonstrates that the reverse is not true.

Example 1.2. 2*The set $K = (-\infty, -a] \cup [a, +\infty)$ where $a \ge 0$, is invex respecting the mapping $v(y,x) = x$ because it contains the combinations*

$$x + tv(y,x) = (1+t)x$$

for all points $x, y \in K$ and coefficients $t \in [0,1]$.

Definition 1.3. 3 Let $K \subseteq \mathbb{R}^k$ be an invex set respecting a vector function $v: K \times K \to \mathbb{R}^k$. A function $f: K \to \mathbb{R}$ is said to be preinvex respecting v if the inequality

$$f(x + tv(y,x)) \le (1-t)f(x) + tf(y) \tag{3}$$

holds for all points $x, y \in K$ and all $t \in [0,1]$.

Every convex function f on the convex set K is preinvex respecting the mapping $v(y,x) = y - x$. As the following example (see [9]) shows, the converse is not true.
Example 1.4. 4*The function $f(x) = -|x|$ observed on set $K = \mathbb{R}$ is preinvex respecting the mapping:*

$$v(y,x) = \begin{cases} y - x, & xy \ge 0 \\ x - y, & xy < 0 \end{cases}.$$

In the case $xy \ge 0$, we obtain formula (3) with the sign of equality. In the case $xy < 0$, we obtain formula (3).

2. Invex combinations

Let $K \subseteq \mathbb{R}^k$ be an invex set respecting a mapping $v: K \times K \to \mathbb{R}^k$, let $x_1, x_2, x_3 \in K$ be points, and let $t_1, t_2 \in [0,1]$ be coefficients. Then the expression

$$\begin{aligned} &(x_1, x_2, x_3; t_1, t_2)_v \\ &= x_1 + t_1 v(x_2, x_1) + t_2 v(x_3, x_1 + t_1 v(x_2, x_1)) \end{aligned} \tag{4}$$

can be called the invex combination respecting v of points x_1, x_2, x_3 and coefficients t_1, t_2. The related set of invex combinations,

$$\begin{aligned} &\operatorname{inv}(x_1, x_2, x_3)_v \\ &= \{x_1 + t_1 v(x_2, x_1) + t_2 v(x_3, x_1 + t_1 v(x_2, x_1))\} \end{aligned} \tag{5}$$

gdje su $t_1, t_2 \in [0,1]$, can be called the invex hull respecting v of points x_1, x_2, x_3. The combination in (4) is in K because its subcombination $x_1 + t_1 v(x_2, x_1)$ is in K. So, the invex hull in (5) is a subset of K. Visual presentation of invex combinations of points x_1, x_2, x_3 can be seen in Figure 1. Combinations are marked by pairs of coefficients t_1 and t_2, thus the pair $(0,1)$ represents the combination $x_1 + v(x_3, x_1)$.

Doing a double application of formula (3) to the invex combination in (4), we obtain the inequality:

$$f((x_1,x_2,x_3;t_1,t_2)_v)$$
$$=f(x_1+t_1v(x_2,x_1)+t_2v(x_3,x_1+t_1v(x_2,x_1))) \quad (6)$$
$$\le (1-t_1)(1-t_2)f(x_1)+t_1(1-t_2)f(x_2)+t_2f(x_3).$$

The sum of coefficients of the last term of formula (6) is equal to 1, so the last term is the convex combination of $f(x_1)$, $f(x_2)$ and $f(x_3)$.

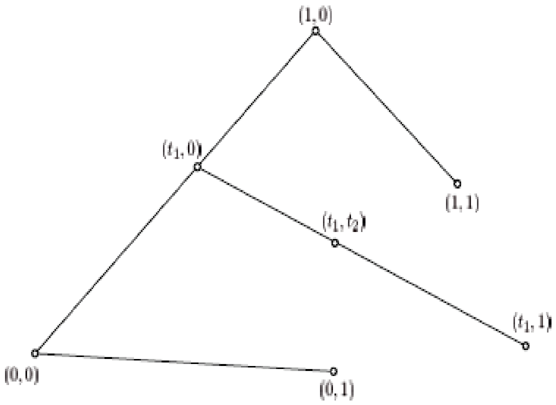

Figure 1. Invex combinations of three points

The generalization of formula (6) can be achieved as follows. If we introduce the abbreviation

$$y_n=(x_1,\ldots,x_n;t_1,\ldots,t_{n-1})_v, \quad (7)$$

then we have the recursive formula

$$y_1=x_1,\ y_n=y_{n-1}+t_{n-1}v(x_n,y_{n-1}) \text{ for } n\ge 2. \quad (8)$$

Relying on the above recursive formula, we can prove the following generalization.

Theorem 2.1. *5Let $K\subseteq\mathbb{R}^k$ be an invex set respecting a mapping $v:K\times K\to\mathbb{R}$, and let $f:K\to\mathbb{R}$ be a preinvex function respecting v. Then the inequality*

$$f((x_1,\ldots,x_n;t_1,\ldots,t_{n-1})_v)\le\sum_{i=1}^{n}t_{i-1}\prod_{j=i}^{n-1}(1-t_j)f(x_i)$$

holds for each n-tuple of points $x_1,\ldots,x_n\in K$, the initial coefficient $t_0=1$, and each $(n-1)$-tuple of coefficients $t_1,\ldots,t_{n-1}\in[0,1]$.

Proof. The proof can be carried out by applying mathematical induction to the positive integer n as the number of points x_i. If $n=1$, the above inequality is reduced to the trivial inequality $f(x_1)\le f(x_1)$. So, the basis step is confirmed. To prove the inductive step, we suppose that the above inequality is true for all positive integers that are less than or equal to $n-1$. Regarding the integer $n\ge 2$, we have

$$f(y_n)$$
$$=f(y_{n-1}+t_{n-1}v(x_n,y_{n-1}))$$
$$\le(1-t_{n-1})f(y_{n-1})+t_{n-1}f(x_n) \quad (9)$$
$$\le(1-t_{n-1})\sum_{i=1}^{n-1}t_{i-1}\prod_{j=i}^{n-2}(1-t_j)f(x_i)+t_{n-1}f(x_n)$$
$$=\sum_{i=1}^{n}t_{i-1}\prod_{j=i}^{n-1}(1-t_j)f(x_i)$$

concluding the inductive step. □

3. Preparation of basic inequalities

We deal with the two most significant inequalities (the Jensen and Hermite-Hadamard) in order to make them applicable to preinvex functions. More specifically, we will present the Jensen (see [4]), Jensen-Mercer (see [5]) and Hermite-Hadamard (see [2] and [1]) inequality concerning a convex function on the line segment in $\mathbb{R}^n$. Extensions and generalizations of the above inequalities can be found in [7].

Let $a\ne b$ be a pair of points in $\mathbb{R}^k$. The line segment between points a and b will be written as the convex hull

$$\operatorname{conv}\{a,b\}=\{\alpha a+\beta b:\alpha,\beta\in[0,1],\alpha+\beta=1\}.$$

Each point $x\in\operatorname{conv}\{a,b\}$ can be presented by the unique binomial convex combination

$$x=\alpha a+\beta b, \quad (10)$$

where (using the norm $\|\ \|$)

$$\alpha=\frac{\|b-x\|}{\|b-a\|},\ \beta=\frac{\|x-a\|}{\|b-a\|}. \quad (11)$$

Lemma 3.1. 6 *Let $a\ne b$ be a pair of points in $\mathbb{R}^k$, and let $\sum_{i=1}^{n}\lambda_i x_i$ be a convex combination of points $x_i\in\operatorname{conv}\{a,b\}$. Then every convex function $f:\operatorname{conv}\{a,b\}\to\mathbb{R}$ satisfies the inequalities*

$$f(\sum_{i=1}^{n}\lambda_i x_i)\le\sum_{i=1}^{n}\lambda_i f(x_i)$$

and

$$f(a+b-\sum_{i=1}^{n}\lambda_i x_i)\le f(a)+f(b)-\sum_{i=1}^{n}\lambda_i f(x_i).$$

Using the secant line passing through the graph points $A(a,f(a))$ and $B(b,f(b))$, the Jensen inequality can be extended to the right side, and so enlarged can be written in the symmetric form. Using the Jensen inequality, the Jensen-Mercer inequality can be refined by inserting the intermediate term.

Theorem 3.2. *7 Let $a \neq b$ be a pair of points in $\mathbb{R}^k$, let $\sum_{i=1}^{n} \lambda_i x_i$ be a convex combination of points $x_i \in \operatorname{conv}\{a,b\}$, and let $\sum_{i=1}^{n} \lambda_i x_i = \alpha a + \beta b$ be its unique convex combination of segment endpoints a and b. Then every convex function $f : \operatorname{conv}\{a,b\} \to \mathbb{R}$ satisfies the double inequalities*

$$f\left(\alpha a+\beta b\right) \leq \sum_{i=1}^{n} \lambda_i f(x_i) \leq \alpha f(a)+\beta f(b) \quad (12)$$

$$\begin{aligned} f(a+b-\sum_{i=1}^{n}\lambda_i x_i) &\leq (1-\alpha) f(a)+(1-\beta) f(b) \\ &\leq f(a)+f(b)-\sum_{i=1}^{n}\lambda_i f(x_i). \end{aligned} \quad (13)$$

Hermite-Hadamard inequality can be carried out from the inequality in formula (12) by using the integral method. That procedure is suitable to perform on the invex line segments, where we will do it.

Lemma 3.3. 8 *Let $a \neq b$ be a pair of points in $\mathbb{R}^k$. Then every convex function $f : \operatorname{conv}\{a,b\} \to \mathbb{R}$ satisfies the double inequality*

$$f\left(\frac{a+b}{2}\right) \leq \frac{1}{\|b-a\|}\int_a^b f(x)dx \leq \frac{f(a)+f(b)}{2} \quad (14)$$

Using the segment equation $x = a + t(b-a)$ through the real parameter $t \in [0,1]$, the middle term of (14) can be expressed by

$$\int_0^1 f(a+t(b-a))dt. \quad (15)$$

To refine the Hermite-Hadamard inequality, we first determine three midpoints with respect to segment endpoints and any segment point. Then we combine the application of the Jensen and Hermite-Hadamard inequality.

Theorem 3.4. *9Let $a \neq b$ be a pair of points in $\mathbb{R}^k$, let $c \in \operatorname{conv}\{a,b\}$ be a segment point, and let $c = (1-\alpha)a + (1-\beta)b$ be its unique convex combination of segment endpoints a and b. Then every convex function $f : \operatorname{conv}\{a,b\} \to \mathbb{R}$ satisfies the series of inequalities*

$$\begin{aligned} f\left(\frac{a+b}{2}\right) &\leq \alpha f\left(\frac{a+c}{2}\right)+\beta f\left(\frac{b+c}{2}\right) \\ &\leq \frac{1}{\|b-a\|}\int_a^b f(x)dx \\ &\leq \frac{\alpha f(a)+\beta f(b)+f(c)}{2} \leq \frac{f(a)+f(b)}{2}. \end{aligned} \quad (16)$$

4. Applications to preinvex functions10

The following lemma explores invex line segments.

Lemma 4.1. *11 Let $a,b \in \mathbb{R}^k$ be a pair of points, and let the segment $\operatorname{conv}\{a,b\}$ be invex respecting a mapping v. Then $v(y,x)$ is collinear with $b-a$ for every pair of points x and y.*

Proof. Take a pair of points $x, y \in \operatorname{conv}\{a,b\}$, suppose that the $x = a + t_1(b-a)$, and take a coefficient $t \in (0,1]$. Since the point

$$x + tv(y,x) = a + t_1(b-a) + tv(y,x) \quad (17)$$

belongs to $\operatorname{conv}\{a,b\}$ by assumption, then it follows that

$$a + t_1(b-a) + tv(y,x) = a + t_2(b-a), \quad (18)$$

and consequently

$$v(y,x) = \frac{t_2 - t_1}{t}(b-a), \quad (19)$$

which proves the required collinearity. □

If the conditions of the above lemma are satisfied, then $v(y,x)$ is collinear with $y-x$ for every pair of segment points x and y.

Corollary 4.2. 12*Let $K \subseteq \mathbb{R}^k$ be an invex set respecting a mapping v, let $a,b \in K$ be a pair of points such that the generated segment $\operatorname{conv}\{a, a+v(b,a)\}$ is invex respecting v. Then $v(y,x)$ is collinear with $v(b,a)$ for every pair of segment points x and y.*

If K is invex respecting v, and if $a,b \in K$, then the generated segment $\operatorname{conv}\{a, a+v(b,a)\}$ is not necessarily invex respecting v. The requirement that the generated segments of the invex set be invex provides the condition introduced in [6].

Definition 4.3. 13 *Let $K \subseteq \mathbb{R}^k$ be an invex set respecting a vector function $v : K \times K \to \mathbb{R}^k$. It is said that the function v satisfies condition C if the equalities*

$$v(x, x+tv(y,x)) = -tv(y,x) \quad (20)$$

$$v(y, x+tv(y,x)) = (1-t)v(y,x) \quad (21)$$

hold for all points $x, y \in K$ and $t \in [0,1]$.

A consequence of condition C is the equality

$$\begin{aligned} v(x+t_2 v(y,x), x+t_1 v(y,x)) \\ = (t_2 - t_1)v(y,x) \end{aligned} \quad (22)$$

which holds for all $x, y \in K$ and all $t_1, t_2 \in [0,1]$.

Assuming the presence of condition C, the following theorem shows where the preinvexity coincides with convexity.

Theorem 4.4. ***14****Let $K \subseteq \mathbb{R}^k$ be an invex set respecting a mapping v that satisfies condition C, and let $f : K \to \mathbb{R}$ be a preinvex function respecting v. Then the function f is convex on the generated segment $\mathrm{conv}\{a, a+v(b,a)\}$ for every pair of points $a, b \in K$.*

Proof. Let $a, b \in K$ be a pair of set points, let $x, y \in \mathrm{conv}\{a, a+v(b,a)\}$ be a pair of segment points, and let $t \in [0,1]$ be a coefficient. We will verify the equality of combinations $(1-t)x + ty$ and $x + tv(y,x)$. Using the representations

$$x = a + t_1 v(b,a),\ y = a + t_2 v(b,a) \tag{23}$$

via formula (22), we get

$$\begin{aligned}
&(1-t)x + ty \\
&= (1-t)(a + t_1 v(b,a)) + t(a + t_2 v(b,a)) \\
&= a + t_1 v(b,a) + t(t_2 - t_1) v(b,a) \\
&= a + t_1 v(b,a) + tv(a + t_2 v(b,a), a + t_1 v(b,a)) \\
&= x + tv(y,x).
\end{aligned} \tag{24}$$

Taking into account the above equality, and applying the preinvexity of f to the invex combination $x + tv(y,x)$, we obtain the inequality

$$\begin{aligned}
f((1-t)x + ty) &= f(x + tv(y,x)) \\
&\le (1-t) f(x) + tf(y)
\end{aligned} \tag{25}$$

which proves the convexity of f on the segment $\mathrm{conv}\{a, a+v(b,a)\}$. □

Formula (24) specifies the mapping v, it follows that $v(y,x) = y - x$ for all points x and y of the invex generated segment $\mathrm{conv}\{a, a+v(b,a)\}$. The type of convexity given in Theorem 4.4 enables us to apply the convex function inequalities to preinvex functions. First and foremost, it refers to fundamental inequalities for convex functions on the line segment which are prepared in the previous section. A version of the Jensen inequality for preinvex functions is the first that follows.

Corollary 4.5. 15*Let $K \subseteq \mathbb{R}^k$ be an invex set respecting a mapping v that satisfies condition C, and let $f : K \to \mathbb{R}$ be a preinvex function respecting v. Let $\lambda_1, \ldots, \lambda_n \in [0,1]$ be coefficients such that $\sum_{i=1}^n \lambda_i = 1$, let $t_1, \ldots, t_n \in [0,1]$ be coefficients, and let $t = \sum_{i=1}^n \lambda_i t_i$. Then the inequality*

$$\begin{aligned}
f(a + tv(b,a)) &\le \sum_{i=1}^n \lambda_i f(a + t_i v(b,a)) \\
&\le (1-t) f(a) + tf(a + v(b,a))
\end{aligned} \tag{26}$$

holds for every pair of points $a, b \in K$.

Proof. Let a and b be a pair of points of K, and let $I = \mathrm{conv}\{a, a+v(b,a)\}$ be the generated segment with endpoints a and $a + v(b,a)$. The function f is convex on the segment I by Theorem 4.4. Since the points $a + t_i v(b,a)$ belong to the segment I, their convex combination

$$\begin{aligned}
\sum_{i=1}^n \lambda_i (a + t_i v(b,a)) &= \sum_{i=1}^n \lambda_i a + \sum_{i=1}^n \lambda_i t_i v(b,a) \\
&= a + tv(b,a) \\
&= (1-t)a + t(a + v(b,a))
\end{aligned}$$

also belongs to I. Respecting the above equalities, and applying formula (12) by using a as a, $a + v(b,a)$ as b, $a + t_i v(b,a)$ as x_i, and t as β, we obtain formula (26). □

The left-hand side of the inequality in formula (26) representing the Jensen inequality for preinvex functions can be written in the form

$$f\left(\sum_{i=1}^n \lambda_i (a + t_i v(b,a))\right) \le \sum_{i=1}^n \lambda_i f(a + t_i v(b,a)). \tag{27}$$

Implementing the integral method through the reflection moment applied to formula (26), we obtain the Hermite-Hadamard inequality for preinvex functions as follows.

Corollary 4.6. 16*Let $K \subseteq \mathbb{R}^k$ be an invex set respecting a mapping v that satisfies condition C, and let $f : K \to \mathbb{R}$ be a preinvex function respecting v. Then the double inequality*

$$\begin{aligned}
f\left(a + \frac{v(b,a)}{2}\right) &\le \frac{1}{\| v(b,a) \|} \int_a^{a+v(b,a)} f(x)dx \\
&\le \frac{f(a) + f(a + v(b,a))}{2}
\end{aligned} \tag{28}$$

holds for every pair of points $a, b \in K$ such that $v(b,a) \ne 0$.

Proof. We utilize formula (16) with the following elements. Take a positive integer n, and select coefficients $\lambda_{ni} = 1/n$ and $t_{ni} = i/n$. Then the coefficient

$$t_n = \sum_{i=1}^n \lambda_{ni} t_{ni} = \frac{1}{n^2} \sum_{i=1}^n i = \frac{n+1}{2n},$$

and the middle term is

$$\sum_{i=1}^{n}\frac{1}{n}f(a+\frac{i}{n}v(b,a))$$
$$=\frac{1}{\|v(b,a)\|}\sum_{i=1}^{n}\frac{\|v(b,a)\|}{n}f(a+i\frac{v(b,a)}{n}).$$

Sending n to infinity, we have that the coefficient t_n approaches $1/2$, the segment point $x_{n1}=a+v(b,a)/n$ approaches a and the segment point $x_{nn}=a+v(b,a)$ approaches $a+v(b,a)$, and therefore the inequality in adjusted formula (26) approaches the Hermite-Hadamard inequality in formula (28). □

The middle term of the inequality in formula (28) can be replaced with

$$\int_0^1 f(a+tv(b,a))dt. \qquad (29)$$

The type of the Hermite-Hadamard inequality involving the Riemann-Liouville integrals and gamma function were considered in [3], wherein some results were achieved for positive preinvex functions on the open invex set $K\subseteq\mathbb{R}$. The results regarding the Hermite-Hadamard inequality for functions whose absolute values of derivatives are preinvex were obtained in several papers.

A refinement of the inequality in formula (28) is based on formula(16).

Corollary 4.7. 17*Let $K\subseteq\mathbb{R}^k$ be an invex set respecting a mapping v that satisfies condition C, and let $f:K\to\mathbb{R}$ be a preinvex function respecting v. Then the series of inequalities*

$$f(a+\frac{1}{2}v(b,a))$$
$$\le tf(a+\frac{t}{2}v(b,a))+(1-t)f(a+\frac{1+t}{2}v(b,a))$$
$$\le\frac{1}{\|v(b,a)\|}\int_a^{a+v(b,a)}f(x)dx$$
$$\le\frac{tf(a)+(1-t)f(a+v(b,a))+f(a+tv(b,a))}{2}$$
$$\le\frac{f(a)+f(a+v(b,a))}{2}$$

holds for every pair of points $a,b\in K$ such that $v(b,a)\neq 0$, and every coefficient $t\in[0,1]$.

Proof. The inequality in formula (16) should be used with a as a, $a+v(b,a)$ as b, $a+tv(b,a)$ as c, and t as α. □

5. Conclusion

In the last few decades, the application of functions that generalize the classical convex functions is constantly growing. A significant generalization of convex functions is that of invex and preinvex functions. Mathematical means and inequalities immediately associate with such functions. Great interest for these type of functions are due to wide possibilities for applications. Generalized convex functions are mostly used in optimization problems and nonlinear programming.

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ADAPTIVE CENTER WEIGHTED MEDIAN FILTER

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Abstract

The weighted median and its propertydistance to center dataare presented. This relation is implemented in the image denoising filter. In the paper impulse image noise model is considered. The quality of reconstructed images provided with proposed filter are measured with PSNR metric.

Keywords: Weighted median, image processing, impulse noise, PSNR

1. Introduction

The weighted medina [1] is a natural extension of the medina. While the median of data vector $\boldsymbol{y} = [y_1, \dots, y_n]^T$, $y_i \in \boldsymbol{R}$, minimizes the L_1-distance (or least absolute deviation,LAD), the weighted median of $\boldsymbol{y} = [y_1, \dots, y_n]^T$ with positive corresponding weight vector $\boldsymbol{w} = [w_1, \dots, w_n]^T$, minimizes the weighted L_1-distance

$$\operatorname{med}(\boldsymbol{w}, \boldsymbol{y}) = \underset{x}{\operatorname{argmin}} \sum_{i=1}^{n} w_i |y_i - x|. \tag{1}$$

If $w_1 = \dots = w_n = 1$, the global minimum is denoted by $\operatorname{med}(\boldsymbol{y})$ and called themedian of data vector.In case that the number of observation n is an odd number ($n = 2k - 1$), the distancebetween center weight median and center observation $y_k$can be observed. It is shownthat distance between center weight median and y_k decrease as the x increase. The weighted median problem is used in many methods for outlier detection [4]and can be found in various branches of applied research (robotics, signal and imageprocessing [2,3], etc.). In image processing the reconstruction of noise image is a problemwhich can be solved with different methods. For that purpose the class of stack filteris developed. Standard median filter removes impulse noise and preserve image edges[2]. However, median filter has detail preserving difficulties. Weightedmedian is useful because of their flexibility. In weighted median filter weights are used topreserve image details and suppress noise as well [3]. For that purposethe new filter represented by thresholds are developed based on relation between centerweight median and distance to center observation. In that case an adaptive centerweighted median filter (ACWMF) is constructed and tested on various experimentalimages. Proposed algorithm has been developed under the PSNR criteria.

2. Weighted median and its application

In this section is given a solution of the weighted median problem [1]. The following theorem proofs minimization problem of the weighted L_1-distances.

Theorem 1 Let $y_{(1)} \le \dots \le y_{(n)}$ denote the ordered observation an $w_{(1)}, \dots, w_{(n)}$ the corresponding positive weights. Then the weighted median of $\boldsymbol{y} = [y_1, \dots, y_n]^T$ is $\operatorname{med}(\boldsymbol{w}, \boldsymbol{y}) = y_{(l+1)}$, where

$$l = \max\left\{h: \sum_{i=1}^{n} w_{(i)} < \frac{1}{2}\sum_{i=1}^{n} w_i\right\}. \tag{2}$$

Proof. Let $F: \boldsymbol{R} \to \boldsymbol{R}$ be a function defined as

$$F(x) = \sum_{i=1}^{n} w_i |y_i - x|. \tag{3}$$

Notice that on each interval

$$(-\infty, y_{(1)}), [y_{(1)}, y_{(2)}), \dots, [y_{(n-1)}, y_{(n)}), (y_{(1)}, \infty) \tag{4}$$

F is a linear function and slopes of those linear function are consecutively k_h, $h = 0, \dots, n$, where

$$k_0 = -\sum_{i=1}^{n} w_i\,,\; k_n = \sum_{i=1}^{n} w_i, \tag{5}$$

and for $h = 1, \dots, n-1$

$$k_0 = 2\sum_{i=1}^{h} w_{(i)} - \sum_{i=1}^{n} w_i = k_{h-1} + 2w_{(h)}. \tag{6}$$

Since $k_{h+1} - k_h = 2w_{(h+1)} > 0$, the sequence (k_h) is increasing and

$$k_0 < k_1 < \dots < 0 \le k_{l+1} < \dots < k_n. \tag{7}$$

It follows from (7) that F is decreasing on $(-\infty, y_{(l+1)})$ and increasing on $(y_{(l+1)}, \infty)$, therefore the minimum of F is attained for $\operatorname{med}(\boldsymbol{w}, \boldsymbol{y}) = y_{(l+1)}$.■

The next theorem shows relation between the center weight vector $\boldsymbol{w}(x) = [1, \dots, x, \dots, 1]^T$ and $|y_k - \operatorname{med}(\boldsymbol{w}(x), \boldsymbol{y})|$.

Theorem 2 Let $\boldsymbol{y} = [y_1, \dots, y_n]^T$, $n = 2k - 1$, be data vector with weight vector $\boldsymbol{w}(x) = [1, \dots, x, \dots, 1]^T$. Then

$$F(x) = |y_k - \operatorname{med}(\boldsymbol{w}(x), \boldsymbol{y})|, \tag{8}$$

is monotonically decreasing on $D_F = [1, \infty)$.

Proof. Let $1 \le x_1 \le x_2$. If $y_k = y_{(k)}$ the function F is constant an the proof in this case is trivial.

Suppose that k' correspond to position of y_k in ordered observation and $k' \le k$. In this case from Theorem 1 it is easy to see that $\mathrm{med}(\boldsymbol{w}, \boldsymbol{y}) = y_{(l+1)}$ where $l + 1 \in [k', k]$. So it is sufficiently to indicate that $l_1 \ge l_2$ where

$$\mathrm{med}(\boldsymbol{w}(x_1), \boldsymbol{y}) = y_{(l_1+1)}, \tag{9}$$

$$\mathrm{med}(\boldsymbol{w}(x_2), \boldsymbol{y}) = y_{(l_2+1)}. \tag{10}$$

Situation when center weights are $x_1, x_2 \ge \frac{1}{2}$ (or $x_2 \ge \frac{1}{2}$) indicate that $l_1 + 1 = l_2 + 1 = k'$, and statement of theorem is proven. Observed nontrivial case is when $x_1, x_2 \le \frac{n}{2}$, i.e. $l_1 + 1, l_2 + 1 > k'$. In that situation, according to Theorem 1, it can be conclude that

$$l_1 = \max\left\{h : h < \frac{n - x_1 - 1}{2}\right\}, \tag{11}$$

$$l_2 = \max\left\{h : h < \frac{n - x_2 - 1}{2}\right\}, \tag{12}$$

what directly implies statement of theorem because $x_1 \le x_2$.

Situation when $k' > k$ is considered also when $x_1, x_2 \le \frac{n}{2}$, otherwise the proof is trivial. Considered that case, it can be conclude that $l_1 + 1, l_2 + 1 < k'$, and it is sufficiently to indicate that $l_1 \le l_2$. According to Theorem 1 it can be conclude that

$$l_1 = \max\left\{h : h < \frac{n + x_1 - 1}{2}\right\}, \tag{13}$$

$$l_2 = \max\left\{h : h < \frac{n + x_2 - 1}{2}\right\}. \tag{14}$$

From (13) and (14) the theorem is proven, i.e. $l_1 \le l_2$, because $x_1 \le x_2$.■

3. Adaptive center weighted median filter

The digital image can be represented $N \times M$ matrix of the form:

$$\mathrm{X} = [x_{ij}]_{(i,j)\in\Omega} = \begin{bmatrix} x_{0,0} & \cdots & x_{0,M-1} \\ \vdots & \ddots & \vdots \\ x_{N-1,0} & \cdots & x_{N-1,M-1} \end{bmatrix}. \tag{15}$$

In such a system, the indices $(i,j) \in \Omega$ of the image matrix correspond to (i,j)-th image intensity x_{ij}. The term *gray level* is often to refer to the intensity of monochrome image. In that situation the matrix elements (image pixels) are integers in the range $[0, \dots, 255]$.

Digital images are often corrupted by impulse noise during the transimssion through communication channels. It appears as black or with impulses on the image. It can be modeled as follows:

$$y_{ij} = \begin{cases} \xi_{ij}, & \text{with probability } \rho, \\ x_{ij}, & \text{with probability } 1 - \rho, \end{cases} \tag{16}$$

where $\mathrm{X} = [x_{ij}]_{(i,j)\in\Omega}$ denote original image, $\mathrm{Y} = [y_{ij}]_{(i,j)\in\Omega}$ noisy image, and ρ noise ratio. For a impulse noise ξ_{ij} is probability distribution with corresponding probability density function

$$P(\xi_{ij}) = \begin{cases} P_p, & \text{for} \xi_{ij} = p, \\ P_s, & \text{for} \xi_{ij} = s, \\ 0, & \text{otherwise}, \end{cases} \tag{17}$$

where $P_p + P_s = 1$ and $P_p, P_s \ge 0$. Most usually observed situation is when $p = 0$, $s = 255$, and $P_p = P_s = 0{,}5$.

In image processing, filters are constructed to process every image elementy_{ij}, $(i,j) \in \Omega$. In that way image$X^* = [x^*{}_{ij}]_{(i,j)\in\Omega}$ is constructed. Filter process different neighborhoods of y_{ij} where 3×3 filtering window are most commonly used for impulse noise. In that case filtering window is defined:

$$Y_{ij} = \{y_{hl} : |h - i| \le \omega \ \& |l - j| \le \omega\}, \tag{18}$$

where ωdenotes size window which is in our case is $\omega = 3$. Filtering window Y_{ij} can be presented as a vector $\boldsymbol{y}_k = [y_1, \dots, y_n]^T$, $m = \omega^2$, where $k = i \cdot N + j$ correspond to (i,j)-th position.

In this paper ACWMF is proposed. Ideally filtering should be applied only to noisy pixels, and noise-free pixels should be kept unchanged,so, a noise detector is used. We proposed a scheme by successfully combining center weighted median filters [3] and compares them with the observed pixel value. The output of proposed ACWMF is obtained by:

$$x^*{}_{ij} = \begin{cases} y_{ij}, & \varepsilon \ge d_1, \\ \mathrm{med}(\boldsymbol{w}(x_1), \boldsymbol{y}_k), & \varepsilon < d_2, \\ \mathrm{med}(\boldsymbol{w}(x_2), \boldsymbol{y}_k), & d_2 \le \varepsilon < d_1. \end{cases} \tag{19}$$

In proposed method d_1 and d_2 are defined as $d_1 = |y_{ij} - \mathrm{med}(\boldsymbol{w}(x_1), \boldsymbol{y}_k)|$, $d_2 = |y_{ij} - \mathrm{med}(\boldsymbol{w}(x_2), \boldsymbol{y}_k)|$ respectively, where $1 \le x_1 \le x_2$. The definition of (19) follows the property that $d_1 \ge d_2$,showed by **Theorem 2**. Note that threshold ε affects the performance of impulse detection. As a results, impulse noise can be removed while uncorrupted pixels remain unchanged in order to preserve the image details. Consequently, the trade off between suppressing noise and preserving detail is well balanced. In the following section we study influence of center weights x_1, x_2, and threshold ε on the filtering performance using variety of the test images.

4. Experimental results

The quality measure of proposed ACWMF has been experimented with center weights $x_1 = 1$ and $x_2 = 2$. The measures are provided via PSNR (Peak Signal-to-Noise Ratio) metric defined as

$$\mathrm{PSNR} = 20 \log_{10} \frac{255}{\sqrt{\mathrm{MSE}}}, \tag{20}$$

where MSE (Mean Squared Error) is defined as

$$\mathrm{MSE} = \frac{\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}(x_{ij} - x^*_{ij})^2}{M \times N}. \qquad (21)$$

PSNR quality measure is appropriate for insight of impulse reducing because of its robust properties to outliers [4]. The PSNR via threshold ε is graphically presented in fig. 1 for256×256test images Lena and Mandrill corrupted with impulse noise $\rho = 0{,}2$.

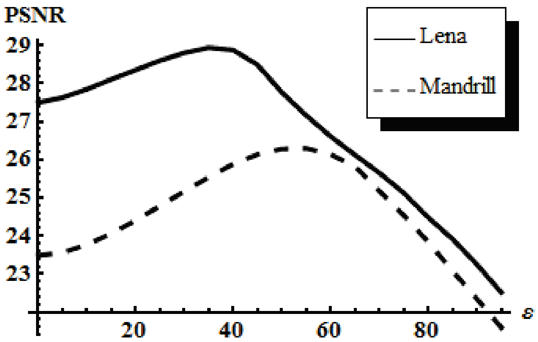

Figure 1. Results of PSNR via threshold ε

It can be seen that the PSNR performance is significantly improved by using threshold ε in the range $[30{,}60]$. In figure 2 PSNR filtering results of median filter (MF)are presented,[2], and ACWMF $(\varepsilon = 40)$for Lena and Mandrill test images for a noise ratio $\rho \in [0{,}05, 0{,}5]$.

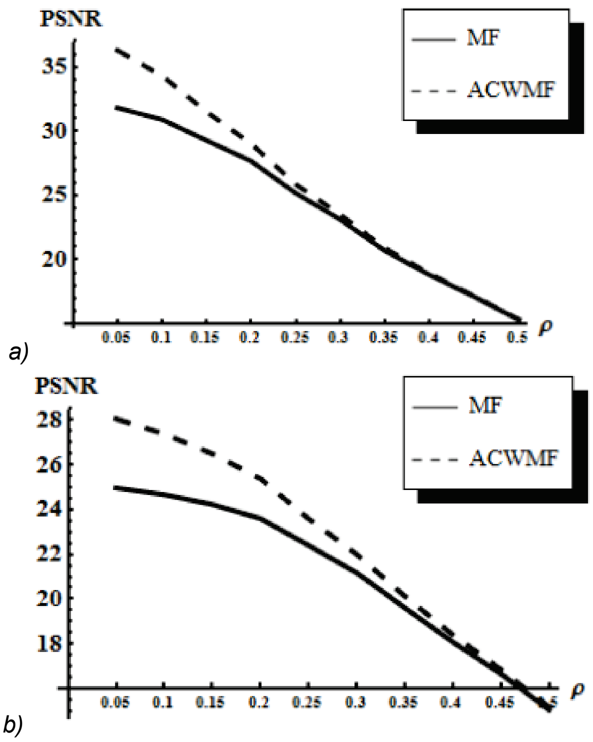

Figure 2. Filtering results: (a) Lena, (b) Mandrill

Referring to figure 3, one can see that the noise suppression and detail preservation are satisfactorily compromised by using our proposed method (d) as compared to using standard median filter (c).

Figure 3. Results of filtering for: (a) original, (b) noisy image ($\rho = 0{,}2$), (c) MF, (d) ACWMF

5. Conclusion

In this work a new median filter ACWMF is introduced. By incorporating the weighted median into an impulse noise detection framework is formed for effectively reducing impulse noise while preserving image details. Given a specified threshold ε the output of our proposed ACWMF may correspond to one of three possible states, namely the origin pixel value (i.e., the pixel is noise-free), or one of the center weighted output. The proposed methodology remains applicable to adjust center weights x_1, x_2, and threshold ε according to different noise ratio ρ. In addition, the proposed filter present a quite stable performance over a wide variety of image.

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OPTICAL MEASUREMENTS OF SURFACE ROUGHNESS CUT WITH WATERJET

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Abstract:

The paper describes method for optical measurement of surface roughness (Ra) with computer vision. The equipment for roughness measurement is expensive, and the process itself is also time-demanding. This study is focused on the design of an instrument for non-destructive measurement and the determination of the roughness class by computer vision. The instrument needs to be of simple design, cost accessible and safe in practical application. It is intended for the fast determination of the roughness class of work specimens obtained by water jet cutting, and the setting of cutting parameters in accordance with the obtained results. The principle of instrument operation is based on measuring the intensity of the visible light spectrum reflected from the surface of the specimen and the correlation between these values and the measured roughness values.

Keywords:

optical measuring, surface roughness, computer vision, water jet cutting

1. Introduction

Reliable measurement of surface roughness (Ra) is critical to quality control in a wide range of manufacturing processes. The purpose of this project is to design a simple, cost accessible device for non-invasive measurement of Ra in process of waterjet cutting. This device must capture the intensity of visible light reflected by a set of controlled surfaces and correlate this value to a measurement of Ra, [1].

2. Waterjet cutting

Waterjet cutting is often used during fabrication of machine parts. It is the preferred method when the materials being cut are sensitive to the high temperatures generated by other methods. Waterjet cutting is used in various industries, including mining and aerospace, for cutting, shaping, and reaming, Figure 1.

Waterjets are fast, flexible, reasonably precise, and in the last few years have become friendly and easy to use. They use the technology of high-pressure water or a mixture of water and an abrasive substance being forced through a small hole (typically called the "orifice" or "jewel") to concentrate an extreme amount of energy in a small area. [2]

Figure 1. Waterjet cutting [3]

While cutting with water is possible for soft materials, the addition of an abrasive turned the waterjet (abrasive jet) into a modern machining tool for all materials. In Figure 2 surface sample after processing with abrasive jet cutting is shown.

Figure 2. Surface sample after abrasive jet cutting of stainless steel

The inlet water for a pure waterjet is pressurized between 1300 to 6200 bar. This is forced through a tiny hole in the jewel, which is typically 0.18 to 0.4 mm in diameter. This creates a very high-velocity, very thin beam of water (which is why some people refer to waterjets as "water lasers") traveling as close to the speed of sound (960 km/h).

An abrasive jet starts out the same as a pure waterjet. As the thin stream of water leaves the jewel, however, abrasive is added to the stream and mixed. The high-velocity water exiting the jewel creates a vacuum which pulls abrasive from the abrasive line, which then mixes with the water in the mixing tube. The beam of water accelerates abrasive particles to speeds fast enough to cut through much harder materials, Figure 4.

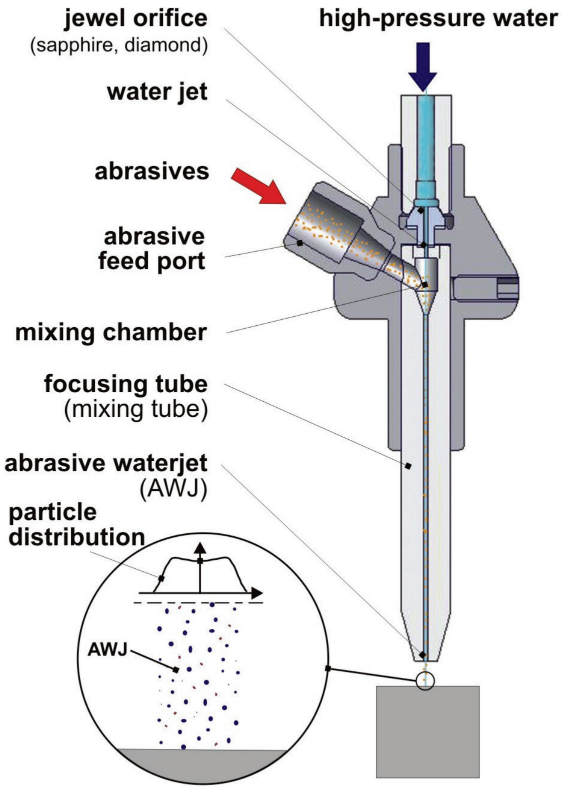

Figure 3. A diagram of an abrasive jet nozzle [4]

In Figures 4-6 dependences between the depth of cut, cutting speed, the flow of abrasives and surface quality (Ra) are shown.

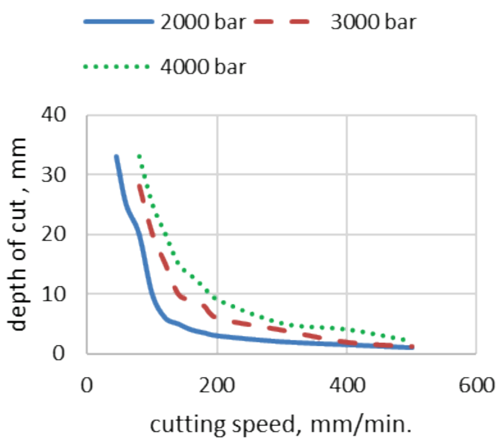

Figure 4. Dependence the depth of cut and the cutting speed [2]

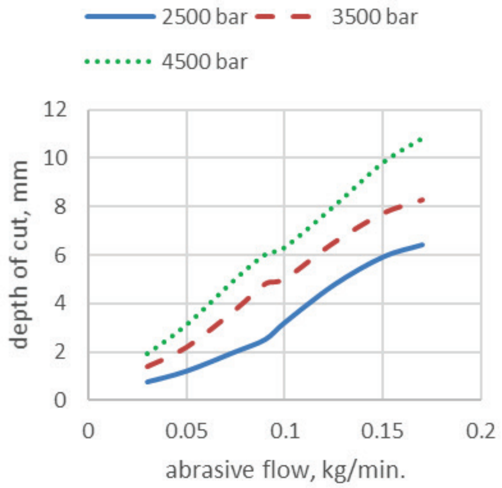

Figure 5. Dependence the depth of cut and the abrasive flow [2]

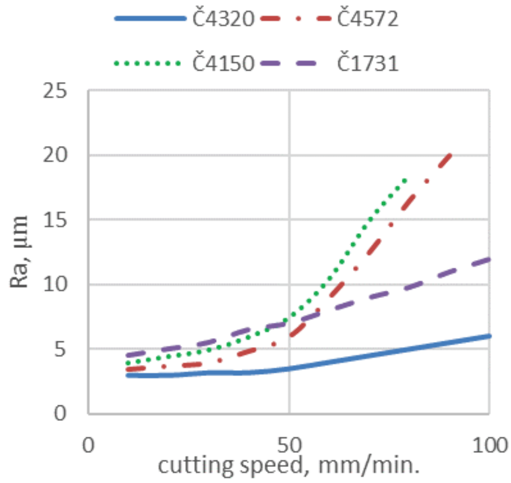

Figure 6. Dependence of surface quality (Ra) and cutting speed [2]

3. Surface roughness measurement methods

Many surface roughness measurement devices currently exist in industry. There are three main categories that we will analyze on a closer scale: stylus-type contact measurement instruments, non-contact laser measurement devices, and non-contact white light measurement devices. All three are currently used in a variety of applications to analyze surface roughness among other surface properties of varying types of material [1].

Stylus Method

Stylus-type contact measurement devices are the most primitive type of device used to measure surface roughness. These devices operate by moving a small probe across the test surface to detect variations in height. This class of devices has many disadvantages, including speed of measurement, invasive nature, and tendency to be highly affected by surface abnormalities [1].

Laser Scattering

Non-contact laser measurement devices are commonly used in many industry applications. These devices operate by emitting a concentrated laser at the test surface, either directly or via mirrors, and using detectors to measure the distribution of specular and diffused light reflected by the surface. The major disadvantages of this class of devices include its limited working distance to the test surface, the potential dangers of high energy lasers, and the laser's inability to examine large spans of surface [5], Figure 7.

White Light Superposition

Non-contact surface measurement devices using white light are much less common in industry. These devices utilize the established technique of interferometry with white light along with a CCD camera to analyze surface roughness of varying materials. This process involves emitting white light on both the test surface and a high-precision reference surface, capturing these images with the CCD camera and superimposing these images in order to get an accurate analysis of the surface. One major drawback of this particular device is the necessity of a high-precision reference surface. This can prove to be especially inconvenient when analyzing materials over a large variety of surface finishes [1], Figure 8.

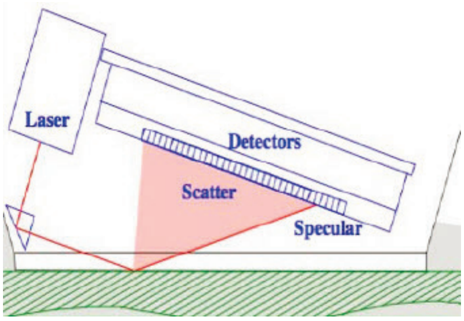

Figure 7. Non-contact laser measurement device [1]

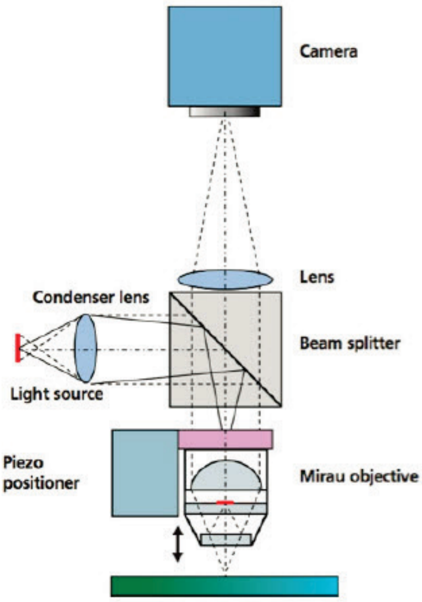

Figure 8. Non-contact white-light measurement device [1]

4. Orientation of light source and sensor

The method of delivering light, orientation between light source and sensor, is the most important factor to consider. Light dispersion affects the accuracy and repeatability of measurements. It also affects the versatility of the sample areas it can measure and the cost.

Coaxial Source and Sensor

The first of possible orientation has the optical sensor located directly on the axis of reflected light, Figure 9. Advantage of this design is that it is simple, and prior knowledge exists to suggest this orientation will be successful in resolving the roughness of the surface. Since the sensor is directly aligned with the reflected light, this setup will also measure the highest reflected light intensity of any of our orientations. If the brightness of the light source is a limiting factor, then this orientation will be suitable for detecting even the weakest reflections.

Drawback to this design is that the size of the unit is intimately dependent on the incident angle (θ) used. If it turns out that a large incident angle is beneficial to surface measurement, this design will be relatively wide in comparison to its height [1].

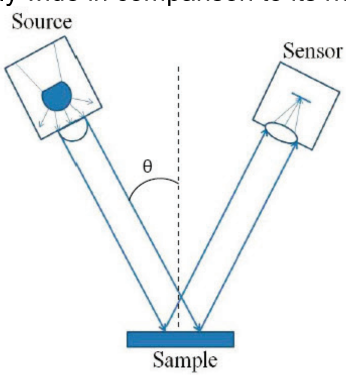

Figure 9. Coaxial orientation [1]

Off-Axis Scattering

In this orientation, the sensor is placed vertically above the sample, while the light source shines at a slant upon the sample, Figure 10. The reflected light beam is not measured directly. This orientation measures only the light that scatters off-axis. In this case the intensity of light upon the sensor is greater for a rougher surface, which theoretically should have a higher degree of scatter. The advantage of this orientation over a head-on sensing approach comes in the data acquisition and analysis portion of the system. It is easier to distinguish slightly varying amounts of light intensity when there is less light than when there is a lot of light. Larger amounts of light will over-saturate the image, making the distinctions between too different intensity reflections less discernible [1].

Vertical Beam with Beam splitter

In order to address the concerns of working distance and the problems associated with a changing distance, as well as having a compact design, an attractive set-up is a vertical orientation. If the light is collimated, it does not need to be focused at an exact distance from the sample. This set-up uses a 50% transmission beam splitter oriented at a 45 degree angle from the horizontal, such that half the light is transmitted through to the sample and half is reflected away. This reflected light, less than 25% of the magnitude of the original light source, less because the sample is not assumed to be a perfect mirror, but is captured by the optical sensor, which sits off to the side. This orientation is the most compact of our choices. It is also the costliest. The amount of light captured by the sensor in the vertical orientation is not affected by the working distance, because there is no angle of incidence. This set-up also requires that the light source be especially bright, because it will lose at least 75% of its magnitude from two passes through the beam splitter [1], Figure 11.

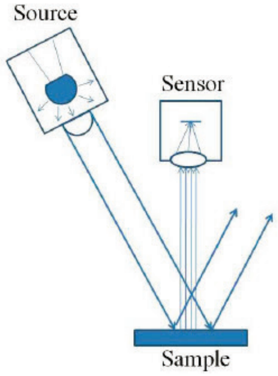

Figure 10. Off-Axis orientation [1]

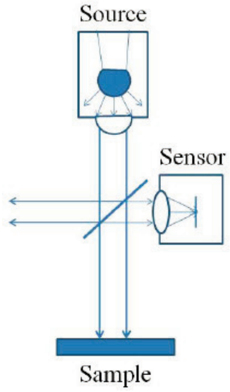

Figure 11. Vertical orientation [1]

5. Construction of device

It is critical to have sufficient clearance between the device and the sample to be feasibly implemented in a dynamic assembly line. Prototype box was designed in Solidworks and exported in STL format for 3d printing. It is made of Acrylonitrile butadiene styrene (ABS) and it is consist of two main compartments, Figure 12. One compartment (larger) is for light source, Arduino microcontroller, beam splitter, signal led and the other one is for USB camera. A computer equipped with our Lab VIEW interface must be connected to the web cam housed inside box during use.

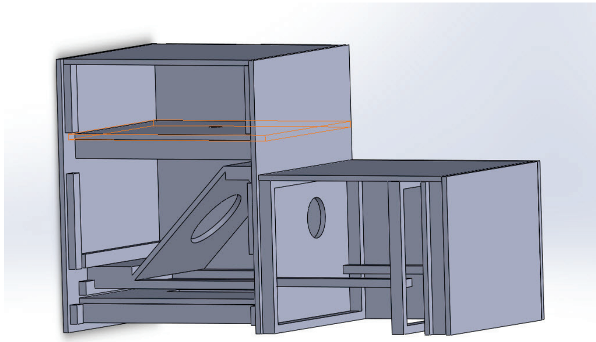

Figure 12. Prototype box design

6. System main elements

Light Source

The wavelength and intensity of the light source are also of great importance. The wavelength will have bearing on the accuracy and resolution of readings, as well as the safety of the device. Some wavelengths such as ultraviolet can have harmful side effects. Purple LED (SSL-LX5093VC): This source produces 2200 mcd and λ=550 nm at an operating current of 20 mA, Figure 13.

Figure 13. LED SSL-LX5093VC

Lens

The Thorlabs EBS1, 50:50 (at 45° angle of incidence) beam splitter operating in the visible (450-600 nm) spectrum was used, Figure 14.

Figure 14. Thorlabs beam splitter EBS1

Arduino

Arduino microcontroller was used as a power source for the purple LED, and as a link to a PC through which we manage the digital outputs and inputs on the microcontroller, Figure 15.

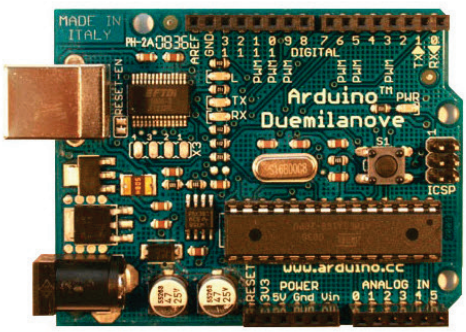

Figure 15. Arduino Duemilanova

USB camera

USB Digital Microscope KLN-J200: 2.0 Mpx, usb 2.0, zoom 25X-200X, focus manual (0-85 mm), picture resolution from 320x240 to 1600x1200, video resolution 640x480, Figure 16.

Figure 16. USB Digital Microscope KLN-J200

7. Labview and application logic

The primary function of device is to receive human activation and output a measurement of Ra. Device is constrained to accomplish this by measuring the intensity of reflected light, so we included the three sub-functions of: providing light to the surface (LED), capturing reflected light (Usb camera), and processing the captured image (LabVIEW). Main user interface and programming has been done with LabVIEW 2013, Figure 17.

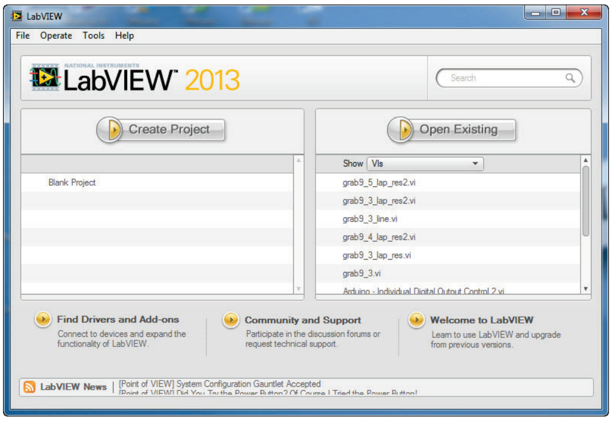

Figure 17. LabVIEW 2013 framework

LabVIEW is a graphical programming language that has been widely adopted throughout industry, academia, and research labs as the standard for data acquisition and instrument control software. LabVIEW is a powerful and flexible instrumentation and analysis software system that is multiplatform, can run on Windows, Mac OS X, and Linux. You can also run LabVIEW on PDAs (PalmOS, Pocket PC, or Windows CE devices), on real-time platforms, and even embed LabVIEW programs into FPGA chips and 32-bit microprocessors.

The method used to analyze the images and output the *Ra* values in certain classes used a combination of multiply methods. As outlined in the flowchart, the algorithm take a picture and turns the raw image to grey scale and makes it an array of intensity values. It then looks at a predefined area from user within the image, ROI (region of interest) which can be a foursquare area or line (user can choose suitable type of ROI on application interface). The intensity values within this area are then averaged. The average intensity is then correlated to a specific class of *Ras*, defined by the numerous measurements of testing samples with known values of surface roughness for device calibration. If the intensity is outside define parameters the algorithm will then show error, as not known values. See the flowchart on Figure 18.

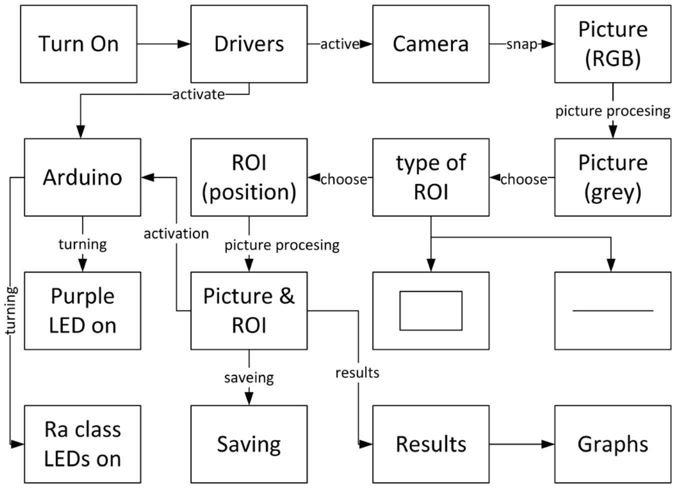

Figure 18. Application flowchart

8. Application user interface (UI)

User Interface is designed to simplify user action and monitoring over device measuring, Figure 19. User needs to perform following steps. First, the user needs to physically position the device directly above the surface being measured. After the prototype is positioned correctly, the user uses the “ON” switch to power on light source. User then use “Snap” button on the UI to capture an image, and choose ROI (type and position) which is shown with green color on third window. In order to ensure that the user captures an image of the desired surface region, there is a “Live Image” window featured on the UI to allow the user to see the potential image to be captured. Lastly, the user uses the “Process” switch on the UI to process the image and output a determined Ra value.

After getting results of Ra class user can see graphical results on tab “Graph” and save all results (picture (RGB and Grey), intensity value, graph) by pressing button “Save” on main tab “Picture”, Figure 20.

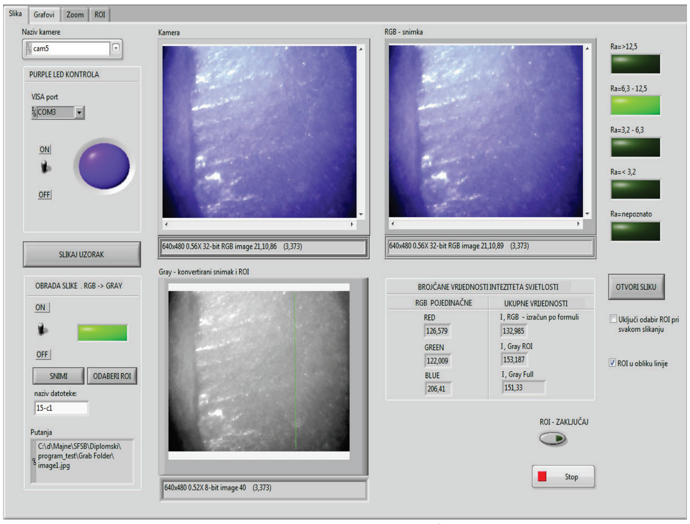

Figure 19. User interface

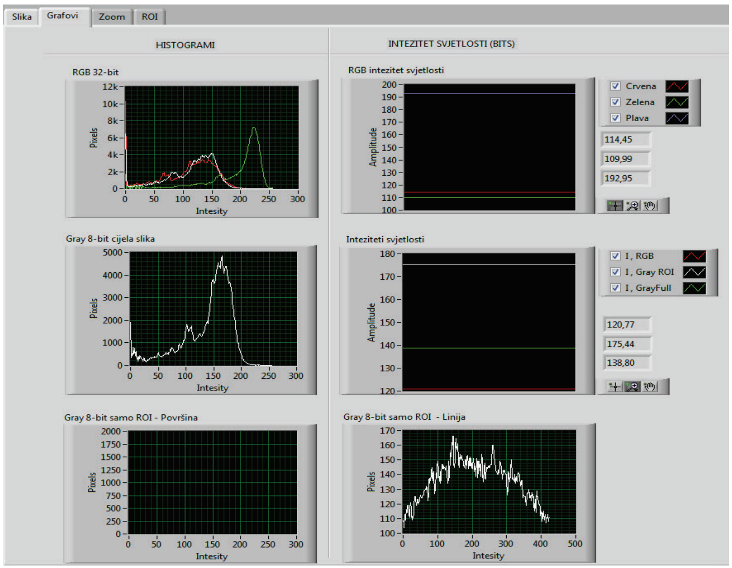

Figure 20. Graph results in tab "Graph"

9. Conclusion

After final testing and measurement of test samples, a prototype device for determining the class of roughness using computer vision has shown that the extensive software solutions and the equipment with very affordable cost can be used to build the device, which in certain conditions of production, can replace a very expensive and sophisticated equipment.

Computer vision system allows the user to check the measurements in the production without interrupting the production process.

Advantage of a designed computer vision system is that it does not require big investments, additional training of workers or major changes in the existing production process. The system for determining the grade of roughness is proposed as a possible solution for facilities with serial production, where without interrupting the process can check the status of samples and then, if necessary, adjust the settings on the machines. For more precise surface roughness classes, further testing and equipment upgrades are needed.

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DRAWINGLESS MANUFACTURING IMPLEMENTATION

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Abstract

The first steps to be taken for smart working of the integrated manufacturing system using no drawings are presented. This contribution deals with the activities which are focused on the devices at our institute. These devices are parts of Drawingless Manufacturing laboratory.

Keywords: Drawingless manufacturing, manufacturing system, robotized manufacturing

1. Introduction

As the world moves from an industrial economy to a global competitive economy, it is very important for enterprises to maintain their competitive advantage. In response to this challenge, enterprises are seeking innovations that will enable them to meet an increasing variety of customer expectations while keeping costs, delays, problems, disruptions, and performance losses at or near zero.

One of the possible way to production costs decreasing is a wilder using the new technological approaches represented by flexible manufacturing systems for the drawingless production.

Flexible manufacturing system is a system that is able to respond to changed conditions. In general, this flexibility is divided into two key categories and several subcategories. The first category is the so called machine flexibility which enables to make various products by the given machinery. The second category is routing flexibility enabling to execute the same operation by various machines. Flexible manufacturing systems usually consist of three main parts: CNC machine tools, transport system and control system. A higher level of flexible manufacturing systems is represented by the so called intelligent manufacturing systems.

Flexible manufacturing systems with particular level of it is own “intelligence” (reaction to changes in inner and outer conditions without need of human intervention) are actual condition for successful implementation of drawingless manufacturing.

Drawingless manufacturing represents effective integration of advanced technologies included in ticular fields, from design of product to product's distribution to the customers. The goal is to achieve effective and cheap production of high quality products in very short period of time.

That makes it basic strategy of organisation and production, which integrates actions in preproduction and production phase with technological devices through digital data streams.

At our institute we build a laboratory of flexible production systems for the drawingless environment. The main target of the project is to build up a laboratory with a flexible manufacturing system consisting of two NC controlled machines (milling machine and lathe). These machines will be interconnected by a transport system and operated by industrial robots. This flexible manufacturing system will also include a quality control station including a camera system and shelf storage.

After the project completion, our Institute will have available a fully functional flexible manufacturing system prototype with robotized operation of individual production machines, integrated with CAx laboratories. However, the final goal is to build up an intelligent manufacturing system. This prototype will enable further exploration of relations and properties of the manufacturing process itself but also in its relation to process of production preparation and planning.

2. Role of component as an information carrier

A flexible manufacturing system (FMS) is a group of numerically controlled machine tools, interconnected by a central control system. The various machining cells are interconnected, via loading and unloading stations, by an automated transport system. Operational flexibility is enhanced by the ability to execute all manufacturing tasks on numerous product designs in small quantities and with faster delivery. It has been described as an automated job shop and as a miniature automated factory. Simply stated, it is an automated production system that produces one or more families of parts in a flexible manner. Today, this prospect of automation and flexibility presents the possibility of producing nonstandard parts to create a competitive advantage.

Flexible manufacturing systems with robotic operation for environment of drawingless production (therein after only FMS) will be represented by the model CIM (Computer Integrated Manufacturing) in the conditions of our institute. It is a systemic approach to planning, management and production itself. The target is to gain experience in these fields at the level of a manufacturing system as a unit.

The flexible manufacturing system at our institute contain the CNC lathe machine and CNC milling machine from EMCO (Fig. 1 poz. 3 and 4). These machines are operated by industrial robots.

At the left side are placed the control station (Fig. 1 pos. 7) and the robotized assembly station (Fig. 1 pos. 6). The automated storage system (Fig. 1 pos. 5) contain a 50 storage position for the raw material, semi product and for the finished products. The material flow is provided by the conveyor (Fig. 1 pos. 2) with 8 pallet holders. The whole system is controlled by the main PC (Fig. 1 pos. 1)

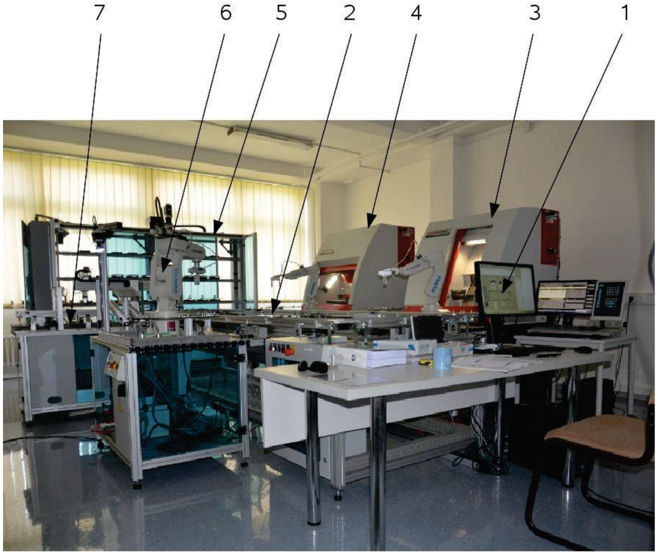

Fig. 1: iCIM 3000 at Institute of Production Devices and Applied Mechanics.

The manufacturing process is based on the orders given from the main control PC. This software have information about an actual state of storage, about a manufacturing process steps and about a current state of each devices.

The manufacturing process for the entire product is described by process steps. These steps are the basic actions what the system do. For example „load to lathe", unload from storage" and others. By using of these base actions we can make the whole manufacturing process for a product family. The system remembers the storage status and makes automated changes after all storage operation, but if we do the storage operation manually, we must do the manual actualization the storage status.

Implementation of drawingless manufacturing consists of several steps.

First step is analysis and pick of proper software for production control (MES) in drawingless environment. Basic functions of systems MES are shown in Fig 2.

Second step is creation of general methodology of executing of drawingless manufacturing on flexible manufacturing system (FMS).

Next step is the specification of actions that are necessary for realization of drawingless production in FMS.

The last step is validation and application of methodology and realization of drawingless manufacturing at particular manufacturing system

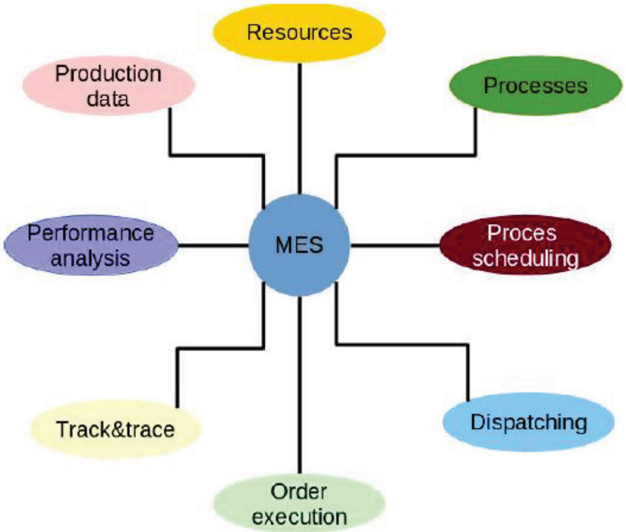

Fig. 2: The functions of MES

These steps result in requirements for technical and organisational actions, which need to be executed during pre-production phase. This actions mainly include pick of proper CAD/CAM software, which makes cooperation with system MES, as well as communication with particular technological devices possible. It is necessary that 3D model of the product not only included information about shape and size but also information about technology and product manufacturing. This kind of integration of resources of information about production is beneficious for future elimination of possible risk of information loss as well as possibility of use of all available information using single interface.

Today, there are many possibilities how to insert PMI into 3D model – all main systems of CAD and are offering possibility of creating PMI information and PMI information are becoming the part of norms ISO and ASME (ISO 1.101: 2004, ASME Y14.41-2003).

The reason for using PMI is transfer of complete information file that is necessary for production of particular components straight to 3D model. This information is then used in all upcoming processes like CAM, CAE, analysis of tolerance and creation of booklets. Also, PMI can be used for communication with supplier or customer in form of digital documentation. Example of PIM inserted into 3D model can be observed at Fig. 3.

Tools for creation of PMI offer complex description of usage of 3D model, size, necessary size tolerance and geometrical tolerance of shape and position.

Another important part of PMI are production information, such as requirements for quality of surface, welding or reference to NC program for particular technological or manipulative design. Options for creation PMI also include tools for creation of notes as well as tools for management of change actions.

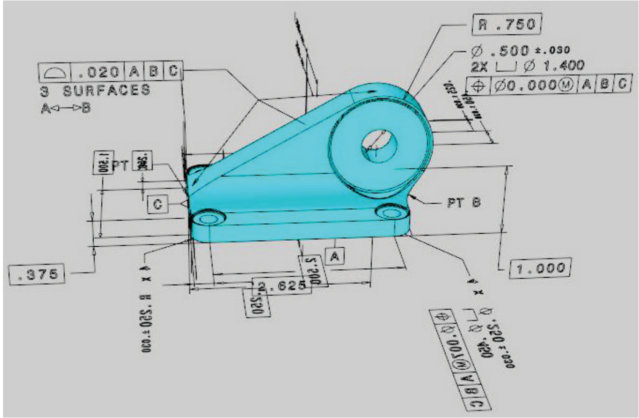

Fig. 3: Example of PIM in 3D model of component

Important ability of all PMI data is associativity between generated informations and objects where the informations are generated. That means, that change of one object results in automatic regeneration of data that are connected to particular object. And on the other hand, any change of data results in change of particular object and regeneration of other data connected to the object.

3D model including PMI serves as document of controlled documentation that is controlled by PLM and MES system, ensuring full management of data and control. Acceptance of data by PLM system has to be provided through defined process in such way, that it would by tracked in every moment.

3. PMI data creation

The only reason for creation of drawing documentation during process of development is its necessity for communication through processes of development. However, this statement is pretty outdated today.

The simplest model of digital communication between entities is already being offered by programs of CAD systems or other digital mock-up systems.

This entities are able to share information with PMI system, through universal formats, such as JT or STEP (AP242). That could be secret entity, that shares secret information or it could be set of related and cooperative entities based on controlled database of data.

Problem can be caused by lack of data shared with suppliers or partners, that can be result of no available connection to database or the disability to use the tools that would help the to cooperate based on sharing PMI data. In this case there is way to share data using DMU browser that is usually available for free.

The speed of creation of PMI data is one of disadvantages of their use. However there are methods and principles for effective use of this data, which help to acquire the necessary data easier and faster.

First principle is simplification which can be achieved by storing only information necessary for production or for achieving desired quality of products.

Second principle is creation of PMI data during process of design. PMI data can be defined during designing, when the constructing person already knows about all the necessary requirements. That prevents unnecessary repeated search for requirements and their creation.

Third principle is creation of parameters. The whole process can be done faster be use of parameters, that are recalculated with every change.

With current level of computing technology it is not only possible to share this data but also thanks to use of PLM systems for direction and control, it is possible to fully implement the system of transition from 2D to 3D.

4. Conclusion

Currently, due to shortened product life cycle, market liberalization, a great competitive pressures and constantly dynamically changing demands of customers, enterprises are forced to gradually rebuilding the nature of its production to mass production and small series with a wide range of products. This phenomenon relates with many problems especially with inventory planning, organization of production, rationalization of work. One of the ways to reduce the production costs is the process plan time reducing and make a better most effective process plan. The possible reactions to this challenge is using the most modern flexible production system with possibility to use in drawingless environment.

The Institute of Production Technologies applies to designing flexible manufacturing system principles including rational and efficient manufacturing and assembly ways and basic intelligence principles.

The goal of this article was analysis of possibilities and necessary requirements for implementation of drawingless manufacturing at flexible manufacturing device iCIM3000, which is located at our institute. This analysis was done in phase of design of the product.

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BENCHMARKING AS A STRATEGIC TOOL FOR STRENGTHENING OF THE COMPETITIVENESS

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Abstract

Competitive ability is the power of enterprise to satisfy customers and competition demands. Enterprise's adaptation to environment and quick response on changes make base for successful business. The competitive advantage occurs when the ability of the enterprise is better than competitors in the elements that are important to the customer. Strategy of enterprise is pathway in which it operates, but also the reason of its existence. Knowing external environment is an important factor in strategies development. Benchmarking is a tool that collects information from the best in the environment and base of knowledge enhances of the business. The learning enterprise is now well-known concept-benchmarking allows learning process through the collection and analysis of data from the environment. Benchmarking should never be a one-time process, its goal is learning by collecting information.

Keywords: Competitive ability, Strategy, External environment, Benchmarking

1. Introduction

The paper deals with detailed topic how a competitive advantage uses benchmarking as a tool for achieving goals. Using a variety of literature that deals with the topic of strategic management and strategy development, focusing on the analysis of the external environment of enterprise. Success of the company's is possible to determine when it's acting is differentiated form rest of competitors-because it is very important when enterprise plans its strategy to be directed to external factors and changes in the external environment. Benchmarking as a method is based on the analysis of strategy and external environment compared with the best competitors in the industry.

2. Competitive ability of enterprise

Enterprise may believe that is very successful, but the success of the enterprise can be accurately determined only in relation to competitors. Enterprise is almost never the only one present in the market with its products or services. Today's dynamic market requires organizations to develop their winning entry strategy in a simple and convincing way. Enterprise must define a competitive strategy that guides and directs their vision in the future, in order to gain a sustainable competitive advantage over rivals, and for it to be successful long term. Organizational results are the consequence of decisions made by the leaders. "A framework that defines and focuses competitive positioning decision is called a competitive strategy; the purpose of competitive strategy is to gain a sustainable competitive advantage" [1]. Essentially developing of competitive strategy includes a formula for business development, what business goals should be and what are policies for achieving these goals. "The competitive advantage of the enterprise occurs when the ability of the company exceeds the strongest competitor in the elements that are important to customers" [2].

3. Strategic management

In defining term of strategic management should be primarily to delineate the basic meaning of two concepts: strategy and management. "Management can be defined as the process by which inputs are transformed into outputs" [3] and also the process of forming and maintaining the environment in order to successfully set and achieve goals. The strategy represents the culture of the organization, the organization's image, relations within and outside the company, product quality and business ethics. "Strategy of enterprise on the one hand is guided by managerial analysis and selection, but on the other hand by adjustments and learning through work" [4]. As the benefits of strategic management states the following:

- ˝ Training managers to expand their horizons and redirect attention to the achievement of the objectives of the organization in the long run.
- Enabling managers to deal with the opportunities and threats in the external environment through monitoring and analysis environment.
- Help to identify the strengths and weaknesses of the organization through internal analysis of management.
- Strengthening the integration objectives of the organizational units that contribute to achieving the objectives of the parent organization.
- Increasing organizational opportunity to become a profitable company in all fields.
- Enabling managers objectivity towards the problems of management and encourage their proactivity, cooperation and enthusiasm.
- Encouraging decentralization and maximizing the use of organizational knowledge.¨ [5]

4. Benchmarking

Benchmarking is process of comparison with competitors. Often it is called as sort of "copy-paste" process. Today enterprise has the features of a dynamic system, which means it is subject to influences from the environment to which is in constant interaction. On the one hand the enterprise affects the environment, on the other, the environment affects the enterprise. When the impact of the external environment of enterprise becomes dominant in relation to the impact that enterprise has on the external environment- that is situation when enterprise is in crisis. "That would not happened if manager continually monitor the environment, to define the current and future threats and opportunities arising from the external environment and the strengths and weaknesses resulting from internal environment"[6]. Environment of enterprise is a set of external and internal factors that can affect the way towards to goals. Company's environment is conceptually broad term that includes:

- Internal environment of enterprises
- External environment of enterprises

Awareness of the environment is very important for the success of the enterprise. Management should continuously gather and consider information from the environment. Analysis of the environment is a set of methods and approaches used by the enterprise in order to increase information awareness about the environment by collecting and analyzing information from the environment and using them to achieve advantage. The analysis of the environment is increasing and action capability of enterprises, because the close observation of changes in the company over time can predict changes or the time to identify and react according to them. "One of the key tasks of environmental analysis is to identify the opportunities and threats from the external environment and the strengths and weaknesses of the internal environment" [7].

Purpose and tasks of environmental analysis are as follows:

"1. Display strategic factors and their pressure on enterprise to help them to achieve their goals (opportunities), and which can completely disable achieving their goals, and even jeopardize their survival and their development (threat);
2. Identify those positive internal capabilities enterprises (power), as well as internal incompetence companies that significantly impede or completely prevent the achievement of goals (weakness).
3. Connect the opportunities and threats with strengths and weaknesses through a SWOT analysis in order to position the company in the area.
4. Provide a basis for formulating strategies that will lead enterprise to successfully exploit opportunities and avoid threats using its strengths and eliminating their weaknesses [6]

The external environment includes all factors that indirectly affect the operation of enterprises. They are divided into:

- General or social environment: presented by five key dimensions (structured by Michael E. Porter, also called Porter's Diamond or Porter's five competitive forces): natural-ecological, scientific and technological, economic, political-legal and socio-cultural dimensions.
- "The business environment or the environment of the task consisting of nine key components: suppliers, customers-consumers, competitors, shareholders, employees and unions, creditors, government (state) agencies, community organizations and professional associations" [8].

Surrounding of enterprise is affected by the change- responds to the stimuli of the environment in two ways:

- Strategic response - choice of appropriate strategies
- "Organizational changes - transformation of existing or select a new organizational structure"[8].

5. Types and stages of benchmarking

Benchmarking or "best practices" is a powerful tool to gain competitive insight, offers an overview of the performance products and the life cycle of the organization based on the evidence. The application of what is learned through benchmarking brings impressive business results. "The basic division of benchmarking is a division of the internal and external benchmarking" [9]. Internal benchmarking carried out within its borders while external benchmarking exceeds the limits and concentrated mainly on the analysis of environment and compared with another organization. As mentioned above includes benchmarking comparison with best practice, so as for the definition of certain types of benchmarking important to ask who compares the organization.

Due to with whom the organization compares distinguish four types of benchmarking:

1. An internal benchmarking
2. External competitive benchmarking
3. External functional benchmarking and
4. External generic benchmarking

Translates into the application of benchmarking process is considered to be applied in company Xerox, which is in the second half of the 70th year compared own production copiers with major competitors on market. "Benchmarking in Xerox initially met with resistance, people did not believe that someone can do better than them" [10]. The results were a shock for the company: the cost of production per unit of production was equal to the sale price of products competitors.

The Xerox had nine times more suppliers, and it took twice as long to eject the product on the market, besides the unfounded belief that Xerox its competitive advantage realized on the basis of quality, benchmarking has proved the opposite. After the initial shock Xerox's reaction of denial followed by a frustration turned to action. After a research Xerox did not stop at the results, but they were being used to develop new strategies that are called by keeping the quality (Quality Leadership), Xerox begins widespread use of benchmarking at all levels of the organization, and develop benchmarking process, which consists of ten stages:

- Planning
  1. Identifying benchmarking entity / team
  2. Identification and selection of benchmarking partners
  3. Identification of collection methods and data collection
- Analysis
  4. Determination of discrepancies in relation to competition
  5. Projecting future business actions
- Integration
  6. Reporting on the results and the acceptance of results
  7. Determination of the goals of improving
- Action
  8. Development Plan of Action
  9. Implementation of the plan and monitor progress
  10. Repetition process stage by stage" [9]

6. Benchmarking role in creating competitive advantages company

Benchmarking is an effective tool for determining whether a company is carrying out certain activities effectively, whether the costs in line with those the company competes or is there a need for improvements in business processes. The basic idea of benchmarking is measuring the intern processes and performance through external standards. Benchmarking is a way of learning that shows that the best companies in the performance of certain functions and activities then mimic the same or even better improvement techniques. Benchmarking allows managers to determine the best practices that will primarily enable the improvement of efficiency in relation to the expectations of the customer or partner, also using benchmarking managers understand the most accurate and most effective ways of doing business and how they carried out the cost-effectiveness and to take action to achieve cost-effectiveness companies.

There are many improvements offered by the acceptance of benchmarking as a company strategy: "reducing labor costs, streamlining work flow through the re-engineering of business processes and common administrative system, improve data center operations through consolidation and downsizing, implementation of new technologies, outsourcing tasks and services, redesign, development and support business process" [11]. The role of benchmarking in the strategy the company lies in its benefits. People constantly evaluate and assess themselves and to make compared with others in various ways. The reason for this behavior lies in the accurate perception of themselves and its own notions. Also people are compared in terms of capabilities, with others who are a little more capable than them. There are two reasons of social comparison: the effort to create and maintain a positive image of yourself and striving for progress and improvement. If a person wants to create and maintain a positive image will be included in a downward comparison, i.e. comparison with another person who is worse. The upward social comparison, and in comparison with some better be included if we want to improve on a field that is important. When it comes to companies the situation is the same if it is to evaluate the performance of the company will move from the comparison by departments which often can lead to a false sense of complacency, just the introduction of the benchmarking process as a company strategy to gain competitive advantage forcing companies to compare the better or the best in the industry, to achieve above-average results. Benchmarking process makes managers strive to a higher purpose, and also changes the working environment which will set for ourselves higher standards of business excellence, and thus take a more favorable or at best leading position in the industry.

7. Conclusion

Competitiveness means having the strength to respond to customer demands and challenges of competition in the ability of the company to long-term and consistently beats its rivals in the competition. Adaptation enterprise environment and quick reactions are the basis of successful companies. An enterprise that does not adjust to changes in the external environment very quickly goes into oblivion. Finally, do not survive, nor the most intelligent, but the strongest companies most sensitive to change. The positioning of the company within the industry, says the company encountered above or below average. Sustainable competitive advantage of the company occurs when the company developed one or a certain group of attributes that make it possible to outdo competitors.

The learning company is now well-known concept which seeks to enhance the intellectual capital. In daily operations managers are faced with a variety of information, which only exceeds the knowledge synthesis. The learning process consists of three stages: data collection, interpretation of information and application of knowledge. Benchmarking consists of almost identical phases and being reflected benchmarking as an instrument of learning and development potential of the company. The process of benchmarking should never be a one-time his goal is learning through information gathering.

The basic idea of benchmarking is measuring the internal processes and performance against external standards. Benchmarking is a way of learning that shows that the best companies in the performance of certain functions and activities then mimic the same or even better improvement techniques. The role of benchmarking in the strategy of the company lies in its benefits. When considering the effect of the company, there is a tendency to compare the company internally by departments which can give a false sense of complacency, benchmarking does exactly the opposite, forcing companies to be compared with the best in the industry, and this is why benchmarking is a successful tool to strengthen competitive advantages.

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THE ANALYSIS OF SPORT PRODUCTS IN SLAVONSKI BROD FROM THE STUDENT POPULATION PERSPECTIVE

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Abstract

The aim of this paper is to analyze the sport product in Slavonski Brod in terms of student population and to determine the differences in opinion and preferences within the population. The analysis was conducted by a questionnaire distributed among the sample of 229 examinees who are full time students of first, second and third year of the three undergraduate university courses of the College of Slavonski Brod. The results gotten by applying canonical discriminant analysis (CanR=0,80 with an error p=0,00) showed that there is a significant difference between the answers given by male and female students, in terms of preferences and attitudes. Furthermore, according to students' answers the sport product is present in Slavonski Brod, but there is an absence of marketing of the product. The results should be considered with respect to the specificity of the tested population.

Keywords: sport, students, sport product

1. Introduction

In modern times sport can be defined as a mass social phenomenon which is no longer a privilege but something that is or at least should be accessible to all parts of society regardless of gender, years, religion and similar. Sport has entered all parts of society, becoming its essential part in terms of culture, healthcare, politics and economy. As a result of such development occurred not only collaboration between sports and economy but the real symbioses between them. Consequently, new disciplines are being developed, such as sport economics, a scientific discipline that analyzes economic principles of optimal allocation of assets and other resources in the field of sport, as well as valorization of social and economic effects of sport, [1], and sport management, the process of organizing and managing sport or sport organization for the purpose of achieving sport or other goals with rational usage of limited resources [1]. Sport became a fertile soil for different types of entrepreneurship and as a result it is coming out on the market in different forms as a sport product. For that product to reach its consumer it is essential to explore the market and its needs. This work offers such analysis with special emphasis on specificity of tested population. The aim of the work was to analyze the view of students' population in Slavonski Brod in terms of sport products, to determine potential differences in opinion within the tested population and to explore the availability of sport product in terms of price, location and content. The product can be defined as everything that can be offered to the market that satisfies a certain need or a wish and that would grab attention of consumers and result in supply, usage or consumption [2]. The modified version of questionnaire IZSRP-2007 was used for establishing preferences among physical activities. The sample was composed of 229 examinees who are full time male and female students at the College of Slavonski Brod. Results showed that the examined population is physically inactive, as well as meaningful differences in preferences and attitudes among them. The results of this research can be used as guidelines for future entrepreneurship activities that ensure profit to sport and from sport, as well as for marketing activities connected to promotion of sport realized through selling of sport product and other connected services.

2. Method

Examinee sample: The sample was composed of 229 examinees who are full time male and female students at the College of Slavonski Brod. Out of 229 examinees 123 are female while 106 male students. Examinees are full time students of first, second and third year at all three undergraduate university courses. All examines answered questionnaire willingly and anonymously. The questionnaire was distributed during the first week of the second semester of the academic year 2014./2015.

Variable sample: The modified version of questionnaire IZSRP-2007 was used for establishing preferences among physical activities. The questionnaire consisted of 17 physical activities which were valued by the examinees on the scale from 1-5, where 1 meant "I would never do this type of physical activity" and 5 meant "I would definitely do this type of physical activity". Furthermore, the questionnaire consisted of questions in which examinees evaluated different sport activities in Slavonski Brod, where 1 meant – unsatisfactory and 5 meant – excellent. The last question dealt with the amount of money students are willing to spend on a monthly basis for participation in here mentioned sport activities.

Description of variables: DOB – chronological age of the examinee; VAŽ - the importance and overall need to do sports in life in general; AKT - number of weekly participations in organized sport activities; AER - aerobic; BIC- cycling; GRU - specific group programs; BOR - martial arts; CAR - cardio fitness; KLI - skating; KUG - bowling; MOM - team sports; HOD - walking (nordic); PLE – dancing; PLI - swimming; REK - sports where rackets are used; GIM- sport and corrective gymnastics; TRČ - running; VES - rowing; FIT - exercising on fitness machines; YOG - yoga; DRU - other; PON - the evaluation of sport activities offered in Slavonski Brod; IZD - monthly amount for participation in sport activities.

Methods of data processing: The methods used for data processing included calculating descriptive statistical parameters for all variables: arithmetic mean (AS), standard deviation (SD), measure of skewness (Skew) and kurtosis (Kurt). In order to determine if there are significant differences between the two groups the canonical discriminant analysis was conducted on the groups of male and female students. Within the canonical discriminant analysis the coefficient of canonical discrimination was determined, as well as groups position on discriminant function and correlation between the variables and the discriminant function. The significance of coefficients of canonical discrimination was tested by Bartlett's test. The data was classified by statistical package STATISTICA 12.0.

3. Results and Discussion

Table 1 shows descriptive indicators of variables for both male and female students. By analyzing the variable "the importance and overall need to do sports in life in general" we can note a high average score of 4,30. While by analyzing only frequency, as many as 94% of examinees think that sport activities should be an important part of life. Furthermore, based on the parameter of standard deviation which is 0,68 we can conclude that students' answers to this question are not variant, but constant. Unfortunately, the results show that students, although aware of the importance of practicing sports, on average practice sports only once a week (AKT=1,12). This shows an obvious physical inactivity of students. When grading sports product in Slavonski Brod students gave an average grade of 3,21 which means that students described the sport product in Slavonski Brod as good. The students are willing to spend an average of 157,27 HRK for sport activity on a monthly basis, which is enough money for any sport activity the students choose. Most distributions are symmetric; only variables "chronological age", "other" and "monthly amount for participation in sport activities" are positively asymmetric while variable "the importance and overall need to do sports in life in general" is negatively asymmetric. Kurtosis shows that most of the variables are platykurtic which further affirms the big dispersion of the results for all variables. Lepotokurtic variables are: "chronological age", "the importance and overall need to do sports in life in general" which are negatively asymmetric and "other" and "monthly amount for participation in sport activities "which are positively asymmetric.

Table 1. Descriptive indicators of measuring variables, male and female students

	AS	SD	Skew	Kurt
DOB	19,93	1,02	1,47	4,52
VAŽ	4,30	0,68	-1,47	*5,47*
AKT	1,12	1,10	0,55	-0,97
AER	2,68	1,45	0,21	-1,36
BIC	3,24	1,30	-0,28	-1,00
GRU	2,59	1,38	0,28	-1,17
BOR	2,69	1,48	0,25	-1,36
CAR	3,07	1,28	-0,20	-1,00
KLI	2,61	1,49	0,32	-1,36
KUG	3,11	1,40	-0,08	-1,32
MOM	3,30	1,52	-0,30	-1,38
HOD	3,04	1,48	0,00	-1,41
PLE	2,95	1,56	0,02	-1,53
PLI	3,16	1,39	-0,27	-1,16
REK	2,93	1,42	-0,08	-1,33
GIM	2,32	1,32	0,53	-0,97
TRČ	3,20	1,36	-0,31	-1,10
VES	2,36	1,31	0,47	-1,03
FIT	3,98	1,15	-1,18	0,76
YOG	2,45	1,47	0,53	-1,12
DRU	0,54	1,18	*2,74*	*7,01*
PON	3,21	0,92	-0,13	0,68
IZD	157,27	90,79	1,96	*4,63*

AS–arithmetic mean, SD–standard deviation, Skew–asymmetry degree, Kurt–curvature degree

Table 2 shows parameters of arithmetic mean and standard deviation for groups of male and female students. The biggest difference between the groups is in a number of times they engage in sport activity per week. On average, male students do sports once a week while female students not even once. The biggest difference in terms of sports preference is that female students gave aerobic a very high grade while male students did not. Furthermore, there is a significant difference in interest in skating and dancing; female students are more prone to these sports. On the other hand, martial arts and team sports are more popular with male students. Both male and female students show an approximately same interest in other sports. Both groups showed the most interest in exercising on fitness machines. Regarding sport activities available in Slavonski Brod, both groups described them as good. Female students are willing to spend 136,67 HRK on average while male students are willing to spend 181,18 HRK on average on sport activity per month. The standard deviation shows a larger fluctuation of results within male students' group then with female students' group.

Table 2. Descriptive indicators of measuring variables, group of male and group of female students

	$AS_{studenti}$	$SD_{studenti}$	$AS_{studentice}$	$SD_{studentice}$
DOB	20,05	1,06	19,84	0,97
VAŽ	4,42	0,55	4,20	0,76
AKT	1,59	1,15	0,72	0,87
AER	1,65	0,89	3,57	1,24
BIC	3,23	1,25	3,26	1,35
GRU	2,56	1,41	2,63	1,36
BOR	3,07	1,46	2,37	1,42
CAR	2,80	1,30	3,29	1,22
KLI	1,99	1,27	3,15	1,46
KUG	2,96	1,37	3,24	1,43
MOM	3,92	1,29	2,77	1,51
HOD	2,70	1,35	3,33	1,53
PLE	2,12	1,31	3,66	1,40
PLI	3,42	1,20	2,94	1,50
REK	3,09	1,28	2,79	1,53
GIM	2,02	1,13	2,58	1,41
TRČ	3,13	1,37	3,25	1,36
VES	2,73	1,35	2,04	1,19
FIT	3,76	1,22	4,17	1,05
YOG	2,00	1,22	2,84	1,56
DRU	0,83	1,47	0,29	0,78
PON	3,09	0,89	3,32	0,93
IZD	181,18	104,88	136,67	70,81

$AS_{studentice}$–arithmetic mean group of female students, $SD_{studentice}$–standard deviation group of female students, $AS_{studenti}$–arithmetic mean group of male students, $SD_{studenti}$–standard deviation group of male students

Table 3 shows that 90% of female students list health problems/issues as the main reason for doing sports, yet the previous table shows that they never practice it. The second two reasons for doing sports, entertainment and esthetics, were chosen by 57% of female students. Sport has a great influence on our health, but it is also a type of entertainment. While doing sports we socialize with others, exchange ideas, experiences, create connections and simply have fun. Considering that these answers were given by female students it is not a surprise that the second reason for doing sports is esthetics. Educational and competitive reasons seem to be least important to female students. We can conclude that female students do not realize that sport can teach us about "fair play", correct behavior, sport ethics and other. Regarding the lack of competitive spirit, we can assume that the female students are less competitive.

Table 3. Main reason for doing sports, group of female students

health	**education**	**entertainment**	**esthetics**
90%	7%	57%	57%
social	**competitive**	**no reason**	**other**
41%	9%	2%	0%

Table 4 shows that male students, same as female, list health problems/issues as the main reason for doing sports, 85%. Unlike female students, the second reason for doing sports is entertainment. 66% of male students list entertainment as the reason for doing sports. Esthetic, social and competitive reasons seem to be equally important to male students. Educational reasons, same as with female students, are on the last place by importance. By analyzing both male and female reasons for doing sports, we can conclude that male students' answers are more diverse.

Table 4. Main reason for doing sports, group of male students

health	education	entertainment	esthetics
85%	15%	66%	37%
social	competitive	no reason	other
39%	36%	2%	0%

Table 5 shows factors which have the greatest influence on (non) participation of female students in sports activities. 69% of female students claim they lack the spare time. This is a bit surprising if we consider way of life and amount of obligations of students. We can only assume that female students lack the ability to organize their free time, but also that they might not be aware of it. The second factor listed by female students is financial reason. But the fact is that doing sports can cost us nothing (for example walking or running). Table 2 showed that female students are willing to spend 136,67 HRK for a sport activity per month . As a comparison, an aerobics class in Slavonski Brod two times a week costs from 150,00 – 180,00 HRK. Furthermore, female students list availability as another factor for not doing sports. Other listed factors are health issues, an illness or a condition preventing them to do sports, prior experiences, which obviously were not pleasant, and an appeal of available sport activities. A lack of information can be considered as a valid factor for inactivity of students since most of our centers, clubs and programs lack the basic elements of marketing. Managing this problem can bring about a considerable improvement.

Table 5. Factors which have the greatest influence on (non) participation of female students in sports activities

time	financial	health	availability
69%	30%	20%	32%
experiences	attractiveness	lack of info	other
12%	18%	18%	1%

Table 6. shows male students' opinions. Same as female students, male students list a lack of free time as the main reason for not doing sports. Should students organize their free time in more rational way? Another important factor for male students is availability. 48% of male students claim that sports activities are not available in Slavonski Brod. We can question the validity of this reason since we know that all sport infrastructures in Slavonski Brod are located in the city center. It takes only 15-25 minutes of walking to access most of the destinations from any part of the city, including the student dorm. Another factor that male students listed is financial reason, although from previous tables we can see that male students are willing to spend more money than female students on sport activity which is more than enough money needed to engage in sport activities available in the town. Same as their female colleagues, 12% of male students listed lack of information as a reason for not doing sports.

Table 6. Factors which have the greatest influence on (non) participation of male students in sports activities

time	financial	health	availability
66%	31%	20%	48%
experiences	attractiveness	lack of info	other
15%	22%	12%	3%

According to Table 7, which shows the differences in arithmetic means and canonical discriminant analysis between male and female students, there are considerable statistically important differences between the groups. This further shows that the differences shown in prior tables are not coincidental.

This further shows that the differences shown in prior tables are not coincidental. The results confirm that sport marketing should be more focused on target groups. Philip Kotler claims that marketing has to be targeted, that market should be researched before we offer an adequate type of marketing for chosen target group. The results show that although both groups are part of the same population, preferences and opinions between male and female students differ considerably. These results should not be discarded as unimportant, at least in terms of student population in Slavonski Brod. Is this difference significant in other populations is yet to be discovered? In addition, Table 7 shows that male students are on a negative pole (average – 1,43 of standard deviation of discriminant function) while female students are on a positive pole. Students (with negative sign) evaluate importance of doing sports, weekly activity, martial arts, team sport games, swimming, racket sports, rowing, other sports and monthly payment more positively, i.e. evaluate those variables with a higher grade. Female students, on the other hand, evaluate aerobic, cycling, specific group programs, cardio fitness, skating, bowling, walking, dancing, sport and corrective gymnastics, running, exercising on fitness machines, yoga and sport activities offered in Slavonski Brod more positively.

Table 7. Differences in arithmetic means and canonical discriminant analysis between group of male and group of female students

Variables	„male students" N=106 AS±SD	„female students" N=123 AS±SD	DF
VAŽ	4,42±0,55	4,20±0,76	-0,13
AKT	1,59±1,15	0,72±0,87	-0,33
AER	1,65±0,89	3,57±1,24	0,66
BIC	3,23±1,25	3,26±1,35	0,01
GRU	2,56±1,41	2,63±1,36	0,02
BOR	3,07±1,46	2,37±1,42	-0,18
CAR	2,80±1,30	3,29±1,22	0,15
KLI	1,99±1,27	3,15±1,46	0,32
KUG	2,96±1,37	3,24±1,43	0,07
MOM	3,92±1,29	2,77±1,51	-0,30
HOD	2,70±1,35	3,33±1,53	0,16
PLE	2,12±1,31	3,66±1,40	0,42
PLI	3,42±1,20	2,94±1,50	-0,13
REK	3,09±1,28	2,79±1,53	-0,08
GIM	2,02±1,13	2,58±1,41	0,16
TRČ	3,13±1,37	3,25±1,36	0,03
VES	2,73±1,35	2,04±1,19	-0,20
FIT	3,76±1,22	4,17±1,05	0,13
YOG	2,00±1,22	2,84±1,56	0,22
DRU	0,83±1,47	0,29±0,78	-0,18
PON	3,09±0,89	3,32±0,93	0,09
IZD	181,18±104,88	136,67±70,81	-0,19
Centroid	-1,43	1,23247	CanR = 0,80
Wilks' lambda = 0,36	χ^2 = 220,70	SS=22,00	p = 0,00

Table 8 shows that male and female students statistically differ significantly in eight variables. These variables are general sport activity, aerobics, martial arts, skating, team sport games, swimming, exercising on fitness machines and monthly payment. The variables that show no significant statistical difference are: cycling, specific group programs, cardio fitness, bowling, walking, dancing, racket sports, sport and corrective gymnastics, running, rowing and yoga. There is also no significant statistical difference in evaluating sport activities offered in Slavonski Brod.

4. Conclusion

The results of this research indirectly show that in accordance to students' opinion sport product is present in Slavonski Brod. It is affordable in terms of price and location, but it is not exploited as it could be according to students' opinion.

Table 8. Differences between group of students and group of students in individual variables

	λ	p
VAŽ	0,36	0,42
AKT	*0,38*	*0,00*
AER	*0,45*	*0,00*
BIC	0,36	0,92
GRU	0,36	0,24
BOR	0,37	0,05
CAR	0,36	0,87
KLI	*0,37*	*0,05*
KUG	0,36	0,59
MOM	*0,37*	*0,01*
HOD	0,36	0,58
PLE	0,36	0,18
PLI	*0,38*	*0,00*
REK	0,36	0,56
GIM	0,36	0,70
TRČ	0,36	0,88
VES	0,36	0,26
FIT	*0,37*	*0,02*
YOG	0,36	0,85
DRU	0,37	0,06
PON	0,36	0,69
IZD	*0,37*	*0,03*

λ–lambda, p– significance level

The results further show that male and female students differ significantly in their answers. Canonical discriminant analysis shows the difference in arithmetic mean between male and female students CanR=0,80 with statistical error p=0,00.

Although a part of the same population, preferences and opinions of male and female students differ significantly; this shows that targeting groups in marketing is very important. Is this difference significant in other populations is yet to be discovered? Furthermore, the results indirectly show that there is probably a lack of professional personnel with business knowledge, an absence of marketing of the sport product but also that the specificity of population in terms of marketing should be acknowledged. Sport product is definitely present in Slavonski Brod. Pursuant to the results of the questionnaire, it is accessible and affordable in terms of content, price and location but marketing of the product should be more targeted. Conducting this type of research and analysis can show if a certain sport product can be sold, if there is a potential consumer within the target group and if there is a market demand for that product. The time has come for sport to adjust to the market demand.

Note: This paper is result of a final thesis of former student at the College of Slavonski Brod.

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CROSS CULTURAL DIFFERENCES AND THEIR IMPLICATIONS ON CROATIA

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Abstract

Human resources of each country or an organization consist of people of different sex, age, race, culture, religion and so on. For this reason, the challenge of today is become to develop awareness, knowledge and skills to manage differences. Cross cultural differences has become strategically important not only to companies in a global business, but also for everyone who participate in the global economy. However, differences that others do not accept, do not understand or do not appreciate can become a source of great problems. Understanding the impact of cultural difference is especially important for every country. This research aims to explain how cross cultural differences, including discrimination and racism, impact on people in Croatia.

Keywords: Cross cultural differences, Culture, Croatia

1. Introduction

Globalization has brought with it great opportunities. One of the most important is the knowledge and understanding differences. Considering the increasing mobility of people in the world and in the European Union or in the Republic of Croatia people are becoming increasingly heterogeneous. This means that are more and more people who are different in terms of culture, ethnicity, religion. More and more people working for international companies and running business that goes beyond the borders and coming to Croatia. All that involves an understanding of how people from different cultures speak communicate and perceive the world around them. With a view to clarifying some of the above mentioned, this research will examine terms used in relation to building cross cultural understanding within the business world.

2. Culture

The definition of culture is very complicated and has many different meanings. Edward B. Tylor was the first anthropologist to define culture. According to him culture is "that complex whole which includes knowledge, belief, art, law, morals, custom, and any other capabilities and habits acquired by man as a member of society." [1] After him, many people have struggled to define culture. One of them is Hofstede that said that “culture is the collective programming of the mind which distinguishes the members of one group or category of people from another…” [2, p.19]

Despite a number of definitions the fundamental dimension of culture consists of values. Values are a set of principles, standards, concepts, beliefs, and ideas that are largely shared by members of groups, societies, or cultures. Culture shapes identity and relationship for others and the world. In all parts of society, culture opens and pervasive cultural norms, values and beliefs to assist its members in adapting to its surroundings. “Culture can be more or less homogeneous, depending on the strength symbols which connect its members. Homogeneity, possible and necessary society at one level, does not exclude the heterogeneity of the lower level, which means that it need not necessarily mutually exclusive.” [3, p 186]

3. Cross cultural differences

Fundamental differences among people arise from culture, nationality, religion and ethnicity and so on. These differences affect behavior, beliefs, practices that influence to each individual. Also it is very often used the name of diversity. There are many definitions of differences or diversity. “Diversity refers to characteristics of individuals that form its identity and experience in the society.” [4, p 80] Diversity implies recognition of certain rights, rights pertaining not merely to the individual, but to the individual as a member of a certain marginalized minority group. It encompasses acceptance and respect. “Differences refer to many of the characteristics which differentiate people, and can be direct and indirect. Direct characteristics are: age, gender, ethnic heritage, race, mental / psychic abilities, and sexual orientation.” [5]

With regard to the problem of how to preserve its own cultural identity and to open the door to cooperation of different cultures UNESCO was 2001 adopted the Universal Declaration on Cultural Diversity. According to UNESCO, “cultural diversity may be defined as a principle for organizing sustainable cultural plurality, both within and across societies.” [6]

According to dictionary cross cultural means “involving or bridging the differences between cultures”, [7].

Cultural diversity/differences face some challenges: “Globalization, in its powerful expansion of market principles, has created new forms of inequality which seem to foster cultural conflict rather than cultural pluralism, countries which were able to handle the demands of culture are increasingly unable to handle on their own the cross-border flow of ideas, images and resources which affect cultural development and the growing divides in have made the renewal of cultural debates and resources an increasingly élite monopoly, divorced from the capabilities and interests of more than half the world’s population, who are now in danger of cultural as well as financial exclusion”, [8]. Methods to manage diversity refer to specific policies, activities and programs of diversity management. Cultural differences manifest themselves in different ways and differing levels of depth. Cultural diversity is a positive characteristic EU. “European program for culture (launched 2007) promotes: Cultural diversity and intercultural dialogue, culture as a catalyst for creativity and innovation, culture as part of the international relations of the EU.” [9, p. 14]

4. The negative impacts of differences

Because of differences of the same situation one can experience as an opportunity, and the other as a threat. Some of negative impacts of differences are described as follows.

Ethnocentrism and stereotype is belief that one group or culture is better and superior than the other. There are two forms of prejudice and stereotypes. “Prejudice is a pre adopted judgment, opinion or assumption of the question of the form of behavior or group of people. A stereotype is a positive or negatives estimation group members or their perceived characteristics.” [4, p.80] According to Oxford Dictionary discrimination is „the unjust or prejudicial treatment of different categories of people, especially on the grounds of race, age, or sex” [10] Racism is a belief that a particular race or ethnicity is superior or inferior to others. Tokenism je when a person is one of the few members of his own group in an organization. When a negative impact is allowed to persist, it can begin to affect everyone in the society. Understanding the effects of differences helps societies to handle promptly every negative impact.

Considering the all of the above managing diversity is a necessary response to cultural changes and today it is one of the most important requirements. There are a number of strategies to manage diversity. According to Adler, N.J. the basic strategies are: „'our way- the only way' - when it ignores the impact of cultural diversity on the organization; strategies' our way - the optimal way "- when cultural diversity is recognized as a source of the problem and is trying to minimize its effects; strategies 'our their way to a creative combination - optimal way' - an approach that looks at cultural diversity as a potential source of advantages. “ [11, p.199]

5. The effect of cross cultural differences on Croatia

Croatia is a diverse country which is officially multicultural providing laws to protect its citizens from any discrimination. On 21 May 2004 Croatia for the first time marked the World Day for Cultural Diversity, organized by the Ministry of Culture and the Office of the Croatian Commission for UNESCO. With this Croatia joined the other Member States of UNESCO. Joining the EU, Croatia has brought Croatian language and their identity, heritage, or diverse nature. Any group that is considered a minority group in Croatia society may be the victim of disrespectful, negative stereotyping which may lead to hurtful and discriminatory outcomes for the individuals involved.

There are several documents in Croatia, regulating the question of diversity. In this sense, some of them are: Constitutional Law on National Minorities, the Law on Gender Equality, anti-discrimination laws, the Law on Labor in the direction of introducing measures to prevent discrimination on grounds of sex in the area of labor and employment.

According to research by the Center for Peace Studies in 2013, racial and religious discrimination is still a major problem. „The conclusion is that Croatian citizens showed approximately equal number of positive and negative attitudes towards the statement that is pleasant to live in a community where there are people of different religions, nations and backgrounds, and also to some extent support the immigration of foreigners in Croatia. "Research has shown that citizens Croatian in varying percentages expressing xenophobia towards certain minority groups. “[12]

There is more and more racism in some European countries such as France and Germany, but also in Croatia at times becomes visible especially at football matches, where he regularly testifies quite racist behavior directed against members of specific ethnic minorities. Besides that, the most common examples of racist attacks are associated with Rome minority. According to World Value Survey it is created a list of nations of the world where people have the most and least tolerant attitudes as shown in table 1.

Table 1 shows the world's 'most racist' countries. Jordan and India named the world's least tolerant countries. Croatia is placed in the most tolerant countries with European countries Spain, Germany, Belgium.

Table 1. List of nations of the world where people have the most and least tolerant attitudes [13]

% of individuals surveyed would not want a person of another race as a neighbor	Countries
40 % +	India, Jordan
30 - 39.9 %	Egypt, Saudi Arabia, Iran, Vietnam, Indonesia, South Korea
20 - 39.9 %	France, Turkey, Bulgaria, Algeria, Morocco, Mali, Zambia, Thailand, Malaysia, The Philippines, Bangladesh, Hong Kong
15 - 19.9 %	Venezuela, Hungary, Serbia, Romania, Macedonia, Ethiopia, Uganda, Tanzania, Zimbabwe, Russia, China
10 - 14.9 %	Finland, Poland, Ukraine, Italy, Greece, Czech Republic, Slovakia
5 - 9.9 %	Chile, Peru, Mexico, Spain, Germany, Belgium, Belarus, **CROATIA**, Japan, Pakistan, South Africa
0 - 4.9 %	United States, Canada, Brazil, Argentina, Colombia, Guatemala, Britain, Sweden, Norway, Latvia, Australia, New Zealand

Table 1 shows that in Croatia only 5 - 9.9 % of individuals would not want a person of another race as a neighbor. However it is considered that the data included too much period and that the study does not reflect the real situation and that many people tried to cover up their intolerant attitudes.

The proof of this is that in Croatia there are employers that encourage diversity in the workplace and which are awarded annually to reward the quality of their practices encourage diversity in the workplace and combat discrimination that table 2 demonstrates.

Table 2. Rewarded companies in Croatia which encourage diversity [14]

Category / year	2011.	2012.	2013.
The general equality/ encouraging diversity of employees	Ericsson Nikola Tesla d.d.	Podatkovni centar Križ u kategoriji	PLIVA Croatia d.o.o.
Gender equality	Privredna banka Zagreb d.d.	Coca-Cola HBC Croatia d.o.o.	Ernest & Young d.o.o.
Age equality	Rivijera Adria d.d.	Allianz Zagreb d.d.	CIKLOPEA d.o.o.
The equality of persons with disabilities	Zvijezda d.d.	Socijalna zadruga Humana Nova	ACT Konto d.o.o.

Table 2 shows employers in Croatia which encourage diversity. These companies are rewarded every year on four categories: the general equality /encouraging diversity of employees, gender equality, age equality, the equality of persons with disabilities. Although the Constitution, laws and policies in Croatia protect and respect the freedom of differences problems also exist. According to the Census of 2011, Croatia is ethnically and religiously very homogeneous country. In Croatia is listed 4,284,889 inhabitants of which 328,738 (7.67%) of members of national minorities. Since this it is considered to be discrimination based on race, ethnicity and religion still a major problem in Croatian society. National minorities are considered a specific category of the population that has the support and protection of the state and for which, among other things, is worth positive discrimination in respect of employment. Although unfortunately - as in many other areas concerning the protection of human rights - is a big difference between the rights guaranteed by law, and the situation in reality. So, despite the existence of many documents, there is still plenty of room in terms of improving the employment situation of persons belonging to national minorities, primarily with a view to achieving their proper representation in administrative bodies.

Currently in Croatia there are not much foreigners but when it comes to legislation that protects their human rights, Croatia has almost completely harmonized with EU directives. Immigrants are often negative presented and perceived as a cultural and economic threat. In finding a job, many women in Croatia face discrimination. “Women in Croatia are in their jobs paid less than men and that an average of 10 percent, every other woman is faced with discriminatory issues - whether she planning a pregnancy, children, and family, something that has absolutely nothing to do with their qualifications.”[15] According to Eurostat, in 2012 only 16% of woman was on the boards of the largest listed companies. Although it has been some progress Croatian women still have been discriminated in the world of business. For this are blame stereotypes that only women do housework and the common perception that it is difficult to harmonize motherhood and career.

6. Conclusion

Changes in values and beliefs can be expected as the result of globalization process. Encouraging and supporting tolerance and acceptance of diversity is the key to overcoming discrimination because understanding and exploiting differences may contribute to the survival and the success of individual organizations. Within the EU accession process, Croatia harmonized its legislation, regulations and standards with the EU. Although Croatia adopted a number of policies that legal and institutional arrangements are trying to solve the problems of negative impacts of differences, really improve of the situation is still not sufficiently achieved. Although there are defined laws and public policies that formally allow women to participate in all areas of social life, in practice it exist significant presence of discrimination against women. To improve this situation, it is necessary that institutions provide consistent application of laws that protect women's human rights, and to ensure an environment in which there will be socially tolerated discrimination against women. To promote better understanding of cross cultural differences Croatia need to in addition to further strengthening the legal and institutional framework in this field, constantly work to raise awareness, education about these rights and their importance, to eradicate harmful prejudices and stereotypes that lead to discrimination.

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SMARTPHONES POSITIONING ON SAMSUNG EXAMPLE

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Abstract

Product positioning is related to creating an image about product in a mind of final consumer. That is the major difference between positioning and differentiation which is related to real product features and segmentation which is focused on market and final consumers. Product positioning and repositioning are two product strategies which are most commonly used. The aim of this paper is to show and emphasize importance between market success of product and company as a producer, and product positioning according to final consumers' needs and desires which are partly real but mostly created by producers marketing activities. This paper is based on market research conducted this year on student population regarding their opinion about Samsung smartphones and other smartphone producers. Market research was conducted in April this year online through internet by e-mail and social networks.

Keywords: Product positioning, product strategies, smartphones, Samsung

1. Introduction

Today, so many products and services exist on the market. Final consumers are getting information regarding products/services on every day basis through different information channels. Mass marketing cannot be effective today as it was in previous period. It is very difficult for producers to gain satisfying market position for their products /services and attract final consumer's attention.

Target marketing is far more appropriate for today's market conditions. Marketing experts must create for each product/service marketing mix and special attention must be taken regarding not only product/service differentiation and market segmentation but also product/service positioning in a mind of a final consumer.

Product positioning starts with product/service but image which final consumer has regarding product/service defines positioning.

Samsung is a company which started as a producer of no name products. Today it is one of strongest and well-known brands all over the world. They distinguished themselves on the smartphones market through innovation and with each new product they worked on satisfying needs and desires of final consumers. With this policy they gained better market position today then their major competitors which were far ahead of them at the start of mobile phones market.

2. Product positioning

Product positioning is one of the product strategies used together with product repositioning, scale of products strategy, product creating strategy and new product strategy.

Product repositioning is a process of revision actual product/service position and marketing mix. Through this process company is looking for new position on the market which would be more appropriate for the product/service. This activities can be directed to actual or new consumers and to new ways of product/service consumption.

Scale of products strategy is related to product portfolio company produce. It can be one product strategy, multiproduct strategy with complementary products and product portfolio strategy which is created according to needs and desires of final consumers.

Product creating strategy is based on the product standardization level. Product can be standardized, adapted and standard product with certain modifications.

New product strategy consists of all operations related to creating new product and putting it on the market regarding existing product line. There are three basic ways for this process which are modification of existing product, product imitation and product innovation.

According to Kotler product position is how product defined by final consumer is related to important product attributes – place taken by product in relation to competition products. [1]

Product positioning is not something connected to product features it is image of concrete product in a mind of final consumer. It means that product positioning means creating product image in a mind of final consumer on specific way. [2]

Product positioning as a term was first time mentioned and defined in articles written by advertising directors Al Ries and Jack Trout in late sixties. Their definitions of product positioning are still today in all marketing textbooks.

Product positioning starts with establishing differences in terms of product, service and image related to products produced by competition. Next step is establishing criteria for selection the most important differences relevant to final consumer. At the end, selected differences relevant to final consumer must be communicated to targeted market segment through promotional activities.

It is important to select wright differences which will be pointed out.

According to Kotler difference must be important, distinctive, superior, communicable, preemptive, affordable and profitable. [1]

Positioning can be applied on company image, specific product or product line. Positioning as a process has steps showed in next table.

Table 1.Positioning process steps

1.	Identification of competitors products-brands
2.	Identification of criteria/attributes relevant for positioning
3.	Present market situation analysis
4.	Positioning strategy selection
5.	Market launch of selected positioning strategy
6.	Measuring positioning strategy efficiency

The most common mistakes in positioning process are under positioning when final consumers do not know anything particular about the certain product brand, over positioning when final consumers image about the product brand is too narrow, mixed positioning which occurs due to often position changes of certain product brand and suspicious positioning when final consumers have doubts regarding promoted attributes of product brand. [2]

Positioning is connected with differentiation and segmentation but differs from this two processes. Nevertheless, this three different processes are often mistaken. Basic difference between this three processes comes from their definition. While positioning is related to final consumer's product image, differentiation is connected with product itself and product characteristics that differ certain product from similar competitors' products.

Market segmentation is a process through which company selects different market segments to which creates appropriate marketing mix. This process often includes product differentiation which means that for each market segment is created specific product that suits the best to expectations of final consumers in certain market segment. Market segmentation is focused on final customers and differentiation is focused on product/service.

3. Market research results

Market research was conducted this year on student population regarding their opinion about Samsung smartphones and other smartphones producers. It was conducted in April this year online through internet by e-mail and social networks. Research covered student population and included VUSB students, other faculty students and employed persons. Total number of respondents was 222.

Majority of respondents is between 20-25 years old which shows figure 1.

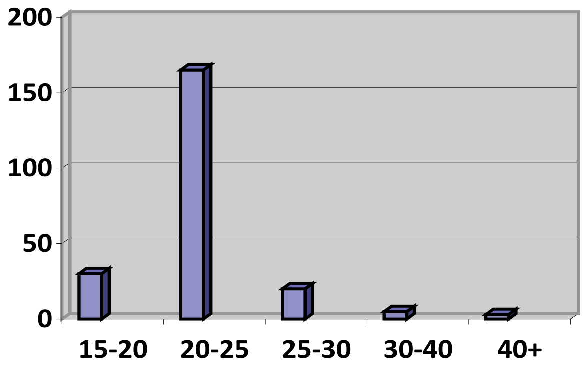

Figure 1.Age of respondents

Majority of participants, 185 (83%) owned Samsung smartphone. They are satisfied with product but their opinion is that improvements can still be done, as shown in table 2.

Table 2. Are respondents satisfied with their Samsung Smartphone?

Yes, they are perfect.	I'm satisfied with Samsung.	Not bad, but Samsung can do better.	I don't like it.
35	92	70	25

Samsung smartphones design market research participants characterize as attractive and modern. Only 11 participants answered that they don't like design.

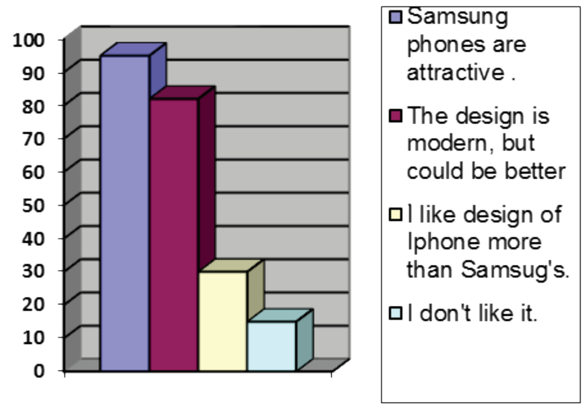

Figure 2. Design of Samsung smartphones

After-sales activities especially guaranty, delivered by the company Samsung, are rated with average mark. Some had rather bad experience but others had no problem with solving problems with product or time needed for that.

Participants answered question regarding Samsung smartphones quality and price ratio. Majority of participants wants to have this smartphones but they can\t afford it. They mostly wait for price reduction and regard price as higher than it should be.

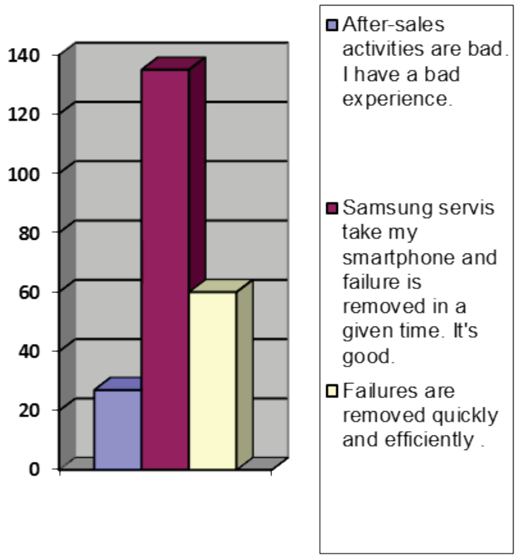

Figure 3. After-sales activities

Table 3.Quality vs. price

Price is proportional to quality, but I still can't buy their mobile phones	They cost a fortune. The price is not reasonable.	I'm waiting for discounts on products because I want to buy high-quality mobile phones at a lower price.	Price of Samsung mobile phones is not problem for me. The price is okay.
25	60	112	25

Quality is major factor which determines purchasing decision. It is more important than image or range of products produced by the certain company. Nevertheless, majority of our participants believe that well known producers guaranty better quality. It is shown in table 4.

Table 4. The importance of corporate image

I have more confidence in companies that are stable and well known in the market	No, important to me is the design of the phone.	Most important to me is the quality of the product, no matter who produces it .	No, I think „no name" products can be as good as the products of famous companies.
40	20	111	51

Marketing activities are stated as important and participants consider Samsung as company with good marketing concept. They also emphasized innovation as an important factor.

Table 5. Samsung marketing activities ratings

Marketing does a good job. Samsung smartphones are very advertised and very popular.	Marketing is one of the key elements of the company Samsung . Marketing is very important.	Marketing is good.	Marketing is the weakest part of the company .
82	120	15	5

Participants in our survey consider price reduction of Samsung smartphones to be the most efficient strategy to increase the sales figures. They also see quality improvement as second area for company's development

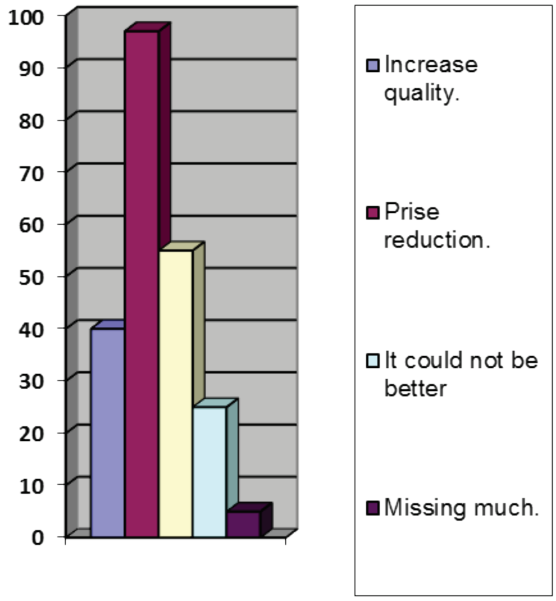

Figure 4. Opportunities for advancement in company's business

Participants in our market research selected Samsung to be a leading smartphones producer today. Very popular Iphone took second place and HTC third. Nokia took fourth place and it is hard to believe that it was a leading company on the very beginning of the mobile phones market. It is interesting that no one mentioned Sony as a producer of smartphones. Figure 5 shows how our respondents rated major producers of smartphones today.

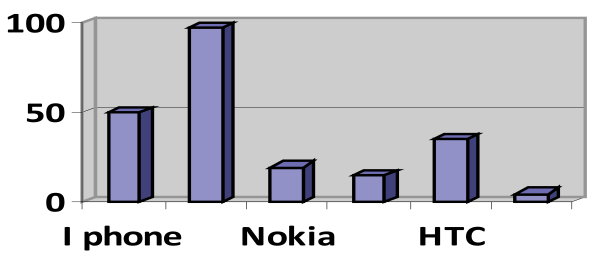

Figure 5. The best mobile phone company today

Product Galaxy S4 is Samsung smartphone regarded as the best smartphone on the market today. Second place is taken by another Samsung smartphone, Galaxy S5, Figure 6.

4. Samsung smartphone positioning

Samsung Galaxy S4 is smartphone regarded as one of the best on the market today by participants of our market research. Introduction of this product on the market created interest on the global market.

High technology features and quality improvement created great interest among final consumers.

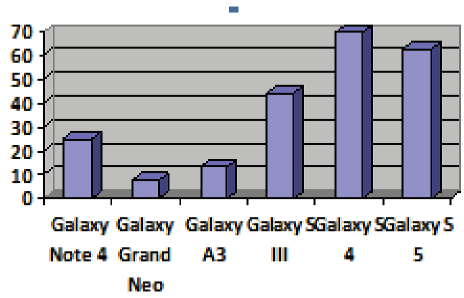

Figure 6. The best Samsung smartphone in the market

Galaxy S4 is smartphone from product line Galaxy. Previous model Galaxy S3 was very popular due to high quality and new model from that product line Galaxy S4, only continued good sales figures. Each and every new model in this product line was well accepted on the market because of quality improvements and new technological features.

All functions of this product are focused on final costumer's needs and desires. Sales are supported with marketing activities and image of Samsung as a company strongly support all products from this product line.

Product design of Samsung smartphones is related to customers' needs so Galaxy S4 has larger screen and it is lighter than previous model. Corners are slightly rounded which improves handling the product such as typing.

After-sales activities such as servicing the product and guaranty are mostly, in reasonable time. Price of Samsung Galaxy S4 is slightly lower than same products from competitors.

Distribution of Samsung smartphones is excellent so their products can be bought almost everywhere and anytime.

Marketing activities were focused on raising demand even before the product was placed on the market. Therefore Galaxy S4 was well accepted from the beginning it was introduced. Advertising included internet, social networks, press and television and product presentations on sales points.6. Aim and Scope of the conference

5. Conclusion

Every company once when defines its market position must work on achieving goals set by the company management. Positioning is not just wishful thinking or well-designed marketing advertising massages, it is whole process of designing products /services according final costumers expectations and desires.

Samsung example showed us how they worked with each new product on improving their products characteristics in terms of features but also in creating better image regarding not only products but company as a whole.

Their smartphones are today very popular and well accepted, especially among younger population. On the very start of introducing mobile phones market Samsung was far behind market leaders such as Nokia and Motorola.

Today, our participants in market research are pleased with Samsung smartphones in terms of quality, market presentation and other characteristics covered with research. Most of them own Samsung smartphone and in future will stay loyal to this brand. That is the best indicator which shows how well Samsung positioned their smartphones on the market today.

Note: This paper is result of a final thesis of former student at the College of Slavonski Brod

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CONFLICT MANAGEMENT IN THE ORGANIZATION AS ONE OF MANAGERIAL SKILLS

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Abstract

The paper analyzes the concept of organizational conflict and conflict management in the organization. It is displayed the role of managers in organizational conflict. This paper seeks to explain the importance of conflict management as one of the managerial skills. Theoretical analysis has shown that the quality management of conflicts is important to the success of the organization and that sometimes conflicts should be encouraged. Research in practice has been shown that the need for a quality management system conflicts increases with the increase of number of employees. Results of the analysis suggest that managers should focus more attention on developing the skills of conflict management.

Keywords:

Conflict, conflict management, organization

1. Introduction

This paper concerns the conflicts in the organization and management of conflict. Managers meet to face a variety of conflicts, such as conflicts between employees, between departments within an organization, conflicts with customers and suppliers. If conflicts are ignored, they have a number of negative consequences for the organization and reduce the efficiency of performing tasks and therefore the managers should apply the skills of management and conflict management in the organization. In conflict situations the key role has a manager because different viewpoints and disagreements can be helpful, if it is approached in the right way. Manager rotates the conflict into a positive or negative direction because the conflict by itself is neither negative nor positive.

2. The manager and his/her roles

The organization consists of a group of people who through the coordinated work seeks to achieve common goals, while at the same time serve the division of tasks and management control. The role of managers in the organization is great. According to H. Mintzberg, managers can be found in ten roles that are divided into three groups: interpersonal, informational and role in decision making. Some authors added another one, administrative roles [1, p. 45-46]. For the purpose of the work is important one of the roles in decision-making called conciliator. Conciliator is a person in crisis and conflict situations who solve problems.

3. Conflicts in the organization

"Conflicts are an unavoidable part of human activities, and every day, natural occurrence in the private and work environment." [2, p. 188] "The conflict is the existence of opposing interests and goals between two or more persons. It is a natural state of human relations at times in each system. There are no companies, teams or working groups which can avoid conflicts or disagreements among the members" [3].

Conflicts in the organization consequences of different values and situations that cause tensions within the organization. These may be conflicts between co-workers, conflicts with superiors or subordinates, conflicts with customers, business partners and other stakeholders that the organization is facing in their work. To organizational conflicts comes when the behavior of one group prevent or inhibit achievement of the objectives of another group. When individuals or groups believe that there are disagreements between them, it can be said that a conflict exists [2, p. 188-189].

Each conflict has three elements: 1) need at least two parties, 2) conflicting parties may be individuals or groups, 3) interests of conflicting parties are opposed [4, p. 765-766].

4. Approaches to the conflict

There are three different approaches to the conflicts in the organization, namely: traditional, behavioral and interactive.

According to the traditional approach, the conflict is seen as a negative and undesirable phenomenon that should be avoided.

According to the behaviorist approach, the conflict is seen as a natural and inevitable phenomenon in the organization that should be recognized and addressed.

An interactive approach to conflicts is considered potentially useful for increasing the effectiveness of the organization and united group, [2, p. 189].

It can be concluded that the conflicts today are not seen as something bad, and for the modern organization conflicts are the positive effects. From conflicts individuals and organizations output more creative and skillful, if they are appropriately managed, [2, p. 189].

5. Causes of conflicts

Considering the source of conflict, the causes of conflict are divided into, [2, p. 190]:

1. Causes related to the environment: complexity and uncertainty of the environment, faster pace of work, increased competition, globalization, workforce diversity, resource constraints, job insecurity
2. Causes related to the organization: bad division of labor, overlapping roles, communication problems, unavailability of information, different goals, interdependence, scarcity of resources, time constraints, inadequate leadership style, bad reward system, the popularity of team work, reducing the number of organizational levels, disagreement between employees and employers.
3. Causes related to the individual: differences in needs, wants, goals, expectations, values, opinions, perceptions and behavior of individuals, demographic characteristics, personality traits and differences in status.

6. The types of conflict

The basic division of conflicts is on:

1. conflicts with regard to consequences,
2. conflicts with regard to participants and
3. conflicts with regard to subject of conflict.

Conflicts with regard to the consequences may be functional and dysfunctional. Functional conflicts are considered useful and constructive as they contribute to organizational efficiency and effectiveness, and therefore are desirable. Dysfunction conflicts are considered harmful and destructive because they endanger and reduce organizational effectiveness and efficiency and therefore undesirable. While functional conflicts encourage employees to greater effort, cooperation and creativity, dysfunctional conflicts as a consequence leave egotism, lack of creativity, confusion and inability to perform activities, [2, p. 191].

Conflicts with regard to the participants may be: intrapersonal, interpersonal, intragroup, intergroup, interorganizational, intercultural and mixed.

Conflicts with regard to the subject can be cognitive and affective. Cognitive conflicts are conflicts related to task, and occur when individuals or groups clash because of work, when each opinion on how to do a task and make a business decision differs from the opinion of others. This conflict can cause disagreements about goals, allocation of resources, reward system, policies and procedures or work assignments. Affective conflicts are conflicts related to relationships, and occur due disagreement on a personal level, mostly due to differences in personalities. The consequences are distrust, disagreement, hostility, anger and discord between individuals. Cognitive conflicts often have positive consequences and should therefore be encouraged, and affective discouraged.

7. The styles of conflict management

The most famous styles of conflict management are: [1, p. 419-421]

1. Domination - this style of conflict management is characteristic for managers who have a high degree of confidence and use the authority, power and threat in the process of conflict resolution.
2. Cooperation - applied by managers who have a high degree of confidence and understanding to meet requirements of conflicting parties. This style of conflict management usually should be applied because it gives the best results.
3. Compromise - equal impact of cooperation and confidence managers. In this style it is not clear whether manager is the winner or loser.
4. Avoidance - this style of conflict management applied managers who have a low level of cooperation and confidence. It is characterized by ignoring the conflict.
5. Customization - high cooperativeness, but not enough self-confidence of managers. Using this style, managers do not have a big impact on the conflict resolution.

8. Results of the survey

For work purpose was conducted survey on the topic of conflict management in the organization. The survey consisted of two parts. The first part focused on the structure of the organization where the survey was conducted, and the other on the opinion of the organization about the mentioned problem.

The second part consisted of the following five questions and possible answers:

1. How often are you faced with conflicts in the organization? (Rarely, often, every day)
2. Which approach to conflicts you use most often? (Traditional, behavioral, interactive)
3. What are the most common causes of conflict in your organization? (Causes related to the environment, causes related to the organization, the causes related to the individual)

4. What of the following conflict management styles you use most often? (Domination, cooperation, compromise, avoidance, adaptation, mixed style)
5. Do you encourage the conflict in your organization (for the purpose of competition, greater efforts)? (Yes or no)

The research involved 2 small, 3 medium and 1 large firm by number of its employees. Respondents were, in the case of small businesses, the directors themselves, and in the case of medium-sized businesses, branch managers.

The company no. 1 deals with transportation, trade and services. With its 10 employees it is a small business. In the company rarely lead to conflicts. Approach to conflict is behavioral, therefore considers that the conflicts are normal occurrence which should be resolved. The most common cause of conflict in their company stated reasons related to the individual, that is a difference of opinion, behaviors and personality characteristics. When it comes to conflict situations, compromise is applied, whenever possible, in order to find a solution, but sometimes dominance is inevitable.

The company no. 2 is a family business whose main activity is the production of furniture. With its 19 employees it is a small business. The company rarely encounters conflict, and the approach to conflict is behavioral. The most common cause of conflict states causes related to the individual, and when it comes to conflict situations, compromise and sometimes adaption is applied, therefore with little impact on the conflict resolution.

The company no. 3 is a company specializes in making and selling jewelry. Across the Croatia, it has 50 branches and employs about 300 workers. It ranks as medium-sized companies, [5]. In each office works manager. It is known that conflicts in the office happen often, and the approach to conflict is behavioral. Causes related to the environment are stated as causes of conflicts. When it comes to conflict situations, compromise is chosen as conflict management style.

The company no. 4 is a medium company with over 60 branches across the Croatia and over 300 employees [6]. The main activity is the sale of personal care products and household goods, and a research purpose was examined by the head office in Slavonski Brod. The office often leads to conflict, and its approach is behavioral conflicts, as in all previous cases. The most common cause of conflict states causes related to the environment, i.e. fast pace of work, competition and job insecurity. As the style of conflict management has chosen compromise.

The company no. 5 is a store in Croatia, which employs more than 100 workers. Branch office in Slavonski Brod employs 30 workers. For the purpose of the research, survey has met the head of the branch office. He often meets conflicts in the organization and his approach is behavioral. Causes related to the environment are stated as the causes of conflicts, but when it comes to conflict situations, they choose a compromise as conflict management style. This organization does not encourage conflicts, [7].

The company no. 6 is a retail chain in Croatia which employs about 2,300 workers and in Slavonski Brod around 80 workers. They are faced with conflicts in the organization every day. The approach is behavioral conflicts, and the most common causes of conflicts are the causes related to the environment. To solve conflict management uses a mixed style, and for the question whether to encourage conflicts in its organization, reply was negative [8].

Comparison of the surveyed companies

Companies no. 1 and 2, which are small enterprises, rarely meet with conflicts in the organization. Companies no. 3, 4 and 5, which are, according to the number of employees, medium-sized enterprises, often encounter conflicts. The company no. 6, which has the largest number of employees, encounter conflicts every day, as shown in Figure 1.

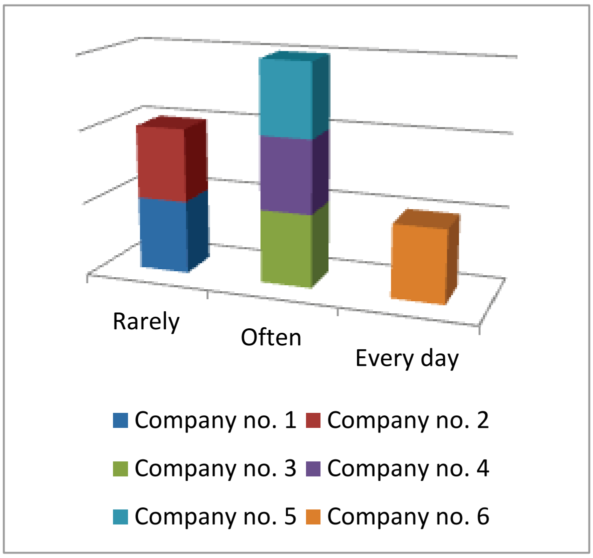

Figure 1. How often do you encounter conflicts in the organization? Source: made by authors

In companies no. 1 and 2 most common causes of conflicts are the causes related to the individual. In the company no. 3 causes are related to the organization, and in companies no. 4, 5 and 6 causes are related to the environment.

All participants chose a compromise, except the largest, company no. 6, which selected a mixed style to solve conflicts.

The only two features common for all surveyed companies is approach to conflicts, which is for all the behavioral, and negative response to the question of whether it foster conflicts in the organization.

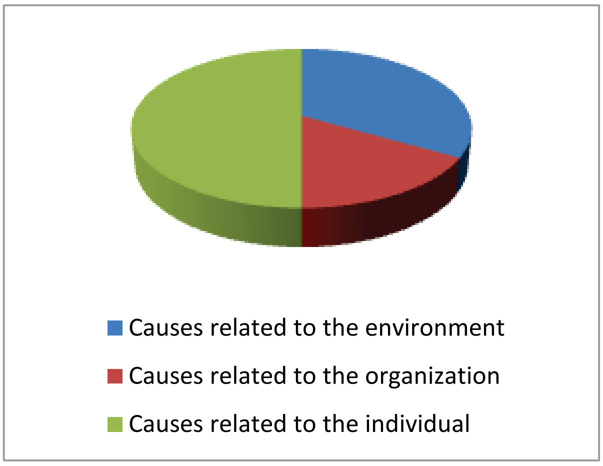

Figure 2. Causes of conflicts. Source: made by authors

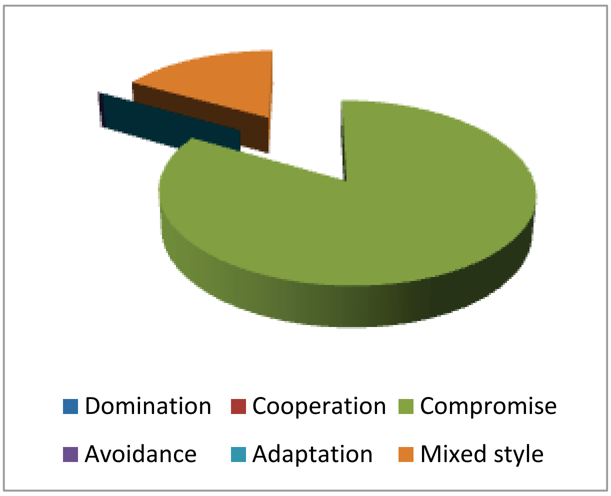

Figure 3. Styles of conflict management
Source: made by authors

9. Conclusion

This paper analyzes the conflict and the importance of conflict management for the success of the organization. The conclusion is that most of the conflicts in organization have a great opportunity to achieve better business results. Conflicts that are properly managed are the best incentive to change and grow the organization. The most important role in conflict management in the organization has a manager. Most managers have a traditional approach according to all conflicts in the organization of destructive phenomena. Managers should strive to maintain an optimal level of conflict, but it is not always possible because conflicts often get out of control.

For work purposes a research was conducted in 6 companies. The analysis showed that the frequency of conflicts in organizations increases with the number of employees and organizations with a large number of employees have a quality management system conflicts. In companies no. 1 and 2 conflicts are rare, in companies no. 3, 4 and 5 conflicts are common, and in company 6, which has the largest number of employees, conflicts are a daily occurrence. The only common feature to all respondents is approach to conflicts, which in all cases is behaviorist. All respondents chosen compromise as conflict management style, which is the most common style of conflict management. Mixed style was chosen only by the largest enterprise. While in small enterprises causes of conflicts is mostly related to an individual, in larger companies causes is related to the environment and organization. The answer to the question whether foster conflicts in their companies, for all was negative. That indicates that awareness of fostering conflict as a positive phenomenon in an organization that brings numerous benefits, is still not represented.

Managers should develop their conflict management and owners of companies should educate their managers about the various benefits that conflicts bring with them, if they are well managed.

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DISTRIBUTION OF THE ELECTRIC FIELD ACCORDING TO THE EVOLUTION OF THE DISCHARGE IN A SYSTEM POINTED PLANE WITH INSULATING BARRIER

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Abstract

The objective of our work is the study by numerical simulation of the influence of the length of the electric discharge on the efficiency of the insulating barrier as a function of its position and on the electric field distribution.

Keywords: Electrical discharge, insulating barrier, finite element, electrical field.

1. Introduction

The mixed insulating structures solid/gas are present in many equipment at high and mid-sized tensions. In certain components, the solid insulators are used like packing of the apparatus for the electrodes [1].

At the time of the setting in service of the devices electric in them make part, these insulating structures can be submitted to different types of constraints and more especially to the electric constraints. And in presence of a field electric, various phenomena can take birth in the volume of these materials or in surface. Indeed, when the electric field passes a certain value so-called doorstep, the discharges volume or surface can be generated and drive to the destruction of the insulating structure (following a straining of the insulating structure or to a bypassing of the strong insulator) or even to the stake out of order of the system [2].

In this work we examine the influence of the position of the insulating barrier and the electric discharge length on the electric field distribution, and we study the influence of these parameters on the relative theoretical efficiency to the distribution of the electric field in the system point-plan.

Indeed, we make a digital study to determine the values of the electric field as well as the effectiveness by using the computer code FEMM [3].

2. Studied Model

The system studied (Fig.1) consists of an arrangement of electrodes points and plane distant d, between which an insulating barrier of length L, thickness e and permittivity εrsolide is inserted, is placed at distance x of the point.

The electrode points radius rp, is connected to the high voltage and the plane electrode of width Lp, is put at the ground. The studied system containing of the air permittivity to εr.

To reproduce the discharge, we work out a square grid between the point and the plan whose nodes represent the points probable to be started by the discharge during its evolution (Fig.2).

The discharge boots of the electrode points whose field is sufficient to make it evolve by step to the plane electrode.

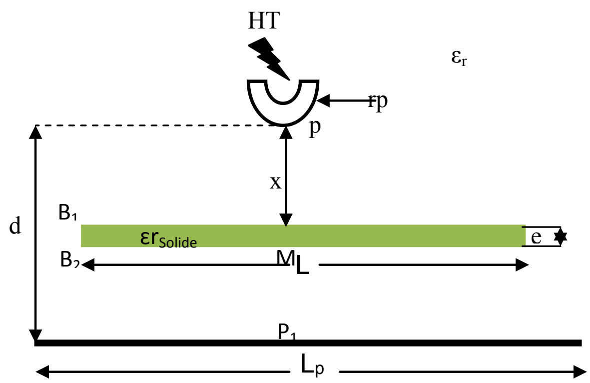

Figure 1. Presentation of the studied system

With each phase, the nodes possible to move present 5 possibilities of progression (Fig.3): D (straight line), C (centrex) and G (left), DH (right horizontal) and GH (left horizontal).

It is considered that there is discharge if the following criterion is checked out:

Ecible>Emax*R (1)

Where:

Ecible indicates the field at the targeted point (D or C or G or DH or GH).

Emax: the maximum field computed with each phase of evolution.

R: Random variable generated by the uniform law (random).

During all the evolution of the discharge, we consider the channel as a pure conductor (not of voltage drop inside the outfall channel).

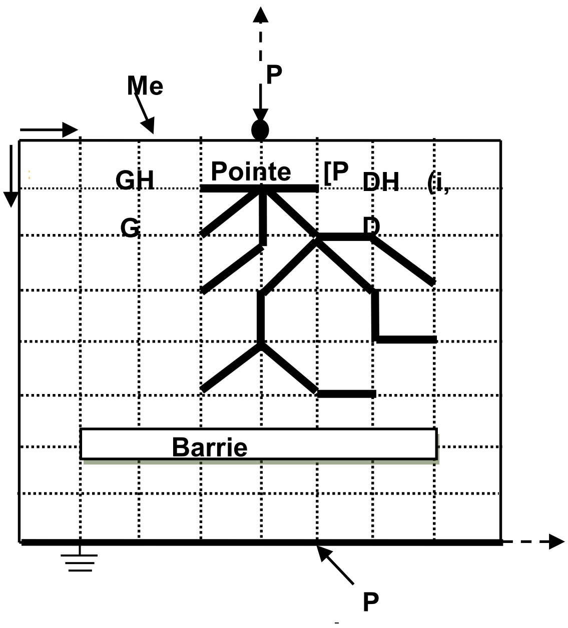

Figure 2. Progression of the discharge.

3. Results

In the figures (3 to 6), we present the distribution of the lines équipotentielles at the time of the evolution of the electric discharge for a distance inter electrodes d = 1000 mm, a thickness of the barrier e = 200 mm, width of 1000 mm and a position x equal to d/2+rp.

Before the initiation of the discharge (l=0 cm), the distribution of the équipotentielles presents a symmetry in relation to the axis passing by the tip and the center of the plan.

Once the discharge started, this symmetry is not observed anymore. Her of as much less noted that the discharge punches or slip on the insulating barrier.

The streamers that take birth or neighborhood of the tip propagate themselves radically on the surface of the insulating barrier and stop to a certain distance of the tip that one will call length final l.

In the goal to have the influence of the electric discharge on the variation of the efficiency, we vary the position of the insulating barrier and let's raise this efficiency according to the length final l of the electric discharge. This to the level of the barrier (surroundings loud (Fig.8) and low (Fig.7) and low sides (Fig.9) and high (Fig.10)).

For the surroundings high and low, the pace of the experimental curves is not observed anymore. On the other hand for the sides, this pace is always kept. It is of as much nearer in value for the point high side that low side.

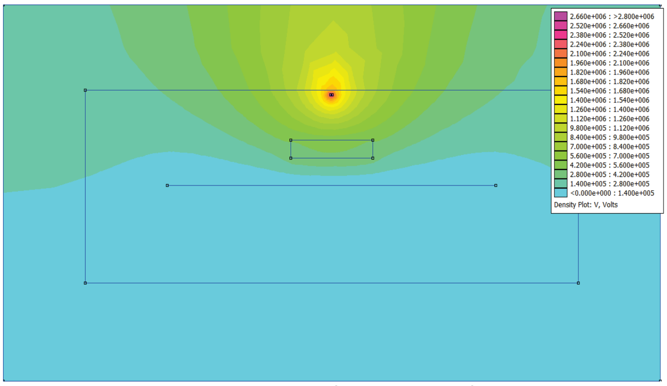

Figure 3. Distribution of the electric field without electric discharge (l=0 cm).

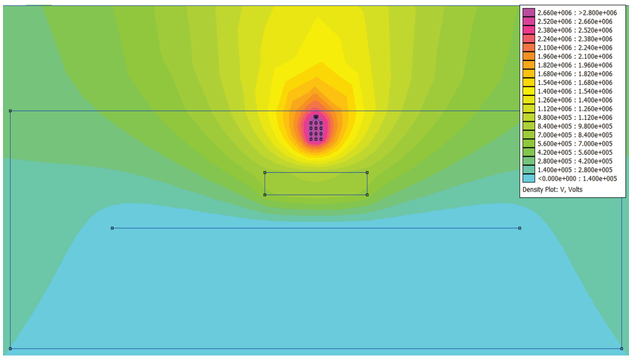

Figure 4. Distribution of the electric field according to the evolution of the pure electric discharge a length of the discharge (l=20 cm)

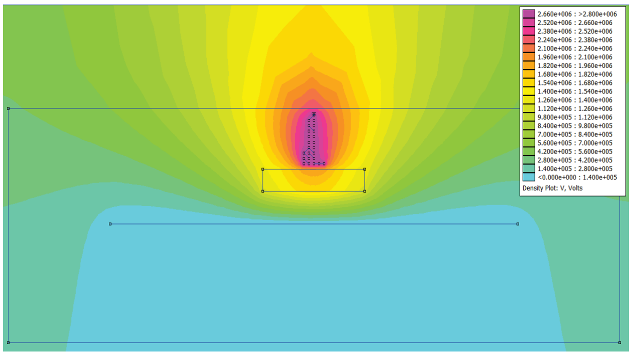

Figure 5. Distribution of the electric field according to the evolution of the pure electric discharge a length of the discharge (l=50 cm).

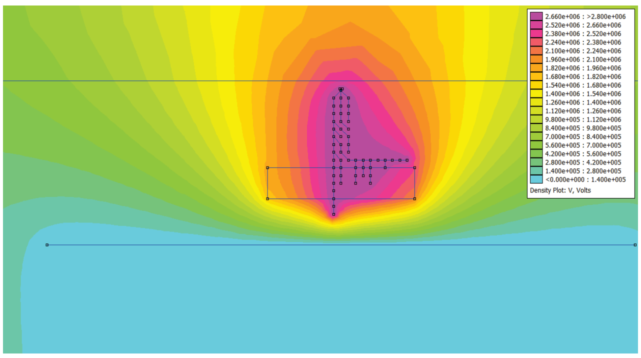

Figure 6. Distribution of the electric field according to the evolution of the pure electric discharge a length of the discharge (l=90 cm).

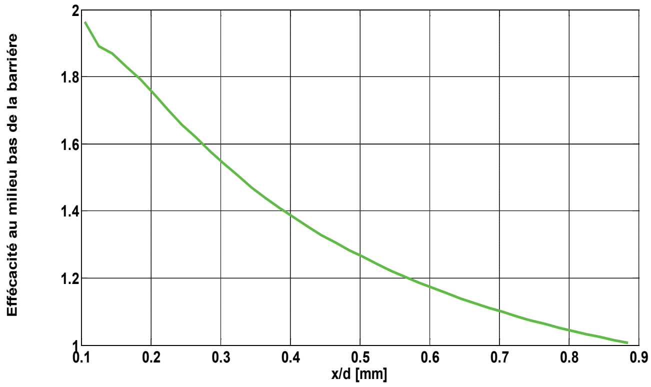

Figure 7. Efficiency to the low environment of the gate according to its relative position for l=100 mm.

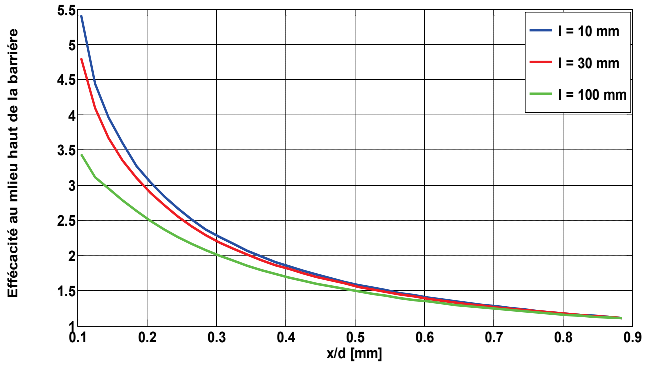

Figure 8. Efficiency to the high environment of the gate according to its relative position for different length of the discharge.

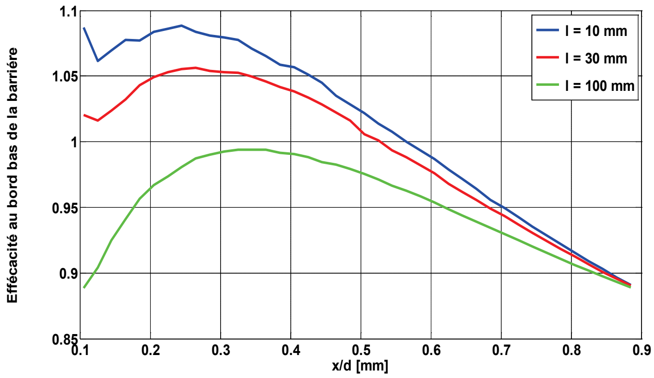

Figure.9: Efficiency to the low side of the gate according to its relative position for different length of the discharge.

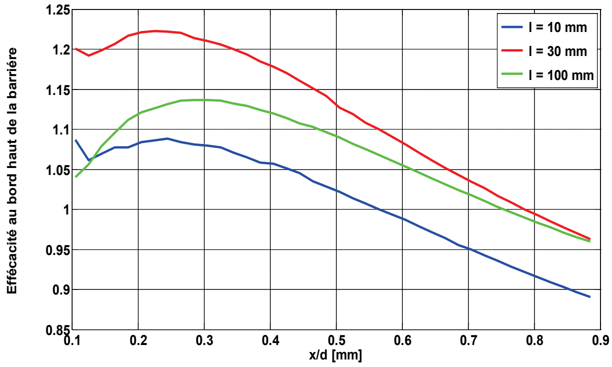

Figure 10. Efficiency to the high side of the gate according to its relative position for different length of the discharge.

4. Conclusion

The insertion of an insulating barrier modifies the card of field. This modification depends on the measurements of the barrier and its position in the interval inter-electrodes.

The presence of the electric discharge influences on the efficiency of the insulating barrier, indeed this last decrease when the final length of the discharge increases.

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NEW METHODS OF MODELLING AND DESIGN OF AUTOMATED ASSEMBLY SYSTEMS BY USING THE SIMULATION TOOL "VIRTUAL COMMISIONING"

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Abstract

Significant trends in production systems and generally in production include rising complexity of product variability and flexibility of production processes and products, increased requirements for development and production non-standard and special-purpose equipment and decreasing batch manufacturing. Using Virtual Commissioning (VC) has achieved significant shortening start-up of production. This paper describes a procedure for how to modify the design methodology of automated assembly devices and implement virtual commissioning in the educational process in modelling and designing of assembly devices and systems with industrial robots.

Keywords: Assembly systems, automation, design, education, virtual commissioning

1. Introduction

The automation of assembly processes is a current trend in engineering production. The issue of assembly, together with the problems of automation is gradually evolving. The aim of the automation of processes is to reduce the initial costs for assembly, shorten assembly times, specify the assembly, and improve product quality. Thus, it is necessary to find such solutions to this issue that optimize and improve the requirements for automated assembly equipment and systems. The planning and design of automated assembly equipment is demanding, because some elements of the device are unique and application-specific. A special feature of automated assembly machines is that they have to be adapted to a frequent change in the shape and size of the assembled product. The reason is an increase in the number of parts of assembled product during the assembly process. Design and development of an automated assembly device is more difficult and more specific, in contrast to other automated devices, since the individual subassemblies and accessory equipment are specific and are directly adapted to the specific assembly process itself, [1].

2. Modelling and design of automated assembly systems according to standard procedures

In the present time modelling and design of automated assembly systems is realized according to standard procedures of the projecting of automated assembly machines and systems. On the ground of these standard procedures was developed and verified the design methodology of automated assembly machines [2]. The design methodology consist of several design steps these are important for successful realization of the model of the automated assembly machine.

The standard model of design and development of all automated devices is generally consistent. It is necessary to determine a certain standard procedures. The design methodology includes procedure for design and final assembled device that provides the assembly process automatically by chosen technological process, having 4 essential phases, Fig. 1.

The first phase is the pre-project phase of development of an automated assembly device, including preparatory works prior to designing the device. The pre-project phase is followed by the design of automated equipment which has two basic steps. Based on the analysis of the assembly process, the selection and placement of individual devices is defined, and the second step is the choice of the automation equipment on the basis of the selected technical devices. The final phase is the constructional phase, which involves the construction and implementation of the actual automated assembly device and its launch into operation. The design methodology of automated assembly devices and the procedures and operations of the methodology are illustrated in the following scheme, shown in Fig.1.

The role of automated assembly equipment is to automatically implement the assembly of individual assembling components into a comprehensive finished assembled product by using means of automation. This task includes not only the assembly of parts, but also a supply of individual components, handling of parts, delivery and possible positioning of parts, and transfer of the final product. Automated assembly equipment, therefore, consists of multiple workstations and components that perform the actual installation, orientation and supply of parts to assembly stations. Selection of individual devices depends on the assembly process itself. The assembly procedure consists of several operations, and therefore they must be performed on the devices that are part of the automated assembly equipment, shown in Fig. 2 [3].

The general functional components remain in this order, but the individual functions can be broken down and grouped into typical subsystems as individual groups, as shown in Fig. 3, [3].

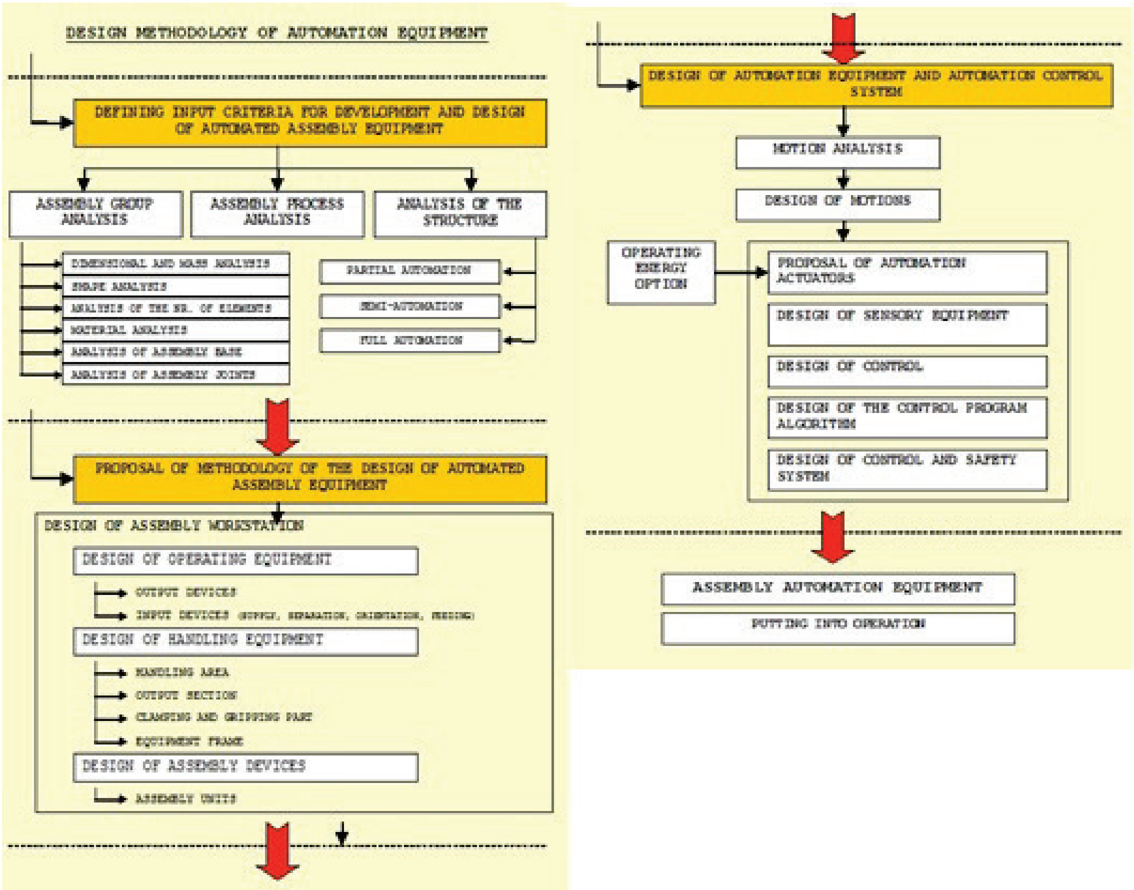

Fig. 1 Scheme of the operations implemented in the design of automated assembly equipment according to the methodology of the design of the automated assembly system [2]

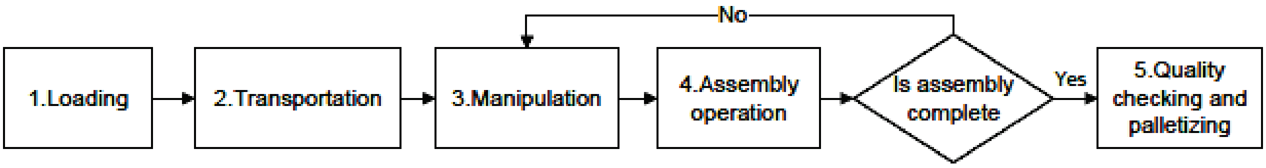

Fig. 2 Functional division of the assembly process

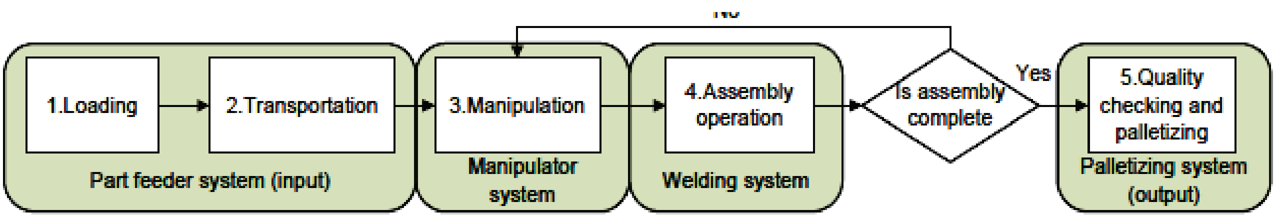

Fig. 3 Function module allocation for the concept of the assembly equipment

Pre-project activity of the design methodology also includes an analysis of the possibilities for automating certain elements of the assembly process. The entire assembly process and the individual assembly and supportive devices can be categorised and divided into different groups, depending on whether they can be automated or operated manually, shown in Fig. 4, [4].

The analysis shows the overall concept and structure of automated assembly equipment (Fig. 5).

In terms of the possibility to automate the assembly process, automated assembly devices can be designed on four basic levels:

1. Automated orientation, automated feeding and automated assembly,
2. Manual orientation, automated feeding and automated assembly,
3. Automated feeding and manual assembly,
4. Manual feeding and manual assembly, [2].

Function	Option 1	Option 2	Option 3	Option 4
Transfer System	In-line indexing system	In-Line indexing system with return carriers in the vertical plane	Rotary indexing system	Pallet system
Part Orienting	Vibratory bowl feeder	Magnetic rotary feeder	Machine vision system coupled with a robotic arm	Manual
Part Feeding	Vibrating conveyor	Linear feeder	Horizontal belt conveyor with passive guides	Manual
Handling System	Pneumatic pick and place	Electric pick and place	Robotic arm	Manual
Part Gripping	Vacuum suction	Magnetic gripping	Pneumatic grippers: radial, 3-point and angular	Manual
Part Inspection Systems	Machine vision system	Colour sensor	Human visual inspection	
Packaging System	Robot based system	Customized automation	Manual	

Fig. 4 Morphological scheme of the assembly system

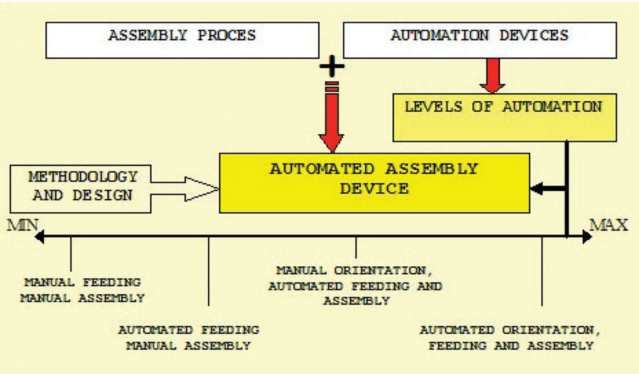

Fig. 5 Structure of automated assembly devices

The second phase of methodology for the automated assembly equipment design is the project part of the development of automated assembly equipment. This phase includes various proposals for assembly devices and units that make up the automated assembly system and ensure the assembly process itself. All assembly systems have the same general high level functional breakdown when analysing the component and material flow through the assembly process. This general functional decomposition is presented below in Fig. 6 [3].

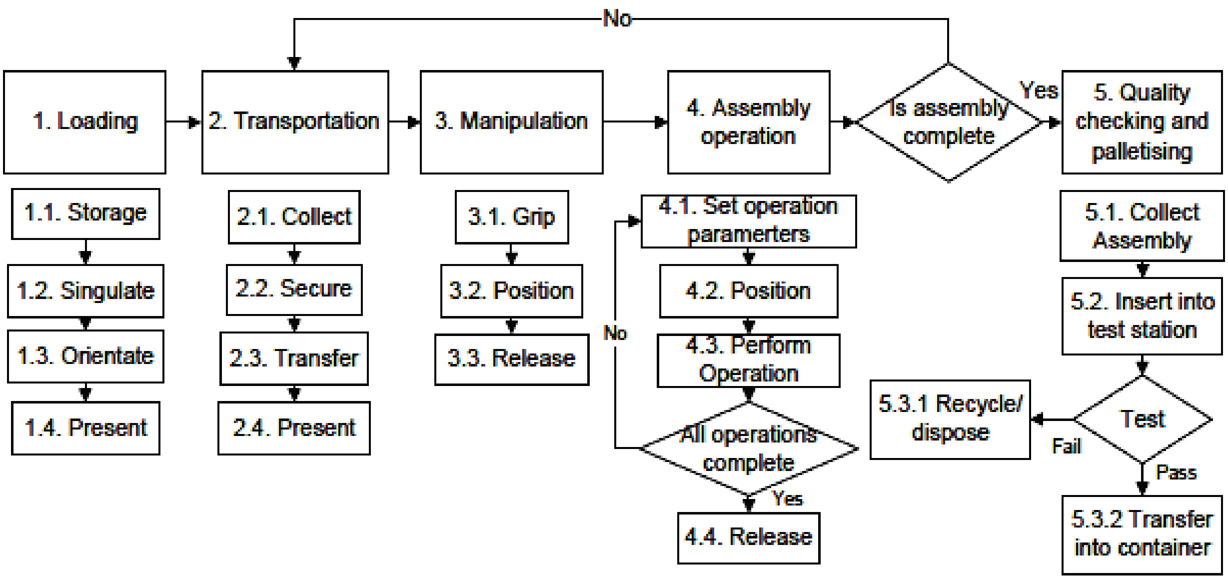

Fig. 6 General high level component functional decomposition for assembly systems

The final phase in the methodology for the design of automated assembly equipment is the design of automation elements and control system, thus ensuring the automated assembly process. These technical means are selected on the basis of the pre-project and project analysis of the methodology and the design of individual subsystems of the automated equipment. Thorough and in-depth analysis of the process and objects in the process will provide a consistent design of individual devices, and thus the rational choice of automation equipment. There are many automation technical means which provide the control of the assembly process. In general, kinetic action elements, sensing elements, and communication and control elements must be chosen. Secondly, the control mechanism which monitors the state of the assembly process can be designed. Furthermore, various safety and computing devices represent the other automation elements.

Development and design of automated assembly equipment is a complex problem which involves and takes into account the issue of making the automated equipment, as well as the issues of the design of assembly devices. The process of the automated assembly equipment design therefore requires a tool which is able to deal with the issue of automated assembly. Such a tool is the proposed methodology for the design of automated assembly equipment, which reflects the possibilities and procedures of the development of such equipment with respect to the requirements imposed by the actual assembly process. Following the output of the design methodology, the result will be the design of the automated assembly equipment.

The last step in the design and development of the automated assembly device or other similar devices includes the important activity tasks before commissioning. The main task is the completion of all the devices into a whole unit. One verification model of the developed design methodology is a complete automated assembly device for assembly of pneumatic cylinders, Fig. 7.

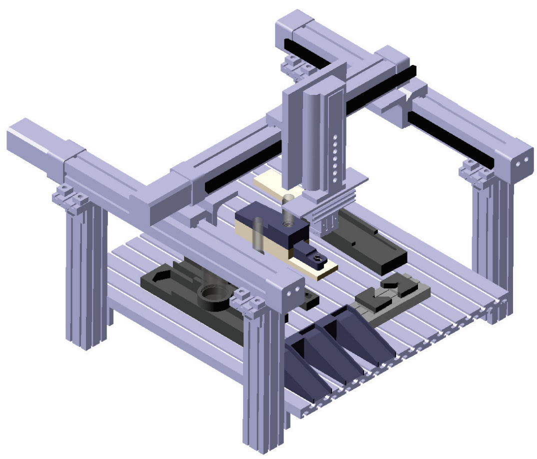

Fig. 7 Designed automated assembly system

Figure 8 shows the verification model of automated assembly device for the selected model of the assembled product.

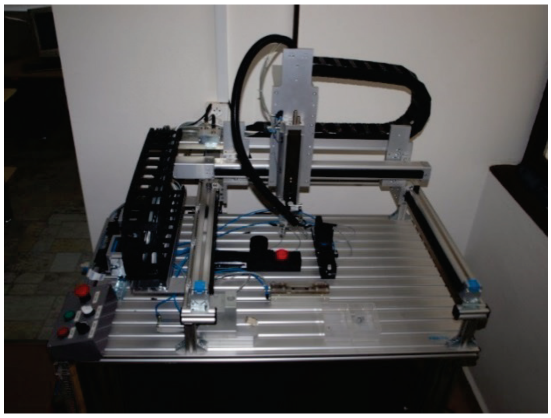

Fig. 8 Verification model of the automated assembly equipment

3. Integration of the simulation tool "Virtual Commissioning" into the design methodology

The standard design methodology for automated assembly devices includes a standard four-phase project. Based on this methodology will create a model technical device intended for mounting the assembled product. This model is the starting model for creating realistic technical device together with the creation of technical documentation. In parallel with the design of technical solutions the actual automated assembly device concept is created an automated control system through automation control software. The wedding takes place both concepts to the after-design phase of the project, which in terms of time starting up the machine is quite late. During assembly and starting the machine with commissioning occur problems that can cause changes in production and technical documentation of the machine itself.

Based on experience in the design of automated assembly devices can be said that it is necessary to use tools to achieve validation of the model in terms of the limits of motion apparatuses of the model [x]. Design methodology should be updated and enriched with additional intermediate phase of the project. In this part of the project it is developed verification of the technical solutions before the actual production of technical project and installation of the necessary software for the control system of the assembly device. Such a design phase of the automated assembly devices is known concept of the virtual commissioning of the machines together with its kinematics model.

Virtual commissioning of automated assembly devices is a technological tool that will speed up to 30% the design of machines and provides shortening the commissioning of up to 70%, avoiding collisions and damage to real machine and validation of real production conditions in a virtual environment.

Virtual commissioning of automated systems and technical operation enables debug function devices already in the development phase, thus avoiding faulty production. Virtual debugging is to avoid mechanical collisions that can cause significant damage, other investments and delayed production. This makes it possible to significantly shorten the time required for product delivery and customer equipment and the guarantee time of delivery. The use of new technology that allows engineers to build a replica production equipment and processes in an interactive 3D virtual environments with complete mechanical, electrical, hydraulic and pneumatic systems separates manufacturing process into operation weeks or months before starting production system [5].

Methods for Virtual commissioning of production systems in cooperation with industrial robots are set in the paper [6] wherein the authors define the conditions and actions to create a simulation model the assembly system by the VC, also as the contribution of other authors [7]. It was found that a new way of designing assembly systems through simulation tools reduces installation time of production system, reducing investment costs [8], and enhances the producibility in respect to time interruptions for reconfiguring when introducing new equipment into the production process [9]. Based on these findings it can be concluded that simulation tools have high application in planning and design of new assembly systems. Thus, the design of automated assembly systems should use the Virtual Commissioning before the actual realization of technical project, Fig. 9.

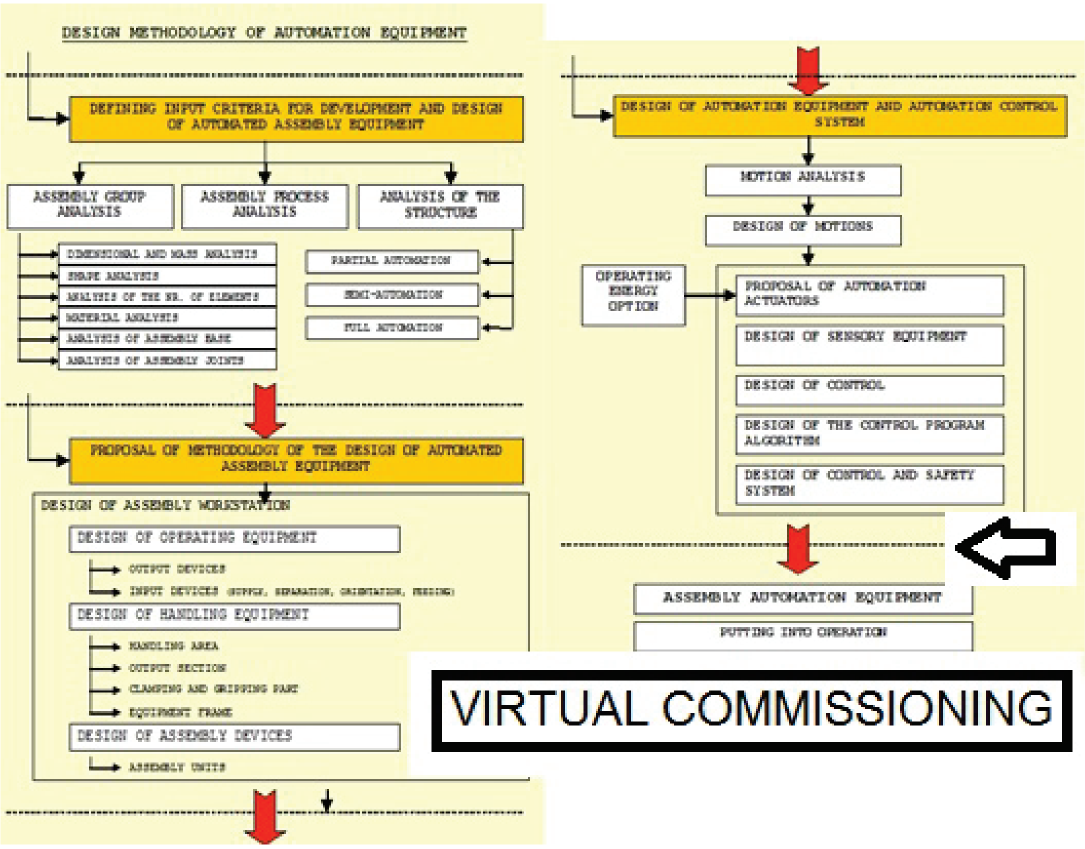

Fig. 9 Virtual commissioning integrated to the design methodology

4. Practices used in the education process for design of automated assembly devices

In study program production technique students meet subjects as industrial robots and manipulators, assembly machines and production systems. During the study students implement the project of automated assembly system, which is implemented in two steps. Student will create CAD-model based on design methodology for mounting devices, Fig. 10.

Students then create a simulation of assembly control system. This simulation does not reflect a realistic simulation of control system and it is not possible to observe the limits of technical device and potential collision situations. The simulation consists from three steps. In the first step basic layout of the control system is created in the system Grafcet, Fig. 11. Then the real control system in Siemens Simatic Manager is made, Fig. 12. The control system and the program is simulated via PLCSIM. The program is controlled and simulated via PLCSIM that can be connect with FESTO FluidSIM via OPC server. In this way it is possible to monitor control of the program through simulation of electro-pneumatic system, Fig. 13 managed through a program created in SIMATIC.

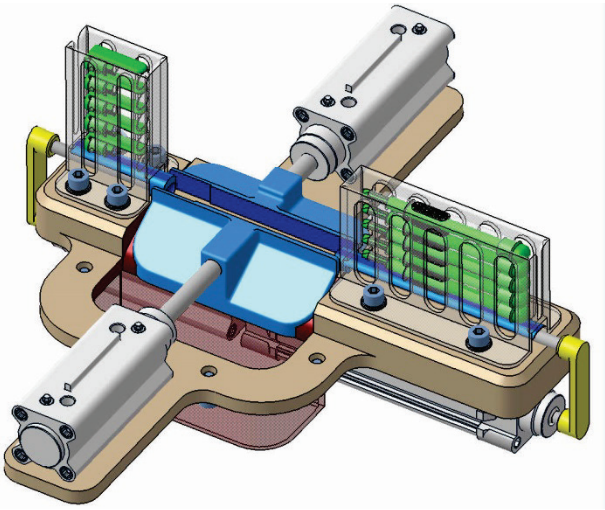

Fig. 10 Automated assembly device for markers mounting

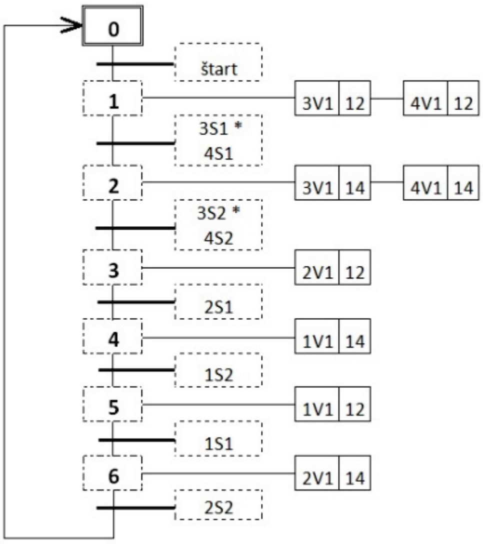

Fig. 11 Basic layout of control system in Grafcet

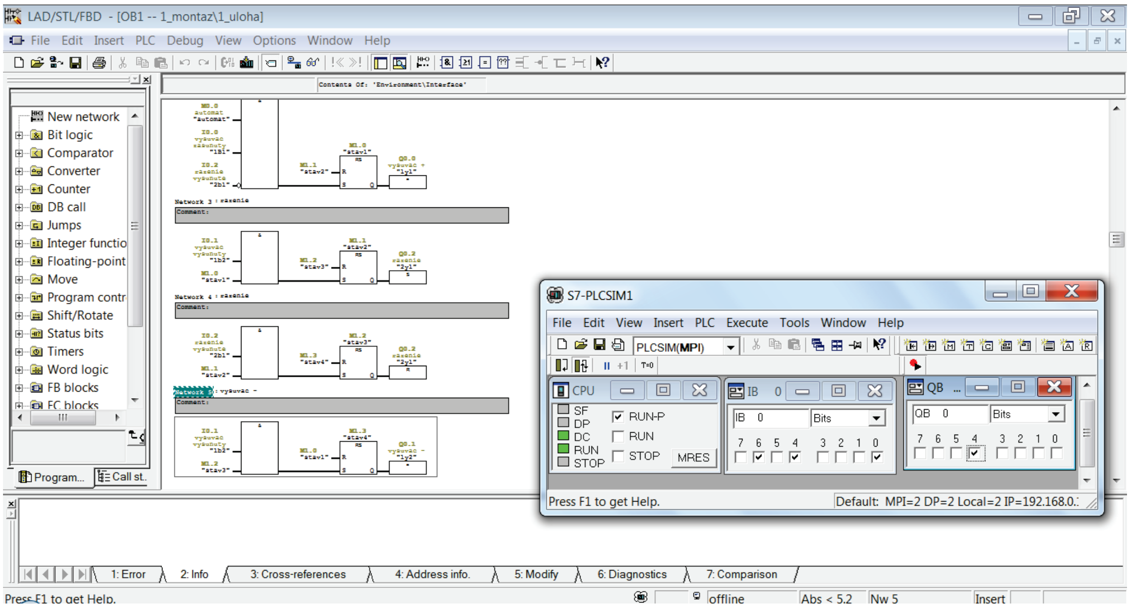

Fig. 12. Created control system and simulated PLCSIM

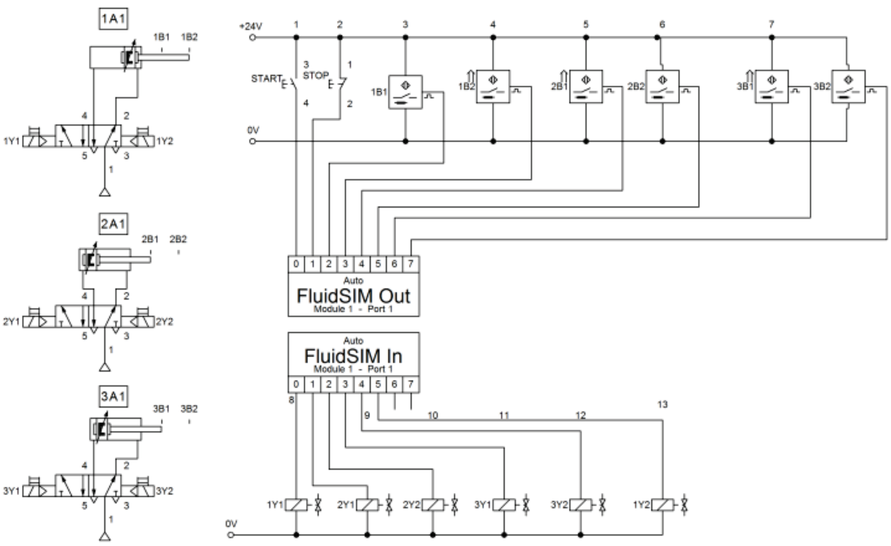

Fig. 13. Electro-pneumatics control system of the assembly device simulated in the FluidSIM

5. Implementation of the Virtual Commissioning into the education of the design of the automated assembly devices and systems

Virtual commissioning of an automation system gives the opportunity to test the real control system on modelled hardware to test performance under different load scenarios and catch problems much earlier in the development stages. The result is less debugging during the commissioning phase and a more robust control system for the duration of operation. The technique involves planned testing stages whereby the virtual commissioning groups run PLC controls to drive a simulated automation subsystem. An installation usually consists of many individual hardware components that are controlled by software. Tests during the real startup indicate whether all the individual parts are working together as they should. Implementation of the VC can be realized in two steps, creating a kinematic model of the machine and creating of the simulation of the assembly process in the Time Based Simulation and Event Based Simulation via tool Tecnomatix. Using Tecnomatix platform from Siemens, and individual project planning tools such as Process Simulate, process designer to create a project of the assembly system with industrial robots, Fig. 14. Real control systems in there then we know the virtual space to be connected via OPC server.

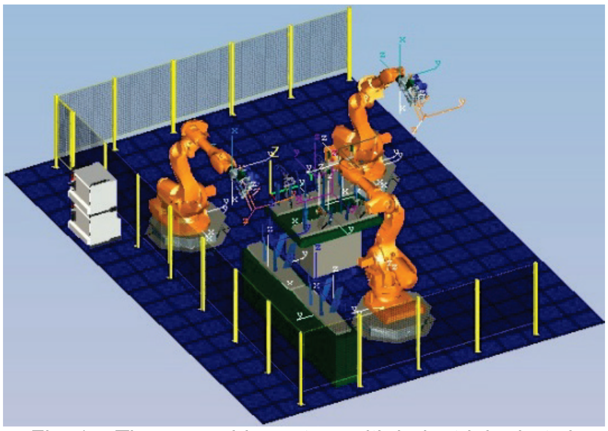

Fig. 14. The assembly system with industrial robots in Process Simulate

Once a CAD model of individual parts of assembly machine is created, it is necessary to establish mutual relations between subsystems. Since it is a moving model, it is necessary to ascertain whether the mutual relations between different subsystems are within the tolerances, preventing collision between the individual parts. This occurs more often during mechanical and practical compilation of individual parts and there is consequently adjustment of technical documentation, and the total remaking of the concept of machine assembly. It is possible to simulate a realistic model of the assembly system with real control system, controlled via OPC server.

Functional processes, cycle times and risks of collision can thus be effectively verified and solved. Also we simulate complex processes PLC programs as well as courses of movement within robotics programs. Tool VC is an appropriate tool which will check the availability and the event of collision, Fig. 15. The yellow color represented possible contact, orange color distance to 1 mm to collision and red a real collision.

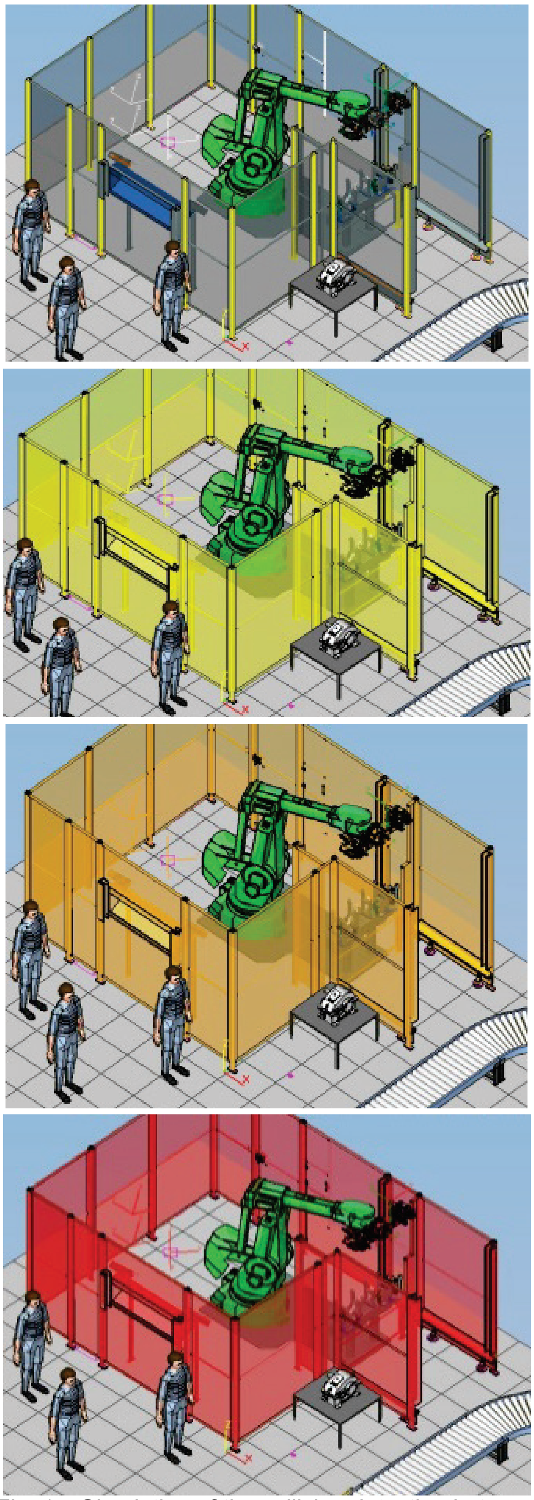

Fig. 15. Simulation of the collision detection between industrial robot and safety fencing

The simulator finds errors early on, during the development stage, and since they would otherwise not be noticed until much later, during the commissioning of the real installation, the virtual startup helps to lower project engineering costs. Hardware settings can also be checked and configured via the simulation, such as the setting of field devices or the flow of sequence chains.

6. Conclusion

Simulation develops its full potential when this technology is used across the whole installation life cycle. In the planning phase, and then continuously during the engineering phase, important basic assumptions can be checked and concepts verified through simulation. This approach is known as simulation-based engineering. This is an important step for more reliable installations, because mistakes in the early phases of development are especially difficult and expensive to correct later on.

7. Acknowledgement

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MONITORING OF WELDING PARAMETERS WITH WELDING MACHINE WELBEE P500L

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Abstract

The paper presents previous experiences related to the monitoring and control of welding parameters. Introducing the new generation of welding machines Welbee P500L, and system for monitoring, collection and analysis of welding parameters contained as part of Welbee P500L welding machines.

Keywords:

Welbee P500L, monitoring system, welding parameters, spatters,

1. Introduction

As the growing need for the development of new devices for welding and so has the need for monitoring the welding parameters and the development of devices for the monitoring of the welding parameters. Current development of equipment has enabled intelligent work of welding equipment through monitoring system it is possible to optimize the welding parameters. The main welding parameters that are usually controlled are: welding current (I), welding voltage (U), welding speed (v), wire feed speed ($v_ž$), the gas flow (f). By processing of these parameters it is possible to remove possible deviations welding parameters of the prescribed limits, and thus reduce the occurrence of various types of defects in the weldand to make reducing costs of the process of welding. The sensors used for monitoring the welding parameters can be with:
- voltmeter and ammeter,
- light sensor,
- fast video camera,
- acoustic sensor,
- ultrasound,

2. On-line monitoring of welding parameters

On-line monitoring system is a device for real-time acquisition and analysis of arc welding parameters. Although on-line monitoring systems have the capability to measure many different parameters during the welding process, those found to be most significant for electrical arc processes are the welding voltage and welding current. A more detailed analysis of recorded welding parameters is usually performed after the weld is completed, i.e., off-line. We selected an analog-to-digital (A-D) conversion card and other components so we could capture and store up to 15000 measurements per second per channel. The data (current and voltage) can be expressed as direct functions of time (I=f(t), U=f(t)), and can be processed to indicate the instantaneous power (Eef=f(t)), or can be processed to show ratios between two variables, for example U=f(I). [1]

Systems for monitoring the welding parameters in real time can be integrated into a single device for welding or represent a standalone device with a separate power supply whose connection with the welding machine or feeder electrode wires usually achieved via InterBus serial port. This type of serial connection in the industry is commonly used to interconnect control systems, sensors and actuators. Depending on the characteristics device it is possible to collect a larger or smaller the number of data, it being mandatory measures current, voltage arc and while the electric arc established. In order to preserve and analysis data via USB connection, local area networks, which can be cable and wire type or via mobile network are transmitted to a computer that is running the appropriate software for data collection and data acquisition. [2]

For all systems for monitoring the welding parameters important consideration is the amount of data that can be written.

The simplest way of monitoring system Welding monitoring of welding parameters with the help of the oscilloscope. The data obtained are analyzed oscilloscope and processed by computers.

Figure 1 shows the card that can be made note data overall top speed sampling measurement 100000 per second. The lowest possible speed is 0.00153 samples per second, or one sample every 11 minutes it is a card AT-MIO-16X, together with appropriate software from the company National Instruments United States, these systems are suitable for studies of transmission drops during the formation of the welded joint.

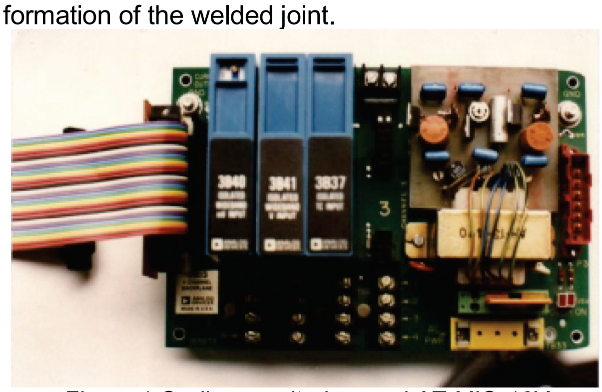

Figure 1 On-line monitoring card AT-MIO-16X

In figure 2 the online welding monitoring system, based on the PCI-6052 card with measurement capability of 333 kS/, is presented.

Figure 2 On-line welding monitoring system [3]

3. The new generation of welding machines with a system for monitoring of welding parameters

Welbee P500L is new generation of welding machine. It is based on the development of nanotechnology and a unique system Welbee. Using welding control LSI Welbee enables high-precision and high-quality welding and perform smart welding control over USB or LAN. Welding machine WB-P500L can work in different welding modes: pulse MAG, Pulse MIG, low-spatter CO_2/MAG, low-spatter SUS-MIG, CO_2, MAG, Al-MIG, SUS-MIG, STICK, TIG, Fig. 3.

Figure 3. Welding with the device for welding Welbee P500L

The characteristics of the devices for welding are shown in Table 1.

One of the characteristics of welding machines Welbee P500L is reducing the amount of spatters, and thus increase the quality of welded products. By using devices it is possible to reduction spatters to 60% when the welding current to the value of 200 A. The device has the ability to take data from different time regimes in table 2 are presented these regimes.

With different timing mode to store data can be selected and the various data that we want the device records such as welding current (A), welding voltage (V), wire feed speed (m / min).

Table 1. Characteristics of welding machines [4]

Specification/ Model	Welbee Inverter P500L
Model	WB-P500L
Number of phase	Three phase
Rated frequency	50/60 Hz
Rated input voltage	400 V
Input voltage range	400 V ± 15 %
Rated input	25 kVA, 22.9 kW
Rated input current	36 A
Rated output current	DC : 500 A Pulse : 400 A
Rated load voltage	DC : 39 V Pulse : 34 V
Rated output current range	30 to 500 A
Rated output voltage range	12 to 45 V
Maximum no-load voltage	80 V
Rated duty cycle	DC : 60% Pulse : 80 %
Number of welding condition	100
Temperature rise	160 °C
Operating temperature range	-10 to 40 °C
Operating humidity range	20 to 80 % (no condensation)
Storage temperature range	-20 to 55 °C
Storage humidity range	20 to 80 % (no ondensation)

Table 2. Sampling speed of data log function [4]

Setting	Sampling interval
1	10 ms
2	100 ms
3	1 s

4. Examples of the measurement of welding parameters with welding equipment P500L

In the practical part was conducted MAG welding general structural steel with a device WB-P500L in laboratory conditions with different flows of gas. When welding is used shielding gas Krysal 18 (82% Ar + 18% CO2). Welding is performed on the three samples.

The length of weld is l = 200 mm, the distance from the nozzle surface to the workpiece is 10 mm. Basic material: P265GH dimensions 300x135 x10 mm. Material P265GH is weldable pressure vessel and boiler steel, commonly found in the oil & gas, petrochemical and chemical industry.

Welding consumables: EN ISO 14341-A: 4 G42 M21 3Si1 - G42 4 C1 3Si1 diameter of 1.2 mm.

The design of the experiment are shown in table 3. Wire diameter, current, voltage and welding speed were set constant while the gas flow is varied. The gas flow is changed to control the amount of spatters which occurs during the welding process.

Table 3. Experimental setup for the welding process

No.	wire diameter φ, mm	I, A	U, V	Welding speed v, cm/min	Gas flow f, l/min
I-a	1,2	200	24	45	10
II-a	1,2	200	24	45	20
III-a	1,2	200	24	45	30

Performing of experimental work on a new generation of devices for welding Welbee P500L is shown in Fig. 4.

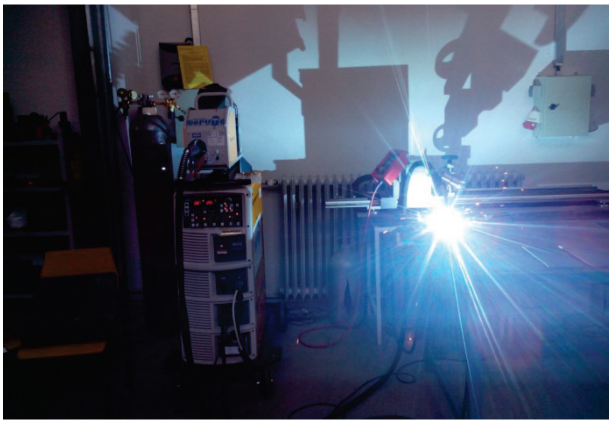

Figure 4. Photo of the experiment

The device has the ability to monitor various parameters during the welding process for the experiment, we used only the record of welding parameters such as welding current (A), welding voltage (V), wire feed speed (m / min).

When analyzing the results of the monitoring of welding parameters took the time period from the first second to five seconds, and the data were recorded every 100 ms.

The data are backed up in the USB flash drive. The USB flash drive to be used should be formatted as FAT32. After data collection data processing is possible in any software package.

The values of the welding parameters after off-line monitoring and analysis of data collected from the device for welding Welbee P500L are shown in the following diagrams.

Figure 5 show diagram of welding voltage distributing during a period of one to five seconds and diagram of welding current distributing during a period of one to five seconds when the gas flow is according to the table 3 was *f* = 10 l/min.

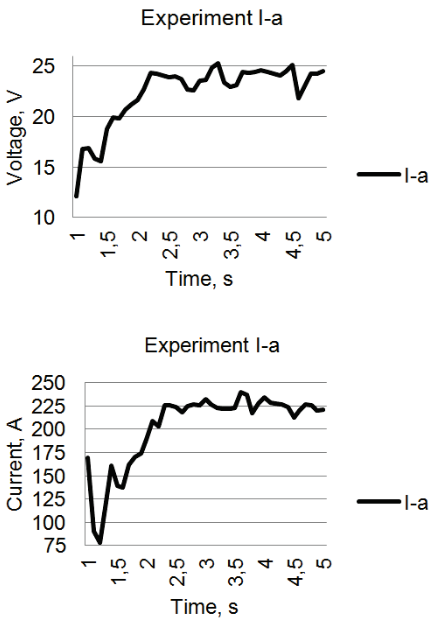

Figure 5. View of voltage and current from the experiment I-a

Figure 6 show diagram of welding voltage distributing during a period of one to five seconds and diagram of welding current distributing during a period of one to five seconds when the gas flow is according to the table 4.1 was *f* = 20 l/min.

Figure 7 show diagram of welding voltage distributing during a period of one to five seconds and diagram of welding current distributing during a period of one to five seconds when the gas flow is according to the table 4.1 was *f* = 30 l/min.

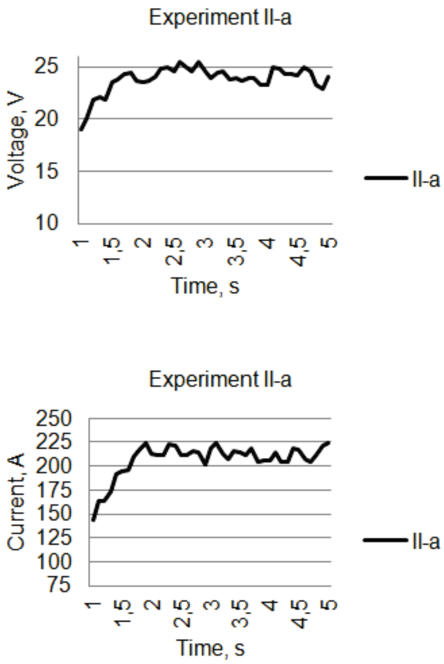

Figure 6. View of voltage and current from the experiment II-a

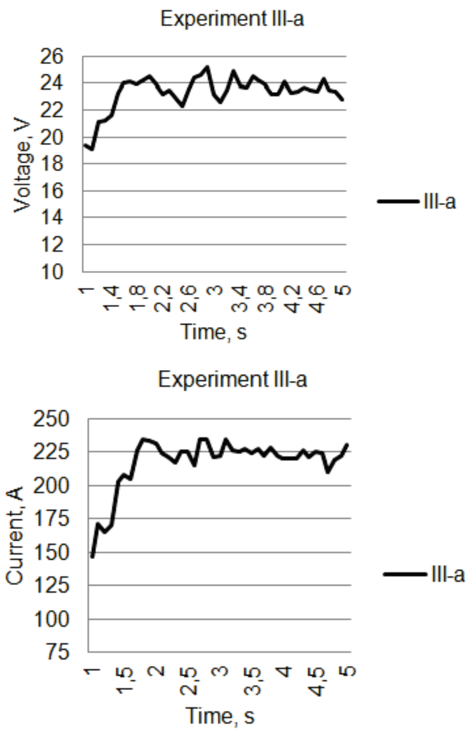

Figure 7. View of voltage and current from the experiment III-a

One of the options system for monitoring the welding parameters are control of the wire feed speede, and on the basis of these data is made diagrams dependence of the wire feed speed and welding current are shown in Figure 8.

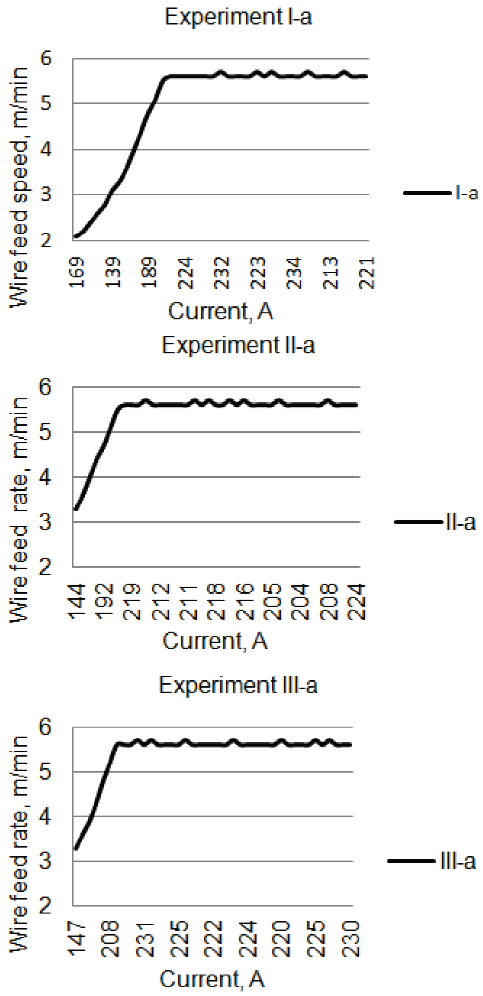

Figure 8. Dependence of wire feed speed and welding current

The on-line monitoring system allows for precise measurement, monitoring and recording of welding voltage *U* (V) and current *I* (A) during the cycle, as well as for off-line analysis of derived values such as [5]:

mean voltage value:

$$\overline{U} = \frac{1}{t_2 - t_1} \cdot \int_{t_1}^{t_2} U(t)dt \quad , \text{V} \qquad (1)$$

mean current value:

$$\overline{I} = \frac{1}{t_2 - t_1} \cdot \int_{t_1}^{t_2} I(t)dt \quad , \text{A} \qquad (2)$$

instantaneous power:

$$P = U \cdot I \quad , \text{W} \qquad (3)$$

instantaneous heat input:

$$E = U \cdot I \cdot t = I^2 \cdot R \cdot t \quad , \text{J} \qquad (4)$$

5. Conclusion

The development of devices for the monitoring of welding parameters went from basic electronic devices ammeter and voltmeter that measure the main parameters of weld, to sophisticated devices that can write data overall top speed of 100,000 per second. Devices that have so far applied for the monitoring of welding parameters demanded huge costs for the introduction of the system, also some of them were not suitable for all welding processes. As the monitoring of welding parameters proved very important in terms of the optimazation of costs, reduction of the number of defects in the weld and in automated and robotized welding processes to reduce the welded joint after-treatment (cleaning spatters) devices have been developed for machines which have as a basic equipment and systems for monitoring the welding parameters. One such device is a new generation of devices for welding Welbee P500L. The device records the data in a simple format that can be a simple way to process and get insight into the main parameters of welding and on the basis of these data could significantly affect the possible errors in welded joints and reduce the cost of welding.

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INFLUENCE OF COLD ROLLING ON ELECTRO-CHEMICAL AND MECHANICAL BEHAVIOR OF 316Ti AUSTENITIC STAINLESS STEEL IN ACID SOLUTION

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Abstract

AISI 316Ti stainless steel is commonly used for the production of construction parts and machines, especially in chemical, petrochemical and pharmaceutics industry, and also for the production of tanks for the transport of aggressive substances. Titanium is added to suppress grain boundary Cr carbide precipitation, and to reduce susceptibility to intergranular corrosion, through the formation of very stable titanium carbide. The stainless steels 316Ti is a general purpose austenitic stainless steel with a face centred cubic structure. It is essentially non-magnetic in the annealed condition, and can only be hardened by cold working. Cold working can, in the case of austenitic stainless steel, cause the formation of deformation induced martensite, which can improve its mechanical properties, but unfortunately can also spoil its good resistance to corrosion The aim of this study is to determine the cold rolling effect on the electrochemical and mechanical behavior of austenitic steel 316Ti in 0.75N H_2SO_4 solution.

Keywords: Austenitic Stainless steels, intergranular corrosion, cold working.

1. Introduction

The austenitic microstructure of metastable stainless steels in annealed condition can partially transform into a martensitic microstructure during cold deformation. The martensite which is formed during cold deformation is important for the mechanical properties of the steel, since it is stronger and harder than austenite [1]. However, the corrosion properties of martensite are poorer than those of austenitic stainless steel – the otherwise good corrosion properties of stainless steels can be spoilt by cold deformation [2]. The mechanism of the deformation martensite influence on pitting corrosion in austenitic steels is not completely understood. Nevertheless, some studies have recently been performed in order to clarify these processes, with emphasis on the determination of the influence of the volume fraction of martensite on corrosion susceptibility [9]. These authors found that, in the microstructure of austenite with partly transformed martensite, the martensitic phase was anodic and sensitive to selective corrosion. Resistance to pitting and general corrosion resistance decrease with an increasing volume fraction of martensite. They suggested that the rapid sensitization of austenitic steel is due to the fact that chromium and carbon diffuse more rapidly in body-centred-tetragonal martensite than in face-centred-cubic austenite.

2. Method

The material that was investigated was the commercially available AISI 316Ti / Z8 CNDT 17- stainless steel. The chemical composition of the investigated material, which was determined by optical emission spectroscopy, is shown in Table1. Before the chemical analysis was performed, the optical emission spectrometer was calibrated by using certified reference material of the same nominal quality.

Table 1. Chemical composition (in wt.%) of austenitic stainless steel AISI 316Ti.

Fe	C	Cr	Ni	Mo	Mn	Ti	S
67,5	0.034	16,52	10,41	2,02	1,690	0.48	0,017

Several specimens with the size of 160 mm X 10 mm X 5 mm were cut from the annealed plates for cold rolling. The multi-pass unidirectional cold rolling was carried out in a rolling mill at ambient temperature. Four percentages of cold reduction were obtained (20%, 40%, 60% and 75%), as shown in Table 2. The rolling ratio is calculated by the following relationship:

$\varepsilon\% = \ln(l0/l)$, where l0 is the initial thickness and l is final thickness.

Table 2 shows the final dimensions of the specimens after each rolling rate.

Table 2. Specimen dimensions after cold rolling.

Rolling ratio (%)	length (mm)	width (mm)	Thickness (mm)
0%	160	10	5
20%	180	10	4.1
40%	213	10.5	3.4
60%	258	11.2	2.8
75%	316	11.5	2.4

For metallographic examinations, several specimens were prepared by grinding using 120, 240, 320, 600, 800, 1000, 2000 and 4000 grits of SiC paper, followed by the final polishing with 3 µm and 1 µm alumina powders, and successively cleaned and rinsed with distilled water and acetone.

Then, the samples were etched by using an aqueous solution (10 ml HNO3 + 30 ml HCl + 30 ml glycerine).

An optical microscope (OM) was employed to observe metallographic structure and an X-ray diffraction analyzer (XRD) was used to verify the metallographic phase.

Microindentation Vickers hardness tests were performed at a load of 10 g using a microhardness Zwick ZH 10 minimum load of 10 g and a maximum load of 10 kg.

These test series are designed to study the influence of cold rolling on the hardness of the substrate.

The electrochemical experiments were performed in a conventional three-electrode cell system with a calomel reference electrode (SCE) and a platinum auxiliary electrode (Pt) the working electrode (316Ti) was anodically polarized from -0.8V vs. SCE to +1.5V vs. SCE at a scan velocity of 1mV/s. During the corrosion tests, the working electrode was immersed in the electrolyte containing 0.75 M H2SO4 at room temperature.

3. Results

Figure 1 is XRD analysis of the 316Ti SS. The microstructure was mainly composed of austenite (γ) and small amounts of δ-ferrite phase (δ).

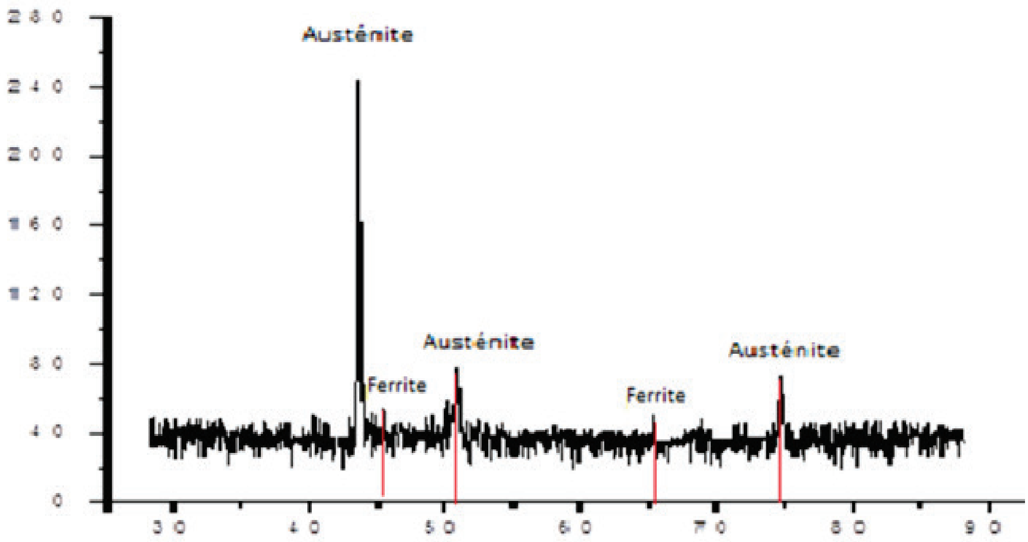

Figure 1. XRD analysis of type 316Ti stainless steel.

Figure (2a, b) shows the results of observations of the optical microstructure 316Ti to its reception state in the transverse and longitudinal direction. These micrograph showing an austenitic structure with a high density of twins, the grain distribution is uniform, the shape is polygonal with apparent grain boundaries. One hand is observed, little difference in grain size between the longitudinal direction and the transverse direction, as shown respectively in the micrographs of figure (2-a, b).

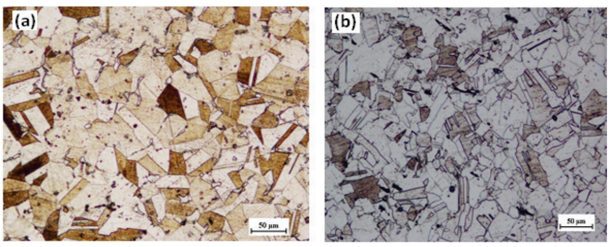

Figure 2. Optical micrograph of type 316Ti stainless steel: (a) in the longitudinal direction and (b) in the transverse direction.

On the other hand, the δ -phase was mainly located at boundaries of the original austenite grains, as shown in Fig. 3. In addition, based on the quantitatively metallographic measurement, the volume fraction of δ-ferrite phase was about 4.2%.

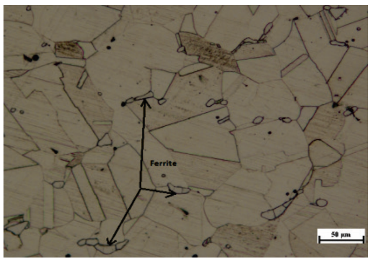

Figure 3. Optical micrograph of type 316Ti stainless steel (arrows show δ-ferrite).

The optical micrographs of AISI 316Ti stainless steel for the cold-rolled specimens are shown in Fig. 4.and Fig.5.

Figure 4 shows the formation of notches and different heights of marches due to the presence of external mechanical stresses which produce changes in the morphology of the surface: heterogeneities make more reactive surface. This is monoatomic steps emergences surface of mobile dislocations occurring in the volume.

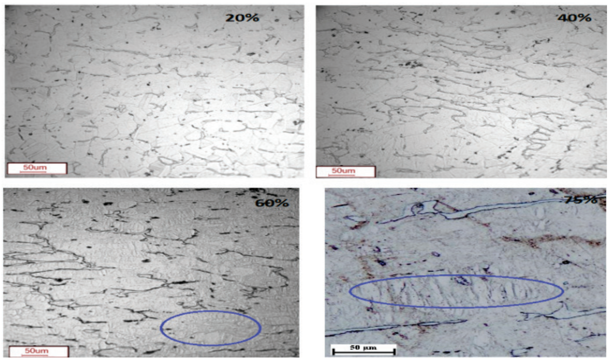

Figure 4. Microstructures of AISI 316Ti stainless steel with different cold reductions.

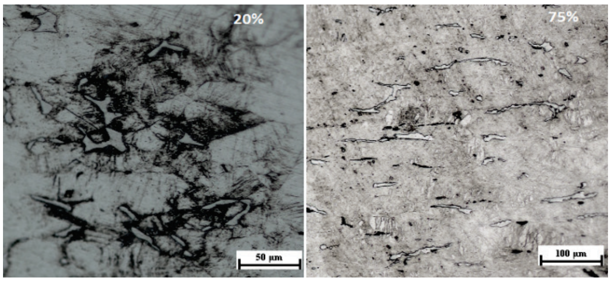

Figure 5. Micrography of sample of AISI 316L with deformation of (a) 20%, and (b) 75%..

Fiure.5 shows the nucleation and the growth of the ά-martensite. At the cold reduction of %20 (Fig. 5a), it seems that the ά-martensite has nucleated on shear bands. It is well-known that shear band intersections can be very effective strain-induced nucleation sites. The shear bands can be in the form of ά-martensite, mechanical twins, or dense stacking fault bundles (Olsen and Cohen, 1972, 1975). In higher deformation levels, the ά-martensite content increases during the deformation below approximately 60%, and then levels off over the reduction. The above results have an agreement with the A. Hedayati, A. Najafizadeh. (2010) observations [3].

Additionally, the δ phase is aligned with the lamination direction and the austenitic grains are more deformed (Fig. 5b).

The microhardness HV results of tests of the different samples obtained are given in Table 3. From Table 3, the microhardness of the non-deformed substrate is 144HV. After deformation of 20%, the microhardness becomes equal to 275HV, is substantially twice the first value.

By increasing the deformation of the substrate the 20% to 40% the microhardness increases, above 40% becomes uniform and it is between 333 and 353HV (Figure 6). These results are in good agreement with those found by A. Hedayati, A. Najafizadeh.

Table 3. Microhardness tests.

Sample	Microhardness HV
Non-deformed	144
20% deformed	265
40% deformed	333
60% deformed	351
75% deformed	353

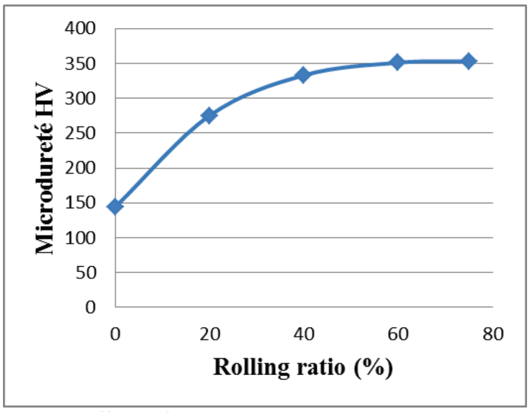

Figure 6. Effect of cold rolling reduction on the Vickers hardness of AISI 316Ti.

The potentiodynamic responses of 316Ti in 0.75M H2SO4 solutions are shown in Fig. 3.

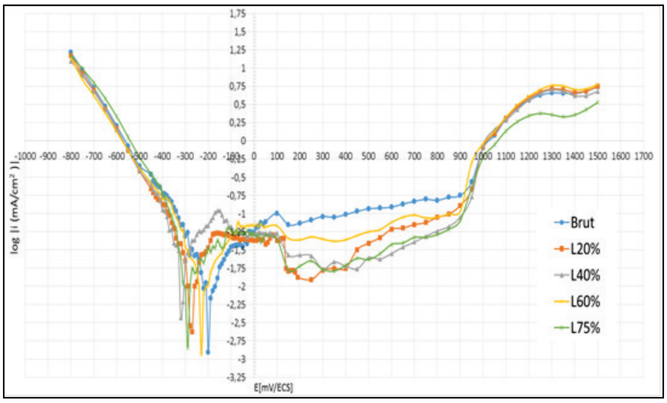

Figure 7. Anodic polarization curves of substrates at different rolling rate.

The anodic polarization curves of 316Ti for the different rolling ratio have the same shape (Fig.7).

The electrochemical parameters (the corrosion potential Ecorr, the corrosion current Icorr and the polarization resistance Rp) were calculated using Corrview software.

The results obtained by the exploitation of the previous curves are summarized in Table 4.

The curves Ecorr, Icorr and Rp as a function of rolling rate are shown respectively in Figures 8.

Table 4. Corr, I corr and R at different rolling rate.

Deformation (%)	ECORR (V/ECS)	ICORR (μA/cm²)	RP (Ω/cm²)
0%	-0,205	6.5	1820
20%	-0,280	9.37	623
40%	-0,319	17.32	814
60%	-0,233	8.25	1357
75%	-0,294	11.36	1125

The cause of the change in potential and current density with cold rolling reduction may be attributed to the effect of the increased dislocation density, and the formation of strain-induced martensite introduced by cold deformation. The curves Ecorr, Icorr and Rp as a function of rolling rate are shown respectively in figures 8.

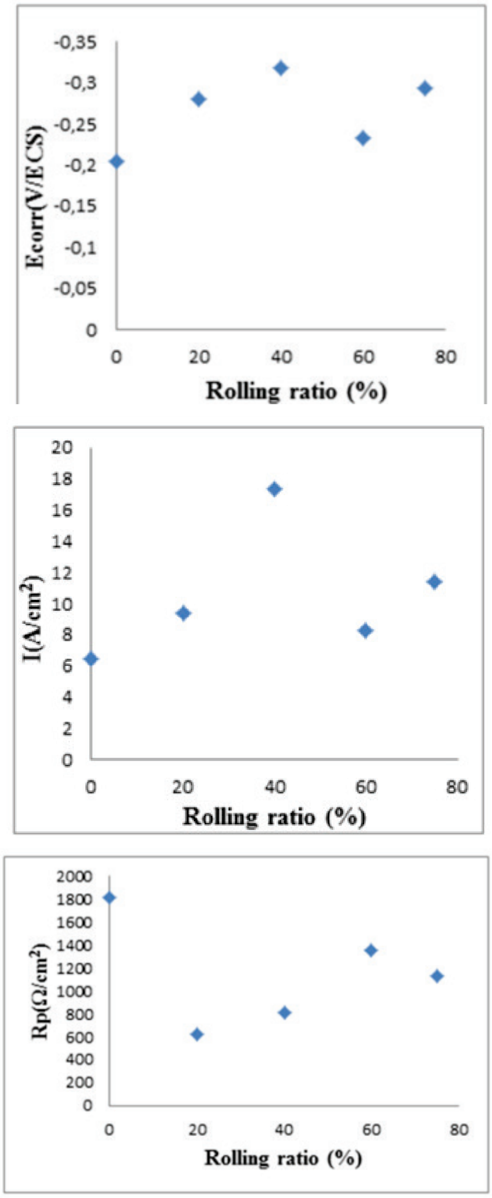

Figure 8. Rolling ratio effect on the electrochemical parameters (Ecorr, Icorr and Rp).

From the results of the voltammetry we have a small decrease of potential and an increase in current density with increasing rolling ratio of 0% to 40%. Hardening associated results in an increase in the dislocation density [3], which are anodic dissolution sites. In addition, a partial transformation of austenite into martensite can lead to formation of local microcells between martensite and austenite. For the higher rolling rate to 40%, we have a small increase in the corrosion resistance, which is due to rearrangement under the effect of the stresses applied to the structure of dislocations [4] and defects of existing structures.

4. Conclusion

In the presence of external mechanical stresses inducing plastic deformation, the changes in the morphology of the surface occur: heterogeneities make more reactive surface. This is monoatomic marches, emergences surface of mobile dislocations occurring in the volume thus forming notches and varying heights of steps. These surface heterogeneities promote a modification of the electrochemical process, the potential of dissolution or adsorption of the oxidizing species. The rupture of the passive film by these emergences lines or surface slip bands exposes the metal to the medium by location, thus promoting the dissolution of the depassivated surface. Plastic deformation mechanisms thus have great importance in the electrochemical reactions as well as hardening the surface conditions [5].

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QUALITY ASSURANCE AT B&H UNIVERSITIES AND THEIR INTEGRATION IN THE EUROPEAN HIGHER EDUCATION AREA

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Abstract

The complexity of higher education institutions' functioning makes the quality concept of their operating multidimensional and dynamic, which, moreover, depends on the social, economic, socio-political context in which these institutions operate. The challenge becomes even greater if one takes into account the fact that the requirements of so-called stakeholder groups with whom universities correspond that are also variable category. External dimension of the quality assurance is consisting of external evaluation and getting implemented by (independent) (inter)national agencies. The process of establishing the national agencies for accreditation and quality development represents articulation of some country's policy. Recognition and credibility of these agencies within the European Network of Quality Assurance Agencies also implies the validity of the issued accreditation. Therefore, these agencies, along with institutions that were awarded with accreditation, are actually the initiator of forming the integral educational area. In Bosnia and Herzegovina this process is still in initial stage, due to the complexity of educational system, legal perplexities and ambiguities. This results in the current legal position and responsibilities of the Agency for the Development of Higher Education and Quality of B&H.

Keywords: Higher education, Bologna declaration, Accreditation, Quality assurance

1. Introduction

In time of rapid change, the ability of organization to learn and adopt good practices with their own vision of changes in accordance with the amending and that builds and maintains good relations with its environment are the basic conditions for its survival. If an organization learns faster than others, then it can be classified as successful. Bologna reform began the process of building a single European area of higher education (EHEA), as a precondition for strengthening Europe's competitiveness and the creation of a knowledge society. The introduction of an explicit system of quality management in universities is one of the focal activities of this reform [3,4]. The common, recognizable and recognized quality standards are the premises for the creation of a single European labor market and success in the global competitive environment [1,3].

The state of Bosnia and Herzegovina, joining the Bologna process, confirmed its commitment to European integration and the inclusion of their higher education systems in EHEA, [5]. At the same time, non-functional and decentralized state [2] took over the complex task of transformation and harmonization of the sector that, otherwise, exist on the margins of B&H. society.

The competent authorities for higher education in B&H, together with higher education institutions have adopted a wide range of commitments within the three main areas of reform:

a) The academic reform. This area includes the development of the national qualifications framework (NQF), reform of the curriculum, the introduction of two-tier system of study and European Credit Transfer System (ECTS) as a measure of student workload, support the strengthening of scientific research and its links with education and economic development, promotion of mobility and international cooperation, internationalization of the study and concept of lifelong learning;

b) Management in higher education. This area includes the democratization of governance: decentralization of decision-making; university autonomy, integration of universities, the development of internal and external dimensions of quality assurance systems;

c) Higher education funding. This area includes diversification of funding sources, the university autonomy in planning and budget management, establishing links between national strategies and priorities for the development of higher education.

Accreditation is a process of recognizing educational institutions for performance, integrity, and quality that entitles them to the confidence of the educational community and the public.

European standards and guidelines for quality assurance (ESG) are the basic parameters for the creation and development of quality assurance systems throughout Europe. They describe the conditions for quality assurance at the level of higher education institutions (internal quality assurance, the first part of ESG), and at the level of the agency and the quality assurance system (external quality assurance, the second part and the third part of ESG).

Application of ESG largely depends on the provisions contained in the national legal framework. Experiences in different European countries show that domestic legislation can facilitate the development of quality assurance that is aligned with the ESG, but they can also make it difficult changes.

2. New relationship between government and higher education

One of the most complex challenges for the state of Bosnia and Herzegovina and its universities refers to the redefinition of relations between the state and higher education institutions. This is also the starting point for the reform according to Bologna principles! As a first, it is necessary to make a new determination of roles and responsibilities in its higher education system.

The most important aspect of new relations between education authorities and universities implies decentralization of decision-making and responsibility in order to allow universities to develop a flexible and integrated institutions. The new role of universities in society implies their functioning as institutions that are able to independently decide on their own profile, strategy, vision, mission, and institutional policies. Universities should, accordingly, be able to adapt quickly to the needs of society and their own maintenance in balance with the environment.

New, changed relations between 'state' and universities reduce responsibility of education authorities to define the framework within which universities have the right to self-determination. This framework includes, first of all, the structuring of educational policy, defining the legal framework, legal supervision, construction quality assurance system, financial planning and investment in higher education. In this way, universities in B&H could be given the status of national institutions with a high degree of control and academic autonomy, which would be balanced with their responsibility for the quality of higher education.

The construction and establishment of the higher education system capable to take over the role of the key initiators and carriers of positive changes and progress of B&H society should be the result of expending great effort and knowledge that this reform undoubtedly requires. In this system, autonomous universities would have the status of social institutions of strategic character and significance. Through its action on achieving excellence results in various fields of science and education, on the one hand, and the pragmatic contribution to solving problems in different sectors of society and meeting the immediate needs of the labor market, on the other hand, universities stimulate and contribute to the overall development of B&H and the prosperity of its citizens .

The reality in B&H, however, is different. Due to the bad and the specific social, political and economic situation in our country, declarative commitment to reform was not accompanied by the will of the political elite that is primarily political, then the legal and material support. Universities in Bosnia and Herzegovina are also left without the necessary preconditions for the consistent implementation of the reform agenda.

This attitude has led the B&H public universities in the state of pressure due to exposure to the legitimate expectations of the public and students on the one hand and the inability of the university to own answers to many open questions and unresolved problems to date in the implementation of reforms, on the other hand.

3. Fragmentation and ideology of higher education

According to Bloom [6], in front of each university, before embarking on any reform of higher education, is the key question: what kind of human beings we want to produce our education system? An education system ... wants to produce a certain type of human being ... it is always an important political regime which requires citizens who are in line with its fundamental principle, [6, p. 26].

Prof. Mujkic, [8], has considered that in most cases, when it comes to public universities, higher education is still expected to perform the task of ideological guardians of national identity, the task of which is supported by the trend of decentralization of universities, which is complementary to the general epidemic of political ethnicization. If that were not the case, then it would be very easy to reach an agreement regarding the implementation of the Framework Law of Higher Education in Bosnia and Herzegovina (FL). Also, today we would have a single, uniform quality of the B&H higher education and effective agency for accreditation, [8, p. 44].

General experience with all previous institutional reforms of higher education, reveals that the cause of their failure lies in the authoritarian political framework within which they taken place, whether it is a communist or ethnic authoritarian framework.

