INTER-KLIMA CONFERENCE

26th International Conference on Heating, Cooling and Air-Conditioning

Zadar, Croatia, The Kolovare Hotel, 20 and 21 April 2023

Book of Abstracts

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Programme

Wednesday, 20 April 2023

15:00 - 16:00 furnishing and arranging exhibition spaces of co-organizers

16:00 opening of exhibition spaces

- the exhibition spaces will be open for visits by professionals and the general public until Friday, 21 April at 15:00 h

Programme

Thursday, 20 April 2023

8:00 - 9:00 gathering and registration of participants

9:00 - 10:30 **KLIMA-FORUM**

1st Thematic Section: GLOBALLY and LOCALLY

- introductory speech from the Organizer
- welcome speeches by representatives of patrons and co-organizers
- invited key-note lectures:

prof. dr. sc. Damir DOVIĆ, dipl. ing., *University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia* - DECARBONIZATION OF ENERGY SECTOR AND ZERO EMISSION BUILDINGS (ZEB)

prof. dr. sc. Vladimir SOLDO, dipl. ing., dr. sc. Luka BOBAN, mag. ing. mech., Dino MIŠE, mag. ing. mech. *and* ***Stjepan HERCEG, mag. ing. mech.***, *University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia* - EXAMPLES OF IMPLEMENTED SYSTEMS WITH HEAT PUMPS

Dinko UZELAC, ing., *Emerson Process Management d.o.o., Zagreb, Croatia* - THE NEW COOL - COPELANDTM CO_2 SCROLL COMPRESSION TECHNOLOGY FOR TRANSCRITICAL APPLICATION WITH CO_2 IN COMMERCIAL COOLING

Leon CIMERMAN, *Engie Refrigeration GmbH / Zenteh d.o.o., Markovci, Slovenia* - HIGH TEMPERATURE thermeco2 HEAT PUMPS WITH NATURAL REFRIGERANT R 744 (CO_2)

- a presentation of a new edition from EM literatura: Orest Fabris - HLAĐENJE I KLIMATIZACIJA (Cooling and Air-conditioning)
- discussion

Remark:
Abstracts of presentations for KLIMA-FORUM were published in the Proceedings of the KLIMA-FORUM.

10:30 - 10:45 coffee break

10:45 - 12:30 **INTER-KLIMA 2023 CONFERENCE**

FRAN BOŠNJAKOVIĆ DAY - 1st Part

Prof. Jurij AVSEC, *University of Maribor, Faculty of Energy Technology, Krško, Slovenia* - DEVELOPMENT AND APPLICATION OF THERMODYNAMICS IN THE FIELD OF ENERGY TECHNOLOGY, FROM HISTORY TO THE FUTURE

Jakša SINČIĆ, mag. ing. mech., dr. sc. Ivan HORVAT, mag. ing. mech., prof. dr. sc. Damir DOVIĆ, dipl. ing. *and* ***Petar FILIPOVIĆ, mag. ing. mech.*** *University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia* - ANALYSIS OF THE STRATIFIED STORAGE MODEL FROM THE NEW prEN 15 316-5 : 2023

dr. sc. Gordan LJEŠIĆ, University of Mostar, Faculty of Mechanical Engineering, Computing and Electrical Engineering, Mostar, Bosnia and Herzegovina and ***prof. dr. sc. Vladimir SOLDO, dipl. ing.***, University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia - EXPERIMENTAL INVESTIGATION OF CONDENSATION PRESSURE DROP OF PROPANE IN HELICALLY COILED TUBE-IN-TUBE HEAT EXCHANGER

Mustafa CANER, Res. Asst. *and* ***Prof. Dr. Ertan BUYRUK***, Sivas State University, Mechanical Engineering Department, Sivas, Türkiye and ***Prof. Dr.-Ing. Ahmet CAN***, *Istanbul Rumeli University, Faculty of Engineering and Natural Sciences, Istanbul, Türkiye* - EXPERIMENTAL INVESTIGATION OF HEAT TRANSFER FROM HELICAL COILED TUBES IN A WATER TANK

dr. sc. Dušan STRUŠNIK, *Energetika Ljubljana d.o.o., Ljubljana, Slovenia and* ***Prof. Jurij AVSEC***, *University of Maribor, Faculty of Energy Technology, Krško, Slovenia* - THERMAL ANALYSIS OF ABSORPTION COOLING SYSTEM BY MACHINE LEARNING METHOD

Petar FILIPOVIĆ, mag. ing. mech., dr. sc. Ivan HORVAT, mag. ing. mech. *and* ***prof. dr. sc. Damir DOVIĆ, dipl. ing.***, *University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia* - EVALUATION OF THERMAL PERFORMANCES OF A NOVEL POLYMER SOLAR COLLECTOR DESIGN

Ivan MATAS, mag. ing. mech., prof. dr. sc. Lovorka GRGEC BERMANEC, dipl. ing. *and* ***doc. dr. sc. Danijel ŠESTAN, dipl. ing.***, University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia - DEVELOPMENT OF IMPROVED MEASUREMENT SYSTEM FOR CHACTERIZATION OF CLIMATIC CHAMBERS

- discussion (after each presentation)

