







UNIVERSITY OF NOVI SAD  
FACULTY OF TECHNICAL SCIENCES  
DEPARTMENT OF PRODUCTION ENGINEERING  
NOVI SAD, SERBIA



11<sup>th</sup> INTERNATIONAL SCIENTIFIC CONFERENCE  
MMA 2012 - ADVANCED PRODUCTION TECHNOLOGIES



**PROCEEDINGS**

Novi Sad, 20-21 September 2012

PROCEEDINGS OF THE 11<sup>th</sup> INTERNATIONAL SCIENTIFIC CONFERENCE  
MMA 2012 - ADVANCED PRODUCTION TECHNOLOGIES  
Novi Sad, 2012

---

*Publisher:* **FACULTY OF TECHNICAL SCIENCES  
DEPARTMENT OF PRODUCTION ENGINEERING  
21000 NOVI SAD, Trg Dositeja Obradovica 6  
SERBIA**

---

*Organization of this Conference was approved by Educational-scientific Council of Faculty of Technical Sciences in Novi Sad*

---

*Editor:* Dr Ilija COSIC, professor, dean

*Reviewer's team:*  
Dr Bogdan SOVILJ, professor  
Dr Dragisa VILOTIC, professor  
Dr Djordje VUKELIC, assistant professor  
Dr Igor BUDAK, assistant professor  
Dr Janko HODOLIC, professor  
Dr Marin GOSTIMIROVIC, professor  
Dr Milan ZELJKOVIC, professor  
Dr Miodrag HADZISTEVIC, associate professor  
Dr Miroslav PLANCAK, professor  
Dr Slobodan TABAKOVIC, assistant professor  
Dr Pavel KOVAC, professor  
Dr Velimir TODIC, professor

*Technical treatment and design:*  
Dr Mijodrag MILOSEVIC, assistant professor  
MSc Igor BESIC, assistant  
MSc Ivan MATIN, assistant  
MSc Alena ZAJAC  
MSc Branislav MILANOVIC  
MSc Darko MILANKOVIC

*Manuscript submitted for publication:* September 10, 2012

*Printing:* 1<sup>st</sup>

*Circulation:* 150 copies

*CIP classification:*

CIP - Каталогизacija u publikaciji  
Библиотека Матице српске, Нови Сад

612.7/.9(082)

**INTERNATIONAL Scientific Conference MMA 2012 Advanced  
Production Technologies (11 ; 2012 ; Novi Sad)**

Proceedings [Elektronski izvor] / 11th International Scientific Conference  
MMA 2012 - Advanced Production Technologies, Novi Sad, 20-21  
September, 2012 ; [editor Ilija Cosic]. - Novi Sad : Faculty of Technical  
Sciences, Department of Production Engineering, 2012 (Novi Sad : FTN,  
Graphics Centre GRID). - 1 elektronski optički disk (CD-ROM)  
: tekst, slika ; 12 cm

*Printing by:* FTN, Graphic Centre  
GRID, Novi Sad

Nasl. sa naslovnog ekrana. - Tiraž 150. - Bibliografija uz svako rad.

ISBN 978-86-7892-419-4

a) Производно машинство - Зборници  
COBISS.SR-ID 273838087

---

*Financing of the Proceedings was sponsored by the Ministry of Education, Science and Technological Development of the Republic of Serbia and supported by the Provincial Secretariat for Science and Technological Development of AP Vojvodina.*

---

*Being held on a regular basis, like some other conferences with long tradition, the MMA 2012 – ADVANCED PRODUCTION TECHNOLOGIES contributes to continuous application of scientific results and professional know-how in the metalworking industry, regardless of the difficulties this industry has been facing during the last two decades.*

*By organizing the MMA 2012 Conference, the research potential of our country relies on its traditional enthusiasm and perseverance in order to contribute to advancement of production engineering in this region – not only through application of scientific results and professional know-how in practice, but also in education of engineers in the field of production technologies and techniques.*

*The eleventh International Scientific Conference MMA 2012 – ADVANCED PRODUCTION TECHNOLOGIES is for the tenth time being held with international participation. Throughout the years, by the number of contributions, their quality and participation of international authors, the Conference has earned a respectable reputation among scientists and industry professionals.*

*This year MMA – ADVANCED PRODUCTION TECHNOLOGIES focuses on the following topics:*

- ◆ METAL CUTTING
- ◆ MACHINE TOOLS AND AUTOMATIC FLEXIBLE TECHNOLOGICAL SYSTEMS, CA<sub>x</sub> AND CIM PROCEDURES AND SYSTEMS
- ◆ METROLOGY, QUALITY, FIXTURES, METAL CUTTING TOOLS AND TRIBOLOGY
- ◆ MECHANICAL ENGINEERING AND ENVIRONMENTAL PROTECTION
- ◆ OTHER PRODUCTION ENGINEERING TECHNOLOGIES
- ◆ BIO-MEDICAL ENGINEERING – CA<sub>x</sub>

*With 129 papers and contributions by international authors from 20 different countries, 11<sup>th</sup> International Scientific Conference MMA 2012 – ADVANCED PRODUCTION TECHNOLOGIES successfully maintains the high level set by the previous conferences. Participation of a large number of domestic and international authors, as well as the diversity of topics, justifies our efforts to organize this conference and contribute to exchange of knowledge, research results and experience of industry experts, research institutions and faculties which all share a common interest in the field of production engineering.*