What should be avoided in the future, is that ideology is the initiator and ultimate purpose of scientific research? Speaking of the past / present, it is the provision of intellectual support in the form of founding of the ruling ideology of communism and nationalism. But when it comes to the future, it's about avoiding taking ideological matrix of neoliberal universities that acts on the so-called knowledge market, [7, 9].

So, the key question emerging from the crisis of universities - in fact, the question of the struggle for true academic freedom that has never been achieved in this area in the full sense. The academic freedom of universities indicates the level of maturity of civil society. Only one such university brings real social benefit. A society that is willing to pay a provocative critical thinking. The question of all questions, when we talk about the reform of universities, is: are we ready to pay such a 'luxury'?

4. Accreditation of institutions of higher education in B&H

The process of accreditation of higher education institutions in Bosnia and Herzegovina, as one of the fundamental areas of reform, represents a new paradigm for all parties (higher education institutions, the competent education authorities, legislators, academics, students). In this way, the development of higher education puts a new focus, with valid state policy of higher education harmonized with European reform process set out in the document Magna Charta Universitatum. At the same time, the development of the national quality management system, which will ensure continuous improvement of higher education, is a prerequisite for achieving the key ideas of the European Union – the creation of a knowledge society.

The existing legislative framework in B&H, which addresses the procedures of accreditation and quality standards, due to shared responsibilities and the lack of consultation between relevant actors is incomplete and not harmonized. Access to the problem of systematic development and quality assurance, then the establishment of common procedures for accreditation and licensing of higher education in some cases has even resulted in a misrepresentation of some parts of the process, incorrect understanding of the concepts, and even the roles and responsibilities.

Because of that, instead of the development of quality higher education in B&H in the context of its harmonization with European standards and achievements, its harmonization with the dysfunctional administrative organization of the state is going on.

The process of reorganization of the field of quality assurance in Bosnia and Herzegovina should consist of two steps: put an end to the fragmentation of external quality assurance and develop a coherent national system of external quality assurance.

Based on the facts and information gathered during the inspection of relevant legislations, it is possible to conclude that the relevant legislation (in particular the Framework law, law on entity levels, cantonal laws and law of Brcko District) and accompanying documents do not provide sufficient information and instructions for making and documenting a clearly defined process of accreditation.

Inconsistent laws at different levels with the Framework law of higher education reflected on the inconsistency of legal provisions relating to the definition and implementation of accreditation process.

Originally planned harmonization of all laws with FL was to be completed within six months after the adoption of FL, which however has not happen. This inconsistency in the legislative provisions preventing production of uniform accreditation process in B&H, which largely affects the accreditation and has already led to many ad hoc solutions.

Present inconsistencies and inaccuracies in the regulations (e.g. criteria for nomination and appointment of committee of experts, who are appointed by the experts, who organizes visits to specialists, who pays them) lead to misunderstandings regarding the competence of actors in the process of accreditation. This raises the question of the independence of experts if nominated by the executive founders of the university that they need to apply for accreditation, as stated above. Moreover, this situation hinders the establishment of a transparent and efficient process of accreditation.

5. Conclusion

Complex constitutional structure of Bosnia and Herzegovina is fully reflected in the field of higher education. Due to different legal provisions related to the submission of an application for accreditation, there is no clear answer to the question of which body in B&H is responsible for accreditation. In particular cases cantons which provide for the submission of the application to different bodies, i.e. Agency or the Ministry of Education, shows that the situation is not clear regarding the main responsibility.

The realization of the project of reform of the system of higher education implies adequate political support, without which the success and achievement of the agreed goals is not possible. The best example of such a situation is the current position of the Agency for development of higher education and quality assurance of B&H, whose work is practically reduced to unimportant affairs in accreditation process.

Despite the existence of the state agency in charge of accreditation of universities in B&H, the absence of political will to organize the area of higher education, has resulted in numerous problems, contributing to further complicate reform of the B&H higher education system.

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FRICTION STIR WELDING OF BMG'S: A REVIEW

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Abstract

Bulk metallic glasses (BMGs) have been formed in numerous types of alloy systems, since Au75Si25 alloy was the first amorphous alloy using a rapid solidification method in 1960. Bulk metallic glasses (BMGs) have tremendous properties including good wear resistance, high strength, corrosion resistance, good magnetic properties, good forming ability, etc. Consequently, BMGs are currently of interest as next generation materials and active research of BMGs are in development. In the past few years, joining of BMG's by different welding methods has been tried by various researchers globally so that the practical application of these unique materials may be widen. Welding of the BMG to crystalline metal or alloy is expected to further widen the application areas of the BMG's. The aim of this review paper is to exhibit and focus previous research, similar or related to this topic carried out by various researchers and also to develop a basic understanding to BMG's and Friction Stir Welding process. This present review paper also provides a basis for the industrial practitioners and researchers to search further new alternatives regarding the Friction stir welding of BMGs.

Keywords: Bulk Metallic Glasses, amorphous alloy, Friction Stir Welding, crystalline metal.

1. Introduction

BMGs were first discovered by Duwez of California Institute of Technology by rapid solidification of Au75Si25 alloy in 1960. Since then BMGs have been developed in various kinds of alloy systems and have been drawing great attention because of their unique properties, such as high strength, high elastic limit, superplasticity, good wear resistance, superior corrosion resistance. To enhance their use as structural material, a method of joining BMGs that will not change their amorphous state is needed [1]. To extend the engineering applications of BMGs, welding technologies need to be developed. Furthermore, in order to better integrate the metallic glass components into the structure of machines or other products, the possibility of joining metallic glass with itself or crystalline materials is desirable. Recently, many welding methods have been tried to join BMGs with themselves or crystalline materials, and they can be classified into two types. One is liquid phase welding method, such as laser welding, electron beam, pulse current, etc. In these methods, the temperature in the nugget is higher than the melting point of work-pieces, which will inevitably induce the crystallization from the amorphous structure or the change of chemical composition in the metallic glass. Another is performed in a solid state, which includes friction stir welding, explosion welding and diffusion welding etc. In these methods, the temperature rise is relatively low and an excellent metallurgical joining can be obtained without any crystallization in the BMGs [2]. Because FSW can be performed below the liquidus temperature of workpiece, it has a strong potential for the joining of BMGs [1]. Friction stir welding (FSW) is a new solid-state joining technology invented at the welding institute (TWI) in 1991 [3]. The basic concept of FSW is remarkably simple. A non-consumable rotating tool with a specially designed pin and shoulder is inserted into the abutting edges of sheets or plates to be joined and traversed along the line of joint (Fig. 1). The tool serves two primary functions: (a) heating of workpiece, and (b) movement of material to produce the joint. The heating is accomplished by friction between the tool and the workpiece and plastic deformation of workpiece. The localized heating softens the material around the pin and combination of tool rotation and translation leads to movement of material from the front of the pin to the back of the pin. As a result of this process a joint is produced in 'solid state'. Because of various geometrical features of the tool, the material movement around the pin can be quite complex. [4, 5] As compared to the conventional welding methods, FSW consumes considerably less energy. No shielding gas or flux is used, making the process environmentally friendly [5].

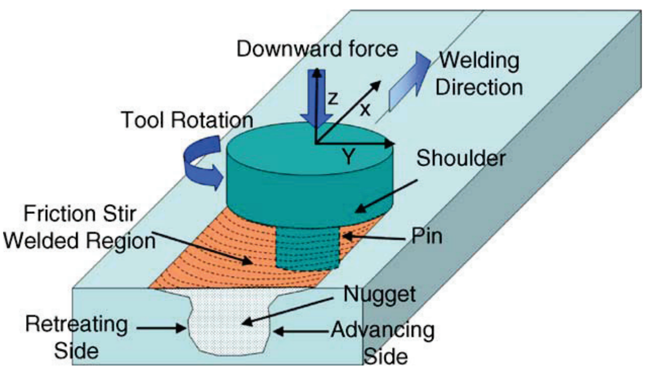

Figure.1. Schematic drawing of friction stir welding. [4, 5]

2. Friction Stir Welding of BMG´s:

Wang el al. (2008) successfully joined Zr55Cu 30Al10Ni5 bulk metallic glass (BMG) 1.7 mm thick and Al–Zn–Mg–Cu alloy plates by FSW, producing defect-free BMG–Al joints. According to his work plates of Zr55Cu30Al10Ni5 BMG 1.7 mm thick and 7075-T651 aluminum alloy with a composition of Al–5.6Zn–2.5Mg–1.6Cu–0.23Cr (wt.%) were friction stir butt welded at a welding speed of 200 mm min^{-1} and a tool rotation rate of 600 rpm. The tool used had a shoulder 12 mm in diameter and a cylindrical pin 4 mm in diameter and 1.5 mm in length. The BMG was put on the advance side and the 7075 alloy on the retreating side. The tool pin was offset into the aluminum side with only 12.5% width of the pin in the BMG side during welding.

Figure 2 (a) shows a typical cross-sectional macrograph of the FSW BMG–7075 alloy joint. No defects were detected in the joint, indicating that the sound joining was achieved between the BMG and 7075 alloy by FSW. There was a clear interface between the BMG (the white zone on the advancing side) and the 7075 alloy (the gray zone on the retreating side). However, some particles of the BMG were detected in the 7075 alloy side near the interface, indicating that part of the BMG was broken into the particles and stirred into the aluminum matrix in the NZ during FSW.

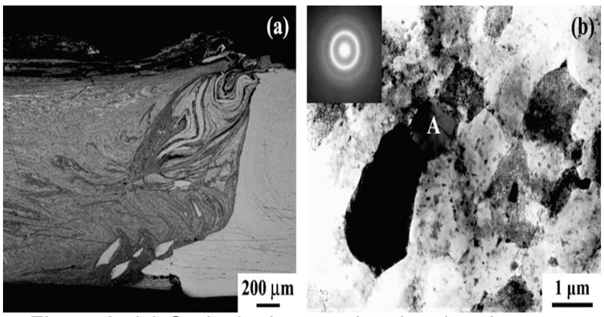

Figure 2. (a) Optical micrographs showing the cross-section across the interface of FSW BMG and 7075 alloy, and (b) a TEM image showing fine grains and BMG particles in the 7075 side near the BMG–alloy interface (inserted micrograph shows diffraction pattern of zone A). (D. Wang el al. 2008)

Figure 3 illustrates the X-ray diffraction patterns of BMG, 7075 alloy and joint. The as received BMG is an amorphous alloy, as shown by curve a. By comparison, the 7075 alloy is characterized by the diffraction peaks of the aluminum and the metastable phase of g0 (MgZn2) (marked by the solid circle in curve c), the main strengthening precipitate in 7075-T651 aluminum alloy. For the FSW BMG–7075 alloy joint, as shown by curve b, in addition to the peaks of both the BMG and the 7075 alloy, no other peaks were detected, indicating that no crystallization of the BMG or reaction between the 7075 alloy and the BMG happened during FSW.

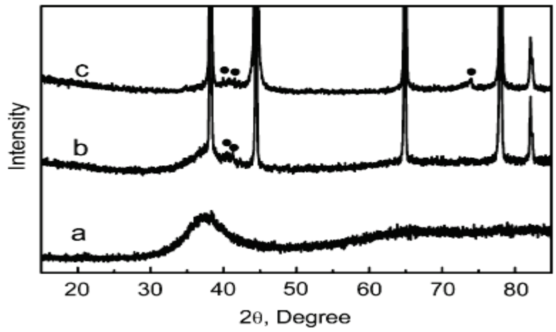

Figure 3. X-ray diffraction pattern of (a) BMG, (b) cross-section of joint, (c) 7075 alloy. (D. Wang el al. 2008)

Figure 2(b) shows the TEM image of the NZ in the aluminum side near the interface. The grains in the NZ were equiaxial with a size of about 1–2 μm, which is much smaller than that (about 100 μm) of the base material. Intense deformation during FSW resulted in the recrystallization in the NZ, thereby refining the grains. Some small particles were detected in the NZ (marked as A in Figure 1b). Energy diffraction spectrum (EDS) analyses showed that this particle was a Zr-rich phase containing 38% Zr, 23% Cu, 4% Ni, 28% Al and 7% Zn (wt. %). The insert in Figure 2 (b) is a diffraction pattern of particle A, which is a typical amorphous diffraction pattern. This indicated that particle A was scraped from the BMG and stirred into the NZ in the welding process and still maintained the amorphous structure. Furthermore, no reaction product was detected on the interface between particle A and the 7075 alloy. This indicated that no obvious reaction occurred between the BMG and 7075 alloy during FSW.

Figure 4 illustrates the hardness profile of the joint on the 7075 alloy side. The zero point denotes the interface of the two materials and the distance from the zero indicates the interval from the tested point to the interface. The hardness of the FSW BMG–7075 alloy joint was lower than that of the 7075-T651 base alloy (˜180 Hv). The ultimate tensile strength of the joint is 423 MPa and reaches up to 74% of the 7075-T651 alloy. The joint efficiency is close to that (75%) for the FSW 7075-T651 joint. The joint failed in the NZ on the aluminum side, ˜1.6 mm from the BMG–7075 alloy interface (not shown). This indicates that the bonding strength of the interface between the BMG and 7075 alloy was excellent.

SEM micrographs of the tensile fracture surface of joint are shown in Figure 5. In the macrograph, some huge particles were observed on the fracture surface, as shown by points A and B in Figure 5a. EDS analyses indicated that point B contained 57% Zr, 15% Cu, 3% Ni, 24% Al and 1%Mg (wt. %). Similarly, other particles on the fracture surface were also determined to be Zr rich particles. A magnified view of region B marked in Figure 5a is shown in Figure 5b, and for the purpose of comparison, the same region on the other side of the failed tensile specimen is shown in Figure 5c. From Figure 5b and c it is clear that the BMG particles in the NZ, which were stirred to the aluminum matrix during FSW, were fractured in the tensile process. And finally while summarizing their study, the following conclusions are reached:

(1) A defect-free FSW Zr55Cu30Al10Ni5 BMG and 7075-T651 alloy joint was successfully achieved by offsetting the pin to the aluminum side.

(2) The NZ consisted of fine recrystallized aluminum grains with some BMG particles being stirred into the aluminum matrix. No crystallization of the BMG and reaction layer around the BMG particles and between BMG/aluminum interfaces were detected.

(3) The strength of the FSW BMG–7075 alloy joint reached up to 74% of the 7075-T651 alloy with the joint failing in the NZ on the aluminum side, indicating that while the interface between BMG and 7075 alloy had an excellent bonding, the large BMG particles in the NZ reduced the strength of the joint somewhat [6].

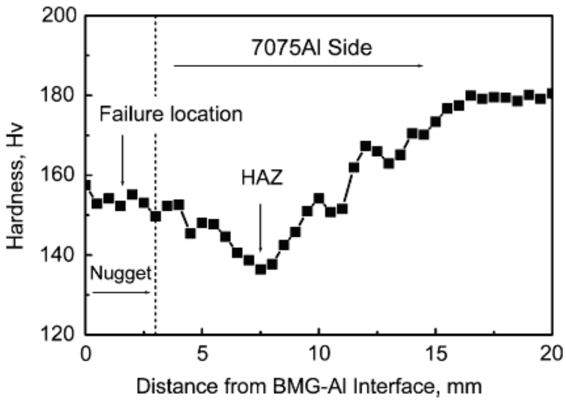

Figure 4. Hardness profiles of FSW BMG–7075 alloy joint in the 7075 side. (D. Wang el al. 2008)

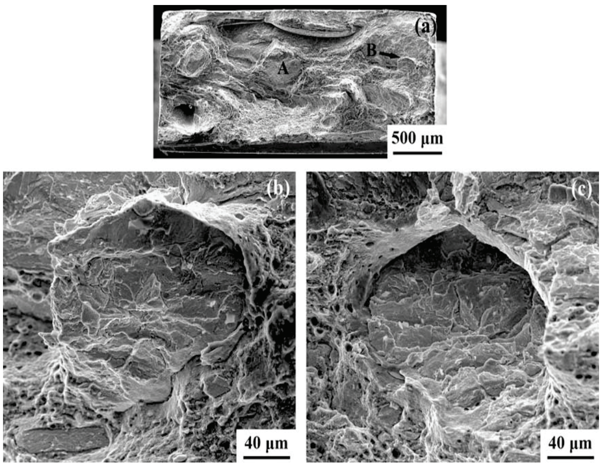

Figure 5. SEM image showing tensile fracture surfaces of FSW joint: (a) macrograph of fracture surface, (b) magnified view of zone B in (a), and (c) the same region as in (b) from other side of a failed specimen.

Ji et al. in their study successfully welded a Zr55Cu30Al10Ni5 bulk metallic glass plate below its crystallization temperature by FSW. The angle of the recessed shoulder surface for their study was 3°. They also used a wider tool to minimize the flash formation and heat concentration at the shoulder edge. The microstructure and mechanical properties were analyzed by them using DSC, XRD, TEM, and microhardness to analyze the crystallization of the base material and stir zone.

Figure 6 shows surface appearances of the stir-in-plate specimens of Zr55Cu30Al10Ni5 bulk metallic glass obtained at different rotation speeds. When the rotation speed is 60 rpm defects are formed on the surface, as shown in Figure 6(a), because the heat input is not sufficient. When the rotation speed is between 80 rpm and 170 rpm, large defects and cracks are not formed in the stir zone, as shown in Fig. 6(b), (c) and (d).

Figure 7 shows XRD patterns of the stir zone of stir-in-plate specimens. When the rotation speed is between 80 and 150 rpm, XRD patterns of the stir zone shows typical broad patterns. This result confirms that the temperature of the stir zone during the stir-in-plate welding was below the crystallization temperature. However, when the rotation speed is 170 rpm crystallization behavior is observed in the XRD spectrum of stir zone. In this case, the welding was performed in a short period. Accordingly, the temperature of the stir zone during the stir-in-plate welding was estimated to be about above the crystallization temperature.

Figure 8 shows the hardness distribution on a cross section perpendicular to the welding direction of the stir-in-plate specimens. There is no significant change the in hardness between the base material and the stir zone when the rotation speed is between 80 and 150 rpm, as shown in Figure 8. The average value of the hardness in the base material and stir zone is 523 HV.

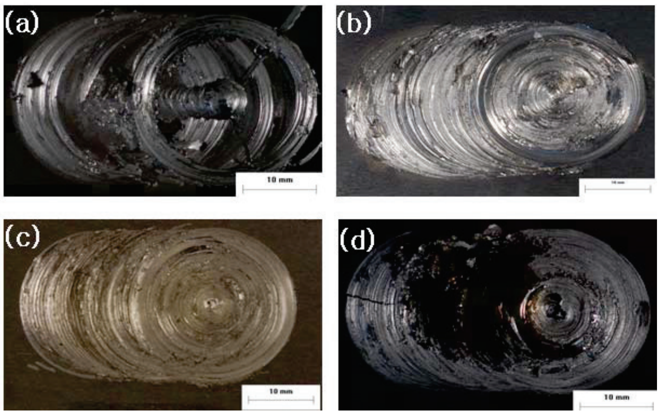

Figure 6. A microscopic overview of the stir zone in Zr55Cu30Al10Ni5 bulk metallic glass: (a) 60 rpm, 100 mm/min, (b) 80 rpm, 100 mm/min, (c) 150 rpm, 100 mm/min, and (d) 170 rpm, 100 mm/min. (Ji et al. 2009)

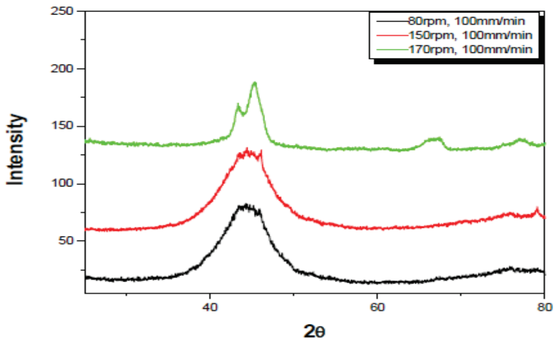

Figure 7. X-ray diffraction patterns of the stir zones obtained at different welding speeds. (Ji et al. 2009)

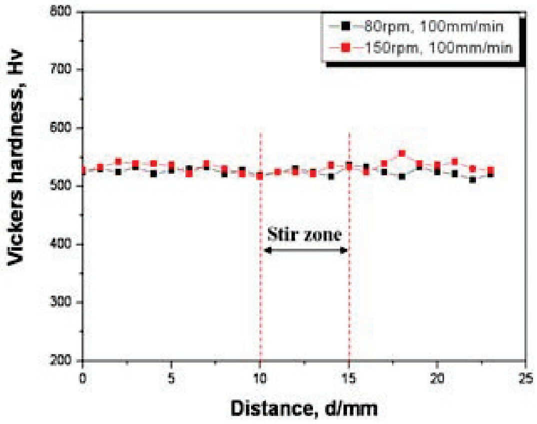

Figure 8. The hardness distribution on a cross section perpendicular to the welding direction. (Ji et al. 2009)

Figure 9 shows DSC results of the base material and stir zone of the stir-in-plate specimens obtained at a 0.33 K/s heating rate. The glass transition temperature (Tg), the crystallization temperature (Tx) and the super-cooled liquid region range (ΔT=Tx-Tg) are about 680, 750 and 70 K, respectively. As shown in Figure 9, the exothermic peaks are clearly observed without any shift in Tg and Tx. These values are similar to that of the base material.

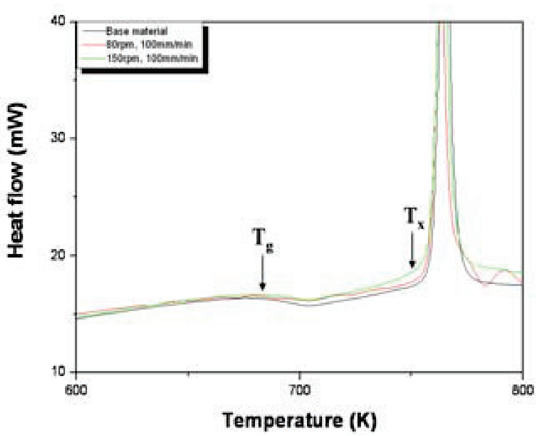

Figure 9. DSC (heating rate=0.33 K/s) of the base material and the stir zone. (Y S Ji et al. 2009)

Figure 10 shows bright-field TEM images and corresponding selected-area-diffraction (SAD) patterns of the base material and the stir zone in the stir-in-plate specimens at 150 rpm. As shown in Figure 10 (a) and (b), no nanocrystalline particles were observed in the bright-field images of the base material or the stir zone. It is recognized from this TEM result that the base material and stir zone are homogeneous and amorphous at 150 rpm.

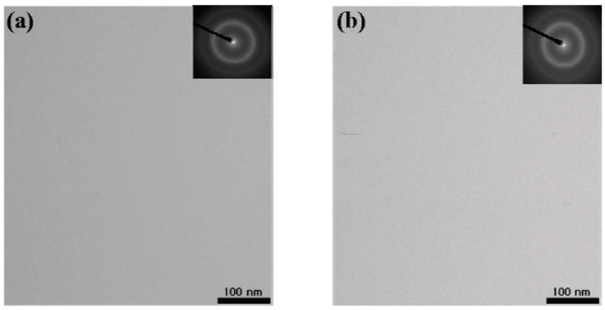

Figure 10. TEM images of stir-in-plate specimens at 150 rpm: (a) base material and (b) stir zone. (Ji et al. 2009)

Figure 11 shows surface appearances and the possible range of the stir-in-plate of Zr55Cu30Al 10Ni5 bulk metallic glass specimens of 2 mm thickness. At a rotation speed of 80 rpm, defects are formed on the surface because the heat input is not sufficient. At rotation speeds between 100 rpm and 150 rpm, no large defects or cracks are formed in the stir zone as shown in Figure 11. However, the possible welding range for the 2 mm plates is narrower than that for the 1 mm plates because a higher heat input is necessary for thicker plates.

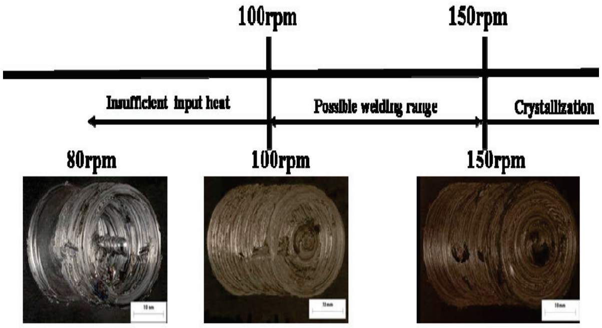

Figure 11. Possible welding range and surface appearance for 2 mm thick Zr55Cu30Al10Ni5 bulk metallic glass. (Ji et al. 2009)

Finally, on the bases of the above stated tests the microstructure and mechanical properties of welded joints were analyzed. It was found that the amorphous structure and original mechanical properties were maintained [7].

Y Sun et al. successfully joined Zr55Cu30Al 10Ni5 bulk metallic glass (BMG) plate and pure copper plates with 2mm in thickness by friction stir butt welding. The BMG plates were friction stir butt welded with a welding speed of 100mm/min and a tool rotation speed of 400 rpm. The coated WC tools were used, which had a shoulder of 12 mm in diameter and a cylindrical probe of 4 mm in diameter and 2 mm in length. During the FSW process, the BMG was put on the advancing side and the pure copper on the retreating side. Fig. 12 shows the details of the tool and work-piece positions during the welding process.

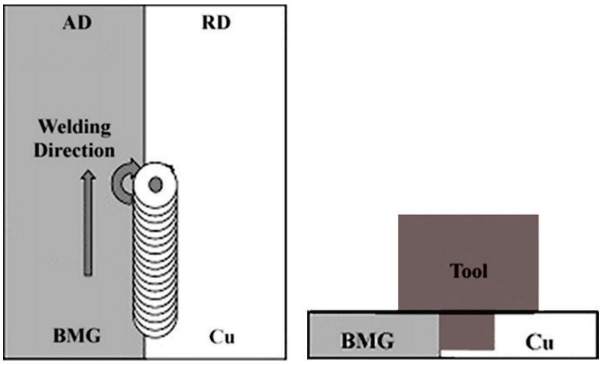

Fig. 12. Schematic illustration showing the tool and work-piece positions during the FSW process. (Yufeng Sun et al.2010)

Figure 13 presents the OM images showing the cross-sectional microstructure of the FSW BMG/Cu joint. From Fig. 13(a), a clear interface can be observed in the stir zone so that the two different materials can be easily distinguished, namely the BMG on the left side and pure copper on the right side of the interface. No weld defects like grooves or cavities can be detected within the entire stir zone, indicating that a sound welding was obtained between the BMG and pure copper by FSW. All the BMG fragments with size less than 100µm and most of the blocky BMG fragments with size larger than 100µm formed a clear interface with the copper matrix, which were shown in Fig. 13(b) and (c) as typical examples. While for some blocky BMG fragments, some micro-voids can be observed and was indicated by a black arrow in Fig. 13(d).

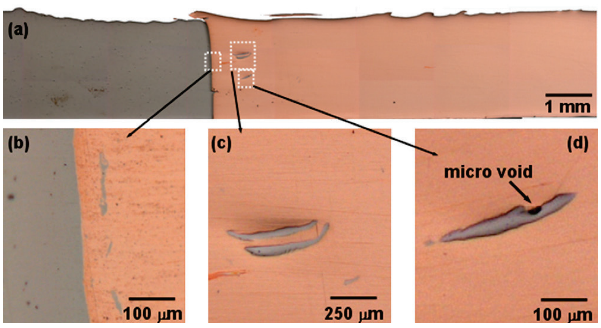

Fig. 13. OM images showing the (a) cross-sectional macrostructure of the stir zone perpendicular to the welding direction, (b) small and (c) blocky BMG fragments with smooth surface, and (d) blocky BMG fragments with micro-void. (Yufeng Sun et al.2010)

Figure 14 shows the XRD patterns measured at the BMG/Cu interface in the stir zone. The XRD curve exhibits a superimposition of several sharp peaks characteristic for crystalline phase on a broad halo peak from the amorphous phase, indicating the existence of a mixture of the amorphous and some crystalline phases. After indexing, the position and the intensity of the sharp crystalline peaks match exactly with that of pure copper. No other phases can be detected within the sensitivity limit of XRD. This result indicates that neither chemical reaction between the two materials nor crystallization from the amorphous phase took place during the entire FSW process.

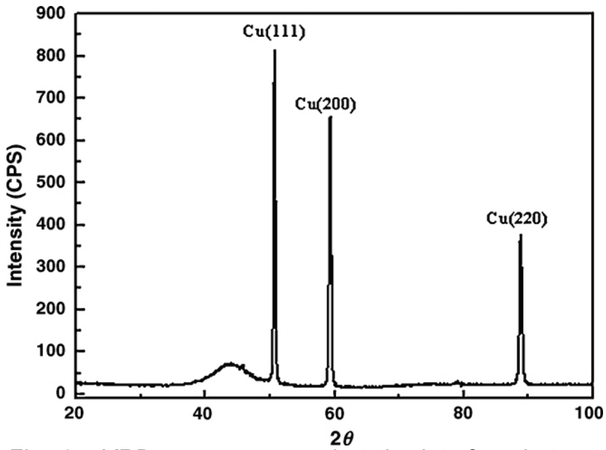

Fig. 14. XRD curve measured at the interface between the BMG and the copper plate. (Yufeng Sun et al.2010)

Figure 15 shows the EBSD orientation map obtained along the BMG/Cu interface of the FSW processed sample. The enclosed rectangle area indicated in Fig. 15(a) was scanned for EBSD measurement, which included a small area of BMG and the copper plate in the joint. At the same time, some BMG fragments can be found emerged from the copper plates because the copper was electro polished when preparing the EBSD samples. In the EBSD maps shown in Fig. 15(b), the black area on the left side indicated the BMG side, because no Kikuchi pattern can be obtained from the BMG due to its disordered atomic configuration. The right side is the copper plate, which shows equiaxial structure from the EBSD observation. It was found that the copper close to the BMG/Cu interface revealed a very refined equiaxial grain structure.

Figure 16 shows the TEM image revealing the detailed microstructure of BMG/copper interface in the welded joint. Similar with the morphology in the OM image in Fig. 13(a), a clear interface without any intermetallic compounds can be found between the different materials, namely the BMG side in the left and copper side in the right. The BMG side still keeps its homogeneously amorphous structure, which can be confirmed by the corresponding selective area electron diffraction (SAED) pattern inserted in the left bottom corner in Fig. 16.

While on the copper side, a transitional microstructure from elongated to equiaxial grain structure formed when departing from the BMG/Cu interface. The elongated copper grains distributed parallel with the BMG/copper interface, together with some gray strips with no contrast inside. The gray strips can be identified as metallic glass by the broaden diffraction ring pattern inserted in the right upper corner in Fig. 16.

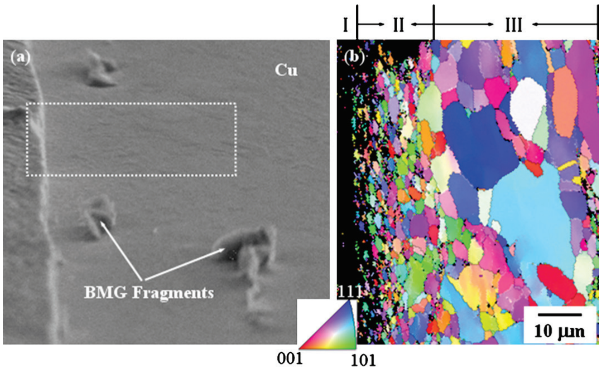

Fig. 15. (a) SEM images showing the area for EBSD measurements and (b) EBSD map obtained at the interface between the BMG and the Cu plate (I, BMG area; II, refined equiaxial area; III, coarse equiaxial area). (Yufeng Sun et al.2010)

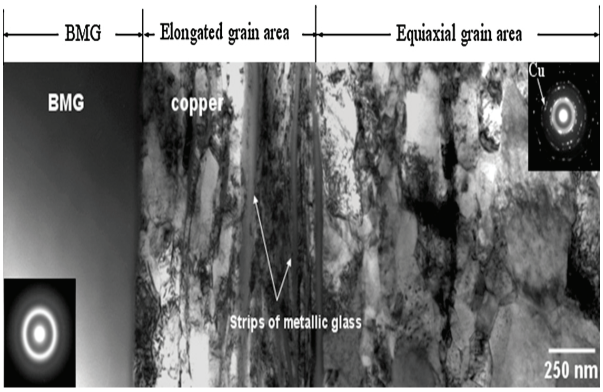

Fig. 16. TEM image showing the microstructural transition across the BMG/Cu interface. (Yufeng Sun et al.2010)

Figure 17 shows the TEM images of the microstructure of copper side in the stir zone, in which a large BMG particle was found embedded in the copper matrix. The BMG particle has a generally smooth surface and still remains its amorphous structure. No transition layer or reaction layer was found at the BMG/Cu interface.

Figure 18 shows the hardness profile of the stir zone across the BMG/Cu interface. The zero position denotes the interface between the two different materials. On the left side to the zero position, the hardness is about 545 HV, which exhibits the intrinsic high strength of BMGs. However, the hardness suddenly drops down to 80Hv around the zero position, i.e., the BMG/Cu interface. While in the stir zone away from the interface, the average hardness decreased further to about 70 Hv.

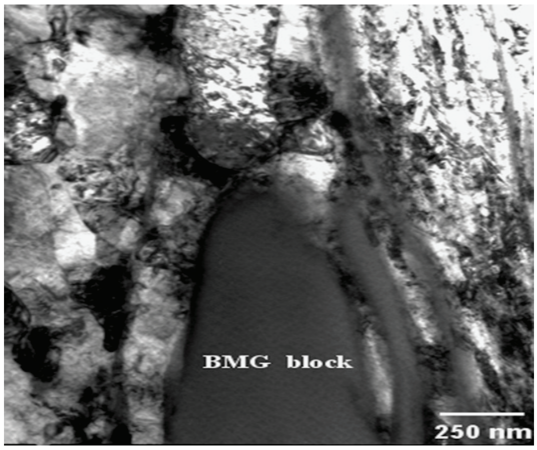

Fig. 17. TEM image showing that the metallic glassy block mixed into the Cu part. (Yufeng Sun et al.2010)

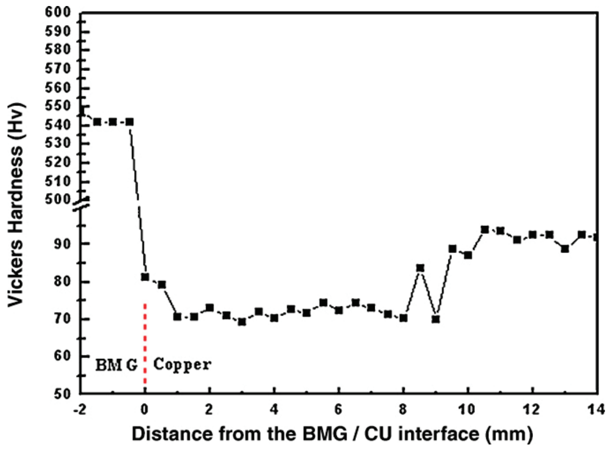

Fig. 18. Hardness profile in the stir zone across the BMG/copper interface. (Yufeng Sun et al.2010)

The tensile tests were carried out to evaluate the mechanical properties of the BMG/Cu joint. Three strain–stress curves were shown in Fig. 19 as a typical example. The strain–stress curves were moved from their original position for clarity. From the curves, the ultimate tensile strengths of the welded specimen are similar after each test and ranged from 240 to 253 MPa, which is a little lower than 266MPa of the pure copper used in this study. That is, the ultimate tensile strength of the BMG/Cu welded joint can reach from 90% to 95% of the base pure copper. From the appearance of two fractured sample inserted in Fig. 19 as typical examples, the tensile specimen usually fractured on the copper side in the stir zone, however, very close to the BMG/Cu interface. The locations of the fracture on one hand confirmed that the bonding of the BMG/Cu interface was excellent and stronger than the stir zone.

Figure 20 shows the SEM image of the fracture surface of the joint after tensile tests. From the macro-view of the fractured plane as shown in Fig. 20(a), no obvious BMG particles or fragments can be observed. However, from the SEM images at high magnification, some BMG particles as indicated by arrows in Fig. 20(b) and some strip-like BMG fragments as indicated by arrows in Fig. 20(c) can be observed. It confirmed that the location where the BMG fragments aggregated is the weak place in the BMG/Cu welded joint.

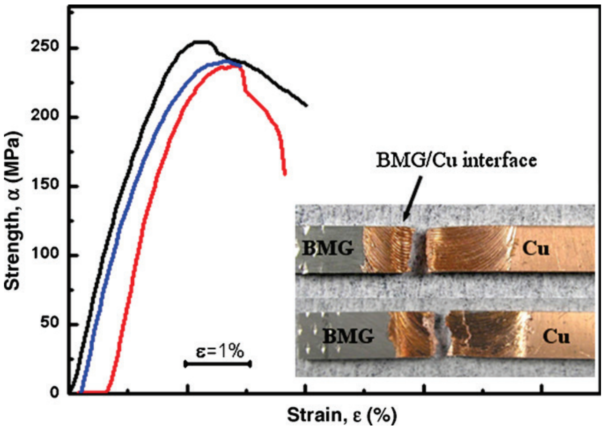

Fig. 19. Tensile strain–stress curve of BMG/Cu joint with the fractured specimen inserted. (Yufeng Sun et al.2010)

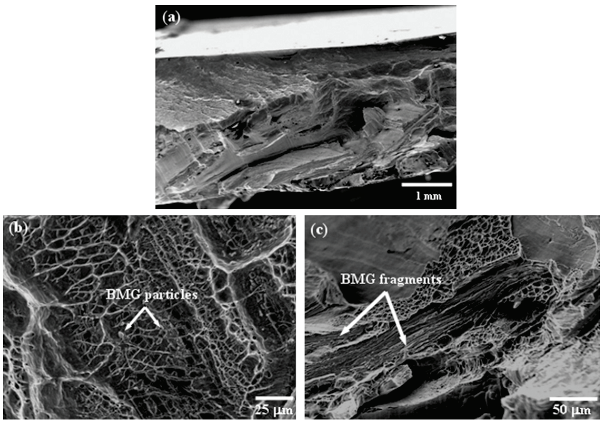

Figure 20. SEM images showing the tensile fracture surfaces of the BMG/copper joint (a) macro-view of the fracture surface; (b) magnified view showing BMG particles on the fractured plane; (c) magnified view showing the strip-like BMG fragments on the fractured plane.

So finally Y.Sun et al. on the basis of the above descriptions concluded as follows:

1. After welding, a straight and clear interface formed between the two dissimilar materials due to slightly touching the BMG side by the rotation tools. No chemical reaction and crystallization from the BMG can be detected at the interface and within the stir zone.
2. From the BMG/Cu interface to the copper side in the stir zone, a transitional microstructure changed from elongated grain structure to refined equiaxial grained structure and finally became coarse grain structure.
3. The bonding of the BMG and pure copper by FSW is strong and the strength of the FSW processed BMG/Cu joint can reach up to 95% of the pure copper [8].

Li et al. successfully joined A 2 mm thick Zr46Cu46Al8 bulk metallic glass (BMG) plate and 4.5 mm thick pure aluminum plate by friction stir welding (FSW), and the defect-free BMG/Al joint is produced. The welding speed was 75 mm/min and the tool rotation speed was 1500 rpm. The tool used is made of the high temperature high speed steel which has a shoulder of 12mm in diameter and a cylindrical pin of 8 mm in diameter and 5 mm in length. During the FSW process, the BMG was put on the down side, and the pure aluminum on the up side. The work-piece was hole drilled the pure aluminum side and slightly touching the BMG side. Fig. 21 schematically shows the tool and work-piece positions during the welding.

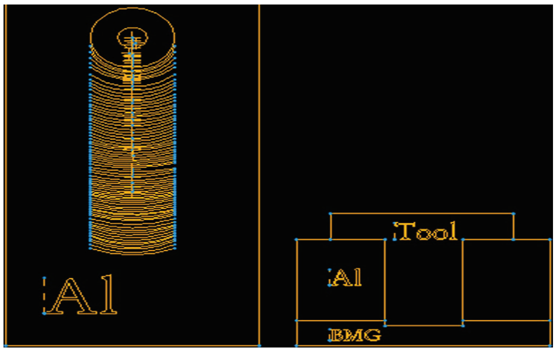

Fig.21. Schematic illustration of the positions of the tool and work-piece during the FSW. (F.P. Li et al. 2013)

Figure 22 shows a typical XRD pattern obtained from the as-cast Zr46Cu46Al8 plate. It exhibits a broad halo peak, and no crystalline diffraction peak is detected on the XRD pattern. The result indicates that the plate used is in fully amorphous structure.

Figure 23a shows the back scattering SEM image at the cross-section across the interface of the joint. A clear interface is observed between the BMG and pure Al, and no defects are detected in the joint indicating that the sound joining was achieved between the BMG and pure Al by FSW. Moreover, some bright and gray particles are detected in the aluminum side near the interface. Energy dispersive spectroscopy (EDS) analyses were conducted at the different positions of the joint marked with A, B, C and D, and the EDS spectra at these positions are shown in Fig. 23b. The EDS analysis results reveal that the bright particle (marked with B) contains 64.21 % Zr, 26.74 % Cu and 9.05 % Al (in atom percent), which is almost identical to the composition of BMG matrix. So the bright particles are the BMG fragments stirred into the aluminum matrix in the FSW process. The gray particle is an Al-rich phase containing 68.87% Al, 14.02% Cu and 17.11 % Zr (in atom percent).

Figure 24 shows the XRD patterns measured at the BMG/Al interface in the stir zone. The XRD curve exhibits a superimposition of several sharp peaks characteristic for crystalline phase on a broad halo peak from the amorphous phase, indicating the existence of a mixture of the amorphous and some crystalline phases.

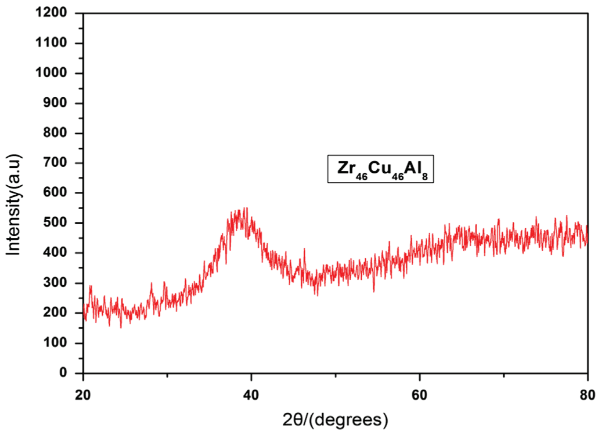

Fig. 22. XRD pattern of the as-cast Zr46Cu46Al8 plate. (F.P. Li et al. 2013)

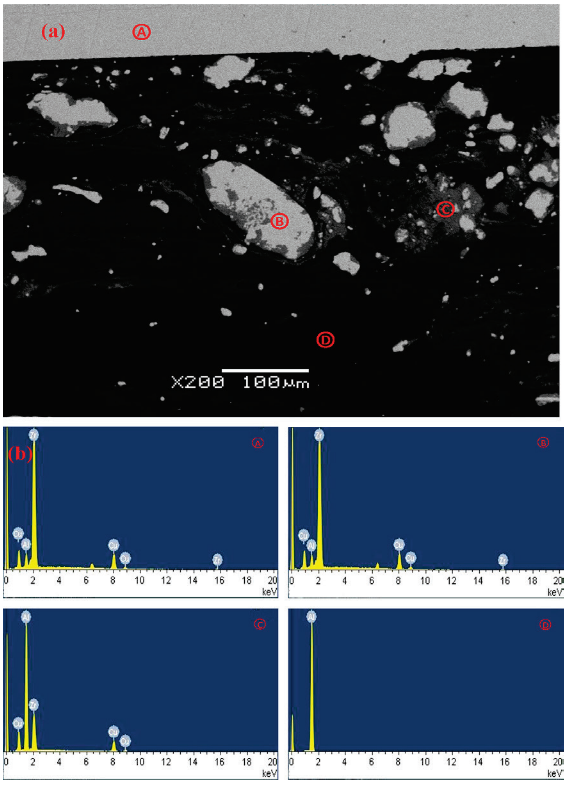

Fig. 23. Back scattering SEM image showing the cross-section across the interface of FSW BMG and aluminum (a) and the EDS spectra (b). (F.P. Li et al. 2013)

Figure 25 shows the hardness profile of the stir zone across the BMG/ Al interface. The zero position denotes the interface between the two different materials. On the left side to the zero position, the hardness is about 545HV, which exhibits the intrinsic high strength of BMGs. However, the hardness suddenly drops down to 150 HV around the zero position, the BMG/Al interface, and its value varied with in a wide range depending on the amount of the BMG fragments involved in the hardness tests. It is clear seen that for the Al matrix without BMG fragments in the stir zone, the hardness is as low as about 50HV, which is slightly higher than that of the base metal (about 25HV).

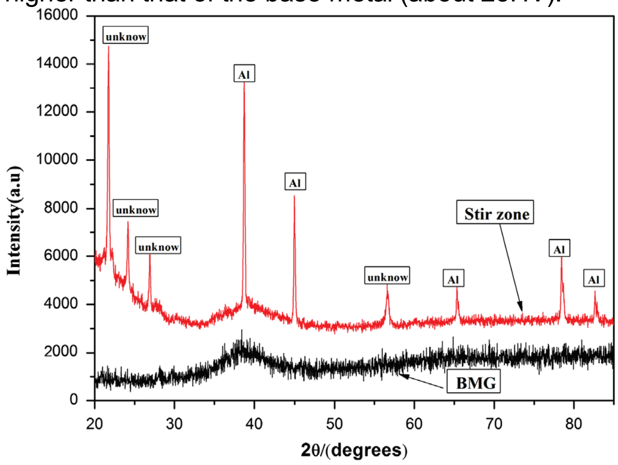

Fig. 24. XRD patterns measured at the interface between the BMG and the Al plate (F.P. Li et al. 2013)

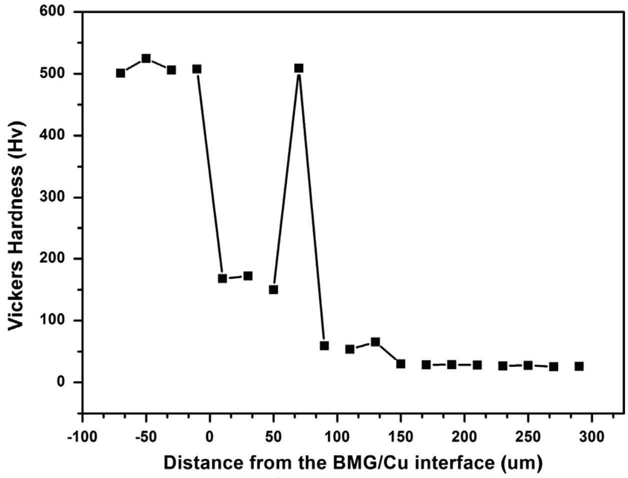

Fig. 25. Hardness profile in the stir zone across the BMG/Al interface. (F.P. Li et al. 2013)

The tensile tests were carried out to evaluate the mechanical properties of the BMG/Al joint. The stress-strain curve of the joint is shown in Fig. 26, and for comparison, the stress–strain curve of pure Al is also illustrated in Fig. 26.

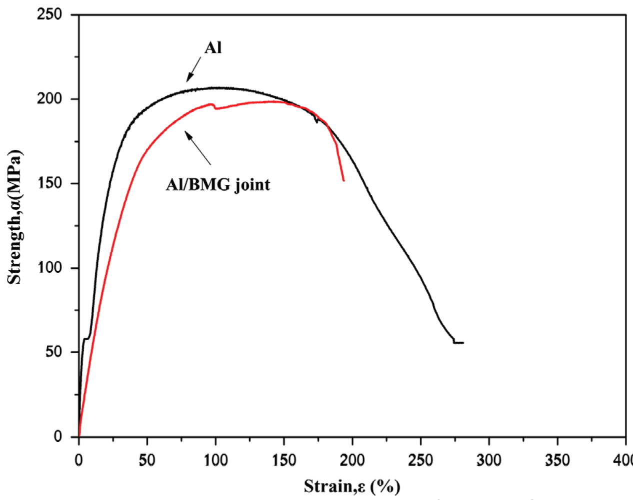

Fig. 26. Tensile stress–strain curve of the BMG/Al joint and pure Al (F.P. Li et al. 2013)

From the curves, the ultimate tensile strengths of the joint and pure Al are about 195 MPa and 210 MPa, respectively. The BMG/Al joint exhibits reduced strength and ductility with the joining efficiency being about 92%.

Figure 27 shows SEM images of the tensile fracture surfaces of the BMG/Al joint. From the appearance of the fractured sample, the tensile specimen usually fractured on the aluminum side in the stir zone very close to the BMG/Al interface. The location of the fracture implies that the bonding of the BMG/Al interface is excellent and stronger than the stir zone. Careful observations reveal that two distinct regions exist on the fracture surface of the joint (see Fig. 27a). One region is characterized by large dimples and tearing ridges (see Fig. 27a and b), implying that the pure Al matrix underwent a large plastic deformation during tensile test. Another region of the fracture surface is characterized by the cleavage plane, which caused by the fracture of the BMG particles or Al-rich phases in the stir zone (see Fig. 27c). So, finally F.P.Li et al. on the basis of the above descriptions concluded as follows:

1) A defect-free FSW Zr46Cu46Al8 BMG and pure Al joint was successfully achieved by offsetting the pin to the aluminum side and slightly touching the BMG side.
2) The sire zone consists of some BMG particles being stirred into the aluminum matrix and Al-rich phases. The BMG fragments can react with the Al to form the Al-rich phase, and the residues still maintained the amorphous structure. However, no crystallization and reaction layer are detected at the inter-face between the BMG/Al.
3) The strength of the FSW BMG-pure Al joint reaches up to 92 % of pure aluminum, and the joint fractures in the stir zone close to the interface of BMG/Al. The presence of the large BMG particles and Al-rich phase in the stir zone is responsible for the reduction of the strength of the joint [9].

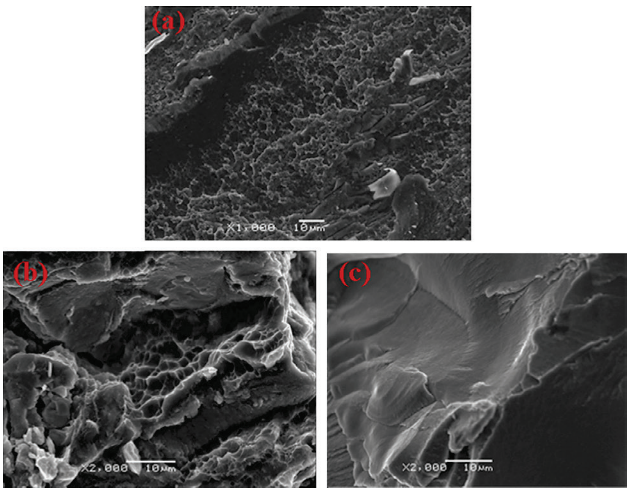

Fig.27. SEM images showing the tensile fracture surfaces of the BMG/Al joint. (F.P. Li et al. 2013)

3. Conclusion

On the basis of the above studies on FSW of BMG's by various researchers this present review paper exhibits and focus previous research, similar or related to this topic and also develops a basic understanding about the FSW of BMG's tried till now. It also provides a basis for the industrial practitioners and researchers to search further new alternatives regarding the Friction stir welding of BMG's.

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MICROSTRUCTURE AND MECHANICAL BEHAVIOR OF TIG BIMETALLIC JOINTS

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Abstract

Bimetallic weld techniques have progressed a great deal in the last decade. In this work, the effect of the filler metal composition on microstructure and mechanical behavior of dissimilar HSLA-X70/304L stainless steels weld joint is investigated. The dissimilar weld joints are fabricated using austenitic, duplex and low carbone filler metal. The mechanical behavior is investigated through microhardness, Charpy impact and tensile test.The results show that, the weld metal composition has a great influence on mechanical properties and microstructure of weldments, in particular the grain size and phases nature, changes with filler metal composition. In addition presence of martensitic slats in the FZ when using the low carbon filler metal, detailed microstructure examination is carried out and related to the mechanical behavior of the dissimilar joints.

Keywords: TIG welding, bimetallic weld, HSLA, DSS, microstructure

1. Introduction

High strength low alloys (HSLA) and austenitic stainless steels have been used widely due to their high resistance to corrosion combined to excellent mechanical properties. Some typical applications include their use as pipelines, oil refining, pressure vessels, chemical and process industries.

Homogeneous weld applications require use of filler metal with the same chemical composition as the base metal in order to get higher mechanical resistance of welded joint; this resistance depending on a number of factors like mechanical properties, wear and friction characteristics. There are many investigations on the characterization austenitic or HSLA steel using arc welding regardless of any assembly between them [1,2]; however, there are little data on the evaluation of mechanical properties to weld together HSLA/stainless steel.

At present, some studies have been conducted on welding of stainless steel with HSLA steel, almost all common fusion welding techniques can be used to weld duplex stainless steel through selecting appropriate welding parameters, corrosion resistance or residual stresses condition, in this study we interest to filler metal selection.

Filler metal composition has a great influence on the solder properties. Mechanical properties and toughness of weldment depend of microstructure of weld metal and heat affected zone.

The welding process used was Tungsten arc welding (TIG). These were chosen because each process is one of the most commonly used welding techniques in industry.

2. Experimental Procedure

Base materials used in present work are austenitic (304L) and ferrite-perlitic (X70) steels. Their chemical composition and mechanical properties are given in Table 1. The steel is welded by semi-automatic tungsten arc welding (TIG), According to moved table in order to set welding speed.

Table 1. Chemical composition of base materials

Elém.(%)	C	Si	Mn	P	S	Al	Cu
X70	0.08	0.7	2.39	0.01	0.001	0.06	0.01
304L	0.07	0.75	1.85	0.045	0.03	-	-
Elém. (%)	Cr	Mo	V	Nb	Ti	N	Ni
X70	0.04	0.1	0.05	0.4	0.09	-	0.02
304L	18.5	-	-	0.08	-	0.08	-

Based on partial plates of base materials, TIG welding was carried with three filler metal, austenitic stainless steel 308, (SampleS1), duplex stainless steel 2209 (S2), low Carbon E7018 (S3), and the fourth sample (S3) is intended to cover welding process without filler metal.Filler metal selection is based on the homogeneity of chemical composition with each base metal: for X70 we take and for E7018 we take 304L.

In order to maintain similar welding parameters conditions, the weld coupon dimensions were fixed at 100 mm X 60m X 2mm (Fig. 1) and the electrode diameter fixed at 1.5 mm.

Figure 1. Plates of Sample number two (S2)

One pass TIG welding was used in order to avoid cracking, supercooling and excessive penetration. Before welding, Pairs of plate were welded together (edge to edge) width-wise for each filler metal (Fig. 1).

Chemical composition of filler metal is given in Table 2. The welding is carried out with fixed parameters (Table 3).

Table 2. Chemical composition of filler materials

Elément	C	Si	Mn	Cr	Ni	Mo
E308L	0.19	0.46	1.72	20.8	10.1	-
E2209	0.03	0.46	0.9	22.5	9.3	2.8
E7018	0.12	0.80	0.90	-	-	0.5

Table 3. Welding parameters

I (A)	MV (V)	V (mm/min)	Φ (mm)	Temps (s)	D (L /min)
72	11.68	2.515	1.5	53	8

The tensile specimens were tested on a servo hydraulically controlled digital tensile testing machine. Each tensile specimen size was prepared in accordance with ASTM E08 standards [5], Fig.2.

The Charpy test was performed according to standard test methods for notch bar impact testing of metallic materials[6]. The total length of the specimen is 55 mm and the rectangular cross-section area is 5 x 2mm, Fig. 2. Specimen has a V-shaped notch with a flank angle of 45° and depth of 2mm in the HAZ and FZ.

Figure 2.Charpy and tensile specimens [6-8].

3. Metallography

For the observation of microstructural changes that take place during welding, corresponding to each filler metal; specimens were taken from the welded plates. The microstructures of the joints were captured with the help of optical microscopy, Fig. 3. Standard polishing procedures were used for microstructural observations, Glycerine reactif was used with the conditions (20ml of nitric acid, 30 ml HCl acid and 30 ml of glycerol) for 3 min.

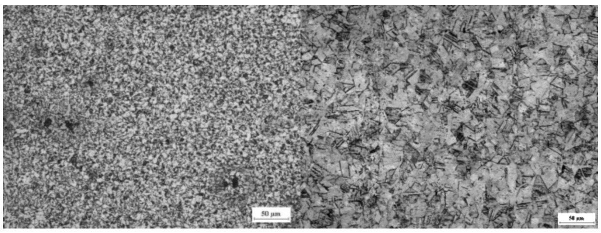
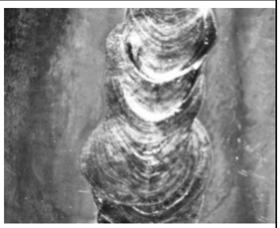


Figure 3. Optical microstructure of the two materials (left - HSLA-X70)

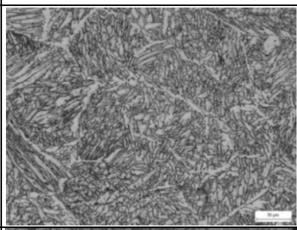
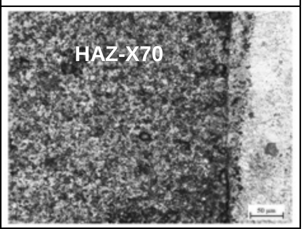
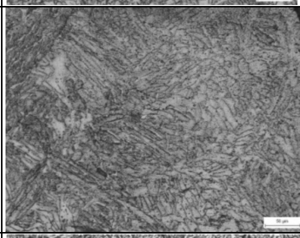
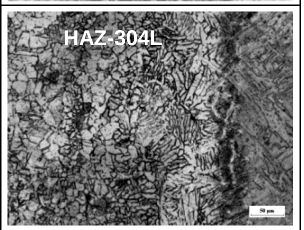
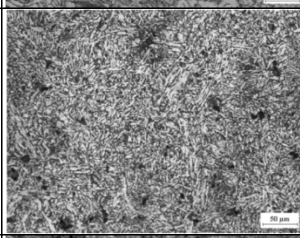
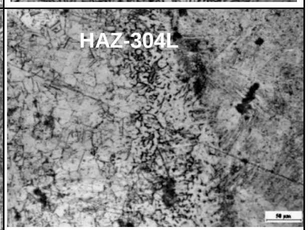
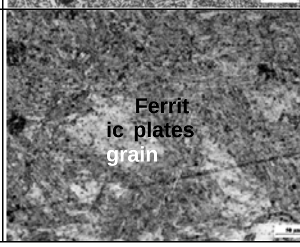
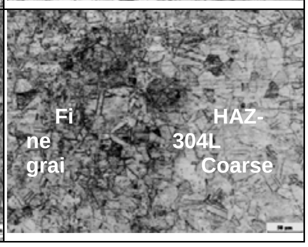
These micrographs show that the weldments are free from welding defects like lack of penetration, undercut, cracks, Tab. 4 and 5.

Table 4. Morphology of welded joints

S1	S2
	
S3	S4
	

Micrograph of X70 base metal describes polygonal ferrite–pearlite containing about 70% ferrite, while the microstructure of 304L consists of polycrystal of single-phase which consists of equiaxed austenitic grains with an average diameter of 17 µm.

Table.5: Micrographs of weldments

	FZ	HAZ
S1		
S2		
S3		
S4		

Polished samples were scanned on the optical microscope along the weldments zones of the fusion zone and the HAZ, and at a few places microphotographs were taken in the middle of fusion line (Fig.3).As a result, this study has many microstructures of dissimilar joints in accordance with various mechanical properties.

The microstructure of the (HAZ-X70) undergoes a decrease in grain size when it becomes close to the base metal, the latter is characterized by a ferritic-pearlitic structure with large ferrite content. it's also distinguished by the presence of acicular ferrite and the formation of martensitic slats, this presence is even greater in S4 with carbides formation in fusion line.

Microstructure of duplex fusion zone revealed that the principal constituents are austenite and columnar ferrite with fine intermetallic precipitation in ferritic phases. Moreover, Microstructure evaluation of austenitic fusion zone reveals essentially a dendritic ferrite in austenitic matrix.With regard to the 4th sample, With regard to the 4th sample, fusion zone presents a continuous casting structure.

4. Mechanical behavior

The microhardness measurements are schematized relative to joint center of the four samples, Fig. 4. For the S1 and S3, there was an increase in the microhardness of both the fusion lines and heat affected zones (HAZ). These higher microhardness values in fusion line are related to the higher Carbon content of 304L and X70 base materials (Table 2), which produced a large amount of Carbide precipitation.

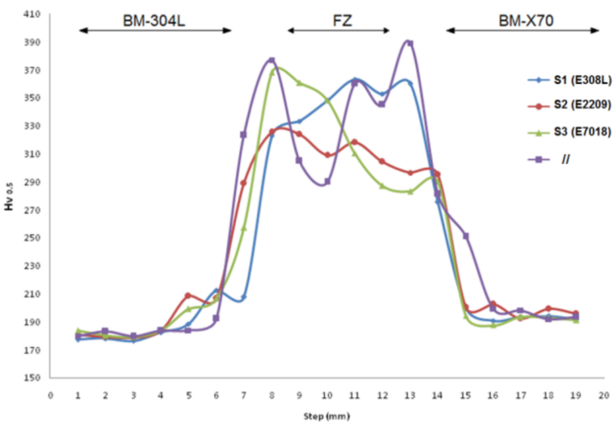


Figure 4.Microhardness profiles

In S4 fusion zone, Microhardness values are severly disrupted, this can be explained by the presence of ferrite plates and martensite lattices in this area.

As regards the austenitic HAZ of samples, austenite grain growth increased from small ratio in S2, and S3 to big ratio in S4, this phenomenon can be explained by cooling rate and solubility modes of filler metals in 304L SS (Table 5).

The fusion zone of S2 is characterized by balanced level of microhardness. Otherwise, In the other samples, microhardness is characterized by high level values.

A brittle microstructure was formed in FZ-S4, which contains primarily large ferritic plates (about 27μm) surrounded by lamellar martensite. This can be explained by the strong instability in microhardness values with the presence of intermetalic inclusions which were found in fusion zone (dark spots in FZ-S4, Table.5).

In fusion line of 304L SS, there is a similar properties of microhardness of duplex filler metal and austenitic filler metal, this is due to the presence of same nature of phases which formed during TIG welding, these phases consist principally of delta ferrite and secondary austenite. The inclusions also were found on fusion line of 304L SS.

The tensile strength of joints has been evaluated. In each sample three specimens were tested, the tensile strength and their elongation are mentioned in Table 6.

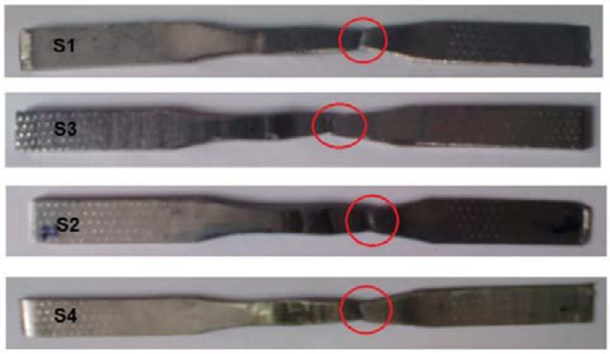


Figure 5. Broken specimens

The Ultimate strength and elongation of S1, S2, S3 and S4 specimen are shown in Table 6, indicating significant dependence on the filler metal, which can be explained on one handby the difference between the four microstructures of fusion zones, and on the other hand by the joining zone, which is influenced, primarily by the fusion zone (FZ/HAZ), and also by austenitic grain growth (in HAZ-304L) and ferritic grain growth (in HAZ-X70).

Among the different testes, a duplex filler metal clearly gives a better combination of strength, ductility compared to the other filler metals (Table 6).

Examination of the fracture surfaces of the broken mechanical test specimens showed that transgranular brittle failure and intergranular ductile failure occur in 304L-S3 specimen, which contains Clefts and river forms, with the presence of several crack arrest lines.

Table.6: Tensile properties of the weld joints

Sample	S1	S2	S3	S4
σ_m (MPa)	522.40	642.02	671.77	487.13
ε_m (%)	15.1	14.8	11.8	9.3
Fracture location	MB(X70)	MB(X70)	BM (304L)	BM(X70)

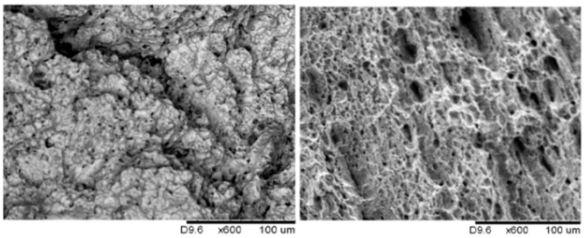


Figure 6. SEM fractographs (X70 in the right)

The fracture surface in X70 base metal indicated a ductile failure with granular aspect, which is consistent with significant ravelling of material. Therefore, ductile cleavage indicates that cracks growth phases were relatively slow compared to S3 specimen.

The impact tests presented in Fig.7 indicated that the combination of impact resistance (K) in second sample (S2) is better than the other samples. However the lower energy was found in S4 fusion zone. Furthermore, it is also apparent that homogeneous bimetallic joints have excellent impact properties (low Carbone fusion zone with X70 base materials and stainless fusion zones with 304L base material) compared to the heterogeneous joints.

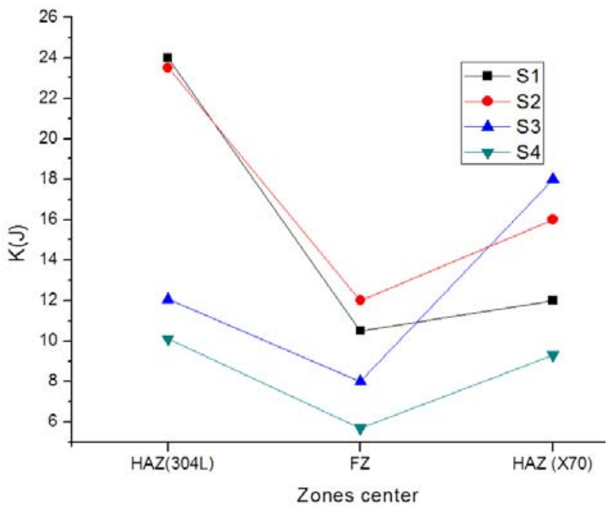


Figure 7.Charpy Impact values

5. Conclusion

Based on the results obtained, it was possible to conclude that Duplex filler have a good weldability with 304L SS/ HSLA-X70 dissimilar joints compared toaustenitic low carbone filler metal by medium energies of TIG process.

This study investigates the effects of filler metal composition on 304L SS/ HSLA dissimilar welds and the formation of microstructures at various weld zones of different filler metal composition, Variation in morphology of microstructures across the fusion zone and heat affected zone is evident within solder. Microhardness profiles charpy test tensile test are made and linked with the formation of the microstructures in different weld zones.

As regards the mechanical behavior, at samples welded by filler metals, there was an increase in the hardness of both the FZ and the HAZ with the best characteristic given by duplex filler metal. This filler metal combines between improvement in maximum tensile and amelioration of impact resistance.

In welded sample without filler metal, we find a significant decrease in mechanical properties. That phenomenon can be explained mainly by existence of ferrite slabs and martensite lattices in fusion zone.

To understand more realistically the application of dissimilar weld joints in industry, electrochemical tests will be very important to evaluate the resistance of weldment against corrosion degradations.

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BUCKLING ANALYSIS OF PERFORATED STRUCTURES MANUFACTURED IN HYBRID COMPOSITE MATERIALS

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Abstract

This study aims to predict the effect of plies number, laminate thickness and diameter of the notch on the buckling behavior of thin cylindrical structures made of hybrid composite material Carall (Al/carbon fiber/ epoxy). The assembly of aluminum with a composite laminate have a synergistic effect on many mechanical properties, hence their attraction is considerable in the aerospace field. Buckling of these structures is induced by an axial compression which results in an imposed displacement. The numerical results obtained through Abaqus code, using the finite element method, show that the rigidity of structures with low fibers inclination angle is improved by increasing the number of plies, while for the important inclinations, it is recommended to increase the thickness of laminate layer.

Keywords:

Buckling, composite laminates, notches, CARRAL.

1. Introduction

In recent years, among the composites families reinforced in fiber, a relatively new family named fiber-metal laminates (FMLs) has attracted a great attention. The FMLs are a kind of hybrid composite materials composed of metal layers bonded to layers of fiber reinforced polymer (FRP). Such laminates have excellent properties of the metal and the composite material, this combination results in laminate composite with an ability to prevent and stop the propagation of cracks caused by the cyclic loading [1]. These materials have been developed to meet the growing demands of the damage tolerant materials in airframe structures. This request was precipitated by the widespread acceptance designs philosophies "Damage tolerant", initially developed by aviation certification authorities.

These materials may be employed in the form of thin cylindrical structures which become a possible substituent to the structures manufactured in conventional materials. Nevertheless, they become unstable when subjected to mechanical or thermal loading lead to buckling, which has become a major concern.

Many works has been conducted on the buckling of the thin and moderately thick cylindrical composite subjected to pure axial compression [2-3], or constant external pressure [4-5]. The main cause of this complex process is the randomness of the initial imperfections (in terms of geometry, material, or boundary conditions) of the structure [6].

Understanding the behavior of this latter is vital to ensure the integrity of these structures during their services. The linear analysis is a valuation method to predict the buckling load and mode of deformation of a structure. In this work, are highlighted, the effect of structure diameter, the thickness of the layer and the fiber orientation with and without the presence of circular notch, on behavior out of a hybrid composite thin cylinder, using the finite element method. In this case the solicitation of buckling is induced under the effect of the imposed displacement.

2. Model and mesh of thin cylindrical structure

The material used is a hybrid composite material a type of FMLs, consisting of two layers of aluminum alloy 2024T3 bonded to twelve plies of composite material (carbon / epoxy), the lamination is asymmetric as follows orderly [Al / (θ / -θ) 6 / Al].

Young's modulus E = 27400MPa and the Poisson's ratio v = 0.26, determine the elastic properties of aluminum. While the mechanical properties of the composite material used T700/E, are summarized in Table1.

Table 1. Mechanical properties

Properties	T700/E
E1 (MP)	143120
E2 (MP)	6672
v_{12}	0.26
G_{12} (MP)	3390
G_{12} (MP)	3390
G_{12} (MP)	1914

The considered structures have a length H = 6000mm and 400mm radius, subjected to imposed displacement (U = -0.2 mm), in the vertical direction. They are provided with a central circular notch. The mesh is of type 8-node quadratic shell element with reduced integration S8R.

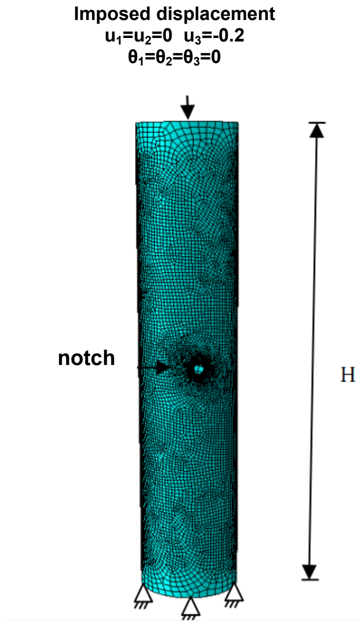

Figure 1. Mesh of thin cylindrical structure containing a central circular notch.

3. Results and discussion

In this part, the effect of several parameters is highlighted to analyze numerically the critical buckling load of thin cylindrical structures, without the presence of notch. Figure 3 shows the variation of buckling factor λ as a function of the fiber orientation, for different diameters of the considered structures. Firstly, it should be noted that the structure behaves in a manner similar whatever of its diameter. The value of λ increases as the fiber orientation of the composite material decreases. 400 mm diameter of the structure has the larger values, beyond, λ decreases with increase of this latter, and we note that λ reached significant maximum values, when the fibers are oriented in a range varying from 0° to 40°. The lowest values are obtained beyond 60°.

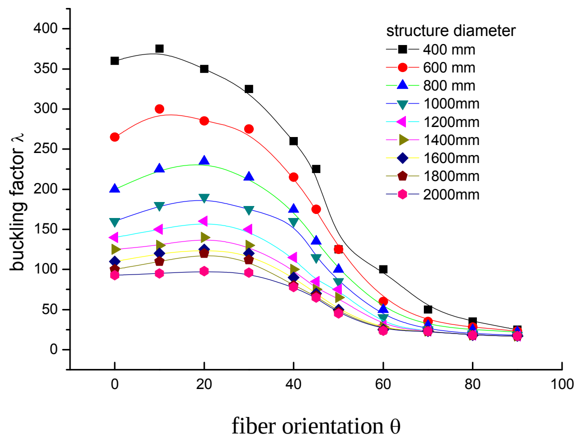

Figure 2. Variation of λ in function of θ, for different diameters of structure.

Buckling of structures of 400 mm diameter and 0.1 mm thick, for different number of plies, is investigated. As illustrated in figure 4, we see that increasing the number of plies contributes to strengthening the thin cylindrical structures. We also note, that this strengthening is considerable for low fiber orientations. While it becomes less significant more than we enlarges the plies inclination.

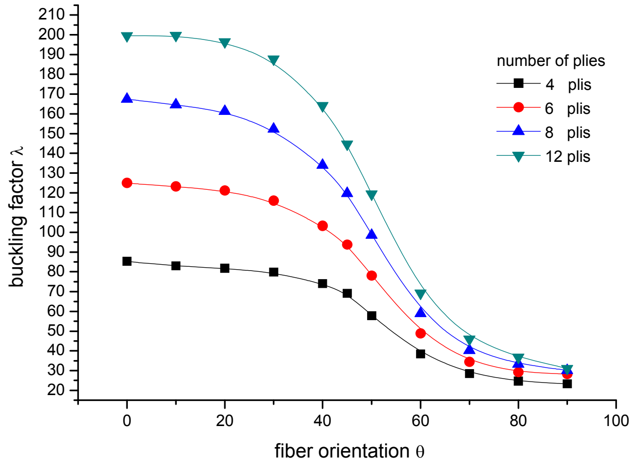

Figure 2. Variation of λ in function of θ, for different number of plies.

In the case of structure with 12 layers, we have varied the ply thickness of the composite only, while that of the aluminum alloy is considered fixed at 0.1mm. From figure 5, it is found that the critical buckling load increases with the enlargement of the ply thickness, which results in an improvement in the rigidity of our structures. In fact, this influence becomes more remarkable as and when the angle of inclination of the fibers is important.

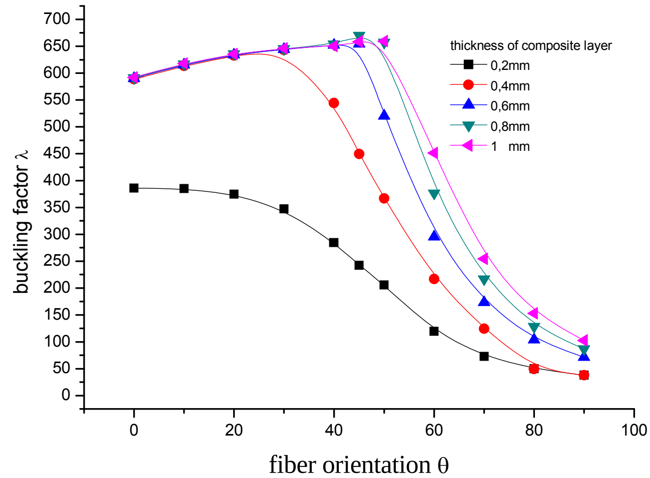

Figure 5. Thickness effect of structures composed of 12 plies

The presence of defects in structures is inevitable that may be due to a manufacturing defect or that may occur during service. In this paper we have studied the effect of a circular notch on the response to the buckling of thin cylindrical structures.

Figures 6 and 7 show the variation of the load factor (λ) as a function of fiber orientation (θ), for structures made of 6 and 12 plies, respectively. According to the results, we find that more the number of layers are important more the effect of the size of the circular notch is less considerable. In the case of 12 plies, the effect of the notch appears from a diameter of 30mm. While the structures containing 6 plies, a notch of 15 mm can cause a decrease in the critical buckling load and becomes more significant by enlarging its diameter.

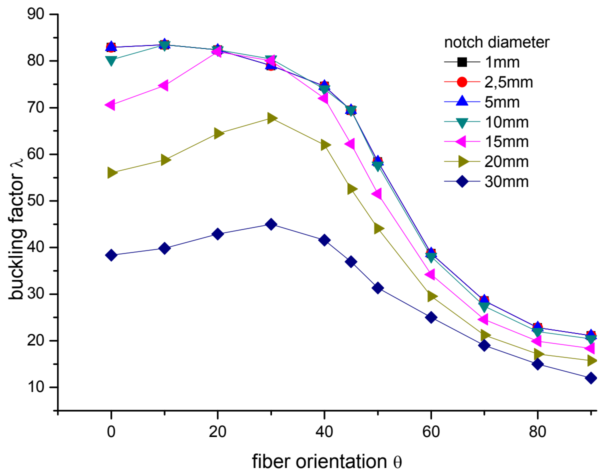

Figure 7. Effect of the diameter of the notch for a structure made up of 6 plies.

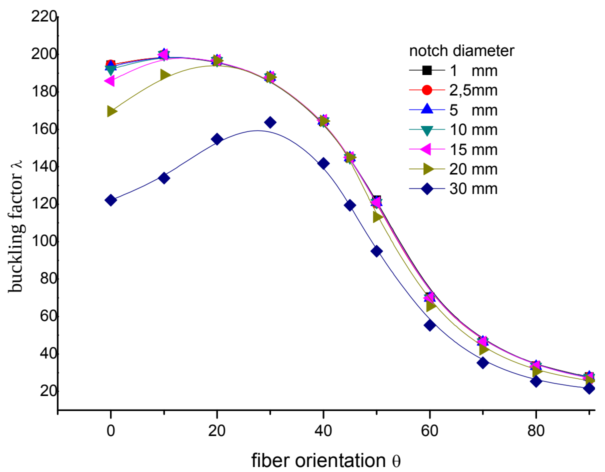

Figure 6. Effect of the diameter of the notch for a structure made up of 12 plies.

4. Conclusion

Based on the results obtained by numerical simulation, we can draw the following conclusions:

- The larger the diameter of thin cylindrical structures is big plus they are less rigid.
- The minimum values of the buckling load are obtained when the fibers are perpendicular to the applied load. While they are important, and maximum when they are oriented in a range varying from 0° to 40°.
- The expansion of the number of plies contributes significantly to strengthening of structures for small inclinations fibers. The effect of the laminate layer thickness on buckling behavior of structures, only appears only to large fiber orientations.

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THE RIGIDITY OF THE WALL OF PISTONS IN RELATION TO THE WALL THICKNESS

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Abstract

One of the most important element of disc brake used on a vehicle is the piston on the caliper. The safety of traffic requires that pistons of the caliper should have high strength which pushesthe brake pad to the brake disc to make brakingtorque. The behavior of pistons (deformation) was examined in the finite element program, where wall thickness with suitable rigidity was defined. When the wall thickness decreases one point can be defined where wall lose rigidity and the top face of the piston effects the deformation. In this study 3 materials were examined: aluminium alloy (3.4335), steel (1.0039) and titanium alloy (3.7165). In all cases the wall of piston loses the rigidity when the wall thickness is 3 mm. Less than 3 mm stiffening effect of top face of piston prevails and affects the deformation of wall.

Keywords: brake, piston, deformation, rigidity

1. Introduction

Safe transport requires a reliably working car brake system. The most frequently used brake system in cars is disc brake, because its operational parameters are better than those of a drum brake. One of the most important parts in the brake system is the piston in caliper. When the brakes of a car are put on pistons press the brake pad to the brake disc to make braking torque.Despite the important role of the pistons little study has been made on the piston's behavior. Many researches examine friction elements (brake pad and brake disc) which have greater impact on performance, [5]. A lot of different material was examined to increase the friction coefficient between brake disc and brake pad and stabilize the degree of friction coefficient when temperature is high. Elements of friction material of brake pad [6] and different materials of brake disc [9] effect coefficient of friction. Examining the brake system its performance and lifetime are also important factors, thus brake pad wear is also studied [7]. A third important area is thermal behavior where researchers aim to decrease the heat stress into parts of brake [2], because high temperature damages elements and decreases the performance of the brake system. There is a large number research in connection with the heat expansion of the brakes [1], where the aim is to learn real thermal expansion. The fourth important area is vibration and squeal which is important in relation to performance and comfort [8].

In this study the pistons behavior was examined when working load effect onthe piston. Pistons made of three different materials were examined where the wall deformation function of wall thickness was defined. Furthermore, wall thickness where wall lose rigidity and piston's top face effect to deformation of wall were also defined.

2. Materials and method

In disc brake piston/pistons is/are important part/parts because pistons press the brake pad to the brake disc. In high performance car 2, 4, 6 or 8 pistons were used which generate high force to braking. Requirement of pistons is low weight and high strength. Pistons increase the unsprung mass of car. Several kinds of material were used to makepistons, three materials were examined in this study (aluminium alloy, steel and titanium alloy). Their properties are given in table 1.

Table 1.Material properties of piston [3.]

Properties	Al alloy (3.4335)	Steel (1.0039)	Titan alloy (3.7165)
Density, g/cm^3	2.77	7.85 g	4,62
Strength, MPa	280 MPa	251 MPa	930 MPa
Modulus, GPa	71	210	96
Poisson ratio	0,33	0,3	0,36

The deformation wall of the piston in the function of the wall thickness was defined. Piston's model length was 29 mm and diameter is 44 mm (radius 22mm). (Fig 1). In this model the brake pad has two parts. One part is steel plate and the other part is friction material.

External constraints and loads were defined after preparing the geometry model. Points on the axis of symmetry do not move in direction X but in Y direction move free. The edge of brake pad connecting the brake disc do not move in Y direction but move free in X direction. The pressure of brake system was measured - it is 5 MPa and in this study a three-fold safety factor means that pressure is 15 MPa. Two cases were examined where sealing ring position is different.

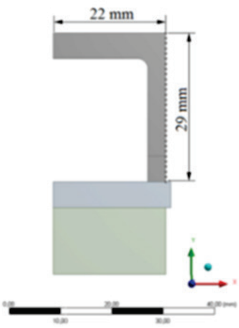

Figure 1. 2D axisymmetric model used in simulation

Figure 2 shows two different models where hydraulic pressure effects different faces of piston: sealing ring into caliper (SIC), Fig 2a, sealing ring into piston (SIP), Fig 2b. Beside constraints and loads connection between parts had to be defined. Between friction material and steel plate of the brake pad bonded connection and between piston and steel plate frictional contact was defined where friction coefficient is 0.1. Piston's wall deformation was defined on 30 point in different cases (wall thickness is different). The smallest wall thickness is 0.5 mm where wall thickness increases to solid piston. Certain parts of the model were meshed depending on the wall thickness. When the wall thickness is 0.5 mm, model consists of 6305 elements (nodes: 19670) and if piston is solid, model consists of 11940 elements (nodes: 36623).

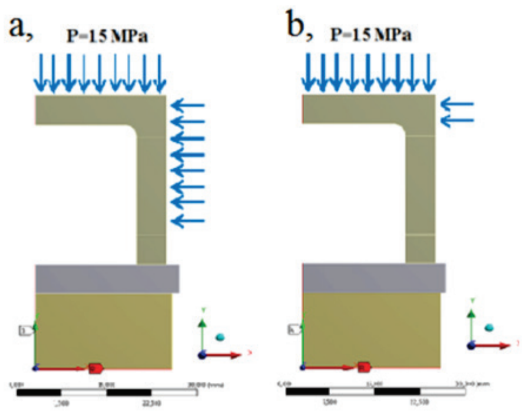

Figure 2. Two models where pressure effect is different a, sealing ring is in caliper (SIC); b, sealing ring is in piston (SÍP)

3. Results

The X direction deformation was examined, because this direction deformation effects to work. High positive X direction deformation is damage, because in a critical case the piston can easily stuck into the caliper and the braking effect do may not be realized (Fig 3). The X direction deformation was examined before, where the optimal wall thickness was defined [4].

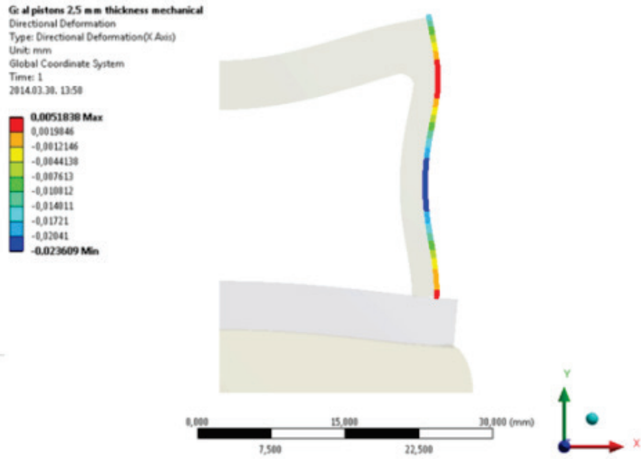

Figure 3. Piston's wall deformation in X direction

Figure 4 shows pistons wall deformation in X direction when the wall thickness has been changed. Figure 4/a shows how the wall X direction deformation changes when the sealing ring is in the caliper (SIC) and Figure 4/b show how change X direction deformation when the sealing ring is in the piston (SIP).

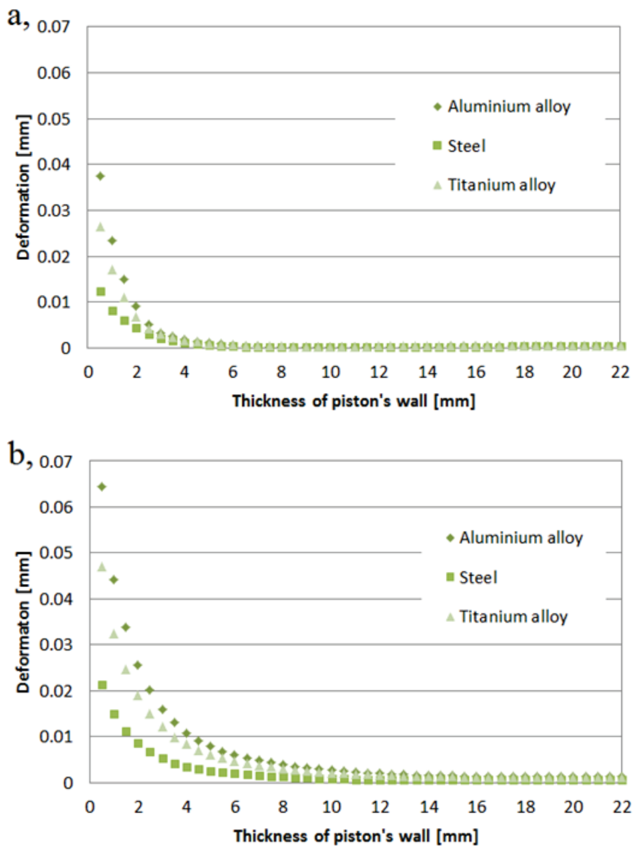

Figure 4. Deformation of piston's wall made of different material: a, sealing ring is in the caliper (SIC); b, sealing ring is in the piston (SIP)

Figure 4 shows that deformation depends largely on wall thickness. When wall thickness is small the X direction deformation is high, when wall thickness increases the deformation decreases but in this case the weight of the piston is getting higher. When optimal wall thickness was defined the weight and deformation was took into account, because piston has suitable strength and low weight. Deformation tests show which case (wall thickness) has suitable rigidity of wall and which case loses this rigidity of the wall and has stiffening effect on the top face of the piston. ΔD/D ration and D/v ration was examined, where ΔD is deformed diameter, D is original diameter, v is wall thickness. (Figure 5.)

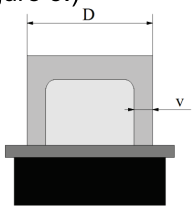

Figure 5. Examined parameters conventions, where D is original diameter, v is wall thickness.

The ΔD/D ration was examined in the function of the D/v ratio, Fig. 6 (SIC) and Fig. 7 (SIP).

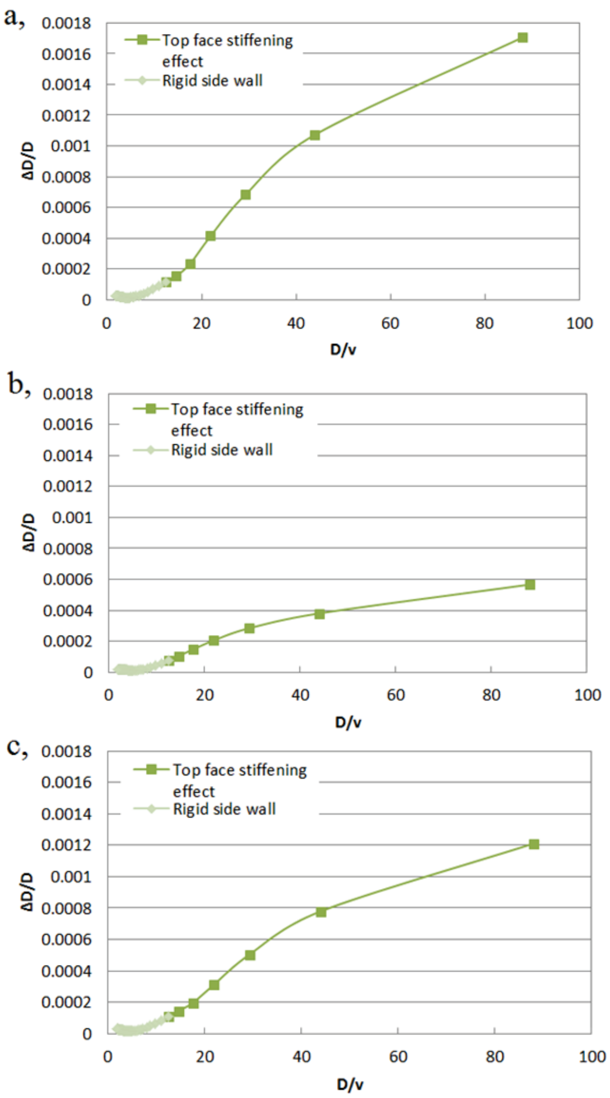

Figure 6.Wall thickness where side wall lost rigidity and top face effect to deformation (SIC): a, aluminium alloy; b, steel; c, titanium alloy

Figure 6 shows results with the sealing ring in caliper. Results can be acquired with two functions. One function shows when the wall has rigidity and the other function shows when wall loses the rigidity. Figure 7 shows results when piston material is different and the sealing ring is in piston. This case is similar to the first when sealing ring is in the caliper. Results can be acquired with two functions.

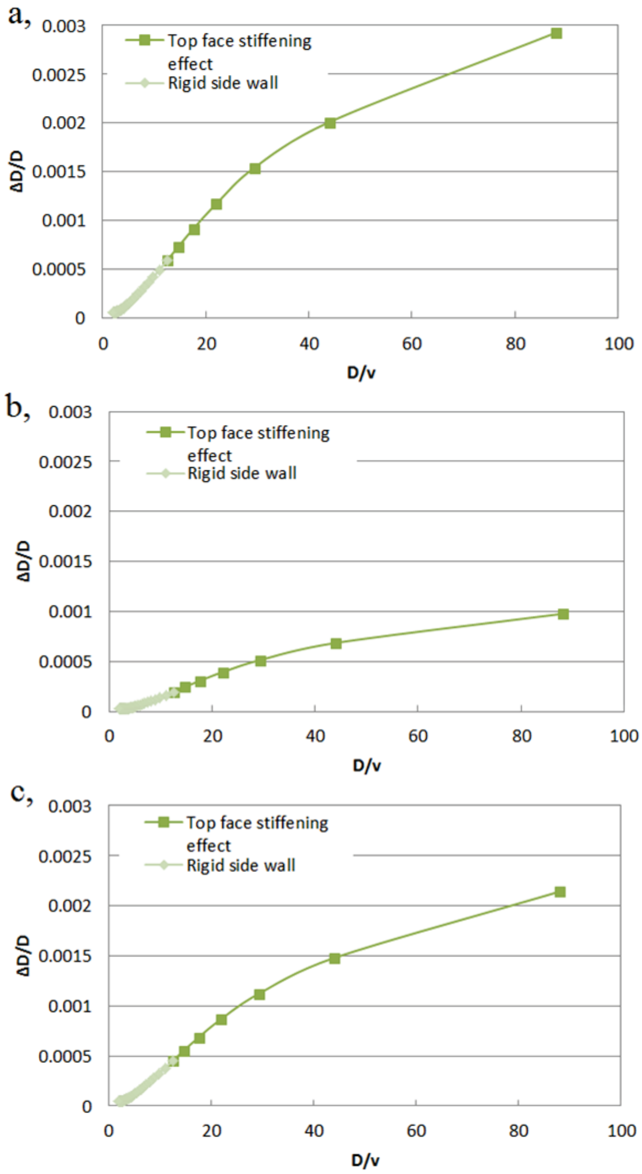

Figure 7. Wall thickness where side wall lost rigidity and top face effect to deformation (SIP): a, aluminium alloy; b, steel; c, titanium alloy

Two functions in the diagram define the point where the wall possesses rigidity and under this wall thickness the stiffening effect of top face stiffens the piston's wall. In all cases (different construction, different material) wall thickness was defined where thealternating point is. This typical wall thickness is 3 mm in each case, over 3 mm wall has suitable rigidity, under 3 mm it has the stiffening effect of top face.

4. Conclusion

In this study wall deformation depending on the wall thickness has been examined. Context was defined between piston's wall deformation and wall thickness, where hydraulic pressure is 15 MPa. Three different material deformation (aluminium alloy (3.4335), steel (1.0039) and titanium alloy (3.7165) was compared. Two different constructionswere examined where sealing ring position is different. In one case the sealing ring is in the caliper (SIC) and in the other case the sealing ring is in the piston (SIP). The sealing ring position definesthe place where the hydraulic pressure works. The result shows that when wall thickness is small the deformation of wall is high and when piston is solid the deformation is negligible. That means wall thickness influences the deformation of piston's wall. The cases where the wall loses stiffness and the cases where top face affects the stiffness are also defined. Results show that over 3 mm the wall is rigidand under3 mm thickness the wall is not rigid enough but stiffening effect of top face increases wall rigidity.

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INFLUENCE OF UV EXPOSURE ON THE MECHANICAL PROPERTIES OF POLYMERIC FILMS USED IN THE CONSTRUCTION OF GREENHOUSES

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Abstract

The effect of artificial ultraviolet exposure on the mechanical properties of polymeric films used in the construction of greenhouses was studied in this paper. The artificial aging was achieved using an original equipment built by the authors which eliminates the infrared component of the radiation emitted by the ultraviolet lamps. After the ultra-violet exposure, the specimens were subjected to tensile testing and the obtained mechanical properties were compared with the properties of the unaged material. Both the tensile strength and elongation at break showed considerable reduction as results of the ultraviolet exposure. The obtained results confirm the performance of the developed experimental equipment and the necessity for further research to improve the durability of greenhouse cover materials.

Keywords:

Polymeric film, artificial aging, UV, mechanical properties, greenhouse

1. Introduction

Today the agricultural industry is striving to produce more diverse crops and crops of higher quality using natural pesticides and fumigants for health, safety and environmental reasons. Greenhouse film covers used in these applications must be formulated to withstand prolonged UV exposure, variable weather conditions and aggressive agrochemical environments which can adversely affect the stabilization systems in the films [1,2]. Optimizing operational costs is also increasingly important to growers and more durable films can lengthen the time between costly replacements.

Therefore continuous focus is on the development of innovative products that will help the agricultural market meet the challenges and grow.

In this context the characterization of polymeric films used for greenhouses is of paramount importance. Furthermore, for predicting the useful lifetime of such films both the critical effect of the various climatic conditions and the effect of the harsh greenhouse micro-environment on their properties should be taken into account [3,4,5].

This paper presents an experimental program during which specimens sampled from polymeric films used in the construction of greenhouses are artificially aged using ultraviolet (UV) radiation. The damage to the specimens was assessed by subjecting them to tensile testing in order to determine the possible influence of artificial aging on the mechanical properties. Also, the efficiency of the original artificial aging equipment is assessed based on the results.

2. Materials and methods

The objective of the experimental program presented in this paper is to investigate the influence of artificial aging on the tensile properties of polymeric films used in the construction of greenhouses. The experimental program had the following steps:

- Preparation of test specimens;
- Conditioning of unaged specimens at 23°C and 50% relative humidity: 24 hours;
- Tensile testing of unaged specimens at different loading speeds (10, 25, 50, 75, 100, 200, 300, 400 and 500 mm/min), in order to determine the speed at which the obtained mechanical properties are stabilized;
- Underwater artificial aging with UV radiation of 3 sets of specimens, – time of exposure: 48 hours;
- Conditioning of aged specimens at 23°C and 50% relative humidity: 24 hours;
- Tensile testing of the aged specimens, using the determined loading speed;
- Comparative analysis of the obtained results.

The artificial aging effect was achieved by using an experimental equipment designed and built at ISIM Timisoara (Fig. 1). The specimens are positioned on a flat surface immersed in a water basin and they are irradiated with UV radiation from above, by the 6 UV lamps. The UV light bulbs are double-ended medium-pressure metal halide radiators with iron and cobalt additives, emitting ozone-free radiation mainly between 300 and 400 nm (UVA domain) and at a power output of 400 W each. More details regarding the UV light sources are provided in [6,7].

Figure 1. Artificial aging equipment fitted with water basin

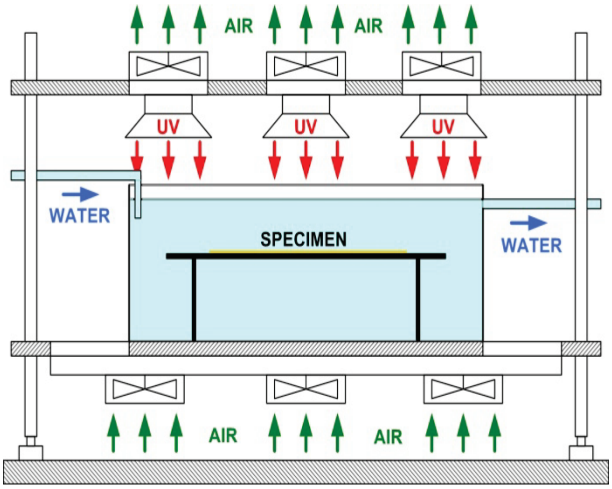

Figure 2. Working principle of the artificial aging equipment

The equipment has protective covering and it is equipped with a forced air cooling system to avoid the overheating of the UV lamps which produce a considerable amount of infrared (IR) radiation. Preliminary tests proved that the forced air cooling system prevented the overheating of the UV lamps, but it could not lower the temperature under 70°C in the test chamber. The effect of such IR radiation would render the results of UV exposure inconclusive and could also physically destroy the exposed specimens before tensile testing.

In order to eliminate the IR component of the emitted radiation, the artificial aging equipment was fitted with a constant level water basin, continuously cooled by added running water while the excess is drained away (Figure 2). The specimens are positioned on a flat support with feet of adjustable length. Thus the depth at which the specimens are irradiated can be controlled. During tests, the water temperature continuously registered by the control unit of the equipment did not rise above 36°C.

The tensile tests were carried out according to EN ISO 527-3:2000, at ambient temperature. Prior to the tensile tests, all the specimens were conditioned for 24 hours at 23°C and 50% RH, according to EN ISO 291:2009. The tensile equipment used was a Zwick/Roell Z005 universal materials testing machine, with a capability of 5 kN, fitted with pneumatic grips, as shown in Figure 3.

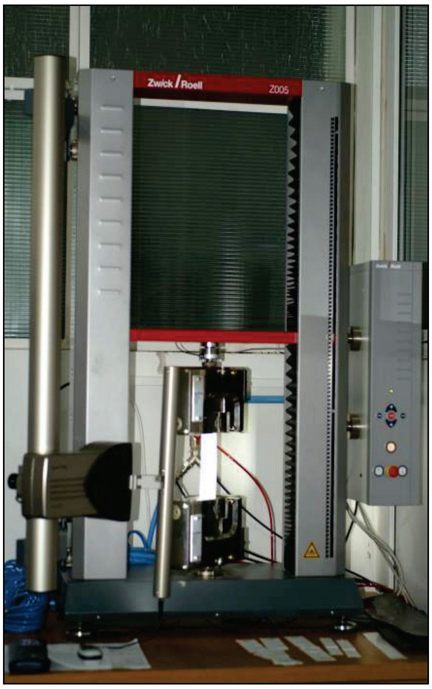

Figure 3. Zwick/Roell Z005 universal material testing machine

Conditioning of the specimens was carried out using a Discovery DY110 climatic chamber, Fig. 4.

Figure 4. Discovery DY110 climatic chamber

3. Results and discussion

The results of the tensile tests carried out at different loading rates are centralized in Figures 5 and 6. Determination of the loading speed at which the material characteristics are considered stabilized is based on two mechanical parameters: tensile strength (Figure 5) and elongation at break (Figure 6).

Based on the variation curves obtained for the tensile strength and the elongation at break, the loading speed of 200 mm/min has been identified as the threshold value above which the mechanical properties do not exhibit significant variation.

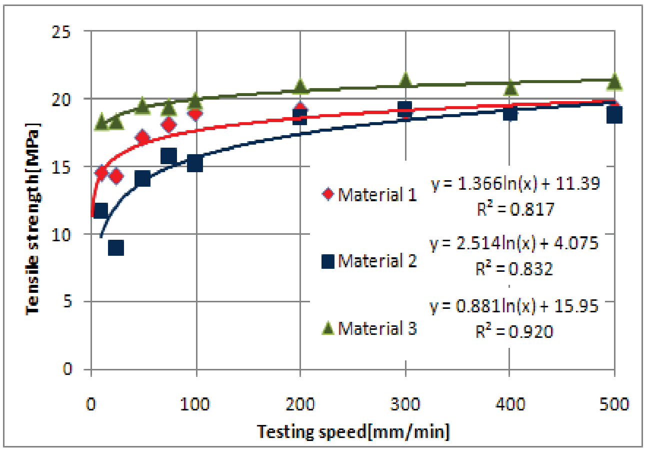

Figure 5. Variation of tensile strength with the loading speed

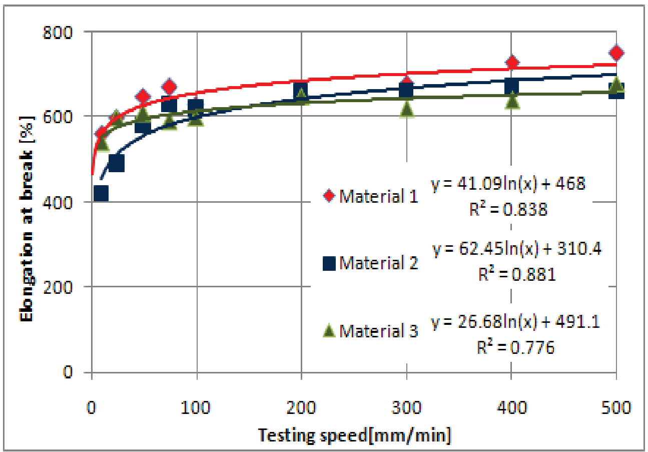

Figure 6. Variation of elongation at break with the loading speed

One set of specimens from each material was artificially aged while one other set was not.

The aged specimens did not show significant colour change or any other physical degradation detectable by the naked eye.

The results of the tensile tests carried out on both aged and unaged specimens are presented in Figures 7 and 8.

The tensile strength obtained during the tests (Figure 7) showed significant reductions due to the aging process for all three materials, as follows: Material 1: 48.5% reduction, Material 2: 61.2% reduction, Material 3: 40.7% reduction.

In the case of elongation at break (Figure 8) even greater reductions due to the UV exposure were identified for each tested material: Material 1: 63% reduction, Material 2: 45.8% reduction, Material 3: 67.4% reduction.

The results show that a 48h UV exposure had a very important effect on the mechanical properties of the tested polymeric films used in the construction of greenhouses.

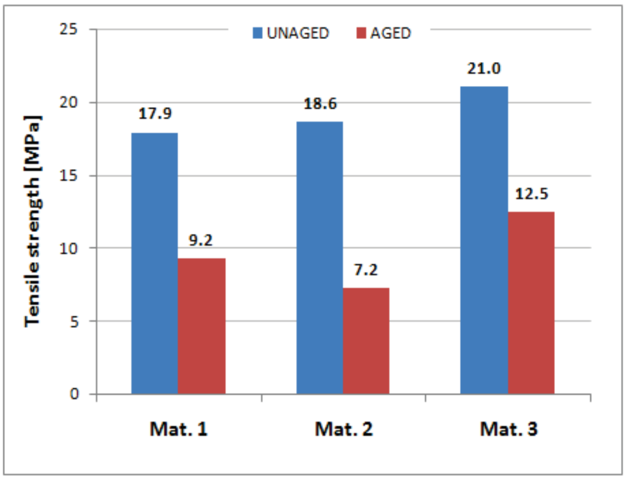

Figure 7. Tensile strength obtained for unaged and aged materials

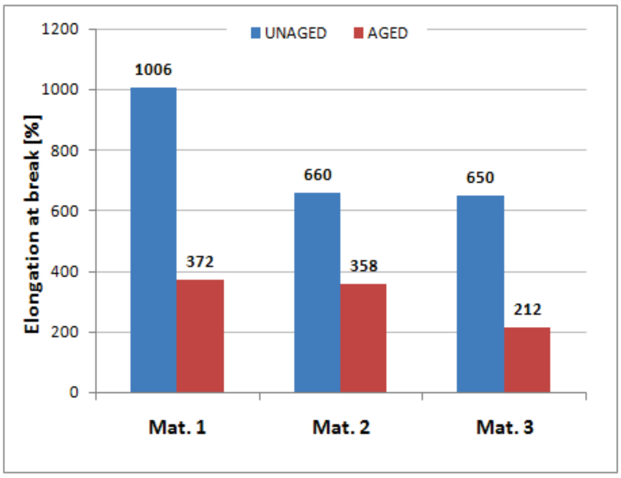

Figure 8. Elongation at break obtained for unaged and aged materials

These preliminary results confirm that the films used in the construction of greenhouses are highly sensitive to UV radiation.

Secondly, the results confirm that the underwater artificial aging method proposed in this work is a viable solution to eliminate the infrared radiation during artificial aging.

4. Conclusion

The effect of accelerated artificial aging with UV radiation on polymeric films used in the construction of greenhouses is studied in this paper. The original experimental equipment built by the authors was used to artificially age three different films positioned in a water basin using UV radiation.

The experimental results showed that both the tensile strength and elongation at break are significantly reduced by a relatively short UV exposure in case of all three tested materials (reduction between 40.7% and 61.2% in case of tensile strength respectively between 45.8% and 67.4% in case of elongation at break). Furthermore, the experimental equipment successfully eliminated the infrared component of the radiation emitted by the lamps, the underwater specimens being exposed only to ultraviolet radiation at temperatures not exceeding 36°C during the whole 48 hour exposure.

The obtained results justify further research in order to improve the performance of polymeric films used for greenhouses which will contribute to the development of the agricultural market.

5. Acknowledgement

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THE EFFECT OF BORON ON STEELS

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Abstract

Handbooks and Materials Standards dealing with properties and selection of metals contain few information about the effect of boron on steel properties. Based on researches from related literatures the aim of this paper is to give an overview about the recent findings in the effect of boron on mechanical properties of steels.

Keywords: boron alloyed steels, hardenability, mechanical properties

1. Introduction

Nowadays boron steels are becoming popular for a variety of applications. Boron enhances the mechanical properties of steels, and ensures a higher through hardenability that makes it a useful alloying element in the case of components with high dimensions subjected to high loadings.

The effect of boron on steels has been a research subject for a long period of time. In the mid 1920's, attempts were made to increase the hardenability of steels by using small amount of boron, and by the mid 1950's began the production of boron steels with high resistance to abrasive wear [1]. The basic effect of boron on the steel is the enhancement of hardenability, which is evident even at a very small concentration of 0.001% of boron. It can be added to low and medium carbon unalloyed and low alloyed steels [2] and can even replace expensive alloying elements such as Cr and Mo.

Experiments were done on high speed cutting tool steels to improve the cutting performance by boron addition as well as on corrosion resistant ferritic steels to improve the surface quality of stainless strips by avoiding errors, such as scale and ribbing which otherwise frequently occur in strip production. Boron steels offer better machinability than boron-free steels with equivalent hardness, and are less susceptible to quench cracking and distortion during heat treatment [3].

The aim of the present work is to summarize some important characteristics related to the composition, mechanical-, and technological properties of different steel groups alloyed with boron, as well as to define the hardening mechanism that takes place in these steels.

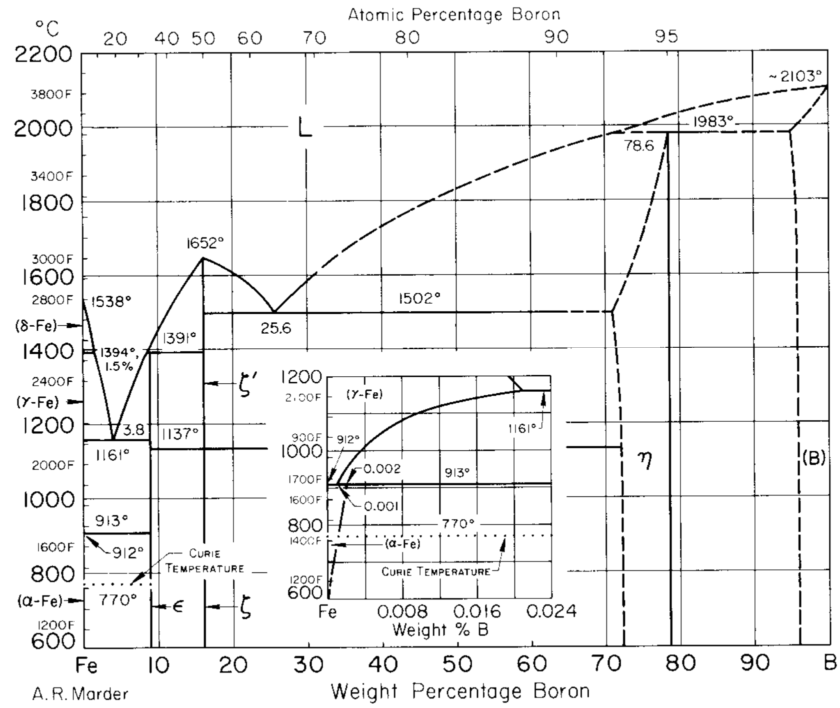

Figure 1. Fe-B equilibrium diagram [6]

2. Boron effect on through hardenability of steels

However, in many references it was found that 0.0007% B is sufficient for increased through hardenability better results were obtained with higher boron additions up to 0.005%. The highest effect was found to be in the case of 0.002-0.003% boron in solution in carbon steels [1,2,3] and has the same effect on through hardenability as 0.7% Cr, 0.5% Mo, or 1.0% Ni. Boron is much cheaper than any of these traditional alloying elements. The limited solubility of boron in iron can be observed in the Fe-B equilibrium diagram (Fig. 1) and has a dramatic effect on transformation characteristics during heat treatment.

The solubility of boron in iron at 913˚C is 0.002% and decreases with the temperature. Like other small size elements (C, N, H, O) relative to the iron atom, boron atoms are likely to be present in the iron lattice interstitially, but some researchers found by X-ray deflection measurements that the lattice parameter of gamma iron is reduced in the presence of boron. This could mean a substitutional location of the boron atoms in the austenite lattice. However, these papers did not exclude the possibility that a smaller number of boron atoms may also occupy intermediate lattice locations.

Low Carbon Steels

The carbon content of low carbon steels varies between 0.05-0.25%. This composition ensures good cold formability and weldability but low strengths. High strength low alloy steels are often used to produce higher strength components by cold forming. Steel for high strength welded structures are supplied in as quenched and tempered state. Boron can be used as a micro alloying element in these steels.

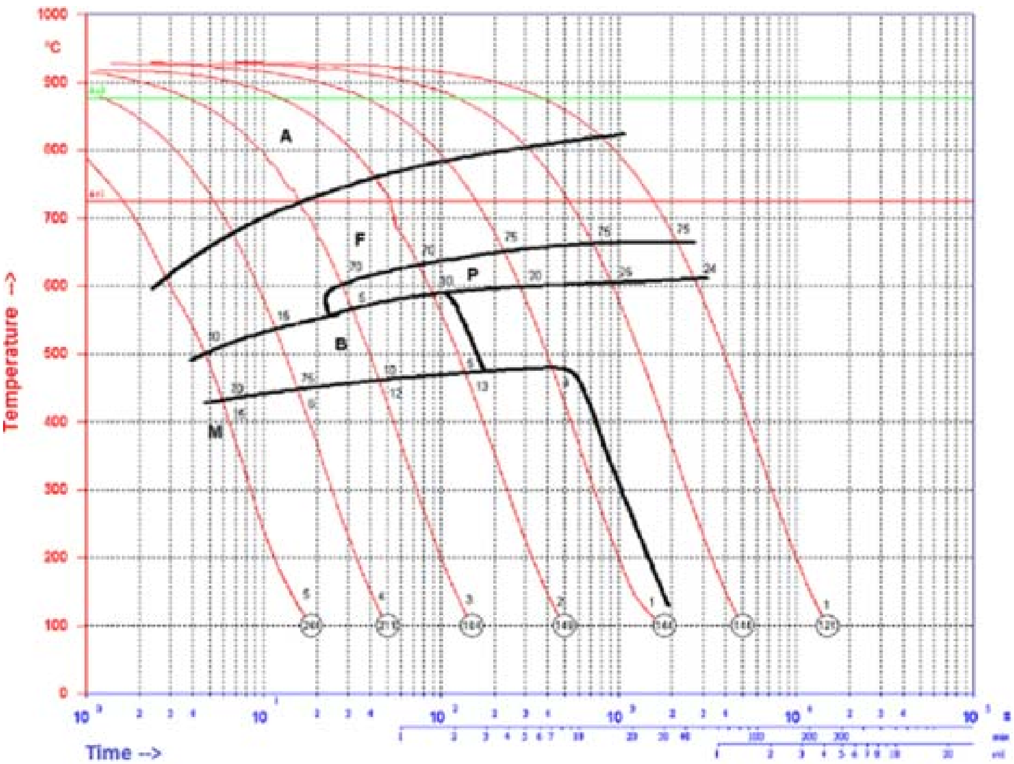

Figure 2. TTT diagram of steel without boron [2]

The hardening effect of boron is based on its segregation that takes place during cooling of the steel from austenitic temperature. Boron can be present in free state or as borocarbide ($Fe_{23}(B,C)_6$) and borocementite ($Fe_3(B,C)$). Boron reacts with oxygen to form boron oxide (B_2O_3), and with nitrogen to form boron nitride (BN). Therefore care must be taken on dezoxidation (Al) and on using strong nitride forming elements (Ti) to protect boron during steel production. The free boron segregates by diffusion at the grain boundaries of the austenite and retards the formation of ferrite [2, 4]. Figs. 2-3 shows TTT diagrams for continuous cooling.

Figure 2 presents TTT diagram for a low carbon steel (0.07%C), while Fig. 3 presents TTT diagram for a steel with the same base composition, but alloyed with 0.003% boron. These two diagrams illustrate the differences in the transformation kinetics of the two steels.

In Fig. 3 the hardening effect of the boron can be seen, and is manifested in shifting the starting of ferritic transformation to the right thus enable the formation of higher strength microstructures such as bainite and martensite at lower cooling rates. Table1 contains data related to the cooling time for different diameters.

If we assume that the cooling time for the core of a 10 mm diameter steel bar in oil from austenitizing temperature to 500˚C is 5 sec [7], according to Fig. 2, in this size 240HV0.5 is the maximum hardness that can be ensured in the case of boron free steel. The same hardness and strength properties can be ensured in dimensions up to 50mm diameter [7] in the case of boron alloyed steel, and the maximum hardness that can be ensured in the core of a 10mm diameter steel bar here is 325HV0.5.

Besides the hardening effect of boron on low carbon steels, its effect on other mechanical properties were also studied, and showed an increase in strength properties and decrease in ductility. Fig. 4 presents the effect of boron content on yield strength, tensile strength and percent elongation in the case of low carbon steel (0.1%C). Another TTT diagram of a low-alloy boron steel (0.003%B) is represented in Fig. 5. In this example the composition of the steel is similar to the previously presented steel, only the carbon content is higher (0.24%C).

This higher amount of carbon, combined with the hardening effect of boron enable to use of this steel for abrasive wear applications. Using the data given in table 1 and Fig. 3, can be concluded that the through hardenability of this steel is ensured by boron, and combined with higher carbon content ensures after oil quenching 431HV10 hardness even in the core of a 50 mm steel bar.

From the examination of impact properties, in the case of the examined steel authors concluded that tempering after quenching is not necessary [1[, this means that beside the hardening effect of the boron does not cause the embrittlement of the (water/oil) quenched steel. This steel has a similar composition with the widely used 22MnB5 steel.

Application of these steels can extend the lifetime of expensive machine constructions in many industries such as mining, agriculture and automotive industries. The suggested heat treatment route for these steels is quenching followed by low temperature tempering in order to obtain high strength and wear resistance.

The same conclusion was found in the case of B27 (similar composition to the 27MnB5) that is one of the typical steel of the boron steel group where mechanical properties were determined in delivery state (hot rolling), after normalizing, and after quenching and tempering at different tempering temperatures [5]. The results of these measurements are presented in Fig. 6.

In this case the boron content of the investigated steel was 0.002%. This amount of boron was enough to ensure a high tensile strength (R_m =1762 MPa) and yield strength ($R_{p0.2}$ = 1245 MPa) beside a tough behavior (KCV = 53 J/cm^2) after quenching.

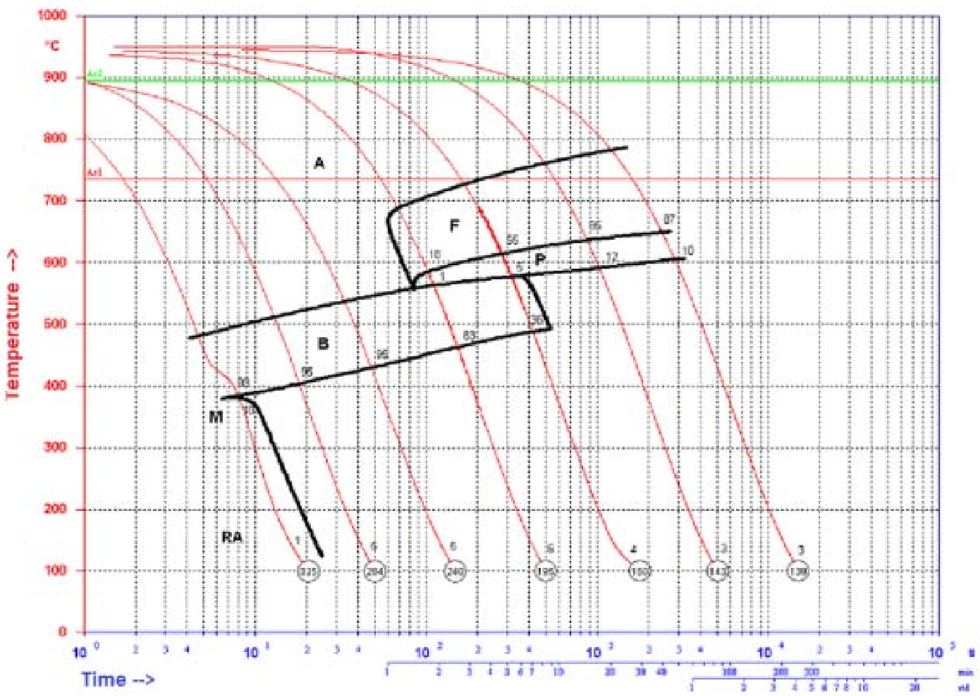

Figure 3. TTT diagram for steel alloyed with boron [2]

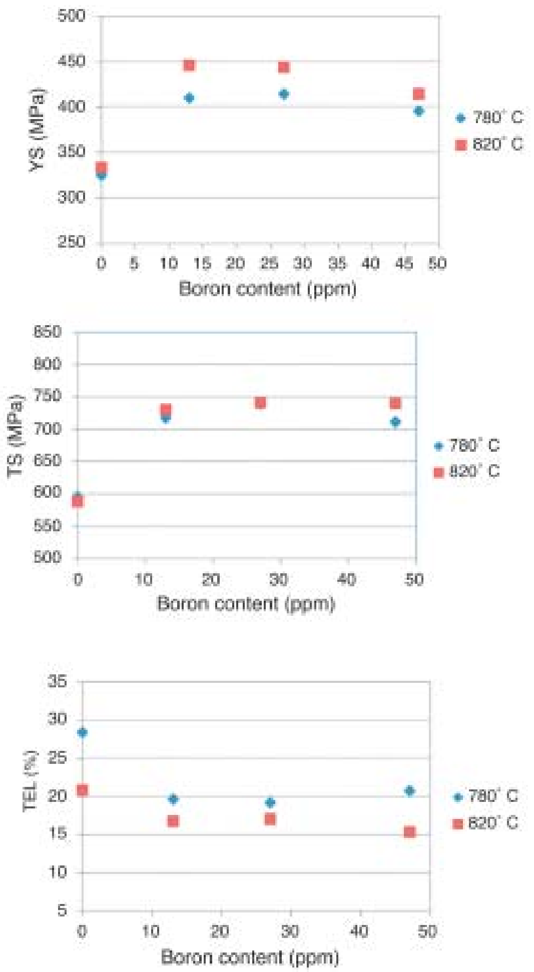

Figure 4. The effect of boron on mechanical properties at different soaking temperatures [9]

Table 1. Cooling time from austenitizing temperature to 500˚C [7]

Diameter d, mm	Cooling time, t (s)			
	Water cooling		Oil cooling	
	Surface	Core	Surface	Core
5	1	1.5	2	2.5
10	1.5	3	4	5
15	2	5.5	6.5	8.5
20	2.5	8.5	9	12
30	3	15	15	21
40	3.5	22	21	32
50	4	30	27	44

The weldability of low carbon steels alloyed with boron was also investigated focusing on the segregation of boron in the heat affected zone [4], and was found, that the non-equilibrium boron segregation is closely related to cooling rate [1,2], and the rate of boron segregation is increased by increased boron content (from 0.001 to 0.003%B). The advantage of boron in the case of weldable steels can be due to low carbon equivalents, and ensuring high strength properties.

Medium Carbon Steels. The carbon content of medium carbon steels varies between 0.3-0.6%. These steels are selected when higher strength properties and hardness are needed. According to some literatures the effect of boron on hardenability reduces progressively as the carbon content is raised, boron had been found to be most effective in low carbon steels (up to 0.25%C) but is also widely used in medium carbon steels (up to 0.4% C).

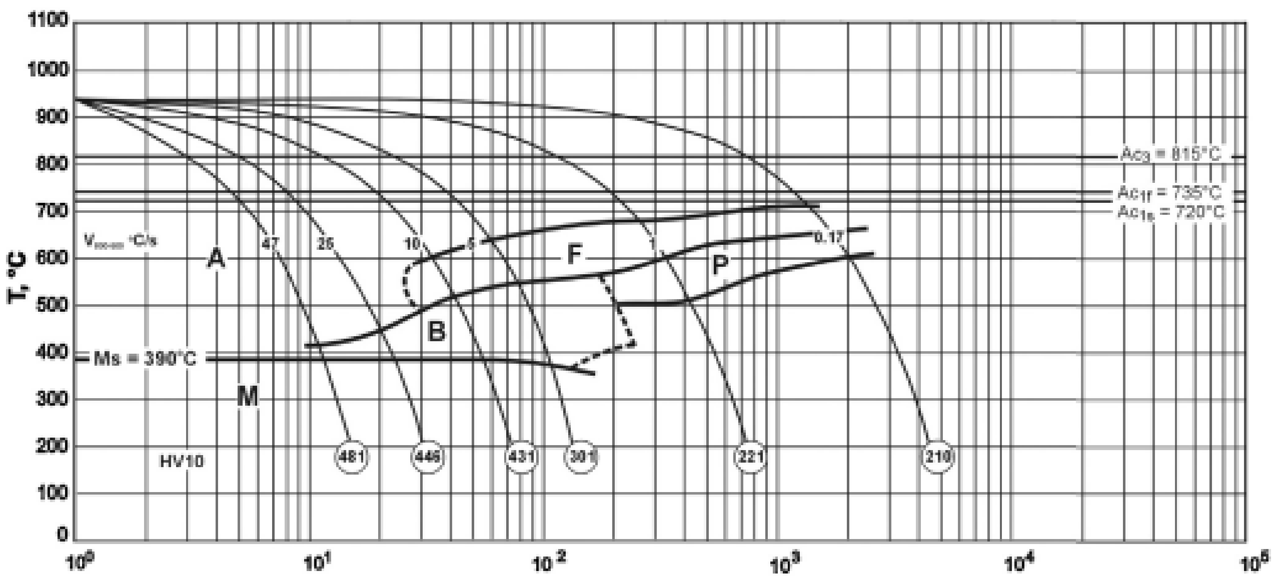

Figure 5. TTT diagram of a low-alloy boron steel [1]

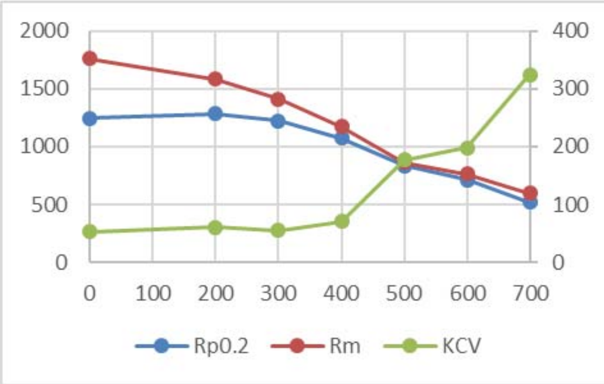

Figure 6. Tempering diagram of steel B27 [5]

An investigation was done on hot forged carbon steel bar (0.3-0.37% C) from 100 mm diameter to 45mm square to determine the effect of boron on yield strength, tensile strength, elongation and toughness [3]. These mechanical properties where determined on quenched (960˚C-30min/water) and tempered (260˚C-30min) steels with different boron additions and are shown in Fig. 7-8.

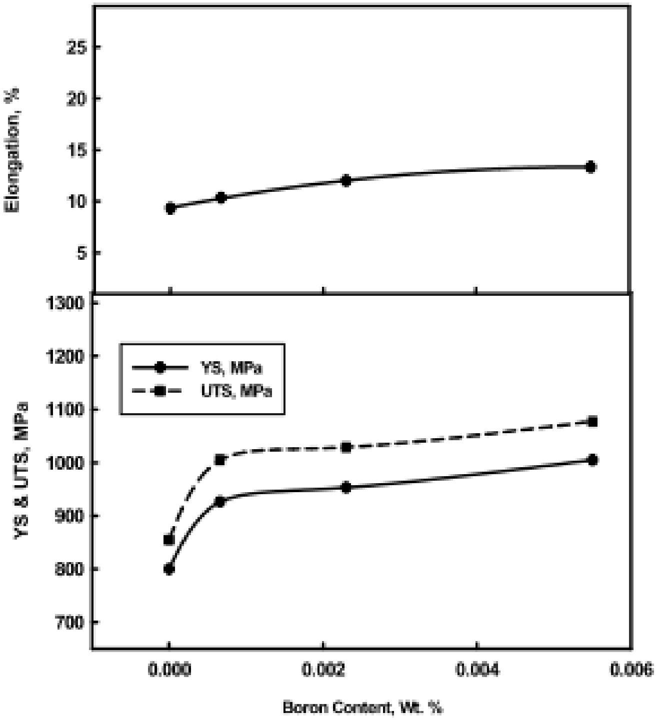

Figure 7. Influence of boron on yield strength, tensile strength and elongation [3]

The results agreed with the previously presented findings that the highest effect of boron on mechanical properties of steels is up to 0.003% B. Hardness measurement were also carried out on quenched steels, and these result correlates with the values presented in Fig. 5.

Boron is used as micro-alloying element in steels for hardening and high temperature tempering and in spring steels. The effect of tempering temperature on mechanical properties of two boron free spring steels with different compositions (60Si2Mn, 60Si2CrV) and two boron alloyed (0.0005%, and 0.0016% B) steels with similar base composition to the previous two steels but with lower carbon content (0.44%C) are illustrated in Fig. 9.

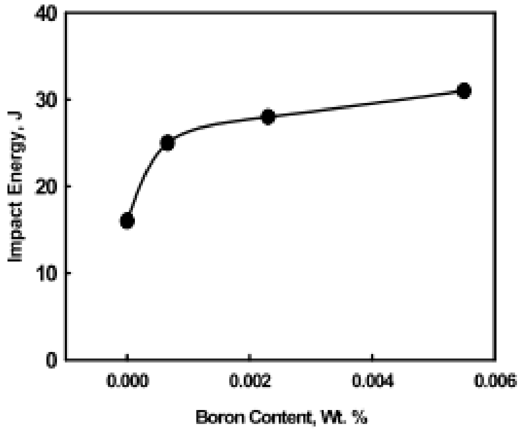

Figure 8. Influence of boron on impact energy [3]

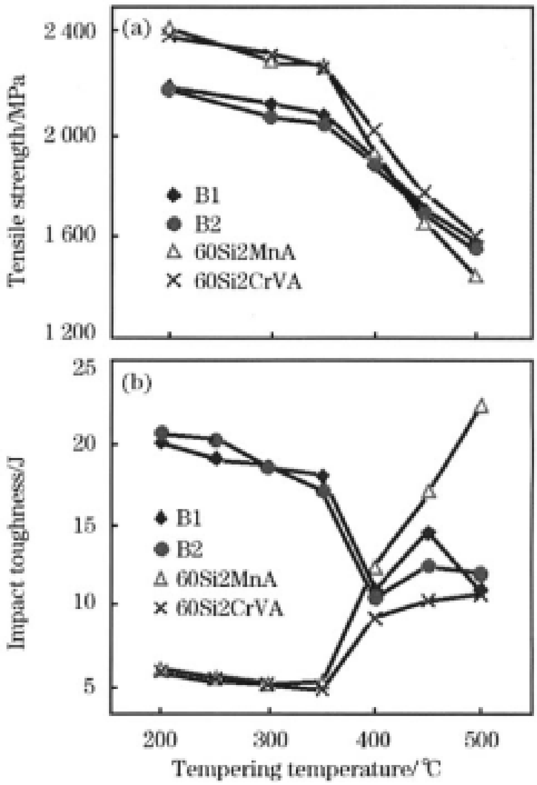

Figure 9. Tempering diagram for spring steels [8]

As these curves show, the effectiveness of boron alloying in these examples is when using lower tempering temperatures (up to 350˚C) that results in relatively high strength and not so brittle structure. This result is in correlation with other papers [3].

It is interesting to note the decrease of impact toughness with the increasing tempering temperature in the case of the two boron alloyed steels. Further research can be carry out to identify the mechanisms that are taking place during tempering that leads to this result.

3. Conclusions

Boron retards the formation of ferrite and pearlite, promoting the formation of martensite during rapid cooling and not depressing the martensite start (Ms) temperature. In this way ensures higher hardness and higher through- hardenability.
The amount of boron in low and medium carbon steel was found to be effective up to 0.003% and increases the strength properties, this is due to that boron is present in steel as interstitial element and has a very low solubility in α-solid solution.
Toughness of boron alloyed steels both in soft and in quenched and tempered state can reach the double of the steel with the same composition without boron.
In order to obtain high strength and high toughness the suggested heat treatment for boron alloyed steels is quenching followed by low temperature tempering.

4. Acknowledgement

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FROM BEGINNING TO MODERN ENGINEERING

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Abstract

The article shows a way of creating small steam engine at home. We have not used any special tools. We use only things which can be found at home, and some simple tools. At the end the SolidWorks are used as tool in which we can simulate our steam engine model in work.

Keywords:

homemade steam engine, steam engine model in solidworks, slider-crank mechanism

1. Introduction

The aim of the article is to present the importance of slider-crank mechanism in mechanical engineering. For this purpose we have made a one small homemade steam engine, with which we want to prove that is possible to make it at home without any special tools. We have also made computer model of the very similar steam engine, because it is very easy to show at computer, in cross section, what positions in the same time take piston and valve.

2. Construction of homemade steam engine

Our model of steam engine was constructed from material and things found at home. Some things were new, but the most parts have been made from scrap metal, which cannot be more used in their regular use.

Figure 1. Homemade steam engine

Assembly of steam engine consists of: base, cylinder block, piston, valve with mechanism, drawbars, flywheel, crankshaft and improvised plain bearings. All support parts are made from wood, which were connected together with screws.

Now you can read few words about how was each part in assebly made.

- Cylinder block

Figure 2. Mounted cylinder block

Main material for creating cylinder block was copper (tubes), which was connected by soldering method. Cylinder block is mounted on base with wire and screws. The sketch below shows the path of steam.

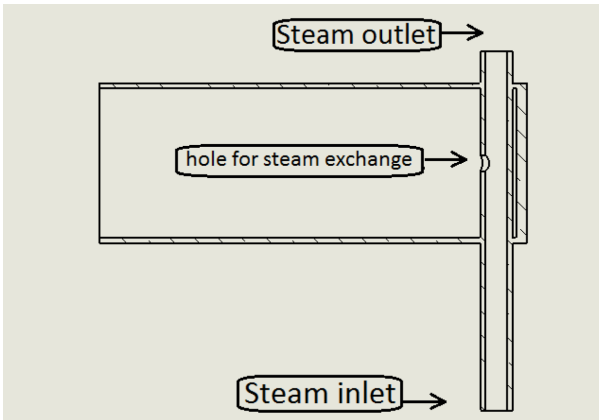

Figure 3. Sketch of cylinder block

- Piston

Figure 4. Piston

The piston is made from threaded rod M8, four nuts, and two cooper shims. Cooper nuts are machined to the dimension by rasp, while whole piston was rotated on the drilling machine.

- Valve with mechanism

Figure 5. Valve

Valve was created from one nail. The head of nail is machined on dimension also by rasp and drilling machine. Head of the valve will be positioned in the smaller tube of cylinder block. Other side of valve must be connected with steering mechanism.

Figure 6. Steering mechanism for valve

Steering mechanism for valve connects crank-shaft via drawbar with valve. The main element of that mechanism is iron triangular plate. Dimension of triangle reduces stroke of valve.

- Drawbar

Figure 7. Mounted drawbar

Drawbar is made from iron wire.

- Crankshaft

Figure 8. Crank - segment on crankshaft

Parts for creating crankshaft were nuts, threaded rod M6, and two small plates.

- Improvised plain bearing

Figure 9. Mounted plain bearing

For plain bearing we used nut M6 with removed thread. Nut are attached to base with screws and iron wire.

- Flywheel

Figure 10. Flywheel

Flywheel is made of wood, and simple connected with two nuts and two shims on crankshaft.

- Assembly

In Fig. 11 every part of assembly is marked, while the list of parts is given in Table 1.

Table 1. List of parts

No	Part:	Material:
1.	Base	Wood
2.	Bearing base	Wood
3.	Cylinder block support	Wood
4.	Cylinder block	Copper
5.	Valve	Iron
6.	Steering mechanism	Iron
7.	Piston	Iron and copper
8.	Drawbar	Iron
9.	Bearing	Iron
10.	Crankshaft	Iron
11.	Flywheel	Wood

3. Working principle of a cylinder block

This paragrapph describes how this single-acting cylinder works. We can say that this steam engine works in two stroke mode. First stroke, we can also call working stroke, because the steam under pressure enters into cylinder and pushes piston. At the start of working stroke, piston is situated at top dead point, and the valve, which are controled by steering mechanism, closes the steam outlet pipe and at the same time makes the steam inlet pipe opened.

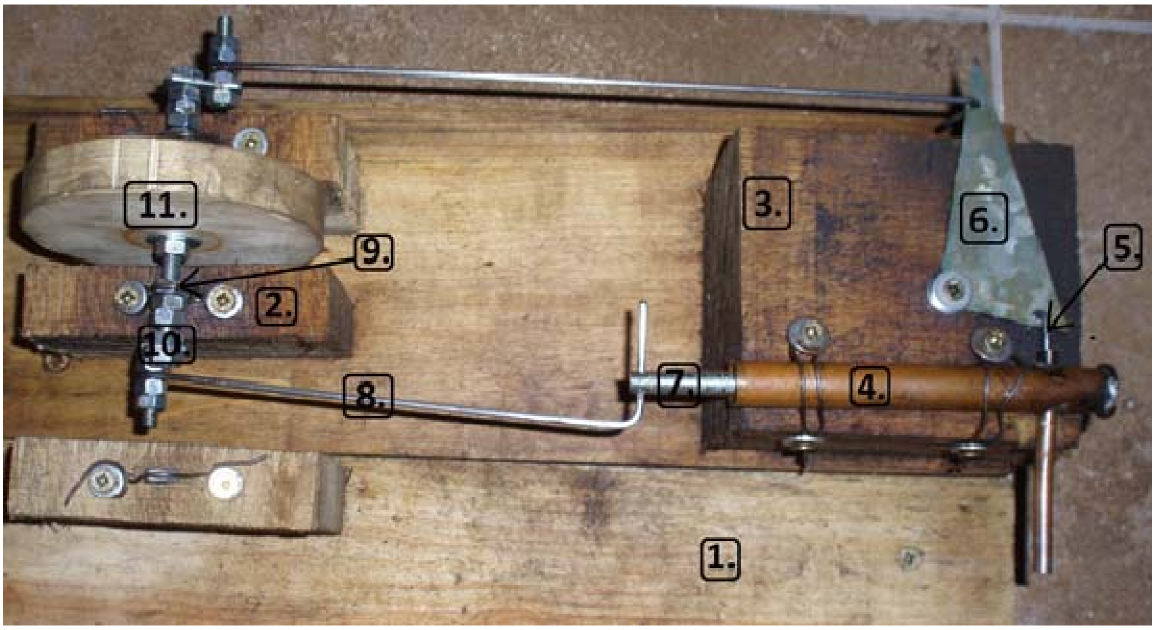

Figure 11. Steam engine with marked parts

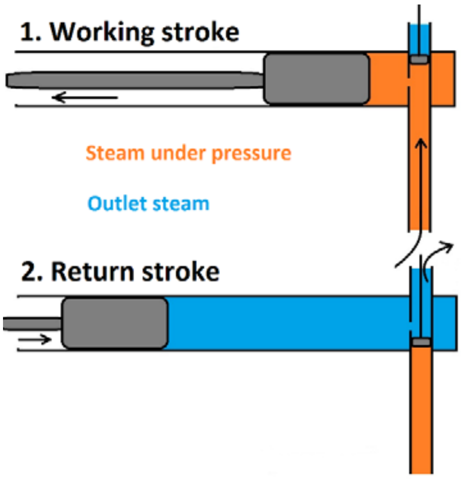

Figure 12. Sketch working principle of a cylinder block

At the start of second or return stroke piston is positioned at lower dead point, and a valve in this case closes steam inlet pipe and opens outlet pipe, through which used steam goes out in athmosphere. Important to say is that in the return stroke piston is not pushed by steam. Energy for motion of piston back to thetop dead point is provided from flywheel. After that cylinder block is ready for new working stroke and this two strokes will repeat forever or while steam pressure is enough to power engine.

4. Characteristics of this steam engine

The characteristics are obtained experimentally. Engine do not have enough power to run something bigger. We used engine mostly for lifting weights during measurments. Presented characteristics are based on this measurments.

CHARACTERISTICS	
Working pressure:	10-30 kPa
Type of cylinder:	Single-acting
Cylinder diameter:	13.6 mm
Stroke length:	34 mm
Displacement:	4.93 cm^3
Power at the crankshaft:	0.3w at 25kPa
Torque at the crankshaft:	0.006 Nm at 25kPa

4. Analyzing RPM

We will present dependence of RPM and steam pressure at graph. We must admit that we were surprised with the high speed at relatively low steam pressure.

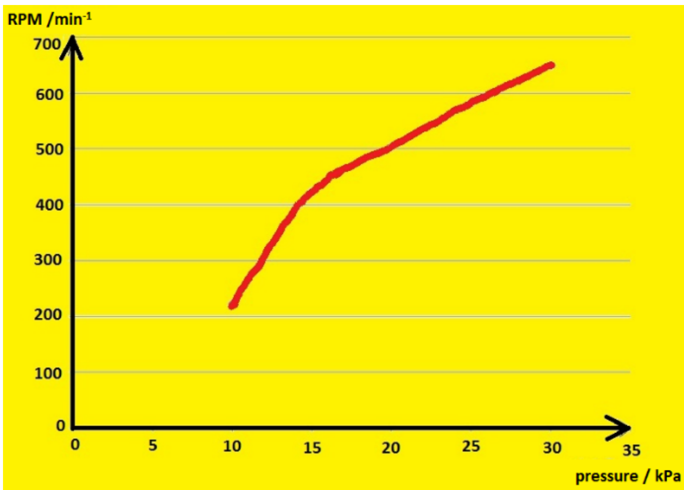

Figure 13. Dependence of RPM and steam pressure

5. Model of steam engine in SolidWorks

In order to simulate the operation of the steam engine, we have developed a simple model in SolidWorks. In SolisWorks we can look at cross section of cylinder block and in real time watch position of piston and position of valve.

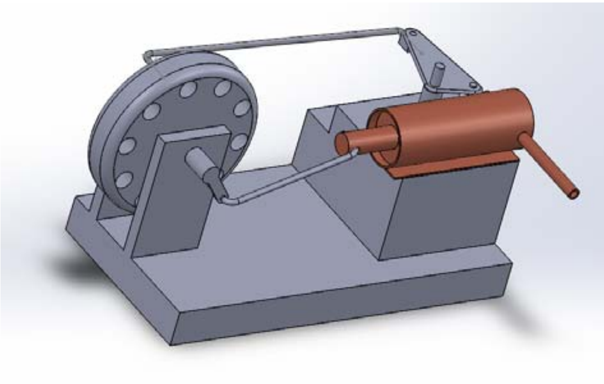

Figure 14. Steam engine model in SolidWorks

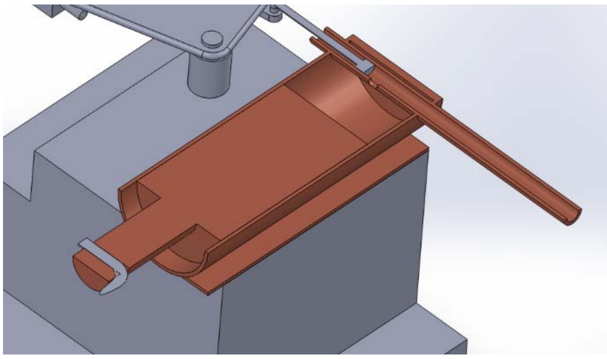

Figure 15. Cross section of cylinder block

6. Conclusion

With our real steam engine and steam engine computer model we have shown the importance of slider-crank mechanism.

We have also proven that it is possible to easily make a small steam engine at home without any special tools.

With help of computer, computer model of steam engine was made. Biggest advantage of computer model is opportunity to make simulation in real time and see what is going on with every part in assembly during rotation of crankshaft.

At the end we can conclude that: whatever we want to make in every case is better first make an computer model and then without any unsolved question go into workshop and make the product.

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COMPARISON OF MACROECONOMIC INDICATORS OF CROATIA AND IRELAND

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Abstract

The paper analyzes data and compares the level of deficit and surplus and GDP trend per capita of Croatia and Ireland. Also, the object of study is population; structure of the same by age. It takes into consideration the competitiveness of countries, as well as the movements of GNI index of two surveyed countries. Conclusion presents the results of comparison of mentioned macroeconomic indicators.

Keywords: macroeconomic indicators, Croatia, Ireland

1. Introduction

In former Irish economy farming had a significant role until 1980, when there are great changes. Through planned industrialization in recent decades, the traditional industries such as food processing, textile, glass and shoe industries are modernized and export-oriented. Their importance is declining due to new labor and technologically demanding industries that do not require a lot of raw materials. These factories were mostly owned by American, British, German and Japanese companies. For example, large part of drive electronics company Nokia has been moved in Dublin from Helsinki, and the US IT company Microsoft of Bill Gates determined Dublin for the European hub for the distribution of software and hardware throughout Europe. Today Ireland is the second largest world exporter of computer programs. Almost a third of all personal computers sold in Europe are produced in Ireland, mostly in US subsidiaries. Ireland is a country of young population on average (36 years, compared to the EU where the average is 42 years), with a record number of 76.762 births in 2010, and positive natural growth. The number of migrants is also increasing year by year. The average gross salary is 40 thousand euros per year [1]. Despite the global crisis and recession that has affected Ireland in 2009, Ireland still has a lot of strong trumps:

- Ireland is the third fastest growing in the euro zone in the 2012
- Ireland exports 16% more than in the period of crisis
- Ireland has the highest FDI per capita in Europe
- Ireland is the second largest exporter of software in the world
- Ireland's eighth largest exporter of pharmaceutical products in the world
- Ireland has the highest number of employees in the high tech sector in Europe [2].

2. Population structure

One of the most important structures of the population is age structure, since it affects the socio-economic development of a particular population. The age structure reflects the development of the population over a long time period [3].

Table 1. Population by age group, Croatia and Ireland in 2011 [author according to 4, 5]

Population by age group, Census 2011		
Age group	Croatia	Ireland
0-14 years	652,428	979,590
15-24 years	505,835	580,250
25-44 years	1,155,372	1,450,140
45-64 years	1,212,621	1,042,879
65 years and over	758,633	535,393

The table shows that the Croatian population is characterized by a very rapid and also a high degree of aging. It indicates a decrease in the number of young people, groups up to 34 years with a particularly strong reduction in the youngest group, on the other hand, it indicates increase the number of old people. According to this data, it can be concluded that Croatia has a problem with the demographic aging of the population as the proportion of the population aged 65 years and over is higher than the share of the population aged 0-14 years.

Regarding Ireland, the situation is different. The table clearly shows that Ireland, according to the 2011 census is marked with relatively young population, most of them are in the group of the population aged between 25 and 44 years, after which there is a more mature age group of the population ranging from 45 to 64 years. Than it comes population age group of 0-14 years, and young people ages 15-24. The population of aged people is least, which is characterized as an aging population in the period over 65 years.

3. Deficits and surpluses in 10 years period

The government's budget is composed of received government payments, taxes and other charges and payments by the state, purchase and paid transfer. The budget deficit occurs when the government spends more money than it receives. Contrary to the budget deficit is a budget surplus, or surplus [6].

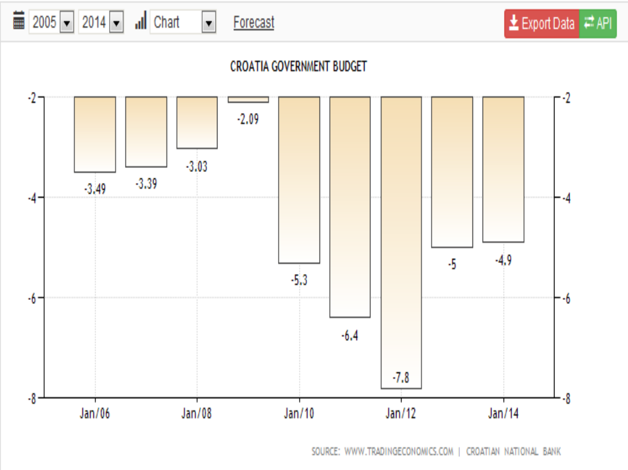

Figure 1. Deficit and surplus of the Croatia in the period of 10 years [6]

Figure 1 shows the Croatian deficit in the last 10 years. The Croatian government in 2013 recorded a budget deficit of 4.9% of the national GDP. In the period from 2002 to 2013 the average was -4.61% of GDP reaching the highest -2.09% of GDP in 2008 and the lowest -7.8% of GDP in 2011. Figure 2 shows the deficit and surplus of Ireland for a period of 10 years.

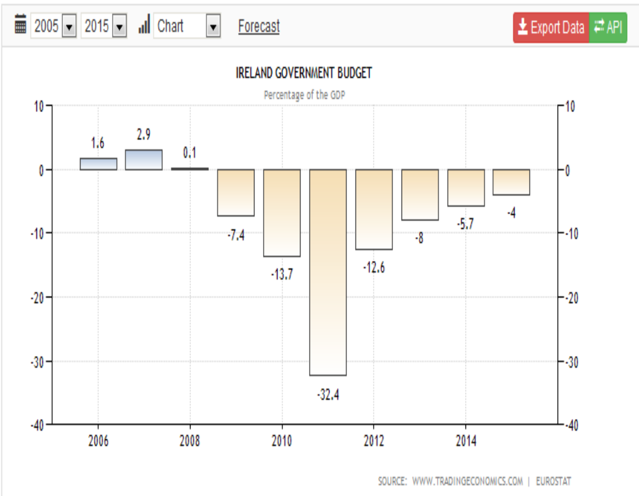

Figure 2. Deficit and surplus of the Ireland in the period of 10 years [7]

Ireland expects that in 2014, the government will record a budget deficit equal to 4% of the total GDP of the country. The state budget in Ireland has an average of -3.40% in the period from 1995 to 2014 year, reaching the highest 4.80% of GDP in 2000 and a lowest -32.40% of GDP in 2010.

4. Trend of GNP per capita by the methodology of WB in the period of 10 years

Gross national product – GNP, represents the value of all final goods and services produced by domestic factors of production within a particular period. It is irrelevant whether these factors of production are in the country or abroad.

Figure 3 shows the movements of the GDP of Ireland and Croatia, according to the methodology of WB (World Bank), in the last 10 years. The values are expressed in US $.

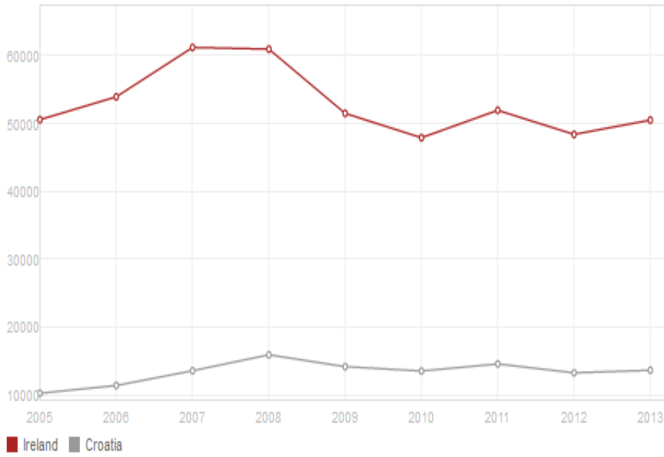

Figure 3. GNP per capita; Ireland and Croatia [8]

Figure 3 shows that the GNP per capita in Ireland is highest in 2007 and it stood at $ 61,215 and the lowest in 2010 ($ 47,901). In Croatia, the highest GNP per capita was in 2008 and amounted to $ 15.889. The lowest was in 2005 and amounted to $ 10,224. Ireland has a much higher GDP per capita than Croatia.

5. The competitiveness in the period of 10 years according to methodology IMD

World Competitiveness Yearbook IMD, says the NCC (National Competitiveness Council), arouses special interest of business and political community as it brings current statistical and survey data on economically most important countries in the world, which is very important in light of the unbalanced exit of some countries from the global crisis.

IMD methodology is based on an analysis of four factors of competitiveness, and these are: economic results, the efficiency of the public sector, efficiency of the business sector and infrastructure, and 5 indexes for each area. Table 2 shows the competitiveness of Ireland and Croatia in the last 10 years indicating that Croatia is in a very bad position, since the ranking conducted among 60 leading global economies. In 2014 Croatia was situated on the 58th place and the best ranking it achieved in 2008 by the 46th place. Ireland was on the 6th place in 2014, while the best ranking achieved in 2006 when it was in fifth place in terms of competitiveness.

Table 2. Competitiveness of Croatian and Ireland according to the methodology IMD in the last 10 years [9]

	Overall Ranking									Investment and development factor	Attraction and retention factor	Availibility factor	**Overall**
Country/Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	**2014**			
Croatia	X	51	53	46	53	55	57	57	57	32	57	58	**58**
Ireland	14	5	6	10	13	18	16	8	11	19	4	8	**6**

6. Trend of GNI index in the period of 10 years

GNI index measures the distribution of income and consumption among individuals and households that the deviates economy from a perfectly equal curve. The chart shows the GNI index for Ireland and Croatia in the last 10 years.

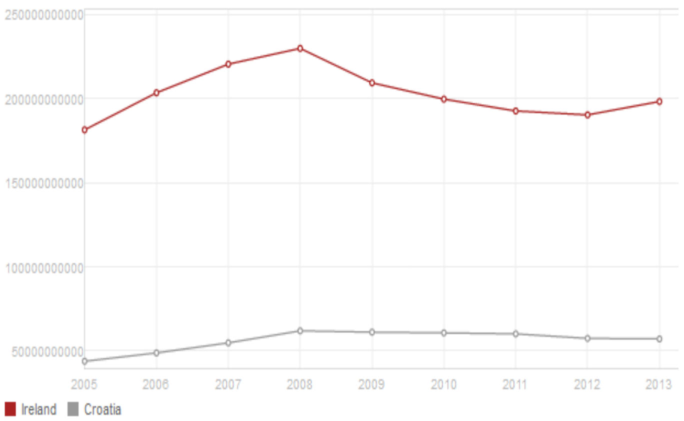

Figure 4. GNI index for Ireland and Croatia in the last 10 years [10]

Figure 4 shows that the highest GNI in Ireland was in 2008, and amounted to $ 229,660,534,401, and the lowest was in 2005, amounting to $ 181,268,233,625. In Croatia, the largest GNI was also in 2008 ($ 61,913,317,821), and the lowest in 2005 ($ 43,856,724,383). In Ireland, GNI is significantly higher than in Croatia in all 10 years.

7. Conclusion

Research has shown that Croatian population is aging; the number of young people is reducing, while the share of the elderly population over 65 years is increasing. On the other hand, Ireland has a large number of citizens who belong to a group of young population, the proportion of the population older than 65 years, is less than the number of very of young population, whose group includes residents from 0 to 14 years. Comparison of young and old population in Croatia gives disturbing data, such ratio of old and of young population is a result of the emigration of young population and reduction of natural growth. These trends can leave lasting effects on the country and its economic development, with the addition of Croatia as a country that gets old must enable young people the jobs and education that will make them stay at their home country.

Ireland has a much higher GNP per capita than Croatia. Croatia achieves the highest revenue from tourism, it even amounts to 15% of GDP, which is significantly less than it is realized in other tourist countries (Italy, Spain), which clearly shows that there is a place for improvement and increase of revenue. Croatia has the potential to increase production of grains, oilseeds, fruits and vegetables, and also meat and milk and local products, it is important to turn to the overall modernization of agriculture.

In Ireland's GNI is significantly higher than in Croatia in all 10 years. According to the IMD, Croatia is in a very bad position observing the 60 countries in 2014; it takes the 58th place, while Ireland occupies an enviable 6th place. Ireland is definitely a country that provides a good example for other economies, and whose results Croatia should strive.

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ENVIRONMENTAL PROTECTION IN INTERMODAL NETWORKS BY MINIMIZING CO_2 EMISSION

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Abstract

The reduction of carbon dioxide (CO_2) emissions, an important cause for global warming, has become a priority and consequently there is increasing pressure on governments and industries to come forward with initiatives to reduce those emissions. Therefore it can no longer be ignored when planning supply chains: on the one hand because companies have a moral obligation to operate in a sustainable fashion and on the other hand because customers are becoming more and more aware of the humongous affect that supply chain design has on CO_2 emissions. This is highly relevant for the transport sector, as the share of transportation is still increasing making growing requisite to consider carbon footprint in transport planning. This paper breaks away from previous approaches which take into account cost and time of transportation as two most common considerations in transport planning problems, incorporating environment into freight transportation planning and proposes a new mathematical model which minimize CO_2 emissions in intermodal transport. The developed mathematical model provides us the opportunity to observe the entire range of possible solutions, and give us the possibility of their ranking, whose choice is made simple selection of the most optimal solutions group, observing the minimization of CO_2 emissions. Global approach to further improve its energy efficiency and effective emission control is needed as intermodal transport will continue growing apace with world trade.

Keywords:

Carbon dioxide emissions, mathematical model, intermodal transport

1. Introduction

Although literature on freight transportation is large, containers assignment on intermodal networks is still an open issue. Decreasing carbon dioxide (CO_2) emissions is one of the most important tasks for the society in the 21st century. The concentration of CO_2 in the atmosphere has been monitored continuously since 1958 [1]. Bauer et al. [2] proposed an integer program in the form of a linear cost, multi-commodity, capacitated network design formulation that minimize the amount of greenhouse gas emissions of transportation activities. Geerlings et al. [3] presented a methodology to analyze the CO_2 emissions from container terminals, illustrated by the Port of Rotterdam. Winebrake et al. [4] described an energy and environmental network analysis model to explore tradeoffs associated with freight transport. Kim et al. [5] examined the relationship between the freight transport costs and the carbon dioxide emissions in given intermodal and truck-only freight networks [6, 7]. Changes in carbon dioxide emissions were also analyzed by Liao et al. [8]. In Lättilä et al. [9] studies impacts of dry ports in a Finnish context and observed level of CO_2 emissions and costs are studied. Chang et al. [10] described an intermodal transportation problem of international container cargoes while incorporating the external costs of the modes into an optimization model in South Korea. Rajkovic et al. [11] proposed multi-objective evolutionary algorithm, minimizing cost, time and emissions using see and land legs together.

In this study we developed mathematical model, which minimize the CO_2 emissions by determining the most ecologically route for container import to Serbia. First leg observed the six world's largest container operators with theirs different type of services. The second leg represents the inland component of the distribution, in which containers are routed from gateways to final destination, by road, rail or barge.

2. Method

In this paper we consider an intermodal transportation chain which based on the importway. The network is composed by three categories of nodes: origin port (port of loading), gateway ports (ports of discharge) and destination (place of delivery), and two categories of links, maritime and inland. Each node type has its own characteristics:

Origin port - as one of the most important foreign trade partners in container imports from the Far East to Serbia is China with major port - port of Shanghai. It is the world's busiest trading port which handles a staggering 32 million containers a year, carrying 736 million tonnes of goods to farflung places around the globe.

Gateway ports are connected with origin port, but only by incoming links. From origin port it is possible to reach a gateway port but the opposite is not allowed since here we are addressing only incoming flows. The main gateways for container import to Serbia are Constanza, Thessaloniki, Bar, Rijeka and Koper port.

Destination - Serbia is hinterland country with capital city - Belgrade. This region represents the largest percentage of Serbian imports in general. It is connected to the gateway ports with a direct link, representing the shortest path to reach it from that gateway, by road, rail and barge.

There are two types of links, maritime and inland, each one with its own characteristics, as described below:

Maritime links are those between origin port and gateway ports. As for intercontinental links, there may be more than one link connecting an origin port to a gateway port, and each such link belongs to a different service with given travel time and frequency depends on different operators (Maersk Line - MSK, Mediterranean Shipping Company - MSC, CMA CGM, Evergreen Line - EMC, China Ocean Shipping Company - COSCO and Hapag-Lloyd).

Inland links are those between gateway ports and place of delivery of containers – Belgrade.There are three available inland transportation modes which could be chosen including truck, railway and barge. Their interconnection is shown in Table 1.

Where there are available rail or barge linkages, line-haul may be done by rail or barge before last mile delivery by truck. Without such facilities, containers could also be transported from gateway ports to end-customers all the way by truck.

Table 1.Modes of transport from discharge ports to final destination

Ports / Modes of transport	Truck	Rail	Barge
Koper	x	x	
Rijeka	x	x	
Bar	x	x	
Thessaloniki	x	x	
Constanza	x		x

x - connection with Belgrade

Our mathematical model is focused on the container import flow considering the total CO_2 emissions from the moment of the ship departure from the port of loading to the moment of the arrival container to the place of delivery in Belgrade, regarding the six different operators, five discharge ports, three different types of services on the see legs and three different modes of inland transport. The total CO_2 emissions included ocean transport emissions from container ships and land emissions produced by truck, rail and barge. This paper excluded CO_2 emissions in ports of discharge due to their negligible share in total emissions. Finally, in this model was given a rank list and possibility to sort and make a list of the best possible solutions regarding minimization of CO_2 emissions.

Table 2.Model formulation

Set	Description
N	set of nodes, let N = OT ∪ DT ∪ D, while OT stands for origin terminal, DT stands for destination terminal and D stands for final destination
A	set of routes connecting the origin and destination nodes, let A = FL ∪ SL, while FL presents first leg arcs (ocean leg) and SL presents second leg arcs (land leg)

Decision Variable	Description
ef_{ij}	binary emission variable representing containers flow on first-leg arc, operator "i" to gateway "j", $1 \le i \le n_i, 1 \le j \le n_j, f_{ij} \in \{0,1\}$
es_{jk}	binary emission variable representing containers flow on second-leg arc, gateway "j", mode of transport "k", $1 \le k \le n_k, 1 \le j \le n_j, s_{jk} \in \{0,1\}$

Parameter	Description
n_i	number of operators
n_j	number of gateway ports
n_k	mode of transport
n_s	type of service
EM	CO_2emission factor on FL
EM_k	CO_2emission factor on SL
m	cargo weight
L_m	max cargo weight
DFL_{ij}^{s}	emission on FL (€)
DSL_{jk}	Emission on SL (€)

The model formulation and corresponding explanation are given as follows:

$$(i,j) \in FL, 1 \le i \le n_i, 1 \le j \le n_j$$

$$(j,k) \in SL, 1 \le j \le n_j, 1 \le k \le n_k$$

Objective Function 1 (Z) minimizes the total CO_2 emission:

$$Z = \min\left[\sum_{i=1}^{m_i}\sum_{j=1}^{n_j}\sum_{s=1}^{n_s} DFL_{ij}^{s} \cdot EM \cdot m \cdot ef_{ij}^{s} + \sum_{j=1}^{n_j}\sum_{k=1}^{n_k} DSL_{jk} \cdot EM_k \cdot m \cdot es_{jk}\right] \tag{1}$$

Constraints:

$$\sum_{i=1}^{m_i}\sum_{j=1}^{n_j}\sum_{s=1}^{n_s} ef_{ij}^{s} = 1 \tag{2}$$

$$\sum_{j=1}^{n_j}\sum_{k=1}^{n_k} es_{jk} = 1 \tag{3}$$

$$\sum_{i=1}^{m_i}\sum_{s=1}^{n_s} ef_{ij}^{s} = \sum_{k=1}^{n_k} es_{jk}, \forall j \tag{4}$$

Corresponding explanations: The objective function (1) minimizes total CO_2 emissions of container import flow through the transport network. They include CO_2 emissions for container ships on the first leg-arc (maritime transport) and CO_2 emissions for inland vehicles - truck, rail and barge on the second leg-arc. Constraint (2) defines a single best solution for CO_2 emission on the ocean and depends on different type of service. Constraint (3) gives a single best solution for CO_2 emission on the second leg-arc. Constraint (4) selects the same port for the first and second leg-arc and represents one route from origin to place of delivery regarding CO_2 emission. To calculate the "Carbon footprint" in intermodal transport, one can use:
CO_2 emissions = Distance x Emission Factor
g of CO_2 / TEU= km x [g of CO_2 / (TEU x km)]
Source: Greenhouse Gas Protocol 'Distance-based methodology' for calculating CO_2 emissions (Maersk Line, 2012).[12]+

3. Results

In this section we analyze the results obtained by our developed optimization model, which minimize the CO_2 emissions in intermodal transport. The model was programmed in MATLAB and simulations were performed on an Intel Core i7-3612 QM 2.1 GHz computer. We use original input data regarding first half of 2014.

We concern one objective optimization ("Min CO_2 emissions") and use different carbon footprint factors for different modes of transport presented in Table 3.

Table 3.Carbon footprint factors (CFF) for different modes of transport

CFF	Ship	Rail	Barge	Truck
CO_2 factor (kg/TEU-km)	0.084	0.205	0.084	0.072

Source: Technical report (Maersk Line, 2012) [12]

The results show that optimal CO_2 emissions in intermodal transport between Shanghai and Belgrade, without taking into account the hypothetical aspect with barge transport, is 1444,75 kg/TEU-km using see and land legs together. They are presented in Table 4. The operator MSK using Asia - Europe Service - AE20 and Greece Link Service - L51 service on the first-leg arc reach to the gateway port, Thessaloniki port, and continues on the second-leg arc with rail to the final destination Belgrade.

Table 4.Optimal CO_2 emissions

Port of loading	**Shanghai**
Operator	MSK
No. of transshipments	1
Service	AE20 / L51
Route	Shanghai - Ningbo - Yantian - Nansha - Tanjung Pelepas - Port Kelang - Jeddah - Port Said / Port Said – Piraeus - Thessaloniki
Port of discharge	Thessaloniki
Mode of transport	Rail
Place of delivery	Belgrade
Optimal CO_2 emission	1444,75 kg / TEU-km
Distance	16096 km

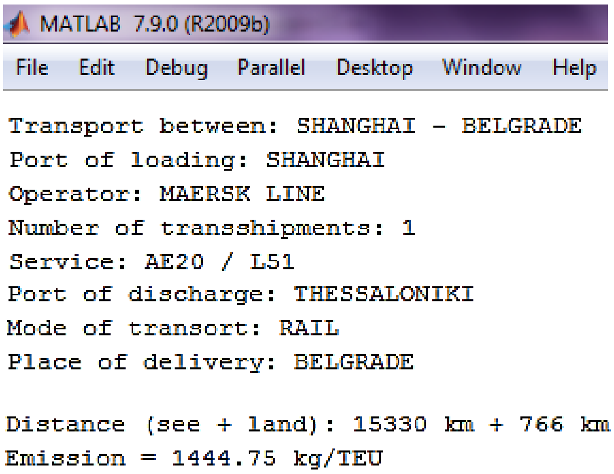

Figure 1.Simulation results

The developed mathematical model also provides us the opportunity to observe the entire range of possible solutions, and give us the possibility of their ranking, whose choice is made simple selection of the most optimal solutions group, observing the minimization of CO_2 emissions. Group of all possible solutions are ranked in ascending particular order and period of observation in the mathematical model does not have to be time-limited. The advantage of the model is that it can be applied to various "point to point" relations where the containers are transported by a combination of sea and land whose implementation of adequate input data can get reliable solutions of the observed problems.

4. Conclusions

International shipping is the most energy efficient mode of mass transport and only a modest contributor to overall CO_2 emissions. Exhaust gases are the primary source of greenhouse gas emissions (GHG) from ships and CO_2 is the most important, both in terms of quantity and of global warming potential. In view of rising environmental concerns of GHG, shipping lines must also consider cutting down their carbon footprints in their strategic and tactical planning.

This paper analyzes the supply chain network with primary focus on import of containers from Shanghai to Belgrade through selected Mediterranean ports (Koper, Rijeka, Bar, Thessaloniki and Constanza), observing the six world's largest container operators (Maersk Line, Mediterranean Shipping Company, CMA CGM, Evergreen Line, China Ocean Shipping Company and Hapag-Lloyd) with theirs different type of services. Serbia is hinterland country and container import from Far East to Serbia needs to use different transport modes on inland to link shipping transport in the sea leg including railway, barge and truck. Some customers prefer lowest freight rates while some others would rather pay more for a faster delivery. The reduction of CO_2 emissions, an important cause for global warming is today one of the most important tasks for the society. The main goal of this research is to provide an optimal route with lowest CO_2 emissions in intermodal transport.

We propose a mathematical model, which give us possibility to get reliable data of the minimal CO_2 emissions on the observed route per TEU. The advantage of this model is that it gives us the possibility of observation the group of all possible solutions, which are ranked in ascending particular order and period of observation in the mathematical model does not have to be time-limited.

The contribution of this paper shows that the experimental results are not only a scientific, since it can be applied in practice. Moreover we tested different scenarios, with a real input data and one hypothetical view.The application of the model is simple. It is recommended to managers who made a policy of the company, in order to improve their businesses following the constant changes in the market and making reliable comparisons.

Further research is needed with lot of new nodes and can be imported with new objectives such as time and cost of container flow.

5. Acknowledgement

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ACHIEVING SOCIAL OPTIMUM AND USER EQUILIBRIUM TRAFFIC ASSIGNMENT ON SPECIFIC TEST NETWORK

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Abstract

Traffic models investigated in our research, are presented, as well as methods applied to compare them. The two main methods used are the Social Optimum and the User Equilibrium. We will examine these situations with a new micro-simulator of our design.We developed a stand-alone, PC based micro-simulator that is based on published lane-changing and car-following models, such as the Intelligent Driver Model (IDM) or the Wiedemann model [2] The simulator is capable of studying arbitrary traffic networks up to the size of a city; and being an open-source module-based software, it is easy to change the underlying mathematical models or extend the simulator with new elements.

Keywords:

Social optimum, User Equilibrium, Traffic networks

1. Introduction

Social Optimum (SO) refers to the global optimum of the traffic network system. It means that after totalling the users' journey times between their origins and destinations, SO is the lowest value found. In case of the User Equilibrium (UE), users aim for an optimum only beneficial for their routes, regardless of other external traffic information [1]. They define their routes based mainly on experience because they know the traffic specifications, different possibilities of previous journeys.

It is important to highlight that SO takes all users into account, while in UE every user can only see itself and choose the route most favourable to themselves. This can lead to traffic jams, as more users can choose the same routes lacking the knowledge of other users' decisions.

Another problematic feature with UE is when a user modifies its decision (i.e. changes the current route), it can only create a new journey as long as (or longer than) the original, but not a better one. Should it find a better route, the original situation cannot have been the UE state. With more than two users changing their routes a more advantageous opportunity may arise, but never with a single user. To get the best results, we need knowledge of the origins and destinations of the users. In case of SO, users are aware of other participants and try to reach a global optimum. However, with UE, users know only their own routes and are ignorant of the advantages (and drawbacks) of other opportunities, therefore, its global optimum is altogether worse than with SO.

Minimising the exhaust emissions and environmental damages as well as reducing the level of noise and smog affecting the population are influential motivators to find a global optimum in urban traffic environments. Reaching their destinations in a shorter time, the vehicles have a positive effect not only on the environment but it can also benefit the population to a great extent.

We will examine these situations with a new micro-simulator of our design. We developed a stand-alone, PC based micro-simulator that is based on published lane-changing and car – following models, such as the Intelligent Driver Model (IDM) or the Wiedemann model [2] The simulator is capable of studying arbitrary traffic networks up to the size of a city; and being an open-source module-based software, it is easy to change underlying mathematical models or extend the simulator with new elements. So far the IDM has been applied and validated for highway situations, however,

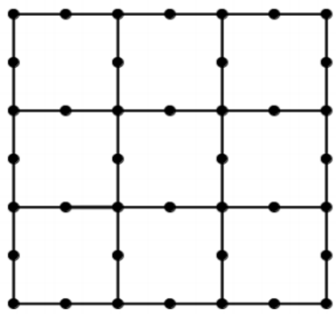

Figure 1. Manhattan network

We have determined the parameters of the IDM for an urban environment where the traffic flow is controlled mainly by traffic lamps. As a result, it was obtained that the IDM parameters in an urban situation differ definitely from those of a highway situation.

In a parallel project we applied a linear optimazation solver in order to determine the so-called System Optimum of traffic system under given boundary conditions. On the other hand, the so-called User Equilibrium state of the same system was also determined by the micro-simulator above. It was found that in the System Optimum state the optimization parameter (the total emission in this case) is better than that in the User Equilibrium state. Based on this result it is possible to design a central control system that helps to achieve a better traffic flow system than one that is formed spontaneously.

2. The traffic network

The Manhattan network shown in Figure 1 was considered for ours purposes. The main features of the traffic network are:
The roads are 500 m longs.
Every intersection is a signalized intersection.
The traffic lights cycle is 100 s long with 25 s green.
The vehicles start from and arrive to the middle of the roads.

3. The micro-simulator

The micro-simulator was developed based on the IDM (Intelligent Driver Model) with parameters calibrated in [3].

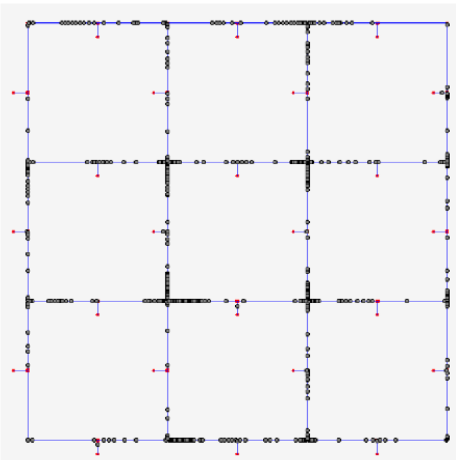

Figure 2. The Micro-simulator

The parameters of the IDM were calibrated for an urban environment where the traffic flow is controlled mainly by traffic lights. Figure 2 shows the complete Manhattan traffic network, and Figure 3 shows an intersection with traffic light, on the screen of the simulator.

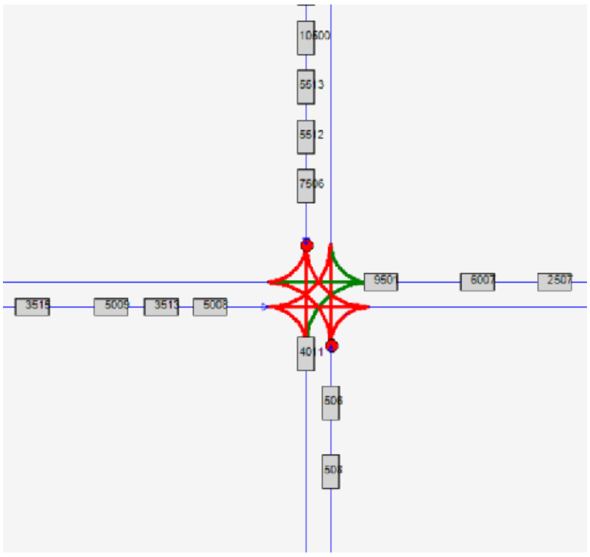

Figure 3. The micro-simulator detail

4. The link performance function (T-Q):

A measured link performance function was obtained with the micro-simulator. The figure 3 shows the measured function and its approximation with linear function, Davidson function, and BPR (developed by the U.S. Bureau of Public Roads) as was done in [4].

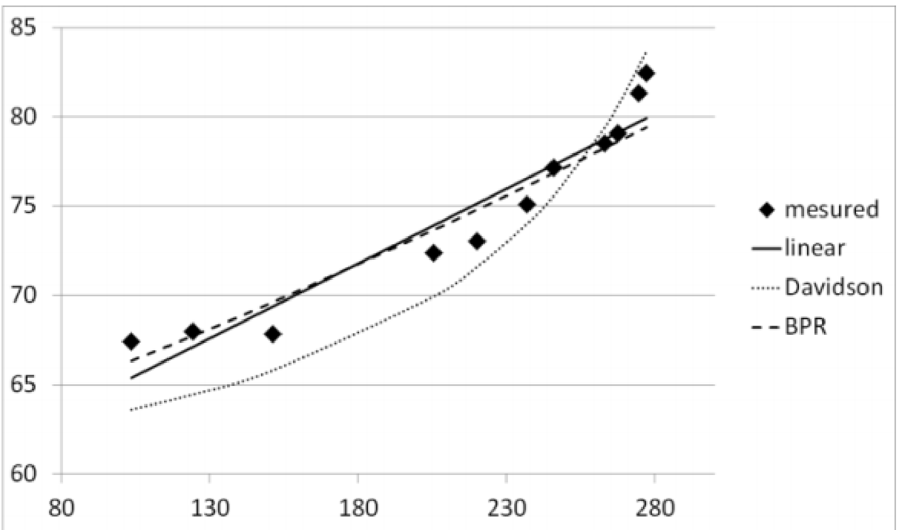

Figure 4. Link perfomance funcion (T-Q). Figure taken from [4]

5. Optimal solution obtained with AIMMS:

We consider the problem of 12,000 vehicles starting from the 24 sources and arriving to the 24 sources (500 vehicles start from each source and 500 vehicle arrive to each sink). The vehicles start with uniform distribution in a given interval of time. The AIMMS (Advanced Interactive Multidimensional Modeling System), [5], was used to obtain the optimal solutions according to:

$$optimum = \min(total\ travel\ time) = \min\left(\sum_i t(v_i)\right),$$

where $t(v_i)$ is the total travel time of the $i-$th vehicle.

Table 1 shows the optimal solutions obtained using a linear approximation of the link performance function and limiting the flow to maximum value (360 vehicles/hour), the capacity of the traffic lights.

Table 1.

Vehicles number	vehicles depature time interval	optimal total travel time (s)	mean travel time (s)
12 000	8 000	4 174 754	347,90
12 000	9 000	3 559 706	296,64
12 000	10 000	3 478 285	289,86
12 000	12 000	3 356 152	279,68
12 000	18 000	3 152 599	262,72

In each case we got a table containing for each source the frequency values that indicate how often continued from each node into neighboring nodes the vehicles departed from that source. Table 2 shows a section of the table obtained in the case that the time interval for the departures of the vehicles is 8000 s.

.Table 2.

From/ To	1	1	3	3	3
Src	2	8	2	4	9
2		71,256		102,767	50,976
4		37,782	47,565		64,934
6		33,625	43,408		49,576
8	71,256			51,691	9,7826
9		9,7826	19,565	40,269	

6. Simulation of the optimal solution

Using the frequency tables we reconstructed the trajectories of the vehicles in the optimal case. With the reconstructed trajectories the optimal solution was simulated in the micro-simulator obtaining very similar results in time to those obtained by the AIMMS as shown in Table 3.

Table 3.

Vehicles number	vehicles depature time interval	total travel time (s)	mean travel time (s)
12 000	8 000	4 276 499	356,37
12 000	9 000	3 595 809	299,65
12 000	10 000	3 380 226	281,69
12 000	12 000	3 269 839	272,49
12 000	18 000	3 180 703	265,06

7. User equilibrium:

In the User Equilibrium state none of the vehicles (drivers) can improve their travel time by choosing an alternative trajectory. In other words, if any user decides to change his route, the total time of the new route will be greater or equal.

The user equilibrium was determined by an iterative process. The results are shown in Figure 5, while the process is illustrated in Figure 6.

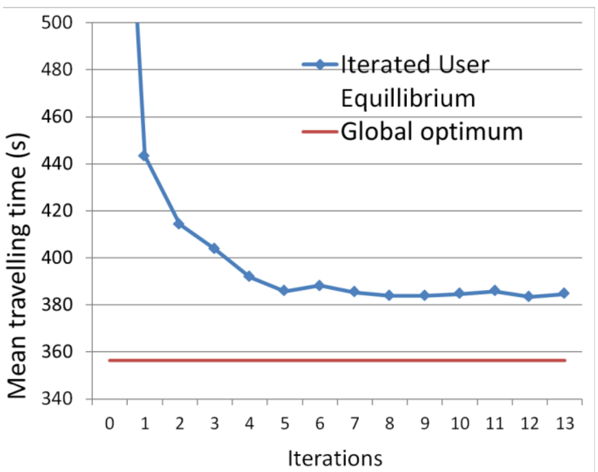

Figure 5. Iterated user equilibrium

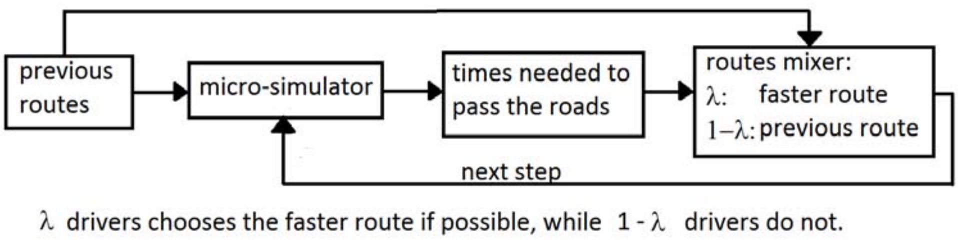

Figure 6. Iterative process to determine the user equilibrium

8. Conclusion

As was noted in the introduction, it was found that in the System Optimum state the optimization parameter (the total emission in this case) is better than that in the User Equilibrium state. So based on this result it is possible to design a central control system that helps to achieve a better traffic flow system than that is formed spontaneously.

A possible future work is to scheme this central control system in details, and using the micro-simulator at hand test the success rate of the various implementations. With the help of the simulator it is possible to take into consideration the limits of the applied real communication systems.

Another future possibility is to combine our micro-simulator with a validated macroscopic simulator, so that the coupling constants between the road elements are determined by the micro-simulator, while the time evolution of the flow-rates is calculated by the macroscopic simulator. Such a system promises a much faster and alternative traffic design tool beside the time consuming real measurements.

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THE COMPLEX MEASURING METHOD (CMM) IN EDUCATION

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Abstract

There are many studies based on TOBBI eye-tracking device, where many questions had already been answered. However we still do not know when the eye is on a fixation point for a long time, the subject is thinking (concentrating), or just relaxing for a while? This important question can be answered by our new self-developed software "Mind-reader" which uses Neurosky Mindwawe EEG device. We plan to use the two devices together as Complex Measuring Method., where both devices gets the timer from the same source, therefore the received data (TOBII & EEG) can be compared exactly. The results of our early studies with the EEG device and Mind Reader software ensure our plans about Complex Measuring Method (CMM).

Keywords: *TOBII; eye-tracking; EEG; signal processing; data-analysis*

1. Introduction

Eye tracking is new technology in the field of education [1]. With the power of the latest developments new doors are opened for the scientist. They have effective tools: the Neurosky Mindwave hardware EEG signal recorder with - our self-developed – “Mind-reader 1.0” software, and the TOBII eye-tracker with TOBII Studio. In this paper I will describe the three tools which were used, then you could read about our experience and its results. In education the effectively of an educational material has very high importance [2] and it is proven eye-tracking can be effectively used even among very young children [3]. It takes more semesters, when a textbook or image can be decided to be a good or bad choice for educational purposes: to get the information from pupils to teachers, from teachers to publisher, from publisher to editors…even the information is not yet up-to date in the textbook [4]. We need a method to decide about a textbook, an illustration or an exercise: how interesting, how difficult for the target population – at once [5]. Or even what reactions can be detected by a picture (e.g. in an anti-smoking pamphlet) [6]. The Complex Measuring Method (CMM) could be the first step to this way.

2. The NeuroSky MINDWAVE

The NeuroSky MINDWAVE, Fig. 1, is a simplified EEG machine based on a PC, [7]. This brainwave technology is mostly used for playing (with the bundled software); in the education the researchers use the math, memory and pattern recognition, Fig. 2, and applications to record attention levels during exercises, [8].

Figure 1. NeuroSky MINDWAVE

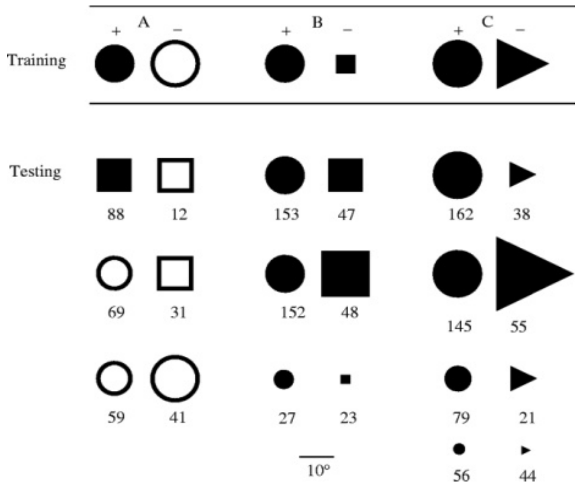

Figure 2. Pattern recognition tool

This device has two sensors and can detect raw EEG signals (Alpha, Beta, Gamma, Delta waves). For us it’s important the attention, meditation levels (calculated data) called:
- eSense meter for Attention
- eSense meter for Meditation
- On-head detection
- eSense Blink Detection
- blink detection [7] which can be a reference point to TOBII data.

3. TOBII's working method

The TOBII device, figure 3, can create gaze plot and heat wave outputs [9]. Graphically fixations are usually represented by dots (chubby dots specify a longer fixation period), where saccades are indicated by lines among fixations. "Gaze plot": a screen shot marking all the fixations the subject completed on a particular illustration or webpage, Fig. 4.

Figure 3. TOBII device T120

Figure 4 .Gaze Plot or Scanpath image.

The gaze activity of a subject can be illustrated by Gaze Plots above the total eye tracking gathering, or numerous subjects in a tiny period interval. "Heat map" [9] is another trendy way to visualize eye tracking information, figure 5.

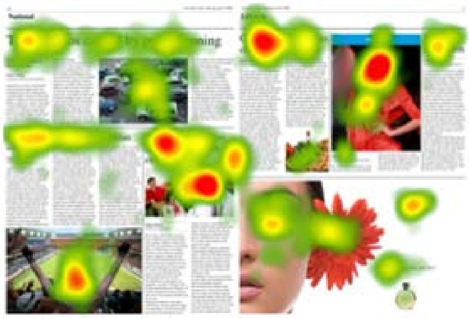

Figure 5. Heat map image

The heat map uses altered colours to demonstrate the quantity of fixations subjects completed in definite areas of the illustration or for how long they fixated within that area. Red typically indicates a uppermost quantity of fixations or the highest time and green the smallest amount, with altering levels in between. A colourless area on a heat map signifies that the subjects did not fixate in the region. This does not essentially mean that the subjects 'saw' nothing in there, however it may have been in their peripheral vision - if it was even detected [10].

4. Our software: "MIND READER 1.0"

One of the bases of our studies is our self-developed program: MIND READER 1.0 [1] which is programmed in C# language (uses .NET 4.5). It's important for our research group to have a flexible tool for our studies. (see figure 6)

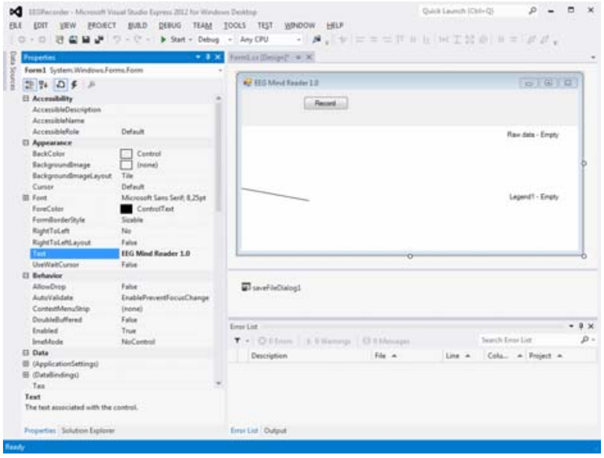

Figure 6. Developing phase of Mind Reader 1.0's GUI in Visual Studio

The Mind Reader application can receive the signals form Mindwave tool:

1. It displays it as a function therefore the researcher can easily see the results;
2. It writes the values into an xls workbook for further analysis.

5. Complex Measuring Method (CMM)

Our software can run on the same PC as the TOBBI Studio (or other eye-tracking application), therefore we can record our data precisely in the same time as the TOBII studio is recording. In this way we could solve the problem that was described in many papers: the EEG machine and the PC with the eye tracking application were not synchronous during the whole experiment. This problem is erased by using the same time source, which made the Complex Measuring Method (CMM) possible: Eye-tracking & EEG in the absolute same time.

6. Population, methods and materials

The sampling population was consisted of 8th grade primary school students (N = 10). The research was conducted using Tobii eye movement recorder and Neurosky Mindwave; the data collection was done using the Tobii Studio software, and Mind Reader. Data was collected in May 2015 in a primary school of Szeged, Hungary. The study consisted of an eye-movement tracking and a survey phase. The eye-movement tracking phases of the students could see pictures were they have to find the differences. In the survey phase the students had to solve easy mathematical problems: summation and multiplications of numbers

7. Results

Only the most important results of the experience are described here. In Fig. 7 the smoothed attention level record can be seen. We received quite noisy signals because of high sampling rate, that's why the smoothing. At „break downs” we recorded the student changed among exercises. Using TOBII, we know where the subject fixes his eyes; therefore we can pair the signals by the timer. The other student needed much more attention to finish the exercises, Fig. 8. The fatigue can be exactly recognized from the signals, Fig. 9. A malpractice: the signal broke because the recording device fallen down from the student's head, Fig. 10. He was distracted, and needed time to get back to the same attention level.

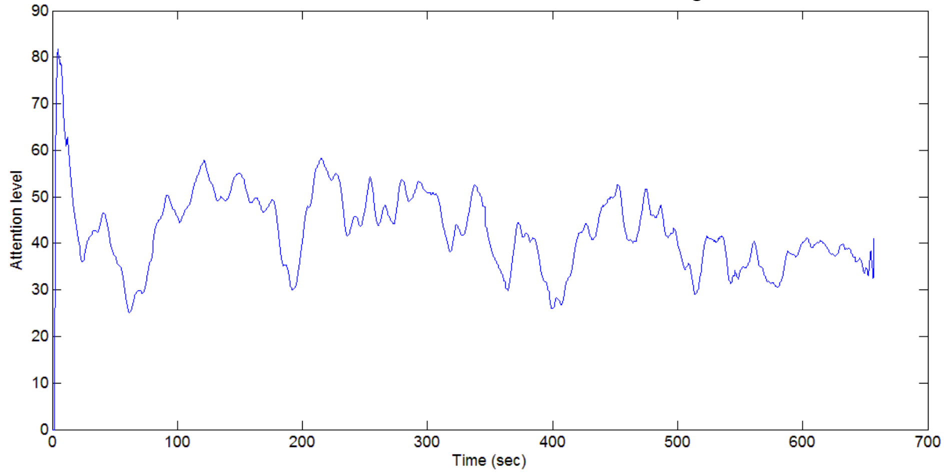

Figure 7. Attention level changes when switching exercises

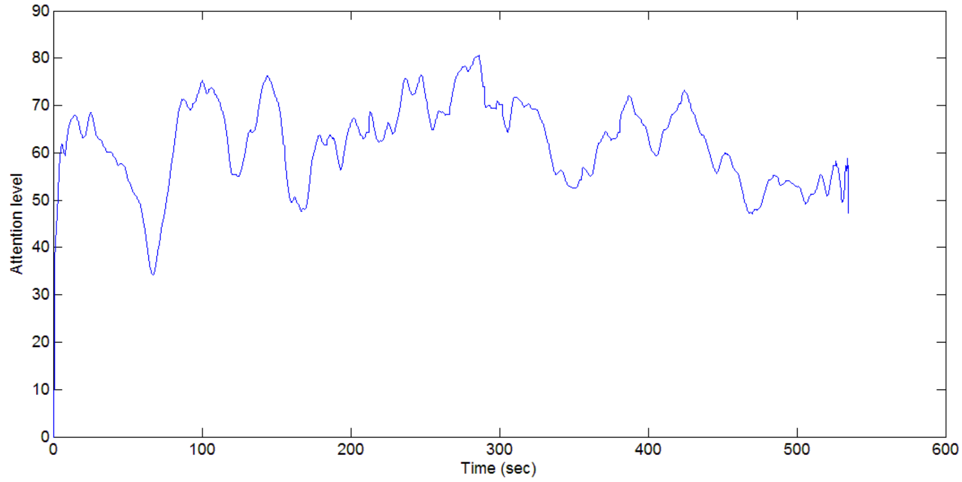

Figure 8. Attention level of another pupil.

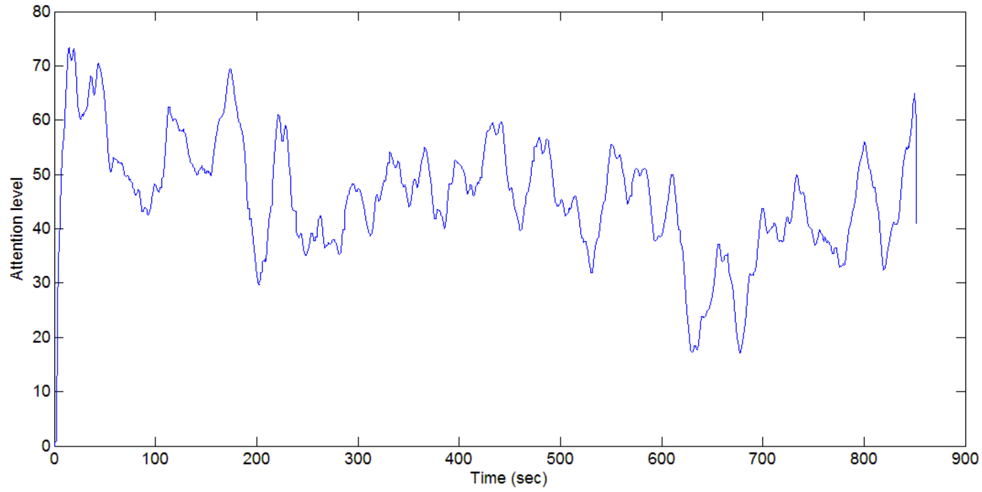

Figure 9. Fatigue can be detected

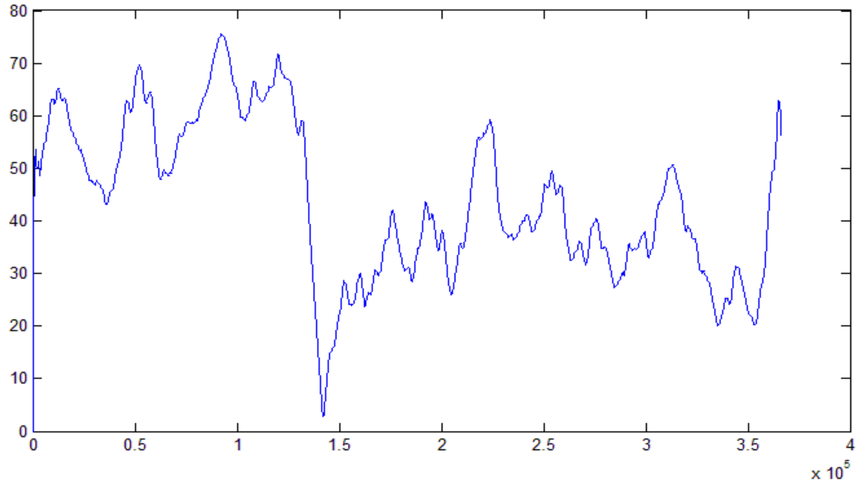

Figure 10. Malpractice and returning to same attention level.

8. Conclusion

According to our results the Complex Measuring Method (CMM) has worked as it was expected. By the data we can decide the type of the pupil's activity. We successfully differentiated the signs of different activity levels, fatigue, switching among exercises. Combining with eye-tracking results we are able to surly decide the subject is actively working on the exercise, or just "taking a rest" while his eyes are kept on the same dot for a long time. Certainly ate CMM is not fully developed yet, however we do believe that CMM will be a good measuring and assessment tool in educational and psychological studies; and can be the base of a - later developing – objective statistical scale of attention and interest, that can be used for rating teaching materials.

9. Acknowledgement

The authors wish to thank to the teachers and students of Szegedi Bonifert Domonkos Általános Iskola for their continued support.

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SPELT (TRITICUM SPELTA L.) - ENERGY PRODUCTION FROM AGRICULTURAL RESIDUES

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Abstract

Spelt is one of the oldest crops. It originates from Asia. In Europe spelt has been was very important cereal during the Bronze Age and the Middle Ages. After the processing grains for food, biomass lags as a by-product or waste. Rising fossil fuel prices and increasing concerns about climate change are creating a growing demand for new sources of raw material for biomass combustion for sustainable heat production. In recent years studies have shown the positive effects of the use of agricultural residues for energy production. Grains of Spelt are processed into various purposes, while the chaff, glumes and stems remain as a by-product. Therefore, it is important to carry out research in order to determine nutritional characteristics of grain and energy characteristics of chaff, glumes and stems. This paper examined the two Spelt varieties: Bc Vigor and Ostro. Collected and homogenized samples were analysed by the energy characteristics: high (HHV) and lower (LHV) heating values of chaff, glumes and stems were determined by standard methods. The results obtained in this research showed that, after the use of grain for food, chaff, glumes and stems are representing by-product but also it is high-quality raw material for energy production because of the high calorific values.

Keywords:

Biomass, energy, environmental protection, Spelt

1. Introduction

Spelt (Triticum Spelta L.) is annual grass in the Poaceae (grass family) native to the Mediterranean region and southwest Asia. It is one of the oldest known wheat types, also known to Egyptians because the oldest findings of this wheat type were found in the Nile valley and they date from the 5,000 B.C. Spelt was an important grain in Europe from the Bronze Age until medieval period, when it was largely replaced by other forms of wheat (T. aestivum and T. durum, durum wheat). By creating high-yielding common wheat this very important species almost vanished and was maintained only in gene banks worldwide. Spelt (Fig. 1) has received attention again in the past two decades along with the development of environmental awareness of the population in Switzerland, Austria and later in other developed countries of Western Europe and North America [3].

Figure 1. Spelt (Triticum spelta L.)
(Source: www.urkorn-biohof.at/dinkel1.htm)

Spelt is very resistant crops suitable for organic farming. It requires less fertilizer and pesticides than other forms of wheat. By including Spelt in organic production it is possible to increase the diversity of grains in the human diet [15].

Nutritional value of spelt is similar to the nutritional value of wheat. It contains all the basic components which are necessary for human beings: proteins, unsaturated fats, vitamins (A, C, B group), minerals (calcium, cobalt, iron, phosphorus, magnesium, manganese, potassium, copper, selenium, sodium) and fibers [3]. It also retains a high antioxidant properties (selenium prevents the formation of free radicals) and therefore is especially suitable for people exposed to stress, for menopausal women and the elderly. Being rich with fiber, it is of great use in diets for weight loss (quickly spread a feeling of satiety and facilitates the work of the intestine), and because of the richness in carbohydrates, iron and calcium is recommended for athletes, anemic persons and those suffering from osteoporosis. The unique nutritional and rheological properties of the grains tend to increase the nutritional value of bakery products [1].

The need for energy is constantly growing and requires the use of all available technologies, because almost all human activity on earth is based on the use of some of the available forms of energy [6].

Considering the fact that the sources of oil and natural gas are not exhaustive, there is a need to develop renewable energy sources which can be a solution in case of a possible energy crisis. In addition to the security of energy supply, one of the main objectives of European energy policy focuses on the protection of the environment through reduced energy consumption and greater use of renewable energy sources. The energy sector creates a significant impact on the environment, whether it is on a local, regional or global impact.

Therefore, energy and development issues must be addressed in the context of two very strongly interlinked and the key issues - energy security and climate change [8].

Climate change, global warming and greenhouse gas emissions have become a priority issue of global development. The main challenge is long-term development of the economy with reduced emissions of carbon dioxide. The goal is a more efficient use of energy, renewable energy, use of energy sources that do not produce greenhouse gases and more efficient transportation system with increased use of neutral fuel with regard to CO_2 emissions. Using renewable energy sources improves the security of energy supply and gives impetus to the development of domestic production of energy equipment and services, as well as the achievement of environmental objectives [8].

The economies of the Western world were faced with a series of ups and downs. The last global recession that began in 2008 in the United States and then spread throughout the world has opened up new questions about the connection between the financial crisis with the energy crisis and climate change. There are more open debate about the human relationship to nature and the environment. Energy, as an essential element driving the economy and all social activities, is one of the fundamental questions for Europe [2].

Total world resources of biomass have the theoretical potential which is ten times larger than the world's total primary energy consumption, which is about 7 billion tons of oil equivalent per year. Total biomass energy potential, which is growing in the country, estimated at 70 billion tons oil equivalent. World oil and gas reserves are estimated at 50-70 years, while the estimate for coal about 200 years. Considering already mentioned problems with global warming, it is not acceptable to continue with the current model of using fossil fuels. It is necessary gradually replacing them with renewable energy sources [4].

The European Commission has adopted a series of regulations and directives to extensively support the consumption and production of green energy from renewable energy sources, primarily because of critical necessity to mitigate negative influence of fossil fuels on the environment [12]. In 1996 the European Commission adopted a document which drew attention to the necessity of increasing the use of renewable energy sources in order to promote non-fossil sources, but also contribute to the environmental protection. Directive 2009/28/EC on the promotion of the use and production of renewable energy has set high goals to be achieved by 2020. This directive, also known by the term Directive 20-20-20 included the so-called "three 20 targets", but in reality it consisted in four proposals. These aims were: to reduce emissions of greenhouse gases by 20% by 2020 taking 1990 emissions as the reference; to increase energy efficiency to save 20% of EU energy consumption by 2020; to reach 20% of renewable energy in the total energy consumption in the EU by 2020 and to reach 10% of biofuels in the total consumption of vehicles by 2020.

Much has been achieved since the EU adopted its first package of climate and energy measures in 2008. While progressing in meeting its climate and energy targets for 2020, EU countries have agreed on a new 2030 Framework for climate and energy, including EU-wide targets and policy objectives for the period between 2020 and 2030:

- 40% cut in greenhouse gas emissions compared to 1990 levels
- At least a 27% share of renewable energy consumption
- At least 27% energy savings compared with the business-as-usual scenario (2030 framework for climate and energy policies, 2015).

2. Agricultural biomass as feedstock for biofuels

The energy stored in biomass can be released to produce renewable electricity or heat. Biomass is the first and oldest source of energy that people are used to form a variety of wood residues that are collected and used for heating, cooking and other purposes. Until the beginning of intensive use of fossil fuels, whose use greatly influenced the development of civilization, biomass was the primary and almost only source of energy. Even today, biomass is the only source of fuel for domestic use in many developing countries. After intensive use of fossil fuels and their negative impact on the environment, biomass is becoming a significant source of energy and interest in biomass use begins to rise again.

In the 1980s in Europe agricultural production shows a surplus of grains, especially wheat. In fact, due to higher yields obtained from wheat and corn, this crop "pushed out" oilseeds. It was considered that the solution is in the export of the surplus. However, all countries that produced cereals had a similar development. The prices in the world market were no longer agriculturally oriented as a result of political actions [10]. At the same time, after extensive energy research, it was obvious that sources of fossil fuels will be largely exhausted by the end of the 21st century. It will be necessary to find new sources of energy, because the consequences of energy resources disappearance are almost unimaginable [7, 9, 13].

Biomass is a renewable source of energy, and through a process of photosynthesis with the help of sunlight on organic matter. Biomass is defined as 'the biodegradable fraction of products, waste and residues from biological origin from agriculture (including vegetal and animal substances), forestry and related industries including fisheries and aquaculture, as well as the biodegradable fraction of industrial and municipal waste. Biomass can be converted through different processes into solid (briquettes, cubes, and pellets), liquid (bioethanol, propanol, and butanol via cellulose process), and gaseous (e.g., methane via anaerobic digestion) fuels [14, 16 and 18].

The use of agricultural biomass for energy production including Spelt biomass has a number of advantages, both in the energy sector and in the sector of agriculture and environmental protection. Some of these advantages are [17]:

- reducing dependence on fossil fuels
- larger number of possible sources of energy
- greater security of energy supply
- competitiveness and sustainability
- reducing greenhouse gas emissions.

It should also bear in mind the socio - economic aspects since the use of biomass provides employment and the creation of new and existing jobs, increasing local and regional economic activity and additional income in agriculture, forestry and wood industry through the sale of biomass as fuel.

The main advantage of biomass compared to fossil fuel is its renewability. Impact on the atmosphere with CO_2 using biomass as fuel is negligible. Biomass utilization on a global scale could contribute to environmental protection, having in mind that biomass sources are CO_2-neutral because it is absorbed during new biomass growing to be used for the same purpose. Most biofuels limits greenhouse gas emissions by more than 30% compared to fossil fuels [21].

Lately, it becomes more and more obviously that today's energy consumption is unsustainable. Biomass is not just potentially renewable but it is enough similar to fossil fuels that can directly be substitute [19 and 20].

Therefore, the world community in 1990s began to discuss how to mitigate the alleged damage. Limitation of the amount of fossil fuels, their increasing prices and the impact of fossil fuels on air pollution represents a strong argument in favor of the growing expansion of the use of biofuels.

According to Directive 2009/28/EC biofuels are liquid or gaseous fuels derived from biomass. Biofuels today represents one of the most valuable forms of renewable energy because of the numerous possibilities of using (Voća et al., 2007., [12]. The various biofuel production technologies available are contributing to the solving of economic and ecological problems [12]. Biofuel production technologies have developed and today, besides first generation technologies, second generation technologies are already in use.

The European Union 's Strategy on Biofuels (2006) distribute biofuels on generation in accordance with the type of raw material used for production:

- 1st Generation - the source of carbon for the biofuel is sugar, lipid or starch directly extracted from a plant.
- 2nd Generation - the biofuel carbon is derived from lignocellulosic biomas, which makes it harder to extract the required fuel.
- 3rd Generation - the biofuel carbon is derived from aquatic autotrophic organism (e.g. algae). Light, carbon dioxide and nutrients are used to produce the feedstock "extending" the carbon resouce available for biofuel production.

Due to the limited amount of sugar, starch and oil resources second-generation biofuels are developed 2nd generation biofuels are derived from lignocellulose biomass.

The goal of second generation biofuel processes is to extend the amount of biofuel that can be produced sustainably by using biomass consisting of the residual non-food parts of current crops, such as stems, leaves and husks that are left behind once the food crop has been extracted, as well as other crops that are not used for food purposes (non-food crops), such as plants and trees grown for energy production (Miscanthus, Sudan grass), and biodegradable fraction of waste.

Since the raw material for second-generation biofuels are not suitable for human consumption, thus avoiding the frequent objection to the first generation to turn food into fuel (Gray et al., 2006).

Lignocellulose refers to plant dry matter (biomass), so called lignocellulosic biomass. It is the most abundantly available raw material on the Earth for the production of biofuels. It is composed of (Gray et al., 2006):

- lignin (15-20 %) - a key component of the cell wall and forms a protective layer between the cellulose and hemicellulose
- hemicellulose (25-35 %) - of short polymers of various sugar sticking together bundles of cellulose together
- cellulose (40-50 %) - consisted of a long series of interrelated disaharidacelobioze molecules (Figure 2).

3. Materials and methods

Laboratory investigations were carried out at the University of Zagreb, Faculty of Agriculture, in the Department of Agricultural Technology, Storage and Transport laboratory. In this investigation, two Spelt cultivars, Bc Vigor and Ostro, were used. Spelt was grown in experiment station of Department of Field Crops, Forage and Grassland, Maksimir, Zagreb in 2014.

Samples were ground in a laboratory grinder (IKA Analysentechnik GmbH, Germany). Each sample was analysed at least three times to provide reproducibility of the analyses.

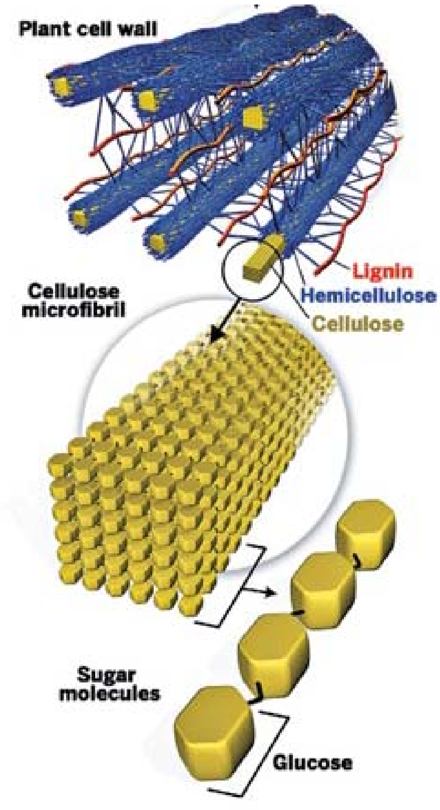

Figure 2. Lignocellulose biomass
(Source: www.secondgenome.com)

High heating value (HHV), one of basic parameters of energy value of a fuel, was determined by ISO method (EN 14918:2010) using an IKA C200 oxygen bomb calorimeter (IKA Analysentechnik GmbH, Heitersheim, Germany). A total of 0,5g of sample was weighed in a quartz crucible and put in a calorimeter for combustion. Higher heating value was obtained after combustion, by using the IKA C200 software. Heating value is reported in MJ/kg on dry basis.

Lower calorific value (LCV) is determined by subtracting the heat of vaporization of the water vapor from the higher heating value.

4. Results and discussion

Calorimetry is considered as the most influential analyze, since it gives the exact data about the heating value of a specific sample (García et al., 2012). Table 1 shows calorific values of investigated samples of Spelt biomass.

Table 1. Calorific values of Spelt biomass

Variety	HHV (MJ/kg)	LHV (MJ/kg)
Bc Vigor Chaff and glumes	16,650	15,300
Ostro Chaff and glumes	16,402	15,052
Bc Vigor Steams	17,367	15,932
Ostro Steams	17,224	15,789

It was found that there is no difference between varieties Bc Vigor and Ostro considering their upper heating value as the total average higher heating value in the chaff and glumes and stalk of the variety Bc Vigor is 17,009 MJ/kg, and the variety Ostro 16,813 MJ/kg, but the analysis of data in Table 1 shows the difference between the upper caloric value of chaff and glumes compared with stems of both cultivars. The highest heating value is defined in the stem of variety Bc Vigor (17,367 MJ/kg). A slightly lower higher heating value determined in the stalk of the variety Ostro (17,224 MJ/kg), while the the lowest higher heating value was found in the chaff and glumes (HHV of chaff and glumes of the variety Bc Vigor is 16,650 MJ/kg, and HHV of the chaff and glumes of the variety Ostro is 16,402 MJ/kg). These values are slightly lower than those quoted by Kričkа et al. [11]. as the average higher heating value of the biomass of wheat (17,953 MJ / kg).

Very similar differences were obtained and the calculation of lower heating value (LHV), which is also slightly higher in the stem of both cultivars (Bc Vigor: 15,932 MJ / kg; Ostro: 15,789 MJ / kg) than in the chaff and glumes (Bc Vigor: 15,300 MJ / kg; Ostro: 15,052 MJ / kg). LHV of the studied Spelt varieties is also smaller than the average lower heating value of the biomass of wheat (16,443 MJ / kg) [11].

5. Conclusion

Spelt is an old and almost forgotten culture, which comes back to a growing number of producers and consumers because there is great potential to expand the cultivation of this crop because of its nutritional and energy value, and due to favorable climatic conditions for growing throughout Croatia.

The results obtained in this research showed that, after the use of Spelt grain for food, chaff, glumes and stems are representing by-product but also it is high-quality raw material for energy production, because of the high its high calorific values: the upper heating value in Bc Vigor stem was 17,367 MJ/kg, 16,650 MJ/kg in the Bc Vigor chaff and glumes, 17,224 MJ/kg in the Ostro stem and 16,402 MJ/kg in the Ostro chaff and glumes.

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A SIMPLE DIGITAL IMAGING METHOD FOR THE ANALYSIS OF THE COLOR OF FOOD SURFACES

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Abstract

*Compared to manual inspection, which is inconsistent and subjective, sorters are able to assure product quality and food safety by more effectively identifying and removing defects and foreign material, while at the same time reducing labor costs and improving operating efficiencies. In this paper we analyzed color of the green beans in the way to find certain parameter which defined good color, acceptable for consumers because homogeneity and appearance have a significant impact on the consumer's decision and to see does and how different lighting effect on the color. The color recorded in the image is not an inherent value of observed object, because it is also influenced by the illumination properties (illuminance, spectral intensity distribution, color rendering index), as well as geometry and surfaces of neighboring objects. The CIE La*b* color space gave good results in a way that it define better the ranges of parameter a*.*

Keywords:

Color, green beans, color space, sorter

1. Introduction

Automated optical inspection systems (also called sorters) have been widely adopted for decades in the fruit and vegetable processing industries.

Some sorters inspect only an object's color, others inspect an object's color, size, and shape, and some sort based on the object's structural properties, including differing levels of chlorophyll. The processor's products and business objectives determine the suitable sorter configuration.

Some sorters even allow the user to define a defective product based on the total defective surface area of any given object. These object-based considerations put more power into the processor's hands to produce optimal product quality. The use of computer vision technology for food analysis are widely reviewed [1, 2]. The use of different color spaces, quantitative values of color are obtained. Coordinate transformation of the RGB color space to other color spaces is possible and it facilitates achieving greater accuracy and improves color calculation when it comes to food products. The idea of this paper is to examine the influence several types of illuminations on color of the image of the product and to defined range of color values of the good product in RGB and CIELab color space.

2. Materials and methods

In this paper, the color of previously frozen green beans (-18 °C) have been investigated. Product were put in black chamber, dimensions 50x50x50 cm. Olympus VG-110 camera was used. As the illumination Philips bulbs, of color rendering index (CRI) Ra8, and color temperature 2700 K were used. In Table 1, other primary characteristics of illuminations are shown. The snapshots were taken from height of 40 cm in dark room. Total measurements were performed within 10 minutes.

Table 1.Main features of the applied illuminations

Types of illumination	Power (W)	Luminous flux (lm)	Luminous intensity (cd)
Clear	60	655	
Reflector	60		750
Soft White	60	630	
Warm White	14-68	856	

After shooting, pictures are obtained in Adobe Photoshop® 7.0., where they are cropped in dimensions of 50x50 pixels. The obtained images are further processed in Matlab®. A digital color image is represented in RGB form with three components per pixel in the range from 0 to 255 and conventionally stored using eight bits per color component. Each parameter of color: red, green and blue is presented in the form of 50x50 matrix. By subsequent transformation of the images in CIELab color space, parameters *L*, *a** and *b** are also presented in the same form. The *L** defines lightness, *a** denotes the red/green value and *b** the yellow/blue value. The red/green opponent colors are represented along the *a** axis, with green at negative a* values and red at positive a* values. The yellow/blue opponent colors are represented along the b* axis, with blue at negative *b** values and yellow at positive *b** values. The scaling and limits of the a* and b* axes will depend on the specific implementation of*La*b** color, but they often run in the range of ±100 or -128 to +127. Figure 1 show the ilustration of CIELab color space.

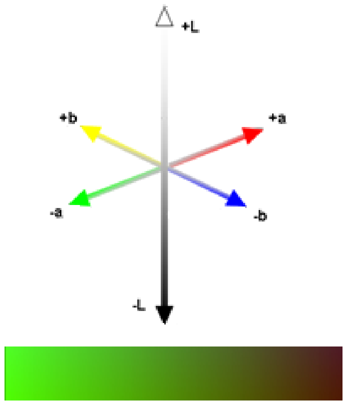


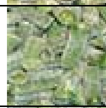
Figure 1. Display L, a and b* coordinates and green color in CIELab color space*

Further statistical analysis where performed in IBM SPSS® 21. At first, descriptive analysis were performed, after that Frequencies test and Wilcoxon signed-rank test were used.

3. Results and discussion

In Table 2, taken images of examined green beans under different illumination are shown.

Table 2.Display samples of beans captured under different illumination

Type of illumination	1 bulb	2 bulbs	Resolution
Clear			50x50
Reflector			50x50
Soft White			50x50
Warm White			50x50

Results of descriptive statistics are summarized in Table 3 for *R*, *G*, *B* and in Table 4 for *L*, *a** i *b** parameters. Based on showed results, we can conclude that the CIELab colors space are more suitable for determinating the range of good color because of the much closer mean values of color parameters and much lower standard deviations of color parameters for all applied illuminations.

Table 3.Descriptive statistics for R, G, B values

	Main values						Standard deviation					
	Red		Green		Blue		Red		Green		Blue	
	1 bulb	2 bulbs	1 bulb	2 bulbs	1 bulb	2 bulbs	1 bulb	2 bulb	1 bulb	2 bulb	1 bulb	2 bulb
Clear	170.63	163.62	182.15	170.50	152.55	138.18	32.10	34.89	30.35	31.66	31.61	37.75
Reflector	154.41	184.89	158.99	183.73	122.68	143.20	35.69	37.23	32.59	35.90	32.09	34.50
Soft White	155.26	146.17	170.81	161.43	134.29	123.64	31.22	32.90	29.04	30.48	32.33	32.87
Warm White	160.23	159.67	179.96	152.60	147.86	152.60	31.53	32.83	29.81	30.80	33.60	33.87

Table 4. Descriptive statistics for L, a, b* values*

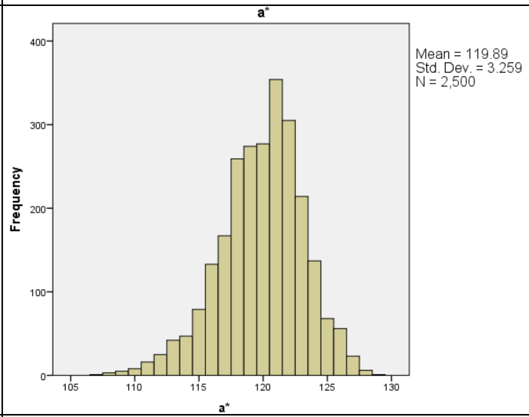
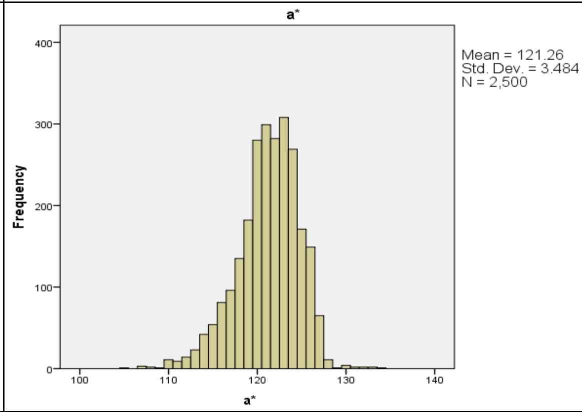
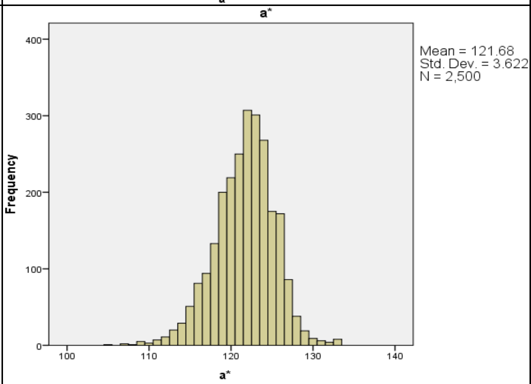
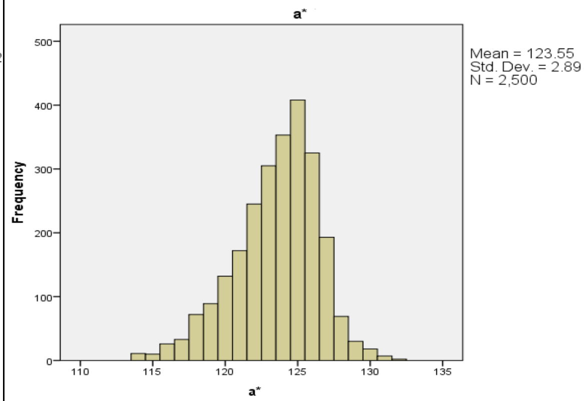
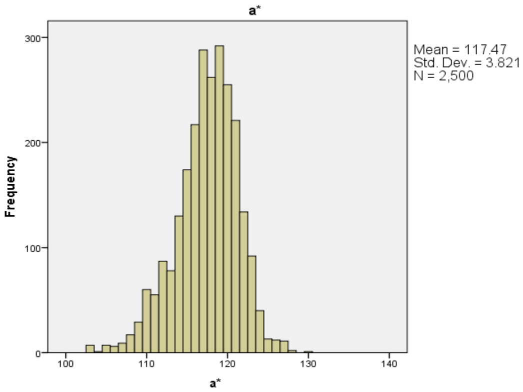
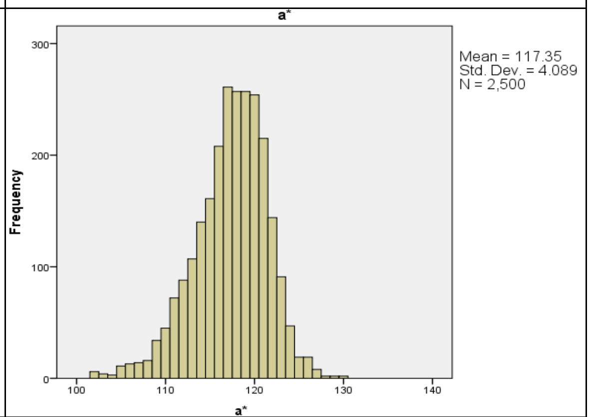
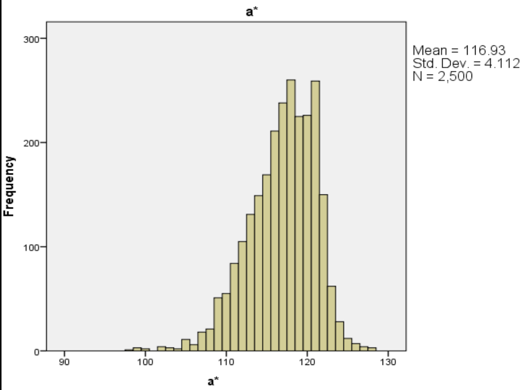
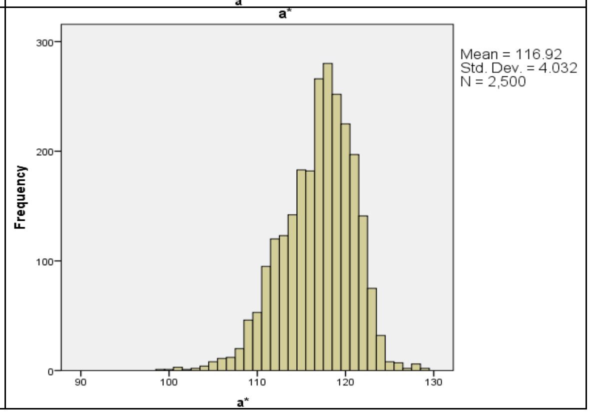
	Main values						Standard deviation					
	L		a*		b*		L		a*		b*	
	1 bulb	2 bulbs	1 bulb	2 bulbs	1 bulb	2 bulbs	1 bulb	2 bulb	1 bulb	2 bulb	1 bulb	2 bulb
Clear	184.62	174.36	119.89	121.26	141.73	143.85	23.54	31.20	3.25	3.48	6.00	6.80
Reflector	163.60	188.03	121.68	123.55	146.43	148.83	32.44	34.72	3.62	2.89	7.61	6.98
Soft White	172.85	163.81	117.47	117.35	145.00	145.85	28.51	30.25	3.82	4.08	7.50	7.97
Warm White	180.29	180.98	116.93	116.92	141.77	139.59	29.04	30.08	4.11	4.03	7.44	7.39

Based on average values and standard deviation from Table 3, the most intensive green color is given by reflector illuminant, and standard deviation are lowest when soft white illuminant were applied. From Table 4, the most intensive *a** values are given by reflector illuminant where standard deviation is lowest. Next, the Frequencies test are performed. Histograms of *a** parameter are given in table 5. Frequences test show us most frequent values. Comparing a* values, it can be defined range of values with minimal standard deviation for every type of illumination and then based on that range in the further research, we can define good color of product.

