

70
1951-2021
SMEITS



ZBORNİK RADOVA PROCEEDINGS

**9. Međunarodna konferencija o obnovljivim
izvorima električne energije**

**9th International Conference on Renewable
Electrical Power Sources**



Beograd, 15. oktobar 2021
Belgrade, October 15, 2021

ZBORNIK RADOVA Proceedings

**pisanih za 9. Međunarodnu konferenciju o
obnovljivim izvorima električne energije**

**9th International Conference on Renewable
Electrical Power Sources**



**ZBORNİK RADOVA
pisanih za 9. Međunarodnu konferenciju o
obnovljivim izvorima
električne energije**

Hotel „Zepter“, Beograd
15. oktobar 2021.

**PROCEEDINGS
9th International Conference
on Renewable Electrical
Power Sources**

Hotel „Zepter“, Belgrade
October 15, 2021

Izdavač

Savez mašinskih i
elektrotehničk inženjera
i tehničara Srbije (SMEITS)
Društvo za obnovljive izvore
električne energije
Kneza Miloša 7a/II,
11000 Beograd

Publisher

Union of Mechanical and
Electrotechnical Engineers and Technicians of
Serbia (SMEITS)
Society for Renewable Electrical
Power Sources
Kneza Miloša str. 7a/II,
11000 Beograd

**Predsednik Društva za
obnovljive izvore
električne energije
pri SMEITS-u**

Prof. dr Zoran Stević

**President to the Society
for Renewable Electrical
Power Sources
within the SMEITS**

Prof Zoran Stević, Ph. D.

Urednik

Prof. dr Zoran Stević

Editor

Prof Zoran Stević, Ph. D.

Za izdavača

Vladan Galebović

For Publisher

Vladan Galebović

Tiraž

50 primeraka

CD umnožava

PR Priprema za štampu „BEOŽivković“, Beograd

ISBN

978-86-85535-09-3

CIP - Каталогизација у публикацији - Народна библиотека Србије, Београд

502.171:620.9(082)(0.034.2)

MEĐUNARODNA konferencija o obnovljivim izvorima električne energije (9 ; 2021 ; Beograd)

Zbornik radova [Elektronski izvor] / 9. Međunarodna konferencija o obnovljivim izvorima električne energije, Beograd, 15. oktobar 2021 ; [urednik Zoran Stević] = Proceedings / 9th International Conference on Renewable Electrical Power Sources, Belgrade, October 15, 2021 ; [editor Zoran Stević]. - Beograd : Savez mašinskih i elektrotehničkih inženjera i tehničara Srbije - SMEITS, 2021 (Beograd : BEOŽivković). - 1 elektronski optički disk (CD-ROM) ; 12 cm

Sistemski zahtevi: Nisu navedeni. - Nasl. sa naslovne strane dokumenta. - Tiraž 50. - Abstrakti. - Bibliografija uz svaki rad.

ISBN 978-86-85535-09-3

a) Энергетски извори - Одрживи развој - Зборници

COBISS.SR-ID 50499081

**Organizator
Organizer**

Savez mašinskih i elektrotehničkih
inženjera i tehničara Srbije (SMEITS),
**Društvo za obnovljive izvore
električne energije**

**Surganizator
Co-organizer**

Institut za arhitekturu i urbanizam Srbije,
Beograd



Sponzor / Sponsor

Apis centar, Beograd



Podrška / Endorsement

MT-KOMEX, Beograd



Održavanje 9. MKOIEE finansijski je pomoglo
Ministarstvo prosvete, nauke i tehnološkog
razvoja Republike Srbije



**Međunarodni programski odbor
International Programme Committee**

Prof. dr Slađana Alagić	Srbija
Prof. Viorel Badescu	Rumunija
Prof. dr Pellumb Berberi	Albanija
Prof. dr Miroslav Bjekić	Srbija
Prof. dr Oleksandr Bondarenko	Ukrajina
Prof. dr Alla Denysova	Bugarska
Dr Silvana Dimitrijević	Srbija
Dr Stevan Dimitrijević	Srbija
Akademik prof. dr Zoran Đurić	Srbija
Dr Aleksandar Ivančić	Španija
Prof. dr Miroljub Jevtić	Srbija
Prof. dr Branko Kovačević	Srbija
Prof. Vladimir Krstić	Kanada

Dr Mirza Kušljugić	BiH
Prof. dr Zoran Lazarević	Srbija
Dr Zorica Lazarević	Srbija
Prof. Nikolay Lopatkin	Rusija
Dr Nataša Markovska	Severna Makedonija
Prof. Nikolay Mihailov	Bugarska
Dr Emilija Mihajlovska	Severna Makedonija
Prof. dr Stefka Nedeltcheva	Bugarska
Dr Marina Nenković-Riznić	Srbija
Dr Dušan Nikolić	Australija
Dr Sanja Petronić	Srbija
Prof. dr Elena Ponomaryova	Ukrajina
Dr Mila Pucar	Srbija
Prof. dr Nikola Rajaković	Srbija
Prof. dr Ivan Rajšl	Hrvatska
Prof. dr Aleksandar Savić	Srbija
Prof. dr Birgit Scheppat	Nemačka
Prof. dr Valerij Sytnikov	Ukrajina
Prof. dr Zoran Stević	Srbija (predsednik)
Prof. dr Zoran Stojiljković	Srbija
Prof. dr Volodymyr Sydorets	Ukrajina
Prof. dr Nada Štrbac	Srbija
Prof. dr Dragan Tasić	Srbija
Prof. dr Michael Todorov	Bugarska
Dr Nataša Tomić	Srbija
Dr Milica Vlahović	Srbija
Dr Suzana Veličković	Srbija
Prof. dr Igor Vušanović	Crna Gora
Dr Zhongying Wang	Kina
Dr Wanxing Wang	Kina
Dr Xuejun Wang	Kina

Organizacioni odbor
Organizing Committee

Borjan Brankov
Vladan Galebović
Miloš Kostić
Dr Sanja Petronić
Dr Mila Pucar
Ilija Radovanović (predsednik)
Jelena Salević
Prof. dr Aleksandar Savić
Prof. dr Zoran Stević
Žarko Ševaljević

PREDGOVOR

Ubrzani napredak nauke, tehnologije i industrije dovodi do poboljšanja kvaliteta ljudskog života, ali i do stvaranja novih rizičnih situacija. Čovečanstvo je suočeno sa rizicima kakvih u ranijoj ljudskoj istoriji nije bilo. Globalno zagrevanje je tipičan primer. Jedan od glavnih problema vezanih za nove rizične situacije jeste – pitanje odgovornosti. Vlade država u svetu ne smeju teret odgovornosti prepustiti isključivo naučnicima i ekspertima, ali takođe ne smeju same odlučivati i preuzimati (ne)odgovornost. Trebalo bi da se konsultuju sa ekspertima i da dobro procene kada i kakve mere treba preduzimati. Potrebna je jaka politička inicijativa da bi se počeli rešavati ozbiljni ekološki problemi kao što je globalno zagrevanje, ali i lokalno zagađenje životne sredine. Politički dogovori na svetskom nivou koji su do sada postignuti u okviru Kjoto protokola, nedovoljni su za zaustavljanje ovog fenomena. Čiste tehnologije - tehnologije koje su dizajnirane da obezbeđuju superiorne performanse za nižu cenu dok istovremeno kreiraju manji gubitak energije od konvencionalnih ponuda - imaju velike šanse da budu motorna snaga koja će obezbediti ekonomski rast.

