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Abstracts

Experimental investigations of intermediate pyrolysis of brewer's spent grain

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Biomass pyrolysis is a process when operating conditions such as temperature, gas atmosphere and volatile residence time have a crucial impact on product generation. Presented study concerns experimental investigation of the influence of sweeping gas on intermediate pyrolysis of brewer's spent grain. Three types of gases were used: nitrogen, argon and carbon dioxide with a constant flow rate of 300 ml/min. Experiments were conducted at 500, 600 and 700 °C in the specially designed horizontal fixed bed reactor.

The main goal of this paper was to compare quantity and quality of obtained products under different conditions as well as to determine a heating curve of the sample during the experiment. Received products were designated to three main groups: solid residue, condensable fraction and light-weight gases. The amounts of solid and liquid pyrolysis products were estimated by weighting. The qualities of solid and liquid products were performed by elemental analysis where carbon, hydrogen, nitrogen and oxygen contents were determined. The composition of gaseous fraction was analysed by the gas chromatography method. This analysis was focused on carbon monoxide content determination in the gaseous phase.

Additionally, the presented studies were supplemented by a micro-scale investigation, using thermogravimetry analysis with heating rate equal to 5 K/min. Based on the thermal analysis it was observed that there were no significant differences under various atmospheres.

Heat transfer characteristics of a fluidized bed heat exchanger with a horizontal tube bundle

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In the research work, energy transport between a dense fluidized bed and a submerged horizontal tube bundle is analyzed in the commercial external heat exchanger (EHE). In order to investigate the heat transfer behavior, Authors carried out seven performance tests in a fluidized bed heat exchanger chamber with the cross-section 2.7mx2.3m in depth and width and the height up to 1.3m. The tests were conducted using bed particles in the Geldart type B range with Sauter mean diameter of 0.219mm-0.246mm and the particle density of 2680kg/m^3-2750kg/m^3 under variable CFB boiler loads conditions. Average bed-to-wall heat transfer coefficient has been calculated by a mechanistic heat transfer model based on the packed-renewal theory. The Authors have developed a mechanistic model for the prediction of average heat transfer coefficient which includes the effect of the geometric structure of the tube bundle and the location of heat transfer surface on heat transfer rate. Additionally, a deep analysis of the heat transfer mechanism took into account the interaction between the emulsion phase dynamics and bed particle sizes for a horizontal smooth tube bundle submerged in fluidized bed. In the case of analyzed range of bed particle size, predicted values of heat transfer coefficient varied between 328W/(m^2K) and 410W/(m^2K). Computational results depict that the average heat transfer coefficient is essentially affected by superficial gas velocity, suspension density rather than a bed particle size. The empirical correlations have been proposed for predicting heat transfer data, since the existing literature data is not sufficient for industrial fluidized bed heat exchangers. On the basis of evaluated operating conditions of an external heat exchanger, optimal conditions could be deduced where heat transfer occurs. The developed mechanistic heat transfer model is validated by experimental data under examined conditions.

Operating problems of heat exchangers submerged in fluidized bed of CFB boilers

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This paper focuses on operating problems of heat exchangers submerged in a fluidized bed in CFB boilers, based on experience with Intrex heat exchangers used in Sumitomo's SHI FW boilers. Intrex heat exchangers work on a steam path as superheaters (SH) or as reheaters (RH) being critical components to achieve designed steam parameters.

The origins of operating problems with Intrex heat exchangers are mainly due to incorrect fluidization levels in Intrex chambers. For lower Intrex where bed material from the boiler chamber is fed to the Intrex chamber through wall openings, problems appear when PSD (particle size distribution) of fuel fed to boiler is out of designed range. In this case, large bottom ash particles are formed and travel with bed material to the Intrex chamber causing fluidization problems.

Operating experience shows that a change of fluidization levels in the Intrex chamber can lead to a significant decrease in heat transfer which can lead to not reaching designed steam parameters and to steam superheat wane. The same influence on heat transfer in the Intrex heat exchanger has incorrect PSD of bed material supplied from the boiler chamber causing a decrease in heat transfer and in extreme conditions to the heat transfer atrophy. A substantial increase of coarse material share in the Intrex chamber leads directly to an increase in fluidization levels to uphold fluidal nature of Intrex bed material and allows the evacuation of coarser material from the Intrex chamber. Increased fluidization levels have a straightforward translation to decrease in heat transfer coefficients due to the increased amount of the air chilling factor. In extreme cases of singificantly coarse material share, steam superheat can be lost.

In this article, the Authors described the test results of fluidization level influence on heat exchange rate and influence of ash PSD as the heat exchange reducing factor based on the test caried out at EC Zabrze - CFB 75 kg/s, 536 ^{o}C, 92 bar, 203 MWth and CFB 1300 El. Łagisza – 361 kg/s, 563 ^{o}C, 282 bar, 966 MWth.

Methanol production in Brayton cycle

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The article presents a concept of renewable methanol production in the gas turbine cycle. As part of the work, an analysis was performed including the impact of changing the parameters in the methanol reactor on the obtained values of power, yield and efficiency of the reactor and chemical conversion. The aim of the research was to investigate the possibility of integrating the system for the production of renewable methanol and the additional production of electricity in the system. The efficiency of the chemical conversion process and the efficiency of the methanol reactor increase with increasing pressure and decreasing temperature. The highest efficiency values, respectively η = 0.4388 and η_R = 0.3649, are obtained for parameters in the reactor equal to 160 °C and 14 MPa. The amount of heat exchanged in all exchangers reached the highest value for 14 MPa and 160 °C and amounted $\dot{Q}$ = 2.28 kW. Additionally, it has been calculated that if an additional exchanger is used before the expander (heating the medium to 560 °C), the expander's power will cover the compressor's electricity demand.

Analysis of methanol production from biomass gasification in oxygen

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The article presents a thermodynamic analysis of the installation for the management of two types of biomass: wood and sludge, using the gasification technology in an atmosphere of pure oxygen, which was integrated with the liquid methanol production plant. The diagram, assumptions and work of the analyzed installation are presented in detail. The gasification installation was modeled in the Ebsilon Professional program, while the installation for the production and purification of methanol was modeled in the Aspen Plus program. The influence of gasification temperature and gasification pressure on the efficiency of the installation and the yield of hydrogen, and thus, also the yield of liquid methanol in a wide range, were analyzed. The analyzed system allowed to achieve the yield for wood biomass at the level of 0.441 kg_{CH3OH}/kg_{Bio} with the energy efficiency of the entire system of 57% and 0.257 kg_{CH3OH}/kg_{Bio} for sewage sludge with the energy efficiency of the entire system at the level of 54.7%.

Issues of improvement safety operation of a 18K370 steam turbine

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The paper concerns a process of improving the safety and reliability of the 18K370 steam turbine in Opole Power Plant since the occurrence of the first failure in 2010, so before installing a monitoring system on-line. The way the block works and the ability to analyze the degree of job control stage as a critical node in the design of the turbine has been presented. The analysis took into account the nature of the flow in different operating regimes CFD approach (Computational Fluid Dynamic) and strength analysis in CSD (Computational Solid Dynamic). Also, the way of management of an individual lifecycle of elements has been briefly described. The action could be considered as satisfactory and improve the safety of operating steam turbines 18K370.

Methodology of mathematical modelling of flow through a real filter material geometry

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Nowadays, there is an emphasis on reducing the emission due to industrial processes. In recent decades, filtering systems have become an integral part of the broadly understood heavy industry systems to reduce the emission of dust and other substances harmful to the environment and humans. Filter systems can also be found in HVAC systems, in the transport industry, and their use in households is also increasing. The effective separation of micro- or nano- meter contaminants is closely related to the development of new, sophisticated filter materials. Thanks to the use of modern tools for a multiphase flow modelling, it becomes possible to model the flow inside the filter material. In this study, we propose a methodology to simulate the internal flow of porous structures with a fibre size of 10-50 µm. The geometry used to build the mathematical model is the actual geometry of the filter obtained through the use of 3D scanning. The mathematical model has been validated against experimental data. In this article, we show the methodology to adapt a geometry scan for use in commercial CFD software. Then, we present the research determining the impact of the modelled filter volume, computational domain and mesh on the pressure drop in the filter. On the basis of the conducted research, the minimum size of the modelled filter volume and the size of the computational mesh elements were determined, allowing to obtain a representative solution of the flow structure through the filtering material. The obtained results and their convergence with the experimental study indicate the potential for the development of a multi-fluid mathematical model that will allow for the study of the filtration process.

Impact of solar energy on the heating and cooling demand of rooms with different orientation in Polish climatic conditions

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The expected increase in the average annual ambient air temperature will reduce energy demand for heating and ventilation, thus increasing energy demand for cooling. The amount of solar radiation absorbed by the interior of the building will be decisive factor forming energy demand in order to maintaining thermal comfort during all year.

The paper presents results of energy balances analysis for hypothetical room during 6 selected weeks of Warsaw typical meteorological year. Selected periods are characteristic for the variable weather condition during winter and summer seasons.

It has been assumed that heat transfer between interior of a room and its ambient surrounding takes place only through an external wall and window, which surface area varies in different variants, and assuming constant stream of ventilation air. In addition, heat transfer coefficients of the external partitions and transmittance of glazing vary in different cases. Internal heat gains are not taken into account. On a base of mathematical model of energy balance of a building (room) simulation studies have been performed using EnergyPlus.

The results obtained allow to formulate conclusions regarding possible future changes in the energy balance of residential buildings and the increasing role of cooling demand in summer.

Direct and indirect methods of GT exhaust gas flow measurement

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Exhaust gas flow together with temperature are the most important parameters in Cogeneration, Trigeneration, ORC and Combined Cycle plants based on the Gas Turbine. While the exhaust gas temperature is measured on most GTs, the exhaust gas mass flow is rarely measured directly. An accurate estimation of exhaust gas flow is important in particular for the control of the HRSG, WHRU or ORC, estimation of available exhaust energy as well as actual emission rates evaluation.

In many applications indirect measurement by means of the axial compressor flow and fuel flow measurements are considered. The axial compressor flow can be measured by the means of dynamic pressure in the inlet belmouth and by the means of flowmeters in the inlet system designed specifically for the GT protype testing. In some applications the estimators of exhaust flow based on main measured GT parameters are developed. During GT Performance Test the GT exhaust gas flow is typically estimated by means of energy balance according to the ASME PTC22 test code.

The article comprises the description of various methods of GT exhaust gas flow measurement and estimation, comparison between them based on the data from GT prototypes testing, as well as the Monte Carlo analysis and a guideline for method selection for specific application.

