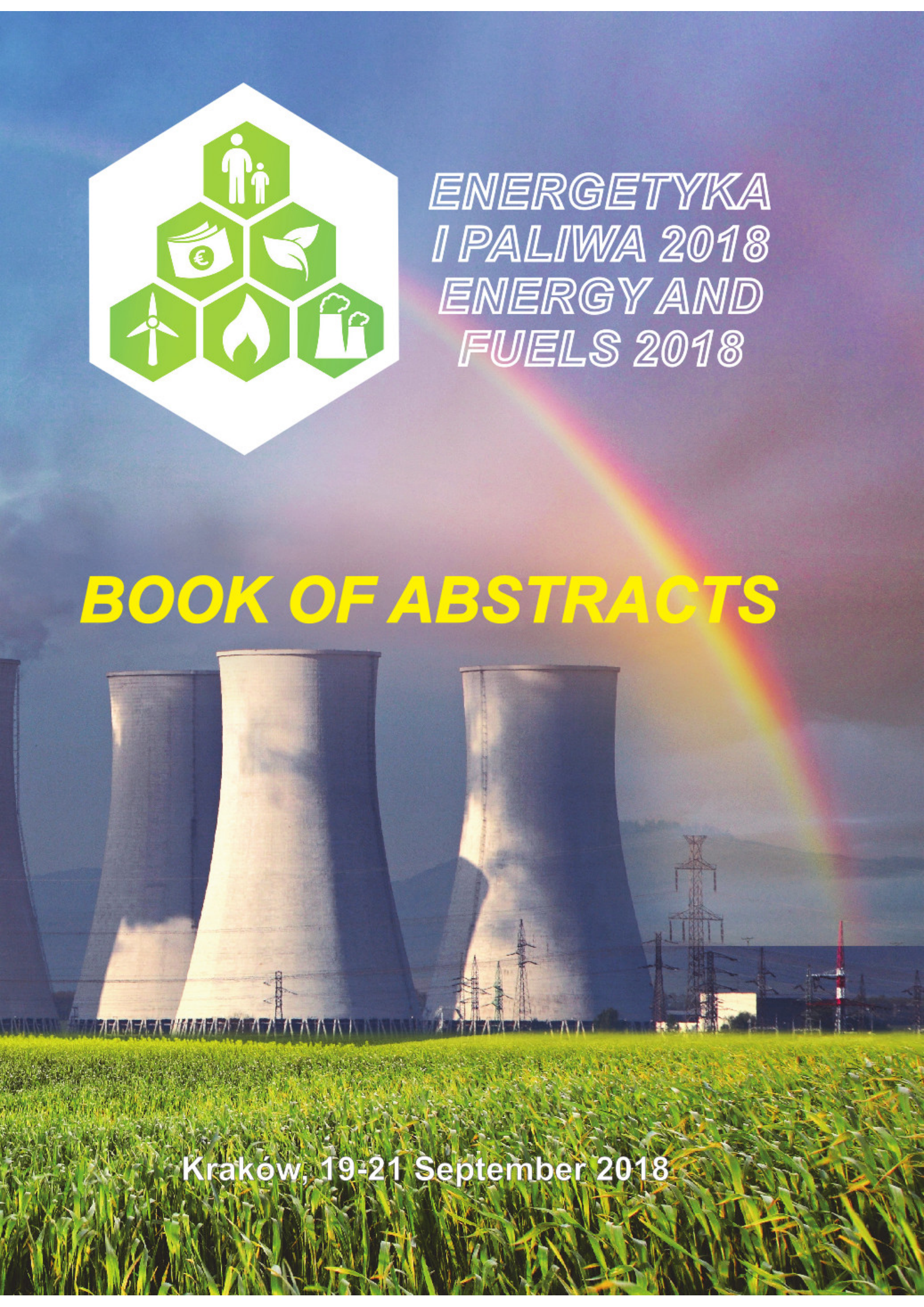

ENERGETYKA I PALIWA 2018
ENERGY AND FUELS 2018

BOOK OF ABSTRACTS

Kraków, 19-21 September 2018

AGH University of Science and Technology
Faculty of Energy and Fuels

Tadeusz Kościuszko Cracow University of Technology
Institute of Thermal Power Engineering

Energy and Fuels 2018

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CONTENT

Preamble

Energy sector is exercising changes and challenges that never occurred in the past. These are of various matters and extent. There is a continuous process of limiting pollutants emissions, especially in the European Union where subsequent directives such as Industrial Emissions Directive and BAT Conclusions set new, stringent emission limit values. The latter, based on the analyses of available techniques forces plants to invest in emissions abatement installations, which leads to higher costs of generated energy. In the same direction go efforts to combat climate change. After over two decades from the Kyoto protocol, an agreement on global efforts was reached on the 21st Conference of the Parties. Although it does not impose decisive limits on greenhouse gases emissions it creates voluntary obligation to undertake actions that will lead to the decrease of GHG emissions. Two countries the USA and China, which are responsible for almost 40% of global GHG emissions, have ratified COP21 agreement. However, the recent declarations of the USA do not follow the strict climate policy, but the changes in the energy mix, coal replaced by natural gas would lead to lower carbon dioxide emissions. General improvements in efficiency and technological changes in industry would also contribute to the lower GHG emissions. European ambition is that in 2050 renewable sources should dominate energy supplies and dissemination of these technologies is observed. One should not forget about the abundant reserves of cheap coal, which has no economic competitor. Despite relatively high emissions and impact on environment and human health, coal will have a role in energy supplies. However, only clean coal technologies would be acceptable, improvements in efficiency and abatement technologies constitute a plausible path for coal employment.

Air quality seems to be most important in case of Poland. While emissions from energy sector are strictly controlled and have been decreased substantially in the past two decades, the so-called "low emissions" mainly from domestic heating and transport constitute a real threat, particularly in winter season during which allowed concentrations are often exceeded. Many Polish cities are among the ones of poorest air quality. The Polish society has become aware of possible adverse impacts on health and projects have been undertaken to lower associated risks.

Introduction of support systems for renewable energy sources has led to the increase of their share in power generation. On the one hand, it helps to mitigate the air quality problem, but on the other hand, as RES have still high capital costs and low capacity factor in Polish conditions, they contribute to increasing the energy costs for final costumers. Additionally, their intermittent nature requires completely new working conditions of electricity supply system, mainly more flexible operation of classical – fossil generators to cover the residual load. Their unpredictability requires also maintaining the back-up capacity ready to balance disappearing supplies. Development of high capacity storage technologies could help to overcome the balancing problems.

Above considerations touch only the surface of the problems. The conference's presentations cover wide range of research fields, what corresponds to diverse problems of present fuels and energy sectors.
This publication has over one hundred abstracts of the papers, that will be presented at the Energy and Fuels Conference 2018 which is the second edition and follow up of previously organised ones by Faculty of Energy and Fuels AGH UST and its predecessors. It is organised biennially together with the Institute of Thermal Power Engineering of Cracow University of Technology. We hope that the Conference will contribute to deeper understanding of these processes as well as finding the means to solve large and small problems of fuels and energy.

The novelty of the current edition of the conference has been the organization of two industry minisymposia in order to highlight the cooperation of science with the industry communities. The main goal of such minisymposia involves the bilateral cooperation between science-industry and any initiatives of joint project grants focused on implementation results in energy and fuel sectors. The innovative formula of the event focuses on the dominant role of the representatives of enterprises, but the researchers, students and other participants will be only listeners and discussants.

The session "Environment" of the Conference "Energy and Fuels 2018" is dedicated to the anniversary of scientific work of Professor Teresa Grzybek

Professor Teresa Grzybek is a graduate of Master and PhD studies at the Faculty of Mathematics, Physics and Chemistry at Jagiellonian University.

She has been dealing with issues related to environmental protection for many years. Particularly, her interests were focused on catalytic processes for treatment of outgases from combustion of fossil fuels and chemical management of greenhouse gases. Within these topics, she cooperated with many scientists from leading foreign centers, such as University of Leipzig, UPMC in Paris, Politecnico di Milano, IST in Lisbon, and others. She is the author of over 230 publications, including 60 with high IF.

She is a respected academic teacher, and was a supervisor of many engineering, master and doctoral theses. Many of her pupils chose scientific career. She was honored with the Medal of the National Education Commission for her didactic activities.

She was three times Vice-Dean for General Affairs of Faculty of Energy and Fuels, and the organizer of the second and third cycle studies, as well as the first director of KIC Innoenergy Master programme Clean Fossil and Alternative Fuels Energy.

Wojciech Suwała
Jacek Leszczynski
Monika Motak

PROBLEMS OF THE POLISH POWER SYSTEM DEVELOPMENT

Wojciech Suwala[1,*], Artur Wyrwa[2]

Keywords: forececasts, modeling, energy sector prospects

ABSTRACT

Energy systems face radical – revolutionary changes, however stretched in long period. Development of intermittent supplies from renewable energy sources poses challenge for the entire power system as it requires specific responses from traditional generation units. They were used to work in stable mode. while now their flexibility is the main issue. The share of RES increases, what on one side has positive environmental impact, but on the other side disturbs economics of classical generation units.

Liberalisation of electricity market led to increased risks in power investments and the capacity market constitutes a remedy and incentive for investments required to fill the gap created by closing exhausted and inefficient plants. On the consumer side electromobility could change the demand, not only in quantity but also in the time distribution.

Climate policy tends to dispose coal based generation which uses abundant and cheap fuel, what was the reason for their high share in Polish power system. Present policy tends to maintain these sources, but their share in energy mix should be lower to reach the levels set by the EU regulations. The results of modelling exercises with TIMES-PL model indicate on what conditions it would be possible, and what costs it incurs.

In the paper these issues are discussed to give a picture of possible development of Polish power system development, in the context of the changing technical, economic and regulatory environment.

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CIRCULAR ECONOMY AND CLEAN AIR AS A PART OF INNOENERGY ACTIVITIES

Marcin Lewenstein[1,*]

Keywords: innovation, funding, energy, circular economy, air pollution

ABSTRACT

As a fund, InnoEnergy aims to simplify and shorten the journey from lab to launch. We focus on developing and investing in innovative and commercially viable products and solutions, and we finance multi-skilled partnerships that significantly reduce the risks of product development. We provide researchers and inventors with access to a deep pool of complementary skills and resources, and connect them to markets and commercial opportunities across Europe. Our collaborative model encourages businesses of all sizes to participate in innovative partnerships, consider new ideas and support new research from across Europe.

With the energy sector becoming more and more diverse, a broad range of products and solutions will be needed, each one addressing a different aspect of the energy challenge. That is why we are working with entrepreneurs, innovators, industry and universities in following critical thematic fields: Energy storage, Energy efficiency, Renewable energies, Smart electric grid, Smart and efficient buildings and cities, Nuclear instrumentation and Energy for Circular Economy.

The last of our thematic fields is a relatively new addition to our portfolio. In this field, we focus on the following themes:

- Energy focused solutions for the circular economy, such as waste-to-energy and bioenergy,
- Solutions for heat networks, including smart district heating, automation in heat networks, digitalization and grid-scale heat storage,
- Transition of conventional energy sources, including how they will converge with the renewable market, and the effect of automation and digitalisation on their operations,
- Air quality improvement measures, such as inter alia combustion optimisation and filtration.

In October 2018 we will finalize a study into the impact of energy innovation, novel business models and policy enablers on the reduction of smog and other forms of air pollution. Our study aims to gain a solid understanding of what can be achieved within the air quality domain, and who are the key players and stakeholders with whom we should engage. This will involve identifying all issues and areas that could be addressed by EIT InnoEnergy investments, before helping us decide how we can support innovators, entrepreneurs and start-ups that are dedicated to tackling the air pollution challenge.

In coming years solutions for tackling air pollution will be one of the key focus points of InnoEnergy investment policy within the Energy for Circular Economy thematic field.

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THE POSSIBILITY OF USING LOW-LOSS AMORPHOUS MAGNETIC MATERIALS IN ENERGY APPLICATIONS

Grzegorz Kmita[1]

Keywords: amorphous metal, low-loss magnetic materials, power applications

ABSTRACT

Soft magnetic materials with amorphous structure have been successfully used in energy and power electronics applications for several decades, however, their use is subject to various limitations due to the physical properties of amorphous alloys and the techniques of making magnetic circuits out of them. Regardless of the application, the problems remain very similar and mainly concern the limited possibilities of production of large-size components, but also the complexity of the production process of cores or chokes with the use of amorphous metal.

Knowledge of the technology of obtaining amorphous magnetic materials, as well as the processes of making magnetic circuits out of them creates wide possibilities of shaping usable properties and additional potential that can be used to design and manufacture devices with increasingly favorable features, both from a technological and economic point of view. Generally, it can be assumed that amorphous materials are characterized by about three times lower specific losses than cold-rolled electrotechnical steels, but with completely different functional parameters of magnetic circuits. Unfortunately, achieving such a level of losses is associated with significantly higher production costs, due to the price of the sheet itself, which is higher by about 20%, as well as a more complicated assembling method of magnetic circuits. Not without significance are also the larger dimensions of magnetic circuits, which are associated with lower magnetic flux densities compared to CRGO materials. Ultimately, the technological advantage of cores made of amorphous plates can be determined by the difference in core losses (at no-load condition), compared to CRGO steel-based cores, however, the economic justification for the production of these cores is often obtained only on the basis of capitalization of losses over the entire period of their functioning, i.e. 20 ÷ 30 years (TOC - Total Ownership Cost).

The issues related to the possibility of shaping the properties of amorphous metal cores are discussed and an additional potential is indicated, which can be used to design and produce devices with increasingly favorable operating characteristics.

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ELECTROMOBILITY: JOHNSON MATTEY THE LIDER OF BATTERY PRODUCTION FOR E-BIKES AND LIGHT E-MOBILITY: COLLABORATION, CAREER

Petr Grzegorz[1], Kinga Młocek-Harazim[2,*]

Keywords: lihium-ion battery, battery manufacturer, battery management system, e-mobility, e-bikes

ABSTRACT

[1]We are Johnson Matthey - our vision is for a world that's cleaner and healthier; today and for future generations.

Johnson Matthey is a global leader in sustainable technologies, applying cutting-edge science to create solutions that make a real difference to the world around us. With over 200 years of sustained innovation and technological breakthrough the company enable cleaner air, improved health and the more efficient use of our planet's natural resources.

Johnson Matthey Battery Systems (JMBS), a part of Johnson Matthey Group, is a leading lithium-ion battery packs produce with over 20 years of expertise in battery assembly processes, located in south of Poland – Gliwice. The company produces over 2,8 million advanced power systems a year, using 50 million cells and employing over 700 people.

With the manufacturing capabilities of battery packs up to 60V and all core competences under one roof (R&D, production, testing, benchmark) - JMBS designs and manufactures advanced power systems of different power. Lighter-sized batteries find their application in home and professional power tools, medical devices and electric bicycles. Larger batteries are intended for a dynamically developing branch of light e-mobility market.

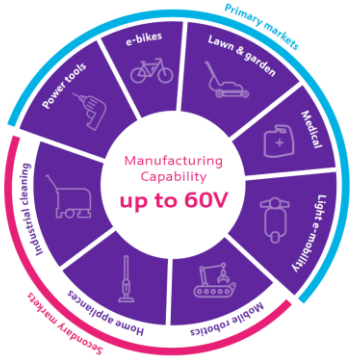

Figure 1. Manufacturing product range

[2]JM offers many interesting career opportunities in our existing facility in as well as in our new greenfield Clean Air project, both located in Gliwice. Typical positions offered to the graduates are in the areas of: R&D, quality, logistics, office administration, customer service and EHS. Trying to find the ideal employees we mainly evaluate their competences. The ideal candidate should be able to identify with our internal values, putting a lot of attention to safety rules and other internal regulations. Moreover, they need to be honest, engaged, cooperative as well as eager to develop internally, realizing their innovative ideas that contribute to the company's success.

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AGH UST, CRACOW UNIVERSITY OF TECHNOLOGY, KRAKOW, SEPTEMBER 19TH-21ST, 2018

ESTIMATION OF ONE-YEAR OPERATION OF HYBRID HEAT SOURCE FOR HEATING THE BUILDING AND PREPARATION OF HOT WATER

Dawid Taler[1,*], Rafał Pitry[2], Jan Taler[3]

Keywords: system performance, condensing boiler, ground-source heat pump, air-source heat pump, solar collector

ABSTRACT

Hybrid systems of supplying residential buildings with electricity, heat and domestic hot water that combine photovoltaic cells, solar collectors, ground and air heat pumps and gas boilers quickly develop [1]. A least-cost investment methodology that optimizes the hybrid power-residential heating system, including thermal energy storage, was developed in [2]. The hybrid ground heat exchangers of ground-coupled heat pump systems using vertical, as well as horizontal heat exchangers, were studied in [3]. The performance of a heat pump with a hybrid heat source including solar and air energy using different refrigerants was simulated in [4]. The efficiency of new power sources (co-generation, tri-generation systems, fuel cells, photovoltaic systems) can be enhanced using heat pipe heat exchangers and solid sorption heat pumps [5]. The paper presents the results of research on the operation and energy efficiency of a 186 kW gas-fired condensing boiler operating in a hybrid heat source system. The boiler co-operates with an 81.1 kW (electric) brine-to-water compressor heat pump, a 27.4 kW air-to-water heat pump and six flat solar collectors. A local, built-in, hybrid heat source is located in a public building and is intended to satisfy the building needs. The study was conducted over a period of 1 year – from 1 September 2014 to 31 August 2015. The gas-fired boiler operates in the heating buffer system all year round. The boiler performance is characterized both in the winter and in the summer season, in terms of the amount of heat produced and the heating power. The calculations results of the heat generation efficiency obtained in the measuring period are also presented and compared to the data given in regulations applicable to performing energy audits and issuing energy certificates. One of the conclusions from the research carried out is that the amount of heat generated throughout a year is not proportional to the installed power of an energy-generating device, which is first and foremost related to the device working time. For example, the results of annual measurements indicate that for the 186 kW gas-fired boiler, its percentage share of the heat generation during the whole year is 51.11%, whereas for the 81.1 kW brine-to-water heat pump, the percentage share of the overall annual thermal energy production is as much as 43.02%.

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IMPLEMENTATION OF ENERGY HARVESTING SYSTEM OF WASTES OF COMPRESSED AIR WASTES FOR ELECTRICAL STEEL CUTTING LINE

Dominik Gryboś[1,*], Jacek S. Leszczynski[1]

Keywords: energy harvesting, pneumatic, energy losses, energy efficiency

ABSTRACT

Pneumatic systems are commonly used in industrial plants to power pneumatic machines and tools. However, since production of compressed air is quite expensive, manufacturing plants are trying to reduce the operating costs of pneumatic systems by improving their energy efficiency [1]. There are three main methods of reducing costs in these systems: averting energy losses, limiting input energy and harvesting energy wastes of compressed air [1].

In this article, the authors focus on the last method mentioned above - recovering energy wastes from cutting line of electrical steel in a production plant, by using their own invention [2-4]. Fig. 1. shows generated power and overpressure drop of air during discharge of tank with change of generator load. The maximum power P_e of the device is changing from 190 W to 60 W and it depends on the value of overpressure p in the tank. In one hour, the device generates about 0,025 kWh energy and uses about 2,5 m^3 of air in overpressure of 6 bar.

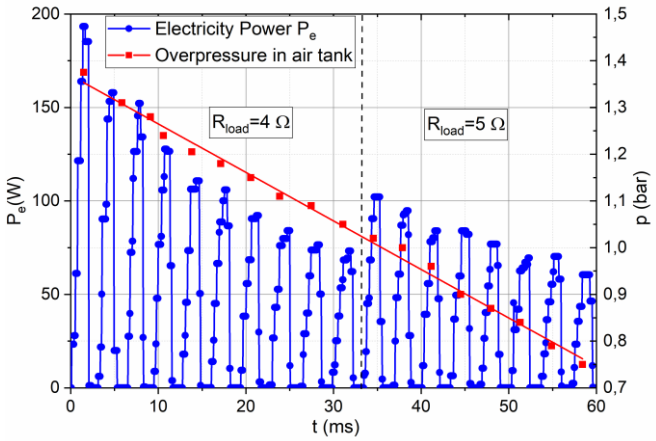

Fig. 1. Generated electricity power P_e and overpressure drop p of air during discharge of tank with change of generator load

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DESIGNING NUCLEAR REACTORS OF ADVANCED TECHNOLOGIES. COMPARISON OF COMPUTER SIMULATIONS AND EXPERIMENT.

Jerzy Cetnar[1], Grażyna Domańska[1,*]

Keywords: nuclear reactor, validation, Monte-Carlo codes

ABSTRACT

The high cost and technological advancement of nuclear reactors of the 3rd and 4th Generation determines the importance of simulating new concept with the use numerical codes. That means in some cases full real system simulation through calculations. Compatibility of simulation with physical reality is becoming an important issue today. In the case of nuclear reactors, the most important designing parameters are: the kinetic parameters, the neutron flux distribution, the power distribution and particularly important the fission reactions rates distribution. Values of these indicators obtained with the Monte-Carlo codes: mcnp and mcb, became the subject of comparisons with values from the "FREYA" experiments / Project to extend the investigations of the subcritical configurations for validation of the methodology for on-line reactivity monitoring of ADS systems/. The experimental project was conducted as a part of the European 7th Framework Programme on the nuclear systems and was located in SCK-CEN in Belgium. The project corresponded to critical and subcritical reactors cooled with lead. Spatial distribution of reaction rate and various kinetic parameters, such as the "void" reactivity coefficient, were analyzed and compared. High compliance of results between simulation and experiment was demonstrated for all tested versions of the analysed system.

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THORIUM BASED FUEL LOADING PATTERN FOR PWR REACTOR

Mikołaj Oettingen[1,*]

Keywords: Thorium, Monte Carlo, MCB, PWR

ABSTRACT

The Monte Carlo Continuous Energy Burnup Code (MCB) developed at the Department of Nuclear Energy, Faculty of Energy and Fuels of the AGH University of Science and Technology, Krakow, Poland was applied for the creation of a full scale numerical model of the Pressurized Water Reactor (PWR). The MCB code couples well-known, general-purpose Monte Carlo N-Particle transport code (MCNP) with the state of the art Transmutation Trajectory Analysis code (TTA) [1]. The functionalities of the code allow application of various core loading patterns with different types of nuclear fuel. In the study we introduce the thorium fuel into the matrix of the PWR reactor in order to investigate bereding capabilities of U233. In addition we show variations of isotopic concentrations in function of time for initial reactor cycle. The reactor core was divided into numerous axial and radial burnup zones for assessment of physical effect in the 3D array of the core. The thorium was introduced into the reactor core in the form of separate fuel assemblies. This heterogenous approach is called Whole Assembly Seed and Blanket (WASB). The seed assemblies provide surplus neutron for effective conversion of the fertile Th232 to the fissile U233 in the blanket assemblies. The approach is known as a Radkowsky thorium fuel concept, named after Alvin Radkowsky, American nuclear physicist and a proponent of thorium fuel cycle. The thorium fuel cycle could complement uranium fuel cycle in the dedicated fissile systems, which supports the related global research [2]. The supercomputer Prometheus of Academic Computer Centre Cyfronet of the AGH University was applied for all numerical simulations.

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CCGT AND SMALL NUCLEAR SMR HYBRIDS SYSTEM FOR FLEXIBLE ENERGY GENERATION

Ludwik Pienkowski[1], Marek Jaszczur[1,*], Michał Dudek[1], Katarzyna Skolik[1]

Keywords: Small nuclear reactor, nuclear hybrid system, thermodynamic analysis

ABSTRACT

Energy consumption is the primary indicator showing the development of the country. The growing demand for electrical energy and rapid development of power technology as well as materials science allow to design and implement modern solutions for nuclear energy, energy security and energy conversion system in order to provide a lower cost of energy.

Future development of the energy conversion systems will be based on second and third generation technology. Additionally, modern power plants are expected to be able to work in a very wide range of power output, going down to 20%. At the same time, frequent, deep and rapid changes in generated power reduce systems lifetime, their average efficiency, and in the case of nuclear energy, introduce additional issues related to nuclear safety.

The hybrid energy systems can give at least a partial solution to such challenges however, it requires significant investments which reduces their attractiveness. Such a hybrid system may constitute a very appealing solution to be implemented mainly for the future use of natural gas or synthetic gas ensuring the lowest level of the emission of CO_2.

In the present work, a thermodynamic analysis of a hybrid system consisting of a nuclear block powered by Small Modular Reactor (SMR) and a gas-steam block Gas Turbine Combined Cycle (GTCC) was performed. The coupling was analysed by means of a compressor in a gas block powered by an electric motor and using steam from a nuclear block in the Gas Turbine Combined Cycle steam power plant block. Some promising and challenging results are shown and discussed.

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THE REGENERATIVE AIR HEATING FOR A BIOMASS BURNING FURNACE

Artur Cebula[1,*], Sebastian Kowalczyk[2], Szymon Szufa[3], Piotr Piersa[3], Łukasz Adrian[3]

Keywords: heat transfer, pins, fins, enhancement heat transfer, boiler

ABSTRACT

The paper concern heat transfer calculation of air pre heating for biomass burning furnace. The boiler power is 100 kW and its outer surface has temperature of 80°C. Authors performed calculation to find pins effective height and pins pitch (fig.1). Aims of work is to extend heat transfer area and intensify heat exchange in order to increase air temperature that flows to the burner. On the other hand pressure drop should low to not increase pumping power of the fan the force air flow through the crated additional channel and washed out hot boiler wall. The calculations are performed with use of numerical tools and compered with hand engineering calculations.