*Novi Sad, September 2012*

*PROGRAMME AND ORGANIZING  
COMMITTEE*





## Contents

### Section A: METAL CUTTING

<b>Baralić, J., Nedić, B.:</b> THE EFFECT OF ABRASIVE WATER JET CUTTING PARAMETERS ON KERF GEOMETRY .....	1
<b>Beniak, J.:</b> OPERATIONAL CHARACTERISTIC OF SHREDDING MACHINES .....	5
<b>Bilic, B., Trlin, G., Vojkovic, V.:</b> APPLICATION OF SIMULATED ANNEALING METHOD IN THE CUTTING PARAMETERS OPTIMIZATION REGARDING SURFACE ROUGHNESS .....	9
<b>Gostimirović, M., Pucovsky, V., Kovač, P., Šooš, Lj., Rodić, D., Savković, B.:</b> MODELING OF DISCHARGE ENERGY IN EDM PROCESS BY THE USE OF GENETIC ALGORITHMS .....	13
<b>Gostimirovic, M., Rodic, D., Kovac, P., Mankova, I., Beno, J., Pucovsky, V., Sekulic, M.:</b> PREDICTION OF SURFACE ROUGHNESS USING NEURAL FUZZY SYSTEMS IN ELECTRICAL DISCHARGE MACHINING .....	17
<b>Homar, D., Kopač, J., Dolinšek, S.:</b> ADDITIVE MANUFACTURING AND HIGH SPEED CUTTING INCLUDED IN HYBRID MANUFACTURING .....	21
<b>Janković, P., Radovanović, M.:</b> EFFECT OF PROCESS PARAMETERS ON CUTTING ABILITY IN ABRASIVE WATER JET MACHINING .....	25
<b>Kopac, J., Cus, F., Stoic, A., Zabkar, B.:</b> SOME IDEAS ABOUT SUSTAINABLE MANUFACTURING CONCEPT .....	29
<b>Kovač, P., Radonjić, S., Mitrović, A., Sovilj-Nikić, I.:</b> DETERMINING THE PROCESSING PARAMETERS FOR STEEL AISI 6150 IN LASER CUTTING .....	33
<b>Kramar, D., Sekulić, M., Kovač, P., Gostimirović, M., Kopač, J.:</b> THE IMPLEMENTATION OF TAGUCHI METHOD FOR QUALITY IMPROVEMENT IN HIGH-PRESSURE JET ASSISTED TURNING PROCESS .....	37
<b>Nagode, A., Klančnik, G., Gojić, M., Kosec, B., Bizjak, M., Zorc, B., Kosec, L.:</b> AN INVESTIGATION OF THE SURFACE DAMAGE OF HOT PLATES AFTER BLACK OXIDE COATING .....	41
<b>Peterka, J., Kováč, M., Beňo, M., Zvončan, M.:</b> EFFECT OF CUTTING PARAMETERS ON DELAMINATION FACTOR IN ROTARY ULTRASONIC MACHINING OF FIBERGLASS .....	45

<b>Šogorović, D., Mišković, A., Višekruna, V.:</b> DESIGN OF DEVICE FOR HIGH-PRODUCTIVE CUTTING OF THREADS .....	49
<b>Tanović, Lj., Puzović, R., Klimenko, S.:</b> THE PHENOMENA OF GRANITE MICRO – CUTTING PROCESS .....	53

## **Section B: MACHINE TOOLS**

<b>Čiča, Đ., Zeljković, M., Lakić-Globočki, G., Sredanović, B., Borojević, S.:</b> IDENTIFICATION OF CONTACT PARAMETERS OF SPINDLE–HOLDER–TOOL ASSEMBLY USING ARTIFICIAL NEURAL NETWORKS .....	57
<b>Dučić, N., Čojbašić, Ž., Slavković, R., Radonjić, S.:</b> APPLICATION OF NEURAL NETWORKS FOR PREDICTING CHARACTERISTICS OF ELASTIC SUPPORTS TO PRODUCTION MACHINES .....	61
<b>Epler, I., Djapic, M., Lukic, Lj.:</b> RISK - BASED MAINTENANCE OF THE FLEXIBLE TECHNOLOGICAL SYSTEM .....	65
<b>Gyenge, C., Rafa, A., Pacurar, A., Bob, M.:</b> SOME CHARACTERISTICAL ASPECTS REGARDING CNC GRINDING OF SPUR GEARS .....	69
<b>Milutinovic, M., Slavkovic, N., Milutinovic, D.:</b> KINEMATIC MODELING OF THE TRICEPT BASED 5-AXIS MACHINE TOOL .....	73
<b>Pecenica, N., Lukic, Lj., Nikolic, N., Djapic, M.:</b> COMPARATIVE ANALYSIS AND FLEXIBLE CONVENTIONAL NC TECHNOLOGY THE EXAMPLE FROM INDUSTRY .....	79
<b>Popp, I.O.:</b> SOMES ASPECTS REGARDING THE MAINTENANCE OF BEARINGS .....	83
<b>Šooš, E., Križan, P., Matúš, M.:</b> OPTIMIZATION OF THE SPINDLE-BEARING SYSTEM .....	87

## **Section C: METROLOGY, QUALITY, FIXTURES, METAL CUTTING TOOLS AND TRIBOLOGY**

<b>Antić, A., Šarić, T., Živković, A.:</b> ANALYSIS ON THE METHOD AND DEVELOPMENT OF THE MODEL FOR THE TOOL WEAR CONDITION MONITORING SYSTEM .....	93
<b>Assenova, E., Kandeveva, M.:</b> TRIBOLOGY and SELF-ORGANIZATION .....	97
<b>Beju, L.D., Zeljković, M., Navalušić, S.:</b> STRATEGIES FOR IMPROVING THE AGILITY LEVEL IN THE MANUFACTURING BEARING INDUSTRY .....	101
<b>Benkó, P., Peták, T.:</b> STRAIGHTNESS MEASUREMENT OF LINEAR MOTION GUIDES .....	105
<b>Borojević, S., Jovišević, V.:</b> SELECTION AND CONFIGURATION OF MODULAR COMPONENTS FOR MODULAR FIXTURE DESIGN .....	109



<b>Bouzakis, K.-D., Skordaris, G., Gerardis, S., Bouzakis, E.:</b> ADVANCED ANALYTICAL-EXPERIMENTAL PROCEDURES FACILITATING THE EFFECTIVE APPLICATION OF MICRO-BLASTING ON COATED TOOLS CONSIDERING AMONG OTHERS THE FILM BRITTLINESS .....	115
<b>Jakovljevic, Z.:</b> POINT CLOUD REDUCTION USING SUPPORT VECTOR MACHINES .....	121
<b>Koldžin, D., Medić, V.:</b> HOW THE OPEN INNOVATION CONCEPT AFFECT THE INNOVATIVE ENTERPRISE STRATEGIES.....	125
<b>Kravchenko, M.P., Nochvay, V.M., Polonsky, L.G, Melnic, A.L.:</b> STATISTICAL ANALYSIS OF THE QUALITY OF SURFACE COATED PARTS (DEPENDENCE OF ROUGHNESS OF MACHINING ALLOWANCE AND CUTTING MODES).....	129
<b>Krecu, D., Sovilj-Nikić, I., Sovilj, B., Gajić, V., Legutko, S., Varga, Gy.:</b> ANALYSIS OF TOPOGRAPHY OF CYLINDERS MACHINED BY CUTTING TOOLS.....	133
<b>Kukuruzović, D., Berić, J., Kakaš, D., Škorić, B., Kovačević, L., Terek, P., Miletić, A., Vilotić, M.:</b> APPLICATION OF A NEW DEVICE FOR MEASURING HARD COATINGS THICKNESS UNIFORMITY APPLIED ON LARGE SIZE TOOLS .....	137
<b>Kukuruzović, D., Blagojević, D., Kakaš, D., Škorić, B., Kovačević, L., Terek, P., Miletić, A., Vilotić, M.:</b> THE EFFECTS OF CUTTING PARAMETERS AND TOOL WEAR ON THE ROUGHNESS OF MACHINED SURFACE.....	141
<b>Kuzinovski, M., Tomov, M., Cichosz, P.:</b> INVESTIGATION OF GAUSSIAN AND 2RC FILTRATION IN SURFACE ROUGHNESS MEASUREMENT FROM THE STANDPOINT OF AMBIGUITIES IN STANDARDS. PART I-THEORETICAL ANALYSIS.....	145
<b>Morača, S., Milin, D.:</b> CLUSTERS AND NETWORK VALUE SYSTEM .....	149
<b>Nemedi, I., Hadzistevic, M., Hodolic, J., Sekulic, M., Todic, V.:</b> BASIS OF MODEL DEVELOPMENT FOR REAL FORM DETERMINATION OF ROUNDNESS MEASURING OBJECTS .....	153
<b>Penfold, N.:</b> INNOVATIONS IN TOUCH-TRIGGER PROBE SENSOR TECHNOLOGY .....	157
<b>Peták, T., Benkó, P.:</b> CALIBRATION OF THE LENGTH MEASURING MACHINE.....	163
<b>Radlovački, V., Delić, M., Kamberović, B., Vulcanović, S., Hadžistević, M.:</b> HOW MANAGERS ESTIMATE MANAGEMENT SYSTEMS TODAY IN SERBIA .....	167
<b>Reibenschuh, M., Zuperl, U., Cus, F., Irgolic, T.:</b> NEW USER INTERFACE FOR DETECTING EDGE WEAR ON CUTTING TOOLS .....	171
<b>Savic, B., Slavkovic, R., Veg, E., Urosevic, V., Vlajković, H.:</b> USE OF VIRTUAL AND ACTUAL VIBRO-DIAGNOSTICS FOR BETTER CONDITION MONITORING .....	175
<b>St. Sekulic, S., Nikolic, B.:</b> PROGNOSIS OF RELIABILITY AND MEAN TIME TO FAILURE OF CUTTING TOOL IN FUNCTION OF CUTTING CONDITION OF ELEMENTS IN TURNING.....	179
<b>Šešlija, D., Dudić, S., Milenković, I.:</b> COST EFFECTIVENESS T OF PRESSURE REGULATION ON RETURN STROKE OF PNEUMATIC ACTUATORS .....	183

