

Novi Sad, Serbia 4-7 July 2011

The 24th International Conference on Efficiency,
Cost, Optimization, Simulation and Environmental
Impact of Energy Systems

ECOS²⁰¹¹

BOOK OF PROCEEDINGS



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ECOS 2011

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24th International Conference
on Efficiency, Cost, Optimization, Simulation
and Environmental Impact of Energy Systems

Novi Sad, Serbia
July 4–7, 2011

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ECOS Conferences History

1987, May 25-29, Rome, Italy	4 th International Symposium on 2 nd Law Analysis of Thermal Systems.
1989, June 5-8, Beijing, China	Thermodynamic Analysis and Improvement of Energy Systems, International Symposium, (TAIES '89).
1990, May 28-June 1, Florence, Italy	Florence World Energy Research Symposium, (FLOWERS '90).
1991, June 3-6, Athens, Greece	Analysis of Thermal and Energy Systems, International Conference, (ATHENS '91).
1992, June 15-18, Zaragoza, Spain	International Symposium on Efficiency, Costs, Optimization and Simulation of Energy Systems, (ECOS '92).
1993, July 5-9, Cracow, Poland	Energy Systems and Ecology International Conference, (ENSEC '93).
1994, July 6-8 Florence, Italy	Florence World Energy Research Symposium, (FLOWERS '94).
1995, July 11-14, Istanbul, Turkey	International Conference on Efficiency, Costs, Optimization, Simulation and Environmental Impact of Energy Systems, (ECOS '95).
1996, June 25-27, Stockholm, Sweden	International Symposium on Efficiency, Costs, Optimization, Simulation and Environmental Aspects of Energy Systems, (ECOS '96).
1997, June 10-13, Beijing, China	Thermodynamic Analysis and Improvement of Energy Systems, International Conference, (TAIES '97).
1998, July 8-10, Nancy, France	Efficiency, Costs, Optimization, Simulation and Environmental Aspects of Energy Systems and Processes, (ECOS '98).
1999, June 8-10, Tokyo, Japan	Efficiency, Costs, Optimization, Simulation and Environmental Aspects of Energy Systems, (ECOS '99).
2000, July 5-7, Enschede, Netherlands	International Conference on Efficiency, Costs, Optimization, Simulation and Environmental Aspects of Energy and Process Systems, (ECOS 2000).
2001, July 4-6, Istanbul, Turkey	Efficiency, Costs, Optimization, Simulation and Environmental Impact of Energy Systems, (ECOS '01).
2002, July 3-5, Berlin, Germany	15 th International Conference on Efficiency, Costs, Optimization, Simulation and Environmental Impact of Energy Systems, (ECOS 2002).
2003, June 30-July 2, Copenhagen, Denmark	The 16 th International Conference on Efficiency, Costs, Optimization, Simulation and Environmental Impact of Energy Systems, (ECOS 2003).
2004, July 7-9, Guanajuato, Mexico	17 th International Conference on Efficiency, Costs, Optimization, Simulation and Environmental Impact of Energy and Process Systems, (ECOS 2004).
2005, June 20-22, Trondheim, Norway	The 18 th International Conference on Efficiency, Costs, Optimization, Simulation and Environmental Impact of Energy Systems, (ECOS 2005).
2006, July 12-14, Aghia Pelagia, Crete, Greece	The 19 th International Conference on Efficiency, Costs, Optimization, Simulation and Environmental Impact of Energy Systems, (ECOS 2006).
2007, June 25-28, Padova, Italy	The 20 th International Conference on Efficiency, Costs, Optimization, Simulation and Environmental Impact of Energy Systems, (ECOS 2007).
2008, June 24-27, Kraków, Poland	The 21 st International Conference on Efficiency, Costs, Optimization, Simulation and Environmental Impact of Energy Systems, (ECOS 2008).
2009, August 31-September 3, Foz do Iguaçu-Paraná, Brasil	The 22 nd International Conference on Efficiency, Costs, Optimization, Simulation and Environmental Impact of Energy Systems, (ECOS 2009).
2010, June 14-17, Lausanne (EPFL), Switzerland	The 23 rd International Conference on Efficiency, Costs, Optimization, Simulation and Environmental Impact of Energy Systems (ECOS 2010).

Following ECOS Conferences

2012, Italy (ECOS 2012)
2013, China (ECOS 2013)

Preface

It is our pleasure to host ECOS 2011, the 24th International Conference on Efficiency, Cost, Optimization, Simulation and Environmental Impact of Energy Systems, in Novi Sad, Serbia, near the magnificent Danube River that connects so many countries. Four of the major Universities of Serbia, the University of Niš, the University of Novi Sad, the University of Belgrade, and the University of Kragujevac, with the University of Pennsylvania, USA, have jointly organized this conference. The four Serbian Universities are an educational home to a total of about 174,000 students.

Hosting of ECOS 2011 gives an opportunity for Serbian scholars and students to meet colleagues from all over the world (47 countries at last count), and at the same time gives our foreign colleagues a great opportunity not only to meet others but also to enjoy the beauty of Serbia and the hospitality of its people. The ECOS 2011 motto is “*International Smart Energy Networks of Cooperation for Sustainable Development*” and we hope that the conference attendees will indeed take advantage of this precious networking opportunity to meet colleagues, learn, teach, and promote sustainable development of energy.

Apart from paper presentations, the conference includes the World Energy Panel, a Regional Energy Panel, the Symposium about the genius of Nikola Tesla, the Nuclear Energy Panel, and a panel on Ethics in Engineering and Science.

The conference is also a sad time for parting from two colleagues who have passed away last year and who made a lifetime contribution to the energy field and to ECOS conferences: Ricardo Rivero and Yehia M. El-Sayed. They will be missed.

ECOS 2011 also honors four very alive scholars who have contributed much to Serbian and world energy engineering, science, and education: Professors Naim Afgan, Simeon Oka, Marija Todorović and Branislav Todorović.

The conference proceedings contain all of the papers presented at the conference, as well as brief biographies of the scholars who passed away and of the honored ones.

We are grateful to the Serbian Ministry of Education and Science for its professional and financial assistance, as well as to the many sponsors who helped the conference. We are also grateful to the UNESCO Foundation for providing assistance to ten young scientists from the South East European region, which made it financially easier for them to attend this conference.

We would also like to mention the important contributions of the conference support faculty and staff, Goran Vučković, Miloš Đelić, Miroslav Džunić, Dejan Dimitrijević, Marko Ignatović, Mirko Stojiljković, Ivan Čirić, Ana Đelić Zdravković, Nenad Obradović and Ivana Jocić. Special thanks are extended to Dr. Predrag Rašković who prepared and supervised the technical formatting of the conference papers and poster presentations, and who structured the conference proceedings volume.

Respectfully submitted,

Milorad Bojić, University of Kragujevac, Serbia
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Jovan Petrović, University of Novi Sad, Serbia
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Editorial

Testimonial, Yehia M. El-Sayed

Yehia El-Sayed was born in Alexandria Egypt on September 13, 1928. He received his Bachelors Degree from Alexandria University, and his Doctorate in Mechanical Engineering from Manchester University in England.

His academic career took him across the world. He taught and conducted research at Assiut University (Egypt), Kansas State University, Dartmouth College, Glasgow University (Scotland), Tripoli University (Libya) and The Massachusetts Institute of Technology. His legacy persists in the thousands of students and colleagues whose careers and intellectual development he has influenced. He was a recognized international authority in desalination, thermodynamics and thermoeconomics. Over the course of a highly productive career, he authored two books and numerous scientific papers. A Life Fellow of the American Society of Mechanical Engineering, he was a two time recipient of ASME's prestigious Edward F. Obert Award, in addition to a Best Paper Award from the International Desalination Association.

Dr. El-Sayed's contributions brought the fundamentals of science to usefulness in engineering practice, across the spectrum of energy conversions systems – providing principles for optimizing their technical and economic efficiency. The principal objective of his work has been the best possible use of resources. For example, among the various systems benefitting from his efforts – as a writer, teacher and consultant – is desalination, a process very energy intensive and a key to providing water when and where it is scarce. (Incidentally, this work led to a U.S. patent for his design of a unique compressor.)

To his many associates around the world the following excerpt adapted from his Obituary is not surprising: In addition to being a successful scientist, who wrote and published until the end, he was first and foremost a devoted husband of Amina El-Kholi, father of Dr. Yasser El-Sayed (Professor of Obstetrics

and Gynecology at Stanford University) and Dr. Maha El-Sayed (Director of Advanced Technology at Clorox Corporation), father-in-law of Dr. William Fisher (CEO of Optwise Corporation) and grandfather of Tamara and Ramsey Fisher. Despite the professional demands on his time, he loved swimming, bowling and spending peaceful times with his loved ones. He infused his family with his contagious humor, passion for learning, and hunger for adventure and travel.

We, his professional associates, have had the privilege of having Dr. El-Sayed not only as a mentor but, it can be said, 'above all' as a friend. If only one word could be used to describe him it might be 'affable'; if two, then the second, seemingly opposed to the first, could be 'quiet' – calm, helpful, modest, always friendly and considerate, in good humor and a droll gentle-man.

On September 17, 2010, after a long battle with cancer, he passed peacefully at his home in Fremont, California surrounded by his family. Another testimony to his modesty: He never divulged his illness to associate-friends who had been communicating with him. He is and will continue to be missed not only by his family but also by all of us who have had the privilege of his friendship.

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Fast links:

Contents

Keynote Speakers

World Energy Panel

Special Symposium Dedicated to Nikola Tesla

Ethics in Science and Engineering

Track 1: Process and Components

- Basic and applied thermodynamics
- Internal combustion engines I: General
- Internal combustion engines II: Diesel, compound cycles and biofuels
- Clean coal technologies I
- Clean coal technologies II
- Turbines
- Conventional and advanced power plants
- Carbon reduction, capture and storage
- Electricity transmission and the smart grid
- Fuel cells and integrated systems
- Coal and its use

Track 2: Energy: Systems

- Simulation, improvement and optimization of energy systems I: Components I
- Simulation, improvement and optimization of energy systems I: Components II
- Simulation, improvement and optimization of energy systems II: Systems Fundamentals
- Process design, analysis and integration of thermal and chemical systems
- New technologies in heat pumps, refrigeration and air conditioning I
- New technologies in heat pumps, refrigeration and air conditioning II
- Decentralized energy systems, diagnostics and control of energy systems
- Energy and buildings I
- Energy and buildings II
- Energy and buildings III - Envelope
- Water desalination and treatment

Track 3: General Topics in Energy

- Transport energy and emissions
- Mining and drilling and manufacturing
- Energy storage
- Energy planning
- Energy economics
- Life cycle assessment and environmental impact of energy systems
- Nuclear power
- Cogeneration, CHP and district heating I
- Cogeneration, CHP, and district heating II

Track 4: Renewable Energy

- Sustainability and social impacts of energy systems
- Solar integrated systems and components
- Solar thermal collectors, power and solar PV
- Energy and buildings IV: Renewable energy
- Biomass energy I: General
- Biomass energy II: Conversion processes
- Biomass energy III: Combustion, gasification and co-firing
- Renewable energy systems
- Recycling and waste management

Author Index*

Keyword Index*

*In this version of ECOS 2011 Book of Proceedings Keyword index and Author index are not linked with the corresponding pages. For the purpose of fast browsing the readers can use Bookmarks and Page Navigation toolbar. (In Adobe Reader use option Shift+Ctrl+N for quick navigation to a specific page)

Contents

Keynote Speakers	1
Sustainable energy development the need of modern society <i>Naim H. Afgan</i>	2
Building performance simulation for sustainable buildings and zero energy settlements and cities <i>Marija S. Todorović</i>	23
In which manner the thermal behaviour of human body is copied in buildings – similarities and differences in thermal reactions <i>Branislav Todorović</i>	38
World Energy Panel	46
EU energy and climate change strategy <i>Maria da Graça CARVALHO</i>	47
Sustainable energy development: A brief introduction to the present (May 2011) situation <i>Noam Lior</i>	53
Exploring energy consumption and demand in China <i>Ying Fan, Yan Xi</i>	80
Sustainable development and low carbon growth strategy for India <i>Kirit S. Parikh</i>	98
Energy context in Latin America <i>Claudia Sheinbaum-Pardo, Belizza J. Ruíz-Mendoza</i>	113
Special Symposium Dedicated to Nikola Tesla	130
Tesla's rotating magnetic field and its economic importance <i>Prof. Stjepan Car</i>	131
Nikola Tesla and future of electric power engineering <i>Dmitry Semenovitch Strebkov</i>	144
Elements of the concept of sustainability in the works of Nikola Tesla <i>Zorica Čivrić</i>	153
Tesla's research in the field of fountains <i>Bratislav Stojiljković, Aleksandar Marinković, Aleksandar Ćosić, Milan Vulićević</i>	161
Ethics in Science and Engineering	169
Professional ethics <i>Alice Ponchio</i>	170
Engineering ethics education: A military academy point of view <i>Brock E. Barry, Gavin K. White, and A. Özer Arnas</i>	177
Education and engineers' environmental ethics <i>Vesna Miltojević</i>	186
Sustainability ethics: A call for damage control and prevention <i>Noam Lior</i>	193
Codes of ethics and engineering education <i>Alberto Mirandola</i>	203
Track 1: Process and Components	210
Topic: Basic and applied thermodynamics	211
The implementation of entropy into the economic process <i>Gerard Hirs and Ger Kupers</i>	212
Thermodynamic analysis and experimental investigation of a Solo V161 Stirling cogeneration unit <i>E. D. Rogdakis, G. D. Antonakos, I. P. Koronaki</i>	225
Classical thermodynamic effects for Bose gases <i>Gulru Babac and Altug Sisman</i>	237
Modeling the exergy behavior of human body <i>Carlos Eduardo Keutenedjian Mady, Maurício Silva Ferreira, Jurandir Itzo Yanagihara, Paulo Hilário Nascimento Saldiva, Silvio de Oliveira Junior</i>	245
Exergy calculations based on fixed standard environmental conditions versus actual ambient conditions <i>Ivar S. Ertesvåg</i>	258