With visual method we can see differences between illuminations, while differences between the illuminations by one or two bulbs are unclear, as we can see in Table 2.

Anyhow, observing table 5, diferent distributions of *a** parametar can be noticed. In order to examine it using statistics, color parameters were evaluated with Wilcoxon signed-rank test and showed a statically significant change in some cases. Wilcoxon signed-rank test are appropriate for determining whether or not there is a significant association between a dichotomous variable and a continuous variable with independent samples data [3].

Table 5. Histograms of a values*

Types of illumination	1 bulb	2 bulbs
Clear		
Reflector		
Soft White		
Warm White		

.Significant difference is present when Asymp. Sig. (2-tailed) – is below p<0,005 and the degree of the difference is determined by the value of r which is defined by equation 1:

$$r = \frac{Z}{\sqrt{N}} \qquad (1)$$

where is N- total number of cases.

Cohen (1988) [4], suggesting that an r of 0.1 represents a 'small' effect size, 0.3 represents a 'medium' effect size and 0.5 represents a 'large' effect size. Table 6 shows results of Wilcoxon signed-ranktest. It compares values of each colorparametar (R, G, B, L, a^*, b^*) when one bulb ofcertain illumination is used, with the value of color parameters when two bulbs of the same illuminationare used.

Results which represent values where exist a large significant difference in amount of applied illumination intensity are labeled. Based on table 6, it can be concluded that the illumination intensity does not have influence on green color only when soft white and warm white illuminationis applied, while in other cases it has significant influence.

Table 6. Wilcoxon signed-rank test for *R,G,B and L, a*, b**parameters

		Z	Asymp. Sig. (2-tailed)	r			Z	Asymp. Sig. (2-tailed)	r
Clear	Red	-28.237	0.000	**0.40**	Clear	L	-38.539	0.000	**0.55**
	Green	-39.480	0.000	**0.56**		a*	-28.129	0.000	**0.40**
	Blue	-41.435	0000	**0.59**		b*	-28.520	0.000	**0.40**
Reflector	Red	-43.271	0.000	**0.61**	Reflector	L	-43.142	0.000	**0.61**
	Green	-43.041	0.000	**0.61**		a*	-31.501	0.000	**0.45**
	Blue	42.477	0.000	**0.60**		b*	-28.845	0.000	**0.41**
Soft White	Red	-12.298	0.000	0.17	Soft White	L	-13.232	0.000	0.19
	Green	-13.450	0.000	0.19		a*	-1.539	0.124	-
	Blue	-13.833	0.000	0.20		b*	-6.297	0.000	0.09
Warm White	Red	-1.546	0.122	-	Warm White	L	-2.918	0.004	0.04
	Green	-3.335	0.001	0.05		a*	-0.104	0.917	-
	Blue	-14.719	0.000	0.21		b*	-29.689	0.000	**0.42**

4. Conclusion

This paper presents a simple method that uses a combination of digital camera, computer and compatible software for measuring and analyzing the color surface of agricultural products. Based on presented results it can be concluded that the CIELab color space is more suitable for determining the good color of tested agricultural products. Soft white or warm white light is the most suitable for determining the optimal range of values of good color from all tested lighting in this paper. The next step in research would be application of these values during the process of recognition of inadequate color product which would be tested.

5. Acknowledgement

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EVALUATING COMPETITIVE POSITION OF AN AIRLINE COMPANY

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Abstract

This study includes a survey carried out with the top executives of an airline company in order to evaluate the competitive position of the company. A list of factors is identified and asked to the respondents for rating the company position relative to its competitors. Evaluating its competitive position provides the company with a direction to formulate appropriate goals and strategies for gaining competitive advantage in the marketplace.

Keywords: Competitive position, airline, strategy

1. Introduction

Companies occupy different competitive positions in their industry. Marketing strategies used by the companies depend on their positions in the marketplace relative to their competitors. They can be classified by the role they play in the target market as market leader, market challenger, market follower, or market nicher [1]. The market leader has by far the largest market share, and drags the market followers behind it [2]. The niche marketer occupies a position that does not represent a threat to any of the other firms, while the market challenger seeks to steal the market share from the market leader, with the aim of becoming market leader in turn [2].

Porter describes three types of generic strategies for competitive advantage which are cost leadership, differentiation, and focus [3]. Competitive performance can come from a variety of sources, such as differentiation of products and services based on price, quality or service, but most sustainable when it is difficult to imitate [4]. Pearson et al. conclude in their research that of the core seven resources for the 49 Asian airlines which account for their competitive advantage from an internal perspective, the top three resources are found to be slots, brand, and product and service reputation [5]. Mallikarjun summarizes the major literature of the airline efficiency measurement and proposes the airline operating efficiency model along with important performance indicators [6].

The airline industry exists in an attractive and intensely competitive market. Demand for passenger and cargo services has been accelerating and the industry has witnessed a positive trend in profitability after huge losses during the 2008-2009 global economic recession [7-8].

There are 15 airline companies operating in the Turkish civil aviation sector [8] and the survey study has been conducted for one of them.

2. Survey Study

By reviewing the literature and interviewing the executives of the airline company, a list of factors related to its internal and external environment was identified in order to rate the company position relative to its competitors. The list included 51 factors falling into the following categories:

- Cost
- Price
- Quality
- Capacity
- Technology
- Marketing
- Sales
- Image
- Personnel
- Innovation
- Efficiency
- Finance
- Authority
- Supplier
- Customer
- Competitor
- Money Market
- Regulations
- Environment

The factors were asked to the respondents for rating the company position relative to its competitors with a 7-point Likert scale where 1 corresponded to extremely below, 2 and 3 to below, 4 to same level, 5 and 6 to above, and 7 to extremely above.

A pilot test was conducted prior to the survey with two executives and questionnaire was improved by their feedback. A face-to-face survey was conducted with 11 top executives of the airline company.

To check the internal consistency of the respondents' evaluations Cronbach's alpha coefficient was calculated. The coefficient value of 0.907 suggested that 51 factors have relatively high internal consistency. The coefficient value can range from 0 to 1 and, in most cases; a value of less than 0.6 would typically indicate unsatisfactory internal consistency [9].

Box plots of the survey data were constructed to examine outliers in the respondents' evaluations (Figure 1). A box plot is used to display information about the shape of a distribution, its central value by median, variability by interquartile range, and outliers by star symbols if exist. Prior to the analysis, outliers were removed from the survey data (Figure 2).

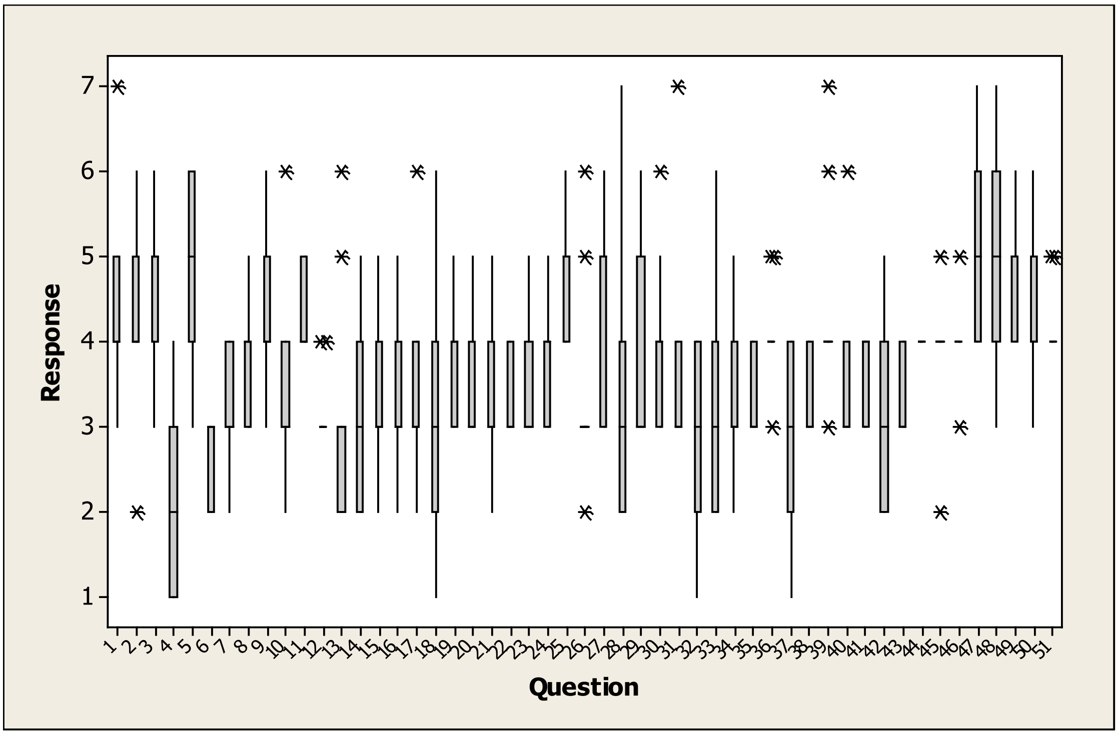

Figure 1. Box plots of survey data

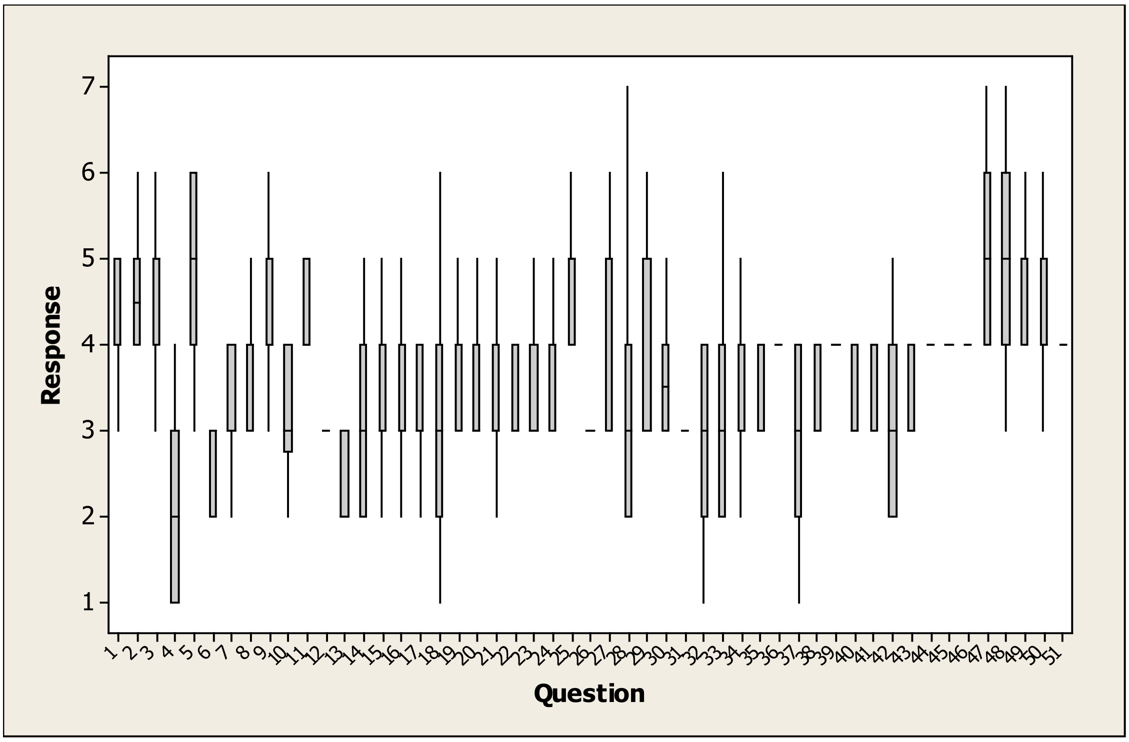

Figure 2. Box plots of survey data without outliers

The data without outliers were summarized by calculating arithmetic mean of the responses for each question (Figure 3).

A question with a mean value of less than or equal to 3 was assumed to indicate that the airline company has weaker performance relative to its competitors on that factor. The factors meeting that criterion were identified as follows:

- R&D costs
- Marketing/advertisement costs
- After sales service
- Fleet size and capacity
- Market share growth
- Knowledge management inside the company
- Capital efficiency
- Financial strength
- Traffic rights/privileges

The findings suggest that the company should give priority to these factors in formulating strategies to improve its competitive position.

3. Conclusion

In this study a survey was used to collect information about competitive position of an airline company operating in the Turkish civil aviation sector. The survey was carried out with the top executives of the company. Based on the survey data, the factors on which the airline company has weaker performance relative to its competitors were identified.

Evaluating its competitive position provides the company with a direction to formulate appropriate goals (where to go) and strategies (how to go) for improving its performance and gaining competitive advantage in the market.

As a further study the same survey will be conducted with the middle-level managers and operational level personnel of the company and combined survey data will be used to examine the relations among factors.

4. Acknowledgement

Authors acknowledge the support of the Marmara University Scientific Research Projects Committee (BAPKO, Project Number: FEN-C-YLP-130515-0185).

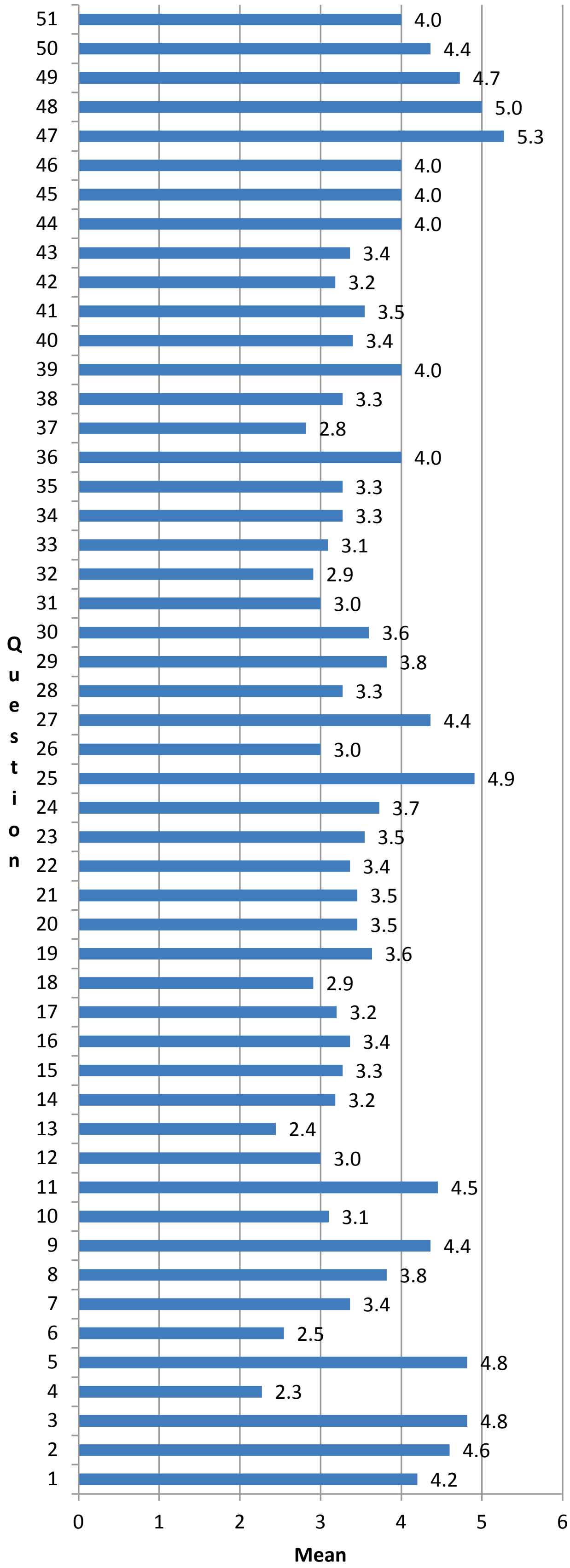

Figure 3. Graph of summarized survey data

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USING NEURAL NETWORKS TO PREDICT ALUMINIUM OXIDE LAYER THICKNESS

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Abstract

The paper shows the possibilities of control the technological process of aluminium anodic oxidation using created prediction model. Prediction model was developed by usage of Design of Experiments (DOE) and compiled by higher order neural unit. Prediction model can also monitor the influence of the significant parameters on the resulting AAO (anodic aluminium oxide) film thickness. It also compares the relationship between individual input factors and their mutual interactions on the AAO thickness at monitored current density of 1.00 A·dm^{-2}. The developed predicted model describes the influence of input factors on the final AAO thickness with reliability of 99.37 % at current density of 1 A·dm^{-2}.

Keywords: Anodic oxidation, layer thickness, prediction model, neural networks

1. Introduction

Pure aluminium and its alloys, such as weight-saving materials, play an increasingly important role of technical, technological and economic terms in the aerospace and automotive industries where lightweight and rigid structure are preferred [1]. Anodic aluminium oxide (AAO) coating has recently attracted the scientists' attention because of its self-organizing nature of vertical (cylindrical) pores in the form of hexagonal arrays, which provides a controlled and narrow distribution of pore diameters and inter-pore distances in addition to the possibility of forming the pores with extremely high aspect ratio [2]. Anodizing is one of the most important processes in corrosion protection and colour finishes for aluminium [3]. Anodizing of aluminium surfaces is carried out in a wide variety of plants for numerous uses in industries. It is an effective process applied to producing decorative and protective films on articles made from aluminium [4]. With the oxidation of aluminium, when forming the electrolyte, the most frequently used are sulphuric acid and oxalic acid, alternatively a combination of them, because of their environmental friendliness [5] The mechanism of an oxide layer formation when using sulphuric acid solution has been examined by Tsangaraki-Kaplanogloua et al. [6], Patermarakis [7], and Aerts et al.[8], who managed to design a mathematical model of local turbulences in the electrolyte and examine their influence on the geometrical dimensions of pores. Aerts et al. were also dealing with the temperature effect on the growth of the oxide layer [9] and the layer porosity [10] of 99.50 % aluminium using the electrolyte comprising sulphuric acid based on which it followed that the structure of the layer, the layer porosity, its thickness and hardness are not so much under the influence of the temperature of the electrolyte compared to that of the electrode.

2. Experiment realization and methods

Alloy EN AW 1050 - H24 with dimensions 101 x 70 x1 mm was used for the specimens. Each applied specimen was degreased in a 38% solution of NaOH at 55-60 °C for 2 minutes and stained in a 40% solution of NaOH at the temperature 45-50 °C for 0.5 min. Consequently, the specimen was immersed in a nitric acid bath (4.00% HNO_3) at the temperature 18-24 °C for 1 min. Between each operation, the sample was rinsed with distilled water.

Electrolyte for each anodizing sample was made from sulphuric acid, oxalic acid and aluminium cations (added like powdered aluminium oxide). Composition of electrolyte and the individual operating conditions were predetermined according to the central composite design of experiment DOE.

The application of a coded scale for the evaluation of experimental results prevents from distortion of the experimental results by absolute values of the individual studied factors. Table 1 shows the conversion of input factors between nature scale and coded scale.

Table 1 Table of transfers between natural scale and coded scale of examined factors

Factor		Factor level				
Coded scale	*Nature scale*	-2.37	-1	0	+1	+2.37
x_1	H_2SO_4 [g.l^{-1}]	33.51	130.00	200.00	270.00	366.49
x_2	C_2H2O_4 [g.l^{-1}]	1.49	7.00	11.00	15.00	20.51
x_3	Al^{3+}[g.l^{-1}]	0.18	5.00	8.50	12.00	16.82
x_4	T [°C]	-1.78	12.00	22.00	32.00	45.78
x_5	t [min]	6.22	20.00	30.00	40.00	53.78
x_6	U [V]	5.24	8.00	10.00	12.00	14.76

3. Problem solution

Higher-order neural unit (HONU), especially the 3rd order HONU based on the iterative Levenberg-Marquardt (LM) algorithm [11] was used to determine the influence of input factors on the thickness of the final AAO layer. This algorithm is often used for training technique of the neural unit. It is a process of updating individual weights in a predetermined number of steps to achieve a minimum difference between the actual and calculated values of observed variable [12]. The equation describing the investigated model is the characteristic equation of given type of neural unit (1st order HONU, 2nd order HONU a 3rd order HONU) for observed factors x_1, x_2, x_3, x_4, x_5, x_6.

4. Results and discussion

After the learning process of neuron unit is done, we get a prediction model that describes the thickness of AAO layer. The final thickness of oxide layer, α is preliminary thickness of oxide layer is expressed in mm·10^{-3}.Table 2 shows significant statistical indicator for compiled prediction models of surface AAO layer thickness for surface current densities 1 A·dm^{-2}. Those indicators are sum of square errors SSE, mean square error RMSE, correlation coefficient R, coefficient of determination R^2, standard deviation of errors se, variation of errors s^2e and biggest error of prediction maxe.

Table 2 significant statistical indicators for compiled mathematical models

SSE	MSE	R^2	R	se	se^2	maxe
87.51	1.9	0.93	0.97	1.38	1.9	6.6

Figure 1, Figure 2, Figure 3, Figure 4 and Figure 5 shows influence of factors x_1(concentration of sulphuric acid in the electrolyte) and x_4 (temperature of the electrolyte) on thickness of aluminium oxide created on sample surface.

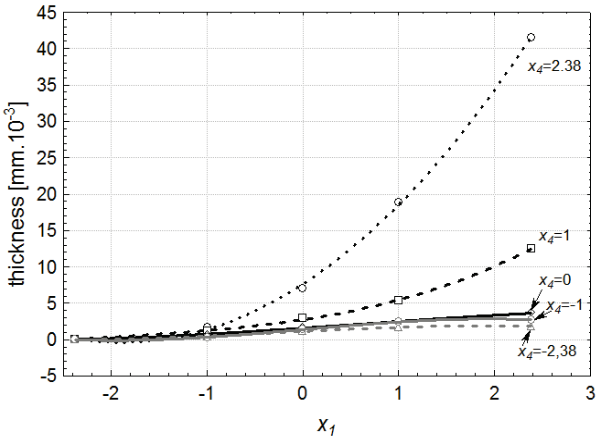

Figure 1 Influence of factors x_1 and x_4 on AAO layer thickness for current density 1·Adm^{-2} and factor x_5 which is set to level -2.38

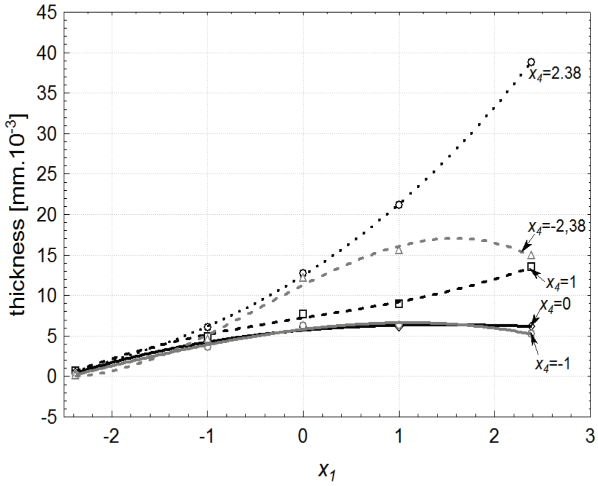

Figure 2 Influence of factors x_1 and x_4 on AAO layer thickness for current density 1·Adm-2 and factor x_5 which is set to level -1

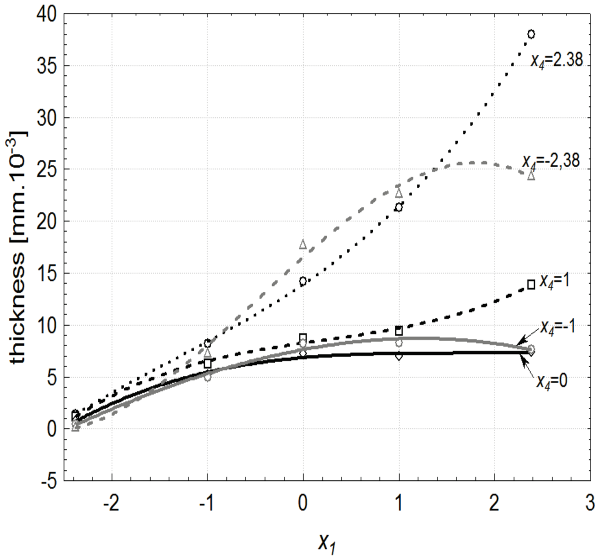

Figure 3 Influence of factors x_1 and x_4 on AAO layer thickness for current density 1·Adm-2 and factor x5 which is set to level 0

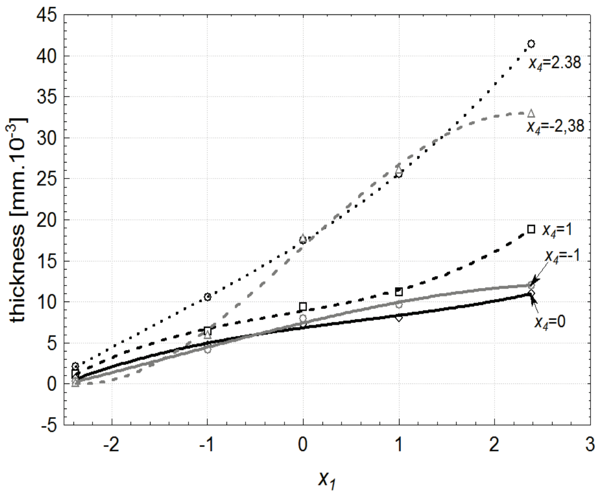

Figure 4 Influence of factors x_1 and x_4 on AAO layer thickness for current density 1·Adm^{-2} and factor x_5 which is set to level 1

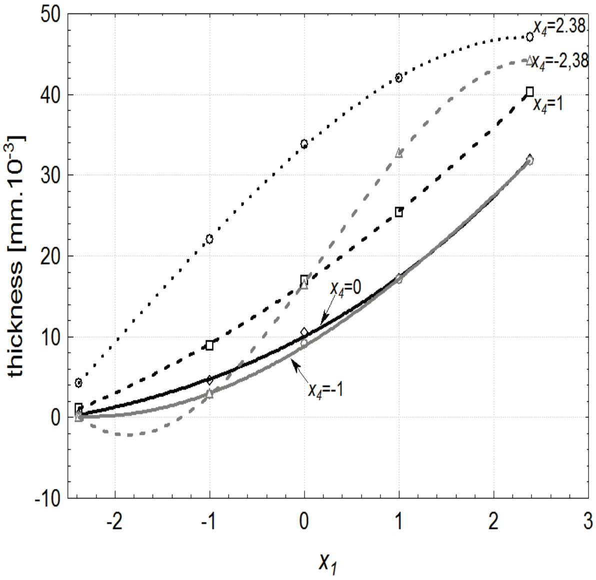

Figure 5 Influence of factors x_1 and x_4 on AAO layer thickness for current density 1·Adm^{-2} and factor x_5 which is set to level 2.38

These graphs also demonstrate influence of the factor x_5 (anodizing time) on the oxide thickness. Level of factor x_5 is set to level "-2.38" (6.22 min) Figure 1, "-1" (20 min) Figure 2, "0" (30 min) Figure 3 "1" (40 min) Figure 4 and "2.38" (53.78 min) Figure 5. Aluminium oxide layer was created on surface areas with1.00A·dm^{-2} current density. Factors x_2, x_3 and x_6 have zero factor level for all these graphs. Zero factor level for factor x_2 is 11 g.l^{-1}, for factor x_3, it is 8.5 g.l^{-1} and for factor x_6 it is 10 V.

From these graphical characteristics, it can be surmised, that the thickness of AAO layer is proportional to concentration of sulphuric acid in the electrolyte (factor x_1). Thus, with an increasing amount of sulphuric acid in an electrolyte also rise an amount of dissociated ions. Increased ion amount in electrolyte increase its conductivity. Oxygen, which is bound to a part of these ions, is used to create a layer of an aluminium oxide. Electrolyte temperature (factor x_4) influences the speed of oxide layer creating and also the thickness of AAO layer. With increasing temperature also rises the speed of chemical reactions on metal-electrolyte interface. However, general claim that with increasing electrolyte temperature also proportionally increases the thickness of AAO layer is not true. This claim is true only in specific case. Which means that some others variables significantly influences the thickness of AAO layer, specifically, the time of oxidation (factor x_5). If the concentration of sulphuric acid in electrolyte influences the amount of ions in electrolyte and if electrolyte temperature influences the speed of chemical reactions on a metal-electrolyte interface, then not only does time of oxidation determinate time of chemical reactions between meal and electrolyte but also between electrolyte and already created oxide layer. Reactions between metal and electrolyte create new molecules of aluminium oxide on the surface of metal and thus contribute to the rise of oxide layer. However, reactions between oxide layer and electrolyte cause reduction in thickness of created oxide layer due to it dissolving in the solution. Thus with the increase in time of oxidation, the thickness of oxide layer decreases, due to increase in electrolyte temperature. After crossing a certain temperature threshold (factor level -1 for Figure 2 factor level 0 for Figure 3, Figure 4, Figure 5), the resulting oxide layer thickness increases. Speed of oxide layer creating is higher than speed at which it before it reaches the temperature of factor -1.

Just as figures Figure 1 through Figure 5 examine the relationship between the amount of sulphuric acid in electrolyte, electrolyte temperature, oxidation time and thickness of oxide layer, figures Figure 6through Figure 10 show the influence of amount of sulphuric acid in electrolyte, electrolyte temperature and voltage levels in relation to the thickness of the oxide layer. Results are shown for cases of current densities 1 A·dm^{-2}.

Figure 6-10 show influence of factors x_1 (concentration of sulphuric acid in the electrolyte) and x_4 (temperature of the electrolyte) on thickness of aluminium oxide created on sample surface These graphs also demonstrate influence of the factor x_6 (the size of an applied voltage) on the oxide thickness. Level of factor x_6 is set on level "-2.38" (5.24 V) Figure 6, "-1" (8 V) Figure 7, "0" (10 V) Figure 8 "1" (12 V) Figure 9 and "2.38" (14.76 V) Figure 10. Aluminium oxide layer was created on 1.00A·dm^{-2} current density surface areas. Factors x_2, x_3 and x_5 have zero factor level for all these graphs. Zero factor level for factor x_2 is 11 g.l^{-1}, for factor x_3 is 8.5 g.l^{-1} and for factor x_5 is 30 min.

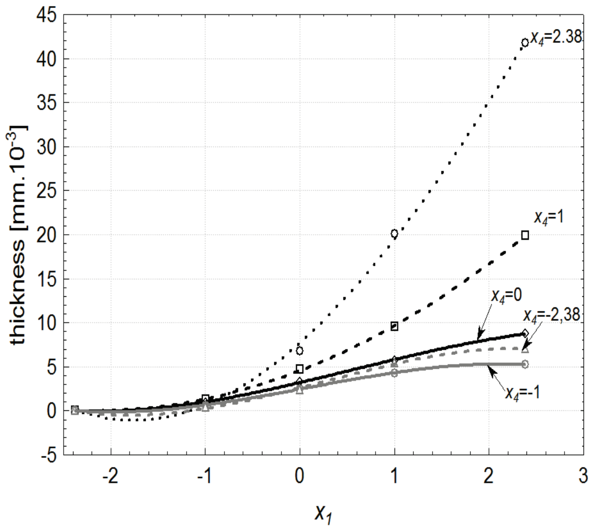

Figure 6 Influence of factors x_1 and x_4 on AAO layer thickness for current density 1·Adm^{-2} and factor x_6 which is set to level -2.38

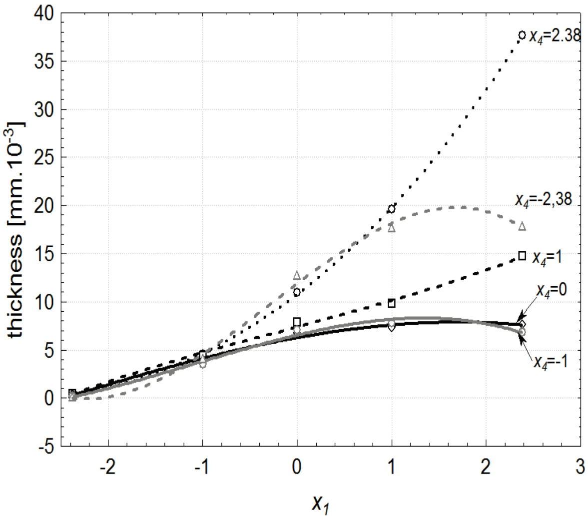

Figure 7 Influence of factors x_1 and x_4 on AAO layer thickness for current density 1·Adm^{-2} and factor x_6 which is set to level -1

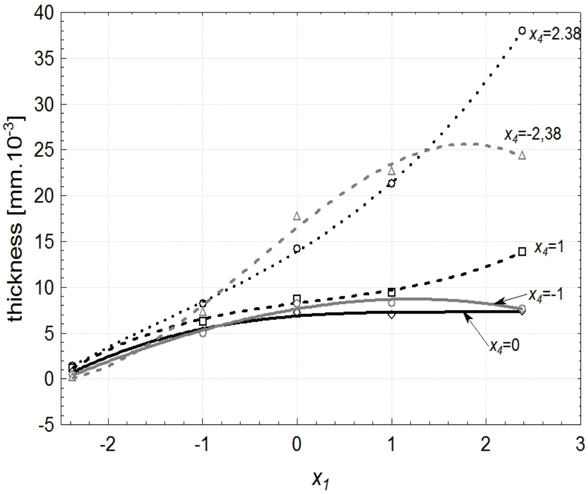

Figure 8 Influence of factors x_1 and x_4 on AAO layer thickness for current density 1·Adm^{-2} and factor x_6 which is set to level 0

Connected voltage levels are proportional to the electric potential. Electric potential is proportional to electrodynamics forces. These electrodynamics forces determine the force with which are positively charged ions attracted to the negatively charged electrode (cathode) and the force with which are negatively charged ions attracted to the positively charged electrode (anode). If we increase voltage, electric potential on anode will also increase. Higher electric potential on anode will attract higher number of oxygen anions. Thus, the surface of aluminium sample will contain higher amount of oxygen anions and more molecules of aluminium oxide will be created on the surface of the sample. Through this, the thickness of AAO layer increases. It is possible to see this process in Figure 6-10 for current densities of 1 A·dm^{-2}, where the thickness of oxide layer increases faster with the increase of voltage.

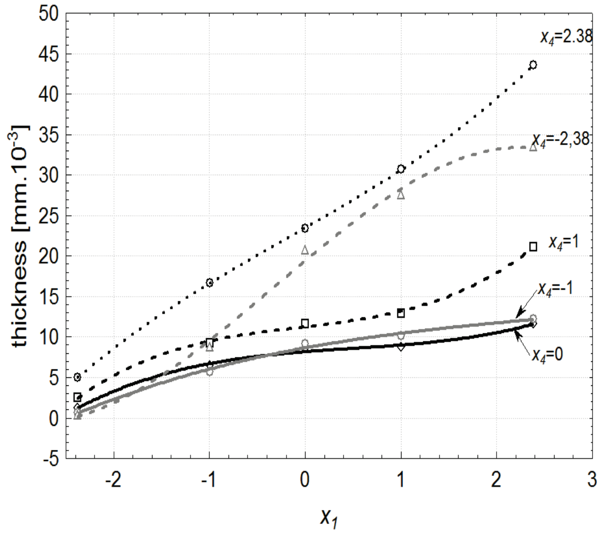

Figure 9 Influence of factors x_1 and x_4 on AAO layer thickness for current density 1·Adm^{-2} and factor x_6 which is set to level 1

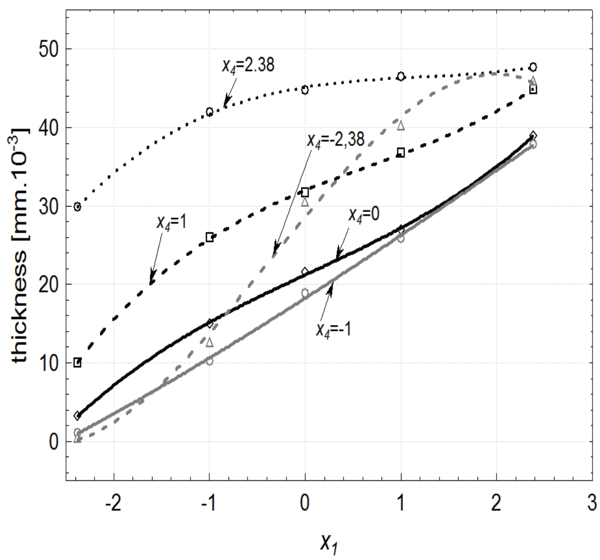

Figure 10 Influence of factors x_1 and x_4 on AAO layer thickness for current density 1·Adm^{-2} and factor x_6 which is set to level 2.38

5. Problem solution

As shown by the evaluation of experimental results presented above, the use of 3rd order neural unit based on the iterative Levenberg-Marquardt (LM) optimization algorithm provides a wide range of options to investigate influence of input factors to AAO layer thickness. By using of neural unit, we can quickly and simply describe the behaviour of the monitored system. This neural unit allowed us to monitor the impact of input factors (concentration of sulphuric acid, electrolyte temperature, anodizing time and applied voltage) on the final thickness of the AAO layer for surface current density 1 A·dm^{-2} and 3 A·dm^{-2}. Also by using the neural unit of 3rd order HONU it was possible to describe the influence of input factors on the thickness of final AAO layer with confidence interval of 93.45% for surface current density 1 A·dm^{-2}.

6. Acknowledgement

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BUSINESS COMMUNICATION COURSE SYLLABI IN UNDERGRADUATE MANAGEMENT AND TECHNICAL EDUCATION IN CROATIA – A COMPARISON

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Abstract

Communication represent essential part of Communication represents an essential part of everybody's daily life routine. Some researches have proved that an average person spends 75% of the day speaking and listening, and about 25% reading and writing (Berko, 1994; quoted in Morreale et al., 2000). The same research has also noted that corporate managers spend 60% of their day in face-to-face communication. Even the US Congress officially added 'effective oral communication' to the basic skills of reading and writing for primary and secondary education as a part of national program for basic skills improvement (PUBLIC LAW 95-561—NOV. 1, 1978). Even though there is considerable scientific evidence indicating the benefits of communication education for the development of a person, pointing out it is even more important for achieving success in a career, particularly for managers, communication education is still rare or inadequate at Croatian Universities, as revealed by this survey. Other researches have also shown that Croatian managers come from different scientific fields, dominantly from economic and technical ones (Bilić, 2011). Earlier researches have revealed several types of communication. However, with the aim to focus our survey we limited it to the content of business communication inclusion in the curricula of undergraduate technical and economic studies at Croatian University. The research focused on the aforementioned content, which covers essential communication skills: writing, reading, listening and speaking/oral.

Keywords: Business communication, Tertiary education, Syllabus, Curriculum development, Management education

1. Introduction

The importance of successful business communication (hereinafter BC) does not need to be emphasized at the present time. Effective business communication is a prerequisite for entering the labour market, running day-to-day operations, and attaining organizational goals. Communication is a means of motivating employees, influencing their behavior, achieving company's goals, communicating new ideas, and implementing changes. Effective BC establishes and fosters good working relationship and teamwork.

This is also the way of presenting company's products and services to potential customers, a means of conducting negotiations and of obtaining the necessary finance.

BC in a company is a thread that holds the parts of an organisation together. If it is broken, it can present various challenges that can ultimately lead to the demise of a company. It is thus clear that business communication is an important segment that needs to be taught to future professionals. It is of paramount importance to include business communication courses in the curriculum, particularly at the tertiary level. It should be stressed that those courses should find their place not only in the education of future business professionals but also in the education of professionals of various professions.

BC is considered by employers a generic skill and businesses are looking for workers who can help them to increase profitability, by reducing costs associated with training (Ferguson, 2007), particularly in generic skills. In all three major surveys on the Top Related Skills (Hodge and Lear, 2011), communication skills have been rated as indispensable top related skills. Everything previously stated, confirms the need for BC education at the tertiary level.

2. Developing Curricula and Designing Syllabi

Professionals working in the field of curriculum development do not fully agree on the meaning on the term. Curriculum is defined as "the subjects that are taught by a school or the things that are studies in a particular subject "(LDOCE), "the subjects that are included in a course of study or taught in a school, college, etc." (OALD), "the subjects studied in a school, college, etc. and what each subject includes" (CALD), "a fixed series of studies required, as in a college, for graduation, qualification in a major field of study, etc.; all of the courses, collectively, offered in a school, college, etc., or in a particular subject" (Webster).[1] Indis-

[1] CALD= Cambridge Advanced Learner's Dictionary, LDOCE = Longman Dictionary of Contemporary English; OALD= Oxford Advanced Learner's Dictionary; Webster= Merriam-Webster's Online Dictionary.

pensable parts of a curriculum are on the one hand objectives and goals that must be achieved by it and on the other hand are outcomes and results. *The curriculum represents a set of desired goals or values that are activated through a development process and culminate in successful learning experiences for students* (Wiles and Bondi, 2007; quoted in Wiles 2009).

Curriculum development describes all the ways in which a training or teaching organisation plans and guides learning…It is central to the teaching and learning process (Rogers and Taylor, 1998). In other words, curriculum development focuses on determining what knowledge and skills students should acquire, how the intended outcomes should be achieved and how the learning and teaching can be measured and evaluated. Curriculum development is a process affected by the context, both spatial and temporal, in which it takes place. It is also both a continuous process relevant to the context and a flexible one which can be adapted so as to meet the changed needs/requirements. Curriculum development thus refers to a range of planning and implementation processes which are involved in both developing and reviewing a curriculum. These processes ideally focus on needs analysis, situational analysis, planning learning outcomes, selecting and preparing teaching material and evaluation. Curriculum development should try to address the following questions: (1) What procedures can be used to determine the content?; (2) What are students' needs?; (3) How can students' needs be determined?; (4) Are there any contextual factors that need to be considered? If yes, then what are those?; (5) What are the aims and objectives and how can they be achieved?; (6) What are the outcomes / results and how can they be achieved?; (7) What issues are involved in selecting, adapting, designing the teaching material? A good curriculum should be based on the analysis of learners', i.e. students' needs. The skills that students need to develop to be successful professionals in their field must be relevant for the working world and matching skills and jobs has become a high-priority policy concern.

Syllabus is defined as "a plan that states exactly what students at a school or college should learn in a particular subject" (LDOCE), as "a list of the topics, books, etc. that students should study in a particular subject at school or college" (OALD), as "the subjects or books to be studied in a particular course, especially a course that leads to an exam" (CALD) and as "a list of the topics or books that will be studied in a course" (Webster). Syllabus design is related to the broader field of curriculum development. Syllabus design refers to choosing the content to be taught as part of a course. Curriculum development refers to the entirety of the courses to be taught.

Developing a curriculum means choosing what to include in it so as to achieve the desired results, outcomes and aims. Designing a curriculum for any profession should include a business communication course as communication is an important aspect of any profession. BC syllabus should offer a framework of elements which are important for communication of future (business or any other) professionals. The outcome of such a syllabus is their successful communication with both colleagues and partners.

BC course topics range widely but are always aimed at developing related skills: (1) <u>writing</u> Bennet & Olney (1987); Diamond (1997); Wadrope (2002); Wardrope & Bayless, (1999); Tanner; U.S. Congress (1978); Curtis 1998 in Morreale, (2000); Miller & Luse, (2004); Conrad & Newberry (2011); (2) <u>reading</u> Diamond (1997); U.S. Congress (1978); (3) <u>listening</u> Maes et al. (1997); Bennet & Olney (1987); Wadrope (2002); Morreale et al. (2000); Diamond (1997); Curtis 1998 in Morreale, (2000); Montagno et al. (1986); Conrad and Newberry (2011); and (4) <u>speaking/oral topics</u> Oral: Wardrope and Bayless, (1999); Maes et al. (1997); Bennet and Olney (1987); Wadrope (2002); Tanner, Diamond (1997); Curtis 1998 in Morreale, (2000); Montagno et al. (1986); Miller & Luse, (2004); and (5) <u>presentation</u>: (Miller & Luse, (2004); Conrad & Newberry (2011).

3. Importance of Communication Skills for Managers and Their Career Success

Well-known communication scholars, Argenti & Forman (1998) stated that most chief executive officers spend more than a half of their daily activities in communication, that their educational curricula had not adequately prepared them for. Business communication courses are usually included in business, communication and media; nursing education, technical and rarely in other fields of education. As expected, most managers in today's dynamic environment have an economic/business background. However, it should be noted that a significant number of managers today have a technical background. Moreover, a recent survey on the educational background of management boards of the biggest Croatian companies showed that 72.86% of companies have board members with background in economy, and 45.71% with a background in technical sciences (Bilić, 2011).

Communication education improves specific skills and abilities important for the managers, including critical thinking, media literacy and criticism, and leaderships skills (Morreale et al., 2000), which are very important for managers. The fields of business administration and engineering are those where career development is more important (Miller & Luse, 2004; Morreale et al., 2000) for entry-level position hiring (Maes et al., 1997; Ugnah and Evuleocha, 1992) and where one of the prerequisites for career development and upward mobility, particularly for managers, is possession of adequate communication skills (Adams, 2014; Curtis, 1998, quoted in Morreale, 2000; Mallinger, 1998; Morreale et al., 2000; Peterson, 1997; Roof-Steffen, 1991). A recent survey on specific and generic competences required for mechanical engineers, conducted on alumnae of the University of Zenica, BiH showed that respondents see communication as an important generic soft skill. Out of 41 respondents, 41.5% strongly agreed on the importance of this skill, 53.7% agreed, and 4.9% somewhat agreed (Petković et al., 2015).

In Croatia, there are seven public universities which were included in our survey and three private universities which were not included in the survey as they do not offer courses relevant to the survey.

The first step in the qualitative survey included the analysis of web pages of the seven universities and their publicly available syllabi. The survey included only Undergraduate University Study Programmes at the Faculties of Economy/Business and Technical Faculties. The aims of the survey were first to investigate which faculties offer a Business Communication course and then to analyse their syllabi to find out which skills are taught.

A total of 12 Faculties at Universities in Croatia offer a business communication course, some as a core course and some as an elective one. "Business Communication" course is taught at the Faculty of Geodesy, the Faculty of Organization and Informatics (University of Zagreb, UniZG), the Faculty of Economics in Osijek (University of Osijek, UniOS), the Faculty of Economics in Rijeka (University of Rijeka, UniRI), the University of Zadar (UniZD) and the Faculty of Civil Engineering, Architecture and Geodesy and Faculty of Economics (University of Split, UniST). "Communication Skills" or "Skills of Communication" are taught at the Faculty of Electrical Engineering and Computing (UniZG), the Faculty of Electrical Engineering (UniOS), the Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture in Split (UniST), and the Faculty of Civil Engineering (UniRI). At the Faculty of Metallurgy (UniZG), "Ethics and communication skills" are taught. The faculties of the Universities of Pula and of Dubrovnik offer no courses in Business Communication.

The number of ECTS credits allocated to the course ranges from 2 to 6 and it is not related to whether the course is a core or an elective one. Business communication courses are taught in all 6 semesters (except the 2nd one), mostly in the 1st (6 courses) and 5th (4 courses). A comparative analysis of syllabi at the selected Faculties focused on whether the relevant business communication skills, i.e. writing, reading, listening and speaking/oral topics, were developed at a business communication course. Presentation skills as an indispensable part of the speaking skills was added to the analysis.

Table 1. Content of Business Communications syllabi at Economic and Technical faculties.

Faculty & University	W	R	L	O	P
GEOF[2], UniZG	+	-	-	+	+
FOI[3], UniZG	+	+	+	+	+
FOIa[4], UniZG	+	-	+	+	+
GRADST[5], UniST	+	-	+	+	+
GRADRI[6], UniRI	-	-	+	+	*
FER[7], UniZG	+	-	+	+	+
ETFOS[8], UniOS	+	-	+	+	+
FESB[9], UniST	+	-	+	+	+
PFS[10], UniST	+	-	+	-	+
EFOS[11], UniOS	*	*	*	*	-
EFRI[12]", UniRI	+	-	+	+	-
UniZD[13]	*	*	*	*	*
EFST[14], UniST	+	-	-	+	+

Legend: W – writing; R – reading; L - Listening; O – Oral; P- presentation and public speaking; * - the content of the syllabus it more about BC, than for developing BC skills

From the results shown in Table 1 it is obvious that writing, listening, oral and presentation skills represent an important part of the BC syllabi in Croatia, where BC is part of the curricula. Reading is completely neglected, which is a mismatch with the actual needs as most of internal and external communication is in written form – letters, e-mails, instructions, decisions, memos, etc. In addition, the number of 12 faculties in total, where BC is taught as an evidence that most of technical faculties do not recognize the benefits of BC education which is offered only at selected study programmes. The situation at the economic faculties is almost the

[2] Faculty of Geodesy

[3] Faculty of Organization and Informatics, "Information/Business Systems"

[4] Faculty of Organization and Informatics, "Economics of Entrepreneurship"

[5] Faculty of Civil Engineering, Architecture and Geodesy, "Geodesy and Geoinformatics"

[6] Faculty of Civil Engineering

[7] Faculty of Electrical Engineering and Computing, "Electrical Engineering and Information Technology"

[8] Faculty of Electrical Engineering

[9] Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture in Split, "Electrical Engineering and Information Technology"

[10] Faculty of Maritime Studies, Split "Maritime Management", "Maritime Yacht and Marina Technologies"

[11] Faculty of Economics

[12] Faculty of Economics, "International business", "Finance and Banking

[13] University of Zadar, "Management",

[14] Faculty of Economics in Split, "Business Economics"

same and BC courses are available only to students of some study programmes and not all of them.

4. Conclusion

Our research results have shown that BC is taught at several Croatian faculties and is mostly focused on developing writing, listening, oral and presentation skills. Reading skills are neglected, which could pose serious problems in business communication, as understanding written materials is rather important.

The survey of BC syllabi has also shown that some BC courses are focused on the theory of BC rather than on developing practical skills. Teaching theory can provide us with a content for the practical tasks. As Du-Babcok (2006) stated, teaching BC theory and models, without inclusion of applicative materials is inadequate.

In addition, as our research is based on open, publicly available syllabi, it is possible that some topics were delivered differently in the classroom than it is possible to judge from the syllabus. Finally, one of the suggestions for future researches may be to explore the content of BC courses on wider polygon of stakeholders, teachers, human resources managers and employers in Croatia and other countries. When business communication courses are discussed from any perspective, we need to be aware that real output will be measured in longitudinal research on same population, with more precise assessment of education, in depth. The success of a BC syllabus can also be measured by students' success in communication in the professional world they enter after graduation.

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DETERMINING THE THEORETICAL FAILURE RATE FUNCTION OF THE THERMAL POWER SYSTEM IN POWER PLANT "NIKOLA TESLA, BLOCK B2"

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Abstract

Results of reliability theory in thermal power systems are presented and discussed. Exploitation research of the failure rate of thermal power system in the fossil fuel power plant "Nikola Tesla, block B2" during useful life period is based on a twelve-year failure database. By applying the reliability theory, based on statistics and theory of possibility, and using simple and complex two-parameter Weibull distribution, the theoretical failure rate functions of specified system have been determined. The benefit of the study lies in the potential early and continued understanding of the logics and mechanisms underpinning the system uncertain failure behaviour, which complement other methods and information in order to achieve maximum availability through optimized maintenance and prompt recovery.

Keywords:

Thermal power system, failure rate

1. Introduction

Reliability has come to be one of the highest priorities of power systems, and it ranks along with cost and efficiency as a measure of successful operation. Most failures have economic conseque–nces, not only of the necessary repair or component replacement following a failure, but because of other failure effects such as a loss of production. The higher availability of a complex thermal power plant is depending upon higher reliability and maintain–ability of its subsystems and components, which will not perform satisfactorily unless they are maintained properly. The general objective of maintenance is to make use of the relevant information regarding fai–lures and repairs. Therefore it is imperative to investigate the reliability characteristics of the system, for taking necessary measures regarding maximi–zation of power supply.

The essential problem related to the maintenance of complex systems and structures is related to the challenges of predicting the failure behavior of their components with due account of the associated uncertainties. The principal element which has supported the rise of reliability engine–ering as a scientific discipline is the theory of probability and statistics [1]. Reliability theory establishes a foundation for the application of reliability concepts and reliability related quantities to a system. Statistical techniques allow us to extract reliability measures from data, analyze the structure of data and test hypotheses.

A system is usually defined as a group of components assembled in a given functional configuration intending to perform a specific function. From the hierarchical structure point of view, a system is comprised of a number of subsystems, which may be further divided into lower-level sub–systems, depending on the purpose of system ana–lysis. To assess the reliability of a thermal power system, following have to be considered:

- definition of system boundaries to limit the extent of the analysis;
- selection of the analysis method, in order to study the phenomena correctly.

In this study the thermal power system is represented as a set of three subsystems: fossil fuel boiler, steam turbines and three-phase alternator. System boundaries are adopted in order to determine the transmission limits of the thermal power sub–systems within the thermal scheme [2]. The control limit that encloses the thermal power system does not encompass: systems for storage and delivery of fuel, systems for collecting and treatment of cooling water, the block transformer and the ash dump. The large component count, unique component types, high internal stress levels, complex design, manual assembly and abundant opportunities for design errors led to potential high overall failure rates and decrease in reliability.

2. Data collection and classification

Exploitation research on the reliability of thermal power system of coal-fired power plant "Nikola Tesla, Block B2" (TENT-B2), in the period 1997-2008, should define the function, or the proba–bilistic law, according to which occurs the complete unplanned standstill. Although this thermal power plant has two units with individual installed capacity of 620 MW, the reliability characteristics of their thermal power systems may not be the same. Data collection has been carried out over a long period of time for true failure and repair characterization. Maintenance data is collected from the plant's maintenance logbook records over a period of 12 years, which are sorted and classified for analysis. Failure evidence nece–ssary for determining reliability and unreliability indicators for previously mentioned system are presented in tab. 1.

Table 1. The exploitation reliability components of the thermal power system in TENT-B2

Observation period		Reliability				
	Tk_i	Nn_i	f_i	F_i	R_i	λ_i
	[year]	[-]	[h^{-1}]	[-]	[-]	[h^{-1}]
1	2	3	4	5	6	7
1	1997	7	0.034	0.034	0.965	0.035
2	1998	8	0.039	0.074	0.925	0.042
3	1999	11	0.054	0.128	0.871	0.062
4	2000	20	0.099	0.227	0.772	0.128
5	2001	31	0.153	0.381	0.618	0.248
6	2002	17	0.084	0.465	0.534	0.157
7	2003	13	0.064	0.529	0.470	0.136
8	2004	18	0.089	0.618	0.381	0.233
9	2005	15	0.074	0.693	0.306	0.241
10	2006	19	0.094	0.787	0.212	0.441
11	2007	16	0.079	0.866	0.133	0.592
12	2008	27	0.133	1	0	+∞

Operating time intervals that include all data required for system analysis are defined for one year periods, or 8760 working hours, for the period from 1997 until 2008.

3. Determining failure rate function

The properties and behaviour of all technical systems are by nature highly stochastic quantities and processes, what is one of the most important features of the reliability concept. It means that all information related to the reliability of thermal power system in TENT-B2 are random variables, subjected to specific laws of probability. Therefore, collected data could be processed only with the help of statistical mathematics.

Reliability theory is essentially the application of probability theory to the modeling of failures. Modern probability theory bases many of its results on the concept of a random variable and its probability density function.

A useful concept in reliability theory to describe failures in a system and its components is the failure rate. It is defined as the probability that a failure per unit time occurs in the interval [t, t+Δt], given that a failure has not occurred before t. In other words, the failure rate is the rate at which failures occur in [t, t+Δt]. The system failure rate represents the sum of the component failure rates.

Since the structure of thermal power system is not one of the simple forms, it becomes difficult to compute the exact reliability [3]. Moreover, when a law of probabilistic distribution is based on empirical data, the mathematical form of the distribution is usually not easy to determine [4].

Interrpretation of data is one of the key elements of the theory of reliability. Using probability and statistics analyses, the reliability of a power system can be studied in depth [5].The primary question that requires an answer is which theoretical distribution model best fits existing data. The physical properties of the stohastic process that is analized in some cases may suggest possible form of probability distribution.

A statistical distribution is fully described by its probability density function. The functions most commonly used in reliability engineering and life data analysis, namely the reliability function and failure rate function, can be determined directly from the definition of probability density function. Each of different mathematical distributions individually has a predefined probability density function. These distributions were formulated to mathematically model or represent certain behavior.

The parameters of the distribution are estimated from the exploitation data. Once these parameters are estimated, the probability density function is fully defined and its value can be obtained for any given value of time.

Some distributions tend to better represent life data and are most commonly referred to as *lifetime distributions*. In common use is the Weibull distribution that models increasing failure rates with age. Previous studies indicate that the behavior of the thermal power systems in therms of reliability could be best approximated by two-parameter and three-parameter Weibull distribution, while using normal, lognormal and exponential distributions could lead to considerable disagreements [2].

The Weibull distribution is very flexible and capable of modeling life of mechanical systems with time dependent failure rate [6, 7]. Failures of such systems are dominated by aging and mechanical or electrical wear out.

In this study the grafical method and probability papers were applied for analysis of the statistical set of data obtained by the exploitation survey of the thermal system in TENT-B2. The grafical method was chosen due to its relative simplicity and capability of providing a better understanding about the behavior of any repairable system [8].

On the other hand, the two-parameter Weibull distribution is selected in order to simplify graphical analysis. Principles of constructing probability plotting graph paper and empirical data entry are described by many authors [2, 9].

After calculating of failure probabilities, the corresponding cumulative percentage of failures (t_i, $F(t_i)_{50\%}$) were plotted in a Weibull probabilistic paper. Median rank positions were used instead of other ranking methods because median ranks were at a specific confidence level (50%).

The graphical-analytical procedure for obtaining parameters for simple and complex two-parameter Weibull distribution, as well as differences between them, were described by different authors [2, 9, 10], and for the purpose of brevity, only their values are shown here:

- simple two-parameter Weibull distribution

$$\eta_s = 6.562;\ \beta_s = 1.928;$$

- complex two-parameter Weibull distribution

$$\eta_{Ic} = 3.819;\ \beta_{Ic} = 2.2881;$$

$$\eta_{IIc} = 8.875;\ \beta_{IIc} = 7.6154.$$

Analytical expressions for theoretical reliability functions which represent the distribution laws of the observed random variable, obtained by simple two-parameter Weibull distribution are:

- reliability (eqs. (1) and (2)):

$$R_{ts}(t) = \exp\left(-\left(\frac{t}{\eta}\right)^{\beta}\right) \tag{1}$$

$$R_{ts}(t) = \exp\left(-5.0497\cdot 10^{-10}\cdot t^{1.9283}\right) \tag{2}$$

- failure density (eqs. (3) and (4)):

$$f_{ts}(t) = \frac{\beta}{\eta}\cdot\left(\frac{t}{\eta}\right)^{\beta-1}\cdot\exp\left(-\left(\frac{t}{\eta}\right)^{\beta}\right) \tag{3}$$

$$f_{ts}(t) = 9.919\cdot 10^{-6}\cdot t^{0.9283}\cdot\exp\left(-5.0497\cdot 10^{-10}\cdot t^{1.9283}\right) \tag{4}$$

failure rate (eq. (5)):

$$\lambda_{ts}(t) = \frac{f_t(t)}{R_t(t)} = 9.919\cdot 10^{-6}\cdot t^{0.9283} \tag{5}$$

It is important to note that for the complex two-parameter Weibull distribution case, the samples of failure probabilities for observed time interval were divided into two parts [11], after which the cumulative percentage of failures is calculated and plloted for each. In this particular case, first time interval covers 7, while seconod cover 5 years.

The parameters for the best fitted statistical data are estimated by least-square method. Theoretical reliability functions for each interval are (eqs. (6)-(9)):

$$R_{tI}(t) = \exp\left(-\frac{t}{\eta_I}\right)^{\beta_I} \tag{6}$$

$$R_{tII}(t) = \exp\left(-\frac{t}{\eta_{II}}\right)^{\beta_{II}} \tag{7}$$

$$R_{tI}(t) = \exp\left(-3.281\cdot 10^{-11}\cdot t^{2.2881}\right) \tag{8}$$

$$R_{tII} = \exp\ (-2.0783\cdot 10^{-38}\cdot t^{7.6154}) \tag{9}$$

Analytical expressions for theoretical reliability functions which represent the distribution laws of the observed random variable for the complex two-parameter Weibull distribution are:

reliability (eqs. (11) and (12)):

$$R_{ts}(t) = \frac{n_I}{n}\cdot R_{tI}(t) + \frac{n_{II}}{n}\cdot R_{tII}(t) \tag{11}$$

$$\begin{aligned} R_{tc}(t) = 0.5833\cdot\exp\left(-3.281\cdot 10^{-11}\cdot t^{2.2881}\right) + \\ +0.4167\cdot\exp\left(-2.078\cdot 10^{-38}\cdot t^{7.6154}\right) \end{aligned} \tag{12}$$

failure density (eqs. (13) and (14)):

$$\begin{aligned} f_{tc}(t) = \frac{dF}{dt} = \frac{n_I}{n}\cdot\frac{\beta_I}{\eta_I}\cdot\left(\frac{t}{\eta_I}\right)^{\beta_I-1}\cdot\exp\left(-\left(\frac{t}{\eta_I}\right)^{\beta_I}\right) + \\ +\frac{n_{II}}{n}\cdot\frac{\beta_{II}}{\eta_{II}}\cdot\left(\frac{t}{\eta_{II}}\right)^{\beta_{II}-1}\cdot\exp\left(-\left(\frac{t}{\eta_{II}}\right)^{\beta_{II}}\right) \end{aligned} \tag{13}$$

$$\begin{aligned} f_{tc}(t) = 4.3792\cdot 10^{-7}\cdot t^{1.2881}\cdot\exp\left(-3.281\cdot 10^{-11}\cdot t^{2.2881}\right) + \\ +6.591\cdot 10^{-34}\cdot t^{6.6154}\cdot\exp\left(-2.07\cdot 10^{-38}\cdot t^{7.6154}\right) \end{aligned} \tag{14}$$

failure rate (eq. (15)):

$$\lambda_{tc}(t) = \frac{f_{tc}(t)}{R_{tc}(t)} \tag{15}$$

Graphical comparisons between exploitation and obtained values for theoretical functions of reliability, failure density and failure rate of thermal power sys–tem in TENT-B2 during considered observation period were shown in figs. 1, 2 and 3, respectively. The data required for drawing functions of exploi–tation reliability and unreliability were given in tab. 1.

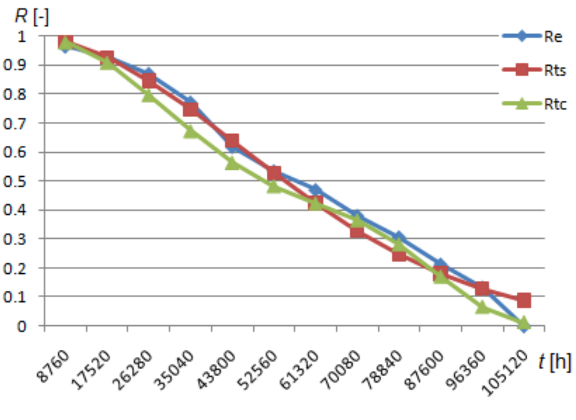

Figure 1. Exploitation and theoretical forms of the reliability functions

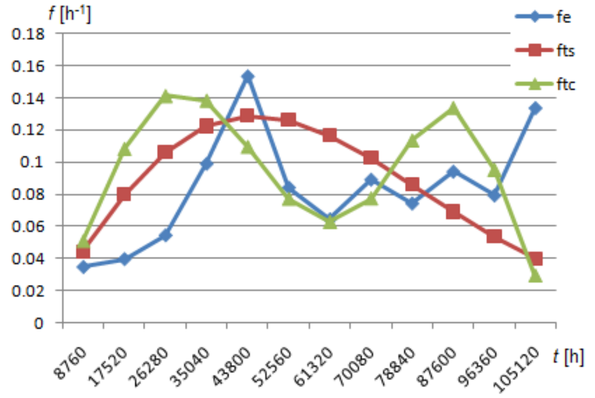

Figure 2. Exploitation and theoretical forms of the failure density functions

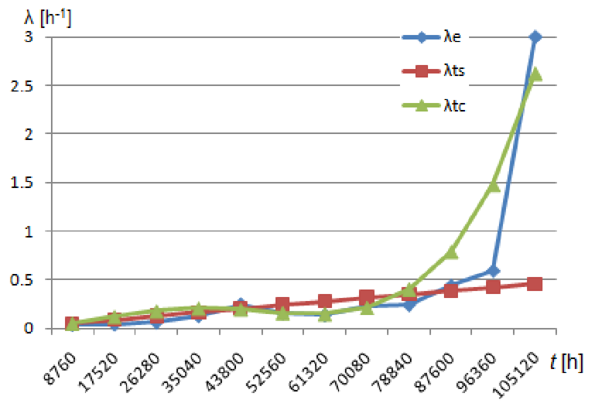

Figure 3. Exploitation and theoretical forms of the failure rate functions

4. Conclusion

Application of the reliability theory enabled deter–mination of the theoretical distribution laws of random variable according to the exploitation research of the thermal power systems in TENT-B2. The initial hypo–thesis that the distribution of the observed random variable approaches the Weibull distribution has been confirmed. The primary objective of the study was to determine theoretical failure rate function of the considered thermal power system, which inevi–tably demanded determination of the theoretical failure density and reliability functions also. Empirical form of the failure density shows zigzag-type beha–vior, what is almost impossible to be exactly repre–sented by any distribution function. The comparison of empirical and the theoretical failure density functions displays that function obtained by simple two-parameter Weibull distribution practically does not match, while function obtained by complex two-parameter Weibull distribution exerts smaller discre–pancies with coinciding value trends. Finally, good matching between empirical and theoretical failure rate function obtained by complex Weibull distribution was demonstrated. It has led us to the conclusion that for describing the theoretical distribution law of the failure rate during the useful life period of the thermal power system, it is more precise to use rather complex than the simple Weibull distribution.

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WEED FLORA OF THE EASTERN LATERAL CHANNEL "JELAS POLJA"

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Abstract

Research of wild weed flora of the first order lateral channel in the Brod Posavina County (Croatia) was conducted in mid-April and mid-August 2015. Floristic analysis of the weed flora determined 57 species belonging to 23 families. The most abundant species were from the Asteraceae family, then the family Fabaceaea and then the Poacea family. Taxonomic analysis of the weed flora determined a large presence of broadleaf weeds (91.22%), while the life-cycle analysis showed the dominance of perennial species. The most common weeds in observed area had hemicryptophyte character and originated from Eurasia.

Keywords:

weed, weed flora, water drainage, lateral channel

1. Introduction

Optimal water management relations in the root zone of the ecosystem becomes more challenging due to the global climate change and variability, and insufficient investment in the management of land and water resources [1]. Because of its geographic position Brod Posavina County is highly exposed to the risk of flooding. The frequency and intensity of rainfall in the Brod Posavina County influenced building of the first order lateral channels [2]. Their task is to drain excess rain and catchment water in the recipient. The first order drainage channel is basically regulated watercourse, which in certain circumstances can serve as a water recipient. The length of investigated eastern lateral channel "Jelas Polja" is 20.33 km. It is the first order collection channel that collects water from the tributaries of the southern slopes the hill Dilj and the river Glogovica [3]. In addition to the benefits of rapid drainage of excess water through open channels there are some disadvantages: loss of the large agricultural area and rapid growth of hydrophilic vegetation and weeds. Due to the growth of hydrophilic vegetation and weeds the necessity of regular annual maintenance is enhanced, especially cutting the channel slopes and dredging the channel [4].

Historically speaking, mowing and chemical treatment with herbicides were the standard methods for drainage channel maintenance, but resulted in fish pestilence in Oregon. Restocking with the grass carp fish didn't result in maintenance of hydrophilic vegetation but it could be due to the low water temperature in channels [5]. Arid climate, as in East Saudi Arabia, influence the decrease of one-year species and the increase of perennial species along the slope and terrace of drainage and irrigation channels [6].

The cause for increase of the number of perennial plants may be the dispersal of seeds due to the erosion of an unstable slope, variable water level of drainage channels and regular mowing [7]. River environmentalists have been warning for long time that the rivers and streams are under the influence of the landscape through which they flow [8, 9].

The aim of this paper was the determination of floristic composition of the first order eastern lateral channel of "Jelas Polje" in Brod Posavina County.

2. Method

Research of the weed flora was conducted in the Brod Posavina County (east part of Croatia) in two terms in mid-April and late August 2015 on the grassy site of the first order eastern lateral channel of "Jelas polje" (Figure 1).

Figure 1: Eastern lateral channel of "Jelas polje"

Weed flora is found on the site 45º8'51" of north latitude and 18º2'18" of east longitude which is some 500 m from the mouth of the eastern lateral channel in the recipient of the river Sava. The first order lateral channel has the width of the bottom of 6 m in the place where the weeds are determined, the width of the top of the slope of 40 m and depth of 4 m, and it is regularly maintained by mowing of grassy slope. In the summer months water from the channel is used for irrigation of the surrounding plantations (Figure 2).

Figure 2: Irrigation of plantation by pump motor and transmission system of sprinkling

For the weed determination standard key and atlas of weed and ruderal flora have been used [10, 11]. Families and plant species are listed in alphabetical order with their associated characteristics for each weed species such as: life-cycles (L. C.), life forms (L. F) and floral element (F. E.) [9]. For each type of weed founded at the slopes of the lateral channel information on the life form are provided and coded in the following way:
H – hemicryptophytes,
T – therophytes,
G – geophytes,
N – nanophanerophytes.

Information is also given on the duration of the life cycle for each weed species:
J – one-year species,
D – two-year species,
J-D – one-year – two-year species,
V – perennial species.

Floral element for all plant species is as follows:
1 – eurasian,
2 – adventive species,
3 – submiddleeuropean,
4 – submediteranian,
5 – cosmopolitan,
6 – middleeuropean,
7 – circumpolar,
8 – euroasian-continental-submediteranian,
9 – subcircumpolar,
10 – subsouthsibirian.

3. Results and Discussion

Floristic analysis of the weed flora determined 57 species belonging to 23 families (Table 1).

Taxonomic analysis of the weed flora of the eastern lateral channel "Jelas polja" identified the dominance of broadleaf weeds (dicots) as belonging to 52 weed species, which makes 91.22% of the determined 57 weed species. The thin-leaf weeds (5 of them) make 8.77% of the determined species.

Table 1. The list of wild weed flora

No	LATIN NA	CROATIAN N	L.C.	L.F.	F.E.
	I. *Amaranthaceae* ili ščirovi				
1.	*Amaranthus retroflexus* L.	Oštrodlakavi ščir	J	T	2
	II. *Apiaceae* ili štitarke				
2.	*Daucus carota* L.	Divlja mrkva	D	H	1
3.	*Pastinaca satova* L.	Sjetveni pastinak	D	H	1
	III. *Aristolochiaceae* ili vučie stope				
4.	*Aristolochia clematitis* L.	Žuta vučja stopa	V	G	4
	IV. *Asclepiadaceae* ili svilenice				
5.	*Asclepias syriaca* L.	Prava svilenica, ciganско perje	V	G	2
	V. *Asteraceae* ili glavočike				
6.	*Achillea millefolium* L.	Obični stolisnik	V	H	1
7.	*Ambrosia artemisiifolia* L.	Pelinolisni limundžik ili ambrozija	J	T	2
8.	*Bidens tripartita* L.	Trodjelni dvozub	J	T	1
9.	*Centaurea jacea* L.	Livadna zečina	V	H	1
10.	*Cichorium intybus* L.	Divlja vodopija	V	H	1
11.	*Cirsium vulgare* Ten.	Strjeličasti osjak	V	H	1
12.	*Conyza canadensis* L.	Kanadska hudoljetnica	J	T,H	2
13.	*Crepis capillaris* (L.) Wallr.	Nitasti dimak	J	T,H	5
14.	*Erigeron anuus* Pers.	Jednogodišnja krasolika	J-D	T,H	2
15.	*Lactuca serriola* L.	Divlja salata	V	H	3
16.	*Matricaria chamomilla* L.	Prava kamilica	J	T	1
17.	*Picris echioides* L.	Lisičinasti jagušac	J-D	T,H	4
18.	*Taraxacum officinale* Web.	Ljekoviti maslačak	V	H	1
	VI. *Boraginaceae* ili oštrolisti				
19.	*Symphytum officinale* L.	Ljubičasti gavez	V	H	3
	VII. *Brassicaceae* ili krstašice				
20.	*Capsella bursa-pastoris* L.	Pastirska torbica	J	T,H	5
21.	*Cardamine hirsuta* L.	Oštrodlakava režuha	J	T,H	9
22.	*Rorippa sylvestris* Bess.	Šumski grbak	V	H	1
	VIII. *Caryophyllaceae* ili karanfili				
23.	*Stellaria media* Vill.	Srednja mišjakinja	J-D	T,H	5
	IX. *Chenopodiaceae* ili lobode				
24.	*Chenopodium album* L.	Bijela loboda	J	T	5
25.	*Chenopodium polyspermum* L.	Višesjemena loboda	J	T	1
	X. *Convolvulaceae* ili slakovi				
26.	*Convolvulus arvensis* L.	Poljski slak	V	G	5
	XI. *Equisetaceae* ili preslice				
27.	*Equisetum arvense* L.	Poljska preslica	V	G	7
	XII. *Euphorbiaceae* ili mlječike				
28.	*Euphorbia esula* L.	Oštra mlječika	V	H	1
	XIII. *Fabaceae* (*Leguminosae*) ili mahunarke				
29.	*Astragalus cicer* L.	Livadni kozlinac	V	H	8
30.	*Glycyrrhiza glabra*	Gospino bilje	V	H	1
31.	*Lathyrus tuberosus* L.	Gomoljasta graholika	V	G	10
32.	*Lotus corniculatus* L.	Roščićava svinduša	V	H	3
33.	*Trifolium pratense* L.	Crvena djetelina	V	H	1
34.	*Trifolium repens* L.	Bijela djetelina	V	H	1
35.	*Vicia cracca* L.	Ptičja grahorica	V	H	1
	XIV. *Lamiaceae* ili usnače				
36.	*Glechoma hederacea* L.	Puzava dobričica	V	H	1
37.	*Lamium purpureum* L.	Grimizna mrtva kopriva	J-D	T,H	3
38.	*Mentha longifolia* (L.)	Dugolisna metvica	V	G	3
39.	*Prunella vulgaris* L.	Obična celinšćica	V	H	1
	XV. *Plantaginaceae* ili trpuci				
40.	*Plantago lanceolata* L.	Suličasti trputac	V	H	1
41.	*Plantago major* L.	Veliki trputac	V	H	1
	XVI. *Poaceae* ili trave				
42.	*Alopecurus pratensis* L.	Livadni repak	V	H	1
43.	*Cynodon dactylon* Pers.	Prstasti troskot	V	G	5
44.	*Echinochloa crus-galli* (L.) PB.	Obični koštan, kokošje proso	J	T	5
45.	*Lolium multiflorum* Lam.	Višecvjetni ljulj, talijanski ljulj	V	H	4
46.	*Setaria glauca* L.	Crvenkasti muhar	J	T	5
	XVII. *Polygonaceae* ili dvornici				
47.	*Polygonum aviculare* L.	Ptičji dvornik	J	T	5
48.	*Polygonum lapathifolium* L.	Kiseličasti dvornik	J	T	9
49.	*Polygonum mite* Schrank	Mekani dvornik	J	T	6
50.	*Rumex obtusifolius* L.	Tupolisna kiselica	V	H	3
	XVIII. *Portulacaceae* ili tušnjevi				
51.	*Portulaca oleracea* L.	Obični tušanj	J	T	5
	XIX. *Ranunculaceae* ili žabnjaci				
52.	*Ranunculus repens* L.	Puzavi žabnjak	V	H	1
	XX. *Rosaceae* ili ruže				
53.	*Potentilla reptans* L.	Puzajući petoprst	V	H	1
54.	*Rubus ceasius* L.	Modrosiva ili plava kupina	V	N	10
	XXI. *Rubiaceae* ili broćevi				
55.	*Galium mollugo* L.	Livadna broćika	V	H	3
	XXII. *Scrophulariaceae* ili zijevalice				
56.	*Linaria vulgaris* Mill.	Obični lanilist	V	H	3
	XXIII. *Urticaceae* ili koprive				
57.	*Urtica dioica* L.	Dvodomna kopriva	V	H	1

The daisy family (*Asteraceae*) is the largest with 13 determined species which amounts to about 22.8% of the determined weeds, followed by legumes or legume family (*Fabaceaea*) with 7 determined species or 12.28% of the total determined weeds and the grass family (*Poaceae*) with 5 determined types, i.e. 8.77% of the determined species. These three families occupy 43.85% of the total floristic composition of weeds determined in eastern lateral channel "Jelas polja" in the Brod Posavina County.

The weed flora of slope of irrigation and drainage channels in Croatia is poorly studied but the weed flora of wild orchards in the Brod Posavina County is well investigated [12], the results of which are similar to this study.

From the analysis life-cycles of determined weed species the greatest incidence of perennial species is found, 35 of them (accounting for 61.4% of all the determined weeds), then annual species, 16 species of them (which makes 28.07% of the determined species), then one-year – two-year species, 4 of them (which makes 7.01% of determined species), and at the end 2 two-years species (3.5% of the total determined species). The analysis of life forms of determined weed found the dominance of hemicryptophytes (37 species), which makes 64.91% of the total determined species. Weed species belonging to nanophanerophytes life form have the smallest share (1 species), which amounts to 1.75% of the determined species.

Phytogeographical analysis of the weed in the lateral channel "Jelas polja" demonstrated the dominance of plant species of eurasian floral element (with 24 species), which makes 42.1% of the total determined species.

4. Conclusion

The analysis of weed flora of the first order eastern lateral channel in the Brod Posavina County determined 57 weed species from 23 families. The most abundant species were from the *Asteraceae* family (13 species), followed by *Fabaceaea* family (7 species) and *Poaceae* family (5 species). Weed flora of investigated channel has hemicryptophyte character and the phytogeographic analysis shows the dominance of the eurasian group of floral elements. All the results point to the diversity of plant cover, which with its root further ensure the slopes of investigated lateral channel of the abrasive action of the excess water.

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MACHINING OF MATERIALS BY ABRASIVE WATER JET TURNING WITH THE PROPOSAL OF ON-LINE MONITORING USING ACOUSTIC EMISSION

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Abstract

The paper deals with increasing the feed speed influence on the quality of machined surface of work-piece using the technology of abrasive water jet turning, and the proposal of on-line monitoring of the process using acoustic emission. Titanium materials of degree 3 (diameter of work-piece d_w = 46 mm) and Incoloy 925 alloy (diameter of work-piece d_w=53 mm. The experiment was implemented using continuous abrasive water jet (Australian garnet, MESH = 80) with working water pressure p = 400 MPa. Rotation speed was the same for both experiments, and was adjusted to the value n = 34 RPM. Feed speed (v_f = 1.5 – 7.5 mm.min^{-1}) was gradually changed at the constant cut depth a_p = 2 mm. Visualization of the machined surface was implemented using the Olympus LEXT OLS 3100 laser co focal microscope. Roughness parameters (Ra, Rq, Rz) were measured using the MicroPro FRT optical profilometer.

Keywords: abrasive water jet, work-piece, turning, titanium, Incoloy, hydrophone

1. Introduction

High-pressure abrasive water jet is the technology currently used for the cutting and preparation of planar materials. The force of water and abrasive particles allows for the cutting of material where conventional technologies cannot be used, are not economical, or their quality is insufficient. Innovative machinery moves the abrasive water jet technology to highly precise methods of manufacturing parts with complex shapes. The diameter of abrasive water jet can be decreased to 0.2 mm, therefore the consumption of water was reduced to 0.17 l.min^{-1} and the consumption of abrasive was reduced to 0.016 kg.min^{-1}. The roughness of the machined surface achieves the value *Ra* = 0.8 μm [1]. The technology of abrasive water jet turning combines abrasive water jet and work-piece clamped in the rotary chuck into an application that can be used for machining almost all materials. Its suitability can be seen mainly in machining grinding wheels [2], preparation of rock samples for laboratory tests [3], and abrasive water jet turning of ceramics [4] and glass [5].

2. Method

The main rotary movement is carried out like in the case of conventional turning by the work-piece clamped in the rotary chuck, and auxiliary movement (in-feed and feed) carried out by focusing nozzle (Fig. 1). The focusing nozzle represents the end nozzle, from which abrasive water jet flows out. The change of high-pressure water to high-speed jet is implemented in the cutting head before output from the focusing nozzle. Abrasive particles are mixed into the water jet in the mixing chamber. The high kinetic energy of abrasive particles dispersed in the water jet ensures the removal of material upon impact on the work-piece surface.

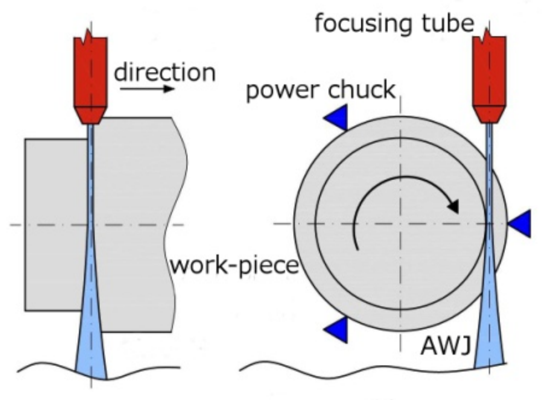

Figure 1. AWJ turning [6]

3. Experiment

Material from titanium and Incoloy alloy was used for the experiment. Values of technological factors are illustrated in Table 1.

Table 1. Adjustment of technological factors

FACTOR	VALUE
water pressure	*p* = 400 MPa
feed speed	v_f = 1.5; 3; 4.5; 6, 7.5
focusing nozzle	d_f = 1.02 mm
cut depth	a_p = 2 mm
lift	*z* = 10 mm
abrasive mass flow	m_a = 04 kg.min^{-1}
revolutions	*n* = 34 min^{-1}
MESH	80
adjustment angle	**φ = 90°**
diameter - titanium	***dw* = 46 mm**
diameter - Incoloy	***dw* = 53 mm**

Turning was carried out on the device intended for conventional cutting of planar materials using the 2D X-Y cutting table PTV WJ2020-2Z-1xPJ. The required pressure of water was generated using the PTV 75-60 pump with two pressure multipliers. Experiments were carried out on the technological assembly at the Institute of Geonics AS CR v.v.i. in Ostrava.

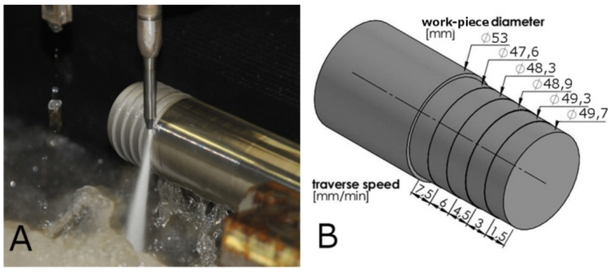

Figure. 2 A - AWJ turning of Incoloy alloy;
B – Change of the work-piece diameter with changing v_f

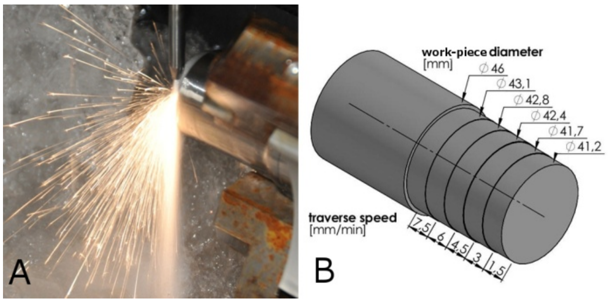

Figure. 3 A - AWJ turning of titanium
B – Change of the work-piece diameter with changing v_f

4. Measurement and Results

Measuring values (*Ra, Rq, Rz*) was carried out using the FRT profilometer, and values of machined surface diameters were measured using the contact digital calliper, always at the beginning of a section with changing feed speed.

Table 2. Values of measured diameters

v_f [mm/min]	work-piece diameter [mm]	
	titanium (T)	Incoloy (I)
1.5	41.2	47.6
3	41.7	48.3
4.5	42.4	48.9
6	42.8	49.3
7.5	43.1	49.7

Table 3. Values of roughness parameters

v_f [mm/min]	*Ra* [µm]		*Rq* [µm]		*Rz* [µm]	
	T	I	T	I	T	I
1.5	6.2	4	7.9	5.1	43.5	29
3	5.1	6.8	6.3	8.4	33.5	41.
4.5	10.	7.8	12.6	10	58.2	47.
6	7.6	9.4	9.2	9	45.7	45.
7.5	7.9	7.6	10.3	11.4	52.1	55

From the point of view of macro geometry, it can be seen that increasing feed speed affected the diameter of work-pieces almost linearly. In the case of the change of feed speed from the value v_f = 1.5 mm/min to the value v_f = 7.5 mm/min, the diameter of both work-pieces has changed by 2 mm. The accuracy of material removal from the point of view of cut depth achieved the deviation of approx. 1 mm both for titanium and Incoloy alloy. Measuring *Ra* values highlights the interesting result of the experiment, because it can be seen that one time titanium and another time Incoloy alloy obtains higher value with change in feed speed. It can also be seen that in the case of the change of feed speed from v_f = 1.5 mm/min to v_f = 3 mm/min, *Ra, Rz, Rq* values are decreased for titanium, which is not the case for the work-piece from Incoloy alloy. Repeated increases and decreases of *Ra, Rz, Rq* values occur in titanium, which is not valid for Incoloy alloy. Visualizations of the machined surface were made using Olympus LEXT OLS 3100 laser confocal microscope (Fig. 4, 5).

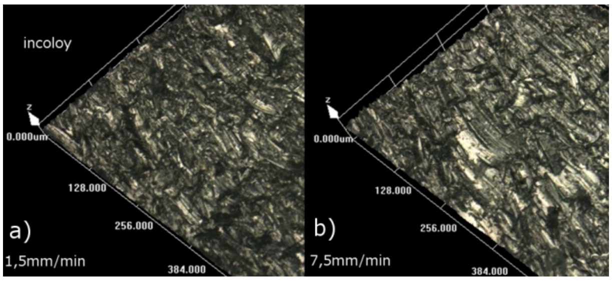

Figure. 4 Topography of work-piece surface from Incoloy alloy at feed speed v_f =1.5 mm/min (a) v_f =7.5 mm/min (b)

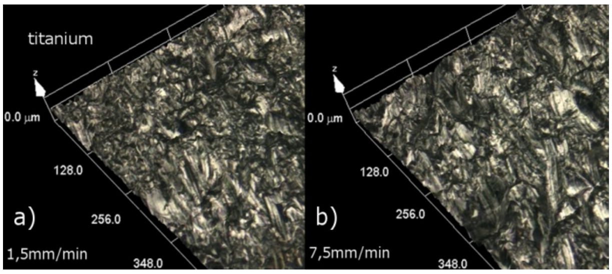

Figure. 5 Topography of work-piece surface from titanium at feed speed v_f = 1.5 mm/min (a) a v_f = 7.5 mm/min (b)

Figures 4 and 5 illustrate machined surfaces, where left traces of abrasive grains in the material can be seen. The change in length of trace and the change of direction and regularity of left traces occurred on the basis of the change in feed speed and different material properties. Substantially shorter trajectories of scratches caused by abrasive grains can be seen at feed speed v_f = 1.5 mm/min. These scratches also have more regular directions. Longer and irregular scratches caused by abrasive grains can be seen at feed speed v_f = 7.5 mm/min.

Sparks were produced during the turning of the titanium work-piece. Properties of fine chips of titanium cause a reaction with ambient air, where ignition occurs. This is caused by the high activity of non-oxidized titanium surface and high exothermic reaction with air [7]. Almost complete machining was achieved at the adjusted cut depth only at the lowest feed speed, so the machining rate for the adjusted cut depth is also relatively small.

5. Assessment and Future Orientation of Research

The experiment highlighted the fact that abrasive water jet turning is a technology that can be used for the machining of very hard materials. The machining of new materials such as titanium, Inconel, Monel and composites causes problems in machining using conventional technologies that are associated with high wear of the cutting edge, and the high heat generated during the action of the tool on material creates a thermally affected zone and degradation of material properties. These materials can be machined using abrasive water jet (AWJ), eliminating impacts on material properties.

6. Conclusion

However, higher values of roughness parameters and lower accuracy of machining have remained disadvantages, because abrasive water jet is disintegrated with increasing distance from the focusing nozzle mouth. On-going research, improvement of machines and development of new materials can lead this technology to being the only suitable alternative, in comparison with conventional machining, of very hard and composite materials. But it is necessary to look for the optimum adjustment of technological factors to make the AWJ process more effective. On-line monitoring of the AWJ turning operation using the hydrophone is a very interesting research field. It is represented by the sensor (microphone) located in the working tub (Fig. 6). Using the hydrophone, we can obtain the time course of acoustic emission during the AWJ turning operation. The hydrophone is connected to a measuring device, which scans the time course of acoustic emission, and with a PC, where the input signal is stored, from which it is possible to monitor and analyse the change in course of acoustic emission in the change of values of technological factors.

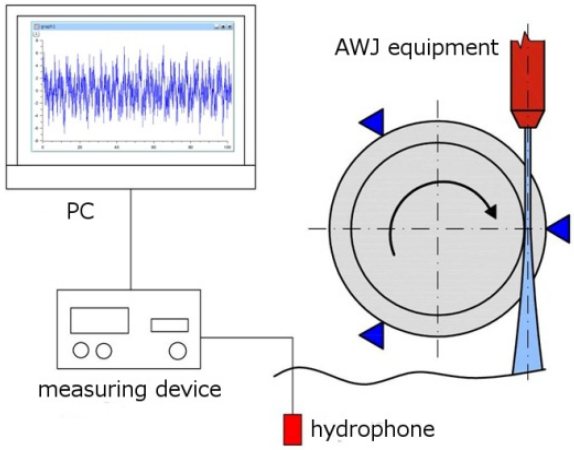

Figure. 6 Proposal of acoustic emission measurement system using the hydrophone

7. Acknowledgement

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Thanks also belong to members of the Institute of Geonics AS CR, v.v.i. in Ostrava, namely to Josef Foldyna, Petr Hlaváček and Jiří Ščučka.

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AISI 304 STAINLESS STEEL DISINTEGRATION USING A WATER JET INTENSIFIED BY MECHANICAL VIBRATIONS WITH FREQUENCY OF 20 kHz

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Abstract

The main aim of this experimental investigation is evaluating the volume of material removed from stainless steel AISI 304 by using an ultrasonic pulsating water jet. For this experimental investigation, a central five-level composite design of experiment was chosen. Factors of interaction were pressure p = 33; 40; 50; 60 and 67 MPa, feed speed rate v = 0.3; 0.5; 0.8; 1.1 and 1.3 mm/s, and round nozzle diameter d = 0.889; 1.067; 1.321; 1.575; 1.753 mm. All samples were weighed and later processed by the Minitab. The results of the investigation show that the combination of higher pressure p [MPa], larger round nozzle diameter d [mm] and lower feed speed rate v [mm/s] incre–ases the volume of stainless steel removal Δ *[g].*

Keywords: Pulsating water jet, disintegration, mass material removal, AISI 304 stainless steel

1. Introduction

At present, the water jet is used for the separation of various types of materials and, as a technology, it has many modifications. The basis is a continuous water jet. However, this type of jet has certain limits in terms of separating certain amounts, particularly concerning the thickness of materials; therefore, other ways to improve the flow have been searched for to increase efficiency and to achieve a more efficient separation. For this reason, the modifications of an abrasive and pulsating water jet have been developed that concern the traditional continual water jet. With the pulsating water jet (hereinafter referred to as PWJ) the jet efficiency is increased by the generation of ultrasonic pulses. The water jet flows from the nozzle first as a continuous jet, only later at a certain length does it form into separate liquid clusters. The material is then disintegrated by the individual pulses of water clusters with high kinetic energy.

The field of Aisi 304 stainless steel separation using a pulsating water jet has not been the subject of almost no scientific studies thus far and therefore the aim of the presented research is to evaluate the influence of technological factors on the effectiveness of material disintegration at the changing values of pressure *p* [MPa], feed speed rate *v* [mm/s], nozzle orifice diameter *d* [mm] and the search for an optimal setting of all technological factors to achieve the maximum level of the PWJ's erosion efficiency.

The experimental investigation described in this article is an initial experiment aimed at the evaluation of the maximum erosion efficiency of the pulsating water jet on metal materials using a round nozzle. The chosen experimental material is AISI 304 stainless steel.

The evaluation of the erosion effects and the mass material removal is particularly important in ensuring the required micro geometry and surface cleanliness and for creating the appropriate conditions for the adhesion of new layers. The potential use of this knowledge is in the automotive and machine industries. The experimental investigation was carried out in cooperation with the Faculty of Manufacturing Technologies with seat in Prešov and the Institute of Geonics AS CR v. v. i., Ostrava - Poruba.

2. Current status

The technology of separation using a pulsating water jet is the subject of only a small amount of research works and is constantly developing. The ultrasonic jet modulation created by the vibrating tip of the ultrasonic tool placed inside the nozzle is the topic of authors works such as *Puchala* [1], *Vijay* [2], *Vijay* & *Foldyna* [3-5]. A detailed description of an ultrasonic vibration transducer, attached to a speed transformer, can be found in the works of most famous authors dealing with the topic of ultrasonic jet modulation and the effects of the PWJ's impact on the material are *Foldyna* [6-14], *Klich* [15, 16] and *Sitek* [17] from the Institute of Geonics AV ČR, v.v.i. in Ostrava, who intensively deal with the possible uses of the technology in various, not only industrial, fields. The authors focus on the experimental investigation mainly of the process and principle of the volume of material removal using a water jet with generated pulses.

The currently known uses of the PWJ in practice include surface reinforcement in the machine industry, the removal of scales, and as a replacement for sandblasting and shot peening of materials (reinforcement of steel surfaces using balls (shots) [14]. In the automotive industry they take into consideration the application of PWJ in the removal of burrs after machining the inner parts of motor valve blocks. In the construction industry the PWJ can be used to remove concrete layers, concrete reconstructions and for the preparation of surfaces by applying coatings. PWJ has a great potential also in the cleaning and removal of surface layers and deposits, e. g. in shipyards, for the cleaning of ship hulls, or in the food processing industry. The pulsing current can also be used for the surface treatment of decorative stones because it is able to roughen the surface of stones and to maintain their aesthetic qualities at the same time [14].

3. Material and working methods

The experimental material was stainless steel with the marking AISI 304. With this type of steel we are talking about a material with a high level resistance to corrosion. Due to the low carbon content it has good machinability and formability. It is used in cases where the material has been deformed by a high heat load and it is also used in the machine and nuclear industries, architecture, transport facilities, in the food processing industry, in pharmaceutical and cosmetic industries, in the construction of chemical tools and vehicles, in the manufacture of surgical instruments, art items and household appliances [18].

The technological set up consisted of the 2D XY table, separation head (Fig. 1), specially designed for this experiment of the proposed preparation (Fig. 1), round nozzles StoneAge with the required equivalent diameter, high pressure hydraulic pumps Hammelmann HDP 253 (max. 160 bar operating pressure, and maximum flow of 67 $l.min^{-1}$), ultrasound device Ecoson WJ-UG_630-40 that is used to generated the impulses and robot ABB IRB 6640-180//2.55 for handling the separation head.

The investigation was aimed at the varying pressure factors *p* [MPa], the nozzle diameter *d* [mm] and the feed speed rate *v* [mm/s]; power *P* [kW] and frequency *f* [kHz] are constant values. Nozzle stand-off distance from material z [mm], have been adjusted according to the value of power and the frequency, taking into consideration the values of power *P* [kW] and frequency *f* [kHz] with regard to the achieved maximum value of the mass material removal (Tab. 1).

The designed five-level central composite experiment was carried out with the change of three factors: pressure *p* [MPa], nozzle diameter *d* [mm] and the feed speed rate *v* [mm/s]. In this type of experiment it is possible, with a smaller number of measurements and samples, to achieve results adequate to a full factorial experiment. Values of variables in the central composite design of experiment are chosen according to the mean value of factor. In this case, the mean value of variables is as follows: *p*=50 MPa, *d*=1.321 mm and *v*=0.8 mm/s. In the five-level central composite design of experiment we added up and subtracted the values in the range of ±1 and ±1.673 times the selected range to the central values. The values are shown in Tab. 1.

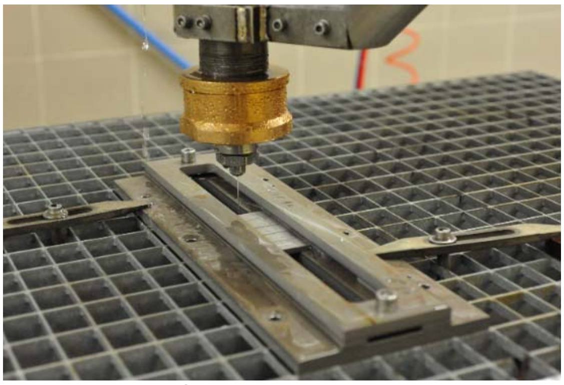

Figure 1. Separation head + substance

The experimental samples were of a rectangular shape and the disintegration took in 85 samples which were pinned into the substance in various sets of 5 pieces (Fig. 1). The samples were disintegrated by the PWJ under the combination of selected factors for the particular series. Altogether, 17 disintegration pass-overs of the pulsating water jet through the material were carried out. Before and after disintegration, all 85 samples were weighed on a digital table weighing machine and the mean value of the removal was counted from the resulting values in the particular series (Fig. 2, samples in the left bottom corner). 17 samples were chosen for the representative presentation of the particular weighing (Fig. 2), each showed sample presents the mean sample of the series.

Table 1. Technological conditions of the experiment

Central composite design of the experiment					
***p* [MPa]**	33	40	50	60	67
***d* [mm]**	0.889	1.067	1.321	1.575	1.753
***v* [mm/s]**	0.3	0.5	0.8	1.1	1.3
***f* [kHz]**			20.14		
***P* [W]**			250		
***z* [mm]**	adjusted according to *f* and *P*				

4. Results

The main objective of the experimental investigation was to evaluate the maximum erosion effectiveness of the PWJ, i.e. the maximum mass material removal, from the samples of stainless steel AISI 304 with the selected variables.

When comparing the weights of the particular samples shown in Fig. 2, it is possible to determine the highest and lowest values of the mass material removal. The highest values (Fig. 2 - red colour) were measured at the pressure of *67; 60* and *50* MPa, the nozzle diameter of 1.575 and 1.321 mm and the feed speed rate of 1.1; 0.8 and 0.5 mm/s. The lowest values of the mass removal (Fig. 2 - blue colour) were in the samples at the pressure of 33 and 40 MPa, the nozzle diameter 1.067 and 1.321mm and the feed speed rate of 0.8 and 1.1 mm/s.

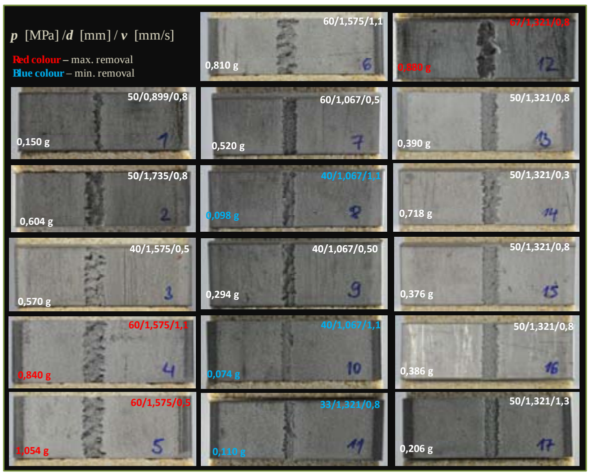

Figure 2. Experimental samples of stainless steel AISI 304

The measured values of the mass material removal show that the mass material removal of stainless steel AISI 304 increases if we work with the combination of the observed factors of increased pressure, a larger nozzle diameter and a lower feed speed rate. The following pictures (Fig. 3, 4, 5) verify this fact; they graphically show the values of the material removal in the interaction of two variable factors and the constant mean value of the third factor. The colour scale shows the changing values of the mass material removal.

The graph in Fig. 3 shows the changing values of the material removal in the interaction of the pressure, the nozzle diameter and the mean value of the feed speed rate of 0.8 mm/s. The graph expressly shows that if we use a particular combination of factors, the highest values of the material removal are achieved at the pressure of 60 MPa and the nozzle diameter of ± 1.575 mm. On the other hand, the variance of the lowest values - shown in Fig. 3 - is in the area where we used the lowest pressure with all types of nozzles.

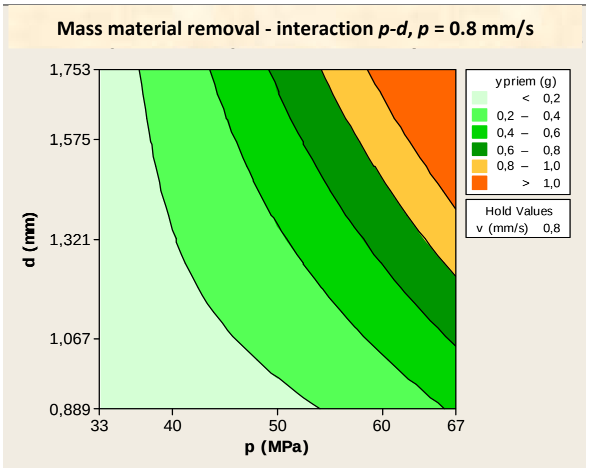

Figure 3. Graph of the mass material removal in the interaction of p-d and constant v

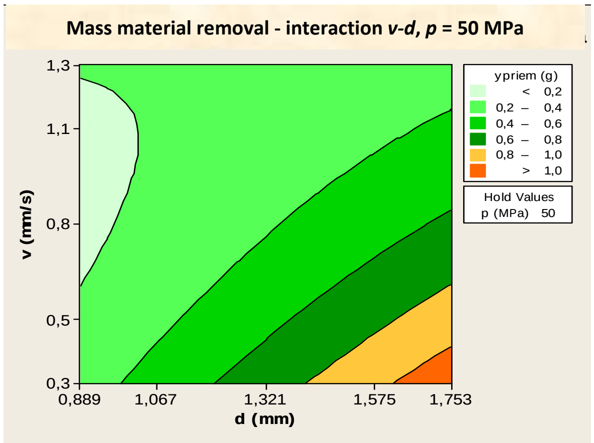

Figure 4. Graph of the mass material removal in the interaction of v-d and constant p

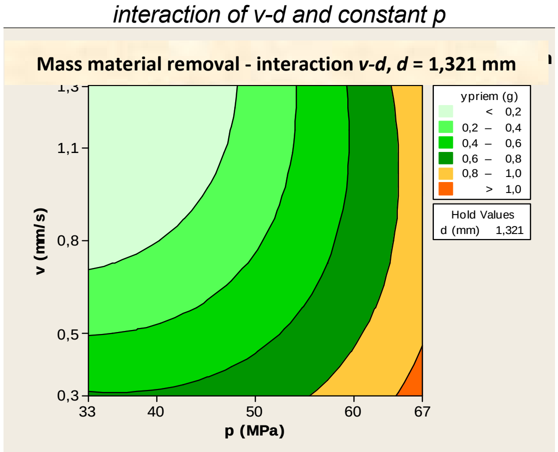

Figure 5. Graph of the mass material removal in the interaction of v-p and constant d

The graph in Fig. 4 shows the values of mass material removal in the interaction of feed speed rate and the nozzle diameter with the constant pressure value of 50 MPa. As in the previous graph (Fig. 3), the highest measured values are achieved with the largest nozzle diameter of 1.753 mm/s. However, for the disintegration of material with a higher weight, it is necessary to choose lower feed speed rates.

The last presentation of the relations among the variables, feed speed rate and pressure with the constant nozzle diameter of 1.321 mm, it is evident that the highest values are achieved at a pressure of approximately 67 MPa and a feed speed rate of 0.3 mm/s, this is confirmed by Fig. 3 and 4 also.

5. Conclusion

The presented findings suggest a clear conclusion that with an increasing pressure value, larger nozzle diameter and lower feed speed rate, the maximum value of the mass material removal in the disintegration of stainless steel AISI 304 using a pulsating water jet increases.

In the continuation of the experimental investigation we will focus on the disintegration of other metal materials, particularly aluminium, copper, brass and bronze. The experimental conditions will be the same as those presented in this part of the study and we will evaluate the maximum erosion efficiency of the PWJ in regard to the technological possibilities of material disintegration. The surfaces of all grooves in the selected representative samples will be analysed and evaluated using the optical profilometer MicroProf FRT. The measured values of the material removal will be used in the last part of the experimental investigation to determine the regression coefficients and we will create a basic mathematical model of the removal process for various metal materials. The usability of the created model will be verified in repeated random experiments.

6. Acknowledgement

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THE CHALLENGES OF RISK MANAGEMENT OF CRITICAL INFRASTRUCTURE

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Abstract

Critical infrastructure, such as the production and supply of electricity and fuels, water supply, transport infrastructure, telecommunications and the public health system, meeting the basic needs of the population, is essential for the smooth running of economic and social activities and is a prerequisite for sustainable development, energy and national security. Today's world is characterized by an increase in natural and human-initiated hazards, risks and threats. This is why it is essential to develop effective protection, mitigation and recovery measures for critical infrastructures. This paper presents areas of study and the methods and challenges the risk management of critical infrastructure involves.

Keywords: Critical infrastructure, complexity, dynamism

1. Introduction

In today's globally interconnected world, the security of critical infrastructure is extremely important. A critical infrastructure represents a complex system of interconnected key resources on local, regional, national or international levels. It means that a single critical infrastructure system needs products and services from other critical infrastructures in order to operate normally. As a result we find complexity across different levels of dependency between critical infrastructure systems.

The critical infrastructures considered in this work follow the European Commission's "Green Paper" on the European Programme for Critical Infrastructure Protection [1]. This document specifies following infrastructures as being critical:

1. Energy;
2. Information and communications technology;
3. Water;
4. Food;
5. Health;
6. Financial;
7. Public and legal order and safety;
8. Civil administration;
9. Transport;
10. Chemical and nuclear industry; and
11. Space and research.

The Council Directive2008/114/EC on the identification and designation of European critical infrastructures [2] emphasizes the vital role that critical infrastructures play in modern society.

It defines a critical infrastructure as "an asset, system or part thereof located in member states which is essential for the maintenance of vital societal functions, health, safety, security, economic or social well-being of people, and the disruption or destruction of which would have a significant impact on a member state as a result of the failure to maintain those functions."

The Directive also defines

- 'Risk analysis' as consideration of relevant threat scenarios, in order to assess the vulnerability and the potential impact of disruption or destruction of critical infrastructure;
- 'Sensitive critical infrastructure protection related information' as facts about a critical infrastructure, which if disclosed could be used to plan and act with a view to causing disruption or destruction of critical infrastructure installations;
- 'Protection' as all activities aimed at ensuring the functionality, continuity and integrity of critical infrastructures in order to deter, mitigate and neutralise a threat, risk or vulnerability

The notion of resilience was introduced in the early decades of the twentieth century in a variety of scientific domains, such as physics, psychology and psychiatry, ecology, business, industrial safety and telecommunications [3]. Resilience is a concept concerned fundamentally with how a system, community or individual can deal with disturbance, surprise and change, is framing current thinking about sustainable futures in an environment of growing risk and uncertainty, [4].

2. Risk management of critical infrastructure

Since various sectors have particular experience, expertise and requirements concerning critical infrastructure protection, a Community approach to critical infrastructure protection should be developed and implemented taking into account sector specificities and existing sector-based measures including those already existing at Community, national or regional levels, and where relevant cross-border mutual aid agreements between owners /operators of critical infrastructures are already in place. In practice, policies and rules are focused on the identification and protection of key resources and the implementation of apropriate risk management systems, but it takes considerable efforts to make improvements to critical infrastructure security and resilience (CISR) across all sectors.

A major problem is posed by the fact that detailed information about critical infrastructure dependencies is highly sensitive and is usually not publicly available. [5]

The common frameworks established by protection plans can be summarized in terms of a risk management plan that involves five steps:

1. establishment of safety goals;
2. identification of risks and resources;
3. assessment of risks;
4. prioritization and implementation of actions;
5. monitoring of effectiveness
6. improvement according to new circumstances

The figure below presents the continuous nature of risk management of critical infrastructure.

Figure 1. Risk management cycle

When aiming at evaluating interconnected risk systems, all subsystems must be considered.

When processing the data for each subsystem, a particular risk, i, with n risk components is evaluated using the equation:

$$(Risk)_i = \frac{1}{n}\sum_{i=1}^{n}(Likelihood\ x\ Severity)_i$$

The average evaluation of each risk component is made after using past experience, technical data, expert knowledge and judgment.

The European Commission has taken the initiative to organize a network consisting of research and technology organizations within the EU with capabilities in critical infrastructure protection [6].

Following extensive consultations with the various stakeholders, the priorities were shifted slightly and the following eleven objectives were identified:

1. Build the European Reference Network for Critical Infrastructure Protection (ERNCIP) on existing facilities and capabilities.
2. Develop an environment of trust and sharing.
3. Understand the state-of-the art of experimental critical infrastructure protection.
4. Agree on European good and best practices for critical infrastructure protection.
5. Advance certification efforts.
6. Ensure that the EU is self-sufficient with regard to issues of priority.
7. Improve the body of knowledge in the domain of critical infrastructure protection.
8. Consider the evolution and change of critical infrastructures.
9. Use the EU's inherent diversity to enhance resilience and competition.
10. Promote international standards.
11. Collaborate with countries outside the EU.

The fast development of ICT at the end of XX century has resulted in a significant increase in the reliance on computers to conduct daily business.

While ICT technologies have improved the speed and efficiency in most sectors of our lives, they have increased the reliance on and the interdependence of the energy and ICT infrastructures that support these systems.

In determining the security model of critical infrastructure it is necessary to define the vital elements and therefore priorities of the system.

The aim of determining the main indicators of safety is to identify the potential for an accident before it happens. Past efforts in managing safety were focused on identifying the main general indicators, such as lag and / or omissions in maintenance, which can be encountered frequently in industrial systems. Other leading indicators of safety are system-specific, with the beginning of the hazard analysis and thus are limited to finding the cause, according to the traditional techniques of hazard analysis. Most rely on quantitative metrics, often based on probabilistic risk assessment, [7].

The table 1 presents a general approach to managing risk with critical infrastructure including principles and restrictions for each given category.

3. Case: Floods in Serbia

There was an example in Serbia of endangered critical infrastructure during the floods of May 2014, when the energy system was threatened because coal mines were flooded. Excavated coal is used for combustion in power plants. For the continuous operation of power plants that are supplied with coal from this deposit, the annual need is about 6 million tons of coal, and an additional 500,000 t/y of bulk lime of coal for household consumption.

Floods in May 2014 affected not only settlements, but also areas in which there are coal mines and the Nikola Tesla thermal power plant, the largest thermal power plant in Serbia, which provides nearly 50% of electricity in Serbia. But the plant remained operational thanks to qualified intervention by professionals. The town of Obrenovac was most affected by the floods, and it was estimated that 90% of the settlements submerged. The whole town with about 8700 inhabitants was evacuated.

Damage caused by floods in the the Kolubara Mining Basin is estimated at over 100 million euros.

The Kostolac thermal power plant, which provides 11% of electricity in Serbia, was threatened by the river Mlava. Two ring of sand bags were punctured, but the water did not break the last line of defense [8] .

Material damage from the flood is estimated at over 1.07 bn euros, of which more than two-thirds related to critical infrastructure, particularly in the energy sector (thermal power plant Nikola Tesla, coal mines Kolubara, Kostolac power plant, etc.), including 150 million provided by the World Bank for the purchase of electricity. Further efforts of the state in the direction of solving these problems should lead to a rapid adoption of appropriate laws that will be oriented on prevention, primarily on establishing a system for risk management.

Figure 2 presents a contingency model of safety management of critical infrastructure.

4. Conclusion

Our world today is characterized by rapid changes and uncertainty, so we are challenged to approach safety in various ways in all areas and apply new concepts and models with the aim to be able to manage safety. Theoreticians of the safety of critical infrastructure are continually seeking new paradigms for problems revealing contradictory and changing requirements; solutions are often difficult to conceptualize due to the complex interdependence of problems.

High-risk systems are designed to be highly reliable and managed in a way that avoids disaster in the environments in which accidents provoked by risk factors and complexity can be expected.

In doing so, research facilities are expanded to areas that have so far not been the subject of scientific research, with the aim of building capacities for resistant engineering and adequate risk management.

Table 1. The approach to the management of security of critical infrastructure

Category		The principles and restrictions	
1	Definition of goals	1.1.	Unknown value of benefits of the safety management (value of not events) and economic constraints
		1.2.	Multidimensional goals
2	Parts of the system	2.1.	Categorization of parts of system - the basic unit of analysis
		2.2.	The nature and level of risk
		2.3.	Defining factors of influence
		2.4.	Determination of interdependence: the relationship with other subsystems, their nature and structure
3	Directions for modeling	3.1.	Determination of security priorities
		3.2.	„Multi-level“ approach
		3.3.	Defining rules and procedures
		3.4.	Previous knowledge
		3.5.	Human factor / deviations from the rules and procedures
		3.5.	The dynamic characteristics of the system
4	Techniques	4.1.	Techniques for measuring
		4.2.	Modeling techniques
		4.3.	The system of maintenance of equipment

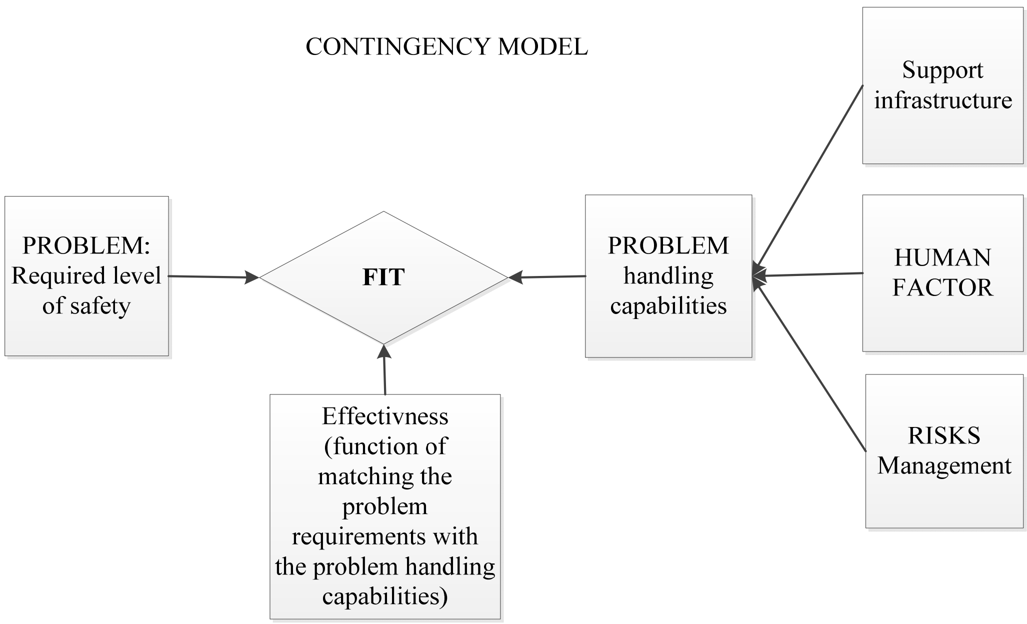

Figure 2. Contingency model of safety management of critical infrastructure

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DOES THE AGRICULTURAL PRODUCERS RECOGNIZE THE IMPORTANCE OF BRANDING THE LOCAL PRODUCTS?

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Abstract

In the last few years the importance of branding domestic agricultural products in the Republic of Croatia is increasing, the reason being that, by using the recognizable Labels and trademarks we protect domestic agricultural production and we are giving it recognition on the market. These projects are linked in a single chain with three key links that must function perfectly if we want to succeed, the three key links are producers – processors – consumers. All of them must be informed and educated. Several institutions in the Republic of Croatia are working on the implementation of branding domestic agricultural products and one of them is the Croatian Agricultural Agency. First marketing projects of Croatian Agricultural Agency were Milk from Croatian farms and Meat from Croatian farms, based on these projects we wanted to conduct an analysis to see just how much are the agricultural producers informed about these kind of projects and to hear their opinions. The survey was conducted in May 2015 and it included 100 farms in Republic of Croatia. The paper also contains the guidelines that must be met if we want our agricultural products to become more competitive on the market, so they can offer a secure market placement to their producers as well as add value which in return will secure their existence on the market.

Keywords: branding, agriculture product, consumer

1. Introduction

There are more and more demanding consumers on a saturated market, the decision to purchase a particular product each individual makes by following their own inner motives, but also being driven by the influence of numerous external factors.

Nowadays, the need for promotion and protection of domestic agricultural products is increasing because the market is overflowed with products that are extremely diverse in terms of declarations and origin, and consumer demands are growing too.

Today, an individual pays great attention to reading nutrition labels when buying agricultural food products, and shows a great interest in the ingredients contained in the product as well as it's origin. Lifestyle plays a big role in all of that with the increased orientation to healthy living and consumption of healthy and safe food. In the moments of decision making to purchase a product a visual appearance is of great importance, especially if it the product is marked with distinguishing Label that guarantees that it is healthy, domestically produced and of homemade quality.

Marketing in agriculture and food production in the Republic of Croatia is not sufficiently present. Marketing business methods are applied only in some companies involved in the food production, while a large number of firms, especially agricultural farms are not even familiar of marketing business principles.

When we look at the food production, we realize that marketing alone has a greater importance than one might assume. Marketing performs several important functions, it is connecting producers with consumers, it helps food producers to have better understanding of consumer's needs but also it helps all producers to decide how, when and which product will be produced and offered on the market.

Product as a basic factor in marketing is very important as well as making a range of decisions before its release on the market. Great care must be taken in quality of products offered on the market, packaging, labelling and quantity of products offered on the market.

The protection of the agricultural and food products is of great importance for manufacturers, processors, but also for the consumers. Production chain producers–processors–consumers is essential to ensure that the products can be protected but also that labeling projects are going to be successfull. The organization on implementation of protecting agricultural food products is taken on by an institution responsible for quality control of these kind of products.

Today a number of institutions in the Republic of Croatia is implementing projects to protect agricultural food products such as the Ministry of Agriculture (protected designations of origin (PDO), protected geographical indications(PGI) and traditional specialties guaranteed (TSG)), Croatian Chamber of Economy (Croatian quality, originally from Croatia) but also Croatian Agricultural Agency.

Croatian Agricultural Agency as a government institution has a long tradition in agriculture. There is a number of activities in which Croatian Agricultural Agency participates in Croatian agricultural sector with a significant emphasis on the development of the livestock sector, and among other things, carrying out the tasks related to the marketing and promotion of agricultural production, with the main aim of its protection.

Labeling system of agricultural food products is based on a quality control by Laboratory for milk quality control, Department for Carcasses Classification Control, the Department of honey quality and data base from the Central Register of Livestock.

The main goal of marketing projects is to promote domestic agricultural production as well as informing consumers about the origin of products, with the aim of protecting and strengthening the agricultural production in Republic of Croatia.

As mentioned above producers, processors and consumers are the main participants of these projects which carry certain advantages for them. The producers gain the ability to increase their production, processors receive distinctive range of products while consumers have a dual role. On the one hand by buying labeled products consumers get a high quality, distinctive and cost-competitive products while on the other hand, by buying such products, they have an effect on the increased consumption of the same which ultimately contributes to the development of agricultural production.

Voluntary labeling of agricultural food products through distinctive labels and trademarks has been used for a number of years in countries of European Union. In the Republic of Croatia, the implementation of these projects started ten years ago.

The research results are not at a high level. The biggest problem in the implementation of these kind of projects appears to be lack of information among all the participants. For this reason, our aim was to investigate the real situation of one of the most important participants, the producers in relation to the projects - Milk from Croatian farms and Meat from Croatian farms - implemented by Croatian Agricultural Agency.

The main aim of the research was to determine the problem that has been present by producers in the implementation of projects with the additional hypothesis that is focused on research about the protected labels - Milk from Croatian farms and Meat from Croatian farms. It was necessary to examine their way of thinking, their motivation and does the voluntary labeling of their products with protected labels - Milk from Croatian farms and Meat from Croatian farms - helps their production.

2. Method

The study used a method of primary data collection through a questionnaire as an instrument of research. The questionnaire contained 12 questions of closed type.

Research was conducted in May 2015 year. The study included 100 agricultural producers from all over the Republic of Croatia. The success of the research is 100% because all the farmers fill up the questionnaire.The results will be processed through a statistical data analysis, and the results will be presented graphically.

3. Results and Discussion

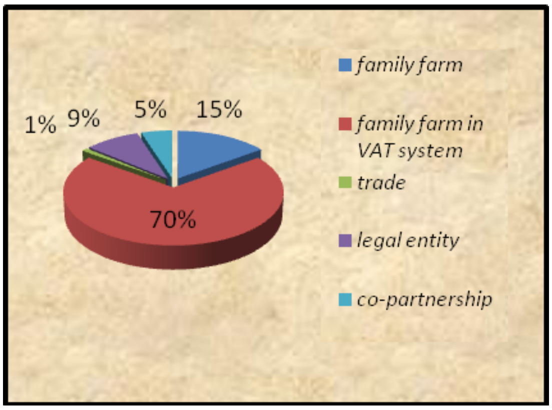
Since the Republic of Croatia joined the EU, the branding activities of domestic agricultural products started to be intensified, because it developed the possibility that the protection of products increased the food competitiveness on the market.

A major problem in this successful path, is lack of information from participants: producers, processors and consumers. Those same problems has also the Croatian Agricultural Agency, although according to some conducted research, labels Milk and Meat from Croatian farms have recorded a slight increase in the eyes of consumers.

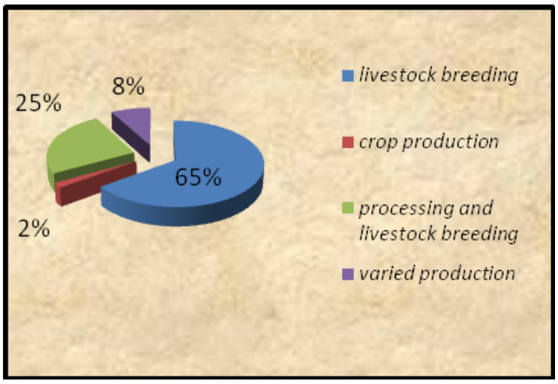
Because of these reasons mention above, we decided to make a brief research of agricultural producers and see their side of the story. We wanted to explore their way of thinking and their motivation.

Questionnaire consisted of twelve questions, and we received the following answers:

1.What is the structure of your agricultural belong?

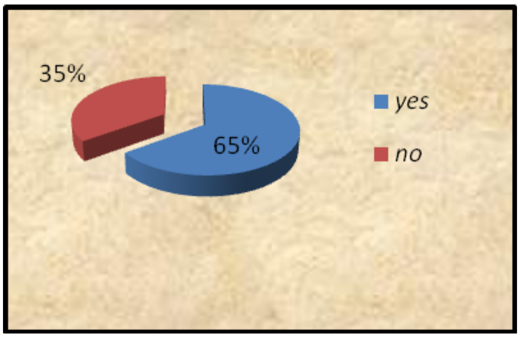


2. What is your branch of agriculture?

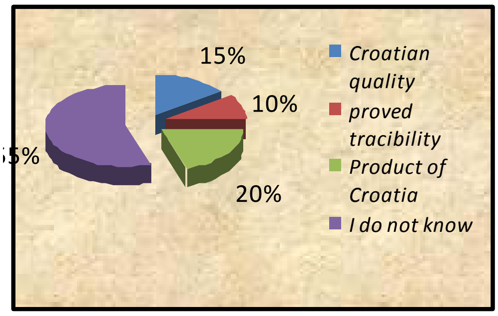


The results show that 70% of respondents are family farms which are in the VAT (value added tax) system, while the smaller percentage of respondents are legal entities, co-partnerships and trades. We can also conclude that the majority of respondents are in livestock production which is very positive considering that the labels (milk and meat) which are the subject of these research are related to livestock production.

3. Have you ever heard of a Labels Milk and Meat from croatian farms?

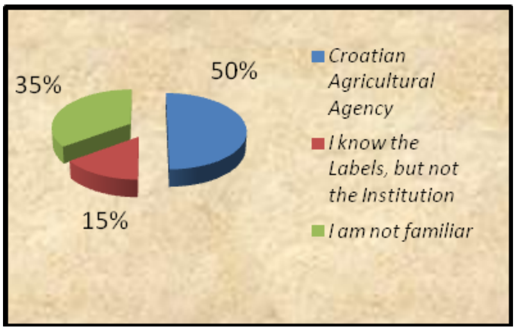


4. What does the Label mean?

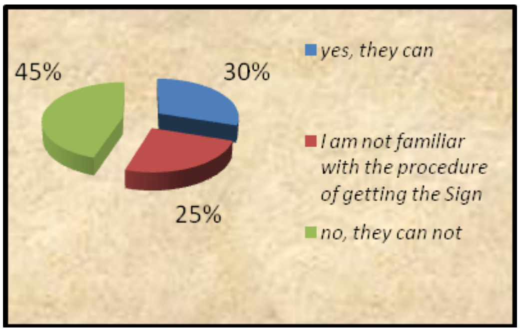


65% of producers heard about protected labels Milk and Meat from Croatian farms, while 35% did not. Unfortunately, only 10% knows the meaning of these signs and even 55% of respondents claimed that the signs means croatian quality, and not the real meaning - proven tracibility.

5. Which institution is responsible for the registration of these signs?



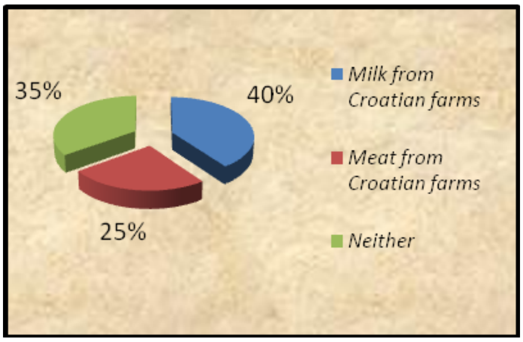
6. Do you think that your products can carry some of the mentioned labels?



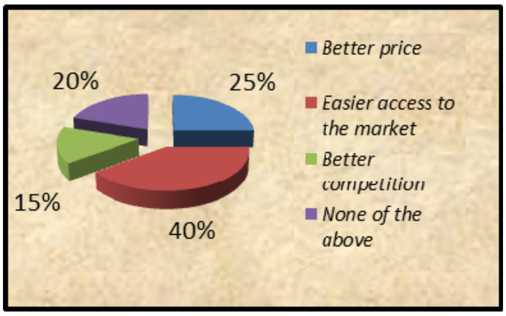
The question of which institution is responsible for their implementation of the protected signs, 50% of respondents answered accurately, while 35% of them do not know the institutions, but have heard of the signs.

15% of respondents never heard of signs and do not know who is responsible for their implementation. Also, 45% of respondents believe that they can't get any of these label, but 30% considered that they can get and use the labels. 25% of respondents are not familiar with the procedure of getting a protected label.

7. Which label could carry your products?



8. What would mean for you to label your products with protected labels?

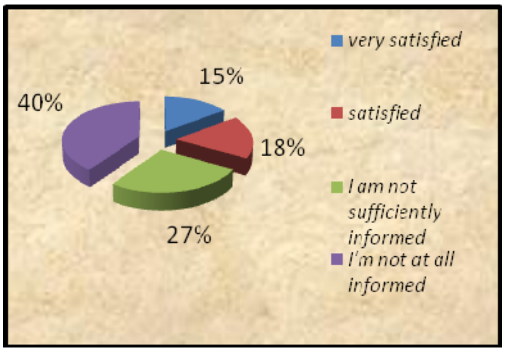


The percentage of respondents who think that their products can carry some of the labels prefer the label Milk from Croatian farms compared to meat from Croatian farms. To the question 8, 40% believe it would be easier to access to the market whit labeled products, 25% think they would get a better price, 15% think they would achieve a higher level of competitiveness for their products and 20% of respondents have no opinion.

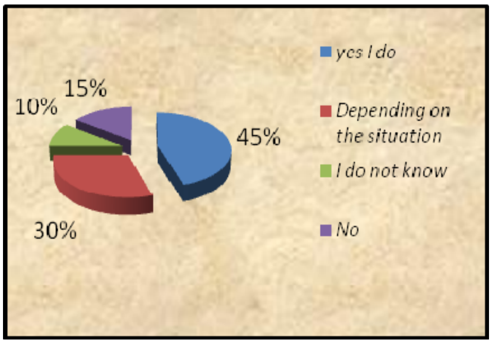
To the question 9, 40% are not at all informed about the labels, 27% are not well informed, 18% are satisfied with the level of information, and only 15% are very satisfied. Regardless of insufficient information 45% of them would prefer to see their product labeled with Milk or Meat from Croatian farms. 45% of interviewed said that they are familiar with other marketing labels and signs of food products as buy Croatian. Also, 40% of respondents stated that they do not know a single label, and 10% of respondents know the labels – protected designations of origin (PDO) and protected geographical indications (PGI). Unfortunately, 55%

are not familiar which institutions are responsible for the registration of the labels they seen.

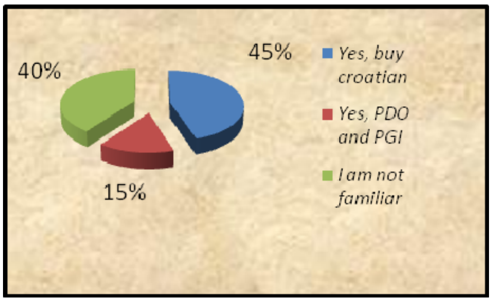
9. What is your satisfaction level of information about labels Milk and Meat from Croatian farms?



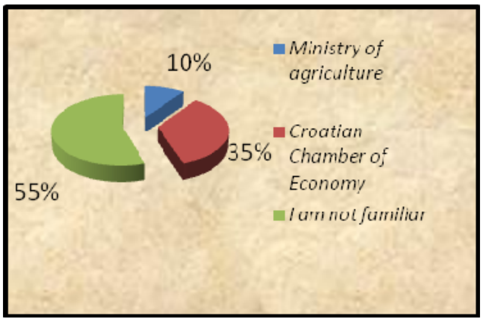
10.Do you plan to start the process of getting protected labels?



11. Are you familiar with other Trademarks? Which ones?



12. Which institution is responsible for the labels you mentioned?



4. Conclusion

The results of a questionnaire indicate that the situation is constantly repeating, it means that when we speak to agricultural producers and we get the feedback, the conclusion is always the same – the agricultural producers are not sufficiently informed or educated about this kind of labeling of domestic food products.

The first reason for this kind of situation that we can point out is the poor communication between the Union of the agricultural producers and the Associations in the agricultural sector that operate in Republic of Croatia. The Associations and Unions representatives are familiar with the branding of agricultural products but the information about it is not carried down to other small producers who are crucial in the whole story.

Another reason is the difficult situation in Croatian agriculture, particularly in the dairy sector, and the milk producers who submit their product to the purchasers, because of poor motivation do not take into consideration the importance of such projects.

One of the reason is also the appearance of many labels and trademarks on food products on the domestic market since the Republic of Croatia joined the EU.

What we need to do to make the situation initiated and producers to be familiar with the labels that help their production and their product seems safe on the market, is to make high-quality marketing strategies and thus provide information to consumers of the agricultural food products. It is also necessary to inform the agricultural producers through a variety of education in the form of lectures, providing informations through flyers on livestock events, etc.

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ANIMATION DESIGN IN THE PROCESS OF DEVELOPING A NEW MECHATRONIC PRODUCT

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Abstract

This paper presents the procedure of animation design in the innovation project "Pill Reminder" developed at the Technical College in Bjelovar. The Motion Manager module allows for creating an animation assembly by means of elements that define motion input for each part of the assembly. This allows for a complete presentation of the assembly and functionality check accompanied by a very detailed presentation of practical usability. This paper presents the development of a new mechatronic device within the Student Entrepreneurial-Technological Incubator Bjelovar and the individual approach towards developing competences of Mechatronics students at the Technical College in Bjelovar.

Keywords: SolidWorks, Motion Manager, pill reminder, animation design

1. Introduction

SolidWorks Motion Manager is used for studying the relation between movement, velocity and acceleration acting on components in movement. The module allows for observing forces and moments acting on all relations between components and simplifies the design study of complex constructions. It is very useful for detail analysis of all types of springs, axles, shafts, girders and many other engineering components [1].

2. Animation design of 3D model in SolidWorks

After designing 3D model, it is possible to present it using the animation module Motion Manager. Animation is very useful while presenting a product which is in the process of being developed. In the development phase of a completely new product, it is possible to recognize potential flaws in the construction, i.e. assure quality producibility. While presenting new ideas animation may be of assistance. It is well-known that all users may not possess engineering knowledge that would provide them with easier conception of the idea, its functionality and the very design of the product. Engineering animation design and simulations are frequently used at the Technical College in Bjelovar. This paper presents the design of an innovative product called the "Pill Reminder". It is a very complex mechatronic product, where it is necessary to pay attention to design, functionality, position of electronic components, appropriate positioning of boxes and the seating etc. All interrelated functional and technical details may be connected by applying CAD/CAM software solutions.

The process of animation design starts by positioning the model in the anticipated initial state [2, 3].

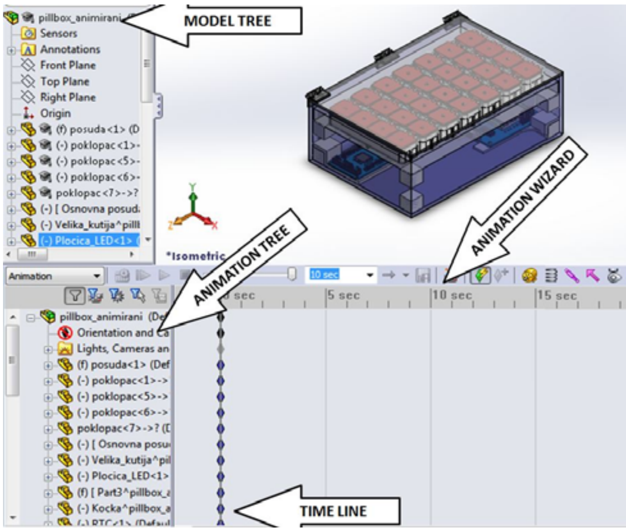

Figure 1. SolidWorks interface

After defining the initial position, the model rotates around the vertical axis for a few seconds.

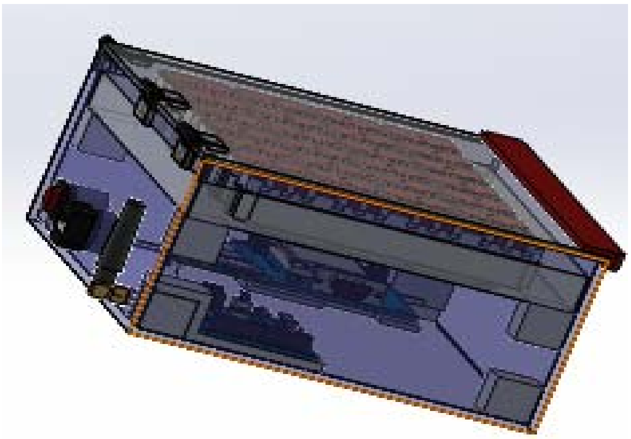

Figure 2. Device rotation for the purpose of presentation

Simulation is initiated by using the option Animation Wizard, followed by selecting rotation and setting parameters. Timeline defines a part of animation.

Due to model complexity often it is necessary to make the exploded view showing the subparts or individual elements of the assembly in order to present it better. A complete device model includes:

1. external box (260x170x100 mm)
2. GSM module

3. ATMega microcomputer
4. LED board
5. plexiglass carrier for dispensers
6. set of dispensers with caps an LED opening

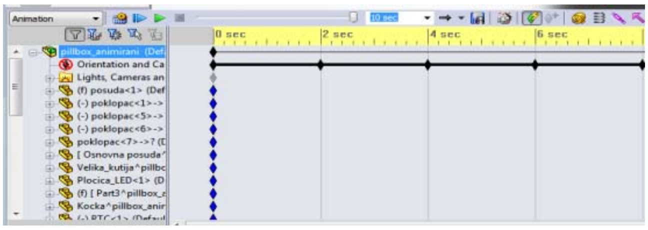

Figure 3. Timed animation flow with key moments

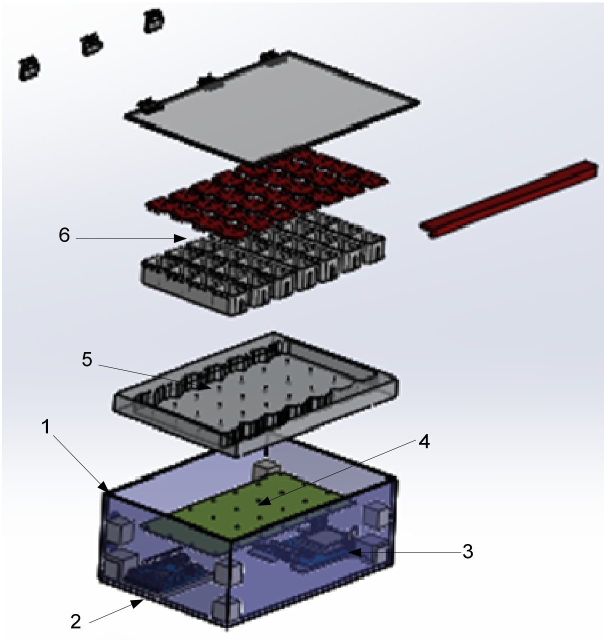

Figure 4. Exploded view

This view is made by selecting the Explode option in the Animation Wizard.

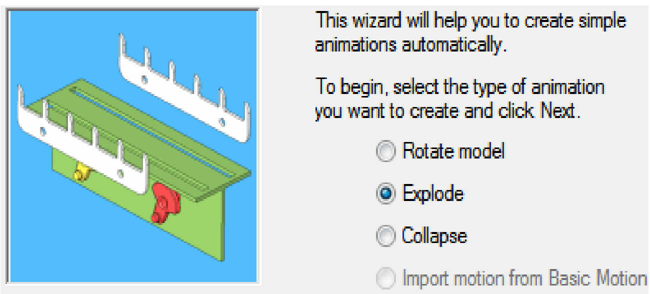

Figure 5. Animation Wizard

Upon setting the parameters the position of the exploded assembly is defined by selecting the Exploded View option in the upper menu under Assembly. A simple left click allows for dragging the movable part of the assembly in the motion direction until exploded assembly is obtained. The shift is defined in millimeters. For selecting more elements, i.e. a sub-assembly, the Ctrl key is used combined with the left mouse click.

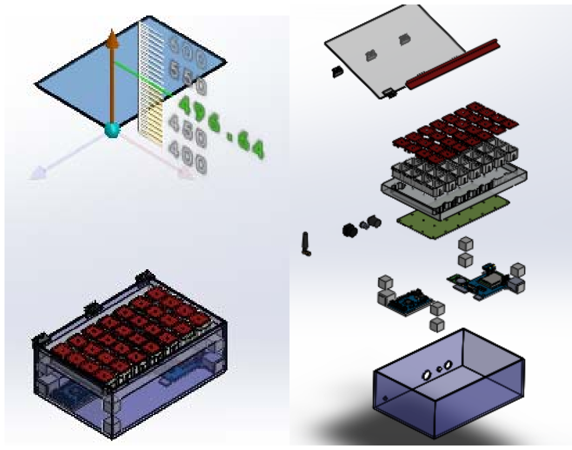

Figure 6. Creating an exploded view

For demonstrating the composition the Collapse option is to be selected in the Animation Wizard.

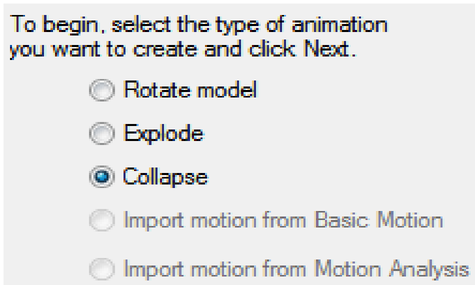

Figure 7. Selection options in Animation Wizard

In the case of the innovative model "Pill Reminder", the alternating state of LEDs that are included in the functional assembly is presented.

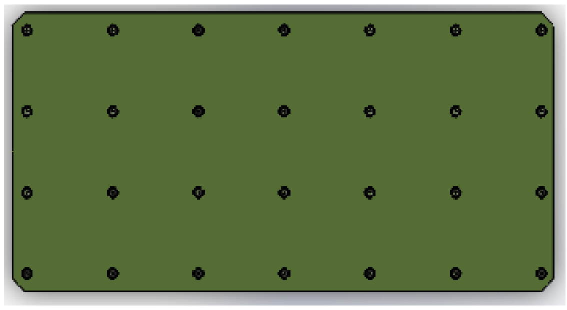

Figure 8. Printed circuit board with LEDs

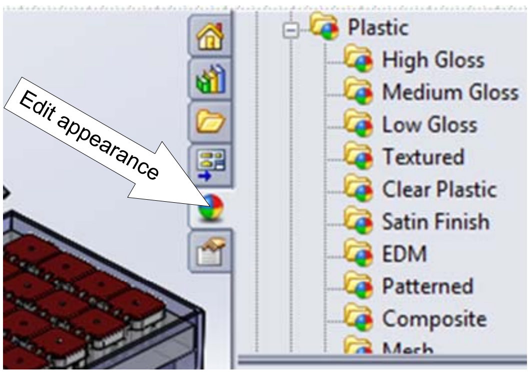

Figure 9. Color selection

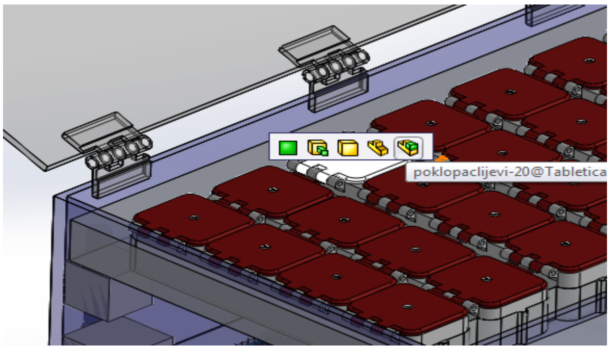

Figure 10. Surface selection

A similar principle applies to disappearance of elements, i.e. assembly from the animation or its appearance. This is done by setting the key moment that represents the beginning of disappearance of a component from animation. Time line is set to a defined moment, and in the menu that opens by a right mouse click the option Hide Components is selected.

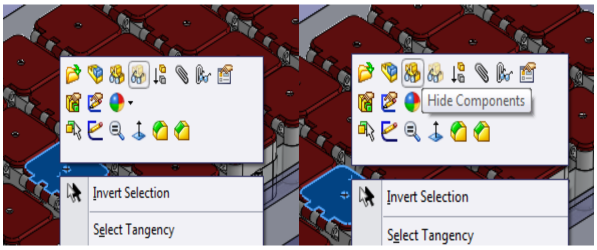

Figure 11. Selection of action

The start or end moment of event is changed by dragging the key moment in the selected direction.

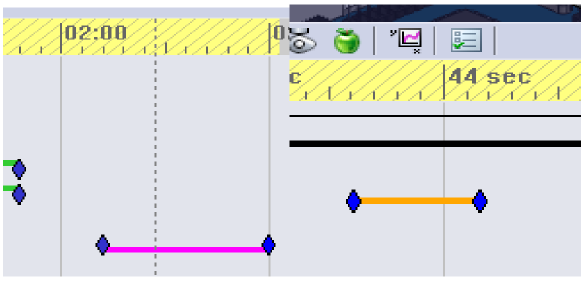

Figure 12. Event on the time line

Element rotation is performed by cancelling, i.e. if needed by adding one or more limitations (*Mate*). At the initial moment of rotation Key is added, which is positioned on the limitation line and is suppressed.

Figure 13. Flowchart of individual limitations

Upon setting the limitation into the required state, time line is set into the next moment where the rotation stops. In this key moment the element is set in the position in which it will remain until the event finishes. Between the start and end of the event a required number of points is added and subsequently they are set to a required distance in order to adjust the rate [4].

For adjusting the animation in a format suitable for other computers and programs for video viewing, the Save Animation option is used [5].

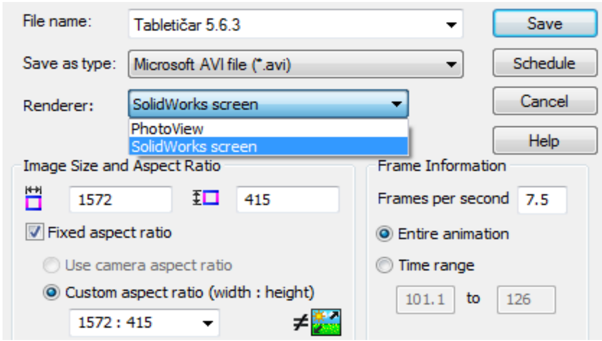

Figure 14. Menu for preparing the video format

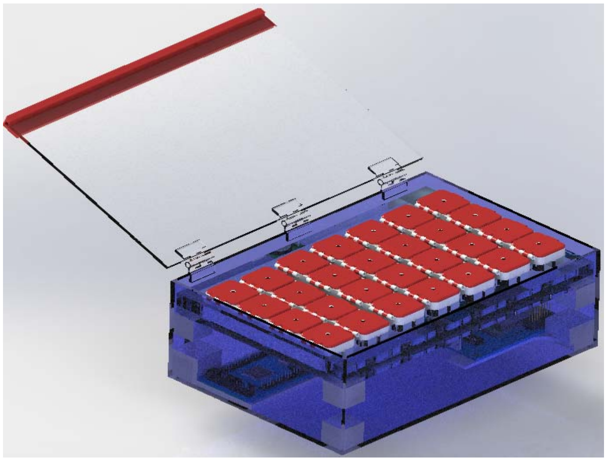

Figure 15. Animation in the PhotoView converter

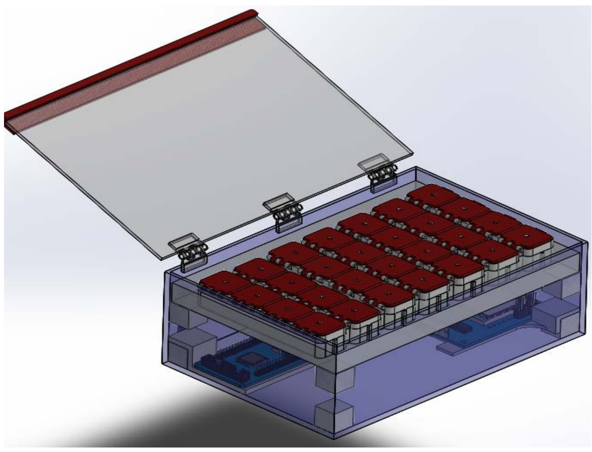

Figure 16. Animation in the SolidWorks Screen converter

3. Results

The innovative device was completely designed and almost completely constructed at the Technical College in Bjelovar, which adds a special significance to it. The plexiglass carrier was manufactured by 2.5D milling [6], while the dispensers, caps and printed circuit board carriers were manufactured using a 3D printer [7].

Figure 17. Dispensers with caps

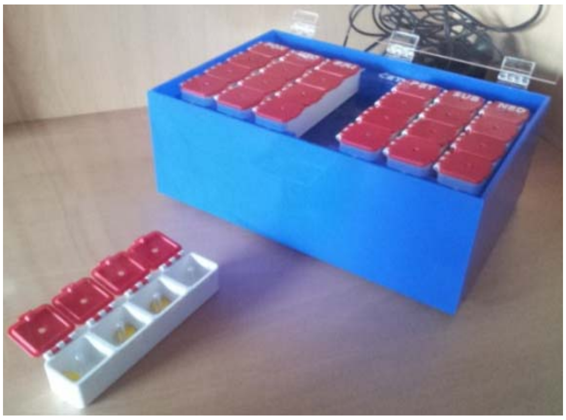

Figure 18. Device prototype

4. Conclusion

SolidWorks Motion Manager significantly simplifies the presentation process of an assembly, i.e. device, so it is possible to highlight the possibilities and qualities of almost any device in a very simple way.

While designing complex constructions it is important to check if each assembly unit or individual element may perform its function in the anticipated way. In this way time required for manufacturing complex constructions is reduced and the possibility of errors is minimized. The video showing the animation and the process of making a new mechatronic device may be found in [8]. The manufacturing of the device and the activities connected with it are used for individual development and training of students through various workshops [9, 10], cooperation of teachers of the study program in Mechatronics and the Student Entrepreneurial-Technological Incubator Bjelovar.

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THE ELECTROCHEMICAL IMPEDANCE SPECTROSCOPY STUDY OF ULTRAFINE-GRAINED TITANIUM IN ARTIFICIAL SALIVA

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Abstract

The enhancement of mechanical properties of commercially pure titanium (cpTi) can be achieved by grain refinement obtained by severe plastic deformation, but corrosion resistance of ultrafine-grained (UFG) cpTi is still under discussion. Therefore, the aim of this study was to estimate electrochemical behavior of UFG cpTi obtained by high pressure torsion under a pressure of 7.8GPa with a rotational speed of 0.2 rpm up to 5 rotations at room temperature. Electrochemical measurements were performed in artificial saliva with pH value of 4.0 at 37°C in order to simulate oral environment, because UFG cpTi is primarily developing for dental implant applications. UFG cpTi was investigated by electrochemical impedance spectroscopy (EIS). The obtained results indicate that HPT process significantly reduces the grain size and UFG cpTi shows better corrosion resistance compared to its coarse-grained (CG) counterpart.

Keywords: titanium, corrosion resistance, electro–chemical behavior, artificial saliva

1. Introduction

Commercially pure titanium (cpTi) is the most commonly used metallic biomaterial. Several applications of titanium can be found in biomedicine, for instance, in devices for artificial hearts, structural applications such as screws and dental implant pins, and prostheses [1]. CpTi and Ti-alloys have demonstrated high mechanical strength, low elastic modulus, excellent biocompatibility and corrosion resistance [1]. To determine the suitability of a material for body implant applications, several properties must be evaluated. Among these properties, the corrosion behavior is of crucial interest, because the metallic ion release from the implant to the surrounding tissues may give rise to biocompatibility problems. The corrosion resistance is of great importance, not only because it determines the device's useful life, but also due to the harmfulness of corrosion processes taking place in the living organism. It has been established that the corrosion products may affect cell metabolism [2]. CpTi shows very good corrosion resistance in many media due to the formation of passive TiO_2 thin film on its surface upon exposure to air. It should be noted that corrosion rate of cpTi is significant in concentrated acid solutions at room temperature because the protective oxide film tends to dissolve in aggressive media [3].

Therefore, it can be concluded that formation and protective rate of the passive film layer is dependent on the environment conditions.

Although cpTi is considered to be the best biocompatible metallic material for dental application because its surface properties result in the spontaneous formation of a stable passive oxide layer, it does not have high enough strenght for more applications. Therefore, in order to improve mechanical properties of cpTi, different thermomechanical treatments had been examined. Further enhancement of mechanical properties of metallic materials may be achieved by severe plastic deformation (SPD) procedures, leading to the formation of finer microstructures. Large number of different SPD methods, such as equal channel angular pressing (ECAP), high pressure torsion (HPT) and others similar processes, have been extensively studied in recent years [4]. High pressure torsion (HPT) is SPD method where deformation is obtained mainly by simple shear. This method applies very large strains in a material due to the applied hydrostatic pressure during deformation. An equivalent strain (ε) imposed on the sample can be estimated using the formula [4]:

$$\varepsilon = \frac{2\pi N r}{\sqrt{3}t} \tag{1}$$

As can be seen, the equivalent strain depends on the number of rotations (N), the radius (r) and the thickness (t) of the sample obtained by HPT process. Ultrafine-grained (UFG) metals and alloys produced by severe plastic deformation (SPD) techniques have better mechanical and physical properties compared to their coarse-grained (CG) counterparts. There are numerous studies about mechanical and physical properties of UFG cpTi produced by severe plastic deformation (SPD) techniques [5,6], but only a few about corrosion resistance of this material [7-14]. Furthermore, most of papers investigated ultrafine-grained cpTi produced by equal-channel angular pressing (ECAP) [15]. Therefore, the purpose of this study was to evaluate corrosion resistance of UFG cpTi obtained by high pressure torsion. Schematic overview of performed experiments is presented in Fig. 1.

2. Method

The cpTi grade 2 (Goodfellow, Germany) in the shape of a rod with 16 mm in diameter was used in this study. The cpTi samples were cut into disc-shaped samples with 8.0 mm in diameter and 1.0 mm in thickness.

The one group of cpTi samples was subjected to HPT process under a pressure of 7.8 GPa with a rotational speed of 0.2 rpm up to 5 rotations at room temperature. The obtained samples of UFG cpTi was disc-shaped with 8.0 mm in diameter and 0.7 mm in thickness. In order to analyse micro–structure of cpTi before and after HPT process, scanning electron microscope (SEM) MIRA3 TESCAN was used. The SEM operated at an accelerating voltage of 20 keV.

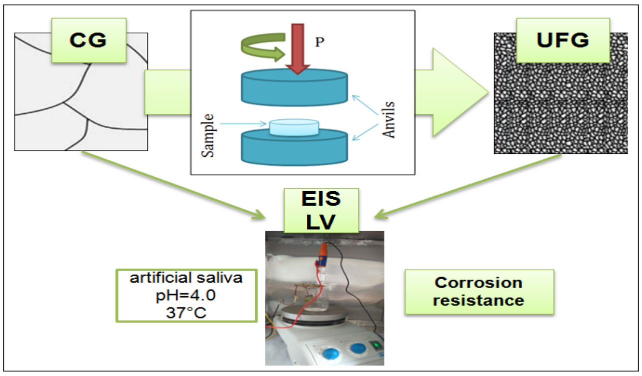

Figure 1. Schematic overview of performed experiments

Electrochemical measurements were performed in a artificial saliva solution (Pharmacy Belgrade, Serbia) with pH value of 4.0, using a Gamry Reference 600 potentiostat with in a Faraday cage, at 37°C ± 1°C. The composition of artificial saliva solution is shown in Table 1. The apparatus used in this study is shown in Figure 2.

Table 1. Chemical composition of artificial saliva

Component	Contetnt, %
NaCl	0.0844
KCl	0.1200
$MgCl_2$ x $6H_2O$	0.0052
$CaCl_2$ x $2H_2O$	0.0146
Sorbitol	0.3000
KH_2PO_4	0.0342
Carboxymethylcellulose sodium	0.1000
Water	99.3416

Figure 2. Faraday cage with system of electrodes

Fresh solution was used for each experiment. The assembly was embedded into an epoxy resin in order to form working electrode.

After that, the samples were ground with SiC abrasive paper (up to 2000 grit). Ultimately, the samples were cleaned in methanol in ultrasonic bath followed by rinsing with deionized water. After immersion into artificial saliva solution, the cpTi and UFG cpTi disc specimens were held for 30 min to achieve a steady open-circuit potential (OCP). Electrochemical impedance spectroscopy (EIS) was performed at OCP over a frequency range from 100 kHz to 0.01 Hz using a sinusoidal AC voltage amplitude of ±10 mV. Subsequently, potentiodynamic polarization was carried out in the range of -0.25 to 0.25 V with respect to the OCP at a scan rate of 0.15 mV s^{-1}. In order to maintain a high statistical accuracy, all electrochemical measurements were repeated at least three times.

3. Results

Ti has two allotropic forms: *α* - the atoms are arranged in a hexagonal close-packed (hcp) array (up to 882.5 °C) and *β* - the atoms are arranged in a body-centered cubic (bcc) array (above 882.5 °C) [16]. Thus, the *β*-to-*α* transformation temperature of pure Ti either increases or decreases based on the nature of the alloying elements [16]. Accordingly, the *β* phase is found only at high temperatures unless Ti is alloyed with other elements which maintain the *β* phase at lower temperatures. The characteristic microstructures of the examined materials are shown in Figure 3. Figure 3a shows equiaxed *α* grains in the cpTi microstructure. As can be seen from the SEM micrographs, HPT progressively leads to the transformation of the initial structure into a new ultrafine structure upon continued straining.

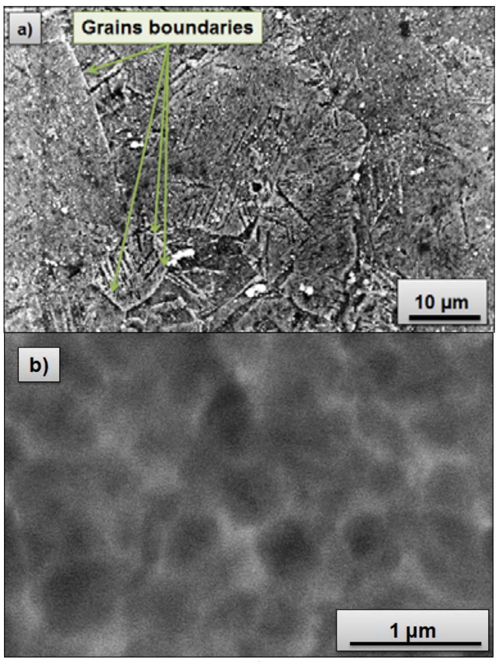

Figure 3. Microstructure of the examined materials: a) cpTi, b) UFG cpTi

Sergueeva et al. [17] revealed that the microstructure of UFG cpTi is sufficiently homogeneous after HPT deformation under 5 GPa pressure up to 5 rotations at room temperature, but there is evidence of significant lattice distortions associated with large internal stresses.The presence of large internal stresses in UFG structure of cpTi was also confirmed by in [18]. They showed that a large fraction of the grain boundaries have high angles of misorientation, but they are ill-defined and lack the banded contrast that is a characteristic feature of the well-formed grain boundaries observed in annealed metals. Additionally, the grain boundaries in HPT-processed materials are typically wavy, curved or corrugated, indicating their non-equilibrium character [18].

The Bode plots for the examined materials in artificial saliva with pH value of 4.0 were shown in Fig. 4, while the Nyquist plot was shown in Fig. 5.

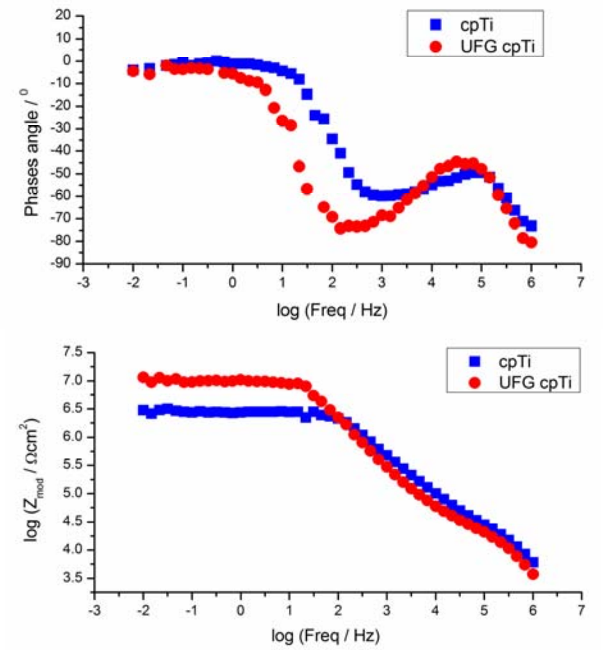

Figure 4. The Bode plots of cpTi and UFG cpTi

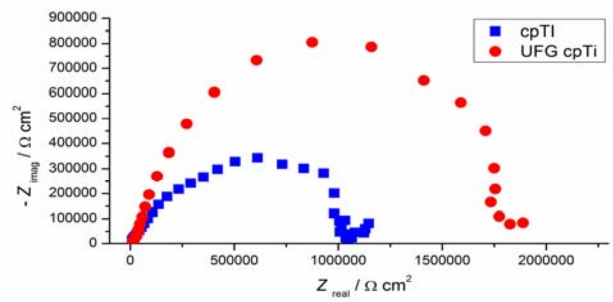

Figure 5. The Nyquist plot of cpTi and UFG cpTi

As can be seen in Figure 5, Z_{imag} and Z_{real} values for UFG curves are higher than that of CG sample. Therefore, it can be concluded that cpTi had less corrosion resistance than UFG cpTi. Furthermore, the total impedance value for the UFG sample is higher than that of the CG sample according to Bode plots, Figure 4.

The equivalent circuit related to the data extracted from EIS test is presented in Figure 6 [19]. R_{Ω}, R_b and R_p represent the resistance of the electrolyte, inner barrier layer and porous outer layer, respectively. On the other hand, C_b and C_p represent the capacitance of the inner barrier layer and porous outer layer, respectively. A good agreement between the measured and simulated data was achieved when a constant phase element (CPE) with the exponent *n* was utilized for data fitting instead of an ideal capacitor. The value of mentioned parameters for both CG and UFG cpTi is presented in Table 2.

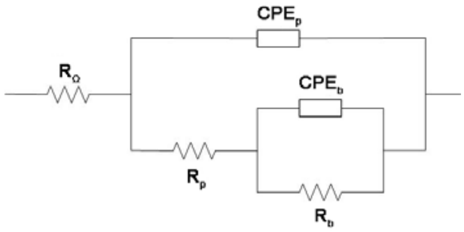

Figure 6. The equivalent circuit of the examined materials in electrochemical tests

Table 2. The electrochemical parameters - EIS data

Material		cp Ti	UFG cpTi
R_b [Ωcm^2]		2.89 x10^4	3.89x10^2
CPE_b	Y_o [$S^n\Omega^1cm^2$]	2.49x10^{-9}	1.28x10^{-5}
	n	0.803	0.877
R_p [Ωcm2]		1.47x10^6	1.05x10^5
CPE_p	Y_o [$S^n\Omega^1cm^2$]	7.96x10^{-10}	1.72x10^{-10}
	n	0.822	0.907

The values of the ‘Goodness of Fit’ were 2.64x10^{-3} for cpTi and 3.19x10^{-3} for UFG cpTi.

4. Discussion

Corrosion resistance of the implant material depends on the material composition and sample dimensions, as well as on the type, composition, temperature, pH value and volume of testing solution. For instance, Qu et al. [20] analyzed the corrosion behavior of cpTi in artificial saliva with and without lactic acid by OCP, polarization curves and EIS. The corrosion of cpTi in artificial saliva was resulted in a slight decrease in the pH value of the solution. The corrosion of cpTi was distinctly affected by lactic acid and the corrosion rate increased with increasing the amount of lactic acid. Lactic acid is suitable to form a chelate compound ($[Ti(OH)_3]\cdot L$), which dissolves in water. The formation of $[Ti(OH)_3]\cdot L$ accelerates the dissolution of passivation film (TiO_2) on cpTi, and this causes the deficiency of the protective film, leading to a tendency of pitting corrosion. Similarly, Balyanov at al. [21] also investigated the corrosion behavior of cpTi with both UFG and CG microstructures. In that study, they found that UFG cpTi produced by ECAP had better corrosion resistance than CG cpTi in both HCl and H_2SO_4 solutions.

In addition, compared with CG cpTi, UFG cpTi has lower corrosion current densities, more positive corrosion potential, lower critical currents, i_c, at the passive potential, and more positive passive potential, E_p. Higher concentration of HCl or H_2SO_4 led to higher corrosion rates for both UFG and CG cpTi. The corrosion resistance of UFG cpTi is believed improved by rapid formation of passive films at surface crystalline defects including grain boundaries and dislocations. Likewise, Balakrishnan at al. [22] analyzed the corrosion behaviour UFG cpTi produced by equal channel angular process (ECAP) in simulated body fluid (SBF). Tafel extrapolation studies showed the corrosion resistance of the UFG cpTi to be 10 times higher compared to coarse-grained (CG) cpTi. On the similar way, Kim et al. [1] showed that UFG cpTi obtained by (HRDSR) high-ratio differential speed rolling had better corrosion properties than CG counterpart in H_2SO_4 solution.

In all those papers, as in our work, the obtained results indicate that UFG cpTi shows better corrosion resistance compared to its coarse-grained (CG) counterpart. The difference between corrosion behavior of CG and UFG cpTi may be related to the volume fraction of grain boundaries [13].

5. Conclusion

The obtained results indicate that HPT process significantly reduced the grain size. Furthermore, UFG cpTi produced by HPT has better corrosion resistance compared to CG cpTi. The difference between corrosion behavior of CG and UFG cpTi may be related to the volume fraction of grain boundaries. Further examinations will include electrochemical testing of CG and UFG cpTi in different testing conditions (different pH values of artificial saliva, presence of lactic acid and fluoride, etc.) in order to prediction of behavior of these materials in oral environment.

6. Acknowledgement

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CORPORATE SOCIAL RESPONSIBILITY AS A CHALLENGE OF MODERN SOCIETY

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Abstract

For decades, the modern world has been faced with the request for a global, shared responsibility for the development that would be in line with the needs of people and nature. Every day, the business community is challenged to be more responsive and more sustainable, because we should not sacrifice the future of the company nor the society for today's profit. It is necessary to constantly work on the integration of economic, social, and environmental aspects. Corporate social responsibility is not an extra element of business activities, but it is its essential and inseparable component. No business, regardless of its size and outcome, is isolated from the community in which it operates. In this paper we outline the concept of social responsibility as a model to whom tend successful modern companies , as well as the presence of the CSR concept in companies in Serbia.

Keywords: Corporate social responsibility, human resources, benefits from CSR

1. Introduction

All society actors – the state, companies, local communities, citizens, non-governmental organizations, have some responsibility towards society. In particular, companies have a significant influence, and they are often neglecting the aspects of corporate social responsibility, taking account of the economic aspect of business. A long-term positioning of the company on the market and continuous business improvement are only possible if the core values of the philosophy of social responsibility are incorporated into the company's business policies.

2. Concept of social responsibility

Corporate Social Responsibility is linked with giving back something to the society. It is a process whereby the management of a company practices several moral and ethical initiatives, using codes of conduct to manage the impact of their activities on customers, shareholders, employees and the environment, [1].

Hopkins defines corporate social responsibility as the attention with which, in the ethical and socially responsible way, we treat stakeholders that are outside, but also within the organization. The wider aim of social responsibility is to create higher and higher standards of living, while preserving the profitability of the corporation or the integrity of the institution, for people both within and outside these entities, [2].

In order the concept of corporate social responsibility has been adequately implemented, it is necessary to know its structure. According to Carroll, B., [3], who designed the pyramid of corporate social responsibility, there is a schedule: at the top is the philanthropic responsibility below is ethical responsibility, then legal responsibility and at the end the economic responsibility as it is shown in the picture below.

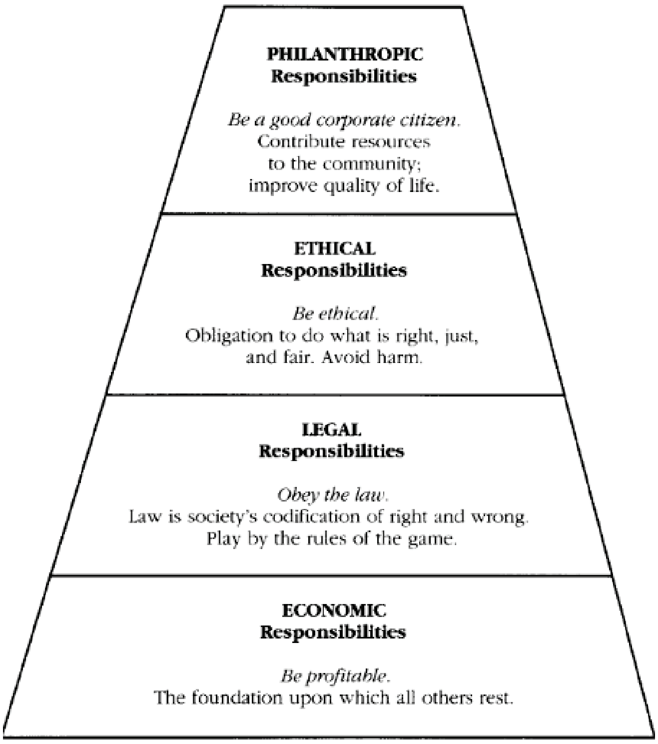

Figure 1. The pyramid of CSR, [3]

Job satisfaction is very important for employees and research suggests that a firm that practices CSR activities induces better job satisfaction in employees, [4].

According to the European Commission, companies should work together with public authorities to find new ways for CSR development, so that this concept is widely accepted, [5].

It brings benefits to individual companies as well as corporate groups. In this day and age, when we are faced with numerous challenges, this concept is becoming an increasingly important means with which modern societies, for which Serbian society strives, are trying to respond to them and achieve a transformation towards a richer and more equal society, in which the natural environment and cultural achievements are rationally spent and kept, and in which each member of the community feels good. The balance between achieving economic interests, social development, and environmental protection, while preserving natural resources, is today considered the primary objective, for which the entire community strives, and CSR is one of the main strategies to establish a harmonized relationship between business community and wider community.

CSR is the awareness of the new position and importance that companies have in modern, global society, and the responsibility that stems from them. The CSR practice refers to the entire sphere of influence and range of a company's activity, as well as the relationships that the company establishes thereby: what it produces, the manner in which it buys and sells, whether it complies with the law, the manner in which it employs, trains, and affects the development of human resources, how much it invests in the local community, and respect for human and labor rights, the manner in which it contributes to environmental protection.

In the literature today, we can find a number of benefits of CRS for the company, community and environment, as it is shown in the picture below.

The European Commission states that corporate social responsibility can have a positive impact on the achievement of strategic goals to make the EU the most competitive and dynamic knowledge-based economy in the world. Corporate social responsibility is defined as a set of activities of the company directed at meeting the legal obligations defined by law and treaties, as well as activities with which the company meets the obligations that do not stem from the formal legal framework, such as investment in human capital development, environmental protection and relationship improvement with all stakeholders, [5]. This report divides CSR activities into two dimensions: internal and external.

The internal dimension includes, [5].

- Investment in human resources
- Adapting to changes through restructuring and keeping in mind interests of all groups
- A rational use of resources and energy.

The external dimension of corporate social responsibility involves the following elements:

- Local community development
- Enhancing relations with business partners, customers and suppliers
- Respect for human rights of all social groups with whom the company interacts
- Environmental protection.

There is an evidence that CSR reporting is associated with better future firm performance, [6]. Reporting and communication on the impact of companies on society also support:

- building trust through openness and transparency of business activities
- encouraging the implementation of changes in the company
- providing the requested information for all participants
- seriousness of its own intentions in relation to CSR issues of the company
- strengthening the company's reputation
- fostering changes within the business sector and the society as a whole
- becoming an attractive employer
- motivating workers to perform CSR activities (through bonuses for workers who have participated or supported a corporate social responsibility program).

In today's world, there are many legally mandated reporting requirements referring to CSR. However, the logical consequence is that companies that report on corporate social responsibility in the sphere of society and the environment are better accepted by the public. Numerous international companies consciously carry out the practice of connecting their annual reports with the reports on corporate social responsibility, thus clearly showing that there is indeed a systemic approach of the company to the issues of its own influence on society and the environment. However, those parts that refer to corporate social responsibility have to be linked to the main logic and purpose of the business. It is important not to exaggerate in statements and not to give oneself too much credit, because such behavior may create the impression that all the activities have been done solely for promotional purposes.

According to International Institute for Sustainable Development, [6], we made the scheme of benefits from using the concept of CSR, Fig. 2.

For example, commercial sponsorship should not be presented as investments in the community. Also, the law provides for the employment of persons with disabilities, and if the company complies with such requirements, it should not be presented as corporate social responsibility, but via the employee analysis instead. Companies should not pose as if they had solved all their business problems, and it is far better for the company to work hard to constantly improve its business, even when taking small steps.

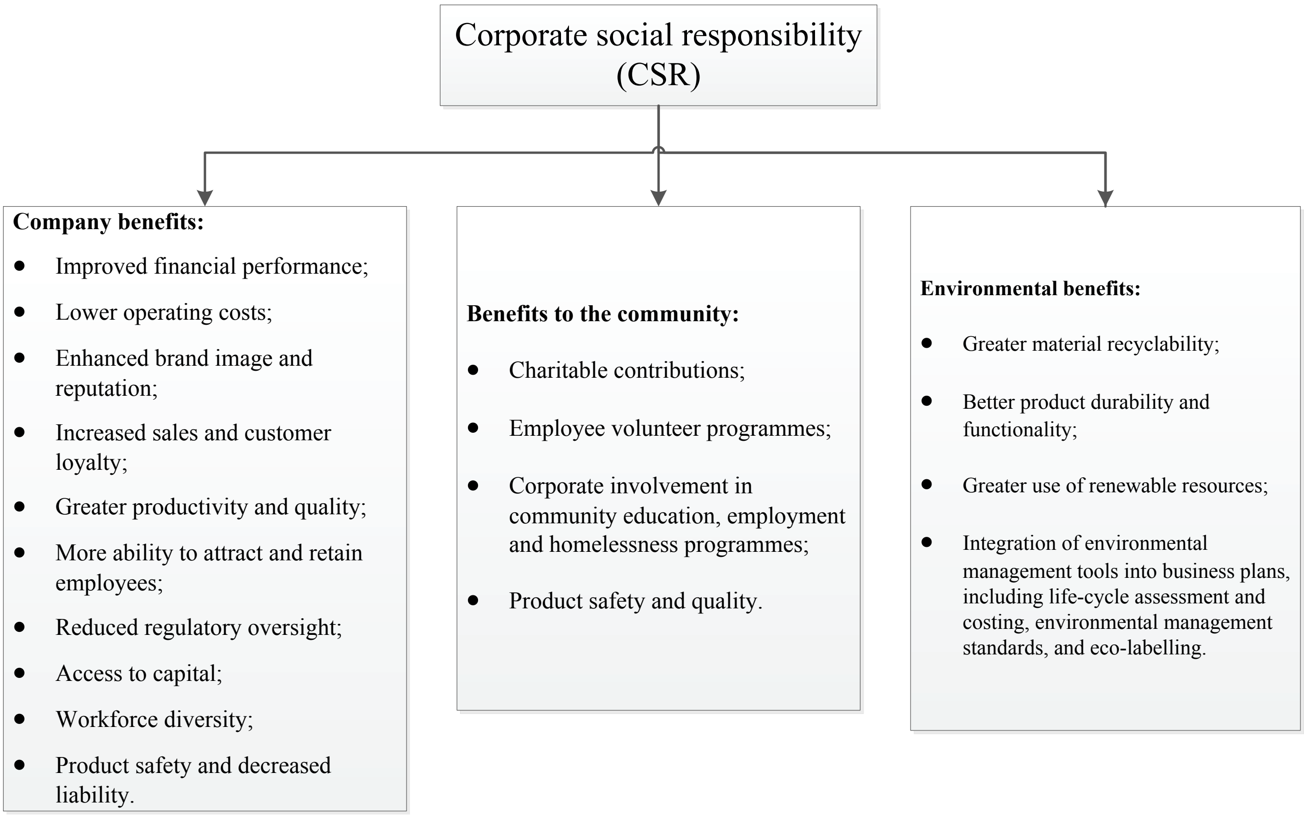

Figure 2. The scheme of CSR

3. CRS an Human Resource Management

In most EU countries, it is much taken care of the interests of employees (especially of workers' compensation insurance and working conditions), whereby this segment of CSR is largely covered by the laws and numerous formal principles that apply nationally. Therefore, the state is forcing companies to behave morally towards employees, because any violation of the regulations mentioned is sanctioned by harsh penalties. In every society, employers significantly contribute to both the economy and society, on both local, and regional and global levels. The company pays taxes and contributions, thus stimulating the economic development of the community in which it operates.

4. Corporate Social Responsibility in Serbia

Companies in Serbia have gone through a difficult period in recent years, i.e. have been faced with the economic consequences of war, sanctions, as well as the global economic crisis, and that the companies that have managed to survive are facing economic challenges of the accession to the EU in the near future, so CSR should not be seen as a means of achieving competitive advantages over increasingly dynamic market competition as Serbia approaches the full membership in the EU. Although investing in CSR activities is not a priority to most companies in Serbia, their management still has to be aware of the its positive influence and think long term. With the arrival of large enterprises in Serbia, through CSR activities, Serbia has to develop awareness of its own brands, and all this in order to survive in the competition, which is more ruthless day after day. Just CSR encourages companies to be innovative, encouraging sustainable development, responsible for risk management and reduce costs and at the same time achieve better business results for their clients and the company as well as for the community in which they perform business activities and its employees, [7].

Companies should consult with professionals in this field. Large enterprises in developed countries have a person in the management of the company or even a special department, which is responsible specifically for CSR activities. Every action within the policy of responsibility of the company has to be beneficial to stakeholders. Accordingly, communication is planned, and it should be directed in such a way that consumers are properly informed on what the company does in favor of the community in which it operates. The amounts of money allocated for CSR activities in Serbia are still considered as confidential. Many are afraid that competition donates more. However, reporting is necessary for the local community to recognize companies that actively participate in CSR activities, but continuously.

Human resources will, in the context of contemporary economic trends and places that Serbia wants to take in them, in the future, have an even greater importance in comparison to the importance attributed to them today. In order to provide motivated and professional staff, employers will have to constantly identify and monitor trends.

In order to leave an impression of a reliable partner, world-class companies pay much attention to public relations and solving social problems. Therefore, Serbian companies have to recognize all forms of corporate social responsibility and to develop in this direction. A big problem in Serbia, as well as in other countries in the region, is mutual misunderstanding between the media and companies. While companies believe that the media do not report enough, or at all, about good CSR practices that they have implemented, the media see these activities as a move or a means of cheap advertising. However, nothing is black and white. In developed countries, media companies have special managers only for CSR, so the media in Serbia should take a more energetic stand. Round tables, seminars, luncheons, and the like with journalists and business representatives are imposed as a solution. The media should not block the transmission of information that have importance for the common good, because, by objective reporting on humanitarian activities, they encourage other companies to help the necessary organizations in the field of CSR. Also, the media should be a source of information for CSR activities, because employees in companies learn about community problems from newspaper articles or television reports. Companies very often seek advice from PR agencies. All this has its advantages and disadvantages. The people from the PR world do not necessarily know much about CSR, and they have a PR view of the world, and most often propose projects that look good in the picture and that are well-known. In Serbia, there is a small number of journalists who have been trained to monitor CSR. Newsrooms are understaffed and there is little room for CSR in the media, so it is necessary for the editorial board to pay more attention to and recognize socially responsible actions. It should be borne in mind that the media has a dual role – socially responsible companies and a responsible attitude towards reporting on CSR actions and campaigns of other actors.

The aging of the workforce in the European labor market, but also in Serbia, will significantly affect both the business sector and the society. A reduced number of people entering the labor market will have a major impact on lifelong learning, and will lead all interested parties to pay significantly more attention to this issue than it has been done so far. Not only this issue, but also the issues of pension schemes and workplace health will also increase in importance.

Various programs of cultural intelligence development, respect for other people, minority groups, races, religions and their customs will increasingly become the focus of attention.

The issue of corporate social responsibility towards workers also increases in importance with the EU integration. Two areas that are extremely well regulated by the EU laws and regulations are the area of human rights, i.e. the issue of equality, and the area of occupational safety. In both cases, Serbia has to undergo significant adjustments, especially when it comes to the direct application of legislation in companies. Furthermore, the expected increase in labor mobility, which is especially important to young and educated people, will escalate the issue of their retention in companies. To become and remain a desirable employer will be even more important in the future than it is today.

New technologies are constantly changing business environment, and this trend will undoubtedly continue. Redefining the ways, organization, and workplace ensues. With the introduction of telework, office and commercial activities will increasingly be performed via the Internet, which will have great implications for managing people and workplace, communication between people, and flexibility in achieving a balance between personal life and work.

5. Conclusion

On the contrary, the success or failure of one is largely determined by the success or failure of the other. It is Corporate Social Responsibility(CSR), that encourages companies to be innovative, responsibly manage the risk, encourage sustainable development, and reduce costs, while simultaneously achieving better business results for their clients and the company, but also for the community in which they perform business activities. There is always some room for growth and improvement, because, in the end, everyone is very eager to live well in a society of justice, solidarity, responsibility. The quality of the legal framework for the activities of civil society organizations will depend on the society of active citizenship, and thereby the overall diagnostic picture of the vitality of democracy and the welfare state. The existence of a competitive advantage in the market today is considerably facilitated by corporate social responsibility, and funding socially responsible activities should not be considered as a cost, but an investment that pays off in the long run.

New management systems should be based on continuous improvement of business processes in accordance with corporate social responsibility. The profitability of the company may have a deeper meaning when decisions can be made to affect the future course of development of the country and to plan a better world for all of us.

Earning money can have a deeper meaning when an employee works for a responsible, socially active employer, an employer of which the employee can be proud. Corporate social responsibility is a strategic framework for the management of the company, based on investment in the long-term and stable relations with all key stakeholders and the commitment to actively contribute to the development and welfare of the society, of which the company is an inseparable part. It is CSR that urges companies to be innovative, encourages sustainable development, encourages them to be responsible for risk management and reduce costs, while achieving better business results for their clients and the company, but also for the community in which they perform business activities, and for their employees.

Investors want to invest in socially responsible companies, because in this way, they are certain that their investments will be sustainable in the long run. To be a company that nurtures social responsibility and continuous development means to survive in both good and bad times. Social responsibility is a part of the modern development vision and strategic directions of the company. Only socially responsible companies encounter stakeholders' understanding in times of crisis and are able to survive in the long run in the turbulent environment of the 21st century. However, this does not affect positively only companies, but also the economy in which they operate. A socially responsible economy implies a better standard for all, from workers through investors to end users, and all this has the effect of improving the business environment and working conditions.

This is especially important for countries in transition and on the way to the EU, so that they would, in an easier and less painful way, survive the free competition in the larger EU market and find their place. The importance of CSR is also expressed by business activities of large enterprises, which can serve as a good example to SMEs, but also to large national enterprises. In scientific research, both empirical and analytical, CSR has been gaining in importance in recent years.

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DYNAMIC BEHAVIOR AND STRESS FIELD OF EXCAVATOR SchRs740 EXTENDED BOOM

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Abstract

Bucket wheel boom represents the most loaded and the most responsible part of the excavator structure, participating only with 6 to 13% in the entire excavator weight. Its length is selected depending on the technological requirements of mining deposit, and it has to be adjusted with the designed possibilities of the excavator. At the request of mining technology that is in compliance with the soil-mechanical properties of deposit, conditions are created for the selection of excavator optimal parameters, and therefore to determine the required length of the boom. In this paper, analysis of dynamic and static behavior of boom extended from 1 to 10m with a step 1m was done. The maximum possible extension is defined as the aspect of structural performance, dynamic behavior and stress field. Finite Element Method (FEM) is used to obtain natural frequencies, displacements and stresses.

Keywords: bucket wheel boom, increasing the boom length, dynamics, stress, FEM

1. Introduction

One of the basic prerequisites for the efficient operation of the excavator is the adjustment of structures, primarily the bucket wheel boom of the excavator, and working conditions. It involves the use of such structures that will best suit the specific conditions of the working environment, but also that structural loadings are within acceptable limits, in order to stay long in exploitation. Bucket wheel boom is the most exposed to a wide range of both static as well as dynamic loads. In order to determine the behavior of the bucket wheel excavator SchRs740 boom structure, firstly the static and dynamic loads are analyzed. Then, development of the model was performed, and ultimately finite element analysis. FEM will determine the level of membrane, bending and equivalent stresses and deformations, as well as, values of free frequencies of the structure. Based on theoretical considerations on the one hand, as well as relevant diagnostic indicators of certain design solutions on the other side (concentration of stresses, deformation energy, distribution of potential and kinetic energy on the main oscillating modes), can be marked weak points and found design solutions depending on technological requirement, that best suit the specific conditions of the working environment on opencast mines. In this case technological requirement is increasing the bucket wheel boom length of the excavator SchRs740.

Analysis of the dynamic behavior and condition of the BWE elements using the finite element method, are shown in many papers [1, 2, 7, 8, 9, 10]. In [3, 7, 8] experimental results are compared with appropriate theoretical basis. Modelling of the BWE SchRs740 bucket wheel boom in this paper was carried out because of the technological requirement to increase the length of the boom.

2. FEM model of the BWE SchRs740 Bucket Wheel Boom

The basic procedure in diagnostics of the structure is its computer modelling and the corresponding static, dynamic and thermal calculation using a numerical method FEM. The FEM is a universal method that can help in solving various problems both related to the behavior of steel structures and in mining and metallurgical industry.

The software package KOMIPS is developed at the Faculty of Mechanical Engineering in Belgrade [5], which enable modelling and calculation of complex structures and problems.

The most sensitive, the most important and most difficult manageable procedure of the calculation process is structure modelling. One of the most important factors is modelling represents experience and user's intuitive. Modelling, in fact, is mapping the physical to computational model according to technical documentation, selection of the type or types of finite elements and defining of physical model discretization by finite elements, nodal points, boundary conditions and loads.

For modelling of the excavator SchRs740 boom, software package KOMIPS is used. Taking into account the appearance of the excavator SchRs740 boom structure, and to all the above mentioned in relation to the finite element method, the structure was modelled by beam elements (elements of short beam).

Beside the truss steel structure of the boom, all the other elements that affect the rigidity of boom structure were taken into account. That means that model includes following elements: transverse stiffeners, shafts of the wheel and return drum, torque leverage of both gearboxes, parts of the belt structure and stays. Finally, the boom model consists of 290 beam elements and is shown in Figure 1.

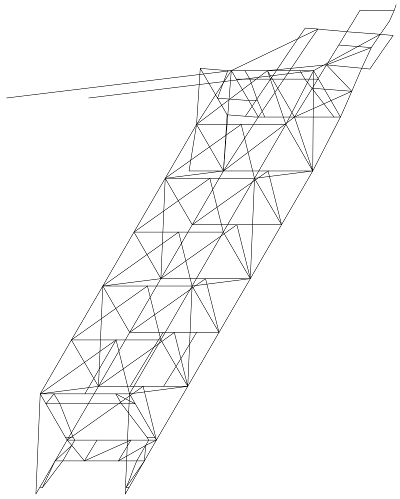


Figure 1 Model of the boom, beam elements

3. Calculation of the Free Frequencies of BWE SchRs740 Bucket Wheel Boom Oscillations

The excavator boom for which is made dynamic analysis is shown in Figure 2.

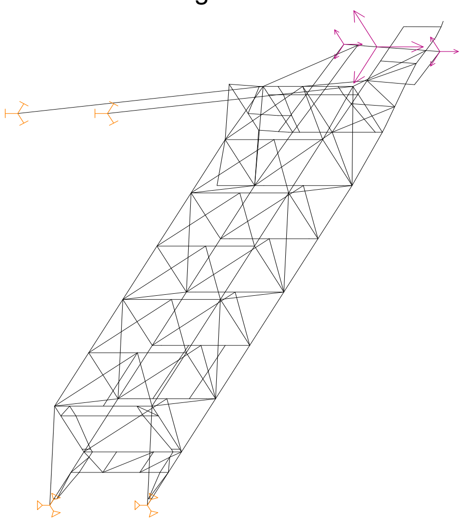
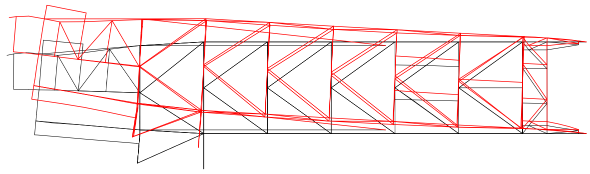


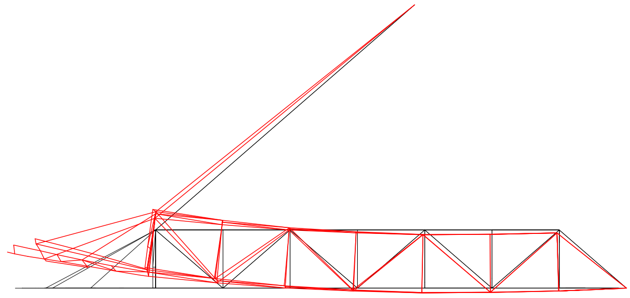
Figure 2 Dynamic model of excavator boom, boundary conditions and loads

Boom is located in an elastic environment, that means model included the stays and the yoke.In points that are bearings of the boom is prevented translation in all three directions. In points of connection stays and yoke all the moves (translations and rotations) are prevented. In points that represent attachments of the boom and the stays the rotation in the joint around the axis parallel to the bearing axis is allowed. Masses of the gearboxes (by around 8t) and the wheel (about 20t) are taken into account as a concentrated mass in dynamic calculations, as can be seen (Fig. 2). The actual length of the basic boom is 34.93 m, and its weight is 64.869 t.

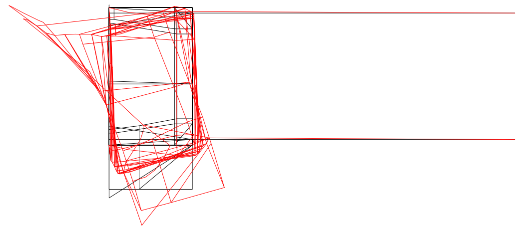
The first three oscillating modes and corresponding free frequencies are shown in Fig. 3.



Bending in the horizontal plane, the first mode, 1.44 Hz



Bending in the vertical plane, the second mode, 3.98Hz



Torsion, the third mode, 5.47Hz

Figure 3 First three oscillating modes, the original boom structure

4. Extension of the Bucket Wheel Boom

Boom has been extended in a step of 1 m, without changing the cross-sections of beams, height and width of the truss. From 1 to 5 m beam was extended, so that the extension was uniformly distributed on five segments in the middle, which are almost structurally identical (there are small differences, i.e. reinforcement in the lower band of the first and in the upper band of the last segment). Total extension of 6m distributed to these five segments means extending of one segment for 29.56% of the length. That is negative in many aspects of the structure stiffness. For this reason, the total extension of the boom for 6 m involves a new segment and the entire extension now is distributed to six (5 + 1) segments. Numerically it is checked that by the addition of this segment are retained the dynamic characteristics of the structure, regardless of the weight increase (about 1 ton). That confirms that such conceptual solution for extension from 6 m has grater stiffness compared to a solution where the extension of 6 m is distributed to five segments. That is why the further extensions are done by retaining the inserted segment, and the total length is now distributed to six segments.

During this calculation the original stays of the existing boom were used for each additional extended boom. In addition, stays position was dictated by the geometry (length) of the yoke and stays, which means that it is not the same for the original and the extended booms (Fig. 4)

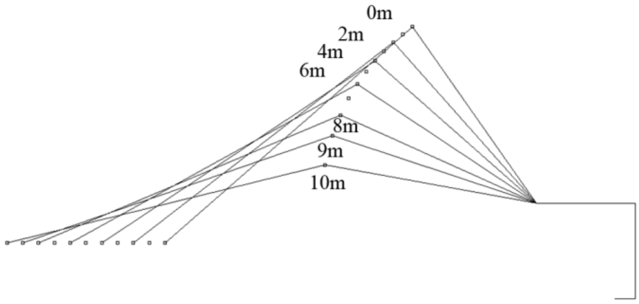


Figure 4 Geometry changes of the yoke-stays by the boom extension

Therefore, with extension of boom the position of stays is changed, i.e. the angle made by boom structure and stays is smaller. In addition, 10 m represents the end border up to which can be used existing stays and yoke, because for the each subsequent extension the two circles representing the yoke and stays would not intersect at all.

However, from Fig. 4 it can be seen that at 10 m extension geometry yoke-stays is disrupted (the angle between the stays and boom is very small, and between the yoke and stays is very large).

These variations necessarily require a change in the geometry of the mechanism for the lifting /lowering of the bucket wheel boom, which implies the necessity of elements redesigning (pulleys, ropes, rope drums, drive).

In addition, for the extension of 10 m the total weight of the boom was increased by about 7.6t, which would have consequences on the supporting structure of the whole excavator. However, this is not the subject of this article, consideration here is limited only to the boom structure. Results of dynamic calculation are presented in Table 1 for the boom extended from 1 to (fictitious) 10 m.

Table 1. Results of dynamic calculation

Boom length[m] + extension [m]	Total boom weight [t]	Free frequency [Hz]		
		Bending, horizontal plane	Bending, vertical plane	Torsion
35+0	64.869	1.44	3.98	5.47
35+1	65.532	1.39	3.89	5.39
35+2	66.198	1.34	3.80	5.29
35+3	66.867	1.29	3.69	5.16
35+4	67.538	1.26	3.56	4.99
35+5	68.211	1.22	3.41	4.79
35+6	69.862	1.19	3.22	4.60
35+7	70.526	1.16	3.00	4.31
35+8	71.191	1.13	2.72	3.98
35+9	71.855	1.11	2.35	3.59
35+10	72.524	1.07	1.83	3.10

5. Stress and Deformation Field in the BWE SchRs740 Boom under the Workload

Numerical calculation of structure loaded by the reference workload (static analysis) and its own beams weight (dead load)is done. The boundary conditions are the same as for the dynamic calculation. As fictional workload is concerned, the overall digging force of 25 t was distributed in real terms in the three forces (vertical 1, lateral 0.3 and radial 0.15). It was not taken into account the weight of gearboxes and bucket wheel, as well as other loads (weights) to which a bucket well boom is exposed in real working conditions. That's why it was obtained the stress levels significantly lower than expected (by calculation is obtained a stress of about 40 MPa). The aim of this analysis was to show the trend of changes in the stress by increasing the boom length. Load is entered on the bucket wheel perimeter (concentrated force at one point), simulated by rigid beam. Figure 5 provides the appearance of elastic structure outline exposed to fictional workload for the existing boom.

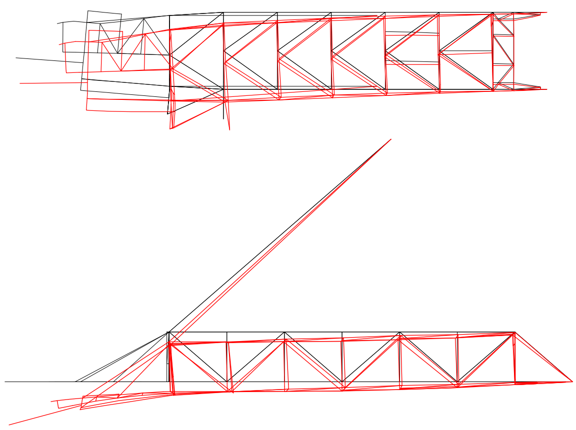


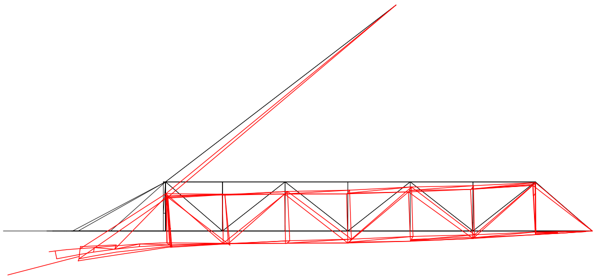
Figure 5 Displacement outline, original boom

The change of stress in an element of the lower band of the first segment (near boom bearing), which indicates respectively a high level of stress in the case of basic and extended booms, is given in Table 2.

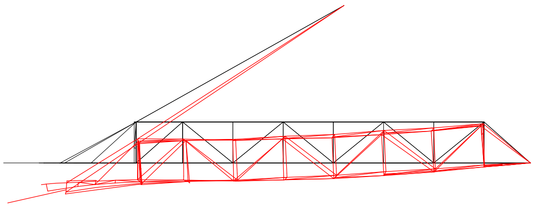
Table 2 Change of stress in one element

Boom extension [m]	Stress [MPa] (fictional)	Stress increasing [%]
0	39.97	0
1	41.44	3.68
2	43.31	8.36
3	45.82	14.64
4	48.29	20.82
5	51.37	28.52
6	54.16	35.50
7	57.89	44.83
8	64.09	60.34
9	71.25	78.26
10	89.38	123.62

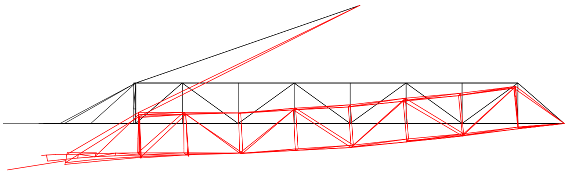
It may be noted that by the boom extension of 6 m stress in this element is increased by more than 30% of the stress value in the same element of the existing excavator boom. In addition, it can also be noted that a large extensions of the boom (8, 9 and 10 m) are not technically acceptable. Displacement outline for the boom extended for 2, 6 and 9 m can be seen in Figure 6.



Boom extended for 2 m



Boom extended for 6 m



Boom extended for 9 m

Figure 6 Change of the displacement outline by the change in length, static calculation

The excavator boom acts as a beam with overhang. Workload is a force at the end of overhang, and the whole beam is continuously loaded by its own weight (dead load). It can be seen that for a small extensions the boom remains rigid, while for the big it becomes elastic. Table 3 shows the total deflection for all steps of the boom extension.

Table 3 Deflection change by the boom extension

Boom extension [m]	Deflection [mm] (fictional)	Deflection increasing [%]
0	30.43	0
1	31.39	3.15
2	32.39	6.44
3	33.76	10.94
4	35.29	15.97
5	37.27	22.48
6	38.92	27.90
7	41.91	37.72
8	47.14	54.91
9	55.60	82.71
10	81.26	167.04

6. Conclusion

Bucket-wheel excavators are complex systems with a large number of functionally important elements. In order to find out a valid criterion for defining the structure elements and also for the assessment of technical conditions, it is necessary extensive diagnostic tests. The first step is modelling the structure with derived optimizations.

Bucket wheel boom can be classified as a very responsible construction, because failures of certain elements on the bucket wheel boom can lead to a breakdown condition of the BWE.

Conclusions and recommendations based on the all foregoing is that, without changing of the truss structure, the maximum boom extension is 5m.

7. Acknowledgement

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RELATION RESEARCH OF SITE-SPECIFIC TRITICALE YIELD AND COMBINE SPEED

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Abstract

The paper analyzes the impact of sensor readings of dry grain mass yield of triticale on combine speed during harvesting. On the basis of mean values for group ranks and using Kruskal-Wallis H test, the highest combine speed on triticale plot has been found in the low-yield-level group. Therefore, subsequent analysis of differences was conducted between the groups using Mann-Whitney U test. In the case of comparing recorded in groups of small and middle-yield triticale in the analyzed plot effect size value is 0.13. It would be considered a very small impact according to Cohen's criteria. In the case of comparing recorded in groups with middle and high yield effect size is just over that 0.286, and it is considered a medium influence on Cohen's criteria. When comparing the speed of a group of small and large, Z statistic is equal to -26.110 to 4931 treated cases, the effect size is 0.37 and still be considered a medium influence.

Keywords: combine speed, sensor, triticale, grain mass yield

1. Introduction

Reported accuracy of continuous yield monitoring depends on the type and brand of yield monitor, calibration regime, flow rate and conditions at harvest. Accuracy ranges from 93 to 99,5 % [1,2,3]. Gradual and sudden speed changes affect the accuracy of yield measurements. Arslan and Colvin [2] showed that average error rates at a constant speed were 3 %, but varying speed between 8 and 11 km/h increased the average error to 5,2 %. When combine speed varied gradually, depending on yield variation, the measurement error almost doubled. Larger errors are observed when ground speed changes abruptly [4]. Many studies [5,6,7] have found that non-normal yield distributions are due to a high proportion of low yield measurements. The analiyzed field in this paper have also non-normal yield distributions.

Yield monitoring in combine harvesters is a cornerstone of precision agriculture. It relies on measurement of the grain flow through the harvesting equipment. Typical mechanisms that have been implemented to monitor grain flow through a combine can be grouped into volumetric flow sensors, mass flow sensors, and indirect measurement devices. Among them, impact-type mass flow sensors are widely used in many state-of-the-art yield monitors [8]. They consist of an impact plate and a force transducer that converts the net time-averaged impact force into a voltage signal. This type of structure is so simple that impact-type sensors can be easily mounted on combine harvesters and risk of causing an obstruction of the normal threshing process, even when the sensors are damaged, is minimized [9]. The goal of this paper was to evaluate impact of sensor readings of triticale mass yield on combine speed.

2. Materials and methods

Tritical combine harvester Claas Lexion 450 used in this investigation was fitted with a header, 6m wide and a grain mass flow sensor positioned on the top of the clean grain auger. The main sensor im measuring yield system was mass flow sensor, Fig.1, by producer AG Leader Technology. Mass flow sensor measures the impact force with which the grain expelled from the paddle elevator strikes against the impact plate Using this force, as well as known header width, speed of ground motion and grain auger speed, the moist grain mass yield is calculated. The effect of combine vibrations was eliminated by previous sensor calibration. In general all the theoretical statements have to be experimentally verified. This paper presents the results of investigations carried out throughout the harvest of triticale (*Triticosecale*), variety Odyssey, on plot near Belgrade, Serbia. Note that harvest time, June 2014, was ideal for research activities of this concept, because yield level in experimental plot was average and markedly non-uniform due to high precipitation amounts, exellent cultural practices during vegetative growth and especially denser assembly plants per m^2.

The system for measuring grain yield is adjusted to successively record data at 2-second intervals. This was a constant time interval of measuring. The only parameter that changed was the distance travelled during that time, depending on the combine speed and was also recorded at 2-second intervals. The recording of measurements at 1-3 second intervals generates large datasets, even for small fields [4].

Actual delay times vary between the type and model of harvester, yield monitor and GPS receiver [10-12] and within fields due to crop conditions

[10]. Data time shift used in this paper calibrated to 10 sec. Various factors such as combine separator design and settings and monitoring systems can affect the data gathering process so that the time shift should be adjusted. Without this adjustment, the grain flow and moisture values cannot be properly coordinated with location and area information to deliver data that accurately represents that location [1]. Low-cost positioning devices that rely on free correction signals, such as EGNOS, provide enough accuracy for some agricultural operations and should be taken into account for the standard tests [13].

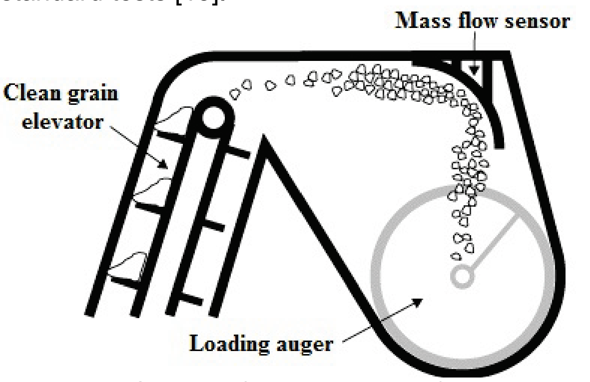

Figure 1. Scheme of sensor position of impact plate mass flow sensor with modul behind gap between clean grain elevator and loading auger (view from left side of grain tank)

3. Results and discussion

Followed by presentation of the results of the assessment of the normality of the distribution of the mass yield of dry grain triticale, based on 7376 measurements, Figure 2.

In order to research conducted procedures as required by the Kruskal-Wallis H test was performed categorization of continuous variables by weight of dry grain yield for this plot, so it is divided into the following groups (bands):

- small yield ($\leq 4.490\frac{t}{ha}$),
- middle yield ($4.491 - 4.970\frac{t}{ha}$),
- large yield ($\geq \frac{4.971}{ha}$).

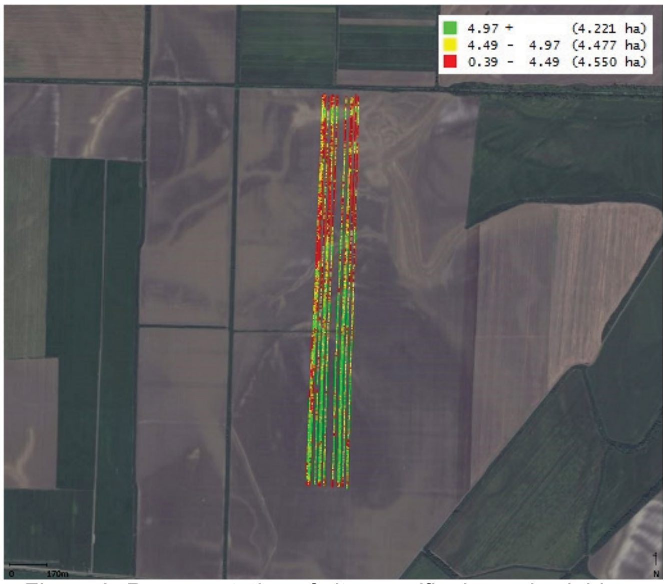

Figure 2. Representation of site-specific dry grain yield, tons per hectare

Based on the shown distribution, it can be seen that the number of samples within each group each (Table 1). Site yield of dry grain triticale on this field per display distribution, is given in Figure 2. Such groupings yield of dry grain can be defined organizational zone explored part of the plot. This view is particularly characterized by long passes of 2.3 km. Harvesting the plot is done three to five combines, but only one was equipped with tracking devices yield. Further statistical analysis where performed in IBM SPSS® 21.

Table 1. Average rang of speed for binned mass yield dry grain

	Mass yield dry grain (Binned)	N	Mean Rank	Median
Speed	<= 4.490	2475	4394.31	5.620
	4.491 - 4.970	2445	3912.87	5.480
	4.971+	2456	2753.87	5.220
	Total	7376		5.430

Table 2. Results of Kruskal-Wallis H test for harvest speed

Grouping Variable:Mass yield (Dry) (Binned)	Speed
Chi-Square	772.223
df	2
Asymp. Sig.	.000

Kruskal-Wallis H test revealed a statistically significant difference in the speed of the combine in parts of plots belonging to different groups yield (group 1, N=2475: $\mathbf{do\ 4.49}\frac{t}{ha}$; group 2, N=2445: $4.491 - 4.970\frac{t}{ha}$; group 3, N=2456: > $\frac{4.97t}{ha}$), χ^2 (2, N=7376)=772.223, p=0.000. Low yields group is characterized by higher median ($M_d = 5.62$) than the other two groups yields, whose median is $M_d = 5.48$ for a group of middle yield and $M_d = 5.22$ for the group of the largest yields. In the above results, the level of significance is 0.000. This is less than the alpha level of 0.005, so we conclude that there is a difference in the speed of combine parts plots with different groups of crops. Review of the medium (average) values of ranks groups, we see that the velocity of this plot highest in the group with low yields.

However, it is still not known which group are significantly different from each other. For this purpose, there will be used a number of subsequent Mann-Whitney U test between all possible pairs in the group. Therefore will first be applied Bonferroni correction of alpha value to avoid errors of the first kind. Bonferroni adaptation of means to share the alpha value of the 0.05 number of tests to be performed and then use so revised alpha level as a criterion for determining significance to the alpha in all tests together remained at a reasonable level. This would mean more stringent alpha level of 0.05/3=0.017. For each comparison group after the completion of Mann-Whitney U test will be calculated effect size, i.e. strength of relationships between variables and evaluated based on Cohen's criteria.

In the case of comparing the speed of combines in the fields of small and medium yield by Mann-Whitney U test plot was analyzed Z statistics equal to -8.87 with a significance level of p=0.000. This leads to the conclusion that there is a significant difference in the average level of speed for these two groups yields. Average value ranges For a small contribution to 2639.02 and the average yield of 2279.79. This difference shows the direction of the difference velocity levels. As in calculating the rank lowest value given a value of 1, it is clear that the yield values for speed in the medium yields, on average, received lower rankings.

By using the value of Z in the above results, we can calculate the approximate value of effect size:

$$\mathbf{r} = \frac{\mathbf{Z}}{\sqrt{\mathbf{N}}} \qquad (1)$$

where N is the total number of cases (observations) that in the case of speed measurements arose every two seconds during the combine on the grounds and along the corresponding walk. In statistics, the effect size *r* is a measure of strength of the relationship between two variables in a statistical population or its random samples. The impact is calculated based on the data descriptive statistics that convey the estimated value of relationships without any conclusion on whether the apparent relationship in the data reflects a true relationship in the population. In this way, the effect size *r* is the complement of inferential statistics such as the *r* value [14].

In the case of comparing recorded in groups of small and middle-yield tritical in the analyzed plot $(Z = -8.87 \ i \ N = 4920)$ effect size value is 0.13. It would be considered a very small impact according to Cohen's criteria [15]. In his influential book on statistical significance, Cohen gave his general impression of the level of influence *r* contained in research in order to differentiate less than significant impact. For Cohen, the size of the impact of about 0.1 may be a "small" effect, around 0.3 a "medium" effect and 0.5 to infinity "large" impact. Since then, these values have been widely cited as a standard for assessing the magnitude of the effects that are found in the survey, despite Cohen's personal warning about the inadequacy of the general public. [16].

In the case of comparing recorded in groups with middle and high yield (Z = -19.997 and N = 4901) effect size is just over that 0.286, and it is considered a medium influence on Cohen's criteria. When comparing the speed of a group of small and large, Z statistic is equal to -26.110 to 4931 treated cases, the effect size is 0.37 and still be considered a medium influence on Cohen's criteria.

4. Conclusion

On the basis of presented analysis results a general conclusion cannot be drawn about combine speed depending on yield level of particular crops. However, it is inferred that combine speed change on the plot during harvesting depends of the crop homogeneity stand and distribution uniformity of the yield level of triticale on the observed plot.

Analysis of the results of measurements of mass yield of triticale on this plot indicated the great importance of extreme value in assessing the normal distribution and the large differences in the descriptive statistical parameters which evaluates the normality. Therefore, when measuring the mass flow rate during the harvest necessary to eliminate all possible sources that affect the occurrence of extreme values of the measured flow and consequently yield. Before the start of the harvest is necessary to make a correct and optimal calibration for the given conditions in the field. During harvest, it is necessary to continuously operate the combine without abrupt changes in particular those that cause shock and vibration. After harvest, if the occurrence of an extreme value in the site-specific information about the yield, it is necessary to carry out filtering of data.

Based on these analyzes can't be made a general conclusion about the speed of the combine, depending on yield at harvest triticale. However, the Kruskal-Wallis H test and Chi-Square, mean rank and median, are a powerful and reliable tool for analyzing the dependence of the speed of the combine's yield and can be applied when any need for each plot individually. The analyzed land speed is varied by group. Subsequent Man-Whitney test for the analyzed plot with triticale showed that the rate between the groups differ significantly, but according to Cohen's criteria of small and medium-sized influence of certain based on the value of effect size.

5. Acknowledgement

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MAIN ATTRIBUTES OF SME´S INNOVATION ACTIVITY IN SLOVAKIA

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Abstract

Innovation activities are the drive of economic development advancing the possibilities of future competitiveness in the form of new knowledge and increasing economy´s efficiency and performance, particularly through small and medium enterprises (SME). The aim of the article is to present the innovation performance of Slovakia and the main attributes of innovation activity of Slovak SME. It presents secondary data and results of empirical research. The paper points out the most significant barriers of innovation activity identified among SME. Consequently, it presents presumptions and recommendations for relevant public institutions as well as for SME to overcome the barriers.

Keywords: Summary Innovation Index, innovations, small and medium enterprises, barriers, recommendations

1. Introduction

Current economy tends to be characterized as a new, global a knowledge-based economy. The new, global economy is the economy of knowledge and ideas, where innovative ideas and technologies, fully integrated in services and products, became a key to generation of new working positions and higher life standard. Only dynamic businesses are able to respond to the market demand swiftly and are capable of research and development of new products, innovations and technological changes.

The aim of the article is to present the innovation performance of Slovakia and the main attributes of innovation activity of Slovak SME. It presents secondary data as well as results of empirical research. The paper points out the most significant barriers of innovation activity identified among SME. Consequently, it presents presumptions and recommendations for relevant public institutions, as well as for SMEs, to overcome the barriers. The paper was elaborated as a part of the VEGA project 1/0494/15 "The research of factors influencing the successfulness of innovative small and medium enterprises in the Slovak Republic".

2. Innovation performance of Slovakia

Innovation performance of the country is important indicator, describing situation and effectiveness of state policy and other tools supporting the innovation performance of domestic and foreign enterprises.

In order to secure international comparison of success of innovations support within EU, the Summary Innovation Index (SII) was created. Summary Innovation Index takes into account a score of 25 indicators, which are divided into five groups.

The first three groups of indicators include innovative inputs and the last two groups include innovative outputs [3]:

1. Innovation enablers (5 indicators), measuring the structural conditions required for innovation potential.
2. Knowledge creators (4 indicators), presenting the value of investment into research and development activities, which are considered to be a key determinant of the knowledge-based economy development.
3. Innovation and entrepreneurship (6 indicators), measuring the effort of enterprises on innovations, the effort of SME, private and cooperative, spending on research and development, venture capital and GDP.
4. Application of innovations in practice (5 indicators), measuring innovation performance expressed through business activities and participation in employment and added value in innovative sectors.
5. Intellectual property (5 indicators) measuring the achieved results in terms of successful know-how, such as patents, trademarks and new design.

Classification of countries is consequently made upon the results of measurement for the 25 indicators. The countries in EU are classified into four categories: innovation leaders, innovation followers, moderate innovators, modest innovators.

From a long-term point of view, Slovakia belongs, according to the Innovation Union Scoreboard international comparison, to the EU countries which lag behind the EU average in the innovation performance. Slovakia ranks with regard to the SII into the group of moderate innovators (with the Czech Republic, Hungary, Poland and other 9 countries).

From Figure 1 it is evident that innovation performance in Slovakia has increased between 2007 and 2014, but declined in 2010 and in 2013. The performance relative to the EU has had more fluctuations but over time has increased significantly. Performance relative to the EU reached a peak in 2012 at 69 % of the EU, but fell to 64 % in 2014. Based on the obtained values of the Summary Innovation Index 2014 for Slovakia it was 0,35. while the EU average was 0,55 [3].

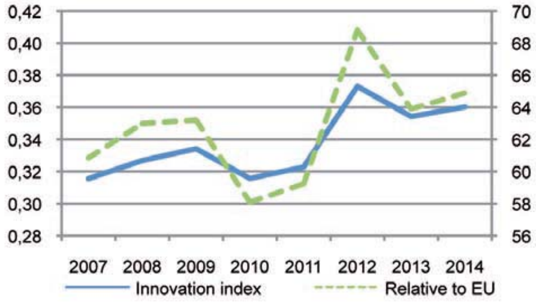

Figure 1. Innovation Performance of the Slovak Republic (Innovation index relative to EU). Source: EC, 2015

Figure 2 shows that Slovakia performs below the EU average for all dimensions, except Human resources and also for most indicators. Large relative strengths in terms of indicators are in Sales share of new innovations and New doctorate graduates. Large relative weaknesses are in License and patent revenues from abroad. Non-EU doctorate students, PCT patent applications in societal challenges and PCT patent applications.

Performance in most dimensions and most indicators has improved. The highest growth in terms of indicators is observed for Community trademarks (18 %) and Non-EU doctorate students (14 %). A very strong decline in performance can be observed in License and patent revenues from abroad (-38 %), and a more modest decline for Non-R&D innovation expenditures (- 8,8 %).

Unfortunately all other indicators were below the EU 27 average. All these low valued indicators are presenting the weaknesses of Slovakia in innovation performance (not only in entrepreneurial, but in academic and governmental area, too). The worst value was achieved by the indicator license and patent revenues from abroad.

Special SII indicator on innovation is the share of small and medium enterprises with innovation activity.

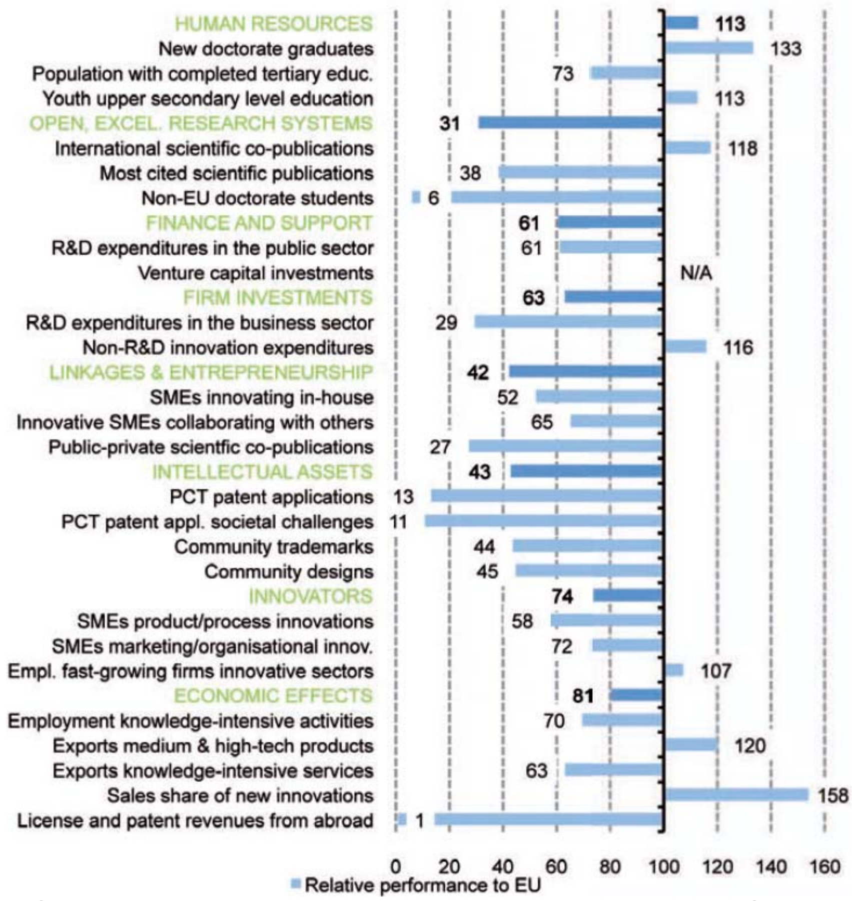

Figure 2 SII indicators value relative to the EU 27 average in the year 2014. Source: EC, 2015

3. Innovations in small and medium enterprises in the Slovak Republic

From a long-term point of view the innovation activity of Slovak SME is according to the Innovation Union Scoreboard behind the EU average.

The value of the indicator on SME with innovation activity in Slovakia corresponds to slightly less than half of the EU average (- 58 %).

In Table 1 the share of enterprises with innovation activity in total number of enterprises (by their size) is presented.

Table 1. Share of enterprises with innovation activity in total number of enterprises by their size in Slovakia (%)

Indicator	2006	2008	2010	2012
All enterprises	25,1	36,1	35,6	34,0
Small enterprises	19,2	31,5	29,3	29,8
Medium enterprises	34,4	48,7	43,6	40,0
Large enterprises	56,0	67,6	65,1	62,1

Source: Statistical Yearbook of the SR, 2014

It is evident that the share of enterprises with innovation activity in small and medium enterprises has decreased during the last 4 years in small enterprises by 6 %, in medium enterprises by 18 %. To identify the main reasons of the decrease we have conducted in the year 2013/2014 the large empirical research aimed at evaluating innovation activities in SME in Slovakia. One part of the research was oriented on identifying the main barriers of innovation activities in SME in Slovakia.

Barriers to develop innovation activity can be classified in various ways; a usual one differentiates between external and internal barriers [1]. External can be subdivided into supply, demand and environmental barriers. Supply barriers include difficulties in obtaining technological information, raw materials and finance. Demand barriers have to do with customer needs, their perception of the risk of innovation and domestic or foreign market limitations. Environmental ones include various government regulations, antitrust measures and policy actions. External barriers (include) have to do with external environment (government policy and policy actions, market factors, stake holders' factors).

Internal barriers can be further subdivided into resource related, e.g. lack of internal funds, culture and innovation systems related barriers, and human nature related, e.g. quality of human resources, attitude of top manager to risk or employee resistance to innovation.

4. Results and discussion

The research conducted at our school in the year 2013/2014 was aimed at three areas: evaluation of innovation activities of SME in Slovakia, identifying the barriers of their development and formulating the recommendations to elimination of identified barriers. The research was conducted by the questionnaires distributed via electronic mail.

Selective sample was created by 527 enterprises, 384 of them were small and 143 medium-sized enterprises. Representativeness of the sample was verified statistically by means of non-parametric test – chi-square test. The test confirmed a representative sample of selected set. From the overall number of enterprises more than 40% of enterprises worked in industrial branches (engineering, woodworking, electro technology, chemistry, and rubber industries), 30% in the sector of market services, 20% were from building industry and 10% acted in information-communication technologies.

For the question, if SME practice innovation activities, 174 enterprises responded positively from the overall number of 527 enterprises (33,02 %), 112 of which were small and 62 medium-sized enterprises. Together 353 enterprises (272 small and 81 medium-sized) stated that they do not practice any type of innovation activities, while they try to act in the market without changes in entrepreneurial activity and they trust to their strategy.

Table 2 Division of Enterprises According to Size Structure and Realization of Innovations

Enterprise/Realization of Innovation	Yes	No
Small Enterprises	112	272
Medium-sized Enterprises	62	81

The main aim of a survey was finding out and analyzing the main barriers of innovation activity in small and medium-sized enterprises in the Slovak Republic. This question was discussed not only by SME that realize innovations, but as well those enterprises without innovation activity. Innovative enterprises can provide information on barriers; they really meet when realizing innovation activities. On the other hand innovatively inactive enterprises will provide the reasons for innovation activities they do not perform.

We divided the barriers of innovation activity in SME into three groups from the viewpoint of their significance and influence upon innovation activities of SME. The division of barriers according to significance was carried out by means of statistical program SPSS.

As the five main barriers to innovation in SME in Slovakia were identified: lack of financial means for innovation, high costs for innovation, quality of innovative environment, lack of qualified employees and absence of cooperation with other subjects in the field of innovation activities.

The main highly important factors that limit the possibilities of further innovation of Slovak SMEs are cost based factors: *an insufficiency of resources within the enterprise and high costs for innovation* (more than 80% of respondents consider these two barriers as most significant). The main barrier within the group of barriers with a significant influence on innovation activities is the *lack of financial sources for innovation in an enterprise*.