<b>Tomov, M., Kuzinovski, M., Cichosz, P.:</b> INVESTIGATION OF GAUSSIAN AND 2RC FILTRATION IN SURFACE ROUGHNESS MEASUREMENT FROM THE STANDPOINT OF AMBIGUITIES IN STANDARDS. PART II - EXPERIMENTAL ANALYSIS .....	187
<b>Tsiafis, I., Bouzakis, K.-D., Xanthopoulou, M., Tsolis, G., Xenos, Th.:</b> ANALYSIS OF ROLLER BEARINGS' VIBRATION SIGNALS BY HILBERT – HUANG TRANSFORM AS DIAGNOSTIC TOOL.....	193
<b>Vrba, I., Hadžistević, M., Palenčar, R., Lenčič, I.:</b> OVERVIEW OF STANDARDS AND GUIDELINES WHICH DEFINE EVALUATION OF THE MEASUREMENT UNCERTAINTY IN MEASUREMENT OF FREEFORM SHAPED PARTS AT CMM .....	197
<b>Zuperl, U., Cus, F.:</b> FIXTURE ANALYSIS MODULE, AN ESSENTIAL ELEMENT OF THE INTELLIGENT FIXTURING SYSTEM.....	203
<b>Section D: AUTOMATIC FLEXIBLE TECHNOLOGICAL SYSTEMS, CAX AND CIM PROCEDURES AND SYSTEMS</b>	
<b>Andrejkovič, M., Hajduová, Z., Schwartzová, H.:</b> USE OF OPTIMIZATION TECHNIQUES IN A SELECTED ENTERPRISE .....	207
<b>Andrejkovič, M., Hajduová, Z., Majerník, M., Bosák, M.:</b> ASSEMBLY OF STRUCTURAL COMPONENTS OF A BUS.....	211
<b>Bojanić, M., Tabaković, S., Milojević, Z., Zeljković, M.:</b> PROCESSING OF DIAGNOSTIC IMAGES OF THE SKELETAL SYSTEM .....	215
<b>Erić, M., Tadić, B., Stefanović, M., Miljanić D.:</b> MODEL OF REENGINEERING OF TECHNOLOGICAL PROCESSES - ITERATIVE AND VISUAL APPROACH .....	219
<b>Fuerstner, I., Gogolak, L., Nemedi, I.:</b> DIFFERENT SOLUTIONS FOR A SPECIFIC MECHATRONICS PROJECT .....	223
<b>Globočki – Lakić, G., Sredanović, B., Čiča, Đ., Milutinović, A.:</b> APPLICATION OF CAD/CAM SYSTEMS FOR MACHINING OF PARTS OF ALUMINIUM PROFILES .....	227
<b>Jahn, M., Luttmann, A., Schmidt, A.:</b> A FEM SIMULATION FOR SOLID-LIQUID-SOLID PHASE TRANSITIONS DURING THE PRODUCTION OF MICRO-COMPONENTS .....	231
<b>Jovanovic, V., Wang, H.:</b> MECHATRONICS AND ITS APPLICATIONS IN TRANSPORTATION.....	235
<b>Košarac, A., Zeljković, M.:</b> SIMULATION OF PROCESS CONTROLLED BY PROGRAMMABLE LOGIC CONTROLLER PLC IN THE VIRTUAL REALITY ENVIRONMENT.....	239
<b>Lukić, D., Todić, V., Zeljković, M., Milošević, M., Vukman, J., Jovičić, G.:</b> THE POSSIBILITY AND SIGNIFICANCE OF APPLICATION STEP-NC STANDARD IN THE INTEGRATION OF CAD/CAPP/CAM AND CNC SYSTEM.....	243
<b>Mansour, G., Sagris, D., Tsiafis, Ch., Mitsi, S., Bouzakis, K.-D.:</b> EVOLUTION OF A HYBRID METHOD FOR INDUSTRIAL MANIPULATOR DESIGN OPTIMIZATION.....	247

