

**SIMTERM**

# **PROCEEDINGS**

---

**17<sup>th</sup> Symposium on Thermal Science and  
Engineering of Serbia**

Sokobanja, Serbia, October 20–23, 2015

University of Niš, Faculty of Mechanical Engineering in Niš  
Society of Thermal Engineers of Serbia

ISBN 978-86-6055-076-9

Publisher:  
University of Niš, Faculty of Mechanical Engineering in Niš

2015



**SIMTERM**

# **PROCEEDINGS**

---

## **17<sup>th</sup> Symposium on Thermal Science and Engineering of Serbia**

Sokobanja, Serbia, October 20 – 23, 2015

University of Niš, Faculty of Mechanical Engineering in Niš  
Society of Thermal Engineers of Serbia

ISBN 978-86-6055-076-9

Publisher:  
University of Niš, Faculty of Mechanical Engineering in Niš

2015

# **17<sup>th</sup> Symposium on Thermal Science and Engineering of Serbia**

under title:

## **“Energy – Ecology – Efficiency”**

is organized by:

University of Niš, Faculty of Mechanical Engineering in Niš  
and  
Society of Thermal Engineers of Serbia

---

### **Under patronage of the**

GOVERNMENT OF THE REPUBLIC OF SERBIA  
MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGICAL DEVELOPMENT

and supported by:

---

### **Donors and Sponsors**

TESLIANUM  
ENERGOPROJEKT ENTEL  
SERBIAN CHAMBER OF ENGINEERS  
BOSCH  
WILO  
HERZ  
FENIKS BB  
TROX TECHNIK  
VIA OCEL  
YUTKL  
ŠUKOM



Влада Републике Србије  
Министарство просвете, науке и  
технолошког развоја

Energetski inovacioni centar  
TESLIANUM



**ENERGOPROJEKT**  
ENTEL a.d.

ENERGOPROJEKT  
ENTEL

Инжењерска комора Србије



**BOSCH**

**wilo**



**TROX**® **TECHNIK**  
The art of handling air



**VIA** **OCEL**  
Excellence as standard



## International Scientific Committee

---

Prof. Dr. Gligor Kanevče	[MK]	Prof. Dr. Ljubica Kanevče	[MK]
Prof. Dr. Slavtcho G. Slavtchev	[BG]	Prof. Dr. Sašo Medved	[SI]
Prof. Dr. Petar Novak	[SI]	Prof. Dr. Jordan Hristov	[BG]
Prof. Dr. Sc. Neven Duić	[HR]	Prof. Dr. Agis Papadoupoulos	[GR]
Prof. Dr. Konstantinos Papakostas	[GR]	Prof. Dr. Sophia Natalia Boemi	[GR]
Prof. Dr. Dušan Golubović	[BA]	Dr. Maria Ichim	[RO]
Dr. Vesna Barišić	[FI]	Prof. Dr. Dečan Ivanović	[ME]
Dr. Gyula Gróf	[HU]	Dr. Friedrich Dinkelacker	[DE]
Dr. Zlatan Car	[HR]	Mr. Sc. Luka Čarapović	[HR]
Dr. Darko Knežević	[BA]	Dr. Zdravko N. Milovanović	[BA]
Dr. Mihajlo J. Stojić	[BA]		

## Program Committee

---

Prof. Dr. Mladen Stojiljković,	University of Niš, Faculty of Mechanical Engineering in Niš
Prof. Dr. Milan Radovanović,	University of Belgrade, Faculty of Mechanical Engineering
Prof. Dr. Simeon Oka,	University of Belgrade, Vinča Institute of Nuclear Sciences
Prof. Dr. Gradimir Ilić,	University of Niš, Faculty of Mechanical Engineering in Niš
Prof. Dr. Bratislav Blagojević,	University of Niš, Faculty of Mechanical Engineering in Niš
Prof. Dr. Dragoljub Živković,	University of Niš, Faculty of Mechanical Engineering in Niš
Prof. Dr. Velimir Strefanović,	University of Niš, Faculty of Mechanical Engineering in Niš
Prof. Dr. Dragoslava Stojiljković,	University of Belgrade, Faculty of Mechanical Engineering
Dr. Predrag Stefanović,	University of Belgrade, Vinča Institute of Nuclear Sciences
Prof. Dr. Dragoslav Šumarac,	University of Belgrade, Faculty of Civil Engineering
Dr. Miodrag Mesarović,	Energoprojekt ENTEL, Belgrade
Prof. Dr. Dušan Gvozdenac,	University of Novi Sad, Faculty of Technical Sciences
Prof. Dr. Milun Babić,	University of Kragujevac, Faculty of Engineering
Prof. Dr. Vladan Karamarković,	University of Kragujevac, Faculty of Mechanical and Civil Eng. in Kraljevo
Dr. Žarko Stevanović,	University of Belgrade, Vinča Institute of Nuclear Sciences
Prof. Dr. Maja Todorović,	University of Belgrade, Faculty of Mechanical Engineering

