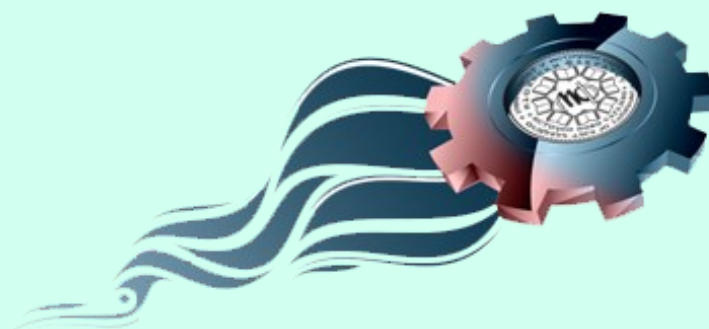




UNIVERSITY OF EAST SARAJEVO
FACULTY OF MECHANICAL
ENGINEERING



6th INTERNATIONAL SCIENTIFIC CONFERENCE



COMETa 2022

***„Conference on Mechanical Engineering
Technologies and Applications“***

PROCEEDINGS

17th-19th November
East Sarajevo, RS, B&H

COMET α 2022

6th INTERNATIONAL SCIENTIFIC CONFERENCE

17th - 19th December 2022

Jahorina, B&H, Republic of Srpska



University of East Sarajevo

Faculty of Mechanical Engineering

Conference on Mechanical Engineering Technologies and Applications

Z B O R N I K R A D O V A

P R O C E E D I N G S

Istočno Sarajevo, BiH, RS
17 - 19. novembar 2022.

East Sarajevo, B&H, RS
17th – 19th November, 2022

ZBORNİK RADOVA SA 6. MEĐUNARODNE
NAUČNE KONFERENCIJE
"Primijenjene tehnologije u mašinskom inženjerstvu"
COMETA2022, Istočno Sarajevo, 2022.

PROCEEDINGS OF THE 6th INTERNATIONAL
SCIENTIFIC CONFERENCE
"Conference on Mechanical Engineering
Technologies and Applications"
COMETA2022, East Sarajevo, 2022

<i>Organizator:</i>	Univerzitet u Istočnom Sarajevu Mašinski fakultet Istočno Sarajevo
<i>Organization:</i>	University of East Sarajevo Faculty of Mechanical Engineering East Sarajevo
<i>Izdavač:</i>	Univerzitet u Istočnom Sarajevu Mašinski fakultet Istočno Sarajevo
<i>Publisher:</i>	University of East Sarajevo Faculty of Mechanical Engineering East Sarajevo
<i>Za izdavača: For publisher:</i>	PhD Milija Kraišnik, associate professor
<i>Urednici: Editors:</i>	PhD Dušan Golubović, full professor PhD Miroslav Milutinović, associate professor PhD Saša Prodanović, associate professor
<i>Tehnička obrada i dizajn: Technical treatment and desing:</i>	PhD Aleksije Đurić, senior assistant MSc Jovana Blagojević, senior assistant MSc Milica Bošković, senior assistant Krstó Batinić, assistant
<i>Izdanje: Printing:</i>	Prvo 1 st
<i>Register: Register:</i>	ISBN 978-99976-947-6-8 COBISS.RS-ID 137162497

REVIEWERS

PhD Dušan Golubović, FME UES (B&H)
PhD Dušan Gordić, FE Kragujevac (Serbia)
PhD Ljubiša Dubonjić, FMCE Kraljevo (Serbia)
PhD Mirko Blagojević, FE Kragujevac (Serbia)
PhD Miroslav Stanojević, FME Belgrade (Serbia)
PhD Adisa Vučina, FMCE Mostar (B&H)
PhD Aleksandar Jovović, FME Belgrade (Serbia)
PhD Aleksandar Košarac, FME UES (B&H)
PhD Aleksandar Živković, FTS Novi Sad (Serbia)
PhD Biljana Marković, FME UES (B&H)
PhD Bogdan Marić, FME UES (B&H)
PhD Branimir Krstić, University of Defence, Military Academy (Serbia)
PhD Damjan Klobčar, FME Ljubljana (Slovenia)
PhD Darko Bajić, FME Podgorica (MNE)
PhD Dejan Jeremić, FME UES (B&H)
PhD Dragan Milčić, FME Nis (Serbia)
PhD Dragan Pršić, FMCE Kraljevo (Serbia)
PhD Goran Orašanin, FME UES (B&H)
PhD Jasmina Pekez, TF "Mihajlo Pupin" Zrenjanin (Serbia)
PhD Jelena Jovanović, FME Podgorica (MNE)
PhD Lozica Ivanović, FE Kragujevac (Serbia)
PhD Milan Banić, FME Niš (Serbia)
PhD Milan Rackov, FTS Novi Sad (Serbia)
PhD Milan Tica, FME Banja Luka (B&H)
PhD Milan Zeljković, FTS Novi Sad (Serbia)
PhD Milija Krašnik, FME UES (B&H)
PhD Milomir Šoja, FEE UES (B&H)
PhD Miloš Milovančević, FME Nis (Serbia)
PhD Miodrag Žigić, FTS Novi Sad (Serbia)
PhD Mirko Dobrnjac, FME Banja Luka (B&H)
PhD Miroslav Milutinović, FME UES (B&H)
PhD Mladen Josijević, FE Kragujevac (Serbia)
PhD Mladen Tomić, FTS Novi Sad (Serbia)
PhD Mladimir Milutinović, FTS Novi Sad (Serbia)
PhD Nebojša Radić, FME UES (B&H)
PhD Nenad Grahovac, FTS Novi Sad (Serbia)
PhD Nikola Tanasić, FME Belgrade (Serbia)
PhD Nikola Vučetić, FME UES (B&H)
PhD Ranka Gojković, FME UES (B&H)
PhD Ranko Antunović, FME UES (B&H)
PhD Saša Prodanović, FME UES (B&H)
PhD Saša Živanović, FME Belgrade (Serbia)
PhD Silva Lozančić, Faculty of Civil Engineering Osijek (Croatia)
PhD Slaviša Moljević, FME UES (B&H)
PhD Slobodan Lubura, FEE UES (B&H)
PhD Slobodan Tabaković, FTS Novi Sad (Serbia)
PhD Snežana Nestić, FE Kragujevac (Serbia)
PhD Spasoje Trifković, FME UES (B&H)
PhD Srđan Vasković, FME UES (B&H)
PhD Stojan Simić, FME UES (B&H)
PhD Uroš Karadžić, FME Podgorica (MNE)

PhD Vladimir Milovanović, FE Kragujevac (Serbia)
PhD Vladimir Stojanović, FMCE Kraljevo (Serbia)
PhD Vlado Medaković, FME UES (B&H)
PhD Zdravko Pandur, FFWT UZ (Croatia)

