University of Banja Luka
Faculty of Mechanical Engineering

DEMI 2019

14th International Conference on Accomplishments in Mechanical and Industrial Engineering

PROCEEDINGS

Banja Luka, 24 - 25 May 2019

University of Banja Luka
Faculty of Mechanical Engineering

PROCEEDINGS

Banja Luka, May 2019

Print:
Comesgrafika, Banja Luka

Circulation:
200

ISBN: 978-99938-39-85-9

CIP - Каталогизација у публикацији
Народна и универзитетска библиотека
Републике Српске, Бања Лука

621(082)(0.034.2)
621.3(082)(0.034.2)
007(082)(0.034.2)

INTERNATIONAL conference on accomplishments in mechanical and industrial engineering (14 ; 2019 ; Banja Luka)
Proceedings [Електронски извор] / [14th international conference on accomplishments in mechanical and industrial engineering] ; [editor in chief Petar Gvero ; executive editor Biljana Prochaska]. - Banja Luka : Faculty of mechanical engineering, 2019 (Banja Luka : Comesgrafika). - 1 elekronski optički disk (CD-ROM) : tekst, slika ; 12 cm

Sistemski zahtjevi nisu navedeni. - Nasl. sa nasl ekrana. - Tiraž 200. - Bibliografija uz svaki rad.

ISBN 978-99938-39-85-9
COBISS.RS-ID 8146456

14TH INTERNATIONAL CONFERENCE ON ACCOMPLISHMENTS IN MECHANICAL AND INDUSTRIAL ENGINEERING

Supported by:
MINISTRY FOR SCIENTIFIC AND TECHNOLOGICAL DEVELOPMENT, HIGHER EDUCATION AND INFORMATION SOCIETY

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 PODGORICA,
UNIVERSITY OF MONTENEGRO, MONTENEGRO

FACULTY OF ENGINEERING OF HUNEDOARA
UNIVERSITY OF TIMISOARA, ROMANIA

For publisher:
Prof. Darko Knežević, PhD

Editor in chief:
Full Prof. Petar Gvero, PhD

Executive editor:
Biljana Prochaska, MSc

Editorial assistant:
Milivoj Stipanović

ORGANIZATIONAL COMMITTEE

Chairman:

Full Prof. Petar Gvero, PhD, Faculty of Mechanical Engineering Banja Luka

Secretary:

Biljana Prochaska, MSc, Faculty of Mechanical Engineering Banja Luka

Members:

Assoc. Prof. Dejan Mitrović, PhD, Niš, Serbia
Assoc. Prof. Uroš Karadžić, PhD, Podgorica, Montenegro
Assoc. Prof. Ludovic Dan Lemle, PhD, Hunedoara, Romania
Full Prof. Darko Knežević, PhD,
Assoc. Prof. Predrag Jankovic, PhD, Niš, Serbia
Full Prof. Zdravko Milovanović, PhD,
Full Prof. Aleksandar Milašinović, PhD,
Full Prof. Snežana Petković, PhD,
Full Prof. Dr Gordana Globočki Lakić, PhD,
Full Prof. Mihajlo Stojčić, PhD,
Full Prof. Mladen Todić, PhD,
Assoc. Prof. Tihomir Latinović, PhD,
Assoc. Prof. Zorana Tanasić, PhD,
Assoc. Prof. Valentina Golubović-Bugarski, PhD,
Assoc. Prof. Milan Tica, PhD,
Assoc. Prof. Dragoslav Dobraš, PhD,
Assoc. Prof. Stevo Borojević, PhD,
Assoc. Prof. Branislav Sredanović, PhD,
Assoc. Prof. Bojan Knežević, PhD,
Assoc. Prof. Milovan Kotur, PhD,
Sanja Maglov, MSc,
Saša Laloš, MSc,
Goran Jotić, MSc,
Milisav Marković, MSc,
Danijela Kardaš, MSc,
Mirko Bojinović,
Slavica Petrović,
Milivoj Stipanović,

PROGRAM AND SCIENTIFIC COMMITTEE

Chairman:

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

Members:

Prof. Radivoje Mitrović, PhD, Faculty of Mechanical Engineering, University of Belgrade

Prof. Nenad D. Pavlović, PhD, Faculty of Mechanical Engineering, University of Niš

Prof. Igor Vušanović, PhD, Faculty of Mechanical Engineering Podgorica, University of Montenegro

Prof. Izet Bjelonja, PhD, Faculty of Mechanical Engineering, University of Sarajevo

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

Prof. Friedrich-Karl Benra, PhD, University of Duisburg-Essen, Germany

Senior Researcher Alexsander Michailov, PhD, OAO NPO "Saturn", Russia

Assist. Prof. Alexander Remizov Evgenyevich, PhD, Rybinsk State Aviation Technical University, Russia

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

Prof. Saša Živanović, PhD, Faculty of Mechanical Engineering, University of Belgrade

Prof. Franci Pušavec, PhD, Faculty of Mechanical Engineering, University of Ljubljana

Prof. Dejan Lukić, PhD, Faculty of Technical Sciences, University of Novi Sad

Prof. Mijodrag Milošević, PhD, Faculty of Technical Sciences, University of Novi Sad

Prof. Miodrag Manić, PhD, Faculty of Mechanical Engineering, University of Niš

Prof. Mileta Janjić, PhD, Faculty of Mechanical Engineering Podgorica, University of Montenegro

Prof. Gordana Globočki-Lakić, PhD, Faculty of Mechanical Engineering, University of Banja Luka

Prof. Simo Jokanović, PhD, Faculty of Mechanical Engineering, University of Banja Luka