## Honoured Committee

---

Prof. Dr. Nenad T. Pavlović,	University of Niš, Faculty of Mechanical Engineering in Niš
Prof. Dr. Dragan Antić,	University of Niš, Faculty of Electronic Engineering in Niš
Prof. Dr. Vlastimir Nikolić,	University of Niš, Faculty of Mechanical Engineering in Niš
Prof. Dr. Čemal Dolićanin,	State University of Novi Pazar
Prof. Dr. Maja Đurović Petrović,	European University, Faculty for International Engineering Management
Jaroslav Urošević,	Energoprojekt ENTEL, Belgrade

## Organizing Committee

---

Doc. Dr. Dejan Mitrović,	University of Niš, Faculty of Mechanical Engineering in Niš
Doc. Dr. Mirjana Laković,	University of Niš, Faculty of Mechanical Engineering in Niš
Dr. Mirko Stojiljković,	University of Niš, Faculty of Mechanical Engineering in Niš
Marko Ignjatović,	University of Niš, Faculty of Mechanical Engineering in Niš
Prof. Dr. Branislav Stojanović,	University of Niš, Faculty of Mechanical Engineering in Niš
Prof. Dr. Mića Vukić,	University of Niš, Faculty of Mechanical Engineering in Niš
Prof. Dr. Jelena Janevski,	University of Niš, Faculty of Mechanical Engineering in Niš
Prof. Dr. Gordana Stefanović,	University of Niš, Faculty of Mechanical Engineering in Niš
Dr. Goran Vučković,	University of Niš, Faculty of Mechanical Engineering in Niš
Doc. Dr. Predrag Živković,	University of Niš, Faculty of Mechanical Engineering in Niš
Mr. Dragan Kuštrimović,	University of Niš, Faculty of Mechanical Engineering in Niš

## **Disclaimer**

---

The contents of the papers presented in this publication are the sole responsibility of their authors and can in no way be taken to reflect the views of the Organizer.

# Contents

---

<b>1. Plenary Session</b>	<b>1</b>
Activities of the automotive industry in the field of environmental protection <i>Dušan Gruden</i>	2
Energy Systems in a Controversial Transition <i>Miodrag Mesarović</i>	22
LEEN* Concept: Driving Force of Sustainable Country Development <i>Eberhard Jochem, Mirjana Prljevic, Michael Mai, Ursula Mielicke</i>	34
<b>2. Experimental Examination of Processes and Plants</b>	<b>46</b>
Integrated evaluation of composite cool thermal insulation materials under temperate climates <i>Sofia-Natalia Boemi, Panagiota Antoniadou, Efrosini Giama, Stella Hadjarakou, Theoni Karlessi, Mat Santamouris, Agis Papadopoulos</i>	47
A Comparison of Various Heating Systems in Greece Based on Efficiency and Fuel Cost <i>Konstantinos T. Papakostas, Georgios Martinopoulos, Agis M. Papadopoulos</i>	53
Development of new traceable European capabilities in thermal metrology <i>Jean-Rémy Filtz, Narcisa Arifovic, Mohamed Sadli, Guillaume Failleau, Bruno Hay, Dubaltach Mac Lochlainn, Ales Blahut, Jovan Bojkovski, Nedzadeta Hodzic, Lenka Knazovicka, Nenad Milosević, Slavica Simić, Danijel Sestan, Radek Strnad, Emese Thurzo-Andras, Davor Zvizdic</i>	67
Measurements and Simulation of the Temperature in the Flow Fields of the Rocket Nozzle with Jet Tabs <i>Sasa Zivkovic, Momcilo Milinovic, Nikola Gligorijevic, Pavle Pavlovic</i>	72
Experimental Measurement of the Temperature Field on the Barrel of Automatic Weapon <i>Aleksandar Kari, Nevena Stevanovic, Momcilo Milinovic, Damir Jerkovic</i>	82
Experimental Equipment Research for Cryogenic Joule-Thompson Microcoolers of IR Homing Heads <i>Aleksandar Sicovic, Momčilo Milinovic, Dragutin Debeltkovic, Olivera Jeremic</i>	89
Experimental and Analytical Research of the Heat Transfer Process in the Package of Perforated Plates <i>Mladen A. Tomić, Predrag M. Živković, Mića V. Vukić, Žana Ž. Stevanović, Biljana B. Milutinović</i>	97
Experimental Research of Effects of Adding Supplementary Component Generated by Catalytic Reactor on Combustion at Gasoline Engines <i>Miloš Milošević, Ljubiša Tjupa, Boban Nikolić, Dušan Stamenković, Dušan Pribak</i>	105
Experimental Determination of the Minimum Fluidization Velocity of Two-Component Fluidized Bed <i>Jelena N. Janevski, Branislav V. Stojanović, Mladen M. Stojiljković</i>	113
Measurement of air pollutants in College of Textile – Design, Technology and Management in Belgrade <i>Marija Živković, Ivan Lazović, Sandra Stefanović, Žarko Stevanović, Danka Kostadinović</i>	122