The indirect measurement method is the most accurate. High accuracy can also be achieved with the estimators of exhaust flow. Energy balance is less accurate, however can be easily applied based only on typical GT measured parameters. The direct exhaust gas flow measurement is found as the least accurate.

MELCOR 2.2 Simulations for the Gen-II NPP Severe Accident Management Studies

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The paper presents severe accident simulations dedicated to developing a database of Nuclear Power Plant (NPP) states which was applied during the development and testing of the Severe Accident Management Guidelines (SAMG) Decision Making (DM) Tool SEVERA. The presented work was performed in the framework of Work Package 5 in the Horizon-2020 research project NARSIS (New Approach to Reactor Safety Improvements). The plant model and simulations were prepared with the MELCOR 2.2 integral computer code for a generic NPP with Generation-II two-loop Pressurized Water Reactor (PWR). The developed database covers the results for phenomena and time evolution of plant status crucial parameters important for both in-vessel and ex-vessel phases of a severe accident. The analysis covered the reactor coolant system thermal-hydraulics response, containment performance studies including combustible gases management, filtered containment venting and Molten Core Concrete Interactions. Two general types of scenarios were considered, low-pressure sequences and high-pressure sequences. In the case of low-pressure, several variants of a Large Break Loss of Coolant Accident (LB-LOCA) were studied, including cold-leg and hot-leg breaks with and without mitigation actions. In the case of high-pressure scenarios, Station Blackout (SBO) was considered with different recovery actions and additional seal LOCA simulations. The presented results have application in SAMG studies and the development of the novel SAMG DM tool.

Review of heat management systems for high voltage accumulator in electric vehicles and its perspectives

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Thermal management of high voltage accumulators used for electric mobility is a complex topic, due to many limiting factors like size, weight, cost of development and implementation, and safety. Advancements in technology created cheaper cells that can store more energy and have higher power density, which enabled manufacturers to create many new electric vehicles. However, the accumulator in EVs is still the most expensive part of electric powertrain and cells are very sensitive to operating conditions. Temperatures outside of their specific window can cause a quicker loss of their capacity; lower power performance or even, cause thermal runaway events that are almost inextinguishable. Consequently, the proper thermal management gets a lot of attention. This paper discloses important aspects of accumulators that have to be considered during a thermal design, reviews every current solution, their advantages and disadvantages, with examples of EVs that use them. Current trends and possible changes in near future are then disclosed to create good knowledge about the current situation and trends on the market to make the early phase of conceptual work easier.

Comparison of inverse uncertainty quantification methods for critical flow test

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A problem of epistemic uncertainties introduced by code input parameters that cannot be estimated other than by a user's expertise exists in the nuclear reactor systems analyses since the first Best Estimate Plus Uncertainty methodologies were introduced. Inverse Uncertainty Quantification (IUQ) methods aim at providing a robust and scientific estimation of the distributions of such parameters. This paper compares and assesses two approaches to quantify the uncertainty of critical flow parameters available in the TRACE code.

The first approach is based on a machine-learning algorithm, using a Random Forest classifier to assign the results of calculations to one of the defined classes of prediction accuracy in respect to experimental data. The machine learning classification resulted in creating a class for which the results with the best fit to the experiment were collected. Derivation of this class created an opportunity to propose ranges and probability distribution functions for TRACE internal variables, which is a goal for IUQ methods.

The second approach is based on the Markov Chain Monte Carlo sampling. The second approach allows for an explicit definition of model discrepancy term modeled in the form of a Gaussian process. Markov Chain Monte Carlo algorithms allow sampling from a probability distribution and can be used to estimate the distribution of parameters given a set of observations.

Both approaches were used to estimate uncertainties for critical flow parameters available in the TRACE code based on the Marviken critical flow experiment.

Experimental studies of the effect of microencapsulated PCM slurry on the efficiency of a liquid solar collector

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The paper presents the results of preliminary research aimed at determining the possibility of using microencapsulated phase change material slurry (mPCM) as a working fluid in installations with a flat liquid solar collector. The following were used as the working fluid during the tests: water (reference liquid) and a slurry of microencapsulated PCM. 10% wt. and 20% wt. an aqueous solution of the product under the trade name MICRONAL® 5428 X were used. As the product contained 43% mPCM, the mass fraction of mPCM in the working liquid was 4.3% and 8.6%, respectively. The research was carried out in laboratory conditions in the range of radiation intensity G = 270-880 W/m^2. The mass flux of each of the three working fluids in the collector was 30 kg/h, 40, kg/h, 60 kg/h, and 80 kg/h. It was found that the increase in the thermal efficiency of the collector fed with slurries was 4% with 4.3% mPCM in the slurry and 6% with 8.6% mPCM in the slurry. At the same time, the slurry is characterized by a lower temperature at the outlet from the collector as compared to the water with the same thermal and flow parameters.

Analysis of Dry-Ice Blasting Cleaning Speed – CFD Modelling and Batch Tests

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Although dry ice blasting seems to be a popular way of industrial dirt cleaning, so far, a few scientists have addressed their research to this method. The study aimed at analysing selected operational parameters impact on the dry-ice blasting cleaning speed. Bench tests described in the paper covered various operating air pressure, dry-ice mass flow rate, cleaning angle, nozzle-surface distance, surface and dirt types. The proposed methodology focuses on cleaning efficiency determination and dry-ice particles transport efficiency, identified as crucial from the nozzle functionality point of view. The mathematical model of the supersonic, two-phase flow was described and implemented in the Ansys CFX numerical environment. CFD helps to analyse flow behaviour in the nozzle and identify the potential drawbacks of the fluid flow channel. The presented model was validated against experimental data, so it can be treated as a valuable tool for further developing dry-ice blasting systems. A simultaneous analysis of modelling and experiment results allows to draw precious conclusions. Particles and flue gases velocity growth contributes to cleaning speed increase. This parameter can be regulated by inlet air pressure, nozzle-surface distance or cleaning angle. What is interesting, physical properties of the cleaning surface also may influence the cleaning speed. Materials characterised by lower heat transfer coefficients are easier to clean as local subcooling supporting cleaning mechanisms is deeper. Moreover, greater particles are more prone to remove the pollution. The knowledge presented in the study may lead to a dry-ice blasting process optimisation and contribute to blasting medium and energy savings due to the effective use of the blasting system.

The use of silicagel-water heat storage devices in a large scale district heating system

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The issue of energy storage has played a huge role in modern district heating systems for many years. The fourth-generation district heating systems include not only the production and transmission of hot water, but also many other services, such as the storage of heat and even cold. Heat and cold can be stored in the form of a water temperature change, but the methods associated with the use of sorption phenomena are much more efficient. The aim of the presented research is to estimate how much more efficient in terms of energy storage is the solution based on water-silica gel adsorption beds. As part of the research, a mathematical model was developed for heat storages that can cooperate with district heating systems in the field of heat and cold storage. It turned out that this type of storage allows energy to be stored in much smaller volumes than in the systems that use storage in the form of a change in water temperature. Due to the low price of silica gel, the solution can be successfully implemented in any heating and cooling district system.

Analyzing of different repowering methods on the example of 300 MW existing steam cycle power plant using gatecycle^{TM} software

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In this paper the different concepts of repowering of existing steam cycle power plant were discussed. Because of the current situation related to the carbon dioxide emissions limitations' politics and the fact related to the remarkable increase in global electricity consumption, repowering is becoming more and more interesting and important solution on the way to the energy transformation realization. The discussed topic refers to the behavior of 300 MW steam cycle power plant (installed on high altitudes) in different repowering conceptual cases.
Using commercial software GateCycle^{TM}, five different repowering methods have been simulated:

1. feed water heating repowering method,
2. hot wind-box repowering method,
3. parallel hot wind-box repowering method,
4. complete repowering method with maximum supplementary firing,
5. complete repowering method without supplementary firing.

After investigation of the thermodynamic analyses of power plant model before and after each repowering method two main repowering concepts were defined - 1) when the main emphasis of repowering is on electrical energy production and the main target of repowering is increase the capacity of the plant and 2) when the main emphasis of repowering is on the efficiency and the main target is the efficiency increase.
The first variant is typical to developing countries (especially Post-Soviet countries, Iran, India and China), which was defined as “Eastern Repowering Experience" and the second variant is typical to developed countries (especially Europe, USA), which was defined as “Western Repowering Experience”.
To those repowering concepts three different gas turbines has been used: Siemens V84.2, ABB GT11N2 and Alstom GT13E2. To analyze the models, calculations were performed with two stages: 1)analyzes of thermodynamic parameters as well as carbon dioxide (CO_2) emissions of the power plant model in mentioned above cases and 2) calculations of thermodynamic parameters in values 100, 90, 80, 70, 60 and 50 % of the power plant net cycle power in the different cases to show the advantage of different repowering methods behavior in part loads.

Influence of dissolved air on the dynamic of cavitating Venturi flow-experimental observation

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The interest to investigate the cavitating flow is its significant influence on the object subjecting to this phenomenon. The highly dynamic and unsteady characteristics of the cavitating flow cause many negative effects such as erosion, noise and vibration in the devices subjected to cavitating flow such as pumps and valves operating in the power plant. These negative effects lead to the lower efficiency and lifetime. Thus, finding the approaches to control this phenomenon is highly desirable. For this purpose, recognizing the behaviour of cavitating flow over various parameters is required. In the real application, it is inevitable to neglect the dissolved air in the water, as a result; it is required to take the effect of dissolved air into consideration during experimental work. The present work conducted sets of experimental tests to analyze the cavitating flow and the corresponding unsteady characteristics in the presence of dissolved air as the third phase. For this purpose, two different amounts of dissolved air in a range of cavitation number were considered in the study of cavitating flow inside a Venturi nozzle. The experimental observations are carried out in the closed-loop cavitation tunnel located at the Department of Power Engineering and Turbomachinery of the Silesian University of Technology. The cavitation evolution is visualized using a high-speed camera and image processing. In addition, the instantaneous pressure fluctuations at the surface of the Venturi nozzle are collected using pressure transducers. In addition, the vibration of the cavitation test chamber is recorded using two piezoelectric transducers. Hence, the FFT analysis is employed to detect the main shedding frequency. The results proved that the shedding frequency reduces by adding dissolved air into the water. On the other hand, the length of cavitating flow considerably enhances at a higher level of dissolved air. In addition, it is observed that the re-entrant jet, as the main reason for the cavity detachment, is more effective in cases with a lower level of dissolved air.