Numerical analysis of adiabatic two-phase flow through enlarging channel <i>Emrah Deniz, Nurdil Eskin</i>	270
Thermal and mechanical aspect of entropy-exergy relationship <i>Pierfrancesco Palazzo</i>	280
Thermodynamic study of an EFGT (Externally fired gas turbine) cycle with one detailed model for the ceramic heat exchanger <i>Paulo Eduardo Batista de Mello and Deiglys Borges Monteiro</i>	293
Thermodynamic aspects of power production in thermal, chemical and electrochemical systems <i>Stanislaw Sieniutycz and Artur Poewiata</i>	305
Acoustic waves generated by a TA (ThermoAcoustic) laser pair <i>Seung Jin Oh, Kuan Chen, Rohit Surathu, Yoon Joon Lee, Jun Ho Hyun, Wongee Chun</i>	316
New methods for calculating the inlet hydrodynamic and thermal length in a laminar nanofluid flow by applying entropy generation theory <i>M. Boghratia, M. Moghiman</i>	325
Topic: Internal combustion engines I: General	335
Study of performance and exhaust emissions of a spark-ignited engine operating with nitrogen enrichment of intake air <i>Roussos G. Papaïannakis, Theodore C. Zannis, Dimitrios T. Hountalas and Petros N. Kotsiopoulos</i>	336
Comparative evaluation of available TDC estimation techniques <i>Dimitrios T. Hountalas, Antonis A. Antonopoulos</i>	348
Optimal injection strategies for low consumption of a GDI engine <i>Michela Costa, Ugo Sorge, Salvatore Alfuso</i>	362
Comparative analysis of three simulation models applied on a motored internal combustion engine <i>Efthimios Pariotis, George Kosmadakis and Constantine Rakopoulos</i>	374
Measure of the volumetric efficiency and evaporator device performance for a LPG SI engine <i>Massimo Masi, Paolo Gobatto</i>	392
Local stability analysis of a thermoeconomic model of a Curzon-Ahborn heat engine with a Dulong-Petit heat transfer law <i>M. A. Barranco-Jiménez, L. M. Cervantes-Espinoza, D. Hurtado-Aguilar, I. Reyes-Ramírez and L. Guzmán-Vargas</i>	410
Calibration of the instantaneous heat transfer correlation from the study of the polytropic index in internal combustion engines <i>Luis Miguel Hernández, Álvaro Delgad</i>	419
Topic: Internal combustion engines II: Diesel, compound cycles and biofuels	428
Integrated system approach for increase of engine combined cycle efficiency <i>Daniela Gewald, Sotirios Karellas, Andreas Schuster and Hartmut Spliethoff</i>	429
Effect of instantaneous rotational speed on the analysis of measured diesel engine cylinder pressure data <i>Dimitrios T. Hountalas, Antonis A. Antonopoulos</i>	444
Effects of a B70 biodiesel blend on the ECU and fuel system operation during steady-state and transient performance of a common rail diesel engine <i>Dimitrios Tziourtzioumis, Anastassios Stamatelos</i>	456
Thermodynamic analysis of a Rankine Cycle applied on a diesel truck engine using steam and organic medium <i>C.O Katsanos, D.T Hountalas, E.G Pariotis</i>	473
Investigation of the performance and emissions of gasoline engine operating on butanol-gasoline fuel blends <i>Hristo Stanchev, Kiril Hadjiev, Abdulamir Abed Ali</i>	489
Electrostatic atomization of hydrocarbon fuels and bio-alcohols for engine applications <i>Maria S. Agathou and Dimitrios C. Kyritsis</i>	496
Effects of gasoline-ethanol blends on cycle-to-cycle variability <i>Pedro Luis Curto-Risso, Alejandro Medina, Antonio Calvo Hernández</i>	508
Fuel composition effect on the electrostatically-driven atomization of bio-butanol containing engine fuel blends <i>Maria S. Agathou and Dimitrios C. Kyritsis</i>	520
Performance study about biodiesel impact on buses engines using dynamometer tests and fleet consumption data <i>Luis M.V. Serrano; Rui M. O. Câmara; Vasco J.R. Carreira; M.C. Gameiro da Silva</i>	533
Optimal selection of the combustion mode in a turbocharged diesel engine for reduced fuel consumption, noxious emissions and radiated noise <i>Michela Costa, Daniela Siano, Fabio Bozza</i>	545
Topic: Clean coal technologies I	559
Modeling and analysis of the selected carbon dioxide capture methods in IGCC systems <i>Anna Skorek-Osikowska, Katarzyna Janusz-Szymańska, Janusz Kotowicz</i>	560
Evaluation of potential cost reduction for a coal-based polygeneration system with CO2 capture in China <i>Sheng Li, Lin Gao, Xiaosong Zhang, Hu Lin and Hongguang Jin</i>	572
Integration and optimization study on the coal fired power plant with CO2 capture using MEA <i>Liqiang Duan, Mingde Zhao, Gang Xu, Yongping Yang</i>	582
Reduction of the flue gas recirculation rate in oxycoal processes by means of non-stoichiometric burner operation <i>Maximilian Blume, Jan-Peter Bohn, Adrian Goanta and Hartmut Spliethoff</i>	594
Analysis of gas turbine combined heat and power system for carbon capture installation of coal fired power plant <i>Tadeusz Chmielniak, Sebastian Lepszy, Katarzyna Wójcik</i>	605

Topic: Clean coal technologies II	618
Investigation of lignite pre-drying in a modern Greek power plant towards zero CO2 emissions <i>Michalis Agraniotis, Antonis Koumanakos, Aggelos Doukelis, Sotirios Karellas and Emmanuel Kakaras</i>	619
Energy and exergy analysis of hydrogen-oriented coal gasification with CO2 capture <i>Marcin Liszka, Tomasz Malik, Giampaolo Manfrida</i>	630
Membrane separation of oxygen from air <i>Katarzyna Janusz-Szymańska, Sylwia Berdowska, Anna Skorek-Osikowska</i>	644
Simulation and optimization of combustion modifications in pulverized coal utility boiler with respect to NOx emission and heat transfer efficiency <i>Srdan Belošević, Branislav Stanković, Miroslav Sijerčić, Nenad Cnomarković, Slobodan Đekić, Dragan Tucaković and Titoslav Živanović</i>	655
Parametric study of GT and ASU integration in case of IGCC with CO2 removal <i>Marcin Liszka, Jakub Tuka</i>	669
The experimental study on catalytic gasification reactivity and kinetics of roto ultra clean coal under different temperature conditions <i>Gahee Lee, Sang-phil Yoon, Young-shin Jeon, Suhyun Kim, Hyung-taek Kim</i>	681
Influence of forward scattering on prediction of temperature and radiation fields inside the pulverized coal furnace <i>Nenad Crnomarković, Miroslav Sijerčić, Srdan Belošević, Branislav Stanković, Dragan Tucaković and Titoslav Živanović</i>	692
Topic: Turbines	704
Steam turbine model for simulation of work under changing conditions <i>Henryk Łukowicz, Piotr Łukowicz, Lukasz Bartela</i>	705
Coarse grid CFD calculations of a dual-fuel gas turbine combustor flow field <i>Paolo Gobato, Massimo Masi, Andrea Toffolo, Andrea Lazzaretto and Giordano Tanzini</i>	719
Preliminary design and CFD-analysis of a single-stage axial impulse UMG <i>Francesco Confortia, Enrico Sciubba</i>	735
Discussion of the effects of recirculating exhaust air on performance and efficiency of a typical microturbine <i>Ward De Paepe, Frank Delattin, Svend Bram and Jacques De Ruyck</i>	745
Design and off design numerical simulation of steam injected gas turbine based on compressor and turbine performance maps <i>Parisa Varjavand, Majid Saffar Avval and Sahand Behboodi</i>	757
Topic: Conventional and advanced power plants	769
Thermodynamic and component analysis of supercritical Carbon Dioxide Rankine Cycle using a low temperature heat source <i>Amlaku Abie Lakew, Olav Bolland</i>	770
3-D model of solid and gas phase flow in the duct bend behind the mill gas classifier at the fan mill <i>Goran Stupar, Dragan Tucaković, Titoslav Živanović, Vladan Ivanović, Vladimir Živanović, Dragan Komarov</i>	786
Analysis of gas turbine air-bottoming cycle and heat exchanger modeling <i>Tadeusz Chmielniak, Sebastian Lepszy, Daniel Czaja</i>	798
Work analysis of the energy steam boiler evaporator with sliding pressure of 350 MW block <i>Dragan Tucaković, Titoslav Živanović, Goran Stupar, Srdan Belošević, Milivoje Cvetković and Vladimir Živanović</i>	814
Theoretical analysis of a transcritical power cycle for power generation from low temperature heat source <i>Fredy Vélez, José J. Segovia, M. Carmen Martín, Gregorio Antolín, Farid Chejne.</i>	822
Exergy and energy analysis of a dry steam power plant with Heller condenser <i>Duccio Tempesti, Giampaolo Manfrida, Luca Madaia</i>	832
Simulation and experimental validation of an ORC system for waste heat recovery of exhaust gas <i>Andreas Grill, Jens-Patrick Springer, Richard Aumann, Andreas Schuster and Hartmut Spliethoff</i>	840
Advanced exergy-based analyses applied to a system including LNG regasification and electricity generation <i>Tatiana Morosuk, George Tsatsaronis, Alicia Boyano and Camilo Gantiva</i>	851
Design and optimization of a small scale Organic Rankine Cycle prototype using a scroll expander <i>Sébastien Declaye, Sylvain Quoilin, Vincent Lemort</i>	863
Thermodynamic analysis and experimental demonstration of 1kW thermoacoustic-Stirling electrical generator <i>Ercang Luo, Zhanghua Wu, Man Man and Wei Dai</i>	870
Topic: Carbon reduction, capture and storage	878
The effect of mechanical rock properties on CO2 storage capacity <i>Domagoj Vulin, Tomislav Kurevija, Iva Kolenković</i>	879
Benchmarking methodology for CO2 capture processes using minimum capture work targets <i>Rahul Anantharaman, Kristin Jordal and David Berstad</i>	892
Reducing CO2 emissions in cement industry – the calcination model <i>Hrvoje Mikulčić, Ivica Minić, Eberhard von Berg, Dimitris K. Fidaros, Milan Vujanović, Peter Priesching, Reinhard Tatschl, Neven Duić, Gordana Stefanović</i>	906
Porous burners for low-emission combustion: An experimental investigation <i>Christos Keramiotis, Björn Stelzner, Demosthenes Trimis and Maria Founti</i>	920

The actual exergy of fossil fuel reserves <i>Antonio Valero and Alicia Valero</i>	931
Technical study of CO ₂ capture process using DGA and mixing amines for a 350 MW power plant <i>Abigail González Díaz and José Miguel González Santaló</i>	939
Topic: Electricity transmission and the smart grid	947
Exergy analysis of an hydrogen fired combined cycle with natural gas reforming and membrane assisted shift reactors for CO ₂ capture <i>Konstantinos Atsonios, Kyriakos D. Panopoulos, Aggelos Doukelis, Antonios Koumanakos, Emmanuel Kakaras</i>	948
Smart metering and systems to support a conscious use of water and electricity <i>Carlos Alberto Fróes Lima, José Ricardo Portillo Navas</i>	961
Application of statistic methods in smart distribution grid concept <i>Goran Švenda, Seka Kuzmanović, Zoran Ovcin</i>	974
Smart grid will be a reality. For developing countries, energetic matrix, socio-cultural issues, regulatory and local development shaping outcomes, incomes and feasibility efficiency awareness <i>Carlos Alberto Fróes Lima, Gilberto De Martino Jannuzzi</i>	987
Analysis of electric and magnetic field reassuring results near power transformer station <i>Jovan T. Nicković, Radoje B. Jevtić, Katarina V. Milosavljević, Vanja P. Nicković, Vladan V. Miladinović and Dragana D. Jevtić</i>	1001
Short-term load forecasting with least square support vector machines <i>Miloš Božić, Zoran Radonjić, Dragan Tasić, Ivan Radović and Zoran Stajić</i>	1010
Topic: Fuel cells and integrated systems	1020
Integration of fuel cells and renewables into efficient CHP systems <i>Petar Sabev Varbanov, Jiří Jaromír Klemeš, Ferenc Friedler</i>	1021
Feasibility study on combined use of residential SOFC cogeneration system and plug-in hybrid electric vehicle from energy-saving viewpoint <i>Tetsuya Wakui, Naohiro Wada, and Ryohei Yokoyama</i>	1034
Numerical analysis of a PEM fuel cell performance using a tree-shaped vascular design for flow distribution <i>Daniel Lorenzini-Gutierrez, Abel Hernandez-Guerrero, Bladimir Ramos-Alvarado and Cuauhtemoc Rubio-Arana</i>	1046
Sensitivity analysis applied to the multiobjective optimization of a MCFC hybrid plant <i>Adriano Sciacovelli, Vittorio Verda</i>	1061
Numerical study of the effect of the height simple channel with straight geometry on the gases flows in a fuel cell (PEMFC). <i>M. Zeroual, S. Belkacem Bouzida and H. Benmoussa</i>	1074
3D-numerical analysis of a PEMFC flow field and comparison with traditional channeled systems <i>Isaac Perez-Raya, Abel Hernandez-Guerrero, Francisco Elizalde-Blancas, and Victor Contreras-Elizarraras</i>	1084
Topic: Coal and its use	1097
Integrating low steam demand CO shift process to coal based polygeneration energy systems: Process design and analysis <i>Fen He, Zheng Li, Pei Liu and Weidou Ni</i>	1098
Coal and char properties for high temperature entrained flow gasification <i>Alexander Tremel, Thomas Haselsteiner, Mario Nakonz, Hartmut Spliethoff</i>	1106
Analysis of the use of waste heat obtained from coal-fired units in Organic Rankine Cycles and for brown coal drying <i>Henryk Lukowicz, Andrzej Kochaniewicz</i>	1118
Diverse configurations of the boiler feed pump drive for the ultra-supercritical 900 MW steam plant <i>Katarzyna Stępczyńska, Henryk Lukowicz, Sławomir Dykas</i>	1130
Estimate of power plants feasibility for coal cocombustion with solid recovered fuel obtained from waste materials <i>Predrag Škobalj, Vuk Spasojević, Marina Jovanović, Valentina Turanjanin and Predrag Radovanović</i>	1141
Life cycle assessment for co-firing potential analysis in a pulverized coal power plant <i>Alvaro Restrepo, Raphael Guardini Miyake, Fábio Kleveston, Edson Bazzo</i>	1152
Comparative exergetic analysis of a coke and charcoal blast furnace <i>Lis Soares, Geraldo França and Angela Souza</i>	1164
A modelling evaluation of synthetic natural gas production from coal/lignite steam gasification process <i>Sotirios Karellas, Kyriakos D. Panopoulos, Jürgen Karl, Emmanuel Kakaras</i>	1175
Exergetic and environmental analyses of a pulverized coal power plant: a Brazilian case <i>Alvaro Restrepo, Raphael Guardini Miyake, Fábio Kleveston, Edson Bazzo</i>	1190
Carbon emission factor of the Kolubara basin lignite <i>Predrag Stefanović, Vukman Bakić, Vuk Spasojević, Zoran Marković, Dejan Cvetinović, Nikola Živković</i>	1202
Track 2: Energy: Systems	1211
Topic: Simulation, improvement and optimization of energy systems I: Components I	1212
Distributing the heat integration of distillation columns for air separation <i>Leen van der Ham and Signe Kjelstrup</i>	1213
Use of neural networks for modeling and predicting boiler operating performance <i>Miroslav Kljajić, Dušan Gvozdenac, Srđan Vukmirović</i>	1228