INTERNATIONAL SCIENTIFIC COMMITTEE

PhD Dušan Golubović, FME UES (B&H) – president

PhD Adisa Vučina, FMCE Mostar (B&H)
PhD Aleksandar Aleksić, FE Kragujevac (Serbia)
PhD Aleksandar Jovović, FME Belgrade (Serbia)
PhD Aleksandar Košarac, FME UES (B&H)
PhD Balasaheb M. Patre, SGGGS IET (India)
PhD Biljana Marković, FME UES (B&H)
PhD Bogdan Marić, FME UES (B&H)
PhD Borut Kosec, NTF Ljubljana, (Slovenia)
PhD Božidar Rosić, FME Belgrade (Serbia)
PhD Branimir Krstić, Military academy, University of Defence in Belgrade (Serbia)
PhD Branko Vučijak, FME Sarajevo (B&H)
PhD Bratislav Blagojević, FME Niš (Serbia)
PhD Damjan Klobčar, FME Ljubljana (Slovenia)
PhD Danijela Tadić, FE Kragujevac (Serbia)
PhD Darko Knežević, FME Banja Luka (B&H)
PhD Dejan Jeremić, FME UES (B&H)
PhD Dragan Milčić, FME Niš (Serbia)
PhD Dragan Spasić, FTS Novi Sad (Serbia)
PhD George Nenes, UOWM (Greece)
PhD Goran Janevski, FME Niš (Serbia)
PhD Goran Orašanin, FME UES (B&H)
PhD Goran Putnik, University of Minho, (Portugal)
PhD Goran Šimunović, MEFSB (Croatia)
PhD Indiran Thirunavukkarasu, Manipal Institute of Technology, Indija
PhD Isak Karabegović, FTS Bihać (B&H)
PhD Ivan Samardžić, MEFSB (Croatia)
PhD Izet Bjelonja, FME Sarajevo (B&H)
PhD Jozsef Nyers, The Obuda University Budapest (Hungary)
PhD Kyros Yakinthos, AUTH, (Greece)
PhD Lozica Ivanović, FE Kragujevac (Serbia)
PhD Ljubodrag Tanović, FME Belgrade (Serbia)
PhD Ljubomir Miladinović, FME Belgrade (Serbia)
PhD Mathias Liewald, IFU, (Germany)
PhD Milan Rackov, FTS Novi Sad (Serbia)
PhD Milan Rakita, Purdue Univerzitet, SAD
PhD Milan Tica, FME Banja Luka (B&H)
PhD Milan Zeljković, FTS Novi Sad (Serbia)
PhD Mile Savković, FMCE Kraljevo (Serbia)
PhD Milorad Milovančević, FME Belgrade (Serbia)
PhD Milosav Ognjanović, FME Belgrade (Serbia)
PhD Mirko Blagojević, FE Kragujevac (Serbia)
PhD Mirko Dobrnjac, FME Banja Luka (B&H)
PhD Mirko Ficko, UM FPME, (Slovenia)
PhD Miroslav Stanojević, FME Belgrade (Serbia)

PhD Miroslav Živković, FE Kragujevac (Serbia)
PhD Mladen Tomić, FTS Novi Sad (Serbia)
PhD Mladomir Milutinović, FTS Novi Sad (Serbia)
PhD Nebojša Lukić, FE Kragujevac (Serbia)
PhD Nebojša Radić, FME UES (B&H)
PhD Nenad Pavlović, FME Niš (Serbia)
PhD Nikola Vučetić, FME UES (B&H)
PhD Nina Anđelić, FME Belgrade (Serbia)
PhD Novak Nedić, FMCE Kraljevo (Serbia)
PhD Obrad Spaić, UES PFM, (B&H)
PhD Pavel Kovač, FTS Novi Sad (Serbia)
PhD Ranislav Bulatović, FME Podgorica (MNE)
PhD Radivoje Mitrović, FME Belgrade (Serbia)
PhD Radoslav Tomović, FME Podgorica (MNE)
PhD Radovan Radovanović, The Academy of criminalistic and police studies
Belgrade (Serbia)
PhD Ranko Antunović, FME UES (B&H)
PhD Risto Ciconkov, FME Skopje (Macedonia)
PhD Saša Randelović, FME Niš (Serbia)
PhD Sergej Alexandrov, Institute for Problems in Mechanics (Russia)
PhD Siniša Kuzmanović, FTS Novi Sad (Serbia)
PhD Slaviša Moljević, FME UES (B&H)
PhD Slavko Arsovski, FE Kragujevac (Serbia)
PhD Snežana Nestić, FE Kragujevac (Serbia)
PhD Spasoje Trifković, FME UES (B&H)
PhD Srđan Vasković, FME UES (B&H)
PhD Sreten Perić, Military academy, University of Defence in Belgrade (Serbia)
PhD Stanislav Karapetrović, University of Alberta (Canada)
PhD Stevan Stankovski, FTS Novi Sad (Serbia)
PhD Stojan Simić, FME UES (B&H)
PhD Strain Posavljak, FME Banja Luka (B&H)
PhD Velimir Stefanović, FME Niš (Serbia)
PhD Vencislav Grabulov, Institut IMS, Srbija
PhD Vladimir Popović, FME Belgrade (Serbia)
PhD Vlado Medaković, FME UES (B&H)
PhD Vojislav Miltenović, FME Niš (Serbia)
PhD Zdravko Krivokapić, FME Podgorica (MNE)
PhD Zorana Tanasić, FME Banja Luka (B&H)

ORGANIZING COMMITTEE

PhD Milija Kraišnik, FME UES – president

PhD Miroslav Milutinović, FME UES
PhD Saša Prodanović, FME UES
PhD Nikola Vučetić, FME UES
PhD Davor Milić, FME UES
PhD Aleksije Đurić, FME UES
Krsto Batinić, FME UES - Technical Secretary
Milica Bošković, ma, FME UES - Technical Secretary
Stanišić Vera – Secretary

GENERAL SPONSOR

Ministry of Scientific and Technological Development,
Higher Education and Information Society
Republic of Srpska



SPONSORS





Veritas
Automotive d.o.o.



TRB



PMP
INDUSTRIES

PMP JELŠINGRAD - FMG A.D. Gradiška



САРАЈЕВО-ГАС А.Д.



РУДНИК И
ТЕРМОЕЛЕКТРАНА
ГАЦКО



ТЕРМОЕЛЕКТРО



GRIJANJEINVEST

Ella Textile
d.o.o. Gradiška, Nova Topola

KOLEKTOR



The conference has been supported by:



***International Federation for
the Promotion of Mechanism
and Machine Science***



***Association
for Design, Elements
and Constructions***



***Union of Mechanical Engineers and
Technicians of Republic of Srpska***

Countries from which conference participants come



PREFACE

The economic power of a society can be expressed by different indicators. However, it is certain that the competitiveness of the economy is one of the most important. In this sense, it is necessary for industrial production to follow modern development trends, which are based on current scientific achievements. Only a holistic approach in the application of knowledge in various engineering fields, and especially in the field of mechanical engineering, is a guarantee of economic progress, which enables long-term stability and prosperity of each country. Precisely for these reasons, the Faculty of Mechanical Engineering of the University of East Sarajevo organized the 1st International Scientific Conference COMETA in 2012, and this year is its 6th edition.

The main goal of the conference is to strengthen cooperation with the academic community, scientific-research institutions and, above all, with business entities. Conference COMETA 2022 is an opportunity for all participants to offer guidelines and create a better environment for more intensive industrial development through the exchange of knowledge and experience. That is going to have impact to increasing the competitiveness of national economic entities on the foreign market. The participation of a significant number of domestic and foreign scientists and researchers strengthens our conviction that in the near future we will be able to overcome challenges that are present in the technical-technological development of an advanced society in the 21st century, mainly through the generation of new ideas and the introducing of modern approaches to solving complex tasks in the field of mechanical engineering. In this sense, all your proposals and suggestions are more than welcome and will be carefully considered by the Scientific and Organizing Committee in order to improve the organization of the next conferences. Acknowledging the importance of the wide field of mechanical engineering for the overall industrial development of society, the work of the conference will take place through 7 sections, including the Student section. The program is focused on the following thematic areas:

- Manufacturing technologies and advanced materials,
- Applied mechanics and mechatronics,
- Machine design, simulation and modeling,
- Product development and mechanical systems,
- Energy and thermotechnic,
- Renewable energy and environmental protection,
- Maintenance and technical diagnostics,
- Quality, management and organization.