Prof. Ardelean Erika, PhD, University Politehnica Timisoara

Prof. Panoiu Manuela, PhD, University Politehnica Timisoara

Prof. Muscalagiu Ionel, PhD, University Politehnica Timisoara

Prof. Slobodan Lubura, PhD, Faculty of Electrical Engineering, University of East Sarajevo

Prof. Sanda Midžić-Kurtagić, PhD, Faculty of Mechanical Engineering, University of Sarajevo

CONTENT

KEYNOTE LECTURES

Vencislav Grabulov
LOADING RATE EFFECT ON FRACTURE RESISTANCE OF ARMOUR STEELS WELDMENTS 3

Slavko Krajcar
THE FUTURE OF POWER SYSTEM 11

PRODUCTION AND COMPUTER-AIDED TECHNOLOGIES

Zivanovic Sasa, Dimic Zoran, Vorkapic Nikola, Mitrovic Stefan
CONFIGURING OF 3 AXIS MINI CNC MACHINE TOOL WITH CONTROL SYSTEM BASED ON LINUXCNC 15

Hasan Smajic, Faruk Bağcı
MODELLING AND DESIGN OF DISTRIBUTED CONTROL SYSTEM BASED ON INDUSTRIAL SOFTWARE AGENT 29

Milija Kraišnik, Jovica Ilić, Goran Jotić, Tihomir Mačkić, Jelica Anić
COMPARING THE ACCURACY OF MASTER MODEL AND THEIR REPLICAS PRODUCED BY RAPID TOOLING USING VACUUM CASTING 37

Aleksandar Živković, Miloš Knežev, Milan Zeljković, Milivoje Mijušković
STATIC ANALYSIS OF FOUR-POINT CONTACT BALL BEARINGS FOR AGRICULTURAL MECHANIZATION 43

Andjelko Aleksic, Milenko Sekulic, Borislav Savkovic, Marin Gostimirovic, Ilija Kamenko, Pavel Kovac
OPTIMIZATION OF CUTTING PARAMETERS BY NATURE-INSPIRED ALGORITHMS 51

Slobodan Tabaković, Milan Zeljković
PREDICTION OF POSITIONING ACCURACY PARAMETERS 57

Dušan Petković, Miloš Madić, Goran Radenković, Predrag Živković
AN EXAMPLE OF MCDM SOLVER APPLICATION FOR MATERIAL SELECTION PROBLEMS 65

Adnan Mustafić, Mirza Krajnović, Džemal Kovačević, Edis Nasić, Jasmin Halilović
SELECTION OF OPTIMAL PROCESSING CONDITION DURING HELICAL COMPRESSION SPRING PRODUCTION USING THE GREY BASED TAGUCHI METHOD 71

Ostoja Miletić, Mladen Todić
THE EFFECT OF CONTACT SURFACES ON ENERGY PARAMETERS OF PROCESS PROFILING 81

Mladen Todic, Ostoja Miletic, Sead Pašalić
ZONE OF THE STRESS AND OF THE STRAINS WHEN BENDING LAMINARY COMPOSITES 89

Dejan Lukić, Mijodrag Milošević, Mića Đurđev, Jovan Vukman, Ivan Kuric, Aco Antić
APPLICATION OF THE MULTI-CRITERIA DECISION MAKING IN THE PRODUCT DEVELOPMENT PROCESS 97

Dragan Lazarević, Bogdan Nedić, Živče Šarkoćević, Ivica Čamagić, Jasmina Dedić
METHODS OF INTEGRATING MODERN MEASURING DEVICES ON MACHINING SISTEMS 105

Mladomir Milutinović, Tomaž Pepelnjak, Dejan Movrin, Plavka Skakun, Marko Vilotić, Saša Ranđelović
EFFECTS OF MATERIAL PROPERTIES AND BLANK HOLDER PRESSURE ON FORMING LOAD IN DEEP DRAWING OF BOX LIKE COMPONENTS 113

Srbislav Aleksandrovic, Djordje Milosavljevic
ACCURACY OF PURE COPPER FLOW CURVES DETERMINATION IN COMPRESSION TESTS 119

Saša Ranđelović, Mladomir Milutinović, Dejan Tanikić, Vladisalv Blagojević
THE TECHNOLOGY OF TUBE HYDROFORMING AND PARAMETERS PROCESS 125

Cica Djordje, Tesic Sasa, Sredanovic Branislav, Borojevic Stevo
INVESTIGATION OF THE EFFECTS OF THE CUTTER PATH STRATEGIES ON MACHINING TIME AND SURFACE ROUGHNESS IN THREE-AXIS SCULPTURED SURFACE MACHINING 131

Zdravko Bijelić, Jelena Petrović, Biljana Milanović
RESEARCH OF THE POSSIBILITY AND LIMITATION OF THE REVITALIZATION OF THE PRODUCTION OF WEAPONS AND MILITARY EQUIPMENT IN THE REPUBLIC OF SRPSKA 139

Hasan Smajic, Jean Bosco, Fraz Ahmad
SIMULATION TOOLS FOR VIRTUAL PLC-TESTING IN EXTRUSION PROCESS 145

Clemens Faller, Tobias Theis, Max Born, Ferdinand Heinemann, Stefan Bäunker, Philipp Stenkamp
CONTROL-SYSTEM-ALGORITHM IMPLEMENTED WITH NODE-RED AND OPC-UA 153

ENERGETICS AND THERMAL ENGINEERING

Nebojša Manić, Bojan Janković, Dragoslava Stojiljkovića, Vladimir Jovanovića, Miloš Radojević, Blanca Castells Somoza
EVALUATION OF SPONTANEOUS IGNITION POTENTIAL FOR SOLID BIOMASS THROUGH THERMAL ANALYSIS 163