Experimental energetic analysis of hydraulic excavator work <i>Predrag Milić, Dragoslav Janošević, Vesna Jovanović</i>	128
Experimental Investigation on Energy Performance of Air Heating Solar Collector with Forced Constant Airflow Rate <i>Milovan Medojević, Jovan Petrović, Milana Medojević</i>	133
A Comparison of Performance of Axial Fans at Full and Partial Geometric Similarity <i>Živan Spasić, Dragica Milenkovic, Jasmina Bogdanović-Jovanović, Vladislav Blagojević</i>	144
Experimental Validation of a Multi-Storey Naturally Ventilated Double Skin Facade <i>Aleksandar S. Anđelković, Jovan Petrović, Miroslav Kljajić, Igor Mujan</i>	151
<b>3. Fluid Flow and Heat and Mass Transfer</b>	159
Study of integral characteristics and efficiency of a finned tubes thermosyphon's type heat exchanger <i>Iliya K. Iliev, Veselka Kamburova, Krisztina Uzuneanu, Vassil Voutev</i>	160
Short simulation test of initial flight total temperature on the small caliber cannon projectile <i>Momčilo Milinović, Damir Jerković, Aleksandar Kari</i>	170
Numerical Modeling of Temperature Field on High Velocity Explosively Formed Projectile <i>Miloš Marković, Momčilo Milinović, Olivera Jeremić, Slobodan Jaramaz</i>	175
MHD Flow and Heat Transfer of Incompressible Electrically Conductive Micropolar Fluid <i>Miloš Kocić, Živojin Stamenković, Jelena Petrović, Milica Nikodijević</i>	181
MHD Flow and Heat Transfer of Two Immiscible Fluids Trough Porous Medium <i>Živojin Stamenković, Jelena Petrović, Miloš Kocić, Milica Nikodijević</i>	192
Universal Method in the MHD Boundary Layer mixed Flow with Effects of Chemical Reaction and Heat Source/Sink <i>Aleksandar Z. Boričić, Miloš M. Jovanović, Branko Z. Boričić</i>	202
Unsteady MHD Thermal and Diffusion Boundary Layer from a Horizontal Circular Cylinder <i>Aleksandar Z. Boričić, Miloš M. Jovanović, Branko Z. Boričić</i>	215
Influence of sorbent particle dispersion in pulverized coal-fired furnace on desulphurization process efficiency <i>Ivan Tomanović, Srđan Belošević, Aleksandar Milićević, Dragan Tucaković</i>	228
Determination of dynamic thermal characteristics of building wall <i>Zorana Petojević, Milica Mirković, Željko Jovanović, Radovan Gospavić, Goran Todorović</i>	236
Re-Design of Deflector's Flow Domain at Howell Bungler Valve Refere to Free Jet and Cavitation <i>Valentino Stojkovski, Zvonimir Kostic</i>	244



