

University of Banja Luka  
Faculty of Mechanical Engineering

**PROCEEDINGS**  
**DEMI 2023**

*Banja Luka, Jun 2023*

**16TH INTERNATIONAL CONFERENCE ON ACCOMPLISHMENTS IN  
MECHANICAL AND INDUSTRIAL ENGINEERING**

**DEMI 2023**

**Supported by:**

MINISTRY FOR SCIENTIFIC AND TECHNOLOGICAL DEVELOPMENT, HIGHER  
EDUCATION AND INFORMATION SOCIETY  
OF THE REPUBLIC OF SRPSKA

**Organizer and publisher:**

FACULTY OF MECHANICAL ENGINEERING UNIVERSITY OF BANJA  
LUKA

**Co-organizer:**

FACULTY OF MECHANICAL ENGINEERING UNIVERSITY OF NIŠ,  
SERBIA

FACULTY OF MECHANICAL ENGINEERING UNIVERSITY OF  
PODGORICA, MONTENEGRO

FACULTY OF ENGINEERING HUNEDOARA  
UNIVERSITY POLITEHNICA TIMIȘOARA, ROMANIA REYKJAVIK

UNIVERSITY, ICELAND

**For publisher:**

Full Prof. Aleksandar Milašinović, PhD

**Editor of chief:**

Full Prof. Petar Gvero, PhD

**Executive editor:**

Biljana Prochaska, PhD  
Milivoj Stipanović, BsC

**ORGANIZING COMMITTEE**

Prof. Petar Gvero, PhD  
Chairman of Organizing and Scientific Committee  
Faculty of Mechanical Engineering, University of Banja Luka

Prof. Aleksandar Milašinović,  
PhD Prof. Zorana Tanasić, PhD  
Assoc. Prof. Stevo Borojević, PhD  
Assoc. Prof. Goran Janjić, PhD  
Assist. Prof. Dejan Branković, PhD  
Prof. Uroš Karadžić, PhD  
(Faculty of Mechanical Engineering, Podgorica)  
Assoc. Prof. Dejan Mitrović, PhD  
(Faculty of Mechanical Engineering, Niš)  
Assoc. Prof. Sorin Ioan Deaconu, PhD  
(Faculty of Engineering Hunedoara, Romania)  
Assist. Prof. David C. Finger, PhD  
School of Science and Engineering University of Reykjavik, Iceland  
Goran Jotić, Senior Assistant, MSc  
Saša Tešić, Assistant, MSc  
Gordana Tošić, Assistant, MSc  
Ivana Savković, Assistant, MSc  
Dijana Đeordić, Assistant, MSc  
Biljana Prochaska, PhD  
Sanja Maglov, MA+  
Boro Marić, BA Law  
Nedeljka Sladojević Putnik, BA Economics  
Milivoj Stipanović, BSc  
Zoran Grahovac, Assistant, MSc  
Milisav Marković, Senior Assistant, MSc

## SCIENTIFIC COMMITTEE

- Prof. Darko Knežević, PhD  
Faculty of Mechanical Engineering  
University of Banja Luka
- Prof. Radivoje Mitrović, PhD Faculty of  
Mechanical Engineering University of  
Belgrade
- Prof. Vlastimir Nikolić, PhD Faculty of  
Mechanical Engineering University of Niš
- Prof. Nenad T. Pavlović, PhD Faculty of  
Mechanical Engineering University of Niš
- Prof. Igor Vušanović, PhD  
Faculty of Mechanical Engineering  
Podgorica, University of Montenegro
- Prof. Gelu Ovidiu Tirian, PhD University  
Politehnica Timisoara Romania
- Prof. Dejan Lukić, PhD Faculty of Technical  
Sciences University of Novi Sad
- Prof. Saša Živanović, PhD  
Faculty of Mechanical Engineering  
University of Belgrade
- Prof. Mijodrag Milošević, PhD Faculty of  
Technical Sciences University of Novi Sad
- Prof. Aleksandar Milašinović, PhD Faculty of  
Mechanical Engineering University of Banja  
Luka
- Prof. Milan Tica, PhD  
Faculty of Mechanical Engineering  
University of Banja Luka
- Prof. Izet Bjelonja, PhD  
Faculty of Mechanical Engineering  
University of Sarajevo
- Prof. Milan Zeljković, PhD Faculty of  
Technical Sciences University of Novi Sad
- Prof. Slobodan Tabaković, PhD Faculty of  
Technical Sciences University of Novi Sad
- Prof. Franci Pušavec, PhD  
Faculty of Mechanical Engineering  
University of Ljubljana
- Prof. Miodrag Manić, PhD  
Faculty of Mechanical Engineering  
University of Niš
- Prof. Milenko Sekulić, PhD Faculty of  
Technical Sciences University of Novi Sad
- Prof. Mileta Janjić, PhD  
Faculty of Mechanical Engineering  
Podgorica, University of Montenegro
- Assist. Prof. Davorin Kramar, PhD University  
of Ljubljana, Slovenia
- Prof. Simo Jakanović, PhD  
Faculty of Mechanical Engineering  
University of Banja Luka
- Prof. Gordana Globočki-Lakić, PhD Faculty of  
Mechanical Engineering University of Banja  
Luka
- Prof. Ardelean Erika, PhD University  
Politehnica Timisoara Romania
- Prof. Petar Gvero, PhD  
Faculty of Mechanical Engineering  
University of Banja Luka
- Prof. Slobodan Lubura, PhD  
Faculty of Electrical Engineering University  
of East Sarajevo
- Prof. Sanda Midžić – Kurtagić, PhD Faculty of  
Mechanical Engineering University of  
Sarajevo
- Assoc. Prof. Srđan Vasković, PhD Faculty of  
Mechanical Engineering University of East  
Sarajevo
- Prof. Bratislav Blagojević, PhD Faculty of  
Mechanical Engineering University of Niš
- Prof. Milan Radovanović, PhD Faculty of  
Mechanical Engineering University of  
Belgrade
- Prof. Dragoslava Stojiljković, PhD Faculty of  
Mechanical Engineering University of  
Belgrade
- Prof. Nebojša Manić, PhD  
Faculty of Mechanical Engineering  
University of Belgrade
- Prof. Milan Lečić, PhD  
Faculty of Mechanical Engineering  
University of Belgrade

Prof. Neven Duić, PhD  
Faculty of Mechanical Engineering and Naval  
Architecture  
University of Zagreb

Prof. Vojislav Novaković, PhD NTNU, Norway

Prof. Milan Rackov, PhD Faculty of Technical  
Sciences University of Novi Sad

Prof. Mirko Blagojević, PhD Faculty of  
Engineering Sciences University of  
Kragujevac

Prof. Sanjin Troha, PhD  
Faculty of Engineering University of Rijeka,  
Croatia

Prof. Nebojša Rašović, PhD  
Faculty of Mechanical Engineering,  
Computing and Electrical Engineering,  
University of Mostar

Prof. Miroslav Milutinović, PhD Faculty of  
Mechanical Engineering University of  
University of East Sarajevo