Nauka, naravno, pre svih uočava probleme opstanka planete i života na njoj. Ona takođe pokušava da ih reši i uspeva onoliko koliko je to realno moguće, imajući u vidu političke, socijalne, ekonomske i tehnološke faktore. Može se konstatovati da su praktično svi prioriteti posvećeni očuvanju života na Zemlji. Nauka i razvoj tehnike i tehnologije mogu tome doprineti u više segmenata:

- obnovljivi izvori energije;*
- energetska efikasnost;*
- smanjenje količine otpada;*
- smanjenje štetnosti otpada;*
- reciklaža;*
- prečišćavanje zemlje, vode i vazduha;*
- neutralizacija preostalog otpada.*

Bitan faktor za donošenje političkih odluka je i javno mnjenje. Zato je jako važno podizanje opšte svesti i što šira edukacija stanovništva o neophodnosti prelaska na obnovljive, ekološki prihvatljive izvore energije, što je jedan od dugoročnih ciljeva ove Konferencije.

Ovaj međunarodni skup po deveti put organizuje Društvo za obnovljive izvore električne energije (DOIEE) Saveza mašinskih i elektrotehničkih inženjera i tehničara Srbije (SMEITS), uz suorganizaciju Instituta za arhitekturu i urbanizam Srbije (IAUS).

U Beogradu, oktobra 2021.

SADRŽAJ / CONTENTS

PREDGOVOR

Prof. dr Zoran STEVIĆ 7

Plenarna predavanja

1. **UPOREDNA ANALIZA PIROMETALURŠKIH I HIDROMETALURŠKIH PROCESA ZA RECIKLAŽU ŠTAMPANIH PLOČA – TEORIJA I PRAKSA**
COMPARATIVE ANALYSIS OF PYROMETALLURGICAL AND HYDROMETALLURGICAL PROCESSES FOR PCB RECYCLING – THEORY AND PRACTICE
Silvana B. DIMITRIJEVIĆ 15
2. **EKONOMSKA PROCJENA BATERIJA KAO FLEKSIBILNE PODRŠKE ZA SUSTAVE S POVEĆANIM UDJELOM OBNOVLJIVIH IZVORA ELEKTRIČNE ENERGIJE: SLUČAJ REPUBLIKE HRVATSKE**
ECONOMIC ASSESSMENT OF BATTERIES FLEXIBLE SUPPORT FOR SYSTEMS WITH INCREASED PENETRATION OF RENEWABLE ELECTRIC ENERGY SOURCES: CROATIAN CASE
Iljko ĆURIC, Ivan RAJŠL 21
3. **POTENCIJAL ZA PROIZVODNJU VODONIKA POSTUPKOM GASIFIKACIJE MISCANTHUS × GIGANTEUS GREEF ET DEU PROIZVEDENOM NA NEKORIŠĆENOM POLJOPRIVREDNOM ZEMLJIŠTU U REPUBLICI SRBIJI**
POTENTIAL FOR HYDROGEN PRODUCTION BY THE GASIFICATION PROCESS OF MISCANTHUS × GIGANTEUS GREEF ET DEU PRODUCED ON UNUSED AGRICULTURAL LAND IN THE REPUBLIC OF SERBIA
Slobodan CVETKOVIC, Radmila PIVIĆ, Aleksandra STANOJKOVIĆ-SEBIĆ, Jelena MAKSIMOVIĆ, Željko DŽELETOVIĆ, Zoran DINIĆ 29

Obnovljivi izvori energije

4. **VETROTURBINE OBLIKA LALE**
TULIP-SHAPED WIND TURBINES
Dragan KRECULJ, Đorđe DIHOVIČNI, Nada RATKOVIĆ KOVAČEVIĆ 35
5. **OPTIMALNO POSTAVLJANJE FOTONAPONSKIH PANELA U FOTONAPONSKIM SISTEMIMA UVAŽAVAJUĆI EFEKAT SENKI**
OPTIMAL PLACEMENT OF PHOTOVOLTAIC PANELS IN PHOTOVOLTAIC SYSTEM CONSIDERING SHADING EFFECT
Nikola KRSTIĆ, Dragan TASIĆ, Dardan KLIMENTA 43
6. **PRIMENA SUPERKONDENZATORA U MIKROMREŽAMA**
APPLICATION OF SUPERCAPACITORS IN MICROGRID
Zoran STEVIC, Tatyana NIKOLAEVNA, Misa STEVIC 51
7. **PROIZVODNJA I KARAKTERISTIKE LEGURA SA MEMORIJOM OBLIKA ZA NAMENU U ELEKTRONICI**
MANUFACTURE AND CHARACTERISTICS OF SHAPE MEMORY ALLOYS FOR ELECTRONIC PURPOSES
Milica VLAHOVIĆ, Sanja MARTINOVIĆ, Nataša ĐORĐEVIĆ, Tatjana VOLKOV HUSOVIĆ, 55
8. **ISKORIŠĆENJE GEOTERMALNIH RESURSA ZA PROIZVODNJU TOPLOTNE ENERGIJE**
HARNESSING GEOTHERMAL RESOURCES FOR THERMAL ENERGY PRODUCTION
Miljan VLAHOVIĆ, Milica VLAHOVIĆ, Zoran STEVIĆ 65

9. JEDNA MOGUĆNOST IMPLEMENTACIJE MPPT-A ONE POSSIBILITY OF MPPT IMPLEMENTATION Lazar ĐUKANOVIĆ, Đorđe LAZOVIĆ, Žarko ŠEVALJEVIĆ, Zoran STEVIĆ	73
10. GBS – GLAGOL BATTERY SYSTEM – MODULARNI BATERIJSKI SISTEMI VISOKIH PERFORMANSI VIŠENAMENSKE ULOGE GBS – GLAGOL BATTERY SYSTEM – HIGH PERFORMANCE MODULAR MULTIFUNCTION BATTERY SYSTEM Nenad ĐALOVIĆ, Nemanja NEŠKOVIĆ, Mihajlo MRVOŠEVIĆ, Marta AVRAMOVIĆ	81
11. AUMA POGONI SA ELEKTRO CILINDRIMA ZA HIDROENERGETSKU INDUSTRIJU AUMA ACTUATORS WITH ELECTRIC CYLINDERS (LINEAR ACTUATORS) FOR HYDROPOWER INDUSTRY Bojana BERDIĆ	91
12. FOTONAPONSKI OFF-GRID HIBRIDNI SISTEM SA BATERIJAMA I DIZEL GENERATOROM ZA NAPAJANJE GRANIČNOG PRELAZA UŽLJEBIĆ PHOTOVOLTAIC OFF-GRID HYBRID SYSTEM WITH BATTERIES AND DIESEL GENERATOR FOR POWER SUPPLY AT THE BORDER CROSSING UŽLJEBIĆ Adis NUKIĆ, Amila BRČANINOVIC, Sanela UŽIČANIN, Almir MAHMUTOVIĆ, Halid VRTAGIĆ	103
13. PRIMENA MEHANOHEMIJE U SINTEZI EKOLOŠKE I ODRŽIVE KATALIZE APPLICATION OF MECHANOCHEMISTRY IN SYNTHESIS OF ECO-FRIENDLY AND SUSTAINABLE CATALYSTS Zara CHERKEZOVA-ZHELEVA, Daniela PANEVA, Stevan P. DIMITRIJEVIĆ, Silvana B. DIMITRIJEVIĆ, Aleksandra IVANOVIĆ	111
14. ISKORIŠTENJE DEPONIJSKOG GASA ZA PROIZVODNJU ELEKTRIČNE ENERGIJE SA DEPONIJA U CENTRALNOJ SRBIJI UTILIZATION OF LANDFILL GAS FOR ELECTRICITY PRODUCTION FROM LANDFILLS IN CENTRAL SERBIA Radmila LIŠANIN, Čedo LALOVIĆ	117