<b>Miletić, O., Todić, M.:</b> SYNTHESIS OF AUTOMAT FOR GUIDANCE OF THE BAND IN PROCESSING SYSTEM OF MULTIPLE OPERATION PROCESS .....	251
<b>Milojević, Z., Navalušić, S., Zeljković, M., Vićević, M., Beju, L.:</b> EXTENSION OF THE PROGRAM SYSTEM FOR NC MACHINING PROGRAM VERIFICATION WITH HAPTIC DEVICE .....	255
<b>Milutinovic, D., Slavkovic, N., Kokotovic, B., Milutinovic, M., Zivanovic, S., Dimic, Z.:</b> KINEMATIC MODELING OF RECONFIGURABLE PARALLEL ROBOTS BASED ON DELTA CONCEPT .....	259
<b>Mircheski, I., Kandikjan, T.:</b> DESIGN FOR DISASSEMBLY METHODOLOGY FOR DETERMINATION OF OPTIMAL DISASSEMBLY SEQUENCE BASED ON CONTACT RELATIONS BETWEEN COMPONENTS AND FASTENERS IN THE PRODUCT ASSEMBLY .....	263
<b>Mladenovic, G., Popovic, M.:</b> MODELLING, CALCULATIONS AND TESTING OF SINGLE GIRDER BRIDGE CRANE AND CRANE RAILS .....	269
<b>Nikolic, N., Lukic, Lj., Vranjevac, I., Djapic, M.:</b> USE OF SIMULATION SOFTWARE IN PRODUCTION TECHNOLOGIES .....	273
<b>Novak-Marcincin, J., Barna, J., Torok, J.:</b> ADVANCED AUGMENTED REALITY APPLICATIONS IN THE PRODUCTION PROCESSES .....	277
<b>Petrović, P.B., Lukić, N., Danilov, I., Miković, V.:</b> CANONISATION OF ACTUATION STIFFNESS MATRIX IN KINEMATICALLY REDUNDANT INDUSTRIAL HUMANOID ROBOTS .....	281
<b>Petrović, M., Miljković, Z., Babić, B.:</b> OPTIMIZATION OF OPERATION SEQUENCING IN CAPP USING HYBRID GENETIC ALGORITHM AND SIMULATED ANNEALING APPROACH .....	285
<b>Stevanović, D., Korunović, N., Trajanović, M., Trifunović, M., Milovanović, J., Stojković, M.:</b> FINITE ELEMENT MODEL OF HUMAN TIBIA AND PRELIMINARY ANALYSIS .....	289
<b>Todić, V., Lukić, D., Milošević, M., Jovičić, G., Vukman, J.:</b> MANUFACTURABILITY OF PRODUCT DESIGN REGARDING SUITABILITY FOR MANUFACTURING AND ASSEMBLY (DfMA) .....	293
<b>Topčić, A., Cerjaković E., Herić, M.:</b> SIMULATION OF RELOADING SEGMENTS OF INTERNAL TRANSPORTATION SYSTEMS BY ARTIFICIAL NEURAL NETWORKS .....	297
<b>Vuković, N., Miljković, Z., Mitić, M., Babić, B., Lazarević, I.:</b> AUTONOMOUS NAVIGATION OF AUTOMATED GUIDED VEHICLE USING MONOCULAR CAMERA .....	301
<b>Zadnik, Ž., Karakašić, M., Čok, V., Kljajin, M., Duhovnik, J.:</b> IMPLEMENTATION MATRIX OF FUNCTION AND FUNCTIONALITY IN PRODUCT DEVELOPMENT PROCESS .....	305
<b>Zeljko, M., Živković, A., Blanuša, V.:</b> THERMAL-ELASTIC BEHAVIOR OF A MAIN SPINDLE ASSEMBLY WITH DOUBLE ROW CYLINDRICAL ROLLER BEARINGS .....	309

## Section E: MECHANICAL ENGINEERING AND ENVIRONMENTAL PROTECTION

<b>Arsovski, S., Lazić, M., Krivokapić, Z., Tadić, D., Grubor, S.:</b> AN APPROACH TO DEFINE OPTIMAL TECHNOLOGY PORTFOLIO OF ELV RECYCLING .....	315
<b>Avdic, N., Goletic, S.:</b> SELECTION CRITERIA FOR CLEAN WATER DECENTERS OF SBR WASTEWATER TREATMENT PLANTS .....	319
<b>Badida, M., Bartko, L., Králiková, R., Sobotová, L.:</b> RESEARCH OF SELECTED ACOUSTIC DESCRIPTORS OF THREE LAYER SANDWICH ABSORBERS .....	323
<b>Dzoganova, Z., Badida, M.:</b> IMPACT ASSESSMENT OF MECHANICAL PROPERTIES OF DEGRADED PET BOTTLES IN ENVIRONMENTAL DEGRADATION OF HIGHER TEMPERATURE.....	329
<b>Fedorčáková, M. , Šebo, J.:</b> THE RESULTS OF APPLICATION OF WASTEWATER BY NEW DEVELOPING ELECTROLYTIC FLOTATION METHODS .....	333
<b>Georgiadis, P.:</b> DYNAMIC DECISION SUPPORT SYSTEM FOR PLANNING AND CONTROL IN CLOSED-LOOP RECYCLING NETWORKS .....	335
<b>Goletić, Š., Imamović, N.:</b> IMPACT OF STEEL PRODUCTION TECHNOLOGY ON ENVIRONMENT .....	339
<b>Hroncová, E., Ladomerský, J.:</b> MODEL FOR EVALUATION OF CO-COMBUSTION OF COMPOSTED SEWAGE SLUDGE .....	343
<b>Hronec, O., Vilček, J., Adamišín, P., Andrejovský, P., Huttmanová, E.:</b> USE OF PHRAGMITES AUSTRALIS (CAV.) TRIN AND ITS REPRODUCTION IN THE REVITALIZATION OF CONTAMINATED SOILS .....	347
<b>Kheifetz, M., Pynkin, A., Pozilova, N., Prement, G., Klimenko, S.:</b> DESIGN DECISIONS DURING MODELLING TRANSFER OF QUALITY PARAMETERS IN LIFE CYCLE OF MACHINE DETAILS .....	353
<b>Kovács, P.V., R., Beszedes, S., Ludányi, L., Hodúr, C., Szabó, G.:</b> DEVELOPMENT OF A CONTINUOUS FLOW MICROWAVE TOROIDAL CAVITY RESONATOR .....	357
<b>Križan, P., Matúš, M., Šooš, E.:</b> DESIGN OF PRESSING CHAMBER OF BRIQUETTING MACHINE WITH HORIZONTAL PRESSING AXIS.....	361
<b>Maňko, M., Košíková, A.:</b> ISO 50001 AS THE BASIS FOR IMPLEMENTING AN ENVIRONMENTAL MANAGEMENT SYSTEM.....	365
<b>Milanković, D., Milanović, B., Agarski, B., Crnobrnja, B., Ilić, M., Kosec, B., Budak, I.:</b> LIFE CYCLE ASSESSMENT OF AN INTERMODAL STEEL BUILDING UNIT IN SERBIA.....	369
<b>Muránsky, J.:</b> DETERMINATION OF THE OPTIMAL PRODUCTION VOLUME RESPECTING THE ENVIRONMENTAL AND ECONOMIC CRITERIONS .....	373
<b>Petelj, A., Hadžistević, M., Antić, A., Hodolić, J.:</b> DETERMINATION OF ABSORPTION COEFFICIENT OF SAMPLE UNDER NON-LABORATORY CONDITIONS.....	377