The majority of SME in Slovakia considers the problems with the accessibility of financial sources for the most expressive factors limiting the innovation activities of SME. Enterprises introduced negative experience when they were acquiring means from the funds of the European Union, structural funds, or other public financial sources (bureaucratic demand, administration, corruption, ineffective redistribution of means, as well as ignorance of their drawing).

The main external source of funding the innovation activities remain the structural funds through the priority axes of the Operational Programme Competitiveness and Economic Growth (Ministry of Economy) and the Operational Programme Research and Development (Ministry of Education). The two Ministries and their agencies (due to strict implementation of the Competence Act) cooperate insufficiently, which leads to fragmentation and implementation deficiencies. The problems with acquiring the financial means force SME to innovate predominantly from their own financial sources. *High costs of innovation* activities are the second main barrier belonging to this group. Realization of innovation activities is connected with high costs. 81% of respondents evaluate them as a significant barrier. Nevertheless, managers of enterprises should take into consideration that innovation is a prerequisite for obtaining a favorable position in the future [2].

The third important barrier is the *quality of innovative environment and infrastructure for innovations*. More than 70% of respondents is critical to the quality of innovative environment. Respondents expressed critical attitude to the existence and activities of institutions supporting innovation activities as well as to the support of the rise and development of innovative SME from the side of the state. Critical is viewed that in Slovak regions the higher territorial units (VÚC) do not have innovation structures; there is no scheme for effective management of the state innovation policy and regional innovation strategies. An institutional framework for a more efficient connection between industry and selected services and results of research and development and practice is missing. The intention to create the regional innovation centers was to ensure implementation of the regional and state innovation policy in regions in order to assure the growth of competitiveness, reduction of regional disparities and growth of regional employment development of innovation tools at the regional level. Slow implementation, lack of coordination and consensus among the relevant ministries appears to be critical. Respondents were critical to the long-term absence of creating regional innovation centers, which should help to start the cooperation between SME on the one side and universities, research centers, technological parks on the other side, as well as to be helpful in the process of establishing the clusters.

Qualified human resources belong to one of the most important factor determining innovation activity. Managers of SME identified the lack of qualified employees as the barrier with average significant influence. In the Innovation Strategy of the Slovak Republic for 2014–2020 "High-quality human resources" was indicated as the second priority, with a special orientation on innovation education for SME, to provide education and training to firms and entrepreneurs in the area of innovation activities.

The reason for the adoption of this measure is a low level of innovation activities and creativity of businesses with SME falling in the category of low innovative enterprises. A series of special training courses on innovative activities and special practices and procedures will to be organized under this measure. Educational activities will be carried out in cooperation with cluster organizations, industrial chambers and associations operating in Slovakia, as well as with higher territorial units and municipalities.

According to results of our research *the absence of cooperation with other subjects in the field of innovation activities* could be included into the group of averagely significant barriers. The cooperation of SME with other subjects in the field of innovation activities brings several synergic effects to the enterprise [7]. The most important of them is common sharing of knowledge and simpler approach to the latest know-how, common sharing of capacities, lower demands for financial sources, etc.

5. Conclusion

SME sector is of paramount importance to improving innovativeness of the entire economy. Given the range of main barriers that have considerable restricting effect on innovation activities of SME, actions need to be urgently identified to overcome the barriers.

In the following part we conclude briefly results of the research aimed at identification of basic presumptions for the development of innovation activities in the SME in Slovakia. We aimed at inside and outside pre-conditions and by means of questions in the separate part of the questionnaire we revealed their importance for small and medium-sized enterprises. Through the analysis we summed them up as follows.

The question, which basic presumptions have to be fulfilled so that the enterprises could realize the innovation activities, was answered that there are 6 basic presumptions.

The main presumption that was stated by the respondents is the *sufficient financial sources*. Enterprises declared the need to simplify the approach to financial sources, liquidation of huge administrative demand and bureaucracy connected with acquiring financial means from the European funds (structural funds) or from other public sources. For the future it will be necessary to mobilize all financial sources in the area of innovation support in order to ensure that innovation activities receive the same level of funding as those in advanced EU countries. In connection with efforts towards the most effective use of allocated financial resources, an indirect state aid has to be provided to profit-generating projects implemented by SME, i.e. financial engineering instruments such as guarantee funds, credit funds, venture capital funds and municipal development funds.

There is an enormous interest of responsible institutions in coordination with the Ministry of Finance of the Slovak Republic to apply the upgraded model of usage of innovative financial tools in order to support innovation activities in SME.

Financing of R&D activities in Slovakia is strongly below the average of the EU 27 countries. We are lagging not only in amount of financial sources, but also the ratio between public and private funds is reversed. The situation could be changed not only by one way financial support from state budget, but we see the solution in overall improvement of the business environment through a reduction in indirect taxes, especially VAT rate, amount of contribution to social and health insurance companies and all other areas mentioned above.

The second presumption for the development of innovation activity was stated the *cooperation and participation of SME in networks and clusters*. Positive examples from EU countries confirm, that the participation of small and medium enterprises in networks and clusters, support of partnership´s building is the way, how to involve small and medium enterprises into innovation activities. Innovation process of a higher level calls for improvement of interaction between small and medium enterprises, research institutions and universities and for creation of various effective networks and partnerships. Building partnership is a way how to be involved into innovation activities. In the Innovation strategy of the SR for the years 2014-2020 was indicated as one of the main measures the support to innovative industrial cluster organizations. The purpose is to improve competitiveness through support to selected activities of industrial cluster organizations, with a view to promoting joint industrial activities in selected areas [6]. It could help in supporting cluster activities which contribute to increasing the competitiveness of the innovative cluster organization's member companies.

As important presumption to develop innovation activity was indicated the *high-quality human resources*. Quality management, as well as employees able to think creatively and implement innovations in their activities, represent one of the most important presumptions of the development of innovation activity of an enterprise. Management must be able to lead and direct the thoughts and ideas in the enterprise, to search and use talents, be aware of the fact that the enterprise will be successful due to being distinguished by the human resources [5]. From the viewpoint of employees proactive approach is expected, as well as the ability to learn and implement knowledge in the innovation activity. Remuneration of employees for their innovation ideas is a significant motivator and presumption for the increased effort of employees when searching for new, innovative solutions [9].

According to our survey results, the fourth presumption is the suitable innovative environment. It is necessary to create an *innovative environment* in the SR that eliminates weaknesses in the area of research and innovation (R&I) and develops mostly opportunities which create the conditions for fundamental enhancement of innovative environment. Of special importance is the development of institutions supporting innovation activities on national and regional level. A critical element is above all the autonomous functioning of sectors of education, research and innovation (R&I) and business practice, which results into different understanding of R&I. Of special importance is the creation of linkages between multinational corporation´s R&I and domestic businesses R&I framework (including the SME), and increasing interest of businesses and industrial clusters in rebuilding of industrial R&I structures (entities). Successful implementation of innovation strategy requires a structural change of current competencies in the management of research and innovation in the SR and a principle man oeuvre in cultural change of innovative environment. According the research results government should pay much more attention to elimination of administrative barriers and create a systematic institutional support to SME on national and regional level.

Some managers agreed on the fact that without *well created vision and clearly formulated aims* the innovation activity in SME is limited. The precondition for clearly formulated aims is the vision corresponding to the possibilities of an enterprise and responding to the situation on the market. Clear vision is a strong predictor of the success [11].

The important pre-condition identified on the basis of responses is the *willingness of enterprises to innovate*. This is inevitable, even if it is connected with certain risk. At present many innovative SME are successful and perspective, and vice-versa many enterprises without innovative activity are getting into financial problems. The willingness to innovate should be accompanied by such an environment that will support the rise of innovation activities [8]. Due to this fact innovation activities will be introduced faster and at the same time several barriers that could retard the rise of innovation activities will be limited.

In today´s entrepreneurial practice innovations must be its natural part. Permanent and regular innovation is becoming a competitive necessity; to be successful in the future requires interrupting conventions. There is a time of changes and the only way how enterprise can be successful is to accept these changes, adapt to them and utilize them.

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INFLUENCE OF FRICTION WELDING PARAMETERS ON HARDNESS, MICROSTRUCTURE AND MECHANICAL PROPERTIES OF THE Al-Cu JOINT

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Abstract

In this paper a theoretical-experimental analysis of the aluminum-copper joining by friction welding is presented. Considering that such Al-Cu bimetal joints are widely applied in industrial practice, experimental analysis in this paper was performed on the concrete elements used in electronics. The fact that the joining is done of the two dissimilar materials points to complexity of the problem, since phenomena that appear in the joint zone extremely influence physical, mechanical and structural properties of the welded/base metals. Besides the theoretical analysis of the basic phases and mechanisms of the friction welding process, the research also included experimental analysis of the geometry changes due to the plastic deformation, the change of structure and hardness in the joint zone, as well as of the basic mechanical properties of the Al-Cu joint. This paper presents some significant results, which point to the possibility for realization of the reliable joints of the two dissimilar metals.

Keywords: Friction welding, Aluminum, Copper, bimetal joint, mechanical properties, microstructure.

1. Introduction

Certain physical properties of copper and aluminum, like the high electric and thermal conductivity, enable their common application in electronics, thermo-technique and other areas, in the form of bimetals. The necessity for their joining is indispensable in joining copper and aluminum electric conductors or the cable endings. Studying and improvement of advanced welding technologies of various metals and their alloys, mainly Al, Ti, Mg and different types of steels, are at present in focus of the modern research. The friction by welding plays a significant role in those researches, whether it is rotational continuous friction welding (when the cylindrical elements are welded) or the FSW (when the welded elements are plates or thin sheets). Friction welding of various materials was the subject of these authors previous research [1-3], as well as of certain other authors [4-10]. In those articles, it was shown that successful joining by friction welding could be done for different classes of steel [1-4], steels and other metals [5] or the light metals [6-9]. It was proven that thus realized joint could withstand successfully both static and dynamic loads in exploitation.

In this paper the procedure of continuous friction welding of parts made of aluminum and copper is presented. The purpose was to determine the influence of the basic welding parameters (friction time, friction pressure and compacting pressure) on the mechanical and micro-structural characteristics of the weld, since the bimetal joint characteristics depend on them.

2. Basic characteristics, phases and parameters of the friction welding process

Friction welding was first applied for joining parts of various types of steel, while welding of light metals started later. The friction welding is a procedure of the compression welding, when the joint is realized by plastic deformation of by friction of the heated contact surfaces. The released heat is supposed to soften and to plasticize the near-the-contact layers of materials, but the melting temperature of the easier melting material must not be exceeded. In the considered case that is aluminum, which means that the joint weld should be formed at temperature little below than 600 °C. The quantity of the released heat depends on the nature of the base metals, thermo-mechanical properties and the friction coefficient.

The friction welding process is very complex. When observing on the micro level, the mechanism of the joint realization is based on forming the metal bond (solid solution) between the base metals, all due to the diffusion process. That bond is created when the metal clean surfaces are coming close at distances that are of the order of magnitude of the crystal lattice parameters. At the beginning of welding, the contact of the welded parts is being realized only at the roughness tips while the increase of the contact area is achieved by the plastic deformation of the surfaces in contact. Compacting is done until the boundary surfaces are brought close to each other to a distance that is of the crystal parameters size, what enables forming of the common crystal lattices. The technological process of the friction welding is done in three phases, as presented in Figure 1.

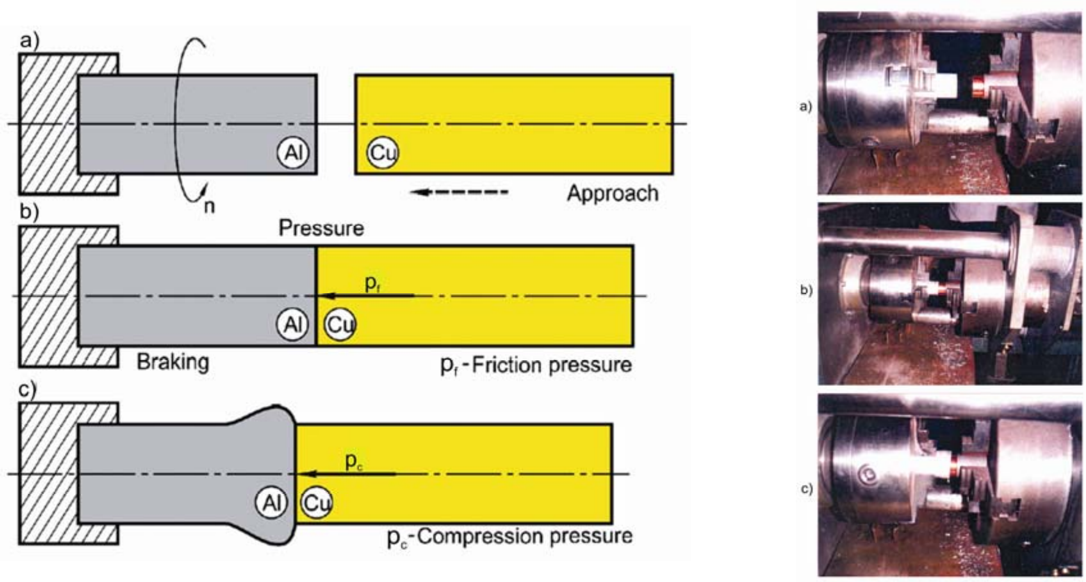


Figure 1. Phases of the technological process of the friction welding [6]

Quality of the joint is determined by the three basic variables, which influence mechanical and micro-structural properties of the welded joint. Those are the relative speed (number of rpms), pressure and time.

The friction speed influences, to the great extent, the character, shape and magnitude of the realized plastic deformation, as well as the heat generating process. It has been proven that within the range of the small angular velocities the plastic deformation process is being realized at larger depth. Unlike that, either at large values of speed, the complete welding cannot be realized, or the joints are of the poor quality.

The pressure during the friction phase has a strong influence on the thermo-deformation phenomena. There are two different pressures – the friction pressure (p_f) and the compression pressure (p_c). The friction pressure action during the heating causes intensive deformation of material, heat release and temperature increase. The friction welding cycle could be realized by different variations of pressure vs. time, while as the optimal is considered the step-wise variation cycle [6].

The time depends on other factors that are influential in the welding process, like base metal properties, friction speed and pressure, shape and sizes of the welded parts. The friction time is the time needed for the contact surfaces to heat up to the maximum temperature.

Technological parameters of the friction welding were adopted based on experience, literature recommendations and large number of trials. The proper selection of parameters affects the output characteristics of the joint, so accordingly, it is necessary to select the optimal parameters. The adopted parameters were:

- number of rpms n = 2500 rpm,
- welding time t = 4 – 15 s,
- friction pressure p_f = 50 MPa,
- compression pressure p_c = 150 MPA.

Estimate of the selected parameters optimality is done experimentally by the tensile test, hardness measurement and analysis of the joint's micro structure.

3. Base metals, structures and metallurgical changes in the mixing zone of the Al-Cu joint

Base metals. Two used base metals, copper and aluminum belong into a group of the colored metals and are characterized by the excellent thermal and electrical conductivity, corrosion resistance, high plasticity, etc. Their mechanical and physical properties are given in Table 1. In this experiment, samples for friction welding were prepared from technically pure Al99.5 and electrotechnically pure Cu99.95.

Structural and metallurgical changes in the mixing zone of the AC-Cu joint. The essence of micro structural and phase processes of the two-component system aluminum-copper for the friction welding could be explained with help of the equilibrium binary phase diagram Al-Cu, Figure 2

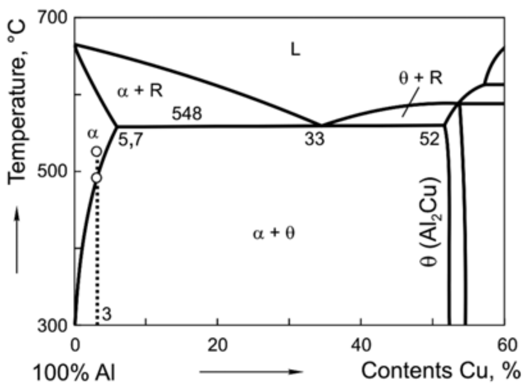


Figure 2. Equilibrium phase diagram Al-Cu [6, 11]

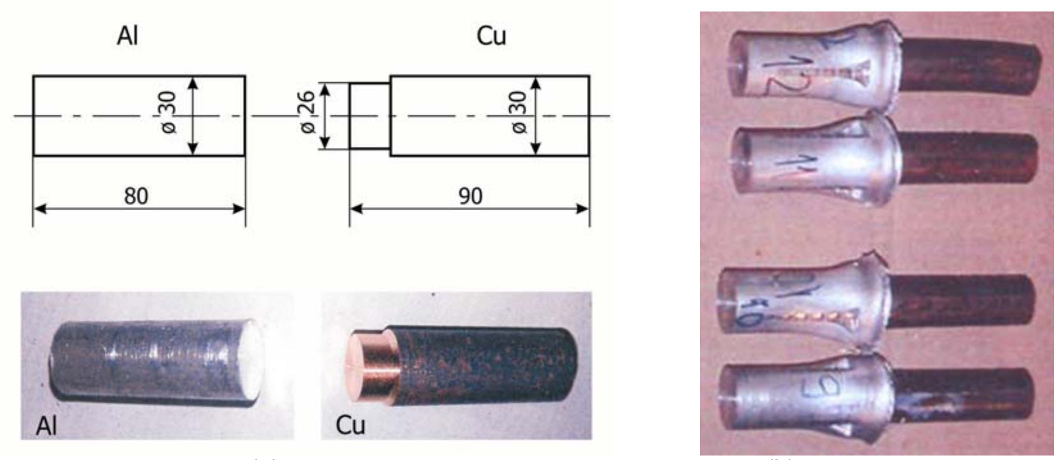
Table 1. Physical and mechanical properties of aluminum and copper

Property	Al	Cu
Melting point, °C	660.4	1083
Thermal conductivity, *W/mK*	222	395
Density, *g/cm*^{3}	2.699	8.96
Coefficient of linear expansion, *1/ºC*	23.9	16.5
Tensile strength, *MPa*	50 ÷ 80	150
Hardness, HB	15 ÷ 20	25
Elasticity modulus, *MPa*	71000	127000
Elongation, %	30 ÷ 45	52
Plasticity	good	good

Samples were made in form of cylinders with sizes presented in Figure 2.

4. Experimental investigations

Quality and properties of the realized joints were determined experimentally by the tensile test, hardness measurement and analysis of the micro structure of the joint's characteristic zones.
Tensile test. For this test, the cylindrical samples were prepared made of the welded Al-Cu joints (Figure 4(a).



(a) (b)

Figure 2. Technical drawing and physical appearance of samples (a) and welded Al-Cu samples (b)

Samples were obtained in different conditions – the duration of the welding process was varied what directly influences the tensile properties of the joint.
On samples welded by friction, the breaking occurred mainly on the aluminum part, Figure 4(b) or in the zone of the Al-Cu joining, what is a very important indicator of the adequate selection of the friction welding parameters.
Results of tensile tests of the base metals and heterogeneous welded joints are shown in Table 2 as a function of the friction time.

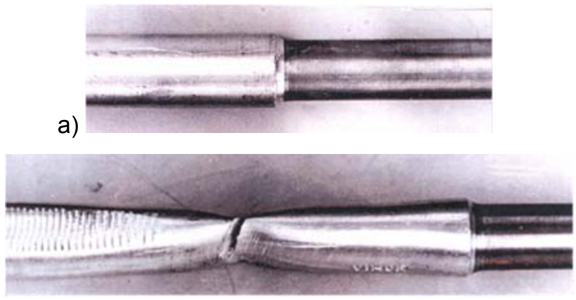


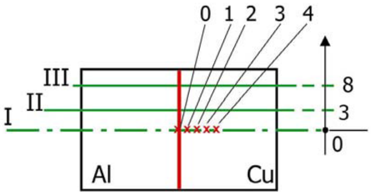
Figure 4. Sample for tensile test (a) and high-quality welded joint after test – fracture in base metal (b)

Table 2. Tensile strength of base metal samples and friction welded joints' samples

Time, *s*	Al/Cu	4	6	7	8	9	10	12
R_m, *MPa*	75/220	61	69	72	85	83	81	75
Breaking spot	BM	joint	joint	Al	Al	Al	joint	Al

Based on results presented in Table 2 one can conclude that the shorter welding time results in obtaining the joint with the properties that are worse than those of the base metals. This is why the recommendation is that the welding should last longer (> 7 s), for the welded joint to obtain better mechanical properties (higher strength).
Measurement of hardness and micro structure analysis. Hardness measurement was performed to determine the homogeneity of the welded joint, namely the presence of the undesired brittle phases ($\theta-CuAl_2$ and $\delta-Cu_9Al_4$). Hardness was measured along the three direction and at 5 points along the sample axis, Figure 5(a). The measurement points are distributed like this: direction I coincides with the welded sample's axis, direction II is at a distance of 3 mm from the axis and direction III is 8 mm away from the axis. Measurement points are at the distance of 1 mm. Obtained results for four tested samples are shown in Table 3, while the distribution hardness for sample # 1 is shown in Figure 6, with micro structures of the joint's characteristic zones.
In majority of samples, hardness was pretty uniform and evenly distributed. As expected, the highest increase of hardness was recorded in the zone of melting/diffusion, where, besides the achieved

high temperature, the Al melting occurred what created conditions for intensive diffusion of Cu and appearance of the intermetallic phases of high hardness. That was confirmed also in [7]. The θ ($CuAl_2$) phase has the body centered cubic (BCC) lattice. By increasing of the Cu content in the alloy, it crosses into the θ-phase area, where the θ-phase transforms into the body centered tetragonal (BCT) lattice. Micro hardness of such a θ-phase is 450 to 650 HB.



a)

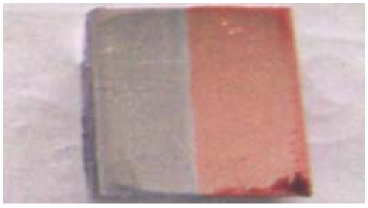

b)

Figure 5. Sample for hardness measurement: (a) Schematic s of the measurements points and (b) physical appearance.

Concerning the microstructure, it could be said that it depends largely on the welding parameters, since during the friction welding of copper and aluminum occurs creating and breaking of micro joints, as well as surfacing of copper layer on the aluminum front surface in the initial phase. That causes the friction plane to move away from the joining plane, while the micro structural processes occur within the mixing zone (Figure 6, position 3).

From analysis of micro structure of joints, it was established that the diffusion zone width was in range 2-10 μm, while the grain size was 0.1-0.2 μm.

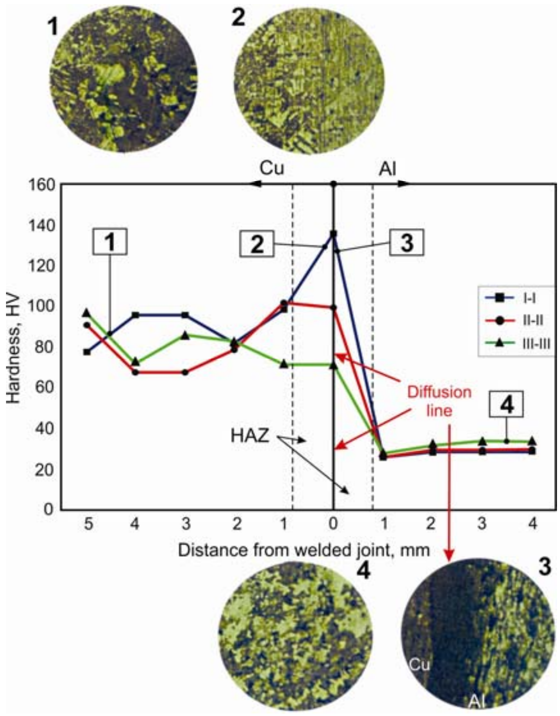


Figure 6. Hardness distribution along the axis for sample 1 with microstructures of the joint's zones.

The welding time influence on the plastic deformation and the samples' lengths. Investigation of the welding time influence was done at the end, since due to friction, the samples are shortened and the part of material is lost into the so-called "mushroom". During the welding of Al and Cu, a very intense plastic deformation of the coupled parts occurs both in the radial and axial direction, of both materials, especially aluminum, as the weaker and softer one. By monitoring the dimensions' changes with time, the relationship was established between the process duration and the samples' deformation, Figure 7.

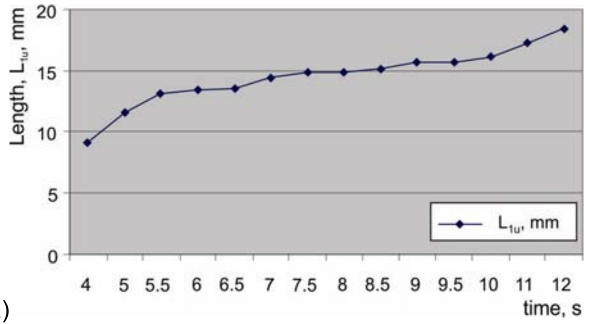
Table 3. Results of hardness measurement for four samples: #1 for 6 s, #2 for 7 s, #3 for 8 s; #4 for 9 s.

Sample No.	Sample 1*			Sample 2			Sample 3			Sample 4		
Direction	I	II	III	I	II	III	I	II	III	I	II	III
BM Cu	78	91	97	97	106	92	97	103	97	111	110	106
	96	68	72	96	96	95	103	110	97	110	100	110
	96	68	86	95	105	93	110	99	95	99	103	111
	82	79	84	95	93	92	119	102	99	103	99	106
		75										
HAZ	99	102	72	44	77	72	59	70	57	40	39	102
	136	100	72	45	78	74	60	70	57	38	39	101
BM Al	27	27	29	32	30	33	34	32	33	34	40	31
	29	30	32	30	30	33	31	31	32	35	32	32
	29	30	35	30	33	32	30	30	32	32	32	32
	29	30	34	30	32	32	30	30	32	35	32	32

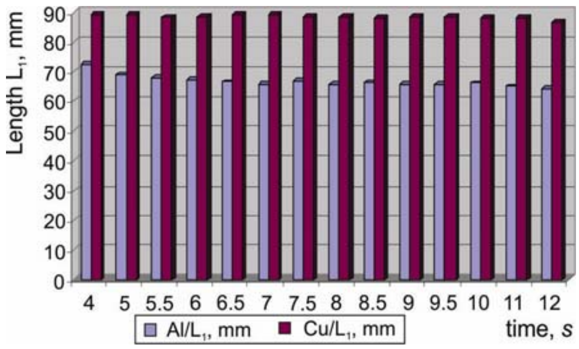
*Hardness distribution and micro structures in Figure 6.

Measurements results show that length reduction of the aluminum part is much bigger than that of the copper one. The difference, depending on the welding parameters, could reach even 10:1 ratio.

Deformation in the radial direction is much harder to measure since the "mushroom" is formed on the front side of the aluminum element. During the welding process the softened aluminum layers are being extruded from the friction plane towards the periphery so the big "mushroom" is formed, which is partially transferred to the frontal part of copper, over the whole perimeter, [6]. The wreath diameter is increasing with extension of the welding time.



a)



b)

Figure 7. Total welded samples' shortening as a function of time: (a) diagram and (b) histogram.

5. Conclusion

Joining of Al and Cu can be successfully performed by the friction welding, but to obtain the welded joint, which fulfills all the required technical conditions, it is necessary to pay special attention to selection of the process parameters. Analyses of the experimental results have shown that the basic process parameters significantly influence joint's structural and mechanical characteristics. If the optimal welding conditions were applied, it is possible to achieve the joint's strength, which is at the level of the aluminum strength, which means that during the tensile test the break must occur outside the joint zone. If that was achieved, then the bimetal Al-Cu friction welded joint is considered as the high quality joint.

However, the welding time influence should also be kept in mind. With increase of the welding time the tensile strength increases, however, the shortening of the sample, especially the Al part, is much bigger. In addition, increase of hardness in the joint zone is expected, where it could reach 130 HV, as well as the grain size increase to 0.1-0.2 μm, with the diffusion zone width of 2-10 μm.

6. Acknowledgement

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STRESS AND DEFORMATION ANALYSIS OF STRUCTURAL MEMBERS OF ONE MULTIPURPOSE KIOSK

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Abstract

The main objective of this paper is the numerical analysis and calculation check of structural elements of one multipurpose kiosk. The model of multipurpose kiosk was modeled in 3D software and then model was used for determination of stress and deformation distribution using finite element method. Data input for numerical finite element method software are obtained from European standard Eurocode. Considered cases of loads on kiosk for calculation were snow load, wind actions and self-weight of the structure.

Keywords:

Kiosk, calculation, finite element method, section, snow, wind, load

1. Introduction

Kiosks are the smallest retail shops, but they are preferred because of their availability so they are exceptionally important for prompt sales of FMCG products. FMCG stands for „fast moving consumer goods“. By definition these are retail outlets that generally sell; magazines, cigarettes and snacks (chewing gums, candies, coffee, carbonated beverages). Except for such goods, they offer other consumer goods such as, for example, personal hygiene products, shavers, razors etc. Retail outlet (kiosk) attendance can depend on location, employee kindness and variety of products, but also on kiosk design. Humans are visual beings and thus are attracted to aesthetically pleasing objects. Design must always be adapted to the location of the object because humans, out of sense of belonging, always choose kiosk that reminds them of something familiar and eye pleasing. Service provider is responsible for object design and safety. It is necessary to determine stress values as well as deformation under other loads acting on construction of kiosk like snow and wind load. Results may differ by location because of different precipitation amount or exposure to wind. There are basic regulations for in-house installations such as electricity, water and air conditioning that may influence kiosk designing. For considered construction of kiosk mounting of solar panels is available so renewable energy source can be harnessed and savings can be made. [1]

2. Kiosk construction

The biggest engineering problem in design process is defining the construction model. Construction modeling relates to construction analysis and design elements checking. Construction analysis and design elements checking are two fundamental steps in estimation of construction reliability. First step is done to define the load effect in every construction point. Second step is done to check resistance to internal forces and bending moment of design elements. It is obvious that modeling is correlation of global analysis and dimensioning methods of design elements. [2]

To make 3D construction model Autodesk Inventor [3] was used. Preliminary design of kiosk model is show on Figure 1.

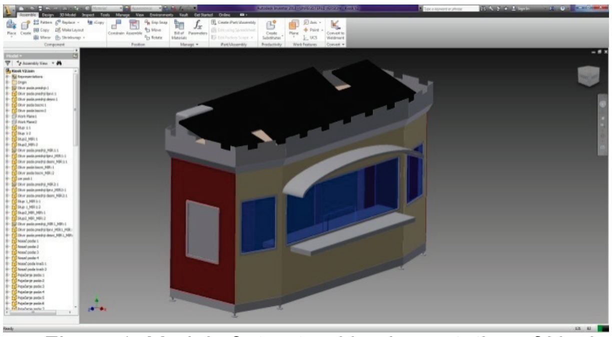

Figure 1. Model of structural implementation of kiosk in software Autodesk Inventor

For rendering of kiosk KeyShot software [4] was used. Figure 2 shows rendered image of kiosk load bearing frame structure.

Rendered image of entire kiosk is shown on Figure 3. Kiosk wall is made of panels, and they are colored in software for more natural look, just like other kiosk elements.

Kiosk floor is made of several different material layers. Their function is to ensure stability of inner parts of kiosk, together with employees and inventory. Kiosk must be designed to resist any external influence, of which the most unfavorable may be damp or water, caused by the influence of the environment. Floor is made of sheet metal panel and wooden floor, reinforced by cross support beams, on which employee is standing. Between those two layers there is insulation layer which prevents heat loss. Floor design is shown on Figure 4.

Figure 2. Kiosk bearing structure frame

Figure 3. Kiosk rendered image made in KeyShot software

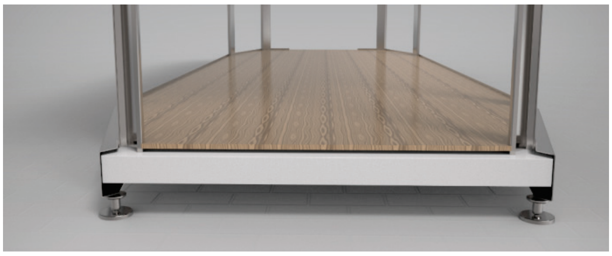

Figure 4. Floor implementation in several layers

Shipping and transport of kiosk on shipping vehicle is done with the crane–object is tethered through intended parts – Fig. 5. Four hooks are used and steel tethers strong enough to handle kiosk weight.

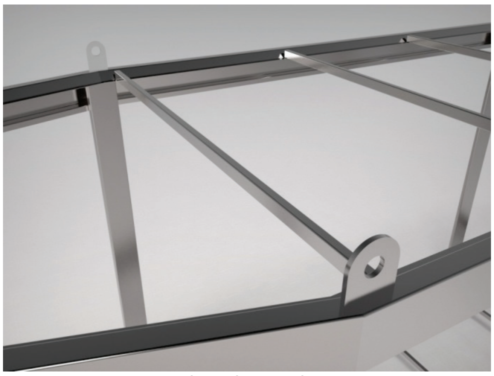

Figure 5. Lugs for lifting of kiosk construction

3. Approach to kiosk structure analysis

On most structures load measurements cannot be precisely defined. Loads used in analysis represent estimation of largest probable load that effects the structure. Some loads, like self-weight, can be estimated more easily than others, like wind load. Variable load estimation, like wind and snow, is based on collected data and probabilistic assessment in order to foresee maximal effects that can happen during lifetime of the structure.

Usage of related loads, like payload, can be estimated only by nature of usage. In most cases there is not enough data for entire probabilistic assessment. Therefore, measurements of the payload are considered by national regulations based on the use of structure.

In limit condition method load values are used as a basis for analysis and dimensioning. Those values are such that they are unlikely to exceed structure life expectancy. In order to accomplish expected level of security, characteristic load values are multiplied by partial safety factors to get load values for calculation. Generally, various partial safety factors can be applied in relation with the degree of unsafely or variability of single load type. This format does not represent strict probabilistic method for estimating the degree of unsafely.

Besides dead load analysis, snow and wind load in special circumstances will be estimated. Data received will be used for further analysis with finite element software. Procedure of analysis was done by European regulation Eurocode [5,6].

Snow loads *s,* are calculated based on characteristic load s_k, according to uniform snow height accumulated on flat ground under calm weather (no wind). This value is modified by taking into account roof shape and wind effect on snow distribution. Snow load can be reduced with exposure factor which takes into account temperature insulation of the roof. Generally, those factors are taken with value of 1,0.

Characteristic values are based on national snow charts and are connected with geographical locations. Croatia is divided into four snow zones, Fig. 6.

Snow load on the roof acquired with following expression:

$$s = s_k \cdot \mu_1 \cdot c_0 \cdot c_1 \tag{1}$$

where: s_k is characteristic snow load on the ground, μ_1 is snow load shape factor, c_0 is exposure factor (generally $c_0 = 1{,}0$, c_1 –temperature factor due to building heating (generally $c_1 = 1{,}0$).

By analysis according to Eurocode 1 – Snow loads [5], snow load is acquired:

$$s = 1{,}09 \cdot 0{,}8 \cdot 1{,}0 \cdot 1{,}0 = 0{,}872 \text{ kN/m}^2$$

Fundamental values of basic wind velocity are chosen according to nominal wind chart printed by ever country based on collected data on separate country regions measured velocity. Fundamental value of wind velocity based on Croatia's wind charts is $v_{b,0}$ = 22 m/s for city of Osijek where kiosks are planned to be situated. [7]

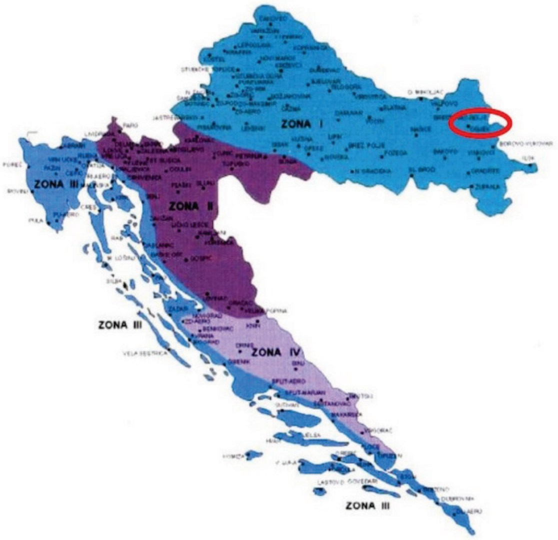

Figure 6. Croatia snow chart [7]

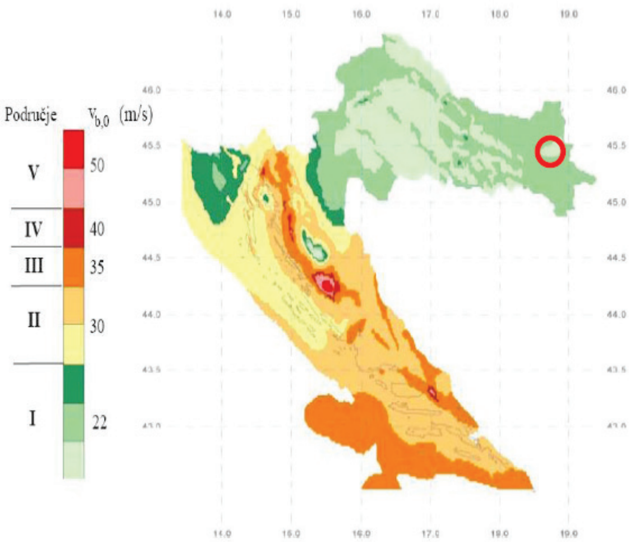

Figure 7. Croatia wind chart [7]

External load effecting building's surface is acquired by following expression:

$$w_e = q_p(z_e) \cdot c_{pe} \tag{2}$$

Internal wind load effecting building surface is acquired by following expression:

$$w_i = q_p(z_e) \cdot c_{pi} \tag{3}$$

where $q_p(z) = c_e(z) \cdot q_b$ is wind pressure on impact, z the height, $c_e(z)$ the exposure factor which takes into account field irregularities, topography i altitude above the ground, and c_{pi}, c_{pe} the internal and external load factor.

For the purpose of wind analysis, kiosk structure is approximated with rectangle in layout. Because roof has inclined lesser than 5°, flat roof data are used.

Wind load effects are estimated in four distinct cases:

- wind effect on side surface when doors are closed,
- wind effect on side surface when doors are open,
- wind effect on cross surface when doors are closed,
- wind effect on cross surface when doors are open.

By summing the effects - multiplying all loads with respective factors, it can be seen that worst case is second case, when wind effects side surface of kiosk and the door is open. Interior elements are multiplied by 1,35; snow load by 1,5; and wind load by factor 0,9.

In Figure 8 wind load from impact on side surface is shown, expressed in kN/m^2, when door is open.

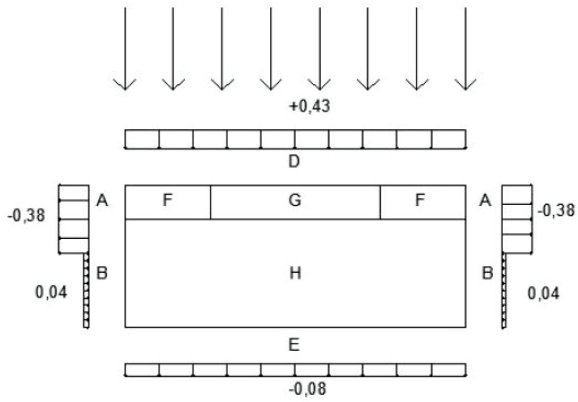

Figure 8. Kiosk layout schematic with assignment of wind effect on surfaces

4. Finite element analysis

Finite element analysis represents procedure of solving engineering problems regarding mathematical physics. In most cases when analyzed structure has complex geometry, uneven load and various materials, it is tedious and time consuming to solve the problem with common analysis. Analytical solution implies acquiring analytical expressions for calculating required characteristic in various areas of the structure. For very complex geometry and load it is not possible to find the solution in analytic form. Because of that numerical methods are widely used and most commonly finite element analysis. Therefore for analysis of structural members of multipurpose kiosk described in this paper the finite element analysis is performed using software ANSYS Workbench. [8] Load results, from previous chapter acquired by Eurocode regulation are used as input data for model loading in software.

Bearing structure frame of kiosk is made in two variants. The difference is in the shape of cross sections of used profile elements. First variant members are made of bent sheet metal profile whose cross section is on shown in Figure 9.

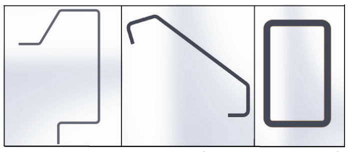

Figure 9. Bent sheet metal profiles used in first variant of multipurpose kiosk

Second variant was made from standard profiles; profile IPE 100 for lower and upper frame, UNP 100 for vertical pylons, and L 75x75x10 for cross girders, Fig. 10. Cross section area of corresponding members of both variants is kept approximately equal.

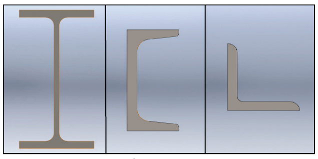

Figure 10. Standard profiles used in second variant

3D model made in Autodesk Inventor is imported in ANSYS Workbench, and Static Structural tool is used and boundary conditions are applied (Fig. 11).

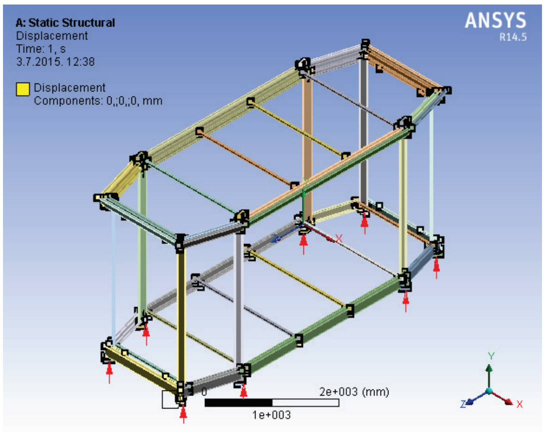

Figure 11. Boundary conditions – restricted displacement of kiosk bearing structure

Applied wind and snow loads are shown in Figure 12 as well as self-weight of structure multiplied by partial safety factor 1,35.

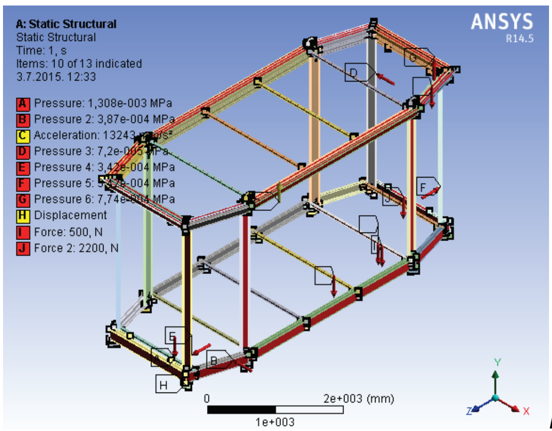

Figure 12. Loaded model of kiosk bearing structure

Model meshing is implemented with tetrahedron elements of the first order, Figure 13. Number of nodes of the meshed model were 373010, while number of elements were 189764. After meshing solver is initialized and results are obtained.

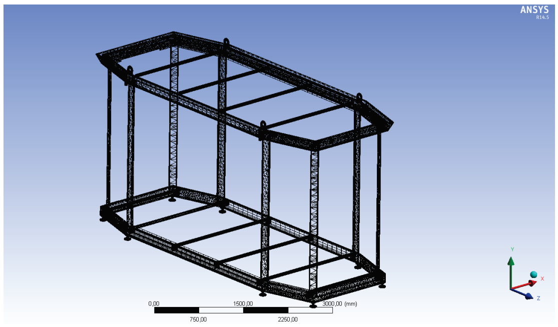

Figure 13. Meshed model of kiosk bearing structure frame

5. Results

After meshing, load assignment and initializing the solver results in form of deformation and equivalent von Mises stress, for both variants of kiosk bearing structure frame are obtained.

Deformation results for first variant are shown in Figure 14. Deformation results of second variant are shown in Figure 15.

In Figure 14 and Figure 15 detail *a)* represents places with maximal deformation along x axis, point *b)* maximal deformation along y axis, and point *c)* maximal deformation along z axis. Result comparison is presented in Table 1.

Table 1. Maximum directional deformation comparison

Deformation, mm	a) X axis	b) Y axis	c) Z axis
Bent sheet metal variant	4,279	2,001	0,335
Standard profile variant	1,215	1,165	0,517

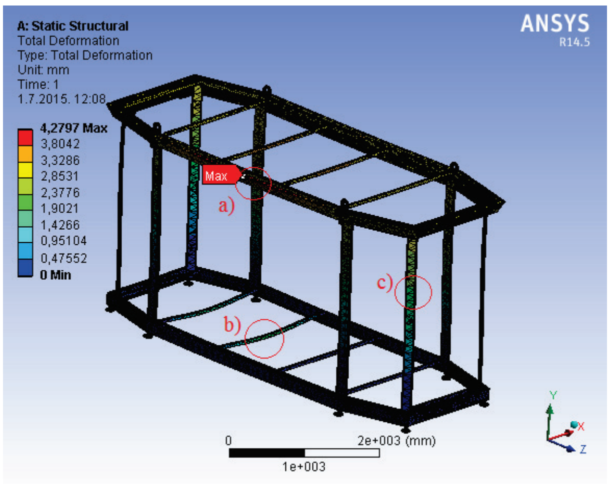

Figure 14. Distribution of total deformation results for bent sheet metal structure, mm

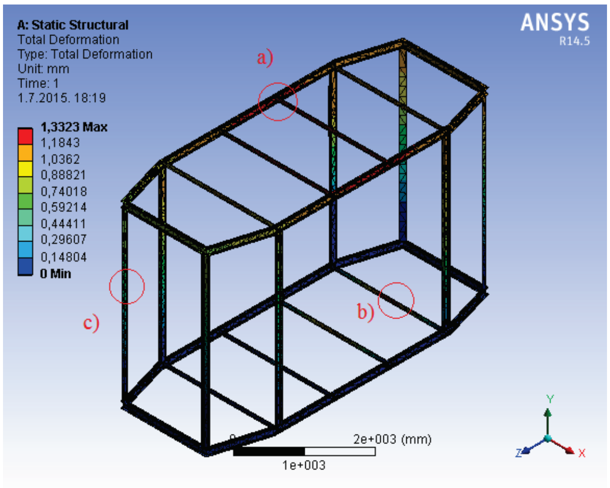

Figure 15. Distribution of total deformation results for standard profile structure, mm

Equivalent von Mises stress for both variants is within limits and meets the conditions. For first variant maximal stress is σ_{ekv}= 134,5 MPa, while maximal stress for second variant is is σ_{ekv}= 33,85 MPa (Figures 16 and 17).

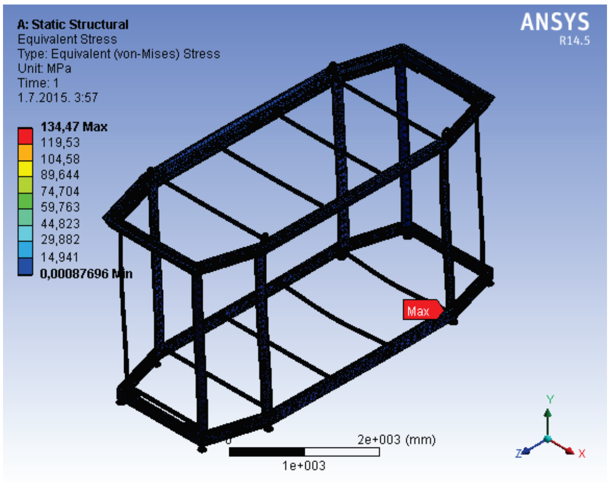

Figure 16. Distribution of equivalent von Mises stress for bent sheet metal structure, MPa

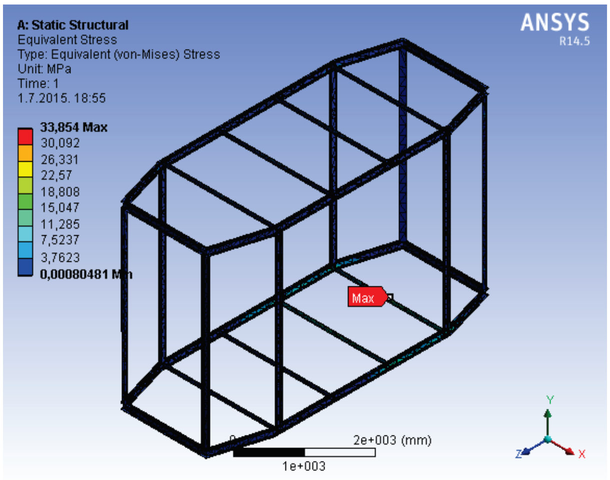

Figure 17. Distribution of equivalent von Mises stress for standard profile structure, MPa

6. Conclusion

In this paper, two variants of one multipurpose kiosk construction were analyzed. Structural members of first variant are made of bent sheet metal while frame members of second variant are made of standard profiles. Cross section area of members for both variants were almost equal, yet cross sections of used standard profiles are slightly bigger than bent sheet metal cross sections.

Deformations in variant with standard profiles are reduced compared to variant with bent sheet metal but both have acceptable values. Regarding the equivalent von Mises stress variant with standard profiles reduces maximum stress and gives less places with stress concentration. This is mostly because bent sheet metal is not totally closed due possibility of required insulation installation. From safety operation point of view both variant are well designed but in context of optimization of steel construction of multipurpose kiosk, variant with standard profiles could be more favorable solution. Also, it can be said that by using standard profiles, kiosk construction is simplified as well as insulation and panel installation.

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AGING BEHAVIOR AND RESTORATION BY HEAT TREATMENTS OF 2205 DUPLEX STAINLESS STEEL

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Abstract

The aim of this study is to try to refine the duplex microstructure without using conventional processes, as the thermos-mechanical treatments. The adopted way consists in carrying out and optimizing aging and annealing heat treatments. A preliminary treatment of hardening at 1250°C was applied to increase the proportion of ferrite in the matrix. The treatments of aging were carried out at the temperature of 850°C during variable aging times. The refinement of the grains occurs mainly in the ferrite phase; this being with the simultaneous germination of ferrite and austenite during the dissolution of the precipitates.

Keywords: Duplex stainless steel, Heat treatments, Microstructure, grain refinement

1. Introduction

Duplex stainless steel (DSS) with a microstructure comprised of nearly equal proportions of ferrite δ and austenite γ, combine the attractive properties of ferritic and austenitic stainless steels. Thanks to these characteristics DSS are widely used in such industries as petrochemical, pharmacy, marine and many other fields. [1-3].

However, a number of undesirable phases such as carbides, nitrides and intermetallic compounds may appear in δ ferrite areas and δ/γ interfaces if the manufacturing processes are not carefully respected. Among these secondary precipitates, σ-phase and carbides with fast formation kinetics have been particularly noticed because they can cause a dramatic deterioration of the toughness and the corrosion resistance of duplex stainless steels [4].

2. Experimental material and procedure

The material used in this study is a SAF 2205 duplex stainless steel (UNS31803). The material was received as tube of 170 mm diameter and 7mm in wall thickness. The chemical composition of this material is reported in Table 1.

Table 1. Chemical composition of 2205 DSS

	C	Si	Mn	Ni	Mo	Cr	N
Wt%	0.03	0.36	1.77	5.7	2.6	22.	0.13

The stainless steel was initially solution treated at 1250°C for 60min. After the annealing, and to search for the optimum heat treatment parameters, samples were aged at 850°C for different time intervals : 02, 10 and 30 hours.

At last, all samples were annealed at 1080°C for 10min., 30min. and 60min., in order to redissolve any precipitates and to restore the δ/γ phases balance of the 2205 DSS. All these heat treatments were followed by quenching in water.

Metallographic sections transverse to the welding direction were prepared for optical metallography using standard techniques for mechanical polishing. The etching was carried out with a glyceregia solution, containing 10 ml HNO3, 20 ml glycerol and 30 ml HCl. And an electrolytic etching was used with KOH solution at a potential of 12 V for 8s. σ-phase and δ-ferrite volume fractions were estimated by automatic image analysis using an ATLAS® computer program attached to a ZEISS optical microscope.

In order to examine the mechanical behavior of the DSS material, HV microhardness and Charpy impact test were performed. Impact tests were performed at room temperature

3. Results and discussion

The microstructure of 2205 DSS is shown in Figure 1. The DSS material has shown a ferrite-austenite structure, where austenite phases is distributed in the ferrite matrix with nearly equal amounts of ferrite.

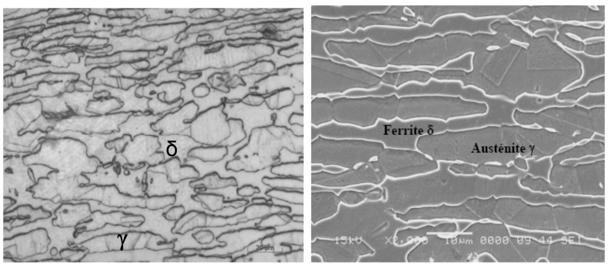

Figure 1. Optical and SEM microstructure of 2205 DSS as received condition

Figure 2 shows the microstructure morphology of the DSS annealed at 1250°C which has changed to a cellular form with a significant increase of δ ferrite grain size, causing a hardening of the material, as shown in figure 3.

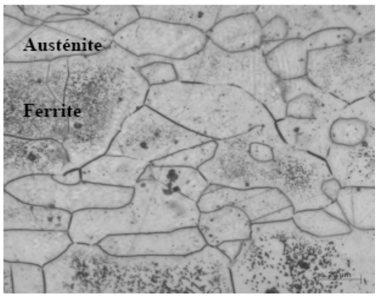

Figure 2: Optical microstructure of 2205 DSS after annealing at 1250°C

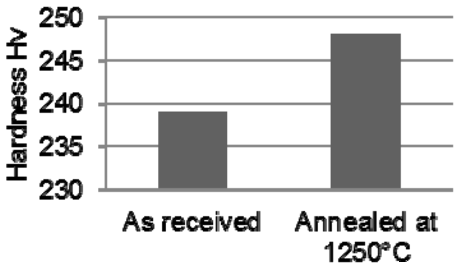

Figure 3: Hardness of SAF 2205 as received and after annealing at 1250°C

Figures 4a, b and c show the microstructures of the 2205 duplex stainless steel respectively, after 850°C aging at 2, 10 and 30 hours.

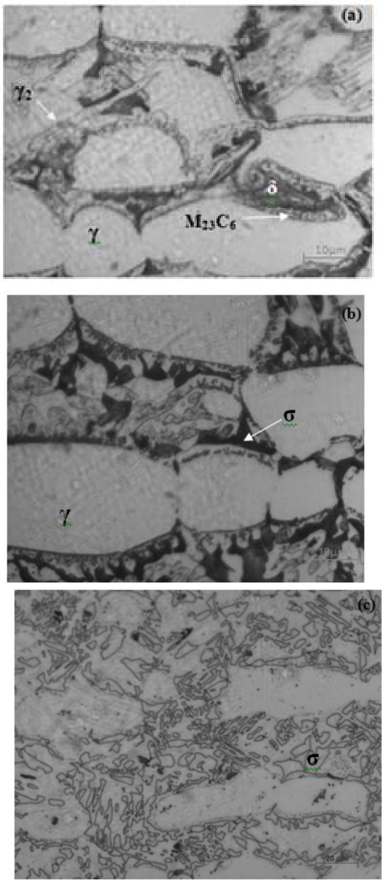

Figure 4: Optical microstructure of SAF 2205 aged at 850°. a: 02 h. b: 10h. c: 30h

Figure 4 shows clearly the presence of sigma phase at the ferrite austenite interfaces, which are considered as preferential nucleation sites for the heterogeneous precipitation of intermetallic compounds. The formation of sigma phase in duplex stainless steels is described by the decomposition of δ ferrite through an eutectoid transformation. After the nucleation process, sigma phase particles grow into the adjacent δ ferrite grains.

The precipitation of $M_{23}C_6$ carbides occurs first at the δ/γ interfaces, and grows with austenite into the δ ferrite grains. The nucleation and growth phenomenon of $M_{23}C_6$ carbides is accompanied with a migration of initial δ/γ interface boundaries into the δ ferrite phase [5-6].

Figure 5 shows a SEM micrograph of SAF 2205 aged at 850°C for 02 hours, revealing clearly the presence of the harmful intermetallic σ phase at the δ-γ interfaces

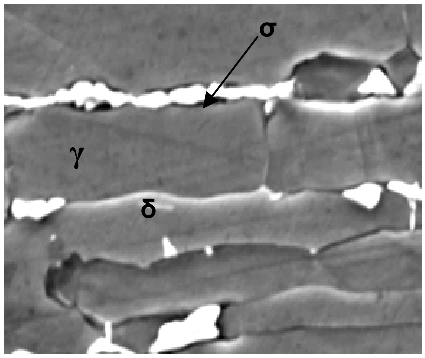

Figure 5: SEM microstructure of SAF 2205 aged at 850°-02h.

Figures 6 and 7 show respectively the evolution of the sigma phase volume fraction and hardness with aging time; the amount of sigma phase increases rapidly between 2 and 10 hours of treatment at 850 °C. After 10 hours, precipitation becomes less rapid. During the sigma phase precipitation in duplex stainless steel, as the amount of sigma phase increases the amount of ferrite decreases, until its total consumption. Because of Sigma is a hard phase, the hardness of the aged steel increases slightly with aging time. [7].

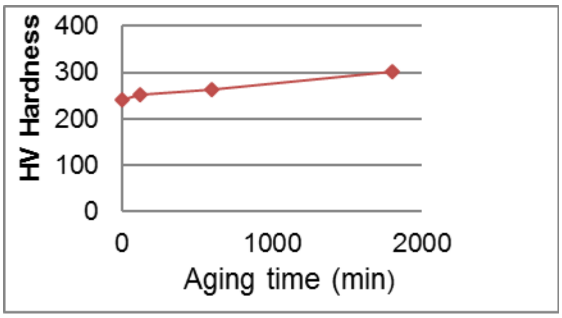

Figure 6: Evolution of Sigma phase fraction with aging time.

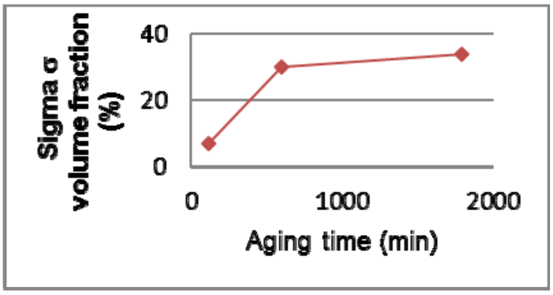

Figure 7: Evolution of hardness with aging time.

After aging treatments, all samples were annealed at 1080°C for 10, 30 and 60 min. and quenched in water. Only the treatment carried out for 60 min led to completely redissolve the sigma phase and precipitates and thus restore the δ/γ balance of the duplex stainless steel

Micrographs below (Figure 8) show a redistribution of δ-ferrite and austenite γ phases and a located refinement of ferrite and austenite grains. We also observe the presence of austenite fine grains within the bands of the δ-ferrite phase

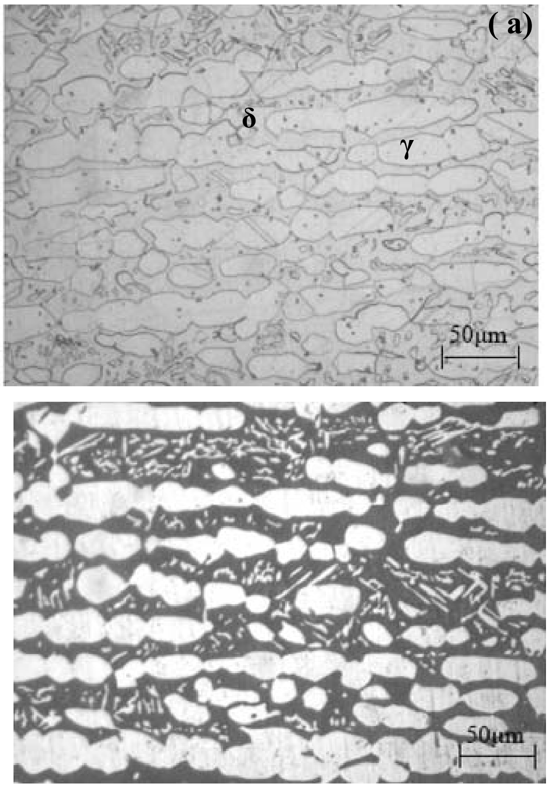

Figure 8: Optical microstructure after annealing at 1080°C-60min. of sample aged at 850°C -02 h
(a) Etching: Oxalic acid (b) Electrolytic etching with KOH

The phase repartitioning in the different samples was measured using a quantitative metallographic technique. The corresponding amounts of δ ferrite and austenite are given in Table 2.

It is noted that δ/γ balance of the duplex stainless steel was restored after annealing after 1080°C for 60 min.

Table 2. Ferrite and austenite volume fraction measured after 1080°C annealing - 60min

Phase (%)	δ	γ	δ/γ
Sample aged: 850°C-2h	49.8	50.2	0.99
Sample aged at 850°C -10h	50.4	49.6	1.01
Sample aged at 850°C -30h	47.1	52.9	0.9

Figure 9 shows fractography of impact testing, which revel a brittle fracture (cleavage). The micro-cavities show the high threshold of 850 °C embrittlement. This brittleness is due to the presence of the hard intermetallic sigma.

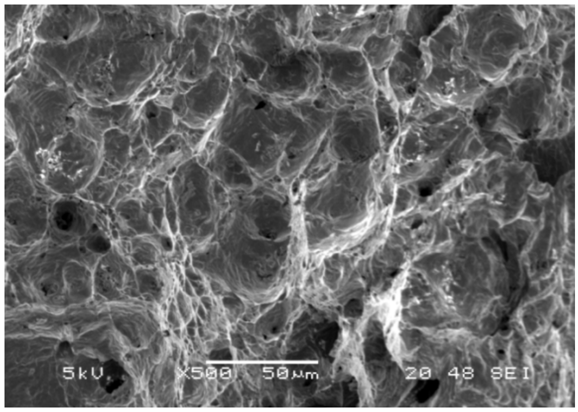

Figure 9: Rupture fractography of samples after aging at 850°C.

The mode of fracture of sample treated at 1080°C, is a ductile dimple fracture, like it is shown in Figure 10. Duplex stainless steels are composed of ferrite and austenite, where both of the two phases have a wide range of plasticity.

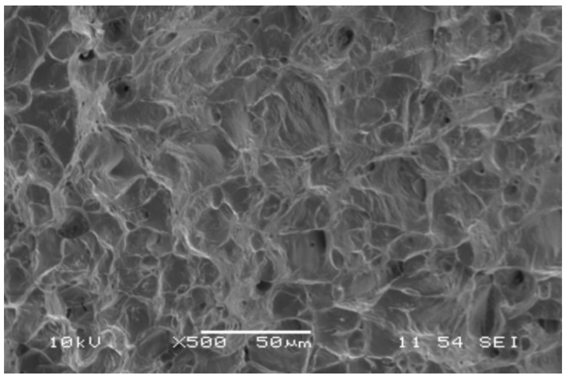

Figure 10: Rupture fractography of samples after annealing at 1080°C.

4. Conclusion

Heat treatments carried out at 850 °C, modified the structure of the 2205 duplex stainless steel by causing the appearance of a precipitation phenomenon. The precipitates were identified by X-rays diffraction as an intermetallic σ phase, and $M_{23}C_6$ chromium carbides.

This precipitation occurs in the interfaces ferrite /ferrite and ferrite/austenite and is propagated inside the ferritic grains.

The phases balance of the duplex steel was restored after treatment at 1080 °C, and grain refining was mainly observed at the ferrite, caused by the simultaneous germination of δ-ferrite and austenite γ at the dissolution of precipitates and intermetallic phases

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SLOVAK AND CZECH FOUNDRIES – BENCHMARKING OF THEIR PROSPECTS IN THE MARKET

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Abstract

In every industry the businesses are adapting to the free flow of information between enterprises, new value chains, or even completely new ways of designing, manufacturing, delivering and servicing product. The paper discusses how the Slovak and Czech foundries can remain competitive in future. The questionnaire survey was conducted to gain information on the prospects of foundries as producers.

Keywords:

competitiveness, quality, SME, foundry industry

1. Introduction

Under the current conditions of globalization and economic turbulences, the companies strive to improve their performance, competitiveness and credibility of in the framework of international markets. In every industry, the businesses are adapting to free flow of information between enterprises, the new value chains, or even the completely new ways of designing, manufacturing, delivering and servicing of a product. The competition has also changed and intensified. Since the traditional industry barriers are disappearing, the competition is international and creates a few significant players in some industries while other smaller and more nimble players move to take advantage of the regional markets.

The main aim of this paper is to discuss if the Slovak and Czech small and medium enterprises (SMEs) doing the foundry businesses can remain competitive in the future. To fulfil this goal, the survey was conducted in foundries to gain deeper information on foundries as the producers.

Nowadays, the Slovak and Czech foundries are recovering again. Nevertheless, there are some threats. The environmental legislation has tightened up, and environmental protection requires more financial resources. In a segment of castings, the market price level is affected by imports from the low-cost Asian countries, especially China or India, which have become the stiff competition and affected inquiries, prices of the raw materials and uncertainty of their availability, the energy and products prices significantly [1]. Under such conditions, foundries can become economically and environmentally sustainable businesses with the system approach offered by implementing lean and green methodologies when the synergetic effect of their adoption has the obvious impact on productivity, quality, cost reduction, continuous improvement, and technological innovation [2].

2. Quality improvement – how to remain in the market

Competitiveness level of SMEs depends mostly on their ability to perform practices like costing, quality, requests response, products delivery, innovation, and their flexibility to adapt themselves to the possible variations in the demands and markets. To keep pace with an international competition, companies of all size are challenged to innovate and improve their products and processes constantly. The innovation, firm's knowledge accumulation and development of internal technical capabilities help the SMEs in achieving a better competitive position in the market. The important feature exhibited by a successful company is its ability to respond to the identified changes in the market or customers' behaviour. Implementing of innovations requires an ongoing effort and understanding beyond that of a continuous improvement because the effective innovation must involve all areas of the SME with potential for having an effect on every process [3].

To meet the rapidly changing product features and the customer needs, SMEs should build a dynamic capability to develop the new-to-market products. An investment in a product research and development will also help with improving in a quality and reducing the costs.

The costs of product development and the market uncertainty are considered to be major determinants confronting the product development. This growing uncertainty in the SMEs' environment has led to increased levels of critical success factors for the applications of the advanced manufacturing technologies. There should be linking between the capabilities of the technologies and the firm's business and manufacturing priorities. The technologies have effect on the competitiveness in two ways. Firstly, by altering the price structure through the development of more efficient and flexible processes and secondly, by enabling the creation of better products of greater quality, better design, after sales service and short delivery periods. The computer integrated manufacturing helps SMEs to reduce the lead time, increase flexibility, reliability and to improve customer service [3]. The timing for introducing the innovation is usually a balance between the urgency with which it is needed versus resources that are made available for its development. For the higher growth, the small firms should focus on the research and innovation in the longer term.

When assessing the competitiveness of SMEs from the view point of innovations and the quality improvement, there is due to mention the importance of a synergy effect between lean methodologies and environmental sustainability. While implementing a lean manufacturing system does not necessarily lead to environmental sustainability, including environmental and other sustainability components within a lean system improves a company's ability to make continuous improvements in both cost and environmental impacts. For example, the use of less toxic, more recyclable, or more easily processed materials was significantly correlated to increased profits as well as increased customer satisfaction and profitability [5]. Another strategy contributing positively to a clean and green production is total productive maintenance, which can by increasing the equipment productivity and environmental compatibility improve the performance of an organization.

To assess comparatively the enterprises' position in the market there can be used the benchmarking. It is known that identification and the transfer of the best practices are considered to be a difficult task for SMEs due to severe resource constraints and limited knowledge of the benchmarking methodologies. However, benchmarking of processes and performance metrics has the positive impact on their competitiveness. For supporting continuous improvements in the different processes and performance, SME should set some benchmark standards as their targets, and adopt benchmarking as an on-going process.

3. Surveys on competitivness of Slovak and Czech SMEs' in foundry industry

In the beginning of the introductory study, the authors conducted the literature review in order to identify the world trends in the casting production [4, 5]. The gained information has shown that the lean and green foundries are the key to the future. Their priority is not simply to increase the production capacity but to form the added value accompanied by the effective integrated environmental protection. The sustainable and competitive foundry with the long-term prospects should focus on the extension of its value added chain in the design, prototyping, testing and the in-house production depth providing machining and assembly, time and cost optimization of process planning, the energy effective technologies, the automation of manufacturing processes, the complex lightweight and the multi-material castings, the continuous growth of the intellectual capital, and the sustained quality improvement in relation to all customers. For the future, their lasting task is the environmental protection especially waste management and air protection.

There were some reasons why authors have decided to analyse the Czech and Slovak foundry industry. Besides the long-time tradition in casting production, in recent years, the Slovak and Czech foundries have faced to similar difficulties like the other industrial productions. The most significant factors having an impact on foundries' economy have covered growing in the raw material prices, energy costs, costs of environmental protection etc. Besides, there are several additional issues which have to be addressed by foundries as qualified labour shortage, increasing labour productivity, investment in progressive green technologies, investment in environment protection, or improving management effectiveness. It is becoming apparent that the shortage of skilled labour is one of the most important and critical production factor caused by long-term little interest in the field of foundry technology. Furthermore, the Slovak and Czech foundries are not drivers for research and development but more consumers of R&D results produced by other institutions. And finally, for the last years there have arisen intense competition of Chinese and Indian suppliers in this branch.

According to the census of world casting production, Slovak and Czech foundry industries have returned to the world market in 2011. Slovak metalcasting output increased of 56% since 2008 when there was produced 71 000 metric tons, with a majority of its tonnage in aluminium. Czech Republic registered the dramatic 34 per cent growth, when there was produced 460 000 metric tons of the castings, with the majority of the tonnage in the cast iron. Although the foundries do not rule the economy, as a main input into nearly all of the industrial product and daily life, castings are indispensable.

The questionnaire survey was chosen as the data gathering method. The reason for using this method was that no earlier information about the theme was available. Its aim was to gain information on the trends in the Czech and Slovak foundry industry, on the basis of which one could identify the crucial factors and highlight the potentials for the next improvement to sustain the competitive ability. It mapped the areas, which the authors considered necessary to assess the domestic development in this industry following the literature review and the opinions presented by the industry representatives. The anonymous questionnaire included the open-ended and closed-ended questions. The set of seventy four questions made up of five groups, which concentrated on (1) basic business information (15 questions), (2) quality management (15 questions), (3) technological characteristics of manufacturing processes

(22 questions), (4) mould sands (12 questions), and (5) the cooperation with universities (10 questions). Authors emailed the questionnaire to 178 Czech foundries and 51 Slovak ones; they received eleven Czech (6%) and nine Slovak (18%) responses. Considering the low involvement in survey the conclusions drawn from processing data are valid for the group of twenty respondents only.

After data collecting, the set of data was sorted according to the size of enterprises; and for the first basic analysis, the records of SMEs were only used. This category consisted of six Slovak and seven Czech foundries, which have a few common characteristics. Generally, they supply the castings mostly in the domestic and EU markets. Because of automotive, machine and energy industries are their primary customers all foundries have implemented and certified quality management system according ISO 9001 or other standards that require substantial and up-to-date documentation, which should help to ensure that the correct and best management methods are followed.

One of key issue of the survey was an analysis of the structure of value added chain. In the competition, the foundries can survive by supplying the ready-to-install cast components or subassemblies directly to customers' assembly line. They should provide not only the assistance in design of components to the assembly supplier, but they should have the active involvement in the part design and in the near future, they even should go into the backward integration with the complete engineering, prototyping, testing and sampling responsibility. Forward integration will be a necessary investment for survival with machining and assembly.

The present structure of the value added chain in sets of participated foundries is documented in Figure 1. It is evident that in Czech foundries the share of design and development activities (D&D) is reaching about 72%, and the Slovak foundries keep the level below 60%. On the other side, more Slovak casters provide the complex services from pouring, finishing to assembly for their customers in one place. In years after 2005, the investments of all foundries were channelled into new technologies and machines relating to the core activities as melting unit, mould and core making, and air protection.

When studying the survey data the authors kept in mind the difference between these two selected foundries consisting in the technological base and the range of casting's material. Participating Slovak foundries specialize narrowly in the high-pressure die casting to produce the castings from the AlSi alloy (66%) or gravity casting to produce the cast iron castings (34%). All participating Czech foundries used gravity casting to produce the castings from the cast iron and moreover, they have diversified their business portfolio into high-pressure die casting and other material as the AlSi alloys, brasses and bronzes (57%). Such flexibility in the technologies and materials makes it possible to them to penetrate into the new markets. In the period 2010 – 2012, all participants insert into a production plan the new types of castings, but only 33 % of Slovak respondents and 71 % of Czech ones began to supply their castings into new market. The use of CAD/CAM technologies should be the common part of engineering activities of the foundry. Survey participants indicated that 86 % of Czech and 33% of Slovak casters regularly use these technologies for their D&D activities but they also stated that the computer simulation of casting processes is used by 71% of Czech and 67% of Slovak respondents.

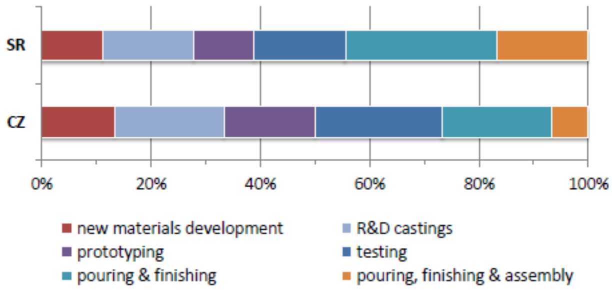

Figure 1. The characteristic of the value added chain in sets of participated foundries.

The next factor that can help to SMEs to endure in the market is applying of appropriate tools and techniques for quality planning and improvement on understanding that they are used correctly. The survey showed that enterprises employ on the average three tools. The intensity of using selected tools and techniques applied to improve the quality and the processes in the participated foundries is documented in Fig. 2. About 60% of all respondents regularly utilize Pareto analysis and statistical process control (SPC), when Slovak casters (67%) prefer to Pareto analysis and the cause and effect analysis, and more than 86% of the Czech foundries uses the SPC methods to monitoring the income materials, melting processes, and the mould and core lines. It is worth noticing that only 75% of foundries supplying the automotive industry reported utilizing the FMEA, although it is an obligatory standard.

The survey highlighted the substantial potential in the area of reducing costs and improving the environmental characteristics. The positive fact is that all foundries have implemented the total productive maintenance programme. The view is less optimistic when considering that only 54 % of respondents reported about implementing the cost reducing strategy. Figure 2 documents that for example the lean manufacturing techniques as green value stream mapping are underestimated, even their positive impacts on business results as the quality, costs, the product design or the process waste were proved.

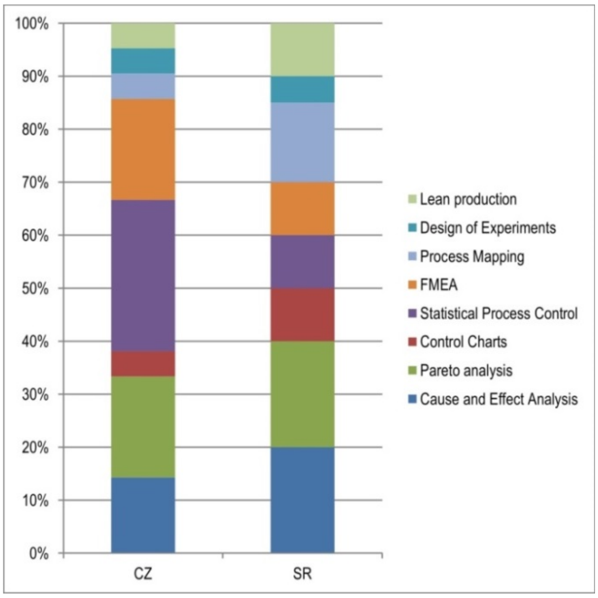

Figure 2. Tools and techniques applied to improving the quality/processes in participated foundries.

The perspective on information gained from done survey corroborates authors' opinion on the need for benchmarking the performance values with the best in class in various areas impacting on the competitiveness. This benchmark comparison could extend from cost reduction for all process steps, energy usage, scrap, the machine overall equipment effectiveness, uptime, lead times, delivery, etc.

4. Conclusion

Today, the organizations deal with the vertical integration, new technologies, just-in-time distribution, total quality management, continuous improvement, business reengineering, etc. To survive into the next decade, they need to adapt their structures, processes, products and markets to be able to quickly respond to the market, to be the customer focused, innovative, flexible and be able to handle the rapid change. The foundries could make the investments in the staff, CAD systems, and the research-and-development capabilities those the true partnership with their customers requires. Authors think that in the future, the foundry should sell its know-how and services instead of the capacity, because the capacity suppliers can be more easily switched to other suppliers, and they are more vulnerable to the imports from low-cost countries.

5. Acknowledgement

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DUAL TRAINING IN THE LIGHT OF VEHICLE ENGINEERING STUDENT FEEDBACK

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Abstract

The Kecskemét College dual training model in higher education is a system during which the students complete half of their practical training within their studies at a given company. The biggest difference between the traditional undergraduate training and dual training is that students acquire theoretical knowledge and related practical training in real-world conditions and learn to use it. The aim of the training is to train highly-qualified, competitive engineers who are ready to respond to the demands of the continuously developing industrial companies, moreover, are able to satisfy the needs of the changing labour market. The dual training was introduced at Kecskemét College, Faculty of Mechanical Engineering and Automation (GAMF) among vehicle engineer students in 2012. Currently the training is realized at all four courses of GAMF; Mechanical Engineering BSc, Vehicle Engineering BSc, Engineering Manager BSc and Information Technology Engineering BSc. 33 industrial companies and about 170 students will take part in the training by September 2015. In the publication we wish to give an insight into the dual training model of Kecskemét College., focusing on its educational importance. Dual training can be assessed from several aspects. In our paper we drew conclusion on the feedback of vehicle engineering students concerning the strengths, weaknesses, development possibilities and risks of the training. We wished to make the interpretation of data more accurate with the help of a controlled trial. The survey was carried out among non-dual students as well. The method based on self-assessment and subjective evaluation was completed with the objective data of the academic achievement of the students. The analyses show those components of the dual training, which are regarded positive by the students or which need improvements. As a result of the research we received a feedback of the motivation and expectations of the students as well as of the efficiency of the training. The paper highlights on those disadvantages and areas of improvements both from the side of the institution or the company, which are to be definitely improved. According to the feedback of the students dual training contains several kinds of educational and methodological challenges, which are to be solved together with the higher education institutions and industrial companies functioning as training places.

Keywords: dual training model, student satisfaction survey, cooperation, industrial companies

1. Introduction

The strive for the development of the dual or practice-oriented higher education in Hungary was introduced by Knorr-Bremse Brake System Ltd and Mercedes-Benz Manufacturing Hungary Ltd in 2010 initiated by Kecskemét College, Faculty of Mechanical Engineering and Automation (GAMF) providing vehicle engineering and technical trainings. With matching the Hungarian conditions and sharing the dual- system training with the industrial companies the aim is to fit the expectations of the industry and to provide labour supply with adequate academic knowledge and practical experience [1].

In this nationwide innovative training the students expand their academic knowledge in real life conditions at companies during the practice period thus gain experience in their future profession.

The training system creates competitive workers who immediately – without several months or even years of training and other financial expenses-are able to enter the world of work and meet the expectations. The last three years proved that there is a huge demand for this practice-oriented training in which Kecskemét College is at the forefront. In the semester of 2015-16 not only Kecskemét College starts (and continues) this type of training but 21 higher education institutions in the country. This is the reason why this system should be examined and monitored continuously according to several aspects and arising problems be treated appropriately.

2. Dual training based on the monitoring test of students' feedback

The first year of dual training was introduced at Kecskemét College, Faculty of Mechanical Engineering and Automation on vehicle engineering BSc in 2012. In 2013 autumn a long-term research was launched among students taking part in dual-training in the interest of collecting student reviews. The aim of the research was to reveal the short-and long-term goals of dual students, moreover, their motivation and their opinion on academic training and related practice.

Following the analysis of the results we wish to make recommendations on those methods and tools, which may contribute to the efficiency of dual training [2].

3. The model of research, its methodology and measuring tool

Our model of research is based on 22 vehicle engineering students taking part in dual training and 32 vehicle engineering students studying in the traditional form as control group. Data collection was made through questionnaires which were filled in during the course of lecture. The given answers were anonymous and voluntary.

The research involved 92 items in closed questions carried out among students in dual training having completed their first year. Students had the possibility to give their independent opinion in six open questions. As background data gender, age, place of residence, employing company and course was collected.

In the first group of closed questions goals and motivation were revealed. The second question group with the help of four-point Likert scale measured the satisfactory of students concerning college and company. In the last unit of closed questions student activity in education and at companies were examined. The open questions on one hand referred to the strengths, weaknesses, development possibilities and risks of the training.

4. Research results

In the first unit of the questionnaire the motivation and concept of students taking part in dual training were revealed.

Most of the asked students chose this alternative way of training in the hope of finding a well-paid job after the seven–semester-period of study. Students hope to get professional practice at a professional company (Figure 1).

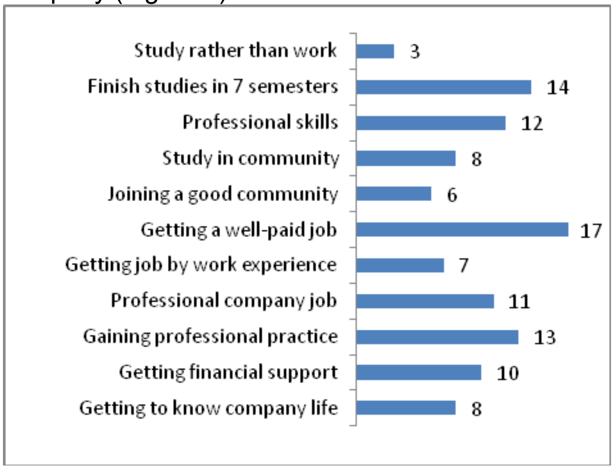

Figure 1, Motivation of dual students (n=22)

Among non-dual students besides getting a well-paid job gaining professional knowledge and community learning and life are specified motivation. It can be seen that students belonging to this group make less effort to finish their studies according to the sample curriculum within 7 semesters, Fig. 2.

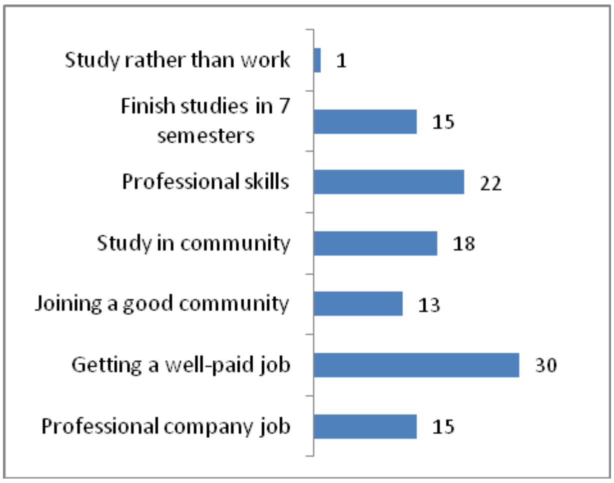

Figure 2, Motivation of non-dual students (n=32)

Besides motivation we were also interested in the opinion of students based on experience after the first year. We wished to reveal the satisfaction of the students both on practical education at different companies and academic education at the College, moreover, on their individual achievement and their point of view on college community.

As not similar numbers of questions were applied on certain factors and the number of people being asked in the two groups was different as well, % accurate composite indexes were created. Based on their first-year experience dual students are significantly more satisfied with the training at companies (88 % in average) than with the academic education at college (62% in average). The students are absolutely satisfied with community life (86% in average) and also with their results (77% in average). Non-dual students are more satisfied with the training at the College than dual students (71% in average). These students are less satisfied with their own results and achievements (51% in average), however, are similarly satisfied with community life as dual students (87% in average), Fig. 3.

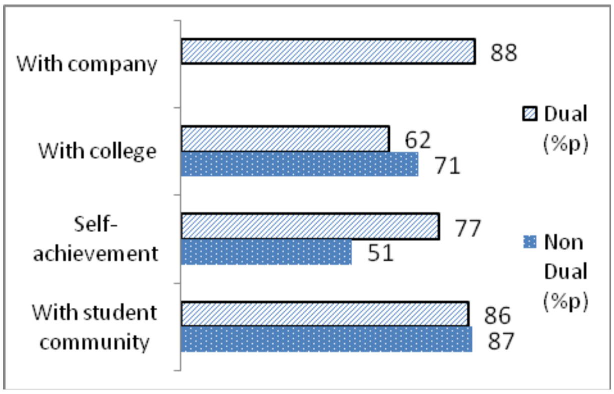

Figure 3, Average satisfaction index

Dual students are more critical on college education than those of their counterparts who do not have a chance to experience company atmosphere. The students on both sides were mostly satisfied with the quality of the tools used at the College and at the company, moreover, with the professor–student relationship. Among non-dual students the least satisfactory is the possibility of gaining practical experience and the standard of practical training. Dual students were dissatisfied with the application of academic knowledge at the companies and with the quantity of tools at the College.

Based on the above written it can be stated that among dual students some company data is slightly better than its college counterpart. This suggests that our students highly value the studies at companies and praise both the readiness of the company professionals and the technical conditions of the companies.

From 18 dual students 14 are satisfied with their own achievement and personal professional development. The dissatisfaction concerning personal achievement refers to high motivation background.

The third unit of the questionnaire refers to the activity of the students in education and practice based on their own admission. Student activity can manifest itself in different ways. One possible form is when students outside lesson pursue professional consultation with college or company instructor. The other metrics of student activity can be the contact with instructors via e-mail. The presentations, project works, attendance at conferences during school year also gives information on student activity. Attending lectures at the college is not compulsory; however, the information on who took part on what percentage at the lectures shows student activity as well. Dual students were significantly more active from professional aspect than their counterpart; during the semester college professors were contacted more outside lectures in relation with professional questions, Fig. 4.

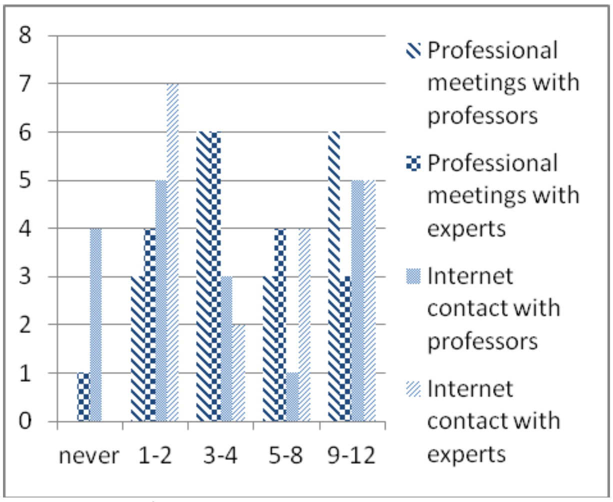

Figure 4, Professional activity among dual students

Likewise dual students gave more presentations at the College. Concerning lecture attendance there was no difference between the two groups. By their own admission students attended 40% of the lectures.

5. Opinions of the students on dual training

During the research getting to know the students' personal views on the strengths, weaknesses of the training is of great importance. The same applies for those fields of the training where students see more possibilities or find the form of training as risk factor.

In our paper we wish to give an insight into the opinion of the system from dual students.

Among the strengths the following were mentioned by most: the possibility of gaining high-quality and professional work experience, learning to work in a team, the acquisition of up-to-date technical knowledge, workplace guarantee and the chance to build professional relationships. In addition financial independence, motivation to be more successful, moreover, getting an insight into company life and the practice of foreign language were also among the strengths of the training.

The comments were the following:

“Learning discipline and getting to know company hierarchy”.

“We get to learn useful things at the company with up-to –date tools which can be really used in the industry”.

“The strength of this training lies in creating engineer vision and approach, thinking system-wide and prepares us for real life.”

"At the end of the training the companies already get to know the students thus they can be placed in position easier."

“The training gives us motivation to be better.”

Among weaknesses the inappropriate communication between companies and the College was mentioned causing misunderstandings and problems at times. Students also lack the harmony regarding the curriculum. Students mention the deficiency of schedule and organization, moreover, the lack of control from the institution towards companies.

Among the weak points the yet not sufficiently developed teaching materials and their coordination between the companies and the College are also mentioned. In many cases the expectations on knowledge from companies are unreal. The lack of pedagogical skill on company expert's side is also considered a problem.

The comments were the following:

"The expectations are much higher, rather suitable for a master's level than a BSc."

"At some level this training divides both student and teacher community"

"Subjects should focus more on practical and up-to-date knowledge."

"There is no full parallelism between the students' daily studies and the ones they get to learn at the College."

"Company experts do not take our knowledge into consideration, we face very high expectations from the company"

"Communication is weak between company and institution as well as between company and student."

"Companies do not have a well-practiced training theme, we face teaching deficiency and inadequate qualified teachers deal with students."

We wished to know what recommendations students made regarding the development of dual training. These suggestions were the following: expanding the training on other courses, involving more companies in the training and taking part in more project works. The recommendations also referred to having common tasks with different companies, the more thorough readiness of college professors concerning the peculiarity of dual training and keeping to the schedule more precisely. The possibilities then arise by themselves as experts aim at eliminating the weaknesses. Among the possibilities students hope to make better use of their time. Many students emphasized the importance of communication in foreign language. In addition they see an opportunity to get more training at practical management skills.

Here are the comments:

"I would like project work from first year in order to develop independent problem-solving skills."

"More communication in foreign language to expand our professional vocabulary."

"Some company experts need to develop methodological skills."

"Institutions should help to create a more practical timetable for dual students."

"With so many different companies taking part in dual training thinking together more often is a good solution to develop this training."

The training is considered to be risky, if it only focuses on one specialized field, and is adapted to only one company's needs. Among the risks the difficulties with the students' schedule are mentioned especially during the examination period. If too many changes are made it can make it more complicated. Dual students can get socially isolated as well due to the lack of free-time. Stress and being overburdened are also mentioned as risk factors among students. The not similar quality of practical education among companies can be a risk as well.

The opinion of students are the following:

"There is a big difference between company and company; it is difficult to achieve the same quality practical education."

"We, dual students have less time to prepare for exams, thus, it might negatively affect our academic achievement."

"The small amount of free time leads to isolation from college community."

"We are oriented in one direction, the interest of a given company is forced on us."

"Due to the popularity of dual training too much stress is put on us as the expectations in some cases are very high."

The collected data on SWOT analyses with the help of the questionnaire show that dual students take their studies and work seriously and are eager to adapt new ideas, teaching methods in order to become professional engineers.

Among future tasks and possibilities the aim is to create a real link between higher education and the world of work. Cooperation between professors and company experts are inevitable as well as transferring up-to-date knowledge.

Dual training gives a chance for the institutions to develop different skills and competencies of company experts who lack pedagogical skills. The aim is to achieve motivated and target-oriented students who can give the basis of a competent engineer.

6. Learning results

In order to assess the training the learning results of the students are of great importance.

We have compared the accumulated average results of dual and non-dual students studying in the academic year of 2014-15. It can be seen that the accumulated average results of the dual students are 0.4 tenths better than those students who study in the traditional form, although, students taking part in dual training spend significant time at companies besides the academic training and get several tasks to fulfill.

In case we have the acquired credits and the fulfilled credits compared it can be well seen that while dual students acquired 33 credits in average fulfilling 59 credits out of it, non-dual students undertook less credit points (31) and fulfilled (45) significantly less (Figure 5,)

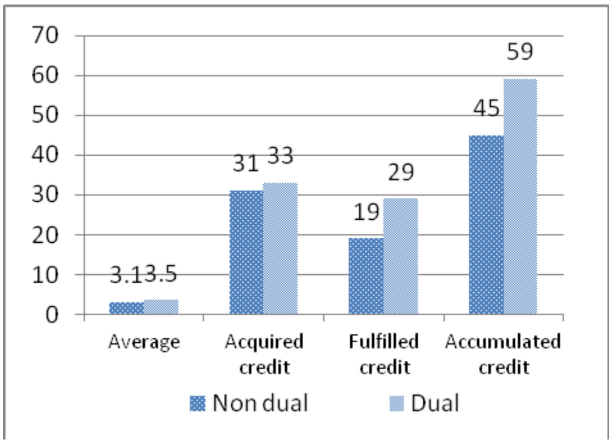

Figure 5, Professional activity among dual students

These results confirm that students trained in the College in the dual type of system achieve better learning results than those of non-dual students. Moreover, a year before their graduation dual students achieved more with the average of 14 credits than non-dual students. Based on the results of similar research carried out in previous years it can be admitted that students studying in dual training form achieve better learning result on regular basis than non-dual students. [3].

7. Conclusion

The first results of our research indicate that dual students starting this training are goal-oriented. They wish to gain professional knowledge and practice besides academic knowledge. Gaining work experience and getting an insight into company life are also important factors. The students are dedicated towards their profession and are ready to study in a different work schedule which provides less free-time than to those students who study in the traditional form. Dual students think responsibly concerning their future in which professional development and fulfillment play an important role.

The students drew attention on a number of factors that after a thorough consideration can contribute to making the training more effective. The systematic development of the training, identifying its processes and integrating the regulations into the system of the College are all important tasks to solve.

From pedagogical and methodological perspective it is essential for college professors and engineers at companies taking part in the training to become familiar with the new student-centered teaching methods and work forms which are suitable for a new type of learning form.

8. Acknowledgement

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RECENT TRENDS IN WHEY UTILIZATION – PRODUCTION OF BIOACTIVE PEPTIDES

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Abstract

In this paper, a process for production of whey hydroysates and bioactive peptides is presented. Whey protein concentrate was hydrolysed by using bacterial protease Proteinase K. After ultrafiltration of hydrolysates through three molecular cut-off membrane (30 kDa, 10 kDa and 3 kDa) bioactive peptides were obtained. Presented results indicate that hydrolysate produced under these conditions could be an effective nutraceutical and utilized in food industry.

Keywords: Whey, hydrolysates, biopeptides, ultrafiltration, activity

1. Introduction

Whey is a valuable by-product of cheese making in dairy industry. The main problem of the dairy industry is that only 10-20% of milk is used for the preparation of products, while 80-90% of milk is waste or whey. Disposal of whey into waterways leads to huge consumption of oxygen and the death of flora and fauna. Totals quantity of produced whey is 50% of waste and the develop–ment of modern industry tends towards a better and more efficient utilization of whey in order to preserve the environment.

Whey is a liquid which remains after coagulation of the casein proteins in cheese production. Lactose and soluble proteins are the major com–ponents of whey solids. Typically, whey contains about 4.6% lactose, 0.8% protein and 0.6% fat.

Today, increasing of cheese production caused the technological development of processing whey. Many studies have been focused on using of whey protein in the human diet due to its bioactive properties [1,2]. Lactose also may be used in the pharmaceutical industry as a supplement in infant formulas, in bakery products and lactose may also serve for bioethanol production.

Whey protein is a mixture of globular proteins and rich in all essential amino acids and the branched chain aminoacids (leucine, isoleucine, and valine) (>20%, w/w). It has a biological value that is 15 % greater than an egg protein, the former benchmark. Approaches to modify protein functional and biological properties are numerous encompassing chemical, physical and enzymatic treatments that cause changes in protein conformation and physicochemical characteristics. Enzymatic modification is the most extensively researched protein modification [3]. Biologically active peptides can be produced from whey protein in the following ways: fermentation of whey with proteolytic starter cultures, enzymatic hydrolysis by digestive enzymes and enzymatic hydrolysis by enzymes derived from microorganisms or plants. Molecular changes occuring during protein hydrolysis result in modified technological behaviour of the hydrolysates, such as altered solubility, viscosity, sensory properties, emulsion and foam properties.

Biopeptides from whey hydrolysates contribute significantly towards various biological functions, including antihypertensive, antimicrobial, immuno–modulatory [4] and antioxidative [5,6] activities, while some of the peptide fragments could exhibit more than one biological function. These activities can significantly contribute functionality of food products [5,6].

These peptides can be then incorporated into food products and/or nutraceuticals, and edible biopoly–mers to obtaining their optimum functionality, bio–availability and stability.

Today in Serbia, manufacture and export of whey is almost non-existent. Annually, the Serbian exports of whey valued at tens of thousands of dollars, while imports were significant, ranging from 1.9 to 4.7 million dollars. Most are imported from Croatia, Belgium, the Netherlands and Hungary. Serbia is a country in which the structure of milk production is such that almost 90% of the products produced each year belongs to the group of fermented products and liquid milk. It is not difficult to see that the production and processing of milk in Serbia is mainly directed to products that do not require a lot of time, for which the technological processes of production are com–plex and lengthy [7].

In terms of prospects of utilizing whey as a raw material in accordance with the existing equipment in Serbia, the main goal should be encouraging the utilization of whey in the food industry. The integ–ration process of processing whey into the food industry does not require large investments and due to whey certainly been thrown, it is not difficult to conclude that this aspect of their exploitation is a direct benefit both in material and functional terms.

This work analyzes whey protein modification using enzymatic hydrolysis with Proteinase K. The objective of this study was to determine and compare bioactive properties of hydrolysates and peptide fractions.

2. Materials and methods

Whey protein concentrate (WPC 80, 80 % protein based on dry weight) manufactured from sweet whey (DMV International, Nederland) were used. Commercially available protease used in this work was Proteinase K from *Tritirachium album* (E. C. 3.4.21.64, Sigma-Aldrich Chemie Gmbh, USA).

WPC was reconstructed in water to give a starting protein concentration of 4% (w/v). The mixture was allowed to hydrate for 1 h at room temperature with gently stirring. Hydrolysis was performed using Proteinase K under optimal conditions: pH 8.0/37°C. The enzyme/substrate ratio was 1% (w/w). During the course of the reaction, pH was kept at a constant value by adding 1M NaOH, using pH-stat method with automatic dosage of the base. The reaction was stopped after one hour by heating the mixture at 90°C for 10 min to inactivate the enzyme. The hydrolysate obtained was cooled down to room temperature and centrifuged at 3,500×g for 30 min.

The use of ultrafiltration (UF) membrane system is appropriate to obtain protein hydrolysates with desired molecular mass range. The ultrafiltration was performed using a Millipore ultrafiltration stirred cell unit (Model 8050 1 Unit, Millipore Corporation, Bedford, MA, USA) through cellulose membranes (Millipore, Merck, Germany) with 30, 10 and 3 kDa molecular weight cut off (MWCO), sequentially, under 20 psi nitrogen gas. A sample of 15 mL hydrolysate was first ultrafiltered through a 30 kDa membrane to obtain two fractions: retentate (representing hydrolysates >30 kDa, fraction F1) and permeate (MW <30 kDa). The permeate fraction was further ultrafiltered through a 10 kDa membrane to yield retentate (represen–ting hydrolysates between 10 and 30 kDa, fraction F2) and permeate (MW <10 kDa). The permeate was further ultrafiltrated through a 3 kDa mem–brane to obtain retentante (representing hydro–lysates between 3 and 10 kDa, fraction F3) and the finale permeate (representing hydrolysates <3 kDa, fraction F4). Procedure is shown in Figure 1.

Radical scavenging activity was determined using a 2.2- Diphenyl-1-Picrylhydrazyl (DPPH) free radical scavenging assay with some modifications [8]. 0.1 mL of sample with different concentration of peptide from each fraction was mixed with 0.9 mL of 0.1 mM-methanolic DPPH free radical. Mixtures were vortexed for 10 sec to homogenize and left to react for 30 min in the dark. Finally, absorbance was measured at 517 nm using UV Visible spectrophotometer. The antioxidant activity was expressed as percentage of DPPH activity calculated as:

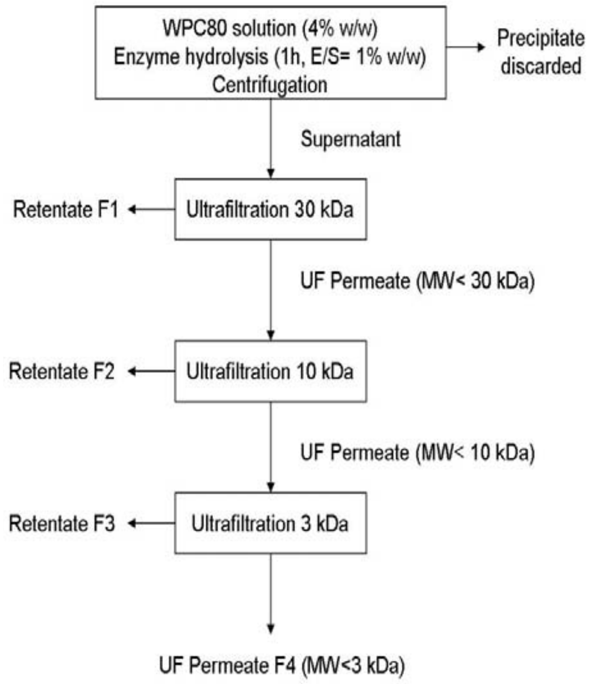

Figure 1. Ultrafiltration scheme

$$DPPH\ activity\ (\%) = \frac{A\ (blank) - A\ (sample)}{A\ (blank)}\ x\ 100$$

The IC_{50} value was defined as the concentration required scavenging 50% of the initial radical. Lower IC_{50} value indicates higher free radical-scavenging ability.

ACE inhibitory activity was measured according to the method described by Staljanssens et al. [9] with some modification. Samples were diluted to different extents with distilled water. The ACE catalyzed reactions (37 °C for 2 h) were performed in cuvettes containing sample solution, ACE solution, and HHL solution (A1). Another mixture containing sample solution and buffer (borate buffer with pH 8.3) (A2), was used to obtain the background absorbance of the sample solutions for the colorimetric method. The third mixture containing buffer, ACE solution, and HHL solution (A3) was used to obtain the data for 100% reaction. The fourth mixture containing buffer (A4) was used to obtain the background absorbance of the OPA reagent. The enzymatic reactions were terminated by adding OPA reagent (pH 12). The absorbance at 340 nm of all samples was measured after 20 min incubation at room temperature. The inhibitory ratios were calculated by the following equation:

$$ACE\ inhibition\ activity\ (\%) = \left(1 - \frac{A1 - A2}{A3 - A4}\right) x100$$

The IC_{50} value (inhibitor concentration leading to 50% inhibition) is used to estimate the effectiveness of different ACE inhibitory peptides.

3. Results and discussion

Many food proteins, including whey proteins, possess biologically active peptides which can be released by hydrolysis. Chemical hydrolysis causes loss in some essential amino acids as tryptophan and many researchers have shown that limited enzymatic hydrolysis can result in improved functional and nutritional properties and biological activities [10-13]. Hydrolysis of WPC with digestive enzymes is a very common practice and it is many results achieved. In this study was examined less used non-digestive enzyme, Proteinase K isolated from the *Tritirachium album*.

Hydrolysis was performed for 1 hour and the degree of hydrolysis is reached 12.55 ± 0.7 %. Hydrolysis time was selected by previous analyzes. It had shown that the degree of hydrolysis increases significantly in the first hour, after that DH increase is considerably lower. This observation is consistent with other researches [14-15]. Some papers report that the extension of the time of hydrolysis leads to stagnation or even decrease in ACE activity and antioxidative activity of hydrolysate [16-19]. Molecular mass of peptides is an important factor in producing protein hydrolysates with desired bioactive characteristics. Short peptides were likely to survive transit through the gastrointestinal tract without modification in structure and loss bioactivity. Peptides with MW lower than 3 kDa prevail in Proteinase K hydrolysate.

Table1. Molecular weight distribution of WPC and hydrolysate

Molecular weight, kDa	Hydrolysate, %	WPC, %
> 30	12.5 ± 0.8	53.86 ± 0.26
10 - 30	6.90 ± 0.8	40.87 ± 0.15
3 - 10	17.77 ±1.2	5.02± 0.07
< 3	62.96 ±1.1	0.20± 0.02

More than 60% of peptides determinate in hydrolysate are fraction F4 (MW lower than 3 kDa), which is significantly higher ($P < 0.05$) than amount of fraction F4 in total content of WPC. Hydrolysate content approximately 80% peptides with MW less than 10 kDa, compared to WPC which has approximately 5% peptides with MW less than 10 kDa. Distribution of fractions is shown in Table 1.

The results presented in Table 2. have shown that hydrolysis of WPC with Proteinase K produced peptides with significantly higher ($P < 0.05$) antioxidant capacity than WPC. The peptide fraction F4 with the molecular weight less than 3 kDa had the highest antioxidant activity. IC_{50} of DPPH activity for F4 was 18.20 mg/mL and fraction F2 consisting of peptides with MW among 30 kDa and 10 kDa had IC_{50} 20.30 mg/mL.

Table 2. Antioxidant activity and ACE inhibitory activity of WPC, hydrolysate and membrane fractions

Activity	IC_{50}, mg/mL	DPPH, IC_{50}, mg/mL
Hydrolysate	0,051 ± 0.009	25.15
F1	0,1959 ± 0.08	59.78
F2	0,545 ± 0.07	20.30
F3	0,0485 ± 0.007	28.02
F4	0,0321 ± 0.005	18.20
WPC	3.005 ± 0.09	39.96

Several researchers have reported that ACE inhibitory peptides are in the molecular weight range of <3 kDa [16-17]. The IC_{50} values showed in Table 2. were ranged from 0.0321 ± 0.05 to 0.545 ± 0.07 mg/mL with the highest ACE inhibitory activity for fraction F4 (< 3.0 kDa). The results presented in Table 2 have shown that ACE inhibition increase with decreasing of MW of peptides. Fractions with highest ACE inhibition capacity were fractions with short peptide chain F4 and F3.

4. Conclusion

The ultrafiltration using a 3-membrane set up was successful in separating peptides with high ACE inhibitory and antioxidative activity. Hydrolysate had significantly higher ACE inhibition activity and antioxidative activity than WPC. By hydrolysis produced hydrolysate with more than 60% peptide <3 kDa and more than 80% peptide <10 kDa. Fractions from the hydrolysate indicated varying bioactivity. Fraction F4 with < 3 kDa showed the highest ACE inhibitory activity. Ultrafiltration is easy method for extrication fraction with desirable characteristics. The major fraction (80%) with great bioactivity can be separated with only one membrane (10 kDa).

Antioxidative and ACE inhibitory peptides obtained and characterized in this study can be applied as food ingredients in functional food to promote human's health.

Such a biotechnological approach might be an interesting strategy for whey processing and contribution to the management and valorization of dairy byproduct.

5. Acknowledgement

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STUDY OF SURFACE MORPHOLOGY OF WATER-JET CUT SURFACE OF FRICTION STIR WELDED JOINT

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Abstract

The friction stir welding (FSW) is used in many industries like aerospace and automobiles etc due to many advantages like no chance of formation of second phases, porosity, brittleness and cracking. It comes under category of solid state joining method since materials are joined below their melting point temperature. So, its vast applicability in industries there is a need of a machining process which can produce complex shape products with exact dimensions. For this a problem i.e. generation of heat affected zone (HAZ) is encountered during cutting by any conventional and non conventional cutting method. So, abrasive water jet (AWJ) cutting method is suitable to cut FSW joint without generation of HAZ. In this paper Friction stir welded joint is prepared for aluminium alloy AA 6101-T6. Then comb profile is cut by AWJ cutting method. The surface which is exposed to water jet is analysed under field emission scanning electron microscope (FESEM) to study the surface morphology. Three distinctive zone i.e. initial damage region (IDR), smooth cutting region (SCR) and rough cutting region (RCR) is observed under FESEM.

Key-words: **Friction stir welding (FSW), Abrasive water jet (AWJ) cutting, Field emission scanning electron microscope (FESEM), Initial damage region (IDR), Smooth cutting region (SCR), Rough cutting region (RCR).**

1. Introduction

These days it is great challenge for researchers and industrial designers to develop and implement new modern technologies of machining materials. They have to find a process that can produce the products having complex shapes and with exact dimensions and also meet the economic point of view. To cope up with the industrial requirement of machining, more modern machines for mid scale and medium scale serial production are used since speed of cutting is doubled in last fifty years [1]. Hence in the last decade water machining has showed rapid development. Water can transmit large amount of energy, hence this phenomenon is used for cutting of materials. Directing a large amount of energy onto a small area a strong water jet is created, generated by a water pump. The effect is further enhanced by increasing the size of the aperture of the jet [2]. Figure 1 shows the schematic sketch of cutting head of abrasive water jet machine. Friction stir welding was developed and patented by Mr. Wayne Thomas in the year 1991 at The Welding Institute (UK) [3]. It is a solid state joining technique since materials are joined below their melting point temperature. In comparison to other traditional welding technique, it is energy efficient, environment friendly and versatile process. Joining of aluminium alloys especially 2XXX and 7XXX series are difficult since during welding of these alloys it is observed that they have poor solidification and porosity in fusion zone. These alloys can be easily joined by friction stir welding technique since it is a low temperature process [4]. Therefore this process has clear industrial potential, so now these days this welding technique is used in several industrial sectors, such as, aeronautics, transportation and automotive. In this process, a non-consumable rotating tool with a specially designed pin and shoulder is plunged into the abutting edges of sheets or plates and traversed along the weld line. As the tool translates along the joint, heat is generated due to the friction between the tool shoulder and the work piece. This heat, along with the heat generated by the plastic dissipation due to the mixing process, causes the stirred materials to soften around the pin without reaching the melting point. The downward force provided by the tool, forces the stirred material from the front of the pin to the back of the pin and consolidated the stirred material in the trailing edge of the tool. As a result the materials are joined in solid state [5].

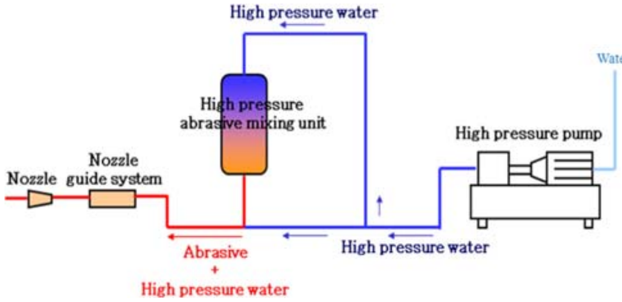

Fig.1 Schematic diagram of abrasive water jet cutting system [6]

Akkurt et al. studied the effect of feed rate on surface roughness in abrasive water jet cutting of Al-6061 aluminium alloy, brass-353 and AISI 304 steel. Through experimental results they explain cutting wear and deformation wear mechanisms are effective in case of cutting [7]. Valicek et al. Analysed surface geometric parameters for advanced quality control of abrasive water jet technology for different steel grades according to the results obtained by means of non contact optical shadow method [8]. Nowdays researchers use abrasive water jet technology for cutting materials like aluminium alloy, steel and also ductile materials. They studied its surface profile and found very satisfactory results [9, 10]. People are using AWJ cutting technology in food industry i.e. cutting of meat through water jet cutting. Now also AWJ cutting is being used in medical field i.e. cutting of bones etc. In medicine field it is also got some potential [11, 12 and 13]. Sharma et al. used taguchi-fuzzy decision method to determine the effective process parameters for improving the productivity of coal mines for coal cutting by water jet technology. They found pressure, stand-off distance, traverse rate and number off passes as influencing parameter for cutting by AWJ technology [14]. From the literature survey of AWJ cutting technology it is found that now these days water jet cutting technology is used for materials as well as non conventional things. But no literature is available to study the surface morphology of AWJ cut surface of friction stir welded joints. Hence, the aim of this paper is to study the surface morphology of AWJ cut surface by field emission scanning electron microscope (FESEM) of friction stir welded joint of aluminium alloy 6101-T6.

2. Experimental Procedure

Friction stir welding set-up is developed on vertical milling machine of HMT 1U make at Indian School of Mines, Dhanbad, India. SS 410 is selected as tool material and aluminium alloy AA 6101-T6 having 6 mm thickness is selected as working material. AA 6101-T6 is used in making bus bar conductors. Figure 3 shows the augmented friction stir welding set-up on milling machine. Work piece i.e. aluminium plate is fixed on milling machine base with the help of fixtures. Tool is fixed on milling machine tool spindle head as shown in figure 2.

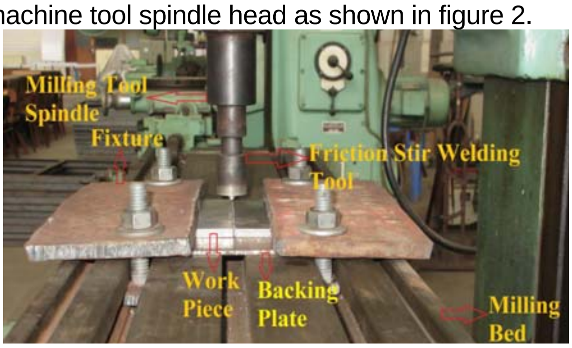

Fig.2 Augmented friction stir welding setup

Friction stir welding is done at the given process parameter in table 1.

Table 1: Friction Stir Welding process parameter

Sample no.	Material	Tool Rotational Speed (rpm)	Welding Speed (mm/min)
1.	AA 6101-T6	1000	40

When FSW aluminium plates are cut through any conventional or non conventional method like wire electric discharge machining method (WEDM), there is chances of formation of heat affected zone (HAZ). So, to overcome this problem these samples are experimentally cut by abrasive water jet cutting method at the laboratory of Institute of Geonics of the CAS, V. V. I., Ostrava. Australian garnet having mesh size of 80 is used as an abrasive material in AWJ cutting process and pressure of water is 350 MPa.

Dimension of Friction stir welded sample is of length 150 mm and width 100 mm. Comb profile is selected for the cut in FSW samples with AWJ cutting method from the centre of weld. Figure 3 shows the trajectory of cut with dimension on FSW plate.

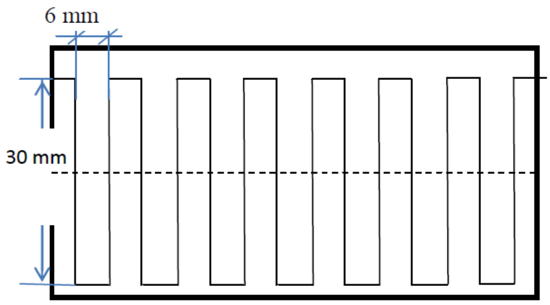

Fig. 3 Trajectory of cut of sample size 30 x 6 x 6 mm

Figure 4 shows the cutting of comb profile cutting through AWJ on FSW aluminium plates. From figure 5 it is clear that AWJ cutting process on FSW aluminium plate is very smooth. There is no chance of formation of HAZ during cutting operation as shown in figure 4.

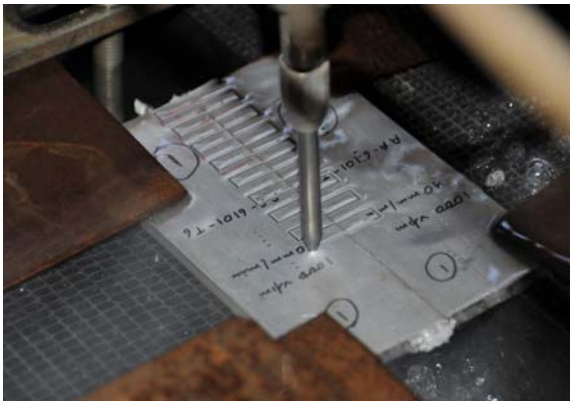

Fig. 4 Progress of Comb profile Water Jet Cutting of Friction Stir Welded Aluminium Plates

After comb profile cutting of FSW, samples one sample is taken of length 30 mm, width 6 mm and thickness 6 mm. Now the surface which is exposed to AWJ as shown in figure 5 is studied under FESEM for surface morphology analysis. As it is clear from the figure 5 that very smooth surface can be achieved by abrasive water jet cutting method.

Fig. 5 AWJ cut surface of FSW joints

3. Result and Discussion

Abrasive water jet cutting surface has three different zones as shown in figure 6. First zone is at the entry of the water jet, which has initial contact with the work piece and it is known as initial damage region (IDR). Second region is known as smooth cutting region (SCR) and third one is known as rough cutting region (RCR) at the exit of the water jet from work piece [15,16]. IDR is cutting zone at shallow angles of attack; SCR is cutting zone at large angles of attack whereas RCR is the jet upward deflection zone. It could be observed from figure 6 that SCR exist in between IDR and RCR having a small area.

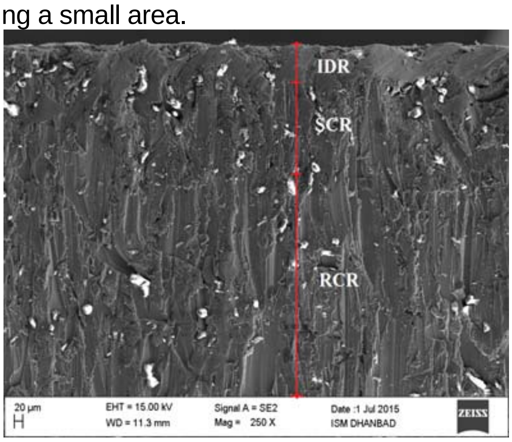

Fig. 6 FESEM image of AWJ cut surface

The surface morphology in different regions of cutting surface is generated from the instantaneous penetration of abrasive water jet. From the FESEM image analysis it is found that the mechanism of material removal was a combination of ductile shear and ploughing action of the abrasive particles [17]. Wang et al. claimed that cutting action takes place in IDR is due to cutting wear while in SCR it is due to deformation wear, whereas in case of RCR the cutting process is considered as being controlled by erosive wear at large particle attack angles. From, top to bottom of the cutting surface degree of plastic deformation increases. Initially when abrasive particles come in contact with material it has high level of kinetic energy, which causes destruction of material. It is clear from the figure 6 that a small rounded corner at the top edge gets damaged due to the plastic deformation of material caused by initial AWJ bombardment [18].

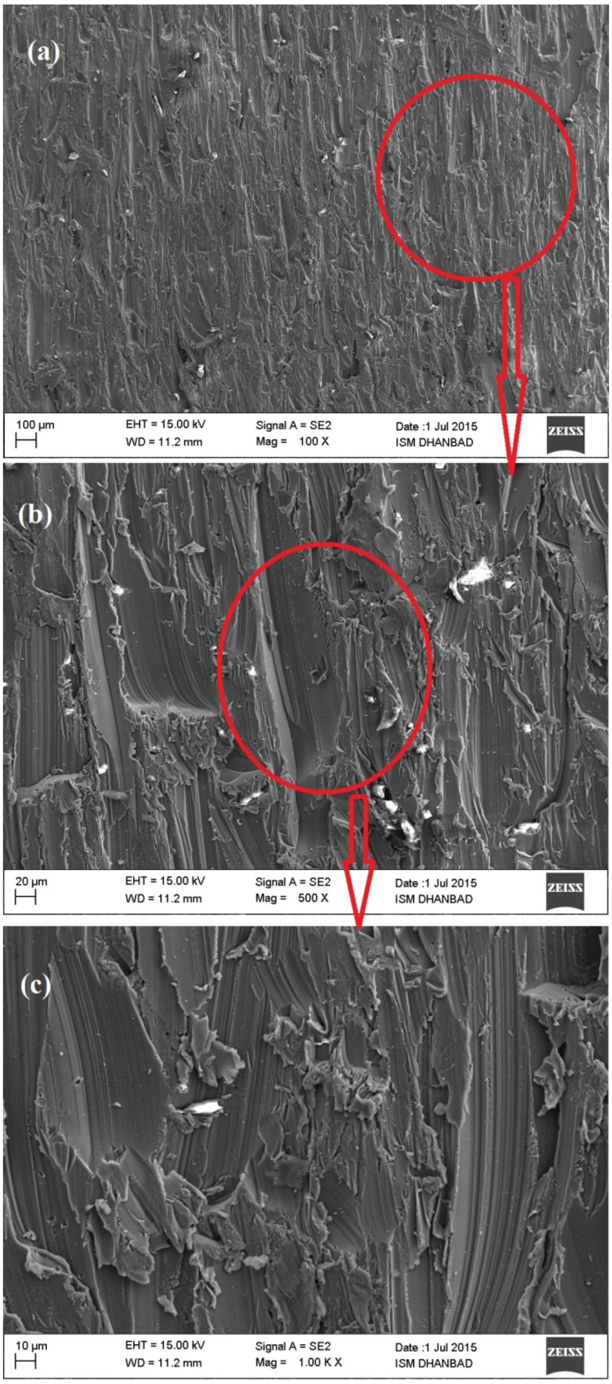

Fig. 7 FESEM micrographs of SCR, (a) image at 100X, (b) magnified image at 500X, (c) Further magnified image at 1000X

After IDR as the abrasive particles penetrate into the material the stream loses kinetic energy, since some of the energy is used in eroding the material. A deflection of jet in the normal direction to the plane of cutting is observed due to lower energy, which causes formation of striations on the cutting surface as can be seen from Fig. 7. Figure 7a shows the FESEM micrograph of SCR at 100X, while figure 7(b) shows the magnified image of the circled portion shown in Fig. 7a at 500X. Further magnified image at 1000 X of circled portion in Fig. 7b can be seen in Fig. 7c.

From Fig. 7 comparatively smooth regions with respect to IDR can be observed in SCR. Vertical cutting tracks can be observed in figure 7(c). From figure 8 smooth vertical cutting tracks can be observed it is due to the lower kinetic energy of the abrasive particle and these tracks are created at large angle of cut [19].

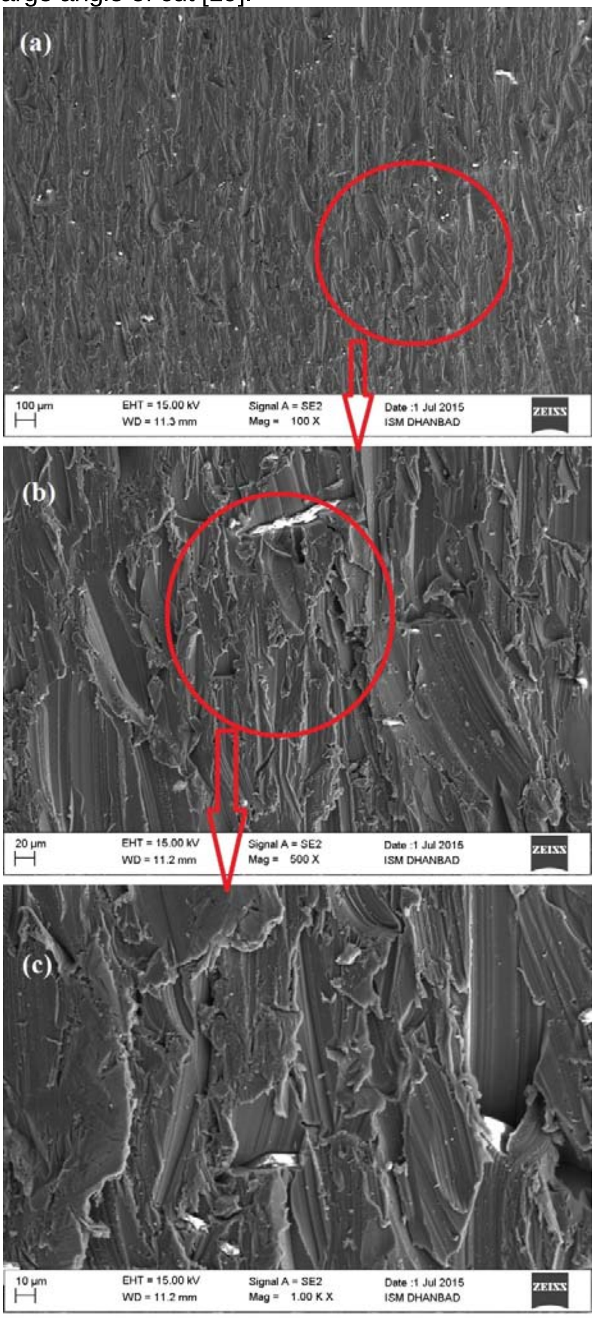

Fig. 8 FESEM micrographs of RCR, (a) image at 100X, (b) magnified image at 500X, (c) Further magnified image at 1000X

After SCR as the AWJ moves forward, the stream gets deflected, which causes the creation of a unique cutting geometry. This region is known as rough cutting region (RCR). In this region irregular striation formation can be observed as shown in figure 8, due to further reduction in jet energy.

Figure 8a shows the FESEM micrograph of RCR at 100X, while figure 8(b) shows the magnified image of the circled portion shown in Figure 8a at 500X. Further magnified image at 1000 X of circled portion in 8b can be seen in figure 8c. According to researchers in this field three major sources contribute to the striation formation simultaneously, i.e. the nature of the step formation cutting process, the water jet dynamic characteristics and machine system vibration [20]. According to microscopic images shown in figure 7 and 8, it can be observed that scratches have a clear direction. It is known that the high speed and high pressure jet, consisting of abrasive particles plays a major processing capacity, has an identified linear path during the machining process. It has been confirmed by the FESEM images the all tracks on the cutting surfaces have a consistent direction. The basic event in the material removal by AWJ is the impact of a single abrasive grain. The major removed material is eroded by abrasive particles under a high impact angle and is directly below the jet. Hence the target material can be easily penetrated and removed by jet. Cutting surface with tracks is left after a series of erosion at a shallow impact angle at the completion of cutting operation. In figure 7 and 8 lot of erosion curves with a unanimous direction can also be observed. In figure 7 (c) and 8 (c) small crater in a large groove shape scratch and overlapped wear marks to each other can be easily observed. This type of phenomenon can be observed due to repeatedly erosion of the surface by the abrasive grain at the same position [21].

4. Conclusion

In this study, surface morphology of the abrasive water jet cut surface of friction stir welded joint of AA 6101-T6 is studied under FESEM. Summarizing the main features of the results, the following conclusion can be drawn:

1. Microstructural evaluation of the cutting surfaces of samples revealed three distinct zones which were identified as: (1) an initial damage region (IDR), which is cutting zone at shallow angles of attack; (2) a smooth cutting region (SCR), which is cutting zone at large angles of attack; (3) a rough cutting region (RCR), which is the jet upward deflection zone.
2. From SCR to RCR surface quality deteriorates because the jet loses its energy due to the jet-material interaction and mutual particle impacts.
3. Due to abrasive wear phenomenon on surface morphology, scratches have a clear consistent direction. Due to the effect of the nature of water jet it is concluded that wear marks on machined surfaces are not in complete straight line.

5. Acknowledgement

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IMPLEMENTATION OF FIWARE IN INTERNET OF FIELDS

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Abstract

In this paper precision agriculture concept based on observing, measuring and responding to inter and intra-field variability in crops is presented, as well as technologies that enable status monitoring. Also, developed system SPA using FIWARE technologies is presented.

Keywords: FIWARE, Precision Agriculture, crop, monitoring

1. Introduction

Agriculture is one of the most important areas of human activity worldwide. As the population rises there is a need to increase the agricultural production. There are a lot of efforts put in utilizing information and communication technology (ICT) for the agriculture needs. Precision agriculture (PA) in primary production [1,2], as well as tracking and tracing of agricultural products along the food value chain [3] characterize initiatives in serving the sector's and consumers' needs. New technology that can help utilising real-time information for farmers that are involved in food production is FIWARE.

FIWARE is a middleware platform for the development and global deployment of applications for Future Internet. This platform is driven by the European Union. FIWARE can deliver Future Internet applications and services in a variety of areas like: industry, agriculture, smart cities, sustainable transport, logistics, renewable energy, environmental sustainability, etc.

In this paper a developed FIWARE system implemented in precision agriculture area is represented. In this system information about a crops and soil are collected using Internet of Things technologies. Because these technologies are implemented in agriculture the term that can be used is Internet of Fields (IoF).

2. Internet of Fields

The Internet of Fields is emerging as one of the major trends shaping the development of technologies in the ICT sector at large [4]. The IoF describes the interconnection of objects for various purposes including: identification, communication, sensing, and data collection. Internet can be used for interconnecting end-user devices and for interconnecting physical objects that communicate with each other and/or with humans in order to offer adequate service.

IoF is build on three pillars, related to the ability of smart objects to [5]:

- be identifiable (anything identifies itself),
- to communicate (anything communicates)
- to interact (anything interacts), either among themselves, building networks of interconnected objects, or with end-users or other entities in the network.

At the single component level, the IoF will be based on the notion of ''smart objects'' which will complement the existing entities in the Internet domain. Smart objects [6]:

- Have a physical embodiment and a set of associated physical features (e.g., size, shape).
- Have a minimal set of communication functionnalities, such as the ability to be discovered and to accept incoming messages and reply to them.
- Have a unique identifier.
- Are associated to at least one name (human-readable description) and one address (machine-readable number or string).
- May have instrumentation to detect physical phenomena (e.g., temperature, humidity) or to trigger actions having an effect on the physical reality (actuators).

Since smart objects generate a number of information there is a need for adequate data capturing. Data capturing devices involving data input and collection functionalities are an essential part of PA system.

The most prominent examples are [7]:

(a) Data collection on fields with sensor networks providing data about production indicators such as e.g. rainfall, water level in soil, use of pesticides and fertilizers, driving lanes of farm machines, etc.

(b) Data capturing of transports including data about the position, ambience information from inside and outside the truck such enabling the evaluation of the current situation in transport logistics.

(c) Data capturing of product quality indicators such as humidity, oxygen and nitrogen content or ethylene content in the air around a product as indicator for perishing fruits and vegetables, which is relevant in storage facilities and during transport.

(d) Data capturing from a products packaging (e.g. logos) for supporting the retrieval of additional information from the cloud.

All these data capturing activities can be realized through devices and functionalities at different levels of sophistication. One of the devices that can be used for data capturing besides sensors are unmanned aerial vehicle (UAV).

UAV can generally be defined as a device used or intended to be used for flight in the air that has no onboard pilot [8]. These devices are sometimes referred to as drones, which are programmed for autonomous flight, and remotely piloted vehicles (RPVs), which are flown remotely by a ground control operator [9].This fact in many cases can result in high maintenance and deployment costs particularly speaking in the industrial and in agricultre domain applications. Some applications implement an autonomous flight mode, however the autonomy in most cases is intended as a simple path planning through several given points.UAV have range of potential environmental or commercial applications (pollution detection, crop spraying, etc.). Also, they can be deployed in surveillance applications and for detecting prohibided marijuana fields [10].

In order to realize IoF implementation, development of network and services infrastructure is necessary. Developed IoF applications will share infrastructure, environment and network elements, and a common service platform. Three different phases of these applications (Fig. 1) are following:

- Collection phase: procedures for sensing the physical environment, collecting real-time physical data about crop, soil and reconstructing a general perception of it. Technologies such as sensors provide sensing of physical objects like animals on fields and sensing of physical parameters of environment, while technologies such as IEEE 802.15.4 or Bluetooth are responsible for data collecting.
- Transmission phase: includes mechanisms to deliver the collected data to applications and to different external servers. Methods are therefore required for accessing the network through gateways and heterogeneous technologies (e.g., wired, wireless, satellite), for addressing, for routing, and
- Process, management and utilization phase: deals with processing and analyzing information flows, forwarding data to applications and services, and providing feedbacks to control applications.

In IoF implementation the first step is the collection of information about the physical environment/farm conditions (e.g., temperature, humidity) or about objects (e.g., identity of crop). Data acquisition is encompassed by using different sensing technologies attached to sensors, cameras, GPS (Global Positioning System) terminals, while data collection is generally accomplished by short range communications, which could be open source standard solutions (e.g., ZigBee, Bluetooth) as well as proprietary solutions (e.g., Z-Wave).

Another essential technology for the development of IoF is wireless sensor networks (WSN). WSNs are a powerful technology for gathering and processing data in a large variety of agriculture domains [11]. Traditional WSNs consist in a high number of static and resource constrained sensor nodes deployed in an area to sense a certain phenomenon, e.g., temperature, and humidity on fields. Sensors are usually powered by small battery, have a limited lifetime and scarce computational and memory capabilities. Sensed data is then transmitted wirelessly via multi-hop communications towards one or a small set of sink nodes, which are more powerful devices where the collected information is elaborated. Independently of the network topology, sensors and sinks mainly operate in the 2.4 GHz band. Communication standards in WSN include: IEEE 802.15.4, ZigBee, Wireless Highway Addressable Remote Transducer Protocol (WHART).

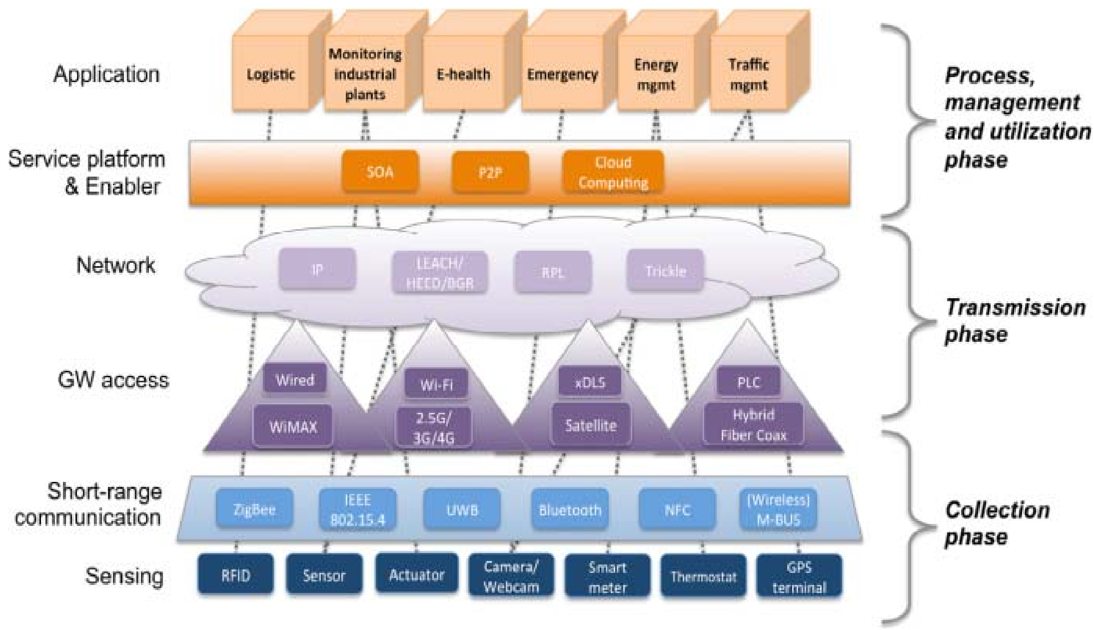

Figure 1. Phases of IoF applications

Once data is gathered through sensing technologies, it needs to be transmitted across the network so that applications can consume it. Heterogeneous communication technologies form the backbone to access the network [12]. Among the wired technologies, the reference standard is Ethernet (IEEE 802.3), supporting transmissions from 10 Mbps to 100 Gbps over twisted-pair coppers, coaxial cables, and optical fibers.Common way to access the network is through Wireless LAN (WLAN). In this case, wireless devices transmit and receive packets to/from a base station, which is connected to the Internet, within a radius of few tens of meters. There are several wireless technologies with different transmission rates and covering different distances [13]. The WiFi family (IEEE 802.11a/b/g/n) may operate in different frequency bands (2.4 GHz or 5 GHz) by implementing different modulation schemes. Data communications may reach up to 54 Mbps, supporting distances up to 100 m. The IEEE 802.11n version includes the possibility of using MIMO (multiple-input multiple-output) antennas to increase the available bandwidth for transmission/reception. WiMAX (IEEE 802.16) is the corresponding wireless communication standard for longer distances (up to kilometres). It operates in a very wide spectrum (i.e., 2–66 GHz) with data rate up to 70 Mbps. It is a connection-oriented technology, thus a station cannot transmit data until the base station has not allocated a channel for it. Broadband technologies (i.e., xDSL) are generally used for connecting home end systems to the Internet.

In processing, managing and utilization phase information flows are processed and then forwarded to applications. The Service Platform & Enabler covers a fundamental role for managing the above operations. It is crucial for hiding the heterogeneity of hardware, software, data formats, technologies and communication protocols characterizing IoF [14]. It is responsible for abstracting all the features of objects, network, and services, and for offering a loose coupling of components. Service-Oriented Architecture (SOA) concept can be inherited and applied to IoF.

3. Precision agriculture

Precision agriculture is a novel crop management concept based on measuring of crop field components variation. The goal is to achieve efficient farming practice by applying optimal amount of fertilizer and pesticides in time. Consequently, PA increases yield and quality, while ensuring environment protection. PA is based on the usage of various communication, sensor, computer and information technologies.

The aim of the developed system name Service for Precision Agriculture (SPA) is to develop a system for collecting data from crops fields and its transmission in order to store it in the database available on the internet. In order to obtain a more complete and enriched data, two ways of data collection are employed. The first one is aerial imaging of the predefined area using light and inexpressive UAVs equipped with a camera (RGB (Red, Green, and Blue), NIR (Near-infrared), IR (Infrared), multispectral, HD (High-definition), etc.). The second sources of information are the mobile sensor stations and WSN installed on crop fields for collection and monitoring of changes in air and soil variables. Each sensor station or node of the WSN is equipped with a processing unit, transceiver and one or more sensors, such as sensors for measuring soil moisture, temperature and pH level, air temperature, humidity, wind speed, etc. Measurements from all WSN nodes are collected by the node coordinator using an IEEE 802.11.4 protocol and further periodically transferred by the cellular network protocol to the dedicated database handler.

The FIWARE-based service will provide farmers with online or nearly online data from crop fields in order to monitor crop growth, effects of actions taken and detection of unexpected events in order to instantaneously make interventions and refinements of the planned agro technical activities. The farmer can review images from required parcels and compare changes in images of the same parcels from different periods. Also, these images will be correlated with the associated online data collected by WSN sensors placed in proximity of the closest locations where these images were taken.

SPA associates collected data for specified parcels with end-users through developed SPA application. This service allows end-users to access comprehensive and diverse crop vegetation data. The end-users such as farmers, agricultural communities and municipal agricultural agencies may get the complete picture of soil and crops conditions using SPA service. Any variation due to, e.g., diseases or inadequate fertilization will be easily detected and identified. This way, the service would serve as a platform for the direct exchange of information between farmers and agricultural consulting agencies.

SPA system is a web-based service consisting of database, user interfaces and application software. SPA database contains end-users parcels data, images and sensors measurement. All of this data is organized by temporal and spatial dependencies.

SPA will allow the registered end-user to define his parcels using available GPS locations and the service interface. More precisely, the end-user will be able to specify positions from where images should be taken, type of images (RGB, NIR, IR, multispectral, etc.). SPA registered end-user will be able to see stored images from specified locations taken in specified time intervals. Simultaneous view of images from the required region in visible /multispectral bands during specified time interval could also be available.

SPA service will be available to its end-users with application software (Fig. 2) realised as:

- Web browser application accessible to users of PC, laptops, etc.
- Android application for users of Android OS based smart phones and tablet PCs.

Figure 2. SPA service application

4. FIWARE architecture of SPA

SPA application will use various data, including data coming from a wide variety of different sensors for gathering properties of vegetation, soil and air.

For storing geo-referenced image files collected using a camera installed on the UAV, Object Storage will be used, because it provides flexible cloud data storage service. Collected image data cannot be analyzed separately from data gathered by other sensors fixed on the soil surface, but needs to be analyzed in a context-aware manner. For this purpose, Orion Context Broker will be used to provide data that is collected from WSNs. Data from WSNs will be collected and managed by Backend Device Management – IDAS, because it can easily handle a large number of sensors (>1000). Also IDAS easily communicates with IoT enabled Context Broker through NGSI9/NGSI10 interface by using IoT agents. For security purposes, a triangle consisting of PEP Proxy, Authorization PDP and Identity Management will be used. These three GEs combined together give comprehensive access control solution for project's application. Moreover, for displaying images with geo-referenced data, Geo Visualization bundle will used. The bundle consists of 3 GEs (3D-UI-XML3D, GIS Data Provider, POI Data Provider) and one SE (FI-Content 3D-Map Tiles). This bundle enhances UI of the application and provides a flexible framework for displaying landscapes automatically generated from the provided map and data. Also, it provides an easy way to highlight special points of interests (e.g. regions with potential crop diseases or lack of fertilizer). In Fig. 3 architecture of SPA system is represented.

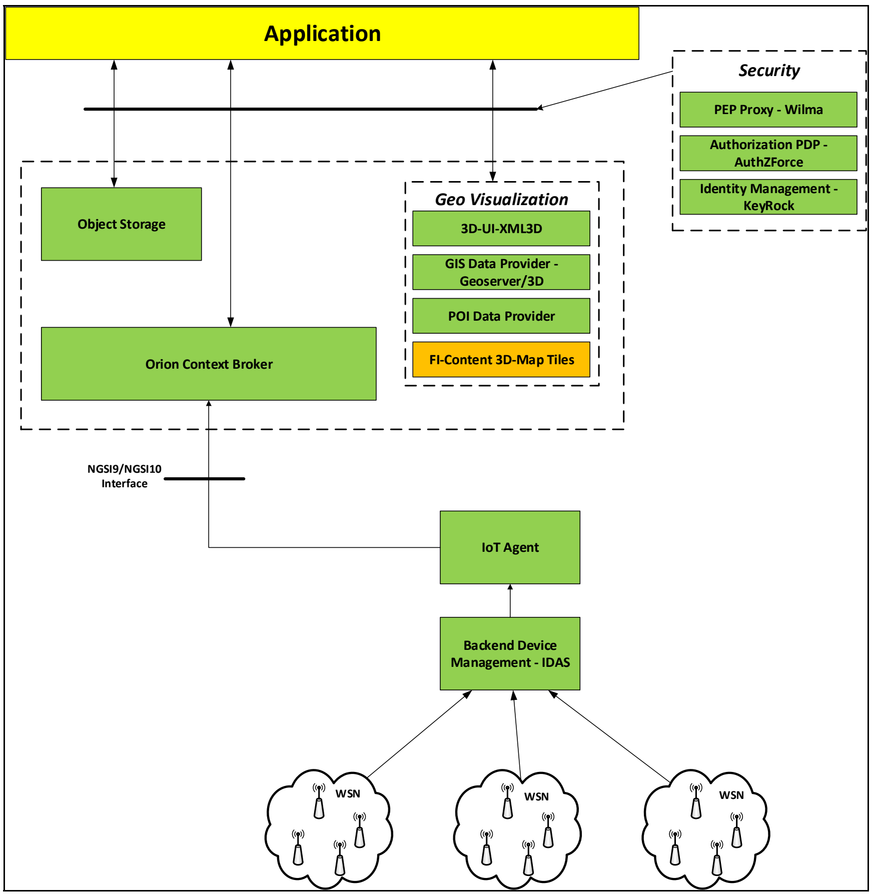

Figure 3. Architecture of SPA system

FIWARE technology used in SPA system consists of 10 following GEs:

- Orion Context Broker - Provides context awareness for data that comes from sensors (context producers). It provides an easy way to use data for context consumers (Android application, web application) in a context aware manner.
- Object Storage - Provides a flexible and robust way for storing data (geo-referenced images).
- Backend Device Management - Easily handles large number of various devices (sensors) and collects sensor observations to the global context broker through an IoT agent.
- IoT Agent - IoT agent provides a context broker with sensor observations through the NGSI9/ NGSI10 interface.
- GIS Data Provider - GIS data provider allows hosting geo-referenced data for mobile/web clients.
- POI Data Provider - POI data provider will give images and sensors geographical context and will store information associated/linked by location.
- Fi-Content 3D map tiles - Fi-Content 3D map tiles SE is able to display different kinds of image tiles.
- PEP Proxy - PEP Proxy - Wilma is completely integrated with FIWARE ecosystem and FIWARE account and together with Authorization PDP and Identity management gives a complete and robust security system for the application.
- Authorization PDP - Authorization PDP provides externalized authorization logic and provides an advantage of flexible access control features. Together with PEP Proxy and Identity management, it provides complete and robust security system for application.
- Identity management - Identity management provides whole-around system for account creating and management. Identity management acts also as single sign-on (SSO) platform and together with PEP Proxy and Authorization PDP provides a complete and robust security system for the application.

User login and user access rights in the application are managed by the Identity Management – Keyrock GE. The user will be logged in to the application through Authorization PDP – AuthZForceGE. The application will be accessing data using http requests to the Context Broker GE and Object Storage GE. For enhancing user experience and displaying geo-referenced data, FI-content 3D map tiles GE, POI data provider GE and GIS data provider GE are used.

Context Broker's database is filled with sensor data from WSNs, by using Backend Device Management – IDAS GE together with IoT Agents. They communicate with the Context Broker through the predefined NGSI9/NGSI10 communication interface.

5. Discussion and Conclusion

There are a large number of companies in Europe that offer terrain acquisition services, as well as software and hardware solutions. Examples of companies that offer software solutions for UAV control and image capturing are DroneAgricole from France and pix4d from Switzerland. There are more companies that offer software solution than those that offer a complete software and hardware system. Leading companies that offer complete systems are: Delair-tech from France, senseFly from Switzerland, PrecisionDrone, Honey Comb, and AgriBotix from USA.

Besides the equipment and software, the vendors offer services for acquisition, terrain mapping and providing the data to the user. Usually the companies sell their complete solutions (service and UAVs) for data acquisition, and then the users can make their own acquisitions and monitoring of agricultural holdings. Prior to starting these operations, the users need to complete trainings provided by vendors, which require both time and money. The abovementioned companies do not offer sensor networks for data acquisition from the fields.

The company Ursula-agriculture from UK, besides acquisition, data processing and providing recordings to the user, also offers measured data from the terrain by hydro spectral sensors.

By reviewing the available systems, it can be concluded that developed SPA is a unique system with many overall advantages. The uniqueness of SPA system suggestion is that it allows the user to individually choose locations that should be measured and monitored with at least one sensor or a sensor network deployed in the agricultural holding. By applying on the service, the user gains access to images and sensor data from the fields marked as his property. Another advantage of SPA service is that the user needs no expertise; they only need to have access to a computer, a tablet or a smart phone with internet connection. Besides the abovementioned, it is envisaged that state consulting agencies that deal with improvements of agricultural sector can access the SPA system. This would provide quality and timely consultation for farmers.

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Drilling of CFRP-Aluhab®-CFRP sandwich structure

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Abstract

Today, special materials are used at more and more places. These materials generally are characterized by excellent mechanical properties. The aluminium foam is one type of special material. This material can be characterized by ultra-light weight and very high strength. Moreover, this material has very good vibration absorbing capability due to the cellular structure. The aim of our research is to investigate the possibilities of machinability of aluminum foam. It can be investigated at different technologies, determined by experimental design.

Keywords: CFRP, composite, aluminium foam, drilling, cutting forces

1. Introduction

Cellular metals such as foamed metals are attractive material for light weight design. Several types of metallic foams have been produced [i,ii] since the first invented “foam-like mass of metal” in 1948 [iii]. A number of metals and alloys can be foamed [iv,v], but among these the aluminium foams are the most studied and have the highest application and market potential [vi,vii]. Despite the developments of different production routes for a range of prototypes and of small scale plants for semi-finished foam products [viii,ix,x,xi], there is still a lack in commercialization of aluminium foams. The Aluinvent Zrt. developed a novel metal foaming technology [xii] which resulted in a new type of aluminium foam called ALUHAB. (figure 1.)

Figure 1. ALUHAB blocks

This foam can be produced with controlled cell size and mechanical properties. It is a new material which combines the light-weight structure of polymers and the strength and resistance of metals. By controlling the cell size of the metal foam a broad range of density and mechanical strength combination can be achieved. It also exhibits excellent sound and energy absorbance, which are essential in the field of safety. This new process is cost efficient and since the resulting foam is stable it can be cast in different shapes and can also be used as a core material to fabricate composite structures.

The matrix alloy of ALUHAB is a special foamable composite containing ultrafine particles (80 nm-20 μm). The composite is made by a special high temperature compounding technology which ensures homogeneous distribution of the foam stabilizing particles. Thus, it is possible to produce foamable alloys from any composition from casting to wrought alloy.

In contrast to previous technologies the size of bubbles (and hence the density of the foam) is adjustable and can be changed during the foaming with the same injector. Thus, foams with mixed cell size can be produced as well. Due to loud-nozzle technology the cell size of ALUHAB can be adjusted precisely. The minimum size of bubble can be as small as the diameter of the nozzle, thus, submillimeter bubbles can be produced. The recent cell size of ALUHAB is in the range of 0.5-5 mm. Foam density is 0.6 g/cm3, average cell size is 1 mm.

2. Research of the machining facilities

The foam can be cut in any direction. Since ALUHAB does not disintegrate during machining, it meets the fundamental conditions and suitable for parts production such as turning, milling, slicing. The ALUHAB aluminium foam can be laminated. It can be applied as a core material of sandwich structures.

In our research, the goal was the machining attempt of such a sandwich structure. We laminated two kind of ALUHAB with CFRP. We used the aluminium foam as a core material. The properties of the used materials are shown in the table 1.

Table 1. ALUHAB material names

	Material name	Mass [g]	Density [g/cm3]
1.	AlSi10_6AlO6	210	0,4
2.	6061_8AlO6Mg	780	0,9

For the CFRP layers, we used prepreg, i.e. a pre-impregnated composite fiber, where the matrix material (epoxy) is already present. As a result, the pre-preg is ready to lay into the mold without the addition of any more resin. In order for the laminate to cure, it is necessary to use a combination of pressure and heat. After the lamination we had the pieces for machining. These are shown in figure 2.

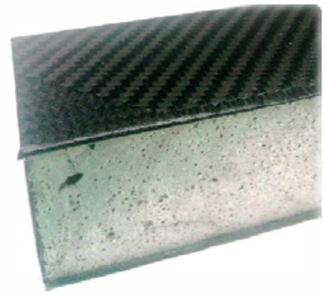

Figure 2. The sandwich structure

Different materials require different machining technology. In a complex structured workpiece like this, it raises a number of machining problems, such as:

- cutting parameters
- different tool material
- different cutting edge angle
- cooling

Problematic points with machining of composite materials are tool wear, tool life, delamination and temperature during the machining.

Our research is mainly focused on the drilling. there are a number of typical inaccuracy, which may occur on drilling. We aimed to examine these errors at the sandwich structure and we tried to create prevention if it is possible:

- reduce the cutting forces
- reduce burr on exit
- avoid splintering-fraying (figure 3.)
- avoid delamination

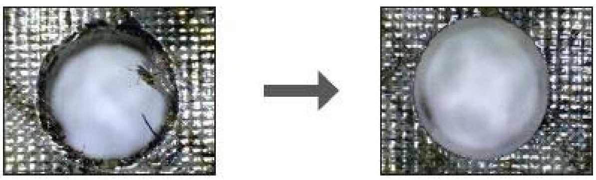

Figure 3. Splintering-fraying

3. Description of the research

The drilling was performed on a CNC milling machine (NCT Tomill-250). The tool was: SECO SD205 A-6.38-35-8R1-C2, fig. 4. When we are drilling the hole quality is in focus. With issues like entrance and exit delamination and splintering, the focus has been clear: use a tool, which is specifically optimized for composite applications, or sandwich materials. In both cases particular consideration was given to achieving excellent performance in both entering and exiting.

Furthermore, the diamond coating secures good dimensional tolerance throughout the long tool life. The drill's edge geometry specially recommended. for sandwich structures (CX2).

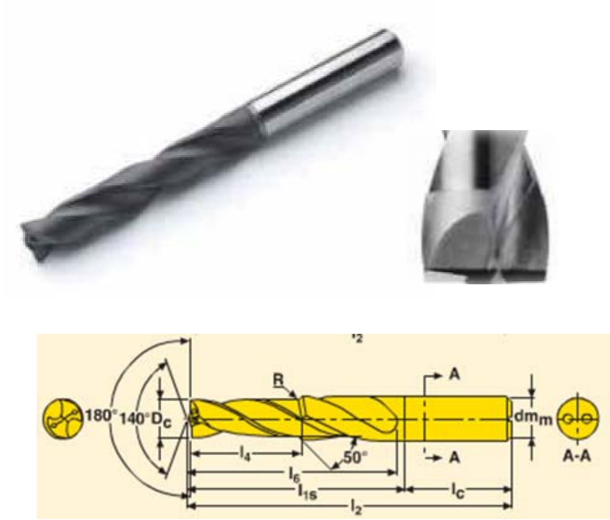

Figure 4. SECO SD205A-6.38-35-8R1-C2

The aluminum foam changes its properties after coolant. Therefore the drilling were carried out without cooling.

We used 3 drilling cycle for holemaking. One of them is a single drilling cycle, while the two other are custom cycles. The plan was to drill 4 holes with every cycle (12 holes). The feedrate changed in every hole. Cutting data:

- v_c=100 m/min (by tool recommends)
- n=5000 1/min
- Three cycles

1 - Simple drilling //G81//

f_1=0.05 f_2=0.075 f_3=0.1 f_4=0.15 [RPM]

2 - Variable feed in every layer //M1// Figure 5.

$f_{30\%}=f_{1\text{-}4}\cdot 30\%$ in enter, and exit layer; $f_{1\text{-}4}$(=x) in mid. layer;

3 - Peck drilling //M2// Figure 6. Q=layer tickness, E=0,5 mm, R=2,5 mm $f_{30\%}=f_{1\text{-}4}\cdot 30\%$ in enter, and exit layer; $f_{1\text{-}4}$ in mid.layer.

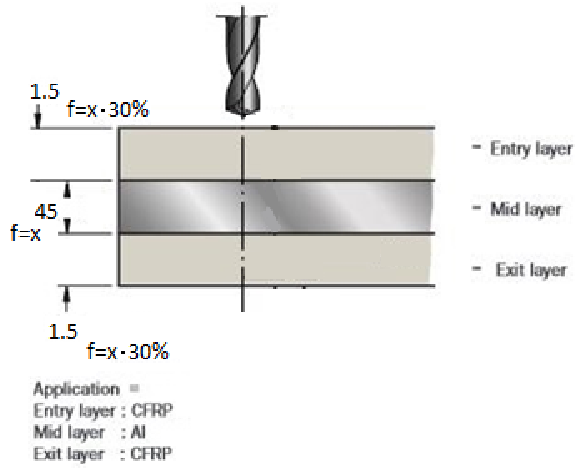

Figure 5. Variable feed in every layer

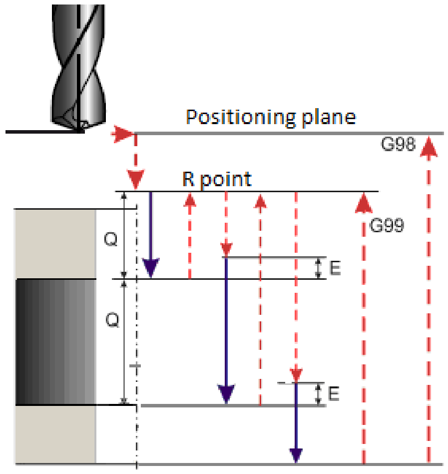

Figure 6. Peck drilling

The CNC program was manually written, then tested in CAM software, Figure 7.

Figure 7. Toolpath in CAM software

Another important element was the workholding system. We designed it to ensure any influencing factors. It is show on the figure 8.

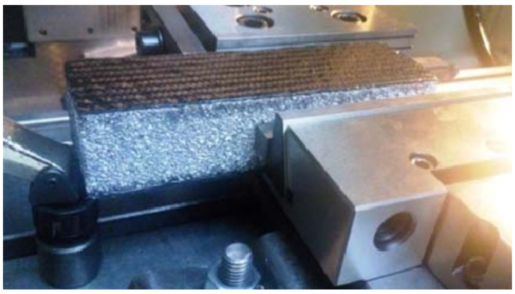

Figure 8. Workholding system

4. Experiment

The experiments location:

- Kecskemét Collage Faculty of Mechanical Engineering and Automation
- Department of Vehicle Technology

Equipments:

- KISTLER Cutting Force Measurement
- Leonova SPM vibration measurement
- Mitutoyo Quick vision ELF PRO

During the experiment, the awaking cutting feed forces were measured. The cutting was started with the 0,4 g/cm^3 aluminium foam. We assumed that, in this case the tool wear will be less. The measurement results are show on the figures (9-10.).

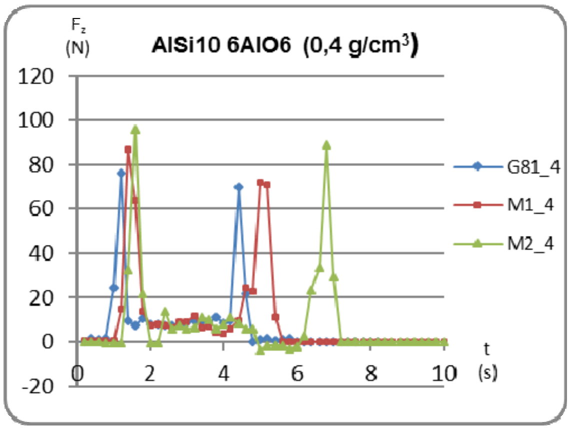

Figure 9. Evolution of the average feed cutting forces in the function of time with the f4 feed rate.

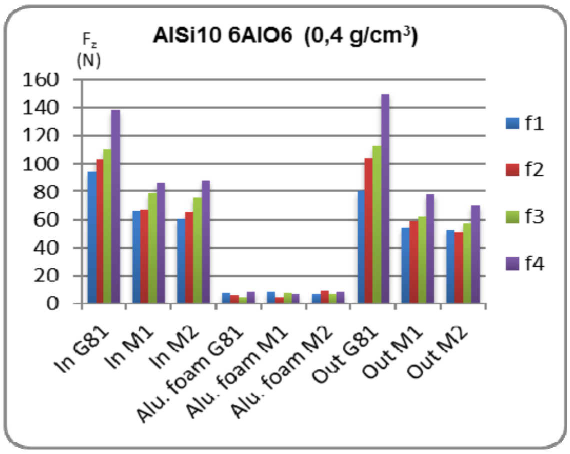

Figure 10. Evolution of the maximum feed cutting forces in cases of the different cycles in every layer (0,4 g/cm^3)

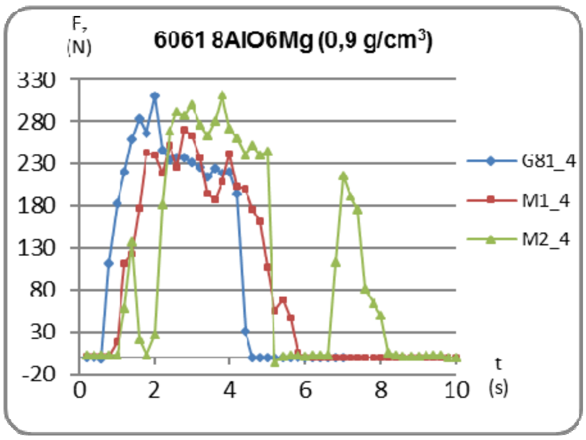

Figure 11. Evolution of the average feed cutting forces in the function of time with the f4 feedrate. The figure shown the various cycles as well

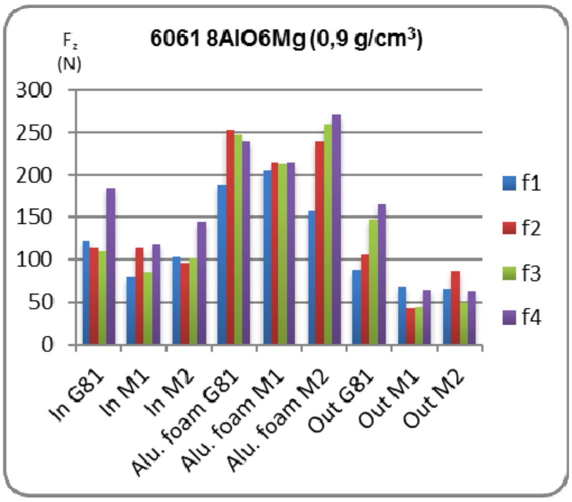

Figure 12. Evolution of the maximum feed cutting forces in cases of the different cycles in every layer (0,9 g/cm^3)

The diagrams show that higher forces generated in CFRP. If we changed the cutting parameters it only slightly influenced the average forces.

As shown in figures, 0,9 g/cm3 aluminium foam has higher force values occur than in the CFRP. This is the opposite of the previous material. The density approx. doubled, while the feed forces of tenfold. In the case of this material, the differences between each cycles were more relevant. It was spectacular especially at the bottom of the sandwich structure.

Table 2. The measured vibration values at the 0,4 g/cm3 aluminium foam

	Vibration			
	G81	M1	M2	
DISP	8,52	11,43	7,08	µm
Vel	0,22	0,23	0,1	mm/s
Acc	0,34	0,27	0,04	mm/s^2

Generally, the aluminium foam has very good vibration absorbing capability due to the cellular structure.

If we changed the cycles it only slightly influenced the vibration values. The measured values were also thanked to the stable holding system.

The chip removal in the 0,4 g/cm^3 material was more continuous, while in the 0,9 g/cm^3, the carbon chips often stucked into the cell-structure. It is shown on the figure 13.

If we changed the cutting parameters it only slightly influenced the fraying. We founded fraying at the all holes which are appeared irregularly at the exit (Figure 14.). Thanks to the well-chosen technologies we did not find delamination at the exit or at the entry area of the hole.

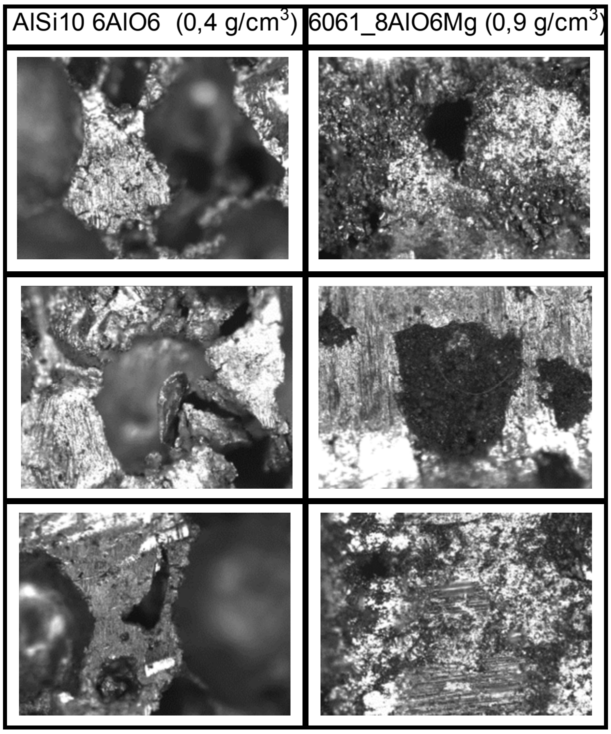

Figure 13. Picture of the bore's wall by Quick Vision microscope with 80x magnification

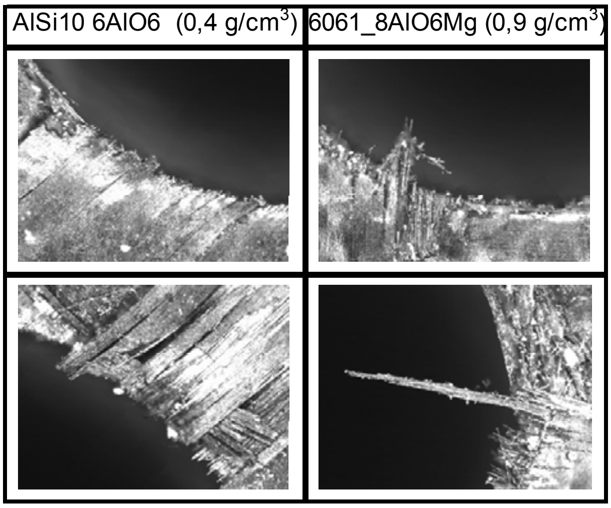

Figure 14. Fraying at the exit areas of the holes

We assumed high temperature at drilling. The diamond coated tool loses its properties at high temperatures, leading to intense tool wear, Fig. 15.

Mainly, we observed this phenomenon while we machined the 0,9 g/cm^3 aluminium foam, which may contain magnesium and AlO as an addition.

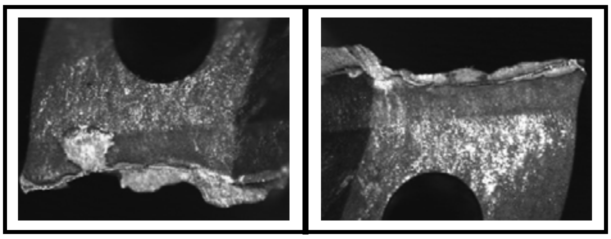

Figure 15. The diamond coated drill's toolwear

5. Conclusion

The sandwich structure is useful because the design (CFRP), the low weight, the minimal sensitivity for vibrations are all its benefits. Basically, the machining of this material is not too complex, but a variety of additional factors are make it more cumbersome:

– fraying
– intensive tool wear

The removal of the Aluhab chips from the linear guideways is especially important due to the abrasive effect. It can cause serious damage to the milling machine. The chips of the different type of materials are shown on the figure 16.

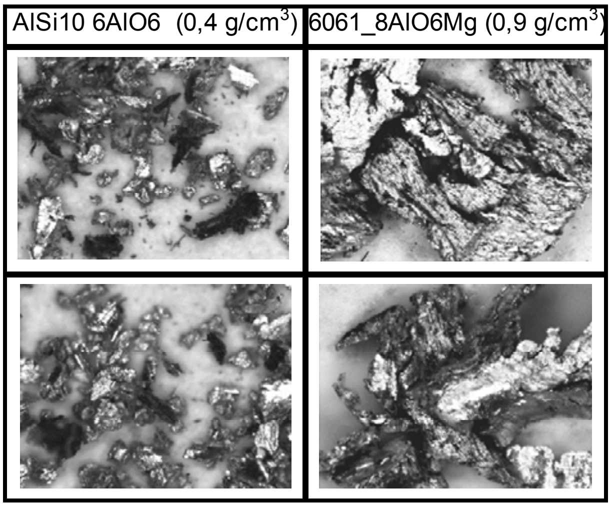

Figure 16. Chips of the two Aluhab®

In the case of lower density material, the G81 cycle is enough:

- The hole quality and the level of forces have no significant difference
- It has the shortest machining time

If the material density is higher, it is more important to build cycle carefully. Where the time is the secondary factor (after the quality) we recommend to use M1 or M2 technology (it depends on the lenght of the bore).

In conclusion, to provide accurate proposals for the technology further studies are needed with various drilling tools. This experiment is a good starting base for the next research.

6. Acknowledgement

TÁMOP-4.2.2.B-15/1/KONV-2015-0012. Support on scientific training workshops - Scientists and scientific workshops at Kecskemét College - The Project is supported by the Hungarian Government and co-financed by the European Social Fund.

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ANALYSIS OF THE STRESS FIELD IN A MODEL OF PIPE BRANCHES

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Abstract

The aim of this paper is to analyze the stress field of a complex geometry model of pipe branches loaded with internal pressure of 10 bar. The analysis will be done by comparing method of strain gauges and a new one (state-of-the-art) 3D optical method to finite element method, as a numerical method. Finite element method is used to determine critical points (places of expected stress concentration) in the branch. In these places (or at least close to them) strain gauges are placed. The main limitation of the method of strain gauges is that it is not possible to place them anywhere. Whole stress field can be obtained using a system for 3D optical stress measurement based on the method of digital image correlation (Aramis system). Comparing the results of strain gauges and Aramis-system the advantages and disadvantages of modern and classical experimental methods are shown.

Keywords: strain gauges, digital image correlation, finite element method

1. Introduction

Use of pipe branches is very wide, which requires diversity to shape and function, as well as the use of different materials [1].

Just because of their wide application they could be exposed to various loads. During operation due to extreme stress values occurring in places of geometric discontinuity can occur fracture or structural failure. Based on previous research can be concluded that to fractures (cracks) of branches comes just in places of the greatest stress concentration [2-4].

Analysis of stress field of complex structures is usually performed by analytical calculations, numerical calculations and experimental methods. The most commonly used method for stress measurement on the real structures and a physical models is a method of strain gauges that gives a value of stress in a small area. One of the goals of this paper is to demonstrate the advantages of 3D digital image correlation method for testing complex geometry structures. This system is used to test all types of materials and has a very wide application [5-9].

In this paper numerically (FEM) are determined critical zones of the branch, i.e. the expected locations of stress concentration. Then experimental testing using the method of strain gauges and DIC is carried out. Finally, the numerical and experimental results are compared. For these testing, the load was the internal pressure of 10 bar. It is concluded that the pressure of this value would not cause initial plastic deformation in the branch model.

2. The Finite Element Method

The subject of these testing is a model of pipe branches made of steel S355J2+N, loaded with internal pressure. Dimensions and thicknesses are shown in Fig. 1.

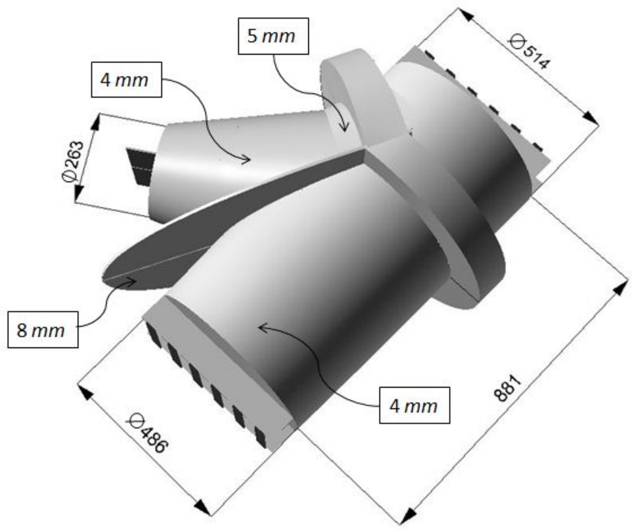

Figure 1 Model of pipe branches, dimensions and thicknesses

Three-dimensional model of branches was developed for the FEM analysis. Considering the symmetry of model, regarding the geometry and load, only half of the model is analyzed (Fig. 2). The grid is denser in places of geometrical discontinuities, i.e. in areas where stress concentration is expected (Fig. 2). The structure is loaded with internal pressure of 10 bar.

The results of FEM analysis (von Misses stress) are shown in Fig. 3.

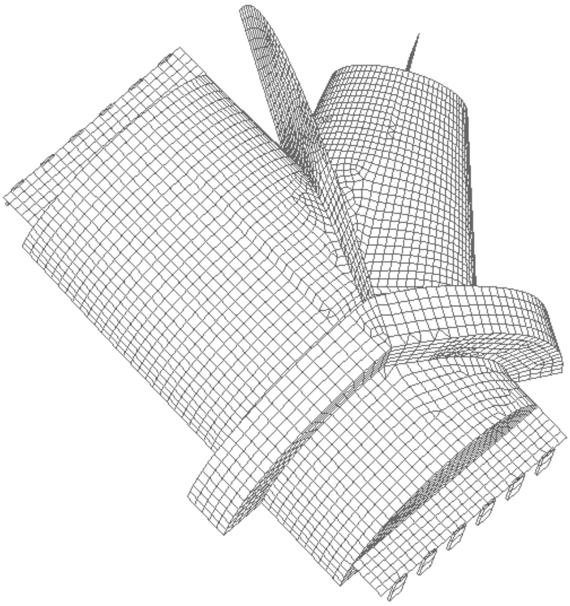

Figure 2 FEM model

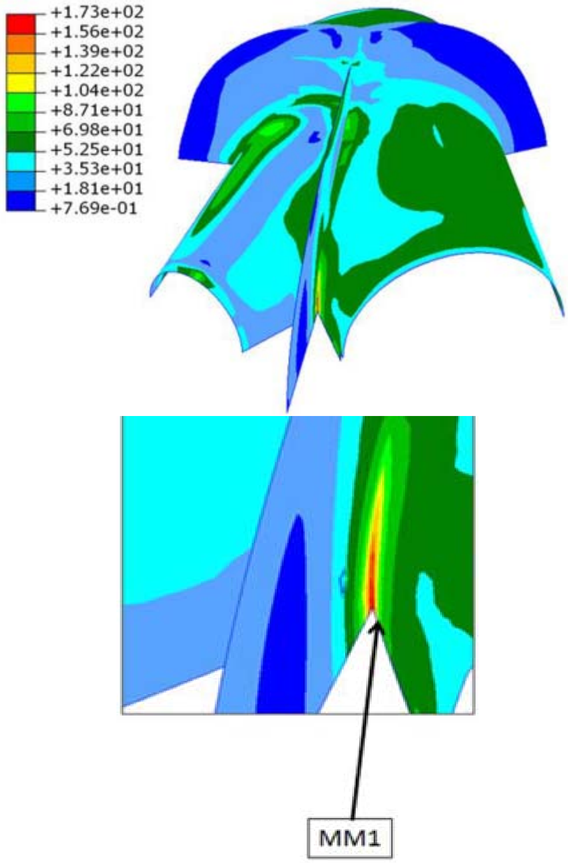

Figure 3 Von Misses stress [MPa], internal pressure 10 bar

The greatest stresses occur in places of geometric discontinuity, as can be seen in Fig. 3. In addition, since the value of stress (even in places of concentrations) is lower than the value of the yield strength of the material (S355J2+N), it can be concluded that pressure of 10 bar would not cause initial plastic deformation.

2. The Experimental Testing

The experimental installation in the Laboratory for Strength of Materials, Faculty of Mechanical Engineering, University of Belgrade is shown in Fig. 4.

Figure 4 Experimental installation

Strain gauges are placed in characteristic points (identified on the basis of FEM calculation). Eight measuring spots are defined. The highest measured value of the stress is obtained in measuring spot MM1 (as estimated on the basis of FEM calculation). Location of MM1 is shown in Fig. 5. The diagram of stresses as a function of pressure value is shown in Fig. 6.

Figure 5 The strain gauge in measuring spot MM

A method of 3D optical stress analysis is based on digital image correlation. This technique involves the digitization of prepared measuring surfaces of painted object before and after loading. Equipment for experimental analysis consists of an optical system for 3D stress analysis, i.e. special sets of stereo cameras and lenses, software package Aramis, a stand that allows the security and stability of sensors, devices to control the supply and image capture, PC systems and additional lighting (Fig. 4). Measured surface has to be sprayed (Fig. 7). Spray creates visible dots in a way of contrast in order to perform more accurate measurement. Aramis system partitions the pixels within the image into a small units - facets, calculating the displacement by tracking the relative movement between facets.

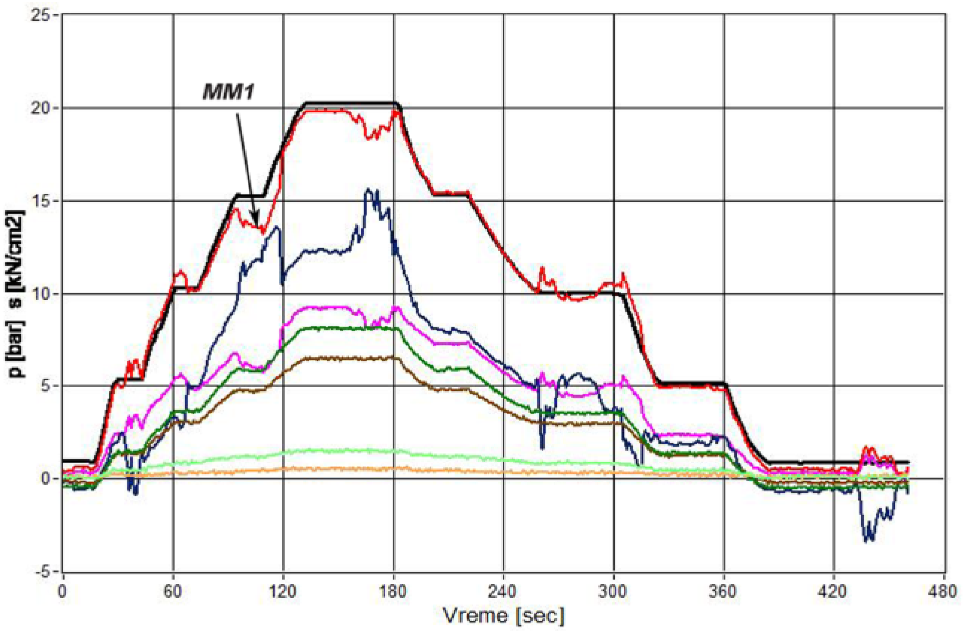

Figure 6 Diagram of stresses as a function of pressure

After performing the experiment, the Aramis software computes the displacement of the every point on the measured surface, and it shows stresses in each direction and is able to calculate Von Misses stress as well.

The measuring results obtained by the Aramis-system in measuring spot MM1 are shown in Fig.7.

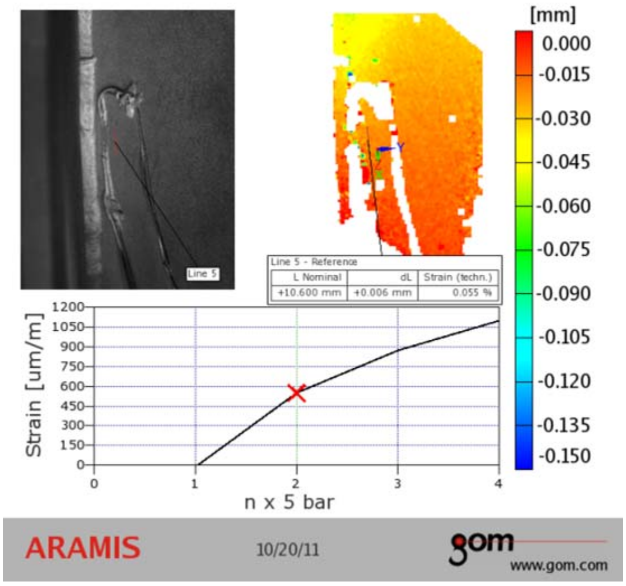

Figure 7 Measuring spot MM1, the Aramis-system, internal pressure 10 bar

The value of the stress at MM1 is

$$\sigma = 580 \cdot 10^{-6} \cdot 21000 = 12.2 \frac{kN}{cm^2} = 122 MPa$$

(Aramis-system internal pressure of 10 bar). This measurement indicates the presence of concentrations of the deformation around the middle horizontal plane of symmetry and closer to the welded joint of the cylinder and the stiffener.

In addition to the field around the MM1, and welded joint of the cylinder and the stiffener is taken. Measurements of 3D deformations in this place (the place of largest stress concentration) had for a goal to determine the degree of stress increase versus stress in MM1. In measuring spot MM1 was possible to place strain gauge (nearest possible to welded joint, about 15mm).

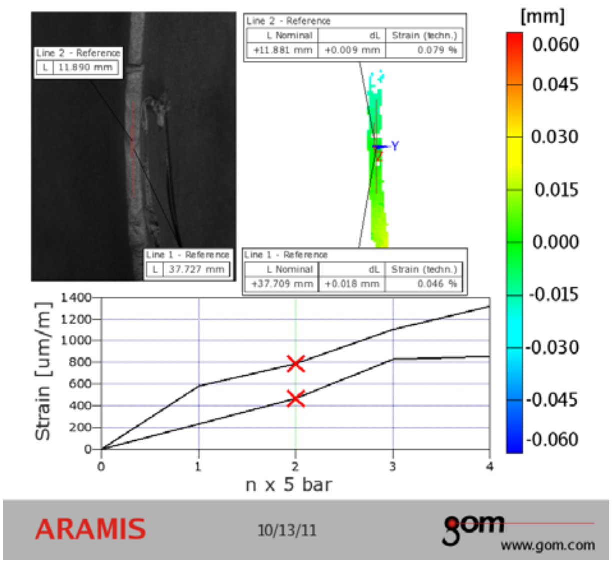

Figure 8 Welded joint near MM1, the Aramis-system, internal pressure 10 bar

The value of the stress in welded joint near the MM1 measured by the Aramis-system is $\sigma = 600 \cdot 10^{-6} \cdot 21000 = 12.6 \frac{kN}{cm^2} = 126\ MPa$ (load is internal pressure of 10 bar).

3. The analysis of the results

In Table 1 the results of measurements and numerical calculations for measuring spot MM1 are shown. Load is internal pressure of 10 bar.

Table 1 Comparison of numerical and experimental results, measuring spot MM1, internal pressure 10 bar

The stress value [MPa]		
The Finite Element Method	Experimental method of strain gauges	Experimental method of 3D Digital Image Correlation, the Aramis-system
115	100	122

Comparing the results obtained experimentally with the results of numerical calculations can be seen that the values are similar, so the numerical model of pipe branches is verified.

Using strain gauges was not possible to obtain the stress value in welded joint, i.e. was not possible to place the strain gauge at welded joint. Using the Aramis-system the value of stress in welded joint is obtained. Measured value of stress in welded joint is 126 MPa, which proves that stress concentration is present.

4. Conclusion

The goal of this paper was not just to analyze behavior of pipe branches loaded with internal pressure, but to demonstrate advantages of the method of digital image correlation comparing to classical measuring techniques. Strain gauges still represent reliable method for stress and strain measurement. In the other hand, Aramis-system (based on DIC) is able not only to deliver precise results but also to illustrate full stress field. Analyzing obtained results can be concluded that:

- The highest stress concentration occurs in welded joint near measuring spot MM1;
- The results obtained by experimental measurements confirmed results obtained numerically;
- Using the method of digital image correlation can be obtained the stress values in welded joint;
- Internal pressure of 10 bar would not cause the model of pipe branches to plastically deform.

5. Acknowledgement

This work is a contribution of the Ministry of Education, Science and Technological Development of Serbia funded projects TR 35040 and TR 35031.

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PUBLIC PERCEPTION OF AN URBAN PUBLIC SPACE RECONSTRUCTION

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Abstract

We analyzed a revitalization of urban green space. Our earlier research focused on determining the value of urban green spaces. Now we wanted to know the opinion of the population. It is how they make the renovated park and which is the most popular park items.

Keywords: Greenery, reconstruction, survey, factor analysis.

1. Introduction

Our earlier research focused on determining the value of urban green spaces [1]. We reviewed the methods of analysis of green space elements. Particularly examined the unique value of the trees, which are the most important elements of green areas. We determined the value of the individual trees of various evaluation methods [2].

The value of green space in the living [3] and built a park elements as the sum of the values obtained [4]. This study was aimed to know the opinion of residents who are recipients of public space.

People are asked to review a completed green space restoration results. The survey was conducted in Kecskemét (Hungary) after the Rákóczi street revitalization.

2. Method

The opinions of survey were selected from among the methods of market research. To ensure workability and evaluation questionnaire compiled.

In order to complete the questionnaire as fully as possible this should be carried out qualified colleagues.

.There were six demographic questions to the respondent's: gender, age (category 5), education (8 class grade, secondary school, college, currently student, other), place of residence type (capital city of the county seat, city, municipality, other) and yearly income (no, not more than € 3,333 / year, from 3,333 to 5,000 € / year, from 5,000 to 6,666 € / year, over € 6,666 / year) and that included local resident or not.

We know what the respondents habits through six questions. In their spare time, how often and how much time they spend each time public square, park (questions 2, 3). Do you have any favorite public squares, parks in the city and if yes, which one (question 4, 5).

Yes-no question was posed to a nearby park place of residence or work location nearest you visit (Question 6, 7). Five questions (questions 8-12) related to the refurbished green space. Went to the park (yes - no) and how much you like the green area (1 very bad - very good 6) (question 8, 9). The tenth issue has requested an opinion some (7) statement, (one very bad - very good 6). The area is clean, good furniture, good that the old trees were preserved, like the planting of plants and flowers, like the casing, like the evening illumination, like so many terrace. The question 11 was open. We asked, what would be better suited to the park to relax. We've been waiting a few sentence answer. The question 12 was directed to the respondents consider it important for the renovation of this green area.

Data was processed in two levels. We were waiting for the diversity and the distribution of opinions by the basic statistical investigations as well. In this study, we sought answers on the assumption that: the result of a four-scale reconstruction has created much popular green space. Are there any gender, age, income or other group under which are formed the same opinion.

More complex relationships recognize the SPSS computer program was used. Using factor analysis, groups were formed, which were based on the assessment of the refurbished green space elements specific answers. We studied and plotted the park's elements are addressed in the opinion-distance map.

Budapest XIII. district also prepared a survey, which is similar to our present findings. Not a revitalized public park focused on the test, but the views of the population assessed at two time points, and in 2008 was the 2011th. This survey was carried out by Ipsos Ltd. (2008) and Ipsos Media, Advertisement, Market and Opinion Research Institute.

3. Results

The number of evaluable questionnaires was 40. The distribution of respondents by gender, 57.5% women and 42.5% men. The respondents were adults, over 18 years of age. Detail on the in Table 1.

The breakdown by level of education of the respondents are shown in Table 2. 40% of respondents education up to secondary level, 57.5% higher education students or graduates.

Table 1. The distribution of respondents by age

Age	Capita	Percent
18-25	13	32,5
26-30	6	15
31-40	8	20
41-50	6	15
50-	7	17,5

Table 2. The distribution of respondents by education

The level of education	Capita	Percent
8 classes	3	7,5
secondary school	13	32,5
student	9	22,5
college	14	35
other	1	2,5

The 72.5% of the respondents live in urban population and 20% of the village. Capital respondent was not, 5% other county seat occupant. The 70% of respondents have an income of up to € 6,666 per year, 27.5% did not have an independent income or their income is not declared. The detailed data are shown in Table 3.

Table 3. The distribution of respondents by income

Income €/year	Capita	Percent
- 3333	10	25
3333 – 5000	11	27,5
5000 – 6666	7	17,5
6666 -	1	2,5
no, no answer	11	27,5

60% of the respondents live in Kecskemét, 40% of the non-resident.

Based on the frequency of occasions spent a green area per day is 15%, 30% weekly, monthly 2.5% and 52.5% occasionally visited them. 75% of the visitors to 0.5 hours (32.5%) or one hour (42.5%) spend in the parks, 2 hours 17.5%, 7.5% more than this.

50% of respondents replied that they have a favorite public park. However, more people (85%) have been identified gladly visited public parks. As my favorite park marked the respondents, 38.4% of urban forestry arboretum, a renovated Rákóczi street of 32.35%.

We asked that, during the visit of more public parks in the vicinity of the place of residence or work places in favor. 27.5% of all respondents would visit the park, which is close to the residence, and 35% of the park which is near the workplace. In the case of Kecskemét respondents residents at the rate equal to 37.5%, which visited the park near the residence or near place of work is. However, those who prefer the Rákóczi Street Park, 66% of them visited the park in the park in the neighborhood of jobs and 33% of the residence close.

The question (9), whether you like the renovated garden Rákóczi Street, to reply in a 6-point scale (1-6) above. The rating in the top third (5 good 6 very good) gave 80%, to the middle third (3, 4) 17.5%, and 2.5% did not like (2, 1). The average rating is 5.08. The average rating of 5.28 local residents and those living elsewhere 4.88.

We asked about the park, where the general opinion is also divided into parts. Seven claim had to be assessed in a six-point scale (question 10).

The respondents declared the park a high purity. 40% of respondents are very good, 52.5% classified as good, 7.5% is rather good. An average of 5.33 points assessed for purity.

According to the respondents, 42.5% of the area of street furniture are very good, 40% good 15% rather good. It gave poor ratings to 2.5%. On average, 5.18 points assessed for furniture.

According to the respondents, 32.5% of the enclosure of the park is very good, 47.5% good and 15% rather good. Poor and very poor rating given 2.5% -2.5%. On average 5.00 point evaluated the covers.

The lighting in the area of 27.5% very good, 40% good 15% rather good. Rather bad rating given 5% and 2.5% very poor. On average, 5.08 points assessed for illumination.

Two questions related to the park's plants. Before the reconstruction, the Japanese acacia (Sophora japonica) had two double line of trees in the area. For this we placed in a new setting: it is good that the old trees were preserved. The preservation of old trees, according to the respondents, 62.5% of very good, 30% good 7.5% rather good. On average 5.55 point evaluated in the preservation of trees.

Figure 1. Rejuvenated old trees in Rákóczi street 2012 (Sophora japonica)

Another question asked about an opinion formed in the plant beds. The beds were in the park 67.5% very good, 25% good 5% rather good. 5% gave poor ratings. On average 5.55 point evaluated in the plant beds.

We asked visitors to the terraces at the park and its surroundings. The existence of the terraces of the respondents, 35% as very good, good, 47.5% of the 12.5% holding rather good, 2.5 to 2.5% rather bad or very bad. The existence of the terraces were assessed an average of 5.05 points.

We asked an open question (11) that what could be more relaxing in the park. 27.5% of those surveyed responded, 55% of these are proposed to reduce vehicular traffic.

The ninth question (whether you like the renovated Rákoczi road) where the average responses of the six-level scale 5.08. Here we sought to find whether the opinion of a group who is linked to a demographic characteristics. A typical value of group difference - not the real numerikes 1-6 scale - over 10% (the difference between the averages of more than 0.6) were considered significant.

The average response of 5.22 for women, 4.88 for men. This difference was not considered significant.

The average younger than 40 years 5,11 opinion, to persons over 40 years of 5.00, which is also not a significant difference.

The ninth question, the average of 19 people with secondary education válszainak 5.29. The average of the higher education and students' opinion 4.91. The difference is 0.38 which is lower than the threshold of 0.6.

The opinion of the average city dwellers 5.28 (72.5% of respondents who have total). The opinion of the average non-residents in Kecskemet 4.55. This difference of **0.73** is **significant**.

The income of the respondents, 87.5% reported. 2.50% of them had no personal income. Those who have an independent income they average 5.12. The <less than € 5,000 / year income respondents the average answer given to the question 9 of 5.29, 4.85 above € 5,000 / year. The larger the difference was 0.43, which was not considered significant.

Using factor analysis, we looked for possible groups. Groups expected to find, based on the similarity of opinions. Seven of the agreement contained 10 questions in the questionnaire qualification statement. These were used as input variables for factor analysis. The results obtained using the IBM SPSS version 20 are rotated in the matrix component are shown in Table 4.

As the method gives only numerical results should be interpreted of times. Examined the first step, the highest values of the component matrix. Within the first component with the highest value (0.829) to achieve classification of the casing. Inside the second component of the 0.859 value to the maximum purity. The third component in the preservation of old trees with the highest value (0.973) is also the overall matrix.

The first component is below the maximum number of relatively high values. These three are all above 0.75, these are being planted, terraces and night illumination.

The second component opinions after the cleanliness of the street furniture, which show a level of above 0.7. The other subject only values below 0.4 are included.

The third component in addition to the preservation of old trees, does not show any value above 0.4 is a subject area.

Table 4. One of the results of the factor analysis

Rotated Component Matrix[a]

	Component 1	2	3
Clean	**,252**	**,859**	**,257**
Furniture	**,447**	**,714**	
Keep trees		**,102**	**,973**
Flowerbads	**,804**	**,262**	**,362**
Pavement	**,829**	**,176**	**,108**
Lightning	**,759**	**,361**	
Terraces	**,774**	**,368**	

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 5 iterations.

The first component respondents typed while walking on a patio just sit there and admire the beautiful architectural and live ambient. We concisely defined **promenade man**.

The second component is typed respondents expecting cleanliness and comfort sits assessment personnel. We succinctly defined: **sophisticated pedestrian**.

The third component is typed next to the respondents in the older trees, flower beds assessor. It is likely that the shadow of trees was also pleased. We concisely defined as the **park lover**.

The mathematical statistical analysis, the SPSS program provided an opportunity to draw up an opinion distance matrix covered, Figure 2.. In arranged in two dimensions we see that over the course of features reviews is guided by the respondents.

The first dimension is that some elements of the built environment (paving, lighting) and hospitality preference is a pole. The live elements of environment, the preservation of old trees, planted in the flower beds is the other pole. This finding created on the basis of similarities faktoranlízis two groups who "promenade man" (Component 1) and the "park-lover" (Component 3).

In both dimensions, according to the central location of cleanliness and flower beds found. This is understandable, since the general expectation is that the purity and annual and perennial flowers are a beautiful park.

The second dimension is the farthest as provided for in the casing and resulted in furniture and lighting. First approach to these common features that the built-technical elements. In our opinion, not the common technical nature, but the fact is causing the opinions distance. Who was only during the day in the green area is not well qualified as the evening illumination.

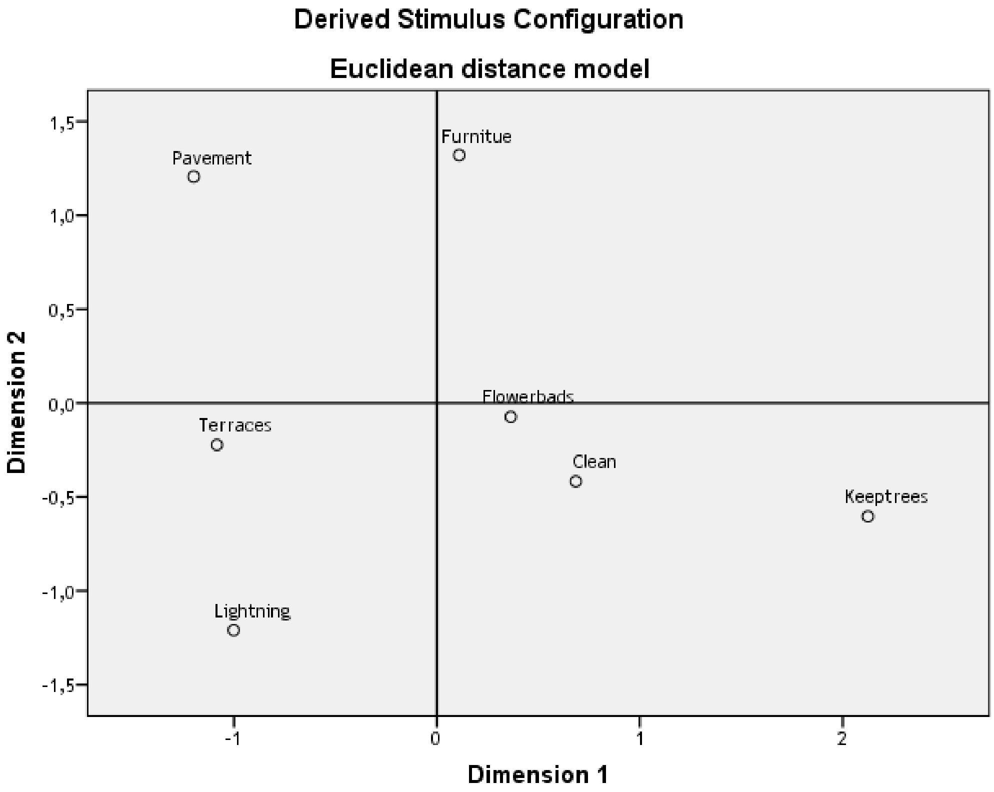

Figure 2. Derived Stimulus Configuration

4. Discussion

45% of respondents at least weekly visits to public parks, 52.5% occasionally and 75% of them spend 0.5-1 hours there. This 45% rate can Kecskemét, Budapest [1] 30% (2008) and 28-32% of the value (2011) 1.5 times.

85% of respondents indicated a favorite park, which are the second most popular the Rákóczi street.

A public park visit for 35% of the population is close to the workplace. Among the residents of Kecskemét rate equal, but higher 37.5%. The people with the Rakoczi street favorite park, two-thirds of them in the park near the workplace like. This study is different from the outcome of Budapest, where [1] public park near the residence of the most visited.

The general question, "if you like", local residents gave a higher value (5.28) than those living elsewhere (4,88).

The perception of green space elements of the case was a statement from the local residents are not significant differences in Kecskemét. The preservation of old trees, an average of 5.25 people living elsewhere, local residents were assessed 5.75 points.

The results of the study in Budapest [1] the second and third development site for the planting of trees and large lawns marked the establishment of the population.

Who has given his opinion on a better relaxation, it has proposed a 55% reduction in vehicle traffic.

The three groups are defined on the basis of factor analysis does not give a real person. But visitors to the types of sets, judgment and acceptable categories.

The opinion distance matrix gives the formed on the basis of factors confirmation of groups of characters.

We know that the number of processed samples is not high, but the choice of the appropriate methods based on the conclusions are sound. Our work can give a good basis for further research to base.

5. Conclusion

The Rákóczi street reconstruction was important, measured 6 on a scale of 5.05, the average of local residents average of 5.21.

38% of residents in Kecskemét favorite green area of the Forest Arboretum, second in the renovated Rákóczi street 32% of them. This high rate, it would certainly not without renovation. The average of 1-6 on a scale of 5.08 reviews. The basis of the average of the seven respondents surveyed favorite part (5.55) in old trees and flower beds, and was followed by the purity of 5.33. It can be concluded that living plants and good quality green space maintenance determining the public's opinion.

Figure 3. Shady walkway and flower beds on Rákóczi street 2014

Answers favorite green area and its location served as an unexpected result. The renovated Rákóczi road and park in the vicinity employees serve more than the residents living nearby.

Based on the factor analysis typified visitors, the "promenade man", the "demanding pedestrian" and "park lover", although non-existing persons, but by definition be a clue to the other parks being upgraded. These requirements assume that appear similar in other renovations.

In our view, the opinions distance matrix pre–sented, strengthens and complements the require–ment laid down in the factor analysis.

Influencing the hypothesis formulated questions whether the factors sex, age, income, Rákóczi street judging our response non relevant factors. Result of investigations by the Ipsos Zrt., Budapest is in line with this. They found no association between public parks formed an opinion and demographic parameters.

.Local residents were assessed the park higher, but this difference was not significant. This can be considered a normal sign of local patriotism.

The reconstruction was successful in Kecskemét green space, it has won the public displeasure. A survey in Budapest (XIII. District) brought the same results in several areas. Both play a major role in the trees, flower beds and lawns and cleanliness of public perception of public parks.

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CRITICAL ANALYSIS OF TIG WELDED JOINT OF TITANIUM G-5 ALLOY SHEET

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Abstract

Current and speed are important parameters in arc welding. This paper aims to have better understanding on the dependency of some mechanical properties of Ti-G5 alloy at micro level on welding current and speed. A Titanium G5 or Ti-6Al-4V sheet of thickness 2 mm were joined by TIG welding. Welding was carried by varying welding current and speed while keeping other parameters constant. It investigates into microstructures of different zone around the welded joint and found that microstructures become coarser near the Fusion Zone (FZ) and Heat Affected Zone (HAZ). The analysis of microhardness shows that as we move from weld centerline to base metal hardness value decreases.The thermal analysis shows that with increase in temperature the combined area of fusion zone and heat affected zone also increases.

Keywords: Titanium G5 alloy, TIG Welding, Microstructure, Micro-hardness, welding current

1. Introduction

Titanium alloys are metals that contain a mixture of titanium and other chemical elements. Such alloys have very high tensile strength and toughness (even at extreme temperatures). They are light, have extraordinary corrosion resistance and the ability to withstand extreme temperatures. At present, Ti–6Al–4V is one of the most widely used alloys of titanium, and it accounts for more than half of all the world's titanium tonnage [1, 2]. It is a two phase α+β alloy, with aluminum as the alpha stabilizer and vanadium as the beta stabilizer [3]. Due to its high strength and low density, along with good tensile and creep properties up to about 300 ^{0}C, it is commonly used in nuclear engineering, civil industries and medically implanted materials, transportable bridge girders, military vehicles, road tankers, and space vehicles, for its above said significant properties [4, 5] The titanium is highly reactive when the processing temperature exceeds 500°C. The surface of titanium can easily absorb the gases such as oxygen, nitrogen and hydrogen from atmosphere. This absorption of gases results in increasing brittleness and hardness. To minimize these issues the shielding gas should cover the weld area [6–8].

With the development of titanium industries, many welding processess, such as Tungsten Inert Gas Welding (TIG), beam welding, resistance welding and diffusion welding, have already been developed. Because of their high chemical activity, titanium alloys easily absorb harmful gas (oxygen, hydrogen and nitrogen) and many problems such as low mechanical properties and unstable structures would appear [9–11].

Conventionally, TIG, plasma arc [12], and electron beam welding [13] have been used to weld titanium alloys. Up to now, TIG welding is one of the most widely used welding methods for titanium alloy, particularly in sheet form [14].

2. Experiment

Titanium alloy G5 which is also known as Ti-6Al-4V of thickness 2 mm is investigated in this experiment. Chemical composition of G5 is given in table 1. In addition to oxygen there are some impurities like C, Si and Fe also present.

Table 1: Chemical composition of base metal (weight %)

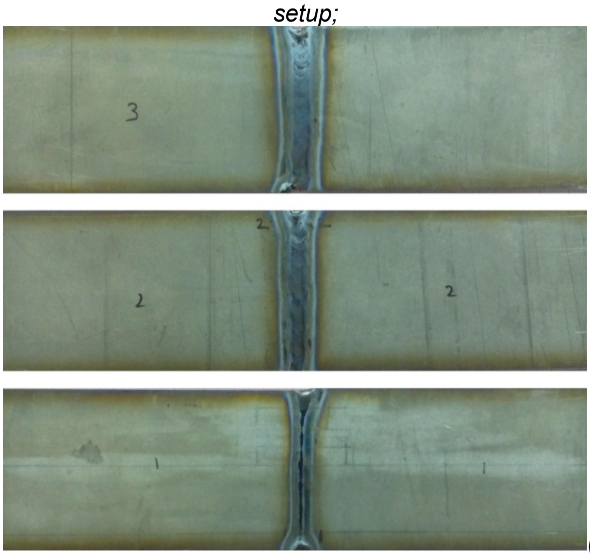
Element	Al	C	Fe	O	V	Ti
Weight %	5.9	0.10	0.20	0.2	3.4	Bal.

In this experiment two sheets of dimension 100 × 50 × 2 mm are joined by modified TIG welding shielded by Argon. In the modified TIG welding process a PUG Cutter is properly calibrated to provide a speed controller in linear direction. Six such samples are welded by varying current as shown in Table 2. The setup for modified TIG welding is shown in Fig 1(a). This arrangement provided a uniform speed and fixed angle during welding. The welding is done along 50 mm dimension of the metal sheet, as shown in Fig. 1(b) and (c).

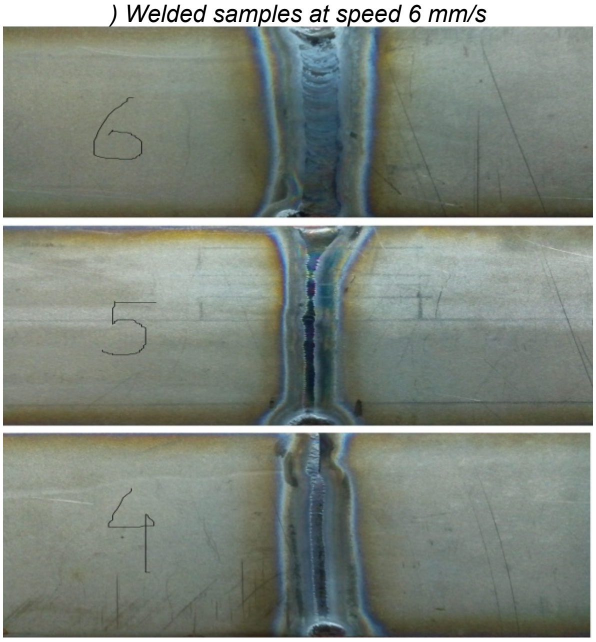
Table 2: Different parameter during welding

Sample No.	Speed (mm/sec)	Current (I)	Voltage (V)
S1	6.0	60	260
S2	6.0	70	260
S3	6.0	80	260
S4	7.5	60	260
S5	7.5	70	260
S6	7.5	80	260

(a) Modified TIG welding setup;



(b) Welded samples at speed 6 mm/s



(c) Welded samples at speed 7.5 mm/s

Figure 1. TIG welding set-up and welded joints

From each welded plate a sample of 25 × 10 × 2 mm is prepared for microstructure analysis. Microstructures of the welded plates are studied in FESEM (Field Emission Scanning Electron Micro-scope) Supra 55 with air locked chamber. Each sample was analyzed at fusion zone (FZ), Heat affected zone (HAZ) and base metal (BM) for studying the changes in the three zones.

The hardness across the weld cross section was measured using a Vickers micro-hardness testing machine (Economet VH-1 MD) with an indentation force of 500g and dwell time of 10 sec.

The T8 Thermal Image Camera is used during welding to measure the temperature of sheets.

3. Results and discussion

Microstructures of Fusion zone, HAZ and base metal were investigated in FESEM. Fig. 2 shows different phases after welding in fusion zone. Similar type of phase with some lesser coarse structure is seen in HAZ while in base metal α phase predominant.

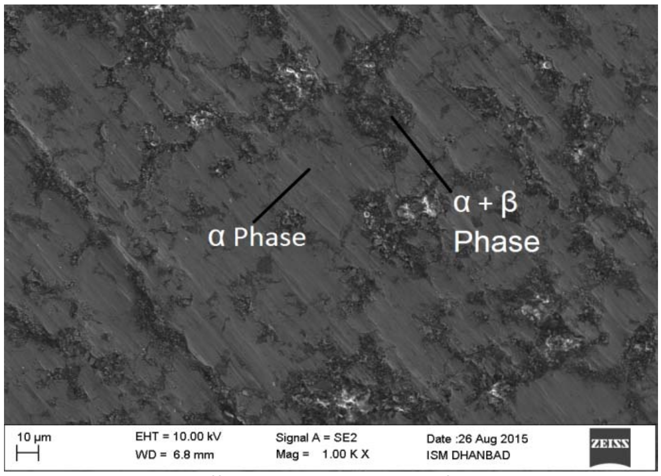
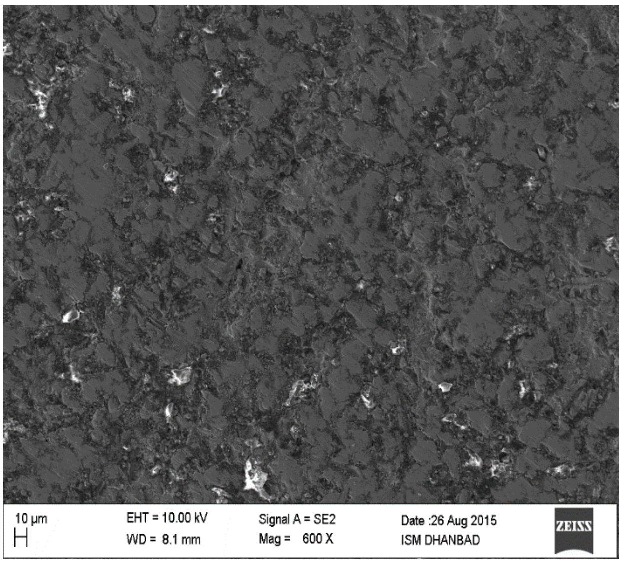


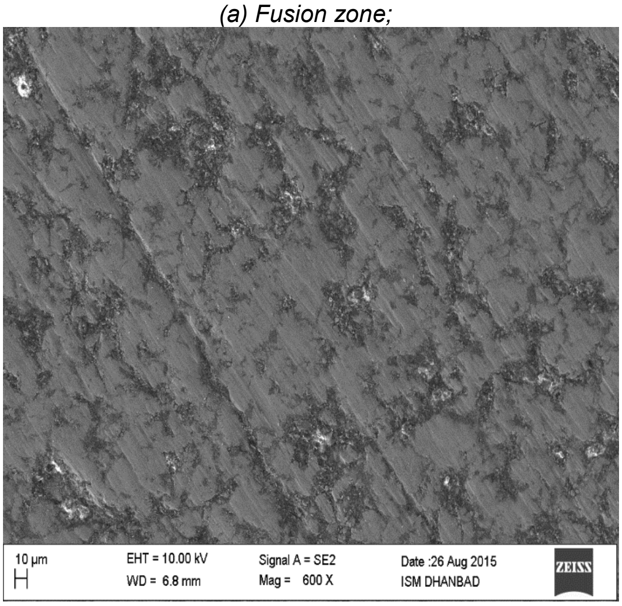
Figure 2 Different Phase seen at fusion zone

The fusion zone microstructure of TIG joint contains the coarse grain and acicular *α* structures of grain boundary α, massive α, and Widmanstat-ten *α+β*. HAZ microstructure of TIG joint consists of the coarse distorted serrate and acicular *α* structures of grain boundary α coarse *α+β* struc-ture while in base metal microstructure equiaxed *α* and granular *β* is obtained.

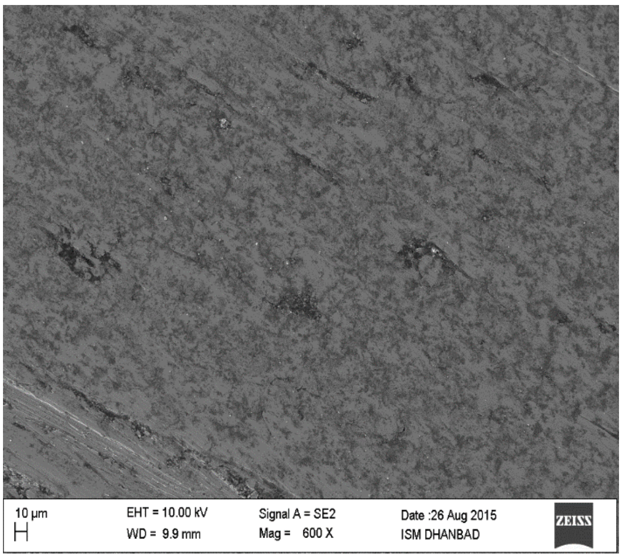
From Fig.3 it can be clearly seen that as we move from base metal to fusion zone the micro-structure grain become more and more coarse. The reason for such changes may be that α+β tita-nium alloy shows extremely low tensile ductilities in fusion zone on account of a large prior-β grain size and an acicular, at least partially martensitic matrix microsturcture [15] .



(a) Fusion zone;

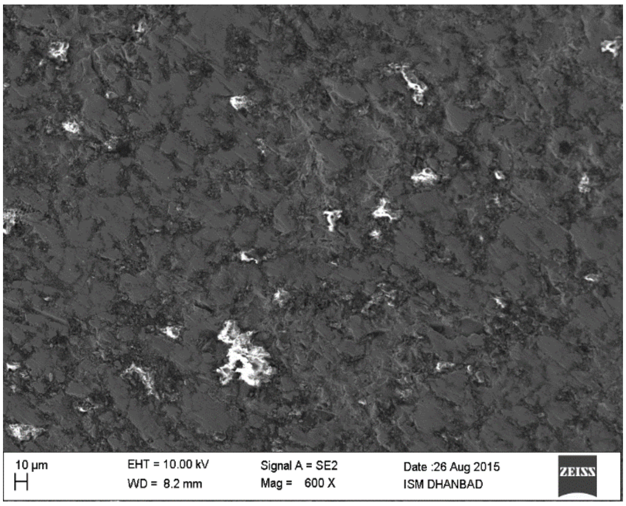


(b) Heat Affected Zone (HAZ);

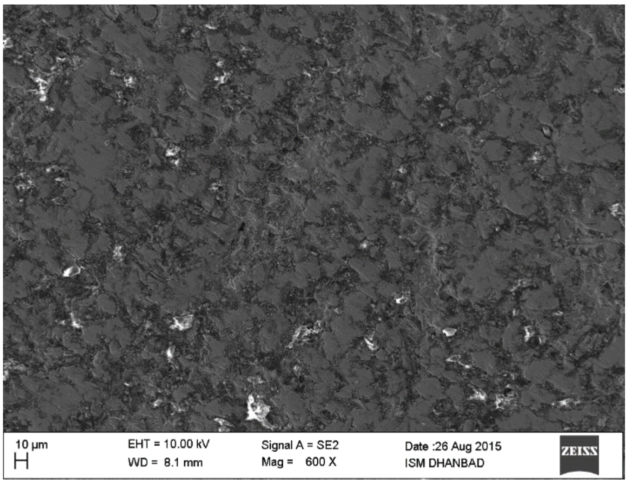


(c) Base metal
Figure 3 Microstructure images obtained by FESEM

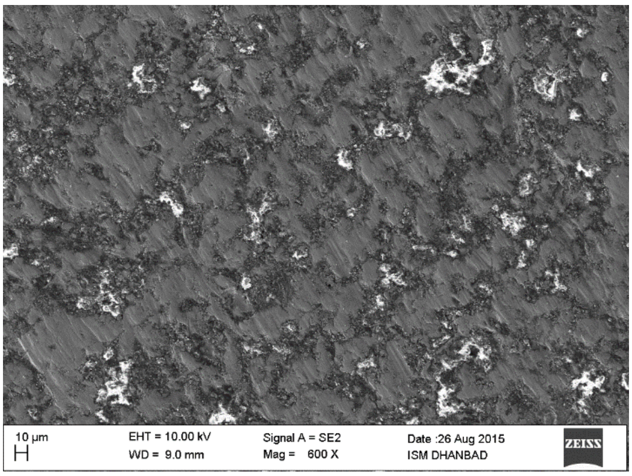
It is also observe that as we increase the current that is from sample1 (S1) to sample3 (S3) and sample4 (S4) to sample6 (S6) the microstructure become more coarse and more α+β phase as shown in Fig. 4



(a) 80 Amp;

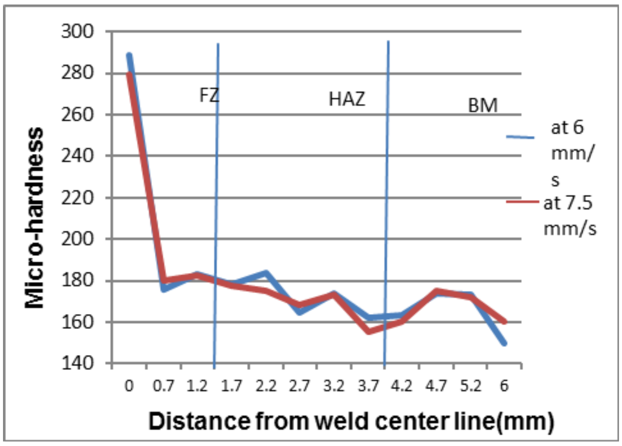


(b) 70 Amp;

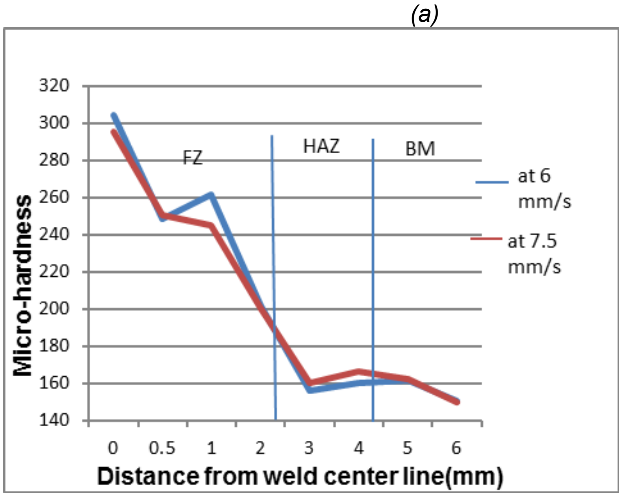


(c) 60 Amp;
Fig. 4 Microstructure of fusion zone at different currents

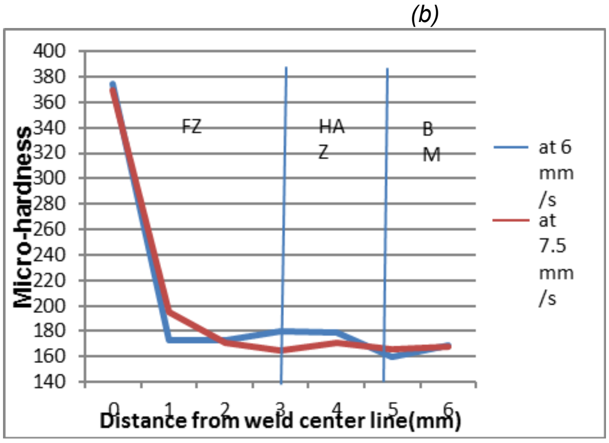
The micro-hardness graph of the samples as shown in Fig. 5 clearly reveals the trend in the hardness in different zones of all the samples. The micro-hardness decreases from center of welded joint to the base metal invariably in all the joints. So by this variation it can be understood that the increase of micro-hardness in the weld zone and decrease of hardness towards the base metal are due to the presence of coarse distorted micro-structure in all the six joints



(a)



(b)



(c)

Figure 5. Micro-hardness profiles across weld center line: (a) S1 & S4; (b) S2 & S5 and (c) S3 & S6

The hardness at the fusion zone of Sample 1 is HV 288.4, for Sample 2 is HV 304.1, for Sample 3 is HV 374.65,for Sample 4 is HV 279.4, for Sample 5 is HV 295.6 and for Sample 6 is HV 369.2 .At Heat Affected Zone (HAZ) the hardness of Sample 1 is HV 164.46, for Sample 2 is HV 165.2, for Sample 3 is HV 178.7 Sample 4 is HV 162.43, for Sample 5 is HV 160.45 and for Sample 6 is HV 170.43 At Base Metal (BM) the hardness of Sample 1 is HV 165.25, for Sample 2 is HV 161.83, for Sample 3 HV is 164.3, for Sample 4 is HV 166.82, for Sample 5 is HV 162.23 and for Sample 6 HV is 165.57.

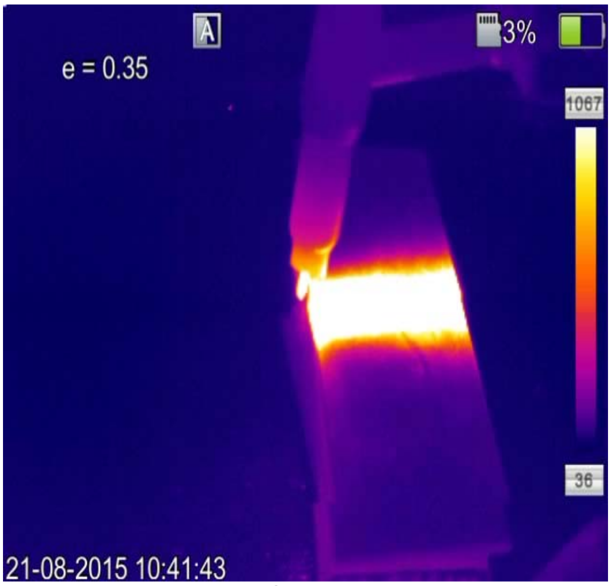
The above data suggests that the hardness at the fusion zone is 1.74, 1.87, 2.28, 1.67, 1.82 and 2.22 times the base metal for S1, S2, S3, S4, S5 and S6 respectively. This increase in the hardness is due to the welding thermal cycle.

The width of fusion zone from centerline were observed to be approximately 1.7 mm, 2.4 mm and 3 mm for S1 & S4, S2 & S5 and S3 & S6 respectively which is due to the highest current input in S3 & S6, lowest current in S1 & S4 and in between in S2 & S5 as shown in table 1.

Due to increase in width of fusion zone in S3 the weld centerline is having the maximum hardness when compared to all th samples

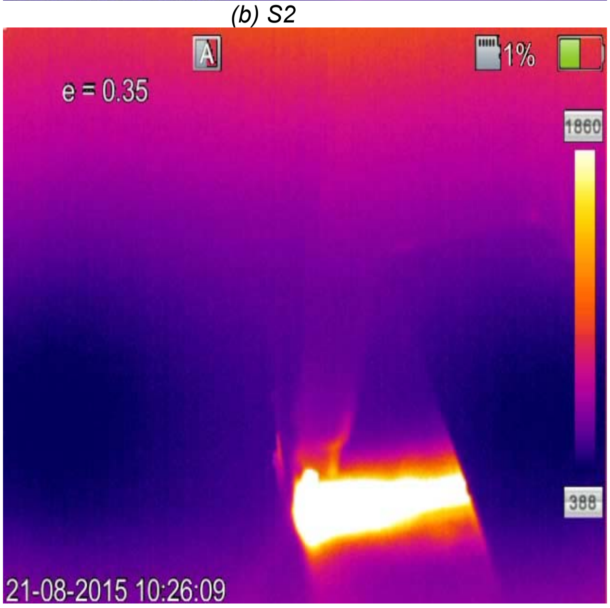
The thermal analysis as shown in Fig. 6 clearly depicts that with the increase in temperature the combined area of fusion zone and heat affected zone increases.

As the current increases from sample 1 to 3, Fig 6(a-c), the temperature also increases respectively from 1067 °C for 60 A, 1200 °C for 70 A and 1860 °C for 80 A. This increase in temperature affects the microstructure and other mechanical properties at the joining area.



(a) S1

(b) S2



(c) S3

Fig. 6: Thermal images of samples S1/S3

4. Conclusion

The modified welding arrangement was implemented for TIG welding of titanium G5 alloy. This arrangement provided a uniform speed and fixed angle during welding. Current and speed are very important parameters in TIG welding. Based on the results of this investigation, the following conclusions are drawn:

- In fusion zone $\alpha+\beta$ phase predominate which results in higher value of hardness
- Increasing the current coarsens the grain structure and as we move from base metal to fusion zone microstructure become coarser.
- As we increase the speed keeping current constant the maximum hardness value at fusion zone decreases.
- The hardness observed at the fusion zone is 1.74, 1.87, 2.28, 1.67, 1.82 and 2.22 times the base metal for S1, S2, S3, S4, S5 and S6 respectively. This increase in the hardness is due to the welding thermal cycle.
- Increase in temperature as a result of high current and low speed widens the combined area of fusion zone and heat affected zone.
- As the current increases from sample 1 to 3, Fig 6(a-c), the temperature also increases respectively from 1067 °C for 60 A, 1200 °C for 70 A and 1860 °C for 80 A.

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THE IMPORTANCE OF NUMERICAL ANALYSIS FOR VSR METHOD APPLICATION – CASE STUDIES

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Abstract

Technology for residual stresses relieving, in addition to a number of others, appears as an alternative method to thermal stress relief, which in certain cases shows as impracticable with the geometric aspects, or expensive and technologically more complex method where it is possible to apply. An application of VSR technology implies not only the application of specific equipment, but also a good knowledge of monitoring the entire process because it is based on the monitoring of appropriate size in terms of proving the efficiency of applied technology. In this context, numerical analysis of treated complex structure appears as a significant tool in providing quality and effective process that leads to the reduction and reorientation of stresses over construction, in order to ensure the integrity of the entire structure. The work presents a numerical approach before the application of VSR method on the specific models for industry needs. This approach is a good basis for the determination of the actual behavior of structures, reliable prediction of structural response in service, determining the parameters of choice and decision, determining the causes of bad behavior, pointing the methodology and parameters that will increase the level of structure relief, and enhance its stability.

Keywords: numerical analysis, VSR method, natural frequency.