Uticaj obnovljivih izvora energije na životnu sredinu

15. OSNOVNI PRINCIPI 3D ŠTAMPE BETONA U SVETLU ODRŽIVOG RAZVOJA BASIC PRINCIPLES OF 3D CONCRETE PRINTING IN THE LIGHT OF SUSTAINABLE DEVELOPMENT Aleksandar SAVIĆ, Miša STEVIĆ, Milica VLAHOVIĆ, Sanja MARTINOVIĆ, Tatjana VOLKOV-HUSOVIĆ, Lazar ĐUROVIĆ	127
16. POBOLJŠANJE ODRŽIVOSTI KONSTRUKCIJSKIH BETONA PRIMENOM KREČNJAČKOG FILERA IMPROVING SUSTAINABILITY OF STRUCTURAL CONCRETE BY APPLICATION OF LIMESTONE FILLER Andrija RADOVIĆ, Snežana MARINKOVIĆ, Aleksandar SAVIĆ	131
17. KVANTNI GENERATOR SA SOLARNOM PUMPOM SA STRANE TEORIJE, EKSPERIMENTA I STVARNOSTI SOLAR-PUMPED QUANTUM GENERATOR: THEORY, EXPERIMENT AND REALITY Milesa SREĆKOVIĆ, Aleksander KOVAČEVIĆ, Stanko OSTOJIĆ, Slađana PANTELIĆ, Nenad IVANOVIĆ, Sanja JEVTIĆ, Zoran KARASTOJKOVIĆ, Slobodan BOJANIĆ	137

18. **BUKA, UTICAJ NA ŽIVOTNU SREDINU, KONTROLA I MOGUĆNOST NJENOG SMANJENJA**
NOISE, ENVIRONMENTAL IMPACT, CONTROL AND POSSIBILITIES OF NOISE REDUCTION
Anđela STOJIĆ, Dejan TANIKIĆ 147

Energetska efikasnost

19. **ZAKONSKI OKVIR U OBLASTI ENERGETSKE EFIKASNOSTI I OIE KAO JEDAN OD KLJUČNIH PREDUSLOVA ZA ODRŽIVI RAZVOJ SRBIJE**
THE LEGAL FRAMEWORK IN THE FIELD OF ENERGY EFFICIENCY AND RES AS ONE OF THE KEY PRECONDITIONS FOR THE SUSTAINABLE DEVELOPMENT OF SERBIA
Mila PUCAR, Borjan BRANKOV, Ana STANOJEVIĆ, Marina NENKOVIĆ-RIZNIC 153
20. **MODELOVANJE SAMOPOBUDNOG ASINHRONOG GENERATORA**
MODELLING OF A SELF-EXCITED INDUCTION GENERATOR
Bogdan BRKOVIĆ, Zoran LAZAREVIĆ 165
21. **RACIONALIZACIJA POTROŠNJE ELEKTRIČNE ENERGIJE PRIMENOM MIKROKONTROLERA**
RATIONALIZATION OF ELECTRICITY CONSUMPTION USING MICROCONTROLLERS
Dragan STOJANOVIĆ, Zoran STEVIĆ, Vesna MARKOVIĆ, Jasna RISTIĆ 173
22. **LABORATORIJSKE POSTAVKE SA SADRŽAJIMA ENERGETSKE EFIKASNOSTI OBLASTI ELEKTRIČNIH MAŠINA I ELEKTROMOTORNIH POGONA NA FAKULTETU TEHNIČKIH NAUKA U ČAČKU**
ENERGY EFFICIENCY CONTENTS IN LABORATORY SETTINGS IN THE FIELD OF ELECTRICAL MACHINES AND ELECTRIC DRIVES AT THE FACULTY OF TECHNICAL SCIENCES IN ČAČAK
Miroslav BJEKIĆ, Marko ROSIĆ, Marko ŠUĆUROVIĆ, Vojislav VUJIČIĆ 179
23. **GPC – GLAGOL POWER CONVERTER – UNIVERZALNI PRETVARAČKI UREĐAJ KAO ODGOVOR NA NOVE TRENDOVE ELEKTRIFIKACIJE**
GPC – GLAGOL POWER CONVERTER – UNIVERSAL CONVERTER IN RESPONSE TO NEW ELECTRIFICATION TRENDS
Nenad ĐALOVIĆ, Nemanja NEŠKOVIĆ 189
24. **SISTEM ZA PREDIKCIJU POTROŠNJE ELEKTRIČNE ENERGIJE**
ENERGY CONSUMPTION PREDICTION
Ivan POPOVIĆ 197
25. **NADGRADNJA POSTOJEĆEG SISTEMA AUTOMATIZACIJE TRAFOSTANICA KORIŠĆENJEM TEHNOLOGIJE DIGITALNOG PAKETSKOG RADIJA**
UPGRADING THE EXISTING SUBSTATION AUTOMATION SYSTEM USING DIGITAL PACKET RADIO TECHNOLOGY
Ivan POPOVIĆ 201

Aplikacije i usluge

26. **PRIMER DOBRE PRAKSE – REALIZACIJA PROJEKTA PROGRAMA ERAZMUS+, ODRŽIVI RAZVOJ ŠKOLE**
EXAMPLE OF GOOD PRACTICE – ERAZMUS + PROJECT IMPLEMENTATION, SUSTAINABLE SCHOOL DEVELOPMENT
Jasna RISTIĆ 205
27. **KORIŠĆENJE SAVREMENIH SAOBRAĆAJNIH REŠENJA U DOMENU UPOTREBE OBNOVLJIVIH IZVORA ELEKTRIČNE ENERGIJE**
THE USE OF MODERN TRAFFIC SOLUTIONS IN THE FIELD OF RENEWABLE ELECTRICAL POWER SOURCES
Predrag STOLIĆ, Zoran STEVIĆ, Aleksandra MILOSAVLJEVIĆ 209