Prof. Nataša Trišović, PhD  
Faculty of Mechanical Engineering  
University of Belgrade

Prof. Mladimir Milutinović, PhD Faculty of  
Technical Science University of Novi Sad

Prof. Dražan Kozak, PhD  
University of Josip Juraj Strossmayer in  
Osijek, Croatia

Prof. Dragan Milčić, PhD  
Faculty of Mechanical Engineering  
University of Niš

Prof. Radoslav Tomović, PhD  
Faculty of Mechanical Engineering  
Podgorica, University of Montenegro

Prof. Janko Jovanović, PhD  
Faculty of Mechanical Engineering  
Podgorica, University of Montenegro

Prof. Nebojša Radić, PhD  
Faculty of Mechanical Engineering  
University of East Sarajevo

Prof. Tomaž Berlec, PhD  
Faculty of Mechanical Engineering  
University of Ljubljana

Prof. Janez Kušar, PhD  
Faculty of Mechanical Engineering

University of Ljubljana

Prof. Platon Sovilj, PhD Faculty of Technical  
Sciences University of Novi Sad

Prof. Gordana Stefanović, PhD Faculty of  
Mechanical Engineering University of Niš

Prof. Miladin Stefanović, PhD Faculty of  
Engineering Sciences University of  
Kragujevac

Prof. Vlado Medaković, PhD Faculty of  
Mechanical Engineering University of East  
Sarajevo

Prof. Valentina Golubović-Bugarski, PhD,  
Faculty of Mechanical Engineering, University  
of Banja Luka

Prof. Strain Posavljak, PhD  
Faculty of Mechanical Engineering  
University of Banja Luka

Prof. Vid Jovišević, PhD  
Faculty of Mechanical Engineering  
University of Banja Luka

Prof. Živko Babić, PhD  
Faculty of Mechanical Engineering  
University of Banja Luka

Prof. Atul Bhaskar, PhD University of  
Southampton United Kingdom

Prof. Socalici Ana, PhD University  
Politehnica Timisoara Romania

Prof. Milan Banić, PhD  
Faculty of Mechanical Engineering  
University of Niš

Prof. Aleksandar Sedmak, PhD Faculty of  
Mechanical Engineering University of  
Belgrade

Prof. Branko Blanuša, PhD Faculty of  
Electrical Engineering University of Banja  
Luka

Assist. Prof. Srđan Savić, PhD Faculty of  
Technical Sciences University of Novi Sad

Prof. Dejan Mitrović, PhD  
Faculty of Mechanical Engineering  
University of Niš

Prof. Goran Janevski, PhD  
Faculty of Mechanical Engineering  
University of Niš

Prof. Uroš Karadžić, PhD  
Faculty of Mechanical Engineering  
Podgorica, University of Montenegro

Prof. Deaconu Sorin, PhD University  
Politehnica Timisoara Romania

Prof. Bordeasu Ilare, PhD University  
Politehnica Timisoara Romania

Assist. Prof. Dejan Branković, PhD Faculty of  
Mechanical Engineering University of Banja  
Luka

Prof. Vinko Babić, PhD  
Faculty of Mechanical Engineering  
University of Banja Luka

Prof. Jovanka Lukić, PhD Faculty of  
Engineering Sciences University of  
Kragujevac

Prof. Goran Petrović, PhD  
Faculty of Mechanical Engineering  
University of Niš

Prof. Radoje Vujadinović, PhD Faculty of  
Mechanical Engineering Podgorica,  
University of Montenegro

Prof. Snežana Petković, PhD Faculty of  
Mechanical Engineering University of Banja  
Luka

Prof. Miodrag Hadžistević, PhD Faculty of  
Technical Sciences University of Novi Sad

Prof. Branko Štrbac, PhD, PhD Faculty of  
Technical Sciences University of Novi Sad

Prof. Bratislav Blagojević, PhD Faculty of  
Mechanical Engineering University of Niš

Prof. Peđa Milosavljević, PhD Faculty of  
Mechanical Engineering University of Niš

Prof. Jelena Šaković Jovanović, PhD Faculty  
of Mechanical Engineering Podgorica,  
University of Montenegro

Prof. Mladen Todić, PhD  
Faculty of Mechanical Engineering  
University of Banja Luka

Prof. Milija Krajišnik, PhD  
Faculty of Mechanical Engineering  
University of East Sarajevo

Prof. Ilija Ćosić, Emeritus Faculty of  
Technical Sciences University of Novi Sad

Prof. Zorana Tanasić, PhD  
Faculty of Mechanical Engineering  
University of Banja Luka

Prof. Mirko Soković, PhD  
University of Ljubljana, Slovenia

Prof. Miroslav Bobrek, PhD Faculty of  
Mechanical Engineering University of Banja  
Luka

Prof. Goran Janjić, PhD  
Faculty of Mechanical Engineering  
University of Banja Luka

Prof. Igor Budak, PhD Faculty of Technical  
Sciences University of Novi Sad

Prof. Tihomir Latinović, PhD Faculty of  
Mechanical Engineering University of Banja  
Luka

Assist. Prof. Bojan Knežević, PhD Faculty of  
Mechanical Engineering University of Banja  
Luka

Prof. Sead Pašić, PhD  
Faculty of Mechanical Engineering, "Džemal  
Bijedić", University in Mostar

Prof. Borut Kosec, PhD  
Faculty of Natural Sciences and Engineering,  
University of Ljubljana

Prof. Darko Bajić, PhD  
Faculty of Mechanical Engineering  
Podgorica, University of Montenegro

Prof. Dragoslav Dobraš, PhD Faculty of  
Mechanical Engineering University of Banja  
Luka

Senior Scient. Eng. Milica Grahovac, PhD,  
Lawrence Berkeley National Laboratory,  
USA

Prof. Doina Frunzaverde, PhD Faculty of  
Engineering Resita Babeş-Bolyai University

Prof. Mihajlo Stojčić, PhD  
Faculty of Mechanical Engineering  
University of Banja Luka

Assist. Prof. Esad Tombarević, PhD Faculty  
of Mechanical Engineering Podgorica,  
University of Montenegro

Assist. Prof. Boško Matović, PhD Faculty of  
Mechanical Engineering Podgorica,  
University of Montenegro

Assist. Prof. Milovan Kotur, PhD Faculty of  
Mechanical Engineering University of Banja  
Luka

Prof. Hasan Smajić, PhD  
University of Applied Sciences Keln Germany

Assist. Prof. David C. Finger, PhD School of  
Science and Engineering University of  
Reykjavik, Iceland

Assoc. Prof. Edin Berberović, PhD  
Polytechnical Faculty University of Zenica

Assoc. Prof. Siniša Bikić, PhD Faculty of  
Technical Sciences University of Novi Sad

Prof. Živojin Stamenković, PhD Faculty of  
Mechanical Engineering University of Niš

Prof. Miloš Simonović, PhD Faculty of  
Mechanical Engineering University of Niš

Prof. Jasna Glišović, PhD Faculty of  
Engineering Sciences University of  
Kragujevac