12:30 - 13:30 lunch

Programme

Thursday, 20 April 2023

13:30 - 15:00 **KLIMA-FORUM**
2nd Thematic Section: SYSTEMS and REGULATION

***Toni GAĆINA, ing.**, Oventrop GmbH & Co. KG, Techical Support for Croatia, Slovenia and Bosnia and Herzegovina, Split, Croatia* - OVENTROP - SOLUTIONS FOR HYDRAULIC BALANCING IN HEATING, COOLING AND DHW PREPARATION

***Samo ŠMID, univ. dipl. inž. stroj.**, BELIMO AG, Technical Office, Kranj, Slovenia* - UNIQUE SOLUTION FOR HYDRAULIC BALANCING AND MONITORING OF ENERGY CONSUMPTION

***Renato LASIĆ, mag. ing. mech.**, Alfa Therm d.o.o., Mostar, Bosnia and Herzegovina* - HUMAN RESOURCES DEVELOPMENT AND/OR DIGITALIZATION (an one-on-one interview)

***Bojan JURINJAK, mag. ing. mech.**, Danfoss d.o.o., Zagreb, Croatia* - DANFOSS NOVOCON - HVAC ENGINEERING 4.0 FOR SMART BUILDINGS

***David DOBRINIĆ, univ. bacc. ing. mech.**, Samsung Electronics Adriatic, Zagreb Branch Office, Zagreb, Croatia* - SAMSUNG SmartThings - Wi-Fi DEVICE MANAGEMENT APPLICATION - SMART HOME SYSTEM

***Dragan GRBA, ing.**, Rittal d.o.o., Zagreb, Croatia* - INDUSTRIAL PRODUCTION WITH REDUCED CO_2 FOOTPRINT

• discussion

Remark:
Abstracts of presentations for KLIMA-FORUM were published in the Proceedings of the KLIMA-FORUM.

15:00 - 15:15 coffee break

15:15 - 17:00 **INTER-KLIMA 2023 CONFERENCE**
FRAN BOŠNJAKOVIĆ DAY - 2nd Part

***Danijel ZADRAVEC, mag. ing. mech.** and **prof. dr. sc. Nenad FERDELJI, dipl. ing.**, University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia* - OPTIMAL TOTAL REFLUX PERIOD DURATION IN BATCH DISTILLATION

***dr. sc. Martina ODELJAN, mag. ing. mech.** and **prof. emer. Antun GALOVIĆ, dipl. ing.**, University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia* - DETERMINATION OF CRITERIA FOR ACHIEVING THE SAME OUTLET TEMPERATURES OF BOTH FLUID STREAMS IN COUNTERFLOW HEAT EXCHANGERS

***Nikola BOROVNIK, mag. ing. mech., doc. dr. sc. Saša MUDRINIĆ, dipl. ing.** and **prof. dr. sc. Nenad FERDELJI, dipl. ing.**, University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia* - MODELLING OF TRANSFORMER VACUUM DRYING PROCESS

***Merima GADARA**, Džemal Bijedić University of Mostar, Faculty of Mechanical Engineering, Mostar, Bosnia and Herzegovina and **doc. dr. sc. Haris LULIĆ**, University of Sarajevo, Faculty of Mechanical Engineering, Sarajevo, Bosnia and Herzegovina* - DYNAMIC MODELING OF THE SOLAR SYSTEM DEPENDING ON THE CHANGE IN THE TILT ANGLE OF THE SOLAR COLLECTOR

***M. Musab BAYAT, Res. Asst.** and **Prof. Dr. Ertan BUYRUK**, Sivas State University, Mechanical Engineering Department, Sivas, Türkiye and **Prof. Dr.-Ing. Ahmet CAN**, Istanbul Rumeli University, Faculty of Engineering and Natural Sciences, Istanbul, Türkiye* - USE OF PCM WITH ALUMINUM FINS TO IMPROVE SOLAR PANEL PERFORMANCE

***Stephen MURPHY**, Technological University of the Shannon: Midlands, Midwwest, Thurles, Ireland, **Dan STEFANICA**, EHPA - European Heat Pump Association, Brussels, Belgium, **Carlos DELGADO**, FCTA - Fundación Corporación Tecnológica de Andalucía, Seville, Spain, **Megan GIGNAC**, ESV - OÖ Energiesparverband, Linz, Austria and **Padraic O'REILLY**, Technological University of the Shannon: Midlands, Midwwest, Thurles, Ireland* - REPLICATING THE SUCCESS OF THE HP4ALL PROJECT: INCREASING HEAT PUMP SKILLS AND INCREASING THE DEMAND FOR THOSE SKILLS

***dr. sc. Alen CUKROV** and **prof. emer. Antun GALOVIĆ, dipl. ing.**, University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia, **Dr. Yohei SATO**, Paul Scherrer Institute, Villigen, Switzerland, **prof. dr. sc. Ivanka BORAS, dipl. ing.**, University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia and **Dr. Bojan NIČENO**, Paul Scherrer Institute, Villigen, Switzerland* - NUMERICAL SIMULATION OF WATER-ICE FORMATION AROUND A PIPE

• discussion (after each presentation)