28.	IDENTIFIKACIJA PROBLEMA SMANJENJA EFIKASNOSTI U RADU DISTRIBUIRANIH PV SISTEMA U PAMETNIM SREDINAMA IDENTIFICATION OF REDUCED EFFICIENCY PROBLEMS IN DISTRIBUTED PV SYSTEMS OPERATION IN SMART ENVIRONMENTS Ilija RADOVANOVIC, Ivan POPOVIC	217
29.	INTEGRACIJA INTERNET OF THINGS I OBNOVLJIVIH IZVORA ENERGIJE AN INTEGRATION OF IOT AND RENEWABLE ENERGY SOURCE Njegoš DRAGOVIĆ	223
30.	PRORAČUN ČELIČNIH SANDUČASTIH MOSTOVA SA ZAKRIVLJENOM DONJOM FLANŠOM STEEL BOX-GIRDER BRIDGE DECKS WITH CURVED BOTTOM FLANGE – DESIGN RULES Filip LJUBINKOVIĆ, OÃO PEDRO, Luís Simões DA SILVA	229
31.	DA LI HIBRIDNO VOZILO REALNO POMAŽE U UŠTEDI ENERGIJE? DOES HYBRID CAR REALLY HELPS IN ENERGY SAVING? Zoran KARASTOJKOVIĆ, Milesa SREĆKOVIĆ	239
32.	ANALYSIS OF APPLICATION OF LOW-ORDER FREQUENCY DEPENDENT COMPONENTS INCLUDED IN THE OPTIMIZATION SYSTEMS OF SOLAR AND WIND ENERGY GENERATION WITH THEIR CASCADE CONNECTION Hanna UKHINA, Ivan AFANASYEV, Anatolii KISEL, Valerii SYTNIKOV	245

Poster sesija

33.	GASIFIKACIJA OSTATAKA BIOMASE ZA PROIZVODNJU ELEKTRIČNE ENERGIJE GASIFICATION OF BIOMASS WASTES AND RESIDUES FOR ELECTRICITY PRODUCTION Marta TRNINIĆ, Sanja PETRONIĆ, Marko JARIĆ	249
34.	MOGUĆNOST REMEDIJACIJE ISTORIJSKE DEPONIJE OTPADNE ŠLJAKE U FIRMI MG SERBIAN BALJEVAC POSSIBILITY OF REMEDIATION THE HISTORICAL TAILING DUMP OF THE MG-SERBIAN BALJEVAC PLANT Aleksandra T. IVANOVIĆ, Silvana B. DIMITRIJEVIĆ, Vojka R. GARDIĆ, Stevan P. DIMITRIJEVIĆ	255
35.	MOGUĆNOST UPOTREBE MIKROARMIRANOG BETONA U KONSTRUKCIJAMA ZA DOBIJANJE OBNOVLJIVE ENERGIJE POSSIBILITY OF USING FIBER REINFORCED CONCRETE IN STRUCTURES FOR RENEWABLE ENERGY HARVESTING Marko POPOVIĆ, Aleksandar SAVIĆ, Zoran MIŠKOVIĆ	261
36.	UTICAJ VREMENA SINTEROVANJA NA GUSTINU I SEM ANALIZA KORDIJERITNE KERAMIKE INFLUENCE OF SINTERING TIME ON DENSITY PROPERTIES AND SEM ANALYSIS OF CORDIERITE-BASED CERAMICS Nataša ĐORĐEVIĆ, Adriana PELEŠ, Nina OBRADOVIĆ, Milica VLAHOVIĆ, Slavica MIHAJLOVIĆ, Sanja MARTINOVIĆ	265
37.	ELEKTRIČNA SVOJSTVA IZOTERMSKI SINTEROVANE KERAMIKE NA BAZI KORDIERITA KAO FUNKCIJA VREMENA SINTEROVANJA I AKTIVACIJE ELECTRICAL PROPERTIES OF ISOTHERMALLY SINTERED CORDIERITE- BASED CERAMICS AS FUNCTION OF SINTERING AND ACTIVATION TIME Nataša ĐORĐEVIĆ, Adriana PELEŠ, Nina OBRADOVIĆ, Milica VLAHOVIĆ, Slavica MIHAJLOVIĆ, Sanja MARTINOVIĆ	269

38. **SEMI-KVANTITATIVNA ANALIZA ZA PROCENU ODRŽIVE PROIZVODNJE ZELENOG VODONIKA GASIFIKACIJOM BIOMASE**
 A SEMI-QUANTITATIVE ANALYSIS FOR EVALUATING THE SUSTAINABLE GREEN HYDROGEN PRODUCTION BY BIOMASS GASIFICATION
 Filip VELJKOVIĆ, Bojan JANKOVIĆ, Nebojša MANIĆ,
 Miloš RADOJEVIĆ, Milovan STOILJKOVIĆ, Ivana STAJČIĆ,
 Milica ĆURČIĆ, Suzana VELIČKOVIĆ 273
39. **IZBOR IZVORA ENERGIJE ZA GREJANJE DOMAĆINSTVA PRIMENOM CoCoSo METODE**
 SELECTION OF ENERGY SOURCE FOR HOUSEHOLD HEATING BY APPLICATION OF THE CoCoSo METHOD
 Zoran ŠTIRBANOVIĆ, Dragiša STANUJKIĆ, Jovica ŠOKOLOVIĆ 281
40. **REKUPERACIJA TOPLOTE IZ OSTATKA PROCESA PROIZVODNJE ALKOHOLNIH PIĆA U DESTILERIJI KAPACITETA 40000 KG/DAN**
 HEAT RECOVERY FROM THE RESIDUE OF THE PROCESS OF ALCOHOLIC BEVERAGE PRODUCTION IN A DISTILLERY WITH A CAPACITY OF 40000 KG / DAY
 Saša MARKOVIĆ, Sanja PETRONIĆ, Marta TRNINIĆ,
 Nikola TANASIĆ, Daniela RISTIĆ 287
41. **HERMENEUTIKA I VIZUELNA PREDSTAVA POLITEHNIČKOG PROMIŠLJANJA – DVE STUDIJE IZ POLITEHNIČKOG MUZEJA U MOSKVI**
 HERMENEUTICS AND VISUAL PERFORMANCE OF POLYTECHNICAL THINKING – TWO STUDIES FROM THE POLYTECHNICAL MUSEUM IN MOSCOW
 Anđelka MILOSAVLJEVIĆ, Suzana POLIĆ, Sanja PETRONIĆ, Marko JARIĆ 291
42. **VAŽNOST PREGLEDA I ODREĐIVANJE PREOSTALOG VEKA TRAJANJA CEVOVODA NA NAFTNOJ PLATFORMI**
 IMPORTANCE OF INSPECTION AND DETERMINATION OF REMAINING LIFE OF PIPELINE IN OIL PLATFORM
 Marko JARIĆ, Sanja PETRONIĆ, Saša MARKOVIĆ, Marta TRNINIĆ, Suzana POLIĆ 299