The Research of Heat Balance of Bearing Mounting Realized by Axial Ball Bearings with Angular Contact Intended For the Threaded Spindles <i>Vladislav Krstić, Dragan Milčić</i>	251
Quality of Thermal Comfort CFD Models Based On Error Analysis and Statistical Analysis <i>Žana Stevanović, Gradimir Ilić, Mića Vukić, Predrag Živković, Mladen Tomić</i>	257
Forced Rayleigh-Benard convection in an inclined fluid layer <i>Miloš Jovanović, Saša Milanović, Vladislav Blagojević, Saša Randelović, Jelena Manojlović</i>	265
Transient CFD Analysis of Rotating Stall in Centrifugal Pump Impeller <i>Živojin Stamenković, Jasmina Bogdanović-Jovanović, Dragica Milenković, Dragan Svrkota</i>	273
Prediction of In-Furnace Flue Gas Desulfurization by Lime-Based Sorbent Injection <i>Srđan Belošević, Stevan Nemoda, Nenad Crnomarković, Ivan Tomanović, Aleksandar Milićević</i>	284
Centrifugal fans with backward-curved and forward-curved blades <i>Jasmina Bogdanović-Jovanović, Božidar Bogdanović, Živan Spasić</i>	290
<b>4. Renewable Energy Sources</b>	297
An assessment of energetic and exergetic efficiency of biomass residues gasification <i>Uzuneanu Krisztina, Marcel Dragan</i>	298
Application of biogas based cogeneration to improve energy efficiency and competitiveness of agricultural farms <i>Dragoljub Živković, Marko Mančić, Milena Todorović, Andrijana Stojanović</i>	305
Assessment Feasibility of Construction a Small Hydropower Plant <i>Filip Stojkovski, Zvonimir Kostic, Valentino Stojkovski</i>	320
Design of wind farm Vinča utilizing WAsP software <i>Aleksandra Mikić, Željko Đurišić</i>	329
Cost optimal energy supply of a livestock farm <i>Marko Mančić, Dragoljub Živković, Milena Todorović</i>	351
Ray Tracing Study to Determine Optical Performance of Dish Solar Thermal Concentrator <i>Saša Pavlović, Darko Vasiljević, Velimir Stefanović, Milan Đorđević, Marko Mančić, Dragan Kuštrimović</i>	364
Use of photovoltaic systems on the facades of buildings <i>Jelena Stevanović</i>	374
Application of wind energy in architecture <i>Jelena Stevanović</i>	382
Main barriers to the implementation of projects utilizing RES in the Republic of Macedonia <i>Vladimir Mijakovski, Tale Geramitcioski, Vangelce Mitrevski</i>	389

Analysis of Rtanj Mountain Wind Energy Potentials <i>Predrag M. Živković, Mirjana S. Laković, Mladen A. Tomić, Žana Ž. Stevanović, Dragana G. Dimitrijević, Milica Jović</i>	397
<b>5. Energy Efficiency and Environmental Protection</b>	403
Analysis of Energy Efficiency of Schools Using the Energy Balance Method <i>Aleksandra Nedeljković, Marko Mančić, Milena Jovanović, Peđa Milosavljević, Bojan Stanković</i>	404
Architectural strategies of wind turbine implementation in buildings and the urban environment <i>Sanja Spasić Dorđević, Hristina Krstić</i>	414
Model of energy efficient and sustainable design through conceptual architectural-urban design of an Eco Green Village in Belgrade <i>Hristina Krstić, Sanja Spasić Dorđević, Dušan Randelović, Miomir Vasov, Marija Gocić</i>	422
Production Process Reengineering - Production of Steel Panel Radiators <i>Dragana Temeljkovski, Miloš Milovančević, Dragan Temeljkovski, Stojanče Nusev</i>	432
Environmental Sustainability and Thermal Comfort with Green Roof Implementation in the Building Envelope <i>Dragana Dimitrijević, Predrag Živković, Mladen Tomić</i>	438
Influence of district heating on future energy systems: Case study for the heat demand mapping and energy planning of the City of Osijek <i>Tomislav Novosel, Marko Ban, Neven Duić, Nataša Markovska, Vesna Borožan, Tomislav Pukšec, Tihomir Tomić, Goran Krajačić</i>	444
Central Heating of Buildings with integrated thermally activated Building Systems <i>Branislav Stojanović, Jelena Janevski, Milica Ljubenović, Marko Ignjatović, Dejan Mitrović</i>	452
Energy balance of College of Applied Sciences in Niš <i>Milan Pavlović, Dragoljub Živković, Biljana Milutinović, Aleksandra Boričić, Dejan Blagojević</i>	459
Potential Energy Efficiency Improvements on Faculty of Technical Sciences Institute <i>Igor Mujan, Aleksandar Anđelković, Momčilo Spasojević, Jovan Petrović, Miroslav Kljajić</i>	466
Sustainability assessment of different heating system options for single family house by multi-criteria analysis <i>Biljana Vučićević, Marina Jovanović, Valentina Turanjanin</i>	474
Electrolyzer based on molybdenum carbide for separation hydrogen from water <i>Aleksandra Stojanovic</i>	480
The Possibility of Energy Saving in Interior Lighting Using the New Type of Lamps <i>Marko Šućurović, Saša Stojković, Snežana Dragičević, Momčilo Vujičić</i>	514
Analysis of zero energy public object <i>Jelena Stevanović</i>	524