19:30 social programme
• Pub Quiz
• DJ

Programme

Friday, 21 April 2023

9:00 - 11:00 **KLIMA-FORUM**
3rd Thematic Section: PROJECTS and SOLUTIONS

Zvonimir STRAPAJEVIĆ, mag. ing. mech., *Samsung Electronics Adriatic, Zagreb Branch Office, Zagreb, Croatia* - SAMSUNG EHS HT MONO QUIET - A NEW HEAT PUMP

Carsten FEUERHAKE, *Bioclimatic GmbH, Bad Nenndorf, Germany* - THE FUTURE OF SAFE AND HEALTHY AIR IN INNER SPACES

Krešimir MATKOVIĆ, mag. ing. mech., *Clivet S.p.A., Clivet South-East Europe, Zagreb, Croatia* - SOLUTIONS FOR HEATING AS WELL

Pavao JERKOVIĆ, mag. ing. mech., *Frigo Plus d.o.o., Soblinec, Croatia* - NEW HEAT PUMPS WITH R 290 FOR HEATING AND COOLING 'MADE IN CROATIA'

Stjepan MIKLEUŠEVIĆ, bacc. ing. techn., *Viessmann d.o.o., Zagreb, Croatia* - VIESSMANN VITOCAL - ALL PURPOSES HEAT PUMPS

Alen SIPIĆ, ing., *IMP termotehnika-regulacija d.o.o., Zagreb, Croatia* - HOW TO ACHIEVE OPTIMAL CONDITIONS FOR THE HEAT PUMP OPERATION IN COMBINATION WITH SURFACE HEATING AND COOLING?

mr. sc. Davor LUČIN, dipl. ing., *Detron d.o.o., Split, Croatia* - MULTIFUNCTIONAL DELTRON SOLUTIONS AND HEAT PUMPS - REDUCTION OF OPERATIONAL COSTS AND CONSUMPTION OF NON-RENEWABLE RESOURCES

Damir BUTKOVIĆ, dipl. ing., *IFMA Croatia Chapter, Zagreb, Croatia* - IFMA MISSION - WITH STRATEGIC MANAGEMENT TOWARDS GREATER FUNCTIONALITY, EFFICIENCY, COMFORT AND SAFETY IN BUILT ENVIRONEMENT

• discussion

Remark:
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11:00 - 11:15 coffee break

11:15 - 13:00 **INTER-KLIMA 2023 CONFERENCE**
ENERGY EFFICIENCY AND RENEWABLES

dr. sc. Luka BOBAN, mag. ing. mech., Dino MIŠE, mag. ing. mech., Stjepan HERCEG, mag. ing. mech. *and* ***prof. dr. sc. Vladimir SOLDO, dipl. ing.,*** *University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia* - LONG TERM PERFORMANCE OF HEAT PUMP SYSTEM UNDER INFLUENCE OF AGING EFFECTS

Franco KROG *and* ***Prof. Jurij AVSEC,*** *University of Maribor, Faculty of Energy Technology, Krško, Slovenia* - ENERGY ANALYSIS OF HYDROGEN USE IN ROAD TRANSPORT OF THE REPUBLIC OF CROATIA

dr. sc. Marko MIMICA *and* ***prof. dr. sc. Goran KRAJAČIĆ, dipl. ing.,*** *University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia* - DECARBONISATION OF COMMUNITIES AND GEOGRAPHICAL ISLANDS - EXPERIENCES FROM H2020 INSULAE AND HE COMMUNITAS

Dino MIŠE, mag. ing. mech., dr. sc. Luka BOBAN, mag. ing. mech. *and* ***prof. dr. sc. Vladimir SOLDO, dipl. ing.,*** *University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia* - INFLUENCE OF DIFFERENT DEFROST STRATEGIES ON HEAT PUMP EFFICIENCY

Urška NOVOSEL *and* ***Prof. Jurij AVSEC,*** *University of Maribor, Faculty of Energy Technology, Krško, Slovenia,* ***Prof. Matej MENCINGER,*** *University of Maribor, Faculty of Civil Engineering, Transportation Engineering and Architecture, Maribor, Slovenia and* ***doc. dr. Brigita FERČEC,*** *University of Maribor, Faculty of Energy Technology, Krško, Slovenia* - COMBINED USE OF HYDROGEN TECHNOLOGIES AND RENEWABLE SOURCES TO REDUCE THE CARBON FOOTPRINT IN THE SAŠA REGION

prof. dr. sc. Damir DOVIĆ, dipl. ing., dr. sc. Ivan HORVAT, mag. ing. mech. *and* ***Petar FILIPOVIĆ, mag. ing. mech.,*** *University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia* - INCREASING EFFICIENCY AND REDUCING POLLUTANTS EMISSIONS FROM THE RESIDENTIAL COOKER BURNING WOOD BIOMASS

Josip MIŠKIĆ, mag. ing. mech., *University of Zagreb, Faculty of Mechanical Engineering and Naval Architecure, Zagreb, Croatia,* ***dr. sc. Hrvoje DOROTIĆ,*** *Hrvoje Požar Energy Institute, Zagreb, Croatia,* ***prof. dr. sc. Tomislav PUKŠEC*** *and* ***prof. dr. sc. Neven DUIĆ, dipl. ing.,*** *University of Zagreb, Faculty of Mechanical Engineering and Naval Architecure, Zagreb, Croatia* - THE METHOD OF DETERMINING THE RADIUS OF TECHNO-ECONOMIC FEASIBILITY OF WASTE HEAT FOR THE PLANNING OF THE DISTRICT HEATING SYSTEM