Towards a rigorous heat loss model of a rapid compression machine for the screening of auto-ignition properties of biofuels <i>Manuel Hechinger, Manuel Dahmen and Wolfgang Marquardt</i>	1237
Real gas flow simulation in damaged distribution pipelines <i>Wojciech Kostowski, Janusz Skorek</i>	1250
Pressure drop optimization in design of multi-stream plate-fin heat exchangers, considering variable physical properties <i>Fatemeh. Joda, Samira. Miryahyaie, Hamid Reza. Fallahi, Nassim. Tahouni, Mohammad Hassan. Panjeshahi</i>	1263
Consideration of variable physical properties in design of multi-stream plate-fin heat exchangers <i>Samira. Miryahyaie, Fatemeh. Joda, Hamid Reza. Fallahi, Nassim. Tahouni, Mohammad Hassan. Panjeshahi</i>	1275
Modelling and optimisation of an integrated marine combined cycle system <i>George G. Dimopoulos, Chariklia A. Georgopoulou, Nikolaos M. P. Kakalis</i>	1283
Topic: Simulation, improvement and optimization of energy systems I: Components II	1299
Gas residence time analysis for efficiency improvement of small-scale straw fired boilers <i>Borivoj Stepanov, Ivan Pešenjanski and Biljana Miljković</i>	1300
Thermal performance and pressure drop in a ceramic heat exchanger evaluated using CFD simulations <i>Deiglys Borges Monteiro and Paulo Eduardo Batista de Mello</i>	1311
Evaluation of retrofitting a conventional cooling tower into a hybrid set in an oil refinery <i>Guilherme de P. Pickler, Thomaz P. F. Borges, Márcia B.H. Mantelli, Diogo F. Isoppo</i>	1323
The analysis of steam separator regulation scheme for the 420 T/h steam generator <i>Adelaida Mihaela Duinea, Mihai Paul Mircea, Ion Mircea, Cătălin Duinea</i>	1335
Numerical investigation of heat transfer and pressure drop in finned-tube heat exchangers with different fin structure <i>Stanislav Perenčević</i>	1340
Numerical method application for thermo-mechanical analysis of hot water boilers construction <i>Dragoljub S. Živković, Dragan S. Milčić, Milan S. Banić and Miroslav M. Mijajlović</i>	1351
Experimental investigation of the performance of a minichannel evaporator <i>Mert Tosun, L.Berrin Erbay</i>	1363
Comparative study on renewal planning of alternative energy supply systems for a hospital <i>Shu Yoshida, Masahiro Inoue, Akira Okano, Koichi Ito, Yoshiharu Amano and Takumi Hashizume</i>	1372
Topic: Simulation, improvement and optimization of energy systems II: Systems fundamentals	1383
A model for energy systems optimization based on energy Hubs theory <i>Anna Stoppato and Nicola Destro</i>	1384
Superstructure-free synthesis and optimization of distributed energy supply systems <i>Philip Voll, Matthias Lampe, Gregor Wrobel, André Bardow</i>	1396
An hybrid algorithm for the synthesis/design optimization of a set of superimposed Rankine Cycles <i>Andrea Toffolo</i>	1408
Application of the EGM method to a LED-based spotlight: a constrained pseudo-optimization design process based on the analysis of the local entropy generation maps <i>Giorgio Giangaspero, Enrico Sciubba</i>	1424
Industrial decision making for energy efficiency – combining optimisation and simulation <i>Nawzad Mardan, Roger Klahr and Magnus Karlsson</i>	1442
Multi-objective investment and operating optimization of energy systems with integer cut constraints and evolutionary algorithm <i>Samira Fazlollahi, Francois Maréchal, and Benoit Beraud</i>	1453
Efficiency optimization of biomass boilers by a combined condensation - Heat pump - system <i>Babette Hebenstreit, Rosemarie Schnetzinger, Ralf Ohnmacht, Ernst Höftberger and Walter Haslinger</i>	1465
Process integration in a “food canning factory” <i>Xueqin Pan, Assaad Zoughaib, Aurélie Vuillermoz, François Luchini</i>	1478
Topic: Process design, analysis and integration of thermal and chemical systems	1491
Evaluation of the irreversibility of extractive distillation with heavy entrainer through entropy production <i>Hassiba Benyounes, Vincent Gerbaud</i>	1492
Two-dimensional fluid structure interaction of a morphed wind turbine blade <i>Piotr Krawczyk, Asfaw Beyene</i>	1505
Simulations of a fixed bed catalytic reactor for the production of methane from syngas <i>Efthymia-Ioanna Koitsoumpa, L. Griendl, S. Karellas, K. D. Panopoulos, A.Nikolopoulos, J. Karl, E. Kakaras</i>	1515
Some thermodynamic properties of water during corn drying <i>Damir Đaković, Jovan Petrović, Momčilo Spasojević</i>	1527
Experimental determination of effective diffusivities during corn drying <i>Damir Đaković, Dušan Gvozdenac</i>	1535
Alkanes as fluids in Rankine Cycles in comparison to water and benzene <i>M. Aslam Siddiqi and Burak Atakan</i>	1544

HEN design with minimal cost over an entire lifetime <i>Andreja Nemet, Jiri Jaromír Klemeš, Zdravko Kravanja</i>	1559
Empirical analysis of corporate energy management practices of energy intensive industries in Turkey <i>Seyithan Ahmet Ates, Numan M. Durakbasa</i>	1576
Optical diagnostics of the combustion process in a PFI SI boosted engine fuelled with butanol– gasoline blend <i>Cinzia Tornatore, Luca Marchitto, Gerardo Valentino, Felice E. Corcione, Simona S. Merola</i>	1595
Topic: New technologies in heat pumps, refrigeration and air conditioning I	1608
Effect of borehole array geometry and thermal interferences on geothermal heat pump system <i>Tomislav Kurevija, Vedrana Krapec, Domagoj Vulin</i>	1609
Experimental analysis of hybrid open cycle air-conditioning systems with conventional heat pumps <i>Irene Koronaki, Tinia Kakatsiou, Emmanuel Rogdakis</i>	1621
Thermoeconomic model of a commercial transcritical booster refrigeration system <i>Torben S. Ommena, Brian Elmegaardb</i>	1632
Characterization of a thermoelectric generator at low temperatures <i>Sevan Karabetoglu, Altug Sisman, Z. Fatih Ozturk and Turker Sahin.</i>	1645
Modelling, design and experimental characterization of a thermoelectric cooler <i>Sevan Karabetoglu, Turker Sahin, Altug Sisman and Z. Fatih Ozturk</i>	1654
Thermodynamic performance of a power/cooling integrated system using mid-and-low temperature waste heat <i>Liuli Sun, Wei Han, Danxing Zheng, Hongguang Jin, Yongfeng Xu</i>	1665
Topic: New technologies in heat pumps, refrigeration and air conditioning II	1685
Long-term on-site evaluation of electrical motor-driven VRF system <i>Masayuki Kiguchi, Tatsuo Nobe and Shigeki Kametani</i>	1686
Optimization of design and operating conditions of thermoelectric heat pumps <i>Benjamin David, Julien Ramousse and Lingai Luo</i>	1693
Conventional thermodynamic and advanced exergetic analysis of a refrigeration machine using a Voorhees' compression process <i>Tatiana Morosuk, George Tsatsaronis and Congyu Zhang</i>	1707
Thermodynamic analysis of an absorption-compression hybrid refrigeration cycle for distributed energy utilization <i>Danxing Zheng, Xuelin Meng, Xianghong Wu</i>	1723
Condition monitoring and analysis for operational management of air conditioning units by gas engine heat pumps <i>Ryohei Yokoyama, Takanori Itoyama and Tetsuya Wakui</i>	1732
CFD simulation of leak in residential HVAC ducts <i>Samir Moujaes, Radhika Gundavelli</i>	1742
Exergetic analysis of passive desiccant wheels <i>Nóbrega Carlos Eduardo, Brum Nisio Carvalho</i>	1752
Performance of desiccant cooling cycle under specific atmospheric conditions <i>Nóbrega Carlos Eduardo, Sphaier Leandro Alcoforado</i>	1761
Topic: Decentralized energy systems, diagnostics and control of energy systems	1769
Micro-generators: The prospects for combined heat and power systems on a domestic scale <i>Geoffrey P Hammond and Adam Titley</i>	1770
What is profitable dispersed generation? <i>Vesselin Chobanov</i>	1785
Study of an innovative micro-CHP system fuelled by LPG <i>Caterina Brandoni, Massimiliano Renzi, Alessia Arteconi and Carlo Maria Bartolini</i>	1794
Potentials of fuel cells as μ -CHP systems for domestic applications in the framework of energy efficient and sustainable districts <i>George Vourliotakis, Dimitrios Giannopoulos and Maria Founti</i>	1808
Investigation on remote control operating status of VRF air- conditioning system <i>Hiroyuki Arai, Tatsuo Nobe, Toshiaki Oda</i>	1819
An application for induction motor fault detection based on vibration analysis and support vector machines <i>Željko Kanović, Zoran Jeličić, Milan Rapačić, Boris Jakovljević and MilenaPetković</i>	1827
Fuzzy-genetic robust fluidized bed combustion control <i>Žarko Čojbašić, Vlastimir Nikolić, Ivan Ćirić</i>	1837
Energy saving in the power plants using automatic control <i>Novak N. Nedić, Vojislav Ž. Filipović, Saša Lj. Prodanović</i>	1843
Review of developments in bilinear systems modelling and control for efficient energy utilization on industrial plant <i>Keith J. Burnham, Ivan Zajić and Tomasz Larkowski</i>	1856

Topic: Energy and buildings I	1871
Optimization of energy efficiency and thermal comfort for residential buildings in Salamanca Mexico <i>Danielle Griego, Moncef Krarti and Abel Hernández-Guerrero</i>	1872
Phase change material cool storage in a Swedish passive house <i>Johannes Persson, Mats Westermark</i>	1884
Computational analysis of the envelope parameters effects on the transient heating energy consumption of buildings <i>Christos Tzivanidis, Kimon A. Antonopoulos, Foteini Gioti</i>	1894
Improvement the Winter space heating by the effect of rotating thermal wall storage <i>M. Moghiman, M. Hatami, M. Boghrati</i>	1909
Residential power demand prediction and modelling <i>Matteo Muratori, Vincenzo Marano, Ramteen Sioshansi, Matthew C. Roberts</i>	1915
Assessment of policy and technical needs for successful municipal energy efficiency planning <i>Ilija Sazdovski, Verica Taseseka, Nataša Markovska, Strahinja Trpevski</i>	1927
Influence of different internal blind on thermal comfort: a new method for calculating the mean radiant temperature in office spaces <i>Francesco Frontini</i>	1937
A novel integrated exergetic approach for the optimization of building conditioning systems <i>Ekaterina Cheremnykh, Marta Cianfrini, Enrico Sciubba, Claudia Toro</i>	1948
Environmental aspects of formation of green roofs in urban areas <i>Marija Stamenković, Goran Vučković</i>	1966
Topic: Energy and buildings II	1972
Influence of additional storey construction to space heating of a residential building <i>Milorad Bojić, Marko Miletić, Jovan Malešević and Slobodan Djordjević</i>	1973
CFD modelling of fire protection system in office building <i>Žana Ž. Stevanović, Marija Živković, Nikola Mirkov</i>	1987
MEC: A new relative method for heat flux sensor calibration. <i>Aurélien P. Jean, Craig Adams, Mario A. Medina, Frédéric Miranville</i>	1998
Numerical evaluation of the degree of phase change materials exploitation in building passive solar heating and cooling <i>Christos Tzivanidis, Kimon A. Antonopoulos, Eleytherios D. Kravvaritis</i>	2007
Optimal scheduling of low carbon investment decisions for a social housing refurbishment case study <i>Mark Jennings, David Fisk, Nilay Shah</i>	2023
Multi-criteria approach to the increase of energy efficiency of the residential object <i>Živko Ralić, Jasmina Vesić Vasović, Stojan Vasović, Miroslav Radojičić</i>	2036
Topic: Energy and buildings III - Envelope	2047
On the development of computational models for the integrated simulation of buildings thermal behaviour: focusing on the phase change material effect <i>Marianna Stamatiadou, Dimitris Katsourinis, Maria Founti</i>	2048
Energy savings and occupant comfort studies for a conditioned open plan office building <i>Kiran Kumar DEVS, Ramachandraiah Alur, Rajasekar Elangovan</i>	2060
Benefits of thermal retrofitting of residential buildings <i>Daniela Popescu, Irina Bliuc</i>	2071
Decreasing energy consumption in thermally non-insulated old house via refurbishment <i>Milorad Bojić, Andreja Stefanović</i>	2078
Mathematical model for the simulation of cumulative emissions generated by energy management of complex buildings <i>Krzysztof Hoinka, Andrzej Ziębik</i>	2092
Passive cooling methods for shopping malls buildings in Nis climate <i>Olivera Ilić, Aleksandar Jovanović, Miloš Đelić</i>	2102
Day lighting in student dorms and recommendations for sustainable design <i>Aleksandar Jovanović, Olivera Ilić, Jovana Milić, Miloš Đelić</i>	2108
CasaB2: A sustainable architecture design for the Mediterranean climate region <i>Giovanni D'Amico, Fabrizio Russo, Marco Giardina</i>	2115
Urban aspects of improving energy efficiency in buildings <i>Petar Mitković, Jelena Đurić</i>	2127
Energy, exergy, CO2 emission, and economic comparison between low temperature radiant panel systems and radiator systems <i>Dragan Cvetković, Milorad Bojić</i>	2137
Topic: Water desalination and treatment	2149
Thermoeconomic analysis of a MED-TVC desalination system coupled to a simple cycle power plant <i>Amirali Dolatshahi, Kambiz Ansari, Arash Saffari</i>	2150