Improvements and Developments Made by CFD Tools Especially for the Semidry CDS Technology <i>Rüdiger Baege, Christian Moser</i>	530
Natural Radioactivity in Coal, Slag, and Fly-ash Samples from “Nikola Tesla” Power Plant – Risk Assessment <i>Bojan Šešlak, Mirjana Đurašević, Milić Erić, Aleksandar Kandić, Ivana Vukanac, Zoran Marković, Zoran Milošević</i>	542
Denitrification Techniques at Biomass Combustion <i>Milica Mladenović, Milijana Paprika, Stevan Nemoda, Ana Marinković</i>	548
An Analysis of NO <sub>x</sub> EU And Serbian Emission Limits <i>Milica Mladenović, Milijana Paprika, Stevan Nemoda, Goran Živković</i>	560
Reduction of Particulate Matter Emission by the Modernization of the Electrostatic Precipitators at Unit B1 of the TPP Kostolac B <i>Milić Erić, Predrag Stefanović, Zoran Marković, Dragan Živić, Željko Ilić</i>	569
Application of Air to Water Heat Pump in Serbian Climate Conditions <i>Maja N. Todorović, Bojan Grujički</i>	577
Influence of Window U-value on Energy Performance of School Building <i>Danka Kostadinović, Ivan Lazović, Marija Živković, Žana Stevanović, Sandra Stefanović</i>	586
The influence of temperature correction factor to determine the buildings heat losses <i>Valentina Turanjanin, Biljana Vucicevic, Marina Jovanovic, Nikola Mirkov, Ivan Lazovic</i>	594
Indoor Air Quality in Office Buildings – Experimental Investigation <i>Tamara S. Bajc, Maja N. Todorović, Agis M. Papadopoulos</i>	601
<b>6. Technologies and Plants</b>	608
Exergetic valuation method for producing energy in cogeneration <i>Marcel Dragan, Uzunescu Krisztina</i>	609
Influence of elemental composition of ethanol - gasoline mixtures on heat transfer in engines <i>Krisztina Uzunescu, Iliya Iliev</i>	615
Sunflower Husk Combustion in 18 MW Boiler Cyclone Furnace in District Heating System - Case Study <i>Ivan Pešenjanski, Biljana Miljković, Đorđije Doder</i>	622
Field Tests Of Mixed-flow Rice Dryer <i>Filip Mojsovski</i>	630
Maintenance of Turbo Generator in Accordance with Monitoring on the Example of TPP Ugljevik with Installed Power of 300 MW <i>Zdravko N. Milovanovic, Darko Knezevic, Svetlana Dumonjic-Milovanovic, Jovan Skundric</i>	635
Analysis of Cooling System at Injection Molding Tool for Products with Different Geometry <i>Saša Randelović, Mladomir Milutinović, Mića Vukić, Tanikić Dejan</i>	649
Comparative Exergetic Performance Analysis for Some Thermal Power Plants in Serbia <i>Dejan M. Mitrović, Marko G. Ignjatović, Branislav V. Stojanović, Mirko M. Stojiljković</i>	655