<b>Sabolová, J., Fedorčáková, M.:</b> HYDRODYNAMIC MODELING OF FLOOD EVENTS IN SELECTED AREA .....	381
<b>Šebo, J., Fedorčáková, M.:</b> ECONOMIC OPTIMIZATION OF RECYCLING ORIENTED DISASSEMBLY OF CONSUMER ELECTRONICS: THE CASE STUDY OF MOBILE PHONE .....	385
<b>Sekulić, M., Hadžistević, M., Kovač, P., Gostimirović, M., Jurković, Z.:</b> CURRENT TRENDS IN SUSTAINABLE PRODUCT DESIGN .....	391
<b>Simonovic, S.:</b> BOTH LEANER AND CLEANER PRODUCTION BY PRODUCT DESIGN .....	395
<b>Tichá, M., Budak, I.:</b> LCA APPLICATION IN EPD AND ECO-EFFICIENCY .....	399
<b>Vasiliev, A., Borodavko, V., Kroutko, V., Kheifetz, M., Gaiko, V.:</b> FORMATION OF QUALITY PARAMETERS IN LIFE CYCLE OF MACHINE DETAILS ON THE BASIS OF TECHNOLOGICAL INHERITANCE .....	403
<b>Vlčej, J., Milanović, B., Milanković, D., Hodolič, J.:</b> IMPLEMENTATION OPTIONS OF LCA METHOD IN PRACTICE IN SLOVAK REPUBLIC .....	407
<b>Vojinović Miloradov, M., Šenk, N., Okuka, M., Turk Sekulić, M., Radonić, J.:</b> POLYPARAMETER MODEL FOR DEFINING PARTITIONING PROCESSES OF SEMIVOLATILE ORGANIC COMPOUNDS .....	411

## **Section F: OTHER PRODUCTION ENGINEERING TECHNOLOGIES**

<b>Alexandrov, S., Lyamina, E., Manabe, K.:</b> A THEORETICAL STUDY ON SURFACE ROUGHING IN PURE BENDING OF VISCOPLASTIC SHEETS.....	415
<b>Božičković, Z., Dobraš, D., Božičković, R.:</b> ELIMINATION OF PERMANENT DEFORMATIONS IN THE LONGITUDINAL WELDING PROCESS OF CONICAL PIPES WITH ONE SEAM .....	419
<b>Brkljač, N., Simić, R., Kovač, P., Brkljač, B.:</b> FEM IN FUNCTION OF PNS - APPLIED IN DERIVING APPROXIMATE FORMULA FOR CALCULATION OF THEORETICAL SCF IN BUTT WELD JOINTS .....	423
<b>Brüning, H., Vollertsen, F.:</b> SELF-ALIGNING CAPABILITY OF LASER BASED FREE FORM HEADING PROCESS .....	427
<b>Deželak, M., Stepišnik, A., Pahole, I., Ficko, M.:</b> METHODS FOR SPRINGBACK PREDICTION AND COMPENSATION .....	431
<b>Ivanisevic, A., Milutinovic, M., Skakun, P., Movrin, D., Kacmarcik, I., Plancak, M., Vilotic, D., Alexandrov, S.:</b> EXPERIMENTAL DETERMINATION OF FORMING LIMIT DIAGRAM FOR BRASS.....	435
<b>Jovanic, D., Jovanovic, M.</b> ECONOMIC EFFICIENCY OF WELDING SIMULATOR USE FOR WELDING PERONNEL TRAINING .....	439
<b>Jovanovic, V., Langraudi, N., Tomovic, M. M.:</b> BOND GRAPH THEORY AND ITS USE FOR HYDRAULIC SYSTEM MODELING .....	443
<b>Karpe, B., Kosec, B., Gojić, M., Anžel, I., Kitak, S., Bizjak, M.:</b> MATHEMATICAL MODELING OF THE MELT COOLING RATE IN THE MELT-SPINNING PROCESS .....	447

<b>Krašnik, M., Vilotić, D., Šidanin, L., Petrović, Ž.:</b> INITIAL MICROSTRUCTURE STATE IMPACT TO STEEL C45E FORMABILITY .....	453
<b>Kuzman, K., Kacmarcik, I., Pepelnjak, T., Plancak, M., Vilotic, D.:</b> EXPERIMENTAL CONSOLIDATION OF ALUMINIUM CHIPS BY COLD COMPRESSION.....	459
<b>Nedić, B., Jovanović, D., Marušić, V.:</b> SOME SCRATCH TEST RESEARCH RESULTS Zn COATINGS .....	463
<b>Neugebauer, R., Voelkner, W., Mauermann, R., Israel, M.:</b> CLINCHING IN STEEL AND RAILWAY CONSTRUCTION, SHIPBUILDING AND COMMERCIAL VEHICLES .....	467
<b>Novak-Marcincin, J., Novakova-Marcincinova, L.:</b> PRODUCTION OF PARTS REALIZED BY FDM RAPID PROTOTYPING TECHNOLOGY AND THEIR TESTING .....	473
<b>Plancak, M., Stefanovic, M., Pecelj, Dj., Mihajlovic, G., Vilotic, D., Ivanisevic, A.:</b> INFLUENCE OF PROCESS PARAMETERS ON LOAD REQUIRAMENT IN ORBITAL FORGING OPERATIONS .....	477
<b>Radić, N., Jeremić, D.:</b> INVESTIGATION THE INFLUENCE OF ELASTIC MEDIA ON THE BUCKLING NANOPLATE APPLYING NONLOCAL ELASTICITY THEORY .....	481
<b>Rajnovic, D., Sidjanin, L.:</b> THE DUCTILE TO BRITTLE TRANSITION TEMPERATURE OF UNALLOYED ADI MATERIAL .....	485
<b>Skakun, P., Plančak, M., Vilotić, D., Lužanin, O., Milutinović, M., Movrin, D.:</b> MANUFACTURING OF GEAR-LIKE COMPONENTS BY METAL FORMING – POSSIBILITIES AND LIMITATIONS .....	489
<b>Topčić, A., Lovrić, S., Cerjaković, E.:</b> COMPARATIVE ANALYSIS OF RE/RP VERSUS CONVENTIONAL APPROACHES OF TOOL DESIGNING IN SAND CASTING .....	493
<b>Vilotić, M., Kakaš, D., Terek, P., Kovačević, L., Kukuruzović, D., Miletić, A.:</b> SEVERE PLASTIC DEFORMATION BY COMPRESSION .....	497