Igor Shesho, Martina Blazheska, Nebojsha Vasikj, Done Tashevski, Filip Mojosvski
PERFORMANCE EVALUATION OF MICRO ORC SYSTEMS FOR POWER GENERATION IN NEARLY ZERO ENERGY BUILDINGS (NZEB) 173

Miodrag Arsić, Srđan Bošnjak, Vencislav Grabulov, Dušan Arsić, Zoran Savić
PREDICTION OF SERVICE LIFE OF COMPONENTS AND STRUCTURES OF HYDRO POWER PLANTS DURING THE DESIGN, PROTOTYPING AND SERVICE PERIOD 183

Sanda Midžić Kurtagić, Samra Arnaut, Šejla Mahmutović
ANALYSIS OF POSSIBILITIES FOR EXPANDING DISTRICT HEATING SYSTEM TO INDIVIDUAL HOUSES IN CANTON SARAJEVO 189

Radislav Brđanin, Jovan Ilić, Uroš Karadžić, Anton Bergant
EXPERIMENTAL WATER HAMMER SETUP AT UNIVERSITY OF MONTENEGRO – DESCRIPTION AND POSSIBILITIES 195

Kire Popovski, Sevde Stavreva, Ivo Kuzmanov, Igor Popovski
MATHEMATICAL MODEL FOR COMPUTER SIMULATION FOR SELECTION OF THE ORDER FOR THE LAYERS FROM THE WALL OF INDUSTRIAL COOLERS 201

Aleksandar Nešović, Vanja Šušteršič, Nebojša Lukić, Novak Nikolić, Ivana Terzić
OPTIMIZATION OF THE FREE FACADE OF THE EARTH-SHELTERED HOUSES IN ORDER TO MINIMIZE THE FINAL ENERGY CONSUMPTION DURING THE HEATING SEASON 209

Jovan Ilić, Ivan Božić, Uroš Karadžić, Radislav Brđanin
COMPARATIVE ANALYSIS OF THE HYDROPOWER PLANT TRANSIENT PROCESSES FOR VARIOUS SURGE TANK TYPES AND IMPROVED GUIDE VANES CLOSING LAW 215

Ivana Terzic, Danijela Nikolic, Vanja Sustersic, Jasmina Skerlic, Vladimir Vukasinovic
PHOTOVOLTAIC THERMAL SYSTEMS – DESIGN AND BUILDING APPLICATION 223

Jasmina Bogdanović-Jovanović, Živojin Stamenković, Živan Spasić, Miloš Kocić, Jelena Petrović
CALCULATION OF MERIDIAN STREAMLINES FOR AVERAGED FLOW PARAMETERS IN LOW PRESSURE AXIAL FANS 229

Vladimir Mijakovski, Filip Mojsovski, Monika Lutovska
ANALYSIS OF VALUES FROM THE CLIMATIC CURVE AND HEAT LOAD ON THE WATER LOSSES IN TPP 'BITOLA' 235

Natalija Aleksić, Vanja Šušteršič, Dušan Gordić, Danijela Nikolić, Nikola Rakić
REDUCTION OF WATER CONSUMPTION IN WASTE WATER TREATMENT SYSTEMS IN THE AUTOMOTIVE INDUSTRY 241

Filip Mojsovski, Vladimir Mijakovski
THERMAL CAPABILITY OF HYPERBOLIC COOLING TOWER 247

Sanda Midžic Kurtagić, Šejla Mahmutović, Melina Džajić Valjevac
ENERGY RECOVERY POTENTIAL OF WASTE FROM CANTON SARAJEVO 255

Viktor Iliev, Marija Lazarevikj, Zoran Markov
ANALYSIS OF THE PRESSURE DISTRUBUTION AROUND NACA 0015 AIRFOIL IN OPEN WIND TUNNEL 261

Velimir Stefanović, Bojan Drobnjaković, Sasa Pavlović
TECHNICAL PERFORMANCE OF A DEEP BOREHOLES HEAT EXCHANGERS 267

Svetlana Dumonjić-Milovanović, Petar Gvero
DYNAMIC THERMAL CHARACTERISTICS OF COMPOSITE BUILDING ELEMENTS AND THEIR IMPACT ON THE DECREASE OF INTERNAL TEMPERATURE IN CONDITIONS OF THE HEATING INTERRUPTION 273

Danijela Kardaš, Petar Gvero, Mirko Komatina, Gordana Tica
COMPARATIVE ANALYSIS OF WASTEWATER AND SOLAR ENERGY AS RENEWABLE ENERGY SOURCES 279

Dragana D. Temeljkovski, Milena B. Blagojević, Bratislav D. Blagojević, Marko G. Ignjatović
RESIDENTIAL BUILDINGS REFURBISHMENT TOWARD NZEB IN SERBIA 287

Vidosava Vilotijević, Uroš Karadžić, Ivan Božić, Jovan Ilić
DESIGN DISCHARGE DETERMINATION FOR SHPPs WITH CAPACITY BELOW 1 MW 297

Sanda Midžić Kurtagić, Petar Gvero, Milovan Kotur, Fejsal Ćorović
TOWARDS ENERGY EFFICIENCY IN BUILDINGS –A STRATEGIC APPROACH TO BUILDING RENOVATION IN BOSNIA AND HERZEGOVINA 303

Predrag Živković, Mladen Tomić, Dragana Dimitrijević Jovanović, Dušan Petković, Jelena Janevski, Mirko Dobrnjac
EXPERIMENTAL STUDY RAYLEIGH-BÉNARD CONVECTION IN A RECTANGULAR ALCOHOL TANK 309

Marko Đekić, Esad Tombarević, Igor Vušanović
LONG TERM PERFORMANCE OF BUILDING WITH VERTICAL GROUND COUPLED HEAT PUMP SYSTEM 317