1. Introduction

In the past 60 years, VSR (Vibratory Stress Relieving) has grown from a little-known to the respective process, especially important in treating of large structures, which was established as an alternative to thermal treatment of castings, pieces requesting additional machining and non-metallic materials. It is important to note that the VSR is not an alternative for all procedures of thermal processes, but there are areas where these procedures are and will be predominant. Thermal and VSR procedure covers three areas, reducing stress, dimensional inspection and dimensional stabilization. Although the complete relief of residual stresses can not be achieve by any commercial process, VSR can stabilize stress and relief its values in components at any stage of the manufacturing process or machine without changing the metallurgical state of materials, without the distortions with low cost and short time.

There are three main VSR approaches: resonant (R-VSR), modal sub-resonant (SB-VSR) and sub-harmonic (SH-VSR). The process of applying vibration technology in relieving residual stresses in the real industrial structure contains several phases of which are very important: the determination of the expected dynamic behavior of the treated structure, determining the boundary conditions of application of available equipment, and monitoring the process during the execution of relaxation technology of residual stresses. The importance of applying a preliminary numerical analysis of structures with complex configuration is to detect the shape and natural frequencies of oscillation to achieve the excitation of the structure caused by a specific frequency oscillations with corresponding shape. The adequate supporting of structures must be provided for all excitation of bending and torsional oscillations in terms of achieving the effect of reduction of residual stress in welded construction, [1,2]. Although the "scan" of structure can be done during the application of vibration procedure, in order to detect the reference oscillation frequency, the application of numerical analysis gives a more comprehensive approach because it indicates the distribution of the supports, i.e. the number of "phase" in which the process is complete.

2. Numerical analysis approach – Case study 1

In this part of the research the numerical analysis of the model of a beam is applied, which is of great help to confirm the boundaries of the planned application of measuring equipment, and proper conduct of VSR process to achieve the maximum desired effect, [3,4,5]. Discretization of the beam model is carried out with 1596 points and 1500 plain finite elements. Since the vibration treatment include two beam positions, vertical and horizontal position, the dynamic analysis gives the first five forms of oscillation and frequencies of the beam model to the level of 100 Hz. In the analysis, the mass of vibration equipment with 27.3 kg is included. In Figures 1-3 views of vibration modes for the three characteristic cases of the vertical beam position are given.

Figure 4 shows frequency response of the structure in the vertical plane, which clearly show the resonant frequency response and dynamic factors. These values are compared with the actual values of the FFT analysis after "scanning" the structure with measuring equipment.

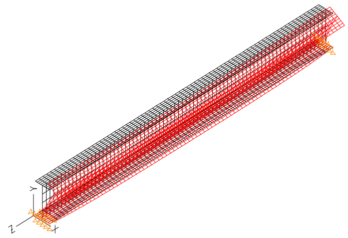

Figure 1. The first natural frequency 18,53 Hz

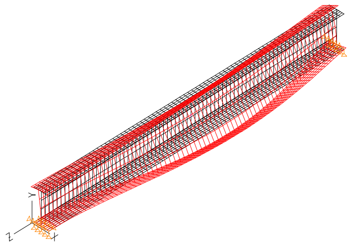

Figure 2. The third natural frequency 52,74 Hz

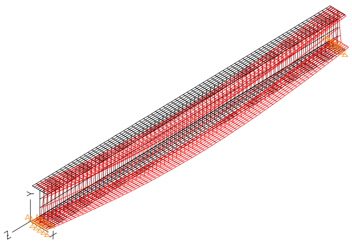

Figure 3. The fifth natural frequency 85,49 Hz

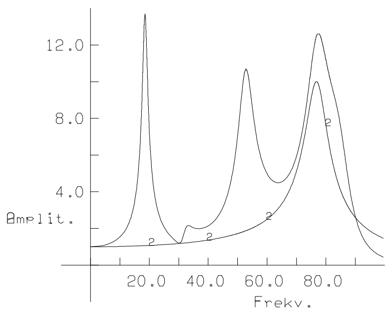

Figure 4. Amplit.-frequence response of the structure

Figures 5-7 show the mode shapes for three characteristic cases of the horizontal beam position. Figure 8 shows frequency response of the structure in the horizontal plane, which clearly show the resonant frequency response and significantly higher dynamic response factors. Such information is very important in positioning of the pieces during the VSR method treatment.

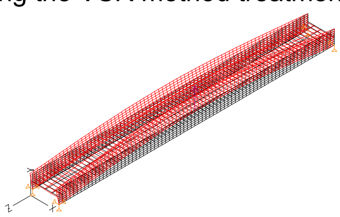

Figure 5. The first natural frequency 29,75 Hz

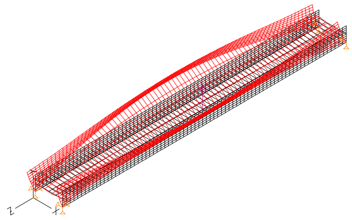

Figure 6. The third natural frequency 53,46 Hz

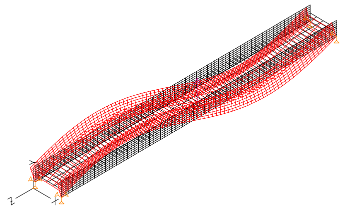

Figure 7. The fifth natural frequency 108,5 Hz

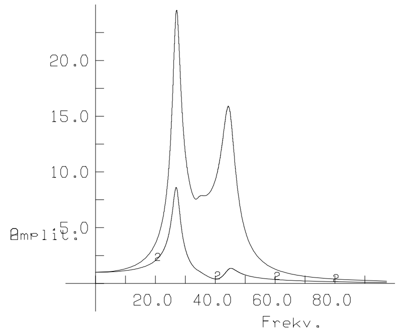

Figure 8. Amplit.-freq. response of the structure

Based on the above implemented dynamic numerical analysis, a summary table of the obtained values for frequencies and displacements can be given, Table 1.

Table 1. Summary values of the beam dynamic analysis

VERTIC. POSITION		HORIZONT. POSITION	
Nat. Freq. (Hz)	Max. displ. (cm)	Nat. Freq.(Hz)	Max. displ. (cm)
18,53	0,142	29,75	0,120
32,07	0,228	46,73	0,156
52,74	0,194	53,46	0,128
76,99	0,109	101,3	0,232
85,49	0,268	108,5	0,144

The presented approach is applicable to real industrial structures with need to take into account the geometric and mass characteristics of the system, i.e. the application of this approach indicates the need for multi-planar and multi-position placement of the force transducer in order to obtain more homogenous residual stress relief effect over the structure.

3. Numerical analysis approach – Case study 2

In this part of the research an analysis of the double-girder crane is done by using of reduced numerical model for residual stress relaxation process application to the main girders of double girder crane with weigh projected capacity Q = 150 kN and wheel main distance L = 24 m, and after completition of welding technology. Real view on double-girder crane is shown in Figure 9. In order to determine the parameters for relaxation methodology natural frequencies of crane structure oscillations are obtained, [6]. Some of results for the first six modes of oscillation are shown in Figures 10 to 12, and all six in Table 2. With the selection of appropriate parameters it is possible to obtain the necessary amplitude of oscillation ranging from 0.3 to 0.6 mm in the treated area. Working and residual stresses are balanced in exploitation conditions, so it is desirable to remove the welding stresses that have tension character in the zone closer to the lower band, while the presence of tension stresses in the zone of upper band are balanced with working stresses of compression character.

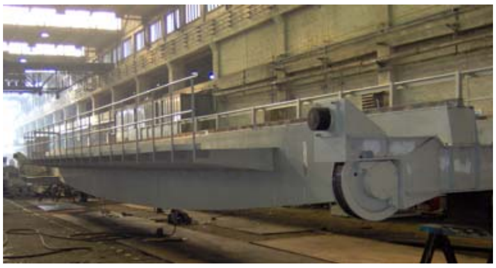

Figure 9. Double-girder bridge crane

VSR process is accompanied on the four measurement positions using strain gauges.

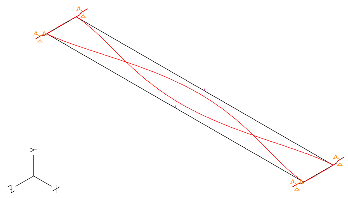

Figure 10. f_{o1}= 38,13 Hz, x-z plane

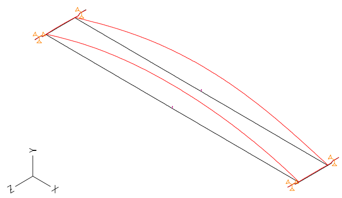

Figure 11, f_{o3}= 63,87 Hz, x-y plane

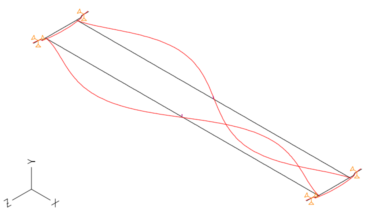

Figure 12. f_{o5}= 109,7 Hz, x-z plane

Places for vibrator positioning can be chosen so that residual stresses of lower band plate and the vertical plates are treated simultaneously.

Table 2. Natural frequency values

Natural frequency	Value [Hz]	Max. displ. [cm]	Plane of movement
f_{o1}	38,13	0,128	x-z (horizontal)
f_{o2}	39,21	0,129	x-z (horizontal)
f_{o3}	63,87	0,116	x-y (vertical)
f_{o4}	75,90	0,119	x-y (vertical)
f_{o5}	109,7	0,128	x-z (horizontal)
f_{o6}	115,1	0,128	x-z (horizontal)

4. Numerical analysis approach – Case study 3

Figure 13 gives real representation of the complex structure of SBG element. Numerical model discretization was performed with 2,438 points or 2,180 plate finite element. Dimensions of the entire construction, the thickness of the individual segments are taken from the submitted structural documentation. The dynamic analysis of the structure in the zone of vibrational excitation and experiment requirements of setting the model is done. According to the specification of equipment available for vibrational relaxation and making range of possibilities of the excitation force can reach flexion analysis of the structure and information on the displacement of 0,058 [cm] in the horizontal plane and the maximum of 0,069 [cm] in the vertical plane. Based on the analysis of their own form of oscillation leads to the first three forms of value in the amount of 160 [Hz], 170 [Hz] and 210 [Hz], respectively, Figures 14 to 16. Also, there was a dynamic frequency analysis that for a given combination of initiatives in the relevant sections of the items offered to consider the dynamic response of the desired location, Figures 17 to 19. Figures 14-16 present analysis of free oscillations of structure just in case one way of setting up the structure of the supports. Complete treatment of complex structure includes at least two ways of setting the supports and treatment in at least two planes in order to excitation of bending and torsional oscillation forms, [7-9].

Figure 13. Real view on complex SBG element

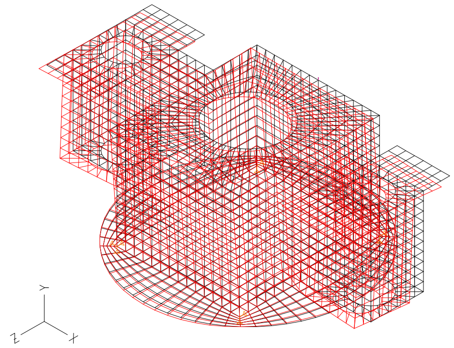

Figure 14. The first natural frequency f_{o1} = 160 Hz, max. displ. 0.058 cm

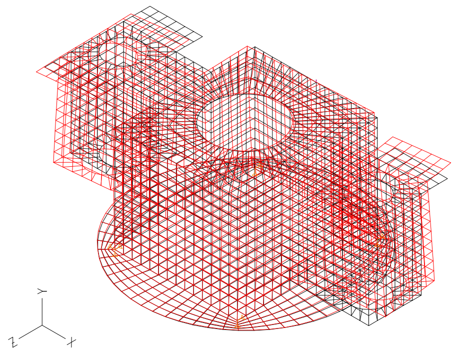

Figure 15. The second natural frequency f_{o1} = 170 Hz, max. displ. 0.069 cm

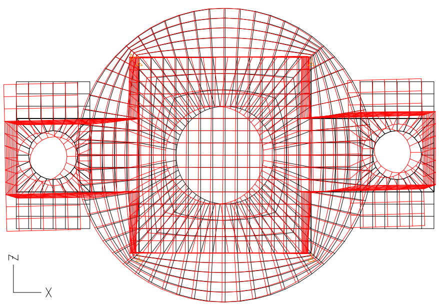

Figure 16. The third natural frequency f_{o1} = 210 Hz, max. displ. 0.059 cm

Based on the displayed image, it is evident that the structure has a certain forms of oscillation in the horizontal and vertical plane.

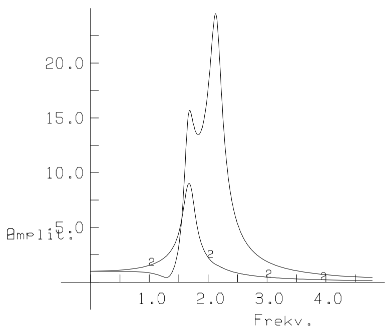

Figure 17. Amplit.-freq. response of the structure, excitation x-y plane,response x-y and x-z plane

Figures 17-19 are given representations of the frequency response of structure to the desired positions and directions vibration excitation response structure.

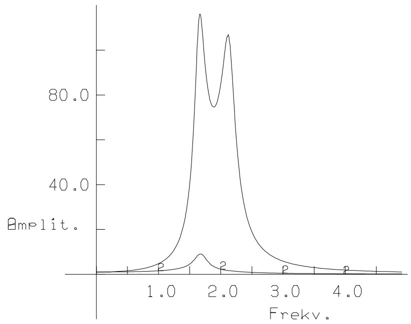

Figure 18. Amplit.-freq. response of the structure, excitation x-y plane, response x-y and x-z plane

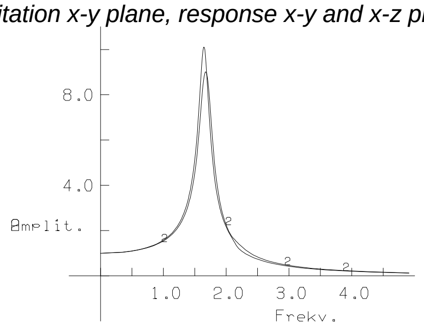

Figure 19. Amplit.-freq. response of the structure, excitation x-z plane, response x-y and x-z plane

Figures are visible preferred values of dynamic amplification factors that initiatives for certain combinations is for example η = 25. This means that the appropriate setting vibration excitation can be achieved by reaction of the structure and to encourage reduction and redistribution of residual stresses in the weld zones.

5. Conclusion

The analytical and numerical approach to dynamic analysis of vibration behavior of the construction indicates specificity of the VSR process and the fact where inadequate monitoring of the parameters often leads to inadequate effects of the process. Numerical dynamic analysis is particularly important for the optimization of the VSR process (proper positioning of exciter and operating parameters). This analysis is very useful in terms of planning the implementation of the VSR methodology because it gives the values of resonant frequencies of structures, mode shapes and displacement of treated structures. Also, for the complex large constructions numerical analysis of dynamic behavior is very important from the point of choosing a position for installation of supports and force exciter because the effect of VSR method depends largely on these parameters, because it is necessary to force the bending and torsional oscillations of the structure.

6. References

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ELASTIC-PLASTIC NUMERICAL ANALYSIS OF TENSILE SPECIMENS WITH SURFACE CENTER-CRACKED ASYMMETRIC WELDED X-JOINTS

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Abstract

The aim of this work is to determine appropriate numerical model to simulate the experimental evaluation of fracture resistance properties of tensile panels with surface crack located in the central section of asymmetric X-joint. The investigation is performed on high-strength low alloyed (HSLA) steel with undermetched weld configuration. Numerical analysis was carried out by ABAQUS three dimensional elastic plastic analysis mode. The work was performed on centre-cracked welded specimens, with two different sized cracks in order to examine the geometry impact on fracture resistance parameters. Comparison between experimental and numerically obtained results is done with attention focused on J-integral, crack mouth opening displacement (CMOD) and J-R resistant curves. Results are discussed in terms of further development on modeling procedure and technique. Approaching to real fracture behavior in similar welded structures with numerical investigation, can be far more economical solution instead of performing experiments. This paper, shows that simulations are promising in respect to their accuracy and can be used as a toll for further development of numerical models that have more complex nature.

Keywords: welded joint, surface crack, hetero–geneity, mismatch

1. Introduction

In engineering structures, particularly in produced welded joints, cracks are likely to arise from weld defects, inclusions, surface damage etc., and it is necessary to design structures with the knowledge that cracks are already present and capable of propagation at stresses below the macroscopic yield stress as measured in a tensile test. The service safety of welded structures is strongly dependent on the integrity and fracture resistance of the welded joints. A proper integrity assessment of a welded structure is more complex than that of the constituent materials because the welded joint may consist of two or more regions of different materials, each region having its own tensile and fracture properties. Considering this, it is necessary to develop an adequate evaluation procedure and systematization of fracture resistance properties of each region of the welded joint. It is commonly accepted to distinguish between three major regions: the base metal (BM), the heat-affected zone (HAZ) and the fusion zone or weld metal (WM). Mechanical properties (such as strength, toughness and ultimate tensile strength) as well as micro-structural properties are significantly different and change as distanced away from the fusion region. At a certain distance from the fusion zone the material is not affected by the welding process and has the properties of the original BM. The WM and BM are considered as different but homogeneous materials. The HAZ material is inhomogeneous in respect to both mechanical and micro structural properties and its located between the BM and WM without any sharp interface. Structural performance, deformation, stress and fracture behavior of welded joints can be distinctly affected by these region differences [1-2].

Crack propagation is strongly influenced by difference in fracture toughness and yield strength of WM, BM and HAZ. If the strength of the WM is lower compared to BM, this generally leads to an undermatched weld configuration (M<1) which is suitable for HSLA steel structures in order to avoid cold cracks [1-2]. In this case plastic strains are localized in weld metal until strain hardening is fully exhausted and then the BM starts to yield. But even this is the ductile type of failure, HAZ is still considered to be a weak point for crack initiation since its straining could be constrained during deformation [2]. When examining the effects of WM undermatching on structural integrity it is essential to determine the materials resistance to crack extension [1]. Many analytical and experimental studies on elastic-plastic fracture mechanics (EPFM) suggest that J-integral and crack mouth opening displacement (CMOD) are the most viable parameters for characterizing initiation of crack growth, the stable crack growth and the subsequent instability that occur in ductile materials [3-

4]. This clearly indicates that the fracture parameters like J-integral and CMOD can be conveniently used to assess structural integrity for both leak-before-break and in-service flaw acceptance criteria in degraded welded structures. J-integral is a suitable parameter for characterization of plastic deformation around crack tip, however, it should be noted that this parameter still possesses some theoretical limitations [4-5]. Nevertheless, possible error is considered tolerable if the relative amount of crack extension stays within a certain limit and if elastic unloading and non-proportional plastic loading zones around a crack tip are surrounded by a much larger zone of nearly proportional loading controlled by the HRR field. Under this condition of J-dominance, both the onset and limited amount of crack growth can be correlated to the critical values of J and J-resistance curve, respectively.The comparison of crack driving force, expressed by J-integral and materials J-R curve provides the critical crack extension. The method of resisting curves is based on elastic-plastic analysis and can provide an adequate assessment in terms of plane state of stress [6]. In this paper, the reader will find basic concepts for numerical investigation of tensile panels made of HSLA steel with asymmetric X welded joint in the central section. In order to study the ductile fracture behaviour of undermetched weld metal, two surface cracks are introduced in the weld metal, refered as long and short. The geometry of the tensile panel and the shape of the surface cracks are given in Fig. 1.

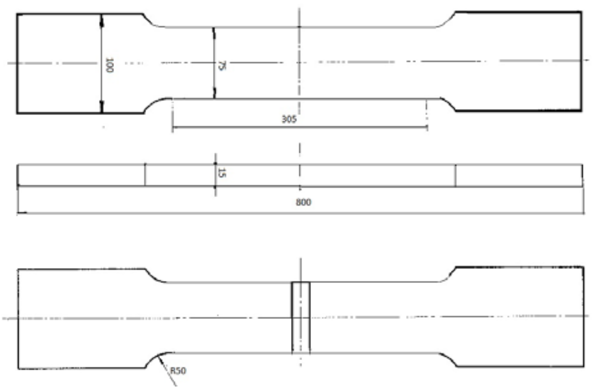

Figure 1. Geometry of tensile panels

The considered problem has an important role in further development of numerical models that will provide solid estimation of mechanical properties and ductile fracture behavior in heterogeneous regions such as HAZ or homogeneous WM with complex asymmetric X groove. The tensile panels are simulated in Abaqus 6.13-1 using the three-dimensional finite element method. The combination of numerical simulation and experimental data obtained from previous investigations, can easily provide accurate results for the fracture response. The comparison between the obtained results is given graphically and several conclusions are drawn from the here elaborated numerical analysis.

2. Experimental procedure and data

In order to get a closer insight in the stress-strain distribution and fracture resistance capability in undermatched butt welded joints, several tensile tests were made on tensile panels. The material used for this investigation is high-strength low-alloyed steel Suminten 80P, commonly used for pressure vessels and pipelines. The modulus of elasticity according to obtained results is E = 206845 MPa and hence the yield stress R_{eh} = 796 MPa and poason ratio v= 0.3, are used as an input data. The welded specimens are produces with submerged arc welding process using consumables of US 80B wire and MF38 flux [6]. Results from tension testing of welded metal show that R_{eh} and R_m are smaller than the one obtained for basic metal, so this is a clear case of undermatched weld configuration. The mismatch factor determined from yield strengths of base and weld metal is 0.74. Three tensile panels are made of base metal (without weld), one without crack and the other two are with introduced surface crack (long surface crack and short surface crack respectively) in the middle of the tensile panel. Tensile tests were also made on six other welded panels (with asymmetric X groove weld), with short crack and long cracks introduced in WM and in HAZ region respectively. In this study, only panels made of basic metal with introduced semi-elliptical short surface crack (2c = 26mm, a = 2,5 mm) and long surface crack (2c = 25mm, a = 5 mm) are analysed. An illustrated preview of a semi-elliptical crack is shown in Fig.2.

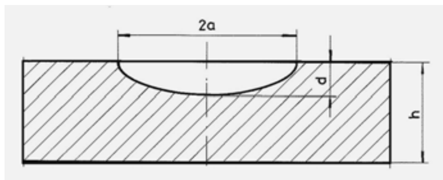

Figure 2. Geometry of tensile panels

3. Numerical simulation

Three-dimensional models are developed for determining fracture and ductile behaviour of cracks through basic elastic-plastic fracture mechanics parameters. The effect of the restrictions around the crack tip, heterogeneity and mechanical load conditions were carefully studied and with the help of Abaqus and finite element method two tensile specimens are modelled with surface cracks with different geometries. For facilitating the calculation process of the parameters, the analysis is made on 1/4 of the specimens with assigned limitations arising from the presence of the material in the surrounding area of the cut. This type of modelling is already used by several researchers in terms of computational economy [7]. In the models the zone ahead of the crack front is modelled with minimum of two layers of elements with a highly refined mesh stretch out across the ligament, because of expected damage and crack propagation in this region. Coarse meshes are applied beyond this region where no significant material degradation is expected. In current models is assumed that the materials of weld metal and base metal are isotropic in order to simplify the finite analysis. It is considered that the coarse grained and fined grained zones are very small and have small effect on stress and strain distributions along the tensile panel and on the overall load capacity of the specimens. Both models have all of the geometrical attributes of the welded joints, but the materials assigned in each zone are the one obtained from the numerical calculations made in the beginning of the investigation for material calibrations with very small variation. The focus of the numerical investigation is analysis of different crack geometries in under-match welded asymmetric joints. The materials of both base and weld metals have been modelled by using conventional von Mises plasticity with large displacement analysis. The mesh size near the cracks was chosen to approximate the mean free path between non-metallic inclusions, that is 0,2 x 0,2 mm quadratic elements. Layers along crack front which are distanced are not influential or significant and so coarser mesh is applied. This is also the case in the areas away from the welded joint, so the smooth transition from very small mesh elements to large ones is applied as indicated in Fig.3.

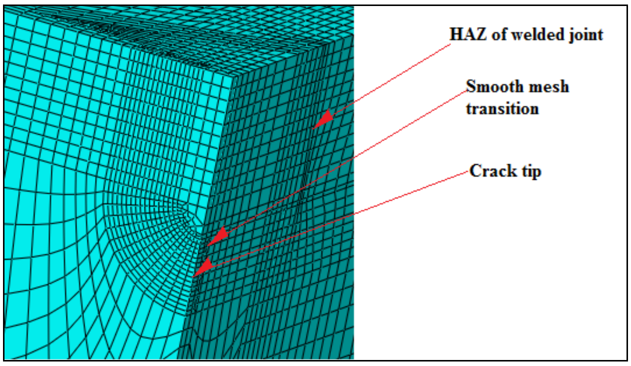

Figure 3. Geometry of tensile panels

The numerical computations were performed using ABAQUS 6.13-1 three-dimensional elastic–plastic analysis mode. The different weld zones (BM, HAZ and WM) are assumed to have isotropic elastic-plastic behaviour. Symmetry conditions are applied, that enabled modeling of one-quarter of the specimen. The elements in both models are 20-node quadratic isoparametric. The crack tip is surrounded by finer mesh for obtaining more precize calculations.The finite element mesh details are given in table 1 and displayed in figure 4.

Table 1.Model details

Model designation		Element type	Elements	Nodes
WMSC	Tensile panel with small crack in WM	C3D20R	26932	118063
WMLC	Tensile panel with large crack in WM	C3D20R	19176	85290

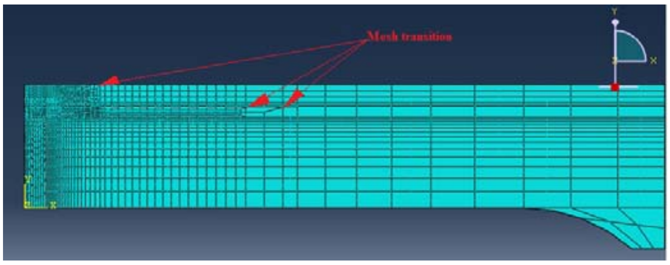

Figure 4. Details showing mesh transition

Details concerning the geometries of tensile panels with semi-elliptical surface cracks in the central region of the asymmetric welded joint are given in table 5.

Table 5.Geometries of center cracked tensile panels

Specimen	t	2W	2c	ao	ao/t	ao/c	c/W
MSC	15	75	16	2.5	0.33	0.313	0.21
WMLC	15	75	26	5.0	0.17	0.384	0.35

4. Results

Based on a series of computations, the relationship between the J-integral and CMOD is obtained for WMSC and WMLC. The specimens have the same weld strength mismatching assigned and have different crack geometries. Results show that the values for J-integral and CMOD change significantly when the loading is increased. When the load becomes significant the effect of the strength mismatching becomes strong. The reason for this may be related to the change in plastic constraint level. In general, undermatching increases constraint.The constraint level produced in specimens containing strength mismatched joints are dependent on the size of the plastic zone in the crack tip [8-11].Figure 5 and 7 display results obtained from model WMSC. Figure 6 and 8 show results obtained from model WMLC. Figure 9 and 10 represents the F-CMOD relationship between results from numerical and experimental investigation for both small and large crack cases.

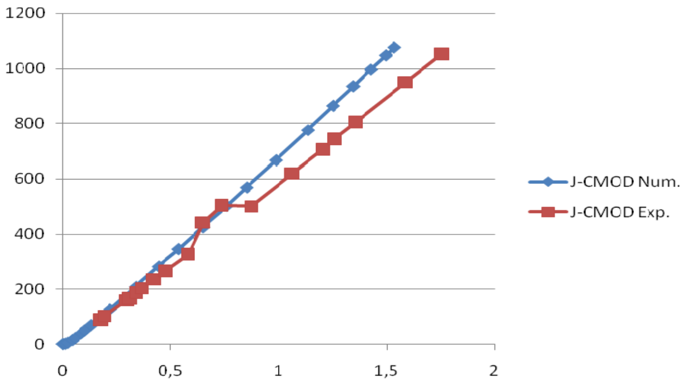

Figure 5. J-CMOD results for 3D model WMSC compared with experiments

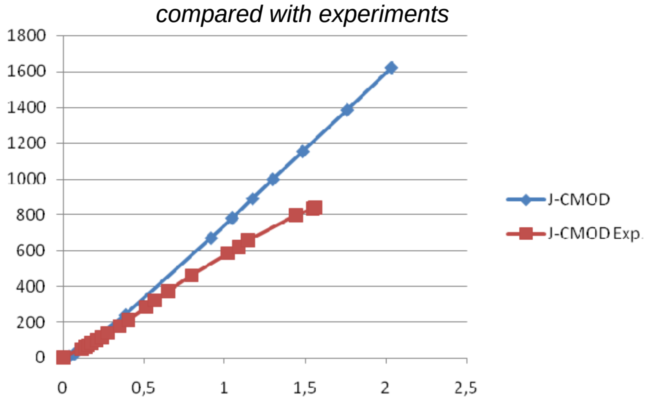

Figure 6. J-CMOD results for 3D model WMLC compared with experiments

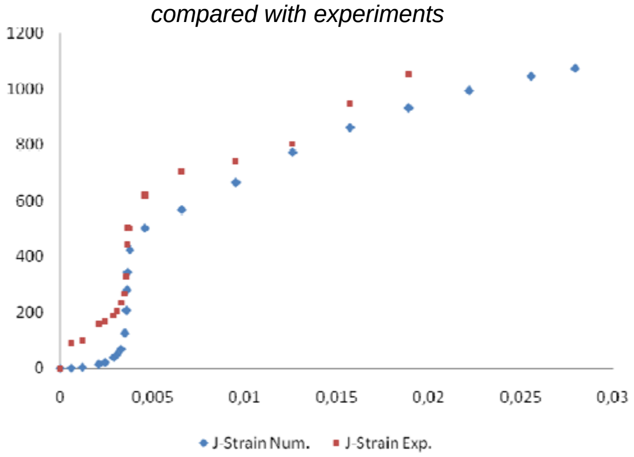

Figure 7. J-Strain results for 3D model WMSC compared with experiments

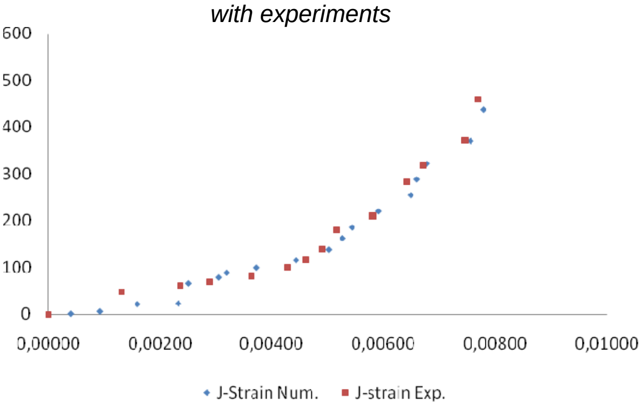

Figure 8. J-Strain results for 3D model WMLC compared with experiments

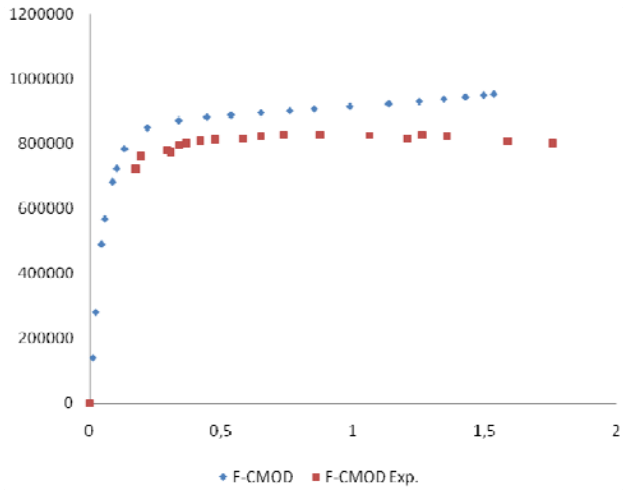

Figure 9. F-CMOD results for 3D model WMSC compared with experiments

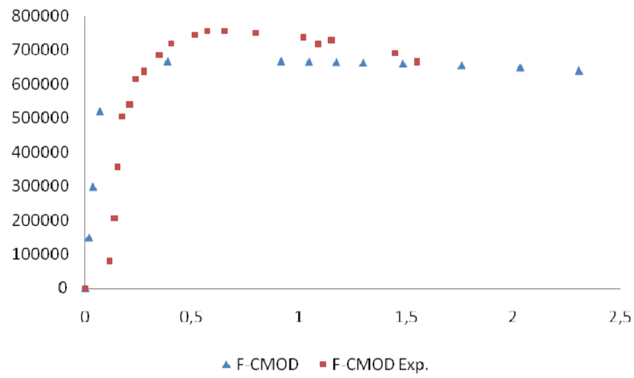

Figure 10. F-CMOD results for 3D model WMLC compared with experiments

5. Conclusion

Based on the results obtained, it is expected that the mismatching effect becomes significant at greater load levels. Moreover, the computation showed that crack size is related to plastic constraint of the crack tip and therefore must have an important influence on the relationship between the J-integral and CMOD. The effect of weld strength mismatching and crack size and geometry on the evolution of the equivalent plastic strain field can be clearly demonstrated. Although some recent results show that the crack length appears to have very little effect on the plastic constraint factor [11], in this investigation it has been shown that crack length have a strong influence on the relationship between the J-integral and CMOD. Figure 6 shows the results for under-matched welded joints in which the rate of increase of the J-integral values with an increase in CMOD values is highest for specimens with large crack.

From the above discussion, it is indicated that the relationship between J-integral and CMOD is affected by loading conditions, flow properties of the base and weld metals, crack size and weld width. This means that if the onset of crack growth occurs when CMOD attains a critical value, the value of the J-integral associated with the onset of the crack growth is not unique. It depends on the weld strength mismatching and geometry factors. It is very difficult to maintain a simple relationship between J-integral and CMOD for the welded joints and other factors must be considered. The results of this work gives future possibilities for calculating the quantification of the change between the J-integral and CMOD occurring in welded specimens.

The numerical analysis proved to be sufficiently reliable in order to serve as a basis for further development and improvement, since they can not cover precisely all the factors and mechanisms that influence the behavior of the material in the non-linear elastic-plastic regime. But, considering the fact that experimental research can not fully anticipate all situations that might affect, further ideas and thoughts should turn towards solutions that will unite several methods. The successful combination of theoretical, numerical and experimental research can be the key for getting results that will bring us closer to the real behavior of cracks.

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MEASURING INTERCULTURALIZM USING FUZZY LOGIC

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Abstract

The world is colourful and is characterized by intercultural diversity from different countries and languages to different cultural backgrounds. It happens due to contacts within the areas of business, science, education but also because of immigration or unstable political situation etc.. Learning about believes and cultures is effective and developing both an intercultural mindset and skill set is really important. We need to learn to recognize cultural differences and also be able to maintain a positive attitude towards those differences. With increased contact of people from diverse cultural background, there is a growing demand for businesses to understand and manage the diverse values, habits, perceptions and behaviour from different parts of the world. It is necessary to making sense based on human experience and therefore the paper describes fuzzy concept for evaluation selected intercultural aspects through two – levelled fuzzy logic and compare it with other type of measurements presented in the past.

Keywords: culture, interculturalism, fuzzy logic

1. Introduction

Culture can be characterised for a particular group of people and can be defined by everything from language, values, habits, behavior patterns, religion, cuisine or music and arts to architecture. Culture can by define as the set of basic perceptions, needs, wants and behaviours in a particular society. Each of countries has its own habits, traditions, norms of behaviour and also taboos. The Center for Advance Research on Language Acquisition defining culture as shared patterns of behaviors and interactions, cognitive constructs and understanding that are learned by socialization.

Cultural diversity - interculturalism is a very important topic to be discussed in daily life. It stands at the interface between the individual, group, even societies or cultures. It is increasingly in direct contact with members of different cultures and these are in relationship with referred to as intercultural relations.

Intercultural aspects refers to culture-specific points, determine the applicability of the behavior, patterns, traditions and habits included education and working in international context.

The specific characteristics of intercultural aspects are assumptions and values which underlie all of thinking, feelings and behavior patterns. Therefore, In order to avoid misunderstandings and communication failure it is important to display a considerable amount of intercultural awareness or cultural sensitivity. It is important to understand the roll of culture.

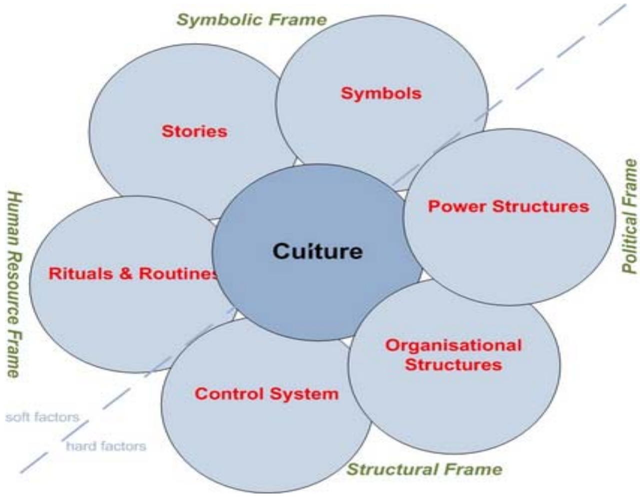

Figure 1. What is culture?

2. Measuring interculturalism

The concept of interculturalism by W. Welsch (1995) is based on interculturalism seeks to coexistence of different cultures means of communication between them. In the context of intercultural cooperation and communication are fundamental cultural differences affecting human behaviour a number of authors such as Abraham Maslow, Edward Halls, Geert Hofstede, Philippe d' Iribarne's, Fons Trompenaar and Henry Mintzberg.

American **Edward T. Hall** (1914-2009) analyzes the theory of intercultural communication. He tried to identify the basic dimensions of human coexistence, they encounter people in all cultures. American scientist defined as the most important dimension of cultural space, time perception and communication in the context of peace. He distinguishes culture with **monochron** and **polychron** perception. Polychrono (for simplification we can say that the members of such a culture are doing more things at the same time, often change and review their plans, many events and activities are taking place parallel to each other) and monochron (members of such cultures prefer to do always only one thing and then start working on the next), plans and agreed terms are complied with and the changes in them are not very welcome. Monochron oriented cultures a linear axis passing of time, on which are placed the negotiations that take place in the intended order. Relatively little is monochron oriented cultural boundaries tolerance time/futures collisions and against interference and interruption of business meetings. Conversely polychrono oriented cultures create their own intentions negotiating different planes, each of which may be several place at one time. This orientation is set high demands on the time and flexibility disproportionately high tolerance for time/futures collisions and tolerance and interruptions.

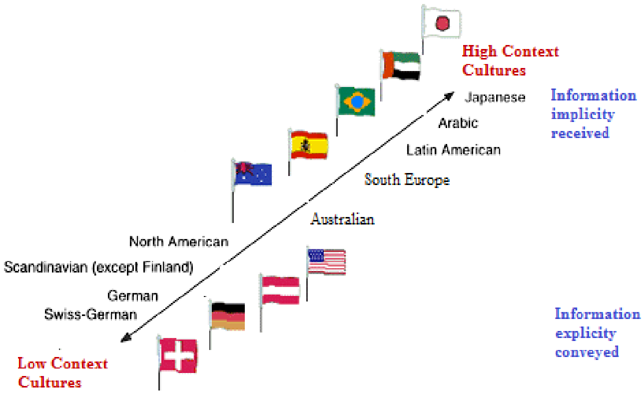

Figure 2. Hall's communication context

	Low-Context	High-Context
Example Countries	US, UK, Canada, Germany, Denmark, Norway	Japan, China, Egypt, Saudi Arabia, France, Italy, Spain
Business Outlook	Competitive	Cooperative
Work Ethic	Task-oriented	Relationship-oriented
Work Style	Individualistic	Team-oriented
Employee Desires	Individual achievement	Team achievement
Relationships	Many, looser, short-term	Fewer, tighter, long-term
Decision Process	Logical, linear, rule-oriented	Intuitive, relational
Communication	Verbal over Non-verbal	Non-verbal over Verbal
Planning Horizons	More explicit, written, formal	More implicit, oral, informal
Sense of Time	Present/Future-oriented	Deep respect for the past
View of Change	Change over tradition	Tradition over change
Knowledge	Explicit, conscious	Implicit, not fully conscious
Learning	Knowledge is transferable (above the waterline)	Knowledge is situational (below the waterline)

Figure 3. Hall's communication context in tabular form

European researcher **Geert Hofstede** (1928-) in his work attempted to quantify the differences between cultures. He defines culture as a collective phenomenon or collective programming of the mind / thought, which differ by individual members of cultures, social groups or categories. Hofstede's approach serves as an instructional guide for models of cultural dimensions. It focuses on a detailed description of the set of expressions and recommending ways and norms of behavior in different cultures on ethnic grounds. He has developed his model of cultural differences polarities consisting of five dimensions, which are the main cultural differences:

1. Power of distance (*LTO Index*)
2. Dimension of uncertainty avoidance (*UAI Index*)
3. Dimension of individualism and collectivism (*IDV Index*)
4. Dimension of masculinity and femininity (*MAS Index*) of life. Important to people and the environment, and there is belief in gender equality.

5. Long / Short-term orientation - Long Term Orientation (*LTO Index*)

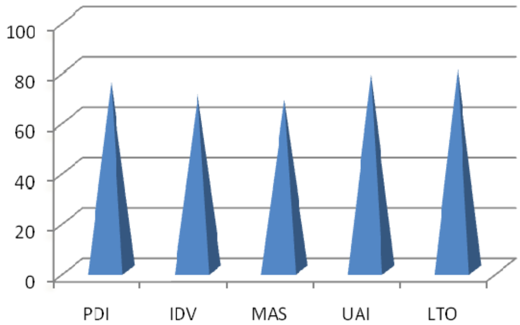

Figure 4. Hofstede's Cultural Index diagram

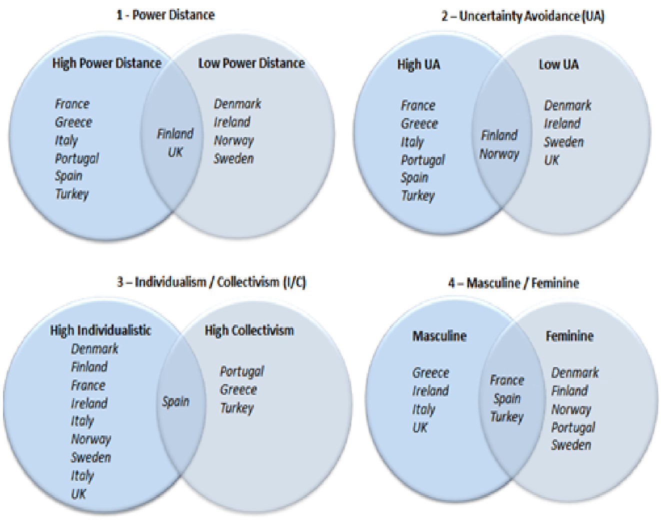

Figure 5. Hofstede's Cultural Dimension for Europe countries

Fons Trompenaars (1952-) who served seven years in the management of Shell, followed the study Hosted and Hall, defined that is the most important dimension of cultural space, time and peace in the context of communication. He tried to advance in the analysis of cultural differences deeper and more specifically identify the dimensions that affect thinking and social behaviour of different cultures. According to him cultural differences arise in three basic areas of human life (of these areas is possible to derive a total of seven cultural dimensions):
• People's attitudes to time
• People's attitudes to nature
• Attitudes towards other / other people

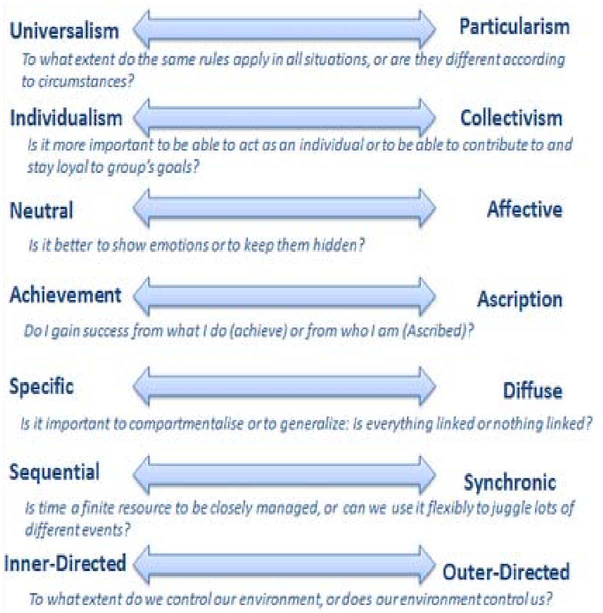

Figure 6. Seven Dimensions of Culture

Henry Mintzberg (1939) created the following organizational arrangements:

1. Entrepreneurial start-up - simple structure, i.e. no sophisticated without self-control system.
2. Managers machines - especially the bureaucracy regarding tuning, "organizational performance", and not "solve the problem"
3. Professional bureaucracy - a trend that has become a machine bureaucracy difficult to control because of the work of specialists
4. Diverse organizations
5. Innovative organizations

a. The operating adhocracy - problems clients are directly addressed

b. The administrative adhocracy - his own problems are solved directly.

6. Missionary organizations
7. Political organizations - they lack real coordination mechanism

Figure 7. Mitzberg ´s organizational models

Some systems for measurement of intercultural aspects are implemented in Hofstede's research. Other concept is to apply new mathematical algorithms for evaluation of human experience described by simple answers to questions in questions forms. For this purpose it is use the Fuzzy logic system.

3. Measurement concept for evaluation of intercultural aspects

The term "fuzzy logic" is isomorphic image of fuzzy sets, which was introduced by American (born in Baku, Azerbaijan) cybernetics and informatics Lotfi A. Zadeh, when in 1965 he published a famous work of fuzzy sets in the journal Information and Control. Fuzzy sets are extremely effective theoretical framework for modeling vagueness of terms, which can be used to specify vaguely bounded concepts such as height, age and the like. It is a mathematical discipline that refutes the traditional assumption that the total area of all considerations, either belongs to the field of reflection or does not belong. We understand it as a kind of logic that recognizes more than just true and false values. Using fuzzy logic problems can be presented with a degree of truth and falsity. For example, the claim that today is sunny could be 100 % true if there are no clouds, 80 % true if a few clouds and 50 % true if the clouds and 0 % true if it rains all day. The classical logic is adopted bivalence principle - that is, no statement can take values other than true or false, and that every statement has one of these values. In classical bivalent logic truth values of statements are taken from the set {0,1}, ie every statement is either true (1) or false (0).

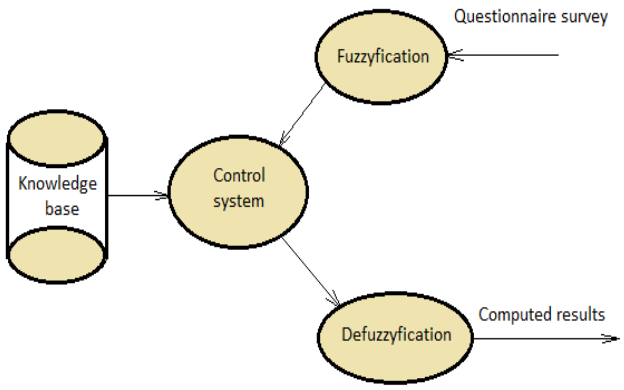

Figure 8. Fuzzy logic methodology concept

Fuzzy logic is a form of many-valued logic. It deals with reasoning that is approximate rather than fixed and exact. Because of human language response to questions, fuzzy logic is useful for evaluating and transforming sentences to numbers for quantitative evaluation of some human meanings. For research was selected following five intercultural aspects to evaluate impact factor:

- Language
- Ethnocentrism

- Religion
- Habits
- Gender

Table 1 describes parameter settings for fuzzy logic system based on Mamdami inference model.

Table 1. Measured selected intercultural aspects

Cultural Aspects	Number of member-ship functions	Type of membership functions	Input range
Language	3	Trapmf	<1,10>
Ethnocentrism	2	Trimf	<0,70>
Religion	3	Trapmf	<0,65>
Habits	3	Trapmf	<0,55>
Gender	2	Trimf	<0,10>

During the research were examined impacts on various intercultural aspects in selected companies. The selected companies have been in the Selected aspects were surveyed by internet questionnaire. For evaluation was used software platform Matlab – Fuzzy logic toolbox.

For each of intercultural aspect in the process of defuzzification was determined coefficient expressing the cumulative effect of a single aspect to the working environment of the selected companies. Coefficient was set continuously between 0 and 1, where 0 indicates that the aspect does not affect the marketing activities, while a value of 1 has profound and significant impact on the marketing activities.

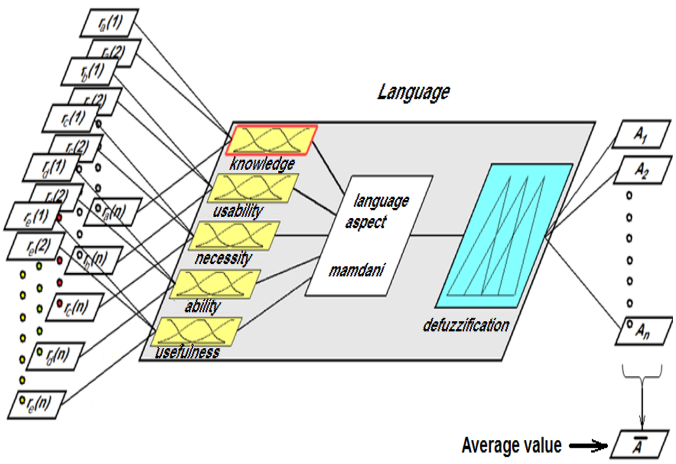

Figure 9. Two– level fuzzy logic concept

In the research were examined selected intercultural aspects and their impact in selected automotive, industrial, economically mixed companies in the Central Europe. The samples of people for this research were employees in mixed companies as a managers and directors of SMEs in the territory of Slovakia, Czech Republic and Hungary.

For selected intercultural aspect was computed coefficient in the process of defuzzification which expressing the cumulative effect of a single aspect to the working environment of the company. [1]

Table 2. Measured inde: Evaluation of selected intercultural aspects

Cultural Aspect	Measured Index
Language	0,41
Ethnocentrism	0,93
Religion	0,71
Habits	0,63
Gender	0,88

Each selected aspect has its own specifics. Religion does not have almost impact on working activities in spite of language skills and ethnocentrism which have high impact[2]. For understanding, it is necessary to point that Measured Index is in range 0 – 1, what means that value close to 0 means that selected aspect is not important as an intercultural aspect. Value close to 1 means that selected aspect is important and has impact to working activity in the company. With comparison the implementation of research to the countries outside the EU can be expected to influence a change in some aspects. For instance in Latin American countries significant change aspect of religion. In the aspect of language is not expected significant change, as globalization creates considerable pressure to overcome language barriers.

4. Results and discussion

We can compare our results – selected intercultural aspects with Hofstede indexes. Because of selected questionnaire are in our research is Slovakia, Czech rep. and Hungary we can summarise Hofstede 5D model for this countries in Table 3.

Table 3. Hofstede index: evaluation of selected countries

Country	PDI	IDV	MAS	UAI	LTO
Slovakia	104	52	110	51	38
Czech R.	35	58	45	74	13
Hungary	46	80	88	82	50

We can say that LTO is close to our, Ethnocentrism and Religion aspects and MAS index is close to Gender aspect. Measured index is common for the whole region, while Hofstede indexes are local.

In table 4 there are computed equivalent values as average value of selected intercultural aspects. Due to measured index is from 0-1 and Hofstede Index is from 0-100, values can be transformed to Hofstede index range. Data for Slovakia in Hofstede tables are more than 100, because of Slo-

[1] Coefficient was set continuously between 0 and 1, where 0 indicates that the aspect does not affect the working activities, while a value of 1 has profound and significant impact on the working environment.

[2] It should be noted that these results are only partial

vakia was not a part of the original survey and data are statistically recomputed.

Table 4. Hofstede indexes: Evaluation of selected countries

Area	Topo+Mob eval (PDI)	Sex+Skin eval (MAS)	Cult+Ethno +Relig eval (LTO)
SK/CZ/HU - average	0,53	0,3	0,47
SK/CZ/HU to Hofstede equivalent	53	30	47
Hofstede average for region SK/CZ/HU	61	81	33

5. Conclusion

While data survey for Hofstede index are from 2006, our data are from 2014 survey. We have point that differences can be under influence of economical and social processes in Central Europe after World global economic crises in 2009 and strong economic problems in selected countries. Influence of different economic development in Hungary with respect to Slovakia nad Czech rep. after 2009 could also influence the results of survey.

Paper focuses on intercultural aspects of these relationships indicate the fact that the various relationships between cultures and peoples and states in recent years have undergone significant changes under the influence of multiculturalism particular policy. The importance of culture in contemporary international trade is still underrated. In today's world, in which every day meet people from different cultures, not enough to know only the language their business partners or subordinates, but it is necessary to know their culture - rituals, customs, norms and values.

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LASER PEENING OF LASER WELDED NICKEL BASED SUPERALLOY SHEETS

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Abstract

Laser welding is a high energy density process with a many advantages such as narrow heat affected zone, lower heat input and lower distortion compared to the conventional welding processes. Laser shock peening is an innovative technique which improve fatigue characteristics, wear and corrosion resistance. In this paper, Nimonic 263 alloy sheets are laser welded using different laser process parameters. Sheets are welded by Nd:YAG laser. Welded joints are further laser peened with the aim to improve the surface roughness and mechanical properties. Mechanical characteristics of peened and welded specimen are investigated, and fractures are observed by scanning and optical microscope. Surface topography is observed by non-contact profilometer and hardness is measured by Vickers.

Keywords: Laser, welding, superalloy, profilometry, microstructure

1. Introduction

Nimonic 263 superalloy is a nickel based superalloy, developed to withstand high pressure and temperature. It has been developed for the welded assemblies that requires better ductility. This superalloy has a good corrosion resistance, optimal thermal properties, strength coupled with ductility, creep and fatigue resistance, as well as optimal impact and wear resistance [1].

Laser welding is a high energy density, low heat-input process. It offers many advantages over the conventional methods such as: high welding speed, narrow heat-affected zone, low distortion, ease of automation, singlepass thick section capability and enhanced design flexibility. The high power density gives the high depth to width ratio bead and together with the low heat input and rapid solidification, result in low distortions and excellent mechanical properties [2]. One of the many features of laser welding is the capability to weld without filler materials (autogenous welding). In this paper, Nimonic 263 superalloy sheets, thickness of 2 mm, are welded without filler material in two passes. The sheets are welded by Nd:YAG laser as it has various advantages such as a high energy absorption rate due to a low reflectivity, a high welding speed and a low residual stress compared to CO2 laser [3].

Laser shock peening is, unlike to laser welding, not thermal, but mechanical treatment. Laser shock peening improves the fatigue characteristics, intergranular corrosion resistance, wear and oxidation resistance, as well as mechanical properties of material. If LSP is successfully applied the fatigue performance of metallic components - the fatigue strength and fatigue life can be increased remarkably owing to the presence of compressive residual stresses in the material [4].

2. Literature preview

Considerable analytical and experimental work has been carried out on laser welding of different materials. Annon [5] performed the welding of four different nickel alloys material thickness up to 2 mm, using CO2 gas laser. Tensile testing showed that repeatedly high values could be obtained in all four materials. Guo et al. [6] compared the microstructure and mechanical properties obtained by laser and arc welding. Bucksons et al. [7] investigated influence of laser welding on fatigue crack growth behavior of a nickel-base superalloy. Shinozaki et al. [8] presented the evaluation of the hot cracking susceptibilities of various Ni-base superalloys during the laser welding. Qi et al. [9] performed the laser welding of superalloy GH4169 plate with a thickness of 1 mm. The maximum tensile strength is is close to the base material tensile strength. They showed that the welded joint can meet the requirements of users. Qi et al. [10] analyzed the application of laser welding technology in aeronautical aluminum alloys, titanium alloys and superalloys aircraft damage repair. Odabasi et al. [11] carried out Autogenous laser beam welding of Inconel 718 alloy sheets (2.1 mm thick). They investigated the relationship between heat input laser beam welding and the microstructural and mechanical properties of superalloy Inconel 718.

Laser shock processing of metallic surfaces and its applications were presented by Devaux et al. [12], theoretically and experimentally. The effects of laser-induced shock waves on metals were studied by Clauer et al. [13]. They reported the effect on material properties, such as hardness, tensile strength and fatigue life. Walter et al. [14] have investigated experimentally the effect of laser shocks on stressed structural materials. LSP and its effects on surface microstructure and mechanical properties of low carbon steel were studied by Chu et al. [15].

A review on laser-shock processing was carried out by Peyre and Fabbro [16]. They presented physical principles of laser shock and induced mechanical effects, and found that higher pressures can be achieved with confinement as compared to direct ablation.

3. Experiment

Samples of superalloy Nimonic 263 are welded by Nd:YAG laser by various parameters: laser energy varied 220 to 270A, pulse duration from 7.0 to 9.0 ms, spot size from 0.8 to 1.3, and pulse frequency from 3.0 to 5.0 Hz. The welded joints are laser peened by laser Nd:YAG EKSPLA, model SL212P with following characteristics: wavelength 1064 nm, pulse duration 170 ps, mode about TEM_{00}, repetition rate 10Hz. Laser peening is performed by pulse energy of 1 mJ, speed 0.01 m/s, and spot size 0.1 mm. Tensile test is performed by tensile testing machine Shimadzu with a grip capacity 250 kN.

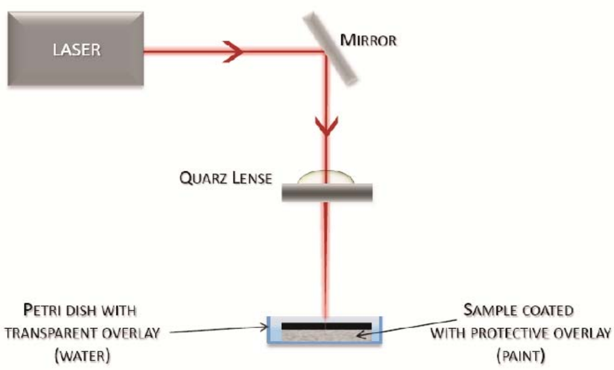

Figure 1. Experimental setup

The resulting surface changes were determined by scanning electron microscopy, SEM model JEOL JSM-5800 and compared with non–treated surface. Elemental analysis of the surface was done by EDS. Microhardness measurements were performed by Vickers using the apparatus – model semiautomatic Hauser 249A and under load of 0.5 N. Also, surface morphology changes of the irradiated areas were analyzed by Zygo NewView 7100 optical profiler and characteristic surface parameters were calculated using MetroPro software.

4. Results and discussion

In this work, the laser welding of Nimonic 263 sheets are performed using the various laser parameters. The optimal parameters provided crack-free weldment, determined by radiography. The mechanical properties, morphology and surface profilometry are improved using laser shock peening.

Figures 2a–c show microstructures of Nimonic 263 weld seam fructure surfaces after tensile test performed.

As expected, all specimen fractured in weld seam due to welding process without the filler material. Also, the mechanical behavior of weldments may be different from the base material because of the inhomogeneous distribution of second-phase precipitate particles in the weldment as well as microsegragation in the interdendritic region and other.

By visual observation of the micrographs, it can be noticed that the fracture surface is rather uniform, with the dimples size up to 2 µm. The dimples indicated that the composition phases possessed certain ductility. The dimpled rupture features show no preferential fracture path, and there are some clearly visible particles and rarely observed gaps.

In Tab. 2 results of energo-dispersive spectrometry of spots denoted in Figs. 2b-c are listed. Results show increased content of Al. The size and morphology suggest Al oxide forming. The existence of these particles on the fracture surfaces suggests that micro voids have begun at the particles/matrix interfaces.

Results of tensile strength tests show that fractures occurred within welded seam. The tensile strength is 432 MPa, which is about 85% of base material. The reason for this could be found in different joining morphology during the laser welding process and forming of particles observed in microvoids.

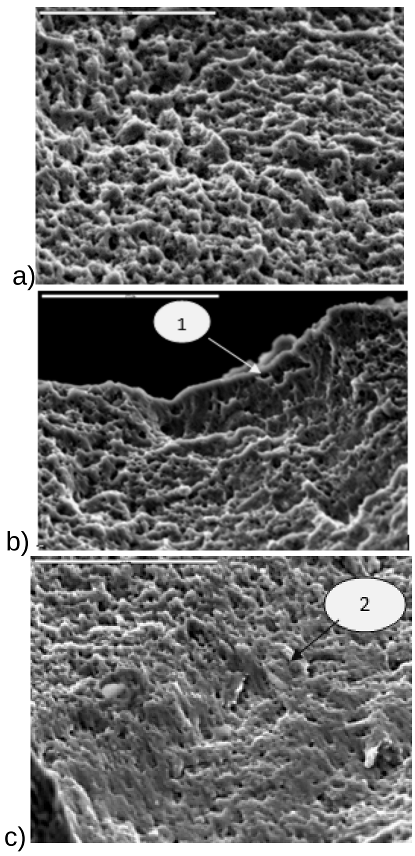

Figure 2. Microstructures of fructure surfaces of Nimonic 263 weld seam; bar in the left uper corner denotes a) 20 µm , b) 20 µm, c) 10 µm.

Table 1. Results of EDS analyses of spots 1-2 in Figs. 2b-c

Element	spot 1	spot 2
Al	16.1	5.51
Si	0.79	0.77
Ti	1.95	2.36
Cr	15.02	17.01
Mn	0.58	0.42
Fe	0.42	0.55
Co	17.49	18.92
Ni	43.37	47.15
Mo	4.29	7.31

Figure 3a shows the fracture surface of welded joints laser peened after welding. Fracture surface is less uniform than fructure surface of non-peened weld seam. There are dumples as well, suggested ductile structure, but their shape is more eliptical. Their size is up to 7 µm. It is consistent with the tensile testing results – yield stress of peened weld speciment is 442 Mpa – very simmilar to nonpeened ones, but the elogation of peened laser weld speciman is about three tiimes longer than elongation of nonpeened weldment.

Figure 3b shows the front side of welded seam subsequently laser shock peened. It can be noticed that after tensile strength test the first layer, obviously performed during the laser peening, was laminated. The small plates are rather similar in shape and geometry, as well as size. The size of these lamellas is up to 10 µm.

In Table 3 results of EDS in spots 1 and 2 and whole area presented in Fig. 5c are listed. The increased content of Al and Ti suggest forming of various phases. According the size and shape, and results in Table 3 there is possibility of formation of Ti carbides Al oxide.

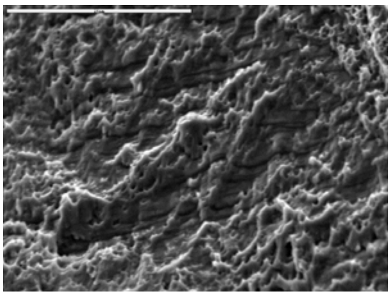

Figure 3a. Microstructure of fructure surfaces of Nimonic 263 weld seam after laser shock peening

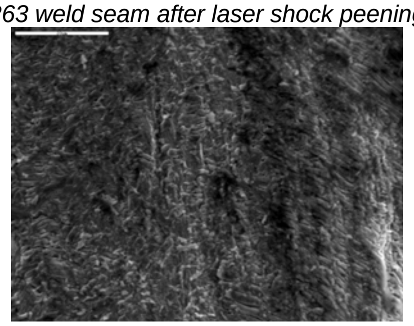

Figure 3b. Microstructure of front side surface of Nimonic 263 weld seam after laser shock peening

Table 2. Results of EDS analysis of the surface in Fig 3b

Element	Fig. 3b
Al	6.04
Si	0.47
Ti	9.21
Cr	17.96
Mn	0.71
Fe	0.56
Co	17.58
Ni	42.45
Mo	5.01

Microhardness tests are performed by Vickers under the load of 10 N for indentation time of 10 sec. Figure 4. shows results of microhardness test for base material (238.1 HV1). After the laser welding the microhardness increased, and in heat affected zone measured value is 248 HV1, while in welded seam the value is 258 HV1. The microstructure of the welded seam was significantly refined due to the laser beam welding induced non-equilibrium rapid solidification and, hence, increased its hardness.

Laser shock peening increases the microhardness of surface. The measured values of heat affected zone and welded seam after laser shock peening permormed are 251 and 278 HV1 respectively.

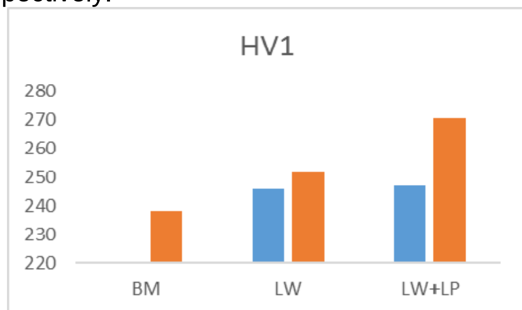

Figure 4. Microhardness test results of base material, welded material and laser peened welded material

LSP improved surface quality and microhardness and caused favourable microstructure transformations, which theoretically indicates possible improvements of mechanical properties and fatigue strength.

Surface morphology/topography plays an important role in the performance of parts of various machines. Surface roughness implies that the surface is not perfectly flat, andconsequently, small sized stress concentrations along the material surface occur. Under fatigue loading, cracks always nucleate from the free surface. Cracks nucleate at positions where the plastic strain concentrations are high. High surface roughness generates local stress concentration and accelerates crack initiation. For wear resistance applications, removal of the roughened surface is necessary, as previously showed by Sahaya Grinspan and Gnanamoorthy,

2006. That is why a significant part of this research was dedicated to the surface roughness analysis.

Two-dimensional profiles and 3D maps of the areas after laser welding is presented in Fig. 5. The noncontact profilometry measurements are based on the intereference between white light reflected from the sample surface and the reference surface.

Results presented in Figure 5. show that PV ratio (peak to valley) is 374.15 µm, root mean square (rms) is 37.5 µm and avarage roughness is 31.3 µm.

Figure 6. presents two – dimensional surface and 3D maps profiles of laser peend welded seam.

It can be noticed that LSP processing of the welded surface caused relatively homogenious modification of the surface throughout the inter–action area. No significant ablation or hydro–dina–mic effects were detected due to low value of fluence and presence of the protective dye layer.

Results presented in Figure 5. show that PV ratio (peak to valley) is 316.15 µm, root mean square (rms) is 32.6 µm and average roughness is 29.1 µm.

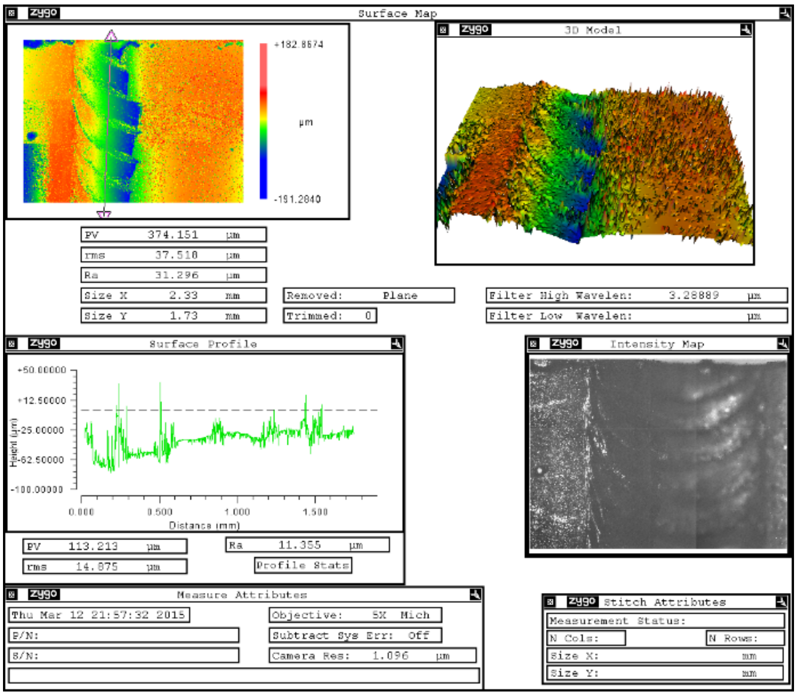

Figure 5. Two – dimensional surface and 3D maps of welded Nimonic 263 sheets

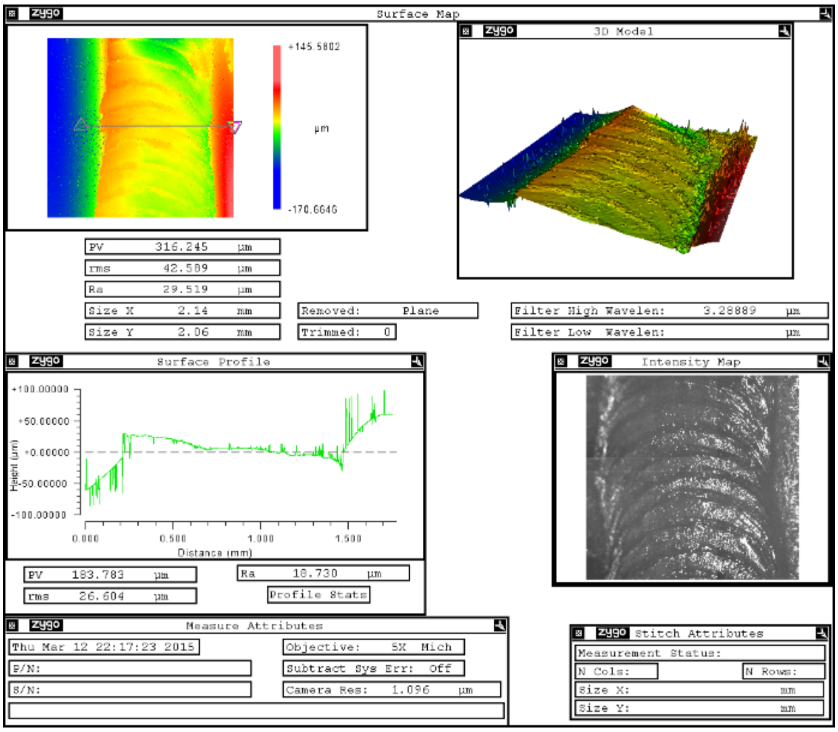

Figure 6. Two – dimensional surface and 3D maps of laser peened welded Nimonic 263 sheet

5. Conclusion

In this paper, laser welding of Nimonic 263 sheets is analyzed. Optimized parameters provided crack free weldments. All specimen fractured in weld seam due to welding process without filler material. Fracture surface is ductile with the dimples spherically shaped.

Mechanical and microstructural properties of weld joints are improved by laser shock peening post-weld treatment. Mechanical properties of peened weldments improved and roughness of peened weld joints decreased. The microhardness in weld seam after laser shock peening is higher compared to the weldment without laser shock peening after welding. Further research might include residual stresses measurements and analysis, as well as the investigation of the same process using different lasers and processing different materials.

6. Acknowledgement

The work was supported by the Ministry of Education and Science of the Republic of Serbia, under the number TR35040 and TR 35024.

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MECHANICAL BEHAVIOR OF A PIPE SUBJECT TO BUCKLING

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Abstract

The thin shell structures like metal are particularly susceptible to buckling or geometric instability. Their sizing is performed by resorting to simplified rules, this approach is generally conservative. Indeed, these structures are very sensitive to the slightest imperfection shape (initial geometrical defects). The design is usually based on the knowledge of the real or perceived initial state. Now this configuration evolves over time, there is usually the addition of new deformities due to operation (accidental loads, creep), but also to loss of material located in the corroded areas. Taking into account these various damage generally led to a loss of bearing capacity. In order to preserve the charge potential of the structure, it is then necessary to find a different material. In our study we plan to replace the material used for pipe, with a composite material made from carbon fiber or glass. 6 to 12 layers of composite are simply stuck. Research is devoted to the study of the buckling of multilayer shells subjected to an imposed displacement, allowed us to identify the key parameters and those whose effect is less. For all results, we find that the carbon epoxy T700E is the strongest, increasing the number of layers increases the strength of the shell.

Keywords: Finite Element Analysis, Square notches, buckling, pipe made Composite Materials.

1. Introduction

Faced with difficulties encountered by the scien–tists on the subject of the Hull buckling for several decades, so we chose for the establishment new guidelines for the design of thin shells buckling.

The composite materials are high-performance materials, constituted by the microscopic scale the association of several materials with additional features. This allows you to associate a set of me–chanical or physical properties that would be impossible to obtain with the components taken of isolated way. Besides weight gain, another advan–tage of composite materials is the multifunctional nature conferred on them by their orthotropic pro–perties.

The characterization of composite materials ba–sed on fiber and resin is generally complex. Unlike metallic materials that require a relatively small number of tests, the composites of fibers and resins are characterized by the need for a multitude of test in order to reach mechanical properties and to characterize the effect of damage.

In order to predict the appearance of this effect, an interesting study of the relations that may exist between geometrical defects and orientation of the fiber reservoir and mechanical properties of materials to resist to the birth of cracks, and total degradation of our structure.

2. Mesh models and stratified pipe without cuts

For our application, we chose a laminate composite pipe diameter d = 64000 mm and a stratification of 6, 8, 10 and 12 alternating layers, the stacking sequence is [θ˚/-θ˚] each has a thickness of 1.5 mm. The pipe has a total length of 30000 mm. The first material is selected carbon/ epoxy, T700/E, the second is the T300/BMP-316 and the third of the Glass-Epoxy. The mechanical characteristics given in (Table 1).

Table 1. Mechanical properties of the pipe material.

Proprieties	(T700/E)	T300/BMP-316	Glass–Epoxy
E_1(MPA)	143120	128800	140000
E_2(MPA)	6672	8300	10300
υ_{12}	0.26	0.335	0.29
G_{12}(MPA)	3390	4100	5150
G_{13}(MPA)	3390	4100	5150
G_{23}(MPA)	1914	4100	4630

To identify the reliability of the conception of this structure relative to buckling, the variability of many parameters must be taken into conside–ration, three cases are detected, the first is a pipe which is not subjected to any pressure, the second an internal pressure of $0.57 \cdot 10^{11}$ MPA, was added and finally, an internal pressure of $0.84 \cdot 10^{11}$ MPA.

Figure 2 illustrates these cases. Shells are encased in one of the ends; the other is subjected to an imposed displacement. Our structure was modeled by 9625 quadrilateral elements S8R types. Three-point Gaussian integration by regis–tered are considered.

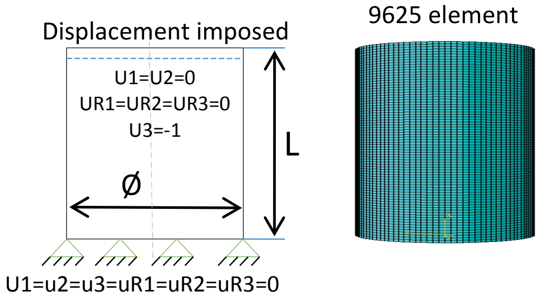

Figure 1. Representation of the boundary conditions and mesh the pipe without notch.

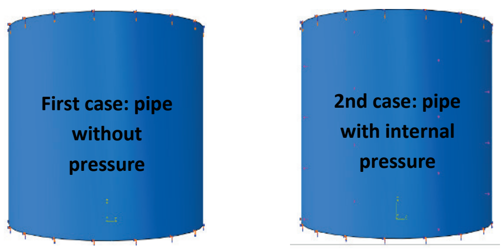

Figure 2. Representation of pipe cases studied

3. Evolution of buckling factor for a pipe without cuts

In this part of the study, the purpose is to see the evolution of the buckling coefficient, depending on the orientation of the fibers under the effect of an imposed displacement U3, with a pipe without geometric defects, the results obtained were translated by the curves of the following figures (Figure 3, Figure 4, and Figure 5).

Varying the number of layers of the reservoir

Figure 3 shows the variation of the buckling coefficient in function of the fiber orientation for different number of layers of the pipe. The representation is done for 6, 8, 10 and 12 layers and a diameter of 64 000 mm for a pressure less reservoir.

Pipe without internal pressure

The first case in which the material chosen is the carbon epoxy T700/ E; clearly illustrates that the buckling coefficient is maximum 20° in the orientation of the fibers. Furthermore, when the angle θ exceeds 70°, the critical load values are almost constant. In the 2nd case, the T300 / BMP-316, we can see that λ takes smaller than the previous case and are maximum values between the orientation 10° and 50°. The 3rd case, the epoxy glass, λ is even smaller than the previous cases.

Comparing the two figures, we see a difference in the values of buckling ratio for a large number of layers, the coefficient λ is greater. Which means that the greater the thickness of the pipe, the greater it is more resistant.

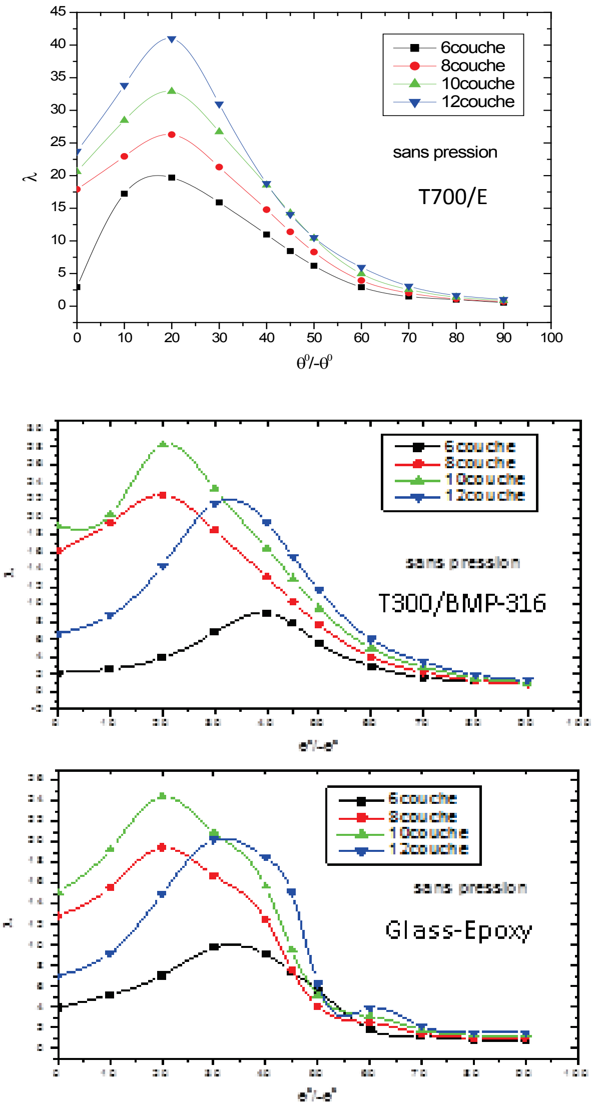

Figure 3. Influence of the number of layers on the buckling coefficient in function of θ ° to the pipe without pressure

Pipe with internal pressure P = 0.84·10¹¹ MPa

For this case, we do the same work as before, but with an internal pressure of P = 0.84.10¹¹ MPa. λ takes higher values for pipe to 12 layers for all three cases (Figure 4).

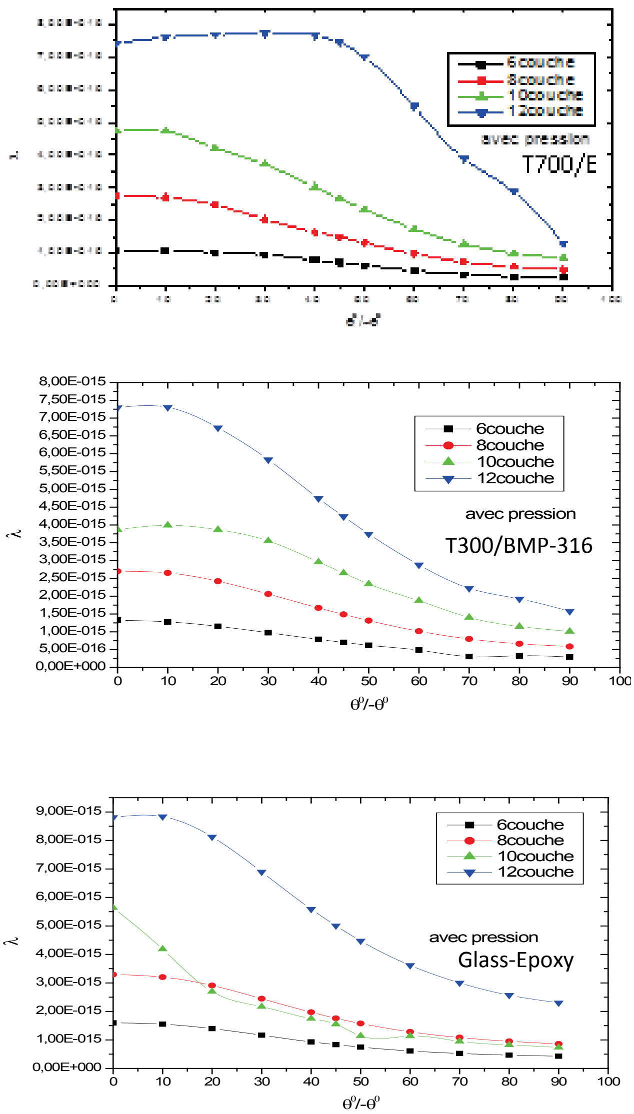

Figure 4. Influence of the number of layers on the buckling coefficient in function of θ ° with a pipe for the pressure of P = 0.84·10^11 MPa

Pipe with internal pressure P = 0.577·10^11 MPa

The third case, the change was made to a pressure, P = 0.577·10^11 MPA, the curves in Figure 5 show the results. We note that the buckling ratio is much more important when the number of layers is bigger, which confirms that the greater the thickness is large it becomes increasingly more resistant another observation made is that be the most sensitive material is glass epoxy, the stronger the carbon epoxy T700/E, which is clearly shown in the following figures (Figure 6, Figure 7 and Figure 8)

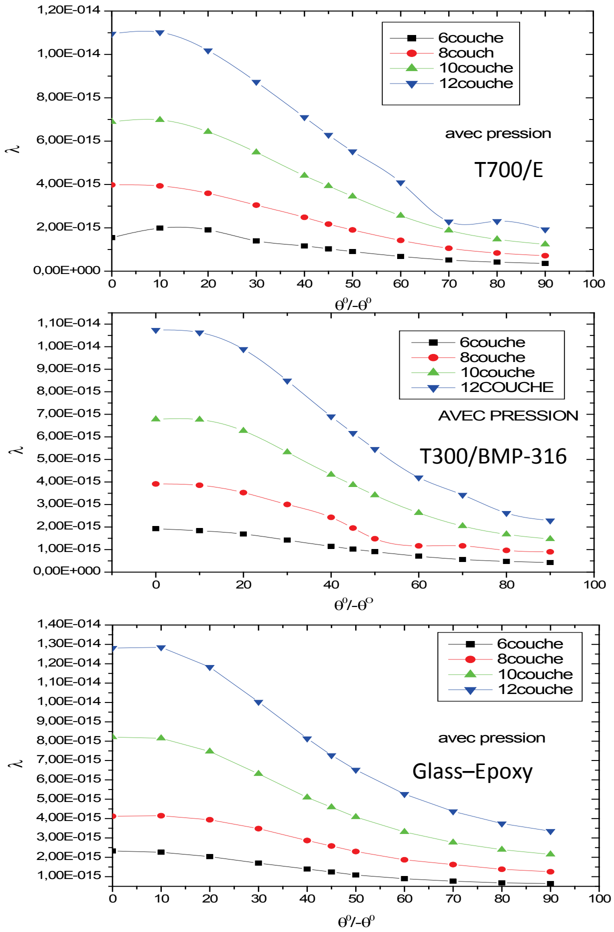

Figure 5. Influence of the number of layers on the buckling coefficient in function of θ ° with a pipe for the pressure of P = 0.577·10^11 MPa

4. Influence of the number of layers on the buckling coefficient as a function θ°

In this section, we try to see the effect of composite materials on the buckling ratio, for it we take the three studied materials and varying the number of layers for the three cases studied, namely, a pipe without internal pressure and then with two different pressures.

Pipe without internal pressure

In the event that the pipe is under no pressure, we clearly notice that the buckling coefficient of T700 / E is the most important, but for the glass epoxy, and T 300/BMP-316, take λ, the very small values, which become linear directions between 60° and 90°. Also the greater the number of layers increases, the coefficient is significant.

Pipe with internal pressure P = 0.84·10^11 MPa

The pipe is subjected to an internal pressure of 0,577·10^11 MPa, the buckling coefficient take smaller values compared to the previous case, but the epoxy Glass-, have the highest values, which leads us to conclude that it is least resistance. The number of layers also affects the rigidity of our structure.

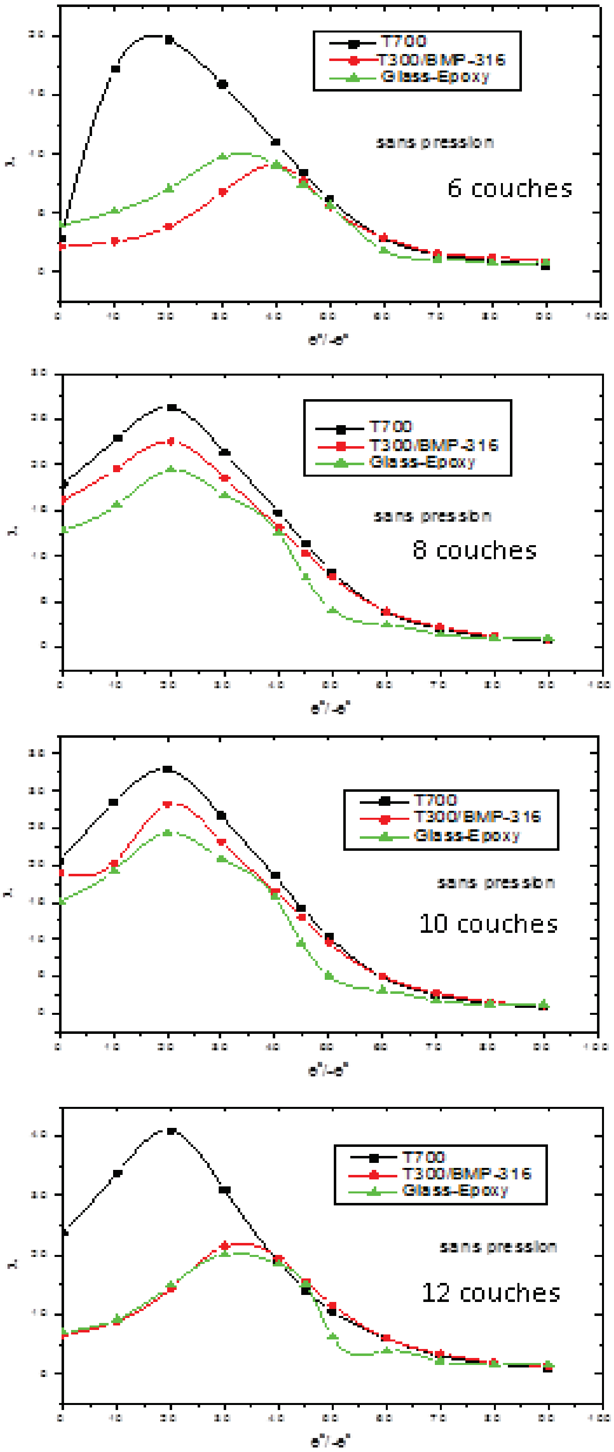

Figure 6. Influence of materials on the buckling coefficient function θ ° to the pipe without pressure.

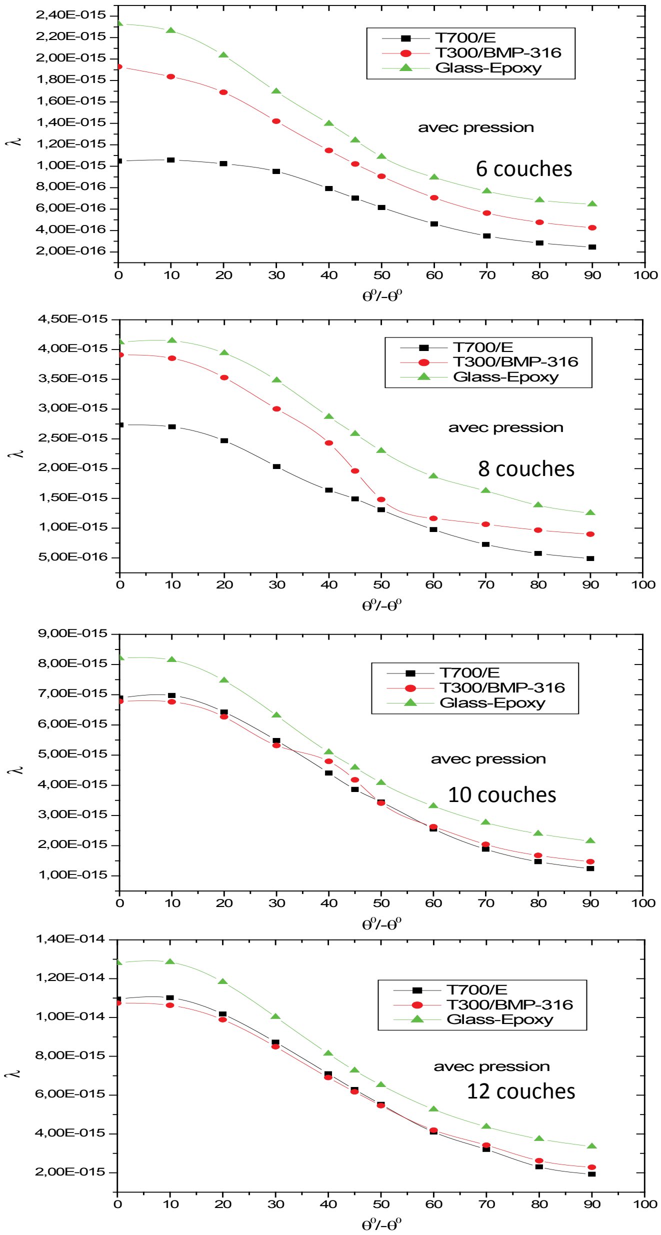

Figure 7. Influence of materials on the buckling coefficient in function of θ ° with a pipe for the pressure of P = 0.84 10^{11}MPa

Pipe with internal pressure P = 0.577·10^{11} MPa

The next case, the pressure was changed, so the same observation was noted, the epoxy Glass, have larger values, which mean it is less resistant. The number of layers also affects the rigidity of our structure.

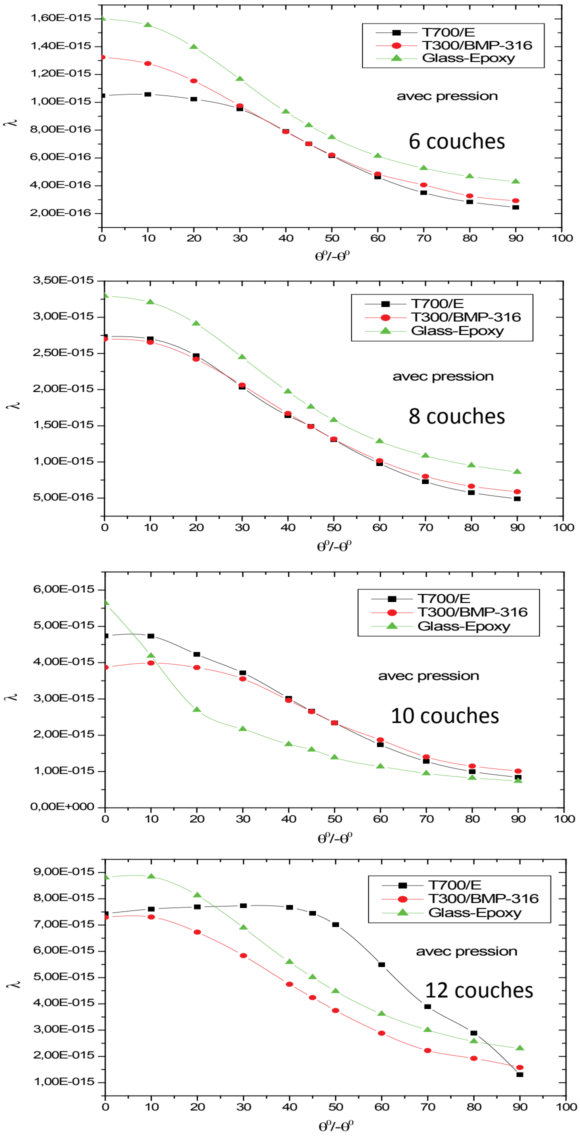

Figure 8. Influence of materials on the buckling coefficient in function of θ ° with a pipe for the pressure of P = 0.577·10^11 MPa

5. Critical buckling load for a pipe with a crack emanating notch

Effect of longitudinal crack on the buckling parameter

To see the effect that can cause a longitudinal crack emanating a square notch on the structure under the effect of buckling (Figure 9), a study was conducted. For this, two sizes of the cut, a = 10 mm and a = 16 mm, have been doing our research. The size of the crack was varied as follows: l = 2 mm, l = 4 mm, 6 mm and l = l = 8 mm for each notch. The reservoir in question is subject to the same boundary conditions as before. The total structure is discretized by a quadratic mesh. Three-point Gaussian integration per ply are considered.

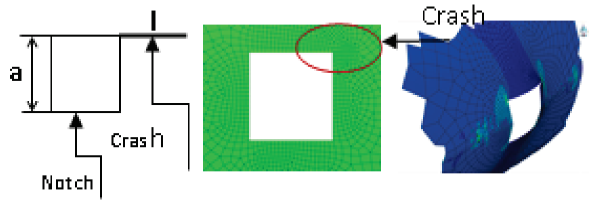

Figure 9. The pattern and mesh at the notch and the longitudinal crack

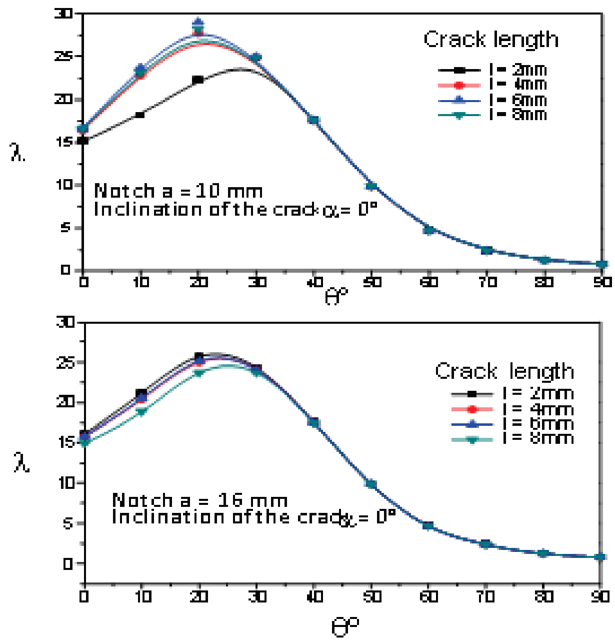

Figure 10. Buckling parameter variation depending on the direction of the folds for a longitudinal crack.

Figure 10 shows the variation in buckling factor depending on the orientation of the folds, for various lengths of cracks. The maximum values are obtained in the range of orientations of 10° to 30° from the orientation factor buckling decreases rapidly and there that from the stacking sequence, the size of the crack n 'no significant effect on the buckling factor, and smaller values of λ are between the stack θ = 70 ° and θ = 90 °.

We also note that for the smallest notches, λ = 29.25 per story for the larger λ decreases slightly and reaches a value of λ = 26 of buckling. So we conclude that the size of the cut plays an important role in the stability of the structure. We also note that it is strongly affected when the orientation is 20°.

Transverse crack effect on the buckling parameter

In this section, we investigate the effect of the inclination of the crack and the orientation of the folds on the variation of the parameter buckling. In this case, a cross crack from notch was planned, α = 90 ° (see Fig. 11).

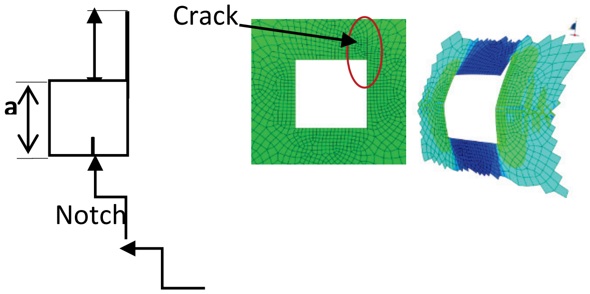

Figure 11. The pattern and mesh at the notch and the crack inclined at α = 90 °

The crack propagation occurs perpendicular to the x-axis, is parallel to the imposed displacement. The figure 12 illustrates the results obtained. The effect of crack length clearly appears interval between 10° and 40°, it is more important for the larger sizes of cracks. And between the 40° to 90°, the size has no effect significant.

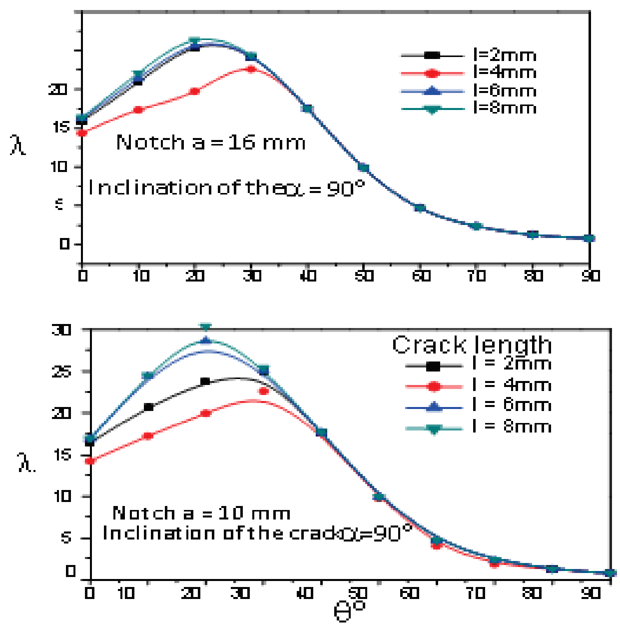

Figure 12. Buckling parameter variation depending on the orientation of the plies (transverse crack).

6. Conclusion

The present study was conducted to determine the influence of a fluid on the walls of a storage tank made of composite materials, subject to buckling; the structure was submitted to an imposed displacement and internal pressures, the overall results are summarized below:

Pipe without pressure

The buckling coefficient reaches maximum and important when the fibers are generally oriented at 20° values.

The lowest values are obtained when the fibers are oriented in the range of 70° to 90°.

The λ parameter decreases with increasing the number of layers of the pipe. This shows the increase in resistance.

Pipe with internal pressure

The internal pressure significantly changes the behavior of pipes and λ become more important, so our structure buckles over, however the number of layers stabilizes the structure and makes them more rigid.

Pipe with crack emanating notch

The size of the cut plays an important role in the stability of the structure. We also note that it is strongly affected when the orientation is 20°.

The length of the crack has no effect on the buckling factor for the slopes of the crack (α = 0° and α = 45°). The maximum values are for 20° fiber orientation.

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DEVELOPMENT OF TRAINING PLATFORM FOR POWER PLANT APPLICATION USING VIRTUAL REALITY TOOLS

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Abstract

Development of a training platform for power plant application using virtual reality (VR) tools supports the safety operation. The VR platform is a computer-based artificial environment where the user can do activites and interact with different objects, and he/she feels the environment realistic. Such immersive, realistic VR world can be applied in the energy sector of the industry, especially in the field of maintenance, operation in normal and emergency conditions to train the staff for the adequate actions. For this, usability test of the recently available devices are performed, followed by the development of an industrial application. Using this power plant application the maintenance training can be performed in such a way that it does not disturb the operation schedule of the plant and the user is not exposed unnecessarily at danger (high temperature, radiation, etc.).

Keywords: Virtual reality, augmented reality, Oculus Rift, LEAP Motion, Virtualizer, mainte–nance, Unity3D

1. Introduction

The virtual reality is nothing more than an artificial environment produced by means of computer systems and information technologies, in which the user, using his/her virtual identity, can do interaction. The aim of the application of the virtual reality is to model, simulate a piece of the real world in such cases where testing a process or product can be too dangerous or expensive. Using the virtual reality, people can be trained for different activities. Such virtual training platform has the advantage that it can be separated from the real world in space and time and in such a way it does not disturb the on-site work. A further advantage is that several places can be displayed using the virtualization system, and there is no need to physically build expensive training areas. The objective is to develop a virtual perception-based event simulation training platform for training people for maintenance of power plant equipments and components. In the energy sector, the application of virtual space for design, control and testing of new facilities increases the safety in point of view of the operability, maintainability and intervention in critical situations, allows early failure detection and realistic training. The training participants can learn the subject of education in a natural way, they can have a realistic contact with the environment in the same way like training on real instruments. A key criterion is that the user needs to "believe" that he/she is present at the relevant virtual world.

The developed virtual reality platform is a computer environment where the user senses the artificial world like the real life. This virtual space is interactive, so the actions of the user effect on the VR environment, it can have even connected to the real world, there is no dangerous condition (the user is not exposed to heat, radiation, high voltage, lack of oxygen or other risk), and the system is not linked to the site.

2. Method

For development of the training platform a virtual power plant environment (Figure 1) is required to be created, where the building and equipments of the plant are generated using 3D scanning tech-nique and CAD modelling. The models then impor-ted to the Unity3D game engine where their physi-cal properties are defined and from these assets the interactive virtual world comes to life.

Figure 1. Virtual environment

Due to the flexible variability of the virtual space there are possibilities to test the components of the simulation system, to develop the fine motor and spatial movements and level of the realism.

Initially, the possibilities of industrial application of the virtual reality were studied through testing some fundamental interactions, such as open the door, turn on the lights, or control proportionally the speed of the industrial fan mounted on the wall. Later a gas turbine is placed in the middle of the hangar in order to practice the movements for the maintenance: getting down the cover, the assembly of the reduction unit is comparable similar to any industrial service task requiring manual skills; with this confirming the legitimacy of the use of VR technology in the power plant trainings.

During a maintenance protocol mostly the manual work is emphasized, however, the spatial movements in space is also considered in natural way. The role of the spatial movements is not insignificant when the maintenance requires spatial motion or visiting different places of the plant. The user can walk with his/her legs in the assembly shop or kneel next to an equipment using the Virtualizer motion detector (Figure 2).

Figure 2. Combination of VR tools – Walking in the virtual assembly shop

Within the virtual environment it is necessary to define such a character who is able to interact with its environment. This character is the avatar of the user, whose movements are controlled by the user motion in the real world - the user movements in the real world are transformed into the movements of the avatar in the virtual space. It is essential for the immersive experience that the user should be able to control his/her avatar and do interactions with such natural movements like he/she does in the real life. To lift up a gear it is necessary to use 2-3 fingers, however, if the object weight exceeds the limits of the one-handed work, the technician must intervene with both hands. Such movements are necessary to happen in the same way in the virtual space as in the reality. Solving the problem requires the combination and joint application of more, recently available VR tools to access the best and most realistic result. These tools are the following:

- Oculus Rift (OR): head-mounted-display for visualising an 3D environment in a realistic, stereoscopic way. It follows the head movement of the user using built-in gyroscope and accelerometer sensors (IMU), which data is used for positioning as well.
- Cyberith Virtualizer (CV): motion control device for detecting the body movement of the user. Detectable motions: walking, running, kneeling, crouching in any direction with arbitrary speed.
- Leap Motion (LM): non-contact optical motion sensor for detecting the fine motor movements of the user. Hand and fingers' motion can be captured, an essential tool for the interaction, for example: equipment installation, maintenance.

To make practical use of the simulation in the training of the maintenance staff, and to have immersive experience, not only a realistically rendered hand model (Figure 3) is necessary, but more important is the realistic physical motion. The aim is that the movements of a specific task in the virtual space should be equivalent with the movements in the real space. Therefore, conditioned reflexes will not build into activities which can be detrimental to the staff work during the actual execution of task.

Figure 3. Realistically rendered hand model

For practising the assembly work, it is essential the precise and latency-free (real-time) motion detection. Many different devices are available in the market, however, for our application the LEAP Motion provides the best solution, as their small-sized, non-contact optical motion sensor can be fixed to anywhere and it does not disturb the free movement of the user. A further advantage of the LM is that the provided SDK (software development kit) allows large freedom for the software development in the field of image processing for the two-camera hardware.

The soul of the maintenance work is indisputably the fine motor movement, for which mapping using dynamic imaging variables the bi-cameras of the LEAP Motion sensor are applied. The advantage of the sensor is the disadvantage as well: as an optical sensor does not require a direct connection with the user, the non-contact design provides the freedom and flexibility of movement for the mechanic during the training, however, the sensor can detect only those movements what are visible for the camera of the LEAP Motion (obscured motions cannot be detected).

As the hardware can not be improved, to get around the problem according to the above mentioned, an algorithm for movement method recognition is under development, which infers typical schemes from the obtained data and automates the smaller joint operations in such a way that it does not detract from the difficulty level of implementation of the task and the user does not recognize the „assistance“. The incomplete data from the sensors are replaced by movement schemes borrowed from the real-life in order to make the operations smoother. Neglecting the false signals, a usable hand model are obtained instead of the trembling and twisted hands.

If we want to assemble a watch, but the magnitude of our hands' trembling is greater than the size of the bore where the screw we want to insert, most probably the operation will be failed and the screw will land on the ground. As similar problem also can happen in the virtual reality due to the hardware deficiencies, such solution is required which intervenes only in the most necessary cases in order not to decrease the realistic level of the operation. According to our interpretation, during the assembly operations the absolute value of the position difference of the vectors of the fingertips per one second provides the trembling phenomenon of the hands which makes difficult the task. In further, this scalar value between 0 and 1 defines that relative distance of the components at which they will be automatically inserted to their position. The importance of this step should be highlighted, because the algorithm, considering the actual environment variables, looks for that smallest distance in which the user need assistance (but only such assistance which is necessary due to the hardware deficiencies).

Method for measurement of the grip force is developed for the Unity3D game engine (Figure 4), which is achieved in practice at given mass of the object with decreasing the force of gravity to the item.

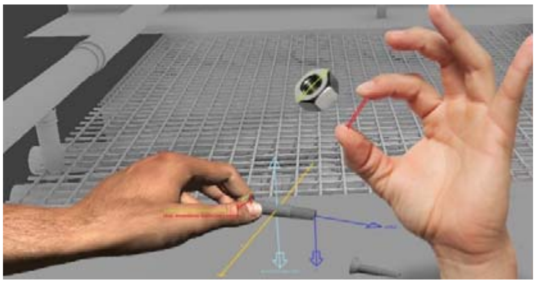


Figure 4. Measurement of grip force in Unity3D

With this method, the objects can be gripped not only from the top direction, but the direction of larger size objects also can be controlled during the assembling.

In contrast to the digital gloves the LEAP Motion models the virtual movement of the hand in-contact way, it does not use resistance-based kinematic-sensors. This is an advantage in many ways; however, it also proposes a serious problem: at the description of the physical properties of the hands not only the markers based coordinates should be considered, but the pressure/force should be also taken into account. When the colliders of the fingers reach the polygon of the objects, a subordinated script resets its absolute position based on the diameter of the widest point of the object. This data is interpreted as zero point in the future; the positive and negative difference will be the numerical data of the grip force. If the value is 0, the force of gravity is equal to the frictional force; the object hangs on the X (vertical) axis. If the value is negative (i.e. greater than the diameter of the polygon) the software interprets that the force of gravity is larger than the frictional force, the logical connection between the fingers and the object is lost, and the object falls down. As for practical application it should be noted that the hardware works with relatively large margin of error, so the negative value is considered till 15 percent of object diameter as 0, in order to avoid the object falls or the interruption of the workflow due to the false signals. When we are closing our fingers in reality the value is positive. This is manifested in the virtual space as the increase of the frictional force, but the movements of the fingers are not visible. The obtained value is also not absolute one but a ratio to the cross-section of the hand-held object. The obtained percentage value is the acceleration of gravity on the square. Thus, if the value is 50%, so the grip force doubled in value, the gravitational force acting at the end of the object will be decreased to one quarter. If the measured value is 100%, the gravitational force acting at the end of object will be decreased to zero, and the bolt remains in the same position as at first it was gripped and lifted up.

Look now for some fundamental interactions in order to understand how the brain recognizes the virtual environment. Lets switch on the light: doing so a trigger box is defined for the mesh collider of the animated switch, in such a way avoiding the physical contact between the two objects (hand and switch), and reducing the number of errors and improves the user experience. When the virtual hand passes through the plane of the trigger box and collides to the collider of the switch, a script activates the function to switch on the light. The occured interaction (switched on light), the clicking sound of the mechanics and the transforming switch together provide such an audiovisual feedback for the user that the human brain can link together the storyline, naturally sense the events without having actually physical interaction, without touching the surface of the switch by fingers (Figure 5).

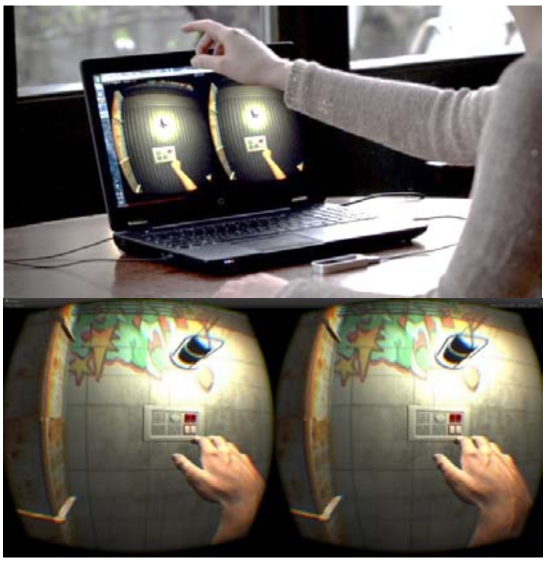


Figure 5. Switch on/off the light

This simple interaction is an excellent example for our response to the largest actual problem of the virtual reality: developments of most of the available VR hardware are infancy, so many clumsy solution appear due to inaccurate sensors, incorrectly mapped movements which are inevitably detract the user experience. With this the reality of the simulation for the user becomes questionable, however, the immersion is the base of the raison d'etre of the virtual reality. An experiment was performed [1-4] to study the adoptation capability of the human brain where the person should link together the flashing object on the computer screen to an audio signal. At first, the flashing and the audio signal occured in the same time, later (after 20 events), when the person get used to them, the audio signal is shifted from the visual stimulation by 15ms. When the person adopted the new situation, the visual and audio signals are presented again in the same time. In this time, the person saw sooner the visual signal than heard the sound, however, both signals are occured in the same time. The software development can be the solution for getting around the hardware deficiency determined by the market, based on a simple thesis: that is true what our brain believes so.

Task of opening a door provides answers to other general questions: in this experiment (in sharp contrast to the previous example), an iron door can be opened using purely physical interaction of two colliders. So the door should be simply pushed with our hands until it opens. This is very important because in this case the haptic feedback has an important role in the reality, from this feedback the user feels how large force is necessary to open the door.

The haptic feedback is not available yet for the virtual reality, however, the brain is able to assess and „sense“ the haptic feedback based on visual signals. For testing it, a "force analysis" formula is developed for the script of the game object, considering the weight and inertia of the door, the gravity and the force of the spring built-in the door effecting on the hand (on the rigid body character).

3. Results

Three tools (Oculus Rift, Cyberith Virtualizer, Leap Motion) together create picture about the reality, their digital extracts are combined into one character (avatar) to generate the complex motion of the avatar of the user.

The system of the connected devices transforms the real world movement to the interaction between the complex character and virtual space. It is possible to walk in the room, switch on/off the light, open the door, proportionally control the speed of the industrial fan, and practise the assembly work of a turbine (Figure 6).

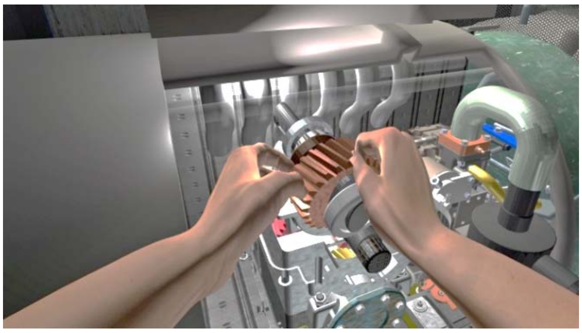
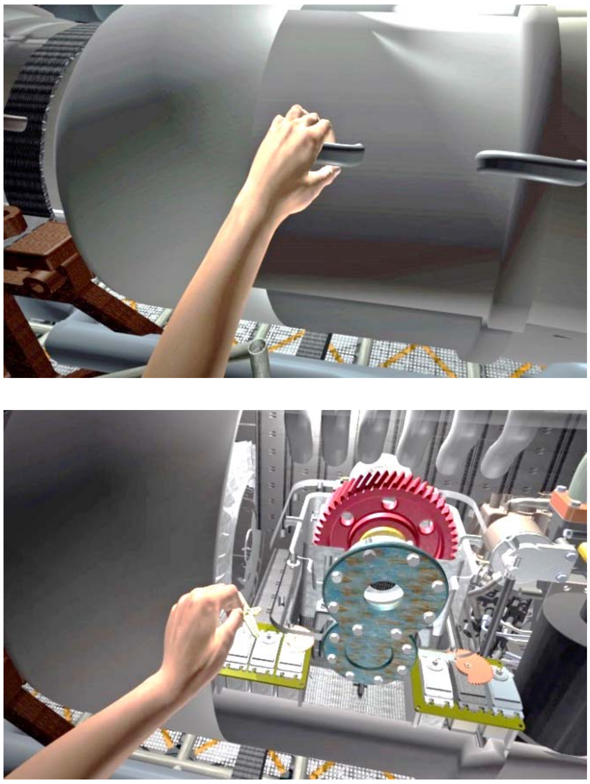


Figure 6. Assembly of a gear using two hands in virtual reality

In the middle of the hangar a gas turbine is placed, on which the assembly (manual work) can be exercised. First of all, the cover of the opening of the turbine casing can get down to ensure free way to the mechanics, creating the possibility for the interaction. Now the revolution reductor is visible. The spherical symmetry servo-arm can be got down gripping with two fingers from the gear ratio controlling servo motors. The servo motors can be pulled out below from their slots. The gearbox can be completely disassembled, following logical order as in the reality: the bolts can be taken out in the order of the tightening, then the cover can be got down and the shaft can be removed horizontally. The main gear can be pull down horizontally from the shaft (Figure 7), then the other parts can be removed above from the slots, except for the bearings.



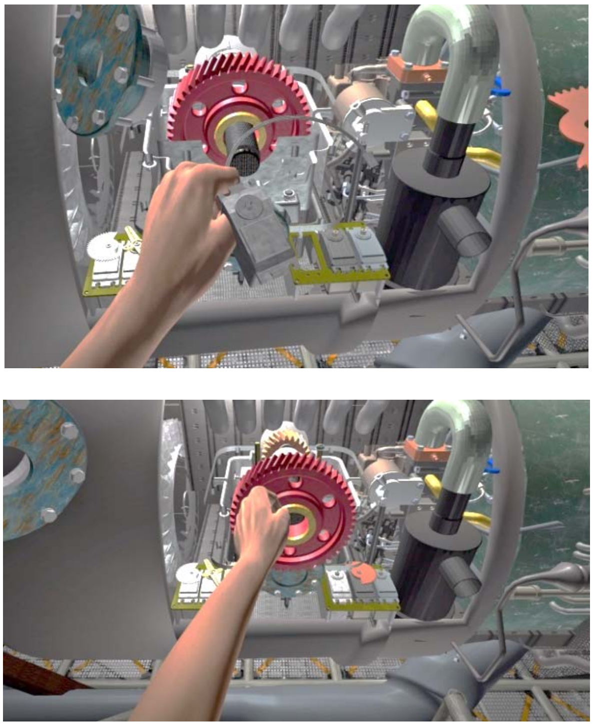


Figure 7. Assembly of a as turbine

From the lower gear box the gear can be taken out only using two hands: in this case a script checks based on the hierarchy states that two colliders should be in contact with the gear in the same time.

If both hands are in contact with the given object, the item will move together with the left hand, and it can be removed. In case of assembly the components can jump to their position from a relatively small distance: the relative distance depends on the resultion of the devices and the dimensions of the components and the character, and determination of its value is based on average distances.

4. Discussion

Without physical contact of the sensors the number of the possible error factors can be significantly increased. The infrared background radiation reduces the contrast of the hand detected by the sensor, thus, to distinguish the fingers in the background is more difficult for the algorithm during the image analysis. Further problems are the blind spots (Figure 8) due to the type of the sensor and the small interaction area which does not cover the area of the activities. Two different approaches of the described problem are combined in the implementation of the project in order to minimize these errors. The small interaction area covered by the LEAP Motion sensor is appropriate for the needs of an average users, who sits in front of the desk and would like to use the LM for gesture control in the daily work or playing games. However, the discussed industrial application of the device requires new expectations, as the spatial and fine motor movements have to be modeled simultaneously with extremely high precision and operational reliability. There are bound to happen that the user can be out of the range of the LEAP Motion sensor.

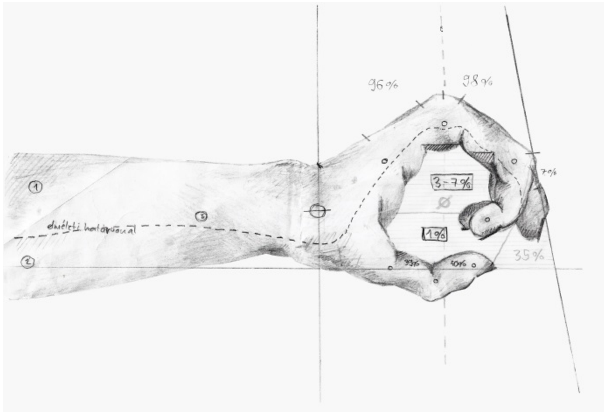


Figure 8. Blind spots and viewing angles of the LM

Due to the problems encountered, it is indispensable to mount the sensor to the head (in this case to the front panel of the Oculus Rift) for the simulation of the maintenance work, since the user follows the assembly with his/her eyes during the manual work.

However, the sensor is designed essentially for static position, so inherently due to the movement of the head; the data of the LEAP Motion about hands become false influencing and often distorting to unusability the interpretation of the incoming data. As a solution, an absolute reference system is developed based on the data extracted in command line from the accelerometer and gyroscope of the Oculus Rift (IMU module inertial sensor), where the vector values of the OR movements are added to the measured values of the LM obtained from the image analysis of the hands in order to compensate each other, so that the head movements do not affect the position of the hands in the virtual space. After this, all the movements are absolute values in the obtained space. Separate software is developed to implement the necessary algorithms and to solve the transformation of the coordinate systems. However, the problems of the basic concept are quickly outlined: determination of the direction can be performed with high accuracy using the gyroscope, but the acceleration values calculated by the accelerometer are not suitable for precise determination of the distance. Based on the data of the accelerometer a "drifting phenomenon" is formed in the absence of reference sensor, thus, the distance is quadratically accumulated in the function of the time until the assigned object disappears in the virtual infinite. To avoid this, the end position determined by the IMU sensor is saved as a reference value in every half second, and the position of the object, based on this, is changed to zero twice per second. Always the previously saved value means the zero position in the space, so there is no way for the drift phenomenon to emerge.

However, the positioning process becomes discontinuous, the background processing capacity increases, and the resolution drops off so much that the positioning of the virtual hand is perceivably influenced for the user.

In the future, alternative solutions can be for example the visual positional tracking system of the Oculus Rift DK2, or application of additional inertial sensors such as the RazerBleed magnetic field strength based positioning system, which can be mounted to the Oculus Rift and provides precise positioning. Using data from such positioning systems the problem of the accelerometer can be avoided, the values after the coordinate transformation can be retrieved to the script which is positioning the handcontroller.

An alternative solution, if the LEAP Motion sensor is fixed to the flange of the rotating element of the Virtualizer using a beam, so the user is not disturbed in the free movement and during his/her turning the hands remain in the interaction area, in front of the sensor.

The head mounted sensor rectify the problem of the field of view, however, it does not solve the problem of the blind spots due to the viewing angle and the problem of the false signals in all cases. The solution can be the connection of two LEAP Motion sensors. However, connection of them generates further problems for what the developments are in progress.

5. Conclusions

A training platform for power plant application using virtual reality tools is developed to support the safety operation. Using combined hardware and software tools and integrated hand model, the system provides realistic and interactive virtual space for training. It is possible to walk in the room or on the territory of the power plant, switch on and off the light, open and close the doors, control the fan speed, and study the assembly work of a gas turbine. The user can be trained in a realistic power plant environment and does not disturb the on-site work and he/she is also not exposed unnecessarily at danger.

In spite of deficiencies the available hardware tools can be applied well not only for gaming, but for industrial applications with the appropriate software support.

6. Acknowledgement

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NUMERICAL SIMULATION OF DISSIMILAR METAL WELDING

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Abstract

This paper summarizes the results of the through-thickness residual stress distributions on dissimilar metal weld (DMW) mock-up. DMWs, as welded joints between ferritic steels and either austenitic stainless steels or nickel-based alloys, are commonly found in piping systems of NPPs as well as in other industrial plants. The welding of the mock-up is simulated by the 3D finite element model using temperature and phase dependent material properties. The commercial finite element code MSC.Marc is used to obtain the numerical results by implementing the Goldak's double ellipsoidal shaped weld heat source and combined convection radiation boundary conditions. Residual stress measurements are performed on welded joints to validate the simulation results. The validated residual stress distributions can be used for the life time assessment and failure mode predictions of the welded joints.

Keywords: dissimilar metal welding, finite element analysis, residual stress, phase transformation

1. Introduction

Dissimilar metal welds are generally used in piping systems of nuclear power plants as well as in other industrial plants to connect low alloy ferritic steel components and austenitic stainless steel or nickel-based alloys. DMWs are produced by fusion welding and their structural stability is strongly affected by welding conditions and post weld heat treatment.

This type of welding process produces large residual stresses. The maximum value of tensile stress is commonly equal to the yield strength of joint materials. The residual stress of welding can significantly impair the performance and reliability of welded structures.The integrity assessment and life estimation for such welded structures require consideration of residual stresses. Therefore it is necessary to map and assess the distribution of these residual stresses in welded joints.

The mock-up reflects the DMW configuration of the WWER-440 reactors connecting the reactor pressure vessel with the hot-cold leg. It involves a bimetallic fusion weld with three buttering layers towards the ferritic side.

The goal of the mock-up is to replicate the conditions of a heterogeneous weld in a type ofWWER 400 RPV nozzle.

In this paper, a 3D thermal-mechanical-metallurgical finite element (FE) model has been developed to investigate the distribution of residual stress. The results of FE analyses were compared with the experimental measurementsin the ferritic steel section of the mock-up. The measurement of residual stresses was performed using neutron diffraction. The experimental procedures including sample fabrication and residual stress measure-ments were followed by the modelling results.

2. Experimental procedure

The experimental mock-up as shown in Figure1 was manufactured for measuring the final residual stresses.

Originally, steel 15H2MFA (Table 1) was the manufacture material for the nozzle rings ofDN 500 nozzles. This steel has a high stability of mechanical properties including the resistance against temper brittleness and temperature ageing. The safe-ends of DN 500 nozzles were manufactured from austenitic steel 08H18N10T. However this type of steel is no longer available so it is substituted with X6CrNiTi18-10 (1.4541), which has a similar chemical composition, as it can be seen in Table 2. The base materials are widely different (15H2MFA ferritic steel and X6CrNiTi18-10 austenitic steel) so in order to perform the welding a transient cladding or cushion has to be implemented.

Figure1.The mock-up

Table 1. Chemical composition of 15H2MFA steel

C (%)	Si (%)	Mn (%)	S (%)	P (%)	Cr (%)	Ni (%)	Mo (%)	V (%)	Cu (%)
0.13	0.17	0.3	0.025	0.025	2.5	0.4	0.6	0.25	0.15

This cushion has two layers. The thickness of the first layer is 3 ± 1 mm and itwas welded on by EA-395/9, Ø 4 mm covered stick electrodes.After the first layer was grinded down to meet the thickness criteria, the second layer was welded on, using EA-400/10T Ø 4 mm covered stick electrodes (the maximal temperature at the time of welding was 100°C on the same conditions as at the 1st layer).The total thickness of the layers has to be 9±1 mm (Figure3). The welding parameters are detailed in Table 3. After cladding, the specimen was heat treated by heating it up to 670°C at a rate of 50°C/h for 16 hours and let it cool down together with the furnace.

Table 2. Chemical composition of stainless steels

	C (%)	Si (%)	Mn (%)	Cr (%)	Ni (%)	Mo (%)	Co (%)	Ti (%)
EA-395/9	0.08	0.35	1.2	13.5	23	4.5	0.08	-
EA-400/10T	0.07	0.5	1.5	17	9.5	2	-	-
316L	0.015	0.4	1.75	18.5	12	2.75	-	-
X6CrNiTi18-10	0.08	0.08	1.5	17	9	-	-	0.4

Table 3.Welding parameters of the cladding

	Welding Process	Current (A)	Voltage (V)	Type of Current	Heat Input (kJ/mm)
1st layer	SMAW	120-130	24-25	DCEP	~0,61
2nd layer	SMAW	130-140	25-26	DCEP	~0,69

The welding was performed in two steps and without pre-heating or heat treatment. Originally the root weld was welded manually from the root side by GTAW method using Sv- 04H19N11M3 Ø 1,6 mm electrodes in flat position.

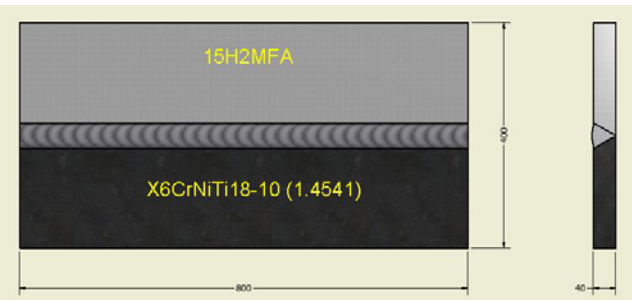


Figure2. Dimensions of the specimen

Unfortunately, this type of electrode is no longer commercially available so a slightly different type of electrode is used, namely Lincoln TIG 316L. As it can be seen from Table 2, its chemical com-position is almost the same as the Sv-04H19N11M3.The filling weld and the capping were welded by SAW method using Sv-04H19N11M3 Ø 2 mm electrodes and OF-6 flux in horizontal position (Figure3).

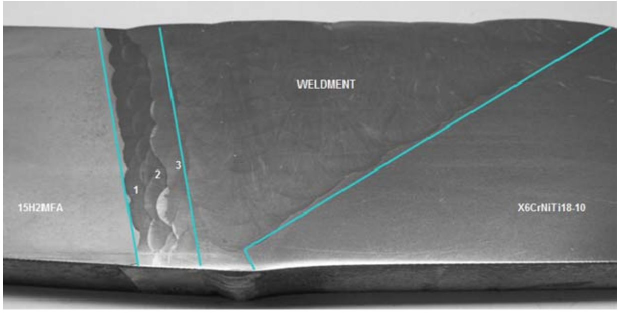


Figure3. Macrostructures of butt-welded joint

However, this type of electrode and flux is also outdated and therefore no longer available. The substitution was LNS 316L with P240 flux. The chemical composition of the original and the substitute material has an almost perfect match and the P240 is also a highly basic fluoride agglomerated flux, with a basicity of three, just like the original OF-6[1],[2]. The welding parameters are detailed in Table 4.

Table 4. Welding parameters

	Welding Process	Current (A)	Voltage (V)	Type of Current	Heat Input (kJ/mm)
Root weld	GTAW	50-60	12-13	DCEN	~0,1
Filling weld	SAW	320-330	28-29	DCEP	~1,16

3. The 3-D finite element modelling

The welding of DMW mock-up is simulated using three-dimensional (3D) thermo-mechanical and metallurgical finite element model. Work tasks:

- Simulate the cladding process
- Simulate the heat treatment after the cladding
- Simulate the butt-weld process

The FEM pre-processing, calculations and post-processing have been carried out by MSC.Marcand Simufact.welding software based on MSC.Marc code. The thermo-elastic-plastic-metallurgic finite element computational procedure is performed to analyse the welding temperature field and the welding residual stress in DMW mock-up(Figure2).
The thermo-mechanical and metallurgical behaviour is calculated using a coupled formulation.

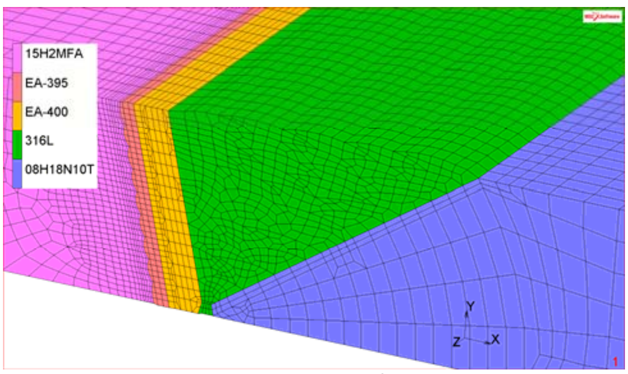
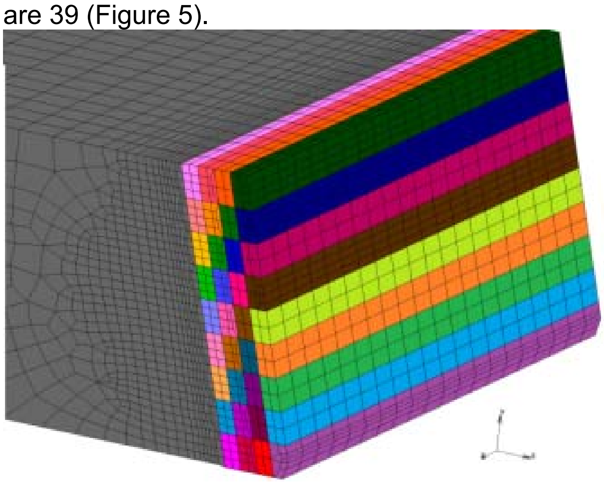


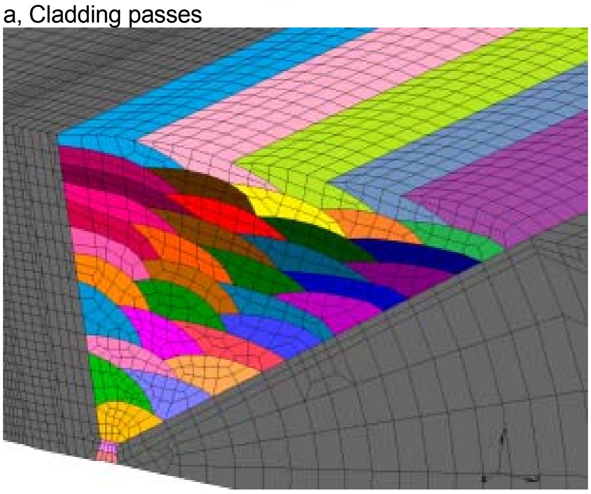
Figure4. FE mesh for DMW

The simulations (in 3D) are done on simplified geometries (Figure4). In case of cladding, the welded plate was 200 mm instead of 780 mm, due to the high costs of computing time and computer resources compare to the case of welding simulation for the full length plate.

One cladding layer is divided to 9 beads along the plate thickness (40mm). The number of cladding layers was four. In case of welding process, 200mm length of weld plate is taken account and the total numbers of simulated passes are 39 (Figure 5).



a, Cladding passes



b. Weld passes

Figure 5. Welding layers

Between welding of layers ~5min cooling time is considered, because the interpass cooling temperature is important factor in the final residual stress distribution. Interpass temperature was 250°C in the first cladding layer and it was under 100°C in the other cladding layers and all layer of butt-weld.

For DMW simulation, the FE models are created by 8-noded hexagonal elements, number of element is 64120, and number of nodes is 68798. The 15H2MFA plate is modelled as simply supported, during both the cladding sequences and butt-weld sequences.

Due to the expected high temperature and stress gradients near the heat source, a relatively fine mesh is used. Element sizes increase progressively with distance from the heat affected zone. In case of butt-weld a relatively coarser mesh is used.

MSC.Marc software uses Goldak's heat source model (Figure6) for welding simulation. The heat source distribution combines two different ellipses, i.e. one in the front quadrant of the heat source and the other in the rear quadrant. Goldak's double ellipsoidal shaped weld heat source can be used to specify volume fluxes in 3D.

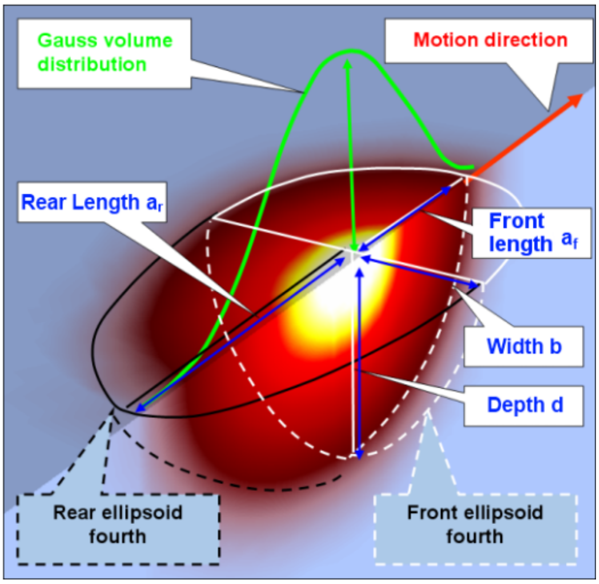


Figure6. Double ellipsoidal (Goldak) heat source profile[3]

MSC.MARC code contains the implementation of material addition or removal technique is very suitable for simulating welding processes. The technique requires that the complete model, including all material volume during the whole process, to be defined and meshed in advance. In the deactivated element method, filler elements are initially deactivated in the analysis and are not shown on the post file. When the elements are physically created by the moving heat source, they are activated in the model and appear on the post file.

Inactive elements have been activated initially to simulate the addition of filler material. The thermal and mechanical activation of the elements are separated. The criterion for thermal activation is that an element should be inside the volume of the heat source. Mechanical activation of an element is achieved when the temperature in the element has dropped below a threshold value. The chosen threshold value is *1800 K*.

On all free surfaces of all FE-models a convective heat loss with a heat transfer coefficient, $h=15W/mK$ and a radiation heat loss using an emissivity coefficient, $\varepsilon=0.5$ are defined.

Full Newton–Raphson iterative solution technique with direct sparse matrix solver is used for obtaining a solution. During the thermal analysis, the temperature and the temperature-dependent material properties change very rapidly. Thus, it is believed that a full Newton–Raphson technique using modified material properties gives more accurate results.

4. Material properties

In order to capture the correct microstructure evolution a number of material properties are required for present simulations (Figure4). The elastic behaviour is modelled using the isotropic Hooke's rule with temperature-dependent Young's modulus. The thermal strain is considered in the model using thermal expansion coefficient. The yield criterion is the Von Mises yield surface. In the model, the strain hardening is taken into account using the isotropic Hooke's law for ferritic steel.

The thermo-metallurgy material properties of 15H2MFA steel were generated with JMatPro software based on its chemical composition (Table 1). Strain hardenings of the phases at room temperature are shown inFigure 7. Transformation data was calculated using Simufact.premap interface with 8 μm grain size starting at 1200°C.

Stainless steel has no solid-state phase transformation during cooling and the heating time is relatively short, it can be expected that the strains due to phase transformation and creep can be neglected in the present simulation. In case of stainless steels, the strain hardening is taken into account using the Chaboche's combined hardening law. The model in MSC.Marc requires at least five parameters (*c, γ, Q, b,* σ_y) which is an acceptable number to be determined from experimental stress vs. strain curves (Table 5). Using these parameters, the model provides an adequate description of the real elastic-plastic material behaviour.

Table 6. Mechanical properties at room temperature

	σ_y [Mpa]	Q [MPa]	b	C [MPa]	γ
EA-395/9	365	1500	50	3000	6
EA-400/10T	420	500	50	1900	3.5
316L	280	600	125	1700	3.2
X6CrNiTi18-	270	300	50	1800	1.9

Other thermo-mechanical material properties of austenitic steels (Table 6) were generated by JMatPro software which can be seen from the chemical composition listed in Table 2.

The mixture of the initial microstructure elements in the FE model has to be defined for each material. In case of 15H2MFA 100% bainite and for other materials 100% austenite initial fractions were used [2].

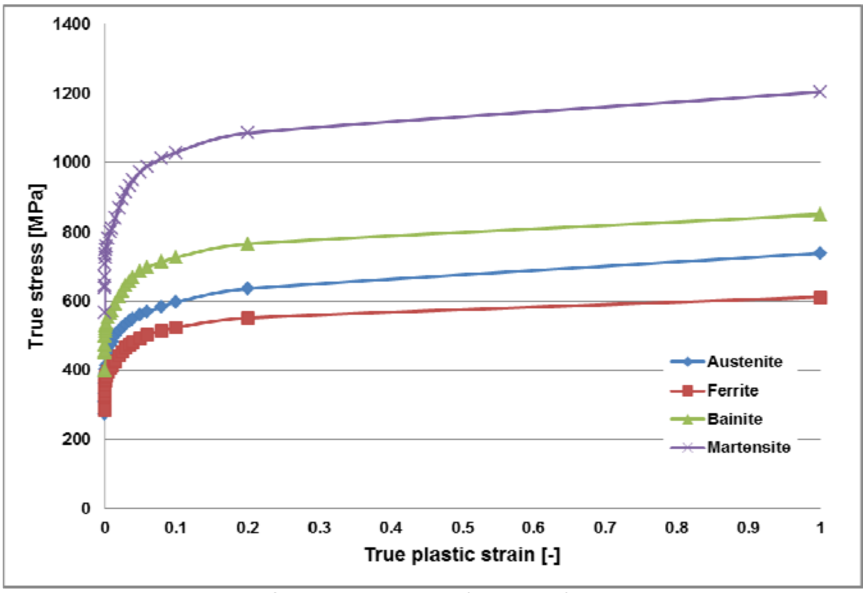


Figure 7. Strain hardening of phases for 15H2MFA

Table 6. Thermomechanical properties at room temperature

	Modulus of elasticity (Austenite) [GPa]	Modulus of elasticity (F./M.B./P.) [GPa]	Specific heat capacity (Austenite) [kJ/kg°C]	Specific heat capacity (F./M./B./P.) [kJ/kg°C]	Thermal expansion (Austenite) [1/°C*10^{-5}]	Thermal expansion (F./M./B./P.) [1/°C*10^{-5}]	Thermal Conductivity (Austenite) [W/m°C]	Thermal Conductivity (F./M./B./P.) [W/m°C]
EA-395/9	212	-	0.434	-	1.623	-	11.95	-
EA-400/10T	203	-	0.443	-	1.831	-	13.46	-
316L	198	-	0.444	-	1.872	-	13.59	-
X6CrNiTi18-10	196	-	0.450	-	1.898	-	14.12	-
15H2MFA	197	212	0.451	0.446	2.431	1.251	17.28	28.77

5. Measurement of residual stress

The measurements have been performed at the residual stress diffractometers at beam tubes HB4 and HB5 at the High Flux Reactor (HFR) of the Joint Research Centre in Petten[2].

Measurements in the welding transverse and plate normal directions have been performed in the ferritic steel section on the diffractometer at HB5. For the welding longitudinal direction, the specimen was mounted on the diffractometer at HB4. Figure8shows the section of the Mock-up during these latter measurements on the table of HB4.

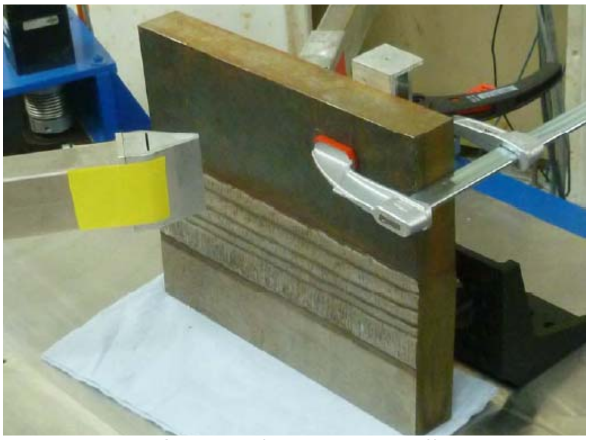


Figure8. Section of Mock-up on diffractometer

The measurement positions were located along a number of parallel lines – mostly 6.66 mm apart – oriented in the welding transverse direction ranging from 3 mm to about 45 mm from the interface between the ferritic steel and the buttering layer. The measurement lines were located at mid-length of the Mock-up section in order to minimize the influence of end effects on the results.Because of the thickness of the Mock-up – 40 mm in the ferritic part – it was necessary to work with relatively large sampling volumes, i.e., 7.5 by 6 by 8 mm3 for the welding longitudinal direction (HB4) and 5 by 4 by 15 mm3 for the other two directions (HB5)[2].

Stresses were derived from the strains measured in the three directions using the generalized Hooke's law.

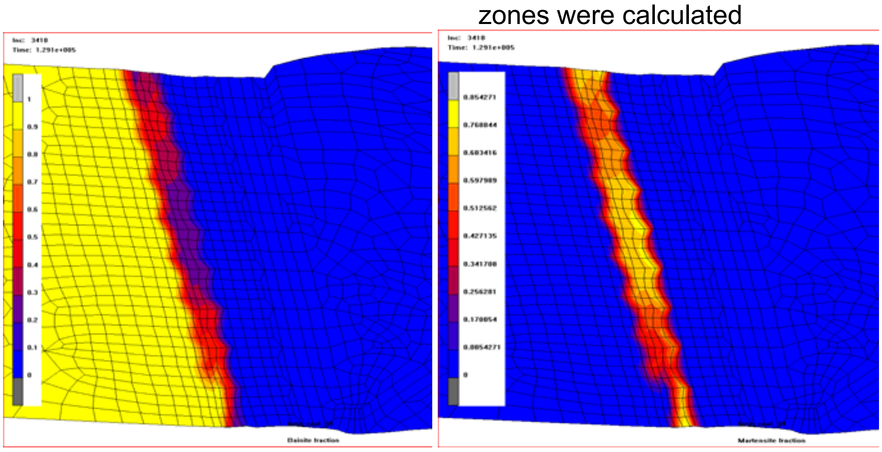
6. Results and discussion

DMW model was validated with available experimental results. A simulation model has been developed and extensive numerical calculations were carried out to find out the residual stress distribution of DMW. The deformed mesh contour and photograph of DMW section are compared in Figure9. The model distortion and the size of the fusion zone andthe heat affected zone (HAZ) are in good agreement with the experimental observations.

Figure9. Distortion after welding

The results of the simulation provide the size of theHAZand the volume of the molten zone. The molten zone is the region of the mock-up where the actual weld is formed, while the heat affected zone is the adjacent region where heat may cause solid state phase transformation, but melting does not occur.An additional capability of the model is the ability to predict the volume fraction of various phases.

The volume fraction of bainite and martensite (Figure10) can be quantified and serve as an additional response that can be used to validate this model with experiments and to predict phase volume fractions under new processing conditions.Figure11 represents the residual stress distributions of the model after welding. As expected, generally lower stresses in base metal and higher stresses in HAZs as well as welded zones were calculated



a, bainite fraction *b) matrensite fraction*

Figure10. Fraction of each phase after welding

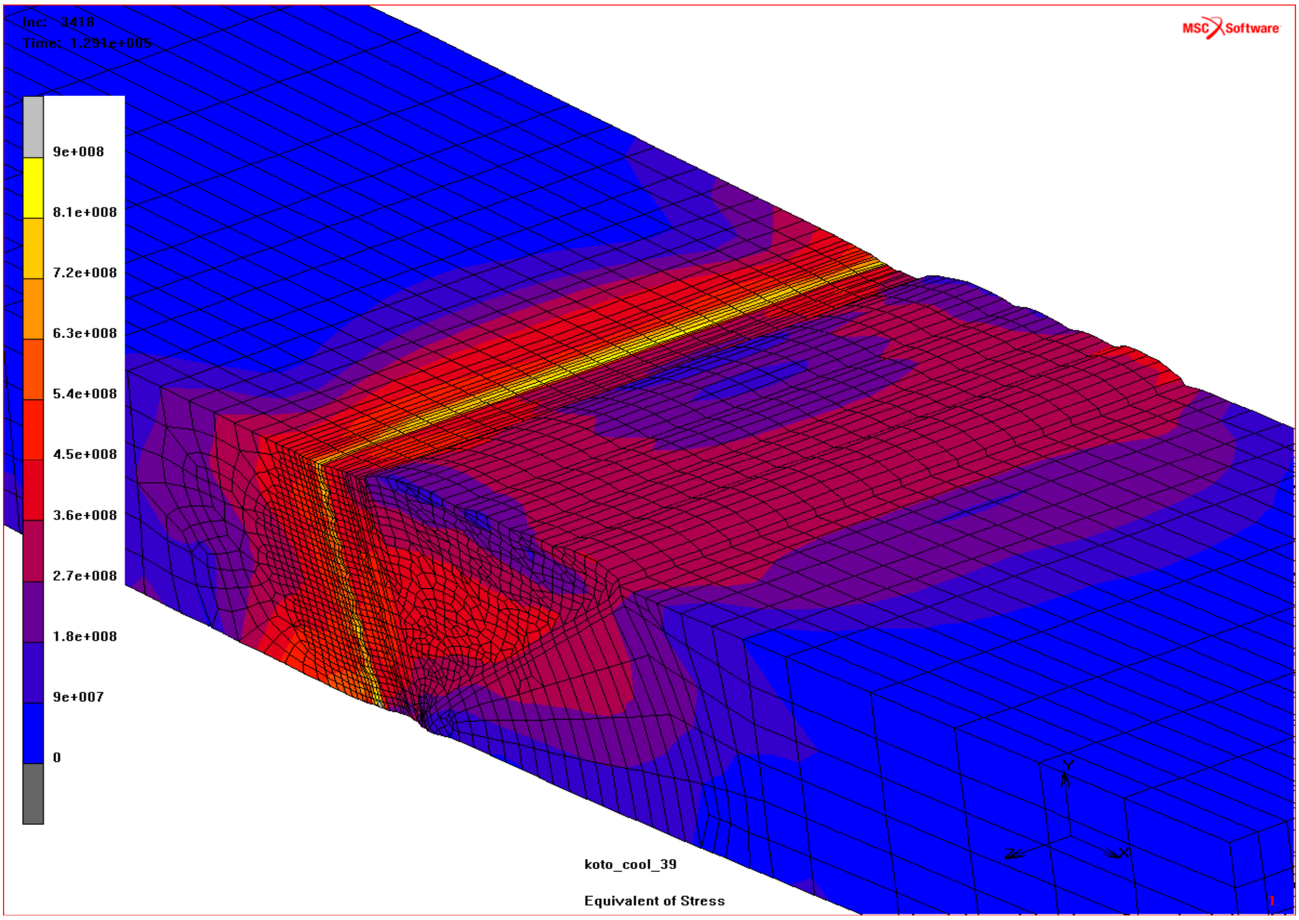


Figure11. Residual stress distribution [Pa] after but-weld

From the FE analysis all the stress components are available. Longitudinal, transverse and through thickness are used to denote the residual stress components of three perpendicular directions. The resolution of the measurements is in the order of 6 to 8 mm. The neutron diffraction measurements were not possible closer to the interface than 3 mm. The simulation results and the measured data are compared along three lines on the ferritic section.

Figures 12-14 show the derived residual stress component for lines at 3.33 mm, 23.33 mm and 33.33 mm from the top surface of the weld plate. In Fig. 12 tensile stresses can be seen near the interface (3.33mm) for the welding transverse (almost 300 MPa) and the welding longitudinal (about 200 MPa), whereas the through thickness component shows nearly no stress as it should be for this near surface line.

Near plate centre (Figure13) tri-axial compression was found. In this case the highest compression of about -400 MPa is found in the welding transverse and through thickness directions, whereas the welding longitudinal component exhibits -200 MPa only. 6.66 mm from the lower surface of the mock-up almost no residual stresses have been obtained for the welding direction (Figure14), and a small amount of tensile stress for the welding transverse direction and an even smaller amount of compressive stress in the through thickness direction[2].

The simulations predict a range in residual stress components achieving good agreement near the outer surfaces, butthe ferritic section of the mid-thickness comparison show that there are some deviations between the predictions and the measurement.In Figure13, although calculated the longitudinal residual stress distribution shape is similar to the measured by the experiment near the weld zone, magnitudes predicted by the numerical model are significantly lower than the measured data.One possible cause is thecalculated yield strength of the base metal for each phases used in the FE model. It seems to be the yield strength variation during the cladding and welding passes resulting in difference between predictions andmeasurements.

One should also note that any effects of phase variations are not yet seen by the neutron measurements, as no reference specimen could be measured so far.One remarkable observation from these results is that in no case the welding longitudinal direction exhibits the highest residual stresses, neither in tension nor in compression [2].

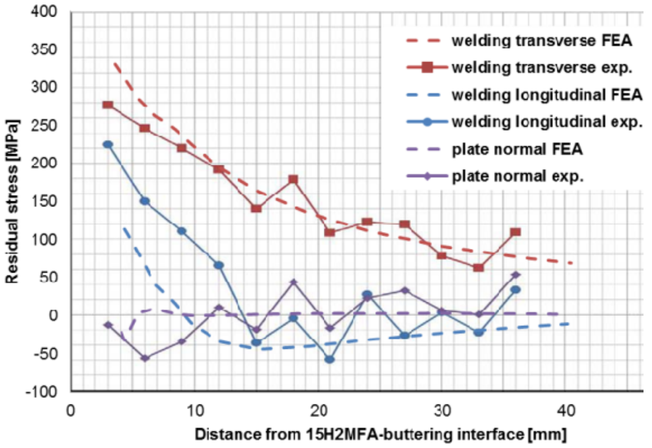


Figure12. Estimate of residual stresses along a line 3.33 mm from the specimen surface

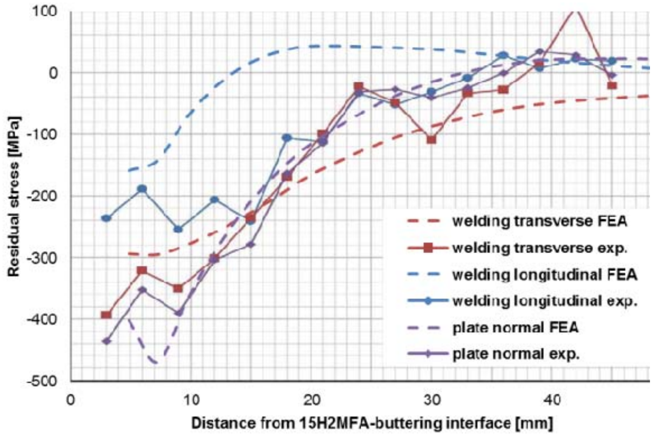


Figure13. Estimate of residual stresses along a line 23.33 mm from the specimen surface

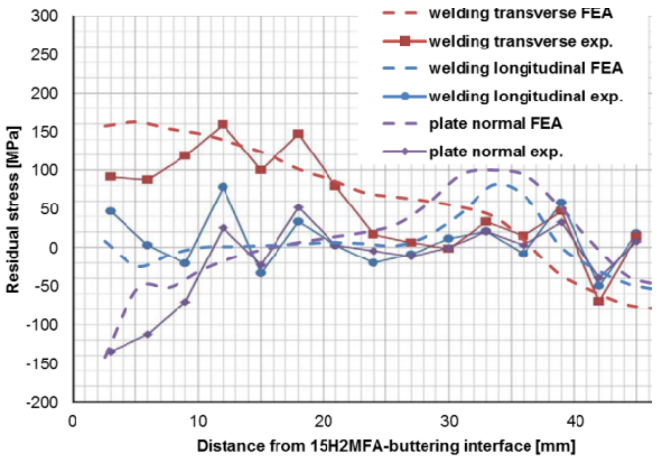


Figure14. Estimate of residual stresses along a line 33.33 mm from the specimen surface

7. Summary

All results are presented considering temperature dependent material properties, phase change, and convection boundary. Also, experimental measurements employing neutron diffraction have been conducted to assess residual stresses within the welded samples. Anacceptable agreement has been found between the predicted and the measured data that verifies the validity of the employed model.

The simulation results provided highly precise prediction of final residual stress in the joint of dissimilar metals.Furthermore, considering the important manufacturing processes and developing more reasonable material models are necessary. Both the numerical model and the experiment show that strain hardening consent to the final residual stresses.

8. Acknowledgement

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[3] Simufact.welding.: Heat source

MECHANICAL BEHAVIOUR OF PIPES STEEL REINFORCED WITH COMPOSITE MATERIALS AND ON STEEL

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Abstract

The metal pipes are particularly vulnerable to internal and external constraints or geometric instability, and their sizing is effected by using simplified rules. Indeed, these pipes are very sensitive to the slightest imperfection or initial geometric operation (accidental loads, temperatures, etc.). Taking into account the various damage generally leads to a loss of bearing capacity. To reserve the potential burden of these pipes, it is necessary to strengthen them. In this study we have made the strengthening of steel pipes with metallic materials and composites in the presence of compressive stresses. One or more layers of composite are bonded to the discontinuity of the pipe. The analytical treatment for this type of problem is complex and therefore we use numerical modelling using the code ABAQUS. The results show that the correct fiber orientation relative to the advance of the crack affects a significant effect on reduction of FIC. The properties of the membership must be optimized to increase performance of the repair piece over. Reducing the FIC becomes important when other decreases.

Keywords: pipe, constraints concentration, stress intensity, adhesion and adhesive factors, finite element analysis.1.

1. Introduction

The metal pipes are particularly susceptible to internal and external constraints or geometric instability, and sizing takes place by having recourse to simplified rules. Indeed, these pipes are very sensitive to the slightest initial geometric imperfection or operation (accidental loads, temperatures, etc.) The taking into account various damages generally led to a loss of bearing capacity. In order to reserve the charge potential of these pipes, it is necessary to strengthen them. In this study we realized the strengthening steel pipes with metallic and composite materials in the presence of compressive stresses .One or more layers of composites are adhered to the discontinuity of pipe.

The analytical treatment for such type of problem is complex and hence we will resort to numerical modeling. The results show that the right orientation of the fibers relative to the advance of the crack influences a huge way on reducing the FIC. The properties of the membership must be optimized to increase the performance of the repair of part compared. FIC reduction becomes important when ea (thickness) decreases. Recently, the use of adhesives is accepted as a process of repair of structures to increase the lifetime of damaged components. Metal or composite parts are glued to a single face or both at once cracked for part for extending its lifetime service [1] Repairing cracks by bonding made of composite material patch has proved its effectiveness in reducing the stress intensity headers cracks, is to reduce speed of crack propagation. This method is employed to repair aging aircraft components. Numerous studies have been conducted to develop the technology of collage of composite patches in aeronautic structures. Alan Baker was one of if not the pioneering of this research at the laboratory of aeronautical and maritime search for the Royal Australian Air Force. [2] It is well known that the finite element method gives with high accuracy the stress intensity factors at the crack tip. Among the authors using the method of calculation of factor in the case of reinforced cracks may be mentioned [3]. A study was conducted on repairing a crack emanating notch lateral by a semi-circular patch semicircular composite [4].

The purpose of this study is to analyze the behavior of a reinforced steel pipe in a mode I and mode II by the finite element method crack. The patch identical to that of steel pipe is used in the repair of cracks. Different authors [5] have shown that in practice the parameters influencing the performance of the reparation are the properties of the patch and adhesive. To do this, the effects of shear modulus of the adhesive, the thickness of the adhesive and the thickness of the patch the variations the stress intensity factor are examined.

2. Geometric model

In this modeling, one considers a steel pipe having the following dimensions: length diameter thickness ep = 3mm A crack length located in the middle of the pipe perpendicular to the plane of stress is assumed. The pipe consideration is solicited diametrical compression in the vertical directorates as the applied stress amplitude As well as, mechanical and geometrical characteristics of the pipe and patch are respectively denoted by the indices p and r. The crack is repaired by a patch of metallic material, and composite patch is another laminated composite patch with four folds varying from 0 °, 30 °, 45 ° and 90 °, the purpose of that variation is to see which orientations is efficient dimension of the pipe is: The length L=50mm, and thickness of the patch er=1mm, material properties are: Er Young's modulus and ur Poisson's ratio The adhesive properties are: Ga shear modulus and thickness ea=0.127mm Given that the geometry of loading is symmetrical half structure is sufficient for the numerical study. Figure.1

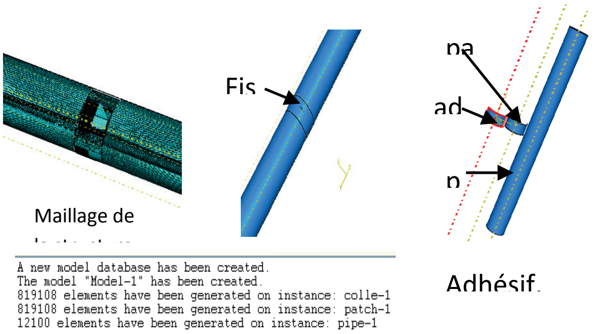

Figure.1. Geometric model and mesh pipe (pipe and patch)

The specification of pipe is done by applying the symmetric terminal conditions. One considers that the behavior of the crack is unstable. To repair the unstable aspects we use a patch and we tied on one side as on both sides of the pipe is practically impossible. The transfer of tensions and deformations of pipe to the patch is assumed that the displacements and tension at the interface of the pipe and patch are continuous.

3. Finite element modeling

We used a finite element code ABAQUS, based on the theory of linear mechanical failure and non-linear [4]. A three-dimensional finite element model where the development of mathematical models for this type of structure is usually very complex.

Table 1. Mechanical properties (pipe, patch and adhesive)

Propriétés	E1(GPA)	v12
Adhésive FM 73	1.0713	0.33
Pipe en Acier	210	0.3
Patch en aluminium	69	0.34
Patch en acier inoxydable	193	0.27
Patch cupro aluminium	117	0.33
Propriétés	Patch Glass/epoxy	
E_1(GPa)	150	
E_2(GPa)	25	
E_3(GPa)	25	
v12	0.21	
v13	0.21	
v23	0.21	
G_{12}(GPa)	7.2	
G_{13}(GPa)	5.5	
G_{23}(GPa)	5.5	

4. Influence of the thickness of the patch

The parameters of the rupture are influenced by the rigidity of the patch, the size of the attachment region and the toughness of the adhesive [3]. The material of the patch influences variation of the stress intensity factor immediately. To highlight the process of repairing a crack, we chose three patches identical geometric shapes having different mechanical properties. The work is to vary the location and shape of the crack repaired with varying thickness of the patch while maintaining the same mechanical characteristics of pipe and patch.

1st case Patch laminate composite. This study deals with the influence of the thickness of the patch on the broad parameters of the rupture. Figure.2 shown the effect of the thickness of the patch on the variation of the stress intensity of the crack for different orientations of of glass / epoxy which are 0 °,30°, 45 ° and 90 ° fibers factor. One can see that the increase in the thickness of the patch reduces the stress intensity of the crack asymptotically factor. The glass / epoxy orientations 0 °, 45 ° and 90 ° allow better stress transmitted by the crack absorption and tend towards a value of zero. The rate of reduction of the stress intensity factor depends on the thickness of the patch. However, we note that the thicknesses of the patch in glass / epoxy 1mm create a strong reduction in FIC and stabilization of the latter tends to a constant value.

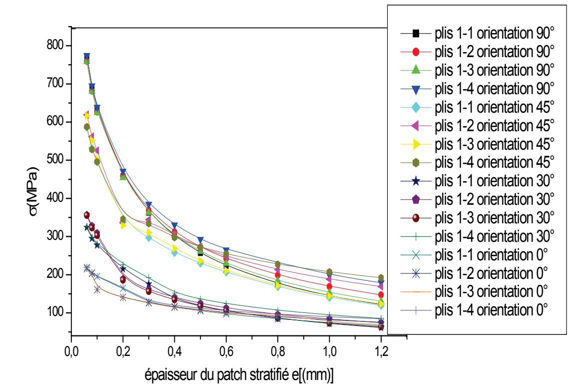

Figure 2. Influence of the thickness of the laminated patch on the max von mises stress

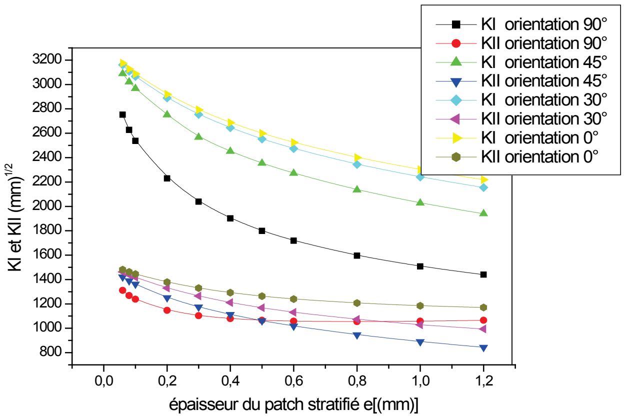

Figure 3. Influence of the thickness of the laminated patch on KI and KII constraint

2nd case Composite Patch

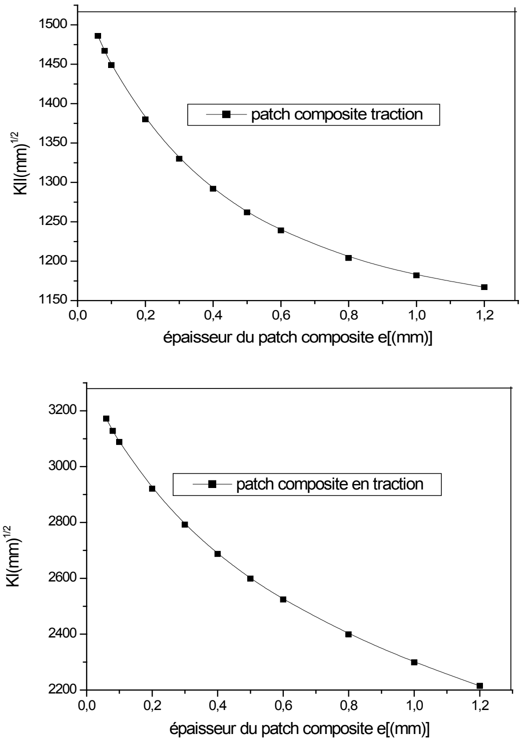

Figure.4. Influence of the thickness of the composite patch on the variation of the FIC

3 cases Patch steel

a) Stainless steel
b) Aluminum Steel
c) Copper-aluminum

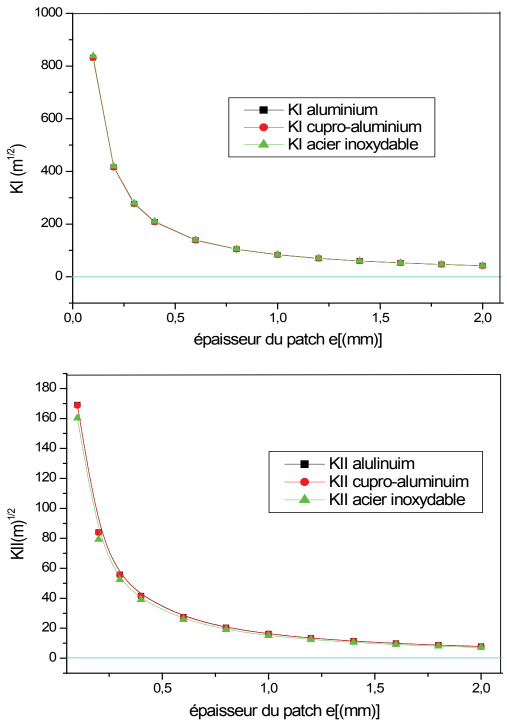

Figure 5. Influence of the thickness of the steelpatch the variation of the FIC.

For the case reinforcement patches steel, Figure 4 has taken three cases of figures whose Young's modulus and poisson are different, a material with respect to to another. It was found that the variation of the FIC is still inversely proportional to the thickness of the patch, the latter reduced to a value close FIC constant, and which tends towards zero. The main point which put out the two factors KI and KII is the reduction of FIC mode that I is very large compared to mode II, therefore whatever the nature of the patch increased FIC is always inversely proportional to the thickness of the patch.

5. Influence of the thickness of the adhesive

The effect of the thickness of the adhesive plays a decisive role in the balance of the reinforced patch cracks. In Fig. 5 the reduction of FIC we show in mode I and II depending on the crack length 2a = 30mm length, for different values of the thickness of the adhesive e_a We can see in this figure that a reduction the thickness of the adhesive decreases in a way like another, the value of the stress intensity factor this can mean a low thickness of the adhesive is desirable to repair cracks. The shape of the stress intensity factor linearly decreases with respect to the increase in the thickness of the adhesive. In other words, increasing the thickness of the adhesive results in the rapid convergence of the shape of the stress intensity factor tends to a nearly constant value.

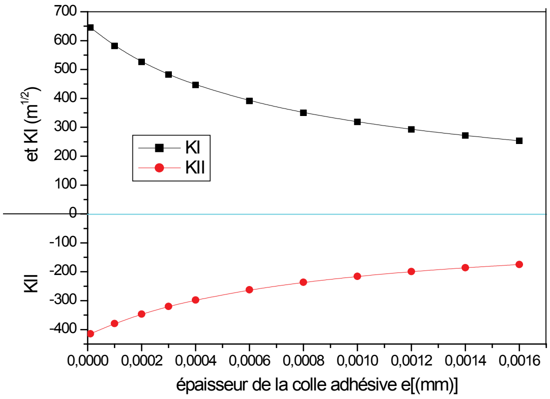

Figure 6. Influence of the thickness of the adhesive on the variation of the FIC

6. Influence of shear modulus of the adhesive Ga

Studies have mounted that the best quality adhesive is characterized by a low shear modulus; it reduces the effort transmitted to the adhesive. [6] In the case of cracks repaired, the goal is to transmit the maximum effort to the adhesive and consequently to the patch to reduce the energy at the forefront of the crack. Theoretically, it is therefore preferable of employing of adhesives possessing a high modulus of shear for the repair of cracks or defect. [7] Figure.6 shown the variation of the stress intensity depending on the variation of the shear modulus of the adhesive factor. One notices, that the decrease of the stress intensity factor is inversely proportional to the increase in the shear modulus of the adhesive, but the reduction of the stress intensity factor which is a function tends to be canceled Ga when increases indefinitely. In evidence an increase in the shear modulus of the adhesive reduces the adhesive stress, and consequently produces the detachment. For this, the choice of adhesive for the repair of cracks must be optimized to allow the transmission of forces to the patch and avoid failure of adhesion due to the increased efforts of tension in the adhesive layer [8].

7. Conclusion

The study of this paper is related to the maintenance and repair of pipelines. Numbers of questions were asked in this study and a few of them have been explored.

A reflection on this subject we bring him to develop and use a numerical calculation based on the Abaqus 6.10.1 software to optimize and see how certain parameters vary depending on the FIC.

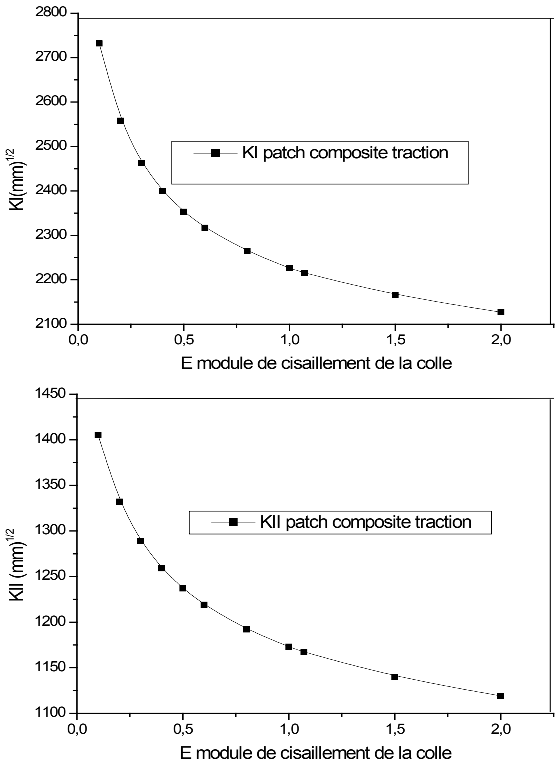

Figure 7. Variation the FIC depending on the shear modulus of the adhesive.

The study involves the repair or strengthening of pipes and damaged with cracks, undergoing a loading which is manifested by a flow of the fluid under pressure 100bar. For this we chose as the remedy (reinforcement) patches composite or metal.

The purpose of this study allowed us to see the variation of the FIC depending on certain parameters, the crack in mode I and II, as well as material properties.

For this purpose, we have presents the following findings:

- The main factors involved problem is to treat, and see the variations of the FIC with crack propagation are: the shearing modulus of the adhesive, the thickness of the adhesive and the thickness of the patch.
- The strengthening of pipes with composite or metal patches crack propagation delays.
- The presence of a patch greatly reduces the stress intensity factor which can delay the propagation of the crack and thereafter increasing the life of the structure.
- The stress intensity at the crack tip factor is inversely proportional to the increase of the rigidity of the patch and its geometric characteristics.
- The choice of the thickness of the patch is one of the best means of increasing the performance of the repair of structures.

- The thickness of the adhesive layer markedly reduces the FIC, so it is desirable to have a thin for the repair of cracks.
- The choice of the shear modulus of the adhesive layer is very important because he believes in strength, it greatly reduces the FIC.

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DEVELOPMENT OF THE SUPPORTING SYSTEM OF AUGMENTED REALITY IN OUTER SPACE FOR THE ENRICHMENT OF TOURIST ATTRACTIONS

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Abstract

The exponential growth of modern technology gives new opportunities to the media which use the potentials of modern technologies. This paper presents the realization of the augmented reality system and its application as a new media in tourism and a critical review of opportunities and benefits its application can bring. One of the great future visual design and communication media is augmented reality. AR technology itself is still considered to be in its infancy and thus, a medium in its conception. The use of augmented and virtual reality media is truly wide, from the application in architectural visualization, through education, tourism, design and art, entertainment industry, military industry and others.

Keywords:

Augmented reality, project Wonderland

1. Introduction

Augmented and virtual reality systems are becoming more relevant nowadays, and are the subject of many commercial and scientific works. The beginning of their development can be attributed to John Sutherland [1]. His famous 1968 prototype demonstrates the basic idea of such systems. However, it was not possible to develop a system that would be portable and applicable in the open space using the technology of that time.

Virtual and Augmented Reality (VAR) today finds its many applications and many companies are working on the hardware components of the system, such as Microsoft HoloLens, Oculus Rift and Google Glass [2].

Augmented Reality allows a user to feel a different perception of reality that surrounds him. In fact, it allows a user to visualize the contextual information of the real and virtual world directly from his point of view. One of the first forms of application of these systems may be the entertainment industry and the development of computer games [3]. The term computer games is today very often linked with the word "serious"., so virtual and augmented reality systems, and serious computer games are gaining important roles related to many areas: health [4], military applications and security [5], learning and teaching [6], [7], culture and tourism [8] - [11].

When mentioning the entertainment industry, where a virtual group of players that need to be overcome and defeated can be displayed in the open space, it is necessary to mention the project called "AR Quake" [12].

The key to the development of the virtual and augmented reality is the development of hardware components, and so its application in many other branches of human activity can be expected. One of these is the application in architecture where a user could, for example interactively edit his future home on an empty plot and immediately walk through it before any works have even started.

The military has been already using for a longer period of time virtual flight and tank simulators. The new technology may bring new elements by the extended reality where, for example, during the soldiers' training, three-dimensional objects, images and video that represent instructions or commands can be projected in real time and thus speed up and improve managing new situations and rehearse the procedures and methods of resolving the already familiar ones.

A large range of human activity is learning and education, where the engineers would, using the augmented reality, interactively observe and simulate new devices or machines. Computer programs allow artists to directly use the virtual reality in designing a model and observe it from any angle [13].

Advanced application of Augmented Reality would have the emergency and rescue services. Police officers can in real-time monitor the alerts projected on a three-dimensional map of the city and have a face-scanning that can quickly isolate the required individuals from large groups of people. ER officials can wear sensors which directly on the head display project the condition of the patient as well as the potential location and severity of injury. Firefighters with the integration of advanced sensors have an overview of the current composition of the air, if it contains any dangerous chemicals. Cameras that see outside the range of human vision can enable them to see through smoke and even walls, and can more easily locate the injured person.

One of the major fields of application can be communication between people [14], social networks where we can move through virtual "walls", or where a chat room is a virtual three-dimensional room through which we can walk and talk to every single person in that room.

Sensors for reconstruction and scanning of three-dimensional objects can be used for recording a person and make a real-time conversation as if he is really in front of us [15]. Augmented reality can also enable us to join a business meeting that takes place in a different city or country from the comfort of the office seeing everyone at the conference table.

It is necessary to highlight the enormous potential of VAR technology and note that there are many other applications yet to be discovered and explored. The aim of this paper is to demonstrate the efforts towards the realization of the supporting system of augmented reality in an open area for the enrichment of tourist attractions.

2. Related work

Examples of such applications of augmented reality financed by the EU are: Greek Parthenon and Pompeii [16]. In Pakistan, the digital reconstruction was created for the Buddhist historical sites [17].

Yuanmingyuan, known as the "Garden of Gardens", was built during the Qing Dynasty in 1707. Unfortunately, it was destroyed and burned by foreign forces in 1860 and only the ruins of large stone pillars are left. A group of scientists started the restoration of the park through the augmented reality. For the purposes of augmented reality they built a pair of binoculars that contains all the hardware needed for augmented reality. Looking through the binoculars at Yuanmingyuan, results in an image of the Yuanmingyuan preserved from the past [18].

The "VisitAR" project is a mobile application that uses the augmented reality to offer the customers a virtual tour guide. The application allows the users to have immersion sightseeing experience providing tourist information in a funny way. A user can plan his own sightseeing tour, by using the smartphone camera looking at the real map that shows 3D information. After choosing the route, the user can be well-guided through the city using the same application. And finally, when they arrive at their destination (attraction), the application allows them to access information from multiple sources such as images, videos, cultural information and other [19].

Imperial Palace in Nara, Japan, is located in the ancient capital of Nara. The palace itself and its monuments are registered on the UNESCO list of World Heritage Sites in Asia. A team of researchers created a telepresence by flying over the palace with an omnidirectional multi-camera system that was installed on the unmanned aircraft. The recorded video is adjusted in a way that the user can look through the CMS in any direction [20].

3. Augmented reality as a new media

Augmented reality technology is being more and more used for improving our perception and our ability to see, hear and feel the environment in new and enriched ways.

The evolution of society is closely connected with the development of communication, i.e. the evolution of media. One of the traditional media of graphic communication is graphic design. The exponential growth and development of computer hardware and software resulted in a shift of communication from printed to electronic, which entails the development of computer graphics. Three-dimensional computer graphics is a fundamental means of constructing a young technology of virtual and augmented reality. In recent years, the technology is characterized by accelerated growth that many scientists consider a potential form of a new medium. Proof of this is the widespread application of virtual and augmented reality for a variety of purposes.

In order to popularize the medium, it is necessary to create high quality content, which in this case is a three-dimensional computer graphics. The synergy of traditional graphic design with a virtual three-dimensional content can result in a new form of multimedia and a step forward in the development of communication.

The term medium as a communication element implies a communication tool or channel through which information is transmitted and thus achieves communication. Information is data that has a meaning for a recipient (target audience). Communication is the process of exchanging information using an agreed system of signs [21]. Design can be interpreted as a sort of a communication process, from which it can be concluded that design products are a form of a communication tool, or media. "Design is an interdisciplinary activity that combines social, humanistic and technical sciences with creative and artistic components" [22].

A famous statement by the Croatian and Bosnian graphic designer Mirko Ilić: "Good design can be done by looking into the past or looking to the future (AR) - It is important not to look at the side." can be paraphrased in favour of a new design technology, in this case, three-dimensional computer graphics and augmented reality. These well-trodden paths of communication through graphic design should look to the future and pave the way to new means of communication such as electronic-graphics and even further to virtual and augmented reality. Furthermore, the fact is that electronic media are becoming increasingly popular. This is due to their advantages, such as: easy access, easy search, faster exchange of ideas, the expansion of distance communication (dialogue), monitored attendance, lower costs, sound, extraction of pieces of information, easier communication and advertising, email, faster communication, easier archiving, freedom in design, interactivity.

Technology is woven into the modern way of life. Everyday activities are conducted in interaction with it. Advances in technology and hardware cause fundamental changes in this interaction.

The reality is the world around us, and virtual reality is virtual environments that are made up of objects and space created by a three-dimensional computer graphics in the form of models. So, first we have to make three-dimensional objects and spaces. Depending on the aim of achieving experience fidelity, creating complex three-dimensional computer graphics in the role of virtual reality is a complex process. The basis of three-dimensional computer graphics are three-dimensional models, but to make the experience more lifelike, the content must be "revived" by animation, enrich with special effects and, finally, make it interactive. Computer graphics is upgraded by a virtual and augmented reality technology, virtual persons, networked virtual environments and visualization. Use of virtual reality is spreading in different areas, such as games, television, design, virtual prototyping, training, simulation, visualization, communications, marketing and many others. Virtual reality technology is progressing rapidly and opens up many possibilities [23].

By combining virtual reality and the reality a new technology - augmented reality is created. According to Alan B. Craig *a*ugmented reality is a medium in which information is added to the physical world in registration with the world*.* [24]. D.W.F. Van Krevelen and R. Poelman, however, believe that the term "augmented reality" –usually abbreviated to AR (Augmented Reality) - refers to new technology that allows the merging of digital information that comes from the real world through the subtle computer interface in real time [25]. Augmented reality technology is applied in various branches from tourism, education, marketing, architecture, to medicine, military and other industries.

Augmented Reality is formed by integrating digital contents (images, sound, video, three-dimensional models, animation and others) with the real world, which expands and enriches the experience of reality. The most famous example of augmented reality are smart phones and tablets that detect and display additional information about the observed object. Although augmented reality is interactive, such augmented reality does not allow for complete immersion in the user experience. The next step in the development of technology is to create a system that makes it possible.

3. Augmented reality in tourism

The idea of application of augmented reality is to give the users walking around the vivid view through augmented reality. Museums often lack the ability to present their archaeological and cultural heritage in a realistic and interesting way. Through the augmented reality cultural sights can be displayed outside the museum. In the exhibition hall through augmented reality cultural sites can be added interactive content, which would allow museum visitors to interact with content in an intuitive and exciting way.

Archaeological museums generally represent items of cultural heritage from various remote sites. The excavations where they come from are perhaps far away or maybe do not even exist any longer. Through augmented reality the original sites may be displayed, with the 3D reconstruction of the historic data connected with the object itself [26].

Using augmented reality in city tours adds a new charm to the tour itself. When visiting a city, visitors can get information through augmented reality and 3D maps of the monuments and historical buildings of the city. A route can be planned, and when you come to certain buildings you can access additional contents such as videos, pictures, cultural information and more related to the building itself.

4. Process of 3D content creation for augmented reality systems

As previously mentioned, the reality makes the world around us, and virtual reality are virtual environments that are made up of objects and space created by the three-dimensional computer graphics in the form of models. As for virtual reality it is necessary to create three-dimensional objects and the environment. Creation of the complex three-dimensional computer graphics in the role of the virtual reality is a complex process. The basic material of the three-dimensional computer graphics is 3D models, created by the 3D modelling.

The process of developing a three-dimensional model can be summed up in a few steps: idea, references, planning and sketching, modelling, materials selection and texturing. Furthermore, a three-dimensional model which is modelled and textured, can be controlled by creating a rig, i.e. reinforcement and use it to "revive" by animation. With the development of computer hardware and software the selection of a number of different techniques and methods is enabled in order to optimize efficiency. You can select a classic 3D modelling, procedural 3D modelling or 3D scanning, which is enabled by a specialized technology. Focusing on the classic techniques of 3D modelling, there are several ways of making a 3D model: using polygons, curves, or a hybrid of the two of these techniques called a subdivision modelling. Note that these techniques do not affect the quality of the final product, but can affect the amount of time spent for creating 3D models. Behind these techniques is a multitude of algorithms that allow the creation and manipulation of the basic primitives and their development up to the complex geometric bodies [27].

The result of modelling an object is a 3D model that has no colour, texture and is impersonal. In order to give colour and property to the model, it needs to be textured and thus make it virtually materialized or revived. Texturing can be implemented in many different ways depending on the needs and possibilities.

If you need to create a high-quality textured model with specific characteristics photo editing programs such as Adobe Photoshop must be used. Texture folders, known as UV maps work on the principle of UV points that allow precise setting and adjusting of textures on the model, which results in reality and specificity of 3D models. The foundation of a texture map of a model is materials on the model. Different materials offer a wide range of variable attributes such as colour, transparency, reflectivity, which give properties to a model [28].

The final version of the model is not necessarily static, it can be animated, if it is a creature or an object that moves. The process starts with the creation of the animation rig, or skeleton. The bones or joints are the basic building elements of the skeleton, related hierarchically to each other. Joints are determined by the interaction of virtual tendons, i.e. IC manipulators that allow easy and accurate positioning of the bones [29]. After creating the skeleton, determining dependency and limiting the movements of bones, the model is ready for animation.

5. 3D contents in the augmented reality system

Augmented reality can be interpreted as a means of communication or a new medium. Each medium has a message that is transmitted in some form of content. Given that this is augmented reality its main content is a three-dimensional computer graphics. Furthermore, a major component of the three-dimensional computer graphics is 3D models. A concrete example of creating contents for augmented reality is linked to the Croatian project "Project Wonderland". The main objective of the Project Wonderland is the implementation of a working prototype of a supporting augmented reality system for open space. The final product of the project will be an integrated system that will consist of a VR helmet upgraded with the equipment for precise positioning and further positioning and / or determining the rotation of sensors. This system will enable the user a view enriched with computer-generated virtual three-dimensional objects placed in the user's environment, fixed in space related to the movement of the user's head [30].

Creating the content that will be displayed in real time to the user for the said project is quite a complex process if it is to achieve a better experience and immersion in the content. In the previous chapter, the process of creating the content that can be divided into three main parts: (i) 3D modelling, (ii) texturing and (iii) preparation for the amination or development of the skeleton was explained.

The result of modelling is a 3D model that does not have characteristics, therefore there is no colour, texture or other attributes, as shown in Figure 1.

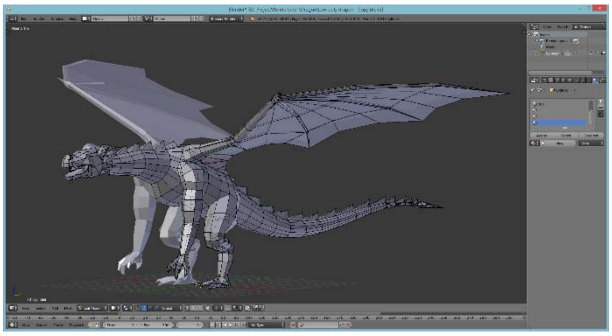

Figure 1. 3D model without textures

After the modelling is completed follows the process of texturing, or adding features and attributes and editing the materials and textures, as shown in Figure 2.

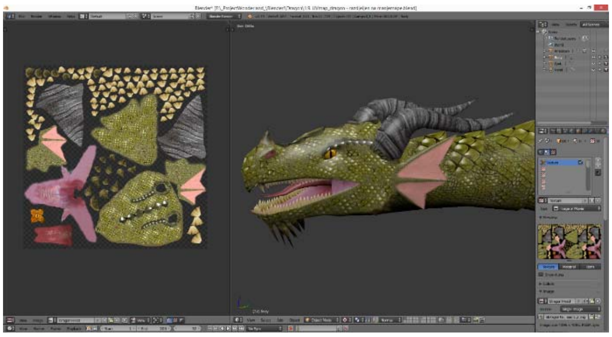

Figure 2. 3D model with textures

After texturing, if it is a moving object, it is necessary to create a skeleton that will manage the 3D model, set to pose for animation, as shown in Figure 3.

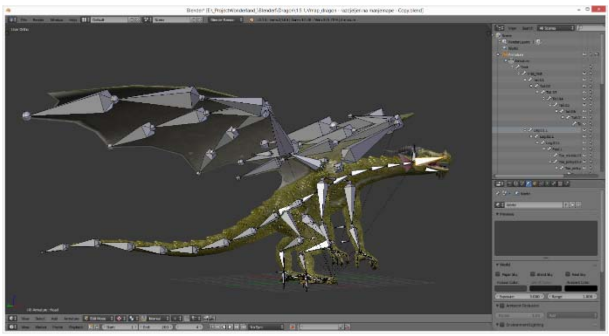

Figure 3. Animation skeleton

Such content can enrich the tourist offer. With the graphic design products, brochures, posters, books with historical legends and many other contents, augmented reality allows the resuscitation of something that is difficult to display or reconstruct in the real world. For example, it is possible to revive the legend, an event in history or reconstruct the missing objects and items.

6. Project Wonderland

An example of the application of augmented reality is a project called "Project Wonderland" headed by the Polytechnic of Međimurje in Čakovec. This project is co-financed by the European Union under the European Regional Development Fund [30].

The project aims to implement a functional prototype of a wearable augmented reality in outer space. The project is realised in collaboration with the Museum of Međimurje Čakovec, and the first demonstration of application will be in the field of tourism. The plan is to extend and enhance the experience of visiting the old town of Čakovec (fort Zrinski).

The result of the project will be an integrated system that will consist of a VR helmet (HMD) upgraded with devices for precise positioning. These devices will allow three translational and rotational freedoms of movement in space. This allows the extension of the user's view with the three-dimensional computer-generated graphics, which is situated in the real space relatively on the holder of HMD, as shown in Figure 4.

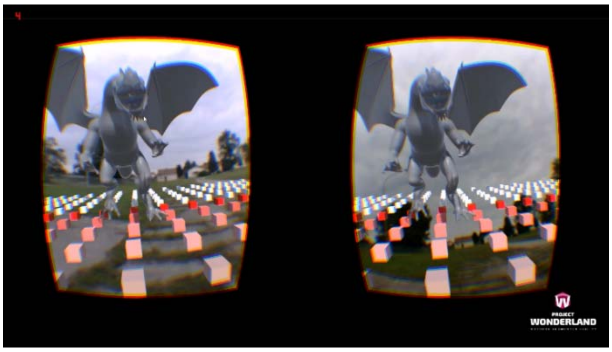

Figure 4. View through HMD for left and right eye made with early prototype

VR helmet has sensors for precise orientation and antennas for precise positioning in space, in addition to carrying the cameras recording the area in front of the user and "act out" the user's eyes. All this is integrated through a powerful computer that the user wears on his back, which allows free movement in the area without being bound by cables to a base / place.

7. Conclusion

The technologies of virtual and augmented reality have only in the last few years become widely available to end users. Due to the wide availability and lower prices such technology becomes more popular and thus begins the exploration of the possibilities and limits of virtual and augmented reality. There are ambiguous views about good and bad connotations that this technology brings, but its integration in almost all aspects of society is not questionable.

Its increasing popularity shows that people give a chance to the new technology and new concept of consuming digital media, such as for example we see in the game and film industry. Virtual and augmented reality gives us something that was previously unthinkable and unattainable, and that is connection of the virtual and real world. In such a way we get a new dimension of perception and capabilities.

We live in a world where the number of information is rapidly increasing and this way we can improve the interaction with them in a quick, fun and exciting way.

The exponential growth in the development and use of technologies of virtual and augmented reality, we will see new capabilities that were not possible until now and will directly affect the progress of human society and the evolution of the media.

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DETERMINATION OF IMPACT ENERGY BY DYNAMIC EFFECT OF FORCE ON THE COMPOSITE RUBBER BANDS

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Abstract

The conveyor belt is basic, most expensive and least durable element of conveyor with a rubber band which is used for transport of scatter material. Charpy impact toughness of the conveyor belt was tested in longitudinal and transverse direction. Tests were performed on instrumented Charpy pendulum, where total impact energy was spitted into energy for initiation and energy for propagation. From the results we can conclude that total impact energy in longitudinal direction is better than transverse direction, because of the core structure of the conveyer belt.

Keywords: Conveyor belt, Charpy toughness

1. Introduction

The conveyor belt is basic, most expensive and least durable element of conveyor with a rubber band, its price makes up a significant share of investment (25÷35%) of the total cost of conveyor. High depreciation rate of conveyor belt is an important factor in determination of the field of application and economics of belt conveyors. Proper calculation and selection of the structure and characteristics of the conveyor belt and appropriate conditions of exploitation have major influence on the extension of conveyor belt lifetime. [1,2]

Selection of other construction elements of the transporter (rollers, drums, etc.) needs to be appropriate for conveyor belt in order to achieve the abovementioned effects. [1]. Depending on the conditions of conveyor exploitation band must meet the following characteristics: sufficient strength in stretching and bending, small elastic and other elongations under workload, antistatic properties, fire resistance, high resistance to fatigue and abrasive wear, layering and breach (for coarse-grained material), extended resiliency in order to avoid excessive extension of drums, and as low as possible degree of aging and weakening due to mechanical and atmospheric effects. [2].

Due to its significance and price, proper selection and dimensioning significantly influences the service life of rubber bands and reliability of the production system, and thus the investment and exploitation costs. Selection of other construction elements of transporter (rollers, drums, etc.) has to be appropriate depending on selection of conveyor belt in order to achieve the abovementioned effects.

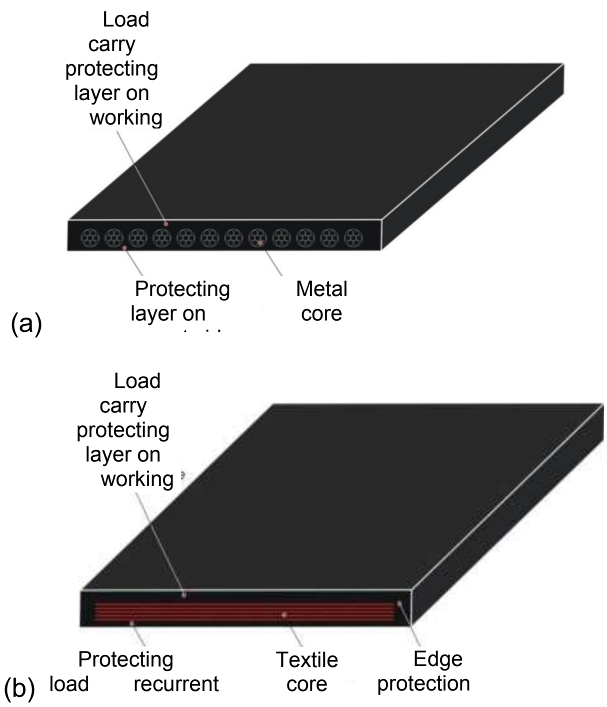

Figure 1. Structure of the of the belt conveyor with textile core (a), with metal wire core (b)

2. Determination of impact energy by dynamic effect of force

Toughness is one of the most important properties of metals and alloys based on the dynamic effect of force. Toughness entails the ability of a material to resist the effects of shock. If the fracture of sample by dynamic impact consumes more work than the material is considered tougher. Materials with low toughness are usually hard and brittle. Toughness and tensile strength are quite different in their correlation so various materials with same tensile strength have different values of toughness.

Materials that have higher values of tensile strength and lower contraction, as a rule, have a lower toughness. However, high values of contraction do not always correspond with increased toughness. Impact test of metals and alloys is applied after almost all variations of material processing.

Most often used method to determine the impact energy by dynamic action of a force or impact toughness testing is Charpy method, Fig. 2. This method is defined by ASTM E23 standard and JUS EN 10045-1 standard.

Testing is done by impact on a test specimen with a U or V notch, Fig. 3. Test specimen is a piece of rod with square cross section made of the tested material. Dimensions of test specimen are length 55 mm, height 10 mm, and width 10 mm. Center of longitudinal side is marked by the notch. The notch is made by milling. Processing of test specimen and marking should not change condition of material. Base of the notch should not have visible traces of processing.

The test specimen with the notch in the middle is placed on two supports. Testing is done by breaking using pendulum, which at its end has a weight in the form of a blade.

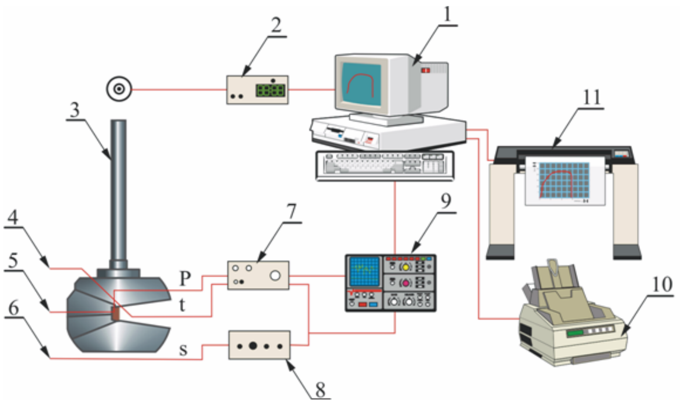

Figure 2.Scheme of instrumented Charpy pendulum

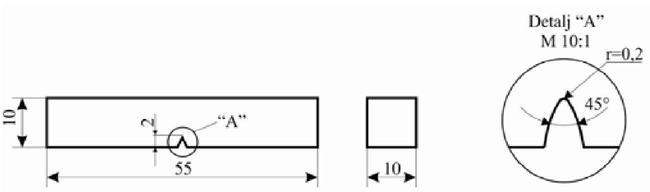

Figure 3.Test specimen for Charpy impact test

The test consists of breaking the specimen with one stroke of the pendulum, where the impact is performed in the direction of notch, but from the opposite side. Consumed energy is measured as the difference of potential energy of the pendulum in the working position and potential energy after breaking the specimen. This is, in fact the work needed for the breaking of the sample or the impact strength of a given sample [3].

Impact energy allows differentiation of different materials in terms of their toughness and their fracture characteristics. Classic method of testing impact energy or impact strength is given by:

$$KV = \int_0^s F \cdot ds \tag{1}$$

This value depends on the test temperature and it provides a comparative value on brittle fracture. The empirical behavior of values of impact energy or transitional temperatures on the temperature of brittle fracture, for the same material with static load of structures is not possible without proper testing of the structure.

Instrumented testing using Charpy pendulum provides additional information on the behavior of material, as well as on the mechanism of breaking.

3. Force-time diagram and determination of impact energy

Determining of impact energy on instrumented pendulum with an oscilloscope for monitoring of the changes of force versus time (i.e. recording of force - time curve), see Figure 4.

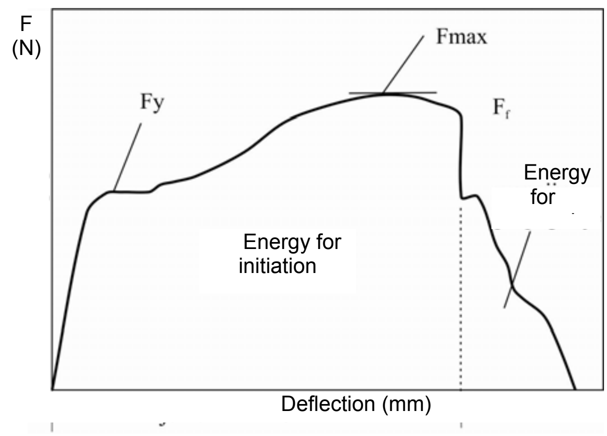

Figure 4. Diagram of force-time obtained on instrumented Charpy pendulum

4. Analysis of components of total impact energy

Overall assessment of the behavior of materials requires data on which part of the energy required for fracture is spent for crack initiation, and which part on the crack propagation.

Distribution of the total energy of the impact, i.e. total work A on the energy for crack initiation A_I and the energy for crack propagation A_p is carried out by various methods.

5. Determination of energy for initiation and energy for propagation of the crack

Determination of crack initiation energy A_I and crack propagation energy A_p is done on one sample (unlike other methods), which provides increased accuracy.

Figure 5 provides a diagram of the force - time with marked surfaces S_l and S_p which are proportional to the energy of crack initiation and crack propagation energy [4,5,6].

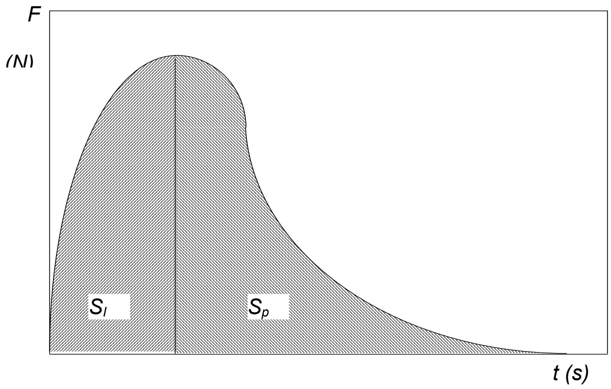

Figure 6. Diagram F (t) with the indicated areas S_l and S_p which are proportionate with energies A_l and A_p

Determination of the initiation and propagation energy of the crack according to this method is carried out on one sample (unlike other methods), which provides greater accuracy. The diagram force - time, Figure 6, shows surfaces A_l and A_p, which are proportional to the energies of initiation and propagation of crack.

6. Experimental procedure and results

Tests were performed at room temperature, at 150 J instrumented pendulum Charpy type, Fig. 7.

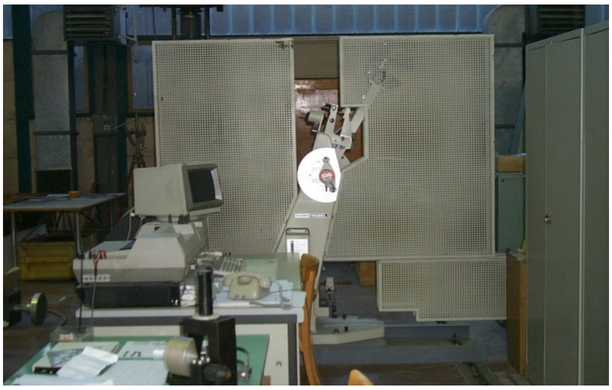

Figure 7.Instrumented SchenckTrebel Charpy pendulum

Six Charpy specimens were tested from conveyor belt in longitudinal and in transverse direction. Designation of the specimens and their direction are shown in Table 1.

Table 1. Direction of the specimen from conveyor belt

Specimen mark	Direction of the specimen
NŠU - 1	Longitudinal direction of conveyor belt
NŠU - 2	
NŠU - 3	
NŠP - 1	Transverse direction of conveyor belt
NŠP - 2	
NŠP - 3	

Testing on instrumented pendulum with oscilloscope obtained force - time and energy - time diagrams, which enabled analysis of the test results, primarily evaluating the impact of composition on the total impact energy and its components, energy of crack initiation A_I and energy of crack propagation A_P.

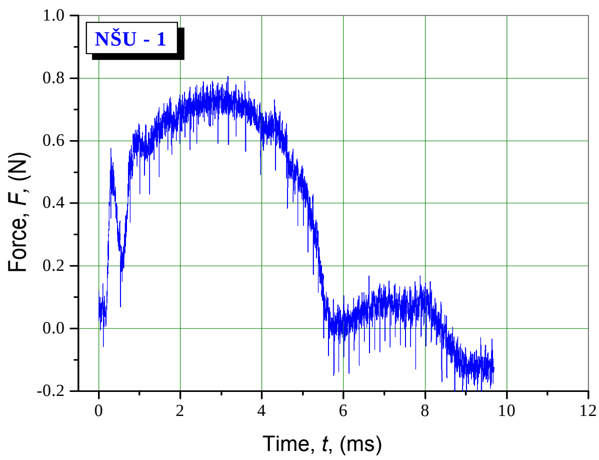

Figure 8. Force versus time diagram for specimen NŠU-1

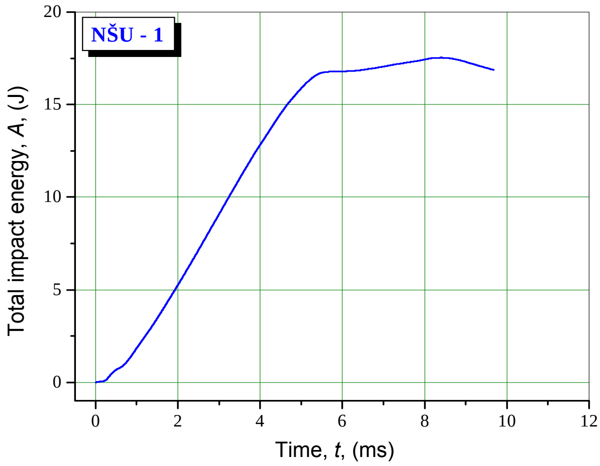

Figure 9.Total impact energy versus time diagram for specimen NŠU-1

Typical diagrams for tested composites are given in Figures 8 and 9 for NŠU-1 specimen and in Figures 10 and 12 for NŠP-1 specimen.

Measured values of the impact energy on test tubes made of rubber as the matrix and polyester-polyamide fabric as reinforcement are given in Table 2 for a new band.

Table 2. Results of impact tests of specimens sampled in longitudinal direction

Specimen mark	Total impact energy A, (J)	Energy of crack initiationA_I, (J)	Energy of crack propagation A_P, (J)
NŠU - 1	17.6	8.8	8.8
NŠU - 2	16.5	8.7	7.8
NŠU - 3	16.0	8.7	7.3

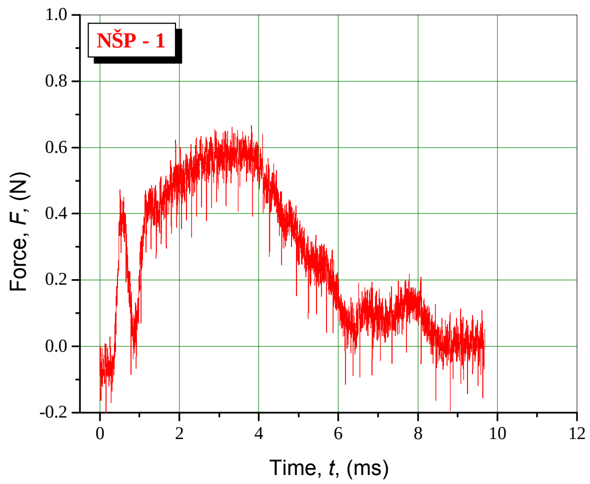

Figure 10. Force versus time diagram for specimen NŠP-1

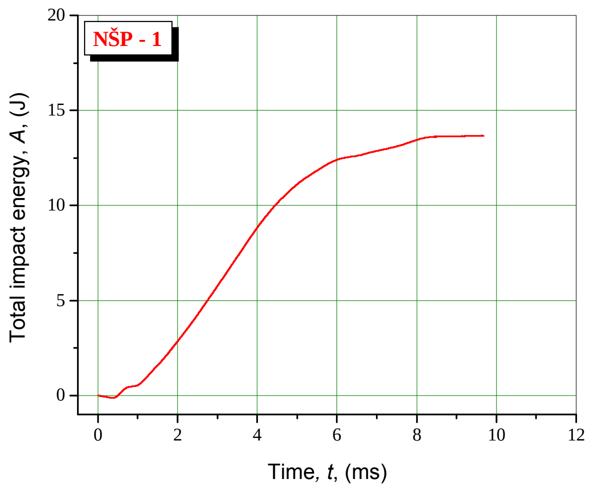

Figure 11.Total impact energy versus time diagram for specimen NŠP-1

Table 3. Results of impact tests of specimens sampled in transverse direction

Specimen mark	Total impact energy A, (J)	Energy of crack initiation A_I, (J)	Energy of crack propagation A_P, (J)
NŠP - 1	13.7	7.1	6.6
NŠP - 2	11.4	6.8	4.6
NŠP - 3	11.5	6.8	4.7

7.Conclusion

Total impact energy of the tested composites poorly depends on the composition. Obtained values of total impact energy range from 11.1 to 12.2 J for transverse test specimen composites and 14.1 to 17.6 J for longitudinal specimens of the composite, which is consistent with literature data and previous tests [7].

Test specimens from the conveyor belt in a transverse direction require more energy for crack initiation and less energy for crack propagation.

8. Acknowledgement

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WAYS OF RECEIVING INFORMATION IN THE LOCAL ACTION GROUP (LAG) TERRITORY

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Abstract

The present research is based on a survey of residents living in the territory of the association "Partnership of Rezekne District Communities" and on the authors' research "Assessment of the Introduction of the Rural Development Programme 2007-2013 Activity "Local Development Strategy" by the Partnership of Rezekne District Communities and Proposals for its Further Development" [2]. The research object is the residents living in the territory of one of Latvia's local action groups (LAG) – the association "Partnership of Rezekne District Communities".

The research aim is to identify the preferred ways of receiving information based on the survey of residents living in the LAG's territory.

The research employed the monographic and descriptive methods as well as analysis and synthesis, data grouping, a sociological research method – a survey – and statistical analysis.

The research results showed that the most preferred ways of receiving information by residents in the LAG's territory were personal contacts, in-person gatherings (meetings, seminars, experience exchange workshops, etc.) and local municipality or government newspapers.

Keywords:

Local action group, residents, ways of receiving information

1. Introduction

As an information society develops in Latvia, an urgent problem is the distribution of public information and its kinds. In an information society, knowledge is a crucial factor of growth and successful competitiveness for every region's residents.

The development of an information society is one of the requirements set by the European Union (EU) and one of the sixth horizontal priorities to be considered in order to successfully absorb EU funds [6].

The term information society reflects the increasing management, systematisation and distribution of knowledge in society, including in this term understanding, comprehension, experience, qualification, competence, know-how, abilities and wisdom. The formation of an information society results in a highly developed community of individuals and a knowledge-based economy that contributes to an increase in the standard of living of every individual and the whole society. With information and communication technologies developing, information and knowledge are exploited at work and in labour relationships, in studies as well as in everyday life [7].

Research studies done by such researchers as Cameron, Wilcox, Reber, Shin (Cameron, Wilcox et al., 2008) [4], (Wilcox et al., 2006) [13], White, Vanc, Stafford (White et al., 2008) [12], Thill, Bovee (Thill et al., 2008) [10], Toth (Toth, 2007) [11] and others have significantly contributed to the field of information and communication.

As technological possibilities developed, the way of receiving information modified and become fragmented. Earlier a phone, mail, a written message, etc. served as a kind of information and a way of receiving information, whereas nowadays communication involves sending messages by means of technologically advanced social tools and networks [9].

The exchange of information in the LAG's territory makes its residents be aware of pressing local problems to be tackled and resources and opportunities to be used to enhance their place of residence.

The research object is the residents living in the territory of one of Latvia's local action groups (LAG) – the association "Partnership of Rezekne District Communities" –, while the research subject is the preferred ways of receiving information in the territory of the association "Partnership of Rezekne District Communities".

The hypothesis is as follows: social network websites are the most preferred way of receiving information for the residents living in the LAG's territory.

The research aim is to identify the preferred ways of receiving information based on the survey of residents living in the LAG's territory.

The research employed the monographic and descriptive methods as well as analysis and synthesis to examine problem elements and identify associations or to define causal relationships. Logical construction was used to identify the most essential features of the research object based on individual facts and to make general findings.

In the paper, the practical research process is based on a survey conducted earlier. The survey results were analysed using statistical analysis methods.

The authors applied the analysis tools of Statistical Package for the Social Sciences and Microsoft Excel to identify the preferred ways of receiving information in the LAG's territory. A questionnaire data analysis employed the following characteristics:

- respondent's age;
- respondent's gender;
- respondent's education;
- respondent's occupation.

The present research is based on the survey of residents living in the territory of the association "Partnership of Rezekne District Communities" and on the authors' research "Assessment of the Introduction of the Rural Development Programme 2007-2013 Activity "Local Development Strategy" by the Partnership of Rezekne District Communities and Proposals for its Further Development".

2. Results and Discussion

To identify the preferred ways of receiving information, the authors performed an analysis of the results of the survey of residents living in the territory of the association "Partnership of Rezekne District Communities".

The association "Partnership of Rezekne District Communities" was registered in January 2008. The association is one of the largest LAGs in Latvia, whose territory is 2811 km^2 with 36.3 thou residents.

The territory of the association "Partnership of Rezekne District Communities" includes:

- Rezekne municipality: 25 rural territories (an area of 2524 km2 with 29 772 residents);
- Vilani municipality: a town and 3 rural territories (an area of 287 km^2 with 6496 residents).

Rezekne municipality borders on Vilani municipality. The municipalities of Rezekne and Vilani are located in the very centre of Latgale region, approximately 250 km from the capital city of Riga. The municipalities of Rezekne and Vilani lie near the eastern border of Latvia and of the entire European Union with Russia and Belarus [3].

The survey involved the residents of the territory of the association "Partnership of Rezekne District Communities" from all 29 territorial units or rural territories/towns. At least 20 questionnaires were received back from each rural territory/town. Totally, 634 valid questionnaires were available for analysis. The method of selection of a sample population for the survey was random sampling. The survey was conducted in the period 5-28 May 2015.

Ticking their most preferred way of receiving information, the respondents made at least 1-3 replies in their questionnaires.

When identifying the most preferred ways of receiving information in the territory of the association "Partnership of Rezekne District Communities", one of the factors to be taken into account was age groups of the residents.

According to the survey results, the most often preferred way of receiving information was local municipality or government newspapers. If broken down by age group, this way was also ticked most often, particularly in the group of age from 41 to 71 and older. The average age of the surveyed residents was 47 years.

Among those aged 30-40, 60 ticked the option that they preferred receiving information on topicalities in-person gatherings (meetings, seminars, experience exchange workshops, etc.).

In contrast, among those aged 41-50, 64 put a tick beside the option that they preferred receiving information through personal contacts (Table 1).

*Table 1. Distribution of residents' replies regarding the ways of receiving information by age group [1, 8] **

Age group		Under 18	19-29	30-40	41-50	51-60	61-70	Above 71
Personal contacts	%	1.6	12.1	19.5	33.7	26.3	6.3	0.5
	count	3	23	37	64	50	12	1
In-person gatherings (meetings, etc.)	%	0.9	12	27.6	23.5	27.6	5.5	2.8
	count	2	26	60	51	60	12	6
Local municipality, government newspapers	%	0	8.5	12.9	31.7	32.1	10.7	4
	count	0	19	29	71	72	24	9
E-mail	%	1.2	17.3	23.2	32.7	22	3	0.6
	count	2	29	39	55	37	5	1
Phone	%	3	12.9	11.9	31.7	29.7	5	5.9
	count	3	13	12	32	30	5	6
Visual aids (brochures, etc.)	%	0	13.8	26.2	33.8	21.5	3.1	1.5
	count	0	9	17	22	14	2	1
Social networks	%	3.3	20.3	20.3	24.4	23.6	5.7	2.4
	count	4	25	25	30	29	7	3
Other	%	0	0	50	25	12.5	12.5	0
	count	0	0	4	2	1	1	0

* Respondents (n=634) made at least 1-3 replies

However, among those aged 19-29, 29 indicated that they would wish to receive information via e-mail. Only 4 surveyed residents aged under 18 indicated they preferred receiving information via social networks: facebook; twitter; draugiem.lv etc. Billboards, mail and websites were indicated as other ways of receiving information in the questionnaires.

Of the female respondents, 183 indicated they preferred to acquire information from local municipality or government newspapers, while male respondents (52) preferred personal contacts. The next most preferred way of receiving information by both genders was in-person gatherings (meetings, seminars, experience exchange workshops, etc.): for 40 men and 177 women (Table 2).

*Table 2 Distribution of residents' replies regarding the ways of receiving information by gender [1, 8] **

Gender	Men	Women	Total
Personal contacts	52	138	190
In-person gatherings (meetings, etc.)	40	177	217
Local municipality, government newspapers	41	183	224
E-mail	35	133	168
Phone	35	66	101
Visual aids (brochures, etc.)	17	48	65
Social networks	31	93	124
Other	2	6	8

* Respondents (n=634) made at least 1-3 replies

The education level plays an essential role in choosing the way of receiving information. As shown in Table 3, most of the residents wishing to improve their knowledge had higher education.

Table 3 Distribution of residents' replies regarding the ways of receiving information by education level [1, 8]

Education level	Primary	Secondary	Secondary professional	Higher	Other	Total
Personal contacts	10	41	68	66	5	190
In-person gatherings (meetings, etc.)	3	27	79	104	4	217
Local municipality, government newspapers	12	46	76	89	1	224
E-mail	2	37	60	67	2	168
Phone	9	20	48	24	0	101
Visual aids (brochures...)	2	4	25	34	0	65
Social networks	5	21	49	47	2	124
Other	0	2	3	3	0	8

* Respondents (n=634) made at least 1-3 replies

Table 3 shows that the residents with primary and secondary education (12 and 46, respectively) preferred receiving information from their local municipality or government newspapers.

However, those with secondary professional and higher education (79 and 104, respectively) preferred in-person gatherings (meetings, seminars, experience exchange workshops, etc.).

The survey revealed whether the residents' occupations influenced their way of receiving information.

The data of Table 4 lead to a conclusion that it was important for self-employed individuals who did not employ others to have in-person gatherings and personal contacts.

In contrast, housekeepers, employers and paid employees preferred receiving information from their local municipality or government newspapers.

The analysis of the survey data revealed that the following ways were chosen most: local municipality or government newspapers, personal contacts and in-person gatherings (meetings, seminars, experience exchange workshops, etc.).

Table 4 Distribution of residents' replies regarding the ways of receiving information by occupation [1, 8]

Status	Paid employee	Employer (owner) or a self-employed individual employing others	Housekeeper	Self-employed individual employing others	Other	Total
Personal contacts	118	5	26	18	23	190
In-person gatherings (meetings, etc.)	155	9	23	18	12	217
Local municipality, government newspapers	161	9	28	9	17	224
E-mail	125	5	17	15	6	168
Phone	59	1	21	5	15	101
Visual aids (brochures, etc.)	49	2	6	5	3	65
Social networks	89	2	14	6	13	124
Other	4	1	0	1	2	8

* Respondents (n=634) made at least 1-3 replies

In any analysis of survey results by using statistical analysis, one of the most important indicators is the average. The arithmetic mean is the sum of all numerical values divided by the total number of values [5].

$$\bar{x} = \frac{\sum x_i}{n} \tag{1}$$

where

x_i – numerical value,

n – total number of numerical values.

According to Table 5: the reply „local municipality or government newspapers" has a mean of $\bar{x} = 3.0$, „in-person gatherings" has $\bar{x} = 2.0$, while „personal contacts" - $\bar{x} = 1.0$.

The variance of numerical values may be characterised by their variance around the arithmetic mean, which is some kind of gravity centre for the sample. The variance may be calculated as the deviation from the central value: $x_i - \bar{x}$.

As shown in Table 5, the standard deviation is 0.000, and it means that the values are not dispersed around the arithmetic mean.

The median and the mode may be in various positions in the data set, depending on the specifics of variance of a variable. Therefore the indicator to be used has to be specified when indicating the research methods [5].

The statistical analysis results for the survey of residents show that the respondents chose their local municipality or government newspapers as the most important way of receiving information.

The mode (M_0) and the median (M_e) were 3.00, as well as the average sum was equal to 3. However, as the second most important way, the respondents preferred in-person gatherings (meetings, seminars, experience exchange workshops, etc.) – M_o, M_e and the mean were 2.00. The third most important way represented personal contacts with M_o, M_e and the mean being equal to 1.00.

Table 5. Statistical analysis results for the survey of residents [5]

Indicators	Personal contacts	In-person gatherings (meetings, etc.)	Local municipality, government newspapers	E-mail	Phone	Visual aids (brochures, etc.)	Social networks	Other
Number of replies	190	217	224	168	101	65	124	8
Mean	1.00	2.00	3.00	3.99	5.00	6.00	7.00	8.00
Std. Error of Mean	.000	.000	.000	.006	.000	.000	.000	.000
Median	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00
Mode	1	2	3	4	5	6	7	8
Std. Dev.	.000	.000	.000	.077	.000	.000	.000	.000
Var.	.000	.000	.000	.006	.000	.000	.000	.000
Min.	1	2	3	3	5	6	7	8
Max.	1	2	3	4	5	6	7	8

The variance for local municipality or government newspapers, in-person gatherings (meetings, seminars, experience exchange workshops, etc.) and personal contacts was 0. The smaller the variance of a factor, the more unanimous the ratings of it.

The representation or standard error is calculated for every kind of average and variance. It shows imprecision arising from the generalisation of the sample to the target population. It is calculated by the formula [5].

$$S_{\bar{x}} = \frac{S}{\sqrt{n}} \qquad (2)$$

where S is the standard error, n the number of numerical values. The variance is the square root of the standard deviation [5]. The calculations showed that the standard error for all the three replies was 0.000, meaning the data were representative.

3. Conclusion

The survey data analysis showed that older residents most often chose their local municipality or government newspapers as the preferred way of receiving information.

However, according to the survey, women preferred local municipality or government newspapers to receive information, whereas men needed mostly personal contacts.

The surveyed residents with primary and secondary education mainly preferred to receive information from their local municipality or government newspapers. In contrast, those with secondary professional and higher education preferred in-person gatherings (meetings, seminars, experience exchange workshops, etc.) that initiated discussions, enhanced their knowledge and contributed to the exchange of their opinions on their experience.

The hypothesis did not prove to be true, as the majority of residents surveyed in the LAG's territory preferred such ways of receiving information as personal contacts, in-person gatherings and local municipality or government newspapers.

Given the problems of population ageing and retirement age, the local organisations and enterprises operating in the LAG's territory have to employ the kinds of information and communication with the public that take into account the public's wishes, regularly conducting surveys concerning the ways of receiving information.

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TEHD CONTACT MODELLING WITH SHELL LIKE LUBRICANT FILM ELEMENT BY FEM

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Abstract

Although several methods have been already developed for solving thermo elasto-hydrodynamic (TEHD) problems, the solution of the highly nonlinear problem is still quite challenging. So the development of a P-version FEM model for calculating the film shape, the pressure and temperature distribution and its implementation to commercial software seems to be timely to study the sliding-rolling materials during operation. Since the general 3D flow problem can be reduced to a quasi 2D case based on the hydrodynamic lubrication theory developed by Reynolds, special lubricant film element can be developed for finite-element modelling of such problems.

Keywords:

TEHD, lubrication, cavitation, FEM, Lubricant film element

1. Introduction

The generalized case of surface pairs contacting along a spot in the status of liquid friction is illustrated in *Figure 1*. The gap between the bodies is filled with lubricant due to the relative motion of the bodies and hydrodynamic pressure develops due to the movement of the lubricant. The movement of the lubricant is caused by the tangential (shear) stress generated in the lubricant as the result of the relative motion of the surfaces. At the particular kinematic condition of the contacting bodies and with a given gap geometry, the pressure distribution acting on the surfaces is able to maintain balance with the force pressing the surfaces to each other and prevent a direct body-to-body contact thereby.

In a given case, however, the local or global temperature rise caused by the heat dissipation generated by the pressure distribution acting on the surfaces and the tangential stresses developing in the lubricant, respectively, influencing the lubricant properties. It can be seen, therefore, that if the circumstances of contact developing under thermal elasto-hydrodynamic conditions of lubrication are wished to be modelled than hydrodynamic, thermodynamic and strength problems – forming highly non-linear systems even by themselves but also because of the status-dependence of the properties of the various continuums – have to be solved at the same time and in combination. However, these three main areas may be separated clearly from each other in respect of their basic equations.

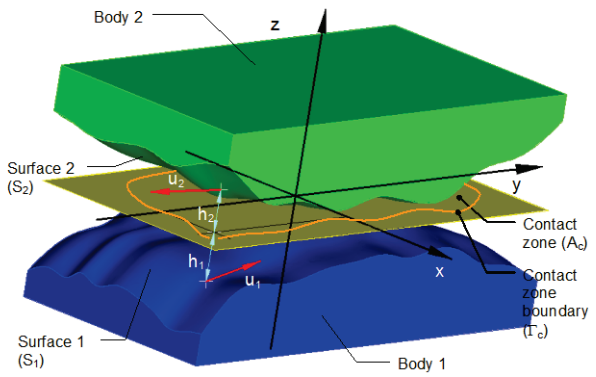

Figure 1. Contacting bodies

Since Osborne Reynolds (1886), who approached the lubricating phenomenon analytically, presented the theory of hydro-dynamic lubrication and the governing partial differential equation for the pressure field, many complex problems in fluid-film lubrication have been studied. Lubrication analysts began looking into the finite element formulation in the sixties and it was found as a promising and reliable method.

2. Dimensionless gap coordinate

For the contact problem of lubrication theory – due to its nature – it is convenient to employ in general a Descartes coordinate system with axis z perpendicular to the centre contact surface. In the case of point or spot contact, however, the centre contact surface may be considered as a plane with its normal being parallel with the line of action of the force pressing the surfaces to each other, i.e., of the contact pressure. Consequently it is the most convenient to use for the investigation and description of the phenomenon an orthogonal coordinate system with its axis z being coincident with the line of action of the contact pressure developed by the compressive force.

Furthermore let us introduce the dimensionless coordinate ζ along the gap as defined below and let the coordinate z is the linear function of ζ:

$$\begin{aligned} z &= -h_1 = 0 & \zeta &= -1 \\ z &= h_2 = h & \zeta &= 1 \end{aligned} \tag{1}$$

$$z = h\left(\frac{1+\zeta}{2}\right); \quad \frac{\partial z}{\partial \zeta} = \frac{h}{2} \tag{2}$$

$$\int_0^h f(z)dz = \frac{h}{2}\int_{-1}^{1} f(\zeta)d\zeta \; ; \; \int_0^z f(\tilde{z})d\tilde{z} = \frac{h}{2}\int_{-1}^{\zeta} f(\tilde{\zeta})d\tilde{\zeta} \qquad (3)$$

3. Gap size, boundary conditions, load case

The film shape can be calculated as a superposition of the initial geometry, the displacement of a rigid surface and the deformation of a half-space under pressure. After deformation, the film shape:

$$h = h_{g_2} + \Delta_{rigid_1} + \Delta_{rigid_2} + \delta_1 + \delta_2 = h_g + \Delta_{rigid} + \delta \qquad (4)$$

where h_g is the initial gap size, Δ_{rigid} is the relative rigid normal displacement between the contact bodies, δ is the total deformation of the surfaces.

The classical approach is to find the stresses and displacement in an elastic half-space due to surface traction [2]. The deformation due to thermal expansion is negligible in most cases.