Energy and exergy analysis of the different configurations of a reverse osmosis desalination plant in Gran Canaria Hosam Sakr, Ana M. Blanco-Marigorta	2161
Solidification of a binary mixture: cooling from above Aroussia Jaouahdou; Mohamed Jomaa Safi; Hervé Muhr	2173
Process integration of a water treatment plant with a new modelling approach Bachir Abou-Khalil, Jean-Pierre Levasseur	2180
Energy consumption related to shear stress for membrane bioreactors used for wastewater treatment N. Ratkovich, T.R. Bentzen, P.R. Bérubé, N. Heinen and M. R. Rasmussen	2195
Track 3: General Topics in Energy	2207
Topic: Transport energy and emissions	2208
Traffic environmental influence assessment in Serbia Vladimir D. Đorić, Jadranka J. Jović	2209
Analysis of the fuel economy improvement potential of ethanol hybrid buses Martina Wikström, Anders Folkesson, Per Alvfors	2220
Local traffic intensity influence on air quality in Niš Predrag Živković, Mladen Tomić, Gradimir Ilić, Mića Vukić, Žana Stevanović, Petar Đekić, Ivica Minić	2230
Transport as a threat to sustainable development IlsaValois, Elizabeth Cartaxo, Jamal Chaar	2239
Transient Organic Rankine Cycle modelling for waste heat recovery on a truck Nicolas Espinosa, Ignacio Gil-Roman, Damien Didiot, Vincent Lemort, Benoit Lombard and Sylvain Quoilin	2247
Balance of the CO ₂ emission on the corridor X through Serbia and proposals for remediation of the part of the emission applying transportation-logistics systems Ilija Tanackov, Jovan Tepić, Gordan Stojić, Siniša Sremac and Dragan Simić	2268
Fundamental analysis on energy consumption and environmental impact of electric Vehicles in consideration of using fast battery chargers Ryohei Yokoyama and Nobuyuki Akiba	2277
Exhaust heat recovery Rankine system for passenger cars: modelling and design Yulia Glavatskaya, Vincent Lemort, Pierre Podevin, Osoko Fredy Shonda, Robert YU	2288
Applying methods to reduce rail wear in the railway systems for environmental protection Jovan Tepić, Milan Kostelac, Gordan Stojić, Ilija Tanackov and Siniša Sremac	2303
Topic: Mining and drilling and manufacturing	2315
Sustainable development of exploitation and use of coal in the countries of the EU (Slovenia) and South-eastern Europe (Serbia) Milan Medved, Ivica Ristović, Milivoj Vulić	2316
Energy optimization in the Premogovnik Velenje (Velenje coal mine) Milan Medved, Ivica Ristović, Janez Rošer, Milivoj Vulić	2325
Study of Istrian unmineable coal utilization Mario Klanfar, Domagoj Vulin, and Želimir Veinović	2336
Exergy mapping of materials Processing: Material separation in a manufacturing case study Michael Schwindel, Bill Young, Tom Henninger,	2349
Clean manufacturing technologies: Water jet cutting case study and a review Predrag Janković, Dragica Milenković	2358
The impact of UK Government industrial energy efficiency research, development and demonstration programmes Paul Griffin, Geoffrey P. Hammond, Kok Rong Ng, and Jonathan Norman	2368
Energy analysis and environmental impact of marble quarrying and processing A. Gazi, G. Skevis, M.A. Founti	2383
Actualities in mining and mineral processing in Serbia Ljubiša Andrić, Nadežda Čalić, Vladimir Andrić	2395
Topic: Energy storage	2402
Thermoeconomic analysis of a solar enhanced energy storage concept based on thermodynamic cycles Samuel Henchoz, Florian Buchter, Daniel Favrat, Matteo Morandin and Mehmet Mercangözü	2403
Thermoelectric energy storage with transcritical CO ₂ cycles Mehmet Mercangözü, Jaroslav Hemrle, Lilian Kaufmann, Florian Buchter, Christian Ohler	2416
Optimal operation of heat storage systems with variable temperature tanks for district heating network Sergio Rech, Andrea Toffolo, Andrea Lazzaretto	2430
Dynamics of steam accumulation Vladimir Stevanović, Blaženka Maslovarić, Sanja Prica	2445
Numerical analysis of a medium scale latent energy storage unit for district heating systems Francesco Colella, Adriano Sciacovelli, Vittorio Verda	2455

Study of pumped storage schemes to support high RES penetration in the electric power system of Greece <i>John S. Anagnostopoulos and Dimitris E. Papantonis</i>	2469
Conceptual design of a thermo-electrical energy storage system based on heat integration of thermodynamic cycles – Part A: methodology and base case system configuration <i>Matteo Morandin, François Maréchal, Florian Buchter, Mehmet Mercangöz</i>	2481
Conceptual design of a thermo-electrical energy storage system based on heat integration of thermodynamic cycles – Part B: studying alternative system configurations <i>Matteo Morandin, François Maréchal, Florian Buchter, Mehmet Mercangöz</i>	2497
Efficiency of compressed air energy storage <i>Brian Elmegaard</i>	2512
Topic: Energy planning	2524
The impact of the EU ETS on the corporate value of European electricity corporations <i>Jian-Lei Mo, Lei Zhu and Ying Fan</i>	2525
Hybrid artificial neural network system for short-term load forecasting <i>Slobodan Ilić, Aleksandar Erdeljan, Filip Kulić, Srđan Vukmirović</i>	2538
The growth of bioenergy in the Brazilian midwest region <i>Eduardo Mirko V. Turdera</i>	2547
Improving the RES absorption capacity of the Macedonian energy system <i>Boris Ćosić, Nataša Markovska, Verica Taseska, Goran Krajačić, Neven Duić</i>	2556
A novel graphical approach to target CO2 emissions for energy resource planning and utility system optimization <i>Mohammad A. Al-Mayyahi, Andrew F. A. Hoadley, and G. P. Rangaiyah</i>	2565
Long term energy demand projections for Croatian transport sector <i>Tomislav Puksec, Brian Vad Mathiesen, Neven Duić</i>	2576
Extended exergy accounting applied to the Turkish society 2006 <i>Candeniz Seckin, Enrico Sciubba, Ahmet Bayulken</i>	2588
Efficient use of energy and resource in Albanian breweries <i>Luljeta Xhaqolli, Entela Pinguli, Gentian Hyka, Elibjonda Gjergjindreaj, Jozefita Marku</i>	2603
Topic: Energy economics	2615
Feasibility of natural gas supply from Russia to Korea <i>Ekaterina Zelenovskaya, Ki Ryun Choi</i>	2616
Managing energy costs in water distribution systems <i>Dušan Kostić, Ljiljana Janković, Nemanja Branislavljević, Zorana Naumović, Marko Ivetić</i>	2631
Financial measures Serbia should offer for solar hot water systems <i>Sanja Stevanović and Mila Pucar</i>	2644
Waste building materials and their usage in the production of pozzolanic mortars <i>Snežana Pašalić, Snežana Vučetić, Dmitar Zorić, Vilma Ducman and Jonjaua Ranogajec</i>	2655
An economic perspective on small-scale cogeneration systems optimisation <i>Ana C.M. Ferreira, Manuel L. Nunes, Senhorinha F.C.F. Teixeira, Celina P. Leão, Ângela M. Silva, José C.F. Teixeira, Luís A. S. B. Martins</i>	2665
Thermoeconomics and industrial symbiosis. effect of by-product integration in cost assessment <i>Sergio Usón, Antonio Valero, Andrés Agudelo</i>	2676
International institutions accession funds in financing projects in sustainable agriculture <i>Radovan Pejanović, Stanislava Delić</i>	2688
Topic: Life cycle assessment and environmental impact of energy systems	2700
Environmental flow in Bosnia and Herzegovina - tool for hydropower environmental impacts management <i>B. Vučijak, E. Kupusović, N. Smolar-Žvanut, F. Antonelli</i>	2701
Emission rates of formaldehyde and acetaldehyde in natural gas confined flames with OEC application <i>Alex Álisson Bandeira Santos, Pedro Afonso de Paula Pereira, Ednildo Andrade Torres</i>	2713
LCA, conventional and advanced exergoenvironmental analysis applied to a combined cycle power plant <i>Fontina Petrakopoulou, George Tsatsaronis, Tatiana Morosuk and Christopher Paitazoglou</i>	2721
PEVs market penetration and impact on fuel taxes <i>Matteo Muratori, Vincenzo Marano, Giorgio Rizzoni</i>	2732
Reduction of environmental impact using exergy-based methods <i>Tatiana Morosuk, George Tsatsaronis and Christopher Koroneos</i>	2745
Refrigerant emissions and leakage prevention across Europe – results from the REAL SKILLS EUROPE project <i>Irene Koronaki, Karsten Beerman, Issa Chaer, David Cowan, Grzegorz Gontarz, Kristina Kaar, Graeme Maidment, Walter Reulens and Rosa Christodoulaki</i>	2756
Uncertainty analysis in life-cycle GHG emissions and energy efficiency of bioethanol replacing gasoline <i>João Malça and Fausto Freire</i>	2769

Life cycle assessment of palm oil biodiesel addressing land use and land use change rica Castanheira and Fausto Freire	2780
The material-energy binomial in epicenter of eco-design. The case of materials for the "Glina" bottled water Gerta Veliu , Shpresa Caslli	2790
Dynamic modeling of air pollution and acid rain from energy system and transport in Kosovo Skender Kabashi, Sadik Bekteshi, Albert Jonuzaj and Aleksander idansek	2803
Radon measurements in the Obiliq thermal power plant and buildings in its vicinity Sadik Bekteshi, Aleksander idansek, Skender Kabashi, Sehad Kadiri, G zim Hodolli, Besim hafa, Fisnik Aliaj	2824
Environmental impact assessment of small hydropower plants Sanda Midžić-Kurtagić, Tarik Kupusović, Nijaz erem, Irem Silajdžić	2829
Topic: Nuclear power	2841
Small modular reactors: simpler, safer, cheaper? Jasmina Vujić, Ryan Bergmann, Radek koda and Marija Miletić	2842
Self-sustaining thorium boiling water reactors Francesco Ganda, Jasmina Vujić, and Ehud Greenaspan	2853
The method of differential cross for detecting boarders between physical zone for neytron transport methods Oksana Yu. Poveschenko	2863
An innovative pool with a passive heat removal system Damiano Vitale Di Maio, Antonio Naviglio, Fabio Giannetti, Fabio Manni	2873
Comparative analysis of environmental impact of various energy sources Versus nuclear power Jasmina Vujić, Dragoljub P. Antić and orka Vukmirović	2885
Analysis of Russian nuclear energy scenarios in the context of sustainability development Lyudmila Andreeva-Andrievskaya, Elena Poplavskaya, Valery Korobeynikov and Alexander Egorov	2900
Conversion coefficients for age dependent ORNL phantoms from natural radioactivity in soil as a source of external exposure Dragana Krstić and Dragoslav Nikezić	2912
Topic: Cogeneration, CHP and district heating I	2916
A Method to determine the power to heat ratio, the cogenerated electricity and the primary energy savings of cogeneration systems after the European directive Christos A. Frangopoulos	2917
Energy efficiency of a district heating system and its possible improvements Andrej Ljubenko, Alojz Poredoš	2935
Optimal coefficient of the share of cogeneration in district heating systems Andrzej iebik, Pawe/ G/adyasz	2945
Thermoeconomic analysis of a micro-CHP installation in a tertiary sector building through transient simulation Ivaro Campos Celador, Estibaliz Pérez Iribarren, José Mar a Sala Lizarraga, and Luis Alfonso del Portillo Valdés	2958
Combined heat and power in Mashhad power plant Ramin Danesfaleh, Mehdi Sharif	2972
Optimal synthesis and operation of advanced energy supply systems for standard and domotic home Dario Buoro, Melchiorre Casisi, Piero Pinamonti, Mauro Reini, and Paolo Sartori	2984
Topic: Cogeneration, CHP, and district heating II	2997
Allocation of economic costs in trigeneration systems at variable load conditions Miguel A. Lozano, Luis M. Serra and Monica Carvalho	2998
Emissions of greenhouse gases from public district heating plants of Republic Serbia Predrag Stefanović, oran Marković, Vukman Bakić, Dejan Cvetinović, Valentina Turanjanin, Marina Jovanović	3014
The impact from building heating system improvements on the primary energy efficiency of a district heating system with cogeneration Per-Olof Johansson, Patrick Lauenburg and Janusz Wollerstrand	3022
Exergy and energy analysis of low temperature district heating network Hongwei Li, Svend Svendsen	3034
Exergy and thermoeconomic evaluation of a refinery utilities plant Julio A. Mendes da Silva, Cl udio Plaza Pinto, Cl udio Rucker, Silvio de Oliveira Junior	3046
Quantifying the reduction of irreversibility of a cogeneration system, by simulating changes in the steam generator and steam turbine Augusto S nchez, Rodolfo Herreras	3059
Mashad trigeneration potential- an opportunity for CO2 abatement in world's greatest mosque Sahand Behboodi and Hossein Rabiei	3069
Potential CO2 reduction by increased integration of absorption cooling in a Swedish district energy system Elsa Fahlén, Louise Trygg, Erik Ahlgren	3081
Evaluation method for the rehabilitation of district heating systems based on cogeneration Liviu Ruieneanu, Ion Mircea, MihaiMircea and Adelaida Duinea	3095

Introduction of absorption cooling process in CHP systems – An opportunity for reduction of global emissions of CO2 <i>Danica Đurić Ilić, Louise Trygg</i>	3105
Assessment of community energy supply systems using energy, exergy and exergoeconomic analysis <i>Audrius Bagdanavicius, Nicholas Jenkins, Geoffrey Hammond</i>	3117
Track 4: Renewable Energy	3131
<hr/>	
Topic: Sustainability and social impacts of energy systems	3132
The Fossil trace of CO2 emissions in energy systems <i>Andrés Agudelob, Antonio Valero, Sergio Usón</i>	3133
Reduction of the CO2 emission in the co-combustion process of solid recovery fuels with pulverized lignite in power plants in Serbia <i>Nikola Živković, Predrag Radovanović, Vukman Bakić, Milada Pezo and Vlado Šimšić</i>	3149
The sustainability of LNG evaporation <i>Lydia Stougie and Hedzer van der Kooi</i>	3157
Thermoeconomic and environmental guidelines for trigeneration projects in the Brazilian Amazon <i>Ricardo Wilson Cruz, Luis M. Serra and Miguel Angel Lozano</i>	3171
Energy consumption and happiness in nations <i>Aleksander Zidanšek, Ivo Šlaus</i>	3183
Applications of underwater radar <i>Uroš Puc, Andreja Abina, Anton Jeglič, Aleksander Zidanšek</i>	3190
Intellectual property protection and biodiesel <i>Marina Jovičević Simin, Radovan Pejanović,</i>	3194
Topic: Solar integrated systems and components	3200
Status of solar photovoltaic power engineering in the Republic of Serbia <i>Dušan Ž. Đurđević</i>	3201
Design and dynamic simulation of a novel solar trigeneration system based on photovoltaic/thermal collectors <i>Francesco Calise, Massimo Dentice d'Accadia, Laura Vanoli</i>	3213
Exergy budget of solar collector: Thermal vs. photovoltaic <i>Michel Pons</i>	3232
Design and dynamic simulation of a novel polygeneration system fed by vegetable oil and by solar energy <i>Francesco Calise, Adolfo Palombo, Laura Vanoli</i>	3244
Cabinet size solar dryer design for multiple ingredient drying with high heat capacity material and phase change material based automatic temperature control <i>Raghib Jamal, Shilpa Choudhary, Sanjay Kumar, Sangeeta Sinha and Hiroaki Mochizuki</i>	3261
Development of an embedded solar tracker using MCU <i>Seung Jin Oh, Yoon Joon Lee, Sang Woong Sin, Wongee Chun</i>	3269
Modeling and simulation of a hybrid PV/thermal collector <i>Enrico Sciubba, Claudia Toro</i>	3276
Topic: Solar thermal collectors, power and solar PV	3289
Prospects for renewable electricity production in Libya, using parabolic trough solar thermal generation <i>Abdussamad Emhameda and Steve Reynolds</i>	3290
Optimal concentration and temperatures of solar thermal power plants <i>Ronan K. McGovern, William J. Smith</i>	3301
Model to simulate and design the power block cycle of a solar tower plant <i>Consuelo Sánchez and Antonio Rovira</i>	3315
Design optimization of a Stirling solar driven system <i>Michel Feidt, Antoine Mathieu, Pierre-Olivier Martin, David Gualino and Benoît Grappe</i>	3327
Optimal design and operation of a volumetric solar-thermal energy receiver and storage <i>Amin Gobeity, Enrique Lizarraga-Garcia a and Alexander Mitsos</i>	3336
Modeling spectral matching in two- and four- terminal thin-film silicon tandem solar cells <i>Steve Reynolds, Vladimir Smirnov and Kaining Ding</i>	3346
Energy effectiveness of photovoltaic modules <i>Stefka Nedeltcheva, Vesselin Chobanov</i>	3358
Zero CO2 emission SOLRGT system <i>Chending Luo, Na Zhang</i>	3368
Mathematical model for determining the irradiated area of the lower absorber surface of the double exposure flat-plate water solar collector <i>Novak Nikolić, Nebojša Lukić</i>	3401
Topic: Energy and buildings IV: Renewable energy	3414
Numerical simulation of energy consumption optimization in residential buildings in Belgrade <i>Valentina Turanjanin, Olivera Ećim-Đurić, Biljana Vučićević, Miroslava Kavgić, Marina Jovanović</i>	3415