Marko Ilić, Velimir Stefanović, Gradimir Ilić
PRELIMINARY COMPUTATIONAL ANALYSIS OF A BIOMASS DRIVEN STOVE FOR ABSORPTION HEAT PUMP 323

Branislav Stojanović, Jelena Janevski, Milica Ljubenović, Marko Ignjatović, Dejan Mitrović
SPACE HEATING ENERGY SAVINGS IN RESIDENTIAL BUILDINGS WITH VARIABLE OCCUPANCY 329

Veljko Begović, Živan Spasić, Saša Milanović
ANALYSIS AND DETERMINATION OF THE PERFORMANCE OF CENTRIFUGAL PUMP USING NUMERICAL SIMULATIONS 335

Živan Spasić, Miloš Jovanović, Jasmina Bogdanović-Jovanović, Veljko Begović, Miloš Kocić
EFFECTS OF THE IMPELLER REDUCTION ON A CENTRIFUGAL PUMP PERFORMANCE 341

Damijan Cerinski, Jakov Baleta, Martina Lovrenić-Jugović
UTILIZING A NEURAL NETWORK MODELLING APPROACH IN THE FIXED BED BIOMASS GASIFIER 347

Katarina Jovanović, Jovan Milić, Mirjana Laković
FURNITURE PRODUCTION AND WASTE BIOMASS – POSSIBILITIES FOR THE USE OF WASTE BIOMASS 353

MECHANICS AND DESIGN

Milicevic Jovana, Djordjevic Zorica, Kostic Sonja, Jovanovic Sasa
MODELING AND STRUCTURAL ANALYSIS OF SCOOTER'S PARTS MADE OF COMPOSITE MATERIALS 361

Srđan Bulatović, Živče Šarkoćević, Mladen Mladenović
MECHANICAL PROPERTIES OF WELDED PIPES PRODUCED BY HIGH FREQUENCY WELDING OF THE STEEL API J55 367

Nedeljko Vukojević, Josip Kačmarčik, Alma Žiga, Nedeljko Babić, Nemanja Tanasijević
DESIGN OF STIFFENERS FOR INDUSTRIAL PIPING UNDER EXTERNAL PRESSURE USING FEM 373

Nadica Stojanovic, Oday I. Abdullah, Ivan Grujic, Jasna Glisovic, Sasa Vasiljevic
STUDY THE EFFECT OF VANES SHAPE ON THE CONVECTIVE COOLING OF THE VENTILATED BRAKE DISC 379

Tihomir Mačkić, Goran Jotić, Milan Tica, Jovica Ilić
MECHANICAL PROPERTIES OF MODIFIED FLIPWING HYDROKINETIC TURBINES 385

Vlada Gašić, Aleksandra Arsić, Milorad Pantelić, Dejan Kočović
CONSIDERATION OF STRUCTURAL ELEMENTS CHARACTERISTICS ON THE STRESSES AT THE I-BEAM END-PLATE MOMENT CONNECTION 391

Aleksandar Radaković, Dragan Milosavljević, Gordana Bogdanović, Milivoje Milanović, Dragan Čukanović
APPLICATION OF ANALYTICAL METHODS IN BENDING ANALYSIS OF CROSS PLY SYMMETRIC LAMINATES 397

Stevan Maksimović, Katarina Maksimović, Ivana Vasović, Mirko Maksimović, Dragi Stamenković
STRENGTH ANALYSIS OF HELICOPTER MAIN ROTOR BLADE MADE FROM COMPOSITE MATERIALS 403

Nenad Miloradovic, Rodoljub Vujanac
DESIGN OF TOWER CRANE BASED ON CONSTRUCTION SITE LAYOUT PLANNING 409

Nenad Petrović, Nenad Kostić, Nenad Marjanović, Mirko Blagojević, Miloš Matejić
INFLUENCE OF BUCKLING CONSTRAINTS ON TRUSS STRUCTURAL OPTIMIZATION 415

Slobodanka Boljanović, Stevan Maksimović, Strain Posavljak
ANALYSIS OF TWO SYMMETRIC CRACKS AT A HOLE UNDER CYCLIC LOADING 423

Dragan Čukanović, Gordana Bogdanović, Aleksandar Radaković, Milivoje Milanović
DYNAMIC ANALYSIS OF FUNCTIONALLY GRADED PLATE USING HIGHER ORDER SHEAR DEFORMATION THEORY 429

Ivan Grujic, Nadica Stojanovic, Oday I. Abdullah, Radivoje Pesic, Jovan Doric, Sasa Vasiljevic
VERIFICATION OF NUMERICAL ANALYSIS FOR THE WORKING CYCLE OF AN IC ENGINE BASED ON THE EXPERIMENTAL DATA 433

MECHATRONICS

Pavle Stepanić, Živko Murar, Aleksa Krošnjar
RETROFITTING A CONVENTIONAL HORIZONTAL MILLING MACHINE TO CNC MACHINE TOOL 441

Vladislav Blagojević, Saša Ranđelović, Predrag Janković
TYPES OF ENERGY EFFICIENT CONTROL OF PNEUMATIC ACTUATOR SYSTEM 447

AUTOMOTIVE AND TRANSPORTATION ENGINEERING

Jovanka Lukić, Slavica Mačužić
SEATED HUMAN BODY RESPONSES TO DUAL-AXIS VIBRATION 455

Radoje Vujadinovic, Sreten Simovic, Milanko Damjanovic
OVERVIEW OF INCENTIVES AND POLICIES FOR ELECTRIC VEHICLES IN THE EUROPEAN COUNTRIES 461

Slobodan Mišanović, Dragan Taranović, Jovica Vasiljević, Nenad Novaković
TECHNICAL AND ECONOMIC ASPECTS OF THE TEST DRIVE IVECO CNG BUS IN BELGRADE, COMPARED TO DIESEL BUS AND E-BUS 471