$\vec{u}_{xy}^{\,T}=[u_x,u_y]$: the velocity in the contact plane, u_z: the velocity in the *z* direction, $\nabla_{x,y}=[\partial/\partial x,\partial/\partial y]$, W_i are the normal velocity of the contact bodies. Due to translation of the surfaces perpendicularly to the contact plane as:

$$u_z\big|_{z=-h_1} = W_1(t,x,y) - \vec{u}_{xy}\big|_{z=-h_1}\left(\nabla_{xy}h_1\right) \qquad (5)$$

$$u_z\big|_{z=0} = W_2(t,x,y) + \vec{u}_{xy}\big|_{z=0}\left(\nabla_{xy}h_2\right) \qquad (6)$$

The integral of the pressure over the contact area should be equal with the external load.

$$F_W = \int_{A_c} p \cdot dA \qquad (7)$$

F_W is the normal load of the surfaces. Load case can be satisfied if the Δ_{rigid} is a variable.

The oil inlet and exit boundaries all have a free temperature condition ($q_n=0$).

Both surfaces S_1 and S_2 can be divided into two sections ($S_{i\vartheta}$, S_{iQ}) enabling thereby to specify a primary boundary condition for the temperature field, on the one hand, and a secondary boundary condition defining the convection of heat through the surfaces:

$$\vartheta(x,y,h_i) = \vartheta_{S_i}(x,y) \qquad (x,y)\in S_{i\vartheta} \qquad (8)$$

$$\frac{\partial\vartheta}{\partial n_{S_i}} = \nabla\vartheta\cdot\vec{n}_S = -\frac{1}{\lambda}q_Q^{n_{S_i}}(x,y) \qquad (x,y)\in S_{iQ} \qquad (9)$$

where $\vartheta_{Si}(x,y)$ is the temperature of surface $S_{i\vartheta}$ while q_Q^{nSi} is the convection of heat through surface S_{iQ} which are either pre-defined or determined during the solution of the associated thermal problem (relationship between the lubricant and the contacting body).

In the case of pure sliding the contact region moves together with one of the surfaces or – worded in another way – this surface is stationary in relation to the contact region. In this case the heat exchange taking place through the surface stationary in relation to the contact zone can be neglected in most cases since it is more intensive by several orders of magnitude through the surface of the body moving in relation to the contact zone. At this time the adiabatic boundary condition proposed by Rohde and Oh [4] can also be applied to the surface moving with contact region:

$$\frac{\partial\vartheta}{\partial n_s} = \nabla\vartheta\cdot\vec{n}_s \approx \frac{\partial\vartheta}{\partial z} = 0 \qquad (10)$$

For calculating the temperature of the contact surfaces the Carslaw & Jaeger [1] model was used as the substructure model when the analytical expression can be joined to the FEM solution by least squares approximation.

4. Reynolds equation including cavitation

For EHD problem the generalized Reynolds equation was developed by Dowson (1961) takes account the changes the viscosity across the film thickness. The generalized Reynolds equation is not valid for the region where cavitation can occur and the lubricant is stuck onto the surface and flowing in stripes. For extending the governing equation to the cavitation zone penalty cavitation method has been proposed by Szávai [4] where the density change as a function of the pressure in the cavitation zone let be approximated by a high gradient slope under the cavitation pressure. The above described criteria can be satisfied with the following density function:

$$\rho^{*} = \frac{\rho_L(p,\vartheta)}{\gamma(p)\cdot(p_c - p)+1}. \qquad (11)$$

where $\gamma(p)$ is the penalty function which is 0 if $p>p_c$ otherwise $\gamma(p)=c$, where *c* is a sufficiently high number. It has to be noticed that the density depends on the pressure not only in the lubrication region, but in the cavitation zone as well. The ρ* is valid in the lubrication region and the cavitation zone as well, and the volume fraction can be written as:

$$\theta(p) = \frac{\rho^*}{\rho_L} = \frac{1}{\gamma(p)(p_c - p)+1}. \qquad (12)$$

Futhermore linear correlation applied between the density and the viscosity in the cavitation zone:

$$\frac{\eta}{\eta_L} = \frac{\rho}{\rho_L} \qquad \rho \le \rho_c. \qquad (13)$$

Applying the linear correlation between the density and the viscosity according to Kumar and Booker the viscosity can be written as follows:

$$\eta^{*} = \eta_L(p,\vartheta)\frac{\rho^*}{\rho_L(p,\vartheta)} = \theta(p)\eta_L(p,\vartheta) \qquad (14)$$

Based on the concepts above the generalized Reynolds equation with penalty cavitation extension is:

$$\nabla_{xy}\left(\theta h\vec{\psi}+\theta\frac{h^2}{2}\vec{k}_{xy}\right)-\nabla_{xy}\left(\frac{h^3}{2}\varphi\nabla_{xy}p\right)-$$
$$-\theta\left(\rho_1W_1-\rho_2W_2-\frac{h}{2}\omega_{\partial t}\right)=0 \qquad (15)$$

while the mass-flow, flow velocity and its derivate by z in the gap is

$$\vec{q}_h=\theta\left(h\vec{\psi}+\frac{h^2}{2}\vec{k}_{xy}\right)-\frac{h^3}{2}\varphi\cdot\nabla_{xy}p. \qquad (16)$$

$$\vec{u}_{xy}=\vec{u}_{xy_1}+\frac{h^2}{2}\nabla_{xy}p\left(\int_{-1}^{\zeta}\left(\frac{1+\hat{\zeta}}{2}\right)\frac{F(\tau_{eq})}{\tau_e}d\hat{\zeta}-\right.$$
$$\left.-\frac{f_1}{f_0}\cdot\int_{-1}^{\zeta}\frac{F(\tau_{eq})}{\tau_e}d\hat{\zeta}\right)+\frac{\left(\vec{u}_{xy_2}-\vec{u}_{xy_1}\right)-\frac{h}{2}\vec{k}_{0xy}}{f_0}\cdot \qquad (17)$$
$$\cdot\int_{-1}^{\zeta}\frac{F(\tau_{eq})}{\tau_e}d\hat{\zeta}+\frac{h}{2}\int_{-1}^{\zeta}A\frac{d\bar{\sigma}'_z}{dt}d\hat{\zeta}$$

$$\frac{\partial\vec{u}_{xy}}{\partial z}=\frac{2}{h}\frac{\partial\vec{u}_{xy}}{\partial\chi}=\frac{2}{h}\left\{\frac{F(\tau_{eq})}{\tau_{eq}}\left[\frac{h^2}{2}(\nabla_{xy}p)\left(\left(\frac{1+\chi}{2}\right)-\frac{f_1}{f_0}\right)+\right.\right.$$
$$\left.\left.+\frac{\left(\vec{u}_{xy_2}-\vec{u}_{xy_1}-\frac{h}{2}\vec{k}_{0xy}\right)}{f_0}\right]+\frac{h}{2}A\frac{d\bar{\sigma}'_z}{dt}\right\} \qquad (18)$$

where

$$\varphi=f_2+g_1. \qquad (19)$$

$$\vec{\psi}=\rho_2\vec{u}_{xy_2}-\frac{\left(\vec{u}_{xy_2}-\vec{u}_{xy_1}\right)}{f_0}(f_3+g_2)-\vec{u}_{xy_1}g_3. \qquad (20)$$

$$\vec{k}_{xy}=\frac{f_3+g_2}{f_0}\vec{k}_{0xy}-\vec{k}_{1xy}-\vec{k}_{2xy}. \qquad (21)$$

$$\omega_{\partial t}=\int_{-1}^{1}\frac{\partial\rho}{\partial t}d\chi+\frac{\partial}{\partial t}\ln\theta(p)\int_{-1}^{1}\rho d\chi. \qquad (22)$$

Where according to [6]

$$\Phi=F_2+G_1;$$
$$\Omega_\gamma=\rho_1\cdot W_1-\rho_2\cdot W_2-\int_{h_1}^{h_2}\frac{\partial\rho}{\partial t}dz-\frac{\partial}{\partial t}\ln\theta(p)\int_{-h_1}^{h_2}\rho dz;$$
$$\vec{\Psi}=h_2\cdot\rho_2\cdot\vec{u}_{xy_2}-h_1\cdot\rho_1\cdot\vec{u}_{xy_1}- \qquad (23)$$
$$-\frac{\vec{u}_{xy_2}-\vec{u}_{xy_1}-\vec{K}_{0xy_2}}{F_0}\cdot(F_3+G_2)-$$
$$-\vec{u}_{xy_1}\cdot G_3-\vec{K}_{1xy}-\vec{K}_{2xy}$$

The viscosity-density functions:

$$f_0=\int_{-1}^{1}\frac{F(\tau_{eq})}{\tau_{eq}}d\zeta;\ f_1=\int_{-1}^{1}\frac{F(\tau_{eq})}{\tau_{eq}}\left(\frac{1+\zeta}{2}\right)d\zeta;$$
$$f_2=\int_{-1}^{1}\rho\frac{F(\tau_e)}{\tau_e}\left(\frac{1+\zeta}{2}\right)^2d\zeta-\frac{f_1f_3}{f_0}; \qquad (24)$$
$$f_3=\int_{-1}^{1}\rho\frac{F(\tau_{eq})}{\tau_{eq}}\left(\frac{1+\zeta}{2}\right)d\zeta$$

$$g_1=\int_{-1}^{1}\frac{\partial\rho}{\partial\zeta}\left(\frac{1+\zeta}{2}\right)\left(\int_{-1}^{\zeta}\frac{F(\tau_e)}{\tau_e}\left(\frac{1+\hat{\zeta}}{2}\right)d\hat{\zeta}-\right.$$
$$\left.-\frac{f_1}{f_0}\int_{-1}^{\zeta}\frac{F(\tau_e)}{\tau_e}d\hat{\zeta}\right)d\zeta;$$
$$g_2=\int_{-1}^{1}\left(\frac{1+\zeta}{2}\right)\frac{\partial\rho}{\partial\zeta}\left(\int_{-1}^{\zeta}\frac{F(\tau_e)}{\tau_e}d\hat{\zeta}\right)d\zeta; \qquad (25)$$
$$g_3=\int_{-1}^{1}\left(\frac{1+\zeta}{2}\right)\frac{\partial\rho}{\partial\zeta}d\zeta$$

$$\vec{k}_{0xy}=\int_{-1}^{1}A\frac{d\bar{\sigma}'_z}{dt}d\zeta;\vec{k}_{1xy}=\int_{-1}^{1}\left(\frac{1+\zeta}{2}\right)\rho A\frac{d\bar{\sigma}'_z}{dt}d\zeta;$$
$$\vec{k}_{2xy}=\int_{-1}^{1}\left(\frac{1+\zeta}{2}\right)\frac{\partial\rho}{\partial\zeta}\left(\int_{-1}^{\zeta}A\frac{d\bar{\sigma}'_z}{dt}d\hat{\zeta}\right)d\zeta; \qquad (26)$$

and

$$\nabla_{xy}=\left[\frac{\partial}{\partial x},\frac{\partial}{\partial y}\right]^T;\ \nabla=\left[\nabla_{xy},\frac{\partial}{\partial z}\right]^T;\ \vec{u}_{xy}=[u,v]^T$$

Furthermore $F(\tau_{eq})$ is the fluid rheological model. For instance for different type lubricant:

$$F(\tau_{eq})_{Newton}=\frac{\tau_{eq}}{\eta};$$
$$F(\tau_{eq})_{Eyring}=\frac{\tau_E}{\eta}\sinh\left(\frac{\tau_{eq}}{\tau_E}\right); \qquad (27)$$
$$F(\tau_{eq})_{viscoplastic}=-\frac{\tau_L}{\eta}\ln\left(1-\frac{\tau_{eq}}{\tau_L}\right);$$

5. Energy equation

In the cavitation zone there are no dissipation and heat-conduction, or these values are ignorable and the heat-conduction factor can be modified as:

$$\lambda^*=\theta\lambda_L \qquad (28)$$

So the energy equation for compressible fluid is

$$\begin{aligned}&\theta\rho_L\left(\frac{\partial(c_v\vartheta)}{\partial t}+\nabla_{xy}(c_v\vartheta)\cdot\vec{u}_{xy}\right)+p\left(-\frac{\partial\rho_L}{\partial t}-\right.\\&\left.-\nabla_{xy}\rho_L\cdot\vec{u}_{xy}-\left(\frac{\partial}{\partial t}\theta+\nabla_{xy}\theta\cdot\vec{u}_{xy}\right)\rho_c\right)=\\&=\nabla_{xy}\left(\theta\lambda_L\cdot\nabla_{xy}\vartheta\right)+\frac{4\theta}{h^2}\frac{\partial}{\partial\zeta}\left(\lambda_L\frac{\partial\vartheta}{\partial\zeta}\right)+\theta\Xi_L\end{aligned}\tag{29}$$

where the Ξ_L dissipation with ignorable error, according to [4], is as follows:

$$\Xi\approx\tau_{xz}\cdot\frac{\partial u}{\partial z}+\tau_{yz}\cdot\frac{\partial v}{\partial z}=\vec{\sigma}'_z\cdot\frac{\partial\vec{u}_{xy}}{\partial z}\tag{30}$$

$$\vec{\sigma}'_z=\frac{\tau_{eq}}{F\left(\tau_{eq}\right)}\left(\frac{2}{h}\frac{\partial\vec{u}_{xy}}{\partial\zeta}-A\frac{d\vec{\sigma}'_z}{dt}\right)\tag{31}$$

6. The weak integral form of the governing equation

In the case of variation methods, the integral forms of the differential equations are used so, certain quantities have to be integrated over the region. With weight function w_R, the weak integral form of the generalized Reynolds equation is:

$$\begin{aligned}&\int_{A_c}\nabla_{xy}w_R\cdot\left(\theta\left(h\vec{\psi}+\frac{h^2}{2}\vec{k}_{xy}\right)-\frac{h^3}{2}\varphi\nabla_{xy}p\right)\\&-w_R\theta\Omega_\gamma dA-\oint_{\Gamma_c}w_Rq_h^{n_\Gamma}d\Gamma=0\end{aligned}\tag{32}$$

The weak integral form of energy equation can also be set up with the use of a weight function w_Q with considering equation:

$$\begin{aligned}&\int_{V_c}w_Q\left(\left(\theta\rho_L\left(\frac{\partial(c_v\vartheta)}{\partial t}+\nabla_{xy}(c_v\vartheta)\cdot\vec{u}_{xy}\right)-p\left(\frac{\partial\rho_L}{\partial t}+\right.\right.\right.\\&\left.\left.+\rho_c\frac{\partial}{\partial t}\theta+\nabla_{xy}\rho_L\cdot\vec{u}_{xy}+\nabla_{xy}\theta\cdot\vec{u}_{xy}\rho_c\right)-\theta\Xi_L\right)+\\&\left.+\theta\lambda_L\cdot\left(\nabla_{xy}w_Q\cdot\nabla_{xy}\vartheta+\frac{4}{h^2}\cdot\frac{\partial w_Q}{\partial\chi}\cdot\frac{\partial\vartheta}{\partial\chi}\right)\right)dV-\\&-\int_{S_1}w_Qq_Q^{S_1}dA+\int_{S_2}w_Qq_Q^{S_2}dA=0\end{aligned}\tag{33}$$

Since x and y coordinates, h and the p are not the functions of ζ, the integration above ζ can be done separately.

$$\begin{aligned}&\int_{A_c}\frac{h}{2}\int_{-1}^{1}w_Q\left(\left(\theta\rho_L\left(\frac{\partial(c_v\vartheta)}{\partial t}+\nabla_{xy}(c_v\vartheta)\cdot\vec{u}_{xy}\right)-p\left(\frac{\partial\rho_L}{\partial t}+\right.\right.\right.\\&\left.\left.+\rho_c\frac{\partial}{\partial t}\theta+\nabla_{xy}\rho_L\cdot\vec{u}_{xy}+\nabla_{xy}\theta\cdot\vec{u}_{xy}\rho_c\right)-\theta\Xi_L\right)+\\&\left.+\theta\lambda_L\cdot\left(\nabla_{xy}w_Q\cdot\nabla_{xy}\vartheta+\frac{4}{h^2}\cdot\frac{\partial w_Q}{\partial\zeta}\cdot\frac{\partial\vartheta}{\partial\zeta}\right)\right)d\zeta dA-\\&-\int_{S_1}w_Qq_Q^{S_1}dA+\int_{S_2}w_Qq_Q^{S_2}dA=0\end{aligned}\tag{34}$$

7. Quasi 2D element and numerical integration

In order to carry out the integration, the integration range has to be divided into shapes characteristic of a particular element type *Figure 2* and then derived into a unified shape by means of conform transformation for numerical integration *Figure 3*.

$$\int_{A_c}f(x,y)dxdy=\sum_e\int_{A_c^e}f^e(x,y)dxdy\tag{35}$$

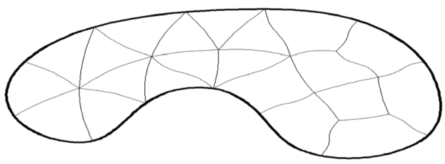

Figure 2 Division of the A_c region for integration

Since coordinate axis z perpendicular to the A_c contact surface such as the dimensionless thickness (ζ), the x and y coordinates, the gap size and the pressure are not the functions of ζ:

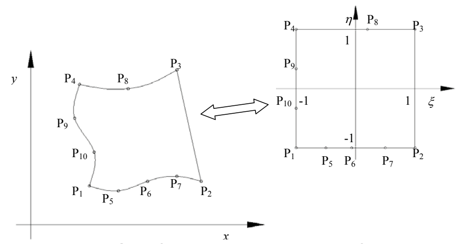

Figure 3 Conform element transformation

$$\int_{A_c}f(x,y)dxdy=\int_{-1}^{1}\int_{-1}^{1}f(x(\xi,\eta),y(\xi,\eta))|\mathbf{J}|d\xi d\eta\tag{36}$$

Conform geometry transformation by Legendre shape functions (***N***) according to [5] looks like:

$$x^e(\xi,\eta,t)=\sum_i X_i^e(t)N_{xi}^e(\xi,\eta)=\mathbf{N}_x^{eT}(\xi,\eta)\mathbf{X}^e(t)\tag{37}$$

$$y^e(\xi,\eta,t)=\sum_j Y_j^e(t)N_{y_j}^e(\xi,\eta)=\mathbf{N}_y^{eT}(\xi,\eta)\mathbf{Y}^e(t)\tag{38}$$

This integration is carried out in most cases numerically by means of Gaussian quadrature [5]:

$$\int_{-1}^{1}\int_{-1}^{1}f(\xi,\eta)|\mathbf{J}|d\xi d\eta=\sum_{i=1}^{n}\sum_{j=1}^{m}w_G^iw_G^jf\left(\xi_G^i,\eta_G^j\right)\left|\mathbf{J}\left(\xi_G^i,\eta_G^j\right)\right|\tag{39}$$

Where ζ_G^i and η_G^i specified points within the domain of integration and w_G^i are weights at specified points [5].

Each element has a dimensionless *ζ(-1..1)* coordinate if the thermodynamical problem or non-Newtonian lubricant is also taken into consideration. Since z is linear in *ζ*:

$$z^e = h^e\left(\frac{1+\zeta}{2}\right) \tag{40}$$

where the gap size (h^e) is an element variable.

Integration above the dimensionless thickness:

$$\int_{-1}^{1} f(\zeta)d\zeta = \sum_{i=1}^{n} w_G^i f\left(\zeta_G^i\right) \tag{41}$$

Determination of $\vec{u}_{xy}$ and (g1, g2, $\vec{k}_{2xy}$) viscosity density functions requires integration above a semi undefined region *(-1.. ζ)* that has to be managed in a certain way. For handing this problem method has been developed for such type integrals:

$$F(\zeta) = \int_{-1}^{\zeta} f(\hat{\zeta})d\hat{\zeta} \tag{42}$$

The function $f(\hat{\zeta})$ is known at any point above the gap. Let us take the Lagrange interpolation of the integrand above the $\hat{\zeta}(-1..1)$ region through *n+2* $\left(f(\hat{\zeta}_k),\hat{\zeta}_k\right)$ points where $\hat{\zeta}_k = \left(-1,\zeta_G^n,1\right)$ and n is the number of the perdefned ζ_G^n Gauss points:

$$f_{Lagr}(\hat{\zeta}) = \sum_{k=1}^{n+2} f(\hat{\zeta}_k)P_k^{n+1}(\hat{\zeta}) \tag{43}$$

where

$$P_k^{n+1}(\hat{\zeta}) = \prod_{m=1}^{k-1}\frac{\hat{\zeta}-\hat{\zeta}_m}{\hat{\zeta}_k-\hat{\zeta}_m}\prod_{m=k+1}^{n+2}\frac{\hat{\zeta}-\hat{\zeta}_m}{\hat{\zeta}_k-\hat{\zeta}_m} \tag{44}$$

are the *(n+1)* order Lagrange interpolation polynomials those can be integrated analytically:

$$I_k(\zeta) = \int_{-1}^{\zeta} P_k^{n+1}(\hat{\zeta})d\hat{\zeta} \qquad k = 1..n+2 \tag{45}$$

So the integral with its interpolation:

$$\begin{gathered}F(\zeta) = \int_{-1}^{\zeta} f(\hat{\zeta})d\hat{\zeta} \approx \int_{-1}^{\zeta}\sum_{k=1}^{n+2} f(\hat{\zeta}_k)P_k^{n+1}(\hat{\zeta})d\hat{\zeta} = \\ \sum_{k=1}^{n+2} f(\hat{\zeta}_k)\int_{-1}^{\zeta} P_k^{n+1}(\hat{\zeta})d\hat{\zeta} = \sum_{k=1}^{n+2} f(\hat{\zeta}_k)I_k(\zeta)\end{gathered} \tag{46}$$

8. Approximation of the element variables

Legendre shape functions (***N***) according to [5] have been used for the polynomial approximation of the un-known variables. Only 2D approximation needed for the gap size, deformation and the pressure:

$$h_g^e(\xi,\eta,t) = \sum\nolimits_k H_{g_k}^e(t)N_{hk}^e(\xi,\eta) = \mathbf{N}_g^{eT}(\xi,\eta)\mathbf{H}_g^e(t) \tag{47}$$

$$\delta_s^e(\xi,\eta,t) = \sum\nolimits_k H_{\delta_s k}^e(t)N_{hk}^e(\xi,\eta) = \mathbf{N}_g^{eT}(\xi,\eta)\mathbf{H}_{\delta_s}^e(t) \quad s=1,2 \tag{48}$$

$$h^e = \left[\mathbf{N}_g^{eT},1\right]\begin{bmatrix}\mathbf{H}_g^e+\mathbf{H}_{\delta 1}^e+\mathbf{H}_{\delta 2}^e \\ \Delta_{rigid}\end{bmatrix} = \mathbf{N}_h^{eT}(\xi,\eta)\mathbf{H}^e(t) \tag{49}$$

$$p^e(\xi,\eta,t) = \sum\nolimits_l P_l^e(t)N_{p_l}^e(\xi,\eta) = \mathbf{N}_p^{eT}(\xi,\eta)\mathbf{P}^e(t) \tag{50}$$

The variation of the temperature through the thickness has been taken into consideration:

$$\vartheta^e(\xi,\eta,\zeta,t) = \sum\nolimits_m T_m^e(t)N_{\vartheta m}^e(\xi,\eta,\zeta) = \mathbf{N}_\vartheta^{e^T}(\xi,\eta,\zeta)\mathbf{T}^e(t) \tag{51}$$

No shape function is required for the displacement like a rigid body $\Delta_{rigid}(t)$, as it is a parameter associated with the body.

For the discretisation of the week integral form of the Reynods equations, the w_R weight functions are $\mathbf{N}_p$ in case of direct solution. If invers solution is chosen the w_R weight function should be $\mathbf{N}_g$. However it has to be considered that the pressure and deformation field are dependent from each other. The two fields are connected by the solid mechanical description of the surfaces. Furthermore the pressure distribution has to satisfy the load case as well. For the discretization of the energy equation w_R weight functions are $\mathbf{N}_\vartheta$.

9. Example

The solution of the problem by the p-version finite element method is presented by means of the examples found in the article published by Wolff at all [6] in 1992 as the basis for which the applicability of the solution method constructed here to the problem has been verified.

The gap was divided along its length into 15 elements also here. The degree of approximations is given in Table 1.

Table 1 Mesh parameters

Element number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Degree of pressure approximation.	6	6	6	6	6	6	6	6	7	7	7	6	6	6	6
Degree of temperature approx..	4 x 4	4 x 4	4 x 4	4 x 4	4 x 4	4 x 4	4 x 4	4 x 4	4 x 4	4 x 4	4 x 4	4 x 4	4 x 4	4 x 4	4 x 4

The calculations were carried out first for the state of pure rolling contact. The elasto-hydrodynamic problem was solved with the use of the optimized Newton-Rapshon method [4] and the thermodynamical problem by the attenuated direct algorithm in iterative manner. The pressure distribution obtained is shown in Figure 4 and the gap size formed as well as the temperature distribution in Figure 5.

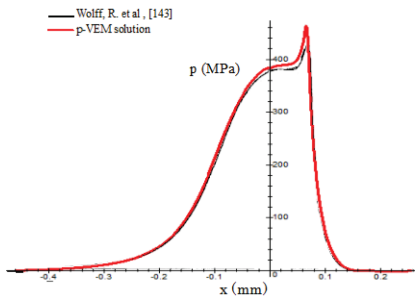

Figure 4 Pressure distribution for pure rolling

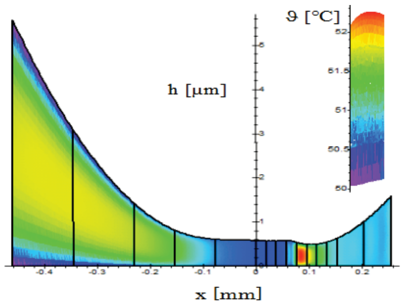

Figure 5 Temperature distribution for pure rolling

Subsequent to the problem of pure rolling contact, the calculations were carried out with 1.9 sliding ratio.

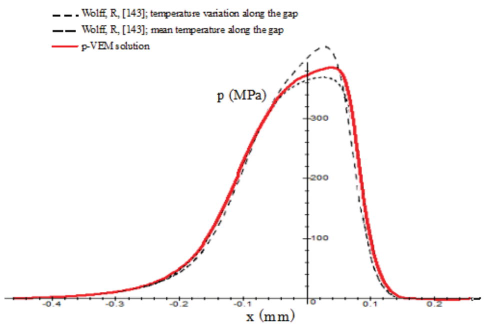

Figure 6 Pressure distribution with S=1.9

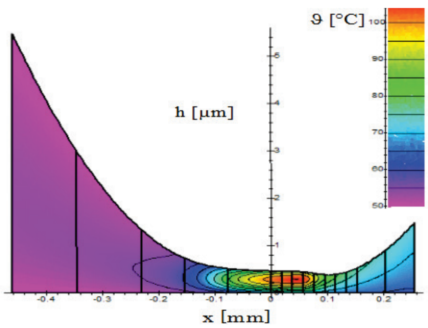

Figure 7 Temperature distribution with S=1.9

Heat generation is much higher in this case, thus the mode of modelling the temperature distribution along the gap strongly influences the results as demonstrated well in the results published by Wolff and his co-authors. The result of the pressure distribution calculation is shown in Figure 6. The pressure distribution indicated develops at the gap shape and temperature distribution shown in *Figure 7* demonstrating well the definite temperature rise near the pressure peak shifting towards the upper surface moving more slowly.

10.Conclusions

For the three-dimensional contact problem of lubrication, a two-dimensional lubrication fluid film finite element was developed. A remarkable property of this element is that only a two-dimensional mesh has to be maintained. Furthermore, pressure and film thickness can be handled as independent element variables. Integration through the thickness is carried out by making use of dimensionless thickness coordinate. Three dimensional behaviour of the fluid film temperature can be modelled using higher order approximations through the thickness direction.

11. Acknowledgement

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HEALTH AND KINESIOLOGY ACTIVITY AMONG STUDENTS

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Abstract

Physical exercise is an important factor in the prevention of many diseases, especially heart disease and in delaying and slowing down the reduction of work capacity which occurs with aging. An improvement and a maintaining of a functional capacity of the body is formed under the condition that the physical activity or exercise is that the kind and scope of exercise is such that it stimulates general aerobic endurance of the body (the ability of a high intensity performance over a longer period), i.e. that it includes a dynamic activity of at least one sixth of the total skeletal muscles cyclically. The purpose of this paper is to determine whether, and in what way, does the amount of physical activity influence the share of body fat and muscle mass.

Keywords: health, physical activity, kinesiology, exercise, adolescence

1. Introduction

Health is a continuum of a student's state, which implies not only the absence of disease or decrepitude, but represents a capacity to deal with challenges of everyday life and the full realization of life potential. In this sense, health also involves functional capacities required needed for a satisfying and fulfilling life of every student. A high ability capacity is also a positive criterion of health degree. Regular physical activity of a proper type, intensity, duration and frequency increases physical ability, especially by improving the function of the oxygen and energy substances transport system, as well as regulatory mechanisms of the nervous system.

Etymologically, the term function, in biological sense, refers to the specific work of the organs, that is, of the organism in general. However, in the kinesiology practice, the aforementioned term usually covers the function of the cardiovascular and respiratory system. These systems are the most responsible for the supply and transfer of oxygen. The respiratory system is the first link in the oxygen transfer system, and distinguishes between two basic functions: air ventilation, air exchange between the atmosphere and the lungs, and alveolar diffusion or transfer of oxygen from the alveolar space into blood, or receiving carbon dioxide from blood into the alveoli space [1]. The cardiovascular system, with the heart as a driving pump and blood vessels as a closed pipe system, participates in the transport of oxygen and nutrient and waste materials, as well as gas exchange [2].It should be borne in mind that the stimuli of a too small intensity are not effective in improving functional ability, and those of a too strong intensity in regards to the body fitness can be harmful. A number of researches [3], [4] are of the view that the activities of different intensities, if carried out almost daily, have a long-term positive effect on health. The total set daily activity carried out several times throughout the day, proportionally of a shorter duration, also increases the functional capacity of the cardiovascular system [5].

Physical activity contributes to the protection and promotion of health, and can have a preventive, curative and rehabilitation role. In account of these benefits the concept of "medical fitness" has been introduced [6], because it can have both a positive, and a negative effect on the health status. Activities that promote sports activity are inherently fun, and rapidly lead to reward in the form of physical progress. When one feels fit, it can raise their self-confidence in other areas of life - social, scientific, professional - in other words, in everything. A physically active person becomes strong and meets physical challenges without much effort. He or she is more durable, and his or her energy lasts for hours. Daily physical efforts can easily be endured and there is a lot of energy to cope with any possible sudden efforts. There are several additional factors that can affect physical activity, fitness and health, which are: lifestyle, physical and social environment as well as biological and psychological characteristics. Lifestyle comprises the action and behaviour of a person in the selection of the content that affects the health fitness and the level of health. Regular physical activity is a form of behaviour over which the individual has a great possibility of voluntary influence. Smoking, diet and alcohol intake, sleep, drugs, avoiding stressful situations, visits to the doctor and many other things have a big impact on our health, but also on physical activity. Under the influence of physical exercise, certain morphological characteristics undergo the greatest physical change [7]. Strength training results in muscle hypertrophy, while the choice of appropriate contents helps in fat reduction [8].

This study is aimed to determine the influence of the amount of physical activity on the proportion of muscle mass and body fat during adolescence that are closely related to the health status of an individual. Previous studies [9] have mainly been putting physical activity in relation to body mass index (BMI). Since body mass index is calculated only on the basis of height and weight, it is not an adequate indicator of changes occurring in the organism under the influence of physical exercise.

2. Method

The aim of this study is to determine whether the amount of active participation in sports and kinesiology activities influences the proportion of subcutaneous fat and muscle mass in the body. The study was conducted on a sample of 146 female and 82 male students of the Polytechnic of Međimurje in Čakovec, average age 19.4 years, ranging from 18.4 to 21.6 years. Data on the amount of physical activity were collected with the prior consent of students via a questionnaire. In the questionnaire, the amount of activity was placed in four scoring groups: 1 complete inactivity, 2 activity in the duration of 1 to 2 hours per week, 3 activity in the duration of 4 to 6 hours, 4 activity in the duration of 6 to 9 hours. Sports and kinesiology activity includes all types of physical active work that causes rapid breathing, heart rate and sweating, no matter whether it is a recreational, amateur, professional or independent type of activity. The level of body fat and muscle mass was measured by Omron BF511 diagnostic scale, which functions as bioelectrical impedance, and is expressed in percentages. Analysis of variance was used to determine the differences between male and female students in the amount of engagement and differences in the level of body fat and muscle mass due to the amount of average weekly activities within the same gender.

3. Results and discussion

Descriptive indicators presented in Table 1 show that a large number of adolescents after high school is completely inactive.

Table 1: Analysis of the amount of activity among female and male students

	total (n=228)		female (n=146)		male (n=82)	
	N	%	N	%	N	%
Inactivity	96	42,11	72	49,32	24	29,27
1 to 3 hours	74	32,46	46	31,51	28	34,15
4 to 6 hours	35	15,35	17	11,64	18	21,95
7 or more	23	10,09	11	7,53	12	14,63

Thus, 42.1 percent of all students declare that they are completely inactive, that is, even 49.3 percent female and 29.3 percent male students. The next group consists of students who are engaged in an activity one to three hours per week. They make a total of 32.5 percent, or 31.5 percent female and 34.1 percent male students. This second group shows the smallest difference between male and female students. A total of 15.4 percent of students, i.e.11.6 percent of female and almost 22 percent of male students are active four to six hours a week. And finally, a total of ten percent, or more precisely, 7.5 percent of female and 14.6 percent of male students are very active and engage in sport seven or more hours per week.

The presented results are quite alarming as far as the data on completely inactive students with a total of 42.1 percent, lead by a half of completely inactive female students. The survey was conducted at the beginning of the academic year, when students have not yet had organized classes of physical education, which is apparently the only form of exercise for most adolescents who enter a college and start a more independent lifestyle. It can be concluded from the results that during childhood physical exercise of children and young people largely depends on the involvement of parents, while at the beginning of the independence the majority of students still do not find enough motivation for independent engagement in sports activities. Another reason for such a large number of inactive people may be insufficient information about the different types of sports and recreational activities that are carried out in a particular geographic area. On the other hand, it is very satisfying that every tenth student is very active and engaged in a sporting activity for more than seven hours a week. The assumption is that these are people who engage in sports at amateur or professional level, and that they will continue to actively engage in sports to a greater or lesser training volume. A total of 47.8 percent of male, or 43.1 percent of female students and 56 percent of students spend one to six active hours per week. Comparing with data from different countries of the European Union and according to the Institute for Public Information, these data show that the population of students of The Polytechnic of Međimurje in Čakovec are slightly above the European average, according to which 40% of the population older than 15 years exercise at least once a week. In Germany, 49 percent of people older than 15 years are engaged in sports activities at least once a week, in Denmark 64 percent, Austria 38, and the Czech Republic 28 percent. It should be taken into account that these data were obtained on a sample of the entire population of people older than 15 years including the elderly, the disadvantaged and the like, which are generally less physically active. Differences in the average subcutaneous fat tissue (% SCF) and muscle mass (% MM) within sex, more precisely, between the four groups are defined by the amount of activity of female students and the four groups of students are shown in Table 2.

The result of the entire sample shows that the differences between the first three groups in the amount of SCF are relatively small. Among the groups G1 and G2 and the groups G2 and G3 there is no statistical significance at the level of error <0.5. This means that from the point of subcutaneous fat tissue there are no significant results among population that is active 1 to 3 hours per week on average.

Table 2: Analysis of differences in the amount of SCF and MM between groups of students of the same sex

TOTAL SAMPLE (MALE AND FEMALE)				
	inactiv (G1)	1 - 3h (G2)	4 - 6h (G3)	7h > (G4)
%SCF	30,86	29,25	28,44	24,45
%MM	27,92	29,77	30,78	31,1
female				
	inactiv (F1)	1 - 3h (F2)	4 - 6h (F3)	7h > (F4)
%SCF	32,21	32,38	29,32	25,21
%MM	25,12	28,65	29,81	29,92
male				
	inactiv. (M1)	1 - 3h (M2)	4 - 6h (M3)	7h > (M4)
%SCF	29,37	27,93	26,64	22,41
%MM	29,22	30,26	32,64	32,82

Statistical significance is present in the analysis of the differences between G1 and G3 and G4 with all other groups. With female students, a considerable variation occurs in the proportion of SCF between F2 and F3 and between F3 and F4, which would mean that with females the activity is needed more than 4 hours per week in order to achieve quality results in the reduction of body fat, while activity up to three hours does not give significant results in the reduction of SCF. With male students there were statistically significant differences found between the groups M1 and M2 and M3 and M4 group. Thus, with the reduction in SCF at adolescent males, significant results are already achieved already through a three-hour weekly activity, whereas no big difference are noted in the results of students who are active 1 to 3 hours and students who are active 4 to 6 hours on average per week. When we compare the results of women's and men's groups, we can conclude that in males physical activity starts to show results faster in the reduction of body fat. The results of all participants together show that the statistically significant difference occurs between G1 and G2, while the difference between G2 and other groups exists but is not sufficiently expressed to be statistically significant. With female students, statistically significant differences were found between groups F1 and F2 and groups F2 and F3. So, the difference in the amount of muscle mass occurs at female persons who are active on a minimum level, while increasing the amount of activity to 3 to 6 hours a week significantly increases the amount of muscle mass. With male students. With the students, significant differences occur only between M1 and M3, and in people who are active four to six hours a week. Hypertrophy, or the increase of muscle mass is most visible as adaptation to strength and power training. On the other hand, due to standstill and inactivity atrophy or reduction in the volume of muscle mass occurs.

It is therefore understandable that even small to moderate activity can mean a lot in terms of maintaining the amount of muscle mass and prevent muscle atrophy. In groups G4, M4 and F4 no significant differences versus the less active group occur. In order to achieve a significant difference, not only the extent (duration) of activity is sufficient. The activity also has to be aimed at a programmed strength training.

Analysis of variance confirmed the hypothesis that the active male and female students have a lower proportion of body fat and a higher proportion of muscle mass. The amount of activity does not equally affect the male and female body but, according to the indicators in this study, some mechanisms are included earlier and some later. What is highlighted as a basic difference is the fact that with women less physical activity affects more the muscle mass than the subcutaneous adipose tissue, while the with males the situation is different - less activity influenced influences the amount of body fat more than muscle mass.

Based on this study it cannot be said with certainty what causes the differences so further research of this area is suggested. Differences may arise due to physiological and anatomical differences between men and women, the intensity of activity or other lifestyle habits that may affect the evaluated parameters. Also, the research found that the activity of a person can be estimated by calculating body fat and muscle mass.

4. Conclusion

Sedentary lifestyle, fast pace and increased stress are a growing phenomenon of modern life of all age groups. The consequence of this way of life are general hypokinesia and growing obesity, which leads to decreased quality of life and to development of various diseases, particularly cardiovascular diseases, and other physical and mental illnesses. Physical activity has a positive effect on the entire anthropological status of man - morphological characteristics, functional and motor skills, cognitive abilities and personality traits. This study has confirmed that even a small amount of continuous activities can affect the morphological status, or the proportion of muscle mass and body fat. With a positive impact on these two components human health is affected directly and permanently and the quality of life is raised. With the implementation of planned and purpose-oriented kinesiology activities remarkable results in the prevention of injury and disease, regeneration the body and the maintenance and improvement of life quality can be achieved.

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THERMO-MECHANICAL ANALYSIS OF TANK WAGON FOR TRANSPORTATION OF MOLTEN SULFUR

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Abstract

An example of specific engineering problem solving by using the thermo-mechanical analysis is given in this paper. Theoretical bases of using the finite element method for numerical solving of heat conduction problem through continuum are pre-sented. Temperature field used as an input for thermo-mechanical calculation is determined by heat conduction calculation. The main purpose of thermomechanical calculation is to check the strength of the wagon after the reconstruction of the heating system that is used for heating of the transported medium.

Keywords:

Heat conduction, FEM analysis, wagon analysis

1. Introduction

Numerical simulations are widely used for solving various problems in industry because they reduce time and cost in developing of new products. The advantage of simulations is that potential problems on product are eliminated in design phase, which leads to significant reducing of product's cost. The most powerful and widely used tool for numerical simulations is Finite element method (FEM). Theoretical bases for numerical solving of the heat conduction problem through continuum, using the finite element method, are presented.

The aim of this paper is the strength calculation of the wagon for sulfur transportation. Wagon for sulfur transportation has been in the exploitation phase for years and reconstruction of the heating system of the transported medium is planned. Heating system of the original variant was located in the interior of the wagon and it was planned to relocate it on the outside. The calculation should confirm that reconstructed wagon structure meets all the criteria prescribed by standards.

2. Theoretical Bases

Differential equation of the energy balance is based on the fundamental conservation of energy principle. Namely, change of the material inner energy in the unit of time, in elementary volume, is equal to the quantity of heat energy accumulated in that same volume in the unit of time, or it is valid for [1]:

$$\frac{dQ}{dt} = \frac{dU}{dt} \qquad (1)$$

where dQ and dU are changes of the heat and the inner energy in the volume dV in elementary time interval dt. Change of the inner energy can be formulated as:

$$\frac{dU}{dt} = \rho C_p \frac{dT}{dt} dV \qquad (2)$$

where: ρ – material density, C_p – specific heat and T – temperature. According to Figure 1, dQ/dt can be formulated as:

$$\frac{dQ}{dt} = \left(q_x + \frac{\partial q_x}{\partial x}dx - q_x\right)dydz + \left(q_y + \frac{\partial q_y}{\partial y}dy - q_y\right)dxdz + \left(q_z + \frac{\partial q_z}{\partial z}dz - q_z\right)dxdy - qdV \qquad (3)$$

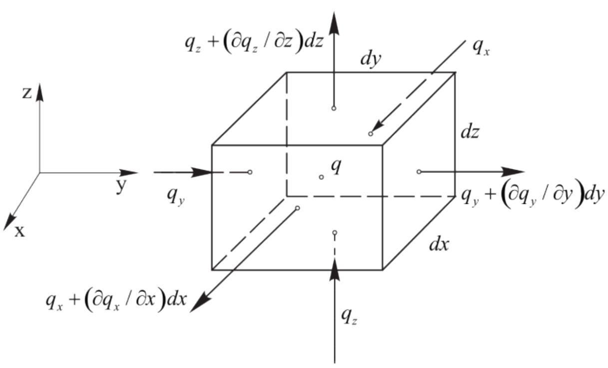

Figure 1. Elementary volume dV with heat flux components

where q_x, q_y and q_z are components the of heat flux vector. These components represent the heat quantity that passes through the unit surface in the unit of time. Power of the heat source *q* represents the heat quantity in the unit of time and the unit of volume. Signs of the flux components are con-sidered in equation (3). Positive sign corresponds to the positive flux projection on the direction of the outer normal unit vector on the surface and negative flux through the surface corresponds to the accumulation of the heat energy *dV*. It is considered that *q>0* if there is a heat source in the volume *dV* (in the point of the material), but *q<0* in the case of the heat sink.

Heat conduction through continuum is defined by Fourier's law of heat conduction:

$$q_i = -\lambda_i \frac{\partial T}{\partial x_i} \qquad i = 1,2,3 \tag{4}$$

where λ_i, or λ_x, λ_y and λ_z, are coefficients of the heat conduction in the case of orthotropic material. In the case of isotropic material, the following is valid:

$$\lambda_x = \lambda_y = \lambda_z = \lambda \tag{5}$$

Replacing equations (2) and (3) in the equation of energy balance (1) and using the equation (4), differential equation for isotropic material obtains the following form:

$$-\rho C_p \frac{dT}{dt} + \sum_{j=1}^{3} \frac{\partial}{\partial x_j}\left(\lambda_j \frac{\partial T}{\partial x_j}\right) + q = 0 \tag{6}$$

When it comes to the practical problem solving, the temperature field *T(x,y,z,t)* solution is searched for satisfying initial and boundary conditions and it represents a unique solution. Initial conditions are given only for unsteady problems and they mean that temperature distribution at the initial moment of time *t=0* is known:

$$T(x,y,z,0) = f_0(x,y,z) \tag{7}$$

Boundary conditions can be:

- given fluxes on the contact surface:

$$q_n = q_n(x,y,z,t) \tag{8}$$

- given heat convection:

$$q_h = h(T_0 - T_s) \tag{9}$$

where T_s is the surface temperature, T_0 is the environment temperature and h is the coefficient of convection. By using the Galerkin method, differential equation (6) transforms into the equation of construction balance whose solving is presented in references [1-3].

3. Technical description of the 4-axle wagon

In order to change the medium heating system the reconstruction of wagon for molten sulfur transportation is done. As part of original structure the heating system was located inside the tank, and because of regular services, corrosion, etc., its reconstruction was planned so it can be relocated outside of the tank.

The reconstructed wagon was designed for the transport of molten sulfur class 4.1, number 15 – RID [4]. Volume of the wagon tank is 38 m^3, and working pressure is 0.15 MPa. The total heating area is 55 m^2, while the temperature of the medium heating is 170°C. The tank insulation is of 150mm thickness, while the material is mineral wool. The cover plate of 0.8mm thickness is placed over the insulation.

The underframe consists of a welded construction. Tank is made of S355J2G3 steel, and external heating half-pipes are made of P355NH steel. Table 1 shows physical and mechanical characteristics of materials. Steel S355J2G3 characteristics are defined by EN10025-2:2007 [5]. Steel P355NH characteristics are defined by EN10028-3:2009 [6].

Table 1. Physical and mechanical characteristics of materials

PHYSICAL CHARACTERISTICS						
Steel mark	E [N/mm^2]		ρ [kg/mm^3]		v	
S355J2G3	2.1 10^5		7.85 10^{-6}		0.3	
P355NH	2.1 10^5		7.85 10^{-6}		0.3	
MECHANICAL CHARACTERISTICS						
Steel mark	R_e [N/mm^2]		R_m [N/mm^2]		KV [J]	
S355J2G3	355		490		27	
P355NH	355		490		27	
Min. values for proof strength $R_{p0,2}$ (MPa)						
Thickness < 16 mm	50°C	100°C	150°C	200°C	250°C	300°C
S355J2G3	343	323	299	275	252	232
P355NH	343	323	299	275	252	232

4. FEM model

Wagon structure is modelled by using Femap software [7], and the analysis was done in the software PAK MULTIPHYSICS [3] that is based on the finite element method. According to the construction type, shell elements of the appropriate thickness and 3D elements (for modeling of support plate, compensating ring, traction stop) were used for creating the finite element mesh. Structure is modeled in details with 230138 elements and 226668 nodes and within the calculation there is a system of about one million and two thousand equations being solved. General element side length is about 30 mm. Figure 4 shows the 3D model of the whole wagon without bogies. Colours in Figure 2 match the various thicknesses of shell elements. Figure 3 shows the half of the model, which will be used taking in consideration corresponding symmetry of the load case.

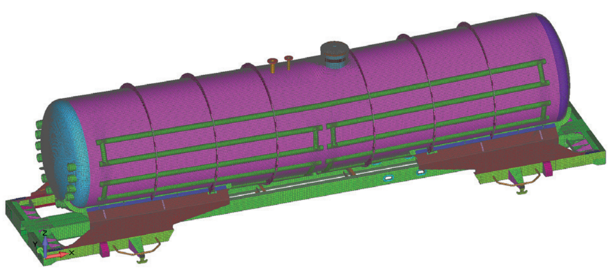

Figure 2. 3D Vehicle model

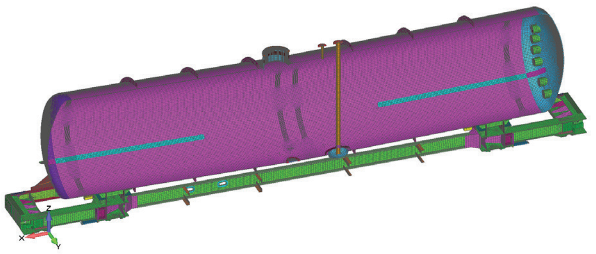

Figure 3. Half of the 3D model

5. Load cases and requirements

According to UIC 577 [8], and BS EN 12663: 2000 [9], Clause 5.2, it is necessary to calculate the wagon structure in relation to different types of loads:

- Exceptional loads, which cover: longitudinal design loads, maximum vertical load, load combinations, lifting and jacking and other;
- Service (fatigue) loads.

The analyses were done for all the variations of loads in accordance with UIC 577 [8], and BS EN 12663:2000 [9]. Results presented in this paper are only for the thermo-mechanical calculation of the wagon loaded with maximal vertical load.

6. Thermo-mechanical analysis - results

Wagon is filled with molten sulfur up to the filling height that corresponds to the maximum allowed loading capacity of the wagon, which is 65t. Molten sulfur density is 1803.9kg/m^3 [10]. The increase in temperature of 170°C is given on the inner side of half-pipes' model which is in contact with tank. On the inner side of tank model increase in temperature of 130°C is given. Calculation of the heat conducting was done first to determine the temperature field (Figure 4) on the whole wagon and then, the temperature field was used in thermo-mechanical calculation to determine thermal strains. It is considered that the heat from the surfaces of half-pipes and from the tank underneath the insulation is transferred by convection, and the heat transfer coefficient was h_1=0.1 W/m^{2}K. On the other side, the heat from the wagon surface which is outside of the insulation is transfered by convection h_2=1 W/m^{2}K. Heat conduction coefficient is k=52.33 W/mK, while the linear expansion coefficient is α=11.5 10^{-6}1/K.

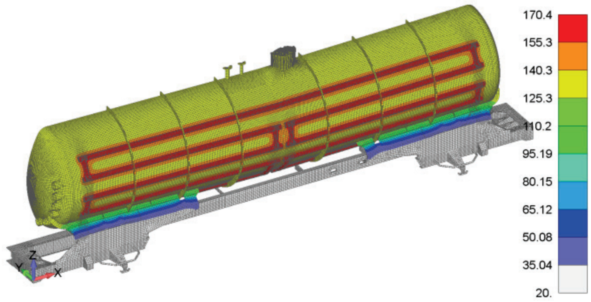

Figure 4. Temperature field – half model of wagon

Von Mises equivalent stress field is presented in Figure 5. Place of maximum value of the equivalent stress is shown in Figure 6.

Obtained stresses in the whole construction are below permissible stress for the static loads [8], [9].

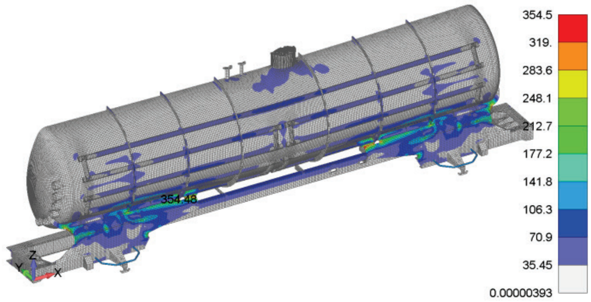

Figure 5. Von Mises equivalent stress field – half model of wagon

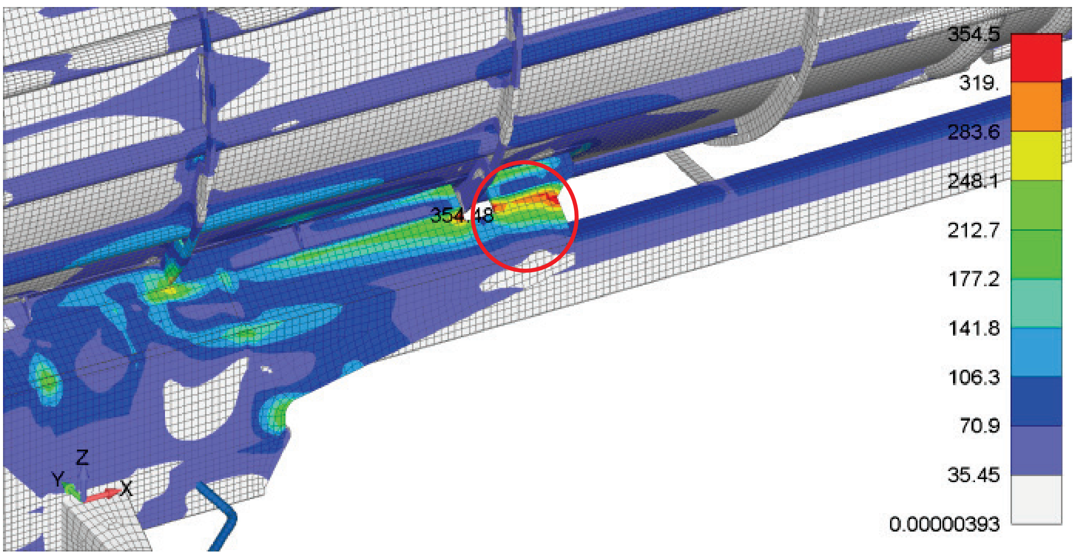

Figure 6. Place of maximum Von Mises equivalent stress

7. Conclusion

The aim of this paper was to demonstrate the possibility of program PAK for solving coupled multiphysics problems. Basic equations for the heat conduction implemented in the program PAK MULTIPHYSICS are presented. Thermo-mechanical analysis of wagon for transportation of molten sulfur is an example of how to successfully solve one practical example that is very commonly found in railway industry.

In this case, the results of thermo-mechanical analysis were used as a test of the reconstruction of the heating system. Based on obtained results and their analysis it can be concluded that the wagon for transport of molten sulfur, with reconstructed medium heating system meets the criteria prescribed by standars.

8. Acknowledgement

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TOPOLOGY OPTIMIZATION USED TO REDUCE WEIGHT OF FOUR-AXLE BOGIE FREIGHT WAGON

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Abstract

The goal of this paper is to show the application of topology optimization for reducing the weight of different types of construction, especially freight wagons. In the first part of this paper a short introduction on optimization techniques is given and characteristics of analyzed model are discussed. In the second section process and results of topology optimization applied on freight, four-axle bogie wagon are given. Final part of the paper includes discussion about achieved results and comments about usefulness of topology optimization.

Keywords: Optimization, topology, wagon

1. Introduction

Maximum speed of freight wagons is limited by the weight of wagons and cargo and their high center of gravity, because the centrifugal forces could cause derailing in short radius curves [1]. In order to have a competitive product in an ever demanding market, engineers must pay attention to weight reduction during design process, which lowers wagon center of gravity, material used, and unit production price [2]. Before exploitation starts, wagons must satisfy rigorous safety standards [3]-[6]. Numerical methods such is the Finite Element Method (FEM) are used to test various shape configurations, and wagon response to different loading condition without need to create prototype which reduces design time and improves overall wagon characteristics [7]. Designers must verify every change they make with a series FEM analysis to check if the new design satisfies all loading conditions prescribed in the standards [3]-[6]. This process can be very tedious, but it can be automated using optimization [8]. Optimization is the process of design improvements by finding best results under given conditions.

In railway industry optimization is not implementted enough, but in recent years, several examples of optimization implementation are published, such is management of freight wagon distribution [9], material selection [10], or composite material design [11]. These examples do not refer to changes of wagon structure, but to the other aspects of wagon design and implementation.

Optimization of wagon structure is given in [12], where parametric optimization is used to reduce freight wagon mass. There are three kinds of structural optimization: parametric (size) optimization (which is presented in [12]), shape optimization and topology optimization which is presented in this paper (Fig. 1)

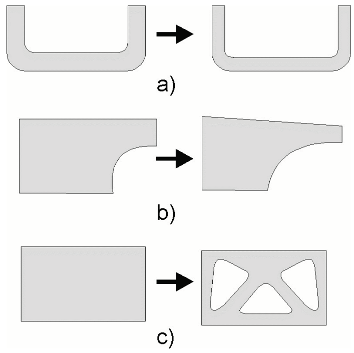

Figure 1. Structural optimization: a) parametric optimization; b) shape optimization; c) topology optimization

Parametric optimization changes only properties of the structures while geometry remains the same [13]. Shape optimization changes dimensions and shape of existing features, and topology optimization implies creation of new features, mostly free shape openings for even stress distribution. Shape and topology optimization are much more complicated and more difficult to implement because it performs changes to object geometry which requires changes in FEM mesh [14] or creating new design analysis model according to which topology optimization is done. Changes of geomerty during topology optimization results in new FEM mesh at the end of the optimization process [15]. In this paper results of topology optimization of freight wagon arepresented. Reduction of mass is achieved by creating and changing geometry of holes that are cut out of the heavy supporting structure where internal stresses are significantly lower than maximum allowed stress defined by mentioned standards.

2. Description of the used model

Wagon analyzed in this paper is freight, four-axle bogie wagon, and it is designed to transport gravel and iron ore. To satisfy condition defined by standards total of 18 analysis using FEM Method are done to confirm static and fatigue strength.

The wagon is modeled using the Femap software with NX Nastran solver, which operates based on the finite element method. According to the construction type, shell elements of the appropriate thickness and 3D elements (for modeling of the support plate, compensating ring, traction stop) were used for creating the finite element mesh. The structure is modeled in details with 236658 elements and 234700 nodes.General element side length is about 35 mm. Figure 2. shows the 3D model of the whole wagon without bogies.

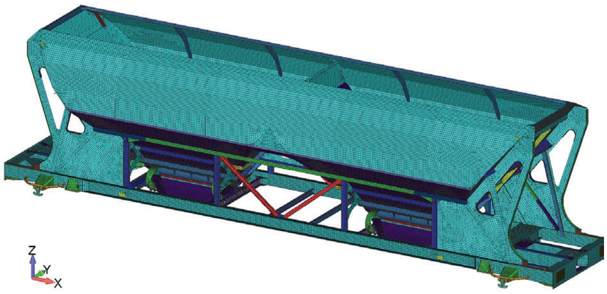

Figure 2. 3D Vehicle model

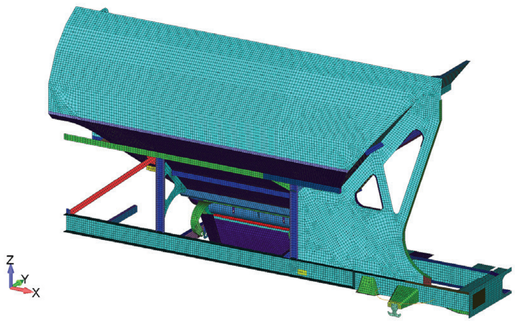

Figure 3. 3D Vehicle model – one quarter

Colours in Figure 2. match the various thicknesses of shell elements. Figure 3 shows a quarter of the model, which will be used, taking in consideration correspondent symmetry of the load cases.

Full model was used for unsymmetrical load cases and a half model for analysis of wagon lifting.

The Models shown on Figure 2. and Figure 3. are final experientially optimized models used for finial analysis and correspond to the real construction. However, the goal of this paper is to show advantages in using advanced software as a tool in engineering practice during problem solving and optimizing the design of products.

3. Topology optimization and its results

Topology optimization is a process of searching for the optimal solution of problem which has one or more constraints involved. Traditional approach to optimization implies a method of trial and error, where engineer relies on his own knowledge and experience. With the application of topology optimization process on optimizing construction of wagons, process itself can be accelerated and more efficient, saving time and reducing the cost of final product. Algorithm of the traditional approach of optimization and software aided approach are shown in Fig. 4.

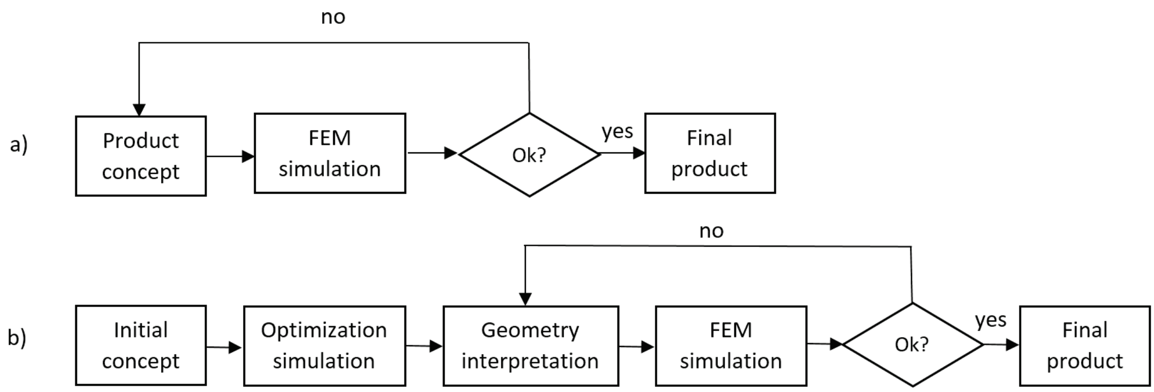

Figure 4. Types of approaches to optimization: a) Traditional approach; b) Software aided approach

Results and principle of study will be shown on one quarter of the wagon due the better visualization and the existence of symmetry. The goal of optimization is the mass reduction because the construction before the optimization exceeded the maximum allowed mass. Initial mesh used for representation of corresponding geometry is shown in Fig. 5.

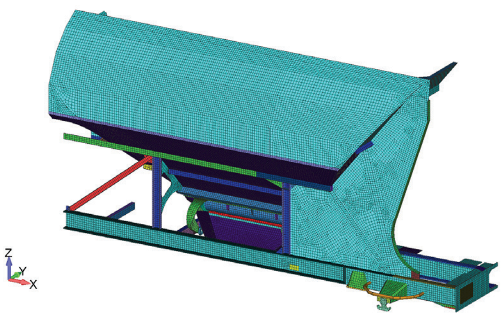

Figure 5. 3D Vehicle model – Initial configuration

The surface shown on figure 6 is chosen as a surface suitable for topology optimization, because it can be seen experientially that there is a large unused area on which, except in some regions, there is no high values of equivalent stress field.

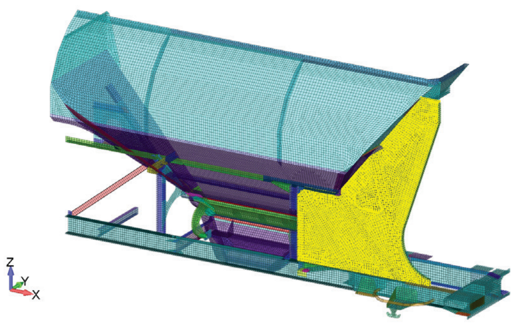

Figure 6. Surface chosen for optimization

When defining the topology optimization parameters, multi set option is used which takes into account existence of all types of loading and all types of constraints.

Volume reduction up to 50% is set as a goal function, while keeping the same stiffness of construction is a constraint. After setting all the parameters, the fallowing results were obtained.

Modified shape of optimized surface in comparison to the initial configuration is shown on Fig. 7.

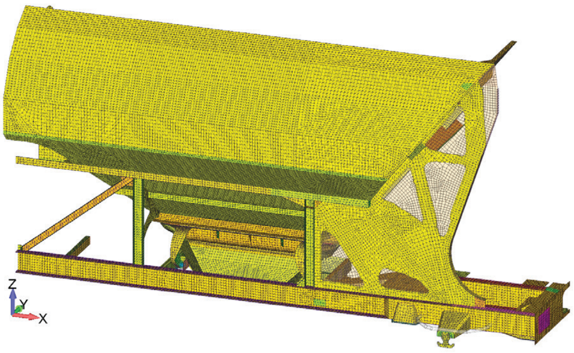

Figure 7. Optimized shape of the chosen surface

Process of topology optimization in NX Nastran is iterative and uses a gradient based algorithm. Function that shows decrease of volume per iteration is shown in Fig. 8.

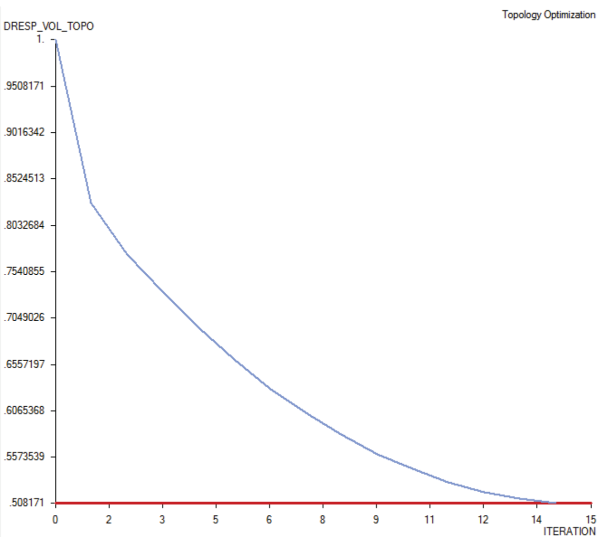

Figure 8. Volume decrease per iteration

From Figure 8. it can be seen that optimizer managed to find optimum of it`s goal function and reduce volume to 50%.

Besides the volume reduction, optimizer had to keep stiffness at the same level or to increase it if possible. The value of stiffness during the iterative procedure of decreasing the volume is shown on Fig. 9. From this figure it can be seen that there were no stiffness reduction, but on the contrary the value of stiffness has increased by 14%. Final optimizer suggested model is shown on Fig. 10.

From Figure 10. it can be seen that the suggested optimized shape of surface is not ideally technological and for finial construction geometry of new openings must be represented on some more suitable way.

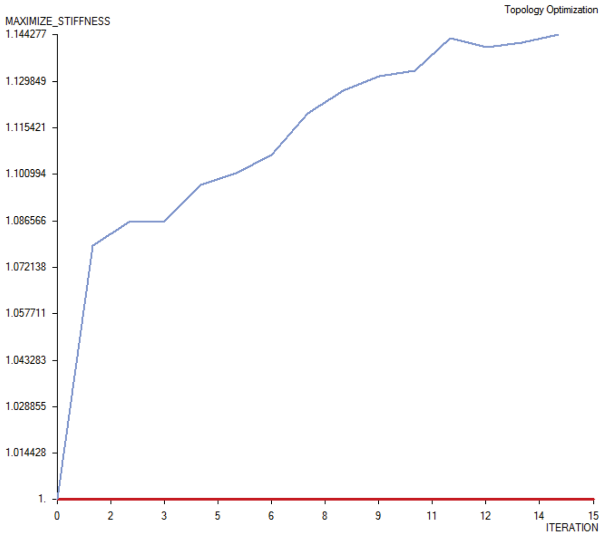

Figure 9. Value of stiffness per iteration

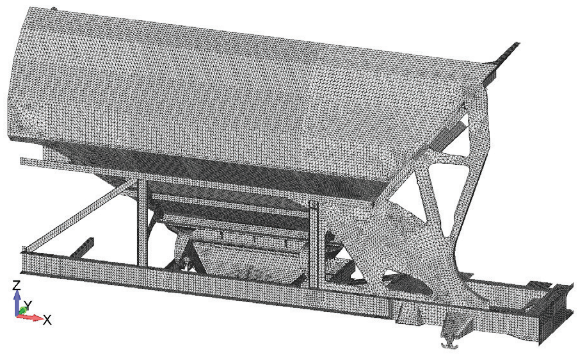

Figure 10. Optimized shape suggested by optimizer

4. Difference between topology optimized and experiential model

Parallel disply of the experientially and topology opimized shape is shown of figure 11.

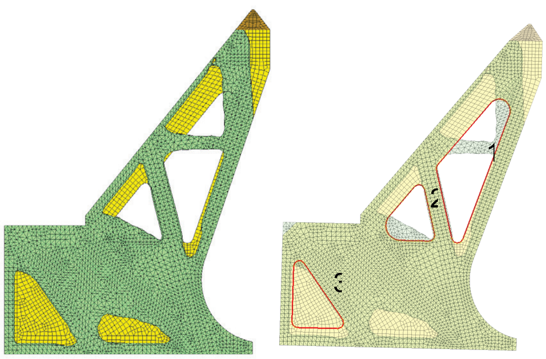

Figure 11. Experientially and topology optimized shape of surface

In Fig. 11 experientially created openings are shown with the red line for better visualization. Opening, labeled with the number 3, is later removed due the customer request, because they planed to put there a panel with description of wagon.

According to the obtained results, it can be seen the big similarity between the experientially and topology opimized shape. Positions and size of openings in both cases are approximately the same. The biggest difference is in time spent on getting the satisfactory results. Time used for topology optimization is much less than time spent for trial and error method. Savings in the mass are given in Tab. 1.

Table 1. Mass of the optimized surface

Initial configuration [kg]	Topology optimized [kg]	Experientially Optimized, [kg]
122.21	69.08	89.6

It can be seen from Table 1 that saving of 26.68% is achieved in the final configuration. The difference in mass on one quarter is 32.61kg and multiplied by 4 is 130.44kg for entire wagon.

5. Conclusion

Reviewing the savings in the mass it can be seen that the total weight of wagon is not significantly reduced by this optimization, nevertheless it should be remembered that this is just one surface optimized with possibility of optimizing much more. In that way of thinking it can be seen that the accumulation of this kind of savings brings to much more weight reduction.

Although once started optimization runs independently from the engineer, validity of results completely depends on the engineer. This is because the parameters of the optimization: goal function, constraints, types of loads, etc. are something that engineer chooses based on his knowledge. The optimizer can not change input parameters or to examine if they are properly chosen by the engineer. Thus, it can be concluded that optimization is useful tool in the process of product design.

6. Acknowledgement

The part of this research is supported by Ministry of Education and Science, Republic of Serbia, Grant TR32036

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ROMANIAN EXPERIENCE IN IMPLEMENTING IIW/EWF MANUFACTURER CERTIFICATION SYSTEM

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1. General

In 1996 the European Federation for Welding, Joining and Cutting (EWF), issued the first harmonized rules for the implementation of the Company Certification System according to the requirements of the EN 729 standard.

EWF has developed a high integrity and specialized certification system to guarantee Manufacturer compliance with ISO 3834. Great care has been taken to detail the interpretation of ISO 3834 in terms of third party assessment, to specify and register properly trained scheme assessors and to devise an operational structure so that certification of Manufacturers will be consistent whenever the scheme rules are applied.

Fabrication by welding is a complex process that cannot be limited to the welding part alone. Therefore, a range of activities needs to be considered and dealt with.

Environmental Management is now a key issue for manufacturing companies. The International Standard EN ISO 14001 ("Environmental Management System – Specification with Guidance for Use") is the key document in this area and systems that comply with this can be integrated with ISO 9001 QMSs.

EWF has recognized this and has also developed special guidelines on Environmental Management "best practices" for companies that use welding as a manufacturing process.

In 2006 a set of documents regarding the EWF Companies Certification System for the Health and Safety Management Scheme were approved.

The harmonized application of the EWF ISO 3834 Certification Scheme is guaranteed by appointing one organization in each country to act for EWF. These organizations, assessed and monitored against specific rules are known as the EWF Authorized National Bodies for Company Certification (ANBCCs) and are responsible for ensuring that the standards of assessment and certification are maintained. In this, the objective is that EWF certified Manufacturers would have demonstrated that they have achieved and identified minimum level of capability over a specified scope of activity, irrespective of the country in which they had been qualified.

In Europe there are 24 ANBCCs implementing the EWF Companies Certification System and more than 600 companies where certified according to this EWF System (11 ANBCC outside Europe).

These rules and guidelines for qualification/ certification of welding personnel and the certification of welded structure Manufacturers have been developed following the principle of mutual recognition, which has been agreed between the International Institute of Welding (IIW) and EWF.

These Rules establish the mechanism by which the Guidelines of IIW are implemented, such that the requirements are applied uniformly by all countries involved, and that the diplomas/certificates granted are mutually recognized. This is done by appointing one organization in each country to act for IIW, and these organizations are assessed and monitored in compliance with the Rules. These organizations are known as the IIW Authorized National Bodies (ANBs)/ Authorized National Bodies for Company Certifications (ANBCCs), and are responsible for ensuring that the qualification/ certification standards are harmonized.

The IIW has delegated all authority for this activity to the International Authorization Board (IAB). This Body consists of a supervisory board and two subsidiary IAB Groups – A and B. The membership of these IAB Groups is restricted to a maximum of two representatives of each existing and applicant ANB.

These Rules are administered on behalf of the Board by IAB Group B – Implementation, Authorization and Certification.

Whereas the Rules follow the general principles of ISO/IEC 17024 latest revision where applicable, ANBs wishing to comply fully with ISO/IEC 17024, for example for the purpose of achieving national accreditation, will need to take further measures than those required by these rules. Similar IAB/EWF Rules and Guidelines apply to the Authorized National Bodies for Company Certification (ANBCCs).

2. Situation in Romania

In the period 1985-2000, in the frame of ISIM Timişoara functioned an assessment group for the certification of manufacturers' capability to execute welded structures according to STAS 11.595-83 "Welding of metals. Evaluation criteria for the capability of welded structure manufacture". The necessity of this certification was stipulated by the order no. 1507/25.01.96 issued by the Ministry of Industries from Romania.

In this period over 100 welded structure manufacturers from Romania were certified according to this standard.

In 2000 the Labor Ministry Order for the certification of welded structure manufacturers was cancelled. Under these circumstances the welded structure manufacturers from Romania asked ISIM to continue this certification activity according to the EN 729 requirements.

Analyzing the situation ISIM chose to create the certification body ISIM Cert 729, on the personnel structure of the certification team for manufacturers.

In 2000, following the assessment of the European Welding Federation (EWF) the new created Romanian Authorized National Body for Company Certification ISIM Cert 729 was authorized for the certification of quality management systems at welding, according to the requirements of EN 729.

In 2005, following the reassessment of the European Welding Federation (EWF), the extension for the certification of environment management systems was also obtained, in accordance with the requirements of EN ISO 14001.

In 2007, with the occasion of the EWF surveillance audit the name ISIM Cert 729 was changed in ISIM Cert. This was necessary because EN 729 was cancelled, being replaced by EN ISO 3834. In the same context the quality management system of the body was reviewed and updated according to the requirements of EN ISO 3834.

ISIM Cert was the first body, within EWF, authorized to realize the certification of manufacturers according to the requirements of EN ISO 3834.

At the end of 2014 more than 120 welded structure Manufactures were certified by ISIM Cert, according to EN ISO 3834.

The welded structure Manufacturers certified were mainly from Romania but included also countries as Israel, Republic of Moldova, Serbia and Bulgaria.

Figure 2 and 3 present the structure of the certificates issued to the manufacturers at the beginning of the activity, in 2001, compared to 2014.

INTERNATIONAL INSTITUTE OF WELDING

Having satisfied the requirements of the IIW Manufacturer Certification Scheme for the Management of Quality in Welding

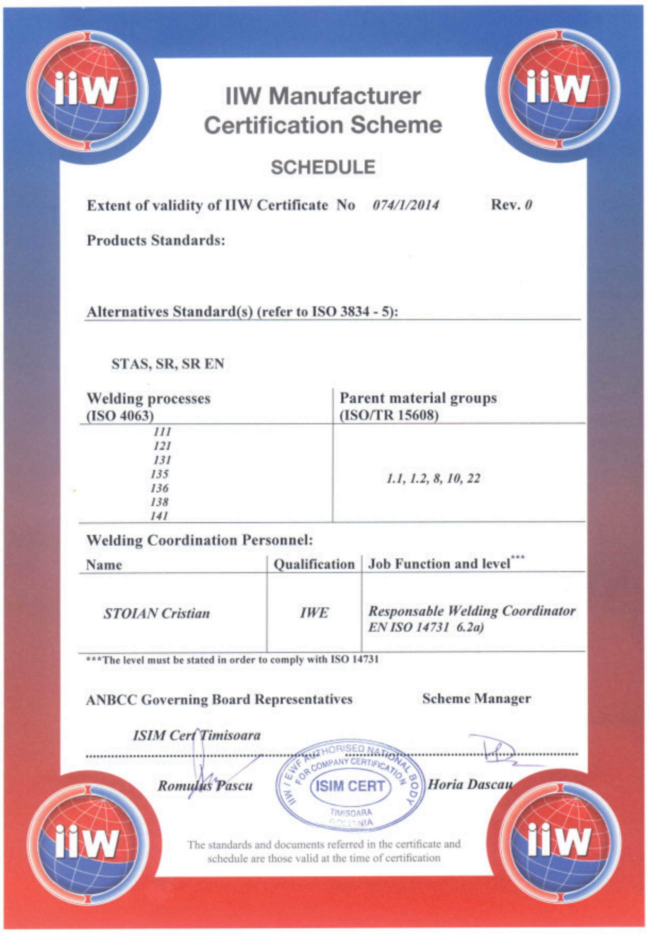
The Unit: SC PRESSAFE S.R.L.
Located in: 307200 Ghiroda, Str. Caprioarei, nr. 3
Company: SC PRESSAFE S.R.L.
is certified in accordance with

ISO 3834 Part 2 - Doc. IAB 340

for the product(s):
Pressure Vessel & Metallic Structures
with the scope of work stated in the attached Schedule
Certificate number and revision status: 074/1/2014 rev. 0
First issue date: 18/11/2014
Current issue date: 18.11.2014
Date of expiry: 17/11/2017

ANBCC Governing Board Representative — ISIM Cert Timisoara — Romulus Pascu
Scheme Manager — Horia Dascău

This Certificate is subject to the rules established by IIW for the certification of Companies



IIW Manufacturer Certification Scheme

SCHEDULE

Extent of validity of IIW Certificate No 074/1/2014 Rev. 0

Products Standards:

Alternatives Standard(s) (refer to ISO 3834 - 5):

STAS, SR, SR EN

Welding processes (ISO 4063)	Parent material groups (ISO/TR 15608)
111, 121, 131, 135, 136, 138, 141	1.1, 1.2, 8, 10, 22

Welding Coordination Personnel:

Name	Qualification	Job Function and level***
STOIAN Cristian	IWE	Responsable Welding Coordinator EN ISO 14731 6.2a)

***The level must be stated in order to comply with ISO 14731

ANBCC Governing Board Representatives — ISIM Cert Timisoara — Romulus Pascu
Scheme Manager — Horia Dascau

The standards and documents referred in the certificate and schedule are those valid at the time of certification

Figure 1. Sample of an issued EN ISO 3834 certificate

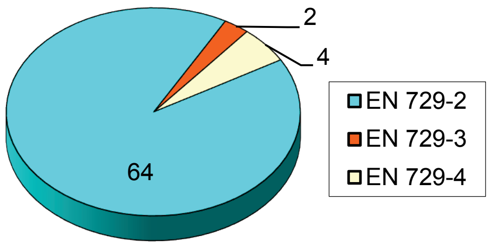


Figure 2. Number of manufacturers certified according to EN 729 in 2001

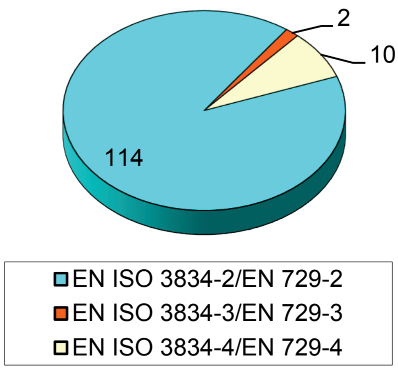


Figure 3. Total number of certified manufacturers according to EN ISO 3834/ EN 729

The EN ISO 3834/EN 729 certified Manufacturers are acting in different industrial sectors such as: metallic construction, petrochemical, machine building, railway, hydro-mechanical construction etc. In the figures 4 and 5 we detailed the sectors of the certified manufacturers; this enabled us to have a clearer view of the sectors mainly interested. The presentation was again realized in a comparative manner, having in mind the starting year of 2001 and the end of 2014.

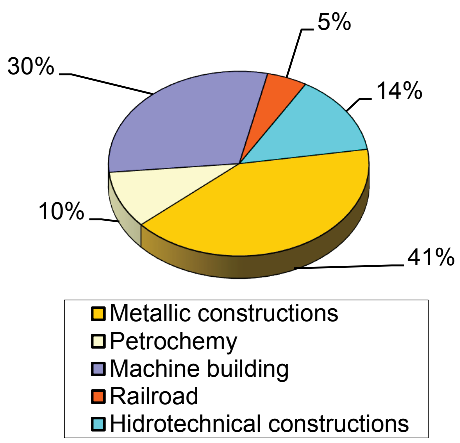


Figure 4. Industrial sectors of the certified manufacturers in 2001

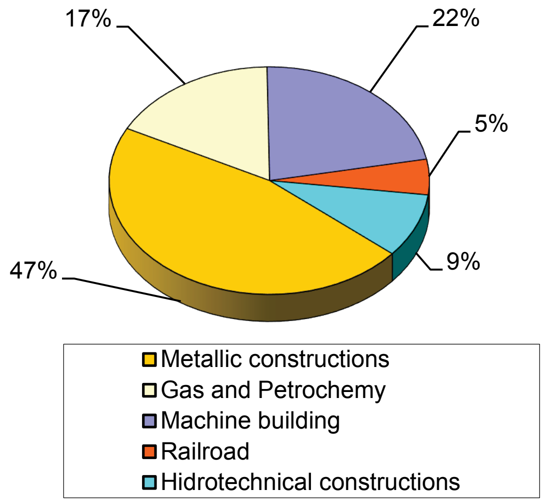


Figure 5. Industrial sectors of the certified manufacturers in 2014

From the moment of joining the European Union we observed an increase in the number of welded structure Manufacturers who wished to implement and certify a quality management system in welding, certified in a harmonized way by ISIM Cert as IIW/EWF Authorized National Body. This increased request for certification of Manufacturer quality systems was due of the necessity to prove, in a harmonized way, the quality increase of the offered products and services, in order to be more competitive on a stronger concurrent market.

3. Conclusion

The development in Romania of the European Welding Federation (EWF) unitary and harmonized certification system of the welded structures manufactures can be considered as a success. This system was implemented also within the International Institute for Welding (IIW), and is now available to all IIW member countries. Romania was one of the first countries that started to implement this system.

At the present moment ISIM Cert has a well established position on the Romanian market, with an increasing trend. The number of certified manufactures by ISIM Cert is one of the greatest in the IIW/EWF member countries that joined the system. ISIM CERT started the process to be able to offer the certification according to EN 1090 to welded structure Manufacturers. This is a must, in an environment where the certification process enables an increased access to contracts and a much faster development.

3D PROFILING OF 12Cr HEAT RESISTANTE STEEL CHARPY V NOCH FRACTURE SURFACES OBTAINED AT DIFFERENT TEMPERATURES

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Abstract

Characterization of metal degradation after prolonged service is necessary for evaluating component exhaustion and its remaining service capability. Martensitic steel X20CrMoV 12.1 has been extensively used as a material for tubing systems and pipelines in thermal power plants. This paper compares data provided by two imaging techniques. Following tests were performed: impact testing at different temperatures and characterization of fracture surfaces of Charpy specimens by scanning electron microscope and 3D digital optical microscope. In this study three new geometrical characteristics were established, as a measure of the ductility change of material.

Keywords: heat resistant steel, microstructure, impact toughness, SEM, 3D microscope

1. Introduction

The service life of thick-walled power plant components exposed to creep, as is the case with pipelines of fresh- and re-heated steam, depend on the exhaustion rate of the material [1].

Steel X20CrMoV 12.1, has been widely used since the 1960s for steam pipelines as well as for other thick section components at a temperatures up to 565°C. The mechanical, creep, and fracture properties of X20CrMoV 12.1 steel depend strongly on the microstructure, which in turn depends on the chemical composition, casting, and cooling processes as well as on thermo-mechanical treatment, [2].

It is well known that many important components in power plants are exposed to material properties degradation under the service conditions. Some of the steam pipelines made of X20CrMoV 12.1 steel have been in service more than 30 years, and as a result degradation of mechanical properties and microstructures has occurred. To evaluate the remaining service life of those pipelines, it is important to examine their mechanical behavior and microstructural stability [1, 3-5]. Characterization of metal degradation after prolonged service is necessary for evaluating component exhaustion and its remaining service capability. This paper presents some results of comprehensive investigation carried out on the thick wall component (part of fresh steam pipeline) made of X20CrMoV 12.1 steel, after more than 170.000 h of service at operating temperature of 545°C and operating pressure of 19MPa. [1].

The main idea of this paper is to provide additional data about characterization of fracture surfaces of Charpy V notch impact specimens tested at different temperatures, as a background for estimation of metal degradation after prolonged service, necessary for evaluating component exhaustion and its remaining service capability.

This paper compares data provided by two imaging techniques for the characterization of fracture surfaces on microscopy, including scanning electron microscopy (SEM) and 3D digital optical microscopy. 3D digital optical microscope as non-contact technique provide roughness information of parts of the fracture surface by processing a sequence of images taken of the sample surface at pre-selected focus intervals into a single in-focus image [6].

Results of 3D profiling of Charpy specimens obtained at different temperatures provided additional information about material ductility and component exhaustion due to prolonged service at high temperature and static loading and low cyclic loading.

2. Material and experimental procedures

The investigated samples were taken from the connected pipe of main steam gate valve (MSGV) in the vicinity of main steam pipeline welded joint. Valve and connected pipe are made of X20CrMoV 12.1 steel welded with matching filler material [3].

Chemical composition of the same investigated samples, other mechanical characteristics (tensile properties at room temperature and at 550°C, impact test at temperature range -20°C up to 100°C and hardness values) and detailed energy-dispersive X-ray spectroscopy (EDS) analyses, as well as more details about specimen position and preparation are presented in previous study [5].

The MSGV with connected pipe and connected welded joint are shown in Figure 1a, while scheme of base material sampling is shown in Figure 1b, [1].

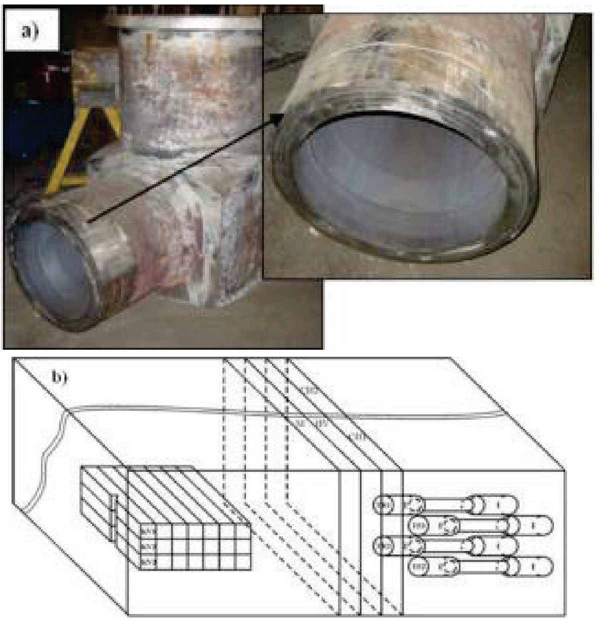


Figure 1. a) Main steam gate valve and sampling zone on connected pipe in vicinity of welded joint; b) Scheme of sampling [1].

Following tests were performed on specimens of base material: a) full size Charpy V notch impact specimens are tested in accordance with the EN 10045-1, i.e. ASTM E23-95 on the instrumented Charpy machine Schenck Trebel 150 J at -20°C, 20°C, 60°C, and 100°C (KV); b) Examination of fracture surfaces of Charpy V notch impact specimens by scanning electron microscope (SEM; type JEOL JSM-6460LV) and by 3D digital optical microscope (HIROX KH-7700). For SEM observation, specimens were polished and etched with 4% picric acid in ethanol.

3D digital optical microscope used in this study is an optical inspection microscope used to image objects with rough surfaces or irregular topology, do optical comparisons, measure feature sizes in 2 dimensions and view objects from multiple perspectives. The optics is optimized for digital imaging, and it has a significantly larger depth of field than conventional optical microscopes [7]. A 50x–400x lens (Hirox MX(G)-5040Z zoom lens with mid-range adapter) was used; this lower magnification allows a wider range of velocities (0.1–100 μm/s) to be tracked. Data processing was carried out using 3D profilometry software [6]. The same 3D equipment has also been previously used to create 3D images of surfaces that are exposed to wear and tear [6, 8].

Different geometrical characteristics and criterion, such as the lateral expansion (CVLE) of the Charpy V specimen on the side opposite the notch [9,10] and lateral contraction, have been already used as "ductility" parameters for the required increase in energy to resist the propagation of fractures when the yield strength of the material is increased [11] and also for determination of the ductile to brittle transition (DBT).

The analyses of the 3D profile of fracture surfaces of Charpy V notch impact specimens presented in this paper have provided background for establishment of particular geometrical characteristics of fracture surface profile as a measure of the ductility change of Charpy specimens.

In this study three new geometrical characterristics were established: a) The angle of inclination of the specimen edge (α), b) The maximum height of the specimen edge (h) and c) The distance between specimen edge and the deepest crater, as shown in Figure 2.

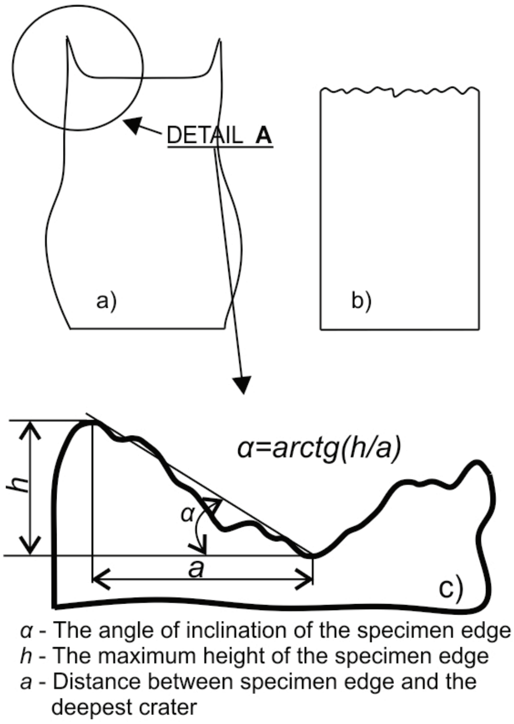


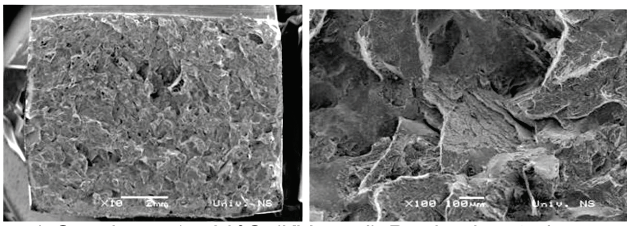
Figure 2. Geometrical characteristics of fracture surface profile as a measure of the ductility of the Charpy V specimen: a) Typical view of the ductile broken Charpy V-notch specimen with noticeably overshoot at the edge close to the notch; b) Typical view of the brittle broken Charpy V-notch specimen without overshoot at the edge; c) Schematic view of geometrical characteristics.

3. Result and discussion

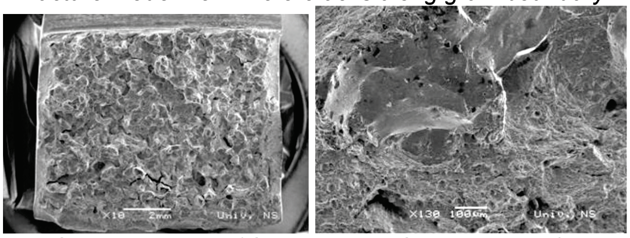
Results of the microstructure examinations carried out on the SEM in the previous study and not shown here, revealed that material microstructure is composed of the lathe martensite and carbide precipitated on the former austenite grain boundaries and on the boundaries of the tempered martensite laths [1].

Results presented in the paper cited above also indicate that samples taken from the MSGV connection pipe made of the X20CrMoV12.1 steel have satisfactory mechanical properties (hardness and tensile properties) and also do not have significant microstructural changes (still tempered martensite), after prolonged service (170.000 h).

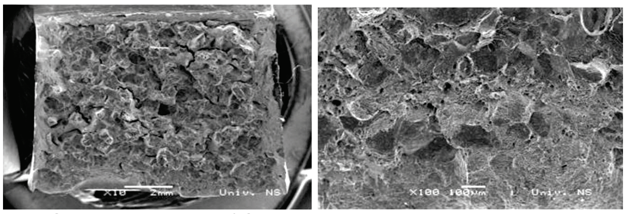
The SEM micrograph of fracture surface of the impact testing specimens (No. 1-4) at different temperature (-20°C up to +100°C, step 40°C) were examined in order to identify the fracture mode and characteristic changes in fracture features caused by temperature changes, Figure 3.



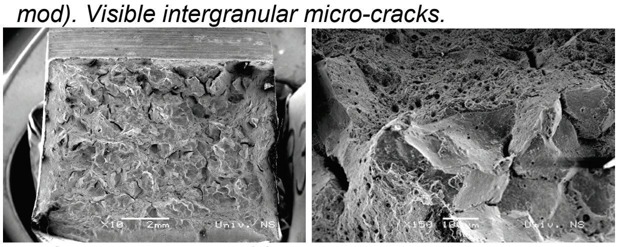
a) Specimen 1. -20°C (KV = 7J) Predominant cleavage fracture mode. Few micro-cracks along grain boundary.



b) Specimen 2. +20°C (KV = 24J) Combination of transgranular cleavage fracture and ductile fracture with microvoid coalescence. Visible larger number of intergranular micro-cracks.



c) Specimen 3. +60°C (KV = 48J) Microvoid coalescence and quasi cleavage (transgranular and intergranular mod). Visible intergranular micro-cracks.



d) Specimen 4. +100°C (KV = 60.6J) Microvoid coalescence and transgranular cleavage fracture.

Figure 3. Fracture surfaces of Charpy V notch specimens (1-4) at different temperatures.

It was found that ductile to brittle transition temperature for this set of specimens made of X20CrMoV 12.1 steel is 30°C [3]. The relatively low impact toughness values - KV (shown in Figures 3a-d) for all specimens and relatively high ductile to brittle transition temperature (30°C) clearly indicates on the significant level of material exhaustion as a consequence of long-term service (170.000 h). The same result for X20CrMoV 12.1 steel has been reported by [12].

At a given carbon content, toughness of martensitic steel depend on the level of chemical impurities such as phosphorous, sulphur and nitrogen as well as the presence of coarsened carbides in the grain boundaries during long-term exposed service at high temperature [13], due to weaken cohesion strength of grain boundaries.

SEM characterization of fracture features indicate on fracture mode transition with temperature increase. The appearance of cleavage, which is a signature of a significant brittleness, (specimen 1, KV = 7J, “low” value) is particularly evident in the case of -20°C, Figure 3a. A few micro-cracks along grain boundary are also visible.

With increasing temperature there is a change in fracture mode from completely brittle mode at -20°C to mix mode at higher temperatures.

The general fracture appearance for specimen 2 at 20°C is combination of transgranular (TG) cleavage fracture and ductile fracture with microvoid coalescence (MVC), as shown in Figure 3b (specimen 2). This type of distinctive mixed fracture mode with the simultaneous presence of brittle TG fracture features and ductile MVC fracture features corresponds to the phenomenon of ductile to brittle transition (specimen 2, KV = 24J, “intermediate” value) which occurs at a very close temperature (30°C).

Also, an increase number of intergranular micro-cracks on former austenite grain boundaries are noticeable. Macro view and 3D image - profile of intergranular micro-crack is shown in Figure 4.

At a higher temperature (specimen 3, 60°C), an increase in ductile MVC fracture features in the mixed fracture mode (MVC and quasi cleavage – TG and intergranular mode) and intergranular micro-cracks are observed, Fig. 3c. This specimen has relatively high impact toughness: KV = 48J.

Further increase in ductility (specimen 4, KV = 60.6J, “high” value) and ductile MVC fracture with simultaneously decrease in TG cleavage fracture in the mixed fracture mode are evident in the case of specimen 4, tested at the highest temperature (100°C), Figure 3d.

Microvoids during fracture are initiated on different particles, mainly non-metallic inclusions according to EDS analyses [3]. Also, it was reported [4,5,12] that nucleation of voids during creep of the steel with the tempered martensite structure in the initial state may be connected with the material decohesion on the interstitial phase boundary between matrix and particles of the carbide precipitates for fine voids or non-metallic inclusions for larger one. It was observed that the voids nucleate most often on grain boundaries of the former austenite and the martensite lathes with beneficial orientation for crack propagation [1].

The 3D profile of fracture surfaces of Charpy specimen (specimens 1-4) are shown in Figs. 5-8. Based on the results presented in these figures, three new geometric characteristics were measured:

a) The angle of inclination of the specimen edge, α,
b) The maximum height of the specimen edge, h,
c) The distance between specimen edge and the deepest crater (see Figure 2c).

Geometrical characteristics of fracture surface profile of all tested Charpy specimens at different temperatures obtained by 3D digital optical microscope are shown in Table 1.

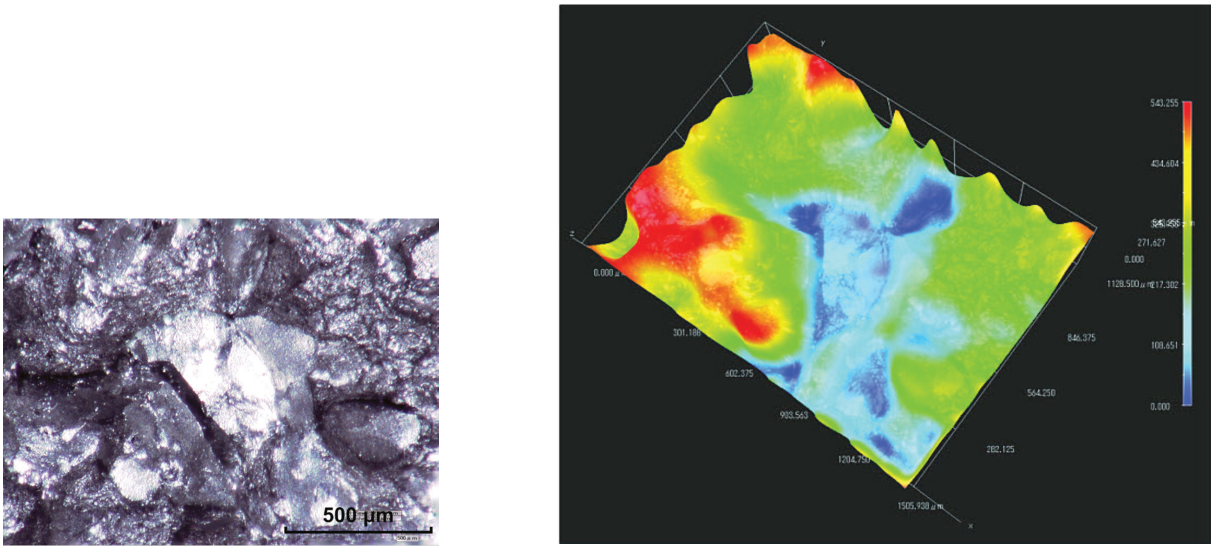


Figure 4. Intergranular micro-cracks, fracture surface of Charpy specimen (20˚C): a) Macro view; b) 3D image and profile (see Figure 3b).

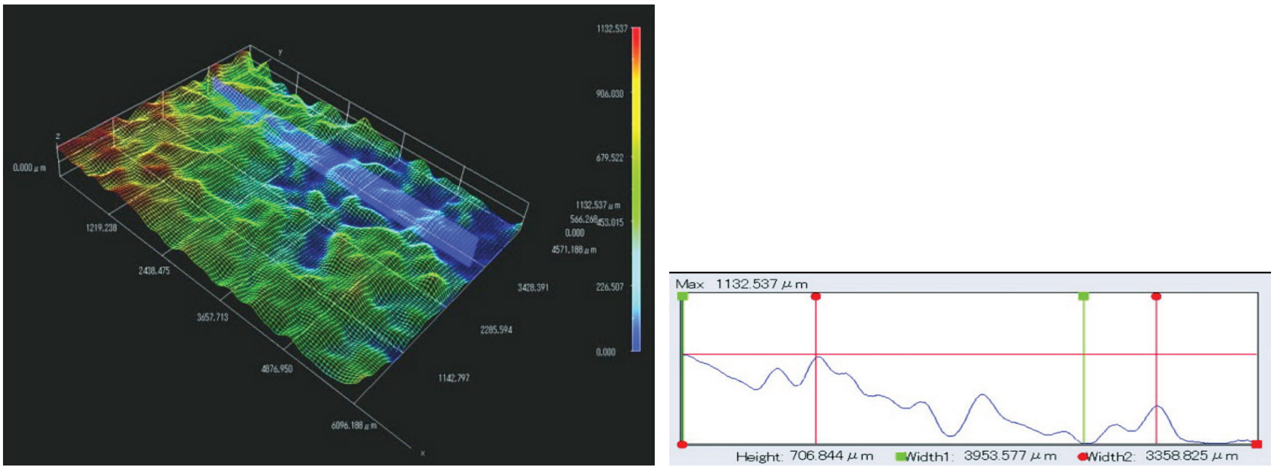


Figure 5. The 3D profile of fracture surface of Charpy specimen 1 (-20˚C).

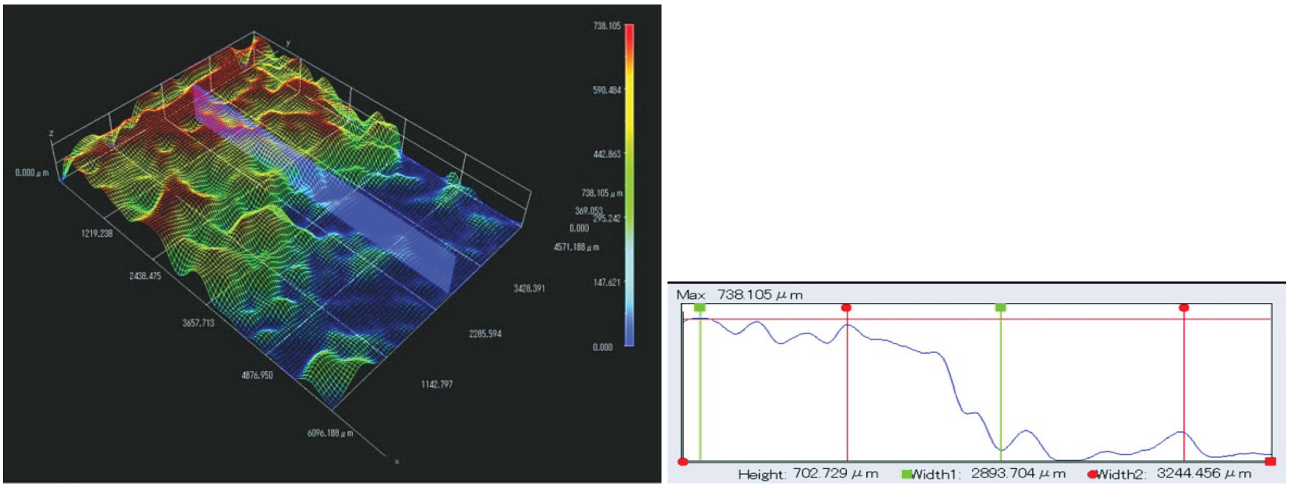


Figure 6. The 3D profile of fracture surface of Charpy specimen 2 (20˚C).

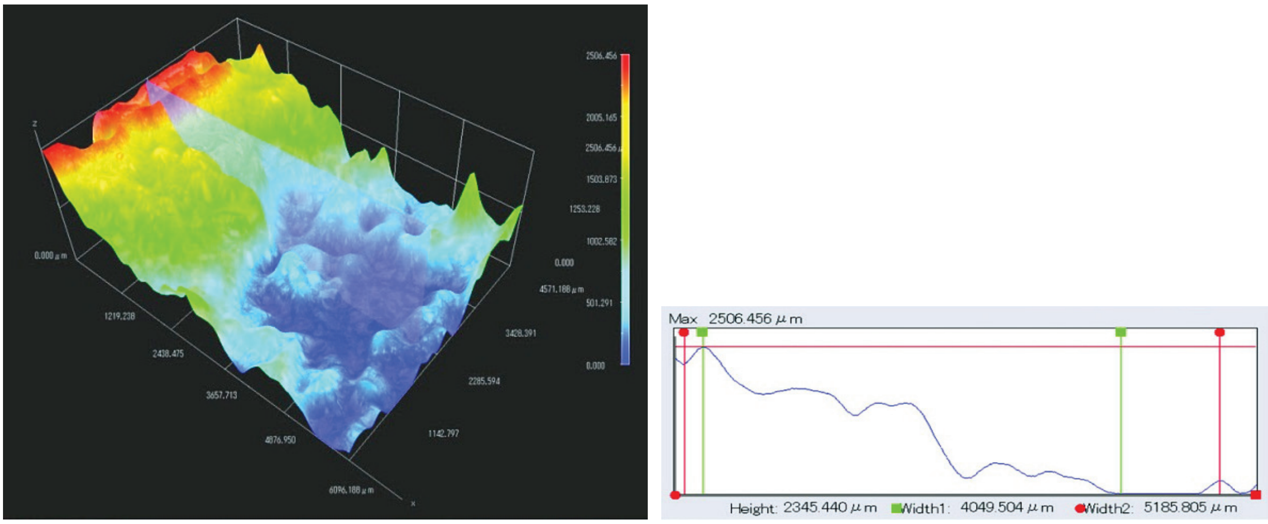


Figure 7. The 3D profile of fracture surface of Charpy specimen 3 (60˚C).

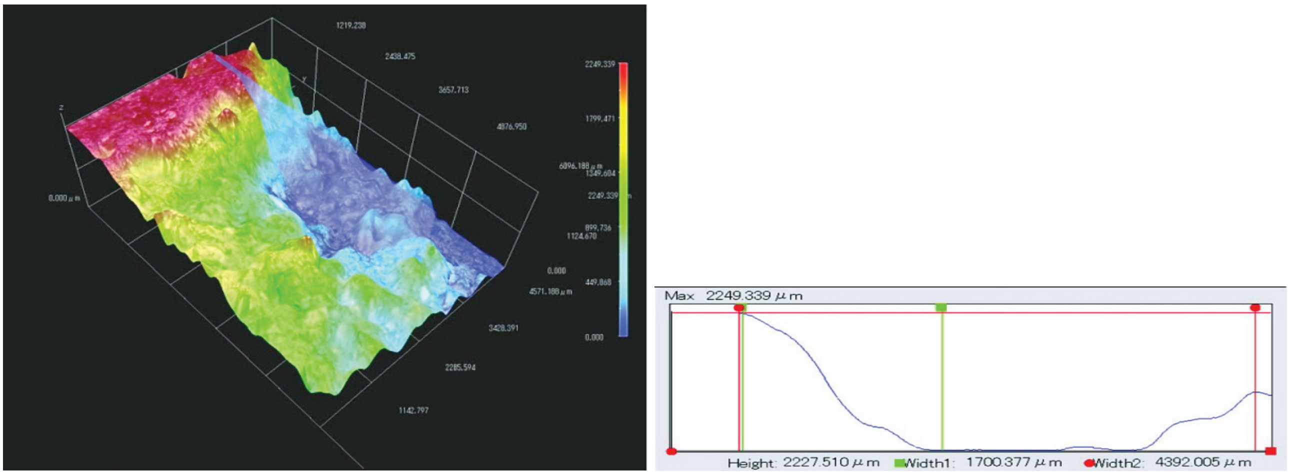


Figure 8. The 3D profile of fracture surface of Charpy V specimen 4 (100˚C).

Table 1. Geometrical characteristics (Figure 2c) of fracture surface profile of Charpy specimens (No. 1-4) at different temperatures, obtained by 3D digital optical microscope.

No.	Temperature, °C	h, μm	α, °
1	-20	764.9	16
2	20	709.5	26.8
3	60	2345.4	22.7
4	100	2227.5	45

Typical view of 3D profile of fracture surface of the ductile broken Charpy V-notch specimen, with noticeably overshoot at the edge close to the notch and increased values of α (see Figure 2a), such as in the case of specimens 3-4, tested at 60°C and 100°C, are shown in Figures 6-8. The 3D profile of fracture surfaces of Charpy specimens 3 and 4 (60°C, 100˚C) have irregular shape, Figures 7 and 8, with the high value of maximum height of the specimen edge (h=2345.4μm; 2227.5μm), Table 1.

The angle of inclination of the specimen edge (α), as a measure of ductility, is the largest in the case of the specimen tested at the highest temperature (α=45°, specimen 4, 100°C), Figure 8 and Table 1.

Typical view of 3D profile of fracture surface of the brittle and mixed mode broken Charpy specimen, without large overshoot at the edge (see Fig. 2b), such as in the case of specimens 1 and 2, tested at -20°C and 20°C, are shown in Fig. 5-6.

The 3D profile of fracture surface of Charpy specimen 1 (-20°) have a smother shape, Fig. 5, with the low value of h=764.9μm and α=16˚C, Table 1.

Variation of geometrical characteristics (see Fig. 2) of fracture surface profile of all Charpy specimens at different temperatures are shown in Fig. 9.

Variation and drop of both geometrical characteristics (h and α) of fracture surface profile of Charpy specimens, as a function of the temperature, clearly indicates a substantial decrease in ductility when temperature decrease, Fig. 9. Both geometrical characteristics, indicating ductile behavior of material, decreases with temperature decrease. These trends and the slopes of h(α)–temperature curves seems to correspond fairly well to the typical variation of impact toughness values and ductile to brittle transition phenomenon with temperature decrease.

A sharp drop in α at 20°C (reduced by a factor of two) and especially h (reduced by a factor of three) are a consequence of ductile to brittle transition phenomenon and a high transition temperature (30°C) [1, 3].

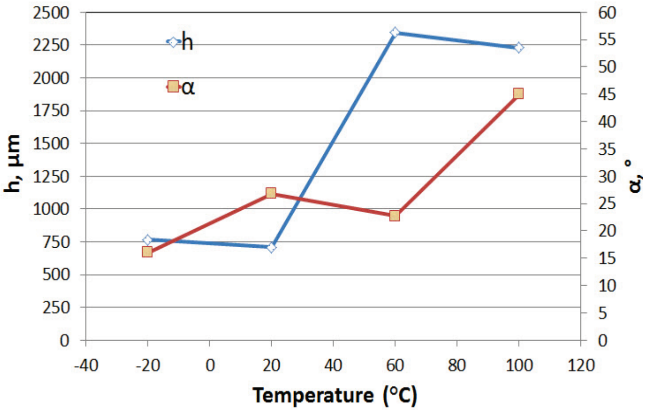


Figure 9. Variation of the geometrical characteristics (see Figure 2) of fracture surface profile of Charpy specimens at different temperatures.

4. Conclusions

This paper deals with the comprehensive investigation carried out on the main steam gate valve parent material (X20CrMoV 12.1 steel), after 170.000 h of service. The principal observations provided by two imaging techniques for the characterization of surfaces: SEM and 3D digital optical microscope are:

1. Relatively low values of impact toughness and increase of brittle fracture temperature clearly show most significant change in material after long-term service.
2. The analyses of the 3D profile of fracture surfaces of Charpy specimens have provided background for establishment of particular geometrical characteristics, as a measure of the material ductility change and could be useful tool in fractography analysis.
3. Variation and drop of both geometrical characteristics (h and α) - "ductility" parameters, as a function of the temperature, clearly indicates a substantial decrease in ductility when temperature decrease.

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ANALYTICAL AND NUMERICAL CALCULATION OF THE EQUIVALENT STRESS OF OPEN SECTION THIN-WALLED "U" PROFILE AT CONSTRAINED TORSION

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Abstract

The purpose of this work is to present analytical and numerical determination of the equivalent stress of the open section thin-walled "U" profile subjected to the constrained torsion. This work can be divided into two parts. In the first part of this paper equivalent stress was obtained with analytical calculation. In the second part the finite element method was applied for calculation of equivalent stress. At the end, the results of analytical method were compared with numerical method.

Keywords:

Thin-walled beam, "U" profile, equivalent stress, torsion, constraints, strain

1. Introduction

Thin-walled beams find a wide application in construction and machinery industry, as they enable obtaining any shape of the beam cross-section. Due to their low weight, thin-walled open section beams are widely applied in many structures. Many modern metal structures are manufactured using thin-walled elements (shells, plates, thin-walled beams) which are subjected to complex loads [1]. In most constructions such as, for example, automotive, railway vehicles, boats and similar constructions, they are installed in thin-walled elements. Thin-walled elements can be disparate shapes, can have greater or lesser bending and torsional rigidity, but their common property is that they have a low weight compared to other possible constructive shapes [2,3].

2. Analytical calculation

Analytical calculation of the equivalent stress of the open section thin-walled "U" profile was performed according expressions (1)-(14). Properties of material used in this paper are given in Table 1.

Table 1. Properties of Č 0360

Materials	Young's modulus	Poisson's ratio
Č 0360	$20000\,\mathrm{kN/cm^2}$	0,3

Cross section of the thin-walled „U" profile is given in *Figure 1.* , where the flanges $b_1=b_3=8$[cm] and the web $b_2=10$[cm] are widths and $t=0,3$[cm] is thickness of this profile.

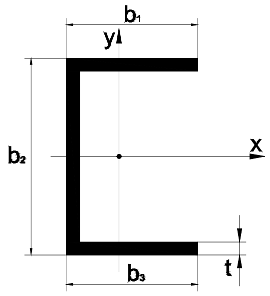

Figure 1. Cross-section U-beam

Area size of the "U" cross-section was calculated using the expression [3]:

$$A = \sum_{i=1}^{3} b_i t_i = 2b_1 t_1 + b_2 t_2 \tag{1}$$

Moments of inertia of the cross-sectional area about the centroidal axes x and y are given by expression [3]:

$$I_x = \sum_{i=1}^{3} t_i \int y(s) y(s)\, ds = \frac{b_1 b_2^2 t_1}{2} + \frac{t_2 b_2^3}{12} \tag{2}$$

$$I_y = \sum_{i=1}^{3} t_i \int x(s) x(s)\, ds = \frac{t_1 b_1^3}{3} \cdot \frac{1+2\lambda}{2+\lambda} \tag{3}$$

Sectorial moment of inertia is given by expression [3]:

$$I_\omega = \int_A \omega^2 dA = \sum_{i=1}^{3} t_i \int_S \omega(s)\omega(s)\, dS \tag{4}$$

Torsional moment of inertia is given by expression [3]:

$$I_t = \frac{\eta}{3} \sum_{i=1}^{3} b_i t_i^3, \tag{5}$$

where η is cofficient of safety.

Torsional section moduli is given by expression:

$$W_t = \frac{I_t}{t_{\max}} \tag{6}$$

Schematic representation of constrained torsion of the console is given in *Figure 2.*

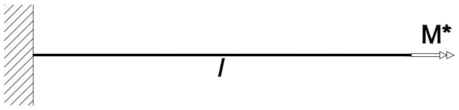

Figure 2. Constrained torsion of the cantilever beam

Console is loaded with a torsion moment according to the expression:

$$M^* = 31{,}4\left[\text{kNcm}\right] \tag{7}$$

The reduced Young's modulus is given by expression:

$$\overline{E} = \frac{E}{1-\nu} \tag{8}$$

The bending – torsional characteristic is given by expression [3-5]:

$$k = \sqrt{\frac{GI_t}{\overline{E}I_\omega}} \tag{9}$$

Bi-moment and the maximum normal stress are given by expressions (10) and (11), respectively [3]:

$$B_{\max} = -\frac{M^*}{k} th\left(kl\right) \tag{10}$$

$$\sigma_{\max} = \frac{B_{\max}}{I_\omega}\omega_{\max} \tag{11}$$

In the case of loads by concentrated torsion moment on the free end of the console, moment of pure torsion on the free end is given by expression [3]:

$$M_{t\max} = M^*\left(1 - \frac{1}{ch\left(kl\right)}\right) \tag{12}$$

Shear stress is given by expression:

$$\tau_{\max} = \frac{M_{t\max}}{W_t} \tag{13}$$

In the case of a complex load (normal stress and the shear stress are taken together in the calculating), can be define the equivalent stress that is calculated by the Hencky-Mises hypothesis [6]:

$$\sigma_e = \sqrt{\sigma_{\max}^2 + 3\tau_{\max}^2} = 31{,}111\frac{\text{kN}}{\text{cm}^2} \tag{14}$$

3. Numerical analysis using finite element method

Calculations were performed using the Finite element method [7]. The material properties used for the simulations are shown in *Table 1*. Numerical simulations [7,8] were performed using ABAQUS and KOMIPS software .

First, the analysis was done in the software package ABAQUS, and then in the software package KOMIPS and finally this numerical results were compared with analytically obtained results.

Model was composed of a plates. All dimensions of plates are given in centimeters. The best results are obtained with a given mesh of finite elements. Generated finite element mesh model of "U" profile, in ABAQUS software, is shown in *Figure 3.*

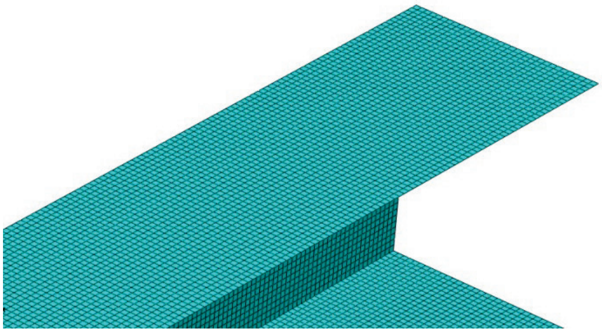

Figure 3. Mesh of finite elements on the model of "U" profile

Constraint, i.e. boundary condition was encastre at the one end of the beam. The torque is represented by the couple produced by two parallel horizontal forces introduced at the free end of the cantilever beam.

Boundary condition and load of model of "U" profile in software ABAQUS are given in *Figure 4.*

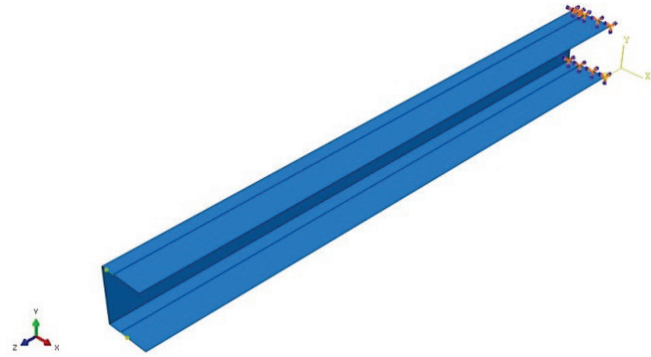

Figure 4. Load and boundary conditions

Figure 5 shows the values of the equivalent stress. The maximum value of the stress occurs at the last finite element. The displayed stress values are given in kN/cm^2.

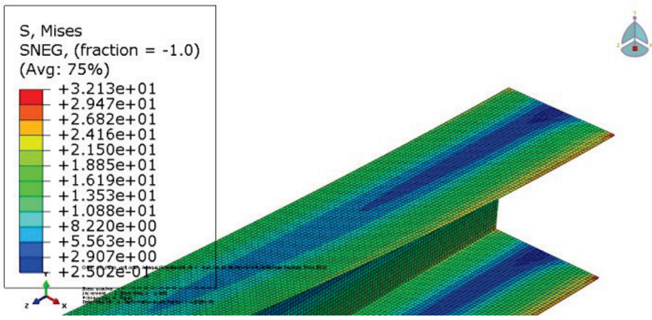

Figure 5. Values of the equivalent stress software package ABAQUS

In Figure 6 the finite element is marked at the end of the considered cantilever thin-walled beam of the chosen shape. In this finite element the value of stress $\sigma_e = 32{,}13\left[\frac{\text{kN}}{\text{cm}^2}\right]$ corresponds to analytically obtained values.

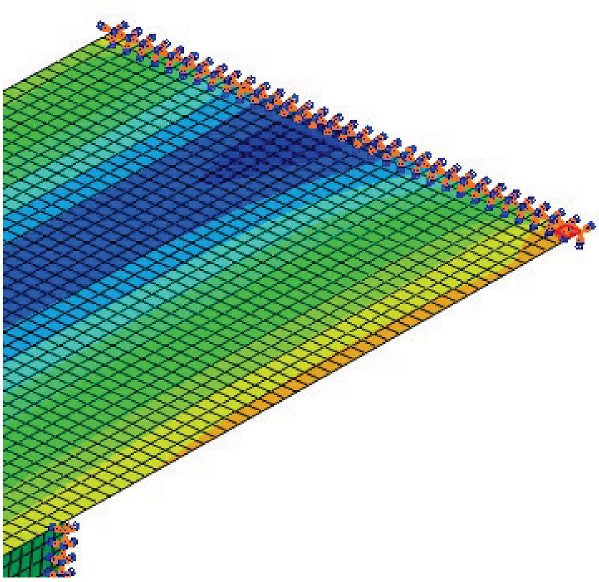

Figure 6. Equivalent stress of the finite element at the end of flange

The numerical calculation was made in software package KOMIPS [7] to verify the results obtained with the analytical calculation and numerical analysis in the software ABAQUS.

Figure 7 shows the constraint, i.e. boundary condition was encastre at the one end of the beam. The torque is represented by the couple produced by two parallel horizontal forces introduced at the free end of the cantilever beam in the software package KOMIPS [7]. The mesh of finite elements on the model of "U" profile is also given in *Figure 7.*

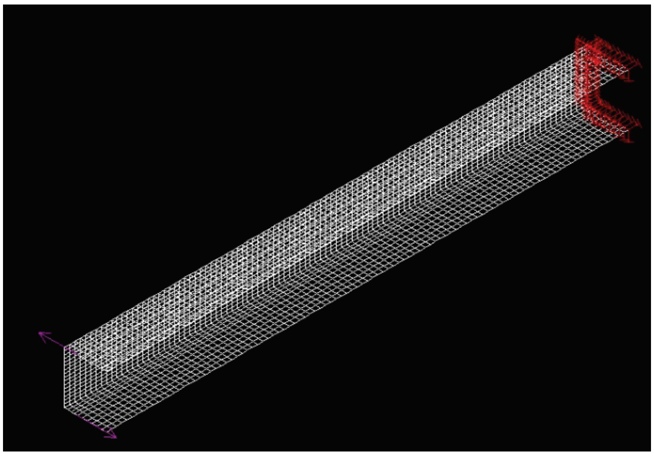

Figure 7. Load, boundary condition and mesh of finite elements in software package KOMIPS

Figure 8 shows the values of the equivalent stress. The maximum value of the stress occurs at the last finite element.

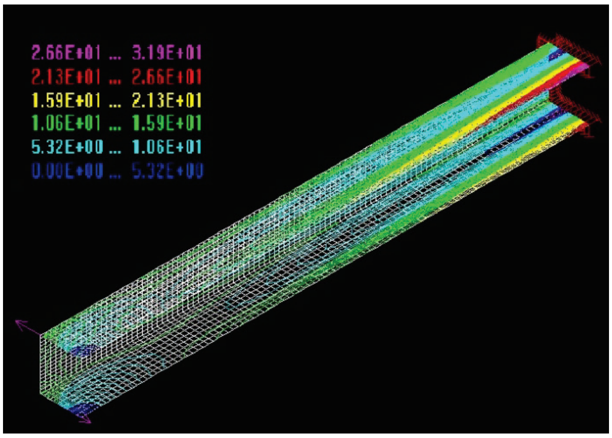

Figure 8. Values of the equivalent stress in software package KOMIPS

In Figure 9 the finite element is marked at the end of the considered cantilever thin-walled beam of the chosen shape. In this finite element the value of stress $\sigma_e = 31{,}19\left[\frac{\text{kN}}{\text{cm}^2}\right]$ corresponds to analytically obtained values.

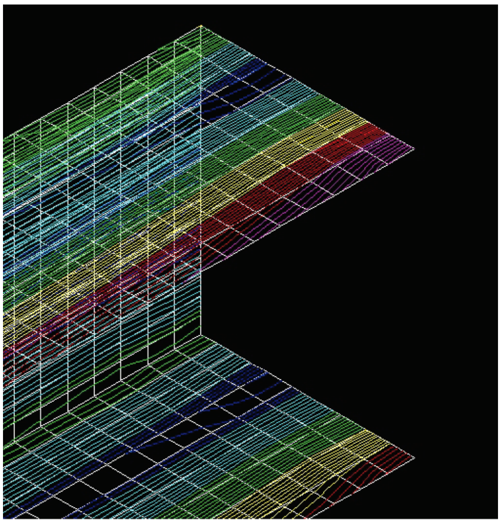

Figure 9. Equivalent stress finite element at the end of the flange

4. Conclusion

The paper shows that the equivalent stress obtained by numerical analysis using finite element method has approximately the same value like equivalent stress obtained with analytical calculation.

Also, it has been shown that using the two different softwares obtains approximately the same values of equivalent stress. Accuracy of results depends on the choice of the finite elements mesh.

It should be noted that the finite element method clearly shows where exactly the maximum value of stress is, and that the value of stress is not the same at the whole cross section.

It is prepared physical model of thin-walled "U" profile and still plans to experimentally test this profile. It is also plan to comparing the experimental results with the previous three calculations.

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CERTIFICATION AND QUALIFICATION OF NDT PERSONEL, WELDERS AND WELDING INSTRUCTORS IN SERBIA

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Abstract

On the market of The Republic of Serbia there is a growing interest in certification of personnel through a third party. Welding Institute, as a leader in welding and non-destructive testing in Serbia has recognized these needs of the market and formed the certification body for certifying personnel, ZAVOD-CERTPers. Three certification schemes are developed, providing certification of welders, welding instructors and personnel for non-destructive testing. At the beginning of 2013, the Accreditation body of Serbia (ATS) has successfully completed assessment of management system of ZAVOD–CERT Pers, in accordance with the requirements of SRPS ISO/IEC 17024. This paper discusses about the current status of certification of: personnel for non-destructive testing, welders and welding instructors in Serbia and also, about the work of certification body- ZAVOD-CERTPers and further, development of certification scheme of personnel for NDT, certification scheme of welders and welding instructors.

Keywords: Accreditation, certification and qualification

1. Introduction

Talking about certification in Serbia it is impossible to not to mention the several important institutions which represent a basic support in that process. These institutions are certainly: Serbian Society for Non-destructive Testing (SDIBR), Institute for Standardization of Serbia (ISS), Accreditation Body of Serbia (ATS) and Welding Institute.

Serbian Society for Non-destructive Testing – SDIBR was formed in 1982 and was the one of the cofounders and members of the Yugoslavian Association of Societies for Non-Destructive Testing. Today, the SDIBR is the only one society in Serbia in this area with 200 active members. This Society assembles: the laboratories, inspection bodies, investors and equipment vendors (representatives of the world brands in NDT area). The SDIBR brings together all interested sides for testing materials with non-destructive methods and with influence to the development and application of new methods.

In 2001 Society became a full member of the European Federation for Nondestructive Testing – EFNDT, and in 2002 accept and include in process ECP EFNDT – European Certification Process with the task as soon as formed and accredited certification body.

After signing of ECP, the Society unsuccessfully attempted to form the certification body and did not succeed because of the voluntary works in Society and constant financial problem. Because of that, in 2009 the Board of Directors decides that Welding Institute forms the certification body, recommending that the only two approved training centers are:

- Welding Institute – Belgrade (for methods: VT, PT, UT) and
- VINCA Nuclear Institute – Center for Permanent Education – Belgrade (for methods: VT, MT, RT)

A reason for this decision was very simple, these two institutions educate the personnel for NDT more than five decades, educated the excellent operators, able to perform the tasks anywhere in the world of industry.

According to International Organization for Standardization – ISO, in the former Kingdom of Yugoslavia, there was an institutionalized form of national standardization. The Institute for Standardization of Serbia is the successor of: Institute for Standardization from 2003 to 2006, Federal Institute for Standardization from 1978 to 2003, Yugoslav Institute for Standardization from 1962 to 1978 and the Federal Commission for standardization from 1946 to 1962.

In accordance with a strategy of Republic of Serbia, The Institute for Standardization of Serbia intensively works on implementation of the European Norms, with the aim of achieving a full membership in The European organization for standardization CEN and CENELEC, and then on implementation of international standards (ISO) and other national standards for which there is an interest.

The implementation of European and international standard in English or some other official language of European organization for standardization, is possibility granted by the law of standardization. However, for users, implementation of standard requirements will be much easier if standards are on Serbian language. The goal is to translate as much as possible, European and international standards.

The President of the board of the certification body in Serbia, ZAVOD-CERTPers is the member of the commission for the NDT standards in the Institute for Standardization of Serbia. President participates in the process of conformity with international and European standards with a possibility of the equal participation in international and European standardization, bringing the national standards and respecting the international and European principles of the standardization.

The Accreditation Body of Serbia (ATS) was established in 1998 under the name, Yugoslav Accreditation Body (JUAT). With a changes in society in Serbia JUAT accreditation activities performed within and out of The Ministry of development, science and environment.

By the decision of founding, The Government of the Republic of Serbia acquired a status of legal entity, independent and non-profit according to the low of accreditation, which began to apply from 01.01.2006. ATS is the only one body in Serbia, whom the law gives the rights to perform the accreditation activities. The accreditation is used to determine the competence of the bodies of conformity assessment to conduct activities of:

- testing
- calibration
- inspection
- products certification
- system management certification
- personnel certification.

In Serbia the accreditation is voluntary, unless the special (sector) laws are established that the accreditation is required. In the accreditation process, ATS uses evaluators which have the appropriate educations, competence and necessary experience in areas which they evaluate, as well as appropriate the trainings for evaluators in a system of accreditation. The hired evaluators and technical experts may be full-time employees in ATS or may be hired as extern evaluators and technical experts.

After signing a global multilateral mutual recognition agreement in 2012 (ILAC MRA) of the International Laboratory Accreditation Cooperation (ILAC) in the field of calibration, testing and inspection, and a multilateral mutual recognition agreement (IAF MLA) of the International Accreditation Forum (IAF) in the field of product certification, the Accreditation Body of Serbia (ATS) continued extending the scope of its activities and signed the new IAF MLA in the field of management system (MS) certification.

Signing of the new IAF MLA was made possible due to formal signing of the new EA Multilateral Agreement (EA MLA) on 27th May 2014 at the 33rd meeting of the EA General Assembly meeting when the new EA MLA, in addition to testing, calibration, inspection and product certification, included certification of management systems and certification of persons. Regardless of the activities of the above presented institutions, the fact is that on day 21 June 2013, there were no accredited certification bodies in Serbia for certification of personnel for NDT in accordance with SRPS ISO/IEC 17024.

The preparations for accreditation of the first certification body for certification of personnel in accordance with SRPS ISO/IEC 17024, Welding Institute – ZAVOD-CERTPers, begin in October 2011. Management decided to develop three certification schemes:

- certification schemes for NDT personnel in accordance with SRPS EN 473 (then still valid in Serbia) and EN ISO 9712:2012,
- certification scheme for welding instructors
- certification scheme for welders.

In developing and validation of certification scheme for personnel for NDT, most of the problems were the provision of qualified evaluators with Level 3 for all NDT methods. Because of that, two employees were sent to training center in Croatia (the Croatian Society for NDT-HDKBR) for NDT methods: VT, PT, MT, and UT and latter to certification.

Welding Institute is an institution with very long tradition in areas of welding and non-destructive testing (57 years of founding), there were no problem for issuing of samples with clearly defined defects according to CEN/TR 15053. The base of the samples is made with supporting documentation (master lists and testing reports from two independent operators).The bank of test questions were made by evaluators with Level 3. This required time.

In order of expansion of regional cooperation, and this is an imperative of EFNDT, Welding Institute sign a business and technical cooperation contract with Croatian Society for Non-Destructive Testing. According to this contract the certification bodies of Welding Institute (ZavodCertPers) and Croatian Society for Non-Destructive Testing can share: evaluators, exam questions and samples for practical part of exams.So far, a total of 280 certificates were issued to persons for non-destructive testing.

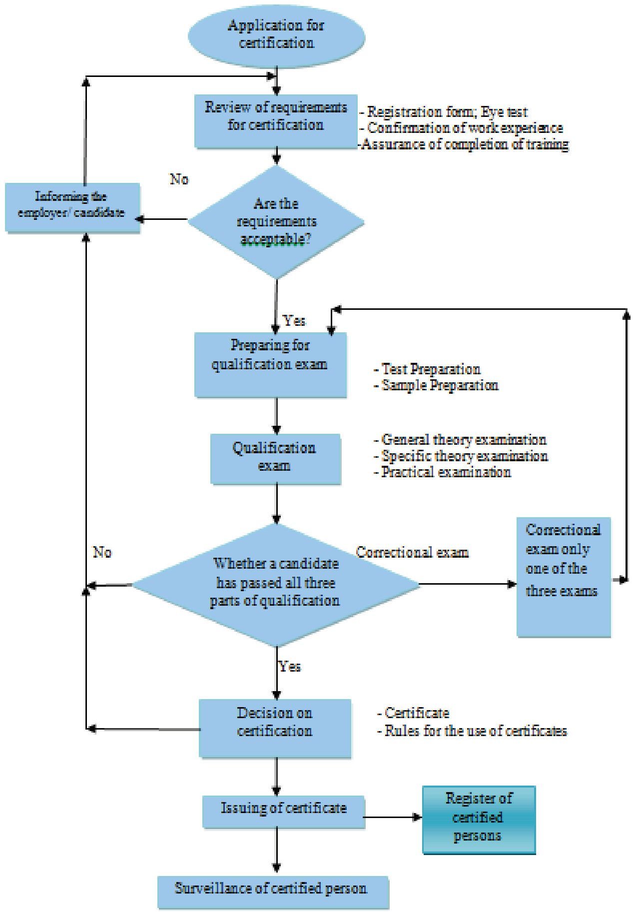
The main criteria in selection of examiners for certification of welders and instructors is the candidates have completed course for IWE / IWT or they are the certified welding instructors or the certified welding instructor specialists, with needs of many years of experience in welding area, what is documented by his biography and certificate of VT, level 2.

The certification process is carried out according to the applicable national and international standards and norms (EN 287-1, Series standard EN ISO 9606, API 1104, ASME IX Section etc.). 1.400 certificates of welders are issued in 2014.

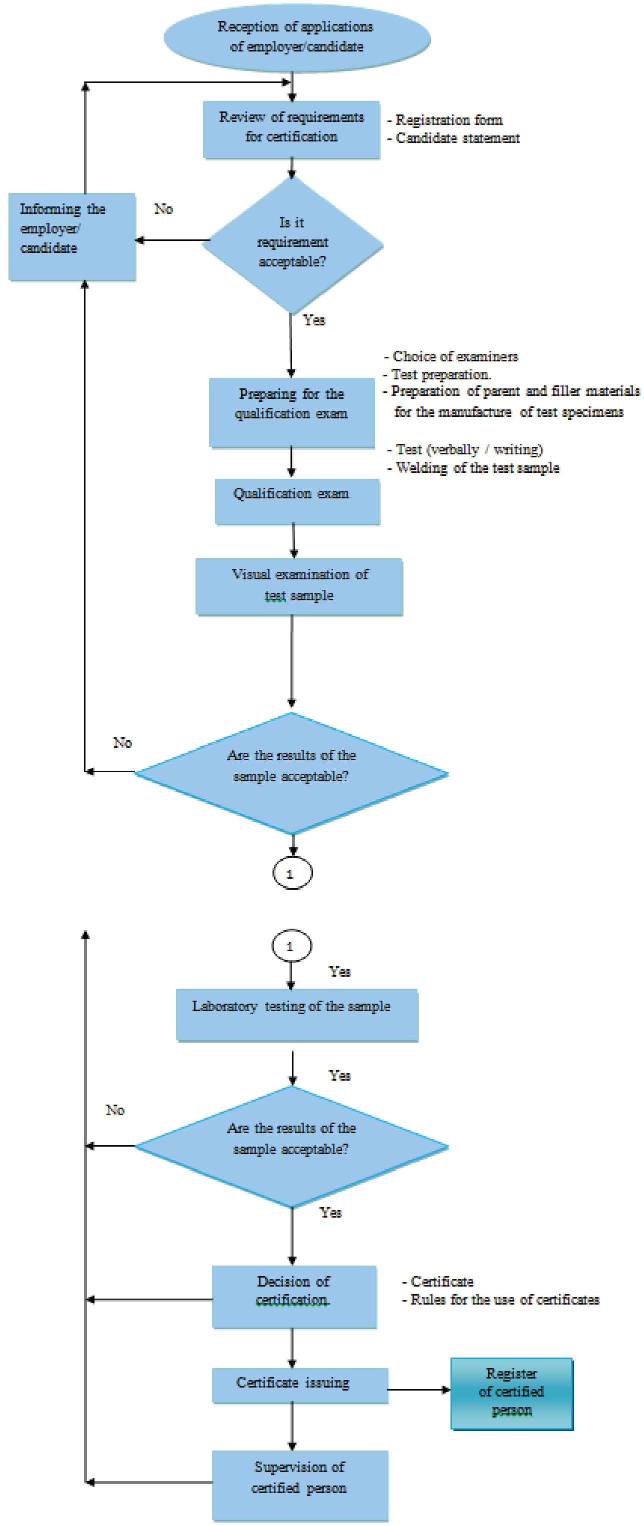
In the scheme of certification of instructors and specialist welding instructors in addition to the application list, a candidate must attach the copies of valid certificates for welding methods, the originals of certificates for inspection, as well as a certificate for VT, level 2.

At 26th May 2013 it was decided to grant an accreditation of certificated body for personnel Zavod za zavarivanje – ZAVOD-CERTPers, accreditation number 07-002. By this decision Welding Institute becomes the only one certificated body for personnel for NDT, welders and welding instructors.

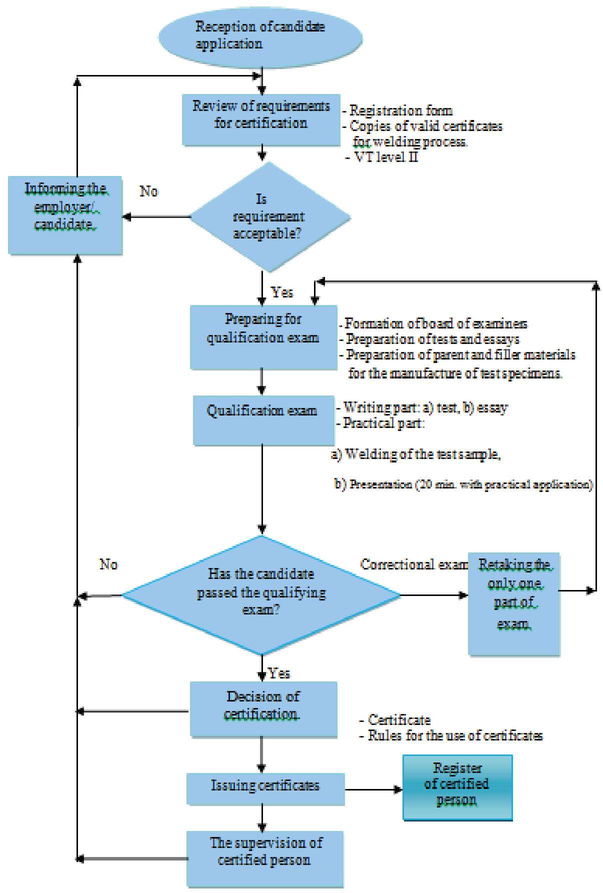
CERTIFICATION SCHEME OF PERSONS FOR NDT



CERTIFICATION PROCESS OF WELDERS



CERTIFICATION PROCESS OF WELDING INSTRUCTORS



USE OF LEARNING OUTCOMES IN ASSESSMENT – NEW PERSPECTIVE BROUGHT BY NATIONAL QUALIFICATIONS FRAMEWORKS IN ENGINEERING HIGHER EDUCATION IN CROATIA

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Abstract

Current trend in implementation of National Qualifications Frameworks (NQFs) in some 155 countries, and introduction of learning outcomes (LOs) based Qualifications Standards brings on board somewhat different approaches to assessment, compared to pre NQF times. This article explores current understanding and practices of the LOs' use in higher education in order to determine baseline for implementation of future study programs based on Qualifications Standards and NQF concept. Presentation of quantitative research results, which covered 102 higher educational teachers in engineering programs in Croatia (both in university and university of applied sciences), reveals significant differences between current practices and the concept of LO's use proposed by NQF. These differences, mostly linked to understanding of very concept of LO's, assessment approaches and use of assessment results, call for further work with higher educational teachers and institutions in order to fully implement NQF concept in higher education and future Qualifications Standards based qualifications.

Keywords: Learning outcomes, Assessment, Qualifications Standards, NQF

1.Qualifications frameworks in higher education

European educational policy development, triggered with the aim of achieving greater competiveness and living standard of EU citizens had its initial push in 2000, through Lisbon declaration [1]. At the time, European policy makers searched for an answer to high grow rates of Chinese economy (exceeding 7% in 1998 and 1999) and recognized knowledge based economy as a vehicle for future EU competitiveness. Keystone position of knowledge have been expressed in Lisbon declaration through its political aim of developing mutual European guidelines, tools and frameworks capable of transforming Europe until 2010 to most competitive knowledge based economy globally. Number of significant educational reforms followed such strategic orientation, one of which was introduction of qualifications frameworks elements and latter European Qualifications Framework. Parallel to this process was reform and development of European Higher education, initiated formally on 19.06.1999. in Bologna through declaration of European educational ministers [2], giving birth to European Higher Educational Area (EHEA), being in fact area of increased mutual trust. Further development of both initiatives; European Qualifications Framework for Lifelong Learning of the EU (EQFLLL), formally introduced in 2008 [3] and today implemented through referencing by 25 countries [4], and Framework for Qualifications of the European Higher Education Area (QF -EHEA), also referred to as Bologna framework, used partially same paradigm (based on learning outcomes - LOs). Convergence of both development processes started between 2001 and 2003 and qualifications framework of the EHEA (QF-EHEA) was adopted in 2005. It was linked in 2008 with the European Qualifications Framework for Lifelong Learning (EQF), a common reference framework developed by the European Commission as a translation device between different qualification systems and their levels, and comprising general, higher and vocational education and training [5].

2. Use and understanding of learning outcomes

Today both frameworks use learning outcomes to describe qualifications and are compatible with each other (QF-EHEA cycles 1, 2 and 3 correspond to EQF-LLL levels 6, 7 and 8) and cover qualifications at ISCED levels 6, 7, 8. [6]. Idea of learning outcomes use in national qualifications frameworks as a bases for description and assessment of qualifications, regardless of site, form and type of curriculum in which they were achieved, was stipulated in 2003 by Young [7], together with other five assumptions underpinning development of national qualifications frameworks (NQFs). Assumption on LOs use within qualifications was challenged since its very formulation, through argumentation that expression of capability for achievement (outcomes statement) cannot be separated from activities that learners have been engaged in while obtaining such capability. Critics mentioned that LOs reflecting just measurable outcomes of educational process should be highly specified, leading thus to narrow outcomes and trivialization of corresponding assessment [8]. When analyzing stated critics of qualifications framework concept and use of learning outcomes, it could be concluded that two opposed understandings originate from two perceived "types" of qualifications.

Such traditional approaches started from division of qualifications to academic and professional [9], while today's dominant belief favors universal national qualifications approach. Within traditional understanding, qualifications are often attributed with cultural significance that is closely linked to context of their acquisition and are separated from published performance standards (LOs). On the other hand, professional qualifications in such traditional approaches are linked to labor market and are measurable through LOs concept. Most critics of universal national qualifications published through standards within NQF argument their standpoint through "un-combinable difference" between nature of knowledge (including also skills) proven by qualification and nature of learning leading to that knowledge. Overarching thesis used by most of such critics points out that academic qualifications should be based on learning while professional qualifications should be based on knowledge, with "universal" qualifications linking two (un-combinable) elements [9].

Even stronger critique of universal national qualifications, such as proposed by NQF approach, could be found with Wheelahan who questions justification of focusing on knowledge and skills needed also for labor market as well as on LOs assessment [10]. More detailed analysis of critical arguments focused on knowledge acquisition methods and LOs use [11-12] reveals their link to first qualifications frameworks (in England, South Africa and New Zealand). Those frameworks were inspired with relatively radical approach to LOs definition, lacking wider focus on knowledge acquisition opportunities within educational process [13]. Such radical approaches were motivated by English system of vocational qualifications – NVQ from late 1980-es, which is today fully abandoned.

Stated critics and arguments against implementation of NQF approach and use of LOs and assessment as cornerstones of qualifications are today rare in scientific and policy debates. LOs become key elements of qualifications standards and building blocks of NQFs. Stated assertion could be best seen within Principles for Quality Assurance in Higher Education and Vocational Education and Training in the context of the European Qualifications Framework, supported by both European Parliament and the Council of EU [3]: *"quality assurance should include context, input, process and output dimensions, while giving emphasis to outputs and learning outcomes".*

Following these recommendation, LO's are defined as: *"learning outcomes are statements of what a learner knows, understands and is able to do on completion of a learning process, which are defined in terms of knowledge, skills and competence".*

In a nutshell, they express the level of competence attained by the student and verified by assessment and should be therefore verifiable.

Furthermore, LOs with related assessment strategies and assessment criteria, should be defined for each educational component (course, modul) [6]. Academic staff responsible for delivering the educational program and its components should ensure consistency between the learning outcomes stated in the program (or qualifications standard), the learning and teaching activities and the assessment procedures [14]. This constructive alignment between learning outcomes, learning activities and assessment is an essential requirement for educational programs [6]. Furthermore, LO's are attributed to individual educational components and to programs as a whole, and are also used in European and national qualifications frameworks to describe individual qualification.

Following common logic, definition of LO's and their role in Qualifications standards development and use, credits are awarded to individual students after they have achieved the defined learning outcomes, as evidenced by appropriate assessment. If the student has not achieved the learning outcomes, no credits will be awarded [6]. In order to make LO's position as clear as possible, some countries stipulated within their legislation or formal guidelines definitions such as one in Scotland [15]: "*A key point to note is that learners must demonstrate achievement of all the learning outcomes within the unit before credit can be awarded. There is no award for partial completion of the LOs because all LO's within the unit are of equal importance and they must all be achieved for the credit to be awarded.*"

Apart of being defined within many national documents linked to NQF implementation in European countries, in ECTS User guide and number of QF-EHEA documents, next chapter will show that common understanding of LO's use (by policymakers and higher educational staff) still do not fully exist in many EHEA countries.

3. Current state of play in EHEA and rationale for research

As identified in Bologna implementation report [5], student-centred learning strongly encourages the use of LOs in study program development and this trend significantly grew over past few years. However, report indicates that the use of LOs in student assessment is much less widespread. Use of learning outcomes in study program development, as indicated within same report, has also substantially grown. This is stipulated in legislation in 32 higher education systems while 14 encourage learning outcomes through guidelines or recommendations.

Within the group of 40 countries in which steering documents mention the concept of student-centred learning, assessment based on learning outcomes has strong perception (4,4 out of 5).

On the other hand, within group of 8 countries in which steering documents do not mention the concept of student-centred learning, assessment based on learning outcomes has much weaker perception (2,7 out of 5) [5].

Structural reforms working group recognized in their report [16] that LOs should ideally be linked to qualifications frameworks and should be obtained in the programs that have been quality assured. Still, in observation of implementation issues linked to assessment based on LOs, they conclude that: *"the concept of learning outcomes is still insufficiently understood by most members of the higher education community."*

Such conclusion lead to one of the most relevant policy positions towards use of LOs and indication of potential damage to mutual trust within EHEA if they are implemented only on formal level. It is also expressed within Report by the structural reforms working group to the BFUG [16]: "*There is good reason to expect that within a few years, all members of the EHEA will have structures that, if judged on the sole basis of their formal design, will be compatible. Structures are, however, useful only if they are put into practice and this is where the real challenge lies. There is, thus, also good reason to fear that unless a common understanding of learning outcomes is developed, what will look like compatible structures will evolve into incompatible realities through uneven practice and diverse understandings of basic concepts."*

Being on one hand aware of significance and potential negative impact of aforementioned incompatibility problem, and on the other of Croatian position identified within Bologna implementation report [5], as a country in which student assessment procedures focus on learning outcomes is encouraged only through guidelines and recommendations, we organized this preliminary research to determine current LOs concept understanding, implementation readiness and current approaches used in Croatian engineering higher education.

4.Research instruments and sample information

Research instrument used for survey of academic staff in involved institutions had three groups of questions with total of 4 demographic questions and 14 research items. All research items used five point Likert type scale with numeric representation as follows: 5 - Strongly agree, 4 - Agree, 3 - Neutral, 2 - Disagree and 1 - Strongly disagree with additional 0 - Do not know, do not want to answer option.

Demographic questions have been used to determine respondent's position within higher educational system (professional vs. academic higher education), teaching rank (teacher vs. assistant), level of self-assessed knowledge in respect to LOs concept: "I'm an expert", "I know the concept", "I need help to define LOs" and "I do not understand the concept") and level of self-assessed knowledge in respect to qualifications system ("I'm an expert", "I know the concept", "I understand part of it" and "I do not understand the concept").

First group of five research items (Q1–Q5) covered conceptual understanding of LOs concept, while second group of nine items (Q6–Q14) covered current practices and use of LOs, table 1.

Table 1. Research items

ID	***Question text***
	PART 1: Understanding LOs concept
Q1	Learning outcomes are in fact just teachers' wishes what student should be able to do after educational process. As a teacher, I do not have obligation to check whether they have been achieved by each student in my course.
Q2	I totally understand LOs concept and I use level descriptors (Dublin, CROQF) in order to map my LOs to relevant level.
Q3	Unless specified differently, when LOs are mentioned they are referred as minimal LOs, being minimal threshold to pass.
Q4	When I write LOs, I'm more focused on use of appropriate active verbs then on corresponding autonomy and responsibility expressed through complexity of context in which specified activity is being achieved.
Q5	LO's are in fact competences which student achieved through learning process and proved during examination. As a teacher, I'm responsible for acknowledgement that each my student who passed exam achieved LOs that I specified for my course.
	PART 2: Use of LOs
Q6	When I prepare assessment tasks I always pay close attention on corresponding LO which should be assessed. By doing so I'm focused on complexity of exam and its fit to LOs complexity.
Q7	I use appropriate assessment method in correspondence with LOs level. For instance, if LO requires critical analysis in some area, I do not assess only ability to define and explain that area.
Q8	If my course has 4 learning outcomes I always cover each of them through assessment.
Q9	While assessing students enrolled in my course, I have detailed documentation on level of each LO achievement by each student (it means that I allocate some kind of "points" to each LO).
Q10	Student took exam in course with 4 independent LOs. Student passed 3 LOs with respectable level of knowledge, but did not show required level of knowledge specified with one LO. Such student would pass my course but possibly with lower mark.
Q11	If we use minimal LO's this means that my most simple exam questions, for passing mark (2), should correspond to the LO. Other, more complex questions/tasks could get higher mark to student (and possible intended LO if we use it).
Q12	If we use just minimal LOs, employer can not exactly know level of knowledge of very successful students but only of those who barely pass (with mark 2). Complexity of knowledge for higher marks is not written within minimal LOs.
Q13	Level of study program and LOs (i.e. graduate) is in fact limiting option to adjust exam questions for low performing students (making them easier).
Q14	To ensure same level of complexity for same educational level and same qualifications (i.e. bachelor of mechanical engineering), it would be useful to use external peer review of exams by teachers in other institution in order preserve same level of complexity for same qualifications.

Survey has been organized using on-line infrastructure of LimeSurvey system hosted on SRCE – University computing center in Zagreb and research items have been checked and adjusted by 3 field experts in order to increase internal validity of the research instrument. Total of 105 candidates answered survey questions but all answers with “Do not know, do not want to answer option” have been excluded from the further analysis. As a result total of 102 valid survey results have been analyzed with sample demographics as shown in table 2.

Table 2. Descriptive information on the sample

Target group affiliation		*Frequency*	*%*
Position within higher educational system			
(1)	University / academic HE	45	44,1
(2)	Professional HE	57	55,9
Teaching rank			
(1)	Teacher	62	60,8
(2)	Assistant	40	39,2
Level of knowledge in respect to LOs concept			
(1)	Expert	27	27,6
(2)	Confident user	61	62,2
(3)	Need some help	6	6,1
(4)	Do not know	4	4,1
Level of knowledge in respect to NQF concept			
(1)	Expert	9	8,8
(2)	Confident user	66	64,7
(3)	Have some understanding	22	21,6
(4)	Do not understand	5	4,9
Total		**102**	**100,00%**

5. Results

Research results covering total survey population and containing descriptive statistical results are shown in table 3. They reveal certain level of LOs concept misunderstanding and more significant level of LOs misuse in respect to qualifications framework (both NQF / EQF and QF-EHEA) definitions of learning outcomes.

Table 3. Overall statistical results

	N	Mean	Med	Mode	Std. Dev.	Min	Max
Q1	101	1,84	2,00	1	1,007	1	5
Q2	93	3,22	3,00	4	1,141	1	5
Q3	97	3,61	4,00	4	1,229	1	5
Q4	94	2,83	3,00	2	1,074	1	5
Q5	100	4,30	4,50	5	0,905	1	5
Q6	100	4,16	4,00	4	0,735	2	5
Q7	100	4,16	4,00	4	0,647	2	5
Q8	98	4,42	5,00	5	0,759	2	5
Q9	95	4,00	4,00	5	1,101	1	5
Q10	99	2,32	2,00	1	1,308	1	5
Q11	97	3,97	4,00	4	0,895	2	5
Q12	97	4,01	4,00	4	0,930	1	5
Q13	95	2,64	3,00	3	0,988	1	5
Q14	97	3,55	4,00	4	1,041	1	5

Still, more detailed analysis reveals also areas of significant discrepancies between groups of respondents. Most statistically significant differences could be found between respondents according to their position within higher education (university vs. professional), where we found statistically significant differences in 7 out of 14 (50%) research items (Q1, Q5, Q6, Q7, Q8, Q9 and Q10). Such differences, although smaller, exist between answers provided by teachers and assistants in items (Q2, Q4, Q10 and Q14). On the other hand, it is far less present when compared in respect to understanding of LO concept in higher education (Q1 and Q2) and knowledge about Qualifications frameworks (Q2).

First significant difference in understanding and definition of LOs within both (NQF/EQF and QF-EHEA) and respondents answers, was found in Q1, where academic staff involved in university program had significantly different perception on LO’s than those in professional higher education. Post hoc analysis of differences between groups of respondents using Mann – Whitney U-test and Wilcoxon rank sum test revealed statistically significant (1%) difference between the groups (p-value < 0.001). Concretely, while respondents from university partly disagree (mean: 2,22, st.dev: 1,166) that LOs are in fact same as educational goals, exempting teachers of students achievement verification according to them, situation in professional HEI is in this respect better (mean: 1,540, st.dev: 0,738), although misunderstanding of the concept exists here also.

Q2 results show poor use of level descriptors in preparing LO’s, questioning very concept of the qualifications levels. Although we found expected differences in their use in respect to group affiliation according to self-assessed knowledge and understanding of both LOs and QFs, statistically significant difference (5%) using Mann – Whitney U-test and Wilcoxon rank sum test (p-value = 0.048) between assistants (mean: 2,88) and teachers (mean: 3,40) showed that more effort should be invested in assistants training in this respect.

Q3, although not revealing any statistically significant differences in respect to group affiliation of respondents, shows that implicit understanding that LOs, if not specified differently, represents minimal achievements students should be able to do after educational process does not exist. This conclusion, per se, shouldn’t be treated as negative, but it leaves significant space for further work on number of levels (policy and institutional) to agree what LOs really stand for if they are not specified as minimal and intended. Further input to this work originates from new (2015) revision of Standards and guidelines for quality assurance in the European higher education area – ESG [17] where syntagma “intended learning outcomes” is only one used in whole document.

When analyzing responses to Q5 we found that 12 out of 102 respondents (11,7%) do not support the idea that teacher should verify students’ knowledge through exam. Deeper insight provided by post hoc analysis of differences between groups of respondents using Mann – Whitney U-test and Wilcoxon rank sum test revealed statistically significant (5%) difference between the groups (p-value = 0.042) of university and professional HEI staff. Concretely, there are more teachers from professional HE (mean: 4,42) then from university (mean: 4,14) who do see their responsibility in assessing student knowledge according to LOs.

Q10 is again challenging idea of LO's use in respect to possibility to pass module (course) without achieving part (in concrete question 25%) of LOs attributed to the course. In such circumstances, most of the respondents would not provide passing mark to the student, but again with statistically significant differences in professional and university HE. Deeper insight provided by post hoc analysis of differences between groups of respondents using Mann – Whitney U-test and Wilcoxon rank sum test revealed statistically significant (1%) difference between the groups (p-value < 0.001). Concretely, there are by far more teachers from university (mean: 3,07) who would issue positive mark even if 25% of LO's are not met then in professional HE where most would not do the same (mean: 1,77).

Q11, although not revealing any statistically significant differences in respect to group affiliation of respondents, shows that idea of minimal LOs and corresponding assessment which should cover level of LO in order for students to get passing mark (2) is not fully understood. Concretely, most respondents in general support such idea (mean: 3,97) but there is still place for additional discussion and possibly work. Same goes for Q13, showing almost compete misunderstanding of LOs levels in respect to qualifications levels and corresponding assessment. When presented with the idea of guarding LOs levels in assessment in order to provide truthful information to the public of students achievement, most (mean: 2,64) disagree and opt for lowering LO levels through assessment in order to "help" lower performing students. Finally, when presented with the idea (Q14) of external peer review of assessment materials in order to adjust and protect level of complexity of certain qualifications, the idea used in some highly successful HE systems (i.e. GB), Croatian academic staff was not supportive (mean: 3,53).

Results of other six questions (Q4, Q6, Q7, Q8, Q9, Q12), not mentioned previously, consistently show level of understanding and use of LO's presented through other eight questions.

6. Conclusion

Research of academic staff attitudes presented within this article revealed significant differences, both in understanding of LOs concept and even more in their use in Croatian higher education (HE), compared to key definitions and documents underpinning EQF and QF-EHEA. Stated results could have been hardly expected after numerous projects and activities supporting implementation of Bologna declaration (QF-EHEA) since 2005 in Croatia. Still, they in fact present current state of affairs and depict actual reform capacity of Croatian higher education in respect to implementation of CROQF which indeed brings reforms and changes. Although presented results show some differences between respondents from professional and university higher education, they are founded on relatively small research sample and call for more extensive research on national level. Results of such future research, covering larger sample, should be taken seriously as a signal to both policy makers and quality assurance bodies in respect to potential significant differences between form (i.e. fact that most if not all HEI programs in Croatia has LOs and most of them are prepared using correct wording) and content (i.e. LOs' understanding and use by academic staff) of Croatian HE qualifications and corresponding programs.

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MANAGING INTELLECTUAL CAPITAL: THE CASE OF MONTENEGRO

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Abstract

This article provides an analysis of management of the intellectual capital (IC) in public administration organizations of Montenegro. Based on the results of the empirical analysis of individual factors, models of IC elements are formed and mechanisms are generated for managing IC in public administration of Montenegro.

Keywords:

knowledge, intellectual capital, intellectual capital evaluation, public administration, Montenegro.

1. Introduction

Intellectual capital management is aimed at meeting economic objectives, such as an increase in production and profitability, efficiency, effectiveness and flexibility of the organization, while at the same time meeting social objectives, such as acting in the interest of the employed, improving their socio-economic standing, raising their quality of life, as well as developing individual abilities of each employee. Creating intellectual capital resulted in a new competitive tool of the new economy where knowledge is the main resource. In the environment where raw material or material have become less important factors, knowledge which becomes a basic life need is being sold ever more. Nowadays, knowledge is not kept only in documents or knowledge databases; it is becoming a part of organizational processes and organizational culture more and more. The importance of knowledge is oriented towards business management, so we can talk about knowledge management as the most important business function. Knowledge can be defined as a non-material resource, a picture of reality expressed in human ideas while observing the surrounding world (space, objects, relations and events in that reality). It consists of intuition, a group of ideas, experiences, skills and teachings, and has a potential to create new values. Knowledge is created in human minds [9], and according to authors who were among the first dealing with the question of its creation and use, Michael Polani, knowledge can be divided into explicit knowledge and tacit or hidden knowledge.

Knowledge in an organization appears in two forms:

- material form (explicit knowledge) – plans, projects, patents, licences, databases, computer programs, handbooks, etc.
- non-material form (tacit knowledge) – knowledge, ideas, visions, experience, the ability to solve problems, culture, etc.

The initial hypothesis of this paper is that intellectual capital is the most important factor in the development of companies and the state of Montenegro. Recognising the fact that this is a very young field, insufficiently researched in Montenegro, one of the aims of this paper is to try to examine the influence of economic surrounding on dominant characteristics of intellectual capital, and thus relevant indicators of intellectual capital. Deviation of the defined relevant indicators, identified in real economic conditions, from relevant indicators in initial methods will confirm the influence of the economic environment on the relevance of indicators.

The research presented in this paper is an endeavour to find answers to the questions:

- Does intellectual capital present the main resource and is it an engine of the development of Montenegro?
- Is intellectual capital development possible only with a quality profiled selection of “knowledge workers”, or implementation of the principle “the right people in the right place”?

On the basis of the problem and the aims of the research, as well as the available information, the following hypothesis was established:

H0. There are relevant indicators for measuring intellectual capital in organizations from a chosen economic environment.

On the basis of zero hypothesis, the following individual hypotheses were defined:

H1. There are relevant indicators for measuring human capital in organizations from a chosen economic environment.

H2. There are relevant indicators for measuring structural capital in organizations from a chosen economic environment.

H3. There are relevant indicators for measuring relational capital in organizations from a chosen economic environment.

2. Literature Review

There is no universally accepted definition of IC in the literature. Following Edvinsson and Malone

[5], IC is 'the possession of knowledge, applied experience, organizational technology, customer relationships and professional skills that provide the firm with a competitive edge in the market'.

On the other hand, Bontis et al. [3] stressed the importance of IC flows and defined IC as 'the collection of intangible resources and their flows'. This definition implies the dynamic nature of IC and its development through time. Lev [11] says that IC is 'a claim to future benefits that does not have a physical or financial embodiment.

There is a widely accepted three-category IC classification into (i) human, (ii) structural, and (iii) customer or relationship capital [16], [5], [17], [15]. First, human capital is represented by the intangible assets embodied by individuals. Roos et al. [15] argued that people generate capital through competence (represented by skills and education), their attitude (which covers the behavior of employees towards their work) and their intellectual agility (represented by innovativeness and openness to changes). Second, structural capital is owned by the firm [18]. Following Bontis [2], it includes routines and structures. Stewart [18] states that culture is also an extensive and valuable element of structural capital.

Third, customer capital is owned by every firm that has customers [18]. It is constituted by customer satisfaction and loyalty, image and brand, and direct distribution channels [12]. Customer capital can be broadened to relationship capital, which also includes relationships with other subjects like business partners, tourism promotion organizations, government, local community, competitors, creditors, special interest groups, the media and the public.

The product value does not arise directly from IC but is created by flows within IC [16], [15], [18], [17], which demonstrate the relationships between pairs of IC categories. In their definition of IC, Bontis et al. [3] spoke about IC flows. The service-profit chain (Heskett et al. 1994) also partly shows the importance of IC flows. Studies in the context of IC research [2], [3] have found relationships among human, structural and customer capital and confirmed IC's impact on business performance. A study of 13 hotels in Norway [7] found a strong connection between human and structural capital. The conversion of IC into financial results should be realized. The financial capital of a firm can only be increased by increasing customer capital, which can be increased by the flows from human and structural capital [16]. Stewart [18] also noted that IC turns into financial results in customer relationships.

It is explicitly recognized in the competitive business environment that knowledge creation and sharing can be an essential source of organizational advantages [1], [4]. However, there are not many organizations that have a clear idea of how to proceed with it. Intellectual capital (IC) is suggested to be the pursuit of effective use of knowledge as opposed to information [2], [5] and used to emphasize the importance of knowledge management as essential to the growth and development of organizations in a knowledge society [19].

Intellectual capital is the resource that comes from the knowledge, experience and transferable competencies of its staff, from the organization's ability to innovate and manage change, from its infrastructure, and from relationships between stakeholders and partners [18]. The IC-approach originally introduced by Edvinsson and Sullivan [6] divides intellectual capital into human capital and structural capital, such that the latter is again divided into organizational capital and customer capital and relationship capital. Some recent studies tend to rename customer and relationship capital as relational capital only [8]. Commonly, IC is categorized with three main constructs including human capital, organizational capital and relational capital. In the literature, the illustrative definitions of these constructs are summarized as follows:

1. Human capital is the individual-level knowledge, such as professional skills, experience, and innovativeness that each employee possesses. It is the human capital that provides the most valuable assets [18].
2. Organizational capital is the sum of all assets pertaining to the firm which make the creative ability of the organization possible.
3. The vision of the firm, management philosophy, organization culture, strategies, processes, working systems, and information technology can be mentioned among the assets [5].
4. Relational capital is the sum of all assets that arrange and manage the firm's relations with the environment. The relational capital contains the relations with customers, suppliers, shareholders, the rival, community, the official institutions, and society [14].

3. Empirical research

The aim of the empirical research presented in this paper is to gather data through a structured questionnaire in order to identify indicators which are in real conditions considered relevant indicators of the intellectual capital of public administration in Montenegro [13]. Based on the empirical research covering executive government (ministries and government agencies), classes of relevant indicators are formed.

Questionnaires were distributed through e-mail and through "face to face" interviews. During the research, a prerequisite for the person filling in the questionnaire was that their work in public administration is connected with HR monitoring and development. The research included the whole population of executive government organizations (ministries, directorates, agencies, services, offices, secretariats) in Montenegro. The questionnaire was divided into several sections:

- Data on the administration structure

- Human capital perception in the administration
- Structural capital perception in administration
- Relational capital perception
- Perception of innovativeness, employee motivation, and investment in HR development

The research was focused on identification of the factors presenting the three key elements of intellectual capital:

1. Human capital
2. Structural capital
3. Relational capital

The intellectual capital value is defined as the mean value of human, structural and relational capital. In order to quantify the human, relational and structural capital values, referential scales were created. Their reliability was examined by establishing the Cronbach's Alpha values, which indicated a high internal consistency, in other words, reliability of all three scales. Thus, the given scales may be accepted as an instrument for long-term monitoring of the capital perception in public administration, but also in other sectors.

Human capital is calculated as a relative value of the human capital scale, including the following nine variables:

1. Employees possess knowledge that the organization needs,
2. Employees are treating their job as “entrepreneurs”,
3. We reward employees showing initiative,
4. Innovativeness is especially rewarded in our organization,
5. Employees are rewarded based on their contribution to the business results,
6. Employees’ creativity is very important in our organization,
7. Employees in our organization are ready and motivated for advanced training,
8. Employees in our organization are satisfied,
9. Work results and business changes are continuously monitored.

Structural capital is calculated as a relative value of the structural capital scale, consisting of the following 18 variables:

1. We try to employ people on positions where they can contribute most to the overall results,
2. The ability to interact quickly and easily is appreciated in our organization,
3. Employees often improve processes and procedures with their ideas,
4. Employees accept the organization’s goals as their own,
5. Organization’s interest always precedes individual interests for all employees,
6. Employees are glad to share their experience with co-workers,
7. Employees’ satisfaction is monitored in our organization,
8. IT usage substantially improved cooperation within the organization,
9. Our employees mostly communicate using technology, like PC (e-mail) and telephones (cell-phones),
10. Employees make maximum use of IT in the work process,
11. In our organization, there is a system of rewarding good ideas,
12. We try to constantly improve processes and procedures,
13. All procedures are consistently observed in our organization,
14. All processes in our organization are properly documented,
15. Depending on the problem, adequate teams are formed,
16. There is cooperation between employees from different parts of the organization,
17. Managers have good and fair relations,
18. Managers and employees have good relations.

Relational capital is calculated as a relative value of the relational capital scale, including the following five variables:

1. Our organization is continually innovating its products and services,
2. There is an atmosphere of trust in our organization,
3. Atmosphere in our organization is stimulating,
4. We openly discuss the strengths and weaknesses of our organization,
5. Our organization invests in development and research.

4. Empirical results

While evaluating the human capital values, we used the results of the given variables’ values perception by HR sector representatives from 39 organizations, because three out of 42 organizations were unwilling to answer all the questions. The human capital scale reliability is very high. Cronbach's Alpha amounts to 0.847. The human capital scale, the absolute one, consists of nine variables, with the minimum value of nine, and the maximum value of 45. The mean human capital value for the 39 administrations that answered all the relevant questions is 33.97, whereas the median is 35. 53.8% of administrations estimate their human capital within the grading range of 19-35 , while 47.2% estimate it very high, within the grading range of 36-45, and on a relative 1-5 scale, 42.7% of administrations estimate their human capital value between 4 and 5. The average relative grade of human capital, according to this scale, is 3.77, with a standard deviation of 0.79.

While evaluating the structural capital values, we used the results of the given variables’ values perception by HR sector representatives from 40 organizations, because two out of 42 organizations were unwilling to answer all the questions.

The structural capital scale reliability is very high. Cronbach's Alpha amounts to 0.938. The structural capital scale, the absolute one, consists of 18 variables, with the minimum value of 18, and the maximum value of 90. The mean structural capital value for the 40 administrations that answered all the relevant questions is 77.52, whereas the median is 83.5. The lowest grade for own administration is 38, and the highest is 90. 22.5% of administrations estimate their structural capital within the grading range of 38-69, while 77.5% estimate it very high, within the grading range of 76-90, and on a relative 1-5 scale, 77.5% of administrations estimate their capital value between 4.22 and 5.

The average relative estimate of structural capital, according to this scale, is 4.31, with a standard deviation of 0.67.

While evaluating the relational capital values, we used the results of the given variables' values perception by HR sector representatives from all 42 organizations. The relational capital scale reliability is very high. Cronbach's Alpha amounts to 0.796. The relational capital scale, the absolute one, consists of nine variables, with the minimum value of 5, and the maximum value of 25. The mean relational capital value for the 42 administrations that answered all the relevant questions is 19.95, whereas the median is 21. The lowest grade for own administration is eight, and the highest is 25. 35.7% of administrations estimate their relational capital within the grading range of 8-19, while 64.3% estimate it very high, within the grading range of 20-25, and on a relative 1-5 scale, 64.3% of administrations estimate their capital value between 4.22 and 5. The average relative estimate of relational capital, according to this scale, is 3.99, with a standard deviation of 0.94. Comparing the human, structural and relational capital values (picture 1), their interdependence was evaluated. The relative value was obtained when the scale value at every point was divided by the number of variables that make the scale, and thus the values of human, relational and structural capital for each point (organization) were obtained within the range 1-5 and so the values of these scales became comparable. The result was an expected linear dependence (pictures 2, 3 and 4), which leads to a conclusion that changes in value of these three capitals are interdependent, and an increase in one intellectual capital type has a positive effect on any other capital type. This conclusion is further reinforced by the graph on picture 2 on which there are several points where human capital is graded substantially lower than the other two capital types, as well as the two points where relational capital is graded substantially better in comparison with the other two.

5. Human capital model

The research also had a goal to point to the most important predictors for the intellectual capital value out of human, structural and relational capital variable categories.

The model is constructed by using linear regression on the 39 questionnaires. The model describes 84.8% variants. In this model, intellectual capital is defined as the mean value of human, structural and relational capital relative values. According to these data, the most important positive predictors from the area of self-estimated human capital for the intellectual capital value are:

- employees' motivation for advanced training (Employees in our organization are ready and motivated for advanced training),
- rewarding innovativeness (Innovativeness is especially rewarded in our organization),
- adequate knowledge (Employees possess knowledge that the organization needs),
- recognizing the importance of advanced professional training as being vital for the success our organization), whereas the negative predictor is fear and insecurity (Our employees feel fear and insecurity at work).

6. Relational capital model

The model is constructed by using linear regression on the 39 questionnaires. The model describes 82.8% variants. In this model, intellectual capital is defined as the mean value of human, structural and relational capital relative values. According to this data, the most important positive predictors from the area of self-estimated relational capital for the intellectual capital value are:

- Open communication among employees (We openly discuss strengths and weaknesses of our organization)
- stimulating atmosphere (Atmosphere in our organization is stimulating)
- service innovation (Our organization is continually innovating its products and services).

7. Structural capital model

The model is constructed by using linear regression on the 39 questionnaires. The model describes 89% variants. In this model, intellectual capital is defined as the mean value of human, structural and relational capital relative values. According to these data the most important positive predictors from the area of self-estimated structural capital for the intellectual capital value are:

- employees innovativeness (They often improve processes and procedures with their ideas);
- rewarding good ideas (There is a system of rewarding good ideas in our organization);
- good business cooperation within the organization (Employees are glad to share their experience with co-workers)
- stimulating atmosphere (the atmosphere in our organization is stimulating).

8. Intellectual capital model

The model is constructed by using linear regression on the 39 questionnaires. The model describes 92.7% variants. In this model, IC was taken as a mean value of relative values of human, structural, and relational capital. According to these data the most important positive predictors for the intellectual capital value are:

- employees' innovativeness (Employees often improve processes and procedures with their ideas);
- rewarding good ideas (There is a system of rewarding good ideas in our organization);
- good business cooperation within the organization (Employees are glad to share their experience with co-workers) and
- stimulating atmosphere (The atmosphere in our organization is stimulating).

9. Conclusion

This is the first attempt to develop a model for measuring intellectual capital in the public administration of Montenegro, and it is logical that in embryo stages these models have their flaws. What is essential to improve and further develop the proposed models for measuring intellectual capital, is to test them in Montenegrin public administration organizations, and to redefine the proposed indicators according to the actual needs of the observed environment. Until now, there is no standardized measurement of intellectual capital in practice, as is the case with the traditional accounting system for measuring financial performance of the company.

Intellectual capital management and emphasis of the value of the human factor in organization's business activities is a course that will certainly lead to a positive move in organization's business activities and general advancement in public administrations.

Important issue for Montenegro is that laws which are adopted quickly (and often hastily and uncontrollably), quickly come into life, and that Montenegrin public administration start to function based on the model of developed administrations of the Western European countries. Furthermore, of the most supreme importance for a fast and efficient development of organizations and proper implementation of laws, plans and procedures is an adequate management of the intellectual capital of organizations.

The assumption is that after several iterations including testing and redefining of the suggested group of relevant indicators, it would be possible to define a satisfyingly precise model for measuring organizational intellectual capital in Montenegro.

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EIGENVALUE AND EIGENVECTOR SENSITIVITY

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Abstract

Iterative methods are presented for eigenvalue problems: eigenvalue and eigenvector derivatives are considered.

Keywords:

Eigenvalue, eigenvectors, sensitivity analysis

1. Introduction

Dynamic response of mechanical systems depends on structural parameters. Our objective is to evaluate the structural response for successive modifications in the design avoiding the difficult solution of the modified equations. The structural modifications may be caused by external factors or by the designer in order to improve the characteristic of the response (eigenvalues and eigenvectors). Modification of dynamic characteristics means change of corresponding design variables to get desired dynamic behavior of structure. The variables design depends on the type of optimization problem. In the design of structural components, such as stiffened panels and cylinders, the design parameters represent the spacing of the stiffeners, the size and shape of the stiffeners, and the thickness of the skin. The thickness of plates, cross-sectional areas of bars, areas, moments of inertia, and torsion constants of beams represent sizes of the elements. Joints and members could be eventually added or deleted during the design procedure so that the geometry of the structures may be modified.

1.1 Literature Overview

The basic theory for determining the existence of solution for frame structure optimization with frequency limits is found in Ref. (Tong at all, 2000). According to this theory, natural frequencies do not change with uniform frame modification and key limitation for determination of optimal dynamic solution of frame structure modification is mostly that of eigenfrequencies. The optimization criteria for space frame structure with multiple limitations in its natural frequencies are considered in (Wang at all, 2004). Knott coordinates and cross sections of elements, although of different nature, have been treated simultaneously in unified design specification for a minimum weight of structure. Optimum first criterion, developed for one limitation based on differentiation of the Lagrange function, indicates that at optimum all the variables are of the same efficiency. In order to solve multiple limitations of frequencies global numbers are introduced, avoiding in this way the calculation of Lagrange's multiplicators.

In the final stage, the most efficient variables are identified and modified as priority. Using the minimal weight increment, optimal solution can be obtained from initial design solution. The procedure is also effective for repeated values of frequency. In paper (Nair at all, 1998) the model for modified dynamic structural system is presented, based on reduced appreciative concept of improved method for the approximation of eigenvalues and eigenvectors of first order. The expressions for local approximation based on Taylor's series are used as base vectors for eigenparameters perturbance approximation. The reduced system of eigenvalues is generated for each eigenvector using eigenvectors as a base and Ritz's vector approximation of first order. The equations for reanalysis are algebraic (Wamg at all, 1986). A new function to limit eigenvalues approximation in the procedure of structural optimization is introduced in (Canfield, 1990). Applied Reyli ratio increases the approximation quality for frequency limitations since it approximates eigenforms energy and kinetic energy instead eigenvalues, producing faster and stable convergent solutions.

The application of iterative method for sensitivity determination in reanalysis of structure due to small perturbances of design variables is applied in numerical procedure, discussed in (Yoon, 1988). In this paper the algorithms for displacements and stresses are given, as well as for eigenvalues and forms. The scheme of iteration is modified saving matrix coefficients as constant and using only one decomposition. Implementation of algorithm is simple, and the convergence fast. The extension of the method to the sensitivity of eigenfrequencies with repeated values is convenient to avoid the conditions of matrix coefficients close to bifurcation points, which occurs when non-linear response of a structure is considered.

It should be noted that dynamic response is given primarily through corresponding eigenfrequencies and main oscillation forms as characteristic (typical) variables. Changing them, by changing design parameters of a structure, it is possible to achieve the required structural dynamic response.

Sensitivity analysis is an important point within the *dynamical modification* procedure. Sensitivity analysis represents a collection of mathematical methods for reanalyzing structures which is, within dynamical modification, related to sensitivity of eigenvalues and eigenvectors. Therefore, the application of sensitivity analysis is limited to construction of segments for which necessary mathematical relations can be determined. If this is not possible, sensitivity analysis is only partially applicable. Dynamical analysis of complex structures are easily conducted with finite elements modeling. Therefore, while finite element analysis method is highly adequate for modeling complex structures, one of its major drawbacks lies in the usage of large number of degrees of freedom in calculating the exact eigenpairs. This number can amount to few tens of thousands, or even more. To reduce the calculation time it is possible to divide the complex structure into connected substructures and analyze each one separately. The dynamical behavior of each substructure is represented only by a reduced set of eigenpairs of interest, which contributes to significant problem simplification. A more general problem of structural dynamic analysis has three important aspects. *Firstly*, the observed physical structure is represented by initial finite element model. Modeling is based on numerous idealizing approximations within an exaggerated elaboration of details, which in essence does not significantly improve the accuracy of output data, especially having available powerful computers and appropriate software packages. Optimal alternative is to have the possibility of verifying outputted data that were measured on a prototype or real structure. *Secondly*, the dynamic characteristics of construction under reanalysis are analyzed. What is basically observed are eigenvalues and main forms of oscillations as characteristic variables that can invoke inadequate actual dynamic behavior. *Thirdly*, on the basis of the analysis of actual dynamic behavior, modification steps are proposed after which a modified model is obtained. Having in mind that mechanical structures are most often very complex, the most convenient modification steps are not easily obtained.

2. Problem Statement

Eigenvalue sensitivity is useful when resonant frequencies or critical buckling loads need to be restricted. Exact analytical expressions for eigenvalue sensitivity can be readily derived for the case of no repeated roots.

On the other hand, phe problem of obtaining eigenvector sensitivity is more complicated; see [1]. Eigenvector sensitivity is useful in obtaining the design derivatives of forced dynamic response. Here, an iterative approach is presented for approximate derivatives of eigenvalues and eigenvectors. The approach is particularly easy to implement in a program and provides both eigenvalue and eigenvector derivatives simultaneously. Furthermore, the derivative of a particular eigenvector does not require knowledge of all eigenvectors of the problem, as with certain analytical methods.

Consider the generalized eigenvalue problem

$$\left[K(b)\right]\{y\}=\lambda\left[M(b)\right]\{y\} \tag{1}$$

where λ is a particular nonrepeated eigenvalue, and $\{y\}$ is the associated eigenvector. For the frequency problem, $[K]$ and $[M]$ represent the structural stiffness and mass matrices, respectively. It is desired to find the sensitivities $d\lambda / db$ and dy / db. Let $\{b\}^0$ be the current design vector and $\lambda_0, \{y\}^0$ be a given eigenvalue-eigenvector pair at the current design. Let $\{b\}^\varepsilon$ be a perturbed design vector. The residual is given by

$$\{R\}=\left[K(b)^\varepsilon\right]\{y\}^\varepsilon-\lambda_\varepsilon\left[M(b)^\varepsilon\right]\{y\}^\varepsilon \tag{2}$$

The aim is to solve the nonlinear equations $\{R\}=\{0\}$ for the unknowns λ_ε and $\{y\}^\varepsilon$. The Newton-Raphson technique is used for this purpose. The Jacobian $[J]$ of the system in Eq. (2) is $\left[\partial R / \partial y^\varepsilon, \partial R / \partial \lambda_\varepsilon\right]$. This, together with normalization condition $\{y\}^T[M]\delta\{y\}=0$, and preserving constant coefficient matrices, leads to solving the system

$$[C]\begin{pmatrix}\delta y\\ \delta\lambda\end{pmatrix}=\begin{pmatrix}-\{R\}\\ 0\end{pmatrix} \tag{3}$$

where

$$[C]=\begin{bmatrix}\left[K(b)^0\right]-\lambda_0\left[M(b)^0\right] & -\left[M(b)^0\right]\{y\}^0\\ -\{y\}^{0^T}\left[M(b)^0\right] & 0\end{bmatrix}. \tag{4}$$

The coefficient matrix is symmetric and non-singular for the case of non-repeated roots. The algorithm for eigenvalue-eigenvector sensitivity is now given.

Algorithm (Eigenvalue-Eigenvector sensitivity)

Step 0: Set $j=0$. Choose the perturbation ε and the error tolerances Δ_1 and Δ_2. Define $\{b\}^\varepsilon$. Decompose the matrix $[C]$ given in Eg. (4).

Step 1: Define the residual

$$\{R\}^j=\left[K(b)^\varepsilon\right]\{y\}^j-\lambda_j\left[M(b)^\varepsilon\right]\{y\}^j.$$

Step 2: Solve Eq. (3).

Step 3: Update

$\{y\}^{j+1} = \{y\}^{j} + \{\delta y\}$ and $\lambda_{j+1} = \lambda_j + \delta\lambda$.

Step 4: Check the convergence criterion

$$\|\delta y\| \le \Delta_1 \text{ and } |\delta\lambda| \le \Delta_2 . \qquad (5)$$

If satisfied, then set $\{y\}^{\varepsilon} = \{y\}^{j+1}$ and $\lambda_{\varepsilon} = \lambda_{j+1}$, and compute the eigen value and eigenvectors sensitivity as

$$\frac{d\{y\}}{db_i} \approx \frac{\{y\}^{\varepsilon} - \{y\}^{0}}{\varepsilon} \text{ and } \frac{d\lambda}{db_i} \approx \frac{\lambda_{\varepsilon} - \lambda_0}{\varepsilon} . \qquad (6)$$

Otherwise, set $j = j+1$ and re-execute steps 1-4 above.

3. Numerical Results

Consider the frame structure in Fig. 1. The design variables associated with the I-section are

$b = (h, w, t_w, t_f)$,

as shown (Fig. 1).

The problem has a total of 24 design variables and 12 degrees of freedom. The sensitivity of the lowest eigenvalue and corresponding eigenvector obtained using Algorithm is evaluated. The iterative method 0.99 s of CPU time compared to 1.72 s taken by Newton's forward-difference formula. Thus, for larger problems, the iterative method will provide a more efficient alternative to analytical sensitivities as compared with pure divided-difference schemes.

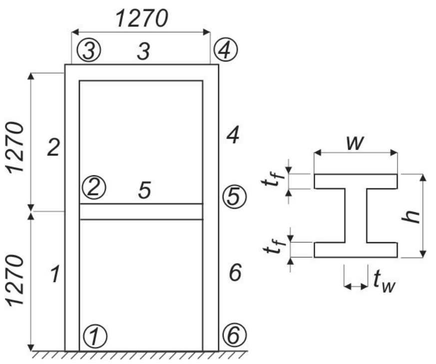

Figure 1.Plane-Frame problem. Units (mm).E=200 GPa (Young's modulus), ρ= 7900 kg/m^3 (Mass density)

The maximum number of iterations required for an error tolerance of 10^{-7} is five, which indicates rapid convergence. Also, the algorithm does not require computation of all eigenvectors to find the sensitivity of a few specific eigenvectors.

4. Conclusion

A numerical method for design sensitivity analysis has been presented. The idea is based on using iterative methods for reanalysis of the structure caused by a small perturbation in the design variable. A forward-difference scheme then yields the approximate sensitivity. We have presented the algorithm for eigenvalues and eigenvector sensitivity. The iterative schemes have been modified so that the coefficient matrices are constant and hence decomposed only once. We have concluded that convergence is very rapid. Implementation of the algorithms is found to be simple. The method can extend to eigenvalue sensitivity of problems with repeated roots. This extension is also important to avoid ill conditioning of the coefficient matrix in the vicinity of bifurcation points, which occurs when nonlinear structural response is considered.

5. Acknowledgement

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MACROSTRUCTURES, DEFECTS AND MICROHARDNESS OF FRICTION STIR WELDED T JOINTS OF AA 5052-H32 AND AA 5754-H111

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Abstract

In this paper, autors present results of research on possibility of production T-joints of aluminium alloy by friction stir welding process. Friction stir welding process is used to weld T-joints of aluminium alloy 5052-H32 and AA 5754-H111. These relatively new welding technologies realizes the high quality weld joints, where strength of joint can reaches the strength of the base material. Visual inspections, macrostructure examination, microhardness measuring and defects of welded T-joints were processed.

Keywords: Friction stir welding, AA 5052-H32, AA 5754-H111, T joints, microhardness, defects

1. Introduction

Friction stir welding (FSW) is relatively new welding process that was invented in 1991 at The Welding Institute (TWI) in United Kingdom. The first application of friction stir welding was for production of railway vehicles and for welding of aluminium alloys. FSW is solid-state welding technology which provides joining of materials without melting and without the use of additional materials.
Joining of material is performed by combined action of heat and mechanical work. Tool and base material stay in solid-state, while in the welding zone base material is in a slightly softened.

The temperatures that occur during the process do not exceed the melting point of the base material, and those are about 80% of the melting point. Welding temperature for aluminium alloys are in the interval from 400-500°C. [1-3]

The introduction of FSW joining technology, due to its performance, simplifies the production scenario of particular shaped profiles. It is well known for instance that in the aircraft and aerospace industries complex profiles and joining of so-called ‘skin and stringers’ are very often utilized for flying structures bodies. In recent years a few results have been presented that investigate the development of welded T-joints, made of lightweight alloys, trough FSW [4-7] with encouraging results. Experimental welding of aluminium plates was performed in order to obtain a T joints without defects.

2. Experimental research

The aim of this experiment was to examine the possibilities of welding T-joints with a selection of optimal welding parameters. It is possible to eliminate the welding defects from the weldment and produce the high quality T-joint, with a proper selection of welding parameters.

There were two welding processes because there were two different aluminium alloys. The first experimental welding of T joint was produced by FSW of three plates of aluminum alloy 5052-H32 which dimensions were 30x175x5mm. Chemical composition and mechanical properties of the first T joint are shown in Table 1 and 2, recpectively. The following limits are given according to EN 485-2 and EN 573-3 standard.

Table 1. Chemical composition of alloy EN AW 5052-H32 [8]

%	Cu	Mn	Mg	Si	Fe	Zn	Ti	Cr
min.	0	0	2,2	0	0	0	0	0,15
max.	0,1	0,1	2,8	0,25	0,4	0,1	0,01	0,35

Table 2. Mechanical properties of alloy EN AW 5052-H32 [9]

Property	$R_{p0,2}$ [MPa]	R_m [MPa]	A [%]	HV5
Value	130	210-260	12	67

Construction of clamping tool for working plates was the same for both welding processes. Radius of backing plates was 2 mm. However, for welding the T joints of AA 5052-H32 the material of clamping tool was carbon steel S355 according to EN 10025 /2004 standard. Material of clamping tool for welding T joint of 5052-H32 was stainless steel 1.430.

The second welding of T joints were produced by welding three plates of AA 5754-H111, which dimensions were 32x200x5mm and whose chemical composition is given in *Table 3.*, and the mechanical properties are in *Table 4*. The following limits are given according to EN 485-2 and EN 573-3 standard.

Experimental welding was performed on the milling machine AG-400 MINA. Rated power of the machine is 12kW, the maximum rotational speed is 2500 o/min, the maximum feed rate is 4500 mm/min and working space is x=600 mm, y=400 mm i z= 300 mm.

Table 3. Chemical composition of alloy EN AW 5754-H111 [8]

%	Mg	Mn	Si	Cu	Fe	Zn	Ti	Cr
min.	2,6	0	0	0	0	0	0	0
max.	3,6	0,5	0,4	0,1	0,4	0,2	0,015	0,3

Table 4. Mechanical properties of alloy EN AW 5754-H111 [9]

Property	$R_{p0,2}$ [MPa]	R_m [MPa]	A [%]	HB
Value	80	190-240	18	52

The special FSW tool used for both aluminium alloys was of material H13 tool steel. Welding tool has tipical geometry, cylindrical shoulder and tapered probe with a cone angle of 20°. Probe was etched curvaceous right coil whose tilt is 5°, which promotes better mixing and secondary flow of softened material. Hight of probe was 5,5mm. Diameter of shoulder was 25mm. Top of shoulder is concave, with a tank. Photo of tool with the basic elements is shown in *Figure 1*.

Figure 1. Photo of FSW tool

The 3D model of clamping tool used for welding was the same for both T joints and is given in *Figure 2*.

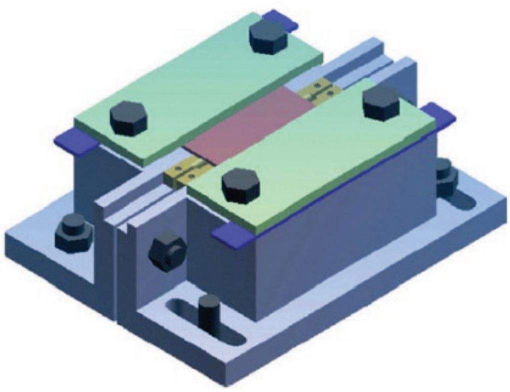

Figure 2. 3D model of clamping tool used in FSW of T-joints [10]

Positions of the welding tool, working plates and backing plates and some piece of construction of clamping tool for fabricating T joint by FSW process, for the T joint of AA 5754-H111 are given in *Figure 3*. Positions of this elements for welding AA 5052-H32 were the same like this in *Figure 3*.

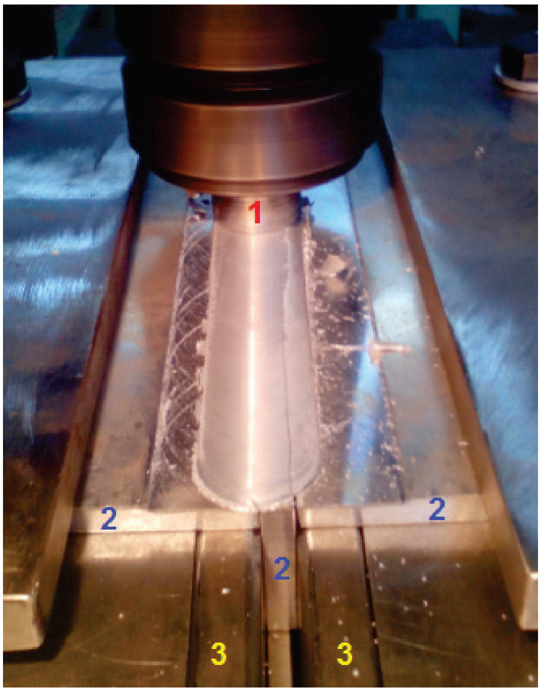

Figure 3. Photo of FSW of T joint and clamping tool, positioning of 1- tool, 2-working plates and 3-backing plates

Figure 3 shows the welding process, too. T joint obtain with two movement of welding tool. First, rotating welding tool passes along the joint line on the advancing side of weld metal, and then the tool goes out from the joint leaving a keyhole. Then the welding tool again comes to the beginning of the joint, and moves along the joint line on the retreating side of weld metal.

There are five welding parameters that affect the quality of welded joints and control of FSW process: the speed of rotation of the tool, welding speed, vertical force to work materials, tool tilt-angle , tool-plunge depth and tool geometry [11-12]. The process parameters used for experimental welding of T joints of both aluminium alloys were the same, and are given in *Table 5*.

Table 5. Process parameters for T-joints

$v_{rot}\left[\frac{o}{\min}\right]$	$v_{wel}\left[\frac{mm}{\min}\right]$	Tool tilt-angle α [°]	Tool-plunge depth $[mm]$
950	27	1	5,8

Non-destructive and destructive methods were used for testing welded T joints. Non-destructive testing reffered to the visual control of weld metal. Destructive testing included the macrostructure and microhardness tests. All tests are conducted in accordance with applicable standards.

3. Results and discussion

First was examined the T joint of AA 5052-H32, and then a T joint of AA 5754-H111. The methodology of testing each of welded T joint is given in Table 6.

Table 6. Methodology of testing T joints

Non-destructive	Step 1	Visual inspection
Destructive	Step 2	Microhardness distribution
	Step 3	Macrostructural appearance

When welding process was completed visual inspection of the face and root sides of the weld metal were done, according the standard EN 571-1 [8]. *Figure 4.* Gives face appearance of welded T joint of AA 5052-H32. It may be noted that here is a defect type tunnel, but we can not be sure to confirm its presence without metallographic tests. A higher flash of material on retreating side of the weld metal has been observed. Flash is a phenomen that with a proper choice of tools can be minimized but not eliminated. Root side of this T joint is given in *Figure 5.* and looks without defects.

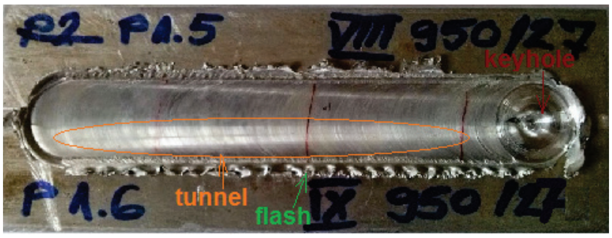

Figure 4. The face of weld metal of AA 5052-H32 T joint

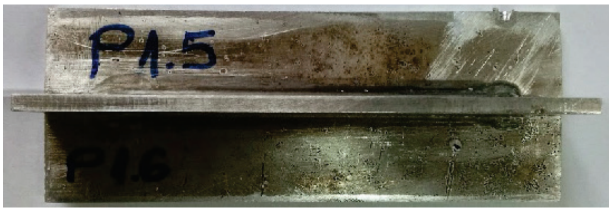

Figure 5. Root side of T joint of AA 5052-H32

The surface of T joint of AA 5754-H111 is given in Figure 6. The face is smooth and tunnel type defect was not noticed. Only small flash of material on retreating side of the weld metal has been observed.

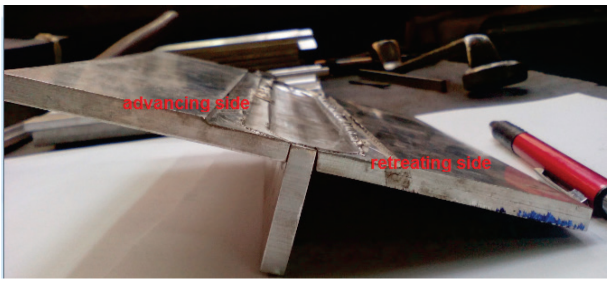

Figure 6. The face of weld metal of T joint

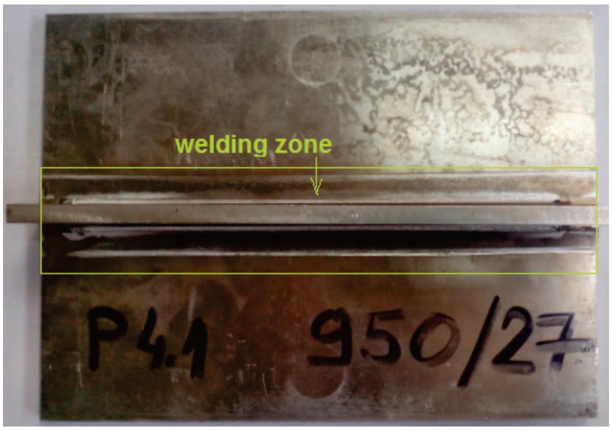

Figure 7. Root side of T joint of AA 5754-H111

Metallographic examination of macrostructure was observed structural changes, as well as the flow of materials. Figure 8 shows structural zone of FSW T joint of AA 5052-H32. There are three structural zones in weld metal: heat affected zone (HAZ), thermo-mechanically affected zone (TMAZ) and nugget zone (NZ). The samples are cutting perpendicular to the direction of welding direction from the T joint. Three types of defects in weld metal were found, as shown in Figure 9.

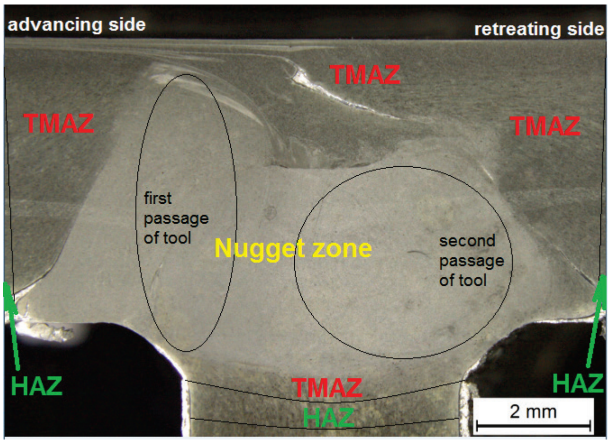

Figure 8. Macroscopic view of section of first T joint

Tunnel was observed on advancing side of the weld (Fig. 9.a). This defect occurs due to lack transport of softened material from retreating side toward advancing side of weld metal, i.e. insufficient mixing softened material due to improper welding parameters.

On root side of the weld, in the immediate vicinity of nugget, a defect type called kissing bond are present (Fig. 9.a). Kissing bond usually occurs due to insufficient penetration of the tool into working plates. This defect usually makes the initial crack in nugget [7].

Bonding line, or OJLwSPD (original joint line with severe plastic deformation) is a relative new type of defects (Fig. 9.b) [13].

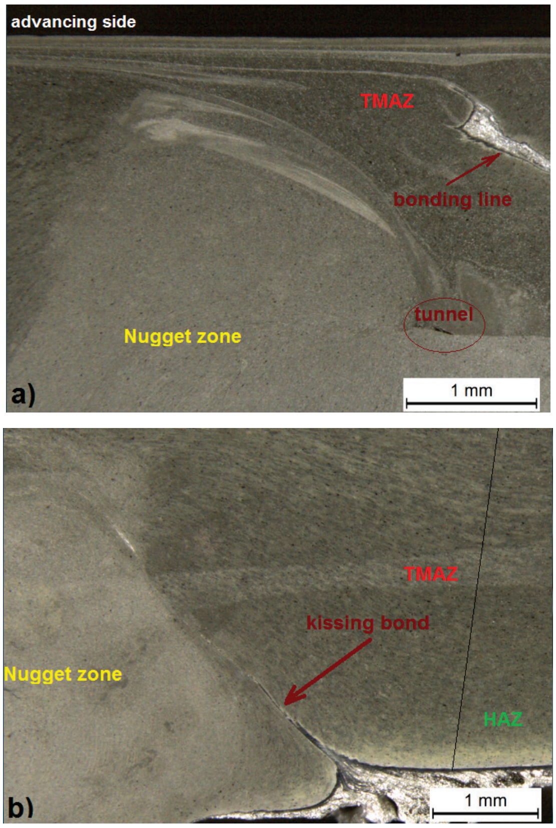

Figure 9. Types of defects in weld metal of AA 5052-H32

There is no doubt that when OJLwSPD defects exist in the weld metal, then there are always initial cracks and are harmful for mechanical properties of joint. Main formation mechanisms and features of the OJLwSPD defect in A2 T-joint can be summarized as the initial joining oxide surface between the two AA6061-T4 blanks is not completely destroyed during the welding process.

In butt joints, OJLwSPD defects could be easily vanished by increasing the tool rotational speed and, meanwhile, decreasing the traverse speed, because of the increased heat input. However, in FSW T-joints, owing to the restrictions from the fixtures, specifications of the base metals, and complex combination modes of blanks, OJLwSPD defect can be reduced by increasing the heat input and improving the welding tool [14].

Structure of nugget are characterised with concentric circles. These concentric circles, called onion rings, are characteristic for this area (Fig. 9.b). In the nugget zone, and part of thermo-mechanical affected zone near nugget structure is recrystallized and fine-grained. This is because grains are roughly mixed in this part of weld. The structure in the heat affected zone is similar to the base material. Lines of material flow can be clearly noticed in Figure 9b.

Second FSW T-joint of AA 5754-H111 (*Figure 10.*) is without imperfections, i.e. defects type tunnel, kissing bond and bonding line. Only small welding imperfections are observed: metallic inclusions which hight h=0,1– 0,13mm.

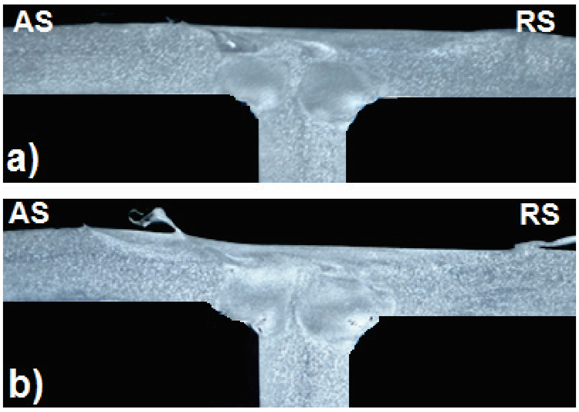

Figure 10. Macroscopic views of section of second FSW T-joint, sample taken at 4cm from the a) beginning of weld metal and b) end of weld metal

Microhardness measurement was performed with force of 9,807 N and was determined according to standard SRPS C.A4.040 and SRPS C.T3.051 [15]. Optical stereo microscope with software were used for image acquisition and processing. Microhardness of AA 5052-H32 was measured near the face and near the root of the weld metal, and microhardness of AA 5754-H111 was measured through middle height of the weld, per each 0.5 mm distance (on two samples from one joint). Figure 11 shows hardness distributions for these two welds.

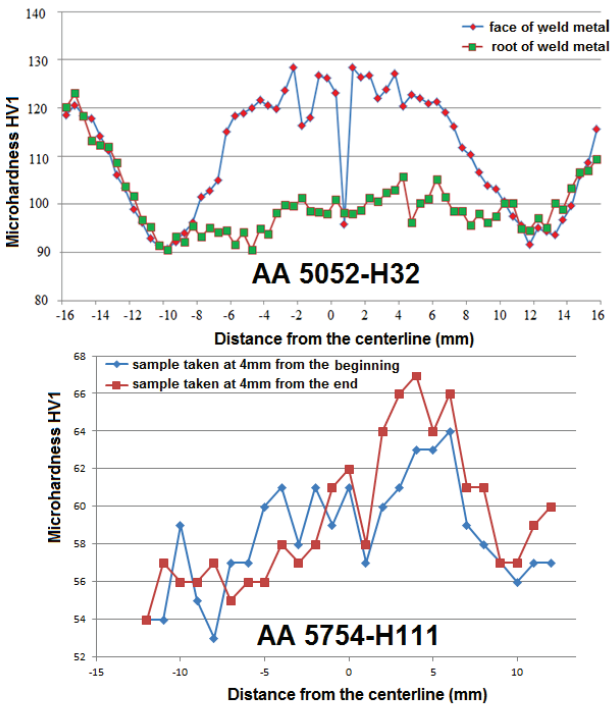

Figure 11. Microardness distributions of two aluminium alloys

The Highest hardness is present in nugget zone. This change of hardness in nugget is due recrystallization and fragmentation of structures. The minimum hardness values are present in the TMAZ /HAZ, as expected, because temperature increasing leads to increasing the grain size of structure. Diagram of hardness distribution of T-joint is different from butt-joint where is tipical "W" shape.

4. Conclusion

With visual examination of T joint of AA 5052-H32 could not establish the presence of defects. Macroscopic examination noticed three types of defects: tunnel, kissing bonds and bonding line. Based on the experience gained during experiment, these defects are caused by incorrect choice of welding parameters and lack of generated heat at the joining zone. One of the main cause of occurrence of these defects is a great heat conduction during FSW of T joint, which is largely determined the choice of material type for the backing plates and clamping tool. Therefore, in order to obtain T joint without defects with said tool and welding parameters, the material of the clamping tool (carbon steel class S355) should be replaced by a material that less conducts heat.

T joint of AA 5754-H111 is without imperfections. Stainless steel 1.4301 and 1.4541 have proved to be good materials for backing plates and clamping tool.

Thus, with used welding parameters is possible to successfully weld a T joint by FSW process.

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INFLUENCE OF INJECTION MOLDING PARAMETERS ON INJECTION MOLDED PART WEIGHT

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Abstract

Polymeric materials processing is one of the fastest growing industries in the world. One of the most important method for processing polymeric materials is injection molding. The characteristics of the process (mass production of wide variety of products from very simple one to extremely demanding, the possibility of achieving high productivity with very little or no additional finishing operations), make it a very interesting and important cyclical polymeric materials processing procedure. A large number of injection molding parameters affects the performance and productivity of molding part. As part of the paper, the samples of polystyrene (PS 495N Nature) were made by adjusting various parameters (packing pressure, packing pressure time). Afterward, the weight of obtained specimens were analyzed. The mathematical models that show dependence of part weight on the injection molded parameters were obtained as the result of analysis.

Keywords: Packing pressure, packing pressure time, injection molding

1. Introduction about injection moldings

Injection moulding is one of the most common processes used to produce plastic parts. It is a cyclic process of rapid mould filling followed by cooling and ejection. A variety of materials both plastic and non-plastic can be used as feedstock. However, the machine must be configured for the type of material used. The material, which is generally available as grains or powder, is plasticised in an injection unit and injected into a clamped mould under high pressure (500-1500 bar). The main advantage of injection moulding is that it is a very economical method of mass production.

Ready parts with tight tolerances can be produced in one step, often completely automatically. In general after-processing is not necessary. It is also possible to integrate different functions into one part to avoid the formation of different components that would be more expensive, e.g., the base of a typewriter with integrated guidance and fixing elements, the springy components of a printer element, lens with integrated prism to stop down a beam of light. [1]

It is worth noting that 75 % of faults in the lifetime of injection molded polymer parts are initiated in the process of developing and designing the parts.

Moreover, in the conventional product development process, approximately 80 % of faults generated during early phases of product design are recognized during production or quality control (Fig. 1). In the later development process phases, it is very difficult and costly to correct these faults. This means that during product development process it is necessary to make correct decisions, and make them as soon as possible. [2]

To guarantee a high quality in the injection molded parts the following points have to be considered: [1]

a) The material has to be plasticized and injected carefully to avoid negative effects on the material properties.
b) The process settings (such as pressures and temperatures) concerning the machine and mold have to remain constant with regard to time and space.
c) Injection molding machine characteristics.

An example of a commercially available injection molding machine is shown in Figure 1.

Figure 1. Injection molding machine installed at Mechanical engineering faculty in Slavonski Brod

2. Influence of packing pressure and packing pressure time

Testing samples were prepared on Dr. Boy injection moulding machine shown in fig 1, with technical data shown in table 1.

Material used for the test samples is polystyrene known under the trade name Styrolution PS 495 N produced by „Styrolution Group GmbH". The main material properties are given in table 2.

Table 1. Technical data BOY XS injection moulding machine [2]

Hydraulic power unit	
Clamping force	100 kN
Distance between tie bars	160 mm (horizontal) x 205 mm (diagonal)
Min. stroke volume	0,1 cm^3
Max. stroke volume	8,0 cm^3
Max. Injection pressure	3128 bar
Screw diameter	12 mm
Max. injection speed	24 cm^3/s

Table 2. Properties of PS 495 N [3]

Density	1040 kg/m3
Melting volume rate (200°C/5kg)	9,5 cm^3/10 min
Tensile Stress at Yield, 23° C	26 MPa
Melting temperature	180 – 260 °C
Shrinkage	0,4 to 0,7%

Table 3 shows the conventional sequence in the central-composite design of experiment with the real values of factors and the sequence of conducting the experiment. Packing pressure is in the range from 37,8 to 462,1 bar and packing pressure time range is from 1,17 s to 6,83 s. The shape of test sample is 5B according to the Standard HRN EN ISO 527-1: 2012.

Table 3. Conventional sequence in the central-composite design of experiment (real values of factor levels)

Number of sample	Packing pressure, bar	Packing pressure time, s
1	100	2
2	400	2
3	100	6
4	400	6
5	37,868	4
6	462,132	4
7	250	1,17157
8	250	6,82843
9	250	4
10	250	4
11	250	4
12	250	4
13	250	4

Precision balance Radwag PS 600.R2 (Figure 2) was used for mass determination. Five test samples for each state of experiment were used for weighing (65 samples).

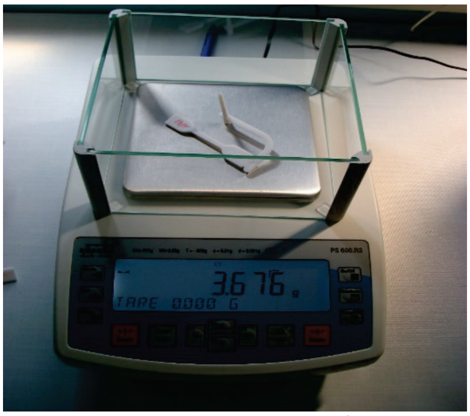

Figure 2. Balance Radwag PS 600.R2

In table 4 mean values of response (sample mass) are shown, calculated for 5 repeated measurement.

Table 4. Results of experiment

Number of sample	Sample mass, g
1	3,5328
2	3,6564
3	3,488
4	3,694
5	3,4498
6	3,6902
7	3,617
8	3,669
9	3,667
10	3,657
11	3,6774
12	3,6618
13	3,6638

Analysing the obtained data (table 4) it was determined the minimum value of mass is 3,4498 g and 3,694 g is maximum. During the diagnostic of the experiment it was observed that one of the condition of the experiment (number 8) has significant deviation in relation to the other and that sample was kicked out for further analysis.

Table 5 presents the report for the analysis of variance of the selected quadratic regression model, which shows the dependence of polystyrene part mass on the input variables. Members of model A, AB, A^2, B^2 are significant in the model (p value – probability for F variables that are less than 0,05).

Table 5. ANOVA for response surface

	Sum of squares	df	Mean square	F value	p value
Model	0,076	5	0,015	369,9	<0,0001
A- packing pressure	0,056	1	0,056	1363,8	<0,0001
B-packing pressure time	$1{,}331 \cdot 10^{-5}$	1	$1{,}331 \cdot 10^{-5}$	0,32	0,5900
A·B	$1{,}697 \cdot 10^{-3}$	1	$1{,}697 \cdot 10^{-3}$	41,31	0,0007
A^2	0,015	1	0,015	357,75	<0,0001
B^2	$2{,}671 \cdot 10^{-3}$	1	$2{,}671 \cdot 10^{-3}$	65,00	0,0002
Residual	$2{,}465 \cdot 10^{-3}$	6	$4{,}109 \cdot 10^{-5}$	-	-
Lack of fit	$1{,}390 \cdot 10^{-3}$	2	$6{,}949 \cdot 10^{-6}$	0,12	0,8904
Pure error	$2{,}326 \cdot 10^{-4}$	4	$5{,}816 \cdot 10^{-5}$	-	-
Cor Total	0,076	11	-	-	-

The lack of fit is here with the probability of F variable 0,89. This probability is greater than 0,05 and the null hypothesis that the deviation from the model is not significant, i.e. that the model estimates the reality well, is accepted.

The coefficient of determination R^2 is the portion of explained variability (how much the regression y deviates from the mean) in the total variability (how much the real y deviates from the mean), and is 0,997.Expression 1 illustrate the reduced regression model with the real values of factors.

Mass=3,36492+1,34119·10^{-3}·packing pressure+ 0,032374·packing pressure time+6,86667·10^{-5}· packing pressure·packing pressure time- 2,11576·10^{-6}·packing pressure^2–6,29660·10^{-3}· packing pressure time^2 (1)

The graphic representation of reduced model is shown in fig 3.

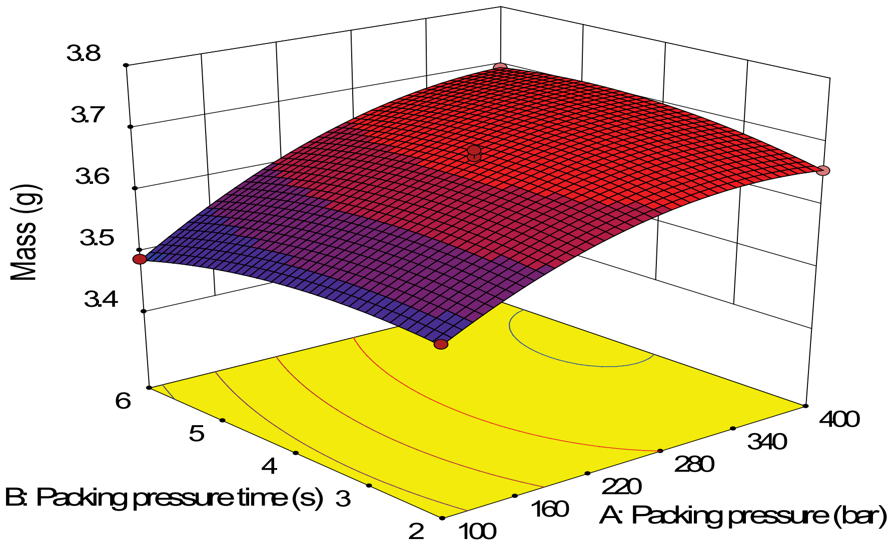

Figure 3. 3D surface view of reduced quadratic model

3. Conclusion

Injection molding is one of the most common cyclic processes used to produce plastic parts. Today more than one-third of all polymeric materials are injection molded. Parameters of injection molding such as melting temperature, mold temperature, clamping force, injection pressure and injection speed, significantly affect the properties of molded parts. In this paper the impact of two parameters (packing pressure and packing pressure time) on mass of polystyrene injection molded part was determined.

The analysis of variance showed that the packing pressure has the significant influence on part mass at the significance level α = 0,05. The regression analysis revealed the expressions that show the function dependence of packing pressure on polystyrene injection moulded part weight. Further research will go in the direction of getting appropriate mathematical model that will determine the dependence of mechanical properties on other processing parameters of injection moulding.

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FRICTION STIR WELDING OF T JOINT – NUMERICAL ANALYSIS

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Abstract

Results of numerical analysis on temperature fields in friction stir welded T joints of aluminium alloy are presented. This relatively new welding technology produces high quality weld joints, where strength of joint can reach the strength of base material. Numerical simulation of welding the three aluminium plates was performed in order to obtain T joint, as well as the production of thermo-mechanical 3D model of T joint.

Keywords: Friction stir welding, Al alloy, T joint, numerical simulation, thermo-mechanical model

1. Introduction

Friction stir welding (FSW) is a new solid-state joining technology invented at the welding institute (TWI) in 1991. The first application of friction stir welding was for production railway vehicles and for welding and aluminium alloys. Compared to the conventional welding processes, FSW process can produce superior mechanical properties in the weld zone. FSW is successfully applied to the aerospace, automobile and shipbuilding industries, [1-4].

The heat transfer process is one of the most important aspects in the FSW study. A good understanding of the heat transfer process in the working plates can be helpful in predicting the thermal cycles in the welding working plates, and the hardness in the weld zone, subsequently, can be helpful in evaluating the weld quality. Significant progress has recently been made of transfer modeling for FSW [5-7].

2. Numerical research

Numerical simulation of FSW process of two aluminium working plates in order to obtain the T joint and making a thermo-mechanical 3D model of T joint was made. Model of plate's position is given in *Figure 1.*

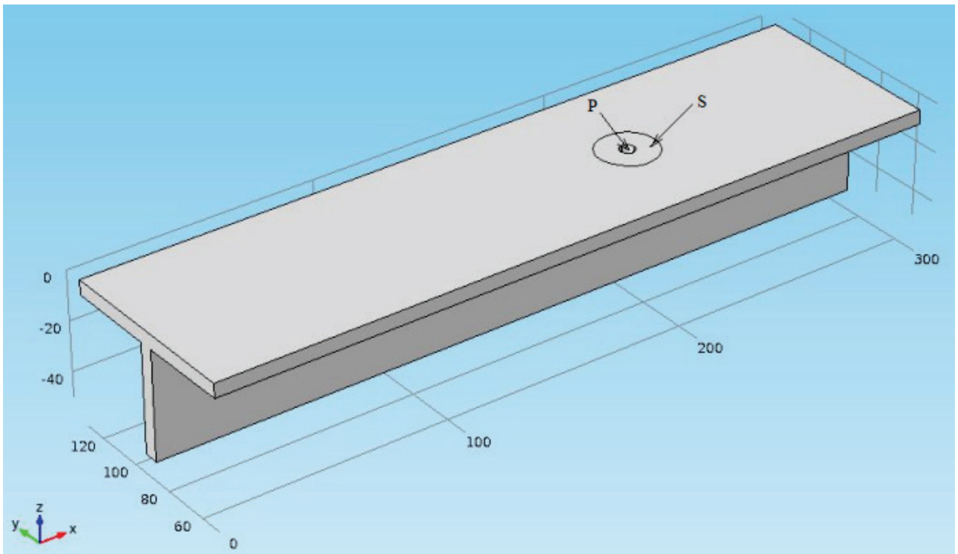

Figure 1. Model of position of aluminium plates

Ring area S represents the location of influence of shoulder top of welding tool on surface of the working plate. The hole P represents a place of effect of the probe of welding tool on working plates. Size of area of the probe is the same size like areas of the holes in the working plates (*Fig. 1*).

Welding tool was not modeled in this paper. The following assumptions are introduced in the numerical model:

- ✓ the heat generated at the shoulder of welding tool/working plate interface is frictional heat,
- ✓ the probe of welding tool is a cylinder, the thread of the probe can be neglected, and
- ✓ no heat flows into the working plates if the local temperature reaches the material melting temperature.

During the FSW process, the tool was moved with a constant speed along the joint line. The heat transfer control equation for the working plates can be written as (for the case of Euler formulations with convection) [8-9]:

$$\rho c \frac{\partial T}{dt} = \nabla(k\nabla T) + q - \rho c v_{wel} \nabla T \tag{1}$$

i. e. when the tool is moving in a positive direction of an x-axis:

$$\rho c \frac{\partial T}{dt} = \frac{\partial}{\partial x}(k_x \frac{\partial T}{\partial x}) + \frac{\partial}{\partial y}(k_y \frac{\partial T}{\partial y}) + \frac{\partial}{\partial z}(k_z \frac{\partial T}{\partial z}) + q - \rho c v_{wel} \frac{\partial T}{\partial x}. \tag{2}$$

Considering that it is a stationary process, the first member of expression is:

$$\rho c \frac{\partial T}{dt} = 0, \tag{3}$$

So that the expression (2) is reduced to:

$$0 = \nabla(-k\nabla T) + \rho c v_{wel} \nabla T - q. \tag{4}$$

Table 1 shows labels used in equations (1-4).

Table 1. Labels and their meanings in equations (1)-(4)

ρ (kg/m^3)	Density
c (J/KgK)	Heat capacity
T(K)	Temperature
t(s)	Time
$\nabla = \frac{\partial}{\partial x} + \frac{\partial}{\partial y} + \frac{\partial}{\partial z}$	Differential operator
k(W/mK)	Heat conductivity
q(W/m^3)	Heat input
v_{wel}(m/s)	Tool moving speed (welding speed)

The heat generating necessary for the thermo-mechanical welding process occurs on two places:

1. forehead of shoulder of tool, i.e. the heat generated at the shoulder of tool/working plate interface, (*Figure 1*., size of marked area S corresponds to the size of areaof the top of shoulder:

$$A_{shoulder} = \pi r_{shoulder}^2 \tag{5}$$

where $r_{shoulder}$ is radius of shoulder of welding tool

2. around the probe of tool, i. e. the heat generated at the probe of tool/working plates interface (*Figure 1*., heat generation is modeling like hole in working plates, where size of area of tool probe is:

$$A_{probe} = h 2\pi r_{probe} + \pi r_{probe}^2 \tag{6}$$

where r_{probe} is radius and *h* is the height of the probe of welding tool.

In order to model the heat transfer process accurately, it is necessary to include the heat generated by the tool pin in the modeling.Heat generated by the pin was estimated to be only 2% of the total heat gene–ration during the FSW. However, this ration was estimated to be up to 20% by some researchers [9].

For the heat generated by friction contact surface forehead top of shoulder and upper surface of working plate forhead the top of shoulder was used expression [9]:

$$q_{shoulder} = \mu \frac{F_n}{A_{shoulder}} r_{shouldr} v_{rot}, \tag{7}$$

where *μ* is the coefficient of friction that varies with the temperature change, and in this model is taken to be constant and its value is *μ* = 0.3. It was not possible to measure the pressure force, i. e. force of effect of tool on the working plate in vertical dire–ction, have taken a constant value which is F_n = *15*(kN). v_{rot} is the speed of rotation of the welding tool, and also has a constant value [8].

Heat generated as a result of plastic deforma-tions of the material of working plates during welding process which are caused by effect of probe is modeled by expression [9]:

$$q_{pin} = \frac{\mu \pi \sigma h r_{probe}^2 v_{rot}}{\sqrt{3(1+\mu^2)}}, \tag{8}$$

where *h(mm)* is height of probe and *σ*(kN/mm^2) is a yield stress of the material of working plates which is obtained from the diagram of dependence of yield stress of material on temperature. This diagram is given in *Figure 2.*

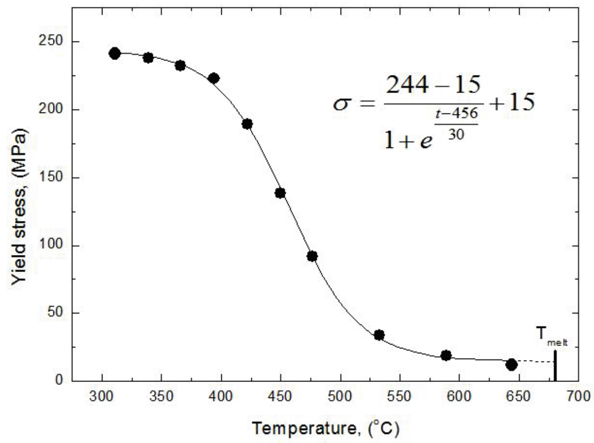

Figure 2. Diagram of depending the yield stress of the working plates material on temperature

In *Figure 3* boundary conditions are schemati-cally presented, as used for numerical model of FSW of T joints.

The initial temperature of the process was 300 K. The initial condition for the calculation was:

$$T(x, y, z, 0) = T_i \tag{9}$$

Four boundary conditions were used. The first two are:

q_1 - the heat flux boundary condition for the working plate at the shoulder of tool/working plate interface, and

q_2 - the heat flux boundary condition at the probe of tool/working plates interface.