## **Section G: BIO-MEDICAL ENGINEERING - CAx**

<b>Matin, I., Markovic, D., Puskar, T., Hadzistevic, M., Hodolic, J., Vukelic, Dj., Potran, M.:</b> RECONSTRUCTION OF THE DENTAL CAD MODEL.....	501
<b>Petrović, S., Matić, A., Devedžić, G., Ristić, B., Čuković, S.:</b> DIFFERENCES IN TIBIAL ROTATION AND TRANSLATION IN ACL DEFICIENT AND HEALTHY KNEES .....	505
<b>Puskar, T., Jevremovic, D., Eggbeer, D., Lapcevic, A., Trifkovic, B., Vukelic, D., Williams, R.J.:</b> DETERMINATION OF CORROSION CHARACTERISTICS OF DENTAL ALLOY BY INDUCTIVELY COUPLED PLASMA MASS SPECTROMETRY .....	509
<b>Radulović, J., Mijailović, N., Trajanović, M., Filipović, N., Radulović, N.:</b> ESTIMATION OF EXPOSURE DOSE OF HUMAN HEAD DURING CT SCANNING PROCEDURE USING MONTE CARLO SIMULATION .....	513
<b>Raspudic, V.:</b> KINEMATIC ANALYSIS OF LOWER EXTREMITIES IN CAD ENVIRONMENT.....	517

<b>Tabaković, S., Zeljković, M., Živković, A., Grujić, J.:</b> DEVELOPMENT OF THE ENDOPROSTHESIS OF THE FEMUR ACCORDING TO THE CHARACTERISTICS OF A SPECIFIC PATIENT .....	521
<b>Trajanović, M., Tufegdžić, M., Arsić, S., Veselinović, M., Vitković, N.:</b> REVERSE ENGINEERING OF THE HUMAN FIBULA.....	527
<b>Uzelac, M., Vilimonović, M.:</b> BASIC PRINCIPLES OF THE USE OF CONE BEAM CT DEVICE IN RADIOLOGY OF A PATIENT'S CRANIOFACIAL REGION .....	531
<b>Vilotić, M., Lainović, T., Kakaš, D., Blažić, L., Marković, D., Ivanišević, A.:</b> ROUGHNESS ANALYSIS OF DENTAL RESIN-BASED NANOCOMPOSITES .....	535
<b>Vitković, N., Veselinović, M., Mišić, D., Manić, M., Trajanović, M., Mitković, M.:</b> GEOMETRICAL MODELS OF HUMAN BONES AND IMPLANTS, AND THEIR USAGE IN APPLICATION FOR PREOPERATIVE PLANNING IN ORTHOPEDICS .....	539
<b>Williams, R.J., Eggbeer, D., Lapcevic, A., Trifkovic, B., Puskar, T., Budak, I., Jevremovic, D.:</b> RE-CAD/CAM APPROACH IN DESIGN AND MANUFACTURING OF DENTAL CERAMIC CROWNS IN COMBINATION WITH MANUAL INDIVIDUALIZATION.....	543
<b>AUTHOR INDEX .....</b>	<b>547</b>
<b>INFORMATION ABOUT DONATORS .....</b>	<b>551</b>





Mladenovic, G., Popovic, M.

## MODELLING, CALCULATIONS AND TESTING OF SINGLE GIRDER BRIDGE CRANE AND CRANE RAILS

**Abstract:** Bridge cranes are used for handling various types of cargo in the production halls, workshops, storage facilities, energy facilities, mills as well as in performing technological processes, assembly or disassembly of equipment. The main characteristic for these cranes are that a major girder (which in most cases is standard I profile) also represents a path on which moving movable hoist. This paper describes the procedures of using the command Frame Generator of the Software Package Autodesk Inventor 2011<sup>®</sup>, which use reduces the total time of modeling the structure which consists of standard profiles, as well as the module Frame Analysis which allows to predict the behavior of constructions under the influence of load. The end of the paper gives the experimental results for displacement and stress condition for given crane for the case of static load.

**Key words:** Single Girder Bridge Crane, Autodesk Inventor<sup>®</sup>, Frame Analysis

### 1. INTRODUCTION

The uses of structures which are composed of standard profiles are common in mechanical engineering. An example of these structures is Single Girder Bridge Crane, Fig. 1.



Fig. 1. Single Girder Bridge Crane

For the cross section is most commonly used hot rolled "I" profile that serves as rails, Fig. 2a. Sometimes it is necessary to achieve stability against side buckling, which can be achieved by placing additional elements on the upper belt Fig. 2b,c.

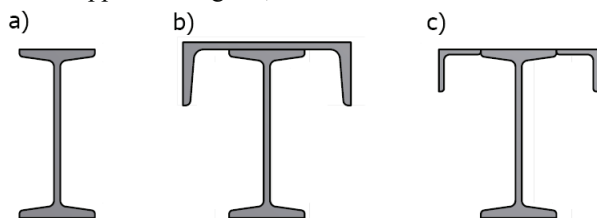


Fig. 2. Examples of cross-section of the main girder and the reinforcement of the upper belt

Therefore it is necessary to find as simply as possible way of modeling and calculations for given constructions. Depending of used software there is different speed of modeling, where most of the software requires drawing a sketch of the cross section, and then the sketch extrude through a trajectory. But, Software Package Autodesk Inventor 2011<sup>®</sup> has the

possibility to select standard profiles from database. First it is necessary to draw skeleton of the structure, and then just set up some of the standard profiles on the corresponding segment of the skeleton. Besides the quick making 3D models, the advantage of this type of modeling is that the Frame Generator assembly is automatically converted into simplified model of beams and nodes with the starting of the Frame Analysis environment and starting a new analysis.

### 2. MODELING CRANE

As it is said in the introduction, for obtaining a 3D model of constructions which are composed of standard profiles it is first necessary to sketch skeleton of structure. It is enough to draw a sketch in the one "sketch"-a. The look of the skeleton crane is shown on Figure 3.

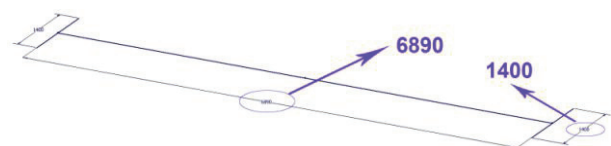


Fig. 3. The skeleton structure with defined dimensions

The command Frame Generator can be used only in environment for working with assemblies. Activation of command (Insert Frame) requires the definition of the standard profile, the choice of materials and segments (lines) on which will be set given profile or defining the start and the end points of segment. It is also defines the position and orientation of the profile in cross section. It can be selected one of the 9 cases, to position the center of gravity of the profile on the selected line or to one of 4 sides profiles match with the projection of line in that plane or the profile that can be moved along the diagonal. For all these cases it is possible to rotate the cross section for the desired angle and to move it by a some direction.

Length of the selected profiles match the length of lines in the sketch and it is necessary to subsequent repair

ends of the profiles using the commands Trim, Extend, Notch, and Miter. Using commands Change it is easy and quick to change a profile on construction which is of great importance for optimization process. For the main girder the standard profile DIN1026 **I260** is used, and for reinforcement for the upper bend the standard profile DIN1026 **U100** is used. For the side girder standard profiles DIN1026 **U120** mutually spaced 110mm are used.