• discussion (after each presentation)

13:00 - 13:15 coffee break

Programme

Friday, 21 April 2023

13:15 - 15:00 KLIMA-FORUM
4th Thematic Section: EFFICIENCY and COMFORT

***Renato JAKUS**, Klimaoprema d.d., Samobor, Croatia* - HIGHLY EFFICIENT PROFESSIONAL KITCHEN VENTILATION SYSTEM

***Vedran VUKASOVIĆ**, Atrea d.o.o., Rijeka, Croatia* - SCHOOL VENTILATION - LET'S PROVIDE QUALITY LEARNING CONDITIONS FOR THE THE YOUNGEST

***Tomislav JURIČEV-SUDAC, ing. mech.**, KAN-therm Hungary kft., Biatorbágy, Hungary* - KAN-therm - RECOGNIZED AND INTERNATIONALLY WELL-KNOWN NAME

***Josip ZORKO**, Testo Kft., Samobor, Croatia* - A SYNONYME FOR PRECISE AND RELIABLE INSTRUMENTS

***prof. dr. sc. Antonio PETOŠIĆ, Domagoj STOŠIĆ i Toni MARINKOVIĆ**, University of Zagreb, Faculty of Electrical Engineering and Computing, Zagreb, Croatia* - OPTIMIZATION OF NOISE PROTECTION MEASURES IN THE AIR CONDITIONING DUCT

***Robert MARINIĆ, mag. ing. mech.**, Vodoprivreda Daruvar d.d., Daruvar, Croatia, **prof. dr. sc. Davor LJUBAS, dipl. ing. i prof. dr.sc. Hrvoje JURETIĆ, dipl. ing.**, University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia* - ZAŠTITA SUSTAVA ZA OBRADU ZRAKA I VODE OD ONEČIŠĆENJA BAKTERIJAMA RODA LEGIONELLA

***prof. dr. sc. Davor LJUBAS, dipl. ing.**, University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia, **Dinko LJOLJO, mag. ing. mech.**, Opus Optimus d.o.o., Zagreb, Croatia i **Robert MARINIĆ, mag. ing. mech.**, Vodoprivreda Daruvar d.d., Daruvar, Croatia* - UPCOMING LEGAL OBLIGATIONS RELATED TO HOME WATER SUPPLY NETWORK

***Damir DIGULA, dipl. ing.**, Siemens d.d., Zagreb, Croatia* - ENERGY EFFICIENCY CLASSIFICATION TOOL

- discussion
- final word from the Organizer

Remark:
Abstracts of presentations for KLIMA-FORUM were published in the Proceedings of the KLIMA-FORUM.

15:00 closing of exhibition spaces

15:00 lunch

Remark
The Organizer reserves the right to amend the Programme up to the conferences and even during the conferences.

Content

Energy Efficiency and Renewables

Development and Application of Thermodynamics in the Field of Energy Technology, from History to the Future

Prof. Jurij AVSEC
University of Maribor, Faculty of Energy Technology, Krško, Slovenia
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Abstract
The development of today's energy technologies is very fast and is related to the development of a scientific discipline such as thermodynamics. As the name thermodynamics suggests, thermodynamics is the study of heat dynamics and their dynamics and energy transformation. It is one of the newest classical scientific disciplines, which began to develop only at the end of the 19th century. However, the beginnings of thermodynamics go back over two thousand years. Democritus and his mentor Leucippus may be regarded as the first serious researchers in the field of thermodynamics, in the 4th century B.C. Thermodynamics is developing today in many areas like classical thermodynamics, statistical thermodynamics, irreversible thermodynamics, nonequilibrium thermodynamics...
The development of thermodynamics takes place today in the so-called classical world, as well as in the world of quantum influences and, of course, also in the area where the theory of relativity mu st be taken into account. The presented article will show the historical outline of the development of thermodynamics in the field of energy technology, show the current state of development in the field of thermodynamics and indicate possible further paths of development of thermodynamics in the field of energy technology.

Analysis of the Stratified Storage Model from the New prEN 15 316-5 : 2023

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Abstract
In 2017, CEN (European Committee for Standardization) introduced a 2nd edition of standards for the assessment of buildings technical system energy performance (EN 15 316 series of standards) supporting the Energy Performance of Buildings Directive. The main novelty is the introduction of an hourly time step calculation methods and of the new standard which takes into account dynamic temperature variations within the storage tank (EN 15 316-5 : 2017). This standard contained many errors in the provided energy balance equations and ambiguities related to calculation procedure. Therefore, the revision of this standard has been made (prEN 15 316-5 : 2023) and is now under approval of the relevant technical committee CEN/TC 228/WG4. prEN 15 316-5 : 2023 comprises two methods applicable to the different types of water-based storage systems and related control system. Particularly interesting is the Method A, which considers the temperature stratification within the storage tank. In the Method A several assumptions, concerning the modelling of water flow through the tank, homogeneity of water temperature within the layer, conduction and convection between the layers, had to be implemented in the calculation procedure.
Currently, there are no analyses in the open literature that validate the introduced assumptions. To address this, the present paper provides a comprehensive analysis of the method accuracy in the case of solar storage by comparison with the results obtained by CFD simulations. Furthermore, the influence of the temperature distributions within the storage tank obtained by 1-layer (Method B of prEN 15 316-5 : 2023), 4-layer, 5-layer model and CFD simulation on the obtained solar collector thermal efficiency is given. The results show are no significant differences in calculated thermal efficiencies, except for the 1-layer model where the differences are up to 8% relative to the CFD simulation.