Prezentacije objavljene na sajtu

43. **KOROZIONA OTPORNOST 1.4713 VATROSTALNOG FERITNOG ČELIKA U 0.5M NITRATNOJ KISELINI**
 CORROSION RESISTANCE OF 1.4713 FERRITIC HEAT-RESISTANT STEEL IN 0.5M NITRIC ACID
 Stevan P. DIMITRIJEVIĆ, Dimitrije STEVANOVIĆ, Silvana B. DIMITRIJEVIĆ,
 Aleksandra IVANOVIĆ, Zara CHERKEZOVA-ZHELEVA, Željko KAMBEROVIĆ 305
44. **PIEZOELEKTRIČNI FILM MATERIJALI ZA PRIKUPLJANJE ENERGIJE IZ OKOLNE SREDINE**
 PIEZOELECTRIC FILM MATERIALS FOR ENERGY HARVESTING
 Zdravko STANIMIROVIĆ, Ivanka STANIMIROVIĆ 313
45. **PROCES SITO-ŠTAMPE DEBELOG FILMA U REALIZACIJI SILICIJUMSKIH SOLARNIH ČELIJA**
 THICK-FILM SCREEN PRINTING PROCESS FOR SILICON SOLAR CELLS
 Ivanka STANIMIROVIĆ, Zdravko STANIMIROVIĆ 317
46. **MODEL ZA IZGRADNJU NOVIH HIDRELEKTRANA NA BAZI DOMAĆEG ZNANJA**
 MODEL FOR CONSTRUCTION OF NEW HYDROPOWER PLANTS ON THE BASE DOMESTIC KNOWLEDGE
 Zdravko BIJELIĆ, Biljana MILANOVIĆ, Mitar BIJELIĆ 321

47. ISTRAŽIVANJE RENTABILNOSTI MALIH HIDROELEKTRANA RESEARCH OF PROFITABILITY OF SMALL HYDROPOWER Mitar BIJEIĆ, Biljana MILANOVIĆ, Radvoj PRODANOVIĆ, Zdravko BIJEIĆ	331
48. SIMULACIJA RADA POLUMOSNOG INVERTORA ZA INDUKCIONO TOPLJENJE METALA SIMULATION OF A HALF BRIDGE INVERTER FOR INDUCTION MELTING OF METALS Dušan ĐURAŠKOVIĆ, Bračan LABUDOVIĆ, Petar MARKOVIĆ, Miša STEVIĆ, Zoran STOJILJKOVIĆ, Zoran STEVIĆ	337
49. POLUMOSNI INVERTOR ZA INDUKCIONO TOPLJENJE METALA HALF BRIDGE INVERTER FOR INDUCTION MELTING OF METALS Dušan ĐURAŠKOVIĆ, Bračan LABUDOVIĆ, Petar MARKOVIĆ, Miša STEVIĆ, Zoran STOJILJKOVIĆ, Zoran STEVIĆ	347
50. METHOD FOR INCREASING THE RELIABILITY OF INCLINOMETRIC TELEMETRY SYSTEMS FOR DRILLING OIL AND GAS WELLS Elena PONOMARYOVA, Sergey PONOMARYOV	369

UPOREDNA ANALIZA PIROMETALURŠKIH I HIDROMETALURŠKIH PROCESA ZA RECIKLAŽU ŠTAMPANIH PLOČA - TEORIJA I PRAKSA

COMPARATIVE ANALYSIS OF PYROMETALLURGICAL AND HYDROMETALLURGICAL PROCESSES FOR PCB RECYCLING - THEORY AND PRACTICE

Silvana B. DIMITRIJEVIĆ*

Mining and Metallurgy Institute Bor, Serbia

Elektronski otpada od starih računara povećala se za oko pet puta, a sa odbačenih mobilnih telefona gotovo 20 puta za 2020. Godinu u odnosu na 2007. E-otpad (elektronski otpad) je jedna od najbrže rastućih vrsta otpada na svetu sa oko 40-50 miliona tona godišnje u poslednjoj deceniji, što predstavlja 2-3% ukupnog otpada koji se godišnje generiše širom sveta. Štampane ploče (PCB) su najvrednije komponente E-otpada. Cilj ovog rada je uporedna analiza pirometalurških i hidrometalurških procesa za reciklažu plemenitih metala iz PCB na osnovu eksperimentalnih istraživanja i rezultata

Ključne reči: Reciklaža; pirometalurgija; hidrometalurgija; analiza

The production of e-waste from old computers increased by about five times, and from discarded mobile phones almost 20 times by the year 2020 compared to the year 2007. E-waste (electronic waste) is one of the fastest growing types of waste in the world, about 40-50 million tons per year in the last decade, representing 2-3% of the total waste generated annually worldwide. Printed circuit boards (PCBs) are the most valuable components of E-waste. The aim of this paper is a comparative analysis of pyrometallurgical and hydrometallurgical processes for the recycling of precious metals from PCBs based on experimental research and results.

1 Introduction

In the last few decades KSKS century, as the amount of e-waste grows because animals age device and product shortens processing e-waste is updated. The importance of these technologies is reflected in obtaining the valuable materials and solving the environmental problems. Technologies for the process usually include a combination of methods due to the complexity of processed materials [1, 2].

In the period of the 1970s and early to mid-1980s, the main method for recycling the electronic scrap was the blast furnace smelting with secondary copper or lead smelters. Since the mid-1980s, this trend has been shifted toward the hydrometallurgical processing.

Recovery of metals from e-scrap by pyrometallurgical processing, include the incineration, smelting in a plasma arc furnace or blast furnace, drossing, sintering, melting and reactions in a gas phase at high temperatures [3-4] became a traditional method to recover the non-ferrous metals and precious metals from electronic waste in the past two decades.

The most active research area on recovery of metals from electronic scraps is recovering the precious metals using the hydrometallurgical techniques [5-6]. Comparing with the pyrometallurgical processing, the hydrometallurgical method is more exact, more predictable, and more easily controlled [7].

The solutions, obtained by a series of acid or caustic leaches of solid material, are the subject of separation and purification procedures such as precipitation of impurities, solvent extraction, adsorption and ion-exchange to isolate and concentrate the metals of interest.

In recent times, the recovery of metals by biotechnology has been one of the most promising technologies [7-9]. Biometallurgy has been the subject to growing investigations for the last 20

* Author's, email: silvana.dimitrijevic@irmbor.co.rs

- [17] Maurice Merleau-Ponty, *Fenomenologija percepcije*; Sarajevo, Veselin Masleša, 1990.
- [18] René Descartes, *Načela filozofije*; Kruzak, Zagreb, 2014. (prvi put objavljeno na latinskom 1644. pod nazivom Principia philosophiae)
- [19] René Descartes, *Razmišljanja o prvoj filozofiji*, Demetra, Zagreb, 1994. (prvi put objavljeno na latinskom pod nazivom Meditationes de prima philosophia 1641. godine)
- [20] Luigi Russolo, *The Art of Noise* (futurist manifesto, 1913), translated by Robert Filliou, UBU-Classic, 2004. (originally published in 1967 as a Great Bear Pamphlet by Something Else Press)
- [21] https://en.wikipedia.org/wiki/The_Art_of_Noises
- [22] <https://martinmessier.art>
- [23] <https://www.kunst-fuer-alle.de/english/fine-art/artist/image/michelangelo-buonarroti/221/1/99144/angel-holding-a-candelabra-1495/index.htm>
- [24] <https://www.tg-m.ru/catalog/en/artists/2834>
- [25] https://en.wikipedia.org/wiki/Angels_in_art
- [26] Ханс Георг Гадамер, *О кругу разумевања, у: Похвала теорији*, Подгорица 1996.
- [27] Friedrich Tomberg, *Mimesis der Praxis und Abstrakte Kunst*, Darmstadt: Luchterhand 1968. (Soziologische Essays) (January 1, 1968)