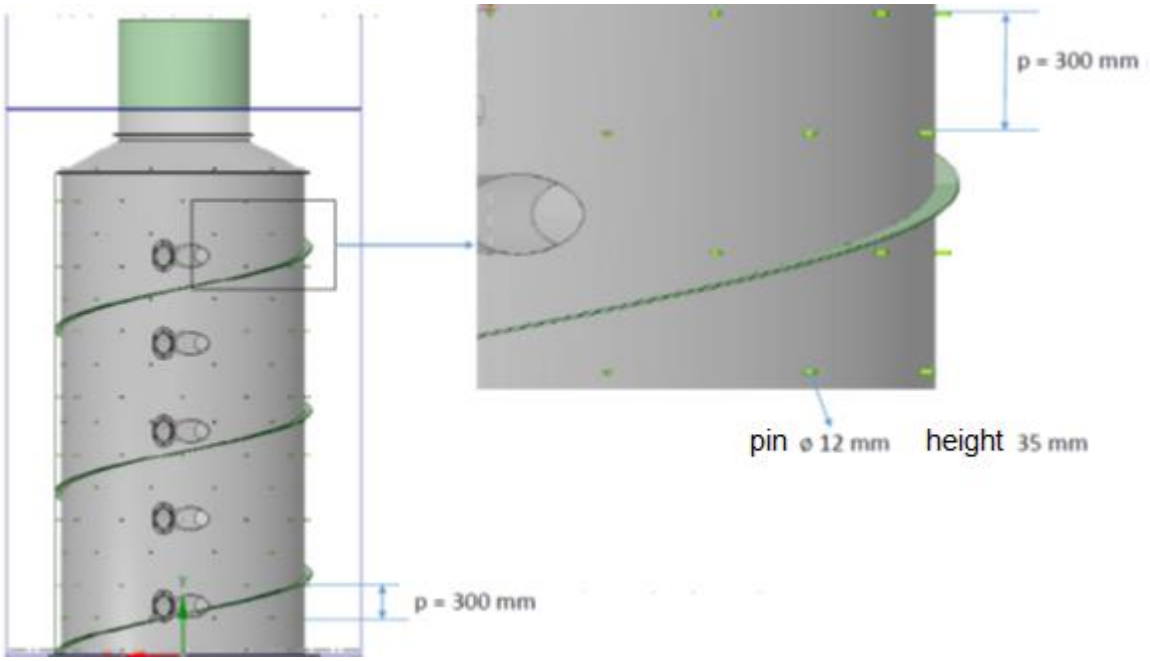

Figure 1. The furnace surface covered with pins and fins.

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MODEL OF MEDIUM-TERM FORECAST OF ENERGY MIX IN POLAND

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Keywords: energy, fuzzy logic, neural networks, ANFIS model, forecasting

ABSTRACT

Available publications by ARE S.A. contain statistics of monthly balances of electricity generation and consumption. The analysis of chronological time-series from statistics confirms the thesis about their periodic variability with dynamic changes. The database of monthly balances allows constructing a forecast model for the production of electricity, and on this basis, the analysis of the generation structure, the so-called energy mix. The scenarios of the development of the energy system are analysed. The Adaptive Neuro-Fuzzy Inference System (ANFIS) seems to be a good tool for forecasting chronological time-series with periodic variability. The issue has been covered by numerous studies.

The balance sheet data regarding electricity production, taking into account its structure, is the basis for building the forecasting model. Data used for calculations include monthly production of electricity from power plants (thermal, hydro and wind), independent producers of electricity and industrial thermal power plants. The prediction method presented in the article enables a mid-term forecasting of power generation and its structure.

In the process of time-series prediction using ANFIS it was assumed that the values of monthly global supply of electricity and technologies (8 variables) $X(t)$ are known for $t=1, ..., T$. A 12-month shift in data for the input variable was chosen because of the annual load variation. Due to a limited number of statistical data ($T=120$), a two-dimensional input vector of training data $w(t)=[X(t-12)\ X(t)]$ was selected in a number of trials, with the input data of the training set corresponding to the prediction trajectory $s(t)=X(t+12)$. In this way 96 values were obtained of the input/output data set using the data from the period 2004 to 2016. The first 48 values were used in the process of training and the other 48 in the process of verification of the prediction model. In the model there are only two input variables, that's why the number of fuzzy rules is 4. The estimation of the ANFIS model and forecasting process were performed. Comparison of the real data on electricity supply and power plants generation with the prediction obtained by means of ANFIS indicates that differences are relatively small (Table 1). Mean absolute percentage errors *MAPE* obtained on the basis of the ex-post prediction is 2.65 % for electricity supply.

Table 1. Mean absolute percentage errors MAPE of the prediction of power generation by technologies

Specification	MAPE [%]
Electricity supply	2,65
Thermal power plants	2,40
Wind power plants	4,62
Hydro power plants	8,94
Independent producers of electricity	6,24
Industrial thermal power plants	6,13
Import	25,96

After constructing the ANFIS models, forecasts of electricity supply and power plants generation were carried out in the horizon until 2020.

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GLOBAL ENERGY INVESTMENTS - TRENDS AND PERSPECTIVES.

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Keywords: energy, energy investment, energy balance, new technology

ABSTRACT

There is no need to convince anyone about the role and importance of the energy sector in the development of individual societies and economies. Currently, the key role is to ensure the continuity and stability of energy supplies to all its users. It should also be borne in mind that there are changes at both national and regional levels aimed at transforming energy systems, based mainly on fossil energy carriers, oriented towards increasing the role of low-emission or zero-emission energy sources. Bearing in mind the specificity of the energy sector, high capital intensity and significant inertia of the entire sector, planning and implementation of individual investments is extremely difficult. Investments are the driving force of the global energy system. The money invested today in our energy systems, in large power plants and transmission lines, energy efficiency, modernization or innovative low-carbon technologies will have a lasting impact on energy supply and demand for decades.

An additional implication is the dynamic changes in the prices of energy carriers, determining the profitability of implemented or planned investments. A sustainable, prosperous and healthy future for the world depends on these investment decisions, which are shaped by the market framework and ultimately defined by government policy. The article will present global trends in the field of investments in the area of obtaining fossil energy carriers, renewable energy sources as well as investments in the scope of research and development works.

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SOLAR-WIND-BATTERY HYBRIDS FOR RURAL HOUSEHOLDS IN POLAND – SPATIAL ANALYSIS OF ECONOMIC JUSTIFICATION

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Keywords: renewable energy, cost-effectiveness, CO_2 emission prices

ABSTRACT

Shares of renewable energy sources in covering the world energy demand are steadily increasing. This process is driven by a multitude of various factor including: environmental concerns, economic superiority of renewables, subsidies or individual preferences. On a country level, this process is usually government dependent and prone to pressure made by beneficiaries of the current market situation. This situation can also be observed in Poland, when promising development of the wind sector was brought to a sudden halt due to unfavourable legal regulations and a decrease in green certificate prices. Nevertheless, Poland in still obliged to meet the European Union targets for 2020 and the ones thereafter.

Considering above in this paper, we address the problem of economic justification of using small scale solar and wind hybrid energy sources coupled with batteries for the purpose of covering energy demand in rural households located across Poland. We use a standard optimization model which aims at selecting the optimal configuration of hybrid sources (installed power in wind and solar generators as well as battery capacity) while meeting imposed constraints. We investigate the impact of CO_2 emission prices on the cost-competitiveness of such hybrids. Furthermore, we visualize (in form of maps) their potential in terms of payback time, CO_2 emissions reductions and level of energy self-sufficiency.

We find that the cost-effectiveness of renewables is strongly depended on local solar and wind (mainly) conditions, future electricity price development scenarios and CO_2 emissions trading. In addition, we show the potential impact of solar-wind hybrid on the typical load profile of Polish households.

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TESTING THE PERFORMANCE CHARACTERISTICS OF SPECIFIC PROFILES FOR APPLICATIONS IN WIND TURBINES

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Marcin Kowalski, Piotr Dudek, Sebastian Bielik

Keywords: wind turbines, blade shape, blade angle

ABSTRACT

The publication presents the results of aerodynamic characteristics of selected profiles for applications in wind turbines. Considering the potential of energy resources and investors' preferences, the amount of energy produced in wind farms in the total amount of electricity generated will be systematically growing and probably for the next few years, wind energy will be the first of all types of power plants. Harnessing the power of moving air masses is now a global phenomenon. Rotor wheel converts wind energy into mechanical energy. It is built with blades of chosen profiles oriented in the terms of the optimum performance. The aim of the measurements was to determine the impact of blade shape and blade angle of attack on the efficiency of conversion of wind energy into mechanical energy on the rotor shaft. The tests were carried out in a wind tunnel for the airflow velocity range up to 30 km / h. The obtained lift and drag factors were presented as results

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E-MOBILITY - INFLUENCE ON THE POWER GRID AND THE PROFITABILITY FOR USERS

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Keywords: battery aging, battery life, electric vehicle, vehicle to grid, e-mobility

ABSTRACT

The growing number of electric vehicles, which are equipped with electrochemical energy storages, makes it possible to use them as an intervention source in the power system. The total power of energy storages in vehicles allows to support power grid and reduce sudden load changes. On the other hand, the batteries used in this way lose their capacity faster, and therefore require more frequent replacement, which is a problem for users.

For this reason, the article discusses aspects related to the impact of energy exchange processes between lithium-ion batteries in electric vehicles and the power grid.

The selected model of the power grid was presented and the demand for electricity in selected European regions was characterized. Electric energy storage is discussed, which are currently used in electric vehicles.

The simulation of the annual use of electric vehicles for the purposes of local power grid unloading has been performed. In addition, the impact of cyclic charging and discharging processes on their lifetime was determined. For selected variants, an analysis of the cost-effectiveness of using batteries for energy purposes from the point of view of the user of the electric vehicle was made. The limit unit value of the energy price was determined, for which it is profitable to sell energy from electric vehicle batteries for regulation purposes in the power system. The results obtained were commented and conclusions were presented.

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FLUE GAS DESULPHURIZATION WASTEWATER TREATMENT BY COAGULATION WITH ALUMINUM-BASED COAGULANTS

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Keywords: flue gas desulphurization, wastewater treatment, coagulation, BAT, aluminum-based coagulants

ABSTRACT

The coagulation process using aluminum-based coagulants was applied to flue gas desulphurisation (FGD) wastewater treatment. Both, sedimentation and coagulation using aluminum-based coagulants and the use of polyelectrolyte allows to achieve a satisfactory FGD wastewater treatment effect. As a result of coagulation use, COD was decreased from 395 mg/L to 244 mg/L and TOC was decreased, depending on the analyzer, from 47.73mg/L (Shimadzu) and 47.95mg/L (GE) to 37.27mg/L and 37.3mg/L, respectively. A comparable degree of treatment has been achieved, regardless the coagulant used and its dose. Sludge settling properties were weak, what significantly hindering potential aluminum-based coagulants use. The polyelectrolyte use does not improve coagulation effectiveness and does not accelerate sludge sedimentation and volume decreasing. Based on statistical analyzes, it was found, that there were no significant differences in COD removal between sedimentation and coagulation processes. Both TOC analyzers can be successfully used to in a complex matrix such as FGD wastewater

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INTEGRATION ADSORPTION CHILLERS WITH CONVENTIONAL POWER PLANT

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Keywords: adsorption chiller, heat transfer, efficiency

ABSTRACT

It is predicted that in developed countries electricity consumption will increase three times by 2020 compared to 1970. In developing countries, where the population may double by 2020 with reference to 1970, electricity consumption may even increase by 20 times. Other sources predict that by 2030 the annual growth in electricity demand will be from 2 to 3%. With such a high rate of development of the global economy, the demand for electric energy will grow, so using only renewable sources to generate electricity will not be enough. Coal will have dominant role in produce electricity in the future. One of the ways to reduce the negative impact of fossil fuels on the natural environment is to increase the efficiency production electricity. Electricity production is associated with large heat losses, this heat can be used to produce cold using adsorption chillers which can be driven by low-temperature heat. The main aim of work presented in this paper was focused on the analysis and assessment influence adsorption chiller on increase the efficiency of use of chemical energy of fuel for electric energy generation in power plant. The paper shows the numerical calculations performed with IPSEpro simulation software by SimTech.

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COMPARISON OF NUSCALE SMR MODELLING AND STEADY STATE PARAMETERS IN RELAP/SCDAPSIM AND MELCOR CODES

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Keywords: RELAP/SCDAPSIM, MELCOR, SMR, NuScale, iPWR

ABSTRACT

Small Modular Reactors (SMRs) are nuclear reactors with thermal power up to 300MW. They use different technologies, however the light water type is the best proven one after many years of operation in Nuclear Power Plants (NPPs) all over the world. NuScale reactor, which is predicted to be commercially available on the market in the next few years is an integrated Pressurized Water Reactor (iPWR) with the coolant flow basing on natural circulation. Its design uses many solutions known from traditional PWRs such as similar fuel assemblies and pressure control provided by the pressurizer. The main difference is the integrated design, which makes the reactor smaller and eliminates the need for coolant pumps. NuScale reactor safety is maintained by the passive safety systems in case of any Design Basis Accident (DBA) and therefore no radioactive releases to the environment or core melting is predicted as a consequence. In the present work two NuScale models are described and compared, one prepared using RELAP/SCDAPSIM code and the other using MELCOR code. These two thermal-hydraulic codes are used in safety analysis of nuclear reactors. However, there are some differences in the input data required, calculation methods and therefore in the results as well. The main geometry parameters and boundary conditions used for both models are presented. The steady state run was performed for 10000s and the obtained plant parameters were compared to the data published by U.S. Nuclear Regulatory Commission (NRC) in NuScale Design Certification Application (DCA). The results show good consistency with the reference data and this comparison proves the reliability of both models. Some discrepancies that occur are described and analysed by the authors.

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MONITORING OF TRANSIENT FLUID TEMPERATURE AND THERMAL STRESSES IN THICK-WALLED CYLINDRICAL ELEMENTS

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Keywords: thermal stresses, pressure components, transient temperature measurement, inverse marching method

ABSTRACT

High thermal stresses arise during the start-up and shutdown in the thick-walled elements of the thermal power plants, both classical and nuclear. For the fast start-up of the power unit, but without reducing the life of the critical pressure components, the thermal stresses should be calculated on-line. The thermal stress can only be calculated correctly if the temperature of the flowing fluid is accurately measured. Unfortunately, massive industrial thermometers used in power units are not able to measure the transient temperature of the fluid with sufficient accuracy due to their high thermal inertia.

The goal of the paper is to present the effectiveness of the new technique of measuring the superheated steam temperature in the transient state in a power plant. It based on the application of a new design thermometer with a calculation method using the solution of the inverse heat conduction problem. Steam temperature was also measured with an existing conventional thermometer so that the advantages of the new measurement technique could be assessed. Temperature measurements using both thermometers were made at the boiler start-up, boiler shut-off and during boiler operation. The thermometers were located downstream of the second superheater attemperator. The results of measurements obtained with new and conventional thermometers were compared. The fastest change in steam temperature occurred after the sudden injection of water into the attemperator header. The temperature measurement errors with the conventional thermometer are the highest in such a case. Dynamic errors of steam temperature measurement using conventional thermometers exceeded 80 K. The measurements made show a much greater accuracy of the measurement of the transient steam temperature using the proposed new technique.

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DEVELOPMENT OF NOVEL MATERIALS FOR THE AIR ELECTRODE FOR SOFC AND SOEC TECHNOLOGIES

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Keywords: hydrogen energy, SOFC, SOEC

ABSTRACT

So-called hydrogen technologies seem to be key contributors for the effective, eco-friendly and reliable energy systems in the near future. Among them, Solid Oxide Fuel Cells (SOFC) and its reversible mode, Solid Oxide Electrolyzer Cells (SOEC), which can be used as basic generators of electricity or as a part of the supporting system in renewable sources grid, are considered as very promising. This is due to the high efficiency, almost no carbon footprint (if hydrogen is used) and fuel flexibility. Unfortunately, their high operating temperature, usually above 800 °C, results in a fast degradation of the components. Also, long and energy-consuming start-up is problematic. At the same time, current price of the SOFC and SOEC systems is very high, limiting their widespread commercialization. The major goal of developmental of such systems is related to decreasing of the operation temperature of the cells down to the intermediate (600-800 °C) or even low (down to 400 °C) range. However, this reduction causes increase of polarization resistance (especially the one of the air electrode), which results in a significant decline of the efficiency. It is therefore essential to obtain new materials with structural stability, high ionic-electronic conductivity and good catalytic activity for the oxygen reduction reaction (ORR) working in such the temperature range [1].

This work includes a short review on development of novel air electrode materials with particular emphasis on the Ni- and Cu-based oxides, as well as on new trends proposed concerning improvement of such the electrodes for SOFC and SOEC technologies. Two groups, $Ln_{2-x}(Sr,Ba)_xCu_{1-y}Ni_yO_{4\pm\delta}$ and $Ln_{1-x}(Sr,Ba)_xCu_{1-y}Ni_yO_{3-\delta}$ (Ln: lanthanide) oxides, are proposed and characterized in terms of their physicochemical properties, crucial for the candidate electrode material. Introduction Ba and/or Sr (with +2 charge state) allows to stabilize perovskite-type cuprates, as well as to ensure high total electrical conductivity of the analyzed materials. This suggests effective electron transfer with 3*d* metal orbitals effectively overlapping with 2*p* oxygen ones [2]. Tests of the chemical stability in relation to commonly used LSGM and CGO electrolytes, as well as the measurements of thermal expansion and total polarization values show that it is possible to develop effective $Ln_{2-x}(Sr,Ba)_xCu_{1-y}Ni_yO_{4\pm\delta}$ and $Ln_{1-x}(Sr,Ba)_xCu_{1-y}Ni_yO_{3-\delta}$ single-phase and composite-type electrodes.

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POTENTIAL OF PHOTOVOLTAICS TO COMPENSATE FOR ENERGY DROUGHTS IN WIND ENERGY SECTOR

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Keywords: simulation, temporal complementarity, variability

ABSTRACT

Wind energy is believed to play an important role in future renewables based energy systems. However, the intrinsically variable and climate/weather-driven nature of wind energy based power sources (wind turbines) makes their integration into the power system a complicated task. This results from the fact that wind energy exhibits significant variation not only on a short time scale (seconds–hours) but also from year to year. Additionally, in the case of variable renewable energy sources, like wind, solar and hydro, one has to overcome the problem defined by [1] as energy droughts, which are characterized as periods of either very low production or significant mismatch between demand and supply.

Considering the above, the objective of this research was to simulate the operation of the Polish wind energy sector based on historical wind speed data for the period 1980–2017 for the installed capacity as of the end of the year 2017. Secondly we estimated the likelihood, severity and duration of energy droughts. Finally, a simulation of potential energy yields from an even distribution of photovoltaic plants across Poland was performed.

The results indicate that the combined operation of PV and wind parks exhibit a significant temporal complementarity on a monthly time scale. Increasing the installed capacity in both sources leads to a greater variability of combined energy generation but significantly reduces the probability and severity of energy droughts from the perspective of fixed load.

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THE VIRTUAL POWER PLANT – A REVIEW OF BUSINESS MODELS

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Keywords: Virtual power plant, business model, distributed generation, smart grid

ABSTRACT

The development of Polish Renewable Energy Sources (RES) sector, especially the development of Distributed Energy Resources should be stimulated by two factors: (1) the complex amendment of the RES Act and (2) the planned introduction of, so called, 'power market'. The former was introduced in Poland since the 1st of July 2016, and its effects are new kinds of entrepreneurship, such as: clusters, energy cooperatives, and the auction system dedicated to the RES installations.

One of the most reliable as well as the most efficient way of ensuring the efficiency, the stability and the competitiveness of distributed generation is using Virtual Power Plant (VPP) technology. The concept of the VPP became possible due to the development of information and telecommunication technologies in recent years.

A virtual power plant is a system that integrates several types of power sources to give a reliable overall power supply. A VPP consists of a central IT control system and distributed energy resources (often renewable energy resources like solar, wind, hydropower, and biomass units) as well as flexible power consumers and batteries. Energy producers offer their free capacities to VPPs. A VPP purchases the capacity flexibilities from energy producers, manages the power plant production based on real-time sales demands, and sells the electricity produced on multiple markets at the same time: on a Power Exchange, on the balancing energy market, and directly to end-users. All these lead to higher margins for small-scale power plants without the additional costs of sales and balancing energy.

By successfully combining business and technology innovations, the VPP has developed a pioneering business concept based on the powerful synergies between the existing energy market segments. The VPP is an IT structure which connects energy producers and consumers with each other and with other market segments in real time through a smart grid. The biggest challenge in Smart Grid are non-technical issues, such as: regulations, law, business model, and the economic effectiveness of investment. The economic and political aspects are the biggest barrier to the development of the innovation in the energy sector.

Therefore, the USA, German, Finnish and Australian VPPs business models will be described in the article. The main aim of this paper is a critical comparison of these business models and pointing out both the common and unique features for each country. Basing of these examples there will be presented potential VPP business model in Polish conditions.

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SENSITIVITY OF FORCED CONVECTION ON INFLUENCE OF MAGNETIC FIELD

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Keywords: forced convection, magnetic field, hydraulic resistance, heat transfer

ABSTRACT

The ability to generate strong magnetic field or rather large magnetic field gradient led to the development of research concerning phenomenon known as the thermo-magnetic convection. At the beginning, the investigations were limited to an influence of magnetic field on the fluid behavior in closed enclosures. The aim of presented works is to extend the state of art on the phenomena occurring in the channels where forced convection of the weakly magnetic fluids takes place.

As an example the Graetz-Brinkman problem was studied. It was supplemented with the presence of magnetic coil located at the adiabatic-thermal boundary connection. The mathematical model consisted of mass, momentum and energy conservation equations. The second one contained an additional term representing the magnetic field impact. In order to resolve the equation set, magnetic induction distribution was necessary. It was obtained with the usage of Biot-Savart's law. The coil diameter to pipe diameter ratio was selected in accordance with the previously conducted research [1]. Laminar, transitional and turbulent flow regimes were investigated. An influence of temperature on the fluid thermo-physical properties was included.

Performed numerical analysis revealed the magnetic field impact on above mentioned fluid flows in a way of momentum and energy transfer modifications. Regarding the momentum transfer, clear velocity field maldistributions could be observed. In the case of energy transfer, change in the local value of important dimensionless parameter (Nusselt number) was found. Influence of magnetic field on the turbulence parameters was also analyzed. Obtained results are promising in the field of possible industrial or medical applications.

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THE EFFECT OF HYDRATED LIME ADDITION ON THE RETENTION OF TRACE ELEMENTS IN ASH FROM COAL DUST COMBUSTION

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Keywords: coal combustion, trace elements, sorbent, thermodynamic equilibrium calculation

ABSTRACT

Trace elements (TEs) are unavoidable components of every fuel. TEs undergo transformation during fuel combustion and are present in fly ash, bottom ash, and flue gases. Partitioning of TEs depends, *inter alia*, on combustion temperature, composition and degree of fuel fragmentation, chlorine content, boiling point of the element, combustion technology, combustion atmosphere, and additives used, for example: limestone, bauxite, or kaolinite.

For coal dust and hydrated lime were determined trace elements and the granulometric composition in this work. Hydrated lime was used as a sorbent added to coal dust in quantities of 5 and 10% by mass. The coal dust combustion in an air atmosphere was carried out in a laboratory tubular furnace. The combustion temperature was 800 oC. Trace elements content in ash during combustion of coal, and coal with the addition of sorbent was it was subject to research.

The analysis of thermal processes occurring in hydrated lime and samples of coal with the addition of lime was also performed in this work. The TG–MS experiments were conducted using the Netzsch STA Jupiter 449 F3 apparatus coupled with the Aëolos QMS 403 quadrupole mass spectrometer. The Arrhenius-type kinetic model was used to analyze the TG-DTG data.

Complementary to experimental studies are thermodynamic calculations carried out using the FactSage 6.3 software package. Thermodynamic calculations made it possible to identify types of compounds containing trace elements in ash and flue gases.

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IMPACT OF THE CAPITAL STRUCTURE ON THE MARKET VALUE OF COMPANIES IN THE ENERGY SECTOR - USING THE EXAMPLE OF POLISH COMPANIES

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Keywords: capital structure, company value, energy sector

ABSTRACT

The article focuses on a study of the impact of capital structure on the value of companies in the energy sector that are traded at the Warsaw Stock Exchange. The proposed study will cover the period of the last four years, i.e. the years 2014 - 2017, divided into quarters. In addition to the aforementioned parameter of capital structure, the analysis will also cover such ratios as return on investment (ROE) and return on assets (ROA). The study will use analysis of multiple regression based on the so-called deltas of individual parameters that describe their changes from quarter to quarter. The author of the paper assumes that capital structure may have an impact on the value of companies in the energy sector. This assumption is due to the market phenomenon where capital structure describes in some way the risk faced by investors: on the one hand, the higher the share of outside capital in the financing of the company's operations, the higher the risk; on the other hand, the higher the share of equity in the financing of the company's operation, the smaller the chance that dividend will be paid to investors in individual companies. The study of this phenomenon will make it possible, to an extent, to determine whether Polish investors accept higher investment risk in exchange for higher rates of return and whether their actions are aimed to reduce investment risk in exchange for lower return on the capital invested in the specific companies.