Keywords: *solar storage tank, stratified storage model, solar system, CFD simulation, solar collector thermal efficiency*

Experimental Investigation of Condensation Pressure Drop of Propane in Helically Coiled Tube-in-tube Heat Exchanger

dr. sc. Gordan LJEŠIĆ
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Abstract
This paper presents conducted comparison of experimentally obtained pressure drop values during propane (R 290) two-phase flow through annular passage of helically coiled tube-in-tube condenser and pressure drop values obtained by Lockhart-Martinelli, Chisholm, Grönnerud, Friedel, Wongwises-Polsongkram and Müller-Steinhagen and Heck correlations. Experimental rig is compression refrigerant cycle that consists of compressor, condenser, expansion valve and evaporator. Compression cycle is equipped with internal heat exchanger that can be bypassed to see the effect of the component on the pressure drop in condenser. The test section (condenser) is made of two copper tubes that are coaxially oriented. Inner tube of the condenser is grooved on its outside surface. Internal diameter of inner tube is 19,7 mm and the nominal outer diameter is 22,2 mm. Inner diameter of outer tube is 30,0 mm. The coil diameter is 280 mm and the coil pitch is 35 mm. The coil axis is oriented vertically, so the pressure drop is affected by gravitational force. Pressure drop values are determined at different saturation temperatures 35 °C, 40 °C and 45 °C, and different heat flux values in the range 15 - 25 kW/m^2.
The research results show that the Lockhart-Martinelli correlation most closely describes the pressure drop for the case of two-phase propane flow in helically coiled condenser.

Keywords: *pressure drop, propane (R 290), condensation, two-phase flow, coaxial heat exchanger*

Experimental Investigation of Heat Transfer from Helical Coiled Tubes in a Water Tank

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Abstract
Heat exchange in hot water storage tanks is commonly conducted with helical coiled tubes. In this study, steady state heat transfer from helical coiled tubes in water are investigated experimentally for laminar flow regime. Helical coiled tubes of different geometric sizes were incorporated into hot water tank. The water in this tank was heated between 50 to 80 °C at intervals of 10 °C via two electrical heaters (with a total power of 7,5 kW) placed at the bottom of the tank. Cold water at 20 °C was pumped through the helical coiled tubes with a flow rate range between 2 - 5 l/min. During the experiments, the inlet and outlet temperatures of the cold water to the helical coils were measured. Outer surface temperatures of the helical coil in each turn and the temperature of the water in the hot water tank were also measured. Then using these obtained data, Nu number was calculated and the effectiveness of the helical coiled tubes compared according to the ε-NTU method.

Keywords: *helical coiled tube, heat exchanger, Nusselt number, ε-NTU method*

Thermal Analysis of Absorption Cooling System by Machine Learning Method

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Prof. Jurij AVSEC
University of Maribor, Faculty of Energy Technology, Krško, Slovenia
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Abstract
In this paper, an absorption cooling system (ACS), based on the solution of lithium bromide-water absorption refrigeration cycle, is analysed. The ACS is characterized by utilisation of intermedium-pressure (IP) extraction steam from the steam turbine for its operation. The thermal analysis of the ACS is set up in detail, based on a machine-learning algorithm, which is validated by using real process data. Real process data was obtained by measurement of the ACS. The results show that the ACS generates 19,9 kW of cold for district cooling and 297 kW of heat for heating of demineralized water. During this time, the ACS for operation consumed an average of 0,06 kg/s of IP steam and operated with a 17,3% average exergy efficiency. The average exergy efficiency of the ACS can be improved by using lower-quality of operation steam or even hot water.

Evaluation of Thermal Performances of a Novel Polymer Solar Collector Design

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Abstract
Experimental and numerical evaluation of the thermal properties of an unique prototype polymer solar collector are reported in this work. The experimental part incorporates an alternative method for determining the optical properties of polymer materials and thermal efficiency measurements. Thermal efficiency functional dependence on solar radiation, working fluid, and air temperature is computed. In order to validate the numerical model developed in the ANSYS FLUENT software suite, simulations are performed on a segment of the polymer solar collector, and the results are correlated with experimental data. The efficiency curve coefficients (η_0, a_1 and a_2) are then derived for an eight-segment collector. During the normal summer operation regime, the obtained efficiency of the proposed polymer collector design is up to 20 percent lower than that of the state-of-the-art flat plate collector (FPC). A parametric numerical analysis of a polymer solar collector is per formed to evaluate the impact of design and operating parameters on thermal performance and to provide guidelines for design optimization. In addition, stagnation temperature measurements are performed in line with EN ISO 9806 : 2017 when a stagnation temperature of 125,1 °C is recorded after the implementation of overheating safety measures.