Parametric analysis of geothermal residential heating and cooling application <i>Zoi Sagia, Athina Stegou-Sagia and Constantinos Rakopoulos</i>	3425
Hybrid energetic supply model for a public university building <i>Rafael de Souza Toledo, Luiz Felipe de Araujo Bastos, Eduardo Rafael Barreda del Campo</i>	3437
Photovoltaic and solar thermal energy conversion in a multifunctional facade <i>Christoph Zauner, Bernd Windholz, Hermann Schranzhofer, Klaus Lutschounig, Marcus Rennhofer, Mario J. Müller and Wolfgang Streicher</i>	3450
Thermodynamic behavior of a passive solar residential building With a greenhouse and thermo-accumulative concrete partition wall <i>Jasmina Radosavljević, Ljiljana Živković, Amelija Đorđević, Nenad Živković, Emina Mihajlović, Miomir Raos</i>	3461
Topic: Biomass energy I: General	3477
Assessment of biodiesel energy sustainability Using the exergy return on investment concept <i>Emilio Font de Mora, César Torres and Antonio Valero</i>	3478
Study on energy and ecological effects of substituting petroleum-derived start-up & backup fuels with glycerol and tall oil <i>Jaroslav Zuwala</i>	3488
Integration Feasibilities for gas turbines in biofuel production <i>Martin Görling, Mats Westermark</i>	3498
Bioenergy and bioproducts from Forest biomass hemicellulose <i>Lew P. Christopher</i>	3509
20 MWel biomass power plant „Koprivnički Ivanec“ in Croatia designed to achieve integrated prevention and control of pollution <i>Živko Ilijevski, Ivica Zavrski, Petra Kitarović, Aleksandra Anić Vučinić, Zvonimir Krapinec, Filip Kelava</i>	3524
Experimental determination thermo physical characteristics of balled biomass <i>Aleksandar Erić, Dragoljub Dakić, Stevan Nemoda, Mirko Komatina andBranislav Repić</i>	3538
Thermodynamic properties of second generation biofuels: Densities and excess volumes of binary mixtures containing 1-butanol <i>Geraldine A. Torin-Ollarves, José J. Segovia, M. Carmen Martín, Miguel A. Villamañán, César R. Chamorro</i>	3550
Topic: Biomass energy II: Conversion processes	3558
Co-production of hydrogen and electricity from lignocellulosic biomass: process design and thermo-economic optimization <i>Laurence Tock and François Maréchal</i>	3559
Mechanical pre-treatment to enhance anaerobic digestion process: overview <i>Fatma Alfarjani, Ayad Mohamed, Khaled Benyounis, and Abdul Olabi</i>	3573
Multi-objective screening of biorefining processes in the early design stage by reaction network flux analysis <i>Anna Voll and Wolfgang Marquardt</i>	3583
Application of mechanical pre-treatment to produce methane from maize <i>Ayad Mohamed, Fatma Alfarjani, Khaled Benyounis, Tim Prescott and Abdul Olabi</i>	3595
The ways to improve the economy of bioethanol production in Serbia <i>Ljiljana Mojović, Dušanka Pejin, Marica Rakin, Jelena Pejin, Maja Vukašinić-Sekulić, Svetlana Nikolić and Siniša Markov</i>	3603
Numerical investigation of a swirled flame model combustor fed with pyrolysis gas <i>Andrea De Pascale, Marco Fussi, Antonio Peretto and Roberta Vecci</i>	3615
Syngas for methanol production from palm oil biomass residues gasification <i>AntonioBula, Jorge Mendoza, Rafael Gomez</i>	3630
Topic: Biomass energy III: Combustion, gasification and co-firing	3641
Combined hydrothermal carbonization and gasification of biomass with CCS <i>Berit Erlach, Benjamin Harder, George Tsatsaronis</i>	3642
Parametric analysis of biomass gasification installation integrated with a combustion engine <i>Janusz Kotowicz, Aleksander Sobolewski, Tomasz Iluk</i>	3658
Integration of biomass gasification with a Scandinavian mechanical pulp and paper mill <i>Johan Isaksson, Maryam Mahmoudkhani, Anders Åsblad and Thore Berntsson</i>	3668
Determining the rate of biobriquette combustion <i>Emina Mihajlović, Jasmina Radosavljević, Nanad Živković,Amelija Đorđević, Sveta Cvetanović, Ljiljana Živković, Miomir Raos</i>	3680
Co-pyrolysis characteristics and kinetics of plastic waste with biomass waste <i>Murat Kilic, Ayşe E. Pütün, Ersan Pütün</i>	3689
Co-pyrolysis of oil shale and biomass <i>Murat Kilic, Zakir Poyraz, Ayşe E. Pütün, Ersan Pütün</i>	3698
Estimation of greenhouse gases (GHG) emissions in the course of biomass co-firing in CHP plant by means of LCA (Life Cycle Assessment) methodology <i>Jaroslav Zuwala, Andrzej Ziebik</i>	3705
Greek lignite / cardoon co-firing: from cultivation to combustion trials <i>Emmanouil Karampinis, Aaron Fuller, Fabio Sissot, Panagiotis Grammelis, Joerg Maier, Fabrizio Rossi, Günter Scheffknecht, Mario Krautz, Emmanuel Kakaras</i>	3719

Topic: Renewable energy systems	3733
Adaptive wind power plant with double fed induction generator <i>Andrey Mazalov</i>	3734
A structural model of the Mura depression - an area with great geothermal potential <i>Bojana Božiček, Peter Novak, Goran Vižintin</i>	3747
Dynamical simulation of PV/Wind hybrid energy conversion system <i>Vukman Bakić, Milada Pezo, Žana Stevanović, Marija Živković</i>	3759
Thermodynamic analysis, performance numerical simulation and losses analysis of a low cost Stirling engine V-type, and its impact on social development in remote areas <i>W. Arias, H.I. Velásquez, D. Florez and Oliveira Junior S</i>	3767
Comparative study of the power production and noise emissions impact from two wind farms <i>Christos Chourpouladis, Eleni Ioannou, Andreas Koras and Anestis I. Kalfas</i>	3779
Analysis of the use renewable energy at commercial and residential sectors of Mexico <i>Augusto Sanchez Cifuentes and Sergio Quezada García</i>	3797
Topic: Recycling and waste management	3807
Integration and management of renewables into total sites with variable supply and demand <i>Petar Sabev Varbanov, Jiří Jaromír Klemeš</i>	3808
Improvement of greenhouse energy efficiency by dynamic modelling of geothermal heating energy storage tank <i>Olivera Ecim-Đurić, Predrag Milanović, Miloš Jelić</i>	3821
Exergy assessment of recovery solutions from dry and moist gas available at medium temperature <i>Fadhel Ayachi, Nathalie Mazet, Pierre Neveu, Elias Boulawz, Assaad Zoughaib, Guillaume Cardon</i>	3831
Bio-syngas as fuel in steel industry's heating furnaces – a case study on feasibility and CO2 mitigation effects <i>Maria T Johansson, Mats Söderström</i>	3842
Cost evaluation of Organic Rankine Cycles for low temperature geothermal sources <i>Andrea Lazzaretto, Andrea Toffolo, Giovanni Manente, Nicola Rossi and Marco Paci</i>	3854
Allocation of wastes in thermoeconomic analysis <i>Andrés Agudelo, Antonio Valero, César Torres</i>	3869
The application of a multi-parameter analysis in choosing the location of a new solid Waste landfill <i>Igor Milošević, Zorana Naunović</i>	3883
Evaluation of the economic viability of waste from ceramic brick and tile industry in the production of historic pozzolanic materials <i>Vladislav Zekić, Jonjaua Ranogajec, Miroslava Radeka, Nedeljko Tica, Zoran Bačkalić, Dragan Milić</i>	3899
Improvement analysis of waste management process in Lucani region, Serbia <i>Neda Nikolić, Snežana Dragičević, Jasmina Vesić Vasović</i>	3906
Potential of municipal solid waste for reduction of GHG emissions and energy production in Croatia <i>Daniel Rolph Schneider, Mislav Kirac, Andrea Hublin</i>	3917
Life cycle assessment of municipal solid waste management: Case study of Niš, Serbia <i>Gordana Stefanović, Dušan Marković</i>	3930
Anaerobic digestion of municipal solid waste from biogas production: A general review <i>Ana Luković, Srđan Glišović, Miomir Stanković, Velimir Stefanović</i>	3938
Author Index	3950
Keyword Index	3954

Sustainable energy development the need of modern society

Naim H. Afgan

Building performance simulation for sustainable buildings and zero energy settlements and cities

Marija S. Todorović

In which manner the thermal behaviour of human body is copied in buildings – similarities and differences in thermal reactions

Branislav Todorović

Numerical method application for thermo-mechanical analysis of hot water boilers construction

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Abstract:

Paper presents application of the Finite Elements Method for stress and strain calculation of the hot water boiler's structure. Goal of the work was to investigate influence of the boiler scale to the thermal stresses and strain in the structure of the hot water boilers. Results show that maximum thermal stresses appear in the zone of the pipe carrying wall of the first heat diverting chamber. This indicates that most critical parts of the boiler are weld spots of the smoke pipes and pipe carrying plate, what in the case of the huge boiler scale can lead to the cracks in the welds and water leaking from the boiler. The results for two cases, the first one with temperature dependent material characteristics and the second one for the average temperature material characteristics, are compared. In order to minimize deformations and stresses, the stiffness of the rear head can be increased by increase of its thickness or by fixing stiffening girders on it. Stresses in the rear head can also be diminished by reconstruction of the flame tube supporting element.

As a reference object boiler Viessmann - Vitomax 200 HW, with installed power of 18.2 MW has been used. CAD modelling is done within Autodesk Inventor and stress and strain analysis is done within ANSYS Software.

Keywords:

Hot water Boiler, Thermal analysis, Finite Elements Analysis

1. Introduction

The paper presents application of finite elements analysis (FEA) on stress and strains analysis of hotwater boiler. The results of calculation show that extreme values of thermal stresses and strains appear in the zone of pipe carrying wall in the first heating chamber. These results imply that welded joints of smoke pipes and pipe carrying wall in the first heating chamber are the most affected parts; adding the fact that huge amount of boiler scale delivers appearance of hot/cold cracks on joint and leakage of boilers water [1,2].

Damaged places on hotwater boilers can appear as a consequence of various destructive mechanisms – in the most of cases several mechanisms act simultaneously. Since damage appearing depends from various parameters of the boiler itself (design, boiler working conditions, work medium, properties of work medium etc.) it is necessary to decompose complete system to components and work medium and investigate them separately and in detail in order to get a clear picture on real conditions of the boiler. Real assessment (about usability and life span) is real only when part-analysis is detailed and gives complete and clear glance on the effect of work.

Stress and strain analysis of the construction requires in depth analysis of its exploitation, loads and behavior while working. The main goal of the analysis is to find qualitative, complex identification of work states (function / non functional / partially functional) a behavior in determined state. This

can be achieved only with development and application of numerical and experimental methods, and advanced methods for monitoring and diagnostic of behavior of construction. Furthermore, real time monitoring of exploitation and measuring of the relevant parameters behavior is a necessity in realization of the tendered goal.

The basic task of condition diagnostics and equipment behavior represents consequence-behavior and cause – consequence analysis, as well as the cause – equipment affection analysis with a goal to find optimal solutions that will provide construction / system work normally, safely, reliably, as long as it is possible with the decrease of maintenance costs.

The main purpose of this paper is to present the goal-tending analysis of a hotwater boiler: to find the most effective changes in design of the boiler to get maximal increase of the strength in the area of pipe carrying wall in the first heating chamber. For that purpose, numerical simulations for the different parameters (variable pipe diameters, ribs application etc.) are conducted on a referent model of known parameters and recognized behavior.

Referent object is the hotwater boiler Viessmann - Vitomax 200 HW M238 , of the heat power 18.2 MW. For stress and strain analysis is used Ansys Software and full FEA analysis.

2. Technical characteristics of the - Viessmann hot water boiler Vitomax 200 HW

Vitomax 200 HW (Figure 1) is an oil or gas fired high-pressure hot water boiler for permissible flow temperatures up to 205°C and permissible operating pressures of 6.5 to 25 bar – i.e. a standard boiler for district heating and industrial applications.

The Vitomax 200-HW benefits at a glance:

- High level of operational reliability and a long service life are assured through wide water galleries and wide spaces between hot gas pipes. The clearance between hot gas pipes exceeds the minimum requirements of the applicable current (national) directives. This results in Viessmann boilers achieving the maximum permissible test periods. In addition, the large water content provides excellent natural circulation and a reliable heat transfer under all operating conditions.
- Three-pass boiler for clean combustion with low nitrogen oxide emissions.
- Economical energy consumption – boiler efficiency without Eco up to 92 %. Substantial increase in the boiler efficiency right into the condensing range through flue gas/water heat exchangers downstream of the boiler.
- Low radiation losses through 120 mm thick composite insulation and insulated flue gas collector.
- Approval according to the European Pressure Equipment Directive 97/23/EC or according to country-specific regulations.
- Low pressure drop on the hot gas side through convection heating surfaces with generously sized hot gas pipes.
- High level of serviceability through water-cooled reversing chambers without firebrick lining – large cleaning doors.
- Removable burner trolley for boilers up to 2500 kW available as accessory for easier maintenance and simplified burner adjustment.
- Walk-on cover on top of the boiler as part of the standard delivery – this simplifies the installation and maintenance and protects the thermal insulation against accidental damage.
- An intermediate flow piece for the integration of measuring, control and safety fittings is part of the standard delivery.
- The Vitocontrol control panel enables the regulation of all boiler-specific control equipment. In addition, suitable components provide operation without need for permanent supervision, a fully

automatic boiler operation with 24 or 72 hour supervision-free operation in accordance with country-specific conditions.