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INFLUENCE OF THE CO_2 EMISSION FACTOR VALUE ON THE RESULT OF THE LOAD DISTRIBUTION ANALYSIS BETWEEN THE HYBRID PV/WT/FC SYSTEM AND THE ELECTRIC POWER SYSTEM

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Keywords: CO_2 emission factor, generation dispatch, hybrid power generation system

ABSTRACT

The article presents the results of the analysis of the impact of CO_2 emission factor value [7,8] on the distribution of loads between a hybrid power generation system consisting of photovoltaic panels, wind farms and energy storage system (electrolyser fuel cell with ion-exchange polymer membrane) [1,2,3,4] and the power system [5,6].

One of the decision criteria for which small scale hybrid power generation systems based on renewables eenrgy sources are used are environmental criteria (reduction of CO_2 emissions).

Electricity systems of European Union member states are characterized by different values of CO_2 emission factor, from the largest, for example, the Polish power system, to the smallest, for example, the power systems of France and Norway. In the Polish electric power system weCO2 equals 810 kg CO_2 per MWh, in French approx. 30 kgCO_2 per MWh.

Studies will be carried out for various ranges of CO_2 emission factor values, based on a multi-variant analysis of load distribution analysis.

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THE OPERATION AND CAPACITY FADE MODELLING OF THE LITHIUM-ION CELL FOR ELECTRIC VEHICLES

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Keywords: lithium-ion cell modelling, battery life prediction, electric vehicles

ABSTRACT

The paper describes the issue of lithium-ion cell operation modelling, taking into account their life. Therefore, both the electrochemical and the circuit model of the lithium-ion cell were presented. In the case of the electrochemical model, processes related to the charge transfer as well as diffusion, occurring on cell electrodes and in electrolyte were discussed. On the other hand, in the circuit model, an exemplary equivalent diagram of the lithium-ion cell, intended for analysis of the operation of the cell in the states of the dynamically variable load was presented, taking into account its wear [1].

The following aging processes, which take place in the cells, and their impact on the cell life were characterised: the formation and evolution of the SEI (Solid Electrolyte Interface), the lithium plating on the surface of electrodes, the electrolyte gassing and electrode corrosion [2].

The methodology of modelling of the life of lithium-ion cells was presented in the state of cyclical operation and in the idle state. The decrease in the useful capacity of the lithium-nickel-manganese-cobalt cell with the rated capacity of 2.6 Ah was subject to analysis depending on the load current, average charging current and ambient temperature. The useful capacity prediction model for the cell was developed using the artificial neural network. The results of the model were verified with laboratory measurements.

Comments regarding the obtained results of measurements and simulations, as well as the characteristics were presented in the paper summary.

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RESPECT INDEX AS A PROJECT PROMOTING THE HIGHEST STANDARDS OF RESPONSIBLE MANAGEMENT IN ENERGY SECTOR

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Keywords: responsible management, Respects Index, energy sector, business models

ABSTRACT

RESPECT Index is the first responsible company index in Central and Eastern Europe. The project was launched by the Warsaw Stock Exchange in 2009 when the first Index was announced. The RESPECT Index portfolio includes Polish and foreign companies from the GPW (WSE) Main Market. Companies with the highest liquidity, i.e. included in the WIG20, mWIG40 or sWIG80 indices, may aspire to the index. The index only includes companies which undergo a three-stage verification conducted by the WSE and the Polish Association of Listed Companies – the companies must also engage in high-quality communication with the market through current and periodic reports and on their websites. The third condition is socially responsible behaviour towards the environment, communities and employees, which is reviewed on the basis of a survey verified by the project auditor – Deloitte. According to the current formula, the audit of companies and review of the index composition is carried out once a year, in the second half of the calendar year. The shares of companies included in the index are determined according to the same rules as in the case of other stock exchange indices – free float shares are taken into account, with the weighting of the largest companies being limited to 25 percent when the number of participants is less than 20 companies, or to 10 percent in other cases. The aim of the article is to present and analyze selected companies from the energy industry included in the Respects Index. The companies will be analyzed for responsible management, including the industry in which they operate. New business models, directions and ways of investing, increasing efficiency, using technological data are just a few of the challenges faced by energy companies.

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COBALT-BASED A-SITE LAYERED PEROVSKITES FOR APPLICATION AS CATHODE MATERIALS IN SOLID OXIDE FUEL CELLS

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Keywords: cobalt-based perovskites, cathode materials, fuel cells

ABSTRACT

Co-based double perovskites with $ReBaCo_2O_{5+\delta}$ formula (where Re = Rare Earth Element) and layered order of the Re-Ba sublattice, are very-well known cathode materials for Solid Oxide Fuel Cells. Those compounds have attracted increasing attention due to their high electrocatalytic activity towards oxygen reduction and mixed ionic-electronic conductivity with the enhanced ionic component, which consequently leads to improved cathodic performance [1, 2]. However, their application in SOFC technology is limited due to a high thermal expansion coefficient (TEC), incompatible with the ones observed for the commonly used electrolyte materials. The mismatch in thermal expansion between components of the cell can results in an additional thermal stress during the SOFC heating up and cooling down operations. Generally, the high TECs of cobalt-based oxides are mainly related to both the oxygen loss and associated reduction of smaller Co^{4+} to larger Co^{3+}, as well as to spin transition of Co^{3+} from a low spin ($t_{2g}^6e_g^0$) through an intermediate ($t_{2g}^5e_g^1$) and to a high spin ($t_{2g}^4e_g^2$) state and consecutive lattice expansion [3]. This problem can be alleviated by substitution of Co with other 3d metals. While it has been shown many times that incorporation of iron, nickel or cooper in the Co-site may indeed result in a decrease of TEC values, information available in the literature concerning impact of the manganese-doping on thermal expansion of considered $ReBaCo_2O_{5+\delta}$ oxides is not complete.

In this paper, results of measurements of physicochemical properties conducted for $ReBaCo_{2-x}Mn_xO_{5+\delta}$ cation-ordered perovskites are shown. It was possible to establish role of the introduced manganese concerning modification of the crystal structure, changes of the oxygen content, total electrical conductivity, thermal and chemical expansion, as well as chemical compatibility in relation to commonly used electrolytes, such as LSGM, LDC and CGO. Reduced thermal expansion together with high values of the electrical conductivity and suitable stability with CGO make the compounds containing larger Re^{3+} cations very attractive from a point of view of application. Furthermore, systematic electrochemical tests of the symmetric cells showed strong dependence of the electrode's polarization on the sintering conditions, such as temperature and annealing time.

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STRUCTURAL CHANGES IN SMALL POWER BOILERS OVER THE LAST YEARS

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Keywords: low-power boiler, water boiler, boiler construction

ABSTRACT

The purpose of this research is to evaluate low temperature, solid fuel boilers with special attention to their standardization. This analysis main purpose is to evaluate excellence in boilers construction. Results contained in this paper are based on analysis of production program of 130 coal boilers manufacturers from Poland. Attributes which are the main subject of comparison and their classify with reference to compatibility with standards requirements consists with parameters indicating energetic properties of construction such as fuel consumption, heating surface, thermal load of heating surface, boiler efficiency, boiler mass, water capacity, slow-burning, and others. Results are compiled in tables and figures which allows to compare construction features boilers in the same standard class. The main reason for this analysis is to show the direction of boiler industry evolution. Simultaneously these results can be used as construction data for new boilers, or to evaluate already existing boiler.

The article will present an analysis of the latest scientific works published in recent years in renowned scientific journals. The latest world research includes e.g.: research on the influence of air distribution in the combustion process on the growth of brown coal combustion effects [3], application of exergy analysis in boiler optimization [1] and use of biomass in commercial boilers [2].

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PERSPECTIVES OF MODERN ENERGY STORAGE IN MINISCULE PHOTOVOLTAIC INSTALLATIONS

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Keywords: energy systems, energy storage, innovations, miniscule photovoltaic installations

ABSTRACT

Renewable energy from the sun, wind, biomass or geothermal waters has become a very interesting topic. Most renewable energy comes either directly or indirectly from the sun. Sunlight, or solar energy, can be used directly for heating and lighting homes and other buildings, for generating electricity, and for hot water heating, solar cooling, and a variety of commercial and industrial uses. These places are considered more environment-friendly than areas where conventional energy sources are used [1]. However, the installation of renewable energy sources is bound with a large investment because it is a large installation with high parameters [2]. This project draws society's attention to the fact that even miniscule photovoltaic installations, which may be found at home [3], in the restaurants, hotels or parks, can contribute to the reduction of environmental pollution which people try to reduce every day.

In this research, the construction and operation of modern models of the solar energy storage are presented. The installations consist of the innovative models composed of photovoltaic panels, batteries and devices that receive the stored energy [4]. The project shows how much the energy costs can be reduced with a low investment, as well as the cost of maintaining the establishment. Another goal of the project is to compare the costs incurred by the owner before and after installing the modern models and the rate of return of the invested money for the purchase of the innovative installations.

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THE INFLUENCE OF THE EMISSION LIMITS ON THE ENERGY SECTOR

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Keywords: energy sector, sustainable development, environmental requirements, emission

ABSTRACT

In Europe and other developed economies, including Poland, there is a visible long-term de-industrialization trend occurring independently from changes in the climate policy. It is an employment shift from industry to services with no decrease in the production volume in heavy industries. Emission reductions included in the Energy Roadmap 2050 and adopted by the member states assume decarbonization of the electrical energy sector and emission reduction by 80-95 % in 2050 in comparison to 1990. The way to reach these goals is developing renewable energy resources, which include biomass and wastes, water, wind and geothermal energy. The framework of the climate and energy package until 2030 was adopted by the EU states' leaders in October 2014. They will become a prime mover for constant improvements towards a low-emission economy and will prove the EU ambitious goal to counteract climate changes during international negotiations. The objectives of the policy framework are to build an energy system which will provide consumers with affordable energy prices, to increase the security of energy supplies to the EU, to lower the EU dependence on energy import, to reduce the greenhouse gases emissions and to create new opportunities for green growth and new environmentally friendly workplaces. The article presents the issues of the climate package adopted in the EU and related to obligations to reduce the emission of CO_2. The key objectives of the climate package were discussed, along with the tool concerning the emission reduction, such as: European Union Greenhouse Gas Emission Trading System (EU ETS). The phenomenon of emission leakage is presented, which may pose a threat to the energy sector development in Poland and can be associated with jobs reduction in the country. The article also shows the influence of the decarbonization policy of energy sector on the economic competitiveness of the member states in comparison to other countries where there are no emission limits.

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$Li_{3x}La_{2/3-x}TiO_3$ AS A CERAMIC MEMBRANE FOR HIGH ENERGY DENSITY LITHIUM METAL CELLS

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Keywords: perovskite, Li-ion, Li-conductors

ABSTRACT

Energy storage is one of the most important challenges of the contemporary development of the energy market. Large power units like nuclear power plants work best at a constant load, but the variable energy demand during the day creates energy storage issue. Among many methods like pumped storage power plants, compressed air, storage in batteries have the advantage of having high storage efficiency and no moving parts. Li-ion cells stand out among many battery technologies due to its large energy density and power density. These parameters effected in a widespread application of Li-ion technology in portable electrical devices, and nowadays cause that they are becoming more and more popular in automotive applications. Unfortunately high cost per kWh, and limited use at elevated temperatures as well as safety issues which are crucial for end users are demanding further research efforts. To improve lithium ion based cells use of solid state electrolyte (SSE) is proposed. Current liquid electrolytes are flammable, could generate leaking problems, has narrow working temperature range. SSE could have many benefits like stability vs Li metal anode, Li metal has higher capacity (3862 Ah/kg) than graphite (372 Ah/kg), so increase of energy density could be achieved. SSE also has high thermal stability, improved safety and can be resistant to formation of dendrite crystals of lithium upon charging. Furthermore, thin dense layer of SSE could decrease total volume of the cell, improving energy density of the battery.

In recent years many candidates for SSE for Li-ion battery have been proposed, particularly promising are $Li_7Zr_2La_3O_{12}$ garnet[1], NASICON structure $LiTi_2(PO_3)_4$[2], lithium sulphide glasses[3], and $Li_{3x}La_{2/3-x}TiO_3$ (LLTO) perovskite[4]. The last one seems to be very interesting because of the very good conductivity inside the grains of the order 10^{-3} S/cm [4], low electronic conductivity, its ability to make very dense sinters[4] and excellent stability at high potentials[5]. In this work optimisation of the synthesis process is presented to achieve low porosity sinters. Relation between ionic and electronic conductivity and porosity is described. Also preliminary results of assembly and electrochemical testing of batteries is reported.

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THE FORMATION OF ORGANIZATIONAL CULTURE IN THE ASPECT OF LEAN MANAGEMENT PRINCIPLES IN THE ENERGY INDUSTRY

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Keywords: Lean Management, organizational culture, energy sector, energy company

ABSTRACT

Nowadays, the aspect of Lean Management is a very fashionable trend of reorganizing the work of production processes, but also in management processes. It affects the approach to work, its quality, cost-effectiveness and the organization itself. The classic understanding of Lean Management comes from Japan (Toyota Motor Corporation). The aim of Toyoda was to eliminate flaws and wastage in the production process [3]. Ohno, who identified seven types of *muda* (waste) [1] - widely described in the Lean literature - continued the elimination of waste in the processes.

Analyzing the organization and its organizational culture it is clear that the enterprises of the energy sector in Poland are undergoing transformation. Organizational behavior is increasingly observed to improve the external and internal image of the company. Guidelines and basic elements shaping the organizational culture more and more often for the managerial staff are a basic tool of work. It is important because that, the Liker [2] added the eighth type of *muda* - untapped creativity of employees, understood as the loss of time, ideas, skills, improvements and learning opportunities due to the fact that employees are not involved or do not listen to them.

In the energy industry, which is highly specific in its functioning, the simple implementation of the principles and classical understanding of Lean may prove to be ineffective. Especially in the technical and technological aspects, where considering the long investment time, rigid modeling of processes, only few paths of process optimization, it is difficult to effectively change and modify Lean Management or Lean Manufacturing. However, it is not advisable to stop thinking about Lean in the energy industry. According to specialists [4], Lean methodologies and principles should be implemented, especially in the areas of maintenance, production and supervision, logistics, administration or sales and customer service. Transformation of the organizational culture to such a character that has Lean in its foundations needs number of actions. This article will present a concept designed to transform the organizational culture of energy companies in Poland. Next steps will be indicated which companies should undertake for transformation and an analysis will be made of how the organizational culture is currently shaped in terms of Lean Management principles.

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INVESTMENT EXPENDITURES TO PROTECT THE ENVIRONMENT IN POLISH MINING

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Keywords: investment expenditures, environmental protection, mining industry

ABSTRACT

Nowadays, the functioning of mining enterprises depends not only on the market situation, but also good relations with its stakeholders. Good relations and relations with the recipients, suppliers, own employees as well as with local communities and environmental organizations become key. Social acceptance becomes one of the basic conditions for mining operations. The main complaint against mining companies is their negative impact on the natural environment. Therefore, it is important to specify not only actions to limit the negative impact of mining on the environment, but also the amount of expenditures that are allocated for this purpose.

The main aim of the work is to present the investment expenditures on environment protection. The second aim of the work is to construct indicators that would take into account environmental protection costs in relation to the actual extraction of minerals. To support the aim of this work, an analysis of statistical data from 2003-2016 as to the structure of expenditure on the environmental protection was done, in the field of: protection of air and climate, wastewater management and protection of water, waste management and soil protection as well as protection against noise and vibration. The results obtained should give the opportunity to answer the question whether the investment outlays incurred are sufficient to limit the negative impact of mining on the environment.

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THE IMPACT OF SELECTED MACROECONOMIC FACTORS ON THE LEVEL OF EXPENDITURES USED TO PROTECT THE ENVIRONMENT

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Keywords: investment expenditures, environmental protection, macroeconomics factors

ABSTRACT

The main aim of the work is to determine the impact of selected macroeconomic factors on the development of the willingness to incur expenditures to protect the environment. Another aim of the work is to present the development of the size of outlays for environmental protection. In order to achieve the objectives of the work, statistical data from the years 2003-2016 were analyzed. The expenditures for environmental protection were considered in the area of separated groups of these outlays: fixed assets, current costs and household expenditures. The analysis also includes the directions of investment expenditures (protection of air and climate, wastewater management and protection of water, waste management, protection and remediation of soils, groundwater and surface waters, protection of biodiversity and landscape, protection against radiation, other environmental protection activities) . When analyzing the data, the division into groups of investors (enterprises, communes, budgetary units) and sources of financing expenditures for environmental protection were taken into account (own funds, from the state budget, voivodship, from abroad, ecological funds, domestic credits and loans). The obtained results from the analysis should give answers to the questions as to whether the amount of investment expenditures allocated for environmental protection depends on the size of selected macroeconomic factors and on the relations between them.

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ELECTRICITY USED AS ADDITIONAL MEDIUM FOR SUPPORT HOUSEHOLD SPACE HEATING

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Keywords: demand side response, energy prices, price elasticity of demand, space heating

ABSTRACT

This article analyses the potential of using electricity for the purpose of support heating of households during low outside temperatures periods. Space heating that uses individual boilers fuelled with solid state fossil fuels, causes significant pollution of the local environment. The concentrations of harmful particles PM2.5 and PM10 exceed the permissible standards, especially during the days with low outside temperatures and low windiness, which is characteristic of frosty highs. Under such conditions, any reduction of emissions, which may result from increasing the use of electricity for heating purposes, is extremely important. Analyses of the growth of consumers' electricity consumption due to price demand side response programmes show only a slight increase in the use of electricity for the heating purposes when changing settlement from the G11 single-zone tariff to the two-zone G12 tariff. The statistics published by the Central Statistical Office and energy suppliers indicate that the number of users of two-zone tariffs exceeds the number of households using electricity for heating purposes. It can therefore be concluded that a large part of two-zone tariff consumers use electricity not as the primary energy carrier for space heating purposes, but for support heating of households.

In order to assess the potential of replacing fossil fuels with electricity for the additional heating purposes, the concept of mutual price elasticity of demand was used, determining financially reasonable changes of the main energy carrier used for heating purposes for electricity, as a result of a change in price of this substitute. It was assumed that increasing electricity consumption for heating purposes does not imply the reconstruction of the electrical installation supplying the heated space, and therefore does not impose other fixed costs than the purchase of cheap portable heaters, using electricity with high efficiency. Mutual elasticity values of energy carriers most frequently used for heating purposes, in relation to changes in electricity prices were determined on the basis of a reduction in average electricity prices, assuming a tariff change from a single zone to a two-zone tariff and in case of increased electricity use only in the off-peak zone. What is more, the potential of anti-smog tariff implemented in 2018 concerning the considered aspect was analysed. The amounts of fossil fuels' combustion possible to eliminate, through the use of electricity at a reduced price in relation to the commonly used single-zone tariff, were determined. The presented analyses present the costs related to support heating of households with the use of electricity as an additional energy carrier for this purpose and may be a source supporting the decision to use this eco-carrier as an alternative to the previously used ones.

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INVESTIGATION OF FLOW NON-UNIFORMITIES IN THE CROSS-FLOW HEAT EXCHANGER WITH ELLIPTICAL TUBES

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Keywords: heat exchanger, finned elliptical tubes, experimental stand, flow distribution

ABSTRACT

In heat exchangers, especially those with cross-flow arrangement, it is nearly impossible to achieve the uniform distribution of the working fluid in the tubular space with the currently used inlet and outlet chambers (in some constructions as well). The improper inflow conditions to individual tubes, including those with an elliptical cross-section - often used because of their favorable features compared to round tubes, is the cause of improper heat transfer. Irregularity of the flow, noted here as significant differences in the flow rates of the working fluid in adjacent tubes, is the cause of unfavorable stress distributions, often having high values, and exceeding the allowable limit. This fact usually leads to damage of the device. In this respect, transitional flow is of particular importance.

The transitional flow regime is complex and difficult to model. Therefore, it is necessary to perform experimental verification. For this purpose, an appropriate stand was built at the Institute of Thermal Power Engineering at the Cracow University of Technology, allowing to investigate the flow of the working fluid (water) to the elliptical tubes in the cross-current heat exchanger. A significant feature of the station is the possibility of changing the inlet and outlet chambers of various shapes, with the inlet and outlet nozzles located in different zones. The heat exchanger consists of 20 elliptical tubes, set in two rows. Other elements of the test stand are: a circulating water tank (with a working fluid), fittings, and measuring apparatus. The latter include ultrasonic flow meters located in the tubes, used to measure the flow rate of liquids. The total flow was verified by means of a flow meter installed in front of the heat exchanger supply pipeline. The system uses a computer data acquisition system. The paper presents the results of measurements for manifold geometry, which are currently used in practice (for heat exchanger constructions). The analysis of the measurement data confirms the non-uniform flow distribution to individual tubes of heat exchanger. Also, the solution to allow more uniform flow distribution in tubular space of heat exchanger are proposed.

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ADSORPTION BED CONFIGURATIONS FOR ADSORPTION COOLING APPLICATION

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Keywords: adsorption chiller, adsorption bed, adsorption bed heat exchanger

ABSTRACT

Nowadays, the compression refrigeration cycle is the most popular technology applied in cooling systems. Adsorption cooling technology can be regarded as an alternative to both compression and absorption chillers. Adsorption chillers (ADC) are driven by heat flux, likewise absorption chillers. Also, the waste heat from other processes can be utilized to produce chilled water, what is the interesting way to increase energy efficiency of the whole system. The ADC uses solid adsorptive material, which is placed in adsorption bed. Adsorption and desorption processes are carried sequentially in the adsorption bed. Those two periods of the cycle enable mass transfer of working fluid vapor from evaporator to condenser. The evaporation is an endothermic process when the heat is taken from the cooling cycle medium. During the adsorption process the heat is released from the adsorbent, so the bed needs cooling from the other circuit with the temperature of about 15-30°C. On the other hand, to release medium vapor from the adsorbent during desorption process, the temperature have to be increased to 50-90°C. Heating and cooling of the adsorbent are carried with the use of heat exchangers (HEX). The heat exchanger and the adsorbent placed together create adsorption bed. One of the reason why ADCs are not commonly used is low value of specific cooling power, which is the cooling power in relation to adsorbent mass, and low value of coefficient of performance, which is defined as cooling power to energy input ratio.

The values of these parameters are strictly dependent on heat and mass transfer conditions between adsorbent mass and the cooling/heating medium. With the aim of energy efficiency increasing it is essential to reduce heat transfer resistance. Different bed configurations and heat exchangers constructions are recommended for adsorption bed application.

In the paper the review of commonly used adsorption bed configurations, i.e. loose-grain beds or fixed beds, is presented. Also, different HEX constructions, e.g. "fin-tube", "flat-tube" or modular HEXs, were described. The characteristic features of commonly applied constructions, both for commercial use and scientific research, were presented. The significant influence of numerous parameters on efficiency and cooling power of ADC was established.

The experimental studies presented in the literature were investigated and the substantial conclusions from the literature review are mentioned. Also, the proposition of new adsorption bed construction using the binder and additives is presented.

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THE TAJIKISTAN PROJECT: ENERGY FOR EDUCATION

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Keywords: solar energy, education, international partnership

ABSTRACT

One of the activities of the FENEC Students' Scientific Association is an educational project known as The Tajikistan Project: Energy for Education. Its aim is to develop didactic and training materials in the fields of renewable energy technology, energy storage, and distributed power engineering systems that are intended for use by students in technical universities in Tajikistan. The project also focuses on the education of school students. Their knowledge in the field of renewable energy will be expanded thanks to classes run by Tajik students with the use of educational Lego sets: Mindstorms, Machines, and Renewable Energy. The project will encompass the following stages: 1) preparation of didactic/training materials which can be feasibly used within the framework of e-learning methods; 2) preparation of a range of laboratory classes to verify the acquired knowledge; 3) a study visit with the purpose of integrating both Cracow technological universities and the Tajik Technical University in Dushanbe.

Tajikistan is a developing country in terms of economy, science, and culture. The country's geographical conditions (mountainous terrain, inland waters) suggest that distributed power engineering systems based on renewable energy technologies may improve the supply of electrical power to its inhabitants, reducing costly power cuts and saving energy resources.

One of the project's tasks involves the development of technological assumptions and construction of test stands for a solar lamp, complete with monitoring and measurement devices. The basic elements of an individual test stand are: A) a solar lamp, consisting of a 150-W photovoltaic panel; B) a 20-W LED floodlight; C) a gel accumulator with a capacity of 120 Ah; D) an MPPT Tracer 2210A charging control unit, manufactured by Solar XXL Group GmbH. One integral element of this test stand is the photovoltaic installation's remotely-controlled monitoring centre, constructed on the basis of a Raspberry Pi minicomputer. This will make it possible to monitor basic installation parameters, such as operating time, power capacity, and quantity of electric power accumulated in the battery through utilisation of the installation. Hence, the installation will become a living lab and a tool for better understanding, as well as a means of promotion of renewable energy technologies among students and others who will have the opportunity to see a solar lamp installed in a public space.