VAŽNOST PREGLEDA I ODREĐIVANJE PREOSTALOG VEKA TRAJANJA CEVOVODA NA NAFTNOJ PLATFORMI

IMPORTANCE OF INSPECTION AND DETERMINATION OF REMAINING LIFE OF PIPELINE IN OIL PLATFORM

Marko JARIC^{1*}, Sanja PETRONIC², Saša MARKOVIĆ²,
Marta TRNINIĆ², Suzana POLIĆ³

¹ Innovation Centre of the Faculty of Mechanical Engineering in Belgrade, Belgrade

² The Academy of Applied Technical Studies Belgrade, Belgrade

³ National Museum in Belgrade, Belgrade

Naftna platforma je velika građevina sa objektima za bušenje bušotina za istraživanje, vađenje, skladištenje i preradu nafte i prirodnog gasa koji leži u stenovitim formacijama ispod morskog dna. Bušenje na otvorenom moru predstavlja izazove za životnu sredinu. Iako, srećom, nije bilo mnogo nesreća na oil platforms, šteta koja nastane je ogromna i u ljudskom i u materijalnom i u smislu zaštite životne sredine. Iz tog razloga, inspekcija opreme pod pritiskom je od velikog značaja. The risk to the pressure vessel in service can be failure due to material degradation. Jedan od tipičnih mehanizama degradacije materijala je korozija. U ovom radu će biti prikazana važnost inspekcije opreme pod pritiskom. Na konkretnom, praktičnom primeru će biti predstavljena inspekcija pipeline i određivanje corrosion rate i remaining life u cilju sprečavanja otkaza i materijalnih I ljudskih gubitaka.

Ključne reči: cevovod, ispitivanja bez razaranja, brzina korozije, preostali vek trajanja

The oil platform is a large structure with facilities for drilling wells for exploration, extraction, storage and refining of oil and natural gas lying in rock formations under the seabed. Offshore drilling poses environmental challenges. Although, fortunately, there have not been many accidents on oil platforms, the damage that occurs is enormous, both in human and material terms, and in terms of environmental protection. For that reason, the inspection of pressure equipment is of great importance. The risk to the pipeline in service can be failure due to material degradation. One of the typical mechanisms of material degradation is corrosion. This paper will present the importance of inspection of pressure equipment. On a concrete, practical example, pipeline inspection and determination of corrosion rate and remaining life will be presented in order to prevent failures and material and human losses.

Key words: pipeline, nondestructive testing, corrosion rate, remaining life

1 Introduction

Pipelines are the most efficient way of transporting oil, gas, water, chemicals, etc. Today the offshore pipeline system is highly efficient, safe and environmentally friendly because the possibility of pipeline failure is extremely small. However, if a malfunction occurs, it can have a great impact on the environment as well. Most operations in the process industry take place at temperatures and pressures that differ from normal atmospheric conditions. These operations are often dangerous and endanger the environment. These structures have their limitations according to the material of construction, the method of design and construction, maintenance schedule and their age. Any defect or deficiency in these aspects would mean that these structures would not do their role perfectly, and accidents would occur. The mechanical designer must ensure that the construction guarantees reasonable safety for a reasonable period and does not fail despite continuous or moderate difficulties conditions according to its construction structure (1, 2). Although pipelines are one of the safest modes of transport and have failure rates much lower than rail or highway, failures do occur and sometimes

* Corresponding author's email: mjaric@mas.bg.ac.rs

with catastrophic consequences. Traditionally, most the pipeline operators shall ensure that safety provisions are created at the design stage that provides a theoretically minimum failure rate for pipeline life. When choosing pipes and other fittings the safety provisions are taken into account (3). Various techniques are routinely used to monitor pipeline status. Any deterioration of the line can cause leakage or rupture. Existing inspection and maintenance practices typically followed by most pipeline operators are formulated largely based on experience. However, operators are developing an organized maintenance policy based on data analysis and other internal studies to replace the basic guidelines. Risk factors that can cause pipeline failures are the following: corrosion (internal and external corrosion), poor construction and poor quality material, human and operational errors and natural hazards (4,5). Internal corrosion is usually caused by a chemical reaction between piping material and fluids or gases, such as CO₂, H₂S and O₂. Corrosion takes the form of general or localized loss of metal from the pipe and can cause cracks in the piping material. The corrosion rate depends on the pipe material, the type of product transported through the pipelines and the corrosion inhibitor. The impact of pipeline failure is determined by factors such as economic loss - total reserves, operation/flow, possible product loss, pipeline function, etc.; and environmental and social effects - environmental severity, human severity, leakage rate and affected area. Regular inspection of the pipeline is very important for the proper operation of the pipeline and safety for people and the environment (6,7). In this paper, the inspection of the pipeline will be presented and, the corrosion rate and the remaining life of the pipeline will be determined.

2 Technical data

The equipment technical data and general pipeline data are listed in Table 1 and Table 2, respectively. Figure 1 presents the sketch of the tested pipeline. The pipeline was tested by the following nondestructive methods: visual, liquid penetrant and ultrasonic inspection.

The chemical composition of the pipeline material is listed in Table 3.

Figure 1 presents the sketch of the tested pipeline.

Table 1. Equipment technical data

EQUIPMENT TECHNICAL DATA			
	Material	Design Thickness (mm)	C.A.
Pipe	ST-Steel SA-312-316L	8.74	0.00
Flanges	ST-Steel SA-403WP-316L		
Blind Flanges	ST-Steel SA-182-F316L		
Flexible Hoses	Plastik		
Expansion joints	ST-Steel SA-403WP-316L		
Injection points	ST-Steel SA-403WP-316L		
Insulation	No	Thickness of insulation:	0.00

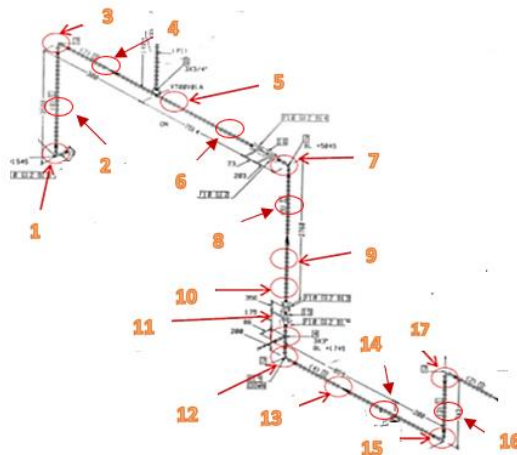


Figure 1. Sketch of tested pipes

Table 2. Pipeline data

GENERAL PIPE/PIPELINE DATA					
Design Code		ASME B 31.3:2016, ASME B16.5:2013			
Inspection Code		API 570:2016, API 574:2016, API 578:2010			
Position in plant	Vertical/Horizontal	Position in relation to the ground		Aboveground/Buried	
Pipe size, DN	65	Nominal thickness		8.74	
Class of pipeline circuit	1	Class of weld joints		A	
Design condition					
Working medium		Liquid/Gas			
Fluid service		M, D, ET, HPr, Hpu, Normal Fluid service			
Minimum pressure, bar		9.78			
Maximum pressure, bar		89			
Minimum temperature, °C		-29.1			
Maximum temperature, °C		100.1			
Operating and test condition					
Operating pressure, barg	9.8	Min. test pressure, barg	89	Max. test pressure	133.5
Operating temperature, °C	55	Min. test temperature, °C	20	Max. test temperature, °C	50

Table 3 Chemical composition of ST-Steel SA-312-316L

Composition	C	Si	Mn	P	S	Cr	Ni	Mo	N
Percentage %	0.08	0.75	2.0	0.045	0.03	16-18	10-14	2-3	0.1

3 Nondestructive testing of pipeline

The periodic inspection of the aboveground pipeline included the following: visual control, liquid penetrate testing and ultrasonic testing. Figure 1 presents pipelines at the oil platform.