At this year's conference COMETA 2022, 105 papers including 4 plenary lectures will be published in the Proceedings.

We are specially looking forward that conference registered a record number of participants from abroad. Namely, 300 authors come from 25 countries. This is certainly the result of strenuous activities that were aimed at raising the international reputation and visibility of the conference in the regional, but also in the wider academic and scientific research space, which will be one of the primary goals in the future.

On behalf of the Organizing Committee of the conference COMETA 2022, we express our great gratitude to all the authors of the papers, reviewers, universities, faculties, business entities, national and international institutions and organizations that supported the conference. Without their help the organization and work of the conference would certainly not be at the level that its status deserves.

East Sarajevo, November 14th, 2022.

President of the Scientific
Committee

PhD Dušan Golubović,
Full Professor

A handwritten signature in blue ink, appearing to read 'Dušan Golubović', written in a cursive style.

President of the Organizing
Committee

PhD Milija Krašnik,
Associate Professor

A handwritten signature in blue ink, appearing to read 'Milija Krašnik', written in a cursive style.

CONTENT

PLENARY LECTURES

1. **Alkiviadis Tsamis**
MICROSTRUCTURE-BASED ENGINEERING OF SOFT BIOLOGICAL MATERIALS 2
2. **Tomaž Vuherer**
DIFFERENT WAYS FOR HAZ MICROSTRUCTURE PREPARATION AND TESTING ON HIGH ALLOY STEEL 13
3. **Sanjin Troha, Željko Vrcan, Milan Tica, Milan Tica**
POSSIBILITIES FOR THE APPLICATION OF REVERSIBLE PLANETARY TWO-SPEED GEARBOXES 25

MANUFACTURING TECHNOLOGIES AND ADVANCED MATERIALS

4. **Panagiotis Chatzisavvas, Stefanos Gerardis, Alkiviadis Tsamis**
INVESTIGATING MECHANICAL RESPONSE AND COLLAGEN STRUCTURE IN THE INTESTINAL WALL 38
5. **Saša Živanović, Goran Vasilić, Branko Kokotović, Nikola Vorkapić, Zoran Dimic, Nikola Slavković**
CONFIGURING AND VERIFICATION OF A RECONFIGURABLE MACHINE WITH HYBRID KINEMATICS MOMA V3 46
6. **Slobodan Tabaković, Saša Živanović**
COLLABORATIVE ROBOTS IN MACHINING TASKS APPLICATION AND PROGRAMMING 56
7. **Milan Zeljković, Slobodan Tabaković**
ABOUT ACCURACY OF MACHINE TOOL – ACCURACY OF POSITIONING 63
8. **Ivica Kladarić, Stjepan Golubić, Goran Šimunović, Katica Šimunović, Slavica Kladarić, Tomislav Šarić**
THE INFLUENCE OF APPLYING PVD COATINGS ON ADHESION WEAR RESISTANCE OF STRUCTURALS STEEL 45S20 91
9. **Tomasz Węgrzyn, Bożena Szczucka-Lasota, Wojciech Tarasiuk, Piotr Cybulko, Adam Jurek, Adam Döring, Aleksandar Kosarac**
MAG WELDING OF DUPLEX STEEL FOR THE CONSTRUCTION OF ANTENNA MOUNTS 99
10. **Aleksandar Vencl, Blaža Stojanović, Slavica Miladinović, Damjan Klobčar**
PREDICTION OF THE WEAR CHARACTERISTICS OF ZA-27/SiC NANOCOMPOSITES USING THE ARTIFICIAL NEURAL NETWORK 107

11. Cvijetin Mladenović, Aleksandar Košarac, Aleksandar Živković, Miloš Knežev, Dejan Marinković, Robert Čep	
ANALYSIS OF MACHINE TOOLS DYNAMIC STABILITY BY APPLICATION OF VIBRATION TIME SIGNAL DECOMPOSITION	115
12. Nemanja Dačević, Marko Vilotić, Mladomir Milutinović, Luka Sevšek, Ljiljana Stefanović, Dragiša Vilotić	
NUMERICAL ANALYSIS OF PLANE STRAIN MULTI-DIRECTIONAL UPSETTING OF PRISMATIC SAMPLES	123
13. Goran Vasilić, Saša Živanović, Milan Milutinović, Zoran Dimić	
MACHINE TOOL WITH PARALLEL MECHANISMS INTENDED FOR CUTTING FOAM MATERIALS WITH HOT WIRE	129
14. Wojciech Tarasiuk, Aleksandar Kosarac, Tomasz Węgrzyn, Bożena Szczucka-Lasota, Piotr Cybulko, Jan Piwnik	
INFLUENCE OF THE SLIDING VELOCITY ON THE INTENSITY OF GENERATION OF AIRBORNE WEAR PARTICLES OF POLYMERIC MATERIALS	140
15. Jovica Ilić, Mladomir Milutinović, Milija Kraišnik, Dejan Movrin	
SHEET METAL FORMING USING VACUUM CAST POLYMER TOOL	146
16. Uros Zuperl, Miha Kovačič	
AN INTELLIGENT ROBOTIC CELLS WITH TRANSPORT SYSTEM FOR FULLY AUTOMATED CUTTING TOOL ASSEMBLY	153
17. Uros Zuperl, Goran Mundar	
PLATFORM FOR TOOL WEAR MONITORING VIA CUTTING FORCE CONTROL	157
18. Goran Mundar, Uroš Župerl	
DEVELOPMENT AND CONTROL OF A VIRTUAL INDUSTRIAL SORTING PROCESS	163
19. Milos Milovancevic, Dalibor Petković	
EVALUATION OF CHIP-TOOL INTERFACE TEMPERATURE BY ADAPTIVE NEURO FUZZY INFERENCE SYSTEM	171
20. Živana Jovanović Pešić, Dragan Džunić, Strahinja Milenković, Nikola Palić, Saša Nježić, Vukašin Slavković, Fatima Živić	
FABRICATION OF ALUMINUM MATRIX COMPOSITES FOR AUTOMOTIVE INDUSTRY VIA FRICTION STIR PROCESSING TECHNIQUE – A REVIEW	187
21. Strahinja Dašić, Suzana Petrović Savić, Bogdan Nedić	
COMPARATIVE ANALYSIS OF THE MACHINING TIME SIMULATION RESULTS FOR 3+2-AXIS AND 5-AXIS MILLING OF THE SHAPER	193
22. Nikola Kostić, Saša Ranđelović, Sandra Stanković	
FEM ANALYSIS OF THE STRESS STRAIN RATE DURING HOT FORGING OF STEEL NONROTATIONAL FORM	201
23. Edin Šunje, Edin Džiho	
EXPERIMENTAL AND NUMERICAL DETERMINATION OF WARPAGE INTENSITY IN ELECTRIC BRAKER PANEL BOX MADE OF UV STABILISED ABS	209
24. Elisaveta Doncheva, Aleksandra Krstevska	
AN OVERVIEW OF ADVANCED JOINING TECHNIQUES FOR POLYMER AND COMPOSITE MATERIALS	217
25. Igor Babić, Aleksandar Košarac	
INFLUENCES OF THE MILLING DIRECTION ON SURFACE QUALITY ON MILLING X155CrVMo12-1 STEEL	225