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THE SECURITY OF THE POLISH OIL SECTOR

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Keywords: crude oil, resources, production, import, consumption

ABSTRACT

Most of the energy is produced from crude oil, which has been ranked first among energy resources in terms of the global energy consumption for many years. Crude oil was the reason behind the spectacular development of our civilization observed throughout the 20th century, especially after the Second World War. Due to the strategic importance for the economy, all countries are monitoring the reserves on a regular basis in order to ensure an adequate level of production or imports at attractive prices. All kinds of political turmoil or natural disasters cause economic crises such as the well-known 1970s energy crisis. Poland, like most countries in the world, is dependent on oil imports. The domestic production is unable to cover the demand, which will grow in accordance with the current Energy Policy of Poland until 2030 from the current 26 million tons to 27.4 million tons in 2020, 29.5 million tons in 2025, and 31.1 million tons in 2030. In addition, according to the latest report of the Polish Organization of Oil Industry and Trade (POPiHN) from 2017, the demand for liquid fuels in Poland will increase both in the optimistic and base scenarios; only the pessimistic scenario assumes a reduction in demand after 2022. This demand can be covered only by imports, but, as we know, the dependence on imports decreases the energy independence and leads to a reflection on the energy security of Poland now and in the future. The article presents oil resources in Poland, which currently amount to 22 million tons of anticipated economic resources (balance resources), including 13.3 million tons of industrial resources. These resources are located in 86 deposits. Oil imports, which, since 2012, fluctuate around 25 million tons, and the consumption, taking into account the domestic production meeting approximately four percent of the demand, were also presented. Furthermore, the energy security requires transmission pipelines and crude oil tanks are also needed. The PERN "Przyjaźń" S.A. pipeline network is the most important pipeline system in Poland. Crude oil storage depots include: Adamowo Depot with a storage capacity of about 770 thousand tons m^3, Miszewko Strzałkowskie Depot - 1464 thousand m^3, Gdańsk Depot - 900 thousand m^3, and the Gdańsk crude oil terminal - 375 thousand m^3, whose target storage capacity, after expansion, will increase to 703 thousand m^3. Actions taken towards the diversification of supplies and the expansion of storage capacities are aimed at increasing the security of the Polish oil sector.

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ANALYSIS OF THE POTENTIAL OF DEMAND SIDE RESPONSE PROGRAMS IN ENERGY CLUSTERS

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Keywords: Energy clusters, Demand Side Response, power system, power balancing

ABSTRACT

Currently, the power industry comes through radical changes which result in the formation of completely new challenges in the field of power system operation and management. One of the key issues that modern power systems are facing at, is power balancing under the increasing variability of generation, conditioned by the growing number of renewable sources [1]. The transformation we observe constitutes not only challenges, but primarily new possibilities and chances. Solving problems which concern the increasing difficulty in terms of balancing the system is sought in transforming the system and implementing solutions for distributed balancing. The concept of power clusters, as self-balancing areas, is one of the most important directions of currently conducted research. However, achieving a high level of a cluster's self-balancing requires taking advantage of the distributed resources operating in its area, in the best possible manner. This concerns especially consumers or prosumers with a regulatory potential. That is why Demand Side Response (DSR) mechanisms seem to be mandatory for efficient development and maintaining the power engineering system in light of the mentioned transformation [2].

In the paper, we analyze the possibilities of DSR applications from the point of view of a power cluster. We formulate several possible scenarios for DSR mechanisms that facilitates balancing the cluster in different time horizons. This includes reduction of planned and unplanned unbalanced energy of the cluster, as well as substitution of planned investments in generating sources with DSR programs. On the base of data concerning the functioning of the Polish power system, as well as information from the Power Exchange and the Balancing Market, an analysis of advantages has been carried out for an exemplary cluster. The analysis has a variant character under various assumptions, for example concerning the flexibility of consumers, degree of their reactions to the incentives created by the DSR programs, and power mix operating within the cluster. We believe that presented results may play an important role to draw the potential development directions for national power clusters.

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MODELING OF NEUTRON FLUX TIME EVOLUTION IN ACCELERATOR DRIVEN SYSTEM

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Keywords: ADS, subcritical, neutron flux, reactivity

ABSTRACT

One of the key areas of the Accelerator Driven Systems (ADS) development are reactivity monitoring techniques, as reactivity should be a known value at any time to ensure safe operation. As the information should be available within the future industrial system in real-time, the applied method of measurement should remain accurate, robust and simple [1]. Since kinetic behavior of an ADS working in subcritical state differs from critical reactor relevant reactivity measurement techniques have been studied within several international projects.

Among the different measurement methods one may point to the Sjöstrand's method, also known as the area method. A well-known phenomenon observed when this method is used to determine core reactivity is dependence of obtained reactivity value on detector position within the system. Proper correction methods have been developed and tested in several studies [2, 3, 4]. However, to achieve better understanding of complexity of neutron flux behaviour, following the neutron pulse from the source, additional calculations using the MCNP code were carried out. Aim of this study was to present neutron flux time evolution in different areas of the core. The neutron multiplication factor was also calculated as observed in the individual core regions on a generation-by-generation basis, as well as for the whole core.

As the study confirmed, neutron flux spatial distribution changes as the time passes, as neutrons gradually spread from the source to the outer regions of the core. This change of flux distribution is also a cause of a gradual change in neutron multiplication factor over time. The results obtained confirm the suspected source of difference in reactivity value, measured across a variety of different regions of the core, as local neutron fluxes are not only result of neutron multiplication, but also nautron migration from neighboring regions of the core.

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ROLE OF NANOFLUIDS IN ENERGY SYSTEMS

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Keywords: nanofluid heat transfer, energy system, magnetic field

ABSTRACT

Nanofluids are kind of fluids which, at the moment, are intensively studied due to their applicational potential. Properties of the nanofluids strictly depend on properties of their components, therefore variety of nanofluid types can be found, similarly to their possible applications. However, many factors and challenges should be taken into consideration, such as: cost of nanofluids components and its preparation, instability and particles agglomeration, pumping power and pressure drop, erosion and corrosion of components [1].

There is strong opinion that nanofluids are the coolants of next-generation. A lot of experimental and numerical studies concerning nanofluid application in the heat exchangers were performed [2]. Most of them reported significant improvement of heat transfer rate with increasing nanoparticles concentration and Reynolds number values, in comparison with the conventional fluids. The special attention was devoted to the automotive heat exchangers and cars radiators [3].

The solar engineering is next example of area, in which the nanofluids are considered as promising medium. Some of the research teams paid a lot of attention to silver nanofluids in this field. The experimental and numerical studies of solar collectors showed that in some cases, the efficiency of solar systems could increase remarkably by using nanofluid [1].

In other studies [4], the impact of magnetic field on the nanofluid heat transfer was analyzed. Such configuration can be found in the systems assigned to: crystal growth, cooling of nuclear reactor or microelectronic devices. Orientation of magnetic field can enhance or attenuate transferred heat rate.

However, lack of standardization among various evaluations is observed [2]. Moreover, the conclusions cannot be generalized for all nanofluids because of different nanoparticles types, their shapes, preparation techniques and used chemical substances (such as: dispersant or surfactants). A system geometry or working conditions cannot be also omitted.

In the paper an overview of various nanofluid application areas are presented and discussed. Emphasis is placed on the authors' own investigations regarding a non-magnetic nanofluid behaviour in the magnetic field.

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AN ANALYSIS OF PHOTOVOLTAICS AS SUMMER'S ON-PEAK SOURCE IN POLAND

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Keywords: Photovoltaic, National Power System, Power Demand, Energy Security

ABSTRACT

Severe weather has a bad influence on the energy industry. There were a few incidents when unfavorable conditions caused danger in the delivery of electric energy in Poland. It is worth emphasizing that all of them occurred in the Summer when the outside temperature was very high. The most serious situation took place in August 2015 when the safety of electric energy delivery was endangered. The author compares alternatives for meeting electric energy demands during summer's on-peaks in Czech Republic, Germany and Poland. Furthermore, the demand for electric energy in Summer is compared with the amount of air conditioners. It is possible to prove that in Summer (especially when the daily outside temperature is higher than 30°C) the increase of the daily outside temperature by 1°C increases the demand for electric energy by about 100 MW. In this article the author analyses the alternatives for fulfilling the demand during summer's peaks by using photovoltaics. Such a solution could be efficient and improve energy security.

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ANALYSIS OF COAL BED METHANE OBTAINING AND USE IN POLISH CONDITIONS

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Keywords: CBM, methane, economic

ABSTRACT

In Poland documented supposed economic resources of coal bed methane are in 63 deposits in the area of the Upper Silesian Coal Basin and, as at end of 2016, has amount to 95 953.81 million m^3.

Most of coal bed methane resources recognized in category C (90.67%), which amounts to 87 004.34 million m^3. Resources in the category of recognition A and B - 8 949.47 million m^3 - this is only 9.33% of resources in Poland. Non economic coal bed methane resources are documented in 8 beds and they amount to 11,419.08 million m3.

Production of coal bed methane in mines by drainage system in 2016 was 357.09 million m3 and with ventilation air 547.22 million m^3. In 2016, exploitation of methane from deposits was begun: Anna 1, Pawłowice 1 and Jankowice-Wschód.

The Upper Silesian Coal Basin is characterized by the largest potential for coal bed methane concentration. The geological prognostic and prospective resources of coal bed methane in Upper Silesian Coal Basin were estimated at the end of 2009 at approx. 107 billion m^3.

Significantly smaller coal bed methane resources are in the Lublin Coal Basin - prospective resources of approximately 15 billion m^3 and the Lower Silesian Coal Basin - prospective resources of approximately 1.75 billion m^3.

In Poland, several of coal mines was closed, and the coal exploitation caused the formation of fractures in the rock mass and coal seams, as a result of which underground gas reservoirs, mainly methane, were created. Methane in deposits occurs in two forms: free and sorbed gas. Sorbed methane is associated with coal and can go into a gas form by crushing coal and getting into the space of the slits of the coal seam or surrounding rocks. Methane from coal seams is gradually released as a result of desorption into the resulting gaps / reservoirs by filling them with gas.

Research as well as investment and implementation works are carried out in the area of producing coal bed methane from abandoned mines by wells made from surface. The first attempts to obtain methane from coal seams with wells from the surface were conducted in the USA in the seventies of the previous century. The first attempt to capture methane sorbed in coal, regardless of coal mining, started in 1990 in coal mine Jastrzębie, lasted continuously until the end of 1999.

The article analyzes the possibilities of producing coal bed methane obtaining by wells from the surface and use it for the following variants: (1) Installation of the gas engine, production and sale of electricity, (2) Building of a gas pipeline, (3) installation of a gas engine, production and sale electricity and heat, (4) Gas compression and transport, (4) Gas cleaning, compression and transport.

For each of the variants, the scope and size of the investment at which it is profitable to capture coal bed methane from inactive mines was developed for polish conditions.

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TRANSPORT OF POLLUTANTS ASSOCIATED WITH PARTICULATE MATTER TO THE ENVIRONMENT – FIELD EXPERIMENTS WITH PHOTOVOLTAIC PANELS

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Keywords: Particulate matter, Photovoltaic panels, Air pollution

ABSTRACT

The photovoltaic modules enable the conversion of solar energy directly into electrical energy. With appropriate level of solar radiation, they are an excellent alternative to methods of obtaining energy using coal combustion, which generates air pollution. The research was carried out in Krakow (southern Poland), which is struggling with this problem. 21 Sharp ND-RJ260 modules provided a large area for collecting samples of particulate matter (PM) which may contain mutagenic and carcinogenic compounds such as Polycyclic aromatic hydrocarbons (PAHs). The size of one PV module was 1.654 x 0.989 m (length, width). The deposition of PM was dependent on weather conditions (for example rain, wind).

Particulate matter from PV modules placed at the roof of the building (C3) of AGH University of Science and Technology were investigated.

Samples were collected from the modules (22.03.2018-16.05.2018) mechanically (with the use of water mist and vacuum pump), lyophilized and analysed applying the GC/MS technique and ion chromatography (IC). The results are discussed in the article.

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COMFORT OF LIFE AND WORK IN THE ASSESSMENT OF THE PROFESSIONAL GROUP OF EMPLOYEES IN THE ENERGY SECTOR ON THE BASIS OF A MINING COMPANY

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Keywords: comfort of life, uncomfortable working conditions, energy sector, mining, work safety motivation

ABSTRACT

There is a large number of jobs in Poland, the performance of which involves working in difficult, arduous conditions. Such jobs include probably the work of miners in hard coal mines. They often go to the mine several times a week for many years. They work several hundred meters underground in the dark, high temperature, humidity, dust and noise with loud machines. Such extreme working conditions cause many occupational diseases caused by these conditions and even life threatening. The total number of accidents in the whole mining has decreased at the turn of the last years, however, in the hard coal mining itself, it remains at a similar level.

When performing work in such difficult conditions, the miner should know well and, above all, observe the work safety regulations. The appropriate organizational culture enables, among others shaping the level of safety culture and improving working conditions. Therefore, miners should be constantly motivated to work safely, but also rewarded.

The results of the literature analysis of the subject were supported by own research in the scope of the subject of comfort of life and work in the assessment of the professional group of energy sector employees on the example of a mining enterprise. The research was carried out among miners, in one of the Polish mines. They were intended to show the magnitude of the problem of discomfort in the work of a professional group of miners in hard coal mining, as well as comfort of life and motivation for a safe working mode

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ANALYSIS OF THE ANTI-ICING SYSTEM USED IN AIR HANDLING UNIT WITH COUNTERFLOW HEAT EXCHANGER

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Keywords: energy efficiency, ventilation system, anti-icing system, recuperation

ABSTRACT

Heating, ventilation and air conditioning systems are increasingly applicable in modern industry as well as for domestic purposes. Skyscrapers, public buildings, hospitals or even houses have been equipped with ventilation and air conditioning systems. The essential part of such system is a heat exchanger which is responsible for effective and efficient energy recovery from exhaust air.
The most commonly used heat exchangers have efficiency up to about 90%. Nevertheless, the relatively high value is received under laboratory conditions and may differ significantly under real conditions especially when conditions are adverse.

The main disadvantage of this type of heat exchangers is that at low-temperature water condensation occurs and whole devices can frost. In order to avoid this phenomenon, manufacturers try to use several solutions (temporary shutdown of the supply fan, bypassing of the heat exchanger or the use of a primary electrical heater). While shutdown of the supply fan is highly controversial, two further solutions for anti-freeze systems contribute to high energy consumption and significantly influence the system efficiency.

In the present paper, one of the most popular anti-icing systems was examined. The different ration of flowing fresh air to exhaust air is applied in order to heat the iced surface of exchanger with warm air. The analysed system demonstrated that system efficiency significantly drop down under unfavourable conditions in winter period. The results show that this solution is insufficient and should not be applied. The long operation with the iced surface can cause irreversible permanent damage in heat exchanger unit and serious system failure. The examined system originally has been combined with cold air by-pass which was deactivated for test needs. Common cooperation of both systems shows good anty-icing protection possibilities at the expense of efficiency.

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THE ROLE OF LNG SUPPLIES FOR BALANCING THE NATURAL GAS DEMAND IN THE EU COUNTRIES

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Keywords: natural gas, energy security, LNG, regasification terminals

ABSTRACT

Over the last decade, changes in the structure of primary energy consumption in EU countries have been noticeable. One of the most important changes is the growing share attributable to renewable energy sources (RES). The increase in RES share results, inter alia, from the policy pursued to reduce greenhouse gas emissions. In achieving the intended goals, these energy carriers are used, the impact of which on the natural environment is the smallest possible, natural gas is included in such fuels. The share of this fuel in the EU energy balance in the analyzed period, ie from 2006 to 2017, remains at a stable level. However, in the case of individual countries, its share in the energy balance depends on the specificity of a given country. Regardless of the share of natural gas in the energy consumption structure of individual countries, they strive to diversify the supply of natural gas. One of the main elements of the diversification of natural gas supplies is the construction of LNG regasification terminals. Access to this infrastructure increases energy security and gives better opportunities when negotiating long-term contracts for the supply of natural gas. Due to the fact that the number of countries interested in exporting natural gas in the form of LNG is increasing, there is also an increasing interest in receiving gas from countries dependent on its imports. In recent years the increased interest in LNG in the EU is particularly visible in the countries of the Baltic Sea basin. From 2011, five LNG regasification terminals in this region were put into operation.

The article presents the utilization of LNG regasification terminals in Europe in the period from 2012 to May 2018. The LNG terminal in Świnoujście was also characterized, its utilization rate and plans for its extension (along with the analysis of changes in Government Act from 5th of July 2018 on investments in the scope of the liquefied natural gas re-gasification terminal in Świnoujście). Europe possesses significant possibilities of importing natural gas through LNG terminals, but until now they have been used to a limited extent, it may indicate that in addition to diversification tasks, terminals are a guarantee in the event of interruptions in gas supplies using gas pipelines.

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COMPARISON OF CO_2 GASIFICATION OF COAL IN ISOTHERMAL AND NON-ISOTHERMAL CONDITIONS

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Keywords: coal, CO_2 gasification, TGA, isothermal and non-isothermal conditions

ABSTRACT

The thermogravimetric method allows to carry out measurements both in isothermal conditions for a given temperature and in non-isothermal conditions at a set heating rate. The isothermal measurements are more common whereas the non-isothermal measurements are more relevance since are less cumbersome and yield more useful data with less experimentation. The aim of this work was to compare the process of gasification of the same coal in an atmosphere of CO_2 under isothermal and non-isothermal conditions. The measurements were carried out with the use of DynTHERM Thermogravimetric analyzer by Rubotherm and char derived from Polish bituminous coal "Janina" was used as material for gasification. In case of the isothermal method the measurements were performed at three temperatures – 850 °C, 900 °C and 950 °C, while in case of the non-isothermal method for three heating rates, i.e. 3 K/min, 5 K/min and 10 K/min. Based on the obtained results, kinetics curves of conversion degree of the gasification process were developed. By means of selected models, kinetic parameters of the gasification reaction i.e. activation energy and pre-exponential factor were determined as well as fitting of the measurement data to the model curves was assessed. Finally, the values of the kinetic parameters obtained from measurements conducted in isothermal and non-isothermal conditions were compared.

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EFFECT OF TEMPERATURE AND TYPE OF BIOMASS DURING THE PRODUCTION OF SOLID FUEL ASHES ON THEIR COMPOSITION AND PROPERTIES IN COMPARISON WITH COAL ASHES

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Keywords: biomass ash, coal ash, ash fusion temperature, slagging and fouling index

ABSTRACT

The waste biomass residuals as renewable sources produce large quantities of biomass ash causing environmental pollution and require its proper disposal. In addition, the residual ash forms slag inside boiler which degrades burning, deteriorates heat transfer, causes high temperature corrosion and erosion problems reducing the lifetime of equipment. In this study, ashes were prepared by annealing the samples of selected types of solid fuels (biomass – corn cob, sunflower husk, waste from olives, hay pellets and rice husk, coal – brown and black, alternative fuel – paper sludge) at different temperatures (550 °C, 815 °C and 975 °C). Analyzes of ashes were performed to determine the effect of the type of ash and the preparation temperature on the composition and properties of the ashes. Based on the XRF results, the slagging/fouling indexes were used to study the effects of the type of ash and the ashing temperature on the ash fouling and slagging properties which were compared with the results of the measurement of ash fusion temperatures. The lowest temperatures show ashes from hay pellets and corn cobs at 550 °C when the deformation temperature (DT) is below 1000 °C. On the other hand, for ashes made from paper sludge at 550 °C, sunflower husks at 550 °C and rice husks at 550, 815 and 975 °C, the deformation temperature exceeds 1500 °C. By calculation of different slagging/fouling indexes, all ashes can result in slagging/fouling problems at different levels.

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THE SELECTION OF OPTIMAL CONDIRIONS FOR OBTAINING HUMIC ACID FROM LIGNITE

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Keywords: humic acids properties, UV-ViS spectroscopy, absorption spectrum

ABSTRACT

The type of plant material from which lignite originated and the conditions of its formation have a significant influence on its characteristics [1-3].

Lignite has a lower degree of coalification and calorific value in comparison with hard coal, but high content of humic substances. Humic acids contained in lignite are also included in the humic substances of soil. Their beneficial sorption and complexing properties is an element that speaks for using them both in agriculture and other branches of the economy.

The article presents a method of preparing a brown coal sample in order to determine the humic acid content. Optimal conditions have been determined in which the amount of humic acid in the sample is the highest. The influence of the proportions of water, KOH and lignite, temperature and mixing time on the solubility of the brown coal test were analyzed. The mixing of the solutions was carried out on specially constructed agitators. The solubility of brown coal in the prepared solutions was controlled spectrophotometrically in the UV-ViS range [4]

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BIOGAS PRODUCTION FROM AGRICULTURAL AND MUNICIPAL WASTE

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Keywords: biogas, biogas plant, digestate, thermal analysis, municipal waste

ABSTRACT

Biogas is formed during anaerobic fermentation of organic wastes from agricultural, industrial and municipal waste. After reprocessing to natural gas quality biogas can be compressed to CBG (Compressed Bio Gas) and liquefied to LBG (Liquid Bio Gas). These are ideal fuels for cars, buses and trucks, especially in urban areas, because they produce virtually no particulate matter or NOx emissions. Use of CBG is growing rapidly in Scandinavia [1-4].

The article presents the results of biogas production from municipal and agricultural waste. Fermentation process was performed according to the DIN 38414-S8. Five types of agricultural waste were used for the research: 100% maize silage, 25% apple pomace and 75% maize silage, 50% apple pomace and 50% maize silage, 75% apple pomace and 25% maize silage and under-size fraction of municipal waste from the sorting drum. Fermentation of waste was carried out for 30 days. Produced biogases were measured for CH_4, CO_2, O_2 as well as the total yield of biogas. To obtain a higher efficiency of biogas production a mixture of organic substances matched to the bio-fermentation of the individual groups can be added, to increase the degree of degradation in the process of co-digestion of agricultural waste.

Additionally thermal analysis (TG and DSC) of biogas digestate was conducted. Due to the impurities present in the biogas digestate derived from municipal waste, it becomes impossible to use it as fertilizer in agriculture.

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DEGRADATION OF PETROLEUM DIESEL FUEL ACCELERATED BY UV IRRADIATION: THE IMPACT OF AGEING ON CHEMICAL COMPOSITION AND SELECTED PHYSICOCHEMICAL PROPERTIES

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Keywords: diesel fuel, oxidation stability, UV irradiation, fuel degradation, GC-MS

ABSTRACT

Regardless of the widespread social debate on the negative impact of diesel as a transportation fuel on the environment, it still remains one of the most important among all the commercial fuels. In 2017 the diesel' car share in EU market reached approx. 44% [1]. Moreover, the worldwide diesel engine sales are forecast to expand of 5.8% per year till 2020 [2].

Petroleum diesel is a mixture of saturated hydrocarbons (*n*- and isoparaffins as well as naphthenes), aromatics, and olefins that typically contain 10–20 carbon atoms per molecule. The boiling temperature ranges within 180–350 °C, while the higher heating value typically equals approx. 42–44 MJ/kg [3]. The base fossil diesel is composed of the fractions obtained by the primary and secondary processing of crude oil [3].

As the diesel fuel contains certain amounts of relatively high reactive unsaturated compounds, the chemical composition of the fuel undergoes certain changes during long-term storage. The degradation of particular components can affect negatively the physicochemical parameters, what, in turn, entails the issues with regular work and performance of the combustion engines. Moreover, the ageing results in the formation of high molecular polymers that form troublesome deposits onto the bottom of the container and disrupt the injection of the fuel to the combustion chamber. The kinetics of the chemical transformations of the fuel is governed by the fuel composition and storage conditions, i.e. the amount of reactive species, the content of biocomponents, water and microorganisms, the average storage temperature and the presence of various additives (antioxidants, biocides etc.). It may also be affected by the exposure to the light, especially in the range of UV radiation.

The present study was aimed to investigate the changes in the chemical composition of conventional diesel fuel stored with unrestricted air access under UV irradiation (λ=254 nm). The chemical composition of fuel was examined by means of gas chromatography coupled to mass spectrometry. The deterioration of the crucial parameters (i.e. density, viscosity, flash point, cloud point, cetane number, cetane index, and distillation characteristic) caused by the photochemical degradation was discussed with respect to the changes in the molecular composition.

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MERCURY EMISSION BENCHMARKS FROM HARD COAL COMBUSTION IN POLISH POWER PLANTS

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Keywords: mercury emission, power plant, benchmark, hard coal

ABSTRACT

The Polish power plants is based on the combustion of solid fuels, the share of hard coal and lignite in electricity production is still over 80% [1]. The introduction of BAT conclusions means for the Polish power plants the need to reduce mercury emissions from solid fuel combustion processes. The most advantageous from the point of view of the power plants seems to be the possibility of mercury removal by air pollution control devices, ie. electrostatic precipitators or wet flue gas desulfurization method. This paper presents the results of mercury emission tests carried out on Polish circulating fluidized bed and pulverized boilers, combusted hard coals. Mercury emission analyzes were performed using the Lumex RA-915+ spectrometer and the modified Hydro Ontario method. The analysis of mercury content in flue gas, combustion by-products as well as substrates were analyzed. On the basis of these studies mercury emission benchmarks were calculated both from circulating fluidized bed boilers and from pulverized boilers. Emission benchmarks have been calculated for boilers working under various loads.