Development of Improved Measurement System for Chacterization of Climatic Chambers

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Abstract
Climatic chambers have proven to be an important tool for testing of various products and materials under specific environmental conditions in different industries as well as in testing and calibration laboratories. Temperature and humidity uniformity are one of the deciding parameters for evaluation of chamber's performance. Traceable and reliable measurement of those parameters is crucial for correct assessment of chamber's eligibility for specific use.
This paper presents an automated measurement system for determination of climatic chambers characteristics with low measurement uncertainty. The presented system has been developed at the Laboratory for Process Measurement and is directly traceable to the Croatian national standard for temperature and humidity. Temperature uniformity evaluation is achieved with ten platinum resistance temperature sensors connected via multiplexer to a precision thermometry bridge. Dew-point temperature is measured with chilled-mirror hygrometer. Control of the system and measurement data acquisition is enabled through a laboratory developed LabView software. The developed system is fully characterized in the temperature range from -40 °C to 170 °C and the results are compared to an existing system comprised of thermocouple temperature sensors.

Optimal Total Reflux Period Duration in Batch Distillation

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Abstract
Batch distillation is a widely used method for mixtures separation and purification most suitable for flexible small-scale separations in chemical, biochemical and pharmaceutical industries. In this dynamical process, product is collected in the production phase which is preceded by the total reflux start-up phase when mixture in column top is enriched by more volatile components necessary for the desired product quality. Most commonly employed start-up strategy is a total reflux operation until achieving steady state composition before product removal which can consume substantial portion of total process energy. In this work, total reflux phase duration is optimised using a binary batch distillation mathematical model. The goal of the optimization is to minimize overall process duration needed to obtain desired product quantity and quality by varying total reflux phase duration. Effect of separation difficulty and tray and reflux tank holdup on optimal total re flux duration is examined.

Determination of Criteria for Achieving the Same Outlet Temperatures of Both Fluid Streams in Counterflow Heat Exchangers

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Abstract
The paper presents an explicit method of determining the values of NTU and consequently determining the heat transfer area A_0, in order to obtain equal outlet temperatures of both fluid streams in counterflow heat exchangers. Such a condition has to be achieved in some technical applications of counterflow recuperators. The paper shows that NTU is determined by the capacity rate ratio and that the effectiveness of these recuperators depends only on the capacity rate ratio. Expressions for the general case of a counterflow heat exchanger were derived, from which expressions for two special cases were obtained. One of those is a case when a stronger stream changes its aggregate state and another one is a case of the so-called balanced recuperator. For these cases explicit expressions for effectiveness were also derived. The calculation results are presented by diagrams and additional description.

Modelling of Transformer Vacuum Drying Process

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Abstract
Widely used material for instrument transformer electrical insulation is an electrical grade paper impregnated with mineral oil. As moisture inside transformer insulation increases the risk of premature failure, before being impregnated, transformer is subjected to a vacuum drying process which usually consists of combined cycles of heat and vacuum application.
This work is focused on modelling the vacuum drying process and analysing how different drying regimes influence the moisture content of transformer paper at the end of a given cycle.

Dynamic Modeling of the Solar System Depending on the Change in the Tilt Angle of the Solar Collector

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Abstract
This paper presents the modeling of the solar system depending on the change in the tilt angle of the collector to the horizontal plane, using the TRNSYS software package. TRNSYS is a software package suitable for simulating energy systems with time-varying parameters, with an open source code architecture that enables modeling and simulation of various systems. Modeling of the solar system was performed using a modified standard function of current thermal efficiency, determined in accordance with the European standard EN ISO 9806 : 2017, in relation to the tilt angle of the collector to the horizontal plane. The obtained model was tested for hot water preparation services for a hotel, located in the city of Sarajevo, Bosnia and Herzegovina for a period of one year. The obtained results were compared with the results given by the standard efficiency function, and with the results obtained using the f-chart method. It is shown that the deviation of the results for the dynamic model obtained according to the modified efficiency function, depending on the tilt angle of the collector, compared to the results given by the standard efficiency function ranges between 5 - 13%. The smallest deviation is for the collector tilt angle 30 ° and is 5%, while the largest deviation for the collector tilt angle is 0 ° and is 13%. Deviations in relation to the results given by the f-chart method are more significant, which is understandable since the f-chart method is significantly more inert to the oscillation of the values of time-varying variables essential for designing solar systems compared to dynamic models.

Keywords: *solar thermal collector, collector tilt angle, efficiency function, dynamic modeling, solar system*

Use of PCM with Aluminum Fins to Improve Solar Panel Performance

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Abstract
In photovoltaic (PV) cells, a large part of the solar radiation turns into heat that increases its temperature and reduces its efficiency. In order to reduce the loss of power due to temperature increment, a system which is phase change material (PCM) with aluminum fins (PV-PCM/Aluminum) has been developed. In this study, aluminum fins were used to increase the transferring heat with PCM to absorb heat energy from photovoltaic panels. This method is a passive cooling method that regulates the temperature of the PV panel in hot climatic conditions. RT28HC was used as PCM to regulate PV panel surface temperature. In order to regulate the temperature of PV cells and increase the electrical performance of photovoltaic panels, the usual PV panel was compared using PCM with flat aluminum fins (MODULE A) and PCM with perforated aluminum fins (MODULE B).
The experiments were conducted in a laboratory for 60 minutes at 20 °C as the starting temperature. Experimental results indicate that the average PV panel surface temperature decreased by 16,9% from 49,24 °C to 40,92 °C (MODULE A) and 17,37% decreased from 49,24 °C to 40,69 °C (MODULE B). With the decrease in the PV panel surface temperature, the electrical features of the PV panel were measured and maximum power generation increased by 7,43% compared to usual PV panel from 1,48 W to 1,59 W (MODULE A) and 9,46 % from 1,48 W to 1,62 W (MODULE B). Results are presented in graphical form of time-dependent surface temperature, current, voltage, and power of PV panels.