Table 1 - Mechanical properties of the steel St35.8

Property	Value
Elasticity module	$2.1 \cdot 10^{11} \text{ N/m}^2$
Poison ratio	0.3
Specific density	7850 kg/m^3
Linear expansion of material	$12.5 \cdot 10^{-6} \text{ 1/}^\circ\text{C}$
Yield strength	$206.8 \text{ MPa (N/mm}^2\text{)}$

Table 2 - Mechanical properties of the steel P265GH

Property	Value
Elasticity module	$2.1 \cdot 10^{11} \text{ N/m}^2$
Poison ratio	0.3
Specific density	7800 kg/m^3
Linear expansion of material	$12.5 \cdot 10^{-6} \text{ 1/}^\circ\text{C}$
Yield strength	$255 \text{ MPa (N/mm}^2\text{) for } d \geq 16 \text{ mm}$

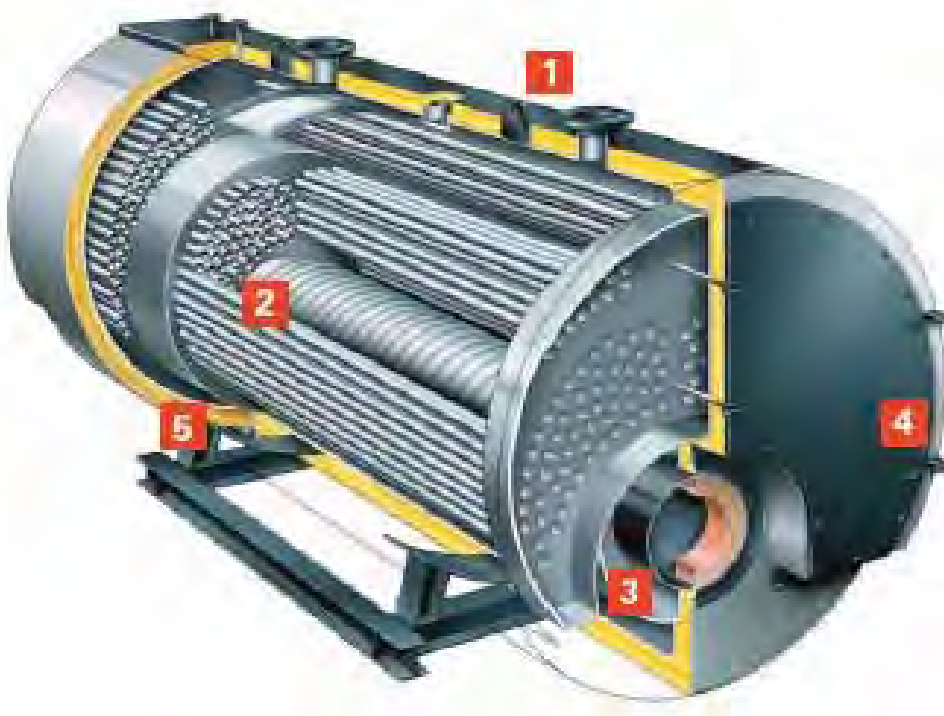


Figure 1 - Oil or gas fired high-pressure hot water boiler Viessmann - Vitomax 200 HW, (1 – Boiler with load-bearing cover; 2 – Duplex pipe with multi-layer convection heating surface; 3 – Water-cooled burner entry for low nitrogen oxide emissions; 4 – Large and light cleaning doors; 5 – Wide water galleries for good natural circulation and low thermal load)

3. Thermo mechanical calculation of the hotwater boiler

Destruction of mechanical constructions appears when extreme values of the stresses appear in the parts of the system. Very often other parameters are significant, as well, since destruction does not appear always on the places where extreme values of stresses appear. Extreme values of stresses can be determined when distribution of the stresses is estimation. Methods for stress distribution

determinations are various: stress concentration factor's determination, fracture layer application, photo-elasticity method or numerical methods – FEA.

3.1. Finite Elements Analysis

The present FEA method dates from the 1956. First introduction is bonded with the work of M. J. Tuner, R. Clough, H. C. Martin i L. J. Topp, with application on simple elements (a beam and triangular plate with planar loads) for the airplane structures. Famous work of that time belong to the O. C. Zienkiewich (1966., 1967., 1971.), J. S. Przemieniecki (1968.), J. T. Oden (1972.), J. Robinson (1973.), R. D. Cook (1974.), G. N. Smith (1971.), R. G. Gallagher (1975.), K. J. Bathe (1974.), E. L. Wilson (1974.) and others [1,3,4,5].

The basic idea of FEA analysis is to find a numerical, approximate solution for a complex structural construction. Continuum of the construction is idealized and discretized with small, regular 3D solids that we call finite elements. Finite elements are bonded one to another over mutual nodes and the number of nodes is in direct proportion with the density of finite elements in the continuum and the size of the finite elements. The higher the finite elements density is, the smaller is possibility to miss extreme values of stresses in discretization process. That is the main principle why it is necessary to increase the density of elements where extreme values of stresses are expected and vice versa.

The change of influencing parameters within finite elements is described with the simple approximation functions. Parameters of the interpolation functions are defined over values of the parameters in the nodes. Strain field of the nodes is estimated as a solution of the matrix equilibrium equation. Based on strain field, deformation and stress fields are determined as well as the stress structure points. FEA is described as a step – by – step procedure:

1. step – geometry modeling, idealization and structure discretization. Type, density, size and number of the finite elements determination and distribution of the finite elements are very important decisions on optimal and convergent solution gaining.
2. step – selection of appropriate interpolation model for strain field. Models are mostly polynomial. They have to provide required model of strain, deformation and stresses in finite elements.
3. step – stiffness matrix forming and vector of loads on finite elements determination. All properties for every finite element are calculated for the local and global system of coordinates.
4. step – determination of the global stiffness matrix, loads, loads vector and boundary conditions of the construction. Every stiffness matrix and loads vector are given to the nodes, with an adequate numeration, as well as the adequate boundary conditions
5. step – calculation of the unknown displacements from the static equilibrium equations.
6. step – calculation of strain and stresses in finite elements.
7. step – calculation of the stress points in the structure.

3.2. Modeling, idealization and discretisation of the structure

Virtual model of the referent hotwater boiler is developed in Autodesk Inventor (CAD software). For development of the model is used documentation of the Viessmann Company. 3D model is given in the Figure 2.

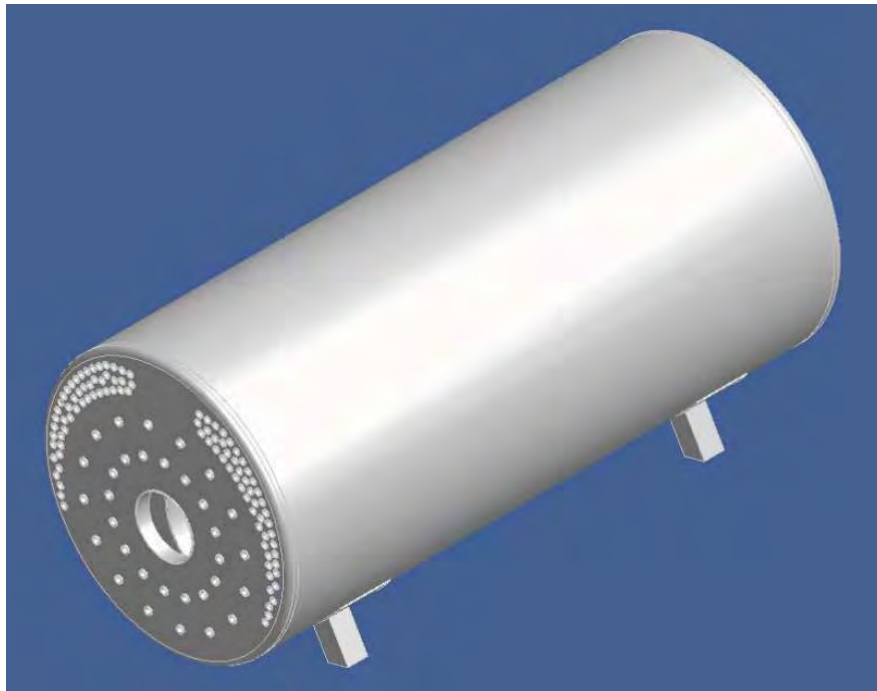


Figure 2 - Virtual model of the referent hotwater boiler

Simplified geometrical model is transformed into the discretized FE model with the application of advanced meshing tools capable to create adaptive discrete models. Discretized model consists of 258476 nodes, which form 91248 finite elements, and 280486 nodes, which form 94337 elements in the case of reinforcement of the pipe carrying wall of the second heating chamber with a radial rib. Discretized model of the hotwater boiler is given in Figures 3, 4 and 5. Finite elements are of the identical topology for thermal and structural analysis and different types of finite elements are used for both models. Automatically, all types of used finite elements are united in a complete, complex mesh of elements that is used for the further analysis.

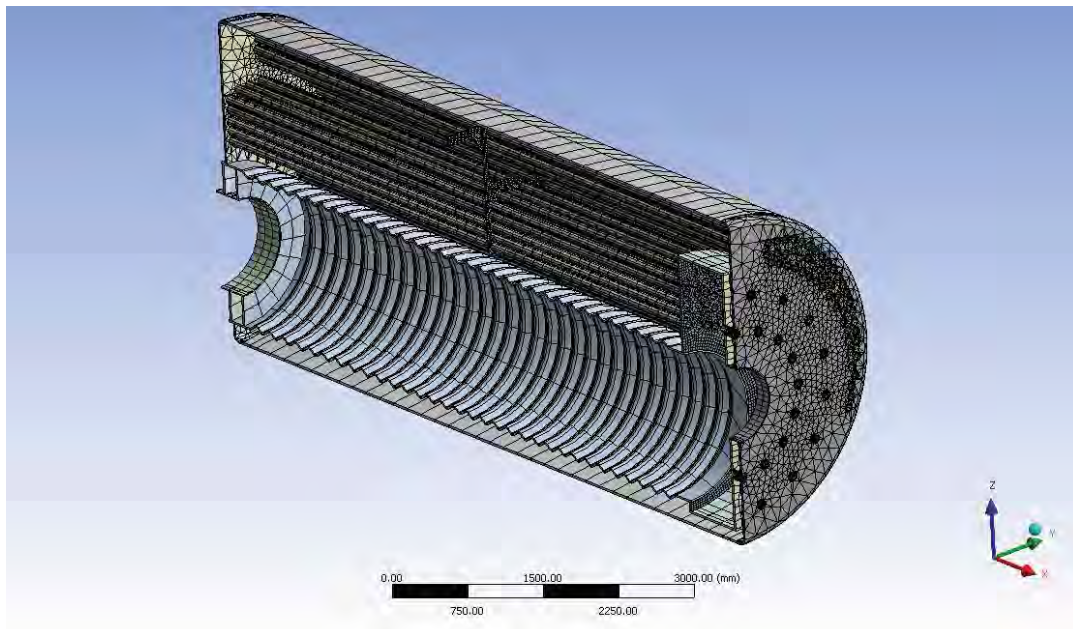


Figure 3 - Discretized structure of the hotwater boiler

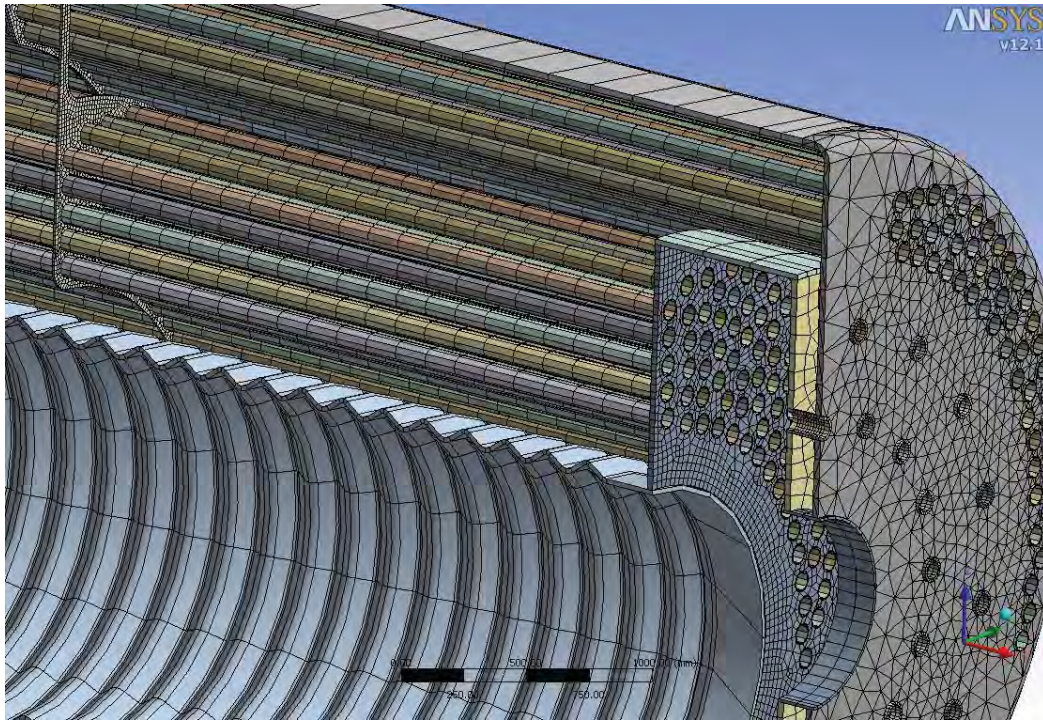


Figure 4 - Discretized structure of the hotwater boiler (detail)

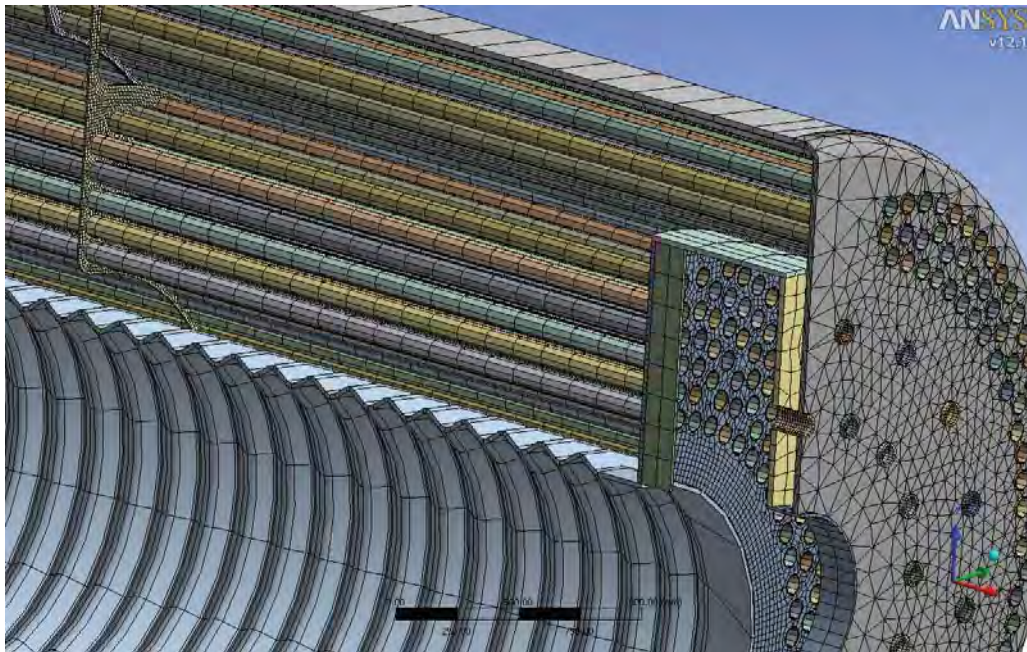


Figure 5 - Discretized structure of the hotwater boiler (detail with discretized structure, with radial rib on the wall of the second chamber)

3.3. Boundary conditions

Thermal calculation of the hotwater boiler is done basing on the median temperatures of the construction on the side of smoke gasses and on the side of the boiler where water flows – data about boiler without boiler scale, according to the Viessmann (Figure 6).