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THERMOCHEMICAL ENERGY STORAGE – FROM FUNDAMENTAL RESEARCH TO TRL IV

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Keywords: seasonal energy storage, solar energy, $MgSO_4$

ABSTRACT

Households and tertiary buildings are responsible for the consumption of approximately 46% of all energies and at the same time cause around 19% of the total CO_2 emissions. In Poland, fossil fuels combustion (coal, natural gas) in individual (residential) and centralized (district) heating covering heating and hot tap water demands are responsible for 56% and 41% of energy supplies respectively. In this context, achieving CO_2 reduction goals in the housing & tertiary buildings sector via improving the energy performance of the buildings is a key issue. Thermal energy storage systems applied in the housing sector could make an important contribution to the reduction of fossil fuel consumption especially when applied in low-energy and zero-emission buildings. Designing and implementation of energy an cost effective energy storage devices would enhance the use of renewable energy sources. Summer solar energy radiation on the low-energy buildings roofs is much greater comparing to the needs for annual space heating and hot tap water. Thus, it would be reasonable to apply long term storage in household heating systems. Such storage could be accomplished by the use of sensible heat storage, latent heat storage, physical sorption and chemical heat storage, offering the highest potential for seasonal storage: highest energy density and lowest heat losses.

Thermochemical heat storage, based on the reversible reactions of hydratation and dehydratation of a solid medium gives an opportunity to accumulate the energy with a storage capacity exceeding 300-400 kWh/m^3. The key stage of the research was to find a new compound (type) of energy carrier, that will be based on cheap and available chemical agents, which is magnesium sulphate $MgSO_4$. It accumulates heat in the phase change reaction described by the following equation:

$MgSO_4(s)\cdot H_2O + 6H_2O(g) <=> MgSO_4\cdot 7H_2O(s)$ ΔH^0_{298} = -327 kJ/mol $MgSO_4$.

Proposed material of heat carrier was pelletised and applied in the in-house made fixed bed heat storage tank (chemical reactor). For the right operation of the reactor, the material of the proper particle size should be used to keep low pressure drop while air flow through the bed. As it was proved, the stability and mechanical strength of the pellets must be ensured (annual repeatable cycles), preferably by enriching raw hydrated salt $MgSO_4$ with novel binding substances and additives. The paper presents the results of the fundamental research devoted to the application of $MgSO_4$ as a heat carrier for thermochemical seasonal storage system devoted for household application followed by the results of 35kWh storage tank (TRL IV) charging and discharging tests. Conclusions are drawn on the scale-up strategy and further optimizations in the field of the heat carrier itself (more stable pellets) and the storage tank (thermochemical reactor) inner design.

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IMPROVING THE PROPERTIES OF $Li_4Ti_5O_{12}$ – A PROMISING ANODE MATERIAL FOR LITHIUM-ION BATTERIES

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Keywords: lithium-ion, batteries, anode

ABSTRACT

Lithium-ion batteries are considered to be the promising energy storage technology not only for the electronic devices but also for the electric vehicles due to their high energy density, high working potential and good cycle life.

The spinel $Li_4Ti_5O_{12}$ (LTO) is one of the most attractive anode materials. Its safety and good cycling performance makes it one of the most important material for the batteries, which are applied in electric vehicles. However, anodes based on $Li_4Ti_5O_{12}$ still exhibit poor specific capacity [1-3].

Main goal of the research was to check if doping with nickel and both copper and nickel will improve the specific capacity and cycling performance of LTO, especially at high current rates.

Two materials with the stoichiometric composition $Li_{3.85}Ni_{0.15}Ti_5O_{12}$ and $Li_{3.80}Cu_{0.05}Ni_{0.15}Ti_5O_{12}$ were obtained by solid-state reaction using lithium carbonate Li_2CO_3, titanium oxide TiO_2, nickel oxide NiO and copper oxide CuO.

The materials were characterized in terms of phase composition, crystal structure as well as cycle performance. Phase composition and crystal structure parameters were determined using X-ray Panalytical Empyrean XRD diffractometer in the range of 10-110° with CuKα radiation. The results were analyzed using Rietveld refinement which was then implemented in the GSAS computer software. The electrochemical properties of the samples were measured by galvanostatic charge/discharge cycles at different rates over a voltage range of 1.0-2.5V and 0.0-2.5V. Cyclic voltammetry measurements were also carried out. Cells were tested on the electrochemical test instrument (BioLogic).

It was proved that the addition of both Ni and Cu results in high specific capacity of LTO especially at high current rates (2C and higher).

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EVALUATION OF GROUND POLLUTION BY HYDROCARBONS USING ROCK-EVAL PYROLYSIS

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Keywords: Rock-Eval, oil, lubricants, ground pollution, gas station

ABSTRACT

The worldwide exploitation and using of petroleum as source of fuel, lubricants, solvents and synthetic materials causes a great danger of penetration of petroleum compounds to the environment. Successful determination of petroleum contamination in ground relies on accurate definition of the type, source and quantity of contaminant. The up-to-date methods of quantity and origin of petroleum contaminations determination use a time-consuming solvent extraction technique.

One of the many methods that can be used to analyze the ground environment for the presence of petroleum-based substances in it and help in their identification is the Rock-Eval pyrolytic analysis. It is currently used mainly for the hydrocarbon (HC) potential analysis of the source rocks in the oil and natural gas exploration [1]. The latest version of the analyser (Rock-Eval 6) provides, in the short time, determination of quantity and fractional composition of petrochemical products contaminating the solid samples (e.g., ground, soil, concrete).

In our study 15 samples of concrete or gravel were taken at different locations at the selected gas station. The Bulk Rock method [1] was applied for screening analysis: determination of total organic carbon content (TOC), HC released during isothermal heating at 300°C for 3 min (S_1 peak) and heavy HC decomposed during programmed pyrolysis (25 °C/min in the temperature range of 300-650°C - S_2 peak). Samples containing the highest HC concentrations (up to 6 wt. %) were recorded in the direct proximity of petrol pumps and close to underground fuel tanks. Samples of concrete or gravel collected outside the gas station contained only traces of organic matter and they were used as the reference material. The applied Multi-Heating Rates method allowed to determine the proportion between the gasoline fraction (up to 180°C), diesel (180-350°C) and heavy fractions (above 350°C) in organic material occurring in analysed samples. In the samples collected at the petrol pumps dominate gasoline and diesel fractions as the result of fuels spill during refuelling of cars. The contamination recorded near fuel tanks (almost 4 wt. %) is dominated by heavy fraction. The source of pollution in this area may be both nearby fuel tanks (during filling - fuel spill and leaks of lubricating oil from engines and car tanker instrumentation), as well as passing cars.

The performed analyses show the possibility of using the Rock-Eval method to quickly estimate the amount and fractional composition of hydrocarbon pollutants in grounds most exposed to hydrocarbon degradation (hydrocarbon mines, refineries, tanks, trans-shipment stations).

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ANALYSIS OF THE POSSIBILITY OF IDENTIFYING INCORRECT OPERATION OF HEATING DEVICES IN REAL CONDITIONS

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Keywords: heating devices, solid fuel boilers, waste

ABSTRACT

The article presents the methods of identification of incorrect boiler operation in real conditions on the basis of continuous analysis of oxygen content in flue gas. The tests were carried out on a measurement stand compliant with the EU guidelines. In the research, a boiler manufactured by Heiztechnik called Q-EKO 15 was used. In order to develop the method of identification of improper boiler operation, the tests were divided into two stages. In the first stage, the boiler was tested in accordance with the PN-EN 303-5 standard, using the fuel recommended by the manufacturer. In the second stage of the experiment, an experiment simulating improper boiler operation in real conditions was carried out. For this purpose, waste was made as fuel. The boiler was supplied with prepared batches of waste: plastics, textiles and a mixture of: plastics, textiles, metal rods and waste paper. For all fuels, a preliminary assessment of the calorific value was made. Oxygen content of [O_2] in flue gases was monitored during the tests [2]. The test results confirmed that a small change in the composition of the fuel can be detected on the basis of [O_2] oxygen monitoring in the exhaust [1]. The presented research results provide the basis for the development of a method to identify incorrect operation of heating devices in real conditions.

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HEAT TRANSFER INTENSIFICATION BY JET IMPINGEMENT – NUMERICAL ANALYSIS USING RANS APPROACH

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Keywords: jet impingement, heat transfer intensification, boundary layer, CFD, turbulence

ABSTRACT

Jet impingement is one of the heat transfer enhancement methods commonly applied in the engineering systems. The idea is to generate small and fast-flow fluid jets which impinge on the heated (or cooled) surface, causing significantly higher heat transfer, in comparison with the situation, when the fluid flows in parallel to the surface. It has been used for example in novel small-scale heat exchangers [1].

Although the flat surface jet impingement is widely described in the literature, the cases, for which the surface is concave or convex, still exhibit lack of the universal models. Numerical analyses can be then very useful and provide valuable data. As such flows can be very complex, a turbulence modelling should also be considered. The most economical, but still accurate method is to use Reynolds Averaged Navier-Stokes (RANS) equations, combined with two or four equation turbulence models, such as k-ε, SST k-ω or v^2-f. Each of them acts in slightly different way, and leads to various results. The reason is that the jet impingement strongly depends on the complex boundary layer effects and their resolving is still challenging for RANS models and until now it is the weakest point of existing models.

Presented simulations are based on the mass, momentum and energy conservation laws, applied to incompressible, axisymmetric cases, solved by OpenFOAM software. In the paper, the hydrodynamic and thermal results of non-flat surfaces jet impingement are presented, depending on selected RANS based models. The aim was to indicate their strengths and weaknesses and especially, their ability to anticipate the turbulence properties.

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OPTIMIZATION OF THE HEAT-RECOVERY, NON-RECOVERY COKE OVEN OPERATION

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Keywords: heat-recovery coke ovens, coke-making process, hydraulic network

ABSTRACT

In order to predict the coking process within the heat-recovery (HR) /non-recovery (NR) coke ovens, a one-dimensional (1D), time-dependent, home-made mathematical model has been developed. The model includes a series of sub-models: hydraulic network [1], coking-bed sub-model (based on direct [2] and inverse approach [5]), Upper-oven sub-model and combustion sub-model [3]. The model predicts temperatures, pressure and gas composition in the main parts of the oven: upper-oven, down-comers and sole-flue. Furthermore, the amounts of primary and secondary air that are entrained to the unit from the surroundings are calculated. Validation procedure of the 1D HR/NR coke oven model has been carried out on the basis of the in-oven measured data concerning gas composition static pressure and temperature.

The model helps to gather a knowledge and understanding of the heat-recovery / non-recovery units operation and allow controlling the coking process and optimizing ovens design. The information such as required oven suction, optimal combustion conditions within upper-oven and sole-flue, position of the so-called sliding-bricks [4] and sliding-gates [4], coking time, or ducts dimensions can be easily and quickly obtained using developed algorithm. The main advantage of the 1D model is in its computation time. The results are obtained much faster if compared to CFD predictions.

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IN-DEPTH INVESTIGATION ON OPTIMIZED PROCESS TECHNOLOGY AND EMISSION CONTROL FOR HORIZONTAL-, HEAT RECOVERY- AND VERTICAL CHAMBER COKE OVEN PLANTS

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Keywords conventional coke oven, heat recovery coke oven, vertical coke oven, 3D-flow/combustion simulation, enhanced heating design

ABSTRACT

In times of unstable prices and availability of hard coking bituminous coals and blast furnace coke, tkIS has started to optimize the established pyrolysis technology in horizontal coke ovens, evolutionary, and investigated additionally on alternative coking procedures to carbonize a greater range of low quality raw feedstock like lignite's or sub-bituminous coals. In comparison to good coking coals these resources are easily minable but difficult to convert into coke. Alternatively, the heat recovery- and the vertical chamber coke oven provide this sought-after flexibility. The benefit of each technology is compared toward a variety of challenges. However, to achieve the best product properties both a customized feedstock preparation and heating regime are essential for every raw material blend, in general. At the same time, the demands on emission control are becoming more stringent worldwide for all coking technologies established. For that reason tkIS has improved the design of the three coking technologies of its portfolio, performing in-depth investigations of the differing processes in terms of enhanced heating and emission control by using various mathematical models.

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ETHERS AS BIOCOMPONENTS OR SUBSTITUTES OF GASOLINE FUELS – THE NEED FOR NEW TECHNOLOGY

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Keywords: liquid fuels, ethers, gasoline, biocomponents

ABSTRACT

The policy of EU assumes that all European countries reach the target of 10% participation of renewable fuels in the communication and transport branch. The way to reach this strategic target is to substitute the fossil liquid fuels by renewable ones – biocomponents or pure biofuels. Two kind of fuels are in common usage in the public transport: diesel fuel and gasoline. Biotechnological substitutes of diesel fuel are well known and technology of its production is mature nowadays. Substitutes for gasoline are in continuous development yet. First regarded biocomponent – Methyl-tert-butyl-ether (MTBE) is recognized as unsafe for environment and human health. Modern applications are focused on Ethyl-tert-butyl-ether (ETBE) which is still toxic but more stable in the contact of water. There is still place for the development of new technologies, both; within technology of ETBE production as well as in invention new kind of compounds which could substitute or be compounds of gasoline.

The conventional production process is based on the reaction of isobutene from the crack fraction C4 with bioethanol in the presence of a catalyst - usually an acidic ion exchange resin. This new compounds are produced in the way of reactive distillation of the mixture of alcohols. ETBE is still regarded as renewable in 47% because of using iso-butanol which is remaining part of other synthesis made on the basis of rock oil. Ideal situation will be to discover substance obtained in 100% from renewable sources and produced with minimal use of external energy together with no toxic interactions in the nature. The future of investigations in this subject takes into account alcohol fermentation with using of targeted microorganisms for special kind of alcohols like:

Another possibility is the reaction of ethanol with tert-butyl alcohol, a by-product of the production of propylene oxide. It allows to reduce the consumption of C4 fraction and, due to the presence of water in reaction products, requires a lower degree of bioethanol purity. Research on fermentation, one of which is isobutene and isopropanol - butanol – ethanol (IBE) fermentation, is the starting point for the production of 100% renewable ethers.

Research of bio-ethers as gasoline substitutes are important from three point of views: European policy (or world tendencies) and environmental protection as well as regarding to fossil fuels resources which amount is limited.

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CHEMICAL COMPOSITION AND THE QUALITY OF COAL FROM THE BOGDANKA BITUMINOUS COAL MINE, LUBLIN COAL BASIN, POLAND

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Keywords: Coal, Bogdanka Coal Mine, Lublin Coal Basin,

ABSTRACT

The "Bogdanka" coal mine, the only currently active mine in the area of the Lublin Coal Basin, is extracting bituminous coal from the Lublin Formation. Coal samples for this study were collected from boreholes and outcrops in the "Bogdanka" coal mine. In total, 76 boreholes were used to analyze the coal quality (thickness, ash, total sulfur, and net calorific value) in the No. 385/2 and No. 391 coal seams. A total of 160 coal samples from the No. 385/2 and 391 seams were subjected to the statistical analysis. The average sulfur content for the No. 385/2 seam is 0.98%, while for the No. 391 seam it is higher and amounts to 1.15%. Based on the coal quality analysis, it can be stated that the total sulfur content is only partially related to the mineral matter in the currently exploited coal seams of the Lublin Coal Basin. There is a strong correlation between the net calorific value and ash yield in both of examined coal seams. According to the UN-ECE International Classification of In-Seam Coals [1], coal from the Bogdanka deposit is classified as Ortho-Bituminous, Medium Grade Coal. The correlation analysis has shown no correlation between the sulfur content and ash. The volatile matter content (dry, ash-free basis) in the examined seams is relatively high and ranges from 37.8 % to 39.8%. The ash oxide analysis has shown that ash from the No. 391 seam is mainly composed of iron oxides, while the No. 385/2 seam is dominated by aluminosilicate ash. The carbon content (dry, ash-free basis) ranges between 79.4% and 81.7%. The chemical composition of coal was analyzed by ICP-ES/MS. The chemical analysis has shown that the oxide composition of ash in the examined seams is highly variable. This may indicate different sedimentation conditions and mineral composition of the mineral matter.

When compared to Clarke values in coal, only Pb, Cu, As, and Hg contents are clearly elevated.

[1] UN-ECE, 1998. International Classification of In-Seam Coals Symbol Number: ENERGY/1998/19

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CHANGES IN THE SPONTANEOUS COMBUSTION TENDENCY OF HUMIC COALS ACCORDING TO THEIR PETROGRAPHIC COMPOSITION AND TECHNICAL AND CHEMICAL PROPERTIES

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Keywords: coal self-ignition, coal properties, maceral composition

ABSTRACT

The coal self-ignition is a dangerous natural phenomenon, which affects the safety of mining and storage of coal. In Poland, coals are divided by their spontaneous combustion tendency into 5 groups based on the following parameters: the rate of spontaneous combustionin 237°C (Sz^a) and activation energy of carbon oxidation (A). The article presents the analysis of the correlation between those parameters and the physical, chemical, technical, and petrographical properties of Polish lignite, sub-bituminous coal, bituminous coal, and anthracite.

32 samples of different humic coals were examined. For each sample, the following coal properties were determined:moisture content, ash content, volatile matter content, sulphur content, gross calorific value, net calorific value, C, O, N, and H contents, total cumulative volume, total specific surface area, total porosity, bulk density, apparent density, total cumulative volume, and self-ignition parameters (rates of spontaneous combustion in 237°C and in 190°C, and activation energy). During petrographic analysis, maceral composition and random reflectance were determined.

To determine the linear correlation between the self-ignition parameters and the analyzed coal properties, Pearson correlation coefficient was calculated. The results show that there is no strong linear correlation between the lignite's tendency to self-ignition and its physical and petrographic properties. However, strong negative correlation between the rate of spontaneous combustion and moisture and volatile matter content was observed. In the case of the bituminous coal, strong correlations, both positive and negative, between self-combustion parameters and various coal properties were confirmed. The most noteworthy are the correlations between self-ignition parameters and the maceral composition; the obtained results suggest that the spontaneous combustion tendency of coal increases with the increasing content of macerals from the semifusinite and liptinite groups

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EXAMINATION OF STEAM GASIFICATION OF COAL WITH PHYSICALLY MIXED CATALYSTS

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Keywords: coal, steam gasification, catalysts

ABSTRACT

Catalytic coal gasification is considered as efficient and environmentally friendly process, therefore it is an interesting alternative to traditional methods of coal conversion. The advantages of the gasification process made that the aim of this study was to analyse the course of steam gasification of "Janina" bituminous coal with and without adding of catalysts. Nitrates of metals commonly regarded as catalytically active, i.e. sodium, potassium and calcium were used as catalysts. The addition of catalysts was carried out by physical mixing because of its simplicity, short time of execution as well as certainty that the amount of catalyst is exactly the same as the adopted one (3wt.%). The isothermal measurements were performed at various temperatures in the range from 800 to 950 °C and at a pressure of 1 MPa. To carried out the research an unique thermovolumetric equipment was used that allows to measure the concentrations of the main components of the resulting gas such as carbon monoxide (CO), hydrogen (H_2), methane (CH_4) and carbon dioxide (CO_2). The obtained results enabled the assessment of the effect of i) catalyst addition; ii) type of catalyst; and iii) temperature on the course of the gasification process as well as yields and composition of the resulting gas. The presence of catalysts as well as an increased operating temperature had the positive effect on the coal gasification process – the reactions rates were higher and durations of the measurements were shorter.

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A TEST-BENCH FOR INVESTIGATION OF SOFC FUELLED WITH GASES CONTAINING SOLID PARTICLES

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Keywords: SOFC, particulate matter, solid particles, fuel cells, PM

ABSTRACT

Despite the solid oxide fuel cell technology (SOFC) has been known since several decades, the problem of fuelling the cells with particulate matter-contaminated fuels has not been yet systematically investigated. Within the current research project, three research hypotheses are studied both experimentally and numerically:

- possibility of deposition of particles in the fuel supply channels,
- possibility of deposition of particles in the pore volume of the anode,
- plausible electrochemical oxidation of entrained carbonaceous particles with oxide ions.

To realise the project goals, commercial and repeatable solid oxide fuel cells on anodic support will be subjected to experimental operation in laboratory conditions with various particulate matter- contaminated gaseous fuels. Current work has been dedicated to the design of special test-bench, that will allow generation of fine-particle aerosols and supplying them to the fuel chamber of the single SOFC cells, and initialize the experimental activities. The setup consists of an electric oven extended by state-of-art SOFC testing equipment such as a sealed (in-house designed) 5 cm x 5 cm AS-SOFC cell fixture, Bronkhorst® mass flow controllers, PC with LabView software for data acquisition and control etc. Additionally, a gastight aerosol generator, allowing to maintain a 600-1000 mg/Nm^3 fine powder in a ca. 1 Nl/min gas flow has been proposed.

Within the experimental activities, the suspension (aerosol) generator has been validated in short (4-8h) and longer runs (up to 72h), proving its repeatability with the reference powder and conditions. Also the SOFC test fixture, initially designed for sealed electrolyte supported SOFC testing, has been modified to operate on AS-SOFC and allowed to obtain a decent power density equal 725 mW/cm^2 at 850°C, with pure hydrogen as the fuel. The knowledge gained within the project is crucial for defining dedicated mechanisms and scenarios towards minimisation or elimination of the negative influence of particulate matter present in SOFC fuel through orientation of future research on new anodic materials and optimisation of solid particles removal sub-systems.

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CHAR FROM COCONUT AND PISTACHIO SHELLS AS PROMISING WASTE BIOMASS FUEL FOR DIRECT CARBON SOLID OXIDE FUEL CELLS

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Keywords: direct carbon, fuel cells, DC-SOFC, biomass, coconut shells, pistachio shells, waste biomass, Boudouard reaction

ABSTRACT

Among fuel cells of all types, solid oxide fuel cells are of special interest. SOFCs, fabricated chiefly from ceramic oxide components, operate within a temperature range of 600–850 °C. The main advantage of SOFCs is their flexibility in terms of fuel; they can be supplied by various gaseous, liquid, and solid fuels. Nowadays, a great deal of attention is being paid to SOFCs powered by solid carbon-rich fuels. Direct carbon solid oxide fuel cells (DC-SOFCs) can be operated on high-purity synthetic carbonaceous-based solid fuels, lignite, coal, biomass, and carbonaceous solid materials derived from waste materials. However, to date no optimum fuels for DC-SOFCs have been identified.

In this study, materials obtained from the pyrolysis of coconut and pistachio shells were investigated as solid fuels in direct carbon solid fuel cells operating within the temperature range 700–850 °C. Char was prepared by means of the thermal processing of pulverised shells in a quartz reactor at a temperature of 850 °C in an ambient gas atmosphere for 1 hour. Elemental analysis identified high carbon and marginally low sulphur contents in char obtained from biomass-derived solid waste. Charcoal was analysed by means of XRD and Raman spectroscopy, which proved that the samples were characterised by a disordered carbon structure. SEM images showed that samples were composed mainly of small isometric particles with porous structures. Thermogravimetric analysis performed in a pure CO_2 gas atmosphere within a temperature range of 25–850 °C demonstrated a substantial loss of mass due to CO production via the Boudouard reaction. Tests showed that DC-SOFCs supplied by char obtained from coconut and pistachio shells were characterised by stable operation with reasonably satisfactory current and power density levels.

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REVERSIBLE SOLID OXIDE FUEL CELLS INVOLVING A CERAMIC PROTON CONDUCTOR

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Keywords: reversible solid oxide fuel cell, proton conducting electrolyte

ABSTRACT

A reversible solid oxide fuel cell (RSOFC) is a device that can operate efficiently in both fuel cell and electrolysis operating modes. Thus, in the fuel cell mode, an RSOFC functions as an SOFC, generating electricity by means of the electrochemical combination of a fuel (hydrogen, hydrocarbon, etc.) with oxygen in the air. In the electrolysis mode, an RSOFC functions as an electrolyser (solid oxide electrolysis cell or SOEC), producing hydrogen (from water) or chemicals such as syngas (from mixtures of H_2O and CO_2) coupled with an energy source (fossil, nuclear, renewable). These systems enable the storage of electrical energy in chemical forms of fuel (H_2, CH_4 or CH_3OH).

Ceramic proton conductors based on $BaCe_{0.9}Y_{0.1}O_3$ are considered promising electrolytes for the construction of reversible solid oxide fuel cells (RSOFCs). The main drawback of this group of electrolytes is their limited stability in gas atmospheres containing CO_2 and/or H_2O. The partial replacement of barium by calcium in $Ba_{1-x}Ca_xCe_{0.9}Y_{0.1}O_3$, where $0<x<0.1$, leads to improved chemical stability of the electrolyte compared to the initial $BaCe_{0.9}Y_{0.1}O_3$. The $Ba_{0.95}Ca_{0.05}Ce_{0.9}Y_{0.1}O_3$ (5CBY) seems to be more adequate ceramic proton conductor for IT-SOFC application. One of the crucial problems in obtaining a high level of energy efficiency from this kind of device in either solid oxide fuel cell or electrolyser mode is the selection of suitable electrode materials. In this study, the electrochemical interface electrodes $La_{0.6}Sr_{0.4}Co_{0.8}Fe_{0.2}O_{3-d}$|5CBCY and $Ba_{0.5}Sr_{0.5}Co_{0.8}Fe_{0.2}O_{3-d}$|5CBCY.