Research Associate Vencislav  
Grabulov, PhD, IMS Institute,  
Belgrade, Serbia

Prof. Nenad Djordjevic, PhD Senior  
Lecturer in Mechanical Engineering  
CASMEC Research Centre Director,  
United Kingdom

Prof. Radovan Bulatović, PhD Faculty of  
Mechanical and Civil Engineering Kraljevo,  
Serbia

Prof. Predrag Živković, PhD Faculty of  
Mechanical Engineering University of  
Niš

## CONTENT

<b>KEYNOTE LECTURE</b>	<b>1</b>
1. BOSNIA AND HERZEGOVINA – ICELAND ENERGY COOPERATION: A PARTNERSHIP TOWARDS CLIMATE NEUTRALITY AND ENERGY INDEPENDENCE David Christian Finger	3
2. CONTEMPORARY PLANETARY GEARBOXES AND THEIR CALCULATION Ž. Vrcan, M. Tica, S. Troha, K. Marković, M. Milutinović	8
<b>PRODUCTION AND COMPUTER-AIDED TECHNOLOGIES</b>	<b>26</b>
1. A POST-PROCESSOR FOR THE FIVE-AXIS MACHINE MULTIPRODESK BASED ON INVERSE KINEMATIC TRANSFORMATION J. Maletić, S. Živanović	28
2. CONCEPTUAL DESIGN OF A NOVEL MECHANISM WITH PARALLEL KINEMATICS BASED ON CHEBYSHEV'S LINKAGE Lj. Nešovanović, S. Živanović	35
3. ENERGY CONSUMPTION ANALYSIS AND PARAMETER OPTIMIZATION IN HIGH-FEED MILLING OPERATION B. Sredanović, S. Borojević, Đ. Čiča, S. Tešić, D. Jokić, D. Kramar	41
4. EXAMINATION OF THE POSITIONING ACCURACY OF THE MACHINE TOOL WITH HYBRID KINEMATICS S. Tabaković, S. Živanović, M. Zeljković, A. Budimir, Z. Dimić	47
6. EXPERIMENTAL INVESTIGATION OF MACHINING PARAMETERS IN TURNING OF ALUMINIUM ALLOY 7075-T6 A. Aleksić, M. Sekulić, B. Savković, A. Košarac, S. Moljević, J. Anić	54
5. FINITE ELEMENT AND EXPERIMENTAL MODAL ANALYSIS OF HIGH SPEED SPINDLE M. Knežev, A. Živković, C. Mladenović, D. Marinković, V. Ilić, M. Moravec	60
6. INDUSTRY 4.0 TECHNOLOGIES AND SYSTEMS FOR THE TRANSFORMATION OF COMPANIES INTO LOW-CARBON COMPANIES L. Črpič, J. Butara, M. Mavko, K. Kofalt, N. Sovec, E. Hozdić	64
7. INFLUENCE OF EXPERIMENTAL METHOD ON PLASTIC STRAIN RATIO DETERMINATION S. Aleksandrović, Đ. Ivković, D. Arsić, M. Delić	76
8. INFLUENCE OF PROCESS PARAMETERS IN THE PROCESS OF DEEP DRAWING WITH PLASTIC TOOL J. Ilić, T. Grbić, M. Hadžistević, M. Milutinović, M. Kraišnik, D. Movrin	84
9. MATHEMATICAL MODELING OF THE ROUGHNESS OF THE ALUMINIUM ELEMENT SURFACE PROCESSED ON A CNC MACHINE Sanela Hrnjica, Sanel Gredelj	90
10. OPTIMIZATION OF CUTTING PARAMETERS FOR MINIMIZING UNIT PRODUCTION TIME IN MULTI-PASS ROUGH TURNING OF S355JR STRUCTURAL STEEL M. Trifunović, M. Madić, N. Vitković	99
11. OPTIMIZATION OF HIGH-SPEED MACHINING PARAMETERS OF THIN- WALLED ALUMINIUM STRUCTURES IN THE FUNCTION OF SURFACE ROUGHNESS J. Vukman, M. Milošević, A. Antić, D. Božić, V. Todić, D. Lukić	104
12. OPTIMIZATION OF SURFACE ROUGHNESS AND ITS VARIANCE IN CO <sub>2</sub> LASER CUTTING USING DESIRABILITY FUNCTION APPROACH V. Marinković, M. Madić, P. Janković	110



13. OPTIMIZATION PROBLEM WITH THE GOAL OF MINIMIZING THE MASS OF GEARS	117
Anja Velemir, Ljubica Spasojević, Nenad Petrović, Nenad Kostić, Nenad Marjanović	
14. OPTIMIZATION SURFACE ROUGHNESS IN POWDER MIXED ELECTRICAL DISCHARGE MACHINING OF TITANIUM ALLOY	121
D. Rodic, M. Gostimirovic, M. Sekulic, B. Savkovic, A. Aleksic	
15. PARAMETRIC OPTIMIZATION IN END-MILLING OPERATION OF ALMGS11 ALLOY USING A HYBRID WASPAS-TAGUCHI TECHNIQUE	126
Adnan Mustafić, Ragib Spahić	
16. PROGRAMMING METHODS AND PROGRAM VERIFICATION FOR 3-AXIS RECONFIGURABLE HYBRID KINEMATICS MACHINE	136
S. Zivanovic, G. Vasilic, Z. Dimic, N. Vorkapic, B. Kokotovic, N. Slavkovic	
17. STRUCTURE AND MECHANICAL PROPERTIES OF MIG WELDED BUTT-JOINTS OF ALUMINUM ALLOY 2024 T351	144
D. Milčića, M. Milčića, D. Klobčarb, A. Đurić, N. Zdravkovića	
18. TOWARDS OPTIMISED END-OF-LIFE PRODUCT DISASSEMBLY SYSTEM SELECTION	151
D. Mlivić, Z. Kunica, J. Topolnjak	
19. DECISION SUPPORT SYSTEM FOR MATERIAL SELECTION	159
D. Petković, M. Madić, P. Živković	
20. DEPENDENCE OF THE TEMPERATURE FIELD ON THE NUMBER OF SIMULTANEOUSLY FDM-PRINTED PLA SAMPLES	165
R.-R. Turiac, V. Cojocar, N. Bacescu, D. Frunzaverde, C.-O. Miclosina, G. Marginean	
21. DETERMINATION OF THE MACHINABILITY OF LEADED BRONZE BY MEASURING CUTTING FORCES AT TURNING WITH WC – CO COATED CARBIDE INSERTS	173
N. Šibalić, M. Mumović, O. Mijanović	
22. INFLUENCE OF THE LAYER THICKNESS AND THE FILAMENT COLOR ON THE SURFACE FINISH OF PLA SAMPLES PRINTED BY FDM	178
N. Bacescu, D. Frunzaverde, R.-R. Turiac, V. Cojocar, C.-R. Ciubotariu, G. Marginean	
<b>ENERGETICS AND THERMAL ENGINEERING</b>	<b>185</b>
1. OCCURRENCE OF CRACKS DUE TO INADEQUATE TURBINE SHAFT CONSTRUCTION	187
Srđan Bulatović, Vujadin Aleksić, Bojana Zečević, Biljana Prochaska	
2. EXPERIMENTAL RESEARCH OF THERMAL DRYING CONDITIONS IN FOOD DRYER	193
F. Mojsovski, V. Mijakovski	
3. FLUE GAS ANALYSIS, NECESSITY OR OBLIGATION	198
Vladimir V. Jovanović, Dragoslava D. Stojiljković, Nebojša G. Manić	
4. INCREASING THE ENERGY EFFICIENCY OF EDUCATIONAL BUILDINGS AS A FUNCTION OF ADAPTATION TO CLIMATE CHANGES	204
M. Radujković, G. Janjić	
5. INFLUENCE OF SOLAR FRACTION ON PHOTOVOLTAIC GENERATED ENERGY AT SERBIAN RESIDENTIAL BUILDING	210
Danijela Nikolić, Saša Jovanović, Vanja Šušteršič, Natalija Aleksić, Zorica Đorđević	
6. LONG TERM SIMULATION OF VERTICAL GCHP SYSTEM FOR A BUILDING WITH ASYMMETRIC COOLING AND HEATING LOADS	216