Zlatko V. Sovreski, Zoran Joševski, Elizabeta Hristovska, Vangelica Jovanovska, Feta Sinani
APPLICATION OF PASSIVE SAFETY SYSTEMS IN PASSENGER MOTOR VEHICLES – CASE STUDY R.N MACEDONIA 479

Saša Milojević, Radivoje Pešić, Dragan Taranović, Aleksandar Davinić
POWER MEASUREMENT OF MECHANICAL LOSSES IN EXPERIMENTAL RECIPROCATING AIR COMPRESSOR IMPACT OF PISTON GROUP 485

Milanko Damjanović, Sreten Simović, Radoje Vujadinović
IMPACT OF CURRENT CHANGES OF TORQUE AND EXTERNAL RESISTANCES ON VALUE OF A CARDAN SHAFT LOAD IN MOTOR VEHICLES 491

Aleksandar Stanković, Danijel Marković, Goran Petrović, Žarko Ćojbašić
A SIMULATED ANNEALING AND PARTICLE SWARM OPTIMIZATION FOR THE VEHICLE ROUTING PROBLEM AND COMMUNAL WASTE COLLECTION IN URBAN AREAS 497

Tijana Ivanisevic, Jasna Glisovic, Dragan Taranovic, Sreten Simovic
AN ANALYSIS OF BRAKING COEFFICIENT AND DIFFERENCE IN BRAKING FORCE OF DIFFERENT CATEGORIES OF VEHICLES INVOLVED IN TRAFFIC ACCIDENTS 507

Vojislav Krstić, Božidar Krstić
HAZARDS IN THE OPERATION OF INTERVENTION UNITS IN CASE OF TRAFFIC ACCIDENTS (EXTERNAL SITUATIONS) WITH HAZARDOUS MATERIALS 515

Vojislav Krstić, Božidar Krstić
PLACE AND ROLE OF INTERVENTIONAL TEAMS IN TRAFFIC INCREASES (IN EXTERNAL SITUATIONS) IN TRANSPORT OF DANGEROUS MATERIALS 527

QUALITY AND ECOLOGY

Milan Ivanović, Miroslav Bobrek
FROM QUALITY MANAGEMENT TO CORPORATE MANAGEMENT QUALITY 537

Branko Štrbac, Miodrag Hadžistević, Biserka Runje, Amalija Horvatić Novak, Ivan Matin, Goran Jotić
THE ANALYSIS OF THE ACCURACY AND EVALUATION MEASUREMENT UNCERTAINTY OF CMM USING BALL BAR 545

Goran Janjić, Vladan Račić, Zorana Tanasić, Danijela Kardaš, Dušica Pešević
THE SIMULATION OF ENERGY PROCESSES IN PUBLIC TRANSPORTATION AND ITS IMPACT ON THE ENVIRONMENT 553

Stefan Đurić, Bogdan Nedić, Slobodan Malbašić, Jelena Baralić
APPLICATION OF NEW TECHNOLOGIES FOR DEMILITARIZATION ORDNANCE IN ORDER TO PROTECT ENVIRONMENT 561

Miroslav Bobrek, Zorana Tanasić, Goran Janjić
SYSTEMS ENGINEERING METHODOLOGIES FOR STUDY PROGRAM DEVELOPMENT 567

Milica Ivanović, Gordana Stefanović, Biljana Milutinović, Sandra Stanković, Ana Momčilović
COMPOSTING AS A WAY OF UTILIZATION OF AGRICULTURAL ORGANIC WASTE 573

Nikola Petrović, Bojan Krstić, Jelena Petrović
EVALUATION OF FREIGHT TRANSPORT MODES BASED ON EXTERNAL COSTS 579

Jasna Glišović, Radivoje Pešić, Saša Vasiljević, Nadica Stojanović, Ivan Grujić
ROAD VEHICLE AS A SOURCE OF NON-EXHAUST PARTICULATE MATTER 585

Biljana Milutinović, Petar S. Djekić
CONTRIBUTION OF LEAN PRODUCTION TO ENVIRONMENTAL PROTECTION IMPROVEMENT 591

Zorana Tanasić, Saša Petrović, Goran Janjić, Borut Kosec
APPLICATION OF LEAN CONCEPT IN THE ELAS METALEXPERT COMPANY 597

Gordana Stefanović, Biljana Milutinović, Ana Momčilović, Milica Ivanović
ESTIMATION OF ROW MATERIAL POTENTIAL IN LANDFILL MINING 603

Pedja Milosavljević, Dragoljub Živković, Marina Spasov, Milena Rajić, Dragan Pavlović
LEAN GREEN MANAGEMENT APPLICATION IN A RECYCLING COMPANY 609

Goran Jotić, Saša Tešić, Čiča Đorđe, Simo Jokanović
QUALITY INSPECTION OF FREE-FORM SURFACE PARTS 623

MAINTENANCE OF ENGINEERING SYSTEMS AND OCCUPATIONAL SAFETY ENGINEERING

Biljana Vranješ, Mile Vajkić, Branko Lazić, Mladen Todić
INJURIES TREND AS AN INDICATOR OF OCCUPATIONAL SAFETY AND HEALTH 631

Nikola Trbojević, Ivana Ribarić, Biljana Vranješ
REDUCTION OF HAZARD LEVELS ON CNC MACHINES 641

Mitar T. Jocanović, Velibor V. Karanović, Marko D. Orošnjak, Dejan O. Lukić, Miodrag Hadžistević
PROTECT WORKERS IN THE WORKING ENVIRONMENT OF THE SAW BLADE 651

Dejan Brankovic, Zdravko N. Milovanovic
MAINTENANCE INFORMATION SYSTEMS IN INDUSTRIAL PRACTICE 657