5CBCY were investigated under polarisation by negative potential ranging from –0.05 to –0.5 V, typical for operation in solid oxide fuel cell mode, as well as under polarisation from 0.05 to 0.5 V, typical for operation in solid oxide fuel electrolyser mode. The oxygen reduction reaction was examined, using electrochemical impedance spectroscopy, at the $Ba_{0.5}Sr_{0.5}Co_{0.8}Fe_{0.2}O_{3-\delta}$|5CBCY and $La_{0.6}Sr_{0.4}Co_{0.8}Fe_{0.2}O_{3-\delta}$|5CBCY interfaces at 600ºC and 700ºC and P_{O2}/P within the range 0.001–1. It was found that the polarization resistance of the electrode reaction is only slightly depended on the oxygen partial pressure for both electrolyte|electrode systems. The LSCF electrode reveals very stable impedance response in dry and wet atmospheres at 700°C.

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SYNTHESIS OF ZEOLITE P FROM SEWAGE SLUDGE ASH

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Keywords: zeolite P, sewage sludge ash, cation exchange capacity, specific surface area

ABSTRACT

An example of waste considered as biomass is municipal sewage sludge. The utilization of sewage sludge is more often realized through combustion, which simultaneously constitutes the recovery of energy from a renewable source [1,2]. However, the obtained ash still requires neutralization. An alternative method for landfilling of sewage sludge ash is its usage as a raw material for the synthesis of zeolites [3].

Zeolite P is one of the synthetic zeolites with a simple structure, in which 4-membered rings fuse to form 8-membered rings.

The study shows the results of the synthesis of zeolite P from sewage sludge ash with the indirect fusion followed by a hydrothermal treatment. The zeolitization of sewage sludge ash was conducted at the melting temperature of 550°C and the melting time of 60 minutes, activation temperatures of 60°C and 90°C, crystallization temperatures of 60°C and 90°C, crystallization time of 72 hours and the SSA:NaOH ratio of 1:1.4.

The research of sewage sludge ashes after zeolitization included the observation of changes of ash particles surface, the identification of crystalized phases, cation exchange capacity (CEC) and specific surface area.

The optimal synthesis conditions for zeolite P are the activation and crystallization temperatures of 90°C. CEC of modified sewage sludge ashes is greater than CEC of sewage sludge ash. CEC of modified sewage sludge ashes equals from 189.56 to 268.28 meq/100g. Whereas CEC of sewage sludge ash equals 49.67 meq/100g. Specific surface area of samples after crystallization at the temperature of 60°C is higher than of samples after crystallization at the temperature of 90°C. Besides, the conditions of zeolitization do not have an important impact on the diameter of pores.

The presented method of sewage sludge ash zeolitization allows to obtain usable material.

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THE INFLUENCE OF DRILLING WASTE MANAGEMENT AND MINING ACTIVITIES RELATED WITH THE EXPLORATION FOR HYDROCARBONS FROM UNCONVENTIONAL ACCUMULATIONS ON THE NATURAL ENVIRONMENT IN POLAND

Justyna Pyssa[1,*]

Keywords: shale gas resource in Poland, environmental monitoring, waste and hazardous waste

ABSTRACT

All stages of works connected with the exploration and extraction of hydrocarbons from unconventional accumulations affect the natural environment. The extent to which drilling works influence particular components of the environment depends on many factors. The most important are the degree of urbanization of the area, sensitivity of individual elements of the environment to pollution, type of drilling equipment, depth of boreholes, sort of drilled rocks, and type and scope of works stimulating the inflow of hydrocarbons to the hole.

In the paper the main threats to the environment arising from works related to the exploration of gas from unconventional accumulations have been discussed. Legal regulations connected with waste management, water resource management and protected areas (Nature 2000) have been presented. Qualitative characteristics of waste generated during the exploration for hydrocarbons from unconventional accumulations have been presented. Due to the high content of water and the consistency of waste as well as its changeable and hard-to-predict chemical composition, the waste is difficult to manage.

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CONDITIONS OF HAZARDOUS WASTE MANAGEMENT IN POLAND IN ASPECT OF SUSTAINABLE DEVELOPMENT

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Keywords: hazardous waste, cost of recovery and cost of disposal of hazardous waste, impact on environment, economic and ecological criteria of selection of method of disposal of hazardous waste

ABSTRACT

Along with the increase of disproportions between the rapidly growing demand for raw and essential materials and limited possibilities of obtaining them, the economy of raw and essential materials becomes the main problem of contemporary and future social and economic politics. One of the important areas of reducing this disproportion is the limitation of intensity of waste generation during production and more consistent management of accumulated waste and waste generated on a daily basis. At the same time it is a major problem of obtaining secondary raw materials and the environment protection.

The selection of technology of hazardous waste disposal should take place according to the principle of sustainable development. It means that the rational waste management, taking into account both ecological and economic factors, enforces the demand for maximizing the utilization of waste in all possible applications while limiting its negative impact on the environment at the same time. Organizing comprehensive hazardous waste management causes a decrease in number of facilities in which such waste is disposed. The desired result of such measure is the limitation of quantity of potential sources of environment contamination and bigger economic effects (than in case of individual enterprises). One cannot also omit the fact that the comprehensive hazardous waste management has a positive impact on the choice of optimal technology of disposal of hazardous waste and this in turn is related with enabling the introduction of modern technologies, full application of technological operations, increase in work efficiency, obtaining lower operating costs and ensuring the environment protection at a proper level. In case of waste disposal, residues coming from that process can be utilized economically. Economic and ecological considerations require minimizing the consumption of primary raw materials from nature and use of any waste arising at different stages of cargo turnover and material trading to the border of economic profitability.

In the article legal acts regulating the management of hazardous waste have been analyzed. Methods of recovery and disposal of hazardous waste (thermal, physical, biological and chemical methods as well as storage) have been discussed. Economic and ecological criteria of the selection of technology of disposal of hazardous waste have been analyzed.

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MICROSPHERES AS POTENTIAL FILLERS IN COMPOSITE POLYMERIC MATERIALS

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Keywords: microspheres, microstructure, chemical composition, polyurethane, composites

ABSTRACT

The vast majority of the electricity generated in Poland is obtained from coal-fired power plants [1]. Fly ashes produced during coal combustion in conventional block contain microspheres of several morphological types. Considering the diversity in the distribution of elements within the fly ash, the formation of microspheres with different chemical and mineral compositions is highly probable. Fly ash-derived microspheres are characterised by valuable properties from the application point of view including low density, hydrophobicity, thermal and mechanical stability [1-5].

The aim of this work was to charaterise the microspheres derived from fly ash and use them as fillers in composite polymeric material.

Microspheres studied in this work were obtained from coal-fueled power plants in Kazakhstan, and separated from fly ash by flotation method in reservoirs. The microstructure, concentration and distribution of elements of the microspheres were analysed. Mineral phases present in microsphere samples were identified and quantifies, the particle size distribution was performed as well.

After characterisation, microspheres were utilised as additives in order to obtain composite polymeric material. The polymeric matrix used was the rigid polyurethane foam. Composite foams, containing different amounts of microspheres, were prepared using one-step method. Elemental analysis, apparent density calculations, and microscopic observations were performed in order to compare the influence of the microspheres on the rigid polyurethane foam structure.

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THE PREPARATION OF COMPOSITE SOLID FUELS USED IN THE COMBUSTION PROCESS

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Keywords: composite fuels, co-combustion, briguetting, roll presses

ABSTRACT

Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, and the annex to resolution 202/2009 of the Council of Ministers of 10 November 2009 on the energy policy of Poland until up to 2030 indicate the necessity of increasing the contribution of renewable fuels in the energy balance of Poland. This increase is supposed to strengthen Polish energy security. The undertakings of the Polish government indicate the increase in utilisation of various renewable energy sources such as biomass. Due to that, new technologies connected with the management of the traditional energy sources, such as lignite, have to be developed. Due to its high humidity, lignite is perceived as a low-efficiency fuel. The calorific value of lignite can be improved upon by mixing it with biomass, e.g. sawdust, and briquetting it in roll presses equipped with asymmetrical layout compacting system. Such technology can be used only if the merged ingredients are adequately prepared beforehand. Research in this field has been conducted in the Department of Manufacturing Systems AGH University of Science and Technology in Cracow. Based on this research, PW 500 roll press design was prepared. PW 500 roll press is prepared to briquette composite solid fuels based on a mixture of lignite extracted in Szczerców and two types of biomass: oat straws and spruce sawdust. The results of the aforementioned briquetting are presented in this article.

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THE SIGNIFICANCE OF ENERGY CONSUMPTION IN ENVIRONMENTAL IMPACT OF RARE EARTH ELEMENTS RECOVERY FROM TAILINGS AND MINING WASTE

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Keywords: energy consumption, rare earth elements (REE), environmental impact, life cycle assessment (LCA)

ABSTRACT

Rare Earth Elements (REEs) are identified as critical raw materials for the European Union economy [1]. Due to high supply risk the effort is put into finding local (primary and secondary) sources of REE in Europe. One of the challenges is to propose the process of rare earth metals recovery, which will be efficient, technically and economically feasible, at the same time involving the least possible negative impact on the environment. The ENVIREE project aims at contributing to REE supply in Europe, by addressing the exploitation of tailings and mining wastes [2]. Two secondary sources: tailings from New Kankberg (Sweden) and Covas (Portugal) are promising and rich in REEs.

The Life Cycle Assessment methodology has been used to evaluate the environmental impact of rare earth elements recovery processes. The functional unit is defined as 1000 kg of a secondary source to be processed as the input for processes of REE recovery. The analysis shows that the electricity consumption has a significant share in the overall environmental impact of the processes studied.

The aim of the work is to present the differences in results of modeling the environmental impact of REE recovery from mining waste in Covas and tailings in New Kankberg, using diverse electricity production schemes: for Sweden, Portugal and average for European Union. The study presents several scenarios of modeling the environmental impact for REE recovery and discusses the share of energy use in the overall impact on the environment, taking into account diversification in the electricity production structure among EU countries.

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ANALYSIS OF HAZARDS OCCURRING DURING THE USE OF HYDRAZINE

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Keywords: hydrazine, aviation fuel, airport rescue group

ABSTRACT

The article presents the safety issue bonded to the Polish Air Force F-16 multirole aircraft. The authors pointed out the issue of fuel used for emergency supply system of these aircrafts. The paper emphasized the fact that these aircrafts require special fuel with designation H-70, which is 70% aqueous solution of toxic hydrazine. For this reason, the rescue services of Polish Air Force bases where Polish F-16 are stationed had to be adjusted accordingly. Just as importantly authors noticed that in the event of hydrazine leakage possibility, or its neutralization in the absence of specialized Hydrazine Response Team, which are part of the Airport Rescue Group, there is need of safety instruction creation and development.

The issue of the safety of operations in the air forces of each country is associated with the operation of certain aircraft. Their construction solutions and applied technologies determine the creation of safety procedures during the occurrence of unforeseen events involving aircraft. According to the authors of this article, these actions in the case of F-16 Polish Armed Forces, where H-70 fuel is used for emergency power systems, should be implemented in two ways and also include emergency situations at airports where there are no specialized HRT teams, ie in military bases where F-16s are not stationed, at civil airports. Few, but emerging, dangerous events indicate that the problem occurs and requires more precise identification in terms of limiting the potential effects on people and the surrounding environment.

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HYDROTHERMAL PROCESSING OF PINE WOOD: EFFECT OF PROCESS VARIABLES ON BIO-OIL QUALITY AND YIELD

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Keywords: hydrothermal liquefaction, bio-oil, biomass, pine wood, analysis

ABSTRACT

Hydrothermal liquefaction processes (HTL) comprise complex chemical and physical transformations of biomass under the conditions of high temperature and pressure, commonly near- or supercritical water. During this processes, the components of biomass undergo various complicated chemical reactions strongly influenced by pressure, temperature, process duration, composition and concentration of feedstock as well as the presence of catalysts. In this study, lignocellulosic biomass (pine wood) has been converted via liquefaction in subcritical water to bio-oil, water-soluble organics, gas and solid products. The process parameters (i.e. temperature and processing time) affecting the bio-oil yields and composition were comparatively studied. The chemical composition of resulting bio-oils was analyzed by means of mid-infrared spectroscopy, gel permeation chromatography, gas chromatography coupled to mass spectrometry and elemental analysis. The maximum bio-oil yield (38.35 wt.%) was reached at 350ºC for 10 min, accompanying with the maximum (54.44%) energy recovery. The higher heating value of resultant bio-oils varies in the range of 24-28 MJ/kg. The resultant bio-oils from HTL of pine wood are complex mixtures of aromatic and cyclic compounds with numerous hydroxyl and carboxyl functional groups. The experiments exhibited that the increase in temperature results in a deeper decomposition of biomass manifested by the higher yield of bio-oil and its gradual deoxygenation. In fact, the obtained oil products are promising, valuable intermediates that may act as a source of many value-added chemicals that could find applications in various branches of industry. However, the downstream processing of bio-oil with respect to upgrading and possibilities of separation of the individual groups of products are needed to open the possibility for application as a transportation fuel.

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FUEL TYPE AND EMISSION OF POLLUTANTS

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Keywords: biomass, emission factor, biomass burning, emission,

ABSTRACT

The paper presents biomass as the renewable energy alternative source to fossil fuels which combustion gives a neutral CO_2 emissions and therefore should be the main carrier of primary energy in Poland.

The paper presents the results of tests of carbon dioxide, carbon monoxide, SO_2 and NO emissions of compounds formed as a result of the combustion of selected biomass pellets (sawdust, straw, peel shell pellets and sunflower husks in the percentage share of 50:50). The results are presented on the background of the results of research combustion of high calorific value coal.

The research work was carried out using an experimental 23kW boiler. The paper presents an experimental scientific and research stand for biomass pellets combustion testing, including a biomass boiler, exhaust gas analyzer integrated with the building management system (BMS).

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PHOTODEGRADATION OF AIR POLLUTANTS USING A CONCRETE LAYER WITH THE ADDITION OF AMPHIBOLITE

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Keywords: Heterogeneous photocatalysis, amphibolite, concrete layers, benzo(a)pyrene

An important fraction of air pollutants from flue gases, heating of buildings and some industrial processes are volatile organic compounds (VOC) and polycyclic aromatic hydrocarbons (PAHs). Heterogeneous photocatalysis is an efficient, economical and environmentally friendly technology for removing organic pollutants from the environment. The popular photocatalyst for decomposing organic compounds is TiO_2 due to its strong photocatalytic activity, chemical and biological inertness and high photochemical stability. Numerous publications has shown many possibilities to improve the efficiency of photodecomposition of organic compounds over TiO_2. One of these methods is dispersing TiO_2 nanoparticles onto the surfaces of clay minerals improves the photocatalytic activity of TiO_2 [1-3].

The aim of the work is to develop a technology for the production of a concrete layer containing as an photocatalyst an amphibolite mineral (belonging to silicates, containing naturally dispersed TiO_2). Addition of amphibolite enables the ecological use of concrete to reduce the various types organic compounds belonging to air pollutants, depositing on concrete elements and constructions. Concrete layers containing amphibolite dust and commercial photocatalyst P25 were prepared in various mass ratios, which were used for the photocatalytic degradation of benzo(a)pyrene depositing on their surface. The content of benzo[a]pyrene was determined before and after irradiation with simulated solar radiation using the solid-liquid extraction and GC-MS methods. All of the examined systems show photocatalytic activity causing the decomposition of benzo(a)pyrene. A significant decrease in the content of benzo(a)pyrene on the surface of concrete layers was obtained after 15 days of continuous exposure with light simulating sunlight.

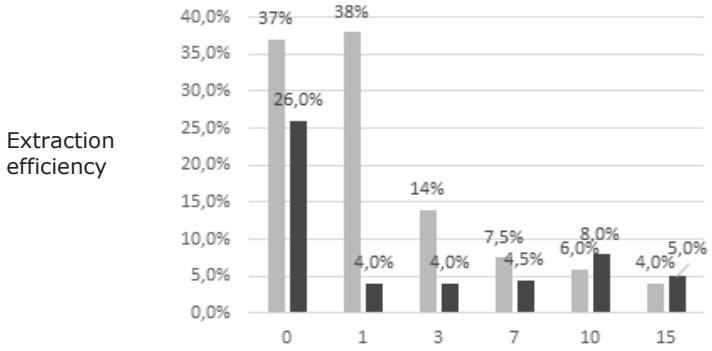

Figure 1. The number of days of illumination

The dependence of the extraction efficiency of benzo[a]pyrene from concrete layers containing amphibolite dust as a photocatalyst on time of illumination (- concrete layer-amphibolite 90:10 wt.%, - concrete layer-amphibolite 80:20 wt.%).

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THE ENERGY EFFICIENCY IN EFFECT – WORK OF GLASS FACTORY TRENDGLASS

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Keywords: glassware, improve energy efficiency

Trend Glass Sp. z o.o. is a private partnership glassware manufacturer in Radom, Poland founded in 2003, however its owners' first ties to the glass industry date back to early 1980's. It took a decade of continuous growth for Trend Glass to become one of the leading manufacturers and distributors of glassware and glass containers.

To maintain this position for years to come we focus on progressive and dynamic growth in all aspects of technology and organisation. For over ten years of steady and balanced growth Trend Glass has expanded greatly. Trend Glass set up its operations as a greenfield investment. The glass product is 100% reused. At present, it produces about 250 tons a day, which gives over 350,000 items [1].

Trend Glass is working to improve energy efficiency such as: 1-modernization of the glass furnace, 2- modernization of compressed-air system and 3-build installation of generate chill technologic [2,3].

Modernization of the glass furnace with electric reheating increase production efficiency – smelting glass per day 80 Mg [2,3].

The result attained effect from the modernization of the compressed-air system is about 85% of stopping leaks.

Tabele 1. The total annual average energy and environmental effect

The glass furnace	The final energy economy	192 846,47	GJ/year
	The primary energy economy	217 022,99	GJ/year
	Reduction of emission CO_2	11 397,21	$MgCO_2$/year
The compressed-air system	The final energy economy	2 724 976	kWh/year
	The primary energy economy	6 812 440	kWh/year
	Reduction of emission CO_2	2 174,53	$MgCO_2$/year

The company's work is a compromise between achieving satisfactory production results, rational fuel and energy management.

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CONTAMINATION ASSESSMENT OF SOIL BY OIL-DERIVED COMPOUNDS OF THE KIELCE AGGLOMERATION USING GAS CHROMATOGRAPHY COUPLED WITH MASS SPECTROMETRY (GC-MS)

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Keywords: contaminants, soil, petroleum-derived compounds, polycyclic aromatic hydrocarbons (PAHs), gas chromatography-mass spectrometry

ABSTRACT

Soil contamination with petroleum-derived compounds is one of the most serious ecological problems. Their main source in urbanized areas is public transport. According to the Regulation of the Minister of Environment on how to conduct the assessment of earth's surface contamination [1], hydrocarbon compounds are divided into: gasolines and oils, aromatic hydrocarbons and polycyclic aromatic hydrocarbons (PAHs). The subject of the research is the use of a gas chromatography coupled with mass spectrometry (GC-MS) method to assess the degree of soil contamination in the vicinity of the main communication routes of the Kielce agglomeration.

This method is useful for the detection and identification of many organic compounds also which occur in samples in very small quantities, that cannot be determined by other common methods [2]. For the purpose of this study, 12 soil samples were collected. After carrying out extraction with various methods, the ultrasonic solvent extraction method was chosen as the most effective way to extract hydrocarbon impurities for the GC-MS studies. During one analysis, both the oil fraction and PAHs quantities were determined. The results of soil chromatographic analyses revealed that both the contents of oil fractions and PAHs are the highest along the Tarnowska street (13.8 mg/kg dry matter (dm) and 3.438 mg/kg dm, respectively), whereas the lowest were recorded near the Radomska street (0.99 mg/kg dm and 0.003 mg/kg dm, respectively). The concentrations of individual components do not exceed the reference values, however they may pose a threat to the environment. The presented method is an alternative to commonly used monitoring methods.

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CONTENTS OF ECOTOXIC ELEMENTS IN POLISH COKING BITUMINOUS COALS AND IN PRODUCTS OF COKING PROCESS

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Keywords: ecotoxic elements, coking coals, products of coking

ABSTRACT

Ecotoxic elements include the ones which have a negative impact on human health and the environment. The highest toxicity is displayed, among others, by mercury, arsenic, lead, cadmium, nickel, thallium as well as chromium. They may cause numerous disfunctions of the human body and most of them are carcinogenic. Hard coal is a fuel which contains significant amounts of ecotoxic elements and the processes of coal combustion, coking and gasification are one of the main sources of their anthropogenic emission.

In the coking process, individual ecotoxic elements in various proportions remain in coke and are released to the raw coke oven gas. During the cleaning and cooling of coke gas, ecotoxic elements are distributed between purified coke gas and other coking byproducts, i.e. coal tar, BTX, sulfur/sulfuric acid as well as quenching water. Certain amounts of the ecotoxic elements are emitted to the atmosphere during the filling of coke oven chambers with the coal blend

In the paper, the measurement results of the contents of selected ecotoxic elements in the Polish coking bituminous coals are presented, i.e. mercury, arsenic and lead. The examination results of their content in the products of the coking process i.e. coke, coal tar, BTX, sulfur, and purified coke oven gas are also shown. The fugitive emissions of mercury are assessed as well. The obtained results are compared with literature data concerning the ecotoxic elements content in foreign coals and selected products of the coking process.

One of the most volatile ecotoxic elements occurring in coal is mercury. In the coking process only 6% of the mercury contained in coal remains in coke while the remaining amount passes to coking products (80%) and is emitted into the atmosphere in the form of fugitive emission (14%). The coal tar is a coking product in which the largest amount of mercury is accumulated (75%)

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THE REDUCTION OF ECOTOXIC ELEMENTS IN HARD COAL VIA DRY SEPARATION PROCESS

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Keywords: dry separation, hard coal, trace elements

ABSTRACT

Hard coal conversion processes are one of the main sources of ecotoxic elements emission to the atmosphere in Poland [1]. In the light of EU regulations [2] (coming into force in 2021) regarding mercury emission standards for Large Combustion Plants, as well as control and reduction of the emissions of other ecotoxic elements, it is necessary to introduce solutions to reduce the content of these pollutants not only by the air pollution control device APCD, but also their removal from coal before its use. Dry separation is one of the methods used to improve the quality of hard coal by removing its mineral matter, which not only lowers the calorific value of the fuel but is also a source of pollution [3]. In addition to classical coal enrichment by wet methods [4-5], dry separation can be a potential method of reducing the emission of ecotoxic elements to the atmosphere. The study were carried out to determine the effectiveness of removing selected ecotoxic elements, i.e. Hg, Zn, Cu, Ni, Cr from hard coal using air concentrating table. The analysis involved 6 coal from the Upper Silesian Coal Basin mines and concentrates obtained through their dry separation. The results indicate that the enrichment conducted by removing the mineral matter resulted in a decrease of the content of examined elements in the coal. The effectiveness in the removal of these elements depends on the amount of mineral matter separated from coal and varies within wide limits: 11 ÷ 53% of Hg; 5 ÷ 85% of Zn; 3 ÷ 40% of Cu; 4 ÷ 52% of Ni and 17 ÷ 73% of Cr. Considering the very high content of these elements in the studied raw coals, which several times exceeds their world average content in hard coals, dry separation can be an additional tool in reducing their emission next to the APCD and an alternative to classical coal enrichment.

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THE EFFECT OF FLUE GAS TEMPERATURE ON MERCURY REMOVAL WITH ORGANIC SORBENT

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Keywords: lignite, anthropogenic emission, mercury removal, flue gases purification, temperature effect

ABSTRACT

Out of many pollutants with the specific threat for the environment, heavy metals, including mercury are of higher importance [1]. Mercury is known for its high volatility, susceptibility for chemical changes and for its high toxicity paired with ability to accumulate in tissue of living organisms [2]. The mercury exist in natural environment in trace amounts, but can be emitted from combustion processes of fossil fuels, making its emission a challenge for still noticeably coal-dependent polish energy sector. It is the main, by more than 50% of the share, the source of mercury emissions to the atmosphere [3].

The aim of the experiment was to determine the effect of temperature of sorbents to the reduction of mercury from the flue gas. The aim of the experiment was to determine the effect of temperature of sorbents to the reduction of mercury from the flue gas. For this purpose applied temperatures: 90, 120, 150 and 180 °C. The study analysed two low-cost sorbents: coke dust and granulated rubber char. The temperature effect of sorbents was examined during lignite combustion

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INFLUENCE OF WATER AND COAL POWER PLANT ASH ADDITION TO DECOMPOSITION OF ORGANIC MATTER IN COAL WASTES. A CASE STUDY OF JANINA COAL MINE WASTE DEPOSIT

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Keywords: self-heating, coal waste, hydrocarbons, Rock-Eval

ABSTRACT

Janina coal mine waste deposit has been put into use in 1965, as a dump for waste rock and coal material from nearby coal mine. After 1994 the character of wastes changed to slightly acidic, causing the need to seal the bottom of the deposit[1]. From 2013, for neutralization of acidic character of wastes, ashes from the coal-fired power plant are mixed with wastes.