	M. Đekić, E. Tombarević	
7.	PERFORMANCE ANALYSIS OF A BIOMASS-FIRED STEAM BOILER WITH FGR USING AGRICULTURAL RESIDUE STRAW AS FUEL M. Tomić, P. Živković, J. Škundrić, M. Kljajić, B. Stepanov, Ž. Vlaović	221
8.	THE CONCEPT OF ESTIMATING THE HYDROPOWER POTENTIAL OF AN UNGAUGED WATERSHED IN MONTENEGRO Milena Ostojic, Goran Sekulic, David C. Finger, Ivana Cipranic	227
9.	AIR TIGHTNESS OF RESIDENTIAL BUILDINGS AND ITS IMPACT ON ENERGY CONSUMPTION E. Tombarević, V. Ivanović	235
10.	THE IMPACT OF CIRCULATING FLUIDIZED BED BOILERS ON THE ENVIRONMENT – ON THE EXAMPLE OF STANARI TPP M. Nježić, V. Babić	244
11.	THERMODYNAMIC ANALYSIS OF THE THEORETICAL COOLING SYSTEM BASED ON MEASURED CLIMATE DATA Danijela Kardaš Ančić, Petar Gvero, Mirko Komatina	256
12.	WASTEWATER AS A NEW SOURCE OF ENERGY V. Sustersic, N. Aleksic, N. Rakic, M. Josijevic	259
13.	AIR FLUIDIZED BED THERMAL DIFFUSIVITY COEFFICIENTS J. Janevski, P. Živković, M. Vukić, G. Cvetanović, M. Tomić	265
14.	CASCADE SYSTEM FOR OPTIMAL USE OF DEEP GEOTHERMAL ENERGY S. I. Deaconu, M. Topor, F. Bu, A. M. Blaj	272
15.	COMPREHENSIVE STUDY OF RAYLEIGH–BÉNARD CONVECTION IN A RECTANGULAR TANK WITH MOTOR OIL P. Živković, M. Tomić, J. Janevski, G. Cvetanović, C. Barz	278
16.	ASSESSMENT OF THE TECHNICAL JUSTIFICATION AND PROFITABILITY OF THE NEWLY BUILT SHPP-S IN MONTENEGRO V. Vilotjević, V. Nikolić, U. Karadžić, V. Kovijanić, I. Božić	282
17.	PARAFFIN IN LATENT HEAT STORAGE SYSTEMS P. Živković, G. Cvetanović, P. Rašković, J. Janevski, D. Petković	288
	<b>MECHANICS AND DESIGN</b>	<b>294</b>
1.	ANALYTICAL FUNCTIONS FOR GRADED COMPOSITE MATERIALS MODELLING D. Čukanović, G. Bogdanović, A. Radaković, D. Milosavljević, N. Velimirović	296
2.	COLD ROLLED VS. HOT ROLLED STEEL SECTIONS IN THE DESIGN OF CANTILEVER RACKING R. Vujanac, N. Miloradovic, S. Vulovic, A. Pavlovic	301
3.	CONTROL CALCULATION OF CLEARANCES IN HIGH-BAY WAREHOUSE OPERATED BY STORAGE AND RETRIEVAL MACHINES N. Miloradović, R. Vujanac	305
4.	DELAYED ACCELERATION FEEDBACK FRACTIONAL ORDER CONTROL OF CART PENDULUM SYSTEM – SOME STABILITY ISSUES M. P. Lazarević, D. Radojević, Lj. Bučanović, S. Pišl	311
5.	DIFFERENT APPROACHES TO THE PHASES OF INDUSTRY 4.0 PRODUCT DEVELOPMENT L. Šarović, B. Marković, A. Đurić	316
6.	METHODOLOGY REVIEW FOR GETTING FUNCTIONALLY GRADED LATTICE STRUCTURE FOR SIMULATION AND EXPERIMENTAL TESTING M. Soldo, D. Šaravanja, N. Rašović	322

7.	SELECTION OF ZIPLINE CABLE T. Jojić, J. Vladić, R. Đokić	327
<b>MECHATRONICS AND ROBOTICS</b>		<b>332</b>
1.	ASSESSMENT OF FRACTIONAL ORDER IMPACT ON PERFORMANCE OF FRACTIONAL ILC CONTROLLER FOR UPPER LIMB EXOSKELETON N. Živković, M. Lazarević, J. Vidaković	333
2.	CONTRIBUTION OF RESEARCH ON THE APPLICATION OF ACTIVE MAGNETIC BEARINGS IN ORDER TO REDUCE THE INFLUENCE OF UNBALANCE ON THE VIBRATIONS INTENSITY OF A RIGID ROTOR A. Tomović, M. Damjanović, R. Tomović, J. Jovanović	339
3.	INTERNAL MODEL CONTROL OF TWO-TANK SYSTEM USING NEURAL NETWORKS P. Stepanić, S. Marinković, J. Vidaković, N. Dučić, N. Živković	345
4.	SYNCHRONIZATION OF TWO NON-SYNCHRONIZABLE INDUSTRIAL ROBOTS R. Jalić, B. Z. Knežević, D. Erceg	351
5.	SYNTHESIS OF THE CONTROL UNIT OF THE DESKTOP ROBOT ARM ACTUATED BY STEPPER MOTORS A. Dević, J. Vidaković, N. Živković, M. Lazarević	361
<b>AUTOMOTIVE AND TRANSPORTATION ENGINEERING</b>		<b>366</b>
1.	DESIGN OF EXPERIMENTAL RESEARCH ON INFLUENCING FACTORS ON THE PARTICLE EMISSION CAUSED BY BRAKE WEAR S. Vasiljević, D. Taranović, J. Lukić, D. Miloradović, J. Glišović	368
2.	IMPACT OF NON-EXHAUST PARTICLE EMISSIONS FROM MOTOR VEHICLES ON HUMAN HEALTH O. Bobičić, M. Damjanović, D. C. Finger, R. Vujadinović, B. Matović	376
3.	RECYCLING OF USED ENGINE OIL FILTERS IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT Diana Miruna Armioni, Sorin Aurel Rațiu, Ioana Ionel	386
4.	THE INFLUENCE OF THE CROSSWIND ON THE LIFT COEFFICIENT, VEHICLE STABILITY AND SAFETY N. Stojanovic, I. Grujic, B. Boskovic	391
5.	THE INFLUENCE OF THE HYDROGEN INJECTION PARAMETERS ON THE COMBUSTION PROCESS OF IC ENGINE I. Grujic, N. Stojanovic, M. Petrovic	396
6.	REALIZING PRIORITIES FOR OCCUPATIONAL SAFETY AT AGRICULTURE M. Lutovska, V. Mijakovski, S. Kjosevski	402
<b>QUALITY AND ECOLOGY</b>		<b>407</b>
1.	IC ENGINE, HYDROGEN, COMBUSTION PROCESS, INJECTION PARAMETERS M. Rajić, B. Šumaković, P. Milosavljević, Z. Kostić	409
2.	CALORIFIC VALUE OF WOOD PELLETS B. Karpe, T. Udir, L. Lavrenčić, Z. Tanasić, A. Benčina, B. Kosec	419
3.	EFFECTIVE MONITORING AND ANALYSIS OF ERRORS THROUGH THE APPLICATION OF QUALITY TOOLS Maja Vuković, Goran Janjić, Zorana Tanasić, Borut Kosec, Miroslav Bobrek	423