Figure 2. Pipelines at the oil platform

After a detailed inspection, it was concluded that the pipeline was in satisfactory condition. Corrosion on the external pipeline was not found. The foundations and supports of the pipe were in good condition. Concrete supports, steel supports of the pipeline and contact points of the pipeline at supports were visually in good condition and corrosion at the contact points on this pipe was not noticed.

The inspection included the soil to an air interface of the pipeline as well. It was in good condition and, corrosion on this pipeline at the soil to air interface has not occurred. Corrosion on this pipeline was not found also 30 cm upwards above this interface and 10 cm down under this interface.

Nozzles, dead legs and pipe caps were found in good condition and, corrosion is not found.

All fittings (elbows, T-joints, reducers) and valves attached to the pipeline were visually in good condition. Weld joints and protective coatings were in satisfactory condition.

The Interior of the pipe was in satisfactory condition.

All of the essential sections/components of the pipe are safe to operate until the next inspection.

Figure 3 presents the results of external visual testing.



Figure 3. Visual testing of external sides of the pipeline. Pipelines are in good condition.

4 Corrosion rate and remaining life

The corrosion rate is calculated according to ASME [8] in two ways: long time corrosion rate and short time corrosion rate according to the following equations:

$$\text{Corrosion rate (LT)} = (t_{\text{initial}} - t_{\text{actual}}) / \text{time between } t_{\text{initial}} \text{ and } t_{\text{actual}} \text{ (years)} \quad (1)$$

$$\text{Corrosion rate (ST)} = (t_{\text{previous}} - t_{\text{actual}}) / \text{time between } t_{\text{previous}} \text{ and } t_{\text{actual}} \text{ (years)} \quad (2)$$

According to API 574, section 12 [9], the required thickness is calculated from the following formula:

$$t_{\text{required}} = P \cdot D / (2 \cdot S \cdot E) \quad (3)$$

where t_{required} is required thickness in mm,

P is the internal design gauge pressure of the pipe in MPa,

S is the allowable unit stress at the design temperature in MPa [8],

E is the longitudinal quality factor [8].

The initial thickness was 8.74 mm and required thickness is 3.7 mm.

The wall thickness of the pipeline was measured at 17 points designed in Figure 1. The wall thickness was measured in 2004, 2018 and 2021.

According to equation (1) and (2), corrosion rate (ST=14) is 0.14 mm/yr, corrosion rate (ST=3) is 0.33 mm/yr and corrosion rate (ST=17) is 0.13 mm/yr.

The remaining life of the piping (in years) shall be calculated from the following formula [9-11]:

$$\text{Remaining life} = t_{\text{actual}} - t_{\text{required}} / \text{corrosion rate} \quad (4)$$

Where t_{actual} is the actual thickness of a CML, in in. (mm), measured during the most recent inspection;

t_{required} is the required thickness at the same CML or component, in in. (mm), as the actual measurement. It is computed by the design formulas (e.g. pressure and structural) and does not include corrosion allowance or manufacturer's tolerances. [9]

Replacing obtained results in equation (4) remaining life for the pipeline is 15.27 years.

As per Plant Inspection Philosophy maximum interval is 2.5 years for PSV inspection which should be done by the Vendor or at specialist repair workshop approved by the Company according to [12, 13].

5 Conclusion

The paper presents the inspection of pipelines on the oil platform. Although nowadays pipelines are the safest mode of fluids transport, the smallest failure can cause great material and environmental damage. For this reason, pipeline inspection is of utmost importance. The principle of inspection is presented, what everything should include and, the results are presented. Also, the long time corrosion rate and short time corrosion rate were calculated and based on the highest value, the remaining life of the inspected pipeline is 15.27 years.

6 References

- [1] Ravikiran, N., V. S. Reddy, G. K. Kumar, Inspection Practices for Piping System Components 3D Modeling and Stress Analysis of Flare Piping, *International Journal of Engineering Trends and Technology (IJETT)*, 16, 3, 2014, pp 103-108.
- [2] Devold, H., *Oil and Gas Production Handbook – An introduction to oil and gas production, transport, refining and petrochemical industry*, 3rd ed, ABB Industries, Oslo, 2013.
- [3] Dey, P.K., S. O. Ogunlana, S. Naksuksakul, Risk-based maintenance model for offshore oil and gas pipelines: a case study, *Journal of Quality in Maintenance Engineering*, 10, 3, 2004, pp. 169 – 183. <http://dx.doi.org/10.1108/355251041055326>
- [4] Bertolini, M., M. Bevilacqua, F.E. Ciarapica, G. Giacchetta, Development of Risk-Based Inspection and Maintenance procedures for an oil refinery, *Journal of Loss Prevention in the Process Industries*, 22, 2009, pp. 244–253. doi:10.1016/j.jlp.2009.01.003.
- [5] Wang, X., Q. Duan, Improved AHP–TOPSIS model for the comprehensive risk evaluation of oil and gas pipelines, *Petroleum Science*, 16, 2019, pp.1479–1492. <https://doi.org/10.1007/s12182-019-00365-5>

- [6] Chang, M.G., C. M. Shu, K. N. Lin, Application of risk based inspection in refinery and processing piping, *Journal of Loss Prevention in the Process Industries*, 18, 2005, pp. 397–402, doi:10.1016/j.jlp.2005.06.036
- [7] Kamsu-Foguem, B., Information structuring and risk-based inspection for the marineoil pipelines, *Applied Ocean Research*, 56. 2016, pp. 132–142. <http://dx.doi.org/10.1016/j.apor.2016.01.009>
- [8] *** ASME B31.3-2014, Process Piping, The American Society for Mechanical Engineers. 2015.
- [9] ***, API PR 571, Damage Mechanisms Affecting Fixed Equipment in the Refining Industry, 3rd ed, American Petroleum Institute, 2020
- [10] Ishizaki, Y., F. Yonekawa, T. Yumoto, T. Suzuki, S. Hijikawa, *Proceedings of the ASME 2017 Pressure Vessels and Piping Conference, PVP2017*, Remaining life assessment of an external pressure vessel in creep range and inspection findings, Waikoloa, Hawaii, USA, 2017. <https://doi.org/10.1115/PVP2017-65194>
- [11] Jayanto, S.T., M. Chendra, A. T. Wijayanta, *AIP Conference Proceedings 2097*, Estimating corrosion rate and remaining life of a pressure vessel of H₂S absorber, 2019, <https://doi.org/10.1063/1.5098182>
- [12] ***, API 570, Piping Inspection Code: In-service Inspection, Rating, Repair, and Alteration of Piping Systems, 4th ed. American Petroleum Institute, 2016.
- [13] ***, API 574, Inspection Practices for Piping System Components, 4th ed., American Petroleum Institute, 2016..