### 3. CALCULATIONS OF CRANE AND CRANE RAILS

When the skeleton of the construction were formed this way it is possible to calculate the construction by activation of Frame Analysis Environment. Frame Analysis is used to understand the structural integrity of a given frame with respect to deformations and stresses, when subjected to various loading and constraints. Once when the criteria are defined, it is possible to run the simulation and view the behavior relative to the conditions which are defined. Simulations help to identify performance issues and find better design alternatives. Beam elements are linear. Frame analysis does not support curved beams. When the Frame Analysis environment is opened and a new analysis starts, the Frame Generator assembly is automatically converted into simplified model of beams and nodes. In the software it is very easy to define a new node (command Custom Node). There is only a need to define on which beam node is and how away it is from the end of the beam. This very simplifies the calculations of structures and reduces the total time of preprocessing. There are two approaches which give identical results, first to define a new node and then set the load on that place. Another way is to define, on which beam load is acting, and how away from the end of beam is the point on which concentrated force is acting. Besides the request for dimensions of construction another request was capacity of a construction which is designed to be 1t. Also, it was given the constraint that the carts can get close to maximum 500mm from the end of the main girder. As the given modeled crane should be installed into the building described in [4] it is analyzed the four loading cases shown on Fig. 4 and these are:

- (a) The axis of the main girder intersects poles axis, the load on the middle of the main girder
- (b) The axis of the main girder intersects poles axis, load on the 500mm from the end of main girder
- (c) The axis of of the main girder on the middle between the two poles, the load on the middle of

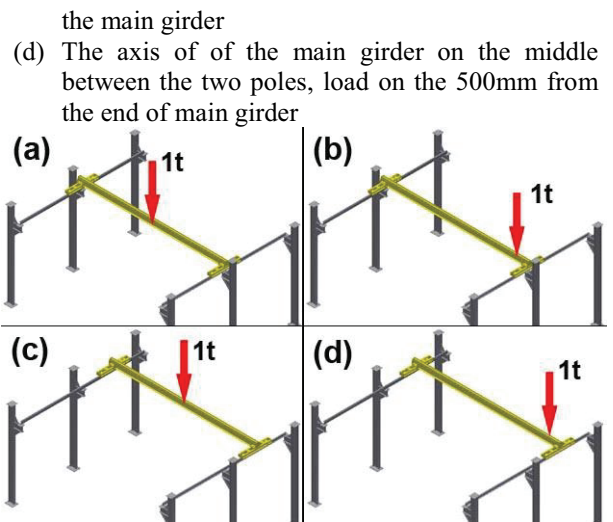


Fig. 4. Four cases of construction loads

Addition to the above the software allows to define rigid links (command Rigid Link) between nodes, which is necessary to do by analyzing the four loading cases. The connection between the crane and crane rails going across wheels, but the Frame Analysis environment works with beams so it is necessary to define a new node on place where wheels are (which is on 150mm from the end of side girder). By analog procedure it is necessary to define a new node on the crane rail at the same vertically relative to the previously formed on the side girder and then mentioned two rigidly connected in order to transferred the crane load to the crane rails as shown on Fig. 5.

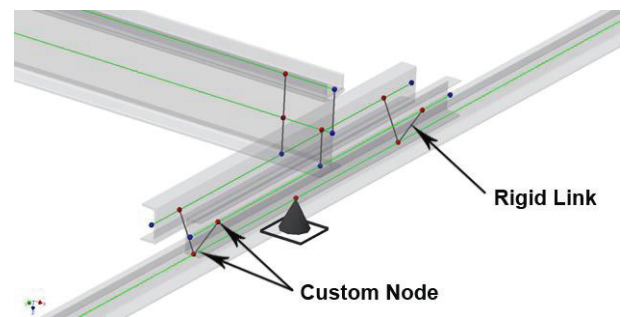


Fig. 5. Defining connection crane with crane rails

Calculation results are given in Table 1. mark  $\delta$  represents the value of deformation. Beside to considering the stress state of the main and side girders, it was also discussed the stress state for the crane rails for that have been selected standard profiles DIN1026 **U120**, and the length of the crane rails is 3m.

Element	Serial number	$\delta$ [mm]	$S_{MAX}$ [MPa]	$S_{MIN}$ [MPa]	$S_{MAX}(M_x)$ [MPa]	$S_{MAX}(M_y)$ [MPa]	$S_{MIN}(M_x)$ [MPa]	$S_{MIN}(M_y)$ [MPa]	Saxial [MPa]
Main girder	a i c	5.05	31.4	-41.49	35.76	8.68	-35.76	-3.9	22.72
	b i d	1.82	12.6	-12.28	10.49	4.04	-10.49	-3.28	8.56
Side girder	a i c	0.13	15.77	-15.77	15.77	0	-15.77	0	0
	b i d	0.20	25.45	-25.45	25.45	0	-25.45	0	0
Crane rails	a	0.38	26.59	-26.59	26.59	0	-26.59	0	0
	b	0.57	40.94	-40.94	40.94	0	-40.94	0	0
	c	<b>4.53</b>	58.68	-58.68	58.68	0	-58.68	0	0
	d	<b>7.12</b>	92.12	-92.12	92.12	0	-92.12	0	0

Table 1. The calculations results for particular construction elements

Based on the table 1, which shows that the according to the stress and deformation, state dimensions of the crane are satisfying. Checking the lateral buckling of the main girder (in case that the cross section is only **1260** profile) was calculated analytically using the forms from [2] according to **JUS U. E7 101/1986**. Limit value for the lateral buckling stresses for this case is

$$\sigma_b = \frac{\sigma_D}{\nu} = \frac{18.86}{1.5} = 12.57 \text{ kN / cm}^2$$

and is greater than maximum normal stresses given in Table 1.

Based on this it can be concluded that there is no side buckling of the main girder. After verifying the previous conditions the creation of complete 3D model of the crane was undertaken. The ribs for reinforcement, bearing wheels with relevant bearings, wheels with relevant shafts were designed. It is foreseen that the drive motor being on the one side, and the motion transfer to the other side with PTO shaft. In accordance to this, the central bearing was projected. Of course, rails on which cables will move, were developed. Crane is designed that it is possible to separate the side girder from the main girder for easier transport or a later redesign of crane. In addition, it is possible to unmount middle bearing PTO. Image of complete 3D model is shown on Fig. 6.



Fig. 6. The complete 3D model of calculated crane

In contrast to crane that satisfies all three criteria, crane rails do not satisfies maximum allowed deformation ( $\leq l/1000=3\text{mm}$ ) so it is necessary to reinforcement the same or change dimensions of the standard profiles which were made.

Based on the fact that the hall has been already made, it was approached to the design of the reinforcement of existing crane rails composed of the standard **DIN1026 U120** profile. The idea was to underside of the crane rails form a truss structure composed of the standard pipes with square cross-section **40x40mm**, with wall thickness of the **2.9mm**. The position of the lower profile is the **500mm** and parallel to the rail. Other profiles consists the grid and placed each other at angle of **45°**, Fig. 7.