4.	ENERGY MANAGEMENT MATURITY MODEL FOR SERBIA: LINKING ISO 50001 AND EXISTING PRACTICES M. Rajić, P. Milosavljević, R. Maksimović	427
5.	GLOBAL ELECTRONIC WASTE B. Dudić, P. Kovač, B. Savković, E. Beňová, D. Ješić	435
6.	INVESTIGATION OF THE INFLUENCE OF CHARACTERISTIC PARAMETERS ON THE ACCURACY OF CT MEASUREMENT G. Jotić, B. Štrbac, T. Toth, M. Ranisavljev, M. Hadžistević, M. Dovica, B. Runje	439
7.	LIFE-CYCLE COMPARISON OF THE HALL-HEROULT PROCESS, INERT ELECTRODES, AND ENERGY SUPPLY IN ALUMINUM PRODUCTION B. Bronkema, G. Sævarsdóttir, D. C. Finger	445
8.	METHODOLOGY OF EVALUATION OF ECOLOGICAL CHARACTERISTICS OF RESIDENTIAL BUILDINGS IN BOSNIA AND HERZEGOVINA Dragica Arnautović-Aksić	452
9.	QUALITY MANAGEMENT OF THE PRODUCTION OF PLASTIC INJECTION MOLDING TOOLS G. Janjić, J. Marić, Z. Tanasić, M. Vuković, T. Berlec	458
10.	THE EVALUATION OF PROCESS PERFORMANCE BY APPLYING THE DEA METHOD FOR EVALUATING 3D PRINTERS A. Tomović, J. Šaković Jovanović, A. Vujović	464
11.	A SURVEY ON LEAN METHODOLOGY IMPLEMENTATION IN A SMALL AND MEDIUM ENTERPRISES IN THE REPUBLIC OF SERBIA D. Pavlović, P. Milosavljević, S. Mladenović	470
	<b>MAINTENANCE OF ENGINEERING SYSTEMS AND OCCUPATIONAL SAFETY ENGINEERING</b>	<b>475</b>
1.	IMPORTANCE OF EXAMINATION OF COLLECTOR FOR IMPURITIES AFTER OIL PURIFICATION FOR HUMAN AND ENVIRONMENTAL SAFETY M. Jaric, S. Petronic, N. Budimir, B. Rajcic, Z. Stevic	477
2.	TECHNICAL DIAGNOSTICS – THE BASIS OF PREVENTIVE OR CORRECTIVE MAINTENANCE? D. Branković, Z. Milovanović	483
	<b>MATERIALS AND WELDING</b>	<b>488</b>
1.	LIFE ASSESSMENT USING THE FINITE ELEMENT METHOD OF HIGH- STRENGTH LOW- ALLOY STEEL SAMPLES EXPOSED TO LOW-CYCLE FATIGUE V. Aleksić, S. Bulatović, B Zečević, A. Maksimović, Lj. Milović	490
2.	CHARACTERIZATION AND HEAT TREATMENT OF ARMOUR STEEL OF NEW GENERATION D. P. Kosec, J. Bernetič, A. Nagode, G. Kosec, M. Soković, B. Kosec	500
3.	EFFECT OF SOLUTION ANNEALING PARAMETERS ON MICROSTRUCTURE AND MECHANICAL PROPERTIES OF NICKEL FREE AUSTENITIC STEELS I. Halilović, D. Sprečić, E. Nasić, Dž. Kovačević	505
4.	FINITE ELEMENT CALCULATION OF REDESIGNED WELDED JOINT AT SUPPORT FOR FRAME STAGE-LIKE STRUCTURE Aleksandra Arsić, Željko Flajs, Vlada Gašić, Nenad Zrnić	511
5.	INFLUENCE OF INJECTION MOLDING PARAMETERS AND GATE POSITION ON THE TENSILE STRENGTH OF POLYMER PART Edis Nasić, Denijal Sprečić, Jasmin Halilović, Džemal Kovačević	517

6. EDUCATION 4.0: APPLYING KNOWLEDGE TO PRACTICE IN A HYBRID LABORATORY FOR  
AUTOMATION AND MECHATRONIC: A SOLUTION  
WITH DIGITAL TWINS AND VIRTUAL REALITY 521  
H. Smajic, F. Tiryaki, D. Janjic, T. Duspara
7. DEEP LEARNING APPROACH FOR MONITORING AND MANAGEMENT OF ENERGY  
EFFICIENCY DATA IN PRODUCTION 528  
H. Smajic, C. Faller, F. Tiryaki



Banja Luka  
1-2 Jun 2023.

## DEMI 2023

16<sup>th</sup> International Conference on  
Accomplishments in Mechanical and  
Industrial Engineering

www.demi.mf.unibl.org



# Importance of examination of collector for impurities after oil purification for human and environmental safety

M. Jaric<sup>a</sup>, S. Petronic<sup>b</sup>, N. Budimir<sup>a</sup>, B. Rajcic<sup>b</sup>, Z. Stevic<sup>c,d</sup>

<sup>a</sup>Innovation Centre of the Mechanical Faculty in Belgrade, Kraljice Marije 49a, Belgrade

<sup>b</sup>Institute of General and Physical Chemistry, Studentski trg 3, Belgrade

<sup>c</sup>University of Belgrade, Technical Faculty in Bor;

<sup>d</sup>University of Belgrade, School of Electrical Engineering in Belgrade

---

### Abstract

The collector for impurities is a temporary tank that collects condensate from the condenser after oil purification process. Large-scale distillation towers use a reflux system to achieve more complete product separation. The collector, or accumulator, serves as a distribution point for reflux and distillate. This paper deals with a collector that uses water and light hydrocarbons as a working fluid, and is designed to operate under a pressure of 12 bar and a temperature of up to 91° C. Considering the working fluid, and work at elevated pressure, it belongs to the category of pressure vessels of a high level of danger. Its maintenance and regular inspection are a mandatory step in the prevention of failures and/or accident, and thus also in the protection of people and the environment. The paper describes tests of collector for impurities after oil purification and their importance; including a liquid penetrate inspection, ultrasonic measurement and visual inspection. Corrosion rate that occurs during the interaction of the working medium and the material of the collector was estimated such as and appropriate remaining working life. RBI analysis is performed.