Keywords: *Phase Change Material (PCM), aluminum fin, potovoltaic, thermal management*

Replicating the Success of the HP4ALL Project: Increasing Heat Pump Skills and Increasing the Demand for Those Skills

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Abstract
The HP4ALL project is a EU Horizon 2020 funded project that was completed in February 2023. HP4ALL aims to facilitate an increased market demand, mass rollout and a further advancement and uptake of heat pumps (HPs) technologies and systems for residential and non- residential applications, through the subsequent market boosting of related skilled workforce demand and provision by:
1. Providing HP related tailored, sound, key information to all relevant stakeholders and users, thereby facilitating their decision-making process.
2. Paving the way for a more robust level of skills in the HP value chain, ensuring high quality and reliability from the supply side.
To this end HP4ALL has developed a set of tools and resources called HP4ALL package that will be used to help replicate the success of the HP4ALL project:
- An HP Competency Framework to facilitate Mutual Recognition of HP Skills. It will allow manufacturers, designers, and installers to benchmark their knowledge and skills to determine if they are meeting the needs of the market. Such a framework will also facilitate mutual recognition across the EU.
- A user-oriented HP Knowledge Hub to provide guidance, support, and tools (e.g., technical information, case studies, procurement guidance) to increase the demand for HP skills and knowledge.
- A HP Benchmarking Tool enabling end users to consider options and performance of HP technologies within different building and application types.
- Tested Awareness Campaign & Training materials, tools, and methods to assist in the EU-wide roll out of heat pumps and the replication of the HP4ALL project success.

- Pilot Activities - to engage Key Stakeholders to ensure High Quality Installations and greater uptake.
  Ireland: Local Authorities, instigate large numbers of heat pump installations, domestic and non-domestic.
  Austria: Large Scale Heat Pump Installations - project owners, designers, and installers.
  Spain: Public Sector Housing - promote greater use of heat pumps for heating/cooling. For existing older equipment investigate ways to increase efficiency - improve building thermal performance, more efficient replacement units to deliver heating as well as cooling, low GWP refrigerants.
- Policy Recommendations that are aimed at all levels of governments from local governments to EU level. These recommendations are for legislative and administrative adjustments to foster labour market consolidation schemes, incentives (based on success stories) and ambitious private and officially supported dissemination & communication packages. The HP4ALL consortium has been interacting with the entire HP value chain, both the supply side (manufacturers, engineers, designers, installers) and the demand one (building owners and end users form all sectors -residential, industry and tertiary) in three pilot regions Austria, Ireland, and Spain, as well as interacting with other countries and stakeholders through our European partners.

Note:
This project is a Horizon 2020 EU funded project that ends in February 2023, but has replication elements after the lifetime of the project.

Numerical Simulation of Water-ice Formation Around a Pipe

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Abstract
The novel approach in computing the mass transfer across the interface in a boiling flow [Cukrov, A., Sato, Y., Boras, I. i Ničeno, B. (2021). Brodogradnja, 72 (4), 141-164. https://doi.org/10.21278/brod72408] is now applied to a mass transfer problem that involves solidification of a water-ice. The governing equation set is comprised of mass, momentum and energy equations, defined on a per-phase basis. In addition, the conjugate heat transfer has been taken into consideration inside the solid material of the pipe. The solution to this problem involves the analysis of the temperature field inside the ice layer, and the evolution of the ice-water interface thorough the simulation process.

Long Term Performance of Heat Pump System under Influence of Aging Effects

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Abstract
Heat pumps are energy efficient devices crucial for energy transition to sustainable heating solutions. Potential of the technology in reaching goals related to increased share of renewable energy in use and reduction of greenhouse gas emissions is directly correlated with seasonal coefficient of performance. Harsh working conditions, improper sizing and lack of maintenance can lead to deterioration of energy efficiency, increased running hours of the system and reduced thermal output during life cycle of equipment. Mentioned leads to the reduction of share of renewable energy in use and negatively affects whole building performance. In this research, model of heat pump system in single family building is used to assess the degradation rate models and discuss their impact on long-term system performance.

Energy Analysis of Hydrogen Use in Road Transport of the Republic of Croatia

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Abstract
In this paper, we will calculate the what needs for hydrogen would be if all traffic in Croatia was driven by hydrogen. In the thesis, we will determine the required amount hydrogen ew need, we will briefly describe fuel cell cars and how much the amount of exhaust gases would be reduced. We will explain the ways of obtaining hydrogen, its transport and what the purchase costs would be. And in the end, we will compare the results and we will make the conclusion.