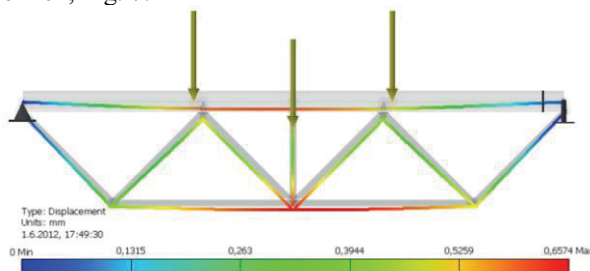


Fig. 7. Image of reinforced rails with corresponding deformation

For this purpose the complete project has not been changed but only the 3D model of reinforced crane rails was made. The effect of the crane was replaced by concentric force that represents the weight of the whole crane that was obtained from the previous analysis, of course with a predefined load capacity of the construction of 1t. It was considered only the worst case of load (case (d) from fig. 4) and the results for the displacement are shown on Fig. 7 (maximum displacement is 0.6574mm). The value of maximum normal stress for a given case of load is 32.26 MPa.

#### 4. MAKING CRANE

Based on the model from item 3 of this paper the creation of technical documentation and making the crane was undertaken. For welding electrodes **Jasenice EVB50 Ø4mm** were used (software has the possibility to define the welded joints, but it is not considered for this time). The wheels are made of cast iron to minimize wear of crane rails. For the drive wheels double row ball bearings **4208** are used which are placed in housings. For a driven wheel single row ball bearing **6208** was used which is placed in the wheels, and the corresponding shaft was fixed, i.e. realized tight fitting in the side girders.

At this stage it was not performed reconstruction of crane rails and the crane was placed on the existing rails.

#### 5. INVESTIGATION OF DEFORMATION CRANE AND CRANE RAILS

Fig. 8 shows the experimental scheme. Crane was loaded with known weights of  $Q=360\text{kg}$  exactly on the middle of the range of main girder. Position of the crane in relation to the crane rails was that the axis of the main girder intersects poles axis. With comparator were measured vertical displacements for two places, the place 1 for measurement deformation of the crane rails, and the place 2 for measurement deformation of the main girder.

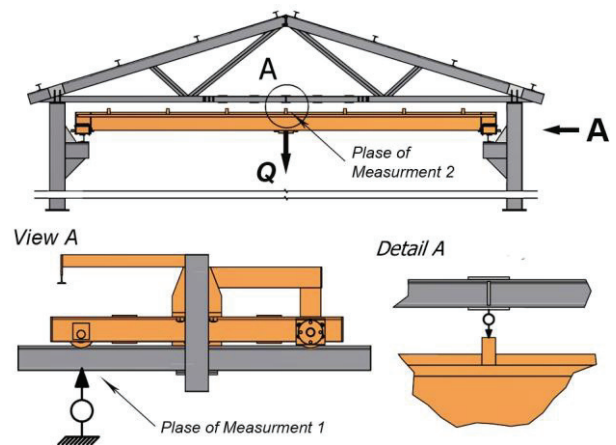


Fig. 8. Experimental scheme

In order to compare calculation results with the actual deformation it is necessary to do the following:

- Calculate the displacement of the 3D model for the case (a) from Fig. 4 only under the influence of self-weight of construction
- After this set a known concentrated load  $Q=360\text{kg}$  and calculate the displacement
- The difference of these two displacement should correspond to the comparator measurement because the deformation under own crane weight were included with setting comparator.

Bearing all this in mind another analysis in Frame Analysis environment was done and the results are shown in Table 2. Fig. 9 shows the simulation results (deformation of crane) obtained in Inventor.



Fig. 9. Simulation from Inventor

	The deformation of the main girder [mm]	The deformation of the crane rails [mm]
The simulation results	1.35	0.09
The measured values	1.48	0.11

Table 2. Simulation results and experimental results

Differences in the data can be explained through the following:

- The dimensions of the profile, because of tolerance for free measures, differ with respect to the tabular values, and consequently are different to the characteristics of the cross section that directly affect on the value of deformation
- The software does not provide the possibility for reading specific deformation on specific place, but the deformation is read based on shades of color from color bar and even then it makes error in reading displacement as in the case of measuring deformation at the contact of the wheels and crane rails.



Fig. 10. Doing the experiment

Figure 10 shows the experimental determination for the deformation for the main girder and the crane rails.

## 6. CONCLUSION

This paper describes the procedures of construction, calculations and optimization at the example of Single Girder Bridge Crane and corresponding crane rails using a method that provides choice of standard profiles from database. Calculation results are compared with the experimentally determined displacement for made crane according to modeled and calculated 3D model of construction.

Using Frame Analysis environment of software package Autodesk Inventor allows the designer to perform with minimal knowledge of FEM analysis, because the software takes care of the required CP and FE, so it is possible to set a load on any part of the KE (beam) in one step, as a result of very advanced preprocessor that recognize and automatically form a network of FE. Analyzing the results from the software and the measured displacement was seen that there was deviation up to 10%, whose reasons described under item 5 of this paper.

## 7. REFERENCES

- [1] Kalajdžić M.: *Metod konačnih elemenata, osnovi statike, statika nosećih struktura, dinamika nosećih struktura, primene*, IAMA, Beograd, 1978
- [2] Ostrić D.: *Dizalice*, Mašinski fakultet, Beograd, 1992.
- [3] Mladenović, G., Popović, M.: *DESIGN AND OPTIMIZATION FOR TRUSS CONSTRUCTIONS USING THE SOFTWARE PACKAGE AUTODESK INVENTOR 2011®*, The 7th International Conference HEAVY MACHINERY HM 2011, Proceedings, p.p. 29-32 Vrnjačka Banja, Mašinski fakultet Kraljevo, Vrnjačka Banja, 2011
- [4] Mladenović, G., Popović, M., Tanović Lj.: *DESIGN, CALCULATIONS AND INVESTIGATION OF TRUSS ROOF CONSTRUCTION*, International Conference Maintenance and Production Engineering "KODIP - 2012", Proceedings, p.p. 307-313 Budva, Faculty of Mechanical Engineering – Podgorica, Budva, 2012
- [5] Autodesk Inventor 2011® Profesional – Help
- [6] <http://usa.autodesk.com/>

**Authors: Goran Mladenovic, dipl.ing., mr Mihajlo Popovic**, University of Belgrade, Faculty of Mechanical Engineering, Department for Production Engineering, Kraljice Marije 16, 11120 Beograd 35, Serbia, Phone.: +381 11 3302-438, Fax: +381 11 3370-364.

E-mail: [gmladenovic@mas.bg.ac.rs](mailto:gmladenovic@mas.bg.ac.rs)  
[mpopovic@mas.bg.ac.rs](mailto:mpopovic@mas.bg.ac.rs)