---

**Keywords** Collector, hydrocarbons, nondestructive methods, remaining life, RBI

---

## 1. INTRODUCTION

In engineering practice, the lifetime of a specific plant and individual devices (apparatus, machines, etc.) implies the following stages: development, dimensioning and production technical documentation, production of the device, checking the functionality of the device after production, plant construction, i.e. installation of devices in a suitable complex system, verification functionality after

installation, maintenance, etc. For each of these stages there are developed technical regulations, as well as professional services that supervise them. During the lifetime of use, there are many factors that affect the lifetime of the device, such as working conditions, working medium, etc [1]. For that reason periodical inspection is very important and must follow developed regulations.

Impurities content undesirable components such as carbon-dioxide (CO<sub>2</sub>), hydrogen-sulfide (H<sub>2</sub>S), nitrogen (N<sub>2</sub>), water, etc. can cause health issues, corrosion of process units, and poorer calorific values [2]. Damage and/or failure of the apparatus affect the environment. Damages/failures occurred at oil and gas plants can be catastrophic for the environment.

---

### Corresponding author

PhD, Sanja Petronić  
sanjapetronic@yahoo.com  
Institute of General and Physical Chemistry  
Studentski trg 12/V  
Belgrade, Serbia

Chemical and petrochemical facilities generate many dangerous phenomena; these dangerous events must be mitigated by protection layers to reduce the risk to an acceptable level [3]. Some working medium, operating conditions and/or the environment condition can cause corrosion, which results in the loss of material, i.e. a reduction in the thickness of the device's wall. A critical reduction in wall thickness leads to leaks and failure, and corrosion is estimated to account for 19% of the failure factor [4].

In this work, the inspection of the collector for impurities after oil purification is investigated by visual examination (internal and external), liquid penetrate testing and ultrasound measurement. The corrosion rate and remaining life were estimated [5-8]. Suppose the equipment's or components remaining life the engineer can perform the necessary maintenance and be able to plan the replacement of the piece of equipment [9, 10].

In oil&gas and the petrochemical industry, the application of the RBI API methodology, which represents the process of creating an inspection scheme, is of great importance. To effectively integrate risk evaluation and benefit evaluation and facilitate investment decision making, it is firstly needed to analyze risk factors [11-13]. This method is based on the assessment of the probability of failure with the consequences of that failure. In oil&gas and petrochemical plants, a certain percentage of equipment represents a high risk and is given more attention, i.e. more time and money, while less money is allocated for maintenance for equipment that carries a lower risk. In this paper, the RBI inspection of the collector which is in long time service in one upstream oil plant has been calculated and discussed, pointing to the importance of the safety and economy of the plant.

## 2. TECHNICAL AND EXPERIMENTAL DATA

The collector for impurities after oil purification process is shown in Figure 1.

Technical data are listed in Table 1.

The collector was subjected to external and internal visual inspection, liquid penetrates inspection and ultrasonic measurement. Corrosion rate and remaining life were determined and estimated while RBI analysis was conducted according to the requirements of API 581.

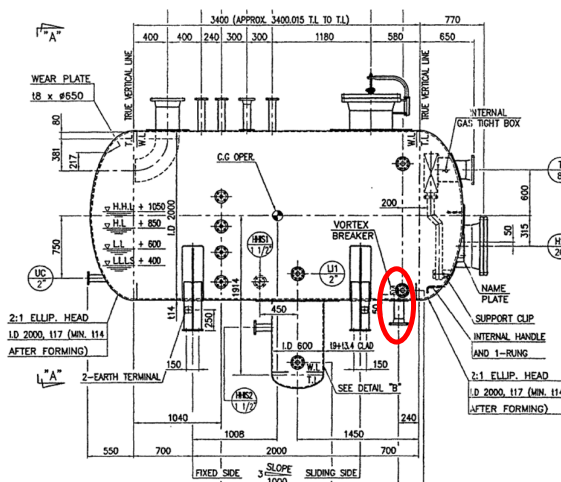


Fig.1. Technical drawing of the collector for impurities after oil purification

Table 1 Technical data

Material	Carbon steel-SA516 Grade70
Working medium	Light carbons and water
Fluid density	0.553 oil/0.986 water kg/dm <sup>3</sup>
Design pressure	12.0 bar
Design temperature	91°C
Operating pressure	8.7 bar
Operating temperature	55°C
Joint efficiency	0.85 (spot radiography)
Capacity	13.1 m <sup>3</sup>
Year of production	2003

## 3. RESULTS AND DISCUSSION

### 3.1. Survey of collector for impurities after oil purification

The collector was shut down for periodical inspection [14, 15]. The inspection covers the conditions of the external metal surfaces, protective coatings and all other external attachments.

Ladders, stairways, platforms, walkways foundations and supports and anchor bolts are in good condition.

The flange on the nozzle F1 (Fig.2) was found to be distorted. This condition of the flange has been spotted also during previous inspection in 2017. The flange is probably distorted during construction period. The flange and nozzle were checked visually and cracks were not spotted. Leaking has not been observed on this location while the vessel was in operation. All other nozzles were found in good condition.





**Fig. 2** The flange at the lower nozzle F1 (4") was found distorted, but leaking has not been observed while the vessel was in service

The grounding connections and cables were found to be in good condition. Electrical resistance has been checked by appropriate department and its value is 3.06 Ohms which is in line with the recommendations [15].

All gauge connections, sight glasses and safety valves were found to be in good condition.

External protective coating and external metal surfaces are in good condition.

The internal periodical inspection covers the integrity of internal metal surfaces, main weld joint, nozzle weld attachment and its internal components.

Pitting corrosion can be observed on the lower part of the vessel, Figure 3, especially from 5 to 7 o'clock position). Maximum depth of the pits was found to be 3 mm (only for one pit). Majority of the pits were between 1.0 to 2.0 mm deep. All pits have depth less than corrosion allowance, so according to API 510 Section 7.4.3 this can be ignored. Interior of the elliptical head of the collector has been found corroded in time of examination and also small pits were observed on circular weld joint (shell-head). Additional UT scanning has been performed for needs of estimation of circular weld joint and minimum value thickness in this area from the outside. Minimum measured value of thickness obtained by this scanning was found to be 10.43 mm. Here should be mentioned that this damaging is caused by corrosion and erosion effects.



**Fig.3.** Pitting corrosion has been observed on the lower part of the shell (from 5 to 7 o'clock position) - majority of the pits are between 1.5 to 2.0 mm deep

The back head of the vessel is corroded (Fig 4). Damaging is caused by corrosion and erosion effect. UT scanning has been performed from the outside. Minimum thickness was found to be 10.43 mm on the left elliptical head.