Numerical research of flue gas denitrification using the SNCR method in a OP 650 boiler

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The presence of Poland in the European Union obliges the domestic economy and the professional energy sector to improve the condition of the natural environment by reducing the emission of harmful substances to the environment. One of the substances that have a negative impact on the environment are nitrogen oxides. The article presents the results of numerical calculations of flue gas denitrification using the SNCR method in an OP 650 boiler. The method of verifying the combustion of the numerical model, in terms of measurement and calculations with a 0-dimensional model, is presented. Then, the results of numerical tests of flue gas denitrification using the SNCR method with the use of urea solution injection in a specific temperature window for various nozzle positions are presented. In the paper, 3 variants of the reagent injection into the furnace chamber were carried out, depending on the height of the nozzles position.

Development of wind farms in Poland in the context of climate change

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This paper summarises the ongoing transformation in the structure of the Polish power system. This is a very complex process which fits into global megatrends in this matter. It needs to take into account such crucial elements as socially responsible investments, life cycle assessment, policy changes and investments strategies. The United Nations climate policy urges to take certain actions to combat climate change and its impact. It highlights new record high levels of greenhouse gases content in the atmosphere. Presented graphs contain data extracted from the Polish power system showing intra-day, monthly and annual load distribution. Particular attention is paid to the variability of wind energy sources and their efficiency (full load equivalent operating hours factor). Discussed aspects do not address any issues related to the stability of the power system. Additionally, it does not contain any polemics with the cited research results. On their basis it can be pointed out that wind farms contribute to a local temperature and precipitation increase. The nature of this phenomenon (positive or negative) in the context of global warming is currently the subject of worldwide research. Nevertheless, it can be said with certainty that the environmental impact of renewable sources usage is significantly lower than in the case of classic power plants based on fossil fuels.

Innovative method for waste heat recovery from coal-fired boilers through additional economizer

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The usage of wet methods for flue gas purification from coal-fired boilers is associated with significant heat losses and water resources. Widespread in Kazakhstan and Russia scrubbers, emulsifiers of the first and second generation are satisfactory in terms of flue gas cleaning efficiency (up to 99.5%), but at the same time do not create conditions for deeper waste heat recovery, leading to lowering the temperature of gases. An innovative method has been proposed, including the installation of an additional economizer in front of the scrubber (emulsifier), as part of the flue gases passes through a parallel bag filter. At the outlet of the emulsifier and the bag filter, the gases are mixed in a suitable ratio, whereby the gas mixture entering the stack does not create conditions for condensation processes in the stack. A technical and economic analysis was made and the economic feasibility of the implementation of the method in several different TPPs was assessed.

Evaluation of a liquid hydrogen regasification cogeneration system

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Hydrogen transportation is one of the main challenges of the hydrogen economy. Many countries have launched their Hydrogen National Plans and expect to switch to a decarbonized economy within the next decades with the aid of the green energy that can be stored in this element. One option is to transport hydrogen from countries with abundant renewable energy to the rest of the world in a liquid form. Hydrogen can be transported in a liquid state similar to the current liquid natural gas (LNG) transportation chain. The liquid hydrogen (LH_2) chain requires cryogenic temperatures and insulation tanks that keep the LH_2 at -253 °C. Once the hydrogen reaches the delivery port, it needs to be regasified before usage or distribution. The hydrogen liquefaction process and regasification are associated with very high energy consumption; therefore, exploiting the heat waste from the process is of extreme value in a large-scale scenario. This paper evaluates from an exergetic point of view one possible configuration for a large-scale cogeneration hydrogen regasification plant. The total exergetic efficiency calculated is 39 %, and it was found that the combustion chamber and the hydrogen vaporizer account for 63 % of the total exergy destruction of the system. Finally, it was demonstrated that the hydrogen vaporization and compression to delivery conditions is a process in which all the thermal exergy of the hydrogen stream is transformed to mechanical exergy.

Assessment of the potential improvement of the performance of solid oxide electrolysis stacks by adjusting the pore phase fraction in the functional layers

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Increasing awareness of the inevitability of the reduction of fossil fuels consumption, under current technical conditions in fuel and power sectors revealed, in a close time perspective a rising demand for alternative energy sources. This together with the foreseen depletion of conventional energy resources, draws the attention of many to alternative, low-carbon technologies such as hydrogen. This boosted and continuously stimulates the development of solid oxide technology which can potentially become a cutting edge solution in the field of water electrolysis for hydrogen production in the nearby future. Among proton exchange membrane (PEMWE) and the well-established alkaline water electrolyzers (AWE) it stands out with the highest efficiency. The performance of solid oxide electrolysis cells (SOECs), the key components of stacks and entire systems is under continuous development. Further increase of the performance can be achieved by the fine tuning of the microstructure of the electrochemically active component. This includes the adjustment of the microstructure of functional layers of SOECs. In this study three different electrode functional layer microstructures of fuel electrode of SOE cells were elaborated. Pore phase fraction inside the layer was varied by the addition of graphite pore former which influenced the active triple phase boundaries shaping. Three 5x5 cm, fuel electrode supported, SOECs with 10Sc1CeSZ as the electrolyte were manufactured, each with different volumetric addition of graphite inside the functional layer. Electrochemical performance of the cells was studied experimentally. Moreover, the microstructure was investigated using imaging which was done with SEM/EDS techniques. Afterwards, the obtained experimental results were used in the mathematical model of solid oxide electrolysis stack. Based on the modelling, performance maps of SOE stacks with modified microstructure of functional layers were obtained. It was proven that the proposed microstructural adjustments of single cells led to the improvement of SOE stack efficiency.

Petroleum coke and refuse-derived fuel co-firing enhanced with hydrogen in an industrial cement kiln – a CFD study

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This work numerically investigated the effects of petroleum coke and refuse-derived fuel (RDF) co-firing in the process of clinker manufacturing, one of the most carbon-intensive industrial processes. The CFD model of an existing, commercially operating rotary cement kiln furnace has been developed to analyse the effects of alternative fuel introduction on combustion characteristics. The influence of hydrogen addition present on-site has also been studied.
The conducted simulations cover flow, heat transfer phenomena, hetero- and homogenous chemical reactions, and different devolatilization schemes for the respective fuels. Moreover, interactions between the clinker bed and the gaseous domain are included. The numerical model also takes into account the difference in aerodynamic properties of both of the used solid fuels, which is of prime importance since particulate matter such as fly ash or unburned fuel to some extent enters the clinker bed and becomes part of it. The calculations also include an approach enabling the clinker movement (down the kiln and circumferential), mixing and the occurrence of endo- and exothermal reactions within the clinker bed.
It was found that the increased share of RDF in the fuel share moves the flame away from the burner, despite the much higher volatile matter content compared to the petcoke. Additionally, the further increase of the RDF share (i.e. over 60% in terms of energy) with the current burner design appears difficult because of the significantly broader range of RDF particles sizes, affecting the flow patterns and the ignition time.
The obtained results have also shown that the current amount of hydrogen fed to the furnace, which accounts for less than 1‰ of the total chemical energy of the fuels, does not substantially affect the course of the combustion process. However, the experiments performed on a semi-industrial test stand and the preliminary simulation data indicate that increasing the proportion of hydrogen allows the flame to be partially returned to its original position.
The study was carried out within the RETROFEED project under financial support of the European Union’s Horizon 2020 research and innovation programme under grant agreement No 869939.

Analysis of corrosion resistance of boiler steel and alloy coatings under ash deposit

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Environmental protection and world energy policy encourage coal replacement by renewable fuels such as biomass and alternative fuels like refuse derived fuel (RDF). The goal of this work was to study the corrosion resistance of boiler steel together with protective alloy coating. These metallic materials are applied in high temperature combustion environment under flue gas atmosphere and ash deposits. In this study, the influence of ash deposits on a metallic surface was investigated. There were analysed four ashes obtained from wood biomass, straw, refused derived fuel and coal. The aggressive components of ash like potassium, sodium, sulphur and chlorine can accelerate the operating problems of heat exchanging surfaces in power boilers leading to enhanced slagging, fouling, agglomeration of ash and corrosion. A series of experimental studies was performed. Four boiler steels were chosen for detailed investigation: 16Mo3, P265GH, Inconel 625 and 686. They were covered with ashes, placed in a furnace and heated through 4 months at 750 °C under oxidizing conditions. The multifaceted analyses of ashes were carried out including a determination of chemical composition (XRF), thermal behaviour (STA), phase composition (XRD) and characteristic ash melting temperatures (DT, ST, HT, FT). Additionally, both slagging and fouling indices were calculated to predict sintering properties of studied ashes. The surfaces of studied steels after the exposure of ash presence were analysed using SEM-EDS technique. The results showed that the corrosive impact of ashes depended on aggressive components presented in ash. Moreover, the FactSage thermochemical equilibrium calculations were used to predict the amount of liquid slag and solid phases at studied conditions and to determine the transformation of mineral phases of the ash.

Experimental study involving methanation reactor for conversion of H_2 and CO_2 into synthetic natural gas (SNG)

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The processing of CO_2-rich waste streams into synthetic fuels (including synthetic natural gas, SNG) offers the potential to reduce greenhouse gas emissions and develop a fuel diversification. One of the possibilities is to convert CO_2 to CH_4 by hydrogenation in the Sabatier (methanation) reaction with the use of hydrogen. However, in order to exploit the potential of this approach, a number of technological challenges related to the methanation reactor design, including thermal management and catalyst deactivation, need to be addressed. The exothermic nature of the Sabatier reaction can lead to overheating of the reactor, while the high temperatures are detrimental to the methanation process, resulting in low CO_2 conversion. Moreover, the deactivation of the catalyst can also lead to low CH_4 production and shorten the operation time. This paper presents the works conducted on the laboratory stand with a methanation reactor. The reactor was tested to maximize CO_2 conversion and CH_4 production. The subject of the research was a nickel bed reactor. The reactor efficiency was assessed in terms of CO_2 conversion and CH_4 yield. The impact of the selected values (temperature, pressure, streams of substrates) on the efficiency of the process was analyzed. The results of the experiment were compared with the mathematical model of the methanation process simulated in the Aspen Plus software. The test results showed that a high conversion rate, exciding 95%, can be achieved.

The replacement of combustion by thermal processing as a promising approach towards a zero-emisssion energy conversion from biomass

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In order to minimize negative environmental aspects associated with the production of heat and power from the combustion of solid fuels (such as e.g. the emission of pollutants, more carbon dioxide in the atmosphere, etc.) the process of biomass thermolysis (thermal treatment) is investigated in this paper. It is demonstrated that the replacement of direct combustion of biomass by its thermal processing and carbonization brings about numerous environmental benefits, not only with respect to the possibility of sustainable production of heat and power from biomass volatile matter but also due to the transformation of the organic substance into CO_2-negative solid residue – the biochar. Some chosen authors' experimental data are shown and discussed, and the possibility to run a comprehensive carbon-negative power generation plant is also demonstrated.