26. Mina Šibalić, Marko Mumović, Aleksandar Vujović, Nikola Šibalić, Jelena Jovanović-Šaković	DIGITALIZATION OF CULTURAL AND HISTORICAL HERITAGE LEADS TO ITS PRESERVATION USING 3D TECHNOLOGIES	233
27. Miloš Pjević, Mihajlo Popović, Mladomir Milutinović, Dejan Movrin, Ljiljana Stefanović	EXPERIMENTAL EXAMINATION OF THE APPLICABILITY OF ADDITIVE TECHNOLOGIES IN THE FIELD OF RAPID TOOLING - INJECTION MOLDING	241
28. Miloš Pjević, Mihajlo Popović, Radovan Puzović	CORRELATION BETWEEN MICRO-CUTTING AND STATIC INDENTATION	248
29. Nada Ratković, Živana Jovanović Pešić, Dušan Arsić, Miloš Pešić, Dragan Džunić	TOOL GEOMETRY EFFECT ON MATERIAL FLOW AND MIXTURE IN FSW	254

APPLIED MECHANICS AND MECHATRONICS

30. Nikola Korunović, Jovan Aranđelović	STRUCTURAL ANALYSIS AND OPTIMIZATION OF IMPLANTS USED IN TREATMENT OF LONG BONES FRACTURES	261
31. Goran Šiniković, Nenad Gubelj, Emil Veg, Ivan Milanković, Mladen Regodić	DESIGN OF THE MECHATRONIC SYSTEM FOR ACCESS CONTROL TO PROTECTED AREAS OF PRODUCTION LINES	265
32. Isak Karabegović, Raul Turmanidže, Predrag Dašić	ANALYSIS OF PATENT TRENDS FROM INDUSTRY 4.0 AND THE IMPLEMENTATION OF ROBOT TECHNOLOGY IN THE COUNTRIES OF CHINA, USA, JAPAN, REPUBLIC OF KOREA AND GERMANY	273
33. Branimir Krstić, Lamine Rebhi, Younes Djemaoune, Mirko Dinulović	FINITE ELEMENT ANALYSIS OF HELICOPTER AEROSPATIALE GAZELLE SA 341H SKID LANDING GEAR DURING NORMAL LANDING USING STATIC LOAD APPROXIMATION	287
34. Stevan Stankovski, Gordana Ostojić	IMPORTANCE OF INDUSTRIAL CYBER SECURITY IN CONTROL SYSTEMS	295
35. Dragan Rakić, Miroslav Živković, Milan Bojović, Slobodan Radovanović, Aleksandar Bodić, Nikola Milivojević, Dejan Divac	STABILITY ANALYSIS OF CONCRETE ARCH DAM USING FINITE ELEMENT METHOD	301
36. Jelena Erić Obućina, Stevan Stankovski, Gordana Ostojić	SPEED CONTROL OF AC MOTOR IN HYDRAULIC SYSTEM BY USING U/f CONTROL METHOD IN MATLAB SIMULINK	309
37. Vule Reljić, Đorđe Dostanić, Slobodan Dudić, Jovan Šulc, Ivana Milenković, Vladimir Jurošević	REMOTELY-CONTROLLED ONE-WAY FLOW CONTROL VALVE – THE FINAL VERSION OF THE PROTOTYPE	315
38. Janani Rajaraman, Saša Prodanović, Ljubiša Dubonjić	DESIGN OF FRACTIONAL - ORDER PI CONTROLLER FOR MULTIVARIABLE PROCESS	322

39. Nikola Vučetić, Gordana Jovičić, Ranko Antunović, Vladimir Milovanović, Branimir Krstić, Dejan Jeremić	
TESTING OF THE FATIGUE PROPERTIES OF ALUMINUM ALLOY 242.0 WITH THE PURPOSE OF THE INTEGRITY ASSESSMENT OF AN AIRCRAFT CYLINDER ASSEMBLY WITH A CRACK	328
40. Jelena Živković, Vladimir Dunić, Vladimir Milovanović, Miroslav Živković	
PHASE-FIELD MODELING OF DAMAGE IN ALUMINUM ALLOY	338
41. Strahinja Djurović, Dragan Lazarević, Slobodan Malbašić, Živče Šarkoćević, Milan Blagojević	
SLOPE ANGLE INFLUENCE ON THE QUALITY OF SURFACEOVERHANGS ON LOW-COST 3D PRINTERS	344
42. Milan Bojović, Miloš Pešić, Nikola Jović, Aleksandar Bodić, Vladimir Milovanović	
IMPROVED PROCEDURE FOR NUMERICAL ANALYSIS OF VEHICLE TRANSPORT PLATFORM	351
43. Zorana Mandić, Slobodan Lubura, Nikola Kukrić	
MODULAR MECHATRONIC SYSTEMS WITH AN INDUSTRIAL-ORIENTED APPROACH	357
44. Rade Vasiljević	
CONTROL AND AUTOMATION OF THE LIFTS: BASIC TECHNOLOGY AND NEW ACHIEVEMENTS	364
45. Milan Simović, Slobodan Lubura	
PROGRAMMING THE OPERATOR PANEL FOR CONTROL AND MONITORING THE OPERATION OF PUMPING STATIONS USING THE WINCC (TIA PORTAL) SOFTWARE PACKAGE	373

MACHINE DESIGN, SIMULATION AND MODELING

46. Goran Pavlović, Mile Savković, Nebojša B. Zdravković, Goran Marković	
ANALYSIS AND OPTIMIZATION OF GEOMETRIC PROPERTIES OF A CRANE END TRUCK OF A TOP RUNNING DOUBLE-GIRDER OVERHEAD CRANE	382
47. Vojislav Miltenović, Biljana Marković, Milan Tica	
BAUKASTEN PLANETARY TRANSMISSION CONSTRUCTION SYSTEM	390
48. Blaža Stojanović, Aleksandar Venc, Aleksandar Skulić, Slavica Miladinović, Sandra Gajević	
INFLUENCE OF MATERIALS ON THE EFFICIENCY OF WORM GEAR TRANSMISSION	402
49. Milan Tica, Tihomir Mačkić, Nenad Marjanović, Sanjin Troha, Miroslav Milutinovic	
ANALYSIS OF GEAR RATIOS OF TWO DIFFERENT TYPES OF CYCLOID DRIVE TRAIN	410
50. Nedeljko Vukojević, Amna Bajtarević-Jeleč	
STRUCTURAL INTEGRITY ASSESSMENT OF THICK-WALLED PRESSURE VESSEL	416
51. Pavle Ljubojević, Ivan Simonović, Tatjana Lazović	
COMPARATIVE ANALYSIS OF LOAD CARRYING CAPACITY OF SHEAR-LOADED BOLTED JOINTS	424
52. Milan Vasić, Mirko Blagojević, Miloš Matejić	
EFFICIENCY OF NON-PIN WHEEL CYCLOID REDUCER CONCEPT	430