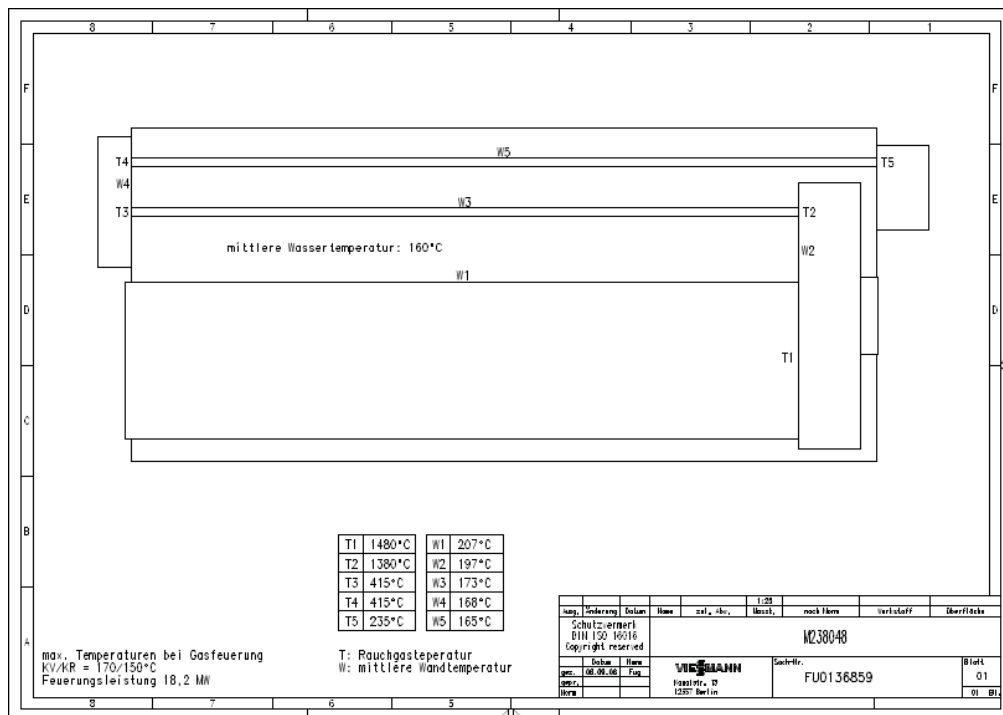


Figure 6 - Median temperature used for calculations

Based on this data thermal loads of the model have been defined (Figure 7).

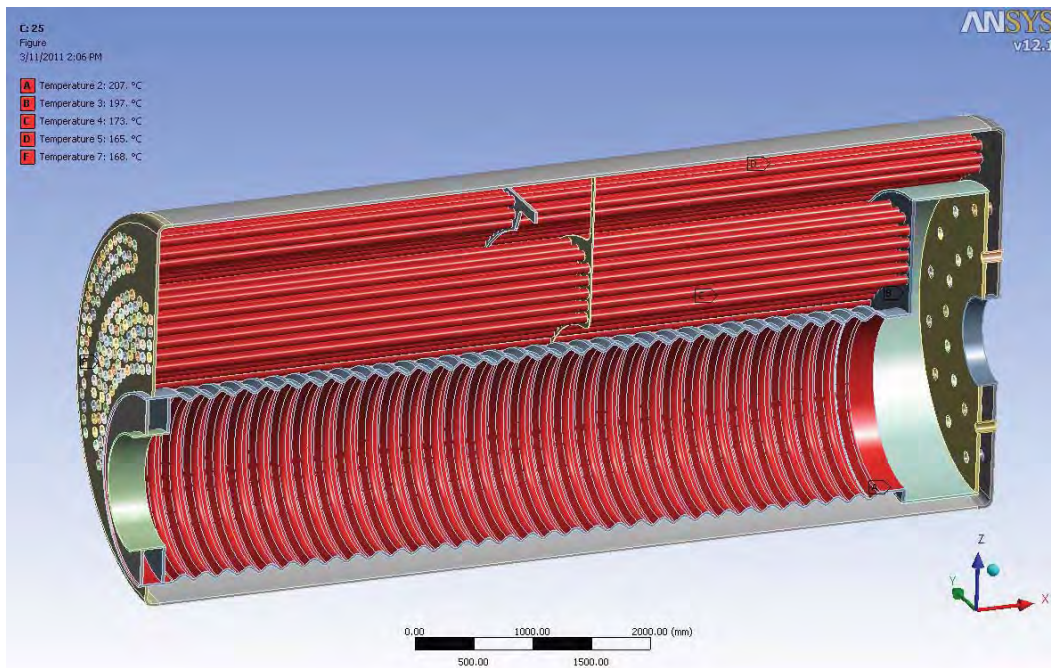


Figure 7 - Defined input median temperatures of the hotwater boiler

4. Thermomechanical analysis of the hotwater boiler's structure

“On field” expertise has shown that destruction of the hotwater boiler appears on pipe carrying wall of the second chamber and several different constructional changes have been investigated. Beside increase of the pipe thickness of pipe carrying wall of the second chamber, it is analyzed the influence of the inserted radial (welded) ribs in the area of pipe carrying wall of the second

chamber. Complex structure of the pipe carrying wall gives the possibility to insert only one rib, in the plane of symmetry of the of pipe carrying wall. Four different cases have been analyzed:

- Basic structure of the hotwater boiler (thickness of the of pipe carrying wall 21 mm) – no changes in referent design,
- Construction with the increase to the 23 mm,
- Construction with the increase to the 25 mm
- Construction with the increase to the 21 mm with the inserted radial rib (Figure 9).

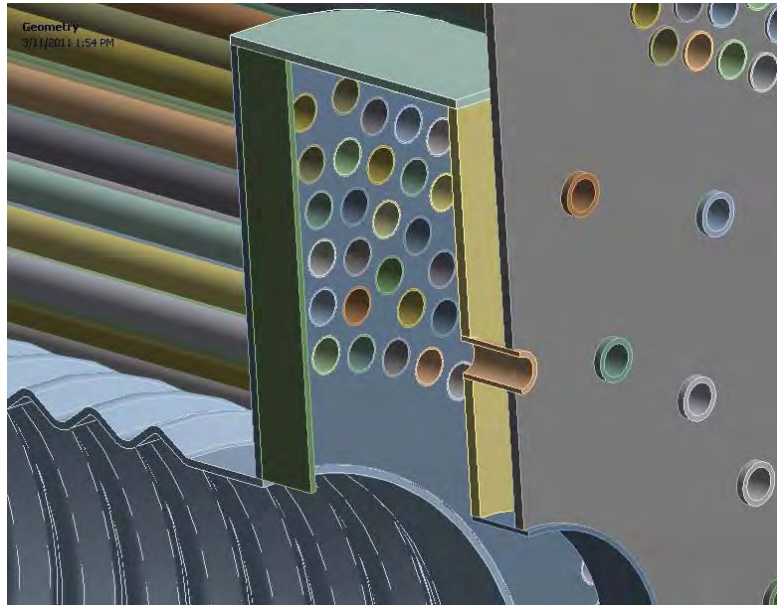


Figure 8 - Radial rib inserted in the hot water boiler

Analysis of structural loads delivered to the boiler shows two different types:

- Loads from the mass of the construction and
- Loads resulting from the thermal dilatations on higher temperatures

Results of the thermal analysis are given – temperature field and thermal flux are shown in Figures 9 and 10.

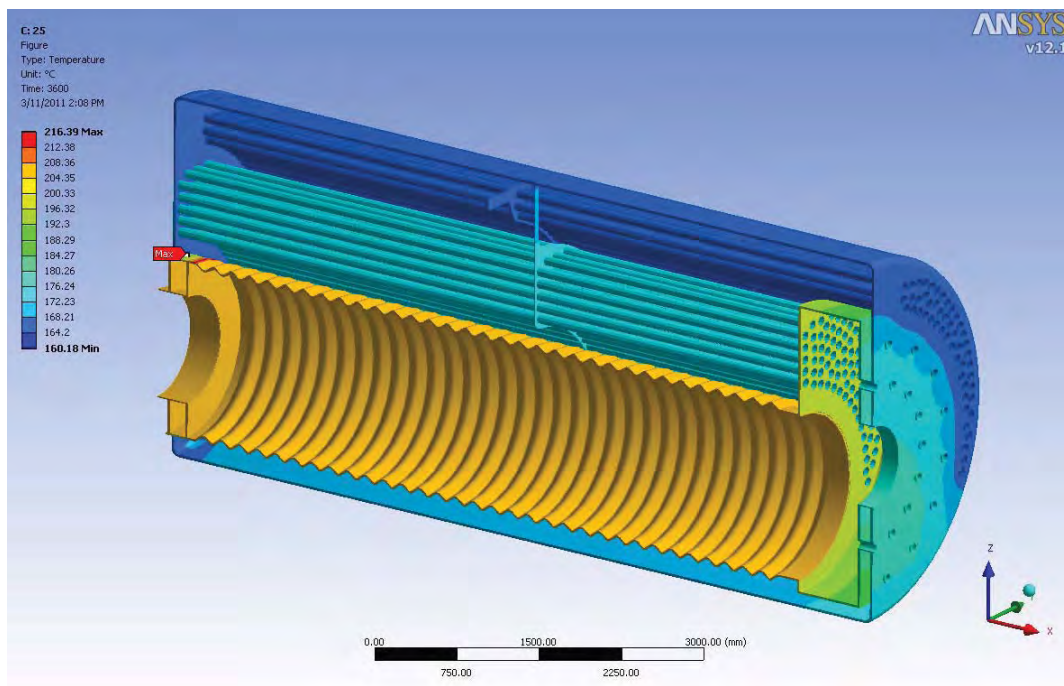


Figure 9 - Temperature field of the structure

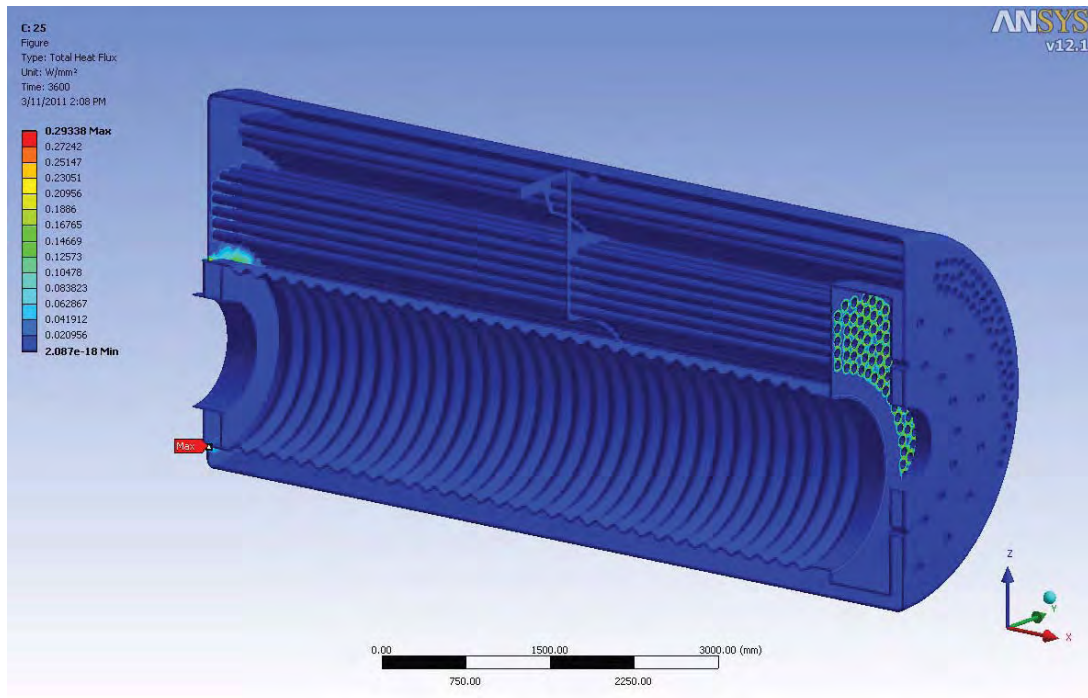


Figure 10 - Temperature flux field of the structure

Based on the thermal analysis of the boiler, structural analysis of the boiler is conducted. Anchorage system is shown in Figure 12.