Aleksandar Majstorović, Mladen Todić
DISTRIBUTION OF TENSION IN BOTTLES OF BREATHING APPARATUS DURING NORMAL AND FAST EXPANSION OF COMPRESSED MEDICAL AIR 663

MATERIALS SCIENCE

Blaž Karpe, Mateja Vodlan, Igor Kopač, Igor Budak, Milana Ilić Mićunović, Alenka Pavlič, Tatjana Puškar, Aleš Nagode, Zorana Tanasić, Milan Bizjak, Borut Kosec
MEASUREMENT OF THERMAL PROPERTIES OF TITANIUM ALLOYS USED IN DENTAL MEDICINE 673

Milena Ćosić, Slobodanka Boljanović
CHARACTERIZATION OF THE STRUCTURAL CHANGES OF Al18SiCuMg ALLOY DURING THE RHEOCASTING PROCESS 679

Marko Pavlović, Marina Dojčinović, Radica Prokić-Cvetković, Ljubiša Andrić
APPLICATION OF GLASS-CERAMICS BASED ON BASALT FOR THE PRODUCTION OF PARTS OF EQUIPMENT IN METALLURGY 687

Belma Fakić, Diana Ćubela, Adisa Burić, Edib Horoz
REGRESSION ANALYSIS OF TENSILE STRENGTH TESTING RESULTS AT STEEL 17-7PH WITH MODIFIED CHEMICAL COMPOSITION 691

Petar S. Djekic, Biljana Milutinovic
STUDY OF APPLICATION OF WASTE GLASS POWDER IN VIRGIN RUBBER BLENDS 699

University of Banja Luka
Faculty of Mechanical Engineering
DEMI 2019
Banja Luka, 24 - 25 May 2019
14th International Conference on Accomplishments in Mechanical and Industrial Engineering

OPTIMIZATION OF THE FREE FACADE OF THE EARTH-SHELTERED HOUSES IN ORDER TO MINIMIZE THE FINAL ENERGY CONSUMPTION DURING THE HEATING SEASON

Aleksandar Nešović[1], Vanja Šušteršič[2], Nebojša Lukić[3], Novak Nikolić[4], Ivana Terzić[5]

Summary: *The use of earth-sheltered houses in the building industry on the territory of Serbia is very modest, even though such facilities have excellent energy performance and a positive impact on the environment. Earth-sheltered houses could also be a good solution to the problem of building density in urban environments where the field configuration allows their application. In this paper, using the Energy Plus software, an earth-sheltered house in the territory of Kragujevac was analyzed from the aspect of final energy consumption for its heating during the heating season, whereby a geothermal heat pump in combination with floor panels was used as the active heating system. At the same time, in order to minimize the final energy consumption for heating, it was also analyzed how the dimensions and layers of transparent elements (windows) affect the production of electricity if the non-transparent surface of the free (southern) facade of the earth-sheltered house were completely covered by PV panels.*
The results showed that the final energy consumption for the heating of the given earth-sheltered house can be reduced from 19.36 to 4.61 kWh/m^2/a.
Key words: earth-sheltered house, geothermal heat pump, free facade, PV panels, transparent elements, Energy Plus.

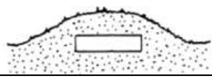
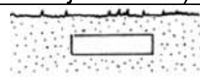
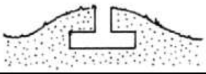
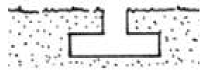
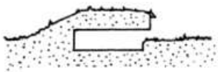
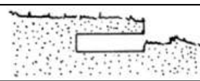
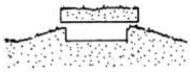
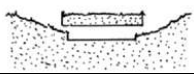
1. INTRODUCTION

Earth-sheltered houses can be defined as buildings that are covered by earth from one or more sides. A more precise definition is that they are buildings with at least 50% of its thermal coating in direct contact with earth [1]. Typically, all earth-sheltered

[1] RT, Aleksandar Nešović, University of Kragujevac, Faculty of Engineering, Department for Energy and Process Engineering, Sestre Janjić 6, 34000 Kragujevac, Serbia, aca.nesovic@gmail.com.
[2] Ph. D., Vanja Šušteršič, University of Kragujevac, Faculty of Engineering, Department for Energy and Process Engineering, Sestre Janjić 6, 34000 Kragujevac, Serbia, vanjas@kg.ac.rs.
[3] Ph. D., Nebojša Lukuć, University of Kragujevac, Faculty of Engineering, Department for Energy and Process Engineering, Sestre Janjić 6, 34000 Kragujevac, Serbia, lukic@kg.ac.rs.
[4] Ph. D., Novak Nikolić, University of Kragujevac, Faculty of Engineering, Department for Energy and Process Engineering, Sestre Janjić 6, 34000 Kragujevac, Serbia, novak.nikolic@kg.ac.rs.
[5] RT, Ivana Terzić, University of Kragujevac, Faculty of Engineering, Department for Energy and Process Engineering, Sestre Janjić 6, 34000 Kragujevac, Serbia, ivana.aa.terzic@gmail.com.

houses can be classified into the following two groups (Table 1).

Table 1 *Types of earth-sheltered houses* [2-4]

Type	Artificial (Terrain configuration is adapted)	Natural (Natural terrain configuration with minimal adjustments)
Buried		
Open		
Elevational		
Infiltrate		

Today, earth-sheltered houses are used for several other reasons [2-3, 5-9]: the need for thermal energy in winter and cooling energy is reduced, the greenhouse gas emissions are reduced, they have a favorable impact on the construction density in urban areas, thermal islands in urban areas are avoided, pollution of water and soil is regulated, the noise level is reduced. It is known that the final energy consumption for heating earth-sheltered houses during the heating season can be further reduced by exposing the southern (northern hemisphere) or the northern (southern hemisphere) facade to the outside. This effect can be further enhanced if the proportion of transparent to non-transparent surfaces on said facades is increased.