Erosion in CFB boilers fired with biomass and coal – analysis of some chosen cases

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The operation of some chosen large-scale circulating fluidized bed (CFB) boilers is discussed in the current paper with respect to boiler hydrodynamics and combustion in the CFB furnace. Particular attention is given to the analysis of gas-solids flow in order to minimize tube erosion in some neuralgic zones of the CFB loop. The analysis is supported by boiler operational parameters and experimental data, as well as by the results of numerical calculations. The data, presented and discussed in the paper, indicate that for the investigated CFB boilers interesting and case-by-case tailored solutions for the decrease of the tube erosion rate may be proposed. The results also indicate that the erosion process may be controlled and maintained below the design limit and thus significant improvement of boilers' operation may be achieved.

Analysis of steam cycles operation under low loads to match a molten salt energy storage

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The paper describes methods of the evaluation and the selection of optimal operating conditions of existing steam turbines cycles. The analysis concerns the operation under low loads and is a part of a preparation to adapt the cycles to a molten salt energy storage. The molten salt storage allows to generate steam for turbines at any given load. It also allows to use existing power generating units, providing that the size of the storage matches the size of the steam cycle. The proposed solution aims at replacing a fossil fueled steam boiler with a molten salt storage. An estimated operation regime includes highly flexible loads to compensate the power changes in the energy system. The main requirement is an operation under loads lower then present minimal load for the steam turbines. The paper describes an analysis of the thermal cycles with the respect to the power generation efficiency. The possibilities to increase the efficiency are presented especially for low loads. Exemplary results are presented as well.

Possibilities of using metal-hydrides tanks to hydrogen storage

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The article describes the technology that enables hydrogen storage with the use of metal hydride tanks. This storage method, under moderate pressure and temperature, represents an important safety advantage over other hydrogen storage technologies. The paper also presents the tests results performed on a measuring stand equipped with metal-hydrides tanks. Each of the tested tanks had a maximum capacity specified by the producer equal 800 Nl. The characteristics of changes in tank temperature, pressure and mass accumulated in the vessel as a function of time are presented.

Techno-economic evaluation of Combined Cycle Gas Turbine (CCGT) and Adiabatic Compressed Air Energy Storage (ACAES) integration concept

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More and more operational flexibility is required from conventional power plants due to the increasing share of weather-dependent RES generation in the power system. One way to increase power plant's flexibility is by integrating it with an energy storage. The storage facility can be used to minimize ramping or shutdowns and, therefore, should lower overall generating costs and CO_2 emissions.

In this article, we examine the effects of Combined Cycle Gas Turbine (CCGT) power plan and Adiabatic Compressed Air Energy Storage System (ACAES) integration. The key assumption of the CCGT-ACAES integration concept used in our model is the ability to charge the compressed air storage with electricity generated in the CCGT plant.

The objective of this article is to build a model of CCGT-CEAS plant and give a valid prediction on the value the integration could generate. In order to assess the improvement in flexibility, we optimize the operation of the CCGT-CEAS plant on a yearly basis. Polish day-ahead electricity prices are used as a measure of the profitability of the power plant operation. By means of mixed integer linear programming we find the optimal production schedule for the stand-alone operation of the CCGT power plant, the virtually integrated CCGT-ACAES power plants and the two physically integrated power plants. The results contradict our supposition that an integration of a CCGT plant and a CAES is economically viable.

Application of the artificial neural network for determining the parameters of the PWR reactor

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The paper shows the implementation of an artificial neural network (ANN) used to determine selected parameters of the PWR (Pressurized Water Reactor) core. The Westinghouse 3411 MWth PWR core model was used as a demonstration case. PARCS 3.2 core simulator model was prepared and validated and then used to generate the training dataset. ANN has been trained to derive values such as initial and maximum reactivity, initial and maximum power peaking factor and length of the cycle, using the configuration of the fuel assemblies as the input. The results showed that the network is able to predict the above-mentioned parameters with a relative uncertainty of less than 4%, performing the calculations instantly. Therefore, the network can potentially be used for design optimization, uncertainty-sensitivity analyses, simplified ANN-based core simulator, and anytime when fast but not so accurate calculations are needed, e.g., during preliminary core design.

A regressive model for periodic dynamic instabilities during condensation R1234yf and R1234ze refrigerants

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This paper presents the results of experimental research and mathematical modelling on the influence periodic dynamic instabilities have on the condensation phase change of the R1234yf and R1234ze refrigerants in tubular mini-channels. This agents is currently utilised as a temporary substitute for R134. Besides the results, the paper contains a dimensional analysis procedure based on the *Π-Buckingham* theorem that has allowed for the development of a regressive model for the velocities of pressure dynamic instabilities. The experimental part of this paper was conducted using tubular mini-channels with an internal diameter of d_{ID} = 1.40 - 3.3 mm.

Experimental and numerical analysis of solid oxide electrolyzer with steam as a sweep gas in the oxygen electrode

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The paper presents investigation of the concept of substituting air with steam in the oxygen electrode compartments of solid oxide electrolyzer (SOE). The approach which was earlier proposed by Barelli et al. was currently analyzed in depth. The experimental investigation complemented by the preliminary numerical modelling was conducted to assess the effect of such an approach at the level of SOE stack. Experimental procedure included gradual increase of the content of steam in the gas directed to the anodic compartments of SOE (the air electrode). Voltammetry was used to register the voltage of the cell loaded from the OCV conditions to below -1 A/cm^2. Following the measurements which were performed at the level of single SOC operated in electrolysis mode, the numerical modelling was applied. In the first phase, the single cell was modelled. Upon successful completion of the validation against experimental data, the SOE stack was analyzed. The modeling tool which was earlier proposed for the investigation of SOE stacks allowed generation of performance maps of SOE stack which are presented and discussed. It was observed that the performance of the SOE is not compromised, and the concept which was studied aids reduction of the complexity of systems with SOE. Moreover, using steam as a sweep gas is beneficial for oxygen separation in the system.

System-level analysis of degradation of solid oxide electrolyzers operated in off-design conditions

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Currently, the installed capacity of renewable energy sources (RES) in gradually increasing. While the small-scale systems are often coupled with battery-based energy storage systems (ESS), the large scale storage of electricity in that form is not technically viable, nor economically justified. Batteries offer limited capability for long-duration storage of energy, and the discharge rate during seasonal storage becomes one of the key drivers of the increase of operational expenditures (OPEX). Additionally, the storage capacity of batteries can be only increased by scaling up of the packs. This expects large capital expenditures (CAPEX) which are needed for these devices. As an alternative, power-to-gas, power-to-liquid and power-to-ammonia systems, known under the common name power-to-X or P2X are currently under the rapid development. The core component of such systems is an electrolyzer which can be built in one of the existing technologies: alkaline water electrolyzer (AWE), proton-conducting membrane electrolyzer (PEM) or solid oxide electrolyzer (SOE). While the two former represent low-temperature electrolysis, the later is a high temperature unit. High operating temperature makes it possible to substantially reduce the energy demand in the hydrogen generation process. Moreover, operation between 600 and 700°C eases the integration with various downstream process which can generate synthetic fuels using hydrogen from SOE.

Solid oxide electrolyzer operated as a part of P2X system is expected to be exposed to the dynamic change of working conditions as well operation in partial load. Such modes can result in different degradation rates which are typically studied at the level of single SOE cells. In the study, the system-level approach was proposed to investigate the performance of degrading SOE stacks by the analysis of their current-voltage and current-power maps. In the work, reference scenarios were chosen and characteristics of the stacks were predicted using the model.

Currently, there are several ongoing projects in Poland which are focused on systems with SOE. For that reason, understanding the effects of various operating conditions on the degradation rate which affects the voltage and power demand of SOE can be beneficial to improve the performance.

Overview of turbine flow losses and efficiency

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The article concentrates on the investigation of flow losses in turbines of steam, gas cycle and ORC. Loss mechanisms are described depending on the place of occurrence in a turbine as well as depending on the underlaying physical phenomena. Among turbine flow losses the most visible are: boundary layer, trailing edge and flow separation losses, a variety of mixing losses, supersonic flow and shock wave / boundary layer interaction losses, as well as secondary and leakage flow losses. Special attention is paid to unsteady flow losses and losses connected with operational control of variable load turbines. Several measures to decrease the particular flow loss components and raise the turbine efficiency are also discussed.

Electrochemical and thermodynamic analysis of a solid oxide fuel cell powered by ammonia

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Climate change forces the development of the economy and technologies towards environmentally friendly solutions. They concern, among others, transition of transportation, development of efficient energy technologies, energy storage and alternative fuels based on low-carbon hydrogen. As a result of the complexity of hydrogen handling, alternative fuels such as ammonia, methanol, or synthetic methane are introduced into the industry. They are believed to resolve issues related to high energy demand for hydrogen purification, storage, and transportation in large quantities. Among the aforementioned alternative fuels, ammonia is characterized by negligible CO_2 emissions once produced using hydrogen from electrolyzers powered by renewable electricity and nitrogen separated in low-CO_2 processes. This makes it one of the most promising hydrogen carriers, a well-suited candidate for a large-scale energy storage. Furthermore, the use of ammonia in solid oxide fuel cells (SOFCs) further reduces the associated nitrogen oxides (NOXs) emissions. The analysis presented in the paper focused on the development of a numerical model based on a three-dimensional approach, considering electrochemistry and fluid dynamics. It made it possible to simulate the operation of an ammonia-fueled SOFC fueled by ammonia operated under varied conditions. The preliminary phase of the analysis included a benchmark and verification of the modelling approach using the experimental data for a hydrogen-powered cell. Following this step, the model of a cell operated with ammonia was validated against data available in the literature.

Cogeneration with HTGR for industry and district heating in Poland

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The main premise for the development and implementation High-Temperature Gas-cooled Reactor (HTGR) technology is the demand for heat, which in Europe is distributed at the level of 600-900 GWh/year in the temperature ranges below 250°C, between 250-550°C, and above 1000°C, with a rather small demand between 550°C and 1000°C. The lowest range may be satisfied by Light Water Reactors (LWR). However, industrial installations using these temperatures are generally small and dispersed, which makes the use of nuclear reactors difficult. The district heating sector offers significant opportunities which in several countries use waste heat from large power reactors. The source of the urban heat reactors could be SMR LWR, but thanks to inherent safety features, HTRs can be built closer to human settlements. Steam at temperature around 500°C is the standard heat carrier in many large industrial plants, mainly chemical. HTGRs could replace gas-fired or coal-fired boilers while maintaining existing installations, including turbines producing electricity for the plant. The demand of Polish industry for steam at such temperature is about 6.5 GWt in several locations.

The implementation of HTGRs for the industrial heat production requires changes in national law, but also preparation of organizational and technical instruments.