53. Mirjana Bojanić Šejat, Ivan Knežević, Aleksandar Živković, Milan Rackov, Imre Kiss	
ANALYSIS OF THE CLEARANCE INFLUENCE ON THE FOUR POINT CONTACT BALL BEARING DYNAMIC BEHAVIOR	442
54. Milan Rackov, Siniša Kuzmanović, Vojislav Miltenović, Ivan Knežević, Milan Banić, Aleksandar Miltenović, Sandor Bodzas	
MECHANICAL TRANSMISSIONS DIVISION SHOWING THE BASIC CONCEPTUAL SOLUTIONS OF UNIVERSAL MOTOR GEAR REDUCERS WITH HELICAL GEARS	450
55. Rodoljub Vujanac, Nenad Miloradovic, Snezana Vulovic	
MEZZANINE FLOORS AS A PART OF RACKING SYSTEM	458
56. Snežana Vulović, Miroslav Živković, Rodoljub Vujanac, Ana Pavlović, Marko Topalović	
DETERMINING THE NUMERICAL VALUES OF THE POTENTIAL AT THE MEASURING POINTS	465
57. Miloš Matejić, Marija Matejić, Ljubica Mudrić-Staniškovski, Ivan Miletić	
IMPLEMENTATION OF MATHEMATIC MODELS IN DESIGN AUTOMATION	471
58. Nenad Kostić, Nenad Petrovic, Nenad Marjanović, Jelena Petrović	
TRANSPORTATION OPTIMIZATION WITH EXCEL SOLVER	479
59. Svetomir Simonović	
ON DESIGN AND CALCULATION OF LEVER TYPE LIFTING MECHANISM MULTIPLIERS	487

PRODUCT DEVELOPMENT AND MECHANICAL SYSTEMS

60. Biljana Marković, Aleksija Đurić	
EDUCATION FOR INDUSTRY 4.0, SITUATION AND CHALLENGES – STUDY OF THE STATE OF SECONDARY SCHOOL LEVEL	496
61. Miroslav Milutinović, Madina Isametova, Spasoje Trifković, Sanjin Troha, Milan Tica, Kulwant Singh	
IDENTIFICATION DESIGN PARAMETERS OR LOAD CAPACITY IN MANUAL GEARBOX FOR DIFFERENCE WORKING CONDITIONS	506
62. Miloš Pešić, Marko Miljaković, Vladimir Kočović, Živana Jovanović Pešić, Nikola Jović, Jasmina Miljojković, Aleksandar Bodić	
OPTIMIZATION AND EFFICIENCY ANALYSIS OF MUZZLE BRAKE FOR SNIPER RIFLE	518
63. Marija Matejic, Milos Matejic, Jovana Zivic, Lozica Ivanovic	
DESIGN AND TESTING OF ABRASIVE BELT GRINDER	527
64. Anita Vasileva, Elena Angeleska, Kristina Jakimovska, Sofija Sidorenko	
APPROPRIATE ERGONOMIC DESIGNS TO IMPROVE THE SAFETY OF THE CRANE CABIN	535
65. Miloš Knežev, Aleksandar Živković, Hasan Smajić, Aleksander Stekolschik, Clemens Feller, Cvijetin Mladenović, Dejan Marinković	
THERMAL MODEL OF HIGH SPEED MOTORIZED SPINDLE	543
66. Dejan Marinković, Aleksandar Živković, Cvijetin Mladenović, Miloš Knežev, Dejan Lukić, Nicolae Ungureanu	
MODELING OF THE MACHINE TOOL SLIDERS MOVEMENT USING ARTIFICIAL INTELLIGENCE	551

67. Sara Jerkić, Fuad Hadžikadunić, Mirza Oruč, Kenan Varda DESIGNING OF A SOCKET MODEL OF A LOWER LIMB PROSTHESIS USING 3D SCAN/CAD TECHNOLOGIES	559
--	-----

ENERGY AND THERMOTECNIC

68. Srđan Vasković, Petar Gvero, Stojan Simić, Gojko Krunić, Velid Halilović, Slavenko Popović, Maja Mrkić Bosančić DETERMINATION OF THE WEIGHTS OF THE CRITERIA IN THE OPTIMIZATION PROCESSES OF ENERGY CHAINS OF FUELS BASED ON WOOD BIOMASS	568
69. Nemanja Dobrnjac, Sasa Savic, Nemanja Koruga, Mirko Dobrnjac, Izet Alić COMPARATIVE ANALYSIS OF HEAT PUMP OPERATION USING GEOTSOL SOFTWARE	576
70. Aleksandar Luketa, Jelena Perišić, Srđan Vasković, Gojko Krunić COMPARATIVE ANALYSIS OF HEATING CONSUMPTION OF FAMILY HOUSES AND APARTMENTS IN VIEW OF DIFFERENT ENERGY SOURCES	585
71. Kristina Paunova, Vlatko Cingoski PERSPECTIVES FOR ENERGY GENERATION IN SOUTHEAST EUROPE USING CLEAN COAL TECHNOLOGIES	593
72. Valentino Stojkovski, Marija Lazarevikj, Viktor Iliev DILLEMA ABOUT INFLUENCE OF SPLITTER VANES ON HYDRAULIC CHARACTERISTIC AT RECTANGULAR RADIUS ELBOW	602
73. Davor Milić, Stojan Simić, Dušan Golubović, Goran Orašanin, Radomir Žugić ANALYSIS OF THE PROBLEM AND PROPOSED MEASURES FOR OPTIMIZING HEAT ENERGY CONSUMPTION IN INDUSTRIAL THERMAL ENERGY PLANTS	615
74. Jela M. Burazer, Dragiša M. Skoko, Đorđe M. Novković, Milan R. Lečić, Goran S. Vorotović MEASURING NOZZLE TIP GEOMETRY INFLUENCE ON THE PNEUMATIC COMPARTOR PERFORMANCE	623
75. Dalibor Petkovic, Milos Milovancevic OPTIMIZATION OF WIND TURBINE ACTIVE POWER BY ADAPTIVE NEURO FUZZY ALGORITHM BASED ON TURBINE ATTRIBUTES	629
76. Marina Milićević, Budimirka Marinović PREDICTION OF INFLOW USING ARTIFICIAL NEURAL NETWORKS WITH DIFFERENT NETWORK STRUCTURES	638
77. Meho Kulovac, Krsto Batinić, Dušan Golubović, Azrudin Husika, Nihad Harbaš IMPROVEMENT OF ENERGY EFFICIENCY TROUGHT ESCO MODEL	646
78. Jovan Mitrovic, Mitar Perusic A BACK VIEW OF THE HISTORY OF THERMODYNAMICS	655