KOROZIONA OTPORNOST 1.4713 VATROSTALNOG FERITNOG ČELIKA U 0.5M NITRATNOJ KISELINI

CORROSION RESISTANCE OF 1.4713 FERRITIC HEAT-RESISTANT STEEL IN 0.5M NITRIC ACID

Stevan P. DIMITRIJEVIĆ^{1*}, Dimitrije STEVANOVIĆ², Silvana B. DIMITRIJEVIĆ³,
Aleksandra IVANOVIĆ³, Zara CHERKEZOVA-ZHELEVA⁴, Željko KAMBEROVIĆ⁵

¹ Innovation Center of TMF Belgrade, University of Belgrade

² TEKON – Tehnokonsalting d.o.o. Belgrade

³ Mining and Metallurgy Institute Bor

⁴ Institute of Catalysis, Bulgarian Academy of Sciences, Sofia, Bulgaria

⁵ Faculty of Technology and Metallurgy, University of Belgrade

U ovom radu su predstavljena eksperimentalna istraživanja korozionog ponašanja i otpornosti feritnog (EN 1.4713/X10CrAlSi7) čelika u azotnoj kiselini koncentracije 0,50 mol·dm⁻³. Korozione karakteristike ovog čelika ispitane su sledećim elektrohemijskim metodama: potencijal otvorenog kola (POK), ekstrapolacija polarizacione krive u Tafelovom regionu i metoda linearnog polarizacionog otpora (LPO). Pored toga, korišćena je metoda gubitka mase (u trajanju od 10 dana) i upoređena je sa metodama polarizacije. Rezultati merenja pokazali su izvrsno međusobno slaganje elektrohemijskih metoda, sa razlikama u određenoj korozionoj struji u okviru ± 10%. Metoda gubitka mase pokazala je oko polovine vrednosti brzine korozije u odnosu na ove elektrohemijske metode. Iako izgleda kao značajna razlika, može se smatrati dobrim rezultatom, jer je to uobičajena razlika između ovih metoda; jer one određuju brzinu korozije u različito vreme izlaganja uzoraka u korozivnom okruženju. Opšti zaključak je da ispitivani nerđajući čelik otporan na visoke temperature ne pruža visoku otpornost na koroziju u 0,5M rastvoru azotne kiseline. Ovo istraživanje je izvedeno uzimajući u obzir procenu pogodnosti materijala za opremu za obnovljive izvore energije, poput baklji za odlagalište gasa (LGF) i dodatnu opremu tog sistema. Iako čelik 1.4713 ima dobre mehaničke i toplotne karakteristike, za upotrebu u takvim radnim uslovima potrebna je dodatna zaštita od korozije.

Ključne reči: feritni čelilk; nitratna kiselina; korozija; baklja deponijskog gasa.

Experimental research of corrosion behavior and resistance of ferritic (EN 1.4713/X10CrAlSi7) steel in nitric acid with the concentration of 0.50 mol·dm⁻³ is presented in this paper. The corrosion characteristics of the steel were tested using the following electrochemical methods: open circuit potential (OCP), extrapolation of the polarization curve in the Tafel region, and linear polarization resistance (LPR). Additionally, the weight-loss method (with a duration of 10 days) was used and compared with the polarization methods. The measurement results have shown excellent agreement between electrochemical methods with the differences in determining corrosion current within ±10%. Although it looks like a significant difference, it can be considered a good result since that is the usual difference between these methods because they determine the corrosion rates at different times of the samples exposal in corrosion environment. The general conclusion is that examined heat-resistant stainless steel does not provide high corrosion resistance in the 0.5M nitric acid. This research was performed considering assessing the suitability of the material for renewable energy equipment like landfill gas flares (LGF) and additional equipment for that system. Although the 1.4713 steel has good mechanical and thermal characteristics, it requires additional corrosion protection for use in such working conditions.

Key words: Ferritic steel; Nitric Acid; Corrosion; Landfill gas flare.

* Corresponding author's email: stevad@gmail.com

- [3] **Novalov A.A.**, Small spacecraft magnetic control system using fuzzy logic, modern problems of orientation and navigation of spacecraft, Space research institute, Tarusa, Russia, 2012.
- [4] **Koskov V.N., B.V. Koskov**, *Well logging and data interpretation*, Perm Technical University, Perm, Russia, 2007.
- [5] **Karasova E.A, A.V. Kornilov**, Methods for monitoring and backing up sensors of primary information of the attitude and navigation system of an aircraft, *Privolzhsky scientific bulletin*, 12-3 (2015), 52, pp. 36-41.
- [6] **Kovshov G.N., G. Yu. Kolovertnov**, Devices for monitoring the spatial orientation of wells while drilling, Gilem, Ufa, Russia, 2001.
- [7] **Ponomarova O.A., S.M. Ponomarov, I.V. Pyzhkov**, On the issue of constructing a mathematical model of the components of the orientation system based on gimbal frames, *Construction, materials science, mechanical engineering*, 101 (2017), pp. 178-183.



auma prodajni i servisni centar

ELEKTROMOTORNI POGONI ZA SVE VRSTE VENTILA

APIS CENTAR je prodajni i servisni centar **AUMA Grupa** za područje **Srbije, Hrvatske, Bosne i Hercegovine, Makedonije, Crne gore, Slovenije i Albanije.**

APIS usluge:

- tehnička podrška
- montaža i puštanje u rad
- rezervni delovi
- servis pogona u APIS servisnom centru
- servis pogona na postrojenju
- servis pogona u Eksplozivnim zonama
- održavanje i revizije
- automatizacija i modernizacija
- školovanje



AUMA Grupa je jedan od vodećih svetskih proizvođača elektromotornih pogona za sve vrste ventila, sa proizvodnjom u Nemačkoj.



AUMA Grupu čine brendovi **AUMA, SIPOS, DREHMO i HASELHOFER**, sve proizvođači elektromotornih pogona.

APIS CENTAR d.o.o. Srbija AUMA PRODAJNI I SERVISNI CENTAR

Ugrinovački put 41a, Zemun
11080 Beograd, Srbija
Tel.: +381 (0) 11 4075 730
Fax: +381 (0) 11 4075 731
Email: auma@apis-centar.com
www.apis-centar.com

APIS CENTAR d.o.o. BiH AUMA PRODAJNI I SERVISNI CENTAR

Ulica Hisata broj 15
70000 Sarajevo-Centar, BiH
Tel.: +385 (0) 1 6531 485
Fax: +385 (0) 1 6531 484
Email: auma@apis-centar.com
www.apis-centar.com

APIS CENTAR d.o.o. Hrvatska AUMA PRODAJNI I SERVISNI CENTAR

Novačka cesta 58, Rakitje
10437 Bestovje, Hrvatska
Tel.: +385 (0) 1 6531 485
Fax: +385 (0) 1 6531 484
Email: auma@apis-centar.com
www.apis-centar.com

auma[®]
Solutions for a world in motion

SIPOS
AKTORIK

DREHMO
VALVE ACTUATORS

70
1951-2021
SMEITS