We will present the impact of deployment HTGR technology in Poland, opportunities, cogeneration options including hydrogen production and the ongoing activities at NCBJ.

Application of artificial neural network for Molten Carbonate Electrolysis modeling and optimization

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This research proposes the usage of an artificial neural network to model the Molten Carbonate Electrolysis. This modeling method is known as a powerful tool for solving complex modeling issues. Several network configurations for different operation scenarios were proposed in this research. The most advanced model can ensure a dynamic prediction of the electrolysis operation considering the thermal-flow parameters. All the models represented an accurate operation with an average error of 0.3%. In addition, the ANN-based algorithm was applied for optimizing the cell operating conditions.

Theoretical investigation and implementation of PEM fuel cell into UAV

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Nowadays, unmanned aerial vehicles (UAVs) are more implemented in humans' daily life. They are used for civil and military applications in different fields. Most of the currently used power supply systems cannot assure stable and continuous work for a long period. Proton Exchange Membrane (PEM) fuel cells can provide high power and efficiency without noise, vibrations, and greenhouse emissions. Due to the high specific energy of hydrogen, the energy density is much bigger than combustion engines and battery-based solutions, resulting in an extended operation time. This paper investigates the fuel cell technology, provides the simulation model of the fuel cell, proposes the conceptual design from the results obtained during the simulation, and implements it into an already existing UAV. There has also been done an analysis between currently used power supply (battery) and fuel cell for selected UAV.

ISHTAR thermostatic irradiation device for advanced nuclear technologies research in the MARIA reactor

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Studies of high-temperature materials behaviour irradiated by neutrons are required to develop advanced fission and fusion power technologies. A novel irradiation device, ISHTAR, has been developed in the MARIA Research Reactor's Nuclear Facilities Operations Department in response to scientific interest. The irradiation conditions in the device reflect those occurring in the core of the advanced helium-cooled nuclear reactor at very high temperatures reaching 1000°C. Additionally, the highly flexible core of MARIA reactor enables studies in various neutron conditions, including the fusion-related neutron spectrum. This work shows the design of the ISHTAR capsule, together with computational studies in thermal-hydraulics and neutronics. Comparing computational data with the experimental data gathered during ex-core and in-core test campaigns proves that the device is reliable, inherently safe, and provides required irradiation conditions.

An improved Müller-Steinhagen and Heck model for two phase pressure drop in relation to flows at high reduced pressures

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A better understanding of the two-phase fluid behaviour is necessary to optimize the design models of the components containing a two-phase refrigerant especially in the light of the fact that more and more applications are sought in the high reduced pressure ranges. For example, evaporator is the key heat exchanger in Organic Rankine Cycle system or a high temperature heat pump. Nowadays, we seek implementations at high evaporation saturation temperatures where the refrigerant evaporation occurs at temperatures higher than 90^{o}C. However, a literature analysis shows that there is a gap in knowledge of the two-phase flow for synthetic refrigerants at high saturation temperatures. The reliable prediction of pressure drop in two-phase flows is an important prerequisite to accurate optimization of thermal systems. The total pressure drop of a fluid is due to the variation of potential and kinetic energy of the fluid and to the friction on the channel walls or between the phases (60-120 ^{o}C) and moderate reduced pressures (0.2-0.5). In the paper, a modification to the Müller-Steinhagen and Heck (1986) model for two phase pressure drop in relation to high reduced pressures flows has been presented. Model validation has been done in comparison to a well established experimental data from Charnay et al (2015). Modification exhibits a significant improvement to the calculations presented in the literature.

Analysis of Organic Rankine Cycle efficiency and evaporator dimensions in function of the reduced pressure

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In the paper the Authors present is a simple analysis of the influence of pressure of heat supply process in case of subcritical and supercritical Organic Rankine Cycle (ORC) cycle on its efficiency and size of vapor generator. Compared two cases of subcritical and supercritical ORC's have a similar arrangement of heat source supply, that is with a single phase fluid, and the same condensation temperature. The analysis is helpful in the selection of the appropriate pressure of heat supply for the specified wet working fluid in ORC and the known range of heat source temperatures with respect to installation and operation costs. From the point of view of the cycle efficiency and the size of the generator, the pressures close to critical fluid pressure are usually optimal. For some working fluids exist even optimal pressure. However, usually the size of heat exchangers is not known. For that sake in the region close to critical point the Authors worked out the method for heat transfer coefficients elaboration which is then useful in more exact estimations of heat transfer process in heat exchangers.

A mathematical model of charging and discharging processes in a thermochemical energy storage reactor using the hydrated potassium carbonate as a thermochemical material

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The paper presents a mathematical model of charging and discharging processes of a thermochemical energy storage reactor for a potential application in a single-family residential building. It also contains the results of the numerical implementation of the developed model. A system for heat accumulation using solar collectors and a fixed bed thermochemical reactor was proposed for the analysis. The potassium carbonate K_2CO_3 hydration/dehydration reaction was selected for the simulations, but the model is also valid for other reversible reactions. The following parameters describe the reactor operation: specific humidity and temperature of the moist air in the reactor, degree of transformation of $K_2CO_3 \cdot 1.5H_2O$ into K_2CO_3 and bed temperature across the storage. Computation of these parameters variation in time and space enables finding the amount of energy accumulated in the storage during charging process (or the amount of heat rejected to the moist air in the reactor during discharging process). This in turn allows to determine the efficiency of the storage process (or efficiency of the discharging process). The simulation results help to understand the phenomena occurring in the thermochemical reactor and enable to select the parameters that have the greatest impact on its operation.

Numerical simulation of Seasonal Thermal Energy Multi-Storage

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This article presents the results of modeling a new method of reducing heat losses from seasonal solar energy storage. The idea is to use multiple tanks so that only one of them has a thermocline. It also presents a short review of the literature on seasonal storage of solar energy in the form of large storage tanks, and the location of these tanks in relation to other elements of the system (solar collectors, heat pumps and others). While the concept of using multiple solar energy stores was proposed by other authors, here we focus mainly on developing a dynamic model of a system of this type and presenting the results of the simulation. The article also presents a short outline of dynamic models of selected elements and the assumptions that were made for the purpose of modeling. The data in the form of heat production and demand for heat come from an actual production plant. Another key element is the heat insulation of solar energy stores. The thickness of the insulation has been analyzed and its critical size determined, above which any further increase in thickness does not reduce heat loss to the environment.

A concept of SOE-MCFC hybrid system for supporting power–to–gas installation

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The paper is based on three process innovation novelties as the project results (all of them are on the scale of the World market) by introducing of technological changes in technology, and equipment. The TENNESSEE project substantially increases the functionality of power-to-gas installation gaining additional operational flexibility, increasing the efficiency of the process and is based on low-cost materials.

Based on the experimental investigations, the achievable CO_2 separation rate was determined at above 90% by adjusting the cathode inlet flow. Flue gas needs to be mixed with air prior to feeding the MCFC. The adequate anode inlet flow raises electric efficiency to above 35% even for a laboratory–size cell. It was proven at laboratory scale (TRL4) that MCFC can be used for CO_2 separation, removing it from hard coal–based fuel gases with high electric efficiency and a high CO_2 separation factor.

Silica gel impregnated with metal salts composites as potential adsorbents in sorption cooling devices – a comparative study

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Global electricity consumption is drastically increasing, especially in the summer season. Nowadays, a heat-driven adsorption cooling device seems to be a good alternative for standard compressor cooling systems. However, to increase the efficiency of the sorption chillers, new adsorbents characterised by high sorption capacity and thermal conductivity coefficient must be developed and examined.

In this study, three silica gel impregnated with metal salt composites were tested and compared with the most common commercial adsorbents, narrow porous and wide porous silica gels. Raw silica gel was impregnated with LiCl, $LiNO_3$ and $CaCl_2$ using wet impregnation method. To determine impregnation efficiency, a phase analysis was used. Based on extended sorption tests using mercury intrusion porosimetry, gas adsorption, and dynamic vapor sorption measurements with water as adsorbate, the structure and sorption properties of the composites and reference materials were examined. The morphology of the samples was analysed using a scanning electron microscope. Thermal stability was analysed using simultaneous thermal analysis, and finally, the laser flash method was used to define the thermal diffusivity coefficient of the adsorbents.

Both, thermal and sorption properties of composites were enhanced. The active surface area of composites was decreased in comparison to raw silica gel. But, in the case of LiCl impregnation, the measured mass change during adsorption process for the P/P_0 value of 100% was above 120 % and in case of other composites even above 150% at 60°C. Impregnation with $CaCl_2$ enables to enhance thermal diffusivity coefficient up to about 2 W/mK in the analysed temperature range. For raw silica gel, it was observed that the pore size of the sorbent is essential in the case of water adsorption, and microporous adsorbents with pore sizes smaller than 5 nm are not recommended in working pairs with water.

Challenges in design of systems with reversible solid oxide cell in comparison to stand-alone SOFC and SOE installations

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Research and development related to the energy sector is focused both on highly efficient power generation, and effective methods to store energy in large quantities. Currently systems based on the power-to-X concept are attracting the attention of various areas. Electrolysers using renewable electricity can produce hydrogen for direct use or for processes which generate synthetic fuels, either gaseous or liquid. Depending on the reactors which are coupled with electrolyzer, different fuels can be produced, including such energy carriers as SNG, methanol and ammonia.

Such a technology enables efficient storage of energy in a form of alternative and easy to handle gases or liquids which can be transported over long distances and stored for an extensive period of time. Among the available electrolyzers, solid oxide electrolysers (SOE) require the lowest amount of energy per each kilogram of hydrogen produced. Additionally, this technology can also operate in a fuel cell mode (SOFC), in which hydrogen is electrochemically converted into electricity with outstanding efficiency exceeding 60-65%. Stacks that can switch between electrolysis and fuel cell modes are called stacks of reversible solid oxide cells (rSOC). As a result, hydrogen or electricity can be produced, depending on current demand. Designing process of such systems is more complex than typical stand-alone SOFC-based or SOE-based units. This paper discusses selected issues related to these differences from a manufacturer's perspective. The work summarizes modelling activities leading to determination of the size, configuration and operational behaviour of rSOC-based installations along with the key manufacturing problems.

Computational Fluid Dynamics investigation of stone packed bed dedicated to Adiabatic Compressed Gases Energy Storage systems

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Changes in global trends in the methods of power production entail the need for the development and implementation of energy storage systems on an industrial scale. One of the proposed solutions is the development of the adiabatic compressed gases energy storage technology (CGES) due to its high flexibility and the elimination of fossil fuels combustion in the process of releasing stored energy. An indispensable element of such a system is the Thermal Energy Storage (TES), whose characteristic dimensions and filling material affect the overall performance of the system. The presented paper is focused on the numerical simulations of the TES bed. The investigations were performed in the Ansys Fluent software. The microscale phenomena were considered with the use of the model representing the real geometries of the packed bed and the macroscale phenomena with the use of the porous zone model. The comprehensive simulations allowed the determination of an appropriate modelling method of pebbles-packed bed that may be further used for the optimization of TES parameters.