Penetrant testing results are presented in the Figure 5.

There is no sign of cracks and other irregularities on the inspected locations.



**Fig. 4.** Left head - close up view on the corroded surface (whole elliptical head has been scanned and minimum thickness was found to be 10.43 mm)



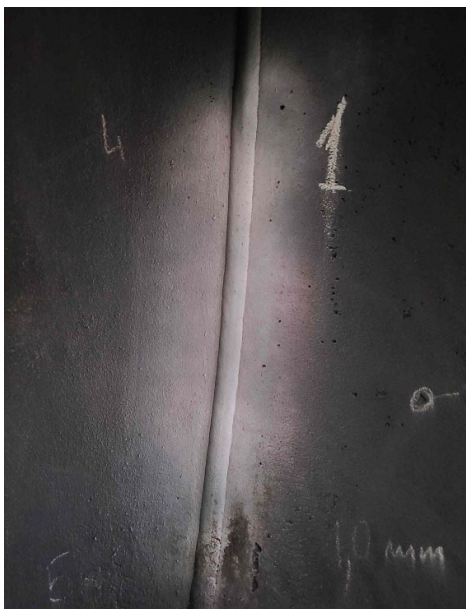


Fig.5. Liquid penetrate inspection performed on weld 1

### 3.2 Corrosion rates and remaining life

Operating pressure of the collector is 8.7 bar (as per vessel design data), but in reality this pressure is even lower. Maximum pressure is limited to 12 bar by the pressure safety valves. Limiting the pressure to maximum 10 bar will provide additional corrosion allowance of 1.87 mm (actual thickness - required thickness for 10bar = 10.43 mm - 8.56 = 1.87 mm). For this purpose, PSV which protect the collector should be additionally adjusted according to this pressure limit (10 bar).

During one of the first examination of the collector pitting corrosion was observed on the lower part of cylindrical shell and on left elliptical head. This situation was detail analyzed and after that injection of corrosion inhibitor CH1038 was started on 09-Dec-2009.

Here should be mentioned that corrosion inhibitor-CH1038 is belonging to blend of aliphatic amines and aminic derivates in high boiling point aromatic solvent. Result of this activity was manifested in corrosion rate reduction and slow growth of pit depth.

According to previous thickness measuring Corrosion Rate (CR) was calculated according to [16,17] for period 2009 to 2022:

$$CR \text{ (long-term)} = (11.0-10.43)/11.25=0.05067 \text{ mm/year}$$

CR (short-term) could not be certainly determined because previous and actual thickness readings are almost the same.

Hence, value of Corrosion Rate (long-time) was adopted as a relevant:

$$CR=0.05067 \text{ mm/year.}$$

Remaining Life (RL) of the vessel is:

$$RL = (\text{actual minimum thickness} - \text{required thickness}) / \text{corrosion rate (LT)}$$

$$RL = (10.43 \text{ mm} - 8.56 \text{ mm}) / 0.05067 \text{ mm/year}$$

$$RL = 36.9 \text{ years}$$

### 4. RBI calculation

RBI analysis is method of estimation of process equipment which including in itself the most probably damage mechanisms which can appear at appropriate process equipment depending on working mediums in the equipment (and their process parameters) and material from which equipment is made. Calculation of risk in API 581 [12] RBI involves the determination of a probability of failure (POF) combined with the consequence of failure (COF) presented by the following equation:

$$R(t) = P(t) * C(t)$$

The probability of failure is calculated as following [5]:

$$P_f(t) = gff * D_f(t) * F_{MS}$$

The risk for the presented collector for impurities after oil purification is calculated according to [12] and the most important results have been summarized in Table 2. The risk is calculated at the RBI date, the age at the RBI date is 20 years, while a Probability of failure at RBI date is  $1.17 * 10^{-3}$ .

Table 2 Calculation results summarized for the collector for impurities @ RBI date

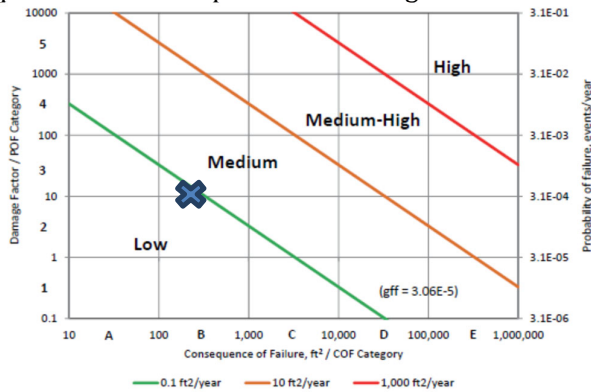
Art	0.29361
Inspection Effectiveness Category	B
Damage Stage	
Total Damage Factor	72.23
POF with inspection, failures/yr	00.001193
Final Consequence Area	492
The final financial consequence	4760000
Risk, m2/yr	1.3
Risk €/yr	12680

The final consequence area is 946m<sup>2</sup>, and the Total damage factor is 42.66 at RBI date. Table 3 presents numerical values associated with POF and Area-Based COF Categories taken from API 581 standard. In this analysis, these values have been taken as referent values for the iso-risk plot and risk matrix.

**Table 3** Numerical values associated with POF and Area-Based COF categories [12]

Cat.	Probability Category (1,2)		Consequence category (3)	
	Probability range	Damage factor	Range cat.	range (m2)
1	$P_f(t) \leq 3.06E-5$	$D_f \leq 1$	A	$CA \leq 9.29$
2	$3.06E-5 < P_f(t) \leq 3.06E-4$	$1 < D_f \leq 10$	B	$9.29 < CA \leq 92.9$
3	$3.06E-4 < P_f(t) \leq 3.06E-3$	$10 < D_f \leq 100$	C	$92.9 < CA \leq 929$
4	$3.06E-3 < P_f(t) \leq 3.06E-2$	$100 < D_f \leq 1000$	D	$929 < CA \leq 9290$
5	$P_f(t) > 3.06E-2$	$D_f > 1000$	E	$CA > 9290$

According to results presented in Table 2 and categories presented in Table 3, the presented collector for impurities after oil purification belongs to category B3 @ RBI date- medium risk. The results have been presented in the Iso-risk plot for the consequence area in Figure 5.



**Fig.6** Iso-risk Plot for the Consequence area. The vessel belongs to medium risk

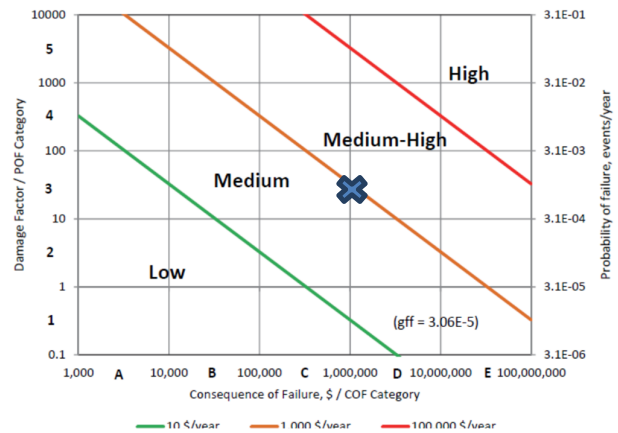
Table 4 presents Numerical Values Associated with POF and Financial-Based COF Categories taken from API 581.