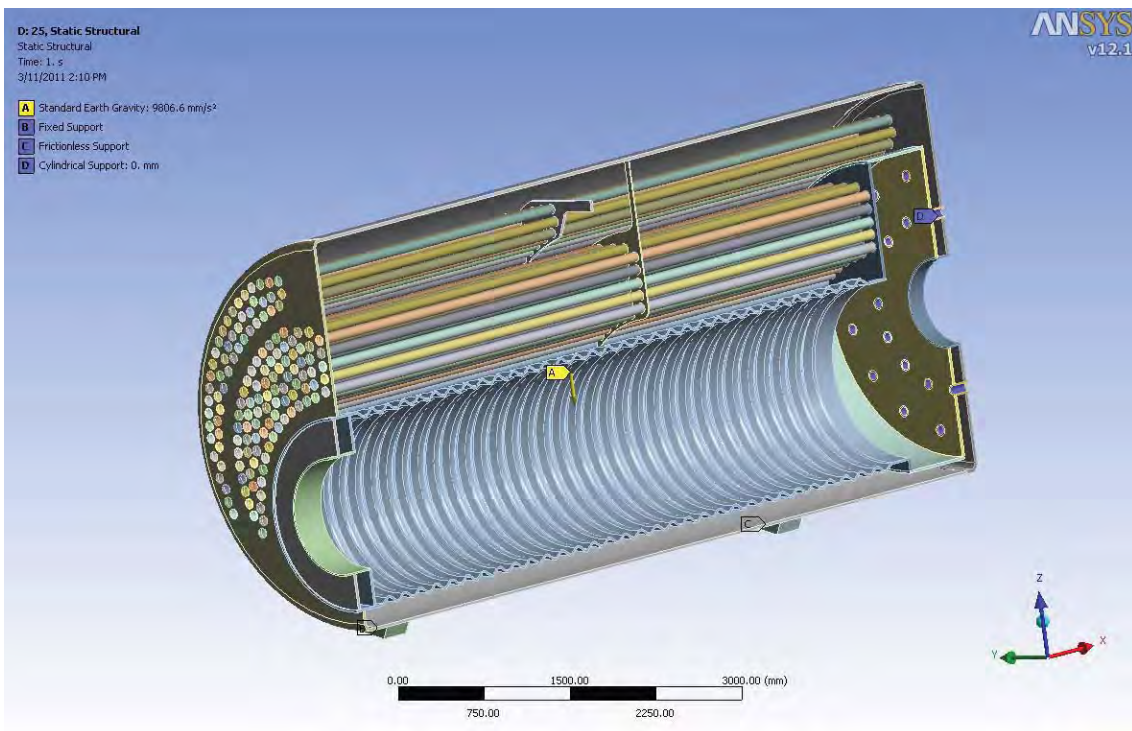


Figure 11 - Anchorage system of the hotwater boiler

Results from the stress and strain analysis of the boiler, for the previously mentioned cases are given in Figures 12 to 15.

As seen from the noted figures, the maximum stresses occur on the between pin key and the bolster at the back wall of the boiler. The contact stresses are byproduct of the Finite Element Method. Those are a consequence of the simplifications of design features (omitting of chamfers, fillets and radiuses) due to high computational demands and model complexity. Stress contraction occurs in

sharp edges which in reality do not exist in the structure. In such case it is appropriate to perform the more detailed analysis with usage of actual geometry without simplifications or to use non linear material model in order to include strain-hardening effects. But noted procedures are very computational demanding and will be object of research in future. Maximum stresses were omitted as they occur on the place which is not interesting for analysis, as the boiler defects due to thermal loads occur on the pipes carrying wall [1].

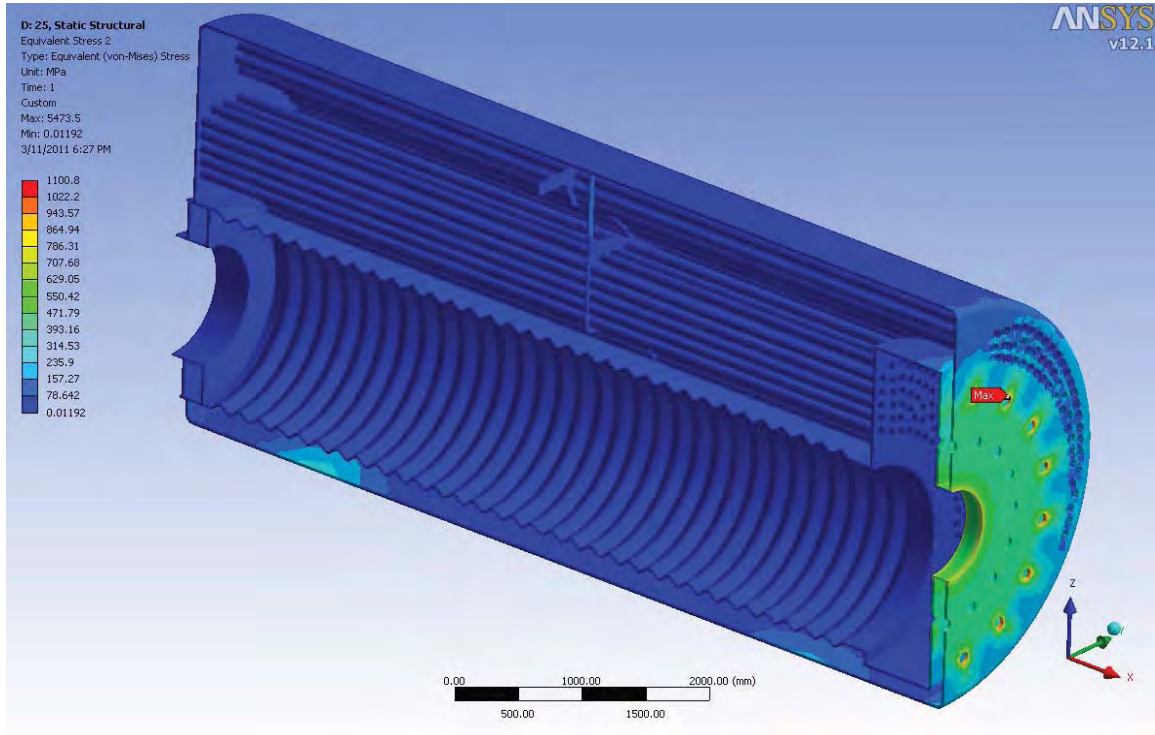


Figure 12 - Stress and strain of the boiler, case: (pipe carrying wall - 25 mm)

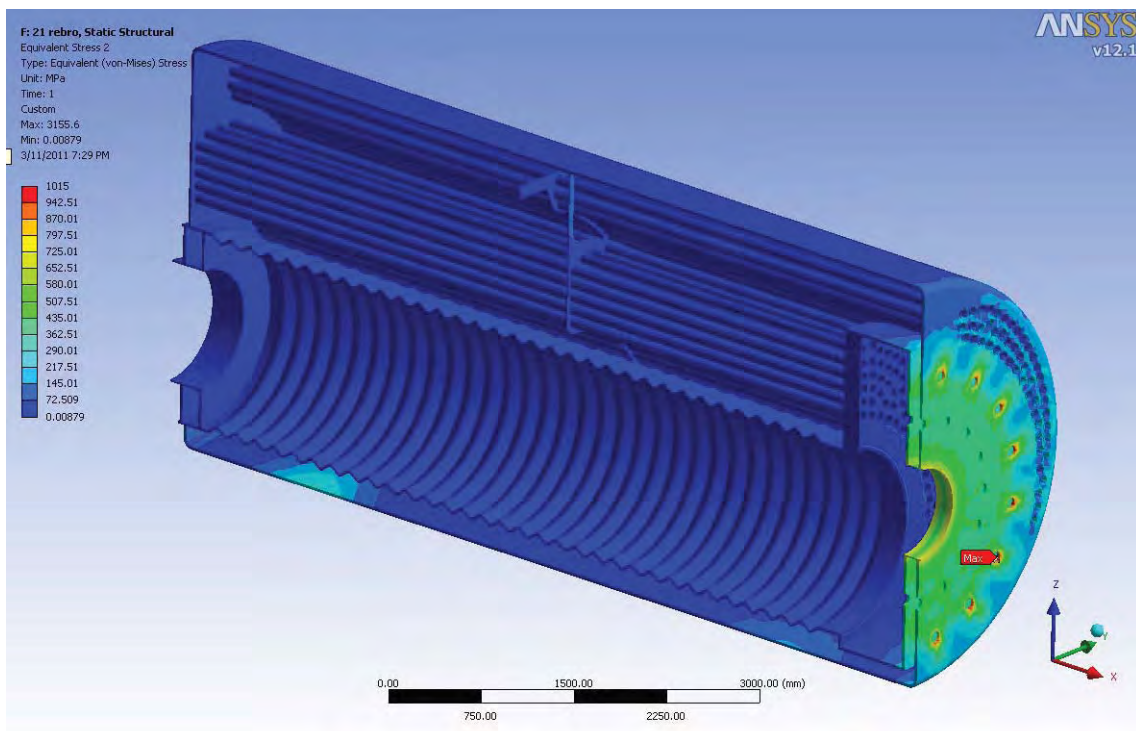


Figure 13 - Stress and strain of the boiler, case: with the radial rib

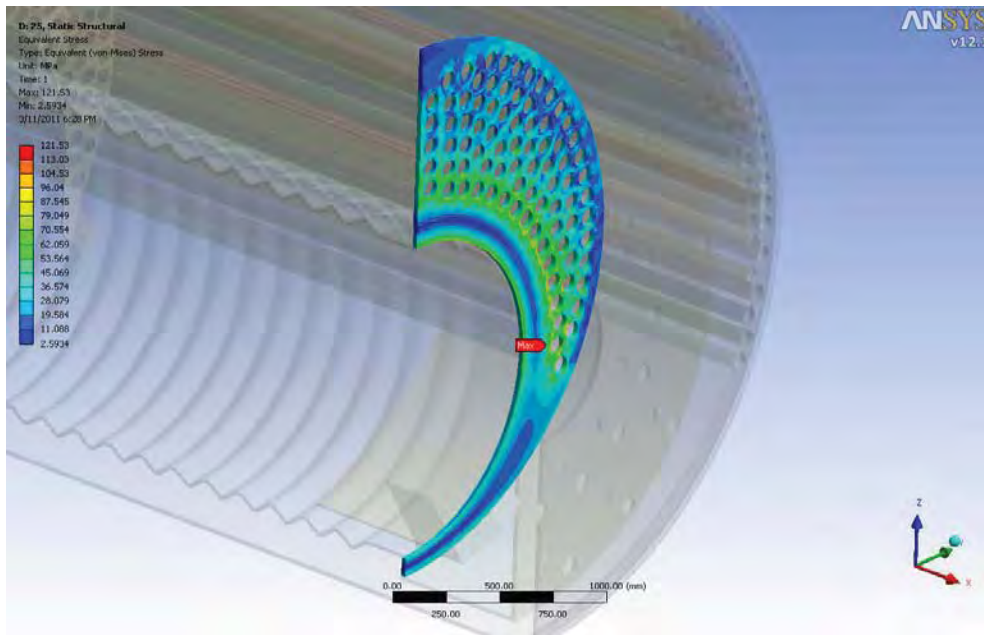


Figure 14 - Stress and strain of the boiler, case: (pipe carrying wall - 25 mm)

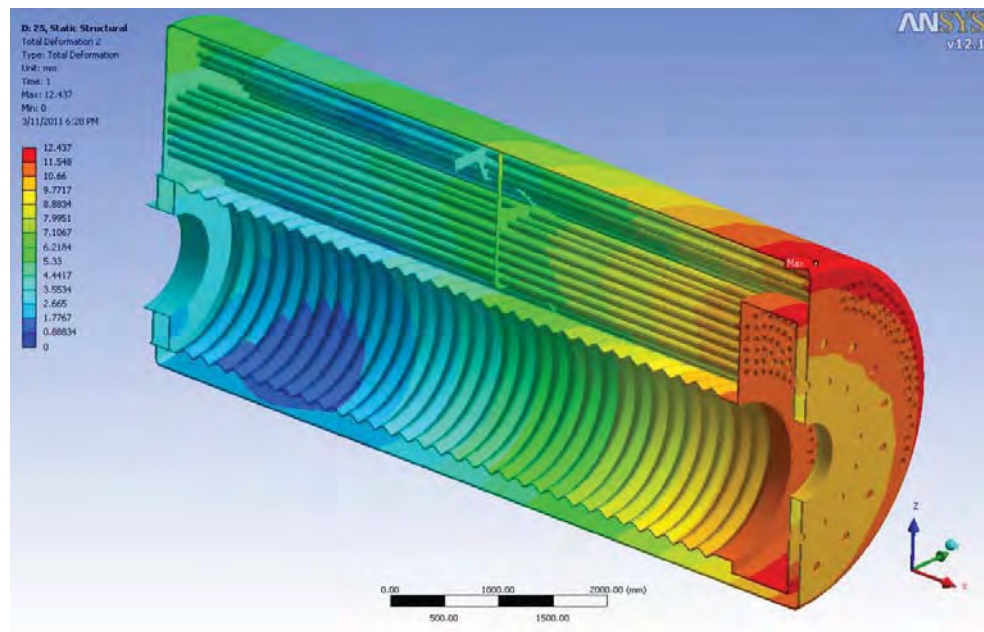


Figure 15 - Deformation of the boiler, case: (pipe carrying wall - 25 mm)

Table 3 gives representative values of stress and deformation of the pipe carrying wall of the second chamber for all analyzed cases.

Table 3 - Stress and deformation – comparison of the results for different cases

	pipe carrying wall ≠21 mm	pipe carrying wall ≠23 mm	pipe carrying wall ≠25 mm	pipe carrying wall ≠21 mm, with the radial rib
Stress N/mm ²	146.51	136.66	121.53	143.01
Deformation in mm	11.186	11.218	11.265	11.098

Results show that maximal thermal stresses and deformation appear in the zone of pipe carrying wall in the first chamber. This endangers welded joints of smoke pipes and pipe-plate what in the case of significant boiler scale could cause hot / cold cracks appearance and leakage of the water.

5. Conclusions

Based on the results of the thermomechanical calculations done by FEA, it can be said that:

1. Maximal stresses appear in contact between pin key and the bolster at the back wall of the boiler. Values of the stresses are extremely large which is a byproduct of Finite Elements Method. Simplifications on model and stress extreme values in noted region have no credibility for the analysis stress and deformations of boiler.
2. Stresses at the carrying wall of the second chamber, where referent model has shown the weakness, reach the value up the 147 N/mm^2 .
3. Properties of the material P265GH DIN EN 10028-2, used for the pipe carrying wall, are $R_m=410 - 530 \text{ N/mm}^2$, yield strength $R_p=265 \text{ N/mm}^2$, yield strength at $T = 200 \text{ }^\circ\text{C}$, $R_{p200} = 200 \text{ N/mm}^2$, and allowed stresses $\sigma_{doz} = 133 \text{ N/mm}^2$ are less than resulting stresses and destruction of the hotwater boilers made by company Viessmann are inevitable even without boiler scale.
4. Possible leakages may appear on the welded joints of pipe wall and pipes, what is already found on the referent model.
5. Deformations of pipe carrying wall are about 11 mm.
6. Based on the numerical results, it can be concluded that better results about the carrying strength of pipe carrying wall can be achieved with the increase of the pipe wall thickness rather than radial rib.
7. Insertion of the radial rib minimally increases strength of the pipe carrying wall and it is recommended, based on specific design of the hotwater boiler and it should not be considered considering the complexity of the boiler.

6. References

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