Optimization of dual-purpose thermal desalination plants

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This paper addresses the optimization of the design of dual purpose thermal desalination plants – simultaneous generation of electricity and production of freshwater. Most of the large seawater desalination plants in the world are dual-purpose facilities. In these plants, the working fluid in the Rankine cycle (water) is heated in a boiler – if a conventional power plant is considered – or in a heat recovery steam generator (HRSG) – if a combined cycle power plant (CCPP) is considered – to a high energy level and it is passed through steam turbines before the steam is extracted for use at a lower temperature to provide the energy required to run the distillation plants. In the dual purpose plants, the main design specifications are the desired electricity and freshwater demands, which have strong influence on the optimal structure and operating conditions. When the desired electricity demand is more dominant than the desired freshwater demand, the design of the power plant is more important than the design of the desalination plant, and vice versa. When both demands are equally dominant, the designs of power and desalination plants have the same importance. In addition, several structures and designs are possible for the power and desalination plants, leading to a combinatory problem. Then, the systematic determination of the optimal structure and size of dual purpose desalination plants and the operating conditions of each plant's component is a necessary and challenging task. To this end, a mathematical model involving both discrete and continuous decisions is developed. For electricity generation, a CCHP is considered and modeled by embedding several candidate structures; while for freshwater production two candidate thermal desalination systems are embedded. The model is able to select: a) the optimal configuration of the CCPP, b) the optimal gas turbine (GE Frame 6/39.1 MW or Siemens V 64.3/67.5 MW), c) one or two burners in the HRSG, d) a medium-pressure steam turbine, e) steam reheating at low pressure, f) the best desalination system between a multi-effect distillation (MED) desalination system or a multi-stage flash (MSF) desalination system, g) the optimal operating conditions and sizes of all system's components. The proposed model is implemented and solved in the General Algebraic Modeling System (GAMS) software. Several case studies considering different demands of electricity and freshwater are presented and optimal solutions discussed.

Optimization of geothermal energy-powered multi-effect distillation and reverse osmosis desalination systems

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The world's demand of freshwater and electricity is rising fast. Much research is being conducted at addressing the challenges of using renewable energy for electricity generation and meeting the energy requirements of seawater desalination plants. The coupling of renewable energy sources such as wind, solar, and geothermal with desalination systems holds a great promise for increasing water supplies in water-scarce regions. The effective integration of these technologies would allow countries to address water shortage problems with a domestic energy source that does not produce air pollution or contribute to the climate change problem. In this paper, the optimization of a process that integrates a double-flash geothermal power cycle with reverse osmosis (RO) and multi-effect distillation (MED) desalination systems is addressed. To this end, a nonlinear optimization mathematical model of the integrated process is developed and implemented in GAMS – a high-level, general purpose algebraic modeling system for mathematical programming and optimization – and simultaneously solved using the solver CONOPT – a code based on the generalized reduced gradient (GRG) algorithm. The total annual cost of the integrated system is the proposed objective function to be minimized. The main design specifications are the electricity and freshwater demands, which are considered as model parameters. Also, the number of effects in the MED unit and the seawater specifications (temperature and salinity) are considered as model parameters. The influence of these parameters on the optimal solutions is investigated. Several process alternatives based on an existing geothermal power station are studied.

Techno-economic assessment of Power-to-Gas (PtG) systems based on solid oxide electrolyzers (SOE)

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The rapid development of renewable energy sources defines the necessity for large-scale energy storage systems able to balance the unpredictable nature of solar and wind. Power-to-Gas (PtG) is a promising way to store energy in a long-time and big-scale horizon. Systems of such a type offer a great advantage over conventional battery-based energy storage units. While the batteries are charged/discharged and the storage capacity is limited by the size of the packs, the PtG units are flow systems which can operate continuously and are not a subject to limitations by storage capacities provided that they are coupled with gas grids. This paper presents a recent techno-economic analysis of a reference PtG system in scale from 10 kW to 40 GW. The analysis is based on the model which includes the key components, such as the solid oxide electrolyzer (SOE) and methanation reactor. Capital and operating expenditures, CAPEX and OPEX, respectively, are estimated and analyzed. The Green Deal scenario expects 2x40 GW to be installed in electrolyzers in Europe and in the associated countries, therefore PtG systems which will produce synthetic natural gas (SNG) using renewably produced hydrogen are expected to be among the implemented technologies. The PtG system which was investigated, demonstrated the product price equal to 1.98 EUR/kg_{SNG} and conversion efficiency of 68%.

The experimental characteristics of current generation in Peltier thermoelectric modules

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The paper provides experimental analysis of current generated in Peltier modules according to Seebeck effect. The temperature difference produces voltage difference. This is used to produce current in electrical circuit. The description of the experimental stand is introduced in manuscript. The temperatures on thermocouples and external electrical resistance are variable parameters. These parameters allow to obtain voltage and current in the external electrical cirquit. All of values are recorded and then the specific characteristics are provided. The results are compared to mathematical model. The disturbances in stability of the temperature and generated current are underlined. The temperature differences 30, 40, 50, 60 K gives electrical power from 2 mW to 14 mW depending on Peltier modules configurations.

On-line optimization of turbine components heating

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On-line stress control in the critical parts of steam turbines in coal-fired power plants has many benefits. It enables the constant monitoring of the material stress-and-strain state, which helps in the process of controlling the operation and protection against the consequences of major failures. It also allows to forecast the wear degree and the residual lifetime of power unit components based on the collected data.

Due to the growing requirements for flexible operation of conventional power units, the information on the current stress values in critical areas of the turbine rotor allows to optimize the temperature increase of the steam washing the rotor. The obtained effect is the start-up losses reduction by shortening the start-up time (economic optimization criterion), while maintaining a safe level of maximum stress occurring as a result of heating. By selecting the optimal start-up time, it is possible to accelerate the heating process while ensuring an acceptable level of operational risk. Combining the optimization process with on-line stress monitoring allows to control the operation in real time.

The paper presents the process of selecting the optimal temperature increase of the steam washing the rotor of a 200 MW coal-fired unit, using the algorithm of on-line stress control. The stresses are determined taking into account variability of the heat transfer coefficients, which substantially improves the accurancy of their modelling. The calculations are presented for the data from actual turbine start-ups and for different assumed level of the maximum allowable stress.

Experimental studies of pebbles-packed thermal energy storage system performance

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An increase in the share of renewable energy sources in the energy mix poses a great challenge in terms of the reliability of the energy system and continuity of power supply to the grid users. These energy sources are characterized by high unpredictability and rapid changes in power generation, therefore, their seamless adaptation to the electric grid requires systems that mitigate these adverse effects. One of the possible means to deal with this problem is the development of high-capacity energy storage systems that can store surplus energy and release it when the power demand is high. Compressed gases energy storage (CGES) technologies address this issue well and have become a viable option due to high efficiency and lack of emission of greenhouse gases.

The research presented in the paper concerns the experimental investigations of the working conditions of the thermal energy storage (TES) bed, which is an important part of the CGES system. The test stand consists of a compressor, 17.5 kW heater, piping and pebbles–packed bed of 150kJ/K heat capacity. Heat is accumulated in pebbles that are washed over by hot air with a temperature up to 200^{o}C. The measurement system makes it possible to investigate different mass flow rates (up to 300kg/h), pressure drop and temperature distribution in the bed. Preliminary investigations allowed the determination of the bed charging and discharging dynamics. Collected data will be used for the validation of numerical and analytical investigations.

Modelling the condensation process of low-pressure refrigerants in mini-channels

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The measure of the energy efficiency of the non-adiabatic two-phase condensation process of refrigerants in minichannels is both the value of the heat transfer coefficient α and the flow resistance expressing the external energy input required to realize the flow. The modelling of this very complex process is effective if the condensation mechanism in minichannels is correctly identified. It has been proven that the effects of changes in the condensation mechanism are the different structures of the two-phase flow resulting from process interactions both in the channel cross-section and along the flow path. Among the characteristic parameters that affect the formation of the structures are the mass flux density G, the variation of the vapour and liquid phase velocity values, the phase density, the vapour quality x, the void fraction φ, while the nature of the flow can be determined by the dimensionless Reynolds number Re. Thermal and visualization studies of the condensation process of low-pressure refrigerants were carried out: Novec649, HFE7100 and HFE7000 in tubular minichannels with diameters d_h=0.5; 0.8; 1.2; 2.0 mm. Based on visualization studies, flow structures were proposed to be divided into 3 main groups: dispersive, stratified and intermittent. Based on this, a computational correlation was derived for determining the heat transfer coefficient and frictional resistance depending on the type of flow structure. This was intended to improve the accuracy of the modelling process for condensation of low-pressure refrigerants, with low ODP and GWP values, in tubular minichannels.

Energy Management in the decarbonisation of the EU energy-intensive industries

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Decarbonisation of the EU industry is the prerequisite for meeting the EU GHG reduction goals. The energy-intensive industries (EIIs) shall, therefore, undergo the process of deep decarbonisation.

The article defines and identifies the EIIs in the EU and values their share in energy consumption and GHG total emission. It reviews the methods of GHG abatement in the EII's and the potential of that emission reduction. Reasons, other than decarbonisation, for the privileged politically supported position of the EII make the industry indispensable for the EU economy.

Energy Management (EM) is one of the means of increasing sustainability of the EIIs by managing energy in a way based on evidence in coherent and consistent ways. The classical role of EM consists in organising and maintaining a system that enables to tackle energy-related issues at any organisation.

The paper concentrates on EM as an effective measure to lower energy consumption (energy insensitivity) and GHG emission in the EIIs. It promotes an extended definition of EM, which better suits the current trends of low emission transformation of the economy, especially the industry. EM is discussed in the light of ongoing political, technological, end economic trends within emerging environmental or societal demands and limits. It places EM in the whole framework, making the concept of EM better understood and easier implemented in practice. Thus, EM, as proposed, combines several elements which up-to-now have been considered rather loosely. It examines the barriers to industrial EM and reviews new elements that make EM indispensable in the decarbonisation process of the EIIs.

It provides a list of recommendations at different levels to accelerate the EM application. It is shown that EM can better suit making optimal environmental and societal decisions. As a source of reliable and publicly trusted data, it may increase the social responsibility of business and can increase the EIIs social acceptability at national and local levels. Providing trustworthy information can enable a better just transition in EII's dependent regions.