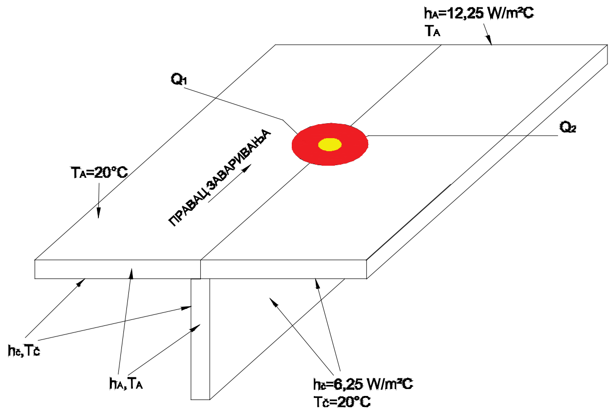

Figure 3. Shematic presentation of boundary conditions for numerical model of FSW of T joints

Expressions for q_1 and q_2 are similar and are calculated according to:

$$k\frac{\partial T}{\partial n}=q \tag{10}$$

The other two are convection boundary condition for all the working plates surfaces exposed to the air, and convection boundary condition for all the working plate's surfaces exposed to the backing plates. Expressions for these boundary conditions are similar and are calculated according to:

$$k\frac{\partial T}{\partial n}=h(T-T_o), \tag{11}$$

where n is the normal direction vector of boundary on the surface of working plate, h is the convection coefficient of heat from the working plates to the ambient air in first case, h_A, and to the backing plates in second case h_A, and T_0 represents the temperature of ambient air in first or backing plates in the second case of boundary conditions.

Figure 4 gives an enlarged representation of the mesh model on the site of the top of shoulder and probe of the welding tool.

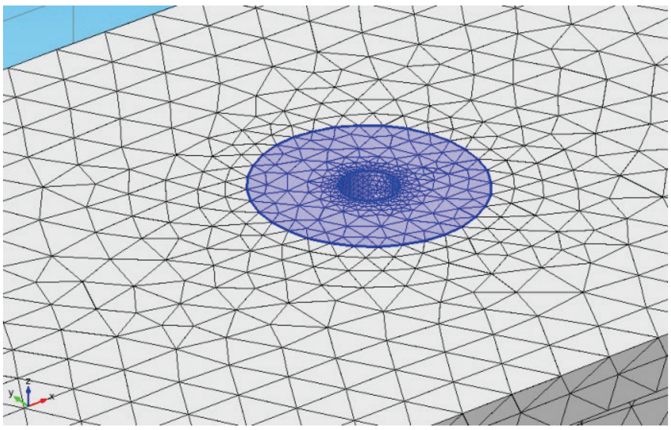

Figure 4. Enlarged view of finite element mesh

Table 2. Welding parameters used for numerical simulation of FSW process and dimensions of welding tool

v_{wel} (mm/s)	1,59
v_{rot}(rot/s)	500
h_A(W/m²K)	12,25
h_b(W/m²K)	6,25
$T_{Al\text{-}melting}$(K)	933
r_{probe}(mm)	3
$r_{shoulder}$(mm)	13
h(mm)	5
k (W/mK)	160
ρ(kg/m³)	2700
c(J/KgK)	900

3. Results and discussion

Figure 5 indicates that temperature fields during welding process are symmetric. The maximum value of the temperature that occurs during the numerical simulation of welding processes is 650°C (933 K). Temperature distribution through cross section of the T joint in the direction of the joint line (x-axis) is shown in Figure 6.

As expected, the highest temperature values are presented in the area immediately around heat sources, i. e. forehead the top of shoulder and probe. $D_{shoulder}$ is diameter of shoulder top, D_{pin} is diameter of probe, height of probe is h and b is a thickness of working plates, and its value is 6 mm.

The values of the welding parameters and dimensions of tool are shown in Table 2.These parameters are input data for the calculation.

4. Conclusion

Three-dimensional, nonlinear finite elements analisys was performednfor a friction stir welding fabrication of T-joints. T-joining have been shown not only to be an extension of a classical butwelding, but featuring some peculiarities in a heat flow and temperature distribution. Such behaviour was attributed to the geometrical aspects of T-joint.

The FEM simulation predicts temperature contours in welded plates with sound distinction of main welding zones. It clearly distinguishes heat-affected-zone from the rest of the welded plates. In particular, detailed heat dissipation within the shoulder and pin region can be analysed in terms of main processing variables and, thus, enabling better understanding of T-joining problems.

5. Acknowledgement

The paper has been supported by Serbian Ministry of Education, Science and Technological Develop–ment "Micromechanical damage and fracture criterias", no. 174004.

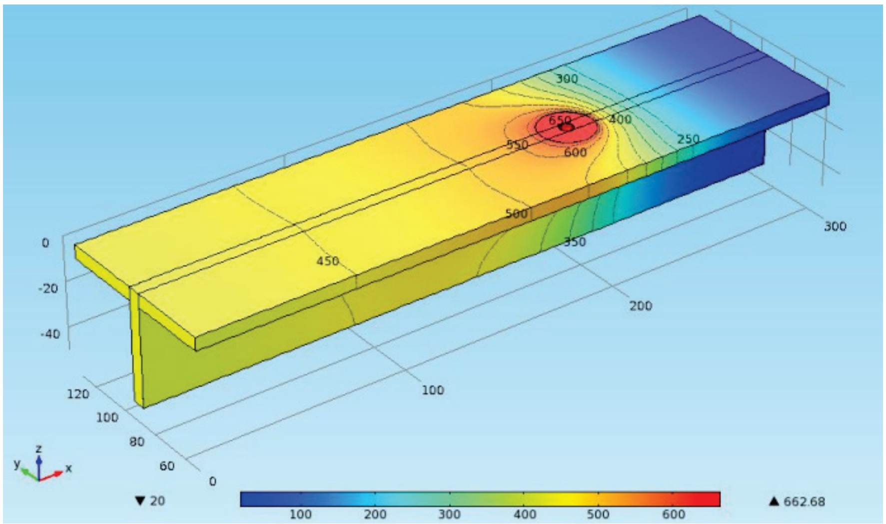

Figure 5.Temperature fields distribution in T-joint model

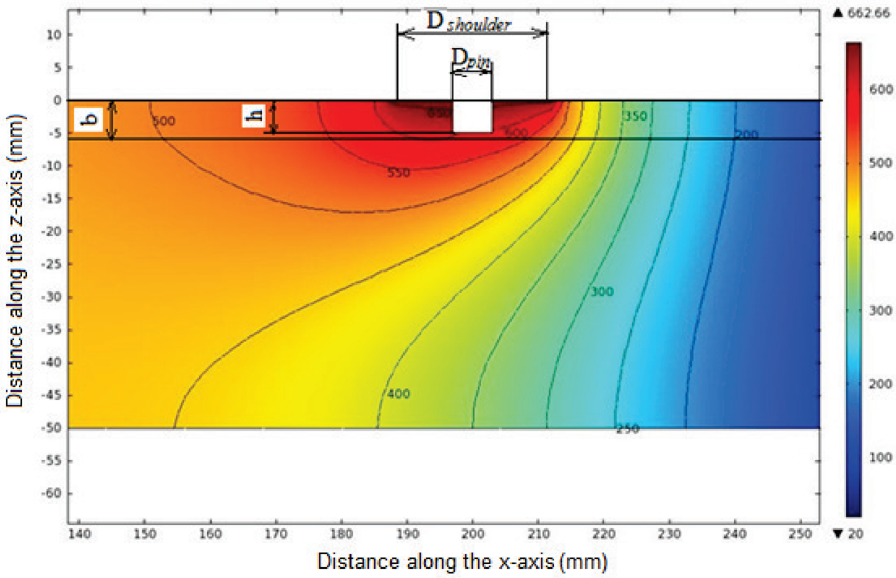

Figure 6. Distribution of temperature fields in x-z plane

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BONE CEMENT DEMOLITION BY PULSATING LIQUID JETS

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Abstract

Paper deals with trial test of using physiological saline 0,9% (NaCl) for disintegration of bone cement Hi-Fatique+G. The objective of the study is substitution of pure water of the physiolgical saline solution. The substitution of pure water for the physiological saline solution will consequently enable to apply the method for reimplantation of cemented bone implants. Test were conducted at pressure 13, 12, 11, 10 MPa, with traverse speed of 1, 2, 3 mm/min. Compared were traces created by both liquids.

Keywords:

Bone cement, pulsating water jet, pulsating physiological saline

1. Introduction

Every surgery the (hip joint replacement is accompanied by potential complications appearing sooner, later, and locally, globally [1]. According to Swedish National Hip Arthroplasty Register the number of total hip joint replacements having been revised was 13 561. 11 543 of the hip joints were revised for the first time and 1 713 revisions for the second time. The main reason of revisions was aseptic loosening with or without ostheolysis (75% of damages) [2]. Damages were caused by the material wear and rupture reached about 5% out of which implant ruptures represented 1.6% and polyethylene wear 0.5%. That represents 7.1% of revision standard corresponding to fatigue and fracture. Average period prior to revision is 10 years. Therefore bone cement removal during revision arthroplasty is very important factor of surgical technique [3]. In many studies were remarked that removal of bone cement si a very important aspect of the surgical technique during revision surgery (hip, knee) [3-5]. Removal techniques were studied by many authors in order to improve bone cement removal during endoprostheses replacement. Currently during reimplantation, oscillation saw, hammer, chisel, punches are used. It often causes complications of thermal and mechanical bone damage, detritus, femur perforation and microfracture, bone loss and loss of mechanical integrity with negative financial and social impacts. Therefore, new revision instrumentation is needed. One of them is using benefits of water jet technology, which can eliminate the aforementioned problems. Advantages of this technology are: athermic effects, selectivity, small tool diameter, application over small areas. Many tests were perfomed in order to utilise of pulsating water jet (PWJ), but in those studies was used as cutting tool pure water. For surgical purposes it is necessary to use sterile physiological saline 0,9% NaCl. Therefore first trial test was conducted in orter to find difference in performance between H_2O and physiological saline B Braun.

2. Experiments

As a sample was used workpiece prepared from Hi-fatique+G bone cement. The mechanical properties estimated by the nanoindentation of the bone cement are shown in the table 1.

Table 1. Mechanical properties of Hi-fatique+G

Name	Mixing	H_{it} [MPa]	St dev	E_{it} [GPa]	St dev
Hi-fatigue + G	DePuy	286.6	11.9	4.48	0.09
		309.3	14.7	4.84	0.20
		283.2	8.6	4.50	0.15

The tests of bone cement demolition were performed ath the Institute of Geonics of the CAS in Ostrava. The technological set up consisted of a pump Karcher (Fig. 1a) and robot ABB IRB 6640-180 for handling the pulsating water head (Fig. 1b). As a source of acoustic waves for the generation of pulsating water jet, an Ecoson WJ-UG_630-40 generator specially designed for pulsating water jetting tools was used. The MVT circular nozzle with an orifice diameter of 0,8 mm was used. The traverse speed was 1, 2, 3 mm/s. The pump pressure varied between 13-10 MPa. Experiments were performed with pulsating water jet with the modulation frequency of 20 kHz. Liquid was pumped from the tank (Fig. 1c). The depth of created traces was determined using the MicroProf FRT profilometer. The mean depth of a cutting trace was calculated as an arithmetical average of 1000 values measured along the trace.

Figure 1a. The liquid pressure pump Kärcher

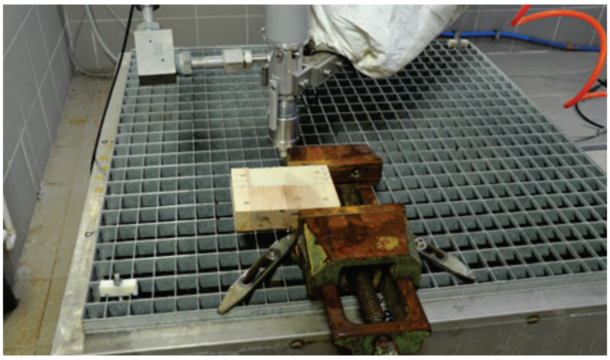

Figure 1b. Fixed sample of bone cement and cutting head withpulsating water head generator

Figure 1c. Tank for liquid (H_2O and for physiological saline 0,9%)

3. Results and disscusion

The results of the bone cement disintegration test are graphically illustrated in Figs. 2. From visual observation (Fig. 2a) and depth traces (Fig. 2f,g) obtained by MicroProf FRT profilometer values of the material removal rise with increasing water pressure and decreasing of traverse speed of the cutting head. Further objective was to find minimal technological set up for bone cement disintegration in order to reduce surgical technological conditions and hence potential hazards for patient. The traces depth of created created by pulsating water jet ranges from 1,2 – 0,4 mm. The traces depth of created created by physiological saline ranges from 1,1 – 0,2 mm, but with stand off distance 5mm. Both types of traces were creted with traverse speed 1mm/s. The character of traces created by the pulsating water jet and puslating physiological solution is illustrated in Fig. 2f,g. The cross-section profile mostly evokes a nonisosceles shape. At traces created by pulsating physiological saline is clearly seen wider upper part. The trace is geometrically due symmetric removal process. It can be caused by higher density of physiological saline.

4. Conclusion

The objective paper is to exploit the positive aspects of the pulsating water jet technology (i.e. disintegration without thermal effects on materials and selectivity) which has been developed at the Institute of Geonics of the CAS, v.v.i. in Ostrava - Poruba. The substitution of pure water for the physiological saline solution will consequently enable to apply the innovative method for reoperations of cemented bone implants (knee and hip). Due to the physical advantages of the process of bone cement disintegration, simplification of surgical procedures, reduction of operative and postoperative complications and shorter hospitalization period are expected.

5. Acknowledgement

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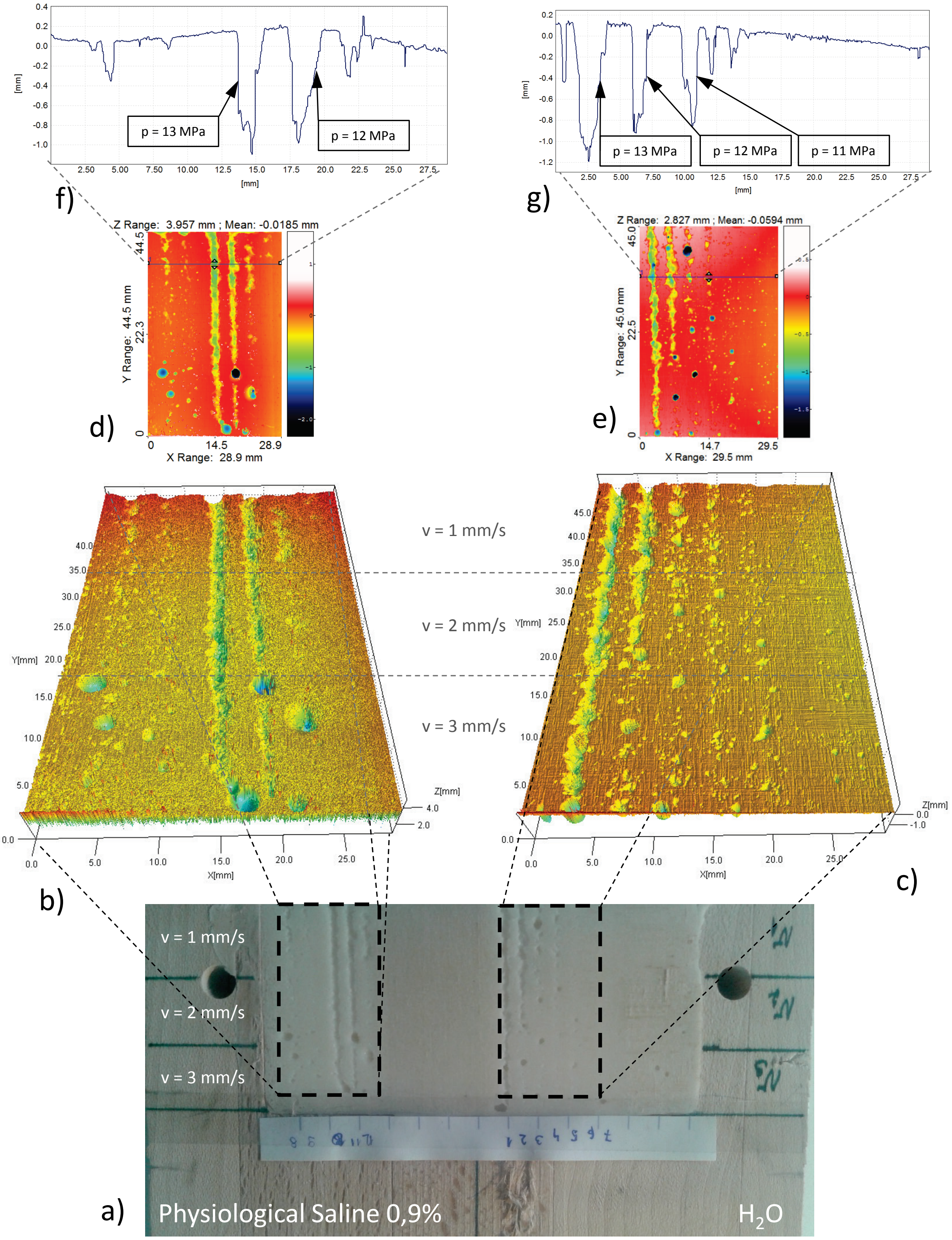

Figure 2 a) Traces on sample from bone cement Hi-fatigue+G fixed in wood matrix created by puslating water jet and pulsating physiological saline, b) 3D view of traces created by pulsating physiological saline, c) 3D view of traces created by pulsating water jet, d,e) position of measurement lines for creating cross-sections of disintegrated bone cement sample – depth profiles f) Created by pulsating physiological saline, g) created by pulsating water jet, obtained by MicroProf FRT profilometer

TWO-SPEED TWO-CARRIER PLANETARY GEAR TRAINS

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Abstract

The following paper reviews all of the possible cases of coupled two-carrier planetary gears with four external shafts. An emphasis is made on the work of these gears with one degree of freedom, one input and one output shaft and brakes on the other two shafts. When switching over the gears, the speed ratio of the gear is changed, thus allowing the use in two-speed mechanical transmissions of technological lifting and other machines. Some relations are deduced for determining the speed ratios and the efficiency of all structural schemes. There recommendations about the choice of the most appropriate structural scheme according to the current necessities.

Keywords: coupled planetary gears, structural analysis, efficiency

1. Introduction

In some cases of machinery there comes the need of using two-speed transmissions with a definite ratio between the two speeds. The ability to switch over while in motion and loaded is a certain advantage and in some cases an inevitable necessity. One proper solution is the use of a coupled two-carrier planetary gear with four external shafts and two brakes. In [1] there is a review on the various possible ways of brake mounting and power flowing in the above mentioned gear when it consists of two simple gears of the most common type (Fig. 1) [2] (consisting of a sun-gear 1, a ring-gear 3 and one-rimmed satellites 2, situated on the carrier).

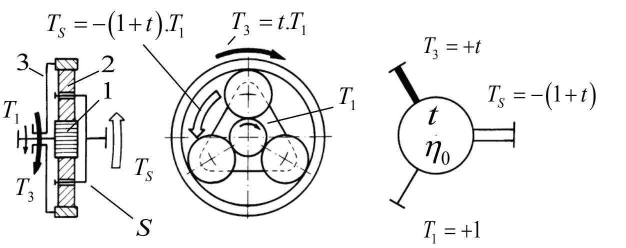


Figure 1 The most often used single-carrier planetary gear train and its torques

Prerequisite: $\eta_0 = \eta_{13(S)} = \eta_{31(S)} = 1$

Torque ratio: $t = \dfrac{T_3}{T_1} = \dfrac{T_{D\max}}{T_{D\min}} = \left|\dfrac{z_3}{z_1}\right| > +1$

Torques: $T_1 : T_3 : T_S = T_{D\min} : T_{D\max} : T_\Sigma =$

$$= T_1 : t.T_1 : -(1+t).T_1 = +1 : +t : -(1+t)$$

$$T_1 \equiv T_{D\min} < T_3 \equiv T_{D\max} < |T_S| \equiv |T_\Sigma|$$

Practice shows that in the structural analysis of coupled planetary gears it is appropriate to use the structural symbol of Wolf, indicating the simple gear with a circle and the three external shafts with three different in width lines, corresponding to the torque magnitude of the corresponding shaft [1, 3, 4]. The main force and kinematic characteristic of the simple planetary gear is the torque ratio t, through which the speed ratios in the gear can be expressed for all 6 cases of work with one degree of freedom [1, 3, 4, 5]

$$t = \frac{T_3}{T_1} = \frac{T_{D\max}}{T_{D\min}}, \qquad (1)$$

where $T_1 \equiv T_{D\min}$ is the torque of the sun-gear (the lowest torque); $T_3 \equiv T_{D\max}$ is the torque of the crown-gear (the higher differential torque);

The aim of the following paper is to analyze the possibilities given by all structural schemes of two-carrier planetary gears with four external shafts, consisting of simple planetary gears of the most common type (Fig. 1).

2. Structural Analysis

Table 1 shows all the possible ways of connecting the coupling gears [1]. The arrows indicate the isomorphism, thanks to which there are only 12 structural schemes for review (11, 12, 13, 14, 15, 16, 33, 34, 35, 36, 55 and 56).

Table 1 Structural schemes of coupled two-carrier planetary gears with four external shafts

	...1 t_{II}	...2 t_{II}	...3 t_{II}	...4 t_{II}	...5 t_{II}	...6 t_{II}
1... t_I	11	12≙21	13≙31	14≙41	15≙51	16≙61
2... t_I	21≙12	22	23≙32	24≙42	25≙52	26≙62
3... t_I	31≙13	32≙23	33	34≙43	35≙53	36≙63
4... t_I	41≙14	42≙24	43≙34	44	45≙54	46≙64
5... t_I	51≙15	52≙25	53≙35	54≙45	55	56≙65
6... t_I	61≙16	62≙26	63≙36	64≙46	65≙56	66

The conducted analysis shows that the most clarity is achieved when reviewing 6 basic variants (according to the situation of the brakes), each of which with two sub-variants according to which brake is activated (Fig. 2).

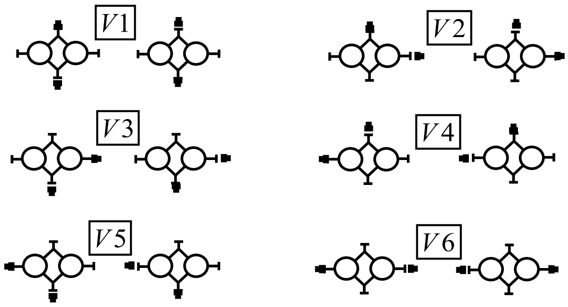


Figure 2 Variants of work of the gears in review

When situating the two brakes on the two single shafts (V6 – Fig. 2) only one of the coupling gears will be working and the speed ratio of the coupled gear will depend only on the torque ratio of the working gear.

When situating the two brakes on the two coupled shafts (V1 – Fig. 2) the two coupling gears are connected in series and the speed ratio of the coupled gear will be equal to the product of the corresponding speed ratios of the coupling gears. It will depend on the torque ratios t_I, t_{II}, the structural scheme and on which of the brakes is closed.

When situating the two brakes on one single and one coupled shaft there are four possible variants in one structural scheme. Having in mind that in the reviewed structural schemes there are different possible ways of power flowing (branching or circulation) with a fixed single shaft, the variants become eighth. When the brake of the coupled shaft is closed the speed ratio will depend only on the torque ratio of one of the coupling gears.

When the brake of the coupled shaft is open the speed ratio will depend on the torque ratios t_I, t_{II}, of the coupling gears and the particular structural scheme. Essentially, the gear will be working as a two-carrier one with three external shafts, a case reviewed in details in [4].

The cases from V1 – Fig. 2 can also be referred to coupled two-carrier gears with three external shafts. They just have to work with a fixed coupled shaft.

3. Kinematic Analysis

The coupled two-carrier planetary gears with four external shafts are appropriate for two-speed drives. The two-speed drive with one main speed and one micro-speed is common for mechanisms of lifting machines with higher positioning accuracy or operating with dangerous loads. It is also observed in technological and other machines.

In this case, given a certain angular velocity ω_A, three angular velocities of the output shaft when closing different brakes should be obtained. For example, a main speed ω_B, and a micro-speed $\omega_{B\mu}$.

Of particular interest is the possibility of reversing the motion - working displacement at low velocity (high torque) and rapid return to initial position.

The torque ratios of the two coupling gears and can vary within the construction limited interval [4]

$$2 \le t_{I\min} \le t_I \le t_{I\max} \le 12 ,$$

$$2 \le t_{II\min} \le t_{II} \le t_{II\max} \le 12 .$$

Therefore, if the necessary speed ratios of the two speeds $i_{AB} = \dfrac{\omega_A}{\omega_B}$ and $i_{AB\mu} = \dfrac{\omega_A}{\omega_{B\mu}}$ can be accomplished by a simple planetary gear, it is good to use structural schemes with brakes on the single shafts (V6 – Fig. 2).

With high speed ratios i_{AB} and $i_{AB\mu}$ it is possible that the above mentioned gear is a second stage, which gives the desired ratio between the two speed ratios. For example, in scheme 45 in Table 1 this ratio could be

$$2 \le \frac{\omega_B}{\omega_{B\mu}} \le 13 .$$

For all the different structural schemes in Table 1 relations are deduced for determining the speed ratios for the 12 cases of work with one degree of freedom. Figure 3 exemplifies the way of determining the speed ratios for variant V2 in scheme 16 when activating the various brakes (V21 and V22). In this case there is an internal power division. Figure 4 shows an example with internal power circulation.

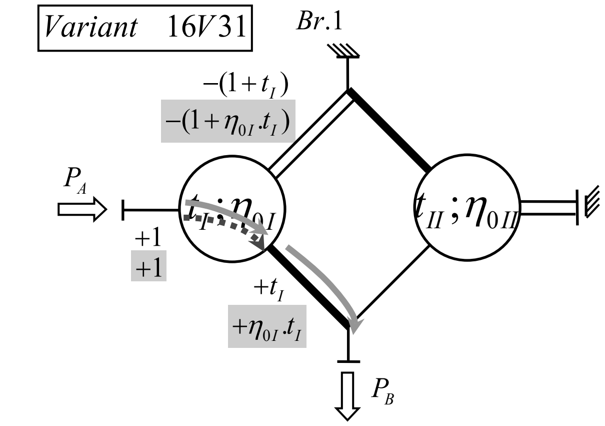
4. Efficiency

In this case it is most appropriate to determine the efficiency η from the input T_A and output T_B torques following the expression [1, 3, 4, 6, 7]

$$\eta = \frac{\left(\dfrac{T_B}{T_A}\right)_{losses}}{\left(\dfrac{T_B}{T_A}\right)_{without\ losses}} , \qquad (2)$$

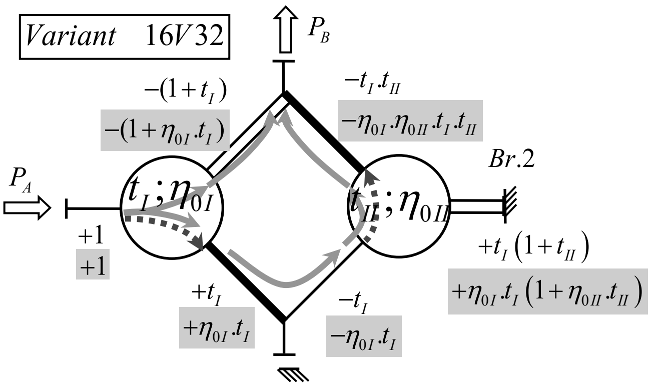
where the torques with losses are determined with reading the direction of rolling power flow in the coupling gears. Relations are deduced for all the structural schemes in Table 1 for determining the efficiencies for the 12 cases of work with one degree of freedom as a function of the torque ratios t_I and t_{II} and the basic (when working with a fixed carrier) efficiencies η_{0I} and η_{0II} of the coupling gears.

The latter could be assumed as constants [4], but they had better be determined with reading the impact of the number of teeth (i.e. of t_I and t_{II}) on the mesh losses by the methods described in [5].



$$i_{Br.1} \equiv i_{V21} = -\frac{T_B}{T_A} = -t_I$$

$$\eta_{Br.1} \equiv \eta_{V21} = \frac{(T_B)_{losses}}{(T_B)_{without\ losses}} = \eta_{0I}$$



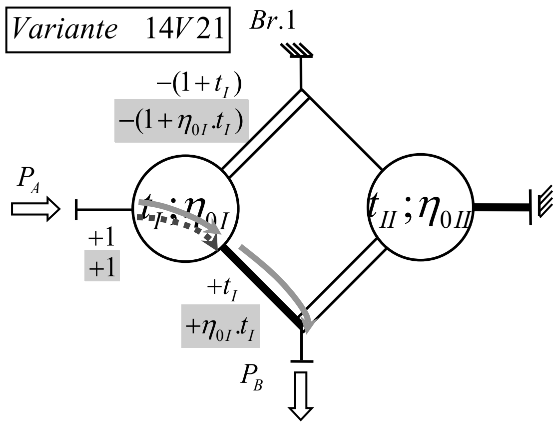
$$T_B = -(1+t_I+t_I.t_{II}) < 0$$

$$T_B = -(1+\eta_{0I}.t_I+\eta_{0I}\eta_{0II}t_I.t_{II}) < 0$$

$$i_{Br.2} \equiv i_{V32} = -\frac{T_B}{T_A} = 1+t_I+t_I.t_{II}$$

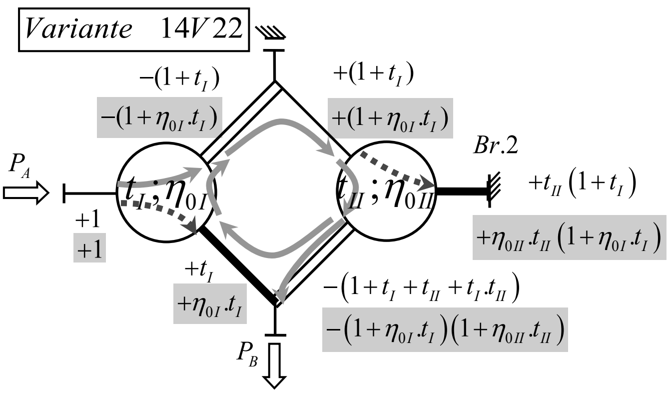
$$\eta_{Br.2} \equiv \eta_{V22} = \frac{(T_B)_{losses}}{(T_B)_{without\ losses}} = \frac{1+\eta_{0I}.t_I+\eta_{0I}.\eta_{0II}.t_I.t_{II}}{1+t_I+t_I.t_{II}}$$

Figure 3 Determining the speed ratios and efficiency for variant V3 in structural scheme 16 in Table , - transmitted power; - rolling power



$$i_{Br.1} \equiv i_{V21} = -\frac{T_B}{T_A} = -t_I$$

$$\eta_{Br.1} \equiv \eta_{V21} = \frac{(T_B)_{losses}}{(T_B)_{without\ losses}} = \eta_{0I}$$



$$T_B = -(1+t_{II}+t_I.t_{II})$$

$$T_B = -(1+\eta_{0II}.t_{II}+\eta_{0I}.\eta_{0II}.t_I.t_{II})$$

$$i_{Br.2} \equiv i_{V22} = -\frac{T_B}{T_A} = -(1+t_{II}+t_I.t_{II})$$

$$\eta_{Br.2} \equiv \eta_{V22} = \frac{(T_B)_{losses}}{(T_B)_{without\ losses}} = \frac{1+\eta_{0II}.t_{II}+\eta_{0I}.\eta_{0II}.t_I.t_{II}}{1+t_{II}+t_I.t_{II}}$$

Figure 4 Determining the speed ratios and efficiency for variant V3 in structural scheme 14 in Table , - transmitted power; - rolling power

Figures 3-4 exemplify the way of determining the efficiency of the given variants. The torques of the shafts (the values on a dark background) are determined with reading the losses and direction of the rolling power in the coupling simple gears. In analysed case $(T_A)_{without\ losses} = (T_A)_{losses} = +1$, which simplifies formula (2).

It has been established that in all cases the expression in the numerator of (2) is obtained when in the denominator the torque ratios of the coupling gears (t_I or t_{II}) are multiplied by the corresponding basic efficiencies (η_{0I} or η_{0II}) when in the simple gear the rolling power is transmitted from the sun 1 to the ring 3.

When the rolling power is transmitted from the ring to the sun the torque ratio of this simple gear is divided by the basic efficiency. In the examples in Fig. 3 and Fig. 4 only the first case is shown.

5. Analyzing the Results

According to the structural scheme and the way of situating the brakes (the variant) different ratios of the output angular velocities are obtained with one and the same input velocity (i.e. of the two speed ratios). In some cases when switching over the brakes the rotational direction of the output shaft is retained (12V1, 12V3, 13V1, 13V5, etc.), whereas in other cases it is reversed (12V2, 13V2, 13V3, 13V4, 14V2, etc.) In both cases it is possible that the gear continues its work as a reducer (respectively as a multiplier) or it might change its way of working – from reducer to multiplier (respectively from multiplier to reducer).

Retaining the rotational direction, In some of the cases of retaining the rotational direction the two speed ratios are close in value (15V3), sometimes close to 1 (15V4), even when the gear works as a reducer with one brake and as a multiplier with the other one (16V5, 36V5).

In other cases of retaining the rotational direction there is a significant difference between the two speed ratios (13V1, 13V6, 34V6, 36V2 and particularly 16V3) when the gear works as a reducer. In schemes 12V6, 13V5, 14V6, 15V5, 35V5 it works as a reducer with one brake and as a multiplier with the other one. Thus a higher difference between the two speed ratios could be obtained (especially in 35V5). In scheme 56V6 when $i_{Br.1} = t_I$, $i_{Br.2} = \dfrac{1}{t_{II}}$ which allows the obtaining of $i_{Br.1} = \dfrac{1}{i_{Br.2}}$ (when necessary).

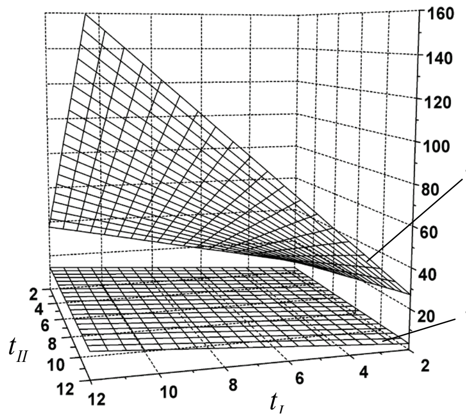
Reversing the rotational direction. A great variety of options exists in the variants where the rotational direction is reversed. In 36V1 both speed ratios are close to 1, in 12V2 $i_{Br.1} = -t_I$ and $i_{Br.2} = 1 + \dfrac{1+t_I}{t_{II}}$ in 13V2 $i_{Br.1} = -t_I$ and $i_{Br.2} = \dfrac{t_I.t_{II} - 1}{1+t_{II}}$, whereas in 14V2 a great difference is obtained between the two speed ratios - $i_{Br.1} = -t_I$ and $i_{Br.2} = 1 + t_{II} + t_I.t_{II}$. The case is similar in 16V1. These schemes are appropriate for a technological machine with one displacement with high resistance (and low speed) and reversion to initial position with a higher speed (for increasing the productivity).

In other variants the gear works as a reducer with one brake and as a multiplier with the other one (15V6, 34V5, 35V1, 35V6) as in some cases there is a significant difference between the speed ratios.

In the structural schemes of the main diagonal in Table 1 for variants V2 and V3, according to the values of the torque ratios t_I and t_{II} of the coupling gears the rotational direction could be either retained or reversed. In the borderline case, when $t_I = t_{II}$, no motion is transmitted. The input shaft rotates, while the output one is motionless. In these cases $i = \omega_A / \omega_B = \infty$ is obtained analytically, but the efficiency equals zero.

The formulae deduced for the speed ratios as a function of the torque ratios of the coupling gears serve as a basis for the establishment of a kinematic analysis program for the structural schemes in Table 1. It can be used for picking out the structural schemes which are capable of providing the desired ratio between the speed ratios in the case of a two-speed drive. The graphical representation of $i_{Br.1}$ and $i_{Br.2}$ as a function of the torque ratios of the coupling gears t_I and t_{II} (Fig. 5a), as well as their correlation (Fig. 5b), facilitates the quick orientation of the designer about the capabilities of the various structural schemes and their variants.

a)



b)

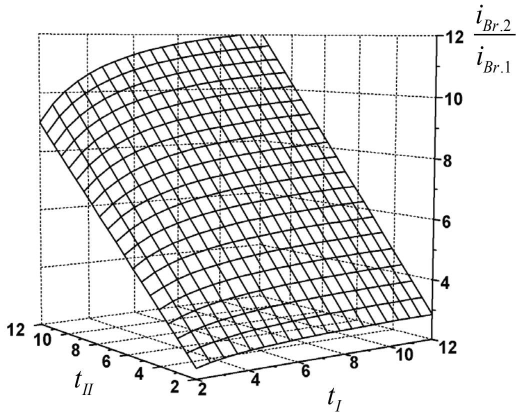


Figure 5 The speed ratios $i_{Br.1}$ and $i_{Br.2}$ (a) and their correlation (b) for variant V3 in structural scheme 16 (with activating different brakes) as a function of the torque ratios t_I and t_{II} of the coupling gears

On the basis of the formulae deduced for the efficiency as a function of the torque ratios and the basic efficiencies of the coupling gears, a program is established for determining the most appropriate structural scheme and its parameters from the standpoint of minimal losses.

Power circulation. Of all the schemes in review 15, 16, 35 and 36 are with internal power division (branching out) and the others are with internal power circulation (as in the case of gears with three external shafts [4]).

It has been established that in the schemes of the main diagonal of Table 1 (the symmetrical structural schemes) the direction of power circulation in one and the same variant is changed according to the magnitude of the torque ratios of the coupling gears. In the rest of the structural schemes with power circulation the direction of the circulating power is not changed.

6. Conclusion

All possible structural schemes of coupled two-carrier planetary gears with four external shafts and two brakes, working with one degree of freedom have been reviewed. The analysis shows that it is sufficient to review just 12 structural schemes with the 6 possible variants for locating the brakes. Relations have been deduced for determining the speed ratios and efficiencies for all the variants of the schemes in review. An analysis has been conducted and recommendations have been given for when a certain scheme is appropriate to be used. The analytical results are shown in Table 2, which allows the quick orientation in the kinematic capabilities of the structural schemes in review.

Program products have been established for kinematic and force analysis of the structural schemes, facilitating designer in the choice of the most appropriate structural scheme and its parameters.

7. References

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Table 2 Kinematic capabilities of the different variants of the structural schemes in review

11V1 – **ret.** V2 – **ret.** $t_I > t_{II}$ – **rev.** $t_I < t_{II}$ V3 – **rev.** $t_I > t_{II}$ – **ret.** $t_I < t_{II}$ V4 ≡ V2 V5 ≡ V3 V6 – **ret.**	**12**V1 – **ret.** V2 – **rev.** V3 – **ret.** V4 ≡ V3 V5 ≡ V2 V6 – **ret.** r.-m.	**13**V1 – **ret.** ! V2 – **rev.** V3 – **rev.** ! V4 – **rev.** V5 – **ret.** r.-m. V6 – **ret.** !
14V1 – **ret.** ! V2 – **rev.** ! V3 – **ret.** V4 – **ret.** V5 – **rev.** V6 – **ret.** r.-m. $i_{V61} = 1 + t_{II}$ $i_{V62} \approx 1$	**15**V1 – **rev.** V2 – **ret.** V3 – **ret.** V4 – **ret.** $i_{V41} \approx i_{V42} \approx 1$ V5 – **ret.** r.-m. V6 – **rev.** r.-m.	**16**V1 – **rev.** ! V2 – **ret.** V3 – **ret.** ! ! V4 – **ret.** $i_{V41} \approx i_{V42} \approx 1$ V5 – **ret.** r.-m. $i_{V51} \approx i_{V52} \approx 1$ V6 – **rev.** $i_{V61} \approx 1$ $i_{V62} = t_{II}$
33V1 – **ret.** V2 – **rev.** $t_I > t_{II}$ – **ret.** $t_I < t_{II}$ V3 – **rev.** $t_I > t_{II}$ – **ret.** $t_I < t_{II}$ V4 ≡ V2 V5 ≡ V3 V6 – **ret.**	**34**V1 – **ret.** r.-m. V2 – **rev.** r.-m. ! V3 – **ret.** $i_{V31} \approx 1$ $i_{V32} = t_{II} + 1$ V4 – **ret.** $i_{V41} \approx i_{V42} \approx 1$ 5 – **rev.** r.-m. ! V6 – **ret.** r.-m. !	**35**V1 – **rev.** r.-m.! V2 – **ret.** r.-m. ! V3 – **ret.** $i_{V31} \approx i_{V32} \approx 1$ V4 – **ret.** $i_{V41} \approx i_{V42} \approx 1$ V5 – **ret.** r.-m. ! V6 – **rev.** r.-m. !
36V1 – **rev.** $i_{V11} \approx i_{V12} \approx 1$ V2 – **ret.** ! V3 – **ret.** $i_{V31} \approx 1$ $i_{V32} = 1 + \frac{t_I}{t_{II}}$ V4 – **ret.** V5 – **ret.** r.-m. V6 – **rev.** !	**55**V1 – **ret.** $\frac{i_{V11}}{i_{V12}} = \frac{t_I}{t_{II}}$ V2 – **ret.** $t_I > t_{II}$ – **rev.** $t_I < t_{II}$ V3 – **rev.** $t_I > t_{II}$ – **ret.** $t_I < t_{II}$ V4 ≡ V2 V5 ≡ V3 V6 – **ret**	**56**V1 – **rev.** ! V2 – **ret.** V3 – **rev.** r.-m. V4 ≡ V3 V5 ≡ V2 V6 – **ret.** r.-m. Suitable for $i_{Br.2} = \frac{1}{i_{Br.1}}$

Note: The following abbreviations are used in the table:
ret. – the rotational direction is retained when working with different brakes;
rev. – the rotational direction is reversed when working with different brakes;
r.-m. – the gear works either as a reducer or as a multiplier according to which brake is activated;
! – the variant is capable of obtaining a significant difference between the two output angular velocities.

THE INFLUENCE OF THE SIZE DISTRIBUTION AND PARTICLE PROPERTIES ON THE FILTRATION PERFORMANCES IN TECHNICAL WATER

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Abstract

When analyzing the experimental data related to technical water quality, the most commonly is used method for determination of particle size distribution. It is needed, also, to derive an adequate approach which can describe model under the study. In order to design adequate filter system, information's about the particle size distribution are crucial. This paper presents results of examining the size distribution of solid contaminants found in technical cooling water, and influence of particles properties on filtration performances.

Keywords: Particles distribution, filtration, technical water, granulometric composition.

1. Introduction

Water which is used for industrial purposes has the main place in production, although role of water in cooling and heating system, and usage of water for removal of excess heat, or heating up by using steam should not be left out. Water sources from which water is supplied are mostly not satisfying required quality for direct usage in industrial application. Because of that, it is necessary to treat water in different ways in order to achieve the set quality requirements which correspond to different application for later utilization in the process.

Preparation and treatment of industrial water begins with purification. On the first place filters need to be free of solids found in the water, after which commonly, by using the chemicals are treated solved matters in water. List of chemicals which are used in these kinds of treatments is long, and mostly are used mixtures of different chemicals, not just one. [1] Water used in production as part of the product is necessary to be suitable for technical use and that is fulfilling demands required for the end product. If water is, for example, used in production of chemicals where water is base product, it is demanded that water is clean and without possibility to find dirtiness in final product. In production in pharmacy, solutions which will later be used as drugs for humans and animals, should have only active substances, and must not be contaminated with other ingredients. Technical water in factory for manufacture of tires, which is used as cooling medium, is considered in paper [2].

When talking about water which is used for cooling or heating (utility water), requirements for purity are not very high, but treatment is necessary. With treating this kind of water, goal is to decrease and avoid technical problems which can occur in a cooling water system, or a heating loop. [3] Possible contamination of utility water is formation of biofilm, biofouling and growth of algae, on the first place if cooling systems are open. Microorganisms are spreading in water and forming biofilm on pipes and in machines, which is affecting heat transfer in system, or it may even clog it. Industries which are dealing with heat-transfer equipment are facing problems with economic loss, due to appearance of fouling. Ensuring the anti-fouling technology on the surfaces of heat exchange systems is of great importance, in order to use effectively energy and reduce production of carbon dioxide. [4] That degree of water contamination is determined with indicators of contamination, and it represents concentration of the substance in milligram per 1 dm^3 of water.

Feed of the water in manufacturing process is constantly composed of particles in different sizes (size distribution), and regarding to the smallest particles in the distribution, many aspects of filtration cycle is controlled. These smallest particles are easily passing through filter material in the beginning stages of filtration, they are accumulating in cake layers nearest to the filter material, and they most intensively interact with ions and other substances, creating the compressibility effect. These particles also affect the most surface and specific resistance of filter cake. When observing the distribution of particles, significant particles for characterization of filtration are rarely the ones which are 50% f size. Filtration is usually controlled by finer particles in the distribution, because even small increase in the number of finer particles can reduce filtration rates. [5]

2. Method

Particles are defined as "any relatively small subdivision of matter, ranging in diameter from a few Angstroms to a few millimeters". Composition and consistence of particles can be very different, concerning the fact that particles can have different shape, may be isotropic or anisotropic, also particles can be molecularly homogenous or inhomogeneous, or composed of organic or inorganic molecules, or they can be suspended in versatile media. Devices which are measuring sizes of particles are under the influence of various parameters, i.e. homogeneity, shape of particles, state, molecular structure, isotropy, or medium in which particles are suspended. [6]

In this research was examined water from the well in municipality Novi Beograd, which is used for heating and cooling in system of heat pump. Raw well water was filtered with 30 μm filter (Profimat, Judo Wasseraufberaitung GmbH, Germany) (figure 1).

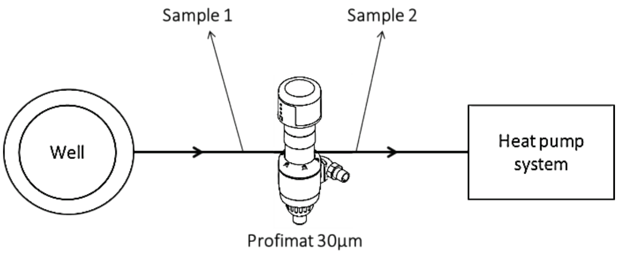

Figure 1. Installment for pumping and filtration of well water showing where samples were taken.

It was noticed that fouling formed on the heat exchangers which are placed in system of heating and cooling, with which is decreased efficiency of system functioning (figure 2).

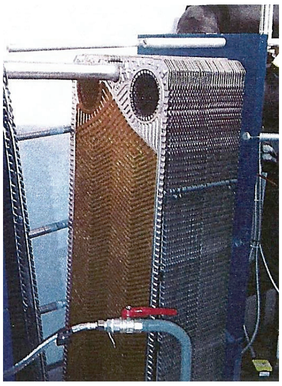

Figure 2. Contaminated heat-exchanger.

Observed process takes place at constant pressure which is meant by type of filtration process. Defining of complete filtration process comprise analysis of media which should be filtered, defining the operation conditions, determination of filtration steps, and filter constructions.

Research comprised examination of water and examination of contaminants in water. For both samples were done physical-chemical examinations of water and granulometric composition of solid particles in ware.

Granulometric composition represents an important characteristic of structure and physical properties of natural and artificial material. It represents the content of granules of different sizes in artificial product, rock, or soil, expressed in percentage of the bulk, or the quantity of granules of examined sample. Data of granulometric composition are not generally classified because of different purposes of examination and different objects for which it should be done.

Samples for testing of Granulometric composition were taken before and after the filter. Technique of granulometric examination of particles firmness in water consisted of sieving on places with retention grade of 125 μm and 63 μm. On that manner are obtained fractions of particles in range of < 63 μm, 63-125 μm and >125 μm. Fraction in range of 0-5 μm was obtained with pipette method.

Granulometric composition of the material from filter is determined with standard laboratory method of sedimentation for fine-grained particles smaller than 0,075 mm, according to SRPS U.B1.018: 2005. Specific weight of the material was determined with standard laboratory method with picometer, according to SRPS U.B1.014:1988.

3. Results

Observed medium, well water, with all its characteristics interacts with already implemented filter, and dependent of characteristics of filter material, there is possibility of filters effect on water.

Standard physical-chemical examination of samples is shown in table 1.

Table 1. Granulometric composition - Material washed out from the filter of 5 microns.

Sample	Unit of	Sample 1	Sample
Electrolytic	μS/cm	870	857
Chlorides	mg/l	24,09	24,14
Sulphates	mg/l	32,17	30,32
Total hardness	mg $CaCO_3$/l	372,2	374,9
Suspended	mg/l	<1	<1
Calcium	mg/l	57,46	61,59
Magnesia	mg/l	55,54	53,70
Iron	mg/l	0,32	1,47
Manganese	mg/l	0,046	0,016
Zink	μg/l	20,1	30,6
Copper	μg/l	<2	<2
Lead	μg/l	<2	<2
Nickel	μg/l	23,8	20,4
Cadmium	μg/l	<0,8	<0,8
Arsenic	μg/l	<20	<20
Mercury	μg/l	<1	<1

It is noticed that iron increased in water in Sample 2 (after filter) which can lead to forming of ferruginous bacteria's, which are very damaging for this kind of closed system.

Specific weight of the material is 3,25, which is not usual for natural ground (value for natural ground is 2,60-2,80). This imply that content of metal (iron or manganese) is increased.

Examined granulometric compositions of hardness of constituents in water before filter have shown that noticed fractions in observed sample are distributed as it is shown on image 3.

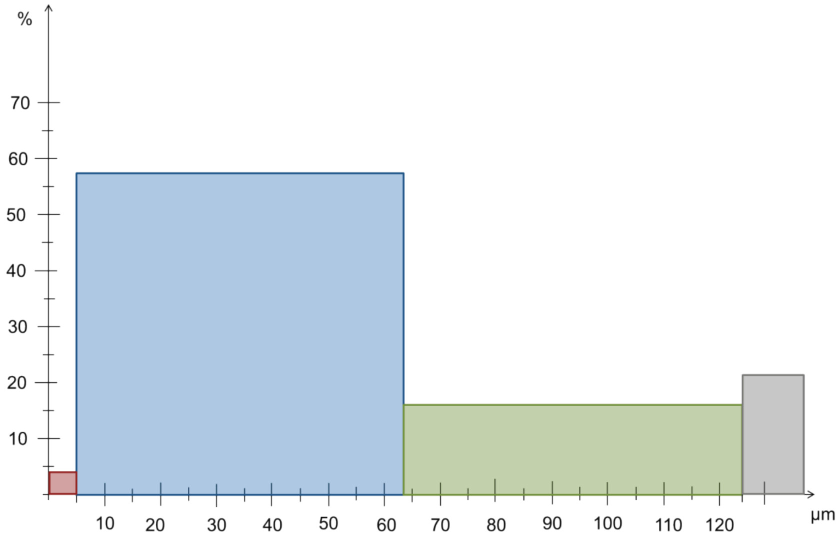

Figure 3. Granulometric composition of hardness of constituents in water.

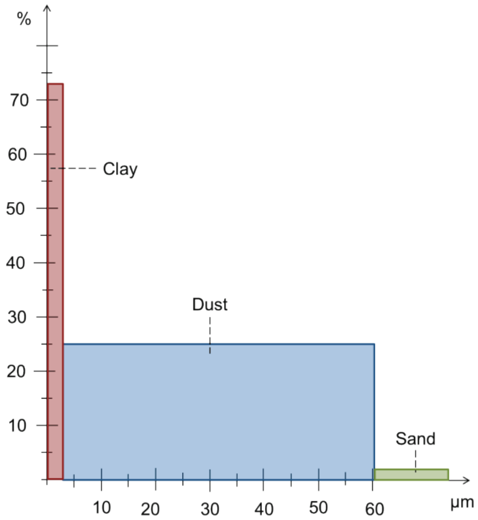

Figure 4. Illustration showing presence of classes in the sample of residue from heat exchanger cover.

Granulometric composition of solid constituents after filters show merely 90% of particles which are smaller than 5 μm. Results of these granulometric examinations by functions < 2 μm, 2-60 μm and > 60 μm are shown in figure 4.

Determination of distribution of particles in fraction 0-5 μm was done by morphologic method. Technique of membrane filtration was used with usage of disc filter membranes, diameter 47 mm and retention rate 0,45 μm (*PALL Versapor, PALL, USA*). Particles extracted on the membrane are digitalized under electron microscope. Particle sizes and number of particles in considered water are measured by digital image analysis technique which is incorporated in the program ImageJ (*National Institutes of Health (NIH), Bethesda, Maryland, USA*).

Results of distribution of particles in technical water before and after filter, obtained on this manner are shown on images 5 and 6.

Distributions of particles before and after filter of 30 μm are showing significant resemblance in the 30 μm distribution. This is result of the fact that nominal filter of 30 μm was not able to play a role of significant barrier for particles whose sizes are in range of 0-5 μm. It is also noticed unexpected increase in quantity of particles sizes 0,6-0,8 μm after the filter.

Observed system with one step constant pressure nominal filtration process represent characteristic incomplete pilot equipment. Technical water in system with heath pump must have certain characteristics which enable reliable function of system. Achieving these characteristics means insertion of one additional filtration step behind existing filter. In case when that is one filtration step, that would be filter whose filter elements have retention rate which covers class of particles concentrated around the value of 1,5 μm. Choice of this additional filtration step most satisfy conditions recommended for filtration practice which enable robust liquid filter process.

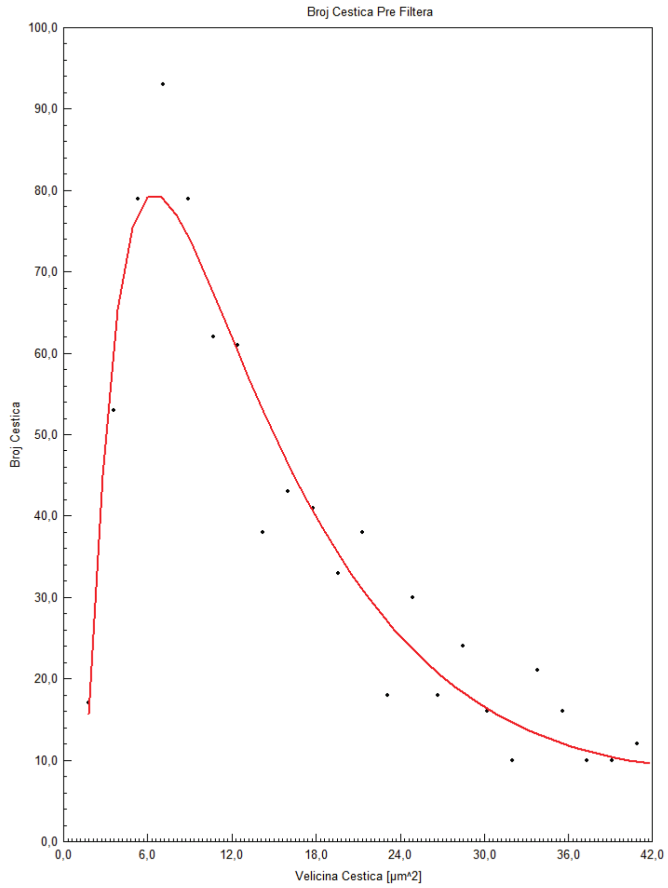

Figure 5. Number of particles before filter - fitted curve.

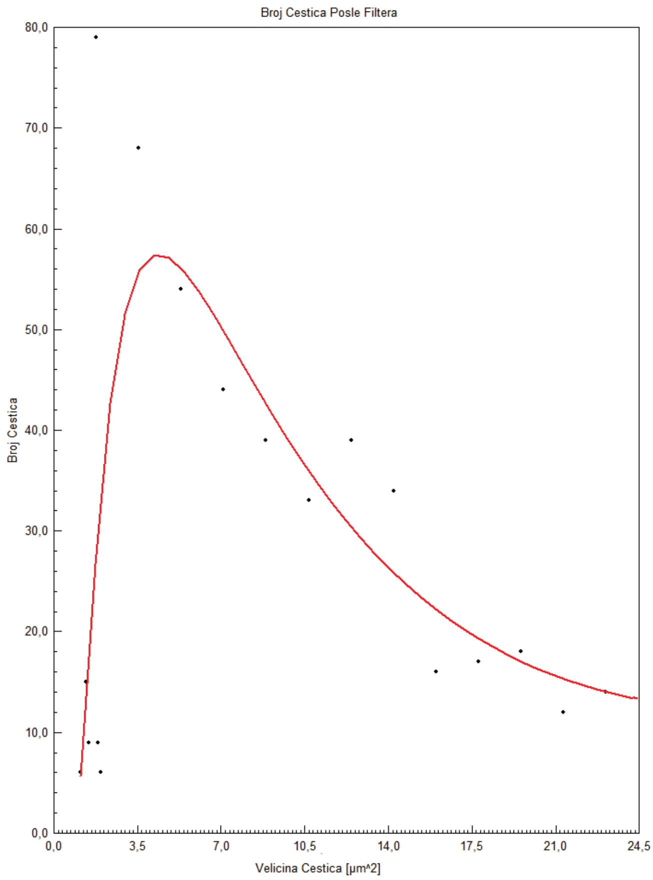

Figure 6. Number of particles after filter - fitted curve.

4. Conclusion

Particle size distribution has a significant influence on constitutive properties of the filter material and filter performances. Because of that, the main reason for measuring the sizes of particles is to predict behavior of filter material in a separation process and to specify the performance of a filter medium in terms of its ability to retain particles of different sizes.

Anyhow, raw experimental data on the size distribution are not suitable enough for a sophisticated analysis and design of contemporary highly efficient filtration systems and their components.

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REGULAR ADAPTRONIC PRODUCTS ENHANCED WITH THE FRACTIONAL ORDER CONTROL

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Abstract

Adaptronics is already present in many mechatronic products (e.g. agriculture, white goods), enhancing vibro-acoustic features in terms of comfort and product features without any substantial design modification. Comprehensive utilization of advanced adaptronics features (e.g. MR dampers) is possible fully to utilize only with proper process control. Here is suggested enhanced adaptronics features utilization with the fractional order control – fractio

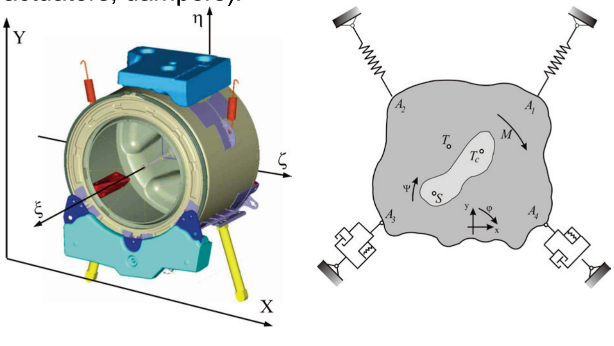
Keywords: Adaptronics, MR dampers, fractional calculus Fractional Order PID (FOPID)

1. Introduction

The control of the contemporary mechatronic product (e.g. agriculture, mechatronics) is very demanding task due the nonlinearity of multibody system, plethora of working profile/modes and rapid control response in shortest possible time. Besides the product features, there is also very demanding feature – comfort (e.g. ride comfort, noise level), which is influenced mostly by the outside factors – e.g. agriculture (uneven and rough terrain) and white goods (wet clothes distributions). Every technical solution has advantages and limitations, which should be taken into the account. Here is presented practical case from white goods and comparison of PID control – classical (non-fractional order) with advanced (fractional order).

2. Adaptronic system

The platform for the adaptronic system is always multibody system (MBS) behavior description (e.g. robotical approach – Rodriguez method), Fig. 1, which should be analyzed as the (non)rigid regarding working load program (modeling and evaluating the system response for (pre)defined excitation). This is crucial for further components selection (e.g. actuators, dampers).



a) *Tub assembly of washing machine with suspension* b.) *Planar model - classical approach*

Figure 1. Multibody system – washing machine

There are many software (e.g. LMS, MSC Adams) as well as analytical tools (2D or 3D methods), which could enable designer quite reliable results for further product development. Main part of adaptonic system for vibration suppression is suspension system, Fig. 2.

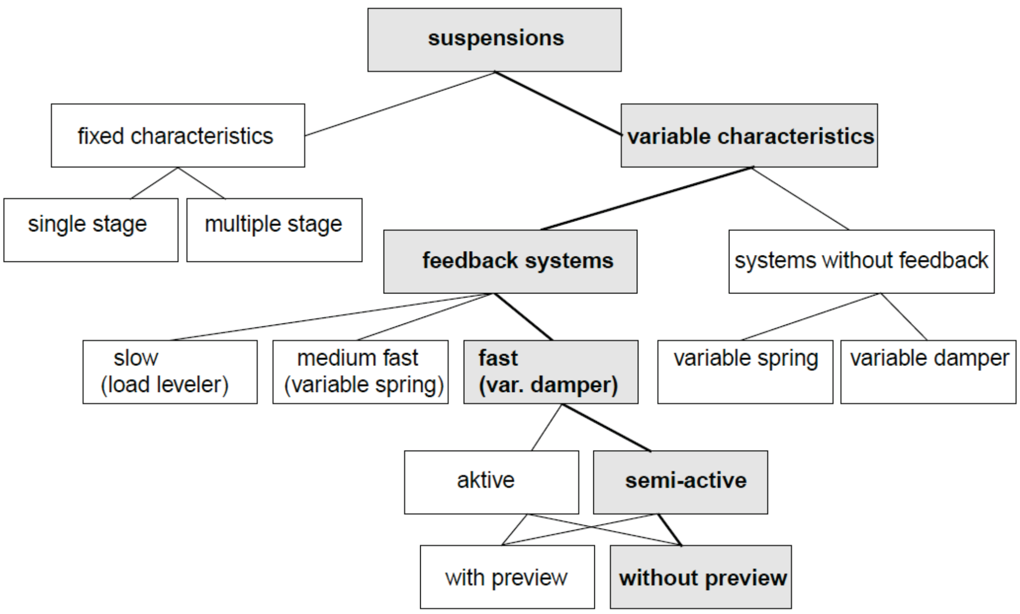


Figure 2. Art of suspensions and variable characteristics

The basic division is on the suspension with fixed and variable characteristics, where is the focus on the systems with the feedback information to the adaptronic system control (semi-active control).

The industrial solutions demands fast response and with the process preview/prediction, which is feasible with the sensor systems (e.g. aircraft landing gear, agriculture machine). The semi-active systems with the variable damping as fast feedback systems are mostly used MR dampers (magnetorheological damper or magneto-rheological shock absorber). Such dampers, as part of adaptronic systems, have proven itself in past two decades as advantageous in terms of the vibration and noise suppression. There were also very soon applications in white goods industry with modeling and experimental tests in various countries in Europe (e.g. Sweden, Turkey and Serbia). Another issue has been also suspension properties deterioration due the ageing and wearing out during the exploitation.

The MR damper used (in our case as part of experiment) is adaptive damper (LORD RD 1005-3), which damping capability is controlled/changed by the current, Fig. 3.

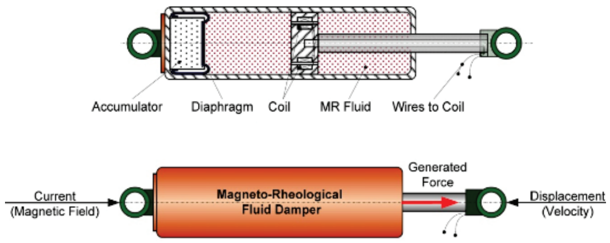


Figure 3. MR damper (LORD RD 1005-3)

The MR damper has in the tube MR fluid contains 20-40% by volume of relatively pure, soft iron particles, e.g., carbonyl iron with consistency similar to that of motor oil. Due the presence of an applied magnetic field, the iron particles in suspension acquire a dipole moment aligned with the external field which causes particles to form linear chains parallel to the field. With solidification of the suspended iron particles is restricted the fluid movement, which could occur in few milliseconds.

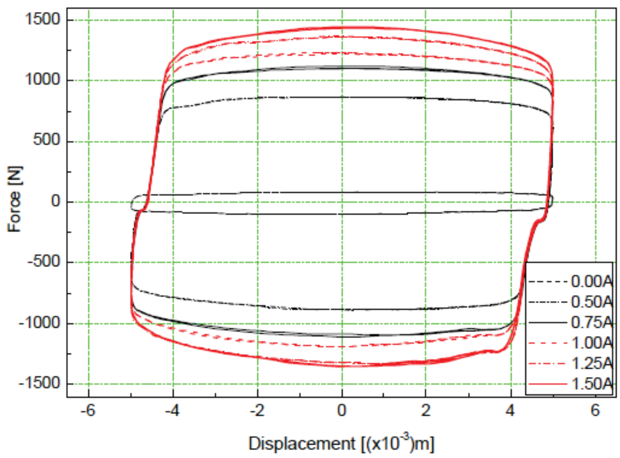


Figure 4. MR damper – response diagram

The control of the damping properties are conducted with the control unit supplying the current (from 0A up to the 2 A), which causes substantial difference in response, Fig. 4. The level of distance or vibration amplitude is the correlated with the level of supplied current to the damper. This response diagram is therefore modified by the process control unit, which correlates many sensors and performance indexes (e.g. as non-dimensional evaluation criteria – peak-to-peak or RMS criteria).

Prior experimental work, there could be also done some predictive modeling of MR dampers upon known MR models (e.g. Bouc-Wen, Bingham model) for certain load profiles to determine overall system response.

3. Process control system

Understanding each component's feature, there is easier way to design process control system with the controlling parameters – measured with the sensors or being non-dimensional as derived values from the system behavior.

Based on the type of the suspension system and the adaptive damper system, we could therefore design the process control system, semi-active, Fig. 5.

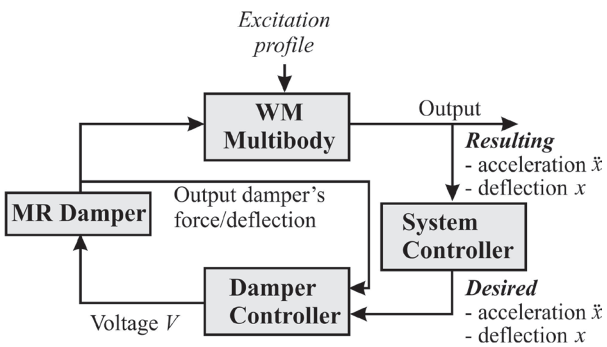


Figure 5. Semi-active control scheme with MR damper for washing machine (WM) multibody

The excitation profile or working profile/load is actually same for the various multibody systems (e.g. tractors, trailers) and represents desired working mode/track.

The resulting values for control are either outer system response (s.c. resulting deflection) which are then modified by the central control unit (s.c. system controller) and pass information to the suspension (damper) controller with its own control loop.

There are many industrial approaches for the semi-active control – like - Skyhook, Groundhook, Hybrid Control, Displacement Skyhook Control, Relative Displacement Skyhook Control, Current Driver Circuit, On-off balance and continuous balance control algorithms.

For all (semi-active) control approaches, there should be the same evaluation for different modes (working profiles) or excitation – the most often it is – single frequency (harmonic) excitation, impulse excitation, transient excitation or hybrid excitation.

Naturally, there should be also response analysis for the control approaches and the excitations (e.g. frequency response, wavelet analysis)

Main issue for all above named (semi-active) control – they all have advantages or disadvantages – e.g. limited performance for impulse excitation or for the transient excitation.

We care here about the dynamic behavior of a system (adaptronic product) and then we are not handling a problem of simple logical control (e.g. traffic lights turned on and off) in a negligible time.

The dynamic behavior of the plant is very important and this behavior is usually described by differential or difference equations. Very often such equation, describing the system includes derivatives whose order is not an integer number. Therefore, we are dealing with the fractional order systems, which are described by the fractional differential equations.

Consequently, a control algorithm for the fractional order is recommendable to have also dynamic behavior described by fractional derivatives too.

The usual approach of control that uses of integer derivatives only is therefore a particular case of fractional control (a generalization thereof).

The fractional calculus and related fractional calculus is also applicable for the adaptronic dampers ((MR) magnetorheological and (ER) electrorheological) to describe the realistic phenomena with less (calculus) aproximations.

The advantage of fractional order PID in comparison to the regular or non-fractional PID is well known and already proven for many actuators (e.g. DC actuator).

On the other hand, there is already done some hardware in loop (HIL) simulation for the system, described with the fractional order derivate (within NI Labview).

4. Problem statement

Main issues, which have to be addressed for successful system description and control:

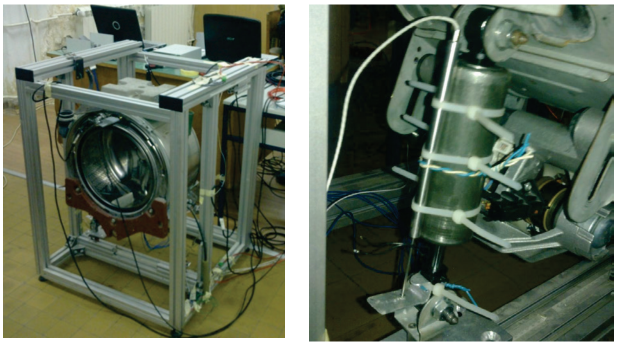
- Excitation profile and related system response – e.g. impulse, step or steep excitations;
- Components description with the fractional calculus (e.g. MR damper, actuator, control);
- The overall control system design/strategy – sensors, actuators and vibration suppression;
- Identification of the fractional derivate for the system component as well as overall control;
- Modeling and simulation prior experimental verification;

Namely, despite the advantage of fractional calculus approach in comparison to the non-fractional calculus – there is need to validate each system's subcomponent or set of subsystems.

5. Some past experimental results

There have been done some experiments on the washing machine with adaptive (MR) dampers and comparison with the (classical) dampers for the various excitation or working profiles.

The experimental setup, Fig. 6, has enabled us to validate some of the theoretical simulations – especially in terms of the accelerations or forces and the (orbital) path).



a.) *Experimental setup* b.) *MR damper - LORD*

Figure 6 - Adaptornic system – experimental setup and MR damper

The experimental setup (Figure 6) consist on:

- <u>system excitation</u> – electronic controller for actuator;
- <u>system measurement</u> – displacement sensors (LVDT), Fig. 6b, acceleration (accelerometers), force (strain gauge)
- <u>suspension control</u> – control the adaptive – MR damper;

Main issue is to harmonize the control of system with the MR damper's force control in order to achieve main effect – more effective damping and less excessive vibrations, Fig. 7.

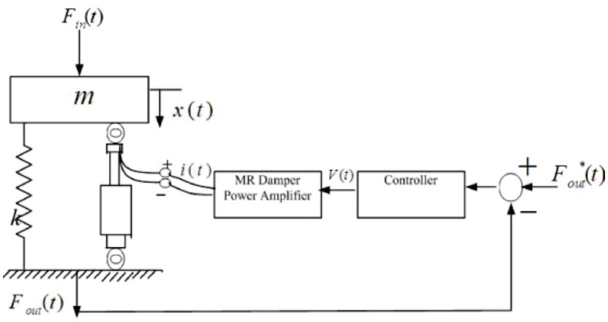


Figure 7. Simple MR damper control

The "preview" sensor (like in Fig. 1) for the effective MR damper's force control (like in Fig. 7) would be displacement sensor (LVDT). Upon the displacement, the time delay process control with the adaptive dampers as well as the process control parameters would enable effective damping and limit excessive vibrations (consequently also noise). Certain limitation is also ability the time response of the MR dampers for quick value changes as well as durability.

Here are also some results of the simulation and experimental work – for MR dampers as well as for the fractional order control (FO PID), Figs. 8-10.

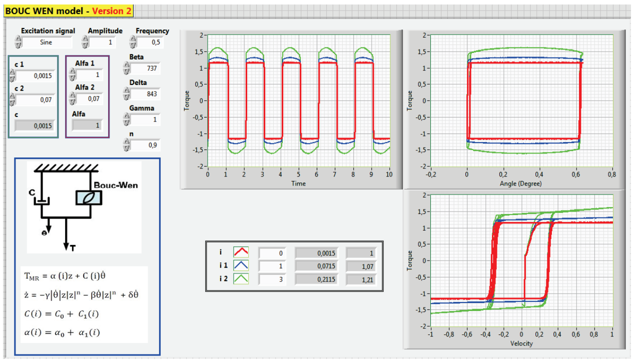


Figure 8. Simulation in LabView – Bouc-Wen model – MR damper

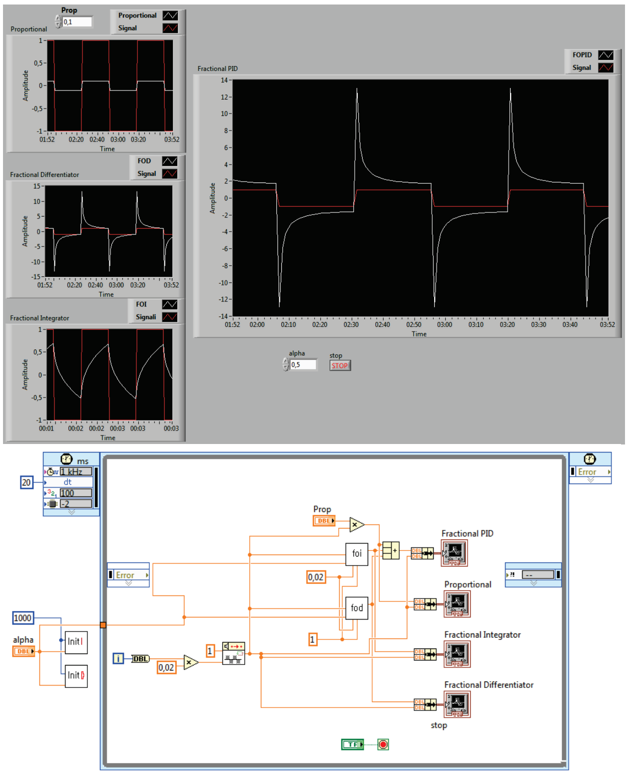


Figure 9. Simulation in LabView – Fractional Order Control – FOC PID

Simulation results for FOC PID enabled sweeping various parameters – as (ideal) harmonic function or even the impulse and adjust FOC parameters.

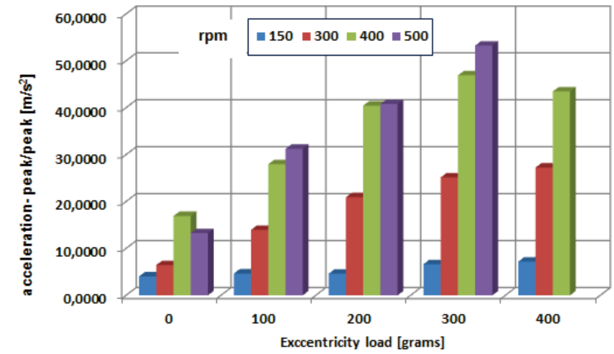
These were set by the equations as transfer function in *s*- domain:

$$C(s) = U(s)/E(s) = K_p + T_i s^{-\lambda} + T_d s^{\delta} \quad (1)$$

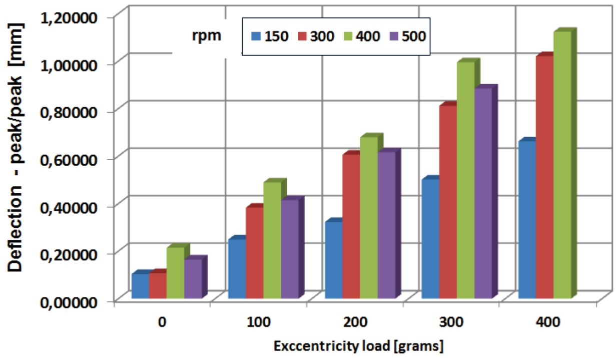
and time domain

$$u(t) = K_p e(t) + T_i D_t^{-\lambda} + T_d D_t^{\delta} \quad (2)$$

Some experimental results have also been gained in the past as part of the experimental setup design, load ("excentricity") upon different excitations, resulting deflections and accelerations, Figs. 6 and 10.



a.) Acceleration



b.) Deflection – peak/peak

Figure 10. Experimental results with adaptive dampers

6. Proposed solutions and guidelines

Main issue to conduct the adaptronic system modelling for further enhancement is to assemble the simulation model of adaptronic system (some call it mechatronic) as a multiphysical system - to interconnect the simulation models of particular subsystems of certain physical nature into one resulting multiphysical (multidisciplinary) modeling, Fig. 11. There are two different approaches, *co-simulation* (tight and weak coupling) and *uniform modelling with different formalism* - equations (algebraic, differential), dynamic blocks, multipoles and bond graphs. Nevertheless, the natural basis of simulation models of adaptronic systems are the multibody models that are feedback controlled, where the mathematical models and corresponding simulation models are being developed for systems from one physical domain. After modeling, simulation and control synthesis - the designer has to proceed with the final stage, hardware in loop (HIL) simulation. Namely, without the real time simulation with actual analog and digital signals the adaptronic product could not be properly validated. In the HILS the stepwise transition from the pure model representation of the adaptronic system to actually mounted mechanical, hydraulic and electrical components takes place.

The modular modeling has to include advanced control strategy, like fractional controllers – e.g. fractional PID.

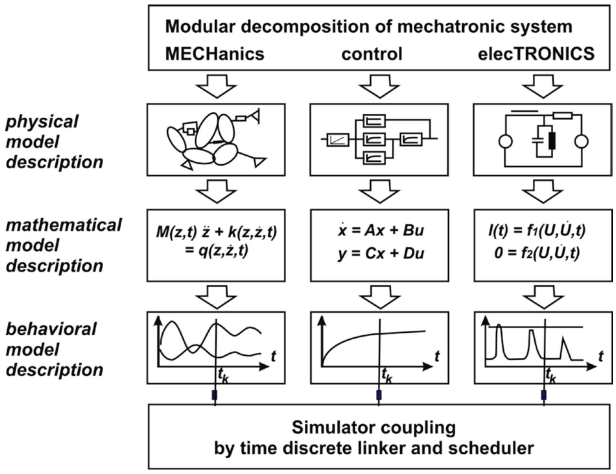


Figure 11. Modular modeling and simulation – adaptornic system

7. Conclusion

The real task system control solutions in the industry are very often quite rigid and rely on the simple ("recipe") solution. On the other hand, the system optimization is also tackled partially (e.g. only the actuators or dampers optimization) and could not substantially enhance the (adaptronic) product. The solution is in the overall adaptronic system modeling with s.c. HIL approach and to implement advanced fractional order controllers.

8. Acknowledgement

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SUBLIMATION OF VARIOUS MODELS RESULTS OF MULTI-CRITERIA ANALYSIS AS A FUNCTION OF IMPROVEMENT OF ALTERNATIVE RANK RELEVANCE

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Abstract

The selection of models for ranking and evaluation of solution variants (alternatives) is a multi-criteria problem, similar to the problems which are solved by its application. Since there is no ideal solution, but only an optimal one, it is clear that any chosen model will have certain, more or less extensive, drawbacks. In addition, results obtained by using various models are presented in different ways and are in different forms. Also, there is always a question of obtained results relevance due to the relativity of selected evaluation criteria. In this paper, a seemingly simple model is presented, which uses magnitude normalization of results obtained using at least three models of multi-criteria rank alternatives, and reduces them to comparable dimensions, and then determines the common result of all processes by sublimation, which greatly increases its relevance and reliability.

Keywords: Magnitude normalization, ranking of alternatives, decision tree, multi-criteria decision making,

1. Introduction

The problems related to determining of an optimal solution, i.e. optimisation taska, are frequently encountered and solved in everyday life. They are encountered almost everywhere, in technical and economic systems, in families, companies, sport temas, etc, [1]. The decision making process and the choice of „best“ alternative is typically based on more than one criteria and a number of limitations.

In all tasks involved in this process, the implicit tendency of a man to find a solution which satisfies his needs as much as possible, i.e. which is most beneficial, without breaking of texisting limitations.

Asuming that the multi-criteria desicion problem is solved using an analytical approach, one can also asume that a decision space (alternatives, actions) also exists, with an introduced variable A_x and the space of possible results, C_q. In case both spaces are normed, with an allowed mapping function, $f : A_x \rightarrow C_q$, the following set of solutions is achieved, $q_0 = f(x_0) \subset C_q$, where $x_0 \subset A_x$ represents the set of acceptable decisions, [2].

Based on this it can be concluded that, unfortunately, such problems (known as multi-criteria optimisation) do not have a unique and global solution, i.e. there is no alternative solution which is optimal for all criteria simultaneously. All of this indicates that a final unique solution cannot be determined without involving the decision maker. The decision maker needs to adopt a solution at the end of the process. The solution accepted by the decision maker is referred to as best or preferred solution.The task of multi-criteria optimisation, i.e. analysts who perform it, is to aid the decision maker in choosing the solution which is considered as best in given conditions.

The basic question related to multi-criteria decision making issues involves the determining of procedures for the selection of decisions which correspond to the desired solution, with the possibility of selecting and singling out (a very common practice) of the most acceptable alternative.

Today, there is a great number of generally accepted methods and models of multi-criteria optimisation. Thus, the selection of evaluation models and solution (alternatives) variant ranking is a multi-criteria problem, like the problem it is solving. Since there is no ideal solution, but only an optimal one, it is clear that any chosen model will have certain, more or less extensive, drawbacks.

Each model treats four basic components of decision making process in a different way, and these components include: the goal, attributes, alternatives and decision making preferences. Hence, output results are often highly heterogeneous and typically expressed in form of greatly varying records.

It is not uncommon to consider the question of relevance, for both the selected criteria and the way in which the decision maker’s preferences are treated, along with the relevance of the way in which the MCA method is selected.

With the idea of contributing to relevance and credibility of the MCA process and the generated solutions alike, suggested in this paper is a model, which, using result magnitude normalisation, obtained by using at least three models of multi-criteria alternative ranking, chosen in a scientifically acceptable and intelligent manner, provides comparable dimensions, and through their sublimation, determines the common, relevant and credible process for result evaluation and alternative ranking.

2. Method

"Multiple-criteria decision aid" (MCDA) is the name of a scientific field which deals with the development of methodologies and methods that are used to aid decision makers in complex situations which involve multiple conflicting goals, i.e. criteria.

Multi-criteria decision making is an area which has gained a lot of significance in the past twenty years, taking into account that every decision making process involves considering of numerous criteria, which are often in conflict with each other or are expressed using different measuring units which cannot be mutually compared.

From the sixties until now, a large number of multi-criteria analysis methods were developed, and can be classified in multiple ways [3]. The most well-known MCA method classification, [4], distinguishes between different methods according to their type and relevant characteristics of information provided by the decision maker (Table 1).

Table 1. Basic classification of MCA methods

Methods without attribute information	Methods which require certain attribute information
Domination method MAXIMIN method MAXIMAX method	Conjunctive method Disjunctive method Lexicographic method Linear assigning method Simple additive weight method AHP method ANP method ELECTRE TOPSIS SAW PROMETHEE

Analytical hierarchy process (AHP) belongs to the class of "soft" optimisation methods. Basically, it represents a specific tool for forming and analysing of decision hierarchies. Above all, AHP enables interactive creation of problem hierarchy as a means for preparing of the decision making scenario, followed by evaluation of pairs of hierarchy elements (goals, criteria (sub-criteria), and alternative) in a top-down direction. Finally, a synthesis of all evaluations is performed, and weight coefficients for all hierarchy elements are determined, using a strictly determined mathematical model. The sum of weight coefficients of elements for all hierarchy levels equals one (1), which allows the decision maker to rank all elements in both horizontal and vertical sense. AHP enables an interactive analysis of evaluation procedure sensitivity to final ranks of hierarchy elements. In addition, during hierarchy elements evaluation, until the procedure ends and the results are synthesised, resonating consistency of the decision maker is checked and the accuracy of obtained alternative rankings and criteria is determined.

Observed from a methodological standpoint, AHP represents a multi-criteria technique which is based on decomposing complex problems into a hierarchy. The goal is located at the top of the hierarchy, whereas criteria, sub-criteria and alternatives are at lower levels. Shown as an illustration (Figure 1), hierarchy is made of a goal, three criteria and four alternatives. Hierarchy does not need to be complete.

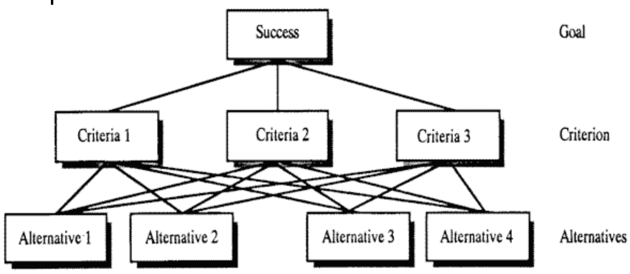

Figure 1. AHP hierarchy

AHP is a flexible method, since it enables a relatively simple way of determining relations between influencing factors, recognising their explicit or relative influence and the significance in realistic conditions and determining of dominance of one factor relative to the other, in case of complex problems with multiple criteria and alternatives. The method, namely, anticipates the fact that even the most complex problem can be decomposed into a hierarchy in a way that ensures that further analysis involves both qualitative and quantitative aspects of the problem. AHP keeps all parts of the hierarchy connected, thus it is simple to observe how a change in one factor influences other factors. Problem complexity increases with the number of criteria and alternatives. The ability of a human mind to distinguish between a large number of alternatives and criteria is limited and thus, when forming a hierarchy it is not recommended to use more than 5±2 elements on the same level [5]. The application of the AHP method can be explained in four basic steps [6]:

- Development of a hierarchy model of the decision making problem, with its goal on top, criteria and sub-criteria on lower, and alternatives at the bottom level of the model (Figure 1).
- Comparison of pairs of elements on every level of a hierarchy structure, wherein decision maker's preferences are expressed using the Saaty scale of relative relevance, which has 5 stages and 4 interstages of intensity, which are verbally described and have corresponding numerical values ranging from 1-9, [5], [6],
- Calculating of local priorities (weights) for criteria, sub-criteria and alternatives based on evaluation of relative relevance of elements of the correspon–ding hierarchy structure level, using a mathematical model, which are then synthesised into total alter–native priorities. Total priority of an individual alter–native is calculated by summing of its local priorities pondered with higher level element weights.In the end, a sensitivity analysis is performed.

The result of an AHP analysis is a ranking list of all considered alternatives, wherein the alternative with the highest relative weight is located at the top of the list.

SAW method (Simple Additive Weighting Method) represents one of the most well-known and frequently used multi-criteria decision making methods. In addition to providing a very simple and practical procedure of ranking alternatives, the results obtained by its application do not deviate from the results obtained by some of the so-called advanced methods. It is applied directly to the decision making matrix and consists of three steps:

- Decision matrix normalisation;
- Multiplying of a normalised matrix using pondered coefficients, and
- Summing of "weighted" parameters for each alternative.

The method is particularly convenient when criteria are of the same or similar nature. The decision maker should assign each criteria a corresponding weight or pondered coefficient (wk, k = 1, 2, ..., m). The best value of an alternative is the one where the sum of "weighted" parameters is the highest.

PROMETHEE method (Preference Ranking Organization Method for Enrichment Evaluations) belongs to a group of multi-criteria choice methods within a set of alternatives described by multiple attributes which are used as criteria. This method enables the aggregation of qualitative and quantitative criteria of varying relevance into a relation of partial arrangement in a set of alternatives (PROMETHEE I) or into a unique score (PROMETHEE II), based on alternatives that can be fully ranked.

The application of the PROMETHEE method is characterised by two following steps:

- Construction of preference relation in a set of alternatives A,
- use of this relation in order to respond to a given problem.

During the first step, a complex preference relation is formed to emphasize the fact that this relation is based on acknowledging multiple criteria (this relation is originally called the outranking relation), based on generalisation of the term criteria. The preference index is defined and a complex preference relation is obtained, which is expressed using a preference graph. The essence of this step is that the decision makers needs to state their preferences between two alternatives (actions, activities) in accordance with each criteria, based on the difference between criteria values being compared. Preference relation created in this way is used so that input and output of each flow in the graph are calculated. Based on these flows, the decision maker can introduce a partial arrangement (PROMETHEE I) or a total arrangement (PROMETHEE II) into the set of alternatives.

An analyst or DSS (Decision Support System) gives the decision maker a possibility to choose a solution using an appropriate algorithm or method, based on the information given by the decision maker. Once all relevant data are obtained from the decision maker, the system suggests a solution.

The analyst or DSS suggest that solution which is ranked first, according to the selected method, i.e. the one that scored the highest number of "points", in other words, has the highest relative weight.

Diversity of methods is not only reflected in the way the basic decision making parameters are treated, but also in the way in which obtained results are presented. Whereas in case of some method the results are expressed in integers, in other cases they are expressed in percents or are shown on a 0-1 scale.

The Decision Tree is a graphically presented decision making technique, which involves a set of connected branches, where each branch represents a decision alternative or state. According to the common convention, the node represented by a square represents the decision alternative (decision node), whereas a circle represents a state (possibility node).

Based on the characteristics of each MCA method, a decision tree was formed in order to select the appropriate method during the solving of a specific multi-criteria problem. Shown in Figure 2 is the decision tree used for selecting of an MCA method, in accordance with the problem being solved.

Considering that the suggested model for selection of an optimal variant of corridors in linear infrastructural objects requires them to be explicitly defined, and that their complete order needs to be defined as well, wherein the decision making matrix is not defined, which should be done during the decision making process, the decision tree decided on selecting the AHP method. The selection path is denoted by the red lines.

The normalisation is a procedure during which physical quantities in expressions are represented by unnamed numbers which in turn are obtained by dividing a given physical quantity by a selected base quantity. Base quantities are chosen to have the same physical dimension as the quantity they are normalising, so that normalisation makes sense, e.g. simplification of expression writing.

By performing normalisation, the values of quantities are equalised. Normalisation can be twofold:

Vector normalisation - each row-vector of decision making is divided by its norm, wherein the normalised value n_{ij}, of the normalised decision making matrix *N*, for *max* type criteria, is obtained by the following expression:

$$n_{ij} = \frac{f_{ij}}{\left(\sum_{i=1}^{m} f_{ij}^2\right)^{1/2}},\ i = 1, 2, \ldots, m,\ j = 1, 2, \ldots, n \tag{1}$$

whereas in case of *min* type criteria, the following expression is used:

$$n_{ij} = 1 - \frac{f_{ij}}{\left(\sum_{i=1}^{m} f_{ij}^{2}\right)^{1/2}},\ i=1,2,\ldots,m,\ j=1,2,\ldots,n \qquad (2)$$

The advantage of this transformation lies in the fact that all criteria can be expressed using measures that have their own units.

The linear scale - output (result) of a criteria is divided by its maximum value, and then the transformed output is determined based on the following expression:

$$l_{ij} = \frac{f_{ij}}{f_j^{*}} = \frac{f_{ij}}{\max f_{ij}},\ f_j^{*} = \left\{ f_i \,\middle|\, \max_i f_{ij} \right\}, \qquad (3)$$

$$i=1,2,\ldots,m,\ j=1,2,\ldots,n$$

Values lij are within the interval (0,1) and results are that approach the value 1 are more favourable.

In the case of type min criteria, the element of linearised decision making matrix is determined in the following way:

$$l_{ij} = \frac{f_j^{\min}}{f_{ij}} = \frac{\min f_j}{f_{ij}},\ f_j^{\min} = \left\{ f_j \,\middle|\, \min_i f_{ij} \right\}, \qquad (4)$$

$$i=1,2,\ldots,m,\ j=1,2,\ldots,n$$

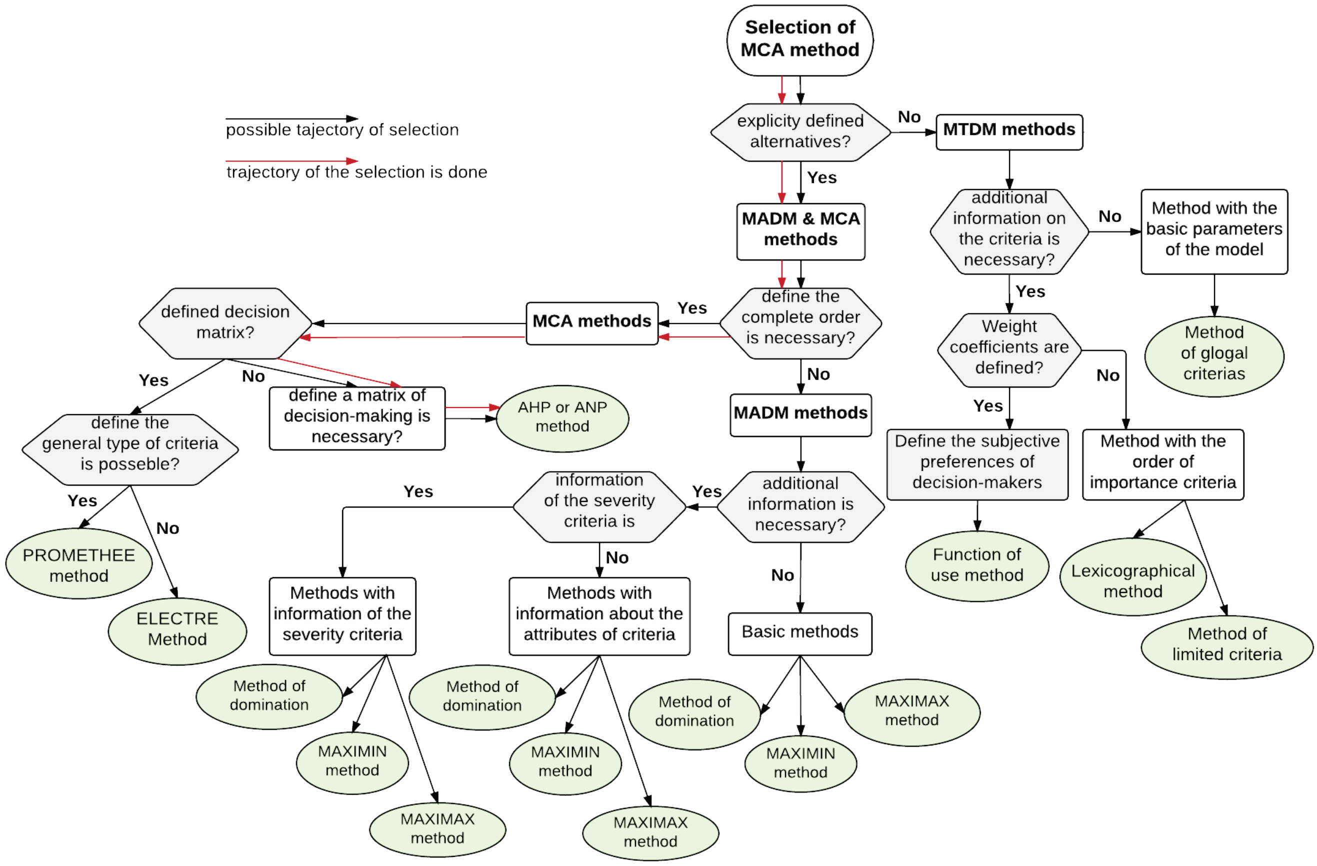

Figure 2. Decision tree for selection of VKA method

3. Results

For the purpose of this research, data from a doctoral dissertation written by one of the authors, [7], in which a complex decision making model for the process of selecting of an optimal urban solution of a corridor for a linear infrastructural object was developed and tested (3N-AHP model). This model was based on the methodology of multi-actor multi-criteria analysis (MAMCA) methodology, [8], and the application of “soft” optimisation AHP, integrated with other scientific methods (stakeholder analysis, survey, descriptive statistics, factor analysis).

A decision tree was used to determine the AHP method as the most adequate method for evaluation and ranking of alternatives in such cases.

However, due to the diversity of infrastructural objects and characteristics of individual problems that occur during their design, certain “detours” in decision tree nodes are possible; hence the line of selection could lead to some other MCA method.

In this case, the SAW and PROMETHEE met-hods were located at the end of the path. For the purpose of this paper, a comparative analysis was performed, along with sublimation and result normalisation, based on applying MCA to each of the three models individually.

Since different models were used, final results are presented in different ways (Table 2).

Table 2. Values of alternative priorities based on three evaluation models

ALTERNATIVE	SAW	PROMET.	AHP
West	0,58676	35	0,200
Centre	0,89568	45	0,261
East 1	0,88902	52	0,274
East 2	0,86347	53	0,265

In order to perform mutual comparison of results, the alternative priority values obtained from SAW and PROMETHEE methods were normalised, and in this way values shown on a scale of 0-1 were obtained.

Shown in Table 2 are the output values obtained in a way during the model application, whereas Table 3 shows the normalised values on a scale of 0-1 for results obtained by applying all three models.

Given in Table 4 are the sums of alternative priority values obtained by simple summing of individual priorities from Table 3, for each alternative.

Table 3. Normalised alternative priority values on a scale of 0-1

ALTERNATIVE	SAW	PROMET.	AHP
West	0,181	0,189	0,200
Centre	0,277	0,243	0,261
East 1	0,275	0,281	0,274
East 2	0,267	0,286	0,265

Table 4. Sum values of alternative priority values based on all three models

ALTERNATIVE	TOTAL PRIORITY
West	0,570
Centre	0,781
East 1	0,830
East 2	0,818

Given in Table 5 are the normalised alternative priority vaues based on the three evaluation models, and based on them, ranking of alternative was performed. Based on the summed results of evaluation obtained from all three models, the best ranked alternative, among the four taken into consideration, was West one with a rating of 0.277. Alternative East had the lowest rank.

Table 5. Final ranking of alternatives based on normalised priority values

ALTERNATIVE	PRIORITY	RANK
West	0,277	1
Centre	0,273	2
East 1	0,260	3
East 2	0,190	4

Results obtained in this way represent a sublimation of individual results of implementing each of the three models, and thereby methodologies, the ways of treating all elements of decision making, along with various decision maker preferences. Such results greatly contribute to the reconciliation of attitudes that interested parties and decision makers have, since generated solutions are made more credible and relevant, i.e. more acceptable for a larger number of them.

4. Discussion

A great number of MCA methods, which represent their output data (results) in various ways (Table 2), largely contribute to the poor understanding that end users have for them. In additions, the diversity of methodologies which are used in MCA resulted in divided opinions among the interested parties regarding which method has a better, more acceptable way of treating their preferences in terms of priorities related to both evaluation criteria and possible alternative solutions of problems.

Thus, a question of which method should be used and when during the decision making process often arises.

The offered model, even though seemingly simple, aids the analyst in selecting the adequate MCA method(s), using a decision tree and based on the characteristics of the problem. If due to the nature of the problem being solved, the path unambiguously and exclusively leads to a single method, then the suggested model implies mutual comparison and result sublimation, i.e. the generating of a single common solution for all MCA models that were used. Through this process all results, with the aid of the value normalisation, are reduced to homogeneous and comparable quantities. This contributes to their easier understanding, as well as easier operating in terms of mathematics. Once the process is complete, a unique (common) solution for all models used is generated.

Results obtained in this way are a sublimation of individual results of the implementation of each of the three models, and thereby the methodologies, ways of treating all decision making elements, along with different decision maker priorities. Such results greatly contribute to the reconciliation of attitudes that interested parties and decision makers have, since generated solutions are made more credible and relevant, i.e. more acceptable for a larger number of them.

5. Conclusion

The selection of a model for ranking and evaluating of solution variants (alternatives) is, similar to the problems it is solving, a multi-criteria problem.

The suggested model, by using a decision tree and the intelligent selection method, aids the analyst in reliably selecting an adequate MCA method (or more methods).

In case the number of used methods is greater than one, the suggested model, with the aid of result magnitude normalisation, which reduces heterogeneous quantities to homogeneous ones, makes results from different models easy to compare.

The possibility of result sublimation into a common result, which does not only sublime values, but also the methodology, interested parties and decision maker preferences, contributes to the reconciliation of attitudes that interested parties and decision makers have, since generated solutions are made more credible and relevant, i.e. more acceptable for a larger number of them.

Further research should focus on defining even more reliable methods of result sublimation, which would greatly contribute to their relevance.

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SELECTION OF STEELS FOR VITAL STRUCTURES AND TURBINE COMPONENTS OF THE HYDRO POWER PLANT 'DJERDAP 1'

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Abstract

Vertical Kaplan turbines, manufactured in Russia and with nominal power of 200 MW, have been installed in 6 hydroelectric generating units at 'Djerdap 1'. During the refurbishment of hydroelectric generating sets A4, A5 and A6, non-destructive and destructive tests were carried out on parent material and weld metal in order to complete the state analysis and assessment of damage level and causes of damage occurrence at vital structures and components, which showed that the selection of suitable material has a crucial role regarding the safe operation of hydro-electric power plants. This paper contains comparative results of mechanical tests performed in order to obtain mechanical properties of materials used for the fabrication of the upper rings of guide vane apparatus installed in 1973 and made of steel St 3 (GOST 977-88) and those recently made through the use of steel S 235 (EN 10025-2), as well as for turbine covers, made of steels S 355 NL (EN 10025-2) and S 355 NL + Z25 + N (EN 10025-3).

Keywords: Refurbishment, turbine equipment, hydromechanical equipment, steel selection

1. Introduction

For the state analysis of turbines in power plant Djerdap, [1], and assessment of the level of damage and degradation, as well as determination of causes of damage occurrence during the refurbishment of hydroelectric generating sets A4, A5 and A6, various non-destructive and destructive tests were performed on parent material and welded joints. Degradation of parent material and welded joints of upper rings of guide vane apparatus is presented in paper [2], while degradation of parent material and welded joints of turbine covers is presented in paper [3].

2. Results of non-destructive tests

Upper rings of guide vane apparatus were created by welding four segments together (identified as 1-2, 2-3, 3-4 and 4-1), made of steel St 3 [4]. Welding of these segments was performed through the application of submerged arc welding.

A large number of surface crack-type linear indications was detected through the application of magnetic particle tests (MT) at all segments. Indications detected at segment 4-1 are shown in figure 2.

In figure 3 segment 4-1 of the upper ring of guide vane apparatus is shown, at which defects like the lack of root penetration and lamellar tearing in the root area of the welded joint were detected. Lamellar tearing was caused by pulling of the 40 mm thick sheet metal in the zone of fusion of parent and filler material.

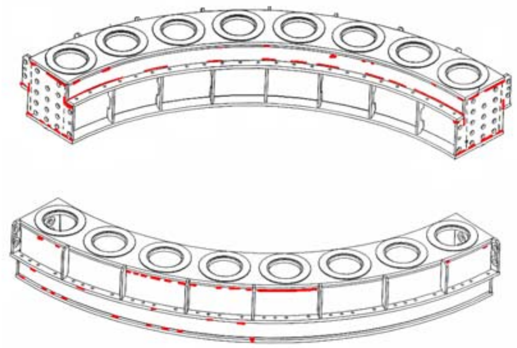

Figure 1. Display of magnetic particle test results, segment 4-1

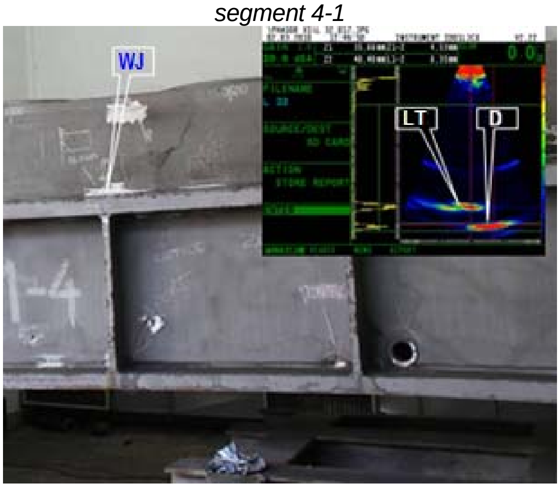

Figure 2. Appearance of segment 4-1 of the upper ring of guide vane apparatus

Turbine cover, shown in figure 4, has been fabri–cated by welding four segments together (identified as 1-2, 2-3, 3-4 and 4-1), made of steel St 3 [4]. In figure 5 one of the segments (segment 4-1) is shown, at which welded joints were inspected, or to be more specific weld metal, heat-affected zone and parent material, in order to detect surface indications (flaws) by magnetic particle testing and internal indications (flaws) by ultrasonic testing.

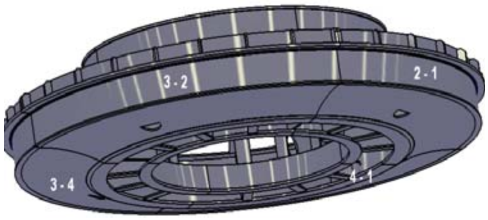

Figure 3. Turbine cover

In figure 3 locations at turbine cover segment 4-1 where surface indications (flaws) in welded joints were detected through the application of magnetic particle testing are shown.

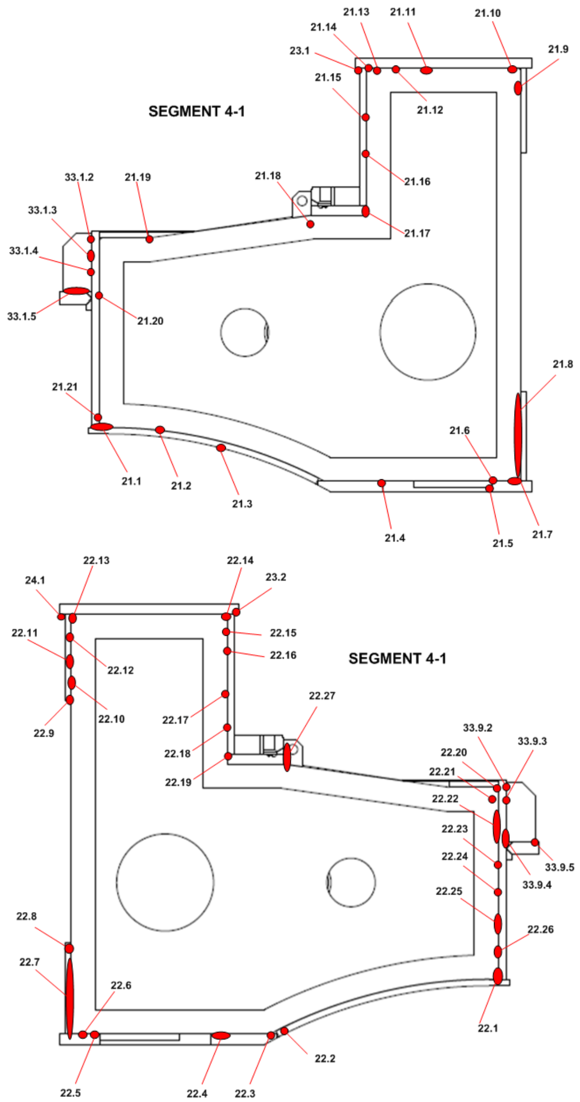

Figure 4. Appearance of results of magnetic particle testing performed at turbine cover segment 4-1

Figure 6 shows the locations where internal indications (flaws) in welded joints of turbine cover segment 4-1 were detected through the use of ultrasonic testing, while figure 7 shows echographs created during the inspection of welded joints and parent material. Lack of root penetration and lamellar tearing in parent material detected during the test are schematically presented in figure 8.

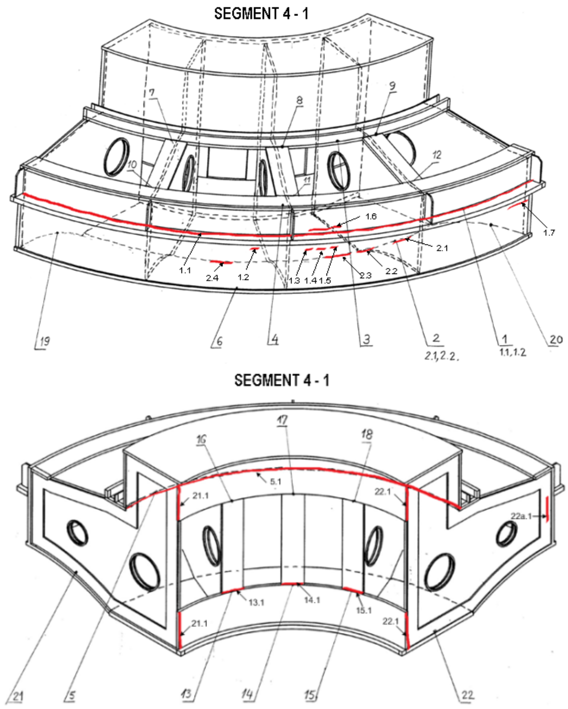

Figure 5. Appearance of results of ultrasonic testing performed at segment 4-1 of the turbine cover

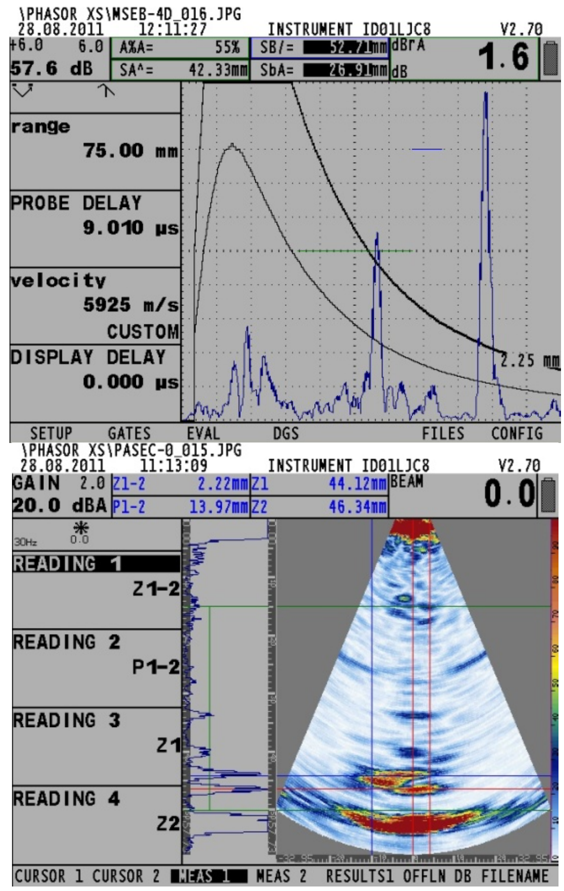

Figure 6. Lamellar tearing indications in the area of the welded joint and echographs - segment 4-1 turbine cover

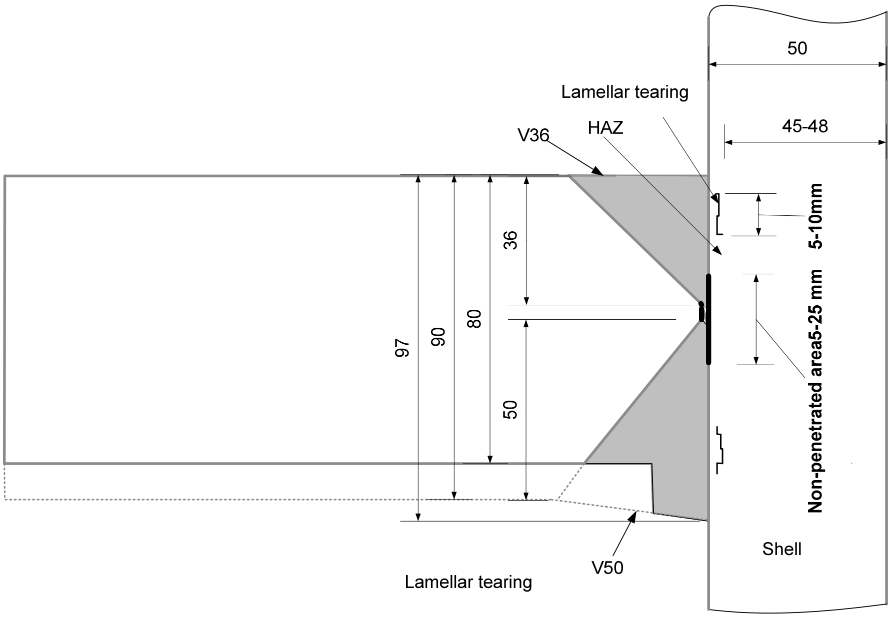

Figure 7. Appearance of lamellar tearing in the welded joint

3. Results of destructive tests

Results of destructive tests performed on samples taken from the upper ring of guide vane apparatus of hydroelectric generating set A6 are presented in this paper.

On the basis of results of chemical composition analyses carried out through the application of the gravimetric and volumetric (G-V) method, performed on samples taken from segments of the upper ring of guide vane apparatus, it can be concluded that chemical compositions, regardless of deviations of C and Mn in segment 3-4, correspond to requirements for steel St 3 [5], Table 1.

For the testing of mechanical properties in the longitudinal (marked as **l** in figure 9) and transverse direction (marked as **t** in figure 9) of the 40 mm thick metal sheet, circular cutting has been performed in order to obtain a sample with diameter of 380 mm from the internal wall (internal coating) of segment 4-1 of the upper ring of guide vane apparatus, as well as cutting of the 450 mm long sample from the welded joint of the 50 mm thick metal sheet (welded joint V50) for metallographic testing of parent material and of the welded joint, or, more precisely, of the material from heat-affected zone and of weld metal from the flange of the upper ring of guide vane apparatus, taken from segment 3-4.

Table 1 Results of chemical analyses of delivered samples, mass percentage

Segment	C	Si	Mn	S	P
2-3	0,17	0,19	0,46	0,026	0,014
3-4	0,12	0,28	0,74	0,023	0,015
1-4	0,20	0,26	0,60	0,034	0,015
In accordance with standard [5]	0,14 – 0,22	0,15 – 0,30	0,40 – 0,65	≥ 0,050	≥ 0,040

Figure 8. Photograph of the sample cut out from segment 4-1 of the upper ring of guide vane apparatus

For tensile testing of the metal sheet in longitudinal and transverse direction, from the surface and central layer of the samples were taken, thickness wise, and 2 standard specimens have been produced, 8 mm in diameter in the measurement section, according to standard [6], figure 10.

For determination of causes of the occurrence of lamellar cracks or lamellar tearing in zones of welded joints of the upper ring of guide vane apparatus, tests in order to determine the ductililty and contraction of the cross-section in “Z” direction were carried out. Three specimens have been fabricated, 6 mm in diameter, figure 11.

Tensile tests have been carried out on a universal machine for tensile, pressure and bending tests "Alfred Amsler", with the maximum range of 98,1 kN.

Results of tensile tests showed that tensile properties of parent material meet the requirements of standards [6] and [7] for steel St 3, table 2.

Table 2. Mean values of tensile test results, ERPS EN 10002-1

Sampling position	$R_{p0,2}$ [N/mm^2]	R_m [N/mm^2]	$A_{5,65}$ [%]
Longitudinal direction - surface layer	301	466	28.50
Longitudinal direction - central layer (thickness wise)	293	465	29.25
Transverse direction - surface layer	296	463	31.35
Transverse direction - central layer (thickness wise)	295.5	466.5	30.40
Transverse direction, steel St 3, in accordance with [7]	min. 235	370-480	min. 25

Significantly lower values of contraction than minimum values prescribed by standard [8] were obtained by testing of tensile properties in “Z” direction, table 3. According to standard [8], as well as standards DIN 50180, SEL 096 and DAST 014, steel sheets used for structures with an enhanced ability to deform in direction transverse to the surface of the product need to have a value of contraction 25% at least. Fracture surfaces of tested specimens were bright with rough structure, without significant contraction of cross-section or visible elongation, figure 11.

From the sample taken from segment 4-1 of the upper ring of guide vane apparatus, standard specimens for impact energy, with dimensions 10x10x55 mm and 2 and 3 mm deep U-notch, were fabricated, figure 11.

Values higher than minimum values prescribed by [9] were obtained by impact tests, carried out in longitudinal and transverse direction on specimens with 2 and 3 mm deep U-notches, as requested by [7]. Impact energy results for specimens taken from the surface layer differ from those obtained for specimens taken from the central layer (thickness wise) up to 50%, tables 4 and 5. Appearance of fracture surfaces for one of test specimens is presented in figure 12.

Results of destructive tests performed on samples taken from the turbine cover of hydroelectric generating set A4 are presented in this paper.

On the basis of results of chemical composition analyses by spectrophotometric method, performed on samples taken from segments of the turbine cover, it can be concluded that chemical composition of segment 4-1 meets the requirements prescribed for steel St 3 [5], table 6.

Table 3. Results of contraction tests, in accordance with standard [8]

Sampling position	Ep	d_0 [mm]	d_1 [mm^2]	Z [%]	Zsr [%]
“Z” direction	1	6.0	5.8	6.56	8.69
	2	6.0	5.7	9.75	
	3	6.0	5.7	9.75	
Prescribed values		Z15		min. 10	min. 15
		Z25		min. 15	min. 25
		Z35		min. 25	min. 35

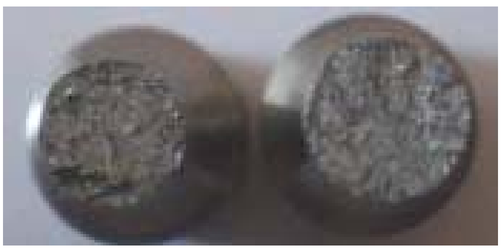

Figure 9. Appearance of fracture surfaces of the specimen for the testing of contraction in z-direction

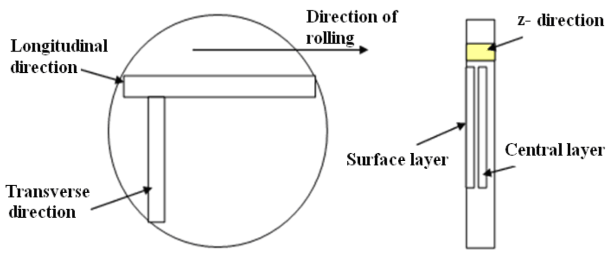

Figure 10. Sampling of specimens for tensile testing

Table 4. Mean values of impact test results for specimens with U2-type notch

Sampling position	T [^{0}C]	$KU_{2/300}$ [J]	$KU_{2/300}$ (KCU) [J/cm^2]
Longitudinal direction - surface layer	+20	59.8	74.8
Longitudinal direction - central layer (thickness wise)	+20	54.9	68.7
Transverse direction - surface layer	+20	80.8	100.9
Transverse direction - central layer (thickness wise)	+20	74.9	93.6
Transverse direction, steel St 3, prema standardu [7]	+20	min. 49	

Table 5. Mean values of impact test results for specimens with U_3-type notch

Sampling position	T [^{0}C]	$KU_{3/300}$ [J]	$KU_{3/300}$ (KCU) [J/cm^2]
Longitudinal direction - surface layer	+20	57.6	82.2
Longitudinal direction - central layer (thickness wise)	+20	74.6	106.5
Transverse direction - surface layer	+20	69.9	99.9
Transverse direction - central layer (thickness wise)	+20	105..6	151.8
Transverse direction, steel St 3, prema standardu [7]	+20	min. 49	

Figure 11. Appearance of fracture surfaces of the specimen for impact testing

Table 6. Results of chemical analysis performed on delivered sample, mass percantage

Segment	C	Si	Mn	S	P
1-4	0,19	0,27	0,58	0,035	0,012
standard [5]	0,14 – 0,22	0,15 – 0,30	0,40 – 0,65	max. 0,050	max. 0,040

Circular cutting of a sample with the diameter of 300 mm taken from turbine cover segment 4-1, figure 13, was performed in order to determine mechanical properties in longitudinal and transversal direction of 50 mm thick sheet metal.

Figure 12. A photograph of the sample taken from turbine cover segment 4-1

Two standard specimens have been fabricated, with 8 mm diameter in the measurement section, in accordance with standard [6], figure 11, and used for tensile testing of the metal sheet in longitudinal and transverse direction. They were taken from the surface and central layer, thickness wise.

For determination of causes of the occurrence of lamellar cracks or lamellar tearing in zones of welded joints of the turbine cover, tests in order to determine the ductililty and contraction of the cross-section in “Z” direction were performed. Three specimens have been fabricated, 6 mm in diameter, figure 11.

Tensile tests have been carried out on a universal machine for tensile, pressure and bending tests "Alfred Amsler", with the maximum range of 98,1 kN.

Results of tensile tests showed that tensile properties of parent material in longitudinal and transversal direction meet the requirements of standards [6] and [7] for steel St 3, table 7.

Significantly lower values of contraction than minimum values prescribed by standard [8] were obtained by tensile tests in “z” direction, table 8. According to standard [8], as well as standards DIN 50180, SEL 096 and DAST 014, steel sheets used for structures with an enhanced ability to deform in direction transverse to the surface of the product need to have a value of contraction 25% at least.

From the sample taken from segment 4-1 of the turbine cover, standard specimens for impact tests, with dimensions 10x10x55 mm and 2 mm deep U and V notch, were fabricated, figure 11.

Values lower than minimum values prescribed by standard [7], as well as those within the prescribed range defined in standard [9], were obtained by impact tests, carried out on specimens with 2 mm deep notches, tables 9 and 10.

Table 7. Mean values of tensile test results, in accordance with standard [6]

Sampling position	$R_{p0,2}$ [N/mm^2]	R_m [N/mm^2]	$A_{5,65}$ [%]	Z
Longitudinal direction - surface layer	247	418	36	60.0
Longitudinal direction - central layer (thickness wise)	222	400	40	60.5
Transverse direction - surface layer	251	414	37	61.0
Transverse direction - central layer (thickness wise)	221	402	49. 5	50.0
Transverse direction, steel St 3, in accordance with [7]	≥ 235	370-480	≥ 23	≥ 25

Table 8. Results of contraction tests in z direction, in accordance with standard [8]

Sampling position	Specimen	d_0 [mm]	d_1 [mm^2]	Z [%]	Zsr [%]
"Z" direction	1	10.0	9.7	5.91	7.75
	2	10.0	9.2	15.36	
	3	10.0	9.9	1.99	
Prescribed values		Z15		≥ 10	≥ 15
		Z25		≥ 15	≥ 25
		Z35		≥ 25	≥ 35

Table 9. Mean values of impact test results for specimens with U_2-type notch

Sampling position	T [^{0}C]	$KU_{2/300}$ [J]	$KU_{2/300}$ (KCU) [J/cm^2]
Longitudinal direction - surface layer	+20	80.7	101.0
Longitudinal direction - central layer (thickness wise)	+20	85.3	106.7
Transverse direction - surface layer	+20	62.1	77.7
Transverse direction - central layer (thickness wise)	+20	71.9	89.9
Transverse direction, steel St 3, GOST 14637-89	+20	min. 49	

Table 10. Mean values of impact test results for specimens with V_2-type notch

Sampling position	T [^{0}C]	$KV_{2/300}$ [J]	$KV_{2/300}$ (KCU) [J/cm^2]
Longitudinal direction - surface layer	+20	35.1	44.1
Longitudinal direction - central layer (thickness wise)	+20	32.4	44.5
Transverse direction - surface layer	+20	25.8	32.3
Transverse direction - central layer (thickness wise)	+20	40.2	50.3
Transverse direction, steel St 3, GOST 14637-89	+20	min. 49	

4. Mechanical properties of material for the fabrication of new upper ring of guide vane apparatus and turbine cover structures

Results of performed tests showed that there are 2 equally important causes for the degradation of parent material and weld metal on a vital mechanical structure:

- degradation due to flaws in steelmaking technology
- degradation caused by flaws during manufacture of the welded structure.

Both mentioned causes influenced the occurrence of lamellar tearing in parent material, as well as in weld metal.

On the basis of analyses performed in order to determine causes and level of degradation of parent material and welded joints at the upper ring of guide vane apparatus and turbine cover, structural steels with improved chemical composition and mechanical properties were selected for the manufacture of new structures. Chemical composition [10] and mecha–nical properties of steel S 235 [11], of which new upper ring of guide vane apparatus was made, as well as of steels S 355 NL [12] and S 355 NL + Z25 + N [12], of which new turbine cover was made, are presented in tables 11 - 13.

Table 11. Chemical compositions of steels S 235, S 355 NL and S 355 NL + Z25 + N, mass percentage

Steel grade	C	Si	Mn	P	S	Cr	Ni	Mo	V	N	Nb	Ti	Cu	Al	C_{ek}
S 235	max 0.22	max 0.266	max 1.334	max 0.015	max 0.007	–	–	–	–	–	–	–	–	–	max 0.45
S355 NL	max 0.18	max 0.5	0.9 - 1.65	max 0.025	max 0.02	max 0.3	max 0.5	max 0.1	max 0.12	max 0.015	max 0.05	max 0.05	max 0.55	max 0.02	max 0.45
S 355 NL + Z25 + N	max 0.20	max 0.55	0.85 - 1.75	max 0.03	max 0.25	max 0.35	max 0.55	max 0.13	max 0.14	–	max 0.06	max 0.06	–	–	max 0.45

Table 12. Mechanical properties of steels S 235, S 355 NL, S 355 NL + Z25 + N and St 3

Steel grade, sheet thickness	YS [N/mm^2]	TS [N/mm^2]	TS in **z** direction [N/mm^2]	$A_{5,65}$ [%]
S 235, 40 mm ≤ t ≤ 100 mm	min 215	min 360	27	min 22
S 355 NL, 40 mm ≤ t ≤ 100 mm	min 315	470 – 630	25	min 22
S 355 NL+Z25+N, 40 mm ≤ t ≤ 100 mm	min 315	470 – 630	25	min 22
St 3, transversal direction, in accordance with [7]	min 235	370 – 480	min 25	min 23

Table 13. Mean impact energy values, V_2 notch

Steel grade, sheet thickness	T [^{0}C]	KV [J]
S 235, 40 mm ≤ t ≤ 100 mm, longitudinal direction	+20	27
S 235, 40 mm ≤ t ≤ 100 mm, transversal direction	+20	27
S355 NL, 40 mm ≤ t ≤ 100 mm, longitudinal direction	+20	47
S355 NL, 40 mm ≤ t ≤ 100 mm, transversal direction	+20	27
S 355 NL + Z25 + N, 40 mm ≤ t ≤ 100 mm, longitudinal direction	+20	47
S 355 NL + Z25 + N, 40 mm ≤ t ≤ 100 mm, transversal direction	+20	27
St 3, transversal direction, in accordance with [7]	+20	min. 49

5. Conclusion

Magnetic particle testing and utrasonic testing were performed during and after the manufacture of new upper ring of guide vane apparatus and turbine cover through the application of steels S 235, S 355 NL and S 355 NL + Z25 + N, which are not prone to lamellar tearing in the area of welded joints when a suitable welding technology is carried out. Apart from a non-allowable 4 mm long area with insufficient penetration, detected by means of ultrasonic testing, test results were satisfactory. In order to reduce expenses and period of time required for the repara-tion of the area where insufficient penetration was detected (human resources, material expenses for the preparation and reparation, consumption of filler material), appropriate analytical and numerical calcu-lations were carried out, and it was determined that such a structure will operate safely during the follo-wing forty years [13], which has been confirmed by the manufacturer „Силовые машины” from Saint Petersburg.

6. Acknowledgment

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TECHNO-MANAGERS IN CAPITALISM AND SOCIALISM: COMPARATIVE ANALYSIS OF THE FORD MOTOR COMPANY AND ZAVODI „CRVENA ZASTAVA“

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Abstract

The Ford Motor Company and Zavodi "Crvena zastava" can be ranked in a group of companies who had a notable influence on the establishment and development of auto industry both within their countries and beyond. Their business results were the standard of a successful company. Apart of engaging a lot of workers, it employed techno-managers who were conceptual creators and exponents of organizational and technological development in auto industry. A lot of books have been written about the life and work of Henry Ford, the president of the Ford Company. Work organization, manufacturing technology, the best selling car models of the Ford and the biographies of the most successful managers of the company were written a lot about as well. On the other side, there are only a few monographies and books that were devoted to the history of industrial production and the history of car manufacturing in Kragujevac. General public does not know anything about organization, technology, successful managers, car models and the contribution of individuals to the development of car industry in Yugoslavia, and the contribution of techno-managers of Zavodi "Crvena zastava" to the beginning and development of car manufacturing in the Soviet Union and Poland. This work gives a comparative analysis of the organizational and technological development of the Ford Company and Zavodi "Crvena zastava" and also the analysis of Ford techno-managers and that of Prvoslav Raković, a long-standing general manager of Zavodi "Crvena zastava". Prvoslav Raković and his work the society have not been given proper attention, let alone due recognition, although he belongs among the most outstanding business people in the second half of the 20th century in Serbia and Yugoslavia.

Keywords: production, organization, self-management, technology, techno-managers

1. Introduction

The automobiles were among the most visible symbols of the affluence and prosperity. Prvoslav Raković general manager of Zavodi "Crvena zastava", was among the people who organized the car production in Factory Passanger Cars (Zastava), inspite of the wishes of economic planners.

FIAT 600 (nicknamed „Fića“ in Yugoslavia), cost less than two average monthly net salaries at the beginning of the 60s. Annual production in Zastava factory rose from 424 cars in 1956, to 25,960 in 1964. It is important to underline the fact that Zastava cars, unlike manufacturers in other socialist countries, faced strong competition from imported cars [1].

American and global car industry was marked by Henry Ford I, the founder and owner of the Ford Motor Company. He was succeeded as the president of the company by his grandson Henry Ford II. Each of them managed the company in his own way, established and changed the organization in the company, developed the production, introduced new products, made project-investment decisions, chose closest staff members and leading managers. Their approaches were similar but different as well. Henry Ford I paid less attention to establishing organizational hierarchy and was not interested in making new car models. He opposed any change and did not want work on making the existing models and designs better. He was goal-oriented, which meant the production of the cheapest car possible available to every American citizen. Financial results, even the worst ones, were not the reason to make any substantial changes in organization or management. Henry Junior, since the moment he had taken the company over, was ready for making changes, was consistent, firm, and quite different than his grandfather. He did not pay much attention to the production of small, cheap cars because they were less profitable, every financial failure he used to make radical changes both in organizational and managerial sense.

The car production in Yugoslavia was organized only in one factory which was started in the second half of the 20th century, much later than the production of the first cars in the United States of America. Then, at the beginning of the 20th century, about 225 companies were making cars and among them the largest ones were the Ford Motor Company (FMC), General Motors (GM) and Chrysler whose market share was 85% [2].

The credit for the beginning of the car production in Yugoslavia is due to Prvoslav Raković. His leadeship and managerial skills have stayed today both in the memory of his fellow-workers and the people who just had the chance of meeting him or heard about him. Prvoslav Raković and Emerik Blum, at that time the director of Energoinvest in Sarajevo, shared the first place on the list of business people in the Socialist Yugoslavia. They were in charge of the two largest companies who were working in the conditions of the socialist self-management system. Although the ownership over the capital of the companies and the decision making were in the hands of the state, Prvoslav Raković and Emerik Blum succeeded in establishing the practice of market economy and persuaded sub-contractors to form a union with Zavodi "Crvena zastava" and Energoinvest, making a difference in the economic system and the total gross profit of the country. They had a knack for carrying out the decisions made in the planning and management centres, and in such economic conditions succeeded in creating substantial business results in their companies. The situation was quite different in the majority of other similar firms. In the period from 1950s to the second half of the 1970s, a large number of successful managers were in charge of Yugoslav companies, but their destiny, unfortunately, was the same as that of Raković and Blum, they were soon relieved of their posts by the decision of the top government officials.

A new generation of political and industry leaders in Yugoslavia (including Prvoslav Raković General Manager of Zavodi "Crvena zastava" - ZCZ), which John Lampe named „liberal coalition", took over during the late 60s.These people were better educated, and as for those in big corporations, more familiar with the Western business practices and new technology. For our purpose, the more ominous were accusations that they were „technocrats" and „techno-managers" who on the one hand preferred experts too much, and on the other hand, neglected moral and political suitability. In such an atmosphere, thousands of „techno-managers" were replaced. One of them was Prvoslav Raković [3].

Through the analysis of the operations and work of the leading managers in large manufacturing companies like the Ford Motor Company in the United States and Zavodi "Crvena zastava" in Yugoslavia and Serbia, we want to show here the important role the managers in the capitalistic and socialist countries had in the development of the companies they were in charge of.

The beginning of car production

The first organized production of cars was started in 1913 in the Ford Motor Company (FMC), when the experimental chassis (vehicle without body) assembly was pereformed. The wheeled platform was connected to a pulley-block via one hundred meter long and strong towing rope used for winding up and dragging the platform. The needed materials for car assembly were at hand along John R. Street which passed through the Highland Park Ford Plant. Six car assemblers were standing on the platform and had to assembly the chassis while the controllers with precise instruments and blocks in their hands noted and controlled every second of the operation. As compared with the old method, when the car, like the house, was made at the same place, the chassis assembly took twelve hours and twenty-eight minutes. Using this new and experimental method, the assembly time was put down to ninety minutes [2].

The production on the assembly line was getting better and better. Henry Ford was mostly dedicated to the realization of large scale car production based on extensive manufacturing lines. Such production process required the standardization of the needed spare parts. The basis of the production process was intensive, mechanized and phased work procedures. The scientific theory of work organization was established by Frederick Taylor, especially in the field of making engineers qualified for the use of the methods in studying, designing and hyper-specialization of labour. Special attention was paid to well-defined division of labour. Every part of the car was produced in a special department, every part of the process was given to unqualified workers. Thanks to such work organization, unqualified and less paid workers, trained to perform just a few simple operations, took the places of qualified and often expensive workers. In that way, the number of labourers gradually rose and wage workers made 90% of the total labour force [4].

Specific quality in the organization of production process in the Ford Motor Company

The basic quality in the organization of production processes was the pyramid control system enabling complete insight into all segments of the production process. All manufacturing departments were connected that way together with the central bureau which was in charge of calculations and control.

Henry Ford did not mind about any changes, he was especially against organizational schemas, levels and positions. No forms of organizational structuring could be found within the company.

In spite of that, the FMC became a respected car manufacturer and had a market share of 45% in the United States between 1920 and 1930.

According to the organizational model of 1920 (Figure 1), the president of the company was the sole authority in decision making and the managing of the company. He personally chose his fellow-workers and relieved them from their posts, and all together made a kind of management in charge of everything. Other lower managerial jobs were held by top-level managers, low-level managers and supervisors. The promotion of managerial staff was based on the gained confidence and the loyalty to the company during long-standing and dedicated work.

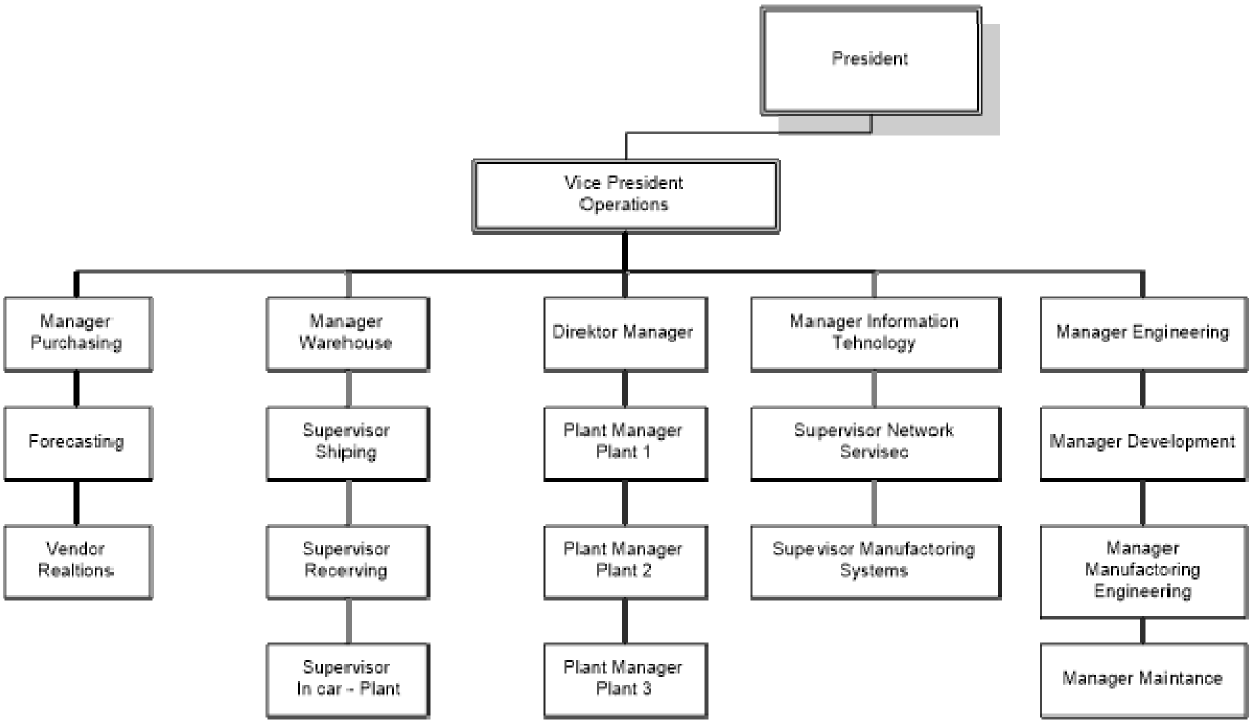

Figure 1.Adapted model of the Ford Motor Company organization (1920s) [16].

The largest competitor of the FMC was General Motors Corporation (GMC). GMC had also centralized organizational structure, but apart of the FMC, there was some interest in making more modern and developed organization. It was noted that the leading managers in GMC, early in the 1920s, began studying the effects of the decentralization of production plants into self-sufficient divisions. The leading figures in the creation of the multidivisional or M-form were Pierre S. Du Pont and Alfred P. Sloan [5].

The decentralization enabled greater flexibility in the complete system of organization. The decisions made in the headquarters were passed on to the production divisions without any impact on their autonomy. Efficient subordination among corporate and division vice-chairmen enabled the establishment of managerial procedures. At the top of the pyramid were Finance and Executive Committees who had the principal role in decision making, together with the Board of Directors and the President of the Corporation. The carrying out of decisions was delegated to vice-chairmen of the divisions themselves.

In the automobile industry itself Sloan's techniques and procedures had a recurring relevance. During late 1940s and early 1950s, for instance, the Ford Motor Company adopted many of Sloan's methods when Henry Ford II succeeded his ailing grandfather [6].

The sutuation in the Ford Motor Company after the World War II

Once powerful, the FMC was in total confusion after the World War II. It was disintegrated with disrupted hierarchy, without precisely defined responsibilities and competences. Executive directors completely lost control over the constituent parts of the company. Everything pointed to radical reorganization, the establishment of modern production technologies, and especially to the need for automated production processes. The losses caused by ill business practices at the end of 1945, amounted to the sum of incredible 60 million US dollars [7].

Henry Ford II became the head of the company and did not hesitate to introduce substantial order. Early in 1946, he hired General Motors executive Ernest R. Breech whose first task was to completely reorganize the company [8].

Henry Ford II with his fellow-workers started the organizational changes of the inherited company. Ernest Breech succeeded in engaging three more top managers from GM, Lewis D. Crusoe, finance vice-chairman, Harold T.Youngren, the chief engineer of GM's Oldsmobile Division, and an outstanding innovator with a lot od patented inventions in the field of car production, Delmar S. Harder, who was well-acquainted with the technology and organization in the production of engine parts.

Until the end of 1946, the FMC started the activities to open seven self-contained divisions: International division, Division for the production of light car instruments, Lincoln-Mercury division, Production division, Engineering division, Sale and post-sale services and the Division for industrial relations, with the tendency to develop organizational structure further on.

Executive Committee supported Harder's decentralization project in all the factories for the production of cars, which enabled the construction and opening of the Cleveland engine factory and enlargement of production capacities with the building of thirty-three new production plants with assembly lines, covering about additional four million square feet of factory floor space. Twenty new plants were as large as the area of the famous River Rouge city. New plants were equipped with 33.000 universal lathes, most of which became parts of automated production process personally designed by Harder.

Globally, Ford's organization in 1951 showed functional organizational structure but with productions plants organized in divisions. The production divisions had centralized management with the strict functional division of labour [9].

The company was headed by the Board of Directors, below it was the Executive Committee which was superior to Henry Ford II, the president of the company, and the executive vice-chairman. Delmar S. Harder was appointed a Vice President of the Manufacturing Divisions, and was the greatest authority in the field of production capacities, introduction of new technologies and automated production management. All these changes enabled the FCM to became alider in car production again.

However, it did not last for a long time. Global crisis on the car market, inadequate financial results, poorly performed business projects, resulted in the loss of the leading position, status and, lastly, affected the jobs of the top ranking managerial staff. Everybody had to conform to business policy. During the whole history of the FCM, the company was run by family members. They had the right to choose the staff and the right to dismiss it. That right was considerably used. These decisions could not be influenced and in no way changed. Henry Ford I, from1913 to 1945, and after him Henry Ford II, from 1945 to 1979, were excellent managers, charitable to talented and successful fellow-workers, mentors to young people, but merciless to those they brought to the company but who fell short of expectations. Mostly, they fired them if they thought they were too competent and that they would endanger their positions. It happened also when new experienced managers appeared or were not needed any more when they did not make any results.

Organizational and technological development of Zavodi "Crvenazastava"

The period after the World War II saw in Yugoslavia the establishment of the centralized planning management in economic activities. The reorganization of large companies had to respect quantitative and qualitative conditions of the existing production capacities. The most important thing was that existing capacities could satisfy, at least partially, the requirements of the business activities in the future. The proposed projects had to justify investments, both in economic and technical terms. The basic documents of management were internal papers of the company called "Rules", which defined all the issues concerning work, management, business activities and organization.

The idea of workers's self-management, conceived in 1950 in Yugoslavia, became the reality in ZCZ the very same year. Planning and the development of economy and companies were in charge of the leading officials in the party. Legal acts defined the models of organizational structure. Stereotyped organizational structure was uniform and all the companies had to stick to it. The market, based on the state interventiontionism, enabled the firms, unable to do business independently, to survive and successfully operate. The managers in charge of the firms were strictly controlled. General managers were loyal officials of the establishment. The government expected that the management in the companies would be able to establish organizational and technological conditions to foster the production, train and promote the working staff, and enable equal share of all the workers in the results of the production.

"Crvena zastava" began to make arrangements for the production of passenger cars in 1954. The Board of Directors introduced the new organizational structure proposed by newly appointed general manager, Prvoslav Raković . The establishment of new organization was delegated to experienced engineers. At the beginning of 1955, "Crvena zastava" had 5.000 employees. The existing production could not secure the income for all the workers. The Minister of Defence, general Ivan Gošnjak ordered Raković, immediately after he had taken the post of the general manager of Crvena zastava, to fire 2.500 workers and to continue, with the rest of them, the production for military purposes. He did not do that because he did not want to win bad reputation among the workers and the citizens of Kragujevac at the very start. He kept the workers because he had an idea to expand the production. The plan was, apart from the military purpose production, to start the production for public purposes. At that time, Zastava was in a special situation, the world was faced with the first atomic bomb and everybody thought that classical arms had had its day and that there was no perspective to produce arms in Zastava any more, which meant that new production projects had to be found.

After the agreement for the purchase of the licence with FIAT had been signed in 1954, the production of the first passenger cars was started. Until the end of 1955, 1.000 cars (model 1400B) were assembled, which was trivial compared to the daily production of 940 vehicles at FIAT's plants in Torino. The productivity of the factory in Kragujevac was far from developed car industry. The choice of the Italian producer was made after the tenders were invited for the licence partner in the production of vehicles. In tough competition, with the participation of the majority of outstanding European car producers, the best terms were offered by FIAT. The choice of the Italian producer was made upon other factors, above all the possibility for the arrangement to include the funds to be paid to Yugoslavia in the form of war indemnity [10].

The cost of the licence was 350 million Italian liras with the expected schedule of repayment in ten years, but not in cash (the given sum implied the obligation to buy up cars or their spare parts). The agreement stipulated complete technical support in the production. Later on, another interest-free commodity credit of 150 million liras was given and included in the agreement. On the base of the contract Crvena zastava was allowed to produce and sell the vehicles from its current production of FIAT models: a) loading capacity of 1,5 tons, model 615, petrol and diesel engines; b) passenger car, model 1400, petrol and diesel; c) off-road vehicles “Campagnola”, civil and military, petrol and diesel engines; d) passenger cars, model 1900 with petrol and diesel engines; e) wheel and crawler tractors, model 25R and 25S, petrol, diesel and petroleum engines [10].

Upon arrival at the head of Zastava, Prvoslav Raković noted the lack of highly educated staff, especially engineers. With ten graduate mechanical engineers, working in the factory at that time, he could not start any production. He decided to recruit a team of experienced specialists. First of all, he engaged Stevan Šuica, a mechanical engineer, who was experienced in the production of motor truck engines which had been manufactured before World War II in Industrija motora Rakovica. When appointed, Šuica started recruiting new specialists. When the needed team was formed, the assembly of vehicles was started with the workers in the factory. At the same time, new methods were introduced making possible assembly-line production.

The workers were suspicious and sceptical of the competence and ability of the engineers and, on the other side, even greater problem was to convince graduate engineers to come to Kragujevac and take part in the production.

Prvoslav Raković asked the representative of FIAT to cede out of their production program one of the cars that would be manufactured apart from the agreed assembly of the licenced off-road vehicles. As the production was not possible within the existing factory capacities, Raković decided to sign the contract with the Italians for the financing of the building of a new factory for the production of cars.

With a selected team of associates Raković started his visits of the most outstanding car producers, spare parts and the machines for their manufacture. During April-May in 1956 the team went to a number of factories. The data about production plants, roof constructions, equipment, tools, work organization, control procedures and other things were collected. All that was taken into consideration and put together in the study on the development conception of the car industry and the tasks of Zastava in that sense. The situation concerning the credit for the building of the factory became more complicated after the authorized commission within the Ministry of Defence had refused to accept the annual production of 12.000 vehicles [11].

The refusal of the project did not deter Prvoslav Raković from his intention to start the production of passenger vehicles. He tried to find a way to begin the self-sufficient production of „Fiat 600“, a car suitable for common use, especially because of the fact that it had been widely present at the Yugoslav market, being the proof that it would be, without any doubt, well sold. Licence purchase ammendments to the previous contract with FIAT was signed at the Zagreb Car Show, on 10 September 1956, which provided the right of Crvena zastava to produce „Fiat 600“ (popularly known as „Fića“) [10].

Although the project for the production of 12.000 cars had been refused, Raković filed a request for a larger project to be accepted, which, apart from the capacities for the production of 12.000 cars, implied the need for the provision of financial funds for the additional production of 20.000 „Fiat 600“ cars. During the next six months the government commission reviewed the project and asked for additional explanations. The experts from Crvena zastava answered all the questions and successfully defended the project. There were no objections on both technical and economic aspects concerning the marketing of the cars. However, the project was refused again by the authorities on the federal level and that was the final decision without the right of appeal [11].

Thanks to the agreement in principle of the Italian representatives and their willingness to invest their funds in the building of a new car factory and the fact that such an investment does not burden government balance both in the building of the factory and the paying off the loan, the authorities started reconsidering the refused project. Finally, on December 1958, the Federal Government, Secretariat for Industry, made a decision to approve the additional investment car factory project of Crvena zastava in Kragujevac. Prvoslav Raković received an assignment to build the factory in five years. As the building of the factory was not included in the Yugoslav development program for the next five-year period, the funds for the financing of the factory construction were not provided [11].

Building and managment of the new car factory

Permitted to begin the building of the factory, PrvoslavRaković started the negotiations with FIAT representatives in Torino on 8 April, 1959. Determination and the knack od negotiation prevailed. Other details were soon agreed upon, and on 25 May 1959 the loan was granted under favourable conditions. FIAT invested 30 million US dollars for the needs of the car factory construction, the capacity of 32.000 vehicles a year [11].

All decisions were made at the worker's meeting. The decisions were prepared by a management body headed by the General Manager with his assistants and division managers, all of whom were members of the board meeting. The General manager was subordinate to the Workers' Council and the Board of Directors. Production-technical Sector consisted of Construction-technological Division, Preparation division, Technical Control Division with laboratory and experimental group, Capital Construction Bureau with the Maintenance Division. The Section Ward head was responsible for production divisions with their plants. Organizational structure also included Accounting, Commercial and Legal and General Affairs Department (Picture 2) [11].

This organizational model was was in line with the legal acts on the organization of companies. Some small variations could be accepted but great ones that differ substantially from uniform model of organizational structure were not allowed.

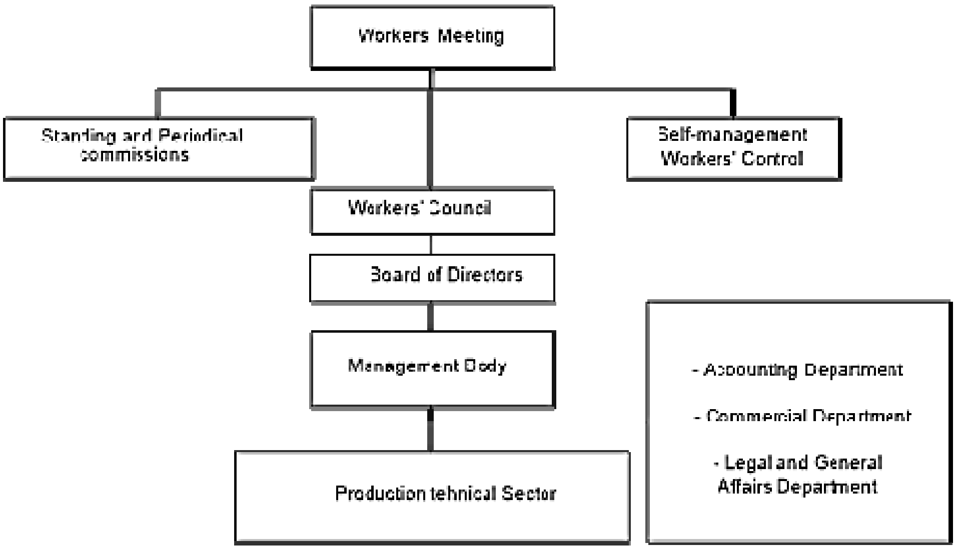

Figure 2.Organizational model of Zavodi "Crvena zastava" early in 1960s.

The car factory was finished on schedule and pre-production was started on 6 July, 1962. The formal opening was attended by Aleksandar Ranković, Vice President of the Republic of Serbia, ambassadors of various countries, a large number of business people, government and army officials, and FIAT officials together with its general manager and principal shareholder Dr. Giovanni Agnelli. Present were also a lot of foreign general managers representing the suppliers of machines and equipment, and the representatives of designers at home and abroad [12].

Renowned contractors of the whole country together with the youth labour brigades from all the republics took part in the construction of the car factory. The project provided for the production of 27.000 passenger cars and complete mastering of modern technological procedures until 1964. However, the demand for cars was larger than the provided capacities; because of that, additional investments were made which enabled in 1965 to manufacture 34.600 passenger cars and off-road vehicles, and 42.000 of them in 1967 [13].

Zavodi "Crvena zastava" became a real industrial giant in 1962. It included in its structure the following firms: Car factory "Zastava", Kragujevac; Engine Factory "21 maj", Belgrade; Zastava Arms, Kragujevac; Tools Factory, Kragujevac; Forgings Factory, Kragujevac. Separate organizational sectors: Power Supply anf Maintenance Sector in Kragujevac and "Zastava" car service in Belgrade. Kragujevac opened the following branch offices: Sales sector; Export-import as ector; Spare parts sector; Purchasing sector; central laboratory; Exploatation and service shop sector; Mechanographic sector; general sector with the social standard department; Educational centre. Management worked as a special organizational unit [14].

The cooperation with FIAT was successfully continued by making a joint venture agreement for the realization of the „II phase" project in the building of the car factory. According to the joint venture agreement, FIAT invested 12 million USD, the agreement was signed on 23 February, 1968. International Financial Corporation (IFC) invested 8 million USD, the agreement was signed in March, 1970. The International Bank for Reconstruction and Development (IBRD) supplied a credit as well. Joint ventures with foreign partners, realized in Yugoslavia for the first time, were, at the same time, the proof of projects' quality, market prospects and the competence of the experts who worked on them in various phases during design, realization and the use of these investments [12].

Raković wanted to enlarge the production of cars to other Yugoslav republics. At the end of 1970, he made an agreement for the building of the car factory for the production of a national car in Zagreb (the Republic of Croatia). The agreement was signed with the president of Croatian Chamber of Commerce and the occasion was attended by Dr. Givanni Agnelli, the president of FIAT. The factory should have started production in three years with the capacity of 50.000 cars. It was planned to employ 2.400 workers, the financial operations should have been carried out by Crvena Zastava [15]. However, this project faced a heated debate and opposition of a number of institutions in Croatia and was never realized [12].

Prvoslav Raković acted as a mediator in establishing business cooperation between the representtatives of Fabryka Samochodow Osobowych – FSO (Passanger Automobile Factory), Poland and the Italian FIAT. Dissatisfied with its outmoded cars „Warszawa“ and „Victory“, the Polish manufacturer had Zastava made the project for their factory. As the manufacturing licence could not be transfered to the third party, PrvoslavRaković persuaded the Italians to make an agreement, and it was signed in 1965. Completely new factory for the production of „Fiat 126“, a small city car, was constructed in southern part of Poland, the town of Bielski-Biala, in 1972; three million cars were manufactured here during the next twenty years [14]. Raković also acted as a mediator between the Soviet government and FIAT to cede the licence for the production of „Fiat 124“ model. The car factory VAZ (Volski Automobilski Zavod) was built in the town of Togliatti on the river Volga in 1966 with the capacity of 600.000 car a year. The production line in VAZ was 270 kilometres long and the factory employed 180.000 workers. The first model was named „Žiguli“ and labeled „VAZ 2101“ [12].

Zavodi had, after being reorganized in 1970, twelve independent organizations of associated labour (which were not legal entities) in Kragujevac: Zastava Arms; Car factory; Off-road Vehicle Factory; Spare Parts and Equipment Factory; Fordgings Factory; Other Products Factory; Tools Factory; “Ramiz Sadiku” Factory, Peć (Kosovo and Metohija); Factory of motor car parts “Heroj Toza Dragović”, Ohrid (Macedonia). Administrative and Commercial Departments, and Educational Centre were situated in Kragujevac [12].

Economic and production requirements in industrial companies constantly influenced the considerations to make changes of the staff, organization and technology. The practice was to visit faculties and recruit the best students for the work in the car factory. Raković controlled the list of scholarship holders on regular basis, checking his/her qualities and when to expect him/her. He knew in advance where and when a student can contact him. There were not enough experts and the recruited persons were immediately given responsible duties because there was no time for their internship [11].

Democratic and self-management principles were introduced in the factory, but Raković kept under control the actions of unions and party organizations. The limits of claims and initiatives allowed were clearly determined. The general manager and authorized staff had the sole competence in the matters of production, technology developments, investments and upgrading of the factory business.

Due to down-size sale, Raković himself realized that the situation was not optimistic, not only in Zastava but also in the car industry as a whole. The world car industry was faced with the first oil crisis caused by the Arab oil producers’ blackmail. There were between 25.000 and 30.000 cars either on the factory lot or in the distribution networks. Zastava was struck by this situation at the moment when it had to pay off the loans taken for the investments in the development of capacities and the beginning of assembly line production of the “Zastava 101” model. It was expected that the new general manager, Milenko Bojanić, would solve the problems of supplying the funds in order to resolve the standstill of sales [11].

The efforts of introducing universal model of organizational structure in 1974 as to make the business activities better did not give any results. The productivity was still under the expected level, manufacturing costs were not reduced. Self-management model soon came into a crisis both politically and socially. General managers of large production systems at that time were often fired and were accused of being “technocrats” who caused harm both to the economy and society.

The effects of political influence on the economy were, in spite of bad results, more and more pronounced. Inactivity became widespread, managers on all levels lost their authority and were not able to recover work and technological discipline. Self-management was taken as an open hunting practice on managers and directors, who found themselves on the hit list. The function of managing a company became senseless and everything was left to give-and-take practice. The “policy to keep on good terms with everybody” was the cover for inactivity, indiscipline, and poor level of productivity. The existing way of making decisions was especially unfavourable because the strategic issues were discussed on equal footing by worker-managers and directors.

2. Conclusions

That strategy determines the structure was realized in both companies analysed here. The leading management in the Ford was forced to change centralized functional organization and make decentralized one with a large number of divisions as to enable decision making and exchange of information among organizational units more flexible. The aim was to endanger the advantage of its direct competitor General Motors. The introduction of multidivision structure model and management based on the model of financial results, were instituted in the Ford company by General Motor's managers themselves, having in mind everything that was successful in the Ford. Readiness to make organizational changes, research and development, the use of better technology then the existing one, recruiting the „know-how" managers, made it possible to overcome the problems of insufficient efficacy and the influence of bureaucracy within the Ford Motor Company.

Zavodi "Crvenazastava" based its organizational and technological development on the transfer of knowledge and technology from its partner FIAT. New factory facilities and assembly lines were equipped by already used machines from the factory in Turin. The purchased licenced models were outmoded, and the finished models and could be sold only at the local market and those with low standards of living because they belonged to the category of cheap cars. According to the contract FIAT was obliged to train the needed staff. A large number of engineers was trained in the factory of Turin. FIAT's experts also trained the workers at the assembly lines in Kragujevac.

The contribution of Prvoslav Raković in the development of the car industry in Yugoslavia and the socialist countries in the region gives the reasons to say that the manager like Raković was not, with his leadership and managerial qualities, much behind the leading managers and techno-managers working in one of the greatest car factories such as the Ford Motor Company.

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THE ADVANCED MECHATRONIC AGRICULTURE MACHINES - CHALLENGE FOR THE FUTURE -

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Abstract

The art of the agriculture harvest have been in the past few years strongly influenced by the mechatronic machines. Besides being multifunctional, they become available and financially feasible also to the small farmers. Presented case study is small agriculture, multifunctional machine in terms of the harvest activities as well as the transport, but also some other technological activity on the contemporary farm. The product is not limited only for the single (EU) market, but has world-wide applicability.

Keywords:

Mechatronics, multifunctional machine, collecting fruits, harvest transportation, techno-economic feasibility, electronic position control -- load-sensing hydraulic

1. Introduction

The orchards in some parts of the Europe (especially high hills or Alps) have often been limited to a plant height of about 2 meters. Working with ladders and similar climbing aids such as harvesting sled, drink crates or stilts is uneconomical. This is questionable in terms of the performance and also because of the rapid fatigue of the workforce. Consequently on the long-term is the numerous workforce, despite sometimes to the (low) wages, is outperformed by the harvesting (mechatronic) machine.

Nevertheless, such harvesting (mechatronic) machines have to fulfill certain features:

- easy to operate or handle,
- durability of the parts;
- managing steep and rough slopes;
- stability on the steep slopes;
- environmentally friendly;
- small and economic power consumption;
- versatile application on the farm;
- independently of the farm size (small farm, plantation or flat/hill country);
- economic feasible;

Presented is the case, advanced mechatronic machine from South Tyrol, where the trees are traditionally higher (up to 3 meters) because of higher amounts of sunshine and also slopes are rough and steep. For such tree maintenance and harvesting work, mobile platforms are used.

2. Multifunctional mobile mechatronic machines

The multifunctional mobile mechatronic machines for the harvesting and other (agriculture) application is result of the sustainable development.

There are certain types of the basic mechatronic machines mostly for various applications (Figs. 1-3):

- orchards – e.g. ATI Pegasus;
- vineyards – e.g. ATI CAT 100;
- greenhouses – e.g. ATI Piccolo;

Their common features are like permanent electric (four-wheel) drive and additional functions like with a hydrostatic drive:

- Optimal off-road and climbing ability as well as traction;
- Powerful torque;
- Maximum mobility through tank steering;
- Programmable driving mode;
- Electro-mechanical discharge system for fruit containers;

Figure 1. Orchards applications - ATI Pegasus

Figure 2. Vineyards applications - ATI CAT 100

Figure 3. Greenhouses applications - ATI Piccolo

There some main components of the multipurpose mechatronic machine – e.g. harvesting ladders, working platform, vineyard chair, steering.

The harvesting ladders

Fruits in the top area of the tree can comfortably be harvested with the ladders. They can be mounted easily on the machine platform.

The working platform

The single-person working platform can be used for all pruning and tree maintenance jobs around the year. It is mounted easily on the machine platform. The handrails can be folded out. Therefore fruits located at the foot level of the machine remain undamaged and the position of the person working on the platform is more ergonomic while carrying out all the different jobs. The foldable handrail can be adjusted in different positions.

The vineyard chair

For comfortable work in the vineyard, a chair can be supplied to be mounted on the machine platform. The control panel of the machine can be moved in such a way that the machine can be operated easily from the chair.

The drive power

These mechatronic machines are driven by the batteries - the operation time of the maintenance (free Lead-Gel batteries) is approx. 8 hours depending on the operation of the machine. Subsequently, the batteries will be taken out from the fitting and connected to the battery charger.

The steering

The steering is done by the joystick, which automatically slows down machine when the joystick is released. The timer function of the electronic control system permits an automatic short ride with a certain speed.

3. Feasibility study and advantage of multifunctional mechatronic products

The advantage of the multifunctional mechatronic products should be presented in comparison to the "traditional" platforms on the (larger) agriculture businesses.

Due to the different activities necessary when working at heights above 4 meters, larger businesses of over 10 ha are often already equipped with a work platform. In smaller companies these work platforms are too large and too expensive to purchase.

In such cases a cheaper solution, e.g. the multifunctional mechatronic vehicle (like ATI Piccolo), could be considered. This would develop the smaller area of the market that is less attractive for traditional work platforms.

For larger companies, the work platform is not efficient enough when used on its own for harvesting or even for pruning. For this reason, smaller work units like the multifunctional mechatronic vehicle (like ATI Piccolo) are more rational solution. They are more versatile, less expensive to buy and have lower maintenance costs. This gives larger businesses the opportunity to develop in smaller steps.

Due to its significantly lower weight, the consumption of the small unit is estimated at around 25% of a work (traditional) platform.

An important advantage of the multifunctional (mechatronic) vehicle (like ATI Piccolo) is the significantly lower purchase price and the lower yearly depreciation. With a total investment of €45,000 a work platform provides space for a maximum of 4 workers. For smaller orchards up to 10 hectares, the high investment for a work platform is not only an economic barrier but also a psychological one. They would probably be better to consider buying 4 smaller machines than one large work platform (see Table 1).

Table 1. Feasibility comparison with the (traditional) harvesting platform

	ATI Piccolo	Platform
Purchasing price	€ 6,500	€ 45,000
Depreciation	€ 650	€ 4,500
Operating costs	€ 325	€ 2,250
Energy	25%	100%
Number of machines	7	1
Workers per unit	1 to 2	Max 4
Total work force	7 to14	Max 4

4. Discussion

Based on the data (Table 1), even seven multifunctional (mechatronic) vehicles can be purchased for the same cost as once work platform. They do not differ significantly in function to the work platform and in some situations are more economical because it is not necessary to coordinate a whole group of 4 workers. Up to 14 workers can be assigned to these 7 units.

The experience from practical cases has shown the multifunctional (mechatronic) vehicles (like ATI Piccolo) to be more rational and efficient for practical use with fruit trees. The machine is easy to handle and is (multi)functional.

A positive factor is the simple transport of the machine to the site of operation using a trailer, because the orchards be further away from the main premises.

In terms of sales opportunities, the multifunctional mechatronic machine (ATI Piccolo) is an affordable alternative to an expensive work platform for smaller businesses.

Larger farms often already have a working platform. When a further work platform is being considered, a multifunctional (mechatronic) vehicle is an interesting alternative since it is smaller, more versatile and much less expensive to purchase than a platform.

An interesting question is the possible use in drupe (stone fruit) orchards in southern Europe (like Serbia, Montenegro or Bulgaria) where there are differing types of tree cultivation. Inefficient climbing aids are still commonly used in these orchards. The large stone fruit orchards (like Greece) in these areas offer further application opportunities for small mechatronic machines.

There are many end-customer benefits, like – time saving, work-load reduction, environment, energy saving, maintenance.

Time saving

Through the utilization of the ATI Piccolo, up to 30 – 50% working time can be saved depending on the type of work. In a fruit cultivation farm of 4 – 5 ha, the machine is in use for about 150 days a year.

Carefully estimated, it is possible to save about 60 working days. With an hourly salary of 8 €, working expenses are reduced by 3.000 € – 4.000 € per person per year.

Work-load reduction

Work load reduction in a fruit orchard is of great importance. For example, per year 7 – 10 work operations are carried out in average on each fruit tree. For each operation, a person has to climb about one meter up and down the tree. This amounts to climbing up and down 3.000 trees on each ha of the orchard. With an orchard of 3 ha, this almost amounts to climbing the Mount Everest.

Environment

As our working platforms are electrically operated, they do not create noise and air pollution through exhaust emissions. In addition, a diesel engine creates strong vibrations during operation. This is not the case with mechatronic machines (like ATI Pegasus or ATI Piccolo).

Energy saving

An electrical engine has 50% better power efficiency as compared to a conventional combustion engine. Therefore the operation expenses are considerably lower than with a conventional diesel engine.

5. Conclusion

This paper has clearly shown advantage of the small and multifunctional mechatronic agriculture machine in comparison to the (traditional) big platforms.

The contemporary trend in the field of agriculture is therefore more in smaller and flexible, environmental friendly mechatronic machines.

These solutions enable more reliable and efficient harvesting and maintenance solutions for small and big farms. Above all they are cost effective and acceptable also for the small farmers.

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MOST COMMON PITFALLS WITHIN CREATION OF PROJECT PROPOSALS FOR EU FUNDING

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Abstract

In this funding cycle, method of work of EU financing sources, along with same success rate, remained very similar to previous ones. So far gathered evaluators` experience, demonstrates the presence of same pitfalls in this financial round, as in previous ones. This paper addresses most common and obvious pitfalls associated with the process of project proposal creation, usual reasons for their occurrence and with some recommendations to overcome them.

Keywords: EU funding, project proposal, project proposal pitfalls, consortium, task distribution, activities

1. Introduction [1-5]

During previous EU funding era (period 2007-2014), there were over 400 funds, from which financial (direct and indirect) support could have been drawn. Re-composition of these sources, while introducing new round of EU financing, did not change the situation much, in terms of number of funding sources. Other aspect of funds utilization remained the same: call for proposals, i.e. the necessity to create and submit project proposal, in one or two stage process. Average success rate was 8-11%, with new funding cycle demonstrating, till date, more or less, the same percentage. Although, the orders of evaluating parameters have been somewhat changed, and are:

- Quality and efficiency of the implementation
- Impact
- Excellence

The same success rate, along with evaluators` experience, demonstrates the presence of same pitfalls in this financial round, as in previous ones.

2. Most common pitfalls [1-5]

1. Wrong composition of the consortium.

Within published call for proposal certain criteria for consortium are established, but, usually, defining only the minimum number of participants (usual number is three, except in some limited number of cases), and that is, very often, interpreted as sufficient number, leading towards too small consortium. This especially happens when scope of work, available resources, and desired outcome(s) are being put aside, or are not being properly seen through. Usual reasoning behind this approach is either "*We can do this alone, we do not need anyone outside our little company*", or "*We want to keep all the money*". Response to that attitude is that if one can do something alone - it is not the case for EU funding schemes, and that EU is promoting cooperation and distribution of work load, results, knowledge and financial resources.

Opposite situation happens when too big consortiums are created, due to the wish that consortium composition appears more serious (reasoning is that larger number of consortium members will carry more weight with evaluators), or there is pre-requirement for one or more consortium participants. Usually that pre-requisite is participation of one or more SME(s) - so required number of SME(s) is adjoined to the consortium. Or, when EU funding is perceived as good source of money, so "*let's introduce good friend's company into the consortium, so they can get some money*". This, again, happens when the distribution of the workload, associated with necessary resources for goal achievement, is neglected. This approach leads to one mistake immediately noticed by the evaluators: role of some partner.

Desire to work with known partners is understandable, as is the connections existing among similar companies within one region (for example neighboring countries). But, creation of consortium of that provenance is not a good way to go, since the pre-requisite that impact and knowledge distribution for EU funded projects must be at least on EU, if not world level, is being dropped out.

2. Lack of understanding of the documents

Whichever the founding source is, always there are available documents, supporting that funding scheme, intended for the use of proposers. Main document, in which problem of interest is defined, along with expected solution/goal to be achieved, all of it accompanied with timetable with expected dates of interest is called work plan. Noticeable is that proposers, very often, read only call for proposals (Call fiche), in which summary of the work-plan is presented, along with mentioned timetable. This approach leads directly to not understanding what the identified problem is, and what level/kind of solution has to be provided in exchange for public funding. Also, this leads to confusion on number of consortium participants, and expected level of public funds contribution, thus maximally diminishing chances for successful project proposal submission.

Even if work plan has been studied, it might not be enough: for example, it could be written that ''…solution for processing of large quantities of real time data is required…''. Appropriate document, defining what that large quantity is, has to be found. These kinds of documents are public and available; it is only a matter of time needed to find exact explanation.

3. Lack of understanding of prescribed goal/interest

In majority of the cases problem is pre-defined in work plan and supporting documents, along with the goal realized project must achieve, constituting top-down approach. On the other hand, proposers have pre-defined idea, of their own, usually developed in line of own engagement, and again, usually without consulting of relevant EU documents, but with a strong wish for that idea development to be financed by public funds. In that case, tendency, on the proposers' side is to try to find any call for proposals remotely resembling to their interest and try to "squeeze in the idea". Some extreme cases, when proposers did submit their proposals, even if the call was, clearly, intended for NCP network, to which they do not belong. This attitude leads to complete "miss of the target", set by EC. Other, more radical approach is "*This call should be about this, I/we will write the project and explain to the Commission how this is important/genial/revolutionary....*".

In principle, "I/we will explain..." attitude is sound one, but only during the programming stage of the next funding cycle, around year and a half before current one ends. In all other stages, it is a pure waste of time. Both situations derive from proposers being in love with own idea, perceiving it as something of outmost importance, displaying a bit of autistic approach to way how public funding works.

4. Lack of understanding of Guideline for applicants

Every Call for proposal is accompanied with set of documents necessary for submitting of proposal and supporting its creation. One of these documents, usually, is Guideline for applicants, which contains necessary explanations (including what form of justification should be provided beneath which headline in the project proposal template, as well as other useful information) and examples, and, thus, very often, comprises of more pages than main text-body of the proposal should include. Additionally, that document contains a very important segment: - evaluation grid/table. In that table, overview of evaluation criteria are listed, along with the questions concerning that particular criterion. Those are the questions that will guide evaluator in his/hers work, meaning that there is a clear presentation (yielding a supportive role for the proposers) of the successful project proposal creation "trick": answer the evaluator's questions. Good project proposal will posses explanations provided, which are in line with Guideline, but having in mind mentioned table, i.e. mentioned questions. Never the less it is noticeable that very often this document is neglected, almost ignored, again, usually, due to the "*...I shell explain to them...*", and/or "*...I know what to put down on the paper...*" thinking matrix. In all fairness, it should be noted that there are "tips and tricks", acquired through experience, not presented within supporting documents, which proposers with lack of experience do not notice, but, utilization of that kind of knowledge differentiates outstanding or excellent project proposals from good ones, not from ones of poor quality.

5. Unverifiable sources of information

A very common pitfall, associated with lack of experience in project proposal creation. It is additionally enhanced if main "writers" background lies out of scientific community - which is accustomed to reference and sources of information quoting within papers. Other reasons for lack of sources of information within core text are "*...it takes too much space to quote references, a space needed to explain how much this idea is a great one....*" or "*…believe me on my word...*". Situation does not change when too local, too obscure or not well known and acknowledged source is stated. In all of the cases, what neglected is that credible sources quoting enhances the credibility of the proposal (especially, since evaluators are from the area dealt with in the proposal, and there is a very good chance they know those sources and information contained within them). In addition, what majority of the proposers do not realize is that evaluators are more in the position of investigators, searching what is wrong with the proposal, making sure that the-best-value-for-money principle is secured.

6. Unclear starting- and end-point, prescribed impact not reached

Every project financed by public/EU funds must have a beyond-state-of-the-art result. It is expected that proposal is created by a proposer/consortium dealing in the area and being at the-state-of-the-art or having a clear knowledge where that state-of-the-art level is, thus being capable of clearly depicting it. This level should be pictured as a pillar, whose height is defined (again, clearly) by that level. Justification on that pillar's height, i.e. what is keeping it from being at a higher level (a.k.a. constraints) should be provided. Next step is to depict which of these constraints will be addressed and how, providing a clear picture where the result of funded project will lead – to which level. This result should, also, be pictured as a pillar, whose height is defined by a level of knowledge, or technology, or else, attained at the end of the project, i.e. after achieving the project goal, providing clearly defined new state-of-the-art level. if the ''height'' of both pillars is clearly defined, the difference between before the project state-of-the-art, and after it, defines the ''beyond'' component, which is measurable (a very important aspect of the proposal: for progress to be clearly measurable). Last step would consist of analysis whether that ''beyond'' component corresponds with one required by relevant EU documents, i.e. is prescribed impact reached or not.

Very often proposers do skip this line of steps, and the tendency of being encapsulated within the similar way of engagement of similar legal, i.e. within the surrounding, is visible. This implies knowledge on the-state-of-the-art, but it may be on local, rather than on EU or world level.

7. Work load not distributed properly

As stated in 1), in cases when composition of the consortium is not well thought through, problem(s) with role of some partner emerges. If some person (legal or natural), does not have well justified role, in the core text; if necessary expertise does not suit the call; if tasks multiply and/or overlap across the partners - that, immediately stands out, demonstrating that EU does not get best value-for-money, since there is "dead weight", in form of unnecessary project partner(s) presence, whose lack of work, and/or expertise is to be paid for. Since composition of the consortium is one of the main checkpoints for the evaluators, this is not going to happen.

Regardless of consortium size and composition, more problems with partner roles can immerge and are associated with core competences, capabilities, experience, past track record and available resources. Core competence problem is displayed when some legal entity is interested, at all cost, to participate in EU financed project, with area of engagement "*not exactly right, but, at some point of view - close enough*", and with project coordinator inexperienced to recognize this, or interested in extending the work to particular company. That is why most successful consortium leaders work with trusted and checked collaborates, and carefully check any new partner profile and references.

Project proposals with company, few people strong, few thousand euro in capital, with past track record of few projects (project partner role) worth under hundred thousand Euros, proposed as a coordinator of consortium of over 10 partners, with proposal several millions euro worth, have been seen, demonstrating lack of proper task distribution within consortium. Also, legal entity, previously only partner on national size project (order of value under 50 thousand euro), appearing as WP (worth several hundred thousand euro) leader, have also been seen, demonstrating, again, poor task distribution within the consortium.

8. Inconsistencies and its connection to activities

Preparation of project proposal is time consuming and a bit of a "moving target", meaning it is evolving through time (to remind: around 12 months). Usually, it is not written in one pass, but there are certain time disruptions, which can lead to certain inconsistencies. For example, the number of perceived conferences to be organized, instead of 2 at the beginning of the work, comes up to 4, but at the beginning of the text 2 remains, while in some later part of the text 4 appears, leading the evaluator into confusion. This especially happens when more persons are writing the text and integration is not done, because it was not deemed necessary or there was a lack of time (late start of preparation, and, thus, deadline time pressure). It is important to execute this integration (especially in case of multiple persons writing the proposal, since different people have different writing styles, and difference between them will be noticeable). Checking the consistency of the text can be a problem to person(s) writing it, since, after all that time spent on writing, and due to the information saturation, when reading what is on paper or screen, the brain does not read what is written but what it expects to be written.

Other inconsistencies are associated with depicted activities, and occur in cases of wrong consortium composition and poor task distribution within the proposed consortium, i.e. when work to be done was not seen through properly. There is a simple cycle: problem identified by EC → project general goal and specific goals (denominating what will be achieved) → activities (demonstrating who, when, how and why something will be done) → resources (demonstrating with what something will be done), which has to be followed and justified, with clear causal string. Any deviation will be highly noticeable.

9. Late start of preparation

There are a few main pitfalls connected to the start of preparation:

- first one occurs when interested party downloads templates for project preparation and submission, and if encountering it for the first time, or not having enough experience on the project preparation process, gets spooked by the looks of it and its requirements. Usual reaction is in line with: ''*It is too complicated for me…, or,… I do not have the time (knowledge) for this…*'', and the usual result is withdrawal from the creation of the proposal
- second one occurs when interested party downloads templates for project preparation and submission and deduces that is is a very simple thing to fill in and that it can be done in ''*only few hours…*'', or ''*in few days*''. Consequence of that approach is that proposal will not be created, nor submitted by deadline.
- the third and most complicated one is when higher instance issues a directive to lower subordinate (something like: ''*You see what is that all about. Prepare and submit proposal and get us some money, but do it along with your normal working*

engagement'', which will lead to work extreme overload to the person in question, and, still, will yield no really tangible results (almost totally regardless of the person-in-question's experience).

It should be noted that successful preparation of the EU project proposal demands dedicated, experienced person(s), and, around 12 months of work.

Poor presentation (language, format of the text...)

Knowledge of the language, i.e. used terminology is of great importance. One should bear in mind that most of the proposers and vast majority of evaluators come from surrounding where language of the proposal is not native, or speaking language, hence knowledge on terminology makes a difference.

Many of the inexperienced proposers tend to try to ''pack'' as much text as possible, using single space and the smallest font possible, text being from one margin to the other. What is forgotten in that approach is the appearance of the text to the evaluator. It is not a good idea to inhibit evaluator form being able to follow what is written and to him/ her a headache. Better solution is to use bullets, italic, bold fonts, table overviews and pictures, in order to break the monotony of plain text.

3. Recommendations [1-5]

Most obvious recommendation is to avoid mentioned pitfalls, bearing in mind that listed ones are not the only ones, but, rather, most common and obvious one.

Of significant help is utilization of the ''fresh pair of eyes'', meaning that, at least, after completion of the work on project proposal preparation, that proposal should be given to someone, not involved in its creation, for reading, regardless of the experience. Whatever that person sees as an unclear bit, there is more than strong probability that evaluator will see the same, since, most probably, that bit presents some inconsistency. Naturally, care on accuracy and needed level of proof for statements /descriptions, should be taken.

The use of consulting services (during creation of the proposal, pre-evaluation, research, etc) is highly recommended, especially for inexperienced proposal creator(s).

4. Conclusion [1-5]

Besides recommendations on pitfall avoidance, ''fresh pair of eyes'' and experienced consultants services utilization, it can be concluded, by paraphrasing a saying, known in project advisors' circles, that one offering the solution to Brussels gets the funding.

5. References

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DESIGN OF CYLINDRICAL SHELL STEEL STRUCTURES WITH BILLBOARD TOWER AS THE CASE STUDY

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Abstract

According with EN1993-1-1 [1], in the definition of the classes of the elements, the tubular cross section elements are considered as class 3 for cross section that respects the relation: $d/t \leq 90\ \varepsilon^2$. For which cross sections this relation is not satisfied, the [1] norm is not valid and the cross section is classified as a curved thin walled element – shell element. Thus the designing will be done according with EN 1993-1-6 [2] normative.
The paper presents some aspects regarding the shell design with a case study – a 30m tall billboard pillar. The designing process is detailed regarding the used analysis and the ultimate limit states checking.

Keywords: Shell steel elements, steel structures, cylindrical shell structures

1. Introduction

For designing of shell steel structures can be used simplified or complex analysis methods. The simplified methods are based on analytical formulae for determining the bifurcation critic load, plastic limit capacity, sensitivity to imperfections, elastic-plastic interaction and the combining mode of the efforts. A higher step is the finding of the bifurcation critical force of the plastic limit capacity using finite element software.

The most complete approach, and more complex, is based on the numerical evaluation (using FEM software) of the parameters that are involved in dimensioning of the element: determining the critical bifurcation load following a stability analysis and determining of the plastic capacity of the element following a non-linear analysis. Thus, according with [2], for designing thin shell structures, are four limit states (LS): LS1 – plastic limit, LS2 – cyclic plasticity, LS3 – Stability and LS4 – fatigue. The present paper is considering the design procedures and a case study for LS1 and LS3 limit states.

The EN normative is presenting the following designing possibilities for shell structures: using and comparing the stresses with the von Mises equivalent stress in the most strained point; through direct designing using the normative analytical relations; using a global numerical analysis through a FEM software.

Thus the design should be based on one or more types of analysis: membrane theory of shells (membrane equilibrium), linear elastic shell analysis (LA) (linear bending and stretching), linear elastic bifurcation analysis (LBA) (linear bending and stretching), geometrically non-linear elastic analysis (GNA) (non-linear), materially non-linear analysis (MNA) (linear), geometrically and materially non-linear analysis (GMNA) (non-linear), geometrically non-linear elastic analysis with imperfections (GNIA) (non-linear), geometrically and materially non-linear analysis with imperfections (GMNIA) (non-linear).

2. Global numerical simplified analysis

The design buckling resistance is determined from the amplification factor r_{Rd} applied to the design values F_{Ed} of the combination of actions for the relevant load case. Thus $F_{Rd} = r_{Rd} \cdot F_{Ed}$. F_{Rd} is obtained from the plastic reference resistance $F_{Rpl} = r_{Rpl} \cdot F_{Ed}$ and the elastic critical buckling resistance $F_{cr} = r_{Rcr} \cdot F_{Ed}$, combining these to find the characteristic buckling resistance $F_{Rk} = r_{Rck} \cdot F_{Ed}$,.

The plastic reference resistance ratio r_{Rpl} (figure 1) should be obtained by materially nonlinear analysis (MNA) as the plastic limit load under the applied combination of actions. This load ratio r_{Rpl} may be taken as the largest value attained in the analysis, ignoring the effect of strain hardening.

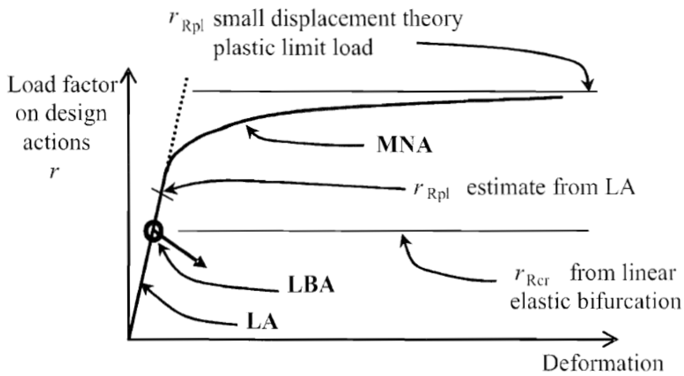


Figure 1. Definition of plastic reference resistance ratio r_{Rpl} and critical buckling resistance ratio r_{Rcr} derived from global MNA and LBA analyses

Where it is not possible to undertake a materially non-linear analysis (MNA), the plastic reference resistance ratio r_{Rpl} may be conservatively estimated from linear shell analysis (LA) conducted using the design values of the applied combination of actions. Thus the evaluated membrane stress resultants $n_{x,Ed}$, $n_{\theta,Ed}$ and $n_{x\theta,Ed}$ (figure 2) at any point in the shell should be used to estimate the plastic reference resistance:

$$r_{Rpl} = \frac{t \cdot f_{yk}}{\sqrt{n_{x,Ed}^2 - n_{x,Ed} \cdot n_{\theta,Ed} + n_{\theta,Ed}^2 + n_{x\theta,Ed}^2}} \tag{1}$$

The lowest value of plastic resistance ratio so calculated will be taken as the estimate of the plastic reference resistance ratio r_{Rpl}. The relation will be verified in the three points in which the stresses reach highest values.

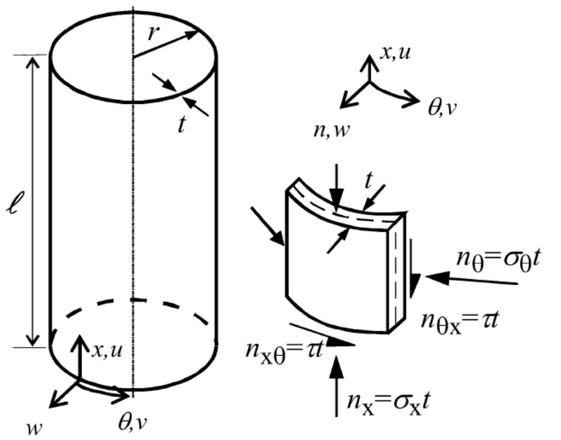


Figure 2. Geometry of the cylinder, membrane stresses and stress resultant

The elastic critical buckling resistance ratio r_{Rcr} should be determined from an eigenvalue analysis (LBA) applied to the linear elastic calculated stress state in the geometrically perfect shell (LA) under the design values of the load combination. The lowest eigenvalue (bifurcation load factor) should be taken as the elastic critical buckling resistance ratio r_{Rcr} (figure 1).

3. Complete numerical global analysis

The imperfect elastic-plastic buckling resistance ratio $r_{R,GMNIA}$ should be found as the lowest load factor r_R obtained from the three following criteria CI , C2 and C3 (figure 3)

Criterion C1: The maximum load factor on the load-deformation-curve (limit load);

Criterion C2: The bifurcation load factor, where this occurs during the loading path before reaching the limit point of the load-deformation-curve;

Criterion C3: The largest tolerable deformation, where this occurs during the loading path before reaching a bifurcation load or a limit load.

A conservative assessment of the imperfect elastic-plastic buckling resistance ratio $r_{R,GMNIA}$ may be obtained using a GNIA analysis of the geometrically imperfect shell under the applied combination of actions. In this case, the following criterion should be used to determine the lowest load factor r_R.

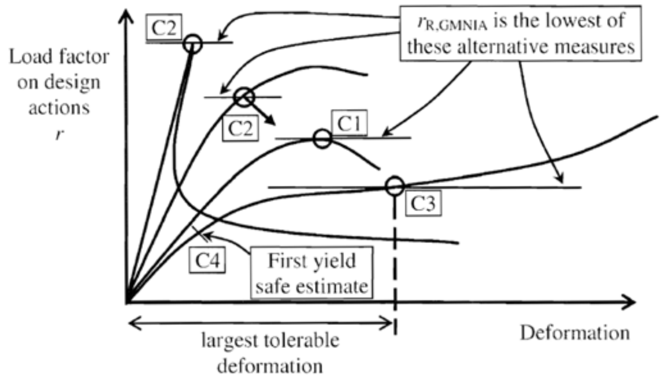


Figure 3. Definition of buckling resistance from global GMNIA analysis

Criterion C4: The load factor at which the equivalent stress at the most highly stressed point on the shell surface reaches the design value of the yield stress $f_{yd} = f_{yk}/\gamma_{M0}$ (figure 3)

In formulating the GMNIA (or GNIA) analysis, appropriate allowances should be incorporated to cover the effects of imperfections that cannot be avoided in practice, including: a) geometric imperfections, such as: deviations from the nominal geometric shape (pre-deformations, out-of roundness); irregularities at and near welds (minor eccentricities, shrinkage depressions, rolling curvature errors); deviations from nominal thickness; lack of evenness of supports. b) material imperfections, such as: residual stresses caused by rolling, pressing, welding, straightening.

The imperfections should generally be introduced by means of equivalent geometric imperfections in the form of initial shape deviations perpendicular to the middle surface of the perfect shell, unless a better technique is used. The middle surface of the geometrically imperfect shell will be obtained by superposition of the equivalent geometric imperfections on the perfect shell geometry.

The correctness of the imperfect elastic-plastic buckling resistance ratio $r_{R,GMNIA}$, numerically determined, must be validated throughout numerical analysis considering the same procedures and parameters and comparing the numerical models and experimental results.

4. Ultimate limit state design – analytic design

Following the loads and element types, Eurocode ([2]) requests taken into account four types of limit states: plastic limit state (LS1), cyclic plasticity limit state (LS2), buckling limit state (LS3) and fatigue limit state (LS4).

For LS1 limit state, the designing is done by determining the stress design values. Although stress design is based on an elastic analysis and therefore cannot accurately predict the plastic limit state, it may be used, on the basis of the lower bound theorem, to provide a conservative assessment of the plastic collapse resistance which is used to represent the plastic limit state.

In this case is used the Ilyushin yield criterion – a rather conservative criterion, mainly because it only considers yield at a single point – not an incremental mechanism. Thus at each point in the structure the design value of the stress $\sigma_{eq,Ed}$ should be taken as the highest primary stress determined in a structural analysis that considers the laws of equilibrium between imposed design load and internal forces and moments.

Using a membrane theory analysis, the resulting two-dimensional field of stress resultants $n_{x,Ed}$, $n_{\theta,Ed}$ and $n_{x\theta,Ed}$ may be represented by the equivalent design stress $\sigma_{eq,Ed}$ obtained from:

$$\sigma_{eq,Ed} = \frac{1}{t}\sqrt{n_{x,Ed}^2 + n_{\theta,Ed}^2 - n_{x,Ed}\cdot n_{\theta,Ed} + 3n_{x\theta,Ed}^2} \qquad (2)$$

where an LA or GNA analysis is used, the resulting two dimensional field of primary stresses may be represented by the von Mises equivalent design stress:

$$\sigma_{eq,Ed} = \sqrt{\sigma_{x,Ed}{}^2 + \sigma_{\theta,Ed}{}^2 - \sigma_{x,Ed}\cdot\sigma_{\theta,Ed} + 3\cdot\left(\tau_{x,\theta,Ed}{}^2 + \tau_{x,n,Ed}{}^2 + \tau_{\theta,n,Ed}{}^2\right)} \qquad (3)$$

in which:

$$\sigma_{x,Ed} = -\frac{N_{Ed}}{2\cdot\pi\cdot r\cdot t} + \frac{M_{y,Ed}}{\pi\cdot r^2\cdot t} \pm \frac{M_{z,Ed}}{\pi\cdot r^2\cdot t}$$

$$\sigma_{\theta,Ed} = \left(q_{eq} + q_s\right)\cdot\left(\frac{r}{t}\right)$$

$$\tau_{x,\theta,Ed} = \frac{M_{t,Ed}}{2\cdot\pi\cdot r^2\cdot t} \pm \frac{V_{z,Ed}}{\pi\cdot r\cdot t}$$

and $\tau_{x,n,Ed} = \frac{q_{xn,Ed}}{t}$ $\tau_{\theta,n,Ed} = \frac{q_{\theta n,Ed}}{t}$ (due to the low value, these stresses can be ignored).

The q_{eq} is the equivalent distribution of the wind load onto the cylinder surface (figure 4).

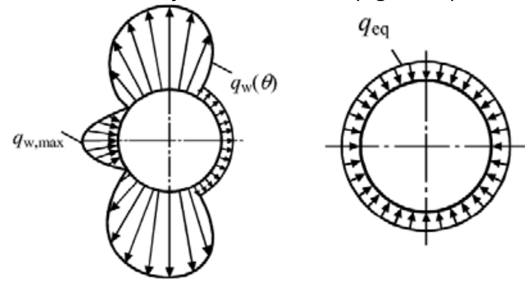


Figure 4. Transformation of the wind pressure distribution - (a) Wind pressure distributed around the shell circumference; (b) equivalent axial symmetric pressure distribution

The stresses will be limited to: $\sigma_{eq,Rd} \le f_{eq,Rd}$,

where $f_{eq,Rd} = \frac{f_{yk}}{\gamma_{M0}}$.

For LS3 limit state, the buckling resistance is represented by the design buckling stresses, which are obtained from the relations: $\sigma_{x,Rd} = \sigma_{x,Rk}/\gamma_{M1}$, $\sigma_{\theta,Rd} = \sigma_{\theta,Rk}/\gamma_{M1}$, $\tau_{x\theta,Rd} = \tau_{x\theta,Rk}/\gamma_{M1}$

The characteristic buckling stresses should be obtained by multiplying the characteristic yield strength by the buckling reduction factors χ:

$\sigma_{x,Rk} = \chi_x f_{yk}$, $\sigma_{\theta,Rk} = \chi_\theta f_{yk}$; $\tau_{x\theta,Rk} = \chi_\tau f_{yk}/\sqrt{3}$

The stresses will be limited to the design stresses.

5. Case study – 30 meters tall billboard tower

The case study presents the global analysis and the simplified designing of a 30 meters height tower elements – only the pillar. The tower is located in the north part of Netherlands.

The structure has two components: the column which is a 1680 mm S355 steel quality tube and the head of the tower where the billboard is fixed. The head is made of a truss system in order to undertake the dead and wind loads and to transmit them directly to the pillar (figure 5).

Due to the triangular shape of the billboard area structure, and the size of the billboard (21m length), the wind loads evaluation must be in depth evaluated. It was used the EN 1991-1-4 norm [3], considering the National Annexes for Netherland.

The pillar is made of four sections – from the base to the top: Tube 1680 x 20mm – 7m, Tube 1680 x16mm – 8,00m, Tube 1680 x 12 – 7,00m and Tube 1680 x 10 – 8,00m. The sections are joint by bolted endplate connections.

For the model was considered self weight, dead load, live load (for maintenance), wind load and a geometric imperfection. The imperfection was taken into account as presented in EN1993-3-2 [4] – Chimneys

$$\Delta = \frac{h}{500}\sqrt{1+\frac{50}{h}} = \frac{30{,}00}{500}\sqrt{1+\frac{50}{30{,}00}} = 0{,}0979m \qquad (4)$$

The wind load was evaluated as concentrated forces and as radial pressure onto the column surface and onto the billboard.

In table 1, the forces on the tower from the wind action are presented. Following a dynamic analysis of the structure, results a frequency of η_{1x} = 0,69 Hz, thus the calculated coefficient $c_s c_d$ = 0,984.

The wind on the billboard area was considered according with [3] Ch. 7.4.3 :

$$F_w = c_s \cdot c_d \cdot c_f \cdot q_p(ze)\cdot A_{ref} \qquad (5)$$

and resulting F_w = 146,664 kN.

According with [3] Ch.7.9.1 the pressure onto the cylinder (tower) was determined. The pressure coefficients are depending on the Reynolds number Re, defined by

$$\mathrm{Re} = \frac{b\cdot v(z_e)}{\nu} \qquad (6)$$

with ν = 15 □ 10^{-6} m^2/s (cinematic viscosity of the air) and b = 1,68 m (diameter of the pillar).

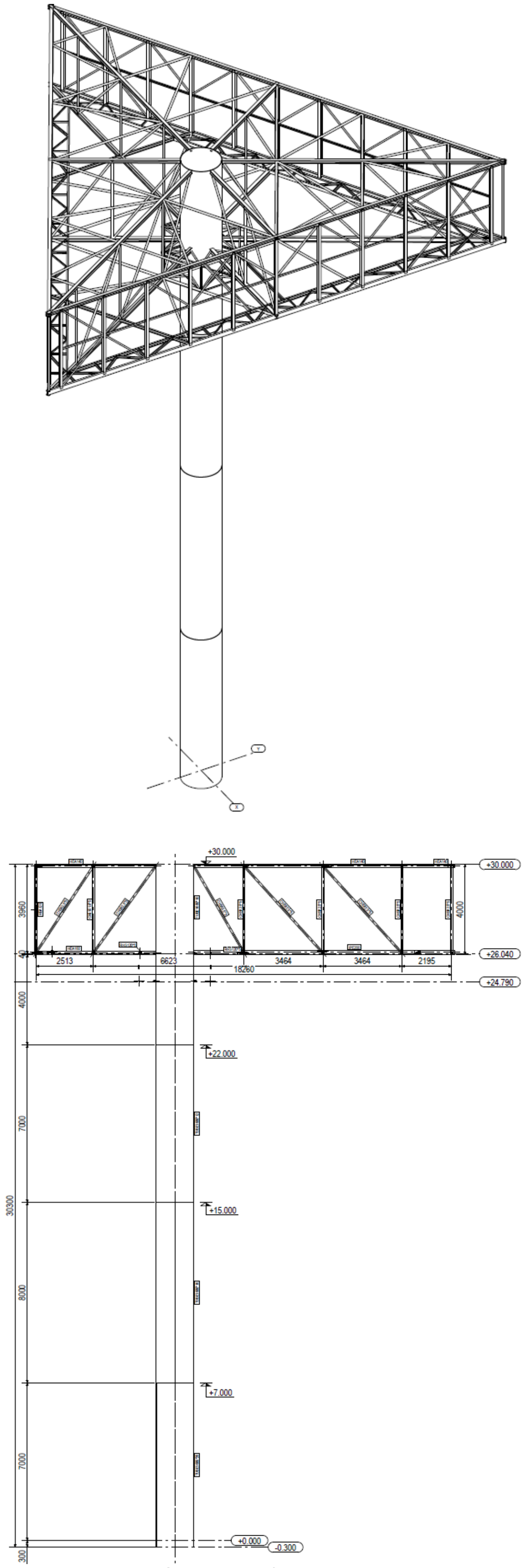


Figure 5. Geometry of the billboard tower

Table 1. Wind load forces at different heights

h [m]	$q_p(z)$ [kN/m^2]
2.00	0.352
3.00	0.432
4.00	0.492
5.00	0.541
6.00	0.582
7.00	0.617
8.00	0.648
9.00	0.676
10.00	0.702
11.00	0.725
12.00	0.747
13.00	0.767
14.00	0.786
15.00	0.804
16.00	0.820
17.00	0.836
18.00	0.851
19.00	0.865
20.00	0.879
21.00	0.892
22.00	0.904
23.00	0.916
24.00	0.928
25.00	0.939
26.00	0.950
27.00	0.960
28.00	0.970

$$v(z_e)=\sqrt{\frac{2\cdot q_p(z_e)}{\rho}}-39{,}403\,\mathrm{m/s} \tag{7}$$

Through interpolation (figure 6), the pressure coefficients for different positions - α values (table 2).

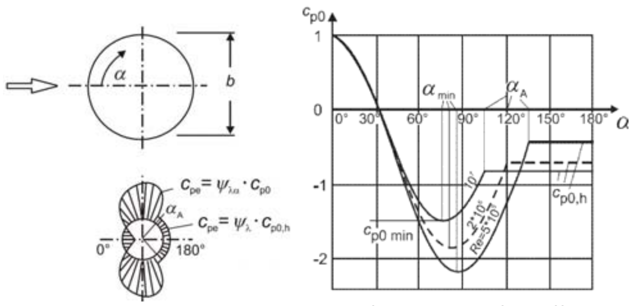


Figure 6. Pressure distribution for cilinders for diffrrent Reynolds number values.

Table 2. Wind pressure coefficients

α	c_{p0}	$\psi_{\lambda\alpha}$	c_{pe}	w_e
0°	1	1,00	1	0,95
30°	0,1	1,00	0,1	0,095
60°	-1,25	1,00	-1,25	-1,187
90°	-1,65	0,968	-1,597	-1,517
120°	-0,75	0,720	-0,540	-0,513

In order to assess the concentrated wind load, it was done the calculation of the force coefficients $c_f = c_{f,0}\cdot\psi_\lambda$ = 0,562. The concentrated wind load is $F_w = c_s\cdot c_d\cdot c_f\cdot q_p(z_e)\cdot A_{ref}$. In table 3 is presented the wind load forces onto the tower.

Table 3. Wind load forces on the tower

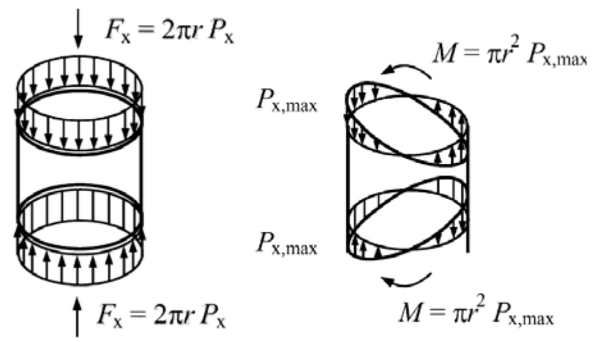
z_e	l	A_{ref}	$q_p(z_e)$	F_w	F_w/l
2.00	2.00	3.36	0.352	0.665	0.333
5.00	3.00	5.04	0.541	1.532	0.511
9.00	4.00	6.72	0.676	2.555	0.639
13.00	4.00	6.72	0.767	2.897	0.724
17.00	4.00	6.72	0.836	3.157	0.789
21.00	4.00	6.72	0.892	3.368	0.842
24.00	3.00	5.04	0.928	2.628	0.876
26.00	2.00	3.36	0.950	1.794	0.897

Following the structure analysis it result the following internal forces presented in table 4.

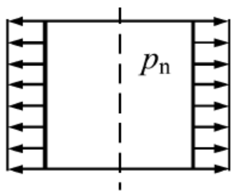
Table 4. Internal forces on each section of the tower

Height (from-to) (m)	Cross section (D x t) (mm)	N_{ed} (kN)	$V_{y,Ed}$ (kN)	$V_{z,Ed}$ (kN)	$M_{t,Ed}$ (kNm)	$M_{y,Ed}$ (kNm)	$M_{z,Ed}$ (kNm)
22-30	1680x10	372	130	224	1120	1430	673
15-22	1680x12	418	136	235	1110	3052	1611
7 - 15	1680x16	488	142	247	1111	4997	2731
0 - 15	1680x20	566	147	255	1111	6772	3749

Determining the critical stresses, the meridian and circumferential stress, is done using annex D ([1]) – buckling design of the unstiffened shell element. The design of the stresses which appear in the walls of the tube pillar is done using annex A2 ([1]) using shell theory (figure 7). In case of circumferential stress following the wind load, is considered an equivalent pressure (q_{eq}) which is uniformly onto the surface of the cylinder – k_w = 0,165 ([1] D.1.3.2 chapter).



a) Axial uniform load; b) Axial load from global bending;



$$\sigma_\theta = p_n \cdot \frac{r}{t}$$

c) internal pressure

Figure 7. Membrane theory stresses in unstiffened cylindrical shells

The designing results are presented in table 5 for each limit state design – LS1 and LS3.

Table 5. Design results – ratio of the elements

Height (from - to) (m)	Cross section (Dxt) mm	$\sigma_{x,Ed}$ (MPa)	$\sigma_{\theta,Ed}$ (MPa)	$\tau_{x\theta,Ed}$ (MPa)
22 - 30	1680x10	103,18	0,0552	33,909
15 - 22	1680x12	184,51	0,043	28,67
7 - 15	1680x16	227,98	0,032	21,88
0 - 15	1680x20	248,51	0,026	17,74

Height (from - to) (m)	Cross section (Dxt) mm	LS1	
		$\sigma_{eq,Ed}$ (MPa)	RATIO $\sigma_{eq,Rd} / \sigma_{eq,Ed}$
22 - 30	1680x10	118,7	0,334
15 - 22	1680x12	191,06	0,538
7 - 15	1680x16	231,09	0,651
0 - 15	1680x20	250,39	0,705

Height (from - to) (m)	Cross section (Dxt) mm	LS3			
		$\sigma_{x,Rd}$ (MPa)	$\sigma_{\theta,Rd}$ (MPa)	$\tau x_{\theta,Rd}$ (MPa)	RATIO
22 - 30	1680x10	207,96	3,78	47,31	0,848
15 - 22	1680x12	226,44	5,45	59,48	0,96
7 - 15	1680x16	250,43	9,72	85,96	0,921
0 - 15	1680x20	265,54	15,25	107,26	0,936

It can be noticed that the circumferencial design buckling stress has low values ($\sigma_{\theta,Rd}$) in comparison with other design stresses, the dimensioning stress being the meridional design buckling stress ($\sigma_{x,Rd}$).

6. Conclusions

The present paper describes the analysis procedures of cylindrical shell elements and designing procedures underlining the analytic design possibility.

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MICROMECHANICAL STUDY OF DUCTILE FRACTURE INITIATION AND PROPAGATION ON WELDED TENSILE SPECIMEN WITH A SURFACE PRE-CRACK IN (HAZ)

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Abstract

In this paper, crack initiation and propagation was predicted in weldment using micromechanical approach and material properties determined by experimental and numerical procedure. Welded tensile specimen with a surface pre-crack in heat-affected zone (HAZ) was experimentally and numerically analyzed. High-strength low-alloyed steel was used as base metal, in quenched and tempered condition. Crack initiation values and J-R curves were obtained for specimen. The complete Gurson model (CGM) was used in prediction of J-R curve and crack initiation. The results show that the resistance to crack initiation and growth can be predicted using micromechanical analysis and material properties determined by experimental and numerical procedure.

Keywords: Ductile fracture, micromechanical approach, crack initiation.

1. Introduction

Crack initiation and stable growth in ductile materials are conventionally characterized by *J-R* curves obtained from standard fracture mechanics tests. However, testing of the same types of welded specimens (notched in different positions) and loading conditions revealed considerable differences in the *J-R* curves, due to the constraint caused by microstructural and mechanical heterogeneity [1-3]. Therefore, transferring fracture parameters from specimens to components is questionable. Constraint effect is very important in homogeneous structures, where the fracture resistance is dependent on geometry of the structure and the crack [4, 5]. Moreover, recently produced high strength steel typically exhibit large-scale deformation and plastic straining during tearing. This helps to prevent rapid unstable fracture. However, such fracture behavior cannot be accurately predicted using existing correlations that are characterized by J-integral. In the presence of large-scale yielding, the traditional J-integral approach to elastic-plastic fracture mechanics is known to become inaccurate or even inapplicable for engineering purposes as it cannot adequately characterize the crack tip stress field [6].

Therefore, more accurate characterizations of defects in welded high strength steels are of particular interest to provide more accurate failure assessments.

Using local damage approach to model crack initiation and propagation in ductile materials seems to be the solution for transferability problem in fracture mechanics. This approach can simulate the physical processes of void nucleation, growth and coalescence of investigated material using continuum mechanics.

The complete Gurson model [7] has been shown to give accurate predictions for different levels of stress triaxiality, for both strain non-hardening and strain hardening materials, and is therefore selected to assess the fracture behavior of welded joints in this work. Welded tensile specimens have been modeled; crack in the HAZ was considered. The aim of this work was to predict ductile crack initiation and propagation of high strength steel weldments using micromechanical model. Experimental work and three-dimensional finite damage model for welded tensile specimens with a pre-crack in HAZ was performed. Crack initiation value and *J-R* curve for tensile specimen with pre-crack have been obtained experimentally and numerically.

2. The complete Gurson model (CGM)

Micromechanical models have been recently developed for modeling the behavior of ductile materials. Among these models, micromechanical model proposed by Gurson is considered, as most widely used one for ductile porous materials. The yield function of Gurson [8], modified by Tvergaard [9,10] and Tvergaard and Needlman [11,12], is used to describe the evolution of void growth and subsequent macroscopic softening. The modified yield function is defined by formula:

$$\varphi(q,\sigma_m,\bar{\sigma},f) = \left(\frac{q}{\bar{\sigma}}\right)^2 + 2q_1 f^* \cosh\left(\frac{3q_2\sigma_m}{2\bar{\sigma}}\right)^2 - \left(1 + (q_1 f^*)^2\right) = 0 \qquad (1)$$

where σ_m is the mean stress, $\bar{\sigma}$ is the flow stress of the matrix material, f^* is the modified void volume fraction, and q is the von Mises effective stress:

$$\sigma = \sqrt{(3s_{ij}s_{ij}/2)} \qquad (2)$$

where s_{ij} stand for the deviatoric components of Cauchy stress.The constants q_1 and q_2 are fitting parameters introduced by Tvergaard [9], to improve the ductile fracture prediction of Gurson model.

The modified void volume fraction, f^*, is the damage function [11]. More details about CGM model are given in [13].

3. Materials and experimental procedure

The material studied in this investigation was high strength low alloyed steel, NIOMOL 490K, which is used as the base metal. Shielded metal arc welding process (SMAW) was used with consumable VAC 60Ni to weld a plate (300 x 300 x 16 mm). A mixture of shielding gases; 3.8% CO2+93.7% Ar+2.5% O2, was used in order to get acicular ferrite, which raises toughness of welded joint. The estimated mechanical properties are given in Table 1 for base metal (BM), coarse heat-affected zone (CGHAZ), fine heat-affected zone (FGHAZ) and weld metal (WM). The Poisson's ratio is assumed ν = 0.3. More details are given in [13].

Table 1. Mechanical properties of used materials.

Material	Young modulus, E [GPa]	Yield strength, σ_Y [MPa]
BM	202.9	520
CGHAZ	203	550
FGHAZ	195	500
WM	200	530

Quantitative microstructural analysis was performed to estimate the micromechanical parameters: volume fraction (f_v) and mean free paths (λ) between the non-metallic inclusions for the zones of the welded joint, according to [14] (Table 2). In the initial stage of ductile fracture of steel, the voids nucleate mostly around non-metallic inclusions. Hence, the initial porosity f_0 is here assumed to be equal to the volume fraction of non-metallic inclusions (f_v).

Table 2. Microstructural parameters of materials

Material	f_v	f_N	λ [μm]
BM (NIOMOL490K)	0.0094	0.014748	578
HAZ	0.0086	0.014748	497
WM	0.0194	0.010685	202

4. Finite element models

For the determination of the value of stress and strain components and the value of damage parameter (f) in the specimens exposed to external mechanical loading, the FEM program Abaqus (www.simulia.com) was used, with CGM user subroutine, UMAT, developed by Zhang based on [7]. To simplify the finite element analysis, materials of all regions of welded joint were assumed to be isotropic. The mesh size, l_c, was chosen to approximate the mean free path between non-metallic inclusions. A fixed mesh size l_c = 0.5 mm of elements was chosen on vertical planes on the crack front of the tensile specimen with semi-elliptical surface crack in HAZ, but along the crack front is about 5 l_c because the variation of stress/strain in this direction is not significant (Figure 1).

In order to apply CGM model to simulate ductile tearing in tensile specimen with pre-crack in HAZ, various model parameters must be determined.

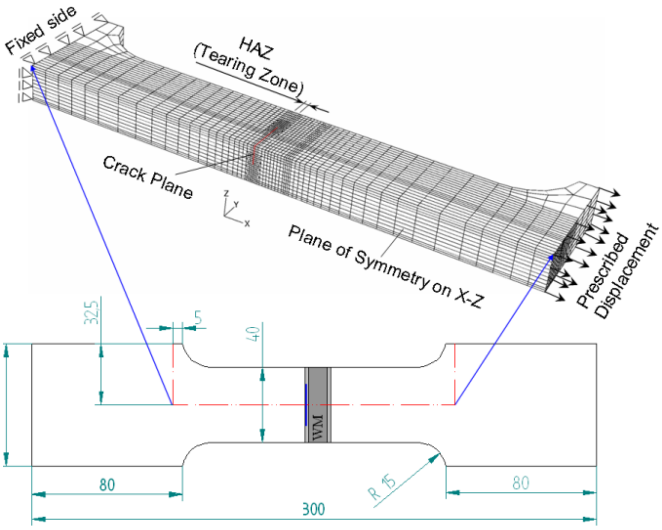
The first set of constitutive parameters is q_1 and q_2, which related to the hardening of the matrix material. In this study, q_1 and q_2 were determined to be 1.2 and 1.0, respectively, for tensile specimen with a pre-crack in HAZ. The values of q_1 and q_2 were considered according to the study in [15]. The second set of parameters is void initiation and coalescence parameters (f_0, f_c and f_F). Like mentioned previously, the initial void volume fractions (f_0) are assumed to be equal to the volume fraction of non-metallic inclusions (f_v), which is given in Table 2 for BM, HAZ and WM materials. The critical void volume fraction (f_c) is crucial damage parameter in CGM, since it represents the end of stable void growth and the start of void coalescence. It is not a material constant according to CGM, but it is automatically determined during the processing, based on the stress and strain fields. Void volume fraction at final fracture (f_F) is determined according to the relation $f_F = 0.15 + f_c$, [7], used in the complete Gurson model in the present study. The third set of parameters (ε_N, S_N, and f_N) is related to void nucleation. The volume fraction of void nucleating particles (f_N) has been evaluated from Fe_3C content in materials. The nucleation parameters, ε_N = 0.3 and S_N = 0.1 determined by Chu and Needleman [16,17,18], were considered for analysis model.

5. Numerical modeling of crack initiation

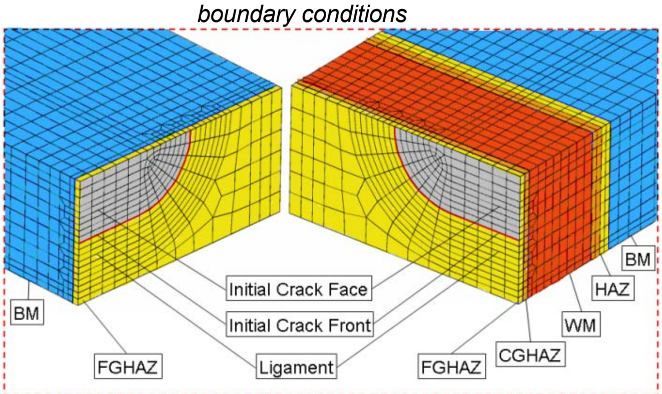
Crack initiation can be predicted by using the CGM model according to failure criterion. Failure is defined by the instant when the first element in front of the crack tip becomes damaged. The condition for the onset of the crack growth (as determined by the J-integral, J_i, or crack tip opening displacement, $CTOD_i$) is most adequately defined by the micromechanical criterion [19]:

$$f \geq fc \qquad (3)$$

When the condition given by Equation (3) is satisfied, the onset of the crack growth occurs. The critical void volume fraction (f_c) in CGM model is determined at the end of every increment step. To determine numerically crack initiation, the increase of void volume fraction (f) should be monitored at the nearest Gauss point to the crack tip. When current monitored f reaches f_c and Eq. (3) is satisfied, the fracture mechanics parameter at crack initiation (J_i or $CTOD_i$) is determined.



(*a*) *3D finite element mesh for half of specimen with boundary conditions*



(*b*) *Detailed mesh for the region near the crack front*
Figure 1. Three-dimensional finite element model for tensile panel with surface crack in the HAZ.

Ductile crack growth initiation described here by J-integral at initiation (J_i) is modeled for tensile panel with surface crack in HAZ based on critical void volume fraction criterion (f_c) which represents the end of stable void growth and the start of void coalescence in the material. The value of J_i has been estimated numerically at the middle of the specimen thickness in front of crack line, where the highest value of void volume fraction occurs. The value of J_i for tensile panel with surface crack in HAZ (TP-HAZ) is given in Table 3 in comparison with values of J_i for SENB specimen with pre-crack in HAZ (SENB-WM) (See [13]). The J_i of TP-HAZ was experimentally determined using stretch zone width, SZW according to [20].

Table 3. Numerical values of J_i for tensile and SENB specimens with pre-crack in HAZ.

Specimen designation	$J_{0.2/BL}$ [N/mm]	J_i [N/mm]	
		Using SZW	CGM
SENB-HAZ	84	-	57
TP-HAZ	-	309	346

6. Numerical modeling of ductile crack propagation

Crack growth in ductile materials is conventionally characterized by fracture resistance curves, obtained from the standard fracture tests. However, these standard fracture tests introduce a high degree of conservatism in engineering critical assessment of real structures such as pressure vessels. Therefore, using specimens such as cracked tensile panels may present better integrity assessment.

The J-R curve for HAZ has been numerically obtained using tensile panel with surface crack in HAZ. It has been simulated by tracing the path of completely damaged elements, which appear completely in different colors in this work (Figure 2).

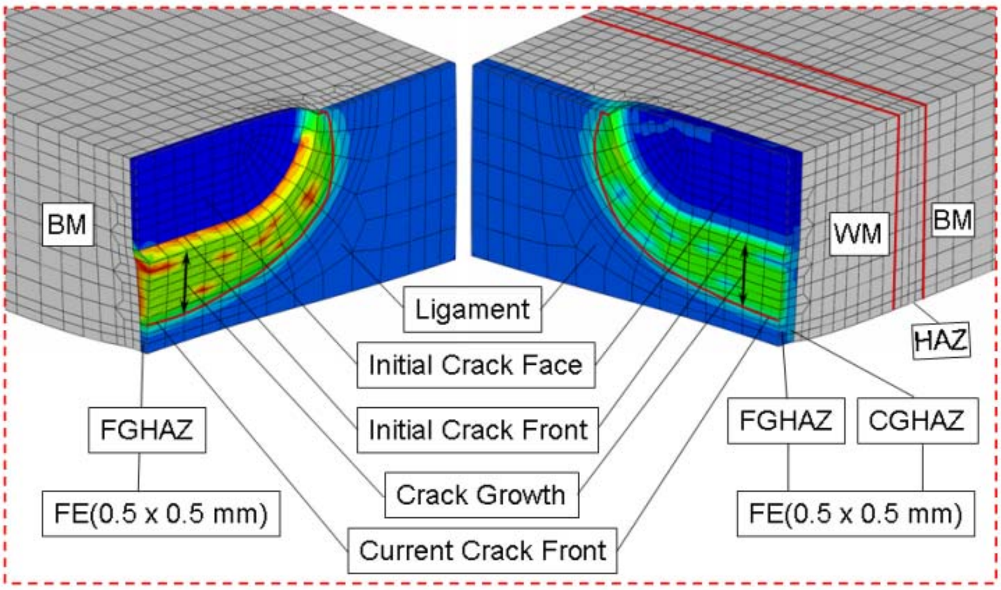


Figure 2. Distribution of void volume fraction, indicating crack growth for tensile panel with surface crack in HAZ.

The element is assumed to be failed (completely lost its load carrying capacity) when the void volume fraction at final failure (f_F) is reached according to the relation $f_F = 0.15 + f_0$. Then, the corresponding value of *J*-integral is numerically obtained. The crack growth resistance curve is presented in Figure 3 for tensile panel with pre-crack in HAZ at the deepest point of crack front for tensile panel where the largest crack growth occurs. The result has been compared with *J-R* curve for SENB specimen with pre-crack in HAZ which was obtained previously in [13] based on ASTM E1820-08. Obviously *J-R* curve obtained using SENB specimen is more conservative than one obtained using tensile panel.

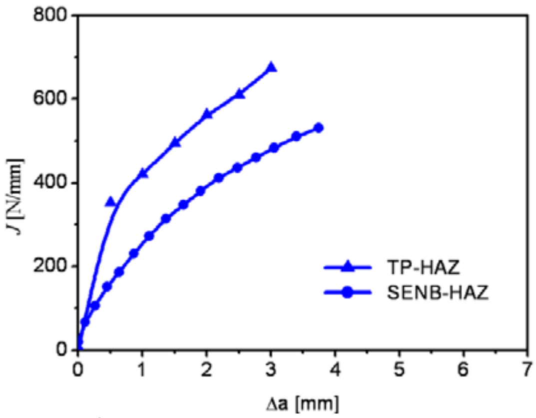


Figure 3. Comparison between experimental J-R curve of SENB specimen and numerical J-R curve of tensile panel with crack in HAZ.

7. Conclusion

The micromechanical CGM was applied to estimate damage level (void volume fraction, f) in welded tensile specimen with a pre-crack in HAZ. True stress-true strain curves of welded joint zones were determined by a combined experimental-numerical procedure, using stereometric strain measurement and finite element modeling.

The crack initiation value was successfully predicted using CGM and true stress-true strain curves which were estimated by the experimental-numerical procedure. The results show that the constraint effect due to the geometry can be predicted as well.

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ROLE OF HYDROELECTRIC POWER PLANT IN DEVELOPMENT OF UZICE AND BAJINA BASTA SETTLEMENTS

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Abstract

This paper demonstrates the link between the construction of hydroelectric power plant and the development of settlements in the surrounding area. The influence of electrification and industri–alization in urban restructuring is viewed through different social conditions in the socio - political system, which determines the nature and engage–ment of investments, and the degree of techno–logical development, which conditions the possi–bility of electric energy use. In this way, the distinctiveness in the economic, spatial and social development of settlements was observed relative to the stimulus of hydroelectric plant in different socio- economic and technical and technological conditions and it may serve as the foundation for defining the set of guidelines in the planning of restructuring and developing settlements.

Keywords: Electrification, industrialization, hydro–electric power plant, settlement

1. Introduction

The development of manufacturing technology and transmission of electric energy and the expansion of possibilities of its use made a huge impact in all areas of social life and action, primarily as an incentive for industrialization as the basis for economic growth, closely related to the creation of new urban structure and functions and changes in the quality and way of life. The process of electrification denotes the construction of power plant facility, which, as a system of specific function, influences the transformation of its close surroundings. The subject of this paper is the research of the impact hydroelectric power plants had on the growth of local environment within the framework of hydroelectric plant case studies “Pod Gradom” (Uzice, 1900.) and “BajinaBasta” (Bajina Basta, 1966.). The research entails multidisciplina-ry approach through plans of relations of social processes in different social conditions. The impact of electrification and mechanisms used to accom-plish it are examined through the relation between planned and achieved changes in the settlements, regarding the economic, spatial and social aspect. The main objective of this paper is to establish a connection between the development of settle-ments and the construction of hydroelectric power plant through the role of electrification and industrialization in the processes of urban restruc-turing, discerning the general and specific occur-rences in the process of settlement development. Main material of the research is the technical documentation of hydroelectric plants (plant’s draft projects, studies of accumulation influence on the coastal area, plans for regulating the settlements affected by the construction), general documen-tation (workers’ council meeting transcripts), tech-nical documentation of investments put into the development of local environment (regional and local spatial plans, architectural projects of individual objects), sources for the settlement development (primary sources: plans and statistics, secondary: studies and monographs) and historic and sociological studies of observed periods in Serbia.

Electrification beginnings in Serbia

The initial period of electrification in Serbia took place within the framework of personal initiative, directed toward stimulating the economy as the basis of settlement development. At the end of the 19th century Serbian economy was backward and predominately agriculturally-oriented with almost the whole population working in agriculture, /1/. Engaging in supra-regional markets and diffusion of monetary economy changed the existing ways of entrepreneurial and social life by the beginning of the 20th century, but the contours of modern industrial society could have been only vaguely recognized. Not until the electrification developed and the electric power was used as a driving force, could the industrial production reach new heights. At the beginning of the 20th century electric power became the main prerequisite for economic and social advancement, therefore the idea of electrification in Serbia was the attempt in direction of overcoming the arrested economic development by adopting modern technologies. The first power stations produced direct current which could not be transmitted over long distances; therefore its usage was limited mostly to poorly developed industry and had no significant role in households. The expansion of possible usage began by producing alternating current, and the first power plant of this type in Serbia was the hydroelectric plant “Pod Gradom” in the town of Uzice.

Uzice: a small town transformation into an industrial centre

Despite the district town status, at the end of the 19th century Uzice was the back of beyond. Land and town development was carried out by plan, but the urban equipment was very modest. The streets were either of beaten earth or gravel, only the occasional one covered in cobblestone. There existed no water supply system nor the wastewater disposal system, and the public lighting implied sixty lanterns placed in front of taverns and hospitals. According to the 1898 census, Uzice had approximately one thousand family homes, and even though they were built from solid material, they had very poor housing conditions. There were a few public institutions; a gymnasium, primary school, church and military barracks. The economy was underdeveloped and based on leather processing and fabric manufacturing in small craft shops. The elementary impediment to the industrial development was the poor railway interconnectedness to the rest of the country and the foreign market. The main source of income was the export of cattle to Austro- Hungary, which, overtime, started to grow and provided the means for the development of other industries. At the outset, the textile manufacturing was launched because it had already had a tradition in the area. In the year 1898, The Shareholding Weaver Workshop was founded which marked the beginning of industrial development in Uzice. Firstly, the construction of textile factory was planned, which had to contribute not only to the economical and social growth of the town, but also to the development of national economy, since it would reduce the import of foreign textile merchandise and thus enabling the domestic production to come to the fore.