Impact of disconnecting the Apartment from Central Heating System in Multi-Family Building <i>Branislav Stojanović, Jelena Janevski, Milica Ljubenović, Marko Ignjatović, Dejan Mitrović</i>	666
Heat Pump Drying of Green Peas <i>Jelena N. Janevski, Stefan D. Jovanović, Mladen M. Stojiljković</i>	671
Optimal Design of Combined Heat and Power Production Plant Using Particle Swarm Optimization <i>Emina Petrović, Dejan Mitrović, Vlastimir Nikolić, Miloš Simonović</i>	677
Techno-Economic Analysis of the Closed-Cycle Cooling System in the 110 MW Thermal Power Plant <i>Mirjana Laković, Milica Jović, Miloš Banjac</i>	686
Parameters of the Atmospheric Air in the Dimensioning of Industrial Cooling Tower <i>Laković Mirjana, Laković Slobodan, Jović Milica</i>	695
<b>7. Automatics, Process Control and Expert Systems</b>	706
Algorithm of Practical Tracking with Vector Settling Time: Application in Process Industry <i>Mihajlo J. Stojčić, Vlastimir Nikolić</i>	707
Pulse Width Modulation Asymmetric Hydraulic Cylinder Control <i>Vladislav Blagojević, Miodrag Stojiljković, Miloš Jovanović, Živan Spasić</i>	717
Computationally Intelligent HVAC Controller Optimization <i>Žarko Čojbašić, Milan Ristanović, Nemanja Marković, Stefan Tešanović</i>	723
Thermal vision based intelligent system for human detection and tracking in mobile robot control system <i>Ivan Ćirić, Žarko Čojbašić, Danijela Ristić-Durrant, Vlastimir Nikolić, Milica Ćirić, Miloš Simonović, Sofija Pavlović</i>	735
Heat Consumption Prediction of Small District Heating System Using Artificial Neural Networks <i>Miloš Simonović, Vlastimir Nikolić, Ivan Ćirić, Emina Petrović, Sofija Pavlović</i>	741
Determining the Theoretical Reliability Functions of the Thermal Power System in Power Plant "Pljevlja" <i>Dragan Kalaba, Milan Đorđević, Vladan Ivanović</i>	749
Influence of the Soil Layer on the Roof Membrane in the Green Roof Assembly <i>Dragana Dimitrijević, Miloš Milošević, Miša Tomić, Vukašin Pavlović</i>	756
Breakdowns of hot water boilers <i>Milena Todorovic, Dragoljub Živković, Marko Mančić</i>	761
Analysis of PV/Wind/Battery/Hydrogen Systems for Supply of Meteorological Mast in Very Low Temperature Conditions <i>Saša Stojković, Vukman Bakić</i>	770
Techno-economic Analysis of PV/Battery/Diesel Generator System for Supply of Meteorological Mast Equipment in Cold Climates <i>Vukman Bakić, Saša Stojković</i>	780

Determination of Flow Rate through Radial Clearance at Zero Overlap inside the Hydraulic Components <i>Darko Knežević, Aleksandar Milašinović, Saša Laloš</i>	790
A Numerical Study on Laminar Forced Convection of ZnO-Ethylene Glycol Nanofluid in a Trapezoidal Microchannel <i>Cuneyt Uysal, Kamil Arslan, Huseyin Kurt</i>	802
Analysis of dynamic stability of excavator depending on the temperature of the hydraulic oil in excavator drive system <i>Vesna Jovanović, Dragoslav Janošević, Jovan Pavlović</i>	814
Modeling of Cutting Temperature in the Biomedical Stainless Steel Turning Process <i>Dušan Petković, Miloš Madić, Miroslav Radovanović, Predrag Janković, Goran Radenković</i>	822
Mathematical Model for Evaluation of Cost-effectiveness of Waste-to-Energy Treatment Technique <i>Biljana Milutinović, Gordan Stefanović, Ksenija Denčić-Mihjlov, Petar S. Đekić, Aleksandra Boričić</i>	829
Numerical Investigation on the Convective Heat Transfer in a Spiral Coil with Radiant Heating <i>Milan Đorđević, Velimir Stefanović, Mića Vukić</i>	836
On Mathematical Modelling in Solving Scientific and Engineering Problems <i>Ljiljana Petković</i>	845
Influence of Polynomial Coefficients on the Weighted Sum of Gray Gases Model Optimization <i>Nenad Crnomarković, Srđan Belošević, Ivan Tomanović, Aleksandar Milićević, Andrijana Stojanović, Goran Stupar</i>	853
Genetic Algorithm Approach for Optimization of Energy Integrated ATAD System under Uncertainties <i>Natasha G. Vaklieva-Bancheva, Raika K. Vladova, Elisaveta G. Kirilova</i>	859
Structural Assessment of Guyed Mast – Finite Element Method Approach <i>Milada Pezo, Vukman Bakić, Zoran Marković</i>	871
Tribological criteria of efficiency evaluation in work of loader manipulator <i>Jovan Pavlović, Dragoslav Janošević, Vesna Jovanović</i>	879
Three Phase Eulerian Model Applied on Numerical Simulation of Oil-Water Mixtures Combustion in a Bubbling Fluidized Bed <i>Stevan Nemoda, Milica Mladenović, Milijana Paprika, Aleksandar Erić, Dejan Đurović</i>	885
Numerical Investigation of Nucleate Pool Boiling Heat Transfer <i>Andrijana Stojanović, Vladimir Stevanović, Milan Petrovic, Dragoljub Živkovic, Branislav Stanković</i>	900
Design Aspects and Analysis of Adhesive Bonded Joint <i>Nataša Jovanović, Boban Anđelković, Biljana Đorđević, Vukašin Pavlović</i>	911