RENEWABLE ENERGY AND ENVIRONMENTAL PROTECTION

79. **Stojan Simić, Goran Orašanin, Davor Milić, Srđan Vasković, Jovana Blagojević, Krsto Batinić**
BASIC ASPECTS OF ENERGY PRODUCTION BY BURNING WASTE AGRICULTURAL BIOMASS IN BURNES 663
80. **Aleksandar Nešović**
NUMERICAL ANALYSIS OF THE TOTAL INCIDENT SOLAR RADIATION ON THE FLAT-PLATE SOLAR COLLECTOR WITH SINGLE-AXIS TRACKING – CASE WITH INCLINED N-S AXIS AND E-W TRACKING 672
81. **Aleksandar Nešović, Mladen Josijević, Nebojša Lukić, Novak Nikolić, Dušan Gordić**
HEAT LOSSES OF THE ALUMINUM FLAT ABSORBER PLATE AS A FUNCTION OF THE VECTOR WIND CHARACTERISTICS – NUMERICAL ANALYSIS 681
82. **Velid Halilović, Jusuf Musić, Muhamed Bajrić, Jelena Knežević, Maida Jaganjac, Dino Hadžidervišagić, Srđan Vasković, Gojko Krunić**
ANALYSIS OF TECHNOLOGIES AND TECHNOLOGICAL PROCESS OF FOREST HARVESTING – CASE STUDY ZE-DO CANTON 689
83. **Tatyana Sereda, Sergey Kostarev, Oksana Fotina**
RESOURCE-SAVING TECHNOLOGIES AND ANALYSIS OF THE USE OF SECONDARY RAW MATERIALS EXTRACTED FROM SOLID MUNICIPAL WASTE DURING THE 2020 PANDEMIC IN THE PERM KRAY (RUSSIA) 697
84. **Ana Radojević, Marko Janjušević, Danijela Nikolić, Jasmina Skerlić**
CITIES IN THE FIGHT AGAINST CLIMATE CHANGE USING RENEWABLE ENERGY SOURCES: CASE STUDY OF PRIBOJ MUNICIPALITY 704
85. **Eleonora Desnica, Jasmina Pekez, Dalibor Dobrilović, Ljiljana Radovanović, Dragica Radosav, Luka Đorđević, Milica Mazalica, Siniša Mihajlović**
RESEARCH IN THE FIELD OF RENEWABLE ENERGY THROUGH THE APPLICATION OF MODERN ICT TECHNOLOGIES 712
86. **Jelena Svorcan, Dragoljub Tanović, Aleksandar Kovačević**
COMPUTATIONAL AERODYNAMIC ANALYSIS OF A SMALL WIND TURBINE 719

MAINTENANCE AND TECHNICAL DIAGNOSTICS

87. **Bogdan Marić, Vlado Medaković**
OVERVIEW OF MAINTENANCE STRATEGIES 727
88. **Deda Đelović**
AN OVERVIEW ON PORT MACHINERY PREDICTIVE MAINTENANCE 735

QUALITY, MANAGEMENT AND ORGANIZATION

89. Panagiotis Kolonelos, George Nenes, Konstantinos A. Tasiias A QUALITY CONTROL SCHEME FOR MULTISTAGE MANUFACTURING SYSTEMS WITH MULTIPLE DISRUPTIONS	742
90. Aleksandar Aleksic, Snezana Nestic, Danijela Tadic, Nikola Komatina DETERMINATION OF ORGANIZATIONAL RESILIENCE LEVEL WITHIN BUSINESS PROCESSES IN PRODUCTION COMPANIES	750
91. Angela Fajsi, Slobodan Morača, Slaviša Moljević, Nenad Medić THE IMPORTANCE OF NETWORKING IN THE CONTEXT OF ACHIEVING ORGANIZATIONAL BUSINESS EXCELLENCE	758
92. Branislav Dudić, Alexandra Mittelman, Pavel Kovač, Borislav Savković, Eleonóra Beňová, Dušan Golubović PRODUCTION OF AUTOMOTIVE INDUSTRY IN THE WORLD	764
93. Michael Huber, Nikolina Ljepava, Aleksandar Aleksić BUSINESS MODELS IN TRANSITION - A CHANGE FOR PERFORMANCE ENHANCEMENT AND RESILIENCE	771
94. Miloš Ranisavljev, Andrej Razumić, Branko Štrbac, Biserka Runje, Amalija Horvatić Novak, Miodrag Hadžistević FLATNESS INVESTIGATION OF THE CMM GRANITE TABLE VIA CONVENTIONAL AND COORDINATE METROLOGY	779
95. Mirjana Jokanović Đajić, Tanja Glogovac COMMUNICATION AS A KEY FACTOR OF PROJECT SUCCESS	786
96. Marija Savković, Nikola Komatina, Snežana Nestić, Ranka Gojković COMPARATIVE ANALYSIS COMPETENCIES IN TRADITIONAL AND AGILE PROJECT MANAGEMENT APPROACHES	794
97. Mirjana Jokanović Đajić, Soukaina El Hajjaji, Ranka Gojković PROJECT METHODOLOGIES AND THEIR IMPACT ON THE PROJECT SUCCESS	802

STUDENT SESSION

98. Valentina Lulić ENERGY EFFICIENCY ANALYSIS OF COGENERATION PLANT	811
99. Stefan Adžić THEORETICAL FOUNDATIONS OF PHOTOVOLTAIC SYSTEMS	817
100. Samardzic Srdjan CALCULATION METHOD AND APPLICATIONS OF HARMONIC DRIVE	826
101. Borislav Jović APPLICATION OF CENTRIFUGAL FANS IN INDUSTRY	834
102. Nemanja Vuković LUBRICATION OF STEAM TURBINES	841
103. Nikola Vuković APPLICATION OF AXIAL FANS IN RECIRCULATION COOLING SYSTEMS	851
104. Srđan Suknović, Peko Ninković, Anđela Suknović OPTIMAL SELECTION OF STEAM TRAPS FOR INDUSTRIAL DRYERS	860

COMET_a 2022

6th INTERNATIONAL SCIENTIFIC CONFERENCE

17th - 19th November 2022

Jahorina, B&H, Republic of Srpska



University of East Sarajevo

Faculty of Mechanical Engineering

Conference on Mechanical Engineering Technologies and Applications

PHASE-FIELD MODELING OF DAMAGE IN ALUMINUM ALLOY

Jelena Živković¹, Vladimir Dunić², Vladimir Milovanović³, Miroslav Živković⁴

Abstract: Phase-Field Damage Model (PFDM) is a cutting-edge simulation tool for prediction of damage and crack evolution in materials. This paper shows simulation of AA5083-H321 ductile behavior using the modified PFDM coupled with a von Mises metal plasticity model. Uniaxial tensile tests at room temperature were performed on AA5083-H321 flat specimens in order to identify material parameters for numerical simulation and to verify the modified PFDM implemented into in-house software PAK. Comparison of the obtained results showed good agreement between experimental and simulation force-displacement responses.

Key words: Phase-field damage modeling, aluminum alloy, ductile fracture

1 INTRODUCTION

Phase-Field Damage Model (PFDM) coupled with von Mises metal plasticity was successfully used for simulation of S355 behavior in [1,2] by modifying the hardening function and the coupling variable. Two-intervals hardening function used in that research is then modified in [3], in order to simulate the aluminum alloy (AA) behavior. The improvements of coupled PFDM with plasticity are implemented into the in-house software PAK, developed at Faculty of Engineering, University of Kragujevac, Serbia. This paper shows the verification of implemented model by comparing the force-displacement diagrams obtained by numerical simulations and experimental tests. Sensitivity of the implemented model to the applied displacement increment size was also studied. Three AA5083-H321 flat specimens were investigated by static uniaxial tension tests at room temperature in order to use the representative specimen's recorded results to identify material parameters for numerical simulation. Comparison of results obtained by experiment and numerical simulations showed a

¹ PhD, Jelena Živković, Faculty of Engineering, University of Kragujevac (CA), Kragujevac, Serbia, jelena.zivkovic@kg.ac.rs

² PhD, Vladimir Dunić, Faculty of Engineering, University of Kragujevac, Kragujevac, Serbia, dunic@kg.ac.rs

³ PhD, Vladimir Milovanović, Faculty of Engineering, University of Kragujevac, Kragujevac, Serbia, vladicka@kg.ac.rs

⁴ PhD, Miroslav Živković, Faculty of Engineering, University of Kragujevac, Kragujevac, Serbia, miroslav.zivkovic@kg.ac.rs

good match and implemented model was successfully verified.