EM has been discussed in a broad content of EU energy and climate policy, e.g. the EU ETS impact on technology change; EII as subjects of Energy Efficiency Obligation imposed by the Energy Efficiency Directive. In addition, new elements have been added to the concept of EM to make it coherent, closed and completed, and mergeable with other management systems, e.g. down the chain supplies and products sell out. The Iron Steel Industry in the EU serves as an illustrative case of EM.

The thermal-hydraulic and neutronic design of High Temperature Gas Reactor for non-electrical applications

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The idea of the Hight Temperature Gas Reactors, graphite moderated block-type reactor (HTGR) use for electricity generation was the main concern during the 20th century studies, while for the most recent research programs the utilization of this type of reactors for non-electrical applications became the prime interest.
During one of the Horizon 2020 projects – GEMINI+ the concept of the 180 MW_{th} power reactor, which would supply high pressure steam to the industrial sites was investigated. The proposal of the core thermal-hydraulic and neutronic design was established as a result of joined studies between project partners in the areas of fluid mechanics, heat exchange and reactor neutronic as core design support analyses.
The outcomes of the investigations on the hypothetical reactor and its resulting conceptual core design will be presented, including the analytical capabilities of modern computational software for the accident sequences and neutronic studies performed by respectively thermal-hydraulic/severe accident MELCOR 2.1 and SERPENT 3D Monte Carlo neutronic code.

Mathematical modeling and analysis of possible utilization of renewable energy resources in the fourth-generation thermal network in Polish climate conditions

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Modern district heating offers an economical and ecological solution to meet the demand of the user's need of heating. Heat recovery and renewable heat sources are the key elements of such a system and modern and low energy demanding users. The work consists of a model of a possible 4th generation district heating solution of a newly built district at the side of Warsaw city. The model is based on a day analysis, which means that all the values are averaged to the day. 12 days have been taken as a sample to build the climatic model; based on those 12 days; the profile has been extended to the whole year. The whole work can be divided into seven parts: The first part focuses on the climate and on gathering data about the past year's meteorological conditions. Climatic conditions dictate the energy consumption profile of the user; two main parameters influence it: the temperature and the radiation. The temperature has been taken from the archives data; however, solar radiation has been modeled by means of the Bird’s clear sky model. The second part focuses on the energy source that can be taken from waste heat recovery and heat renewable energy resources. Several solar collector system have been introduced to the system; the solar collector system consists of flat plates solar collectors. Thanks to the model of the clear sky radiation, it is possible to see how the solar collectors respond to the change of the day of the year and the amount of global solar radiation incidents to the plate. In the model, the Viessman Vitosol 200 FM has been used to get the technical data and specifications of the collectors. The third part consists of the model of the network itself; the thermal and hydraulic balance of the system has been made, and the proper pumps were chosen. At this stage, it is possible to identify the amount of energy lost by the pipes network and the energy required to cover the hydraulic losses by the electric pumps. The fourth part is about modeling the receiver, therefore, predicting the energy needed by the end-users. The fifth part is about choosing the right heat storage system. The sixth part is about choosing the right heat source for the peak cold season when the heat demand is the highest. The chosen solution is a LG’s absorption heat pump directly fired and fuelled by natural gas. Its minimum power has been chosen based on the energy demand ratio of the whole system in the coldest modeled day. Its time of working has been calculated. As the final step, the costs of services have been calculated based on the current price for electric and gas energy. The number of working days of the heat pumps translates to the amount of energy taken from natural gas and the price produced.

An experimental study on parabolic trough collector in simulated conditions by metal-halide solar radiation simulator

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The utilization of solar radiation to obtain high-temperature heat can be realized by multiplying it on the illuminated surface by solar concentrators technologies. High-temperature heat with significant energy potential can be used for many technological purposes, e.g. the production of heat, cold, or electricity. The following paper presents the results of the experimental study, on the operation of the parabolic linear absorber in the parabolic concentrator solar system. The presented installation has a geometrical concentration ratio of 30. The parabolic mirror with an aperture of 1 meter and a focal length of 0.25 meters focuses the simulated radiation onto a tubular absorber with a diameter of 1 inch which is placed in a vacuum tube. The investigation length of the absorber is 1 m. The installation is illuminated by the solar simulator, which allows to carry out tests under constant and repeatable conditions. The simulator consists of 18 metal halide lamps, with a nominal power of 575W each, with a dimming possibility of up to 60%.

The paper presents preliminary results of heat absorption by the analyzed absorber, the effect of the lack of vacuum on the losses in the system and the pressure drops crucial for the optimization of the absorber geometry. An analysis of the radiation distribution on the illuminated surface as well the concentrated radiation is presented.

The experimental investigations will be used to validate a previously prepared numerical model, the geometry of which will then be optimized for heat absorption by a parabolic linear absorber.

Influence of the shape of the blade profiles at high operating amplitudes of the Cycloidal Rotor Fan

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Despite the wide range of CRF (Cycloidal Rotor Fan) applications, such as the propulsion system for MAV (micro air vehicles), UAV (unmanned aircraft vehicles), marine Voith – Schneider propellers, wind turbines or tidal energy converters, there are practically no scientific publications examining the possibility of using it as a fan for HVAC (heat, ventilation and air condition) applications. The main advantages of CRF are primarily the ability to direct the flow by changing the pitch angle of the rotor blades, larger flow rates than in a conventional machines without cycloidal control and in some cases, the ability to work in two directions.The paper focuses on the comparison of the characteristic of two rotor variants operating with different blade profiles. Two CRF variants were tested experimentally and numerically. The first one fitted with the asymmetric CLARK Y blade profile, and the second with the symmetrical NACA 0012. For this purpose, an experimental rig was designed and constructed, consisted of a 4-blade cycloidal rotor placed in a rectangular channel. Measurements of velocity profiles were made on a given CRF inlet and outlet plane using the non-invasive LDA (Laser Doppler Anemometry) measurement method. The experimental results for both variants were compared with those obtained from CFD 2D calculations. For this purpose, a corresponding numerical model of the CRF was created in ANSYS CFX. It was necessary to perform the analysis of the influence of mesh density and to develop a script in ANSYS CEL to be able to recreate the rotor motion.

Neutronic calculations of the AP1000 reactor core with the POLARIS and PARCS codes

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The paper presents a detailed description of neutronic calculations for the AP1000 reactor core performed as part of PhD research. A short characteristic of the reactor is presented, applied computer codes and models are described and results of the calculations and their comparison with results included in the "AP1000 Design Control Document" are presented. The POLARIS code was used to create 2D models of all types of the AP1000 reactor fuel assemblies and to generate few-group cross-section libraries. The PARCS code was used to build a 3D model of the whole reactor core, simulate the first fuel cycle using the libraries generated by POLARIS and to obtain a plot of soluble boron concentration versus core burnup, normalized power density distributions at different stages of the cycle, etc. The results of the calculations were satisfactory, and they were similar to the results presented in the above-mentioned US report.

Analysis of energy and environmental effects of replacing a coal boiler by a specially designed and a generic high temperature nuclear reactor in a CHP plant

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High temperature nuclear reactors (HTR) belong to the technology foreseen to be a part of the generation IV power reactors. High temperature of a coolant leaving the reactor's core is a characteristic feature of such reactors. This enables additional possibilites of utllizing the heat produced by the HTR. High-temperature reactors, as a technology that is only to come into use, are rather associated with new nuclear power plants. However, an additional aspect related to this technology has appeared in Poland, namely the possibility of replacing the existing, conventional heat sources in industrial plants, power plants or combined heat and power plants with HTR reactors. As part of this study, the energy and environmental effects of replacing a coal boiler in a combined heat and power plant with a nuclear high-temperature reactor were analyzed. Two cases were considered: the use of a specially designed reactor that allows, in principle, a direct replacement of a coal-fired boiler, and the use of a generic (commercially available) reactor design. The energy analysis was performed with the use of a computational model based on energy and substance balances for characteristic points / elements of the system under consideration. In the case of using a commercial solution of the HTR reactor, the energy analysis indicates the need to expand the existing technological system in order to use the heat source more efficiently. Regardless of the considered reactor variant as a heat source, positive environmental effects are achieved, i.e. reduction of CO_2 emissions. An additional aspect considered in the paper are legal regulations which significantly affect the purposefulness and the possibility of investing in the solutions under consideration.

Turbine stage expansion model including internal air film cooling and novel method of calculating theoretical power of cooled stage

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Systematic attempts to maximise the efficiency of gas turbine units are achieved, among other possibilities, by increasing the temperature at the inlet to the expansion section. This requires additional technological solutions in advanced systems for cooling the blade rows with air extracted from the compressor section. This paper introduces a new mathematical model describing the expansion process of the working medium in the turbine stage with air film cooling. The model includes temperature and pressure losses caused by the mixing of cooling air in the path of hot exhaust gases. The improvement of the accuracy of the expansion process's mathematical description, compared with the currently used models, is achieved by introducing an additional empirical coefficient estimating the distribution of the cooling air along the profile of the turbine blade. The new approach to determine the theoretical power of a cooled turbine stage is also presented. The model is based on the application of three conservation laws: mass, energy and momentum. The advantage of the proposed approach is the inclusion of variable thermodynamic parameters of the cooling medium. The results were compared with the simplified models used in the literature: separate Hartsel expansion, mainstream pressure, weighted-average pressure and fully reversible. The proposed model for expansion and the determination of theoretical power allows for accurate modelling of the performance of a cooled turbine stage under varying conditions.

Transportation of hydrogen blended natural gas in existing high pressure pipeline network

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Hydrogen is a promising fuel alternative in the future energy demand, compared to fossil fuels. Production of hydrogen from renewable energy sources through electrolysis and subsequently injecting it into the natural gas network, gives flexibility in power grid regulation and the energy storage. However, blending hydrogen with natural gas is limited by both durability and structural integrity of existing transmission network key components such as pipelines, valves and compressors. In this context, knowledge about the hydrogen percentage content, which can safely effect on materials in a long time steel pipeline service during transport of the hydrogen-natural gas mixture, is essential for operators of a transmission network. This paper first reviews the allowable content of hydrogen that can be blended with natural gas in the existing pipeline systems, and then investigates the impact on linepack-energy with both startup and shutdown of the compressors scenarios. In the latter case, an unsteady gas flow model is used. To reduce the occurrence of sharp gradients in the solution domain as well as to avoid spurious oscillations, a flux limiter is applied for the numerical approximation. The GERG-2008 equation of state is used to calculate the physical properties. For the case study, a tree-topological high pressure gas network, which has been in service for many years, is selected. The outcomes are valuable for pipeline operators to assess the security of supply when blending hydrogen with natural gas under high pressure.