Decarbonisation of Communities and Geographical Islands - Experiences from H2020 INSULAE and HE Communitas

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Abstract
With its 'Clean Energy for all Europeans' Package (CEP), the European Commission formally recognised and instrumentally brought forward community energy projects, including definitions for 'Renewable Energy Communities' (RECs) and for 'Citizen Energy Communities' (CECs). The new concepts introduced in the CEP set the course for a more active role of EU citizens in the energy markets. To fully concretize the benefits envisioned by the CEP, a myriad of barriers needs to be overcome and progress needs to be done to clarify and streamline the concepts of REC and CEC, enabling its uptake by all interested citizens. Motivated by that challenge, COMMUNITAS will promote energy citizenship, enabling citizens to take control of their own path towards sustainability by becoming an active element of the energy markets. The project will deliver a Knowledge Base that will provide users with technical, administrative, and legal information on ECs, streamlining the creation and expansion of this concept.
COMMUNITAS will also deliver an innovative set of tools - capitalizing on technologies such as IoT, Blockchain and Cloud Computing - to unlock citizens' active participation in energy markets and communities (all integrated into an open, digital 'one-stop-shop' COMMUNITAS Core Platform (CCP)), allowing EC members to have an aggregated position in the energy markets or explore ancillary services using different energy assets or load profiles of the community.
As a project that aims to position citizens in the centre of energy markets, COMMUNITAS has citizens at the centre of its own approach: citizens will be involved in Social and Policy Labs throughout the whole project, in order to frequently factor in their feedback, wishes, needs into the core developments of the project.

Influence of Different Defrost Strategies on Heat Pump Efficiency

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Abstract
Heat pumps are rapidly increasing their share in the HVAC sector with the 10 years average annual growth rate in EU sales of around 10%. Units with air as a heat source are dominant compared to ground and water units. That is why in this article we are addressing one of the main problems of air source heat pumps - frosting of the evaporator. Capacity and efficiency drop caused by the ice on the surface of the evaporator is a well-known phenomenon for which the mostly used solution is reversing the cycle. It results in short periods of taking the heat from heat transfer fluid to defrost the ice accumulated on the exchanger surface. Decreasing the efficiency of the heat pump occurs when the periods between defrost cycles are too long and high thermal resistance of the ice on the walls of the evaporator reduces heat transfer efficiency or cycles are too short which cools the fluid excessively. In this study, improvements in optimally timed parameter driven defrost cycles were compared to traditional timer-driven defrosting.

Combined Use of Hydrogen Technologies and Renewable Sources to Reduce the Carbon Footprint in the SAŠA Region

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Abstract
In the world, they produce a lot of electricity as well as a good part of thermal energy with the help of coal thermal power plants. Due to the influence of ecological factors, a drastic reduction in the use of fossil fuels is planned in the coming decades. The presented article shows an attempt to replace the use of coal with renewable resources and the production of hydrogen in the Savinja-Šalek (SAŠA) region in Slovenia.

Keywords: *Renewable energy sources, hydrogen technology, energy requirements, environmental impact*

Increasing Efficiency and Reducing Pollutants Emissions from the Residential Cooker Burning Wood Biomass

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Abstract
Commission Delegated Regulation (EU) 2015/1185 defines eco-design requirements to solid fuel local space heaters in terms of the seasonal space heating efficiency and pollutants emissions of dust, organic gaseous compounds (OGC), CO and NO_X. The related new series of standards EN 16510 specifies more strict requirements on the pollutant emissions compared to the previous standards. Complying with these requirements entails adaption of the common design solutions of furnaces and other heat exchange parts of space heaters.
This paper describes design measures applied to the residential cooker burning wood biomass in order to satisfy mentioned requirements on the thermal efficiency and pollutant emissions. An influence of primary and secondary air flow rate, as well as position of the air supply within the furnace is investigated in terms of CO and dust emission reduction. The experimental results showed a significant decrease of pollutants with an appropriate flow rate and position of secondary air supply can be achieved, provided the burning rate is adequately adjusted via primary air flow rate. Also, the wood briquettes composition and quality has been proved by tests to greatly affect the dust emissions.

Keywords: *thermal efficiency, pollutants emissions, residential cooker, wood biomass*

The Method of Determining the Radius of Techno-economic Feasibility of Waste Heat for the Planning of the District Heating System

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Abstract
The heating sector is one of the most energy-intensive sectors, accounting for almost 50% of final energy consumption at the level of the European Union. Looking at where that energy comes from, it is noticeable that almost 70% of that energy comes from fossil fuels. In this context, the question arises as to how this dependence on fossil fuels can be reduced, and one of the answers to that question is the utilization of waste heat, not only from industry but also from urban heat sources. Urban heat sources such as the refrigeration system of supermarkets, cooling systems of supermarkets and shopping malls, data centres, and power substations are well known and recognized as systems that can be a reliable source of heat for the district heating system, but what represents a difficulty is their spatial dispersion and therefore spatial planning a district heating system is more demanding and requires considering many factors. In this paper, a methodology is offered that systematically helps in planning the integration of urban heat sources in district heating systems, considering several criteria. The criteria can be divided into criteria characteristic of heat sources: heat source temperature, waste heat potential, and criteria characteristic of the district heating system: temperature regime of the heat network, heat demand, and plot ratio. The main outcome of the paper is to determine the radius of techno-economic feasibility of waste heat, , at different temperature regimes of the district heating network (high-, medium-, low-, and neutral-temperature regimes), different heat demands (environments with the low and high demand), and different plot ratios (high and low population environments). The method has been implemented and tested in the case of the City of Zagreb.

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