2 PHASE-FIELD DAMAGE MODEL COUPLED WITH PLASTICITY

Degradation function $g(d)$ for PFDM is proposed by Ambati et al. [4,5] as

$$g(d) = (1-d)^{2p}, \quad (1)$$

where p represents a variable that couples PFDM and von Mises metal plasticity model. Authors of this paper modified the coupling variable in a way that its value is $p = 0$ until the equivalent plastic strain reaches the critical value, i.e. $\frac{\bar{\varepsilon}_p}{\bar{\varepsilon}_p^{crit}} < 1$, because the material is considered to be undamaged in that case, and the value of coupling variable is $p = \frac{\bar{\varepsilon}_p}{\bar{\varepsilon}_p^{crit}} - 1$ in case that $\frac{\bar{\varepsilon}_p}{\bar{\varepsilon}_p^{crit}} \geq 1$. Dependence of modified coupling variable on equivalent plastic strain is shown as continuous line in Figure 1, and the dashed line represents the value of coupling variable defined by Ambati et al. in [4].

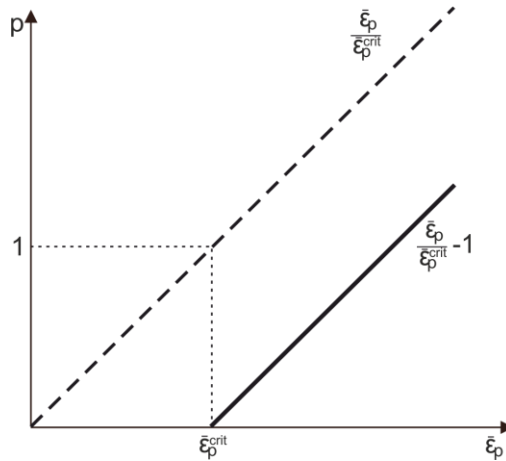


Figure 1. Dependence of coupling variable on equivalent plastic strain

In order to simulate behavior of aluminum alloy, that exhibits linear hardening after yielding occurs, it was necessary to modify the two-intervals hardening function used in [2] to describe the idealized response as continuous line in Figure 2. In the first interval, when $\bar{\varepsilon}_p < \bar{\varepsilon}_{p0}$, the yield stress can be defined by the linear hardening function parameter H_0 as

$$\sigma_y = \sigma_{y0} + H_0 \bar{\varepsilon}_p. \quad (2)$$

The second interval starts when $\bar{\varepsilon}_p \geq \bar{\varepsilon}_{p0}$ and the nonlinear increase of the stress can be defined by Simo hardening function as

$$\sigma_y = \sigma_{y0} + (\sigma_{y0,\infty} - \sigma_{y0}) \left(1 - e^{-n(\bar{\varepsilon}_p - \bar{\varepsilon}_{p0})} \right) + H(\bar{\varepsilon}_p - \bar{\varepsilon}_{p0}), \quad (3)$$

where $\sigma_{y0} = \sigma_{yv} + H_0 \bar{\epsilon}_{p0}$. The dashed line in Figure 2 represents the theoretical influence of modified PFDM coupled with von Mises metal plasticity model. More details and stress integration algorithm for von Mises large strain plasticity are given in [1-3].

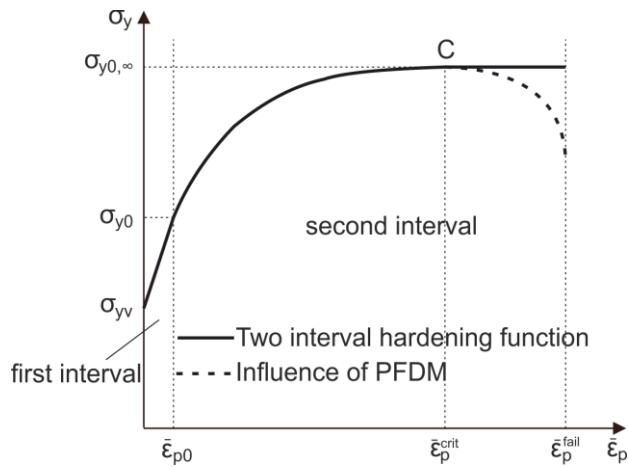


Figure 2. Idealized stress-strain response of AA5083

3 VERIFICATION OF MODIFIED PFDM

Three AA5083-H321 flat specimens, shown in Figure 3(a), were investigated at the Centre for Software Engineering and Dynamical Testing, Faculty of Engineering, University of Kragujevac, Serbia. Static uniaxial tensile tests were carried out at room temperature with a stroke control rate of 3 mm/min. Gauge length of the used extensometer MFA25 is 50 mm. Recorded force-displacement responses are shown in Figure 3(b). Fracture occurred within the gauge length only in case of a specimen with label 26, so those results are chosen as representative for verification of modified PFDM.

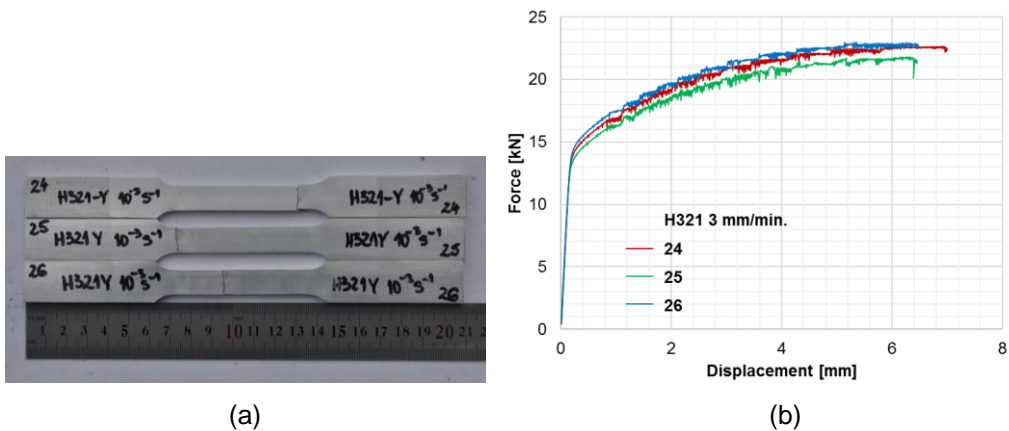


Figure 3. (a) AA5083-H321 specimens after uniaxial tensile tests; (b) recorded force-displacement response for AA5083-H321 specimens

Material parameters for PFDM simulation are obtained from real stress-real

strain curve of the specimen 26 and by calibration using the least squares method. Obtained values are given in Table 1, where E is Young's modulus, ν is Poisson's ratio, H is hardening modulus, G_V is critical fracture release rate per unit volume, n is hardening exponent and l_c is characteristic length-scale parameter.

Table 1. Material parameters used for PFDM simulation

E [MPa]	ν [-]	σ_{yV} [MPa]	$\sigma_{y0,\infty}$ [MPa]	H [MPa]	H_0 [MPa]	G_V [MPa]	n [-]	l_c [mm]	$\bar{\varepsilon}_P^{crit}$ [-]	$\bar{\varepsilon}_{P_0}$ [-]
70150	0.33	200.6	412.89	146.17	19817	2.55	20.3	0.01	0.11	0.0033

Model used for FEM simulation was 1/8 of the gauge section of tested specimen because of the three symmetry planes. Geometrical imperfection was prescribed as a 0.01% linear decrease of width and thickness where occurrence of necking is expected [3]. Four different displacement increments were applied to the top surface nodes of the FE model in order to investigate the sensitivity of the implemented method to the size of the displacement increment and results are shown in Figure 4.