Tariff system for energy resources of the Republic of Tatarstan in comparison with the CIS countries in order to stimulate an increase in the share of electricity in the energy supply balance of buildings

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At present, the issues of organizing energy resources markets, as well as methods of their price (tariff) regulation are relevant in various countries of the world. GOAL. Analyze the current system of tariffs for heat and electricity for the needs of the population of the Republic of Tatarstan in comparison with the CIS countries. To develop directions for improving the tariff policy which will help to stimulate an increase in the share of electric energy in the balance of energy supply of buildings. METHODS. When solving the problem, the computational-analytical method and the method of comparative analysis were used. RESULTS. The search for new model and management solutions aimed at increasing energy efficiency is reflected in the article. The authors analyze the current state of affairs in the CIS countries, Europe and Asia, identify the main problems and offer for implementation successfully tested experience in the fields of electric and heat power engineering. The article analyzes the dynamics of tariffs for electricity and heat for the needs of the population. The calculation of the tariff level for the population for electric energy used for heating and hot water supply, which is equivalent to the tariff for heat energy for these purposes, has been carried out. The directions of improving the tariff policy of the Republic of Tatarstan are presented. CONCLUSION. The mechanisms proposed in the article in the field of improving the tariff policy for electric and thermal energy should be the basis for the principles of tariff formation and the formation of tariff policy for energy resources, which will stimulate an increase in the share of electric energy in the energy supply balance of buildings.

Models of formation of tariffs for heat energy and features of heat supply systems in the largest cities

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The article considers the existing modern model of heat supply in Russia, Europe, the USA and China. There are two trends in the formation of the heat supply system-Central and individual sources of energy supply. Features of models of heat supply and pricing functioning in correlation with state support in the studied countries are reflected. Factors of inefficient pricing in Russia, including the lack of specificity of the market with a focus on the manufacturer, and a high level of state support, were identified.
The factors identified are the need to improve the pricing model taking into account population density and a number of other factors. A comparative analysis of heat supply energy systems is carried out for the following indicators: tariffs for heat energy, the amount of utility payments for heating, the level of average wages, the share of utility payments for heating in the income of the population in the context of major cities in Russia and foreign countries, which allowed us to identify the main trends in the development of energy markets.

Numerical research on the new kind of convective tube banks with intensification of heat transfer and/or cleaning of tubes from ash depositions

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This paper presents the results of numerical analysis of a proposal of new kind of convective tube banks. The aim of numerical modeling was to study a heat exchanger with intensification of heat transfer and/or cleaning of tubes from ash depositions in the case of a dusty medium flow.
The results were achieved using inserted turbulence intensifiers to increase the heat transfer coefficient and/or change of flue gas flow direction to clean the exchanger tubes for the dust-laden medium.
The following four tube bundle arrangements were compared: (A) base - plain tube bundle; (B) a combination of plane tubes and turbulence intensifiers placed at the angle of 45° to the direction of the flue gas outlet; (C) a combination of plane tubes and turbulence intensifiers placed at the angle of 30 ° to the direction of the exhaust gas outlet.
The simulations of heat transfer in a bundle of tubes in the systems (B) and (C) and the base system (A) were carried out in a 2D model using the Ansys Fluent R2021 CFD code.
The results show that turbulence intensifiers increase in the thermal efficiency of the tube bank and clean the tubes from ash deposits.

Photopyrolysis of biomass: an experimental study

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In the European Union countries, biomass is one of the main renewable energy sources used to heat and electricity production and for transportation purposes. There are a number of restrictions related to the production of biomass, in particular legal solutions concerning the environmental protection and the principles of biodiversity crops. The low energy density biomass is distributed in a wide range of remote areas. For energy purposes locally available waste products from agriculture, agricultural - food industry, spatial and other biodegradable waste, like the sludge should be used. The paper presents the experimental analysis of wood photopyrolysis process. Experiments have been conducted on the solar pyrolysis reactor own-designed by the authors. It consists of the copper reactor powered by the artificial light simulating sun. The Impact of investigated biomass chemical composition on actual products distribution and dry gas composition has been presented and discussed. Product shares and dry pyrolysis gas quality followed results published in the literature with well-known trends of increasing bio-oil yield with the increase of final temperature and average heating rate. A xenon-arc lamp provided stable radiant flux and plenty of power. A precise temperature monitor within the pellet bed gave insight into samples behavior during the pyrolysis process. The results show that an increase in lamp power results in an increase in the mass fraction of carbon monoxide (from 9.02% to 9.97%) and a decrease in mass fraction of carbon dioxide (from 55.5% to 53.11%). Changing the lamp power does not fundamentally affect the proportion of methane and hydrogen, which is more or less stable.

Operation analysis of a parabolic trough solar collector

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The parabolic-trough solar concentrating systems are often considered as an element of heat generation system from renewable energy sources. It is important to use appropriate optical systems and the reflectors on a solar tracking system due to the fact that parabolic trough collectors (PTC) utilize only direct solar radiation. Therefore, the operation analysis of the PTC requires the determination of the annual solar radiation distribution for a given location and also share of the diffuse and direct component of global radiation. For the selected type of incident solar radiation and possible imperfections of positioning the solar tracking system, several variants of absorbers were simulated for which the radial density distributions on the absorber surface were obtained. The calculations refer to the actual collector installation located at the Department of Power Engineering and Turbomachinery in Gliwice. The obtained results are the basis for determining the heat flow in the absorber and the energy production in the PTC.

A new calculation method for tube cross-flow heat exchangers

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The paper presents a new calculation method for tube cross-flow heat exchangers, including steam superheaters and other heat exchangers with complex flow systems. The heat exchangers can be cross co-current, cross counter-current and also with mixed flow arrangement, where a part of the heat exchanger is cross co-current and part cross counter-current. The method is suitable for calculations of steam superheaters in which the specific heat of steam strongly depends on temperature, as it is the case in supercritical boilers, and in which heat exchange between flue gases and superheater tubes takes place by convection and radiation.

In the proposed method, the exchanger tubes are divided into finite volumes. The temperature of both fluids at the outlets from a given finite volume is determined by the analytical formulae. Due to the simple form of the calculation formulae, a heat exchanger even with a very complicated flow scheme can be calculated very quickly in a non-iterative manner. Even when dividing one heat exchanger pass into a small number of finite volumes, e.g., into 5 finite volumes, a very good agreement between the calculation results obtained by the proposed method and those obtained by the exact analytical method is obtained. To evaluate the accuracy of the developed method, a calculation of a two-pass cross flow heat exchanger was carried out using the developed method and the exact analytical method. The application of the developed method was also demonstrated on the example of the calculation of a two- and four-pass supercritical steam superheater, taking into account the temperature-dependent specific heat of the steam.

Correlations for the thermal conductivity of selected steel grades as a function of temperature in the range of 20-800ºC

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Reliable knowledge of thermo-physical properties of materials is essential for the interpretation of solidification behavior, forming, heat treatment and joining of metallic systems. It is also a precondition for precise simulation calculations of technological processes. Numerical calculations usually require the knowledge of temperature dependencies of three basic thermo-physical properties: thermal conductivity, heat capacity and density. The objective of this work was to find a correlation that fits the thermal conductivity of selected steel grades as a function of temperature in the range of 20-800°C. Tabular experimental data taken from publicly available sources have been used in order to determine the unknown functions. The coefficient of determination R^2 has been used to assess the goodness of fit of individual regression functions to the experimental data. The determined functions can be used for a numerical analysis of heating of a steel charge connected with heat treatment process optimization. The presented equations allow to take into account temperature changes of the thermal conductivity coefficient of the given steel grade in a numerical model of non-stationary heat transfer based on the energy balance method.

Negative carbon dioxide gas power plant with gasification of sewage sludge

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One of the primary objectives of the negative carbon dioxide gas power plant (nCO_2PP – negative CO_2 Power Plant) project is to develop an innovative technology confirming the possibility of the use of sewage sludge to produce electricity while having a positive impact on the environment. The prototype of the power plant proposed in this project focuses on scrutinising of a new type of CCS/CCU system developed by the group from the Gdańsk University of Technology, the project leader, and subsequently development by the project partners (IMP PAN, AGH, WUST, NTNU, SINTEF, IASE and Bros Control) of the installation for sewage sludge gasification and its utilization in a gas-fired power plant with carbon dioxide capture. The synergy between the CCS/CCU plant and the proposed utilization of sewage sludge (which is considered as a renewable energy source) enables the installation to achieve overall negative emissions of CO_2. The additional advantage of vitrification of sewage sludge, owing to sufficiently high process temperatures, allows turning this problematical waste into a marketable product.

In the conventional gas power plant cycle, where methane is burnt, the emissivity related to the electrical energy is 418.78 kg/MWh_{el} and we have to use an additional set of equipment to avoid carbon dioxide emissions. In the zero-carbon unit, on the other hand, we capture carbon dioxide and, thus, avoid emissivity related to the electrical energy at the level 475.33 kg/MWh_{el}. However, when talking about the nCO_2PP plant, it should first be noted that the emissivity is negative at -727.12 kg/kWh. Another beneficial aspect is that the avoided carbon dioxide is at 1454.23 kg/MWh.

Design and development of oil-free microturbines for micro CHP ORC systems

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Micro CHP systems are playing an increasingly important role as part of modern energy systems. Combined heat and power generation used on a small scale has many advantages. The most important ones include, among others, the reduction of transmission losses, the possibility of using local energy resources, the diversification of energy sources, high-efficiency cogeneration and the possibility of using thermal energy in a rational way. In modern energy systems, the use of renewable resources is also very important. The above-mentioned characteristics are being fulfilled by ORC cogeneration systems, where electricity can be generated from a variety of resources, including non-renewable fuels and renewable energy sources (for example, biomass, solar or geothermal energy).
ORC cogeneration systems use various types of expansion devices to drive the generator. One of the most promising solutions is the use of microturbines which, unlike many types of volumetric expanders, are characterised by small dimensions, high rotor speeds, a high level of durability and reliability, as well as a very low level of vibration and noise. This paper presents three microturbines (with capacities of 1 kW, 3 kW and 10 kW) that have been designed and built for use in modern ORC cogeneration systems. These microturbines have been designed based on oil-free technology, which means that none of their components requires oil lubrication, so no additional lubrication system is needed. Therefore, nonconventional bearing systems and hermetical housings had to be used. The article discusses certain design features of these innovative machines, as well as the results of calculations carried out at the design stage and the characteristics obtained experimentally. The constructed microturbines have successfully passed the preliminary tests performed under laboratory conditions. Currently, work is underway to implement ORC systems with microturbines under industrial conditions. This paper may be of interest to readers looking for new design solutions of expansion devices that can be used in cogeneration systems based on the ORC technology, as well as to designers and researchers of microturbines.