However, if the non-transparent part of the facade were completely covered by PV panels, an increase in the surface of transparent elements would reduce the area for collecting solar energy, resulting in lower electricity production. Due to all of the above, an estimate was carried out in this paper in order to determine the optimum ratio of transparent to non-transparent surfaces on the free (southern) facade of an elevational earth-sheltered house in a field with a natural decline, with the aim of reducing the final energy consumption for heating during the heating season. The non-transparent surface is taken to be completely covered with PV panels. The earth-sheltered house is located on the territory of the city of Kragujevac, Serbia. The research was conducted in the Energy Plus program. The effect of the window glazing on the mentioned effect is also considered.

2. SUBJECT OF STUDY

2.1 LOCATION

The city of Kragujevac is located in Central Serbia, about a hundred kilometers south of Belgrade (44°22' N and 20°56' E). It was built on the banks of the Lepenica river, in the basin between the final branches of the Rudnik, Crni Vrh and Gledicke mountains, at an altitude of 209 m. This area is characterized by moderate continental climate with pronounced seasons [10].

2.2 HOUSE DESCRIPTION

The subject of the research is an elevational earth-sheltered house in a field with a natural decline (Fig. 1), intended for permanent stay of a four-member family.

Fig. 1 *Isometric view*

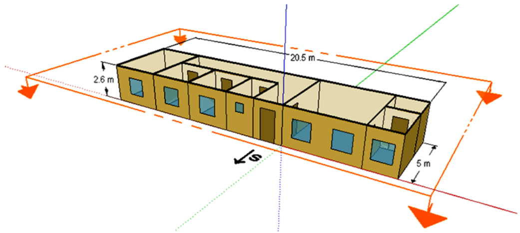


Fig. 2 Room arrangement

As you can see from the attached image, the free facade (where the entrance door is located) is oriented towards the south. The net area of the house is 102.5 m^2. The room arrangement is given in Fig. 2. A description of the building elements constituting the thermal coating is shown in Table 2.

Table 2 *Building physics*

Building element		A [m^2]	U [W/m^2K]
South facade	Wall	44.95	0.295
	Window	6.25	5.855
	Exterior door	2.1	4
North facade		53.3	0.298
East facade		13	
West facade		13	
Floor		102.5	0.235
Roof		102.5	0.312

2.3 GSHP

In order to provide thermal comfort during the heating season, a REHAU GEO 7 [11] heat pump was used, which is coupled with vertical probes (primary heating circuit) on one side, and on the other with underfloor heating (secondary heating circuit).

2.4 PV panels

The surface occupied by the PV panels represents the complete non-transparent surface of the southern facade. Active solar cells occupy 70% of this area. The efficiency of the solar cells is 12%, and the efficiency of the inverter is 75% [12].

3. SIMULATION SCENARIOS

Changing the dimensions and layers of the windows on the free (southern) facade significantly affects the solar gain (on the one hand), but also the production of electricity from the PV panels (on the other hand), under the condition that the non-transparent part of the southern facade is completely covered with PV panels.

In order to find the optimum ratio of transparent to non-transparent surfaces on the southern facade, with the goal of minimizing the final (electric) energy consumption for heating the house during the heating season, 5 simulation scenarios for 3 types of window layers were carried out: single-glazed (U_{SG}=5.855 W/m^{2}K) double-glazed (U_{DG}=2.514 W/m^{2}K) and triple-glazed windows (U_{TG}=1.565 W/m^{2}K).

Each scenario corresponds to certain dimensions of the windows (Table 3), which directly affect the surface of the facade on which the PV panels are placed (Table 4).

Table 3 *Number and dimensions of the windows by zones*

Zone	BD1	BD2	BD3	K	LR	BA
Number of windows		1			2	1
a × b [m × m]	Scenario 1	1×1				0.5×0.5
	Scenario 2	1.2×1.2				0.6×0.6
	Scenario 3	1.4×1.4				0.7×0.7
	Scenario 4	1.6×1.6				0.8×0.8
	Scenario 5	1.8×1.8				0.9×0.9

Table 4 *Non-transparent surface of the free (south) facade depending on the window surface*

A [m^2]	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
A_{SF}	53.3				
A_W	8.35	11.1	14.35	18.1	22.35
A_D	2.1				
A_{NT}	44.95	42.2	38.95	35.2	30.95

4. RESEARCH RESULTS

After conducting the simulations, the following conclusions were drawn: if the windows on the southern facade were single-glazed (Fig 4), the final (electric) energy consumption for each examined scenario is: 19.358 kWh/m^2/a (Scenario 1), 19.142 kWh/m^2/a (Scenario 2), 19.041 kWh/m^2/a (Scenario 3), 19.035 kWh/m^2/a (Scenario 4) and 19.144 kWh/m^2/a (Scenario 5). Electricity production from the PV panels for the mentioned cases is: 12.066 kWh/m^2/a (Scenario 1), 11.328 kWh/m^2/a (Scenario 2), 10.455 kWh/m^2/a (Scenario 3), 9.448 kWh/m^2/a (Scenario 4) and 8.308 kWh/m^2/a (Scenario 5). Based on the obtained results, it can be concluded that the best results are achieved in case of single-glazed windows (7.292 kWh/m^2/a), and they are realized when the windows on the southern facade are placed with dimensions corresponding to the first case (Scenario 1).