16 samples of wastes were collected from freshly deposited waste (mixed with ash), around the sedimentation pond and the reclaimed part of landfill. The pyrolytic Rock-Eval 6 apparatus (TURBO version) was used for determination of total organic carbon content (TOC), free hydrocarbons (released during isothermal heating at 300°C for 3 min - S_1 peak) and pyrolysable organic matter content (decomposed during programmed pyrolysis in the temperature range of 300-650°C - S_2 peak). The Rock-Eval analyses for the freshly deposited wastes were conducted for samples with and after removing of ash. The TOC content is the highest in freshly deposited waste and around the sedimentation pond (average TOC 15.7 wt. %) with the S_2 values up to over 40 mg HC/g rock. For the further study, to determine the organic matter decomposition rate during the self-heating process[2], a sample of the fresh coal-waste material with the highest TOC and S_2 parameters was selected. It was heated in a closed crucible for 2h, 6h, 12h, 1 day and 4 days at 350°C in different conditions (sample with/without ash, with/without water addition). The Multi-Heating-Rates method (Rock-Eval 6) was applied for determination of hydrocarbons released at temperatures: <100°C, 100-180°C, 180-250°C, 250-350°C, 350-450°C and 450-650°C. It was found that the waste degradation process is very fast and depends on the content of ash and presence of water in the reaction environment.

After only 2 hours of simulated self-heating total content of hydrocarbon fractions dropped drastically, from 25.6 mg HC/g rock to 3.43 mg/g (for sample containing ash) and to 0.62 mg/g (for sample containing ash with addition of water). Differences for ash-free samples were even more drastic, showing a drop from 40.7 to 0.39 mg/g (dry sample) and to 0.37 (wetted sample). With increasing time of experiment fractions with lower and lower decomposition temperatures are recorded. After 4 days of heating only traces of organic matter were recorded.

The results show that the decomposition of organic matter in wastes is very fast and it is susceptible to hydrocarbon release, that might be a major source of hydrocarbon pollution. Presence of ash slows down, and water accelerates decomposition process.

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MECHANOCHEMICALLY ASSISTED SYNTHESIS OF SEMICONDUCTING KESTERITE Cu_2ZnSnS_4 FOR PHOTOVOLTAIC APPLICATIONS

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Keywords: Kesterite, photovoltaics, mechanochemical synthesis

ABSTRACT

Kesterite Cu_2ZnSnS_4 is considered a perspective material for making advanced photovoltaic cells, mainly, based on its advantageous semiconducting properties and for being chemically environmental-friendly. Additionally, relatively simple and inexpensive synthesis methods for kesterite preparation are available.

In this presentation, mechanochemically assisted preparation of the quaternary Cu_2ZnSnS_4 is outlined. In the first stage, mechanochemical high energy ball milling of the constituent elements, *i.e.*, copper Cu, zinc Zn, tin Sn, and sulfur S is applied. In the second stage, the raw product is pyrolyzed under a neutral gas atmosphere at 450-550 ºC, preferably at 500 ºC to afford the target material.

The powdered elements, *i.e.*, copper, zinc, tin, and sulfur were weighed out in the near stoichiometric proportion (2 at.% excess of sulfur) and approx. 7 grams of the mixture was charged together with a set of grinding balls in the grinding bowl of the planetary ball mill Pulverisette 7 (Fritsch). The balls and the bowl's lining were made of tungsten carbide WC. 6-7 ml of xylene were also added as a dispersion fluid to prevent from excessive ball abrasion. The typical rotation speeds, 900-1000 rpm and grinding times, 1-20 hours. After completion of milling, xylene was evaporated and the resulting raw powder analyzed and, subsequently, pyrolyzed at an increased temperature under flowing argon for 6 hours. Materials characterization included the use of such analytical methods as powder XRD, SEM/EDX, UV-vis spectroscopy, Raman spectroscopy, and solid state ^{65}Cu and ^{119}Sn MAS NMR.

The prevalent if not the only product after the milling stage was a regular phase tentatively called a pre-kesterite of stoichiometry close to kesterite while exhibiting paramagnetism and no conclusively defined semiconducting properties. After the pyrolysis, the pre-kesterite was found to be converted to the diamagnetic tetragonal phase of kesterite that showed the expected semiconducting properties and the band gap *ca.* 1.4 eV well corresponding with the reported values of 1.0-1.5 eV.

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GaAlN BINARY NITRIDE SOLID SOLUTION AS A POTENTIAL MATERIAL FOR HIGHLY EFFICIENT WHITE LIGHT SOURCES

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Keywords: Nitrides, photovoltaics, semiconductors

ABSTRACT

The search for white light sources with considerable efficiency of electric power conversion to light and, simultaneously, high coefficients of color rendering index (CRI) is frequently focused on the systems based on highly effective radiation sources in the middle to far ultraviolet range (λ = 20-300 nm) and suitable luminophores that convert the UV radiation to the white light. For this kind of radiation, appropriate semiconductors with definite and adjustable band gaps are necessary. Regarding this, the solid solution GaAlN of the related hexagonal nitrides GaN and AlN seems to be an advantageous material by offering composition dependent band gaps in the range 3.4-6.2 eV.

Herein, some selected results of the study on the binary nitride system GaN/AlN processed *via* the anerobic synthesis route is discussed. The method is characteristic of providing oxygen-free and high purity nanopowder products. The preparation started with synthesis of the individual gallium and aluminum tris(dimethyl)amides. Upon being combined in a selected molar ratio, they were reactively dissolved in hexane producing under suitable conditions a certain proportion of the mixed gallium aluminum amide. The isolated mixture of the solid amide(s) was reacted in refluxing liquid ammonia to result in the bimetallic imide(s). This white by-product was subjected to pyrolysis under flowing ammonia gas at 700-1000 °C to yield the final nitride nanopowders.

The product characterization by powder XRD, SEM/EDX, and FT-IR was consistent with nanopowder mixtures of the GaN and AlN individual nitrides and, under selected reaction conditions, some proportion of the GaAlN solid solution. The average crystallite sizes depended on the pyrolysis temperature and, typically, were in the range 5-20 nm. No-additive, high temperature and high pressure sintering of the powders is planned in the near future to make robust nitride ceramics with increased GaAlN contents, which will be suitable for applications in the UV radiation emitters and white LEDs.

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THE IMPROVEMENT OF SYNTHESIS TECHNOLOGY OF OXYGEN-GENERATING ADDITIVES TO DIESEL FUEL

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Key words: transesterification technology, sodium ethoxide, biodiesel, chromatogram, mass spectrometry.

ABSTRACT

Modern motor fuel additive synthesis technologies are rather complicated. Therefore, the improvement of the composition and technology of additives with simultaneous increase of cetane number and improvement of other diesel fuel characteristics with combustion activators is an urgent problem[1]. Raw materials for the biodiesel production are vegetable oils methanol and ethanol with the alkaline or acid catalyst usage. The use of ethyl esters of long-chain fatty acids of rapeseed oil as biodiesel has a number of advantages compared with the methyl ester use [2]. Thus, biodiesel fuel was synthesized by transesterification of rapeseed oil with absolute ethanol (99.9%), which was dehydrated with calcium oxide (95%) freshly prepared, using sodium ethoxide as a catalyst [3]. In order to achieve a high degree of mixing of a heterogeneous system, which consists of natural oil and ethyl alcohol, a specially synthesized non-ionic emulsifier was used as a reagent. The technological features of this type of a rapeseed oil transesterification process were studied and the main characteristics of the new diesel fuels such as fractional composition and molecular mass were estimated using the chromatographic method and mass spectrometry. The yield of biodiesel from rapeseed oil increases from 85-90% to 95-98% [4]. Using this method of transesterification, there is no fraction of glycerol waste (10-15%), since they are converted into glycerol ethyl ethers, which can also be used as biodiesel fuel. The reaction is carried out in an acidic medium. Synthesis can be described by the following equations of chemical reactions:

$$C_2H_5OH + NaOH \rightarrow C_2H_5ONa + H_2O \quad (1)$$

$$3C_2H_5ONa+CH_2OR_1CHOR_2CH_2OR_3 \rightarrow R_1R_2R_3(COONa)_3+ CH_2OC_2H_5\text{-}CHOC_2H_5\text{-}CH_2OC_2H_5 \quad (2)$$

$$2R_1R_2R_3(COONa)_3+3H_2SO_4 \rightarrow 3Na_2\,SO_4+ 2R_1COOH+ 2R_2COOH+ 2R_3COOH \quad (3)$$

$$R_1COOH+ R_2COOH+ R_3COOH+ 3C_2H_5OH \rightarrow R_1COOC_2H_5+ R_1COOC_2H_5+ R_1COOC_2H_5 \quad (4)$$

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SEQUESTRATION OF CO_2 - PROBLEMS AND POSSIBILITIES – CZECH REPUBLIC AND POLAND CASE

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Keywords: coal, energy policy, CO_2 mitigation

ABSTRACT

Carbon dioxide emitted from industrial processes (incl. energy production) is widely regarded as one of the main causes of global warming. Due to the different energy characteristics of their countries, their policies may differ from each other (Table 1).

Table 1. Emissions of CO_2 characteristics in Czech Republic and Poland in IPCC methodology [1-5]

	Czech Republic	Poland
Electric power production [TWh]: total from burning	 82.1 48.4	 152.6 147.9
CO_2 emissions in power production [mln tonnes]	88.7	119.2
Emissivity index [kg CO_2/MWh]: total from burning	 1080 1833	 781 806

In Poland and the Czech Republic, numerous works are led on capturing and sequestering carbon dioxide. A separate issue is the management of recovered carbon dioxide, which can be used in a multi-directional manner. It is possible to convert it into liquid fuel in chemical processes using redundant energy produced in various industrial processes (using hydrogen), CO_2 bonding in the biological way combined with biomass production, and this can then be transformed into liquid and solid fuels, CO_2 bonding mineral forms (carbonation) using redundant energy. Finally, the most often considered method is the storage of CO_2 until the problem of its further utilization is solved - sequestration.

Sequestration is associated mainly with the injection of carbon dioxide into porous rocks or into brine layers, in which CO_2 would dissolve and then be chemically bound in mineral formations. The last method considered is the injection of CO_2 into unexploited hard coal deposits, in which sorption and immobilization would follow.

In the Czech Republic and Poland, research was conducted on the issue of carbon sequestration, both experimental and conceptual. Locations suitable for injecting carbon dioxide were selected, not far from places of increased CO_2 production.

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ENERGY TECHNOLOGIES INVOLVING COAL – PRESENT AND FUTURE IN HUNGARY AND POLAND – A SURVEY

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Keywords: coal, energy policy, power production

ABSTRACT

Increasing energy consumption and adaptation to EU policy induce research which aim is to construct new energy technologies, including modern coal technologies. The technologies of energy production from coal are constantly developed with the use of condensing and supercritical boilers. The coal-nuclear synergy is considered, in which the energy consumption during the production fuels from coals use the excess thermal energy produced in nuclear power units. Likewise, the surplus of nuclear energy could be used to produce hydrogen and oxygen, and these gases can then be used to oxyburning (oxygen) in CCS technologies or to convert carbon dioxide into usable chemicals, including liquid fuels (hydrogen). In Hungary, the energy market looks different than in Poland (Fig.1).

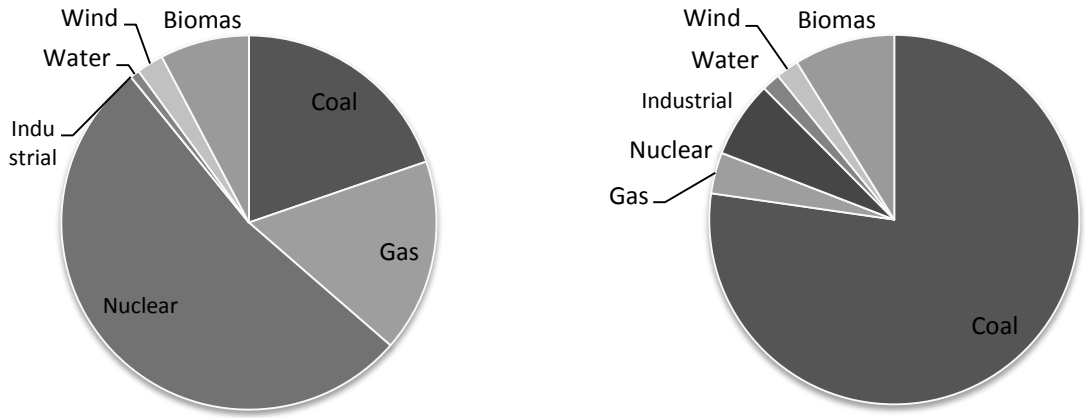

Fig. 1. Structure of electricity sources in percent [1, 2]

Hungary imports 45% of electricity, while in Poland only intervention purchases of 7% are made at peak demand [1,3]. However, imports of electricity to Poland will become a trend, due to the higher price of energy produced from coal (drop in exports). In both countries, different scenarios are necessary to ensure the security and energy independence.

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ANALYSIS OF COAL BED METHANE OBTAINING AND USE IN POLISH CONDITIONS

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Keywords: CBM, methane, economic

ABSTRACT

In Poland documented supposed economic resources of coal bed methane are in 63 deposits in the area of the Upper Silesian Coal Basin and, as at end of 2016, has amount to 95 953.81 million m^3.

Most of coal bed methane resources recognized in category C (90.67%), which amounts to 87 004.34 million m^3. Resources in the category of recognition A and B - 8 949.47 million m^3 - this is only 9.33% of resources in Poland. Non economic coal bed methane resources are documented in 8 beds and they amount to 11,419.08 million m3.

Production of coal bed methane in mines by drainage system in 2016 was 357.09 million m3 and with ventilation air 547.22 million m^3. In 2016, exploitation of methane from deposits was begun: Anna 1, Pawłowice 1 and Jankowice-Wschód.

The Upper Silesian Coal Basin is characterized by the largest potential for coal bed methane concentration. The geological prognostic and prospective resources of coal bed methane in Upper Silesian Coal Basin were estimated at the end of 2009 at approx. 107 billion m^3.

Significantly smaller coal bed methane resources are in the Lublin Coal Basin - prospective resources of approximately 15 billion m^3 and the Lower Silesian Coal Basin - prospective resources of approximately 1.75 billion m^3.

In Poland, several of coal mines was closed, and the coal exploitation caused the formation of fractures in the rock mass and coal seams, as a result of which underground gas reservoirs, mainly methane, were created. Methane in deposits occurs in two forms: free and sorbed gas. Sorbed methane is associated with coal and can go into a gas form by crushing coal and getting into the space of the slits of the coal seam or surrounding rocks. Methane from coal seams is gradually released as a result of desorption into the resulting gaps / reservoirs by filling them with gas.

Research as well as investment and implementation works are carried out in the area of producing coal bed methane from abandoned mines by wells made from surface. The first attempts to obtain methane from coal seams with wells from the surface were conducted in the USA in the seventies of the previous century. The first attempt to capture methane sorbed in coal, regardless of coal mining, started in 1990 in coal mine Jastrzębie, lasted continuously until the end of 1999.

The article analyzes the possibilities of producing coal bed methane obtaining by wells from the surface and use it for the following variants: (1) Installation of the gas engine, production and sale of electricity, (2) Building of a gas pipeline, (3) installation of a gas engine, production and sale electricity and heat, (4) Gas compression and transport, (4) Gas cleaning, compression and transport.

For each of the variants, the scope and size of the investment at which it is profitable to capture coal bed methane from inactive mines was developed for polish conditions.

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EVALUATION OF THE IMPACT OF METEOROLOGICAL CONDITIONS ON THE AMOUNT OF AIR POLLUTION

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Keywords: air pollution, meteorological conditions

ABSTRACT

The publication presents a valuation of the impact of meteorological conditions on the amount of pollutants in the atmosphere in selected location. The subject of work is associated with problems of environmental protection and energy management. The prepared publication notes that regardless the decades of air contamination monitoring, the scale of the air pollution problem has highlighted in only recent years. The presented study shows the relationship between weather-related elements (wind direction and velocity, relative humidity, intensity of solar radiation) and the immissions of pollutants. Prepared analysis indicate a substantial influence of atmospheric precipitation, pressure and boundary layer on a quality of the air. Opportunities of improvement of air cleanliness are presented based on measurement concerning the immission of air pollutants.

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AN ANALYSIS OF COAL PRODUCTS SALES WITH REFERENCE TO ENVIRONMENTAL REGULATIONS OF THE EUROPEAN UNION

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Keywords: sales of hard coal, mathematical modelling, environmental directives of the European Union

ABSTRACT

Hard coal mines deliver to the market energy coal with crucially diversified quality pa-rameters. It proves considerable production capacity of coal industry, which tries to adapt to high quality demands of the market. An essential element influencing the situation of the Polish coal sector is its regula-tory environment. European directives transposed into the domestic legislative system are mainly aimed at decarbonisation actions, which shall result in significant reduction of the role of the qualitatively worst coals in economy. The impact of these regulations on the functioning energy and fuel sectors poses a challenge both for the mining indus-try as well as energy companies.

After Poland had joined the European Union, the issue of mechanical processing, which influences the quality of market coal, became a major issue due to effective European coal quality requirements.

The article presents an analysis of the possibilities of selling hard coal in reference to environmental regulations of the European Union. Analysis of this sale made it possible to develop a theoretical model for forecasting demand on the domestic market. Proper forecast of demand allows for flexible and dynamic adjustment of the level of production or inventory to changes taking place on the market. It also enables the adjustment of the assortment manufactured to the requirements and expectations of the recipients, which in turn translates into increased sales, the release of financial resources, a reduction of the company's operating costs, an increase in the financial liquidity of the mines.

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POLYCYCLIC AROMATIC HYDROCARBONS (PAHs) ASSOCIATED WITH PM10 FROM SMALL CITY OF KRAKOW AGGLOMERATION

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Keywords: Particulate matter, Polycyclic aromatic hydrocarbons, GC/MS

ABSTRACT

Krakow is a city in southern Poland inhabited by about 741,000 people. However, Krakow's agglomeration includes neighboring cities, hence more than 1 million people live there. The agglomeration is struggling with the problem of air pollution. In 2016, admissible average annual concentrations of PM10 (40 μg / m^3) were exceeded at all measuring points. Furthermore, daily PM10 concentrations were regularly exceeded in the winter, which is associated with increased coal combustion during this period [1].

Fortunately, interest in the subject of air quality in the world is constantly growing. People are more often aware of the negative impact on health of chemical compounds present in particulate matter (PM) such as Polycyclic Aromatic Hydrocarbons.

Polycyclic Aromatic Hydrocarbons (PAHs) are organic pollutants which were proved to be cancerogenic and mutagenic for people. That is why it is so important to study their presence in the ambient air. PM10 collected in the center of Wadowice (22.12.2016 – 13.10.2017) were investigated. PAHs were extracted from particulate matter and analysed applying the GC/MS technique. The results are discussed in the article.

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METHODS OF DISPOSAL OF BIODIESEL PRODUCTION BY-PRODUCTS

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Keywords: waste utilisation, lactic acid, glycerol

ABSTRACT

The alternative fuels market has been flourishing for a long time. Due to the protection of the environment and newer directives concerning the generation of fuels and internal combustion engines, new sources for their production are used.

Biodiesel, has long been known as a mixture of the "green" biocomponent FAME (fatty acid methyl esters) with a package of additives containing, among others Anticorrosive substances or antioxidants are currently a large, dynamically developing branch of the fuel industry.

An important issue is also the catalyst, usually alkaline, because the yield and conversion of the raw material is the highest in comparison with other catalysts (eg alkaline resins).

The final product of this technology is the glycerol and oil phase in a ratio of about 1:10. This is a high ratio, despite the fact that glycerin is not considered as waste, but an intermediate suitable for further processing into more beneficial chemical compounds.

Refineries where biodiesel production is in operation face growing residues of the glycerol fraction. Untreated - has not yet found use in the chemical industry, purified - is used in cosmetics and pharmacy. The cosmetics market is overloaded with glycerin, it treats it as a filler in many products, primarily using neutral effects on humans and the external environment. Following this line of reasoning, it is important to focus on other possible ways of applying glycerine to useful chemicals, valuable from the point of view of the chemical industry.

As part of the development of white biotechnology, research is conducted to maximize the share of biotechnology in industry. One of the possible ways of processing the glycerol phase is the biotechnology pathway for the conversion of glycerine to lactic acid. The key to carrying out the selective reaction are microorganisms focused on the production of lactic acid. Bacteria contain enzymes that break down glycerol in one of their metabolic pathways. Process optimization through the control of the pH working range, and the temperature and dosing of the nutrient solution are the three most sensitive points, crucial for microorganisms.

The final stage of the described process is lactic acid. Its use is currently so large that the import to the home country is close to 100%. The most important application for which the greatest emphasis is put on further processing of lactic acid in polymerization to PLA, i.e. polylactide. Optically pure PLA is an extremely valuable tool in the work of surgeons' hands as bone connectors, surgical threads or artificial skin. In addition, medical equipment previously produced from very viable PET is now being replaced with a biodegradable PLA.

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SELECTED ASPECTS OF DESIGN AND CONSTRUCTION OF HYBRID POWER SOURCES (BATTERY AND PEMFC STACK) DESIGNED TO SUPPLY DRONES

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Keywords: polymer membrane fuel cell - PEMFC, electrochemical power sources, unmanned aerial vehicle-UAV

ABSTRACT

Hydrogen is a secondary energy carrier, i.e. it must be produced from primary energy sources such as fossil fuels, biomass, solar energy, wind, hydropower, or nuclear power. Potentially, the hydrogen economy will make it possible to take advantage of local sources of energy, reducing the dependence of the energy sector on imported fuels in accordance with sustainable development. Another advantage arising from the conversion of hydrogen to usable energy is its negligible effect on the environment . Some of sizes, the aircraft-powering hydrogen-fuel fuel cells have been recently built as final yields of many research projects contracted between scientific institutions and industry companies involved in UAVs and the field of fuel cells in the USA, Europe, and Asia.

The aim of this paper is to present the potential for the application of PEMFC fuel cells as components of hybrid energy sources for supplying electrical engine in UAVs. The concept of their construction design, the results of electrochemical tests and performance of an elaborated power sources are described and analysed.

Power sources based on PEMFC stacks are equipped with a number of additional auxiliary devices to improve and secure their appropriate action. These include monitoring systems for moisturising and dosing of gaseous reactants, cooling and temperature control systems, hydrogen leakage sensors, starter accessories, or DC to AC power inverters. They usually operated in hybrid electrical system (battery and PEMFC stack).

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SYNTHESIS OF 2-METHYLFURAN AND FURAN VIA HYDROGENATION OF FURFURAL AND FURFUROL OVER CHROMITE-BASED CATALYSTS

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Keywords: furfural, 2-methylfuran, hydrogenation, chromites, biomass

ABSTRACT

Rapid development of industry and global economy resulted in an increasing need for energy and fuels. The pursuit of new energy sources combined with environmental awareness fosters research to enhance production of biomass-based chemicals. As such, 2-methylfuran (DMF) is identified as a promising bio-additive for fuels. Its properties are better than those of 2-methyltetrahydrofuran, the fuel additive already accepted by US Energy Department. It is thus of utmost importance to seek for effective routes towards production of DMF from biomass. One of such processes might be the hydrogenolysis of furfural and/or furfuryl alcohol derived from hemicellulose. Therefore, our aim was to synthetize a set of chromite-based catalysts and to test them in hydrogenolysis of furfural and furfurol.

Chromites of Ni, Co, Fe and Cu were obtained by citric acid method, whereas copper chromite was additionally obtained by so-called „Adkins" method. The synthetized catalysts were characterized by the following physico-chemical methods: their phase compositions were checked with XRD method, their specific surfaces were determined by BET, whereas their reducibility was accounted for by H_2-TPR approach. Next, the catalysts were tested in the hydrogenolysis of furfural and furfurol in a flow reactor under atmospheric pressure, in the range of temperatures between 150° and 400°C. The selectivity towards the main products of hydrogenolysis (2-methylfuran and furan) as well as by-products (mostly ethane and butane) was measured. The most promising catalysts were additionally characterized by the XPS method in order to determine the composition and oxidation state of the metal component of the active phase.

The proposed catalysts proved active in the studied process of hydrogenolysis of both substrates. As the most promising, copper and iron- based systems were identified and selected for an in-depth studies. The physico-chemical characteristics of the most active samples point to the catalyst reducibility as the key factor controlling their performance. Further, a synergistic effect between iron and chromium components was determined as crucial in attaining high selectivity to the desired reaction product, i.e. 2-methylfuran.

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FROM MINERAL TO CATALYST – TRENDS IN APPLICATION OF LAYERED CLAY MINERALS IN ENVIRONMENTAL CATALYSIS

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Keywords: catalysts, clay minerals

ABSTRACT

Layered clay minerals, especially those belonging to the group of smectites, attract much interest due to their possible applications in various industries. Many scientific reports presenting various methods of their modifications including direct intercalation with metal oxide(hydroxide) oligocations (PILCs – pillared interlayer clays) as well as surfactant-directed intercalation with silica pillars (PCHs – porous clay heterostructures) were published. Both these pillaring methods are very promising for catalyst production. The obtained materials are characterized by high surface area and porosity as well as high thermal and hydrothermal stability. Moreover, surface acidity and ion-exchange properties, make these materials very promising for the potential applications in catalysis. The properties of clay based catalysts can be designed by using various layered clay minerals characterized by different density of acid sites and ion-exchange potential; surfactants and co-surfactants of various structure and size to design pore diameters in PCHs; incorporation of various components into the silica pillars to generate additional acid sites and/or ion-exchange properties.