During the construction planning, an idea arose of powering the facility with hydropower, which had already been done in the industrial production. Building a factory in such immediate vicinity to the river would, however, raise the cost of manufacturing and minimize the competitiveness of the final product price. That obstacle was overcome by the suggestion DjordjeStanojevic made, a man credited for the electrification of Belgrade, that the power used for putting the loom into motion should not be the mechanical energy of water turbines, but electric energy. Driving power obtained in this way would have been extremely cheap; the factory would have been built in the location best suited for the transport of goods and raw materials, while the rest of the electric energy would have been directed towards the electrification of the town. In 1899, the management of The Weaver Workshop made a decision to build a hydroelectric power plant on the river Djetinja, with the intention of increasing the capital investment for the textile factory construction with the profit from electric energy sales.

The financial support for the construction of hydroelectric plant and the power supply network was largely gathered from the private or local sources rather than governmental. Citizens would invest into the plant by shareholding and in return they would gain profit. Hydroelectric plant was first put into regular operation in 1900. The plant was built in with two 50 hp turbines and three-phase electric power generators, and only four years later, the plant had three generators, 130 hp turbines and a dynamo of 90 kW and 28,3 A, /2/.

After only three or four months the produced electricity was sold out. Two distributing networks were established: street lighting with 120 light bulbs of 16 candles and 9 flame lamps of 10 A and a private lighting. By keeping the low prices and installation free of charge, the management of Weaver Workshop wanted for electric power to become available even to the poorest working man and not only for the lighting, but also for every “domestic, economic or agricultural business…”. That way the electric energy “will enter into homes, factories and fields”, /3/. Although modest in light strength, the newly placed light sources were far better in comparison to the kindling wood, tallow candles and lanterns which were used up to then, and with much better hygienic conditions and considerably lower risk of fires. Electric light affected the daily routine and family life, since the part of household chores was left for the evening. In this way the use of electric energy surpassed the framework of manufacturing facilities and became a part of daily activities changing the quality and the way of life in the households. The number of light bulbs in private houses, however, grew very slowly, which indicated low economic viability and adherence to the tradition of frugality.

Although the electrification influenced the traditional way of life of the local population rather unassumingly, it had largely contributed to the expansion of local economy and the development of Uzice from a small town into an industrial centre. During the following few years industrial activity expanded and included a sawmill, still room, brick and tile factory, electric mill and chalk mine. Since the weavers’ workshop production capacities had expanded, new facilities were built in the vicinity of the factory and the electric switchboard and network were upgraded, thus in the year 1904, it counted 1554 light bulbs and two 8A “Bogen” lamps for private and public use, /4/. Jobs for dozens of trained weavers from “The Weaver School” were provided and the manufacturing of textile raw materials was started, which contributed to the income increase in rural households. During this period the development of settlements was carried out by private investments which were directed primarily into the economy development, consequently the urban structure and function development was neglected. Except for the construction of business facilities, nothing major changed in town renovation.

Socialist modernization

The period of socialist modernization in Yugoslavia after the World War II relied upon the electrification as the basis for industrialization, which was viewed not only as the method for structural change of economy, but also as a strategic preference of a complex process of overall socio- economic transformation, seeking support in accelerated development and by its means the radical conversion of the inherited structure was accomplished. One of the objectives in economy plans was the establishing of electric power system based on the large-scale production facilities, which would replace the existing local production and create the conditions to satisfy the growing needs of increasing number of consumers, both in industry and households alike. The structural changes in economy coupled with intense industry development contributed to the rapid growth of Yugoslavia electric power. Production of the electric power from 1953 to 1980 had significantly increased, achieving the average annual growth rate of 11.7, while the consumption in households per capita increased from 16 kWh in 1951 to 729 kWh in 1981, /5/.

The process of rapid industrialization was followed by the transformation of backward urban surroundings and social changes. During the first period of post-war restoration the investments were primarily directed toward the industrial development (“forced growth”), hence there was not any particular strategy for urban development, but the growth of settlements followed the growth of industries. Changes in production, trade and commerce and overall way of life and the use of spare time contributed to the change in lifestyle, both in the city and countryside alike; in places where the people were employed by the industry changes were noticed in the style of construction, interior decorating and daily routines and habits. In the late sixties, a phase of “intense socialistic urbanization” commenced and the investments were redirected from the industry to the structural urban development, utility and traffic network and enhancement of housing conditions, which represented one of the fundamental aspects of city modernization.

Even in the late fifties the increase in personal consumption was noticed, especially in the purchasing of home appliances for the “modern household”, which greatly improved housing hygiene and nutrition. Owing to the radio and television broadcast, the outside world became a part of private life, along with the new media habits which brought a new way of organizing spare time. That marked the beginning of considerable increase in the consumption of electric power, since it was a characteristic of new, higher standard. Social practices, by the late sixties, indicated that Yugoslavia had become an industrial society. The process of socialist modernization accomplished the transformation of social relations in all spheres of life: the social and professional structures had changed, same as the geographic image of settlements and architecture.

BajinaBasta: settlement as a part of socialist modernization project

In post-war period, BajinaBasta municipality was considered as one of the highly undeveloped settlements. The economy barely existed, and the urban equipment, infrastructure coverage and electric power supply were under-represented. The attempt to resolve the backward status of that area was attributed to the construction of hydroelectric plant on Drina River. According to the development plans of Yugoslavia electric power industry that facility was planned as the first in the line of strong power plants which would enable further economic and social progress. The construction was financed by loans from The Investment Bank of Yugoslavia, Commercial bank and International Bank for Reconstruction and Development, and the plant was first put into operation in 1966. Average annual production of 1625 GWh made up for 10% of electric power production in Yugoslavia, which was equal to the overall annual production in 1939. Apart from the production volume, the availability of electric power also increased due to the average price reduction from 13.26 to 11.68 dinars per kWh, /6/.

In order to provide necessary conditions for the power plant construction, numerous works were initiated in the immediate surroundings, primarily in the area of infrastructure. Until the power plant commissioning, a new road and power supply network had been built, utility and water management network had been upgraded, as well as the postal services, which created conditions for economy development in the municipality. Regarding the remodeling of physical structure, urban design and environmental plan for the power plant area and Perucac settlement, planned to build, in 1959 and 1960, a housing colony with outbuildings i.e. a shop, canteen, bathroom and infirmary.

The works also continued for the needs of reversible hydropower plant, which had been set in operation in 1982. The existing roads were reconstructed and the road network was expanded to 40 km and connected the main facilities with the sources of supply. At that time, municipality of

BajinaBasta had the most developed and the highest quality road network in the region. The construction of traffic network was of multiple significance, for the settlement as a whole and for every individual resident. The conditions were created for commerce development, more efficient and faster health services as well as other activities which contributed to the improvement of social standards. Electrical and telecommunication networks were expanded and the remote rural areas were electrified. Water supply system in BajinaBasta was reconstructed and the regional water system was constructed in the mountain of Tara which was more than 50 km in length and its capacity represented a lasting solution for the economy, especially tourism, and for the people living in the area. The construction of water management facilities was carried out, as well as the regulation of watercourses, forestation and beautification of the beach and coastal area of the lake in Perucac , just next to the dam, giving extraordinary options for development of sports and recreation tourism. A hotel was also built with the capacity of 118 beds and an annex of 50 beds for professional and technical staff, which is still being used today. In the town of Perucac two temporary settlements were erected with the accommodation capacity of 2500 people for the workers at the construction site and their families, with the utility and service outbuildings, which are, in part, still used today. The professional staff, that was supposed to stay after the construction was finished, had their permanent settlement built in the town of BajinaBasta, which is today a central area of residence.

Since the beginning of the construction of hydroelectric plant in 1961, the territory of BajinaBasta had been significantly expanded. The change of investment type and socio-economic system in previous decades as well as the plant construction, which was considered as the part of public works, contributed to the demographic imbalance, which was, in the terms of town construction, amortized by the insufficient financial strength of possible investors. Conversely, already in the early seventies, due to the favorable economic situation in the country, began a period of extremely intense construction. During the following twenty years immeasurably more area of municipality was urbanized than in the previous hundred years. Since in this period the development of settlement was an accompanying circumstance of large development projects in economic and social transformation, therefore the town of BajinaBasta was also taken care of in all aspects of development, starting with the infrastructure, construction of new housing fund to the content of supporting functions of culture and entertainment.

The engagement of hydroelectric power plant “BajinaBasta” in solving the issues which did not directly refer to the income, but represented conditions for normal economic activity, exempted the economy of Yugoslavia from some investments, and as a result it could pay more attention to the production and possibilities of its own development. The significance hydroelectric plant construction had on the town of BajinaBasta was represented in the idiosyncrasy of economic development, which relied upon dynamic industry growth in the plan period. In the year 1989, in the economic structure of BajinaBasta, the industry had the largest partake in the forming of income, /7/. Thus, it was the industrial development which represented the basis for further urbanization, which was in most part connected to the needs of hydroelectric plant.

Structural integrity as a prerequisite for the proper functioning of hydroelectric power plant

In order to keep a hydroelectric power plant working smoothly, especially bearing in mind the scope of impact it has on its immediate surroundings, it is essential to make an evaluation of consequences for possible unforeseen circumstances and the way to prevent any possible negative impact. Hydroelectric plants, as large systems of complex equipment and large quantities of water in their accumulations, represent a potential danger, threatening not only the immediate environment but also the wider area. Therefore, it is the matter of special importance to pay attention to proper maintenance of all technical systems in the facility, because any malfunction endangers, not only the facility, but also all locations set downstream. The greatest degree of risk comes from the dam, inlet – outlet pipeline with their water and safety organs, as well as evacuation organs: spillway floodgates and bottom outlets (Fig. 1-2). Breaking of pipelines in the reversible hydroelectric plant “BajinaBasta” would cause water occurring at the water hub, at the slopes and foot of the mountain Tara, mudflow occurrences and the collapsing of facilities and communications. To reduce the risk of malfunction, constant evaluation of working life and structural integrity of aforementioned equipment is conducted, as well as the rest of the equipment intended for the use in electric power production, whether it is in the working condition or not. The checking of equipment and facility status entails a periodic trial run, visual inspection and non – destructive testing, and consulting with specialized institutions.

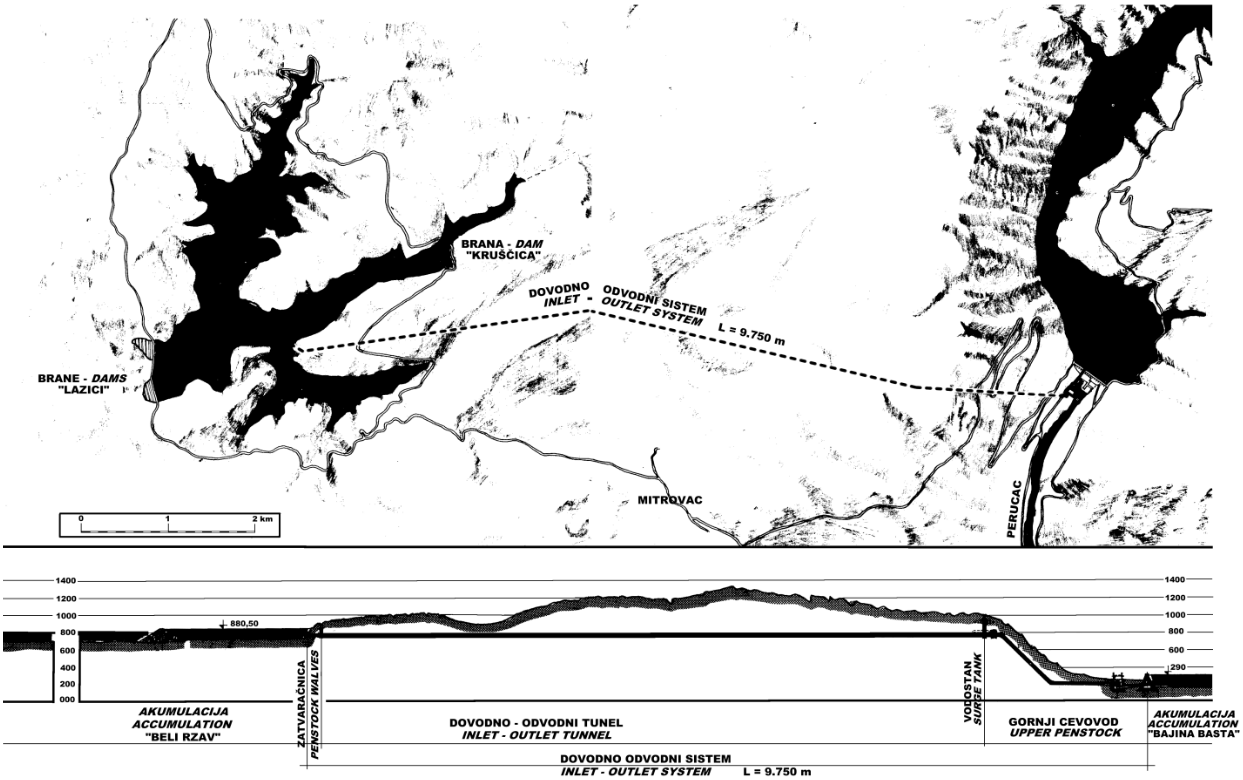

Figure 1.Upper and lower accummulation and inlet-outlet system of hydroelectrical power plant "BajinaBašta".

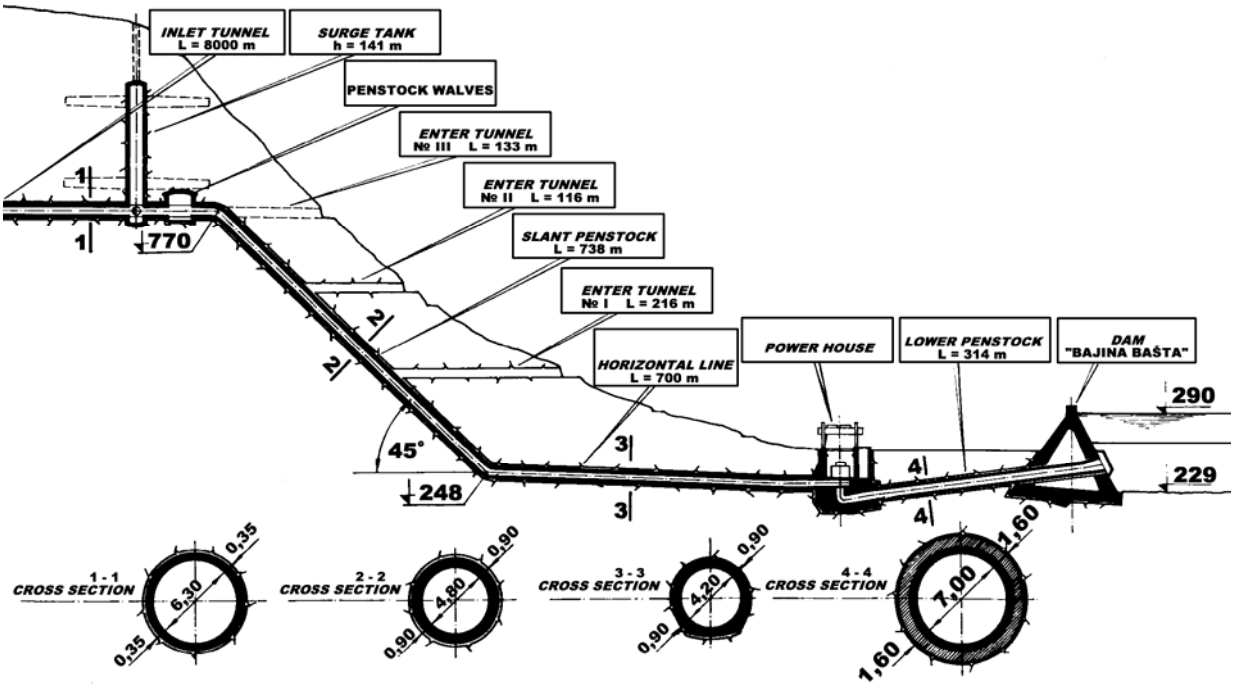

Figure 2.Disposition of penstock (upper and lower pipeline) "BajinaBašta.

2. Conclusion

The contribution of hydroelectric power plant construction to the urban restoration within the framework of local environment development viewed from the stance of history, architecture and urbanism, sociology and technology, gives an insight into the connectedness of technological innovations with the improvement in the way and quality of life. The construction of hydroelectric plant contributes to the economic, spatial and social development of local environment. As an incentive for industrialization, it is the effect of change it has on the production method and volume, which results in the urban development and the forming of new urban structure and functions which follow the new economic activities, and social changes which entail demographic changes, new division of labor and leisure time, conditions of labor and housing and organization of everyday life. This influence is conditioned by ideological framework of socio – political system, which determines the nature of development initiative, the way and scope of investing, and by the degree of technological development, on which the possibilities of electric power use in different areas depend. In the firstly observed period, private initiative and investments were directed primarily towards the development of local economy, while the urban structure and function development was neglected. During the period of socialist construction, the development of local environment was an accompanying circumstance of large development projects, where all aspects of development were considered, starting from the infrastructure equipment and construction of new housing fund to the content of accompanying functions.

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REVITALISATION OF ERs 1000 "VEDRICAR" EXCAVATOR DRIVING WHEEL BY WELDING

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Abstract

Presented in this paper is the quality analysis of repair welded segments of excavator „Vedricar" Ers-1000 driving wheel. The repair welding process was realized by semiautomatic procedure using self-protected filled wire. The excavator is in operation at coal mine "Tamnava west field", RB „Kolubara", Lazarevac.

Keywords:

Repair welding, segment of driving wheel excavator "Vedricar" ERs 1000, self-protected filled wire, semiautomatic feeder.

1. Introduction

The main condition that each welded structure needs to meet is exploitation safety. Properties of the welded joint play an important part in fulfilling of this condition. Within a welded joint, properties of the weld metal, which makes up the most of the weld created by melting, are of great significance.

Based on the fact the exploitation safety of a structure is dictated by mechanical properties, whereas these properties are determined by the weld micro-structure, it can be concluded that, during welding, it is necessary to achieve conditions which will guarantee the best micro-structure possible, which in turn will result in optimal mechanical properties.

Chemical composition and cooling rate are the two basic factors that directly determine the weld metal micro-structure.

Weld metal chemical composition is conditioned by the type of added material and partially by the parent material which is melted during welding, whereas cooling rate is mostly dictated by welding parameters, i.e. the amount of heat input during welding.

Presented in this paper is the quality analysis of repair welded segments of a driving wheel of an "Vedricar" ERs-1000 excavator operating in open pit mine "Tamnava west field" at RB Kolubara.

After wear has occurred, two interlayers were welded using REL welding procedure, in two passes, wherein the second interlayer was welded using self-protecting filled wire *Castolin TeroMatec AN* 3205, and the finishing covering layer was made using self-protecting filled wire *Castolin TeroMatec AN* 4660.

Adhesive wear resistance of welded segment surfaces was tested by measuring loss of mass during exploitation.

Figure 1. Excavator "Vedricar"

Figure 2. Segment damage

Wear of surface layers is the most common cause of failure of parts and machine assemblies. Due to this, tribological properties of used consumable materials are of great importance for the functioning of machine parts and structures.

Welding was applied as a financially convenient method for machine and device maintenance. Various technologies which are used for machine part revitalization enable functionality, and in many cases extend their work life.

Driving wheel segments were subjected to considerable metal-to-metal wear, as a result of high surface pressure loads. Because of the high cost of segment (wheels) replacement, due to wear damage, there is a tendency to extend their work life as much as possible, by repair welding.

2. Parent material

Driving wheel segments no. T-V-078-3/2 were made (cast) from ČL.0601 material, whose chemical composition is not prescribed, and its mechanical properties are as follows: R_m > 590 *MPa*, K_{DVM} > 14 J at temperature *t*=20ºC

3. Technology used for welding of a hard layer of a bucket-wheel excavator driving wheel

Segments were preheated at a temperature of ~280ºC. During the first pass, the interlayer (bonding layer) was welded using an electrode INOX 18/8/65 with a diameter of Ø3,25 mm, in two cross passes (shown in figure).

Figure 3. The appearance of the driving wheel

Figure 4. Welding on the spot

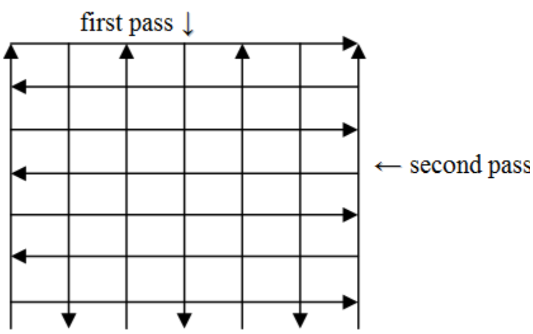

Figure 5. Welding cross passes

It is important to mention that bonding layer welding was performed in a way that ensures the next layer always covers (overlaps) one third of the previous one. This was done so that bonding defects that could lead to micro-cracks in the interlayer are avoided. INOX B 18/8/6 electrode was dried at 300ºC/2h, classification EN 1600: E188Mn B22.

In case of hard welding of surfaces subjected to (extreme) high intensity wear combined with simultaneous heavy impacts (impact damage), problems are related to applying the welds, which require extremely high wear resistance when working in a cold state, good toughness and dynamic impact resistance.

Main criteria when considering welding alloys (materials) are:

1. Resistance to abrasive wear
2. Impact resistance
3. Metal-metal wear

Abrasive wear and impact resistance are mutually exclusive, since high hardness can only be achieved by lowering toughness.

Demand: How to achieve high abrasive wear and impact resistance, in terms of added material and welding procedure. The parent material to which the welded layer should be applied is ČL.0600.

Prior to welding, segments were tested using a non-destructive method - magnetic particles, in order to determine the presence of cracks and micro-cracks in the surface layer.

Repairs were performed on the driving wheel, without disassembling it into components, on the excavator itself.

The selected procedure involved welding with the use of a self-protected filled wire. Main reason for such a choice was the welding rate, along with applying of a greater amount of added material deposits per time unit.

Based on the chemical composition and mechanical properties of the parent material used for driving wheel segments, and taking into account the selected welding procedure, as well as the required hard–ness, the following added materials were chosen: *Castolin TeroMatec AN* 3205 Ø2,8 mm, SRPS EN 14700 T Fe9, *Castolin TeroMatec AN* 4660 Ø2,8 mm, SRPS EN 14700 T Fe15.

For the purpose of welding interlayers using the REL procedure, an austenite electrode E18 8Mn B22 with a diameter of Ø3,25 mm.

Special filled wire for hard welding and interlayers, *Castolin TeroMatec AN* 3205 provides hardness from 40 to 45 HRc.

Welds are highly resistant to cracks in case of increased layer thickness (possibility of multi-layer applying). It is rather convenient for layers resistant to metal-metal friction, high pressure, abrasion and heavy impacts, and also exceptional as an interlayer in case of materials with poor weldability.

Filled wire used for layer, with excellent abrasive resistance, *Castolin TeroMatec AN* 4660 can provide weld hardness of approximately 60 HRc in the first layer, and 64 HRc in the second. Total thickness of a layer welded using this wire must not exceed 8 mm. It has exceptional resistance to heavy abrasion, particularly in the presence of sand, small particles, clay etc.

Prior to welding, surfaces were ground, in order to remove the fatigue (hardened) layer caused by exploitation and to create proper conditions for applying the weld. Following this step, magnetic particle testing was performed in order to detect cracks.

In addition, the part of segments which was to be repaired was preheated before welding, Fig. 6. Preheating was performed using the electro-resistant procedure, wherein preheating temperature was determined according to Seferian's expression:

$$C_{eq}=\%C+\%Mn/6+\%Ni/15+\%Cr/5+\%Cu/13+\%Si/4+\%P/2=0.6$$

$$C_{tot}=C_{eq}(1+0.005\cdot d)=0.6\cdot(1+0.005\cdot 100)=0.9$$

$$T_p=350\cdot(C_{tot}-0.25)^{1/2}=350(0.9-0.25)^{1/2}=282\ ^{o}C$$

Figure 6. Electro-resistant preheating of driving wheel

Figure 7. Welded segment appearance

4. Conclusion

It was proven that using a semi-automatic procedure for the purpose of repair welding of segments on a driving wheel which was a part of the "Vedricar" excavator, has considerable techno-economical advantages compared to segment replacement, especially when self-protected filled wire is used.

By using the current welding procedure, REL, the downtime of the excavator was 7-10 days, whereas welding was performed four times per year. Semi-automatic procedure with the self-protected filled wire whose properties were defined earlier in this paper reduced the number of downtimes to two per year, and their duration to 4-5 days.

This procedure requires the providing of a semi-automatic wire feeder designed for very high amount of material feeding, and convenient for outdoor conditions.

It is of great importance to add that this procedure applies significantly more material per time unit, which reduces work costs by an average of 60%.

This procedure has been successfully used for several years in repairing of knives, pockets, buckets and teeth on bucket0wheel excavators in P.D. R.B. "Kolubara".

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INFLUENCE OF MACHINING PARAMETERS ON MACHINE TOOL LOADS AT ROTARY ULTRASONIC MACHINING OF SYNTHETIC DIAMOND

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Abstract

Mono-crystalline diamond (MCD) is the hardest known material. Therefore only advanced methods are able to treat such material. Advanced machining methods, proper for machining of hard and brittle materials (such as glass and ceramics) include rotary ultrasonic machining (RUM). However, high hardness of workpiece cause higher loads and it could negatively affect achievable accuracy and surface topography. Machine loads are affected by both: machined material and machining parameters. This contribution investigates influence of machining parameters, such as spindle speed, feed rate and depth of cut, on loads of machine tool during machining of MCD by rotary ultrasonic machining.

Keywords: Rotary ultrasonic machining, synthetic diamond, machining parameters, machine tool loads, ultrasonic milling.

1. Introduction

MCD is very hard material which is manufactured by powder metallurgy at high temperature (1500 °C) and high pressure (5 GPa). MCD is characterized by very high hardness. Its value is 10,000 HV (around 100 GPa). MCD is chemically inert. It is usually utilized as a cutting material for machining of the non-ferrous materials, such as alloys of Ti, Ni, Al, Cu, etc. Due to its hardness, additional treatment usually is not necessary – it is often manufactured directly to the final shape. However, there are some applications, where machining of MCD is demanded. There is usually required shape, which is not viable to manufacturing by powder metallurgy (e.g. due to negative bevel or thin walls). These applications often demand high precision and low roughness [1, 2, 3, 4]

2. Method

Rotary ultrasonic machining (RUM) is applied in this experiment. RUM utilize ultrasonic tool with diamond coating. This tool rotate around vertical axis and oscillate by ultrasonic frequency in vertical direction. The interaction of rotating motion and vibration cause micro-cracks on surface of workpiece. These cracks are broken and lead away as micro-chips by coolant. The coolant also enhances this effect by cavitation. Therefore proper properties of the coolant are necessary. The coolant is feed on tool-workpiece interface. Accordingly, very hard and brittle materials (such as ceramics) can be machined. Advantages of this process include decreasing of cutting force, reduction of heat generation, no chemical affection of workpiece, increasing of tool life, improvement of machined surface, etc. In this experiment, rotary ultrasonic milling machine DMG ULTRASONIC 20 linear was used. This machine tool is able to operate continuously in five axes and it can operate as conventional milling machine, high speed cutting machine, ultrasonic assisted milling machine and rotary ultrasonic milling machine.

As a tool, ultrasonic milling cutter Schott 858009 - 3.25 6A9-Da24-2-6-14h6x8,4 MES3 D46H with diameter 24 mm was used. It has harmonic frequency 21,600 Hz and amplitude 10 μm. 3D model of workpiece was created by CAD software PowerShape and NC program for machining (for control system Sinumerik 840D) was generated by CAM software PowerMill [5-9].

Description of the Experiment. As machined material, mono-crystalline diamond (MCD) was used. This specimen of MCD had block shape. This material was provided by its manufacturer – Changsha 3 Better Ultra-hard Materials Co., Ltd (3b diamonds). This company is based in China (2). Specimen had dimensions: 5 x 4.5 x 1 mm. In experiments was used two kinds of spindle speeds, two kinds of feed rates and two kinds of depth of cuts (due to limited space and time). Therefore, only 8 areas were machined. Following machining parameters were used: spindle speed: 4000 and 8000 rpm; feed rate: 100 and 500 mm/min; and depth of cut: 1 and 5 μm. Machine loads was obtained directly by machine tool itself. They was recorded in its own control system Sinumerik 840D Solutionline. To their evaluation, statistical software Minitab 17 was used, supported by MS Excel [10-12].

3. Results

There was obtained several parameters of machine load, such as spindle load, Z axis load, torque momentum, etc. Too high spindle load could damage spindle itself. If machine tool will overload in Z axis, machine tool will automatically activate central stop. Torque momentum is important especially for milling cutters with low diameter.(i.e. low stiffness), because too high value of torque momentum could broke them. In Figure 1 is shown graphically influence of spindle speed on machining parameters at machining of MCD.

According Figure 1 is clear, that increasing of any machining parameter cause slightly increasing of spindle load. However, spindle load is relatively low even at the highest used parameters. According Minitab analysis, load of spindle is affected especially by spindle speed. Separate influence of each machining parameter was 92.22 % and their interaction influence was 2.38 %. The biggest influence on spindle load had spindle speed (48.60 %), then depth of cut (26.13 %), then feed rate itself (17.49 %), then spindle speed and feed rate interaction (1.94 %), and the lowest influence had both: spindle speed and depth of cut interaction (0.22 %) and feed rate and depth of cut interaction (0.22 %). In Figure 2 is shown graphical influence of Z axis load on machining parameters at machining of MCD.

According Figure 2 is clear, that feed rate has the biggest influence on load in Z axis. Increasing of other machining parameters cause slightly decreasing of Z axis load. According Minitab analysis, Z axis load is influenced especially by feed rate. Separate influence of each machining parameter was 57.85 % and their interaction influence was 22.50 %. The biggest influence on load in Z axis had feed rate (57.17 %), then spindle speed and depth of cut interaction (15.30 %), then spindle speed and feed rate interaction (5.51 %), then feed rate and depth of cut interaction (1.70 %), then spindle speed itself (0.61 %), and the lowest influence had depth of cut itself (0.07 %).

In Figure 3 is shown graphical influence of torque momentum on machining parameters at machining of MCD.

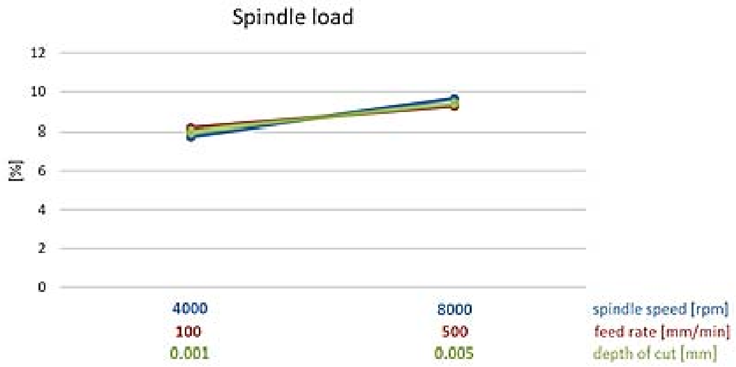

Figure 1.Influence of spindle speed on machining parameters.

Figure 2.Influence of Z axis load on machining parameters.

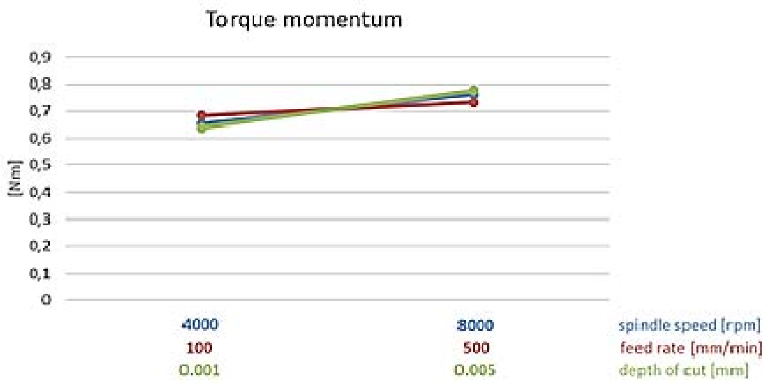

Figure 3.Influence of torque momentum on machining parameters.

According Figure 3 it is clear, that increasing of any machining parameter cause slightly increasing of torque momentum. Reached values should not exceed value 1 Nm. In experiments was used ultrasonic milling cutter with diameter 24 mm. If milling tool with smaller diameter had used (e.g. 4 mm), the tool should be fatally damaged. According to Minitab analysis, torque momentum is affectted especially by depth of cut. Separate influence of each machining parameter was 73.43 % and two factorial interactional influence was 16.05 %. The biggest influence on torque momentum had depth of cut (42.08 %), followed by spindle speed (25.98 %), feed rate and depth of cut interaction (12.08 %), feed rate itself (5.37 %), spindle speed and depth of cut interaction (2.63 %), and the lowest influence had spindle speed and feed rate interaction (1.34 %).

In Figure 4 graphical influence of load of ultrasonic generator on machining parameters at machining of MCD is shown. According Figure 4 is clear, that increasing of spindle speed and feed rate cause increasing of load of ultrasonic generator. However, this load is decreasing with increasing of depth of cut. According Minitab analysis, load of ultrasonic generator is affected especially by depth of cut. Separate influence of each machining parameter was 80.96 % and two factorial interactional influence was only 17.99 %. The biggest influence on load of ultrasonic generator had depth of cut (33.18 %), followed by feed rate (30.85 %), spindle speed (16.93 %), spindle speed and depth of cut interaction (15.28 %), spindle speed and feed rate interaction (2.71 %), and the lowest influence had feed rate and depth of cut interaction (0.00 %).

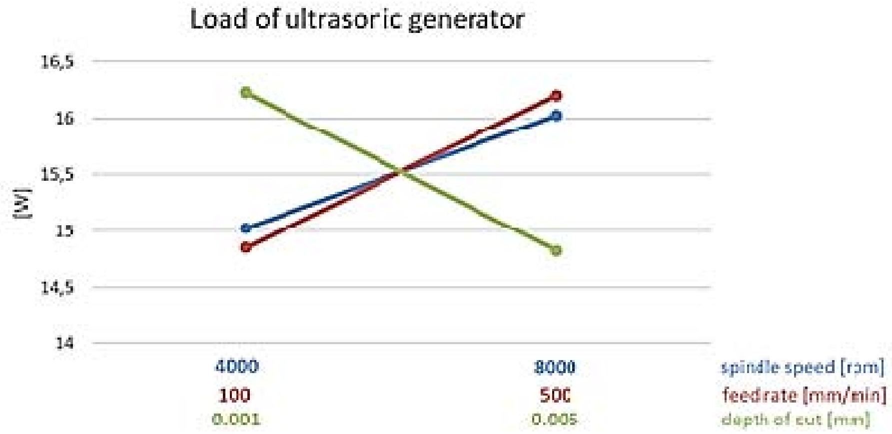

Figure 4.Influence of load of ultrasonic generator on machining parameters.

4. Conclusion

According performed experiments and analysis could be said, that the most limiting factor at machining of MCD is Z axis load and load of ultrasonic generator. Z axis load is affected especially by feed rate. Load of ultrasonic generator is affected by all machining parameters, however, only depth of cut had decreasing character. This mean, to obtain low load of ultrasonic generator is proper increase depth of cut. It cause also increasing of material removal rate, which is positive it terms of cutting time. Higher spindle speed improve surface topography. Therefore, in terms of machine load, surface topography and material removal rate ratio, the most suitable combination of machining parameters is: spindle speed 8000 rpm, feed rate 100 mm/min, and depth of cut 0.005 mm, where there was reached spindle load 9.5 %, Z axis load 11 %, torque momentum 0.8 Nm and load of ultrasonic generator 14.8 W. These loads are acceptable. However, despite of such low loads, tool wear was significant. It was caused by very high hardness of diamond, but also by sharp edges of workpiece. Inclination of diamond workpiece should significantly decrease tool wear.

5. Acknowledgement

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CERTIFICATION OF PERSONNEL FOR API 510 PRESSURE VESSEL INSPECTOR

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Abstract

Paper presents further education of engineering in area of pressure vessel integrity. American Petroleum Institute is leading organization in the World in this area. Standard API 510 for inspection of pressure vessel in operation and for certification of personnel for authorized inspector is presented.

Keywords: Inspection, certification, education of engineering

1. Introduction

It is general accepted phrase for Education in Engineering: After one graduates and receives engineering diploma, education does not end. It is continuous process during all engineering career. It could be even more intense and specialized education after graduation.

For engineers who work with pressure equipment in Oil&Gas and Chemical industry, especially in Quality Control / Quality Assurance sector, including inspection, welding, Non Destructive Testing (NDT), API 510 is usual necessary standard for their guidelines. API 510 is standard published by American Petroleum Institute (API). Full title is Pressure Vessel Inspection Code: In-Service Inspection, Rating, Repair, and Alteration (API 510). According to standard API 510, certification of personnel is performed. If one successfully passed exam, automatically becomes authorized API-510 Pressure Vessel Inspector. API 510 certificate is mandatory for inspection activities in most countries in the World. Besides inspection, it does demonstrate competence of engineer for material, design, fabrication, assembly, welding and NDT of pressure vessels.

2. Condition for API 510 certification

API allows person other than engineers to apply for certification since it is very narrow specialty. Deference is between necessary work experience. Logically, demand experience for technicians is higher than for engineers. To qualify for the certification examination, the applicant's education and experience, when combined, shall be equal toat least one of the following, [1]:

a. Bachelor of Science degree in engineering or technology, plus one year of experience in supervision of inspection activitiesor performance of inspection activities as described in API 510,
b. Two-year degree or certificate in engineering or technology, plus two years of experience in the design, construction, repair,inspection, or operation of pressure vessels, of which one year must be in supervision of inspection activities or performance of inspection activities as described in API 510,
c. High school diploma or equivalent, plus three years of experience in the design, construction, repair, inspection, or operationof pressure vessels, of which one year must be in supervision of inspection activities or performance of inspection activities as described in API 510,
d. Minimum of five years of experience in the design, construction, repair, inspection, or operation of pressure vessels, of which one year must be in supervision of inspection activities or performance of inspection activities as describe in API 510.

3. Recertification of API 510

Recertification is required three years from the date of issuance of the API 510 authorized pressure vessel inspector certificate.

Recertification by written examination will be required for inspectors who have not been actively engaged as inspectorswithin the most recent three-year certification period. Exams will be in accordance with all provisions contained in API 510. "Actively engaged as an inspector" shall be defined by one ofthe following provisions [1]:

a. Minimum of 20% of time spent performing inspection activities or supervision inspection activities as described in the API510 inspection code over the most recent three-year certification period,
b. Performance of inspection activities or supervision of inspection activities on 75 pressure vessels as described in API 510 overthe most recent three-year certification period.

Inspection activities common to other API inspection documents (NDE, record-keeping, review of welding documents, etc.) may be valid as well.

4. Body of Knowledge and Exam for API 510

API Authorized Pressure Vessel Inspectors must have a broad knowledge base relating to maintenance, inspection, repair, andalteration of pressure vessels. The API Authorized Pressure Vessel Inspector Certification Examination is designed todetermine if individuals have such knowledge. To determine whether the applicants have this broad base of inspection knowledge, a minimum of one question from eachcategory listed within this Body of Knowledge will be included on the API certification examination. Only inspection information covered in one of the references outlined in this body of knowledge will be utilized for the examination questions.The examination consists of two parts. The closed book part tests the candidate on knowledge and tasks requiring everydayworking knowledge of API Standard 510 and the applicable reference documents. The open book portion of the examinationrequires the use of more detailed information that the inspector is expected to be able to find in the documents, but would not normally be committed to memory [1]. The following is a list of specific topics in which the API Authorized PressureVessel Inspector should be knowledgeable.All publications for exam are API and ASME standards:

a. API Publications:

- API 510, Pressure Vessel Inspection Code,
- API RP 571, Damage Mechanisms Affecting Equipment in Refining Industry,
- API RP 572, Inspection of Pressure Vessels,
- API RP 576, Inspection of Pressure-Relieving Devices,
- API RP 577, Welding Inspection and Metallurgy,

b. ASME Publications:

- Section V, Nondestructive Examination,
- Section VIII, Division 1, Rules for Constructing Pressure Vessels,
- Section IX, Welding and Brazing Qualifications.

API 510.Inspection code covers the in-service inspection, repair, alteration, and rerating activities for pressure vessels and the pressure-relieving devices protecting these vessels. This inspection code applies to all refining and chemical process vessels that havebeen placed in service, [1].

API RP 571. General guidance in this recommended practice (RP) as to the most likely damage mechanisms for common alloys used in the refining and petrochemical industry is provided. These guidelines provide information that can be utilized by plant inspection personnel to assist in identifying likely causes of damage, and are intended to introduce the concepts of service-induced deterioration and failure modes. The summary provided for each damage mechanism provides the fundamental information required for a FFS assessment performed in accordance with API RP 579 or an RBI study performed in accordance with API RP 580. The damage mechanisms in this RP cover situations encountered in the refining and petrochemical industry in pressure vessels, piping, and tanks [3].

API RP 572. This RP covers the inspection of pressure vessels. It includes a description of the various types of pressure vessels and the standards for their construction and maintenance. This RP also includes reasons for inspection, causes of deterioration, frequency and methods of inspection, methods of repair, and preparation of records and reports, [4].

API RP 576. This RP describes the inspection and repair practices for automatic pressure-relieving devices commonly used in the oil and petrochemical industries. As a guide to the inspection and repair of thesedevices in the user's plant, it is intended to ensure their proper performance. It covers such automatic devices as pressure-relief valves, pilot-operated pressure-relief valves, rupture disks, and weight-loaded pressure vacuum vents, [5].

API RP 577. This RP provides guidance to the API authorized inspector on welding inspection as encountered with fabrication and repair of refinery and chemical plant equipment and piping. Common welding processes, welding procedures, welder qualifications, metallurgical effects from welding, and inspection techniques are described to aid the inspector in fulfilling their role implementing API 510, API 570, API Std 653 and API RP 582. The level of learning and training obtained from this document is not a replacement for the training and experience required to be an American Welding Society (AWS) Certified Welding Inspector (CWI)[6].

ASME Section V. This Section contains requirements and methods for nondestructive examination which are referenced and required by other ASME Sections. It also includes manufacturer's examination responsibilities, duties of authorized inspectors and requirements for qualification of personnel, inspection and examination. Examination methods are intended to detect surface and internal discontinuities in materials, welds, and fabricated parts and components, [7].

ASME Section VIII, Division 1. This Division provides requirements applicable to the design, fabrication, inspection, testing, and certification of pressure vessels. Pressure vessels may be fired or unfired. Specific requirements apply to several classes of material used in pressure vessel construction, and also to fabrication methods such as welding, forging and brazing. It contains mandatory and non-mandatory appendices detailing supplementary design criteria, nondestructive examination and inspection acceptance standards, [8].

ASME Section IX. This Section contains rules relating to the qualification of welding, brazing, and fusing procedures as required by other ASME Sections for component manufacture. It also covers rules relating to the qualification and requalification of welders, brazers, and welding, brazing and fusing machine operators in order that they may perform welding, brazing, or plastic fusing in the manufacture of components. Welding, brazing, and fusing data cover essential and nonessential variables specific to the joining process used [9].

To successfully pass exam, 70% of maximum is necessary. Exam is taking place online at Prometric Testing Centre. Prometric Testing Centre is placed in almost every Capital City in the World. Belgrade has one as well (Decanska 12).

Exam is scheduled three times per year, January, May and September. Application for exam is online (www.americanpetroleuminstitute.com), [2]. Example of certificate is shown at Figure 1. API does not provide training and it is not a pre-request for the exam. Training is performed by many organizations and training body does not need any approval by API. The most important issue for personnel taking API exam and having training, is to choose competent training body. Possible criterion for competence is “does training body perform training with already certified API inspector”. Such a training is provided by the Faculty of Mechanical Engineering, University of Belgrade.

AMERICAN PETROLEUM INSTITUTE
Individual Certification Programs: ICP™

API Individual Certification Programs
certifies that

Igor Martic

has met the requirements to be a certified

API-510 Pressure Vessels Inspector

Certification Number *54962*
Original Certification Date *November 30, 2014*
Current Certification Date *November 30, 2014*
Expiration Date *November 30, 2017*

Tina Briskin
Manager, Individual Certification Programs

ICP

2014-223 | 10M | Printed in the USA |

Figure 1. Certificate API 510

5. Conclusion

Papers presents education of engineering for personnel involved within pressure vessels. Detail for certification according to API are given. API 510 is for pressure vessel. Other standards and certification for personnel exist i.e. API 570 is for process piping, API 653 is for storage tanks.

6. References

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[6] Standard „API RP 577, Welding Inspection and Metallurgy", American Petroleum Institute, 2013.

[7] Standard „Section V, Nondestructive Examination", American Society of Mechanical Engineers, 2015.

[8] Standard „Section VIII, Division 1, Rules for Constructing Pressure Vessels", American Society of Mechanical Engineers, 2015.

[9] Standard „Section IX, Welding and Brazing Qualifications", American Society of Mechanical Engineers, 2015.

STRESS INTENSITY FACTOR ANALYSIS FOR A CRACK EMANATING CIRCULAR NOTCH REPAIRED BY COMPOSITE PATCHING

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Abstract

Bonded composite repair has been recognized as an efficient and economical method to extend the fatigue life of cracked aluminum components. In this work, the finite element method is used to analyze the effect of the presence of crack emanating from a circular notch edge, on the behavior of an aluminum plate three-dimensional, repaired and not repaired by a rectangular patch composite (boron / epoxy). The patch is adhered with an adhesive layer on the damaged portion by calculating stress intensity factors (SIF) on the tip of the crack in mode I. The influence of the thicknesses of the adhesive layer and the patch composite, the effect of the geometry of the patch and the length of the crack on the stress intensity factor are highlighted. The results obtained show that, the SIF crack tip repaired by the patch composite of a height 35mm is reduced by 22% compared to the repaired by a 10mm height patch. This value remains constant up to the height h=80mm. The maximum reduction in composite fiber patch in the y direction is about 90% compared with the unrepaired aluminum plate. A thinner adhesive layer can transmit high stress to the repair patch. It is preferable to use a composite patch contains several layers to repair cracked structures.

Keywords: patch composite, cracks, adhesive layer, stress intensity factor, finite element method.

1. Introduction

Bonded composite repair of aircraft structures was developed by Dr. Alan Baker and his team in 1972. The technology involves adhesively bonding patches of advanced fiber composite materials to repair damaged aircraft structures and to stop stress corrosion cracking. The repairs are structurally very efficient, can be applied rapidly and are cost effective.

The bonded composite patch repair offers many advantages over a mechanically fastened doubler, improved fatigue behaviour, reduced corrosion and good performance to complex aerodynamic contours [1, 2].

It is known that the notches are the main causes of crack initiation. This is why the use of the bonded composite repair can play a significant role in the improvement of fatigue life of the notched structures. This improvement intervenes on the one hand, in the fatigue life initiation by the reduction of the stress concentration at the notch tip, and on the other hand in the fatigue life propagation by the reduction of the stress intensity of stresses at the crack tip.

Jones and Callinan [3] proposed a stiffness matrix for the bonded patch-adhesive used in conjunction with the standard stiffness matrix for both parts. The special elements at the crack tip of the sheet were used. Tarn and Shek [4] modelled the adhesive as a shear spring and they used both FEM and BEM for their calculations.

Ouinas et al. analyzed the repair of a crack emanating from lateral semicircular notch by a semicircular composite patch [5].

With the increase in computational power, the use of the numerical method, especially the finite elements method, contributed considerably to the comprehension of the mechanical behaviour of defects under patch repair. Among the authors whom used the finite element method for the study of the crack patching, we can quote: Ting et al. [6], Callinan et al. [7], Jones and Chiu [8], Turaga and Ripudiman [9], Chung and Yang [10], Schubbe and Mall [11] and Bachir et al. [12].

The aim of this paper is to investigate the effects of composite reinforcement on the crack parameters starting from circular notch in mode I. The stress intensity factors are determined for different crack length. The cracked plate is reinforced by bonding a boron/epoxy composite patch on its one single side. The effect of the geometry of the patch on the stress intensity factor is also examined.

2. Geometrical model

A thin elastic aluminium plate with a circular central notch is considered. It is characterised by the following sizes: height H = 200 mm, width W = 20 mm, thickness e = 1 mm and notch radius r = 3 mm. The plate is subjected to tensile loading giving a remote stress state of σ = 100 MPa. The crack of length ‘a’ starting from the notch root and perpendicular to the loading direction is supposed to exist in the plate. A boron/epoxy patch is bonded to the plate as shown in Figure 1. The dimensions of the patch are: height h, width w = 20 mm and thickness e_R.

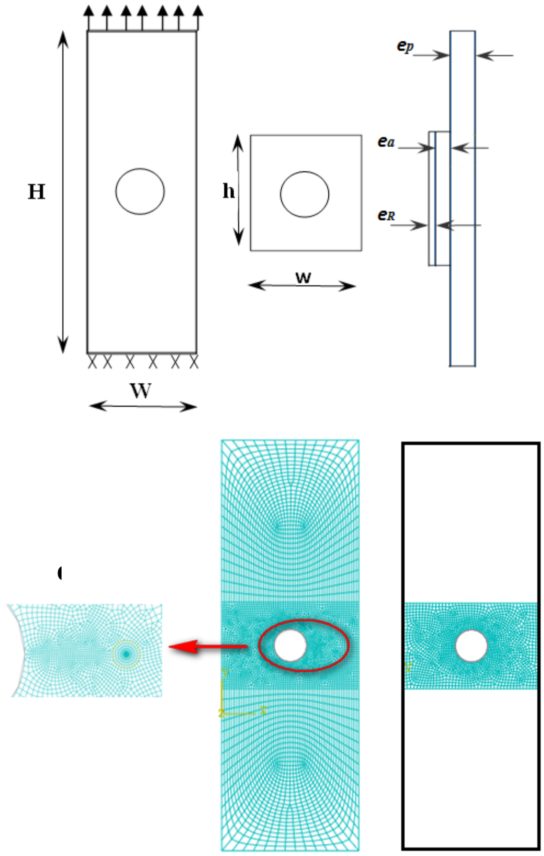

Figure 1. Geometrical model and structural meshing, (a) of the patch, (b) of the plate and (c) near the crack tip. .

The properties of the adhesive are: the shear modulus G_a and the thickness e_a = 0.127 mm.

The mechanical properties of the materials of the assembly (plate, patch and adhesive layer) are reported in Table 1. And Figure 1 illustrious the geometric model of the structure used.

The commercial finite elements code ABAQUS V.6.13-6 was used for computation. The mesh model for the plate contains 10427 quadrilateral hexahedral elements and 74724 nodes of the type C3D20R. In presence of crack emanating from a circular notch, numbers of quadrilateral elements increase by increasing the size of the crack with a grid refined mesh in the vicinity of the crack, as shown in Figure 1.

Table 1. Materials properties.

Proprieties	Plaque AL	Boron/epoxy	Couche Adhésif
E_1 (GPa)	72	208	
E_2 (GPa)		25.4	
ν12	0.33	0.1677	0.32
G_{12} (GPa)		7.2	0.965
G_{13} (GPa)		7.2	
G_{23} (GPa)		4.13	

3. Comparison between patched and unpatched crack

When the plate is loaded by constant external loading, the crack length has direct influence on the SIF. The existence of a crack starting from the notch root repaired with a patch of the ratio R = 3mm is assumed. Figure 2 shows the variation of the stress intensity factor K_I as a function of crack length for patched and unpatched crack, for different orientations of the patch plies (θ = 0 °, 45 ° and 90 °) and for heights h = 10mm, 35mm and 80mm.

It shows that the patch repair highly reduces the stress intensity factor. This is because the patch carries the loads as the crack grows.

When the height h = 10mm of the patch, it can be noted that the SIF increases with increasing of the crack length at orientation of fibers 0° and 45°. However, we notice a slight decrease when the fibers of patch are oriented at 90 ° from a crack size a = 1.5 mm, this may be due to the effect of the central notch on the SIF.

The evolution of the reduction of the SIF as function of crack length for different patch heights (h = 5mm, 35mm and 80mm) is shown in Figure 3. This reduction is defined by [13]:

$$K_R = 1 - \frac{K_p}{K_s} \quad (1)$$

Where Kp and Ks are the SIF at the crack tip with and without patch respectively.

When the patch reinforcement h = 10 mm at six plies, the reduction of the SIF reached 20% and 24% respectively for the orientations of plies θ = 0° and 45°, it increases up to 34% to an orientation of plies θ = 90°. However the reduction of the SIF is proportional to the increase of the height of the patch, this shows that the augment in surface of contact plate-patch leads to a better reduction.

At a height of the patch equals 35 mm, the reduction of the SIF is 63% with orientation of fibers is perpendicular to the advance of the crack, which remains constant with increasing to the surface contact plate-patch up to the height h = 80 mm. The reduction is maximal for the larger size of the crack and is around 85% for a patch oriented at 90%. It equals 52% and 60% for fiber orientations 0° and 45° respectively.

4. Influence of adhesive thickness

Figure 4 shows the variation of the reduction factor of the stress intensity factors versus adhesive layer thickness for a=2mm. It can be seen that a reduction in the adhesive thickness decreases the stress intensity factor, which means that lower adhesive thickness is desirable for repairing crack. However, the effect of the adhesive shear modulus proves that the choice of the adhesive thickness must be also optimized [12, 14].

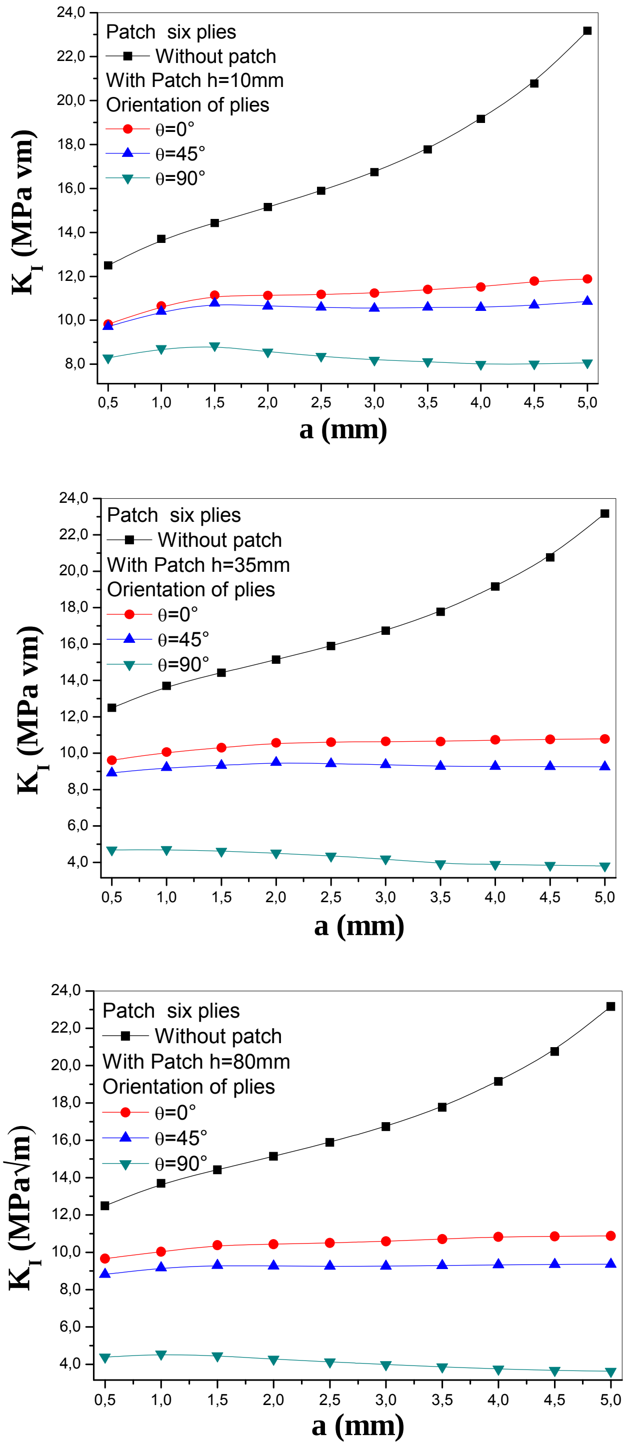

Figure 2. Evaluation of the the stress intensity factor SIF as function the size of the crack for different heights of the patch.

The high thickness reinforces adhesion but attenuates the transfer of the loads towards the patch, reducing the beneficial effects of the patch. On the other hand, a lower thickness supports the transfer of the load towards the patch but increases the risk of adhesive failure. The maximal stress intensity factor is obtained for the crack length a = 2mm repaired by a patch orientation at 90°.

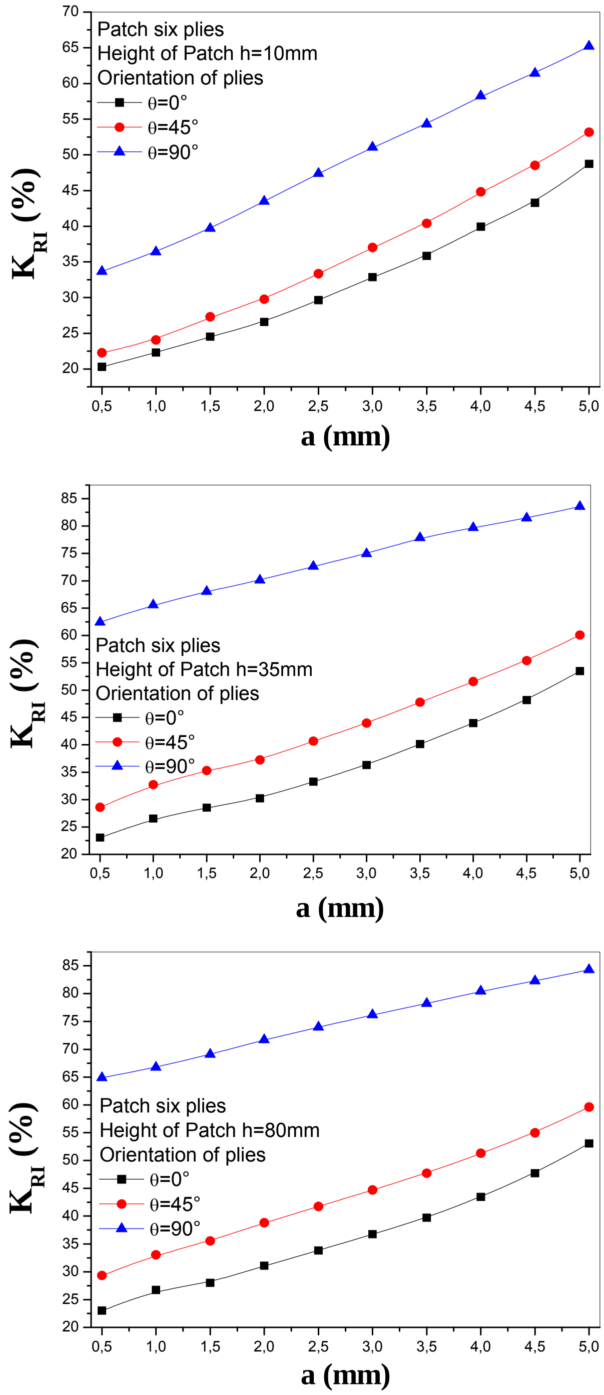

Figure 3. Evaluation of the reduction factor of stress intensity factor SIF as function the size of the crack for different heights of the patch.

5. Influence of e of patch thickness

This effect is illustrated in Figure 5 by the plot of the variation of reduction factor SIF as a function of patch thicknesses for a=2mm. It can be seen that the increase of the patch thickness reduces the stress intensity factor in a proportional way. For a better distribution of the stresses, it is preferable to use a multiple layer of bonded composite patches for repairing cracks. for an oriented patch.

The maximal reduction stress intensity factor is obtained about 90% for a crack a=2mm repaired with an oriented patch 90°.

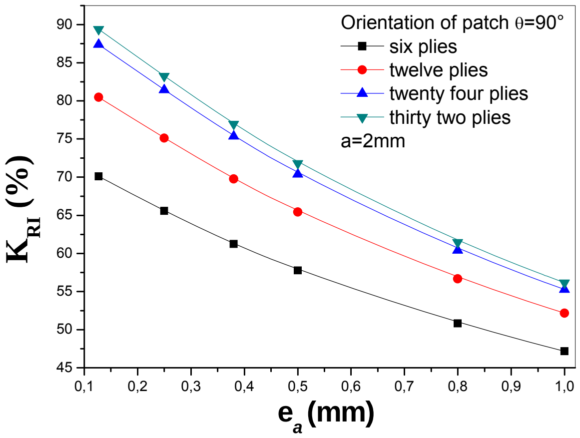

Figure 4. Effect of the adhesive thickness on the variation of the reduction factor SIF (a=2mm).

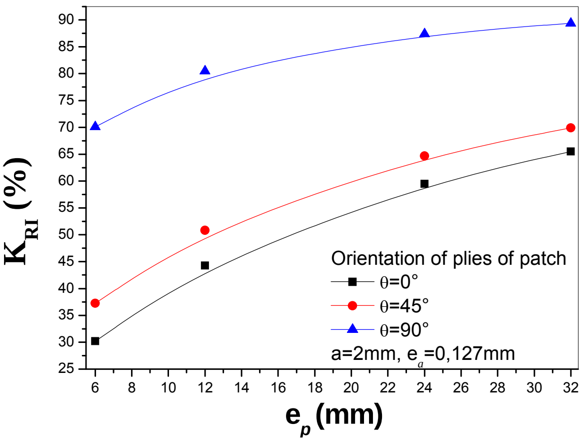

Figure 5. Effect of the patch thickness on the variation of the reduction factor SIF(a=2mm).

6. Conclusion

The results obtained in this study allow us to deduce the following conclusions:

- The mode I stress intensity factor is highly reduced by the presence of the patch.

- The maximum reduction of composite boron /epoxy patch of fiber perpendicular to the crack and for a height h= 40mm, is about 85% with regard to the aluminum patch. This reduction remains constant up to a height h = 80mm.

- A patch of height 35mm reduces the stress intensity factor K_I of more than 22% in comparison with a patch of height 5mm.

- The choice of the adhesive properties for repairing crack, with the bonded composite patch, must be optimised.

- The increase of the patch thickness reduces the stress intensity factor at the crack tip.

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MODELLING OF A CRACKED ALUMINIUM PLATE REPAIRED WITH COMPOSITE PATCH IN MODE I AND MIXED MODE

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Abstract

In this paper, the finite element method is applied to analyse the central crack's behaviour repaired by a boron/epoxy composite patch. The effects of the mechanical and geometrical properties of the patch on the variation of the stress intensity factor at the crack tip were highlighted. The obtained results show that the stress intensity factor at the crack tip, repaired by a patch composite of height 40mm, is reduced by 20% with regard to the one repaired by a rectangular patch of height 5mm, this value remains constant up to the height h=80mm. The maximum reduction of composite patch of fibers in y-direction is about 94% compared to the aluminium un-patch.

Keywords: Patch Composite, Cracks, Adhesive layer, stress intensity factor, Finite element method.

1. Introduction

Adhesively bonding composite patches on either single or double sides of a damaged structure also referred to a bonded composite repair, have been shown to be efficient in reducing the stress intensity at the crack tip and thus improving the service life of the damaged structure.

This method has been used to repair a number of aging aircraft components. The bonded composite patch repair offers many advantages over a mechanically fastened double; i.e. improved fatigue behavior, reduced corrosion and good performance to complex aerodynamic contours [1, 2]. The first use of a composite patch to repair damaged aircraft and marine structures [3], progresses have been made to improve the accuracy of prediction methods and the effectiveness of bonded composite patch repair technique [4–7]. Among the several advantages offered by bonded patches, one can mention the following; the improvement of the fatigue life of the material, the reduction of corrosion and the easy fit to a complex aerodynamic contour. The determination of the SIF at a crack tip is one of the possible means for analysing the performances of the composite patches.

Bonded patch repair reduces stresses near the crack by transferring stresses between the cracked structure and the composite patch throughout the adhesive layer, and therefore retards the crack growth. Jones and Chiu [8] showed that externally bonded composite repairs can be successfully used to extend the fatigue life of thick structural components. Hosseini-Toudeshki [9] analyzed the effect of the number of plies of the composite on the repair performance and concluded that the life of a cracked panel of 2.29 mm thickness may increase by about 65% and 236%, by implementing a 4 and 16 layers patch, respectively. However, for 6.35 mm thickness, life of repaired structures may be improved by only 21–35% according to [9]. Aakkula and Saarela [10] analyzed the effect of the stiffness ratio between the aluminum structure and carbon/epoxy and boron epoxy patches on the repair performance. They showed that this ratio has a significant effect on the fatigue life of repaired structures. Indeed, and according to the results in [10], the fatigue life improvement, for center crack repaired with single-sided patch, was better with the wet-laminated carbon/epoxy having a stiffness ratio of 1.04. For edge-cracked specimens the best repair performance was achieved with the double-sided boron/epoxy repairs having a stiffness ratio of 0.65.

Ouinas et al. [11-12] showed the effect of the composite material of the patch on the amplification of the stress concentration in notch roots, and on the FIC crack tips.

It is well-known that the finite element method gives with a high precision the SIFs at the crack tip. Among the authors having used this method in the case of reinforced cracks; one can quote [13–17].

In this paper, the analysis of the behaviour of a crack reinforced in an aluminium plate in mode I using the finite element method. The composite patch under analysis is the boron/epoxy which had been used successfully in aeronautical repair [18-22]. The effect of the geometry of the patch and the length of the crack on the stress intensity factor is examined.

2. Geometrical model

In this model, an aluminium thin rectangular plate having the following dimensions: length H = 200 mm, width W = 20 mm and the thickness e_P = 1 mm had been considered. A crack length is located in the middle of the plate and perpendicular to the solicitation plane was supposed.

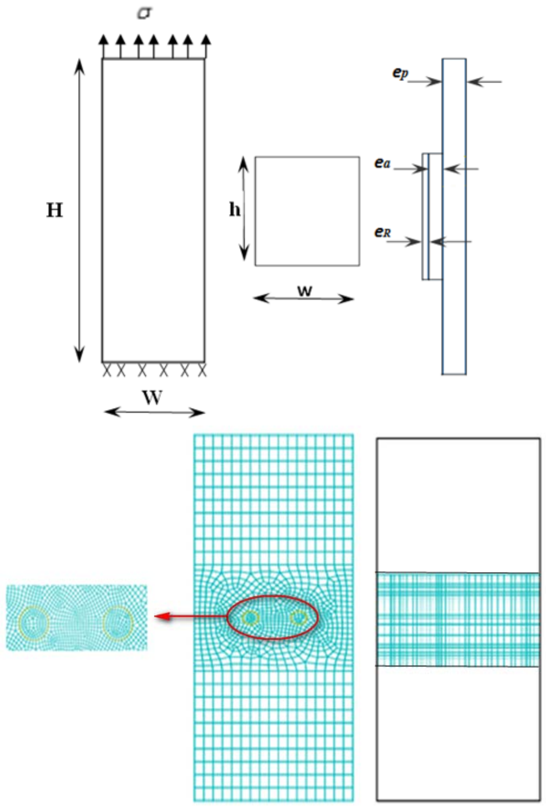

Figure 1. Geometrical model and the structural meshing.

The plate was then subjected to a uniaxial tensile stress σ = 100 MPa. The crack is repaired using a bonded boron/epoxy patch which is considered as a rectangular material having the following dimensions: height h, width w = 20mm, and thickness e_R (Figure 1). The properties of The adhesive are: the shear modulus G_a and the thickness e_a = 0.127 mm.

The mechanical properties of the materials of the assembly (plate, patch and adhesive layer) are reported in Table 1. Figure 1 shows the geometric model of the structure used.

Table 1. Materials properties.

Proprieties	Plaque AL	Boron/epoxy	Couche Adhésif
E_1 (GPa)	72	208	
E_2 (GPa)		25.4	
ν_{12}	0.33	0.1677	0.32
G_{12} (GPa)		7.2	0.965
G_{13} (GPa)		7.2	
G_{23} (GPa)		4.13	

The commercial finite elements code ABAQUS V.6.13-6 was used for computation. The mesh model for the plate contains 8924 quadrilateral hexahedral elements and 59636 nodes of the type C3D 20R. And in the presence of the central crack the number of quadrilateral elements increase by increasing the size of the crack with a grid refined mesh in the vicinity of the crack, as shown in Figure 1.

3. Reduction of stress intensity factor

When the plate is loaded by constant external loading, the crack length has direct influence on the SIF. The analysis consists to vary the length of the crack repaired, keeping the same mechanical characteristics of the aluminum plate and the patch.

The evolution of the reduction of the SIF as function of crack length for different patch heights (h = 5, 20, 40 and 80 mm) is shown in Figure 2. This reduction is defined by [19]:

$$K_{PI}=1-K_p/K_s \quad (1)$$

where K_p and K_s are the SIF at the crack tip with and without patch, respectively.

When the patch reinforcement h = 5 mm at 12 plies, the reduction of the SIF increases linearly with increasing the length of the crack. The maximum reduction is obtained for a patch composite of fibers are oriented parallel to the applied load (65%). By increasing the height of the patch, we note that the reduction of the SIF increases proportionally with the increase in the size of the crack. The same ascertainment is noted for different height h of patch composite when the SIF increases with the size of the crack. However, the reduction of the SIF is proportional to the increase of the height of the patch, this shows that the augment in surface of contact plate-patch leads to a better reduction.

At a height of the patch equals 40 mm, the reduction of the SIF is 82% with orientation of fibers is perpendicular to the advance of the crack, which remains constant with increasing to the surface contact plate-patch up to the height h = 80mm.

4. Effect of surface contact plate-patch

It is important to note that the SIF depends on the orientation of plies compared to the repaired defect. It is clear that the reduction maximum of the SIF of the crack a = 16 mm was obtained by orientations of plies 90% whatever the height of the composite patch. Figure 3 shows the evolution of the maximum and minimum reduction factor of the SIF as function of the contact surface for a patch of twelve folds. The max and min reduction corresponds to crack length a = 16 mm and a = 2 mm, respectively.

It can be noticed that the reduction is almost stable beyond the surface S = 400 mm² whatever the length of the crack (a =2 mm, a = 16 mm). So, the increased surface area does not have a significant effect on deceleration of the crack compared to the importance of the angle of orientation of the fibers of the composite patch. It can be noticed that the maximum and minimum reduction obtained is about 94% and 82% respectively for a patch of the fibers oriented at 90°.

5. Stress intensity factor in mixed mode

Values of K_I and K_{II} as function of the inclination of the crack for a = 8 mm, is illustrated in Figure 4.

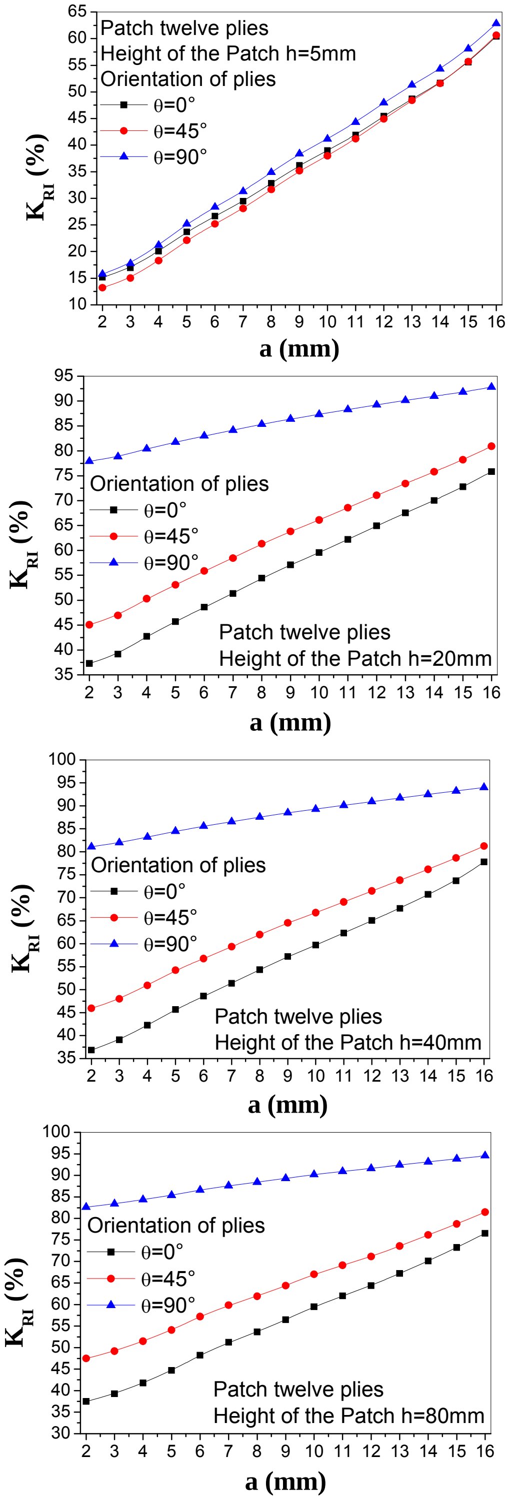

Figure 2. Evaluation of the reduction of stress intensity factor SIF as function of the size of the crack

It is observed that the presence of the composite patch reduces the SIF in mode I and mode II.

The maximum reduction of SIF K_I is 60%, 63% and 77% for a crack repaired by a patch to twelve plies oriented at 0°, 45° and 90° respectively.

A strong decrease of the K_{RI} factor is recognized when the crack is oriented at 60-80 ° repaired by a patch of plies oriented at 0°, this position promotes crack propagation.

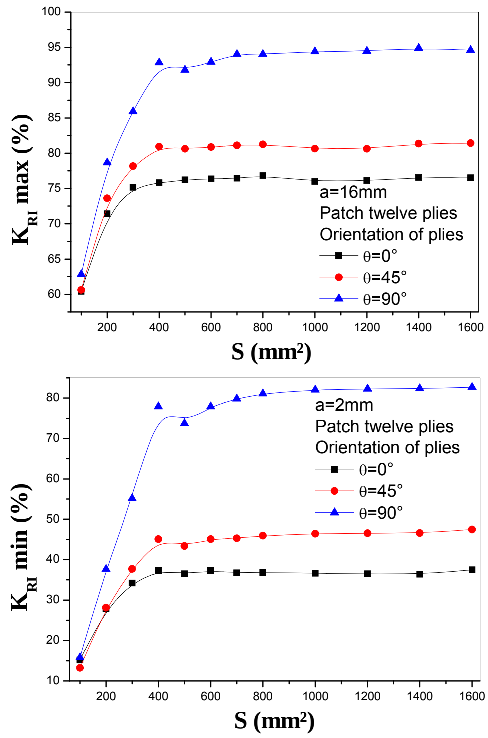

Figure 3. Evaluation of the reduction factors of the SIF maximum and minimum as function of the surface contact plate -patch.

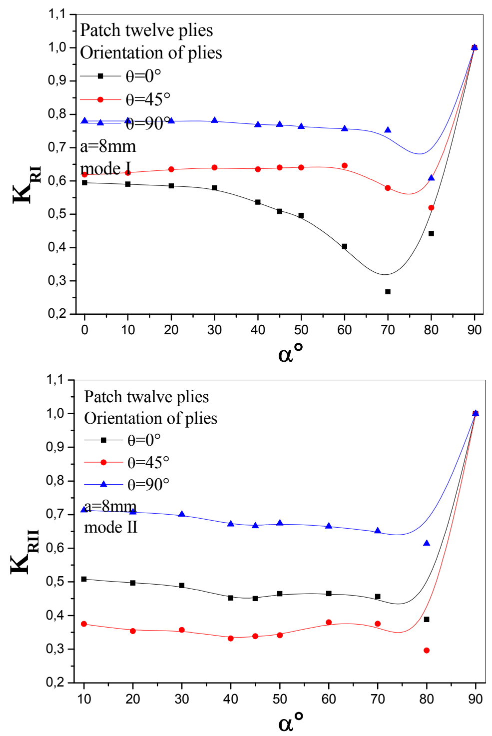

Figure 4. Evaluation of the reduction of the SIF and KI and KII as a function of the inclination of the crack (a = 8mm).

However we see a small reduction for crack strengthened by a patch oriented at 45° and 90°. So it is recommended to avoid a thin patches oriented at 0° to repair cracks located at high angles. The K_{RII} factor curves are almost unchanged as function the inclination of the

Crack whatever the orientation of the plies. The maximum reduction of the SIF K_{II} is 71% for repaired crack by a patch to twelve plies oriented at 90 °.

6. Conclusion

The aim of this study was to use the finite element method to study the performance of repair technique on the structure with a laminated patch composite on a plate subjected to a traction containing a central crack of variable length.

The quality of the patch material and its geometry, play a role essential on the distribution of the stress concentration at the vicinity and the crack tip, the following conclusions are derived from this study

- The SIF to the crack tip is inversely proportional to the increase of the patch rigidity.
- The maximum reduction of composite boron/epoxy patch of fiber perpendicular to the crack and for a height h= 40mm, is about 94% with regard to the aluminum patch. this reduction remains constant up to a height h = 80mm
- A patch of height 40mm reduces the stress intensity factor KI of more than 20% in comparison with a patch of height 5mm.
- The surface of the contact plate-patch to be repaired is the best indicator of slowing the crack propagation and therefore on reducing the SIF. Thus, the reduction of the SIF was almost stable beyond the surface S = 400mm² corresponding to a height h = 20mm whatever the length of the crack.
- In mixed mode, the reduction of SIF in opening mode is more important than that in shear mode.

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DYNAMIC BEHAVIOR OF COMPOSITE PLATES IMPACTED AT LOW VELOCITY

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Abstract

The evolution of damage in composites at a low velocity impact is difficult to observe. In this work, we use the heterodyne technique that provides very fast and non-destructive method is reliable for elastic behavior and damage characterization of polymer matrix composites. An approach based on measurements of the reflected light beam produced by a laser diode proposed to extract the effective stiffness tensor for composite having different levels of anisotropic mechanical behavior of the mean dynamic tests (DM) were conducted to determine damage that may develop during an impact event penetrating. Sixteen specimens of composite glass / polyester woven taffeta, were manufactured and tested in different speed levels. Finite element analysis (FEA) was performed using the ABAQUS / Explicit commercial software with a progressive damage model to simulate the instrumented with Experimental observations crash tests conducted at different impact energies. A good agreement is observed between the numerical predictions and experimental results in terms of impact in the history of the speed of value of the maximum strength, energy consumption and the projected area of damage.

Keywords: Composite materials, Damage mechanisms, Heterodyne technique, Penetrating impact, Finite element modelling (FEM).

1. Introduction

The response of laminated composite structures to foreign object impact at various velocities has been a subject of intense research in recent years. In high velocity impact (HVI) damage is usually detectable by visual inspection though they can be difficult to be detected in some cases such as small stones.

On the other hand, the low velocity impact (LVI) damage cannot be easily identified during routine visual maintenance inspections of structures thus; they become important issue in the design of composite structures. Impact generally causes a global structural response and often results in internal cracking and delamination in the resin rich zone between the actual plies for lower energy levels while high impact energies cause penetration and excessive local shear damage [2]. When a low velocity impact happens, the matrix material overstressed, resulting in micro-cracking which leads to redistribution of the load and the concentration of energy and stress at the inter-ply regions where large differences in material stiffness exist. However this may not necessarily lead to fracture.

Real life examples of low velocity impact include in-service loads such as a dropped tool or impact of debris from runway on an aircraft made from laminated composite. Especially compressive load will cause continuous growth of damaged area when subjected to impact loads, with the corresponding decrease of their residual strength and the subsequent risk of structural failure under service loads. The initiation and rapid propagation of a crack will cause in abrupt change in both sectional properties and load paths within the affected damaged area.

Dimensions and boundary conditions of the laminate are important, because they determine its flexural stiffness, for a given material whose thickness and stacking sequence are fixed [7–9]. In the past few years, considerable amount of studies have been conducted in the area of impact damage resistance of composite laminates. Detailed reviewed of impact mechanics and dynamics of composite structures have been made by Abrate [8-5]. Thanomslip and Hogg [10] have investigated penetration impact resistance of hybrid composites.

They have considered various thermoplastic fibers with different resign system. They have concluded that plastic deformation in the thermoplastic fibers was the key factor in the improvement in energy absorption of the hybrid composites. The low energy impact characteristics of four different E-glass fibers reinforced thermoplastic and thermosetting matrix composites have been studied by Sadasivam and Mallick [11]. Naik et al.[12] have investigated impact behavior and post impact compressive characteristics of glass carbon hybrid composites with alternative stacking sequences.

The aim of the present work is to investigate impact response of the stacking and angle-ply glass/polyester laminate plates. Here, two different clamped cases, three type of stacking sequences and different impact energies are considered. The behaviors are presented forms of the curves of contact force-displacement, contact force-time, absorbed energy-time, velocity-time etc.

2. Numerical modeling

There is a wide variety of failure modes that can occur in impact-induced damage, In order to monitor this damage in composite plates, many failure criteria have been proposed. In the introduction it was mentioned that they could be distinguished into 3 groups: failure criteria based on fracture mechanics, strength-based failure criteria and failure criteria based on damage mechanics. Strength-based failure criteria for each failure mode are discussed in this report. These criteria can be incorporated in material models that are usable for impact simulation with micro- or multi-scale models. The discussed failure criteria comprise the calculated stresses to their related strength parameter.

Many strength-based failure criteria have been proposed. A group of these criteria describe the failure of only one single failure mode. Others describe the failure due to interactive failure modes, like the Tsai-Hill criterion [1]. One other group describes the macroscopic failure in composite plates, for example the Tsai-Wu criterion [13]. These last two groups are generally used in macroscale models and are not sufficient for describing failure at the microscopic level. This study concerns the criteria that describe single failure modes, since that are the ones that are needed for progressive damage modeling on microscopic level. Four failure criteria are presented below:

Mode I: fibre in tensile $(\hat{\sigma}_{11} \geq 0)$

$$F_{ft} = \left(\frac{\hat{\sigma}_{11}}{X^T}\right)^2 + \alpha\left(\frac{\hat{\sigma}_{12}}{S^L}\right)^2 = 1,\ for\ 0 \leq \alpha \leq 1$$

Mode II: fibre in compressive $(\hat{\sigma}_{11} < 0)$

$$F_{fc} = \left(\frac{\hat{\sigma}_{11}}{X^c}\right)^2 = 1$$

Mode III: matrix in tensile $(\hat{\sigma}_{22} \geq 0)$

$$F_{mt} = \left(\frac{\hat{\sigma}_{22}}{Y^T}\right)^2 + \left(\frac{\hat{\sigma}_{12}}{S^L}\right)^2 = 1$$

Mode IV: matrix in compressive $(\hat{\sigma}_{22} < 0)$

$$F_{mc} = \left(\frac{\hat{\sigma}_{22}}{2S^T}\right)^2 + \left[\left(\frac{Y^c}{2S^T}\right)^2 - 1\right]\frac{\hat{\sigma}_{22}}{Y^C} + \left(\frac{\hat{\sigma}_{12}}{S^L}\right)^2 = 1$$

3. Material properties

In this paper, the plate is modelled in commercial code ABAQUS using thin shell element S8R with 8-16-24 sub-layers through the thickness. For modelling damage evolution during the impact of the plate, material Mat1, Mat2, Mat3 is used. This material model is based on Hashin's failure criteria explained in detail in section 3. The impactor is modelled as a rigid body using a rigid material model, Fig. 1. Note that the strength of the elements around the failed elements can be reduced by setting parameter to capture the extent of the damage.

Table 1. Mechanical properties of the composite lamina

E_{11}(GPa)	E_{22}(GPa)	E_{33}(GPa)	ν_{12}	ν_{23}	ν_{13}	G_{12}(GPa)	G_{23}(GPa)	G_{13}(GPa)
260	1.2	1.2	0.25	0.26	0.25	4	3.8	4

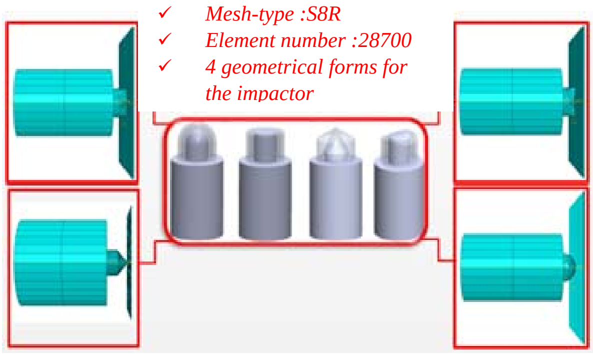

Figure 1. Geometry model of plate-Impactors

4. Simulation results

Following graphs in Figs 2-3 are obtained from various impact energies. Experiments start from minimal damage to perforation of the sample. Three different experiments were performed at the same impact energy and the same conditions because there may be loose connection, defected samples or errors in sensors. As result, total of 48 experiments were conducted. In this work effect of time and deflection parameters such as sample clamp, impact force, displacement, impact velocity and were observed energy on composite materials. Before analyzing the experimental results, perforation and penetration should be defined.

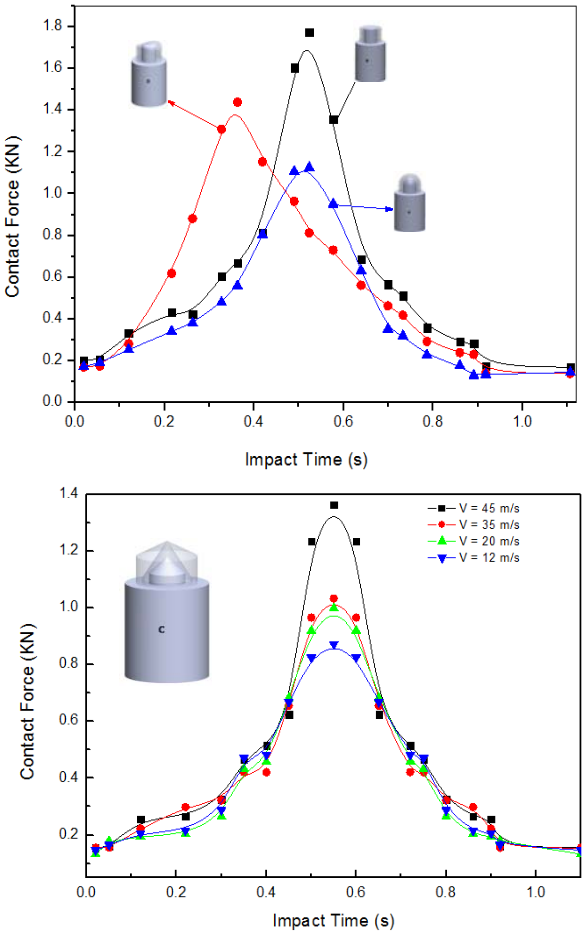

Figure 2. Effects of Impactor shape

In general, the energy of which impactor makes contacts with the sample is defined as penetration threshold. Perforation threshold on the other hand, can be defined as the energy of which impactor reaches the other side of the sample. In ideal case, however, penetration occurs when the conical end of the impactor completely goes into sample.

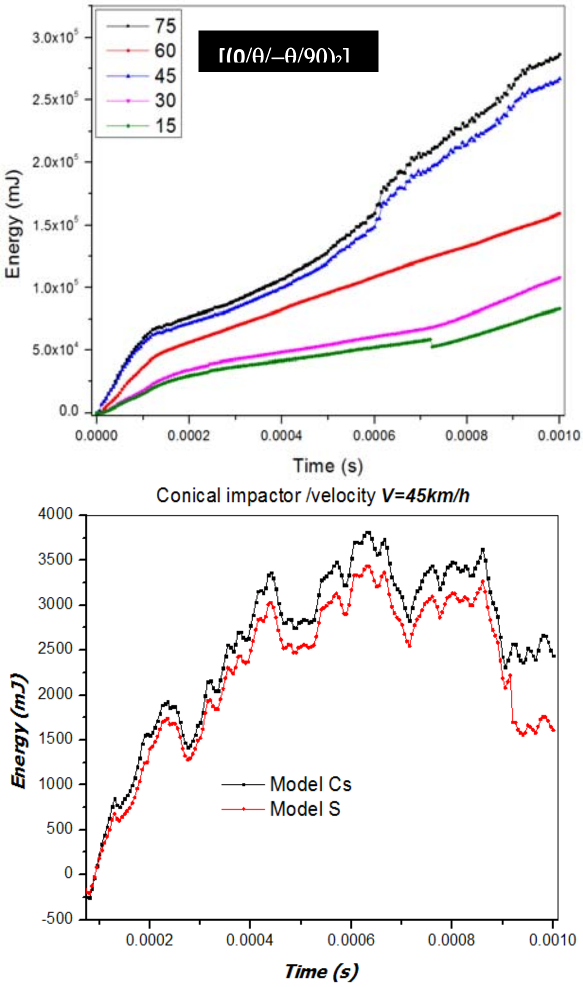

Figure 3. Effect of fiber orientation and the type of pattern used

After dynamic impact tests, the damage mechanism is the same. Firstly, a small local indentation at the contact point is noted for low incident speeds or energies. At that level of the stacking, almost linear with two orientation type of fiber gives a good resistances 450 and 750. Then, after comparative of the result between the patterns used however, shell model and continuum shell are similar (small different value 0.16%).

5. Conclusion

This study allowed visualization of monitoring damage, across of work simulation adequate to experimental test, type fiberglass polyester materials screw the impact for naval use. The companion test, combined with a similar study on other materials, the significant results:

- The geometry of impactor used requires a large difference in the result such as the effort of contact or Maximum stress, growing increase of the impact angle of the facet causes increase contact force and for the same maximum Stress.
- For the second model, the effect of fiber orientation at an angle of 450 and 750 the energy expects its maximum value.
- The simulation results are similar for the impact test of the model using shell or continuum shell.

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THE IMPACT OF THE CONTACT LOAD RESISTANCE TO ADHESION WEAR OF THERMAL-CHEMICALLY PROCESSED STEEL MnCr

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Abstract

The paper analyzes the impact of the contact load resistance to adhesion wear of high-temperature carbonitrided MnCr steel. As an example there is selected tribosystem drive/driven gear of reducers in which they expressed high contact load. The aim of this paper is observing a representative wear systems, as faithfully as possible to define its operating parameters, in order to determine the optimum conditions for investigating the impact of the contact load resistance to adhesion wear. For the purposes of these tests, the samples were first high-temperature carbonitrided, and then they are carried to the appropriate chemical and metallographic analysis, control of the hardness and the resistance to wear. Based on the analysis of the results it was concluded that the increase in contact load, at constant speed occurs an increased loss of mass in high-temperature carbonitrided MnCr steel.

Keywords: tribology, friction, adhesion wear, MnCr steel

1. Introduction

Tribology is the scientific discipline which deals with occurrences and processes in areas that are in interaction, direct or indirect contact and relative motion [1]. Study of the problems of friction and wear as well as the role of lubrication, tribology app–roaches as parts of a whole in which the occur–rences and processes are interconnected and have a major impact on the economy and technical re–sources that are produced and used. Tribological problems are present in all industries. Termination of the functional operation of the parts may occur due to breakage or wear [2], and the effects of corrosion. The aim of this paper is to use chemical and meta–llographic analysis, flow of hardness and wear resi–stance tests on selected high-temperature carbo–nitrided samples and try to spot the dependence of the measured wear intensity of applied contact loads. Selected materials of samples and materials of the counter body must be modeled on observed tribocouple of the gear. The planned tests and analysis should provide insight into the properties of steel reached by the processes of high-temperature carbonitriding and their resistance in terms of adhesion wear at different load levels.

2. Adhesion wear

Adhesive wear is reflected with the transition of materials from one friction surface to the another in terms of direct contact of metal surfaces in relative motion. Event of adhesion is described in three phases: I - generation of adhesion compound, II – breaking of adhesion compound, III - tear off and possible particle breaking [1], Fig. 1.

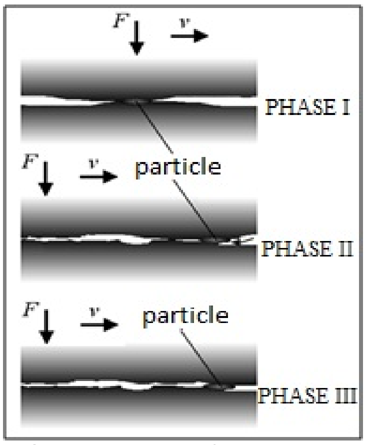


Figure 1. Schematic view of adhesion event [1]

In terms of the relative motion when the surfaces of the body get in contact, plastic deformation of material and contact with a strong adhesion forces occur because there are high specific pressures in these places. The forces are different, from secon–dary weak to primary strong forces. If the forces in the micro compund are stronger than the forces of the cohesion in the material there comes to adhesion and wear during relative movement (sliding) and compounds break [2], Figure 2.

Figure 2. Area damaged by adhesion [1]
Left: adhesion plucked particles;
Rigth:adhesion welded particles

3. Experimental part

As an example of tribosystem reducer gear set is chosen. In this part of drive/driven gears are expressed high contact loads. Drive gear is made of steel 20MnCr5 (Č4321) while driven gear is made of steel 42CrMo4 (Č4732), Fig. 3.

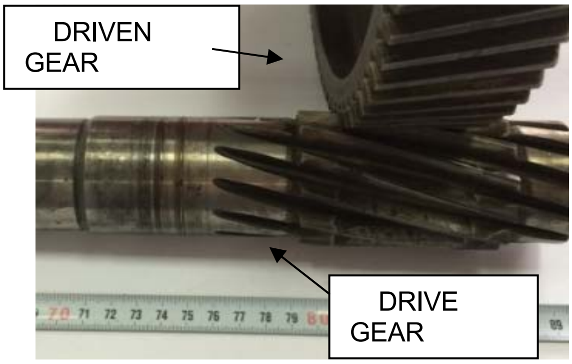


Figure 3. Gear set of reducer

The sample (SP) and counter body (CB) for the adhesion test for resistance to wear, are defined by the model of the observed tribocouple. The sample is made from high-temperature carbonitriding steel 20MnCr5 while the counter body is made of improved steel 42CrMo4, Fig. 4.

Figure 4. Samples of steel 20MnCr5 for testing to resistance of adhesion wear

Samples of steel 20MnCr5, marked with 421 and samples of steel 20MnCr5 marked with 422 during the test of resistance adhesion wear are loaded with different forces: F_1=400 N, F_2=1200 N i F_3=2000 N, with constant rotation speed 600 o/min.

4. Selection of parameters, thermo-chemical treatment of steel

Tables 1-3 show parameters of high–temperature carbonitriding steel 20MnCr5. High-temperature carbonitrided samples are marked with 421 and 422 and they are provided for testing adhesion resistance to wear. Before high-temperature carbonitriding was performed soft annealing, Tab. 1. Carbonitriding parameters are shown in Tab. 2. Upon completion of the 10 h carburizing hardening and subsequent low temperature loosening is directly conducted, Tab. 3.

Table 1. The selection of parameters of the previous heat treatment of steel 20MnCr5

Name	Parameters	
Previous heat treatment Low temperature loosening (MŽ)	Duration	40 ’
	Temperature	660 °C
	Cooling	In the oven

Table 2. The selection of parameters of the thermal-chemical treatment of steel 20MnCr5

Name	Parameters	Process 1	Process 2
High temperature carbonitriding (VTKN)	Duration of carburizing	300 ’	300 ’
	Temperature of carburizing	920 °C	920 °C
	C_{pot}	0,5 % C	1,0 % C
	NH_3	10 %	5 %

Table 3. The selection of parameters of the subsequent heat treatment of steel 20MnCr5

Name	Parameters	
A subsequent heat treatment Hardening (K)	Austenitising temperature	820 °C
	Duration	45 ’
	Cooling	Oil
A subsequent heat treatment Loosening (P)	Loosening temperature	180 °C
	Duration	40 ’
	Cooling	In oven

The high-temperature carbonitriding of samples was done using the variable potential of the C and N. Carburizing was conducted in the furnace with natural gas as a carrier of carbon (C) and ammoniaas a carrier of nitrogen (N) at a temperature of 920 °C. To ensure carburizing with changeable potential C and N have been achieved by a combination of processes 1 and 2. On sample 421 are applied paramateres of process 1 and then parameters of process 2, while on the sample 422 are first applied parameters of process 2 and then parameters of process 1, table 4. Duration of a process is 300’. The only difference is in the order of their application.

Table 4. The labeling method of samples of steel 20MnCr5, intended to test the wear resistance

Steel mark	20MnCr5	
Sample mark	421	422
Carburizing order	Process 1 + Process 2	Process 2 + Process 1

5. Chemical analysis of steel 20MnCr5

Analysis of chemical composition were performed on steel 20MnCr5 (Č4321). A chemical analysis determined the composition of the steel used for high-temperature carbonating. To determine the chemical composition spectrometric method is used and tests were performed on machine BELEC, Figure 5.

Figure 5. Machine for chemical analysis

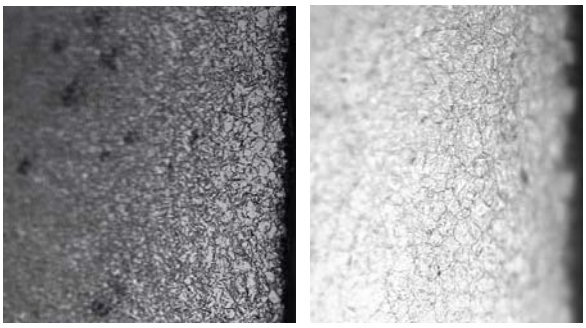
Results of the chemical composition of steel 20MnCr5, as well as the values prescribed by standard EN 10084: 2008 are in table 5.

Table 5. Chemical composition of steel 20MnCr5 (Č4321) according to EN 10084: 2008 [3]

Share %	C	Si	Mn	P	S	Cr
EN 10084: 2008	0,17 ÷ 0,2	Max 0,4	1,1 ÷ 1,4	Max 0,025	Max 0,035	1 ÷ 1,3
	0,19	0,32	1,21	0,022	0,030	1,22

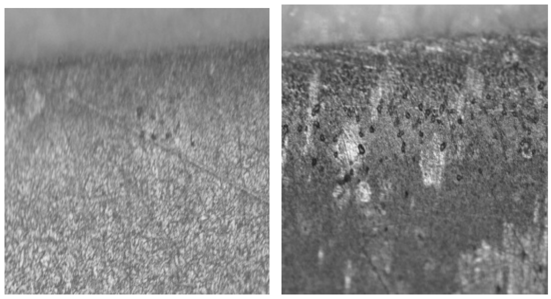
6. Metallographic testing

Metallographic testing and recordings of the microstructure were carried out on the cross-section of high-temperature carbonitriding steel 20MnCr5 on samples 421 and 422. The objective of metallography is to display alloy structure as faithfully and clearly in person and photography. The requirement for microscopic examination of metals and alloys is making straight and very smooth surface. When developing micro samples temperature should not be too high, that there is no change of microstructure pieces. Photos of captured structures are used to document the tested pieces, comparing size of a grain and proportion of individual phases. Microstructure of the edge of high-temperature carbonitriding steel 20MnCr5 are shown in Figures 6 and 7.



a) sample 421 b) sample 422

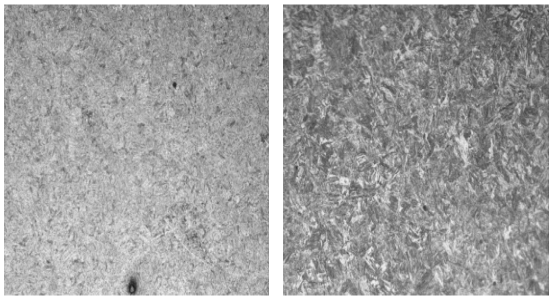
Figure 6. The microscopic appearance of the edge VTKN of steel 20MnCr5 corrosion 3% nital, 200:1



a) sample 421 b) sample 422

Figure 7. The microscopic appearance of the edge VTKN of steel 20MnCr5 corrosion 3% pikral, 200:1

Microstructure of the core of high-temperature carbonitriding steel 20MnCr5 is shown in Fig. 8.



a) sample 421 b) sample 422

Figure 8. The microscopic appearance of the core VTKN of steel 20MnCr5, corrosion 3% nital, 500:1

7. Hardness testing

After metallographic tests micro hardness were measured on cross-section of the sample in order to image the mechanical properties. The hardness flow is measured from the edge to the center of the sample. Hardness were measured by Vickers method HV1. Measuring the flow of hardness HV1 is performed using a „TH 720“, with load of 10 N. The hardness flow of high-temperature carbonitriding steel 20Mn Cr5 was measured with Vickers method HV1 on the cross-section of the sample 421 and 422, and the direction was from the edge to the core of the surface. Results are shown in Fig. 9 (20MnCr5, sample 421) and 10 (20MnCr5, sample 422).

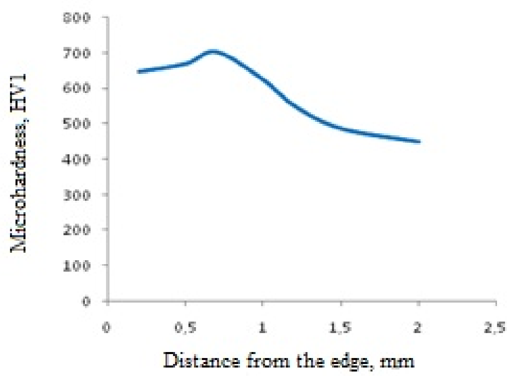


Figure 9. Flow of hardness on the cross-section VTKN of steel 20MnCr5, sample 421

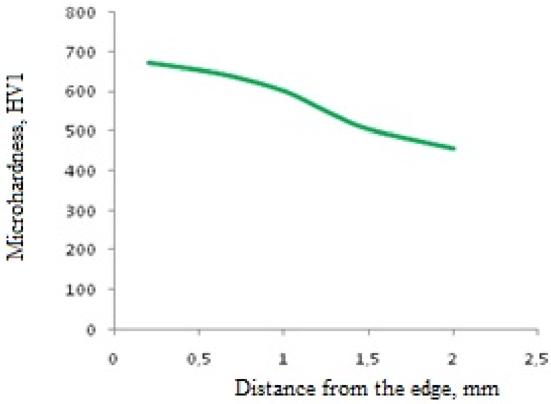


Figure 10. Flow of hardness on the cross-section VTKN of steel 20MnCr5, sample 422

Figure 11 shows the determination of the effective depth of the high-temperature carbonitriding steel 20MnCr5, on samples 421 and 422. Effective depth of the high-temperature carbonitriding steel 20MnCr5 for sample 421 is 1,20 mm and for sample 422 is 1,25 mm.

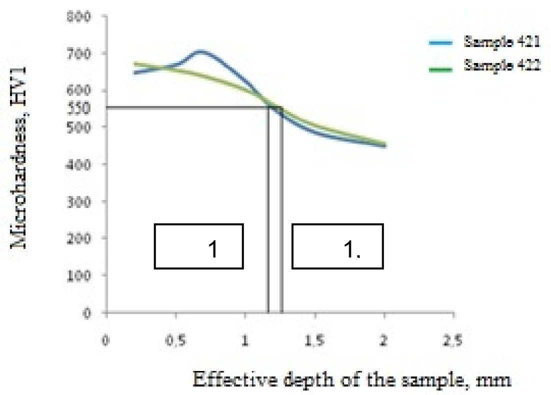


Figure 11. Determination of effective depth VTKN of steel 20MnCr5

8. Testing adhesion wear resistance

Testing adhesion wear resistance was performed using the device SMT-1 2070 with method disc/disc. Table 6 shows parameters of resistance test to adhesion wear of steel 20MnCr5. Marks A, B and C represent parameters of resistance test to adhesion wear with method disc/disc.

Table 6. The parameters of the test of resistance adhesion wear

Mark	A	B	C
F [N]	400	1200	2000
v [o/min]	600	600	600

Figure 12 histogram shows mass loss of the steel 20MnCr5, of samples 421 and 422 for selected conditions of test to wear resistance.

After testing the resistance to adhesion wear 20MnCr5, typical signs of wear patterns are recorded 421 and 422, Figure 13.

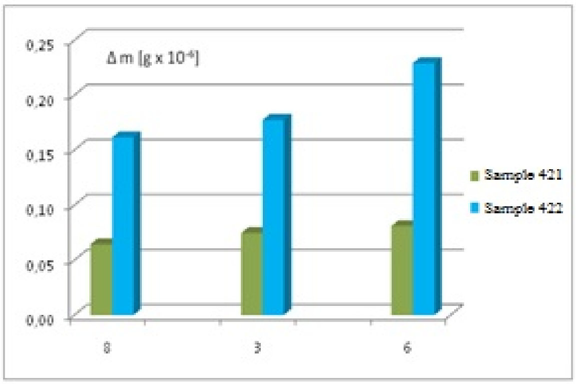
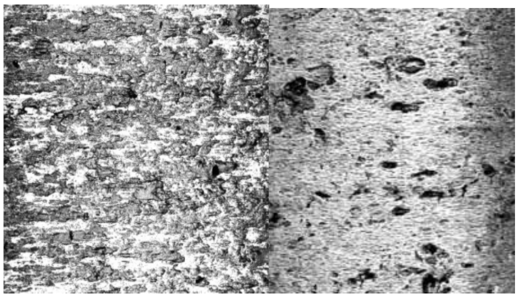


Figure 12. Histogram display of mass loss VTKN of steel 20MnCr5, samples 421 and 422



a) sample 421 b) sample 422
Figure 13. Display of steel wear 20MnCr5, 50:1

9. Analysis of results

The analysis of results obtained by examining the chemical composition of samples of steel intended for high-temperature carbonating, and then testing for wear resistance, is now presented. Figure 6a, on the edge of cross section of sample 421, corrosion 3% with nital, with an increase 200:1, rough martensitic structure can be seen, while in Figure 6b, on the edge of the sample 422, also corrosion 3% with nital with the same increase, finely distributed nitride can be detected. Figure 7a, shows edge of sample 421, while Figure 7b, shows edge of sample 422. Both samples are corrosioned with 3% pikral with an increase 200:1. With the surface of sample 422, we can see a greater number of evenly distributed iron nitride Fe_2N in relation to their negligible presence in samples 421. Corrosion of 3% with nital and with an increase of 500:1, Figure 8a shows the fine grained structure of the core of sample 421, in contrast to coarse grain structure of the core of sample 422. The values of the measured sample surface microhardness 421 and sample 422 are higher than 700 HV1, while the values of the measured microhardness of the core range about 450 HV1. Upon completion of testing the resistance to adhesion wear, signs of wear of sample 421 and sample 422 are recorded, Figure 13. There is an appearance typical adhesion wear on sample 421 and sample 422, noting that the sample 422 has more pronounced presence of surface "craters" which are precisely the consequence of the presence of the fragile chemical compound Fe_2N.

The histogram shows that the increase in power at a constant speed increases wear of sample 422 three times higher than the sample 421.

10. Conclusions

A large number of machines is made of steel. Two basic processes that occur during the relative motion of the machines are friction on contact surfaces and wear of materials with surfaces that are in mutual contact. Adhesive wear is one of the basic mechanisms of mechanical wear in mutual contact. High-temperature carbonating is perfor–med on steel 20MnCr5, varying the potential of the carbon and nitrogen in the furnace during carbu–rizing. It was noted that high-temperature carbonitrided steel is at the beginning of carburizing richer with nitrogen and at the end with the carbon and shows significantly greater resistance to ad–hesion wear. His weight losses are up to three times lower than the loss of mass in samples that at the beginning of carburizing had atmosphere rich with carbon, but in the end with the nitrogen.

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THE INFLUENCE OF PARAMETERS OF THERMO-CHEMICAL PROCESSING ON PROPERTIES OF STEEL 20MnCr5

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Abstract

Gear pumps for plastic injection are exposed to the effect of elevated pressure and temperature. In one such pump there has been frequent downtime due to breakage of the driven gear. Gears which were installed as standard spare parts had stood out in operation for three months. On a sample of a broken gear were conducted metallographic examinations and hardness control on cross section. Surface of the fracture was examined. Conclusion was that it was high quench hardening of a steel of which a part is made, the most likely cause of the fracture of a standard gear. In order to extend the useful life, two test gear are made from steel for cementation 20MnCr5. By applying the appropriate parameters of thermal chemical treatment useful life of the gear is significantly extended. Test gears have worked for nine months after installation.

Keywords: gear pump, cementation, fracture surface, structure, hardness

1. Introduction

Machines for injection molding of plastics are used for making a great array of parts in the automotive industry, for making plastic parts of household appliances and making simple plastic elements [1]. Plastics are polymers which can be added various additives. Given the behavior of the application and processing, are divided into two categories, plastomers and duromers. Duromers are at the beginning of the process soft but during heating at an elevated temperature they irreversibly become a solid material. Further heating results in their thermodegradation. Plastomers are polymeric materials with linear and branched structure. They are soluble in the solvents and fusible. Heating to softening temperatures do not change their structure and therefore their processing includes reversible changes. At these temperatures they can be formed into desired shapes. The structure of plastomers can be amorphous or crystalline [1]. One of the most common methods of processing plastomers is injection molding. This is a procedure of fast injection of melted plastomer into tempered mold and solidification in the workpiece. There is a possibility of process automation that makes it suitable for mass production. Important components of these machines for injection molding are plastic pumps which allow the circulation of heated raw material. They are at work exposed to elevated pressures and temperatures. Gear pumps with external gear, especially a spiral, are often used because they are silent in operation. Tight tolerances in the bearings and shafts mounted on either side of the gear are enabling the achievement of operating pressures above 200 bar. The bearings with narrow tolerances of pumps are not suitable for high temperature application in the presence of abrasive media. Figure 1 shows schematically how gear pumps work. In the initial stage of operation, the gears on the inlet side of the pump affect the media and tend to stand by in the holes on the side of the pump housing. The media is traveling between the gear and the inside of the housing in the moving pockets without passing between gears. Gears displace the affected medium, through the outlet opening, under pressure.

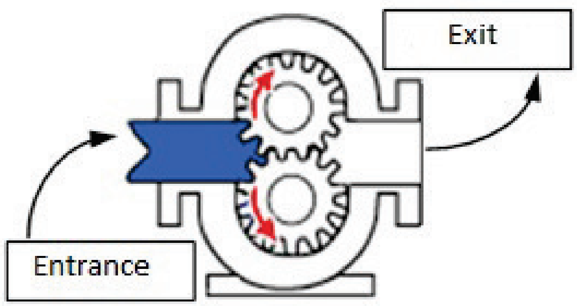


Figure 1. Schematic review of the pump for the transport of the polymer heated at 20 °C

Recording of the situation showed that on machines equipped with this type of pump usually comes to a breakage of driven gear of gear pumps in the area of step-change from diameter of the shaft to diameter of the gear. Bearing of the gear is steel on steel with very tight tolerances and it is unfavorable in terms of wear [2]. One possible approach to extending the life of the gear is testing which steel with app–ropriate parameters of cementation can satisfy the required conditions without breaking.

2. Condition recording

Following the cancellation of the gear pump for transportation of liquid polymer material, damaged driven gear, shown in Figure 2 was submitted to the Laboratory of the Institute of Engineering Materials, Mechanical Engineering Faculty in Slavonski Brod. A few of these gears, the drive and driven are exposed to the operating temperature of about 210 °C. Their task is to manage the rotation and provide transportation of liquid material formed by heating the secondary polymer granules. Part of the gear, on gear pump shown on side B was broken after ≈ 3 months of work. This was one of the failures which have generally occured every 3 months after installing new, standard driven gear. Objective is that after completion of appropriate tests, based on the analysis of the results is noting the potential causes of the breakage. After that, taking into consideration the estimated cause of damage, it is possible to set the guidelines for the preparation of test driven gears.

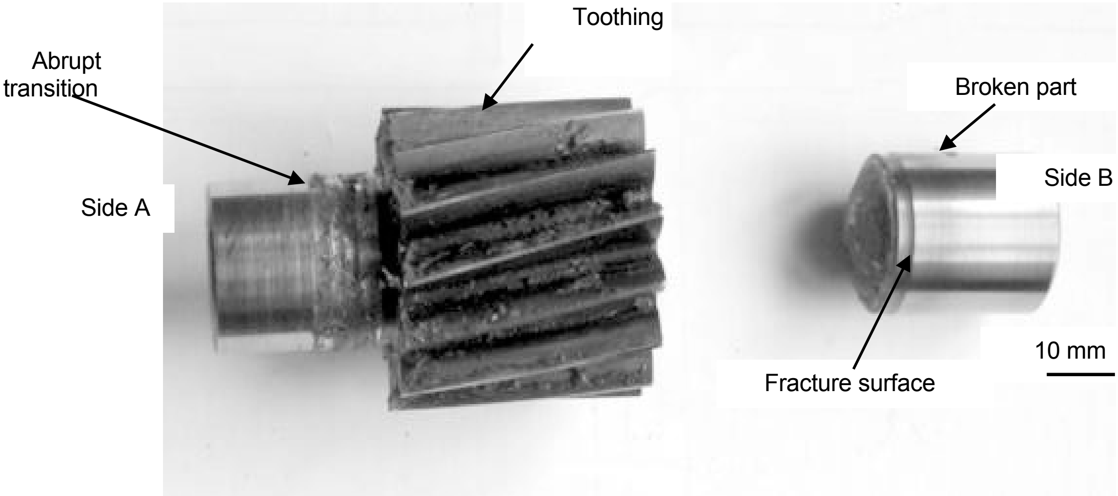


Figure 2. Review of broken standard driven gear of the gear pumps

From CrMo steel for cementing, 20MnCr5, is made one test driven gear. That gear is built into the pump gear and condition was recorded. After 9 months in exploitation there was a fracture of that test gear. The plan for the experiment is to provide same tests on test sample of the gear and on samples of the broken standard gear.

3. Methodology

On broken parts of the gear pump, visual control is performed for the insight of the current condition. Particular attention was paid to the control of the surface fracture on the side „B“, as shown in Fig. 2. Then, using Metasecar cutter, pattern was cut out for continue testing. In order to preserve the existing situation material cutting is performed with intensive water cooling, Fig. 3. Samples are prepared for determination of the chemical composition of the material using an optical spectrometer type Belec. This device allows the selective testing of the sample surface. In this way, with appropriate sample preparation, testing can be carried out both in the core and in the surface of the layer. Metallographic examinations were performed on the cross-section of the sample under different magnifications. Corrosion is performed with nital and microstructure of the core and edge of the samples was photographed by camera of the microscope.

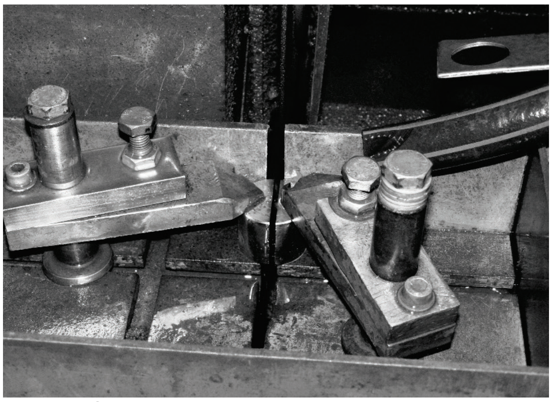


Figure 3. Cutting the sample on the machine Metasecar

4. Experimental results and discussion

Breaking surface of the standard gear is shown in Figure 4. The characteristic appearance of the fracture surface indicates the presence of brittle fracture due to material fatigue. Place of origin of the initial break is not expressed. All over the outside diameter of the surface fracture can be seen zone formed by merging of multiple tiny breaks around the same size. These cracks have created a unique breakout area of annular shape. Look is characteristic for the first phase of breaks with the elements that are in operation torsionally burdened.

The border between growth zone of the fracture and final fracture zone is not expressed. Breaking surface of the shaft of gear is shown in Figure 5.

The characteristic appearance of the fracture surface indicates the presence of ductile fracture due to material fatigue. Place of origin of the initial breaks is expressed and indicated by an arrow. Similar to the previous sample, around the outside diameter of the fracture surface zone formed by merging of multiple tiny breaks around the same size (I) can be seen. The breaks of the formation zone (I) are converted into the The border between growth zone of the fracture and final fracture zone is clearly expressed. Chemical analysis of the material was performed out on samples of one standard and one test gear. Test results are showed in table 1. The results indicate that the standard gear is made of steel 15CrNi6, while test gear is made of steel 20MnCr5. There is an increased content of carbon in the surface layer of samples. It has emerged as a result of the cementation.

Hardness values were measured on the surface of broken part of standard and test gear, on side B. Measured by HRC. Standard gear values range between 57 to 59 HRC and in the trial between 56 to 58 HRC. Hardness values mea–sured on the cross section of the sample were determined using the method HV1. Results are shown in Figure 6.

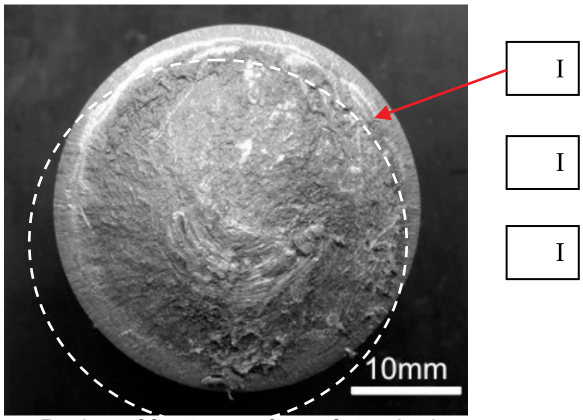


Figure 4. Review of fracture surface of standard gear

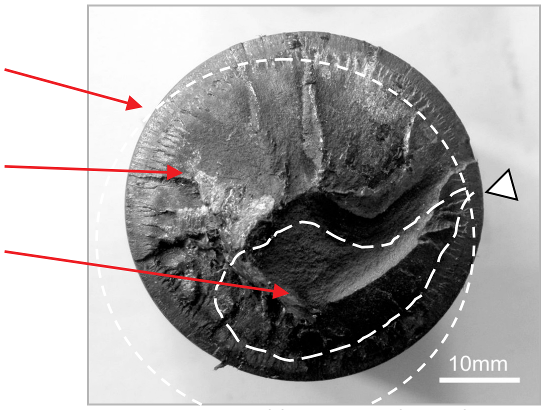


Figure 5. Review of fracture surface of test gear

Table 1. Chemical composition of the gear after cementation

Sample	Measuring spot	Percentage, %							
		C	Si	Mn	S	Cu	Al	Cr	Ni
Standard gear	Core	0,219	0,255	0,917	0,041	0,081	0,027	0,975	0,864
	Surface	0,639	0,305	0,956	0,014	0,055	0,044	0,966	0,764
Test gear	Core	0,197	0,305	1,088	0,026	0,205	0,010	1,077	0,123
	Surface	1,064	0,413	1,224	<0,001	0,159	0,073	1,113	0,131

Results determined the effective depth of ce-mented layers, Edc. For a standard gear, Edc is approximately 2,4 mm and for test gear is 1,6 mm. The values obtained are within the limits expected for the observed steel. The course of hardness measured on cross section of standard and test gear confirmed assumptions about the properties of the material from which they are made. Microstructure is analyzed on surfaces of the samples with method HV1.

Characteristic appereance of microstructure of broken part of the standard gear is shown in Fig. 7. Martensitic layer is noticed with some retained austenite. Characteristic appereance of microstructure of broken part of the test gear is shown in Fig. 8. For it is noticed that the structure of the hardened layer in addition to martensite and bainite has some retained austenite.

The analysis of the test results have found that the standard gears are made of steel 15CrNi6 which are thermochemically processed. Due to its characteristics, and taking into consideration the operating conditions in which pumps are installed, it was proposed to use less hardened steel 20MnCr5.

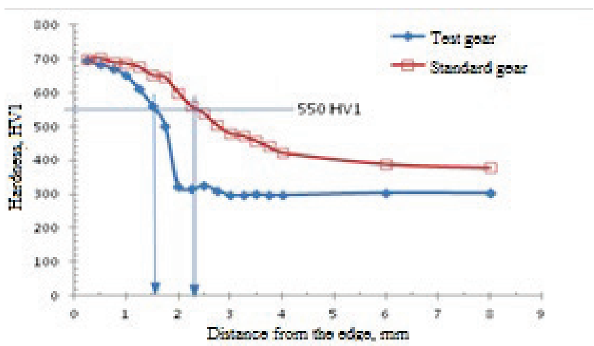
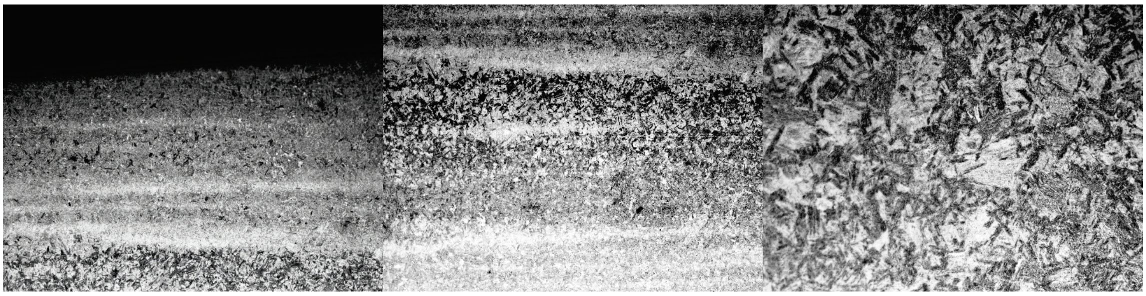
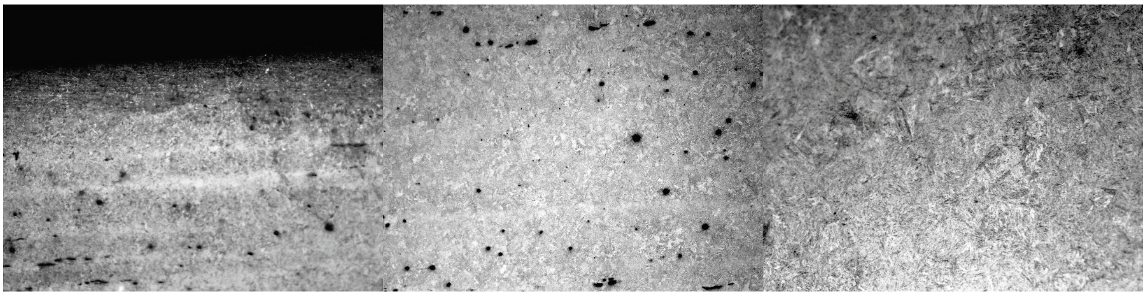


Figure 6. A diagrammatic representation of hardness values on cross section of broken gear



a) b) c)

Figure 7. Microstructure of standard gear (nital corrosion 3%), (a – edge layer, 100x, b – transition zone, 100x, c – transition zone, 500x)



a) b) c)

Figure 8. Microstructure of test gear (nital corrosion 3%), (a – edge layer, 100x, b – transition zone, 100x, c – transition zone, 500x)

The tests performed on the samples of the standard and the test gear, it was shown that steel 20MnCr5 after thermochemical treatment has a significantly different course of hardness of steel 15CrNi6, diagrams in Figure 6. Despite a slightly lower hardness of the surface layer and less effective depth of the layers, because of the less hardened of the core, parts made of steel 20MnCr5 in the same operating conditions lasted 9 months. That is three times longer than standard gear life. Based on the control of working conditions of observed pump problems in the cancellation of the work may be connected with the manner of handling. At the (cold) start, soldified media should be previously warmed in the pump which remained after the previous stop.

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TRANSPARENT BUILDING ELEMENT EFFECTS ON HEAT ENERGY CONSUMPTION

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Abstract

Based on the law for energy transmission, comparative analysis of energy parameters for most common building elements has been performed in order to increase energy characteristics of buildings with change of transparent element surfaces (windows, balcony doors…). Heat energy saving, besides better thermal insulation, can be achieved also by proper choice of transparent elements, as well as by their optimal surface.

Keywords: Heat energy, transparent elements, buildings, energy efficiency

1. Introduction

With an increase of human population and with technology improvement, there is also increasing energy demand. Nowadays, energy is the main driving force for further development of civilization. Thus, its rational use has become one of the major challenges, also because classical energy sources present huge environmental risk. Since cca 40% of energy is spent on residential and business buildings, one can easily conclude about the importance of energy saving in these objects. The notion of building energy efficiency mostly includes two aspects, the first one are objects themselves, and the second one their use. Thus, by energy efficient building we actually mean low energy losses.

In Europe building heating and cooling spends cca 41% of total energy, whereas in Serbia it is as high as 47%! Figure 1 indicates that buildings are large energy consumers.

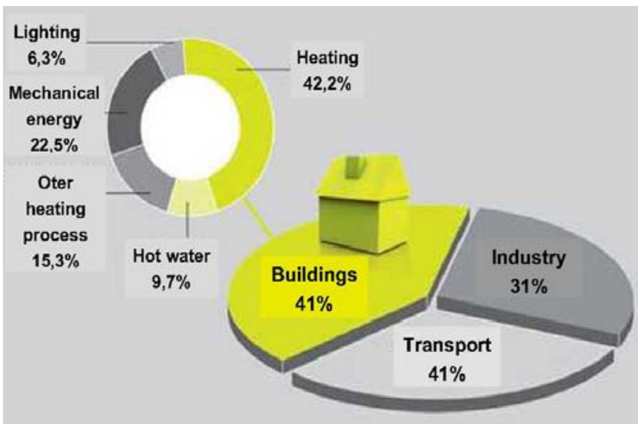

Figure 1. Graphical representation of spent energy distribution, [10]

2. Transparent element heat conduction

According to the building energy efficiency regulations, [1], coefficient of transparent element heat conduction is:

$$u = \frac{A_g \cdot u_g + A_f \cdot u_f + \psi_g \cdot l_g}{A_g + A_f} \qquad (1)$$

where :

A_g – glass surface

A_f – frame surface

u_g – glass heat transfer coefficient

u_f – frame heat transfer coefficient

ψ_g – correction factor for glass–frame connection

l_g – length of glass-frame connection

If there are two or more glasses their total surface is used. Coefficients u_g and u_f are defined in [1] or by producer recommendations. For multiple windows length l_g represent total length of all glass-frame connections.

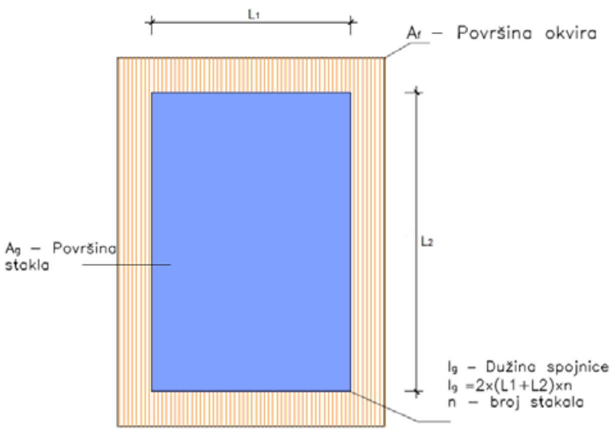

Figure 2. Parameters for calculation of heat transfer coefficient

3. Heat transfer coefficient calculation

Heat transfer coefficient calculation has been performed for window having different dimensions, frame and glass numbers. More concretely, glass dimensions are varied for PVC frame 5 cm. Double and triple glassed are considered, 6-12-6 mm and 6-12-6-12-6 mm, respectively. Dimensions were: width b=40–100 cm, height h=60-120 cm, with an increment 5 cm. PVC frames with two, three, five and six chambers have been analysed. Results are shown in Tabs. 1-3 and in Figs 3-5.

Table 1. Frame (5 cm) and glass surfaces

Transparent element	Glass Dimensions (cm)	Glass Surface (m^2)	Frame surface (m^2)
1	40 x 60	0.240	0.011
2	45 x 65	0.293	0.012
3	50 x 70	0.350	0.013
4	55 x 75	0.413	0.014
5	60 x 80	0.480	0.015
6	65 x 85	0.553	0.016
7	70 x 90	0.630	0.017
8	75 x 95	0.713	0.018
9	80 x 100	0.800	0.019
10	85 x 105	0.893	0.20
11	90 x 110	0.990	0.21
12	95 x 115	1.093	0.22
13	100 x 120	1.200	0.23

4. Comparative analysis of results

Based on the results obtained, the comparative analysis has been made for heat transfer coefficient change with changing of parameters affecting its value. The analysis is illustrated in the following diagrammes. In this analysis the effect of chamber and glass number on the heat transfer coefficient is followed. As the representative simple „9“ with glass dimensions 80 x 100 cm and frame width 5 cm will be used.

Figures 6 and 7 show heat transfer coefficient for double and triple glass, respectively, and different number of chamber.

5. Conclusion

Based on diagrams and results presented here, one can conclude that the increase of number of chambers does not affect significantly heat transfer coefficient for double glass. Figures 3 and 4 indicate that 0.6-3.5% of the reduction of heat transfer coefficient.

On the other hand side, if triple glass (6-12-6-12-6 mm) is used instead of double one (6-12-6 mm), Figure 5 indicates much more significant effect on heat transfer coefficient, up to 22-23%.

If diagrams shown in Figs. 6 and 7 are analysed, one can conclude that surface effect is different, but generally speaking its increase, regardless of number of chambers, lead to the single value. For triple glass this effect is more pronounced (8-11%) than for double glass (1-3%).

Tabela 2. Heat transfer coefficient for PVC two-chamber window with doublé glass 6-12-6 mm

Transparent element	Glass surface	Frame surface	Connection length	Glass heat transfer coefficient	Frame heat transfer coefficient	Connection heat transfer coefficient	Window heat transfer coefficient
	m²	m²	m	(W/m²K)	(W/m²K)	(W/m²K)	(W/m²K)
1	0.240	0.11	4	2.9	2.2	0.04	3.1371
2	0.293	0.12	4.4	2.9	2.2	0.04	3.1230
3	0.350	0.13	4.8	2.9	2.2	0.04	3.1104
4	0.413	0.14	5.2	2.9	2.2	0.04	3.0991
5	0.480	0.15	5.6	2.9	2.2	0.04	3.0889
6	0.553	0.16	6	2.9	2.2	0.04	3.0796
7	0.630	0.17	6.4	2.9	2.2	0.04	3.0713
8	0.713	0.18	6.8	2.9	2.2	0.04	3.0636
9	0.800	0.19	7.2	2.9	2.2	0.04	3.0566
10	0.893	0.20	7.6	2.9	2.2	0.04	3.0501
11	0.990	0.21	8	2.9	2.2	0.04	3.0442
12	1.093	0.22	8.4	2.9	2.2	0.04	3.0387
13	1.200	0.23	8.8	2.9	2.2	0.04	3.0336

Tabela 3. Heat transfer coefficient for PVC two-chamber window with triple glass 6-12-6-12-6 mm

Transparent element	Glass surface	Frame surface	Connection length	Glass heat transfer coefficient	Frame heat transfer coefficient	Connection heat transfer coefficient	Window heat transfer coefficient
	m²	m²	m	(W/m²K)	(W/m²K)	(W/m²K)	(W/m²K)
1	0.240	0.11	4	2.9	2.2	0.04	3.1371
2	0.293	0.12	4.4	2.9	2.2	0.04	3.1230
3	0.350	0.13	4.8	2.9	2.2	0.04	3.1104
4	0.413	0.14	5.2	2.9	2.2	0.04	3.0991
5	0.480	0.15	5.6	2.9	2.2	0.04	3.0889
6	0.553	0.16	6	2.9	2.2	0.04	3.0796
7	0.630	0.17	6.4	2.9	2.2	0.04	3.0713
8	0.713	0.18	6.8	2.9	2.2	0.04	3.0636
9	0.800	0.19	7.2	2.9	2.2	0.04	3.0566
10	0.893	0.20	7.6	2.9	2.2	0.04	3.0501
11	0.990	0.21	8	2.9	2.2	0.04	3.0442
12	1.093	0.22	8.4	2.9	2.2	0.04	3.0387
13	1.200	0.23	8.8	2.9	2.2	0.04	3.0336

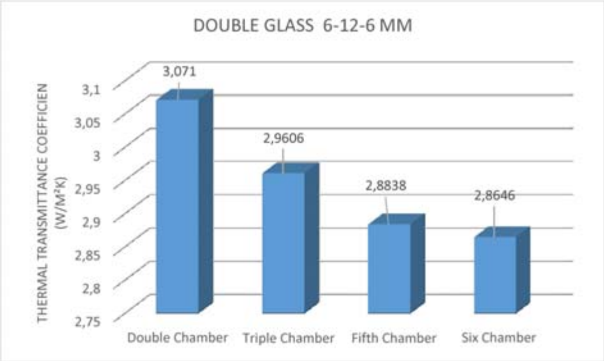

Figure 3. Heat transfer coefficient (W/m^2K) for transparent element "9", Tab. 1 for different number of chambers – double glass 6-12-6

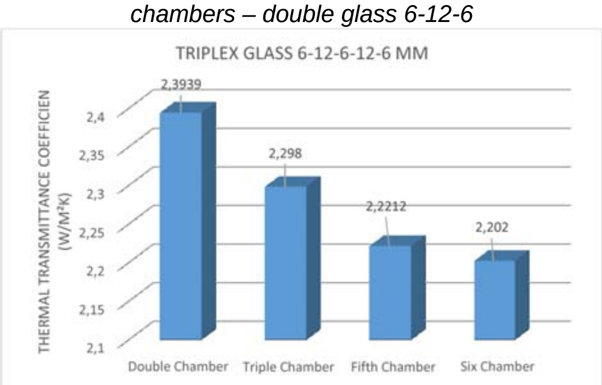

Figure 4. Heat transfer coefficient (W/m^2K) for transparent element "9", Tab. 1 for different number of chambers – triple glass 6-12-6-12-6 mm

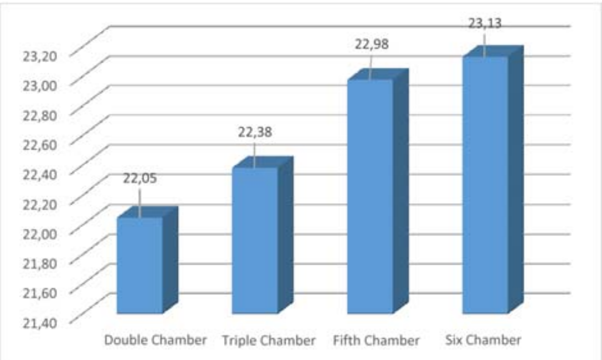

Figure 5. Heat transfer coefficient (W/m^2K) for transparent element "9" for different number of chambers and double and triple glasses, based on Fig. 1 and 2

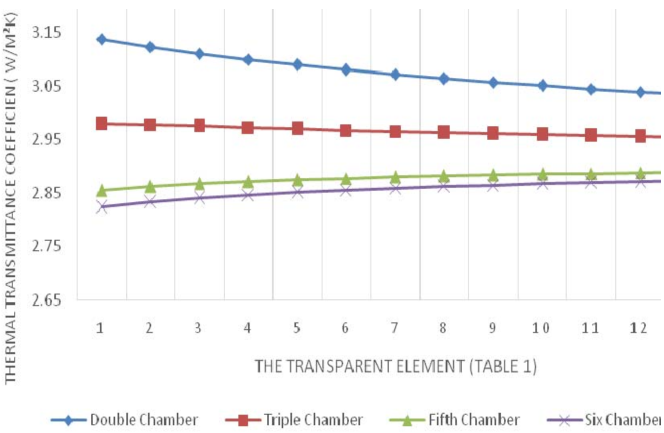

Figure 6. Heat transfer coefficient double glass and different number of chamber

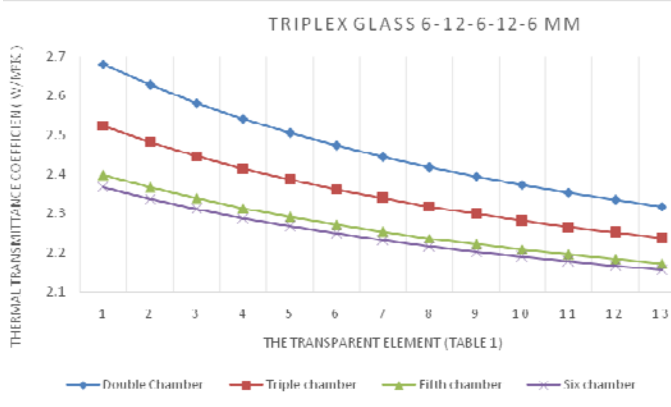

Figure 7. Heat transfer coefficient triple glass and different number of chamber

Therefore, one can conclude that the most effective for heat saving is the glass type (triple or double), than the surface of transparent elements, whereas the number of chambers has negligible effect.

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COMBINED SERBIAN AGRICALTURAL MACHINE FOR TILLAGE FERTILIZATION PREPARATION AND STABILIZATION OF SOIL AND SOWING

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Abstract

Combined Serbian Agricultural machine for tillage, fertilization, preparation and stabilization of soil and sowing (KRM) represents a new design of agricultural machine that combines multiple processes in one machine and allows faster land cultivation with better results. The machine is designed to work with rotating plow without influencing its work. It is estimated that it can provide 97.84 € savings per hectare per year.

Keywords: *Combined operation, agricultural, 3D modeling, innovative design*

1. Introduction

New processing way presented with a use of Serbian agricultural machine, or shorten KRM, is combination of all traditionally separately used operation in one single pass and it includes plowing, fertilization, mulching, flattening, sowing, stabilization of the soil and covering of the seeds. Every operation that has been specified is performed as individual operation which implies certain expenses as well as trampling of the already plowed soil which can lead to harmful soil compression. In order to reduce cost of soil cultivation and sowing there are technical solutions which consolidate certain operations, as well as reduced way of soil cultivation which implies cultivation without plow usage in order to decrease processing costs. This way of processing can be realized only in special conditions such as productions of cereals, but it is not recommended for a spring sowing plant cultures. New innovative way applies usage of a tractor on non-plowed area where one wheel turns on the rut and the other on the non-plowed area, so that the plow area remains undisturbed. KRM shown in a figure 1 is designed to compress plant remains into the soil in order to achieve properly prepared surface of the soil. By combining of multiple operations in one pass it is possible to achieve higher levels of moist in the soil which provides better conditions for the sprouting of the plants. One of the most important engineering tasks during the development was to design system that has capability to work on both dry as well as extremely wet soil.

Figure 1.Serbian agricultural machine- KRM

2. Prototype development

For the different phases of testing and development the whole machine was divided into different section. With this approach it was possible to develop different models and prototypes of individual parts separately.If any issues are discovered, and production must be stopped in order to redesign and redevelop certain parts, it is only on a local level of those parts. Whole system of the machine was divided into three main groups:

- Structural elements group
- Working elements group
- Support element for the tractor

3. Structural group

Furthermore the structural group elements were divided into the tree main sections:

- Base frame with all elements
- A frame
- Extension beam

Figure 2 represents a 3D model of a KRM with a structural group denoted with 1, working group denoted with 2 and support element for the tractor denoted with 3.

Furthermore a structural group can be divided in to Base frame denoted with 1A,A framedenoted with 1B and Extension beam denoted with 1C.

Base frame was produced as a rectangular space frame made out of a box tubes, [1]. Corners were reinforced in order to cope with extreme stresses developed during extremely wet ground conditions. Wheel mounting position was raised above the base frame plane in order to provide better weight distribution as well as the lower position for mountings for all working elements.

Since the plow is to be used in a combination with KRM,A framewas used to provide clearance during work as well as during rotation of a plow. In a case of early models and during the first phase of testing, The frame was constructed with 3 connection points. Two front points were used as pivoting points while the third one was positioned on the back and had an adjustable length. During the testing phase it was determent that significant stresses were accumulated at the third connector during the cornering and design was changed with a five point connection frame.

Extension beam was design with a length of 4870 mm in order to bypass a distance between base frame and a supported element on the tractor. Beam was created with a use of box tubes, [1], and reinforced with specially positioned and bended sheets, in order to produce maximal stiffness and provide adequate stress and strain distribution with the smallest weight possible.

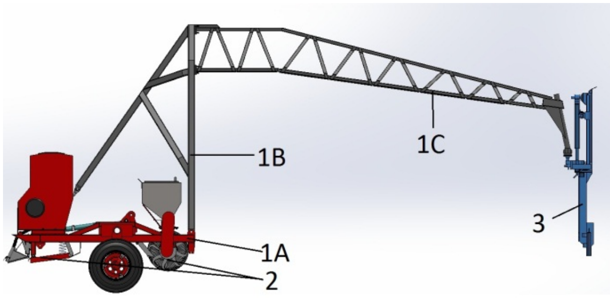

Figure 2.Machine design,1 structural elements, 2 working elements ,3 support element

4. Working elements

Working elements were designed so that each one can be adjusted to the specific conditions of the soil.

First working operation is performed with a use of specially design rotating element used for chopping of large clods of ground. It is made as a cylindrical roller with a main innovation in a form of specially shaped teeth, Figure 3. Teeth are designed to provide smallest contact area in order to reduce drag. Shape has a task to provide rotation of a cylinder, and thereby there was no need for additional drive train. Each row of teeth was angularly rotated in order to provide different time of contact with soil during one cycle of rotation.

In the next phase, vibrating plates, Figure 4, were used to flatten the ground. Plates were made with a pivoting point at the back and special spring preload system at the front of each plate. During work, the whole weight of the machine is transferred to the ground through this plate system.

Figure 3.Cylindrical roller with specially shape teeth

Figure 4.Plate elements system

For the planting of the crops, independent system powered by the motion of KRM, was designed. It has a task of both planting as well as covering the seeds with fresh soil, to protect it from direct influence of the elements. It is designed with a 14 separate planting heads, Fig. 5. Each one has its one shock absorber system used to prevent it from damaging in a case of hitting rocks or other debris.

Figure 5.Planting elements

Container, Fig. 6, used for fertilizer is positioned on the base frame. It is made of stainless steel in order to prevent rusting. It can be used optionally and has a built in pouring system. The system is connected to the cylindrical roller with a sprocket system in order to synchronize amount of fertilizer with the speed of the machine.

Figure 6.Fertilizer containe

5. Support element for the tractor

Support element for the tractor, Figure 7, represents one of the key elements needed for adequate use of the machine. It has a task of translating forward motion of the tractor to the machine, as well as to provide perfect positioning in accordance to the plow. With a use of a hydraulic cylinder it is possible to position a whole machine to either left or right side, depending on the position of the plow. Next to the wheel height operation, support element for the tractor is the only element powered by the hydraulic pressure.

Figure 7.Support element for the tractor

6. 3D modeling and numerical simulation

Parallel to the development of the physical model, a 3D numerical model was created in the Solidworks (Dassault Systems, France).The aim of this approach was to test each of the separate elements before they were made. Most of the pipe elements were developed as a parametric wire-frames in order to allow easiest changes possible determent by the development process. Because of the short development time, a small number of elements were subjected to the stress simulation. The 3D model was used to create a technical drawing and required production documentation for each element individually.

Individual motion study was performed for each element and system that was determine to have a motion during use, and in order to ensure adequate geometry in any given position. The 3D model of the whole assembly, including KRM, plow and a tractor is shown on figure 8.

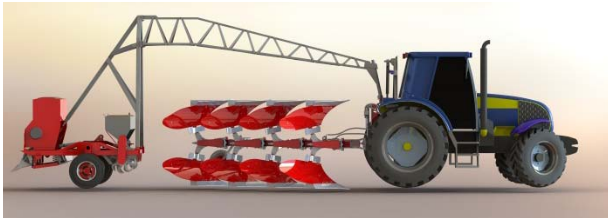

Figure 8. The 3D model of a whole assembly including KRM, plow and a tractor

7. Testing results

KRM is design of multiple new technological solutions which are design to save energy, and is easily possible to pair with a plow. With this approach it is possible to reduce amount of passes with a tractor trough already plowed soil, which is aim to reduce cost.Expected savings on a yearly level per one hectare obtained during preliminary testingare presented in the table 1.

Table 1.Expected savings

Parameter	Classic	SRMA	Saving ha	Saving ha/year
Fuel	47.58	25.1	22.48	17.31
Machine hours h/ha	2.66	1.33	1.33	66.5
Human labor h/ha	2.92	1.59	1.33	3.99
Equipment investment	14.86	9.87	4.98	4.99
Maintenance	14.28	9.23	5.05	5.05
TOTAL				97.84€

8. Acknowledgement

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SOME NOTICES ON TRADITIONAL CHALK AND TALK METHOD VS. CONTEMPORARY E-LEARNING

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Abstract

There are many discussions on the subject can traditional face to face or chalk-talk method be totally replaced with e-learning. In the paper some benefit and disadvantages of both teaching platform are represented. Experimenting with more innovation can improve direct instruction. The technology of e-learning will continue to complement the old fashioned mode.

Keywords: chalk and talk method, e-learning

1. Introduction

We will start from the point that the goal of the 21st century method of instruction is to prepare students to become not only productive members of the workplace, but also self-realized persons. They should be given the knowledge how to cope with the accelerate and permanent changeable modern way of living -in the situation that the generation of today faces more and more uncertainty, no life time employment, an unstable social climate, multicultural society. Some of the most important lessons for them are: how to become independent, responsible and raise their levels of creativity and cognition, how to learn problem solving, group collaboration, public speaking and research skill – all that will define success, employability and competitiveness in their future. It is hard to cover such a big subject, but we must admit that the education, and more specifically – the access to quality education, is one of the most important civil rights issues of today.

2. Two teaching platforms

In the same time the advances in information, computer and communication technology rapidly change the mode of knowledge transfer from teacher to learner, from professor to student. Today's teaching platforms have evolved from the traditional synchronous, face-to-face (figure 1), today known as "**chalk and talk**", to distance flexible manner, known as internet of web-based training, online learning, and finally as "**e-learning**", that can be synchronous, asynchronous, instructor-lead or computer-based, or combination.

Independently of today's hyperbolic world of education methods, the face-to-face method still remains major method of conveying classroom knowledge. The characteristic of this old-fashioned way of teaching method (figure 2) is usually "teacher-centric pedagogy", where teacher expose what they know to their students. To be successive the teacher should know the subject well, to inspire student's interest, explain new concepts in a number of ways, to quote interesting examples, to be really interested in a student progress, and present the course in a logical way that helps student to be well organized.

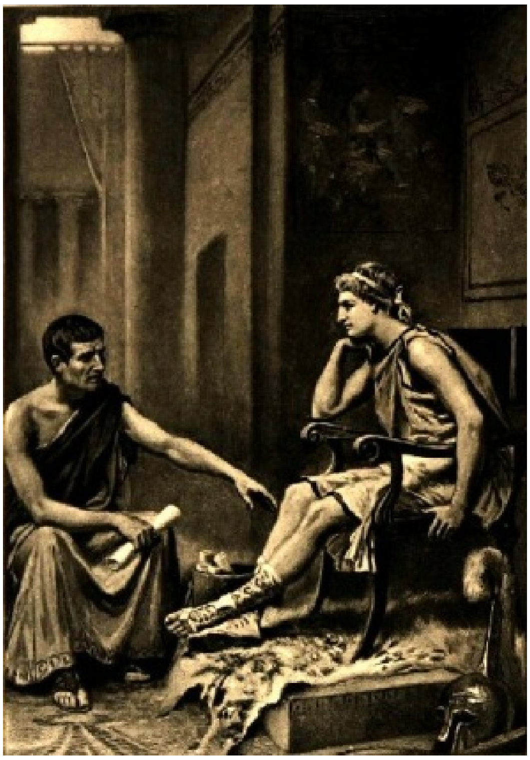

Figure 1 Aristotel teaches Alexander the Great, [1]

Fig. 2 Medieval classroom (Nothing has changed), [2]

It is known that some educators are born to be teacher, simply it is a talent. Probably they feel happy with his/her success and students feel that empathy. Many of them feel like artist, especially with the new white board markers (maybe they are stimulated by its smell!?).

However, those educators who overuse this method reduce the learning capacity of their students. They should be so positive to admit that the students are the ones who need to think, analyse, explain and interpret the content of the class. The teacher is often here only primary communicator of knowledge, without really knowing if the students have learned the material.

This chalk and talk method has some benefits, and also some disadvantages. Students remain in their seats paying attention and are supposed to be quiet while the teacher controls the class. Also, do not the need to worry about the content, because all what is important will be said by the teacher. It is especially good for the students that have the capacity to concentrate and learn what they heard. However, the problem is that many students do not have such capabilities, do not learn to work collaboratively; many get bored, and have little or no willingness to participate in class. With using different (old and new) audio-visual add, like overhead projector or slide projector, computers and PowerPoint etc., the process of teaching maybe more effective.

But it is still the situation where the students are passive learners. The exit is in experimenting with more innovative styles of teaching that is known as inquiry or discovery learning. That way, space for more "student-centred" work is opened.

In the other hand, e-learning use technology in wide aspects and represents any learning deliver by some electronic means (figure 3). It covers a huge set of applications and processes, such as distributed learning, distance learning, virtual classrooms, digital collaboration etc. E-learning includes delivery of contents via internet, audio-and video tapes, satellite broadcast, interactive TV, CD-ROM and more. This teaching-learning platform, with magic letter "e-", is comprehensive, dynamic, with today's content in real time, on-line experts, best sources etc. In a truly open regime student can study in his/her own time in his/her own location at his/her peace – in the style: you get what you need when you need. And it is very important that e-learning is individual, everybody can select activities from a personal menu of learning opportunities most relevant to one's background, job and carrier at that very moment. It enables that learners can select a favourite format or learning method or training provider. Further advantages include possibility of information storage, linkage as over one's own website or global website. It is easily upgradeable from year to year and can be distributed with ease to all concerned.

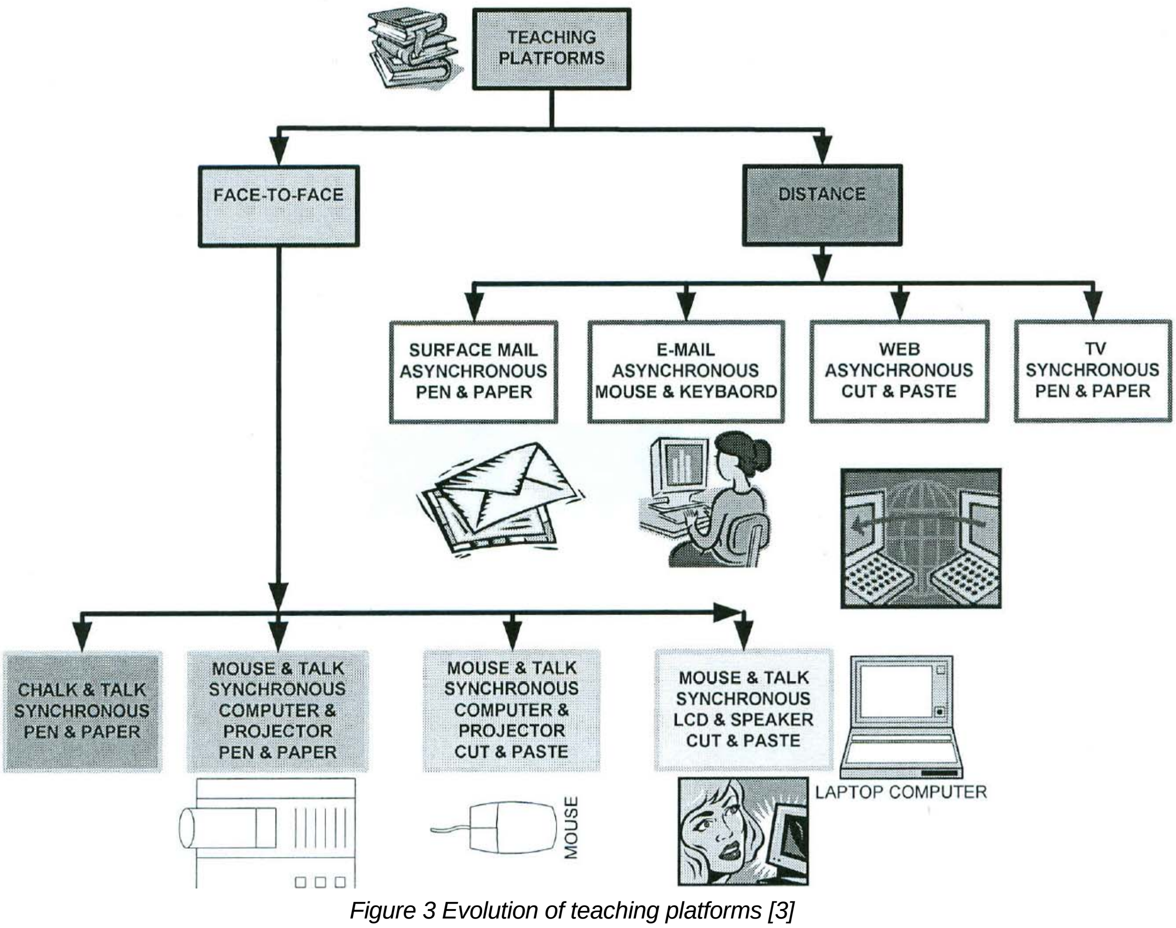

Figure 3 Evolution of teaching platforms [3]

However, in the academic sense, e-learning face problems, one of which is assessment tests or assignments given to the students. It is relatively easy with objective testing or multiple choice questions. In our time more automated and web-based versions for assessing are available. But such use of grading of essays is still difficult issue. Also, the challenge comes when it is need to make simple sketches during on-line teaching. But this art is also in the state of permanent upgrading.

As we can see the "e-"is so comprehensive and dominant in their possibilities to convey information that is reasonable to put a question: can traditional chalk-talk be totally replaced with e-learning, or can mouse and keyboard chase out chalk and black (white) board?

This is very old, but still actual question. It represents the content of many discussions on internet's social website (Facebook, Tweeter and so on). For many experts the answer is negative. They think that e-learning cannot replace the traditional method of learning, because face-to-face interaction is richest mode of communication and will remain so for all times to come. In natural sciences, for examples, a simplest experiments, that teacher performs personally, is worth more than the most advanced artificial electronic simulation. E-learning is just another tool, another kind of chalk.

Other opinion is that classical learning method can be totally replaced by e-learning, but this process must be in gradual manner. E-teaching module takes time and resources to make it acceptable and readable by the students, but its universality makes that active participation of studentsenables student with different backgrounds, learning styles and pace of learning to understand the concept better.The trivial answer is that it is better to combine the two platforms.

In all relevant discussion we must not forget "b-learning" (book learning) that allow many learners to learn from original masters. B-learning cannot replace teachers, but can change and improve the nature of learning. Unfortunately, the visual types of information are more suitable to the young people.

3. Conclusion

Based on presentation and discussion in this paper, one can conclude that there is no definitive answer to old dilemma, which learning method is the best, but rather, one can conclude that blended learning, combining advantages of different methods, is the optimal solution

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THE PrESmod LANGUAGE FOR MODELING (2D)

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Abstract

The PrESmod modeling language uses lines/commands for the description of entities and modifications such that characteristic points, coordinates of characteristic points and other geometrical parameters, relation position expressions and also two types of relation expressions for selecting one of two possible point sets can be used in the primary (geometric) description. Elements from the collection for entity description can be stringed along in different ways. The description can call any characteristic from another or the same real or fictional element. Coordinates and other characteristic geometrical parameters can be used besides common elements in the expression for assigning values to geometrical characteristics.

Keywords: Programming Language, Parametric modelling, Manufacturing, PrESmod

1. Introduction

AutoCAD as the CAD packet most present on the market contains quite rigid procedures when describing forms which are being drawn/modeled. Besides that, in this and other CAD/CAM systems diversity of descriptions is small. It is not possible to in the primary (geometrical) description simultaneously use characteristic points, point coordinates separately and other parameters, and especially not relation statements. Modeling with general dimensions (variables) or a combination of general and concrete dimensions (constants) is different from drawing with concrete dimensions.

With the PrESMod language for 2D geometrical modeling description of the form of technical objects is simple and direct. Description is possible in many ways (diverse descriptions) and it is easy without rigid rules.

The approach to entity selection for modifications in existing CAD systems is not all-inclusive. Partial approaches to this problem are present. In this paper an attempt is made to solve the approach to entity selection in a more universal fashion.

2. General approach to 2D form description

The PrESMod modeling language is primarily intended for modeling, i.e. drawing elements and details and other graphs, i.e. graphical elements used when designing.

This language is used to describe a form with general or a form with concrete dimensions or a combination of general and concrete dimensions of the modeled object.

Expressions containing standard mathematical operations (adding, subtracting, multiplying, dividing, powering), standard mathematical functions (sine, cosine, tangent, logarithm) variables, constants, coordinates of entity section points and other characteristic parameters (diameter, radius, angle, length) of an entity and also the distance between defined points and coordinates of entity section points can be used when defining values of any point (its set of coordinates), point coordinates and other characteristic parameters. Besides that, the value of the coordinate subset of some characteristic points of any other entity can be added to the description of the value of a characteristic point. When an entity is described with a function, the function expression (domain and codomain) can be formed in a similar way as when defining values of characteristic coordinates and other characteristic geometric parameters. Relation expressions (tangential, perpendicular, parallel) are used to define the entity position in reference to another entity.

Relation expressions can be used to give the relation between positions of points of the described entity (using point coordinates and other characteristic geometrical parameters in the relation expression). These are relation expressions where the left and right sides of the expression (larger, smaller and all relations containing the relation larger or smaller) contain expressions which can use coordinates and other characteristic entity parameters besides standard mathematical operations, standard mathematical functions, variables, constants. The expressions on the left and right side of the relation can be formed in the same way as when defining values of any other geometrical characteristic of an entity.

Besides this, a special type of expression, which has an expression on only one side of the relation (larger, smaller or relations containing these relations) and nothing on the other side, can be used here.

These two types of relation expressions can be used for describing entities, when, based on the remaining part of the primary entity, description two or more solutions can exist, i.e. two or more sets of points for the given entity. In this case this expression determines (requests) which of these two point sets should be singled out.

This is solved by including coordinates and other characteristic geometrical parameters in the relation expression. For a special type of relation expression this is most easily solved by requesting that the value of some coordinate of a specific point or the value of some parameter is larger or smaller (for example the x coordinate of some characteristic point is larger, the angle smaller, diameter larger and similar).

Expressions containing relations closer, further, closest and furthest, exist besides these two types of relation expressions. Characteristic entity points are used in these expressions besides stated relations.

Real and imaginary entities can exist in this case, i.e. entities which are drawn and ones that are not. Imaginary entities are primarily used for an easier description of a real entity. Imaginary entities have all characteristics of a real entity and in relation to them can use position relations and all other characteristics (characteristic points, coordinates of characteristic points, characteristic geometrical parameters and other characteristics) for the description of another real or imaginary entity.

These characteristics can be loaded directly or indirectly (they are considered to be there). One file (list and similar) containing a description of a group of basic entities (where descriptions of individual basic entities are clearly separated) can be used to describe any complex graphical entity:

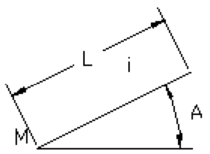
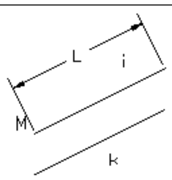
– (identification; entity; primary and secondary description)
– (identification; entity; primary and secondary description)
– ...
– (identification; entity; primary and secondary description)

3. Examples of entity definitions

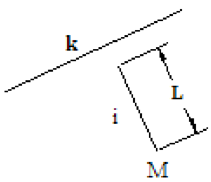
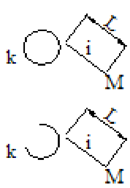
We have here several definitions of entities straight line and arc. A scheme, general definition and examples of entity definition are given for each definition.

The lexical, semantical and syntactic structure of the PrESMod modeling language is given in detail in [a]. In this case only element denotations are given, which are used in entity descriptions in definitions given here:
M denotes the starting point; N denotes the final point; C denotes the arc center; L is the length of the straight line; R is the arc radius, A – angle; xm-x coordinate of the start point; xn-coordinate of the end point; //– parallel; I – perpendicular.; IC – tangential; xn – x coordinate of the end point; yn – y coordinate of the end point.

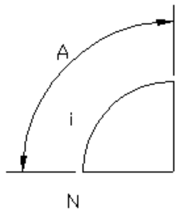
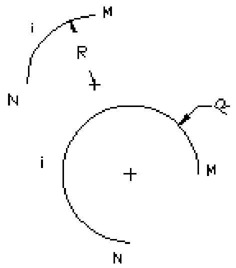
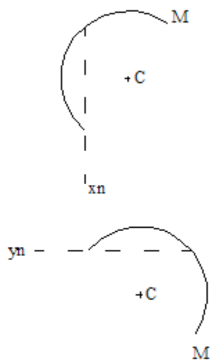
Oriented straight line

 a)	**General definition** **i;L: M=am1,am2;L=al;A=aa LT**
	Examples of definitions of a straight line 18;L: M=2,2;L=20.5;A=pi/6 _._ 19;L: L=(xm(15)-xn(15))*sin(beta);A=PI;M=S(1) 20;L: M=xm(1)+10,ym(1);A=45%;L=a+b-6 21;L: M=N(4);L=L(5);a=30% __ 22;L: M=N(2);L=xm(4)-xm(3);A=A(1)+(pi/6)
 b)	**General definition** **i;L: M=am1,am2;L=al;//(k); direction LT**

	Examples of definitions of a straight line
	23;L: M=30,10;//(2);L=25;xm<xn _._
	24;L: M=(d1+d2)*2,d3;L=L(5);//(12);ym+yc(3)<yn
	25;L://(10);L=b1;XM=xm(10)+10;YM=ab;yn>

 c)	**General definition** **i;L: M=am1,am2;L=al;I-(k); direction LT**
	Examples of definitions of a straight line 23;L: M=30,xm(5)+2;I-(2);L=20;xm>xn _._ 24;L: M=xm(12)+5,ym(12);L=L(5);I-(15);A< 25;L:I-(11);L=b1;XM=xm(10)+10;YM=20;yn> If the length and the relation expression for direction are omitted in the description, the straight line reaches entity k.
 d)	**General definition** **i;L: M=am1,am2;IC(k);L=al; position LT**
	Examples of definitions of a straight line 11;L: M=1,6;L=l1;IC(2);A<arctg(yc(1)-ym)/(xc(1)-xm)) 12;L: M=m(1);L=l1*sin(ax);IC(4);A< 13;L: M=a*cos(b1),e1+2.0;IC(3);L=e1+e2;A> __ The line position in relation to the arc or circle can be determined using the relation statement that the angle of line A is smaller or equal to line M(i)-C(k) – example line 11 ; If the relation statement for the position is left out then a line with a lower angle is drawn A; If it is defined that A< (line 12) a line with a smaller angle is drawn If it is defined that A> (line 13) a line with a larger angle is drawn

Arc

 a)	**General definition** **i;C: M=am1,am2;N=an1,an2;A=aa LT** **Examples of definitions of an arc** 15;c: M=20+b,c;N=n(5);A=45% __ 16;C: A=a(5);N=xm(5),xn(5)+g1;M=(a+d)/2.0,d*cos(gama) 17;C: M=5,5;n=6,6;A=am(5)+pi _._ 18;C: A=a(4)+(pi/4);M=Xm(2)+30,ym(2);N=xm,ym-30 The angle is given in radians; if it is given in degrees then this must be emphasized by adding % to the symbol, like in the example of arc 15.
 b)	**General definition** **i;C: M=am1,am2;N=an1,an2;R=ar; position center LT** **Examples of definitions of an arc** 19;C: M=40,40;n=20,20;r=30 __ 20;C: M=a,b;N=a+c,bc;N=s(3);R=d5/2;yc>(ym+yn)/2 22;C: M=2,2;n=1,1;R=(((xm-xn)~2+(ym+yn)~2)~0.5)/2.0 If the center is in the middle of the straight line joining points M and N (MN=2*R) then the relation expression for the arc center position is excessive.
 c)	**General definition** **i;C:C=ac1,ac2;M=am1,am2;xn=an1; position LT** **i;C:C=ac1,ac2;M=am1,am2;yn=an2; position LT** **Examples of definitions of an arc** 15;C: M=30,20;c=20,20;xn=15;L> 16;c: M=a,b+8;C=a,b;xn=a-4;L< 17;C:M=xm(5),xn(5);C=xm(5),ym(5)+b;yn=yc+b/2;xn<xc

4. Conclusions

The main advantages of the modeling language (PrESmod) primarily lay in the availability of all possible entity description variants. Characteristic points, coordinates of characteristic points and characteristic parameters and also relation expressions used in the primary (geometrical) description enable a large number of variations for the description of each standard entity (straight line, arc, circle). Description of entity geometry can be done using set functions in a parametric and non-parametric form. The same language can be used to describe forms with specific dimensions (constants), general dimensions (variables) and a combination of specific and general dimensions. The use of fictive entities is also allowed, facilitating the description of other entities.

All characteristics of real and fictive entities can be used for describing other entities. In short the description of entities given in the PrESmod modeling language is user friendly as the description is short and description variety is high, besides very good description clarity.

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FATIGUE BEHAVIOUR OF MODELS USING 3D PRINTING TECHNOLOGY

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Abstract

This paper presents 3D printing techniques, Stereolithography, Fused deposition modeling, PolyJet 3D Printing and Selective Laser Sintering. Fatigue Behavior of parts, with experimental results of modeled parts usingof those technologies.

Keywords: 3D printing, FDM, Fatigue.

1. Introduction

3D printing, also known as an additive manufacturing, is any of different processes used to synthesize a three-dimensional object. In 3D printing, additive processes are used, in which successive layers of material are laid down under computer control. These objects can be of almost any shape or geometry, and are produced from a 3D model or other electronic data source. A 3D printer is a type of industrial robot.

2. Stereolithography

Stereolithography (SLA or SL; alias optical fabrication, photo-solidification, solid free-form fabrication, solid imaging and Resin printing) is an additive manufacturing or 3D printing technology used for producing models, prototypes, patterns, and production parts up one layer at a time using lithographic methods, [1]. For example by curing a photo-reactive resin with a UV laser or another similar power source [2]. Stereolithography is an additive manufacturing process which employs a vat of liquid ultraviolet curablephotopolymer "resin" and an ultraviolet laser to build parts' layers one at a time. For each one layer, the laser beam traces a cross-section of the part pattern on the surface of the liquid resin. Exposure to the ultraviolet laser light cures and solidifies the pattern traced on the resin and joins it to the layer below.

After the pattern has been traced, the SLA's elevator platform descends by a distance equal to the thickness of a single layer, typically 0.05 mm to 0.15 mm (0.002 in to 0.006 in). Then, a resin-filled blade sweeps across the cross section of the part, re-coating it with fresh material. On this new liquid surface, the subsequent layer pattern is traced, joining the previous layer. A complete 3-D part is formed by this process. After being built, parts are immersed in a chemical bath in order to be cleaned of excess resin and are subsequently cured in an ultraviolet oven.

Stereolithography requires the use of supporting structures which serve to attach the part to the elevator platform, prevent deflection due to gravity and hold the cross sections in place so that they resist lateral pressure from the re-coater blade. Supports are generated automatically during the preparation of 3D Computer Aided Design models for use on the stereolithography machine, although they may be manipulated manually. Supports must be removed from the finished product manually, unlike in other, less costly, rapid prototyping technologies.

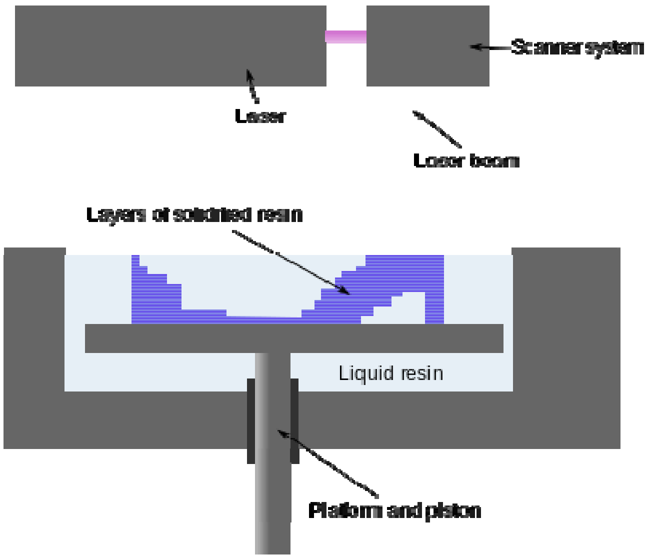

Figure 1. Stereolithography apparatus, [3].

3. Fused deposition modeling (FDM)

Fused deposition modeling (FDM) is an additive manufacturing technology commonly used for modeling, prototyping, and production applications. It is one of the techniques used for 3D printing.FDM works on an "additive" principle by laying down material in layers; a plastic filament or metal wire is unwound from a coil and supplies material to produce a part.The technology was developed by S. Scott Crump in the late 1980s and was commercialized in 1990, [4]. The term *fused deposition modeling* and its abbreviation to *FDM* are trademarked by Stratasys Inc. The exactly equivalent term, *fused filament fabrication* (*FFF*), was coined by the members of the RepRap project to give a phrase that would be legally unconstrained in its use. It is also sometimes called Plastic Jet Printing (PJP).

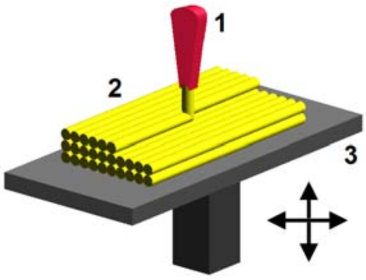

Figure 2. Fused deposition modelling: 1 – nozzle ejecting molten material, 2 – deposited material (modeled part), 3 – controlled movable table, [3]

The FDM starts with a software process which processes an STL file (stereolithography file format), mathematically slicing and orienting the model for the build process. If required, support structures may be generated. The machine may dispense multiple materials to achieve different goals: For example, one may use one material to build up the model and use another as a soluble support structure, or one could use multiple colors of the same type of thermoplastic on the same model. The model or part is produced by extruding small flattened strings of molten material to form layers as the material hardens immediately after extrusion from the nozzle A plastic filament or metal wire is unwound from a coil and supplies material to an extrusion nozzle which can turn the flow on and off. There is typically a worm-drive that pushes the filament into the nozzle at a controlled rate. The nozzle is heated to melt the material. The thermoplastics are heated past their glass transition temperature and are then deposited by an extrusion head. The nozzle can be moved in both horizontal and vertical directions by a numerically controlled mechanism. The nozzle follows a tool-path controlled by a computer-aided manufacturing (CAM) software package, and the part is built from the bottom up, one layer at a time. Stepper motors or servo motors are typically employed to move the extrusion head. The mechanism used is often an X-Y-Z rectilinear design, although other mechanical designs such as deltabot have been employed. Although as a printing technology FDM is very flexible, and it is capable of dealing with small overhangs by the support from lower layers, FDM generally has some restrictions on the slope of the overhang, and cannot produce unsupported stalactites. Myriad materials are available, such as Acrylonitrile Butadiene Styrene ABS, Polylactic acid PLA, Polycarbonate PC, Polyamide PA, Polystyrene PS, lignin, rubber, among many others, with different trade-offs between strength and temperature properties. Recently a German company demonstrated for the first time the technical possibility of processing granular PEEK into filament form and 3D printing parts from the filament material using FDM-technology, [6].

4. FDM Benefits

- The technology is clean, simple-to-use and office-friendly
- Supported production-grade thermoplastics are mechanically and environmentally stable
- Complex geometries and cavities that would otherwise be problematic become practical with FDM technology

5. PolyJet

PolyJet 3D printing is similar to inkjet printing, but instead of jetting drops of ink onto paper, PolyJet 3D Printers jet layers of curable liquid photopolymer onto a build tray.

The process is simple:

- **Pre-processing:** Build-preparation software automatically calculates the placement of photopolymers and support material from a 3D CAD file.
- **Production:** The 3D printer jets and instantly UV-cures tiny droplets of liquid photopolymer. Fine layers accumulate on the build tray to create a precise 3D model or part. Where overhangs or complex shapes require support, the 3D printer jets a removable gel-like support material.
- **Support removal:** The user easily removes the support materials by hand or with water. Models and parts are ready to handle and use right out of the 3D printer, with no post-curing needed.

PolyJet 3D Printing technology offers many advantages for rapid tooling and prototyping, and even production parts including astonishingly fine detail, smooth surfaces, speed and precision.

- Create smooth, detailed prototypes that convey final-product aesthetics.
- Produce short-run manufacturing tools, jigs and assembly fixtures.
- Produce complex shapes, intricate details and smooth surfaces.
- Incorporate color and diverse material properties into one model with the greatest material versatility available.

6. Selective Laser Sintering

Selective Laser Sintering (SLS) is an additive manufacturing (AM) technique that uses a laser as the power source to sinter powdered material (typically metal), aiming the laser automatically at points in space defined by a 3D model, binding the material together to create a solid structure. It is similar to direct metal laser sintering (DMLS); the two are instantiations of the same concept but differ in technical details. Selective laser melting (SLM) uses a comparable concept, but in SLM the material is fully melted rather than sintered,[7] allowing different properties (crystal structure, porosity, and so on). SLS (as well as the other mentioned AM techniques) is a relatively new technology that so far has mainly been used for rapid prototyping and for low-volume production of component parts. Production roles are expanding as the commercialization of AM technology improves.

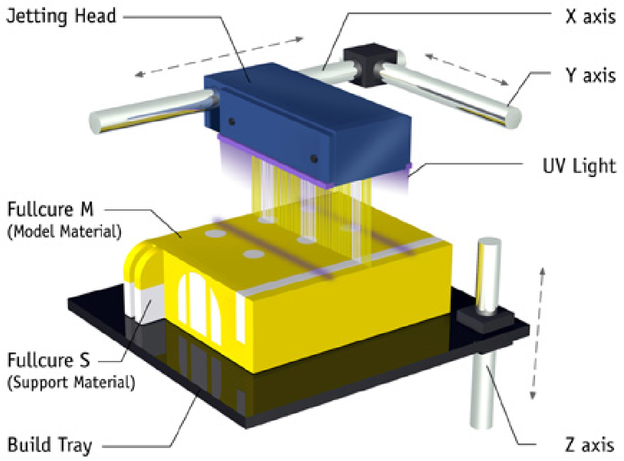

Figure 3. PolyJet, [5].

When we are comparing all those technology it is clear that all are additive manufacturing technologies. All technologies are clean and user (office) friendly for use. SLA, FDM and PolyJet are 3D printing technologies. Dissimilar from some other additive manufacturing processes, such as stereolithography (SLA) and fused deposition modeling (FDM), SLS does not require support structures because the part being constructed is surrounded by unsintered powder at all times, this allows for the construction of previously impossible geometries.

Also is we will mention again that FDM starts with a software process which processes an stereolithography file format, mathematically slicing and orienting the model for the build process. SLS technology is in wide use around the world due to its ability to easily make very complex geometries directly from digital CAD data. While it began as a way to build prototype parts early in the design cycle, it is increasingly being used in limited-run manufacturing to produce end-use parts. One less expected and rapidly growing application of SLS is its use in art.

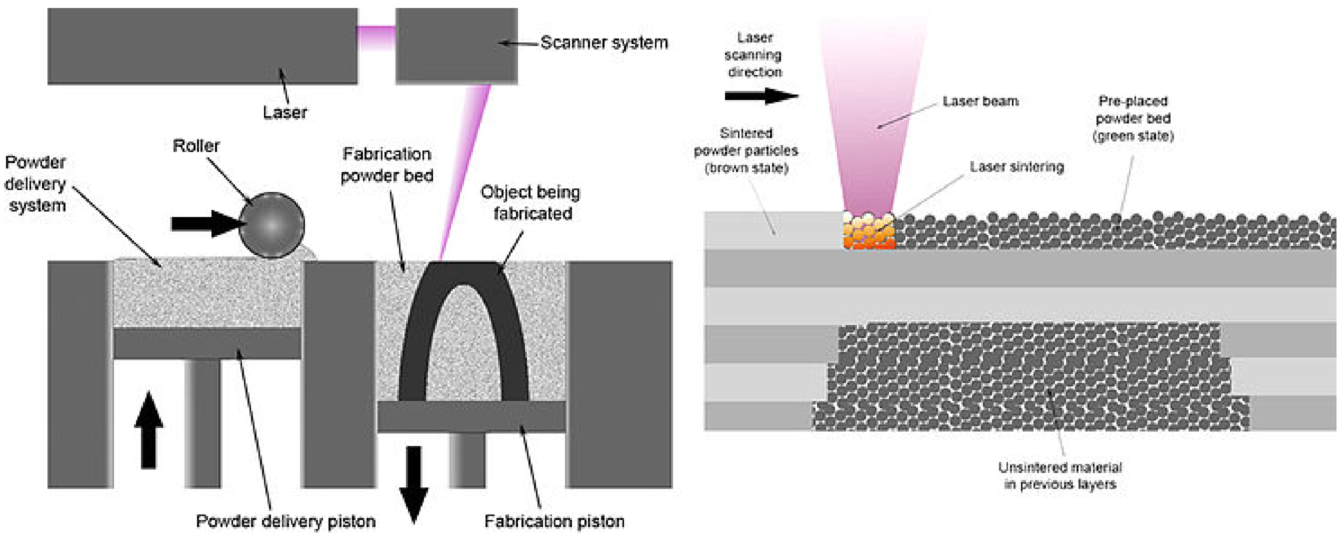

Figure 4. Selective laser sintering process [3].

7. Fatigue behviour of printed objects

Fatigue is an important design consideration for parts subjected to cyclical loading or vibration. In such applications, an uniaxial fatigue diagram (see Fig.5) could be used to predict product life. These curves can be used to determine the fatigue endurance limit, or the maximum cycle stress that a material can with stand without failure. According to the Figure 5, we can conclude that temperature in FDM printer machine, in nozzle/chamber changes during producing samples, does not affect on fatigue test of ULTEM 9085. Also it is very important to notice that ULTEM resin can be ideally suited to the design of long-term high temperature and mechanically stressed applications as confirmed by the uniaxial fatigue diagram in Figure 5.

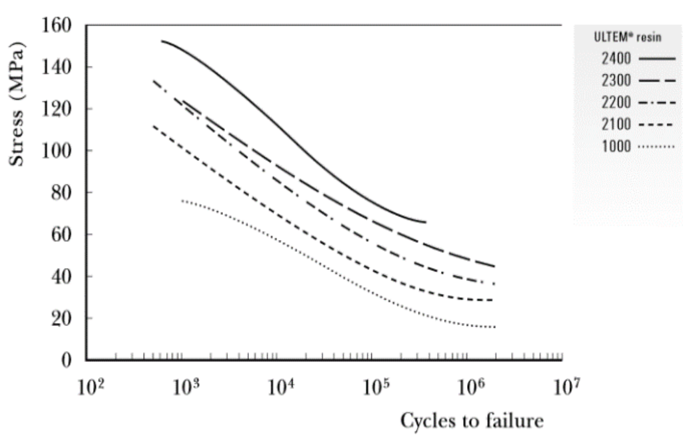

Figure 5. Uniaxial fatigue test of ULTEM, [10]

When considering the mechanical properties of any thermoplastic material, designers must recognize the effects of temperature, stress level and load duration on material performance.

ULTEM resin displays excellent creep resistance even at temperatures and stress levels which would preclude the use of many other thermoplastics. For other polymers we need experimental data like in Figure 5, mechanical and thermal properties, to make this kind of conclusions. But generally, temperature in nozzle /chamber of FDM printer machine does not negatively affects on fatigue behaviour of printed model.

Fatigue ratio - The dimensionless fatigue ratio f is the ratio of the stress required to cause failure after a specific number of cycles to the yield stress of a material. Fatigue tests are generally run through 10^7 or 10^8 cycles. A high fatigue ratio indicates materials which are more susceptible to crack growth during cyclic loading.

8. Applications

In this work we will add example in Medicine is often used Stereolithography as a Rapid prototyping process that creates solid physical models directly from computer data. In industry this data comes from 3D computer-aided design (CAD) data. The process can also be used to build highly accurate replicas of human (or animal) anatomy by using computer images from medical scanners, [9]. Although the advent of improved 3D computer reconstruction and virtual surgical planning means that in some cases models are not needed they remain popular for complex surgeries particularly in cranial surgery, maxillofacial surgery, oral surgery and neurosurgery. Surgeons use models to help plan surgeries but prosthetists and technologists also use models as an aid to the design and manufacture of custom-fitting implants. Medical models are frequently used to help in Medical modelling involves first acquiring a 3D CT scan (or other form of scan data). The CT data should be in a suitable format and acquired using suitable parameters to obtain a high quality model. This data consists of a series of cross sectional images of the human anatomy. In these images different tissues show up as different levels of grey. Selecting a range of grey values enables specific tissues to be isolated. A region of interest is then selected and all the pixels connected to the target point within that grey value range are selected. This enables a specific organ to be selected. Most frequently this will be bone but it could be any tissue that can be identified in the scan image. This process is referred to as segmentation. The segmented data may then be interpolated and have other processes performed on it to translate it into a format suitable for the stereolithography process. There are potential errors possible when making medical models using stereolithography but these are easy to avoid with practice and well trained operators, [3].

9. Conclusions

When we comparing all those technology it is clear that all are additive manufacturing technologies. All technologies are clean and user (office) friendly for use. SLA, FDM and PolyJet are 3D printing technologies. Dissimilar from some other additive manufacturing processes, such as stereolithography (SLA) and fused deposition modeling (FDM), SLS does not require support structures because the part being constructed is surrounded by unsintered powder at all times, this allows for the construction of previously impossible geometries. Also is we will mention again that FDM starts with a software process which processes an stereolithography file format, mathematically slicing and orienting the model for the build process.

According to the historical and technological process dimensional tolerance depend of 2 most important factors, technology of fabrication, and materials witch we use. Dimensional tolerances are the lowest for the Sterioliography, then comes FDM, after that PojyJet, and best results we can get using Selective Laser sintering.

10. Acknowledgement

The work reported here has been supported by the research projects Ministry of Education, Science and Technological Development, Republic of Serbia, TR 35013. The support is gratefully acknowledged.

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WELD REPAIR OF A P91 STEAM PIPE WITH OVER 100.000 OPERATING HOURS EXHAUSTED LIFE

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Abstract

The paper presents the challenges determined by a weld repair of a P91 Hot Reheat pipe which was in service for more than 100,000 operating hours. The pipe was subjected to creep damage during operation and unacceptable defects were found during a regular outage at a butt weld through advanced UT methods of investigation. Defects found were considered to be a result of long time exposure to creep conditions (creep cracks) located at the root pass of the welded joint. Because of long time exposure of the pipe to creep conditions, it was recommended its repair during the next regular outage. Repair done on this pipe was following the ASME Codes for in-service inspection of power plant components as well as other applicable ASME Codes and recommendations. Further on, one shall describe the complete procedure as well as the stages of project development together with various challenges very often recorded in day-by-day activities and the solutions taken to overtake these challenges as well as the final results of it.

Keywords: weld repair steam pipe, life

The 460 MW one unit, coal-fired plant decided to conduct a thorough non-destructive testing on the Hot Reheat pipe in order to assess its condition after long time service (over 100.000 operating h). Hot Reheat (HR) pipe was subjected to creep damage during operation and unacceptable defects were found during a regular outage at a butt weld through advanced UT methods (TOFD) of investigation. Defects found were considered to be a result of long time exposure to creep conditions (creep cracks) located at the root pass of the welded joint. Because of long time exposure of the pipe to creep conditions, it was recommended its repair during the next regular outage.

Repair done on this pipe was following the ASME Codes for in-service inspection of power plant components [1] as well as other applicable ASME Codes and recommendations.

Further on, one shall describe the complete procedure as well as the stages of project development together with various challenges very often recorded in day-by-day activities and the solutions taken to overtake these challenges as well as the final results of it.

2. Description of the component to be repaired

Once the decision was take to conduct repair of an original weld on the HR pipe, the first step was to set up the repair plan. P91 is a steel highly sensitive to welding. A careful preheating, welding, NDT and post weld heat treatment should be conducted on components manufactured from P91 material. This becomes more complicated when repairs are involved on components long-time exposed to creep damage as the one from our example.

HR pipe operating conditions are:

- Design operating temperature – 540 °C
- Design operating pressure – 40 bar

HR pipe has the following sizes:

- OD – 812 mm (32”)
- Thickness – 25.4 mm (1”)

P91 material according to ASME Section II, part A, [2], is described in the SA-335/SA-335M standard [3]. It has the following chemical composition [3]:

- Carbon – 0.08–0.12%
- Manganese – 0.30–0.60%
- Phosphorus (max) – 0.020%
- Sulfur (max.) – 0.010%
- Silicon – 0.20–0.50%
- Chromium – 8.00–9.50%
- Molybdenum – 0.85–1.05%
- Others: V 0.18–0.25, N.030–0.070, Ni 0.40 max. Al 0.02 max. Cb 0.06–0.10, Ti 0.01 max. Zr 0.01 max.

Tensile requirements are as follows, [3]:

- Tensile strength (min.) [MPa] – 585
- Yield strength (min.) [MPa] – 415

Elongation requirements are as follows, [3]:

- Elongation in 2 in. or 50 mm (or 4D), min., [%]: – longitudinal 30, transversal 20.
- Basic minimum elongation for wall 8 mm and over in thickness, strip tests, and for all small sizes tested in full section.

P91 is classified according to ASME Section IX, [4] Table QW-422 as P-No. 15E material.

3. Setting up the repair plan

Considering the component expended life and operating conditions, one was decided to avoid from the beginning a local repair which may cause not only local problems such as local changes in the martensitic structure but also would eventually induce significant residual stresses which would later on strongly accelerate the operation creep damage taking place in the pipe.

Therefore, a complete cut off of the old weld, a new weld preparation on both sides fn the cut area and a new re-weld should be the right approach in this case.

In addition to this, once re-weld should be started, proper preheating (with heating pads), pre-heat maintenance and post weld heat treatment (PWHT) shall be apply.

Preheating, preheat maintenance and PWHT requirements were selected according to ASME B31.1, [5]. Based on this, the following parameters were selected:

- Preheating: 200 °C
- Bake out at 300 °C
- PWHT: 704 °C – 760 °C

The PWHT values were selected to be in the range of 730–740 °C based on [5] and [6] recommendations. Proper care was taken to ensure that the 760 °C temperature threshold shall not be overtaken. As per [7], the lower A_{C1} temperature shall not be overtaken in any case in order to avoid complete damage of the P91 material properties, meaning a significant drop in the creep resistance. The chart for preheating, preheating maintenance, bake-out and PWHT is presented in details in Fig. 1.

After performing the complete PWHT, as a check of the successfulness of the PWHT, hardness tests were conducted on the BM, HAZ and WM in various locations around the weld. According to [6], this method allows us to perform field tests and obtain rather fast results to confirm the proper performance of the PWHT, considering the fact that P91 material experiences a hardening process during its operation in creep conditions or during the weld repair. Thus, as per [6], the new base material has a hardness of around 220 HV, hardness of welds prior to PWHT could go up to 450 HV. Therefore, monitoring the hardening process of the weld repaired zones was considered to be a proper tool for evaluating the PWHT performance.

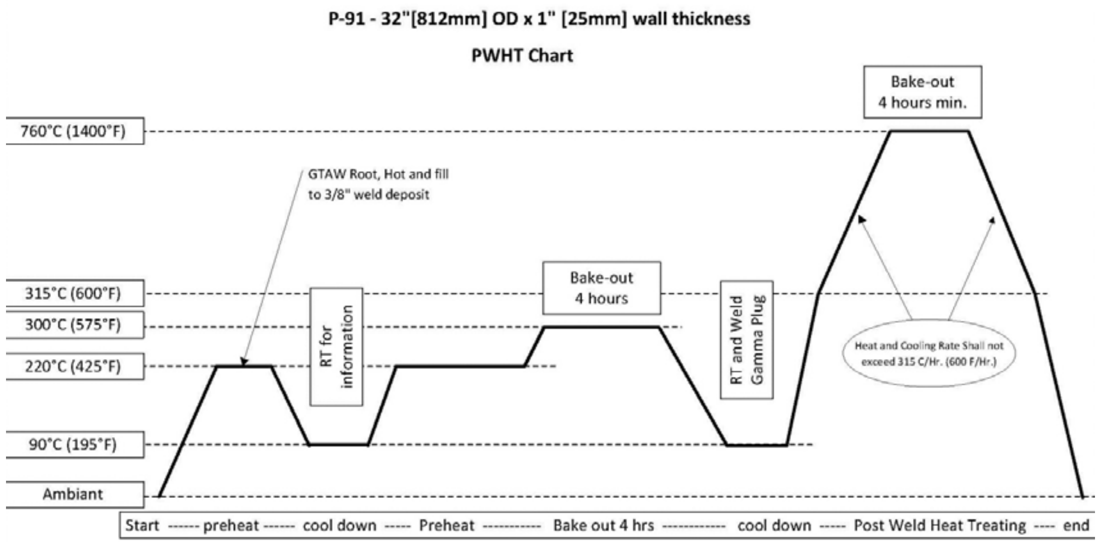

Figure 1. Details for preheating, preheating maintenance, bake-out and PWHT of HR pipe

4. Cutting the old weld

NDT (TOFD) conducted on this pipe revealed unacceptable root defects that were interpreted as creep developing defects. Considering also the extend and location of the defects, as well as the possible complications that a local weld repair might induce in the creep exposed pipe, it was decided to completely remove the old weld by cutting 2" (50 mm) ring which would include the old weld as well as the HAZ from both sides. First, the pipe was properly stiffened, Fig. 2, than, cutting machine performed the cut of the old weld, Fig. 3.

5. Preheating and welding

Once the cut was completed, the two edges were prepared for welding, Fig. 4. Before tack welding was done, thermal pads were installed on the pipe for preheating. After starting up the preheating, the fit up and tack welding were done, Fig. 5.

Welding procedure chosen was qualified as per ASME Section IX Code and was a GTAW root pass and SMAW cap welding procedure. GTAW wire was selected to be a ER90S-B9 and electrodes for the SMAW were selected to be ER9016-B9. Welders selected for the weld were ASME Section IX qualified welders.

6. NDT during and after welding

As per the initial plan, Fig. 1, once 1/3 of the weld was done, the preheating temperature was dropped to 90 °C according to [5] and RT was conducted. RT revealed no problems. Further on, weld was completed and a bake out of four (4) hours at 300 °C was conducted. This bake out is considered useful whenever humid conditions are encountered in the atmosphere. Its role is to allow the weld material to release the H_2 accumulated during welding process.

Figure 2: The HR pipe stiffened

Figure 3: Segments of the 50 mm wide old weld revealing root defects

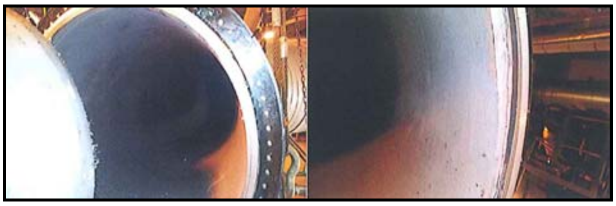

Figure 4: Welds were served and weld preparation conducted

Figure 5: Fit up and tack welding

Thus, in our case, the bake out was also considered useful. After finishing the bake out, the temperature was dropped to 90 °C and a second RT was done for the complete weld.

Second RT results revealed some unacceptable defects in two locations where overhead welding was performed. As per initial plan, grinding was conducted to eliminate the defects. Once defects were completely removed, preheating started up again and the grinded locations were re-welded. After this, a new bake out and a new NDT were done, only on the repaired locations. This time the weld was found acceptable.

7. PWHT and Hardness tests

After final acceptance of the NDT, PWHT was conducted on the new weld following the chart described in Photo no. 1. After proper completion of the PWHT, hardness tests were conducted on the pipe base metal, HAZ and weld using TeleBrineller, Fig. 6.

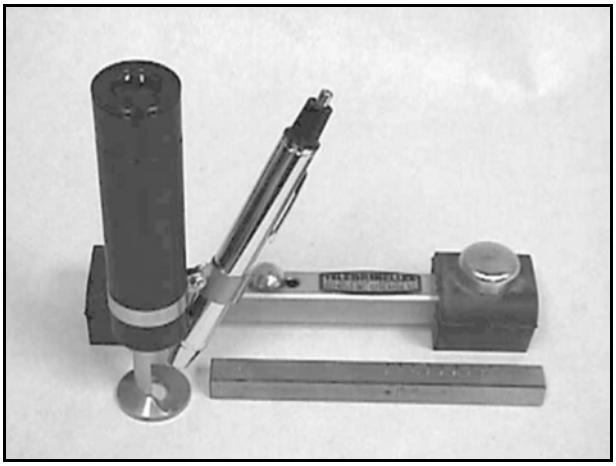

Figure 6: TeleBrinell

TeleBrineller tests utilize the same principle as laboratory Brinell tests with the exception of load application. The TeleBrinell instrument uses the standardized square bar of known hardness that is positioned inside an impacting device. During the test, load is applied via impacting the impact device with at least a 0.91-kg hammer. Upon impact, an impression is made in the standard reference material and the test material concurrently by a 10-mm diameter steel ball. The resulting diameter is measured to within 0.05 mm using a microscope with distance graduations visible through the eyepiece of the microscope. Two measurements of the impression diameter are taken at 90 degrees in relation to one another and averaged from both the standard reference material and the test material. The ratio of the diameter of the indentation made on the test piece to the indentation made on the reference material is then multiplied by the hardness of the reference material to acquire the hardness of the test piece. The standard reference material utilized for the measurements of the various PWHT's was either 165 or 195 BHN test bar [6].

Hardness values below 280 HB are considered to be acceptable as per [6] and [7] for the weld repair of P91 creep-exposed material. Therefore, the TeleBrineller hardness results revealing values of 360 HB were considered to be by far out of the acceptable range.

An analysis of this situation was conducted. How such high harness values could be recorded once the WPS, preheating bake out and PWHT were properly conducted? The TeleBrineller was clearly indicating that the PWHT failed to temper the martensite in the P91 weld.

The calibration of the PWHT machines, although it was supported by proper documentation, was considered to be the cause of this situation. The good side of this situation was that the harness values were above the maximum acceptable one, meaning that the PWHT did not reached the set up temperature range. Therefore, it was recommended to conduct a second PWHT at a temperature of 760 ˚C using an additional independent calibrated temperature recording machine. During the second PWHT significant discrepancies were recorded between the indications of these machines. Therefore, the independent temperature recording machine was used as the reference tool for monitoring the PWHT temperature evolution. After almost 8 h of repeated failing attempts to reach the PWHT temperature, it was recommended to stop the PWHT process and to change the machines. Before redoing the PWHT, MT was conducted on this weld to assess the possible damage that second unsuccessful PWHT was created on this weld. MT revealed no surface defects on this weld. The third attempt on the PWHT was successful in reaching the 760 ˚C for a 1.5 hours soaking time. MT conducted after the PWHT revealed no surface defects. Hardness tests conducted on the weld in three (3) different locations revealed values in between 235 and 255 HB which are acceptable by the applicable references [5], [6] and [7].

8. Conclusions

Weld repair of P91 material is a sensitive process. Among the problems identified during the above example, one cold mention:

- Field conditions of welding such as hard welding positions, moisture in the atmosphere, long time exposure of the films when using Gamma ray RT;
- PWHT equipments which cannot be calibrated or double checked very easily on site;
- The welding of a creep damaged material rises major complications;
- Fit up is by definition is a challenging problem when a pipe circumferential weld is to be done;
- Avoiding interruptions in the repair from starting up of the preheat up to the finishing the NDT after PWHT.

Although one may anticipate all the above difficulties, the repair team should always be prepared for unexpected. The above situation when the PWHT temperature recording machine was found to be out-of-calibration although not predicted, it was properly handled by using a back up, independent differently calibrated temperature recording machine. Also the use of hardness tests such as TeleBrineller harness device to monitor the hardening process during weld repair was considered to be a very useful tool in assessing the PWHT efficiency.

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GEOMETRIC PROGRAMMING FOR OPTIMAL DESIGN OF A WELDED ASSEMBLY: AN ILLUSTRATIVE EXAMPLE

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Abstract

In this paper we have demonstrated, optimization of welded assembly dimensions in terms of welding cost. This elaboration was developed using a typical example of a loaded welded assembly. The presented problem was solved by utilization of geometric programming. The proposed method is elaborated in detail and is given in the form of an algorithm suitable for the practical application. The method has been illustrated by a concrete computational example. It is shown that in the case of a lower degree of complexity the solution can be reached by maximizing the corresponding dual function by means of mathematical analysis.

Keywords: welded structures, optimization, feature limitations, geometric programming, dual function

1. Introduction

Due to the limited space the extensive introductory theoretical considerations are left out. Nevertheless basic theoretical premises can be found in the referenced literature. Authors will be more than happy to provide the complete derivation of the method, explained in detail, to any interested reader.

The optimized structure, used for our example, consists of two elements: beam (girder) 1 and a rigid bracket to which the beam is joined by welds I and II.

2. Method

a) Following conditions regarding the model are given as constants (fixed values): material mechanical characteristics, the free length of the beam (units) L and the maximum force F on the loaded beam.

Other dimensions of the assembly are independent variables. These dimensions are:

$$h = x_1 \; l = x_2 \; t = x_3 \; b = x_4, \tag{1}$$

The value of these dimensions should be determined and optimized to achieve a vector of optimum values $\vec{x}_0 = (x_{10} = h_0, x_{20} = l_0, x_{30} = t_0, x_0 = b_0)$ so that the minimum cost of welding is: *Fcmin = Fco = min T*.

b) Mathematical form of function optimization is defined as follows.

The cost function as a function of optimization can be written as [1-6]:

$$T = T_p + T_1 + T_2, \tag{2}$$

This function consists of three main components (partial charges): T_p - the costs of preparation (preparatory operations),T_1-welding costs,T_2 -the cost (price) of material.

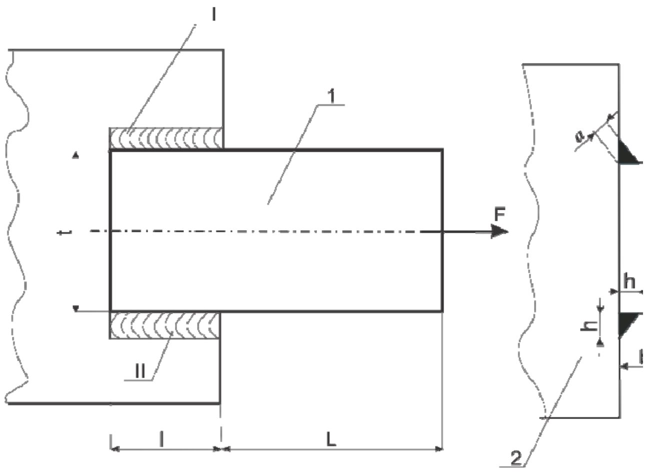

Figure 1. Loaded welded assembly

Costs of preparation T_p refer to all the necessary technological equipment to perform welding operations: welding tools, auxiliary equipment for setting beams on the truss in position, its tightness and more. These costs will be considered constant (non-dependent on x_1, x_2, x_3, and x_4).

Cost of welding operations T_1 can be determined if you know the elements of these costs:

T_{11} - the cost of using welding expressed in monetary amount per unit of time, which includes the cost of amortization and loan repayment appliances, the cost of auxiliary equipment (depreciation) used in welding, the cost of human work (personal income from contributions and other),

Q_z - The capacity ie. volume of weld (weld) per unit time and,

V_z - volume of weldment, weld I and II, that the example given is calculated as:

$$V = V_{z1} + V_{z2} = \frac{1}{2}h^2 l + \frac{1}{2}h^2 l = h^2 l, \tag{3}$$

as follows according to figure 1. On the basis of these elements can be written T1 costs:

$$T_1 = \frac{T_{11}}{Q_z} V_z = \frac{T_{11}}{Q_z} h^2 l, \tag{4}$$

The cost of materials will be:

$$T_2 = T_3 V_z + T_4 V_G, \tag{5}$$

where: T_3 - material price of weld, T_4 - material price beam, V_g - volume of the beam is calculated as:

$$V_G = t \cdot b \cdot (b + l), \tag{6}$$

replacing (3) and (6) to (5) will be:

$$T_2 = T_3 \cdot h^2 l + T_4 \cdot t \cdot b \cdot (L + l), \tag{7}$$

Costs by replacing (4) and (7) in (2) we obtain the desired shape optimization function (objective function):

$$F_c = T = T_p + \frac{T_{11}}{Q_z} \cdot h^2 l + T_3 \cdot h^2 l + $$
$$+ T_4 \cdot t \cdot b \cdot (L + l), \tag{8}$$

respectively:

$$T = T_p + \left(\frac{T_{11}}{Q_z} + T_3 \right) \cdot h^2 l + T_4 \cdot t \cdot b \cdot (L + l), \tag{9}$$

or by (1):

$$T = T_p + \left(\frac{T_{11}}{Q_z} + T_3 \right) \cdot x_1{}^2 \cdot x_2 + T_4 \cdot x_2 \cdot x_3 \cdot x_4 +$$
$$+ T_4 \cdot L \cdot x_3 \cdot x_4, \tag{10}$$

present values of coefficients T_{11}, Q_z, T_3, T_4 and L are known for the given task (objective optimization).

c) Defining and setting up a system function limitations

1. Restrictions on the intensity of the shear stress in the weld [3], [4]. The actual shear stress in the weld will be, taking into account geometry of weld, Fig. 1:

$$a = \frac{h\sqrt{2}}{2} \quad . \quad \tau = \tau(x_i) = \frac{F}{2 \cdot A_z} = \frac{F}{2 \cdot a \cdot l} = \frac{F}{h\sqrt{2} \cdot l} =$$
$$= \frac{F}{\sqrt{2} \cdot x_1 \cdot x_2} \le \tau_d, \tag{11}$$

For the allowable shear stress τ_d, we have:

$$\tau_d \ge \frac{F}{\sqrt{2} \cdot x_1 \cdot x_2} \quad \tau_d \ge \tau(x_i), \tag{12}$$

Dividing equation (12) one gets:

$$1 \ge \frac{F}{\tau_d \cdot \sqrt{2} \cdot x_1 \cdot x_2}, \tag{13}$$

or as a function of the limits being:

$$F_{g1} = \frac{F}{\tau_d \cdot \sqrt{2}} x_1{}^{-1} \cdot x_2{}^{-1} \le 1, \tag{14}$$

This shape of function F_{g1} as well as other functions in this form, as will be seen, is suitable for optimization.

2. Restrictions on the normal stress stretch material of manufacturers [3].

The actual tension will be less than the allowable:

$$\sigma(x_i) = \frac{F}{A} = \frac{F}{t \cdot b} \le \sigma_d, \tag{15}$$

respectively:

$$\frac{F}{t \cdot b \cdot \sigma_d} \le 1, \tag{16}$$

given the limitations of the function being:

$$F_{g2} = \frac{F}{t \cdot b \cdot \sigma_d} = \frac{F}{x_3 \cdot x_4 \cdot \sigma_d} =$$
$$= \frac{F}{\sigma_d} x_3{}^{-1} \cdot x_4{}^{-1} \le 1, \tag{17}$$

3. Restrictions related to the practical possibility of getting welds

This limit is expressed as, b ≥ h, as the beam width must be greater than the weld parameter h. It follows that:

$$x_4 \ge x_1 \quad 1 \ge \frac{x_1}{x_4}, \tag{18}$$

Given the limitations of the function being:

$$F_{g3} = \frac{x_1}{x_4} \le 1 \quad F_{g3} = x_1 \cdot x_4^{-1} \le 1, \tag{19}$$

4. Restrictions on the non-negativity variables x_i.

This limitation is expressed by the function:

$$F_{g4} = x_i \ge 0 \quad i = 1,2,3,4, \tag{20}$$

d) A mathematical model of optimization

According to exposed relations (10), (14), (17), (19), (20) for the observed structural structure, the mathematical model of optimization will be:

$$F_c = T = \min\left[\left(\frac{T_{11}}{Q_z} + T_3 \right) \cdot x_1{}^2 \cdot x_2 + T_4 \cdot x_2 \cdot x_3 \cdot x_4 + T_4 \cdot L \cdot x_3 \cdot x_4 \right], \tag{21}$$

$$D \begin{cases} F_{g1} = \dfrac{F}{\tau_d \cdot \sqrt{2}} x_1{}^{-1} \cdot x_2{}^{-1} \le 1 \\ F_{g2} = \dfrac{F}{\sigma_d} x_3^{-1} \cdot x_4^{-1} \le 1 \\ F_{g3} = x_1 \cdot x_4{}^{-1} \le 1 \\ F_{g4} = x_i \ge 0 \end{cases}, \tag{22}$$

$$i = 1,2,3,4$$

The function (21), the cost of preparation T_p as a constant for the observed relation is not taken into account since they do not affect the mathematical analysis that follows. Once the minimum function of the F_c, the same value must only add the cost of the preparation, with respect to the relation (2).

By introducing:

$$T_{13} = \frac{T_{11}}{Q_z} + T_3$$
$$T_{4L} = T_4 \cdot L \tag{23}$$
$$F_b = \frac{F}{\sigma_d},$$

Relations (21) and (22) are simplified:

$$F_c = T = \min\left[T_{13} \cdot x_1{}^2 \cdot x_2 + T_4 \cdot x_2 \cdot x_3 \cdot x_4 + T_{4L} \cdot x_3 \cdot x_4 \right]$$
$$F_{g1} = F_a \cdot x_1^{-1} \cdot x_2^{-1} \le 1, \tag{24}$$
$$F_{g3} = x_1 \cdot x_4^{-1} \le 1$$

where in:
$x_1 \geq 0$; $x_2 \geq 0$; $x_3 \geq 0$; $x_4 \geq 0$

The corresponding dual function in regard to (24), will be [7], [8], [9]:

$$Q(q) = \left(\frac{T_{13}}{q_1}\right)^{q_1} \cdot \left(\frac{T_4}{q_2}\right)^{q_2} \cdot \left(\frac{T_{4L}}{q_3}\right)^{q_3} \cdot \left(\frac{F_a}{q_4}\right)^{q_4} \tag{25}$$

$$\cdot \left(\frac{F_b}{q_5}\right)^{q_5} \cdot \left(\frac{1}{q_6}\right)^{q_6} \cdot q_4^{q_4} \cdot q_5^{q_5} \cdot q_6^{q_6},$$

after the task has a total of six members: r = 6, and three in the F_c and three in the F_g, since there are three function limitation (t = 1) each having a single member. From the condition of normality (35) and (36) and orthogonal forms a system of five equations with six unknowns:

$$\begin{aligned}
&(I)\ q_1 + q_2 + q_3 = 1 \\
&(II)\ 2q_1 - q_4 + q_6 = 0 \\
&(III)\ q_1 + q_2 - q_4 = 0 \\
&(IV)\ q_2 + q_3 - q_5 = 0 \\
&(V)\ q_2 + q_3 - q_5 - q_6 = 0,
\end{aligned} \tag{26}$$

In this equation (II) is determined by x_1, the equation (III) by x_2, the equations (IV) to x_3, and the equation (V) according to x_4, taking into account their exponents. Total number of q_i (i = 1-6) is equal to the number of members of the F_c function and the function limitation (3+1+1+1=6). By subtracting equation (IV) and (V), it follows that:

$$q_6 = 0, \tag{27}$$

By using the Gaussian algorithm, a simple way to show that all of the unknowns can be expressed in terms of q_1. From the second equation it follows that:

$$q_4 = 2q_1, \tag{28}$$

as follows from the III:

$$q_2 = q_1, \tag{29}$$

At the end of the equation I and IV it follows that:

$$\begin{aligned} &q_3 \\ &q_5 = 1 - q_1, \end{aligned} \tag{30}$$

Rearranging equation (25), it will be simplified:

$$Q(q) = \left(\frac{T_{13}}{q_1}\right)^{q1} \cdot \left(\frac{T_4}{q_2}\right)^{q2} \cdot \left(\frac{T_{4L}}{q_3}\right)^{q3} \cdot F_a^{\ q4} \cdot F_b^{\ q5} \cdot 1^{q6}, \tag{31}$$

substituting q_2, q_3, q_4, q_5, q_6, and by (27), (28), (29) and (30), equation (31) becomes:

$$Q(q) = \left(\frac{T_{13}}{q_1}\right)^{q_1} \cdot \left(\frac{T_4}{q_1}\right)^{q_1} \cdot \left(\frac{T_{4L}}{1-2q_1}\right)^{1-2q_1} \cdot F_a^{\ 2q_1} \cdot F_b^{\ 1-q_1}, \tag{32}$$

Obviously, the dual function Q (q) is expressed in more than q_1, which was the goal.
Logarithmic functions (32) will be:

$$\ln Q(q) = q_1 \ln\left(\frac{T_{13}}{q_1}\right) + q_1 \ln\left(\frac{T_4}{q_1}\right) + (1-2q_1) \cdot \tag{33}$$

$$\cdot \ln\left(\frac{T_{4L}}{1-2q_1}\right) + 2q_1 \ln F_a + (1-q_1) \ln F_b,$$

Let $\overrightarrow{q_0} = q_{j0}$, $j = \overline{1,6}$, the stationary point of the vector in which the $Q(q)_{max} = Q_{0\ max}$, then the same count is achieved and maximum functions lnQ(q), according to the (33).

So to calculate the derivative of the function lnQ(q) the variable q_1 and equates it to zero:

$$\frac{d}{dq_1}\left[\ln Q(q)\right] = 0, \tag{34}$$

Given that this is a complex function, for simplification to (33), we can introduce shifts:

$$\begin{aligned}
&Q_1 = q_1(\ln T_{13} - \ln q_1) = q_1 \ln T_{13} - q_1 \ln q_1 \\
&Q_2 = q_1 \cdot \ln\left(\frac{T_4}{q_1}\right) \\
&Q_3 = (1-2q_1) \cdot \ln\left(\frac{T_{4L}}{1-2q_1}\right) = \ln\left(\frac{T_{4L}}{1-2q_1}\right) - \\
&-2q_1 \ln\left(\frac{T_{4L}}{1-2q_1}\right) \\
&Q_4 = 2q_1 \ln F_a \\
&Q_5 = (1-q_1) \cdot \ln F_b = \ln F_b - q_1 \ln F_b
\end{aligned} \tag{35}$$

With this shift, the function (33) becomes:

$$\ln Q(q) = Q_1 + Q_2 + Q_3 + Q_4 + Q_5, \tag{36}$$

Derivative of (36) will be:

$$\frac{d\left[\ln Q(q)\right]}{dq_1} = Q_1{}' + Q_2{}' + Q_3{}' + Q_4{}' + Q_5{}', \tag{37}$$

Partial derivative of functions (37) for q_1 will be:

$$\begin{aligned}
&Q_1' = \ln T_{13} - (\ln q_1 + 1) \\
&Q_2' = \ln\frac{T_4}{q_1} - 1 \\
&Q_3' = \frac{2}{1-2q_1} - 2 \cdot \ln T_{4L} + 2 \cdot \ln(1-2q_1) - \frac{4 \cdot q_1}{1-2q_1} \\
&Q_4' = 2 \cdot \ln F_a \\
&Q_5' = -\ln F_b
\end{aligned} \tag{38}$$

Substituting extracts partial functions (38) in (37) will be after the arranging, according to (34):

$$\frac{2}{1-2q_1} - \frac{4q_1}{1-2q_1} + \ln\left(\frac{T_4}{q_1}\right) + 2 \cdot \ln(1-2q_1) +$$

$$+ \ln\left(\frac{T_{13}}{q_1}\right) - 2 - 2\ln T_{4L} + \ln\frac{F_a^2}{F_b} = 0, \tag{39}$$

Equation (39), after some mathematical operations can be summarized as:

$$\ln\left(\frac{1-2q_1}{q_1}\right)^2 + \ln\left(\frac{T_{13} \cdot T_{4L} \cdot F_a^2}{T_4^{\ 2} \cdot F_b}\right) = 0, \tag{40}$$

It follows that:

$$\left(\frac{1-2q_1}{q_1}\right)^2 = \frac{T_{4L}^2 \cdot F_b}{T_{13} \cdot F_a^2 \cdot T_4}, \tag{41}$$

and finally, solving to $q_1 \equiv q_0$:

$$q_{10} = \frac{1}{2 + \frac{T_{4L}}{F_a} \cdot \sqrt{\frac{F_b}{T_{13} \cdot T_4}}}, \tag{42}$$

Taking into account (27), (28), (29), (30) and (42) it follows that:

$$q_{20} = q_{10}$$

$$q_{30} = 1 - 2 \cdot q_{10} = 1 - \frac{2}{2 + \frac{T_{4L}}{F_a} \cdot \sqrt{\frac{F_b}{T_{13} \cdot T_4}}}$$

$$q_{40} = 2 \cdot q_{10} = \frac{2}{2 + \frac{T_{4L}}{F_a} \cdot \sqrt{\frac{F_b}{T_{13} \cdot T_4}}},$$

$$q_{50} = 1 - q_{10} = 1 - \frac{1}{2 + \frac{T_{4L}}{F_a} \cdot \sqrt{\frac{F_b}{T_{13} \cdot T_4}}} \tag{43}$$

$$q_{60} = 0$$

Accordingly, an optimal dual vector will be:

$$\vec{q}_0 = (q_{10}; q_{20}; q_{30}; q_{40}; q_{50}; q_{60}), \tag{44}$$

By setting the calculated optimum dual component vectors $\vec{q}_0$ (44) corresponding to a maximum of the dual function of (25)

$$Q(q)_{\max} = \max Q(q) = Q_0 =$$
$$= Q(q_{10}; q_{20}; q_{30}; q_{40}; q_{50}; q_{60}), \tag{45}$$

receives the value of the minimum function optimization, i.e.:

$$F_{c0} = \min F_c = \max Q(q) = Q(q_0) = Q_0, \tag{46}$$

Based on F_{c0}, calculated from equation (24) to (37) components of the optimal vector of the system:

$$(I)\ T_{13} \cdot x_{10}^2 \cdot x_{20} = Q_0 \cdot q_{10}$$

$$(II)\ T_4 \cdot x_{20} \cdot x_{30} \cdot x_{40} = Q_0 \cdot q_{20}$$

$$(III)\ T_{4L} \cdot x_{30} \cdot x_{40} = Q_0 \cdot q_{30}$$

$$(IV)\ F_a \cdot x_{10}^{-1} \cdot x_{20}^{-1} = \frac{q_{40}}{\lambda_{40}} = \frac{\lambda_{40}}{\lambda_{40}} = 1 \tag{47}$$

$$(V)\ F_b \cdot x_{30}^{-1} \cdot x_{40}^{-1} = \frac{q_{50}}{\lambda_{50}} = \frac{\lambda_{50}}{\lambda_{50}} = 1$$

$$(VI)\ x_{10} \cdot x_{40}^{-1} = \frac{q_{60}}{\lambda_{60}} = \frac{\lambda_{60}}{\lambda_{60}} = 1$$

From I and IV of the equation it follows that:

$$x_{10} = \frac{Q_0 \cdot q_{10}}{T_{13} \cdot F_a}, \tag{48}$$

$$x_{40} = x_{10}, \tag{49}$$

From equation IV it will be:

$$x_{20} = \frac{F_a}{x_{10}}, \tag{50}$$

Also, from the equation V it follows:

$$x_{30} = \frac{F_b}{x_{40}} = \frac{F_b}{x_{10}}, \tag{51}$$

The equations of system (II), (III), (VI), which at present are not used, can be used to control the results obtained with respect to all of the system equation, must be satisfied.

For example, the observed arc welding beam bracket, which are made of carbon structural steel (0.25% C), calculated constants:

- The capacity of the welding $Q_z = 0{,}05 \frac{cm^3}{s}$
- The price of basic material $T_4 = 1{,}4 \frac{CENT}{cm^3}$
- The price of electrode material $T_3 = 5{,}7 \frac{CENT}{cm^3}$
- The cost of welding device $T_{11} = 0{,}65 \frac{CENT}{s}$
- Allowable tensile stress of the base material $\sigma_d = 10000 \frac{N}{cm^2}$
- Allowable shear stress of the base metal $\tau_d = 5000 \frac{N}{cm^2}$
- Maximum power load beam $F = 20000\ N$
- Free length of the beam $L = 20 cm$
- Preparation costs $T_p = 73{,}9\ CENT$

Accordingly the value of (23) will be:

$$T_{13} = \frac{T_{11}}{Q_z} + T_3 = \frac{0{,}75}{0{,}05} + 6{,}5 = 18{,}7\ \frac{CENT}{cm^3}$$

$$F_a = \frac{F}{\sqrt{2} \cdot \tau_d} = \frac{20000}{\sqrt{2} \cdot 5000} = 2{,}828\ cm^2$$

$$F_b = \frac{F}{\sigma_d} = \frac{20000}{10000} = 2\ cm^2\ \frac{CENT}{cm^2}$$

The components of the dual optimum vector to be (42), or according to (43):

$$q_{10} = \frac{1}{2 + \frac{T_{4L}}{F_a} \cdot \sqrt{\frac{F_b}{T_{13} \cdot T_4}}} = \frac{1}{2 + \frac{27{,}8}{2{,}828} \cdot \sqrt{\frac{2}{18{,}7 \cdot 1{,}4}}} = 0{,}2115$$

$$q_{20} = q_{10} = 0{,}2115$$

$$q_{30} = 1 - 2 \cdot q_{10} = 1 - 2 \cdot 0{,}2115 = 0{,}577$$

$$q_{24} = 2 \cdot q_{10} = 2 \cdot 0{,}423$$

$$q_{50} = 1 - q_{10} = 1 - 0{,}2115 = 0{,}7885$$

$$q_{60} = 0 \tag{52}$$

The optimum dual vector of (X) will be:

$$\vec{q}_0 = (q_{10}; q_{20}; q_{30}; q_{40}; q_{50}; q_{60}) =$$
$$(0{,}2115;\ 0{,}2115;\ 0{,}577;\ 0{,}423;\ 0{,}7885;\ 0) \tag{53}$$

The optimal values of the dual function Q_0 to (31) will be:

$$Q(q_0)=\left(\frac{T_{13}}{q_1}\right)^{q_{10}}\cdot\left(\frac{T_4}{q_2}\right)^{q_{20}}\cdot\left(\frac{T_{4L}}{q_3}\right)^{q_{30}} \quad (54)$$

$$\cdot F_a^{\,q_{40}}\cdot F_b^{\,q_{50}}\cdot 1^{q_{60}}$$

Finally substituting the values (53) to (54):

$$Q(q_0)=\left(\frac{18{,}7}{0{,}2115}\right)^{0{,}2115}\cdot\left(\frac{1{,}4}{0{,}2115}\right)^{0{,}2115}$$

$$\cdot\left(\frac{27{,}8}{0{,}577}\right)^{0{,}577}\cdot 2{,}828^{0{,}423}\cdot 2^{0{,}7885} \quad (55)$$

$$Q(q_0)=96{,}4$$

where the optimal value of the dual function to function optimization:

$$F_{c0}=Q_0=Q(q_0)=96{,}4\ CENT, \quad (56)$$

On the basis of the value (48), (49) from (50), (51) are determined by the desired optimum vector $\vec{x}_0$:

$$x_{10}=\frac{Q_0\cdot q_{10}}{T_{13}\cdot F_a}=\frac{96{,}4\cdot 0{,}2115}{18{,}7\cdot 2{,}828}=0{,}386\text{ cm}$$

$$x_{40}=x_{10}=0{,}386\text{ cm}$$

$$x_{20}=\frac{F_a}{x_{10}}=\frac{2{,}828}{0{,}386}=7{,}326\text{ cm} \quad (57)$$

$$x_{30}=\frac{F_b}{x_{10}}=\frac{2}{0{,}386}=5{,}181\text{ cm}$$

Control of the results can be performed according to the equations II, III and VI, of system (47), considering that the same are not used.

Now is the optimal primary vector completely determined:

$$\vec{q}_0=(x_{10};x_{20};x_{30};x_{40})=(0{,}386;\ 7{,}367;\ 5{,}181;\ 0{,}386), \quad (58)$$

When an optimal vector (58), an optimum is achieved $F_{c0}=\min F_c$ according to (24):

$$F_{c0}=T_{13}\cdot x_{10}^{\,2}\cdot x_{20}+T_4\cdot x_{20}\cdot x_{30}\cdot x_{40}+$$
$$+T_{4L}\cdot x_{30}\cdot x_{40},$$

(59)

Substituting (57) into (59) will be:

$$F_c=18{,}7\cdot 0{,}386^2\cdot 7{,}326+1{,}4\cdot 7{,}326\cdot 5{,}181\cdot 0{,}386$$
$$+27{,}8\cdot 5{,}181\cdot 0{,}386=96{,}4CENT, \quad (60)$$

as might be expected, given (55).

In calculation, minimal error occurred because of rounding of numbers (four digits).

From the above follows that the optimal values of the dimensions of the welded joint observed:

$h_0=x_{10}=3{,}86\ mm$, $l_0=x_{20}=73{,}26\ mm$,

$t_0=x_{30}=51{,}81\ mm$, $b_0=x_{40}=3{,}86\ mm$.

One can easily show that all the boundary conditions (22) are fully met.

3. Discussion and Conclusion

Application of geometric programming is possible with different functions of optimization and constraints as linear and nonlinear. Complex problems are presented in this system of linear equations that are relatively easy to solve, which is an advantage compared to other methods (for example, simplex method or gradient method). The solution is always obtained directly without optimal search area. Special attention when applying the method of geometric programming should be exercised when the limit function contains more than one member. Then the appropriate member of the effectiveness of a dual function also includes more members.

In most problems, at the end more equations than necessary occur. This allows you to monitor and control the results with respect to all equations of the system that must be met. Also, control can be exercised towards equality $minF_c = maxQ$.

Like any method of optimization, geometric programming method has its drawbacks.

The method cannot be applied to cases where the optimization function and constraints are positive polynomials (when it appears in the polynomial minus sign). It should be noted that the technical practices in such cases are generally rare.

Finally, it should be pointed out that modern optimization methods for efficient implementation require multidisciplinary knowledge of different fields: technology, design, construction, economics, mathematical analysis, mathematical programming. This is probably the main reasons why they are insufficiently applied in common technical practice.

3. References

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