**Table 4** Numerical values associated with POF and financial-based COF categories [12]

Cat.	Damage factor	Range cat.	Consequence category range (\$)
1	$D_f \leq 1$	A	$FC \leq 10000$
2	$1 < D_f \leq 10$	B	$10000 < FC \leq 100000$
3	$10 < D_f \leq 100$	C	$100000 < FC \leq 1000000$
4	$100 < D_f \leq 1000$	D	$1000000 < FC \leq 10000000$
5	$D_f > 1000$	E	$FC > 10000000$

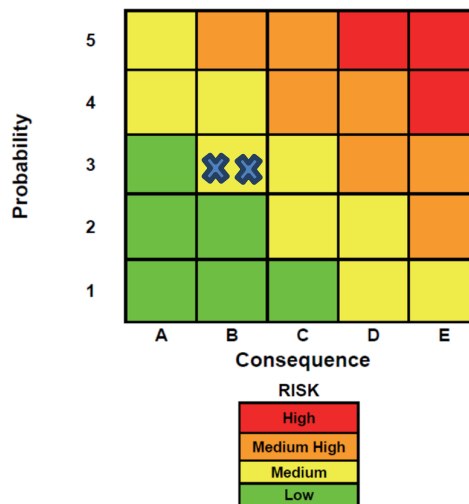
According to results presented in Table 2 and categories presented in Table 4, the damage factor belongs to Category 3 and Financial Consequence to Range category D.

The risk category of collector for impurities from standpoint of financial consequences is D3 and belongs to medium risk, very close to medium-high risk. That is presented in the Iso-risk plot for financial consequences in Figure7.



**Fig.7** Iso-risk Plot for Financial Consequence. The collector for impurities belongs to medium risk

Figure 8 presents the balanced risk Matrix for Consequence Area and Financial Consequence. After detail analysis of the relevant parameters related to probability of failure (POF) it's combined with the consequence of failure (COF) can be concluded that the collector for impurities belongs to category of medium risk.



**Fig.8** Balanced Risk Matrix for Consequence area and Financial Consequence [5]

## 5. CONCLUSION

This paper presents the inspection of collector for impurities after oil purification, determination, and analysis of remaining service life, corrosion rate. RBI inspection is applied and calculated in detail. From the presented the next could be concluded:

- All of the essential sections/components of the presented collector for impurities after oil purification satisfy the API 510 and API 572 Code requirements for maintenance inspection/examination hence, presented vessel is safe to operate until the next scheduled inspection.
- Corrosion rate is extremely high affecting the remaining life which is 36.9 years.
- Collector for impurities after oil purification belongs to medium risk, for Consequence Area while for the financial consequence it practically entering in the medium-high risk area.

**Acknowledgment.** This research was funded by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia through contracts Nos. 451-03-47/2023-01/200051, 451-03-47/2023-01/200131, 451-03-47/2023-01/200213.

## REFERENCES

- [1] Jacimovic, B., Genic, S., Budimir, N., Jaric, M. Acceptance test of induced draft cooling tower with 25 MW nominal heat power, Processing 20, 2007. Belgrade, Serbia.
- [2] Devold, H. (2013). *Oil and Gas Production Handbook – An introduction to oil and gas production, transport, refining and petrochemical industry, 3<sup>rd</sup> ed*, ABB Industries,
- [3] Zennir, Y., Bouasla, S.E.I., Mechhoud, E. Evaluation of Safety Instrumented System in a petrochemical plant using HAZOP-LOPA-Fault Tree Methodology, Case Study: Naphta Stabilizer-A Reflux Drum (LPG separation) in RA1K, 2020 International Conference on Electrical Engineering (ICEE) September 25-27, 2020, Istanbul, Turkey.
- [4] Wang, X., Duan, Q. (2019). Improved AHP-TOPSIS model for the comprehensive risk evaluation of oil and gas pipelines. *Petroleum Science*, vol. 16, p. 1479–1492, <https://doi.org/10.1007/s12182-019-00365-5>
- [5] Ishizaki, Y., Yonekawa, F., Yumoto, T., Suzuki, T., Hijikawa, S. Remaining life assessment of an external pressure vessel in creep range and inspection findings. *Proceedings of the ASME 2017 Pressure Vessels and Piping Conference, PVP2017*, July 16-20, 2017, Waikoloa, Hawaii, USA
- [6] Dedov, A., Klevtsov, I., Lausmaa, T., Hlebnikov, A., Bojarinova, T. (2016). Corrosion and life assessment of Intrex™ superheater tubes in a CFB oil shale boiler. *Appl. Therm. Eng.* <http://dx.doi.org/doi:10.1016/j.applthermaleng.2015.12.061>.
- [7] ISO 9223. (2012). *Corrosion of metals and alloys. Corrosivity of atmospheres. Classification, determination and estimation*. CEN.
- [8] ISO 9226. (2012). *Corrosion of metals and alloys. Corrosivity of atmospheres. Determination of corrosion rate of standard specimens for the evaluation of corrosivity*. CEN.
- [9] Jayanto, S.T., Chendra, M., Wijayanta, A.T. Estimating corrosion rate and remaining life of a pressure vessel of H<sub>2</sub>S absorber. *AIP Conference Proceedings* 2097, 2019. <https://doi.org/10.1063/1.5098182>
- [10] [3] API PR 571. (2020). *Damage Mechanisms Affecting Fixed Equipment in the Refining Industry, 3<sup>rd</sup> ed*. American Petroleum Institute.
- [11] Li, Z.X., Liu, J.Y., Luo, D.K., Wang, J.J. (2020). Study of evaluation method for the overseas oil and gas investment based on risk compensation. *Petrol. Sci.* vol.17, p.858–871. <https://doi.org/10.1007/s12182-020-00457-7>
- [12] API 581. (2016). *Risk-Based Inspection Methodology*. American Petroleum Institute.
- [13] Pilic, V., Balos, D., Gvozdenac Urosevic, B. (2022). Application of innovative methodology for risk assessment and inspection methods on example of small experimental biomass gasification unit, *Thermal Science* vol. 27, p.151-151. DOI: [10.2298/TSCI220606151P](https://doi.org/10.2298/TSCI220606151P)
- [14] API 510. (2020). *Pressure Vessel Inspector*, American Petroleum Institute.
- [15] API 572. (2020). *Inspection of Pressure Vessels*, American Petroleum Institute.
- [16] ASME SEC VIII, Division 1, 2019 ASME Boiler & Pressure Vessel Code 2019, The American Society of Mechanical Engineers, 2019.
- [17] ASME SEC VIII, Division 2: Alternative Rules, 2017 ASME Boiler & Pressure Vessel Code 2017, The American Society of Mechanical Engineers, 2017.