<b>8. Energy Efficiency in Transport</b>	<b>918</b>
Selection of Working Process and Turbocharging System for Locomotive High Boosted Engine Fed with Natural Gas <i>Mikhail G. Shatrov, Alexey S. Khatchiyan, Vladimir V. Sinyavski, Ivan G. Shishlov</i>	919
Research of the Influence of Injection Pressure up to 300 MPa on Diesel Engine Working Processes and Its Fuel System Parameters <i>Mikhail G. Shatrov, Leonid N. Golubkov, Andrey U. Dunin, Andrey L. Yakovenko, Pavel V. Dushkin</i>	927
The Importance of Energy Efficient Transportation <i>Stojan Petrovic</i>	938
Energetic and Ecological Aspects of the Application of Electric Drive Vehicles in Serbia <i>Miroljub Tomić, Zoran Jovanović, Marko Kitanović</i>	948
The characteristics of combustion process of diesel engine using vegetable oil methyl esters <i>Dragan Knežević, Miroljub Tomić, Vlada Stajić, Velimir Petrović, Željko Bulatović</i>	957
Engine with Alternative Otto/Diesel Processes <i>Aleksandar Davinić, Radivoje Pešić, Dragan Taranović, Miroslav Ravlić</i>	965
Downsizing IC engine with Variable Compression Ratio: effects and potentials <i>Radivoje Pešić, Snežana Petković, Emil Hnatko, Stevan Veinović</i>	975
Application natural gas on city buses and their introduction in the traffic <i>Saša Milojević, Radivoje Pešić</i>	987
Human Thermal Model for Evaluation of Thermal Sensation in Vehicle Cabin Using CFD Simulations <i>Dragan Ružić, Siniša Bikić</i>	994
Efficiency of radial-rotary IC engine <i>Jovan Dorić, Ivan Klinar</i>	1004
Some aspects of temperature distribution in IC engine crankshaft bearing <i>Nebojša Nikolić, Jovan Dorić, Života Antonić</i>	1010
Fuel saving through use of new generation of low-viscosity motor oils <i>Snezana Petkovic, Omer Kovac, Zeljko Djuric, Stevan Veinović</i>	1016
Reducing fuel consumption and CO2 emissions from motor transport <i>Velimir Petrovic, Dragan Knezević, Ivan Sirotanovic, Stojan Petrovic</i>	1025
Local Model Networks as Virtual Combustion Sensors in IC Engines <i>Nenad Miljić, Slobodan Popović</i>	1038
Internal Combustion Engine Torque Nonuniformity <i>Milasinović A., Milovanovic Z.</i>	1044
Light Vehicles Test Procedures on an Automated Engine Test Bed <i>Stefan Đinić, Vladimir Petrović, Predrag Mrđa, Slobodan Popović, Nenad Miljić</i>	1056