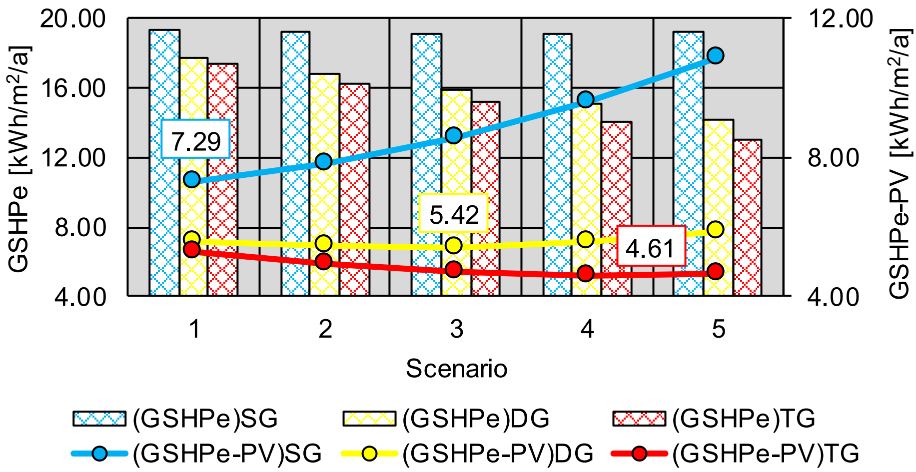


Fig. 3 *Scheme of the heating system*

In the case of double-glazed windows (Fig. 4), the final (electric) energy consumption for starting the GSHPe compressor decreases as the surface of the transparent elements increases. The highest consumption is in the first case, 17.668 kWh/m^2/a (Scenario 1), while the smallest is in the last one (Scenario 5), 14.185 kWh/m^2/a. However, the amount of electricity produced by the PV panels has the opposite behaviour, being the highest in the first case (12.066 kWh/m^2/a), and the smallest in the last case (8.308 kWh/m^2/a).

Considering all of the above, the best results are achieved when windows with dimensions according to Scenario 3 are placed, since the power consumption can then be reduced to 5.419 kWh/m^2/a.

Triple-glazed windows give the best results (Fig. 4). The electricity consumption in Scenario 1 is smaller than in the same scenarios in case of using single-glayed or double-glazed windows. Savings of 0.339 kWh/m^2/a are achieved in comparison to double-glazed windows, while savings of 2.029 kWh/m^2/a are achieved in comparison to single-glazed windows. In this case (as with double-glazed windows), an increase in the surface of transparent elements is accompanied by lower final energy consumption, but also by lower electricity production from the PV panels. When all is taken into account, the best results are obtained in Scenario 4 (4.612 kWh/m^2/a).

5. CONCLUSION

In the case of single-glazed windows, the best results (7.292 kWh/m^2/a) are achieved when windows with dimensions corresponding to the first case (Scenario 1) are placed on the southern facade. In the case of double-glazed windows, the best results (5.419 kWh/m^2/a) are achieved when windows with dimensions corresponding to the third case (Scenario 3) are placed on the southern facade. In the case of triple-glazed windows, the best results (4.612 kWh/m^2/a) are achieved when windows with dimensions corresponding to the fourth case (Scenario 4) are placed on the southern facade.

ACKNOWLEDGEMENTS

This investigation is a part of the project TR 33015 of the Technological Development of the Republic of Serbia and project III 42006 of Integral and Interdisciplinary investigations of the Republic of Serbia. We would like to thank the Ministry of Education, Science and Technological Development of the Republic of Serbia for their financial support during this investigation.

REFERENCES

[1] Earth-Sheltered Houses, Technical Series 94-220, from ftp://ftp.cmhc-schl.gc.ca/cmhc/94_220.html, accessed on 2019-02-27.
[2] Milanović, A. R. (2016). Development of underground residential buildings and their modern application in Serbia, Ph. D. thesis, University of Novi Sad, Faculty of Technical Sciences, RS.
[3] Alkaff, S. A., Sim, S. C., Efzan, M. N. E. (2016). A review of underground building towards thermal energy efficiency and sustainable development - Renewable and Sustainable Energy Reviews, vol. 60, no. 0, p. 692-713.
[4] Hassan, H., Sumiyoshi, D. (2018). Earth-sheltered buildings in hot-arid climates: Design guidelines - Beni-Suef University Journal of Basic and Applied Sciences, vol. 55, no. 4, p. 397-406.
[5] Wendt, R. L. (1982). Earth-Sheltered Housing: An Evaluation of Energy-Conservation Potential, Department of energy, OAK Ridge National Laboratory.
[6] Staniec, M, Nowak, H. (2009). Analysis of the energy performance of earth-sheltered houses with southern elevation exposed, IBPSA 2009 Conference Proceedings, p. 1907-1913.
[7] Tundrea, H., Maxineasa, S. G., Taranu, N., Budescu, M., Gavrilescu, M., Simion, I. M. (2014). Environmental impact assessment and thermal performances of modern earth sheltered houses - Environmental Engineering & Management Journal, vol. 13, no. 10, p. 2363-2369.
[8] Hazbei, M., Nematollahi, O., Behnia, M., Adib, Z. (2015). Reduction of energy consumption using passive architecture in hot and humid climates - Tunnelling and Underground Space Technology, vol. 47, no. 0, p. 16-27.
[9] Terman, M. R. (1985). Earth sheltered housing - Principles in Practice, Van Nostrand Reinhold Company.
[10] Energy Plus, Energy Simulation Software (Weather File).
[11] REHAU, TECHNICAL INFORMATION - HEAT PUMP PROGRAM 952002 RS, from http://plummediaserver.com/grejanje.com/rehau/teh_informacija_toplotne_pumpe_952002.pdf, accessed on 2019-02-29.
[12] Energy Plus, Energy Simulation Software (Engineering Reference).

ISBN 999383985-9
9 789993 839859