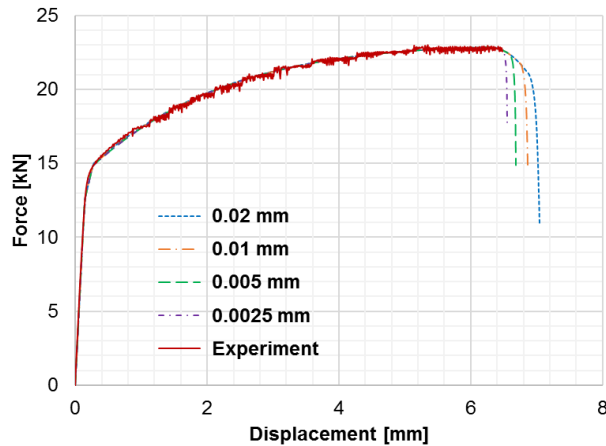


Figure 4. Force-displacement diagrams obtained for different displacement increments

The force-displacement response in softening zone is different for various displacement increments, so the part after the fracture point shouldn't be analyzed using this approach. Comparison of force-displacement diagrams obtained experimentally and by numerical simulations is shown in Figure 5. Two different FEM simulations with displacement increment of 0.0025mm were performed – by von Mises plasticity model ("Plasticity") and by PFDM coupled with plasticity ("PFDM + plasticity"), and the latter successfully reproduced the experimentally recorded response.

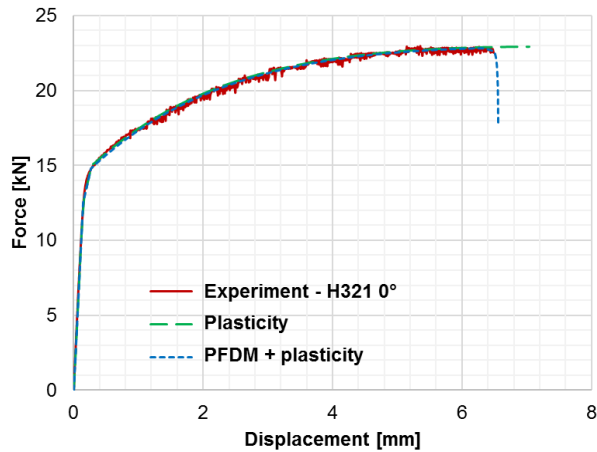


Figure 5. Force-displacement response of the numerical simulations and experiment

Figure 6(a) shows simulation results for the equivalent plastic strain field obtained by "pure" plasticity model and results obtained by PFDM coupled with plasticity are shown in Figure 6(b). It can be noticed that damage field, shown in Figure 6(c), has a big influence on localization of plastic strains and it can be concluded that the fracture process in material is caused by the occurrence of damage. Both equivalent plastic strain field and damage field, obtained by PFDM + plasticity simulation, are localized in the fracture zone of the experimentally tested specimen.

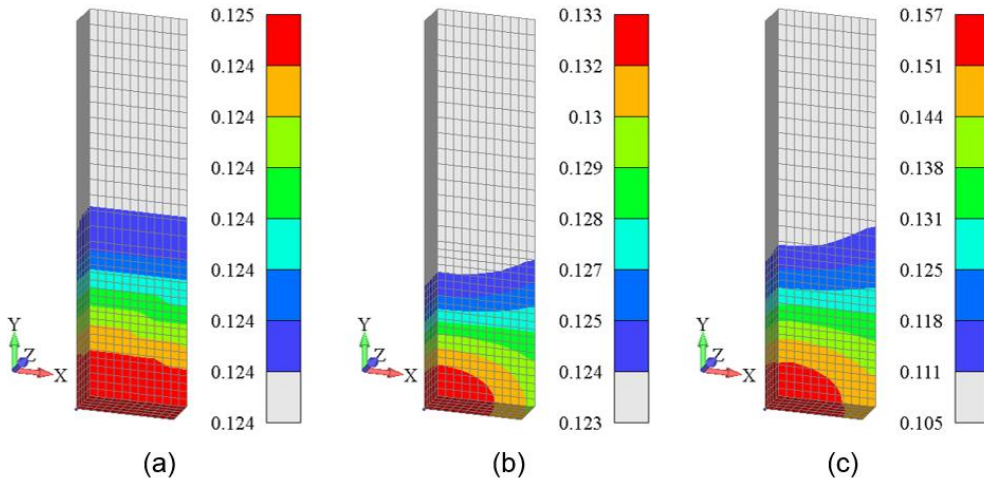


Figure 6. Simulation results: (a) effective plastic strain field – Plasticity; (b) effective plastic strain field – PFDM + plasticity; (c) Damage field – PFDM + plasticity

4 CONCLUSIONS

Authors previously verified [1,2] that PFDM coupled with von Mises metal plasticity, implemented into in-house software PAK, can successfully simulate behavior of steel structures. This paper shows three AA5083-H321 flat specimens that were investigated by static uniaxial tension tests at room temperature and the two-intervals hardening function that was modified in order to simulate the recorded response of

AA5083-H321 by using PFDM coupled with plasticity. Experimentally obtained force-displacement diagram is compared to diagrams obtained by two different FEM simulations - von Mises plasticity model and by PFDM coupled with plasticity and a good match between force-displacement diagrams is observed. Comparison of the damage field and the equivalent plastic strain field obtained by PFDM coupled with plasticity showed that the cause of the fracture of the specimen is the occurrence of damage. This and previous papers [1-3] show that implemented modified PFDM coupled with von Mises plasticity can be used to simulate the experimental response of various types of metallic materials with minimal modifications of the hardening function.

ACKNOWLEDGEMENTS

This research was funded by Ministry of Education, Science and Technological Development, Republic of Serbia, Grant TR32036.

REFERENCES

- [1] Živković, J. (2022). Unapređenje, implementacija i eksperimentalna verifikacija numeričkog modeliranja oštećenja i loma metala primenom faznog modeliranja. *Doktorska disertacija*, Fakultet inženjerskih nauka Univerziteta u Kragujevcu, Kragujevac, Srbija.
- [2] Živković, J., Dunić, V., Milovanović, V., Pavlović, A., Živković, M. (2021). A modified phase-field damage model for metal plasticity at finite strains: numerical development and experimental validation. *Metals*, vol. 11, no. 1, p.p. 47.
- [3] Dunić, V., Živković, J., Milovanović, V., Pavlović, A., Radovanović, A., Živković, M. (2021). Two-intervals hardening function in a phase-field damage model for the simulation of aluminum alloy ductile behavior. *Metals*, vol. 11, no. 11, p.p. 1685.
- [4] Ambati, M., Gerasimov, T., De Lorenzis, L. (2015). Phase-field modeling of ductile fracture. *Computational Mechanics*, vol. 55, p.p. 1017-1040.
- [5] Ambati, M., Kruse, R., De Lorenzis, L. (2016). A phase-field model for ductile fracture at finite strains and its experimental verification. *Computational Mechanics*, vol. 57, p.p. 149-167.