Software and Hardware Challenges of Engine Test Bed Automation – Example of FME ICED Lab <i>Vladimir Petrović, Stefan Đinić, Marko Kitanović, Nenad Miljić, Slobodan Popović</i> <i>Marko N. Kitanović, Slobodan J. Popović,</i>	1062
Parameterisation of friction in engine piston-cylinder assembly <i>Slobodan J. Popović, Nenad L. Milljić</i>	1066
Analysis of experimental and theoretical results of the energy efficiency of different bus subsystems in Belgrade public transport <i>Slobodan Mišanović, Zlatomir Živanović</i>	1074
Energy efficiency trends in the road transport sector in Montenegro <i>Vera Mirković, Mirjana Grdinić, Vladimir Pajković</i>	1083
Activities of the Administration of Montenegro's Capital City, Podgorica, for Energy More Efficient Road Traffic <i>Radoje Vujadinovic</i>	1089
Use of models for the calculation of CO2 emissions for passenger cars in Montenegro <i>Radoje Vujadinovic, Stojan Petrovic</i>	1110
Ecological and economic aspects of installing devices and equipment for LPG-fuelled vehicles <i>Boban Nikolić, Predrag Milić, Miloš Milošević, Saša Milanović</i>	1115
Metaheuristics for solving Vehicle Routing Problems with Stochastic Demands for waste collection <i>Danijel Marković, Goran Petrović, Miloš Milošević, Predrag Milić, Miloš Madić</i>	1123

# Application Natural Gas on City Buses and Their Introduction in the Traffic

*Saša Milojević<sup>a</sup> (CA), Radivoje Pešić<sup>b</sup>*

<sup>a</sup> Faculty of Engineering University of Kragujevac, Kragujevac, RS, tiv@kg.ac.rs

<sup>b</sup> Faculty of Engineering University of Kragujevac, Kragujevac, RS, pesicr@kg.ac.rs

**Abstract:** Compressed Natural Gas (CNG) as an alternative fuel has many advantages: lower cost, more complete combustion, lower emissions, lower noise and longer engine life. CNG technology has been developed for decades and now is available for commercial use in motor vehicles. Natural gas causing about 25% lower CO<sub>2</sub> emissions compared to the same amount of energy diesel fuel, due to the lower carbon content (H/C = 4), and thus contributes significantly to reducing global warming. This enables bus body builders to make natural gas buses comply with the challenging and voluntary Enhanced Environment friendly Vehicle (EEV) emission standard, without using extensive filter technology and expensive additives.

This paper analyzes the technical features of a city bus powered with compressed natural gas, as well as environmental, economic and security aspects of these buses for passenger transport in major cities. In the paper, also is presented the solutions for the reconstruction of diesel powered local bus into dedicated natural gas vehicle.

**Keywords:** CNG Cylinder, Emission, Natural gas buses, Logistics.

## 1. Introduction

There are already more than 22 million natural gas vehicles (NGV's) worldwide (1.76 million in Europe). In the last five years, sales of cars powered by natural gas have tripled in Europe, while they have increased six-fold in Spain in the same period. Between 2009 and 2014 in Italy there was an increase of 31% in the number of NGV's (15% in Germany). Also, CNG buses and trucks have a significant role in the continent: they consume 73.5% of methane applied to vehicles, while in the rest of the world the average is 40.5% [1]. Figure 1 shows the predictions of the Landscape Power trains in the future [2].

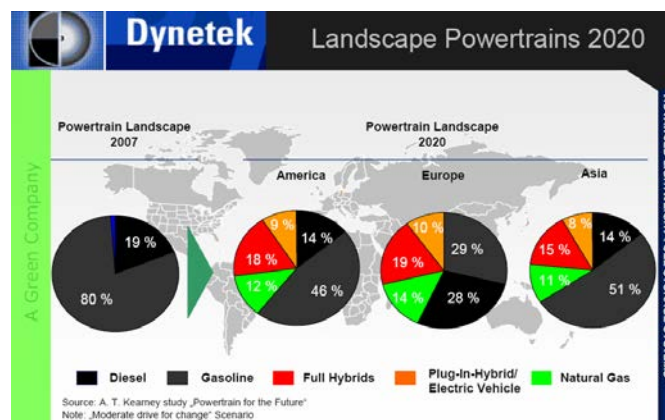


Figure 1. Landscape Power trains and Natural Gas rate [2]

Transit buses are one of the most cost-effective forms of mass transit, and the foundation of public transportation in the developing world. Diesel engines have been the traditional power source for public buses and heavy trucks due to their durability, robustness, reliability, high fuel efficiency and high torque. Because transit buses operate in heavily congested areas under stop and-go traffic patterns, continuous acceleration and deceleration increases the production of particulate matter (PM), typical of high load during vehicle acceleration periods. Critical public health situations related to exposure to high concentrations of exhaust emission and legislation, have pushed local authorities to take actions favoring low-emitting