The examples of various modified clay minerals applications in the selected processes of environmental catalysis will be presented and discussed.

The presentation is dedicated to the anniversary of scientific work of Prof. Teresa Grzybek

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CIRCULAR ECONOMY - NEW PARADIGM OF THE FUTURE

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Keywords: Circular economy, waste management, zero waste, environmental impact, business model

ABSTRACT

In the face of sharp volatility increases across the global economy and proliferating signs of resource depletion, the call for a new economic model is set highly on the agenda of decision makers all over the world. The need for a substantial improvement in resource performance across the economy, businesses have started to explore ways to reuse products or their components and restore more of their precious material, energy and labor inputs. Circular economy - is a concept that minimizes the environmental impact of created products through such a selection of ingredients and design that will enable their re-use.

Circular economy is also associated with the concept of cradle-to-cradle. So it is a concept that is not really new. It is basically a model consistent with what has been happening on Earth for millions of years and whose author is nature itself. We are dealing here with a number of positives. We do not have to limit economic growth, so the wealth of societies can grow. We do not have to take drastic measures to reduce the birth rate. In addition, we are able to approach the ideal state in which we will not use non-renewable natural resources in general.

Transitioning to a circular economy does not only amount to adjustments aimed at reducing the negative impacts of the linear economy. Rather, it represents a systemic shift that builds long-term resilience, generates business and economic opportunities, and provides environmental and societal benefits.

The general discussion on the concept of circular economy, need for shift from the linear model as well as economic and social consequences of its implementation is presented in the manuscript.

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ISOSTERIC HEAT OF SORPTION OF METHANE ON SELECTED HARD COALS

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Keywords: Isosteric heat, carbon dioxide, methane, coal

ABSTRACT

The purpose of the study is to establish the relationship between the sorption processes of methane and properties of a hard coal sample, its physical and chemical structure, capillary structure and permeability. In consideration of the length of the process and stability of the investigated sorption system, of particular importance are the physical properties of coal samples. To ensure the safety of the research projects, key issues associated with sorption and desorption of mine gases need to be addressed: variations of coal porosity and hence permeability in the course of these processes and the risk of coalbed methane explosions. Studies of the energy aspects of sorption are a vital part of the methodology for investigating structural properties of hard coals, permitting a qualitative and quantitative analysis of sorbent-gas interaction forces. In analysed systems the sorption equilibrium is attained after a certain time, the process involves adsorption-desorption and the sorbent volume tends to change. Therefore, application of the isosteric method to the studies of such systems seems fully merited.

This study investigates the sorption of methane on two selected coal samples from the Upper Silesia Coal Basin. Experimental measurements of low-pressure sorption of on selected hard coal samples were taken with the automatic ASAP 2010 apparatus (Micrometrics) utilising the volumetric method of sorption measurements.

Isosteric heats of methane sorption change with the growing surface coverage in a lesser degree only, which is associated with the predominance of dispersion forces in the investigated sorption system.

The results have not only cognitive value, they can be well related to real mining conditions where the gas-containing coal surfaces are rapidly exposed, causing the loss of stability of the system due to rapid desorption and temperature decrease such that a portion of gas remains trapped in coal. Depending on the capillary structure of coal and coalbed permeability, the gas will be released slowly or produce a relatively high pressure within the capillaries.

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FLY ASH DERIVED ZEOLITES AS POTENTIAL Hg SORBENTS IN ENERGY SECTOR

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Keywords: fly ash, sorbents, Hg

ABSTRACT

Taking into consideration the current IED directive, and hence very restricted requirements for mercury pollution included in BAT/BREF, force the many energy sector to seek new efficient gas purification technologies from the gaseous form of mercury. This is due to the fact that actually, none of the primary or secondary methods of removing Hg compounds are able to meet these restrictions (even commonly used methods based on activated carbon). In energy sector mercury is observed in exhaust gas as well as in wastewaters coming from the wet flue gas desulphurization (WFGD) process. One of the tested solution is consideration of zeolites as potential sorbents for mercury capture/removal. Presented studies described test of mercury removal from gas as well as from wastewaters WFGD. Tested materials were synthetic zeolites obtained in hydrothermal synthesis of fly ash with NaOH. Changing the zeolitization conditions i.e. time and temperature of reaction as well as concentration of NaOH a two type of zeolites were obtained Na-X, Na-A. In order to increase the sorption ability terms to mercury the X type zeolite were Ag^+ activated (Ag-X). As a references materials activated carbon with bromine were used. For obtained materials three tests were carried out 1) tests of elemental mercury removal from pure gas stream (nitrogen as a carrier gas), 2) removal of mercury from flue gas stream at laboratory scale; 3) static sorption tests of removal of mercury from real waste waters, where concentration of mercury was 0.500 $mg*dm^{-1}$. Removal of gaseous forms of mercury in 1st test in case of unmodified zeolites is neglect but silver activation significant increase their efficiency. For Ag-X structure the results have shown that zeolite removed mercury five times better than commercial product i.e. bromine modified activated carbon. Based on the obtained results from pure gas stream we can state that the 1 kg of Ag-X zeolite can uptake 375g of Hg from pure gas stream where in case of tested activated carbon (AC) the results was 1kg of AC can uptake only 73g of Hg. In case of removal of mercury from flue gas Ag-X zeolite give also promising results but sorption was at the level of 60%. For removal of mercury from waste waters only unmodified zeolites were considered. The results have shown that all tested zeolites removed Hg from waste waters at a level of approx. 98%. Based on carried out investigation we can stated that fly ash derived zeolite can be promising cost profit sorbent for mercury removal in energy sector

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THE IMPACT OF SUPPORT ON CATALYTIC ACTIVITY OF Ru-BASED CATALYSTS IN THE HYDROGENATION OF SELECTED KETONES

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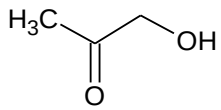
Keywords: hydrogenation, water soluble ketones, Ru-based catalysts, support impact

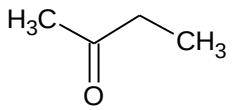
ABSTRACT

Catalytic hydrogenation of the C=O bond constitutes a very important aspect of organic synthesis enabling preparation of a great number of useful products. Our research focuses on the preparation, characterization and application of supported ruthenium catalysts in the heterogeneous reduction of water soluble ketones such as acetole (a) and 2-butanone (b) (Scheme 1) to secondary alcohols. Both studied processes are of practical importance. Thus, 1,2-propanediol, the product of the hydrogenation of acetol finds application as solvent, antifreeze, deicing agent and approved food, cosmetic and pharmaceutical additive. Hydrogenation of 2-butanone yields 2-butanol, a commonly used industrial solvent. It is well known that the nature of the support strongly affects the performance of catalysts due to its impact on the active phase dispersion and stabilization. Therefore we prepared a series of catalysts containing different supports.

a)



b)



Scheme 1. The structure of (a) acetole and (b) 2-butanone

Ruthenium was deposited on the appropriate carrier material by wet impregnation method. The obtained catalysts (2 wt.%Ru/SBA-15, 2 wt.%Ru/SiO_2, 2 wt.%Ru/Al_2O_3 and 2 wt.%Ru/C) were characterized with the aid of XRD, XPS, SEM, HRTEM techniques and nitrogen adsorption/desorption isotherms. The catalytic tests were explored under very mild conditions (R.T, p=1 bar, solvent = H_2O). Recovery/recycling studies were performed as well.

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ROLE OF SUPPORT FOR STRUCTURAL, TEXTURAL AND FUNCTIONAL PROPERTIES OF NICKEL-BASED CATALYSTS ACTIVE IN DRY REFORMING OF METHANE

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Keywords: ceria-zirconia support, nickel-based catalyst, dry methane reforming

ABSTRACT

Positive environmental and technological contexts make dry methane reforming (DMR) an extensively studied reaction. During this process two main greenhouse gases: CH_4 and CO_2 can be simultaneously converted into syngas – a mixture of CO and H_2, which belongs to the most useful chemical components because of a wide range of its possible industrial applications, e.g. synthesis of ammonia or methanol.

Main aim of this work was to elucidate how the design of ceria-zirconia support can influence the structural, textural and functional properties of Ni-based catalysts tested in DMR.

Ceria-zirconia supports were synthesized by supercritical fluid method. The precursors were water or water/ethanol solutions of ammonium-cerium nitrate and zirconium oxynitrate mixed at desired molar ratios. The synthesis has been performed in the reactor under supercritical conditions, i.e. at temperature of 400°C under pressure of 25 MPa. Recuperation solution was filtrated and dried-out. The supports of various compositions were synthesized: CeO_2, $Ce_{0.75}Zr_{0.25}O_2$, $Ce_{0.50}Zr_{0.50}O_2$ and $Ce_{0.25}Zr_{0.75}O_2$ and subsequently calcined at 800°C for 6h in air. Nickel was deposited from nitrate precursor over ceria-zirconia support via classical wet impregnation.

The supported catalysts were characterized structurally (XRD, RS), texturally (BET, SEM) and functionally (UV/Vis-DR, XPS). Catalytic tests in dry methane reforming reaction have been performed to determine activity and stability of the synthesized samples. The latter one was mainly related to the resistance of catalysts to the formation of carbon deposit - main cause of deactivation of NiO_x/CeO_2-ZrO_2 catalysts.

The obtained results showed face-centered cubic structure of synthesized samples with progressive incorporation of Zr^{4+} ions into the cationic sublattice of Ce^{4+}. Average pore size of grains ranged from 4 to 8 nm. Increasing content of ZrO_2 in CeO_2-ZrO_2 systems was responsible for an increase in both pore diameters and specific surface areas. SEM images recorded for Ni/CeO_2-ZrO_2 catalysts, suggested flakes-like morphology. Ni/CeO_2 catalyst exhibited the lowest activity in DMR, whereas at using the CeO_2-ZrO_2 supports synthesized in supercritical conditions it was possible to improve substantially the catalytic performance of nickel-based samples, regardless the amount of ZrO_2.

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APPLICATION OF FLY ASH FOR MINERAL CARBONATION OF CO_2

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Keywords: Mineral carbonation, fly ash, CO_2

ABSTRACT

Carbon Capture, Utilization and Storage (CCUS) technologies are recognized as one with the highest potential technique for lowering the greenhouse emissions from the existing and new designed power plants. One of those techniques, called mineral carbonation, is safe, permanent and environmentally friendly among carbon storage technologies [1]. As substrates for mineral carbonation, calcium and/or magnesium bearing minerals are suitable for CO_2 fixation and utilization. The second group of substrates that can be used for mineral carbonation are industrial wastes containing calcium and/or magnesium oxides or silicate mineral residues [2, 3, 4].

Mineral carbonation was proposed based on polish power plant fly ash coming from burning of brown coal. At laboratory scale conditions for this process were: pressure range 4-16 bar and temperature 323 K. Experiment was performed on unprocessed fly ash as well as specially prepared. Preparation of fly ash included heating of fly ash in air in elevated temperatures to decompose formed carbonates. The aim was to experimentally check and compare the results for such prepared material in correlation to raw fly ash from the same source.

Laboratory investigations proved that the carbon dioxide uptake is increasing with pressure in both analysed cases. Preparation of fly ash for the experiments did not result in increase of CO_2 uptake. The results indicate that no special preparation of fly ash is needed in order to use it as a material for CO_2 utilisation.

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ACIDIC PROPERTIES OF MESOPOROUS [AL]MCM-41 AND [AL]SBA-15

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Keywords: mesoporous aluminosilicates, [Al]MCM-41, [Al]SBA-15, surface acidity

ABSTRACT

MCM-41 and SBA-15 have been widely applied as catalysts and catalysts supports due to their unique features like high, specific surface area, uniform pore structure and thick silica walls that improve their thermal stability [1,2]. As far as synthesis of mesoporous silica materials is concerned, the essential components are appropriate silica precursor (e.g. TEOS, Ludox®) and presence of surfactant (e.g. CTAB, Pluronic® P-123) which enables the pore structure to evolve [3]. Despite attractive surface properties of MCM-41 and SBA-15, the materials do not exhibit noticeable acidity. However, replacement of Si by Al in the material framework generates acidic character. Tetrahedrally coordinated aluminum ions create Brönsted acidic sites [4], which are significant for the variety of catalytic processes, for instance selective catalytic oxidation of ammonia applied in diesel aftertreatment systems [5]. Different methods of Al incorporation into MCM-41 or SBA-15 including grafting or direct introduction of Al precursor during synthesis procedure have been widely investigated in the scientific literature [3,6].

In the following insight [Al]MCM-41 and [Al]SBA-15 (n(Si)/n(Al)=27) were synthesised, while aluminium isopropoxide was added directly to the synthesis batch. Acidic character of the obtained materials involved temperature-programmed desorption of ammonia (NH_3-TPD) and FT-IR spectroscopy studies with NH_3.

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CARBON SUPPORTED CERIUM-COPPER CATALYSTS FOR LOW-TEMPERATURE REMOVAL OF NOx FROM STATIONARY SOURCES OF EMISSION

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Keywords: functionalised carbon, cerium-copper catalysts, NO SCR with ammonia

ABSTRACT

Activated carbon (AC) exhibits high porosity and surface area. Its treatment with acid leads to the formation of the acidic sites active in catalytic reactions. The promotion of such carbonaceous materials with urea results in basic sites and in increasing their thermal stability. Functionalised AC has turned out an efficient catalyst in selective catalytic reduction (SCR) of nitrogen oxides (NO_x) with ammonia and is applied in power plants. Its promotion with transition metals e.g. manganese increases catalytic activity [1-4].

The aim of this work was to obtain a low-temperature catalyst for SCR by functionalizing AC and subsequently its promotion with copper and cerium. Catalytic activity, selectivity and thermal stability of such materials were examined and explained by means of the results of physicochemical characterization.

Activated carbon (Gryfskand, Hajnówka, Poland) was treated with HNO_3, then the oxidised material was additionally modified with urea. Functionalised AC was used as a catalyst support which was impregnated with copper and cerium nitrates to deposit 1, 5 or 10% of copper and 0.5% of cerium. These precursors were thermally treated to obtain Cu-Ce/AC catalysts.

Material characterization was carried out by low-temperature nitrogen sorption, FT-IR and X-ray diffraction. The examination of sample activity, selectivity and thermal stability was conducted during catalytic tests.

The deposition of cerium did not influence the textural properties of functionalized AC and the sample remained hydrophobic as seen from IR data. The addition of 1% Cu resulted in a 10% decrease of SSA_{BET} and micropore volume as well as an increase in hydrophilic properties. An increase in copper content caused twice lowering these area and volume as well as a hydrophilicity decrease. The metal phase was amorphous in Ce and 1CuCe samples, with the increase in Cu loading copper oxides appeared - mainly Cu_2O. The sample with Ce exhibited 90% conversion of NO in the low and medium temperature SCR. This sample was thermally stable and only a few ppm of N_2O was formed. The addition of 5 and 10% Cu increased the NO conversion at temperatures higher than 160°C, at 200°C about 100% conversion was attained. But over these samples significant amount of N_2O was formed and above 220°C the samples became thermally unstable.

Well dispersed amorphous cerium species deposited on functionalised activated carbon form the hydrophobic catalyst - active, selective and stable in NO SCR.

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ZEOLITES FROM ASH AS CATALYSTS IN SCR-NH_3

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Keywords: zeolites, ash, SCR, DeNOx

ABSTRACT

Emissions of nitrogen oxides, which are produced in the process of fuel combustion, is well-known problem for many years. Invariably they conducted studies to improve the system of removing harmful gases from the exhaust stream. One of the ideas is to use fly ash, a waste product of this process, to produce zeolites. These porous materials, which may act both as an adsorbent and catalyst carrier may be used to capture the respective gases from the exhaust gas stream.

In this work, zeolites were prepared by various methods from the ashes coming from the two different sources. Each sample of the zeolites was subjected to an ion-exchange process to check the effect of ion exchange on the change in sorptive and catalytic capacity of the tested material. The obtained material was tested using a selective catalytic reduction of NO using NH_3 as a reducing gas.

Zeolite activated with copper (II) ions shows the highest and most stable conversion at various temperatures. This may lead to little participation in the whole physical or chemical adsorption process.

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INFLUENCE OF PRETREATMENT CONDITIONS OF Ni-CONTAINING Fe-PROMOTED HYDROTALCITE-LIKE MATERIALS ON Ni^0 CRYSTALLITE SIZE

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Keywords: hydrotalcite, nickel, iron, reduction, nanocrystallites,

ABSTRACT

The rising levels of CO_2 in the atmosphere increased concerns and social awareness about the climate change caused by the emission of greenhouse gases originating from combustion of fossil fuels for power generation and other industrial activities. Lowering the emissions of carbon dioxide from anthropogenic sources into the atmosphere includes the transition to carbon free sources of electricity, such as renewables or utilizing biomass as a feedstock for valuable chemicals, as well as CO_2 capture from stationary sources and direct capture of CO_2 from the atmosphere. The transition to renewable energy sources, the most obvious of the proposed solutions, creates an additional important problem, which is the energy availability on demand. This requires the storage of excess renewable energy. One of the proposed solutions is the storage in the form of chemical compounds. Methanation of carbon dioxide offers such possibility in the form of methane, assuming hydrogen will be provided via water electrolysis using excess energy [1]. However, a highly active, selective and stable catalyst still needs to be found. Hydrotalcite-based catalysts containing Ni, Mg and Al were found to be promising catalysts for CO_2 methanation [2, 3]. However, according to literature [4] the catalytic activity in CO_2 methanation is strongly dependent on the Ni^0 crystallite size. On the other hand, the size of crystallites depends strongly on the conditions of catalysts preparation and pretreatment. Therefore, the subject of this study was focused on the optimization of the pretreatment conditions (calcination and reduction) of Ni-Fe promoted hydrotalcite-derived catalysts in order to obtain optimum size of Ni crystallites.

Ni-containing Fe-promoted materials were obtained using co-precipitation method at constant pH=9.5-10. Two aqueous solutions - metal nitrates and 1M sodium hydroxide - were added dropwise into a flask containing sodium carbonate, under vigorous stirring at 65°C. The solution was aged for 1h and dried overnight at 80°C. The obtained materials were calcined at 500°C or 700°C for 5h in air. Both series were than reduced in a flow of pure H_2 at 900°C for 1h. The obtained materials were than characterized using XRD. The obtained XRD patterns were used in order to calculate the crystallite sizes (Ni^0) using Scherrer equation.

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EFFECT OF THERMAL TREATMENT ON THE STABILITY AND CRYSTALLITE SIZE OF Cu-Mg-Fe HYDROTALCITE-DERIVED MATERIALS

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Keywords: hydrotalcite, Cu, Fe

ABSTRACT

Hydrotalcites are layered double hydroxides (LDHs) containing positively charged hydroxide layers and charge compensating anions present in the interlayer spaces. Such materials are widely studied for application in catalysis e.g. dry reforming of methane, partial oxidation of methane, CO_2 methanation or selective catalytic reduction of NOx, because of the possibility of introduction of various divalent and trivalent cations. The physicochemical properties of such materials are strongly dependent on the chemical composition and preparation method. However, some features, regardless of the preparation method, are common for LDHs, such as basic character and memory effect. One of the most important features of such materials is the formation of homogenous mixture of well-dispersed elements in the brucite-like and inter-layers [1]. Other very important features are (i) thermal decomposition behavior of hydrotalcite-like materials is similar even though they may differ in the composition, (ii) High surface area of mixed oxides obtained after thermal decomposition of hydrotalcite-like materials, (iii) Hydrotalcites possess high anionic exchange capacity related to their lamellar structure, which allows to exchange anions present in the interlayer spaces with those from aqueous solution, (iv) Generally, hydrotalcite-like materials are basic, as the surface of those materials possess hydroxyl groups. The basic properties and the distribution of their strength is strongly dependent on the chemical composition of brucite-like layers. Thus, acid-base properties of such materials can be tailored to some extent by substitution of cations present in the layers with other possessing strong basic properties as well as introduction of some species with acidic properties into the interlayer spaces of HTs.

Hydrotalcites containing Cu, Mg and Fe were obtained using co-precipitation method at constant pH=9.5-10. Two aqueous solutions - metal nitrates and 1M sodium hydroxide - were added dropwise into a flask containing sodium carbonate, under vigorous stirring at 65°C. The solution was aged for 1h and dried overnight at 80°C. The obtained materials were calcined at 500°C, 600 and 700°C for 5h in air. The obtained materials were characterized using XRD. Crystallite sizes were determined using Scherrer equation.

The obtained results allowed to evaluate the thermal stability as well as the crystallite size of the obtained materials, which are important factors in case of considering such materials for application is various catalytic reactions such as e.g. alkane dehydrogenation.

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CATALYSTS BASED ON CARBON XEROGELS WITH HIGH CATALYTIC ACTIVITY IN THE REDUCTION OF NOx AT LOW TEMPERATURES

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Keywords: NO_x, carbon xerogel, Fe, Co, Cu

ABSTRACT

Municipal Solid Waste (MSW) is a complex mixture of materials produced by households and public institutions and collected by municipalities [1]. As improper collection and disposal of MSW influence the human health and cause serious environmental problems, waste management plays the vital role worldwide nowadays [2]. Landfilling is the most economical waste treatment option but the limited land for waste disposal make necessary to search for new disposal/treatment alternatives. Waste-to-energy technologies for recovery of energy from wastes can play a vital role in mitigating the problems and, among them, MSW gasification is the most promising technology. However, the syngas (H_2 + CO) produced by gasification is usually contaminated by compounds such as tar, char, NO_x, SO_x or VOCs and requires purification before utilization. Carbon supported transition metals such as Cu, Co, Ni and Fe are proved to be active catalysts for selective NO_x reduction in an oxygen-free atmosphere. In this work, carbon xerogels have been prepared by inverse emulsion by polycondensation of resorcinol and formaldehyde using different surfactants (CTAB, P123 and Span 80). The textural and morphological characterization show that the surfactant mainly affects the interparticular structure of the gel primary particles, while the intraparticular structure (volume of micropores) remains unchanged. The sample prepared with Span 80 is the one with the most developed porosity, thus, Co, Cu and Ni-based catalysts have been prepared by impregnation of this support and by doping during its synthesis. These catalysts were used in the reduction of NO both in absence and in presence of H_2 (the major component of syngas). In absence of H_2, N_2 and CO_2 were detected as major products and the observed increase in CO_2 coincides with the decrease in NO concentration and is accompanied by the production of N_2, which indicates that the carbonaceous matrix is acting as reductant of metal particles. In the presence of H_2, much higher activity was obtained and N_2 was the major product, so that, in this case the carbon matrix is acting mostly as support. The temperature at which the complete conversion of NO was obtained depends greatly on the metal used, decreasing in the following trend: Cu (230 °C)<Co (330 °C)<Fe (420 °C). The highest activity and selectivity was obtained with Cu-based catalysts, which is related to its ability to undergo progressive cycles of oxidation by NO and reduction by the carbon matrix or H_2. However, in the doped materials, the activity was lower than that observed in the impregnated materials which can be related to the lower metal dispersion, as well as the lower accessibility to the active centres, since part of the metal particles are embedded in the carbon matrix.

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PERLITE BASED FIRERESISTANT AND INSULATING MATERIALS

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Keywords: perlite, fly ash, geopolimer, insulation materials

ABSTRACT

Geopolymerization is an innovative technology that can utilize solid aluminosilicate raw materials and alkali metal silicate solutions to produce three-dimensional polymeric structures – materials called geopolymers or inorganic polymers [1]. A variety of solid industrial residues or wastes such as fly ash, metallurgical slags, mine wastes, and industrial minerals such as kaolinite and feldspars can be used as a substrates [1]. Perlite, has not been extensively studied as a potential aluminosilicate source for the synthesis of inorganic polymers through geopolymerization. Application of perilte is aimed at obtain better insulation properties.

In the performed experiments the synthesis of perlite-fly ash geopolymer material has been made based on own-designed synthesis procedure. After time required for seasoning, the samples were analyzed in case of its fire-resistant and thermal conductivity properties. Refractoriness is usually referred to as the temperature at which the standard pyrometric cone is softened (under the influence of heating at a given time and conditions) simultaneously with the identical cone of the material being tested. The thermal conductivity of the tested material is determined by measuring the thermal flux density and temperature difference on both sides of the sample. The values of thermal conductivity coefficient and thermal resistance are in this case calculated from the Fourier equation, assuming a one-dimensional heat flow. [2]

As a result of experiments it was found that refractoriness of received materials is just slightly lower than for chamotte concretes, but still the received value is high. In case of thermal conductivity of material tested, the λ value in comparison to appropriate standards [3,4,5,6], allowed to state that the material is characterized by good insulating parameters.

Received results are very promising. In the following experiments it is planned to analyze mechanical strength of material as well as analysis of humidity impact on the synthesized material.

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ACTIVETED CHAR FROM BROWN COALS FOR CARBON DIOXIDE SORPTION

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Keywords: brown coal, char, CO_2

ABSTRACT

Carbon dioxide emission reduction is crucial when it comes to mitigating climate change. In 2014 fossil fuel emissions (including cement production) accounted for about 91% of total CO_2 emissions from human activities. This portion of emissions originates from coal (42%), oil (33%), gas (19%), cement (6%) and gas flaring (1%) [1]. There is a need for identifying and developing new, efficient methods to reduce CO_2 emissions. There are many post-combustion capture techniques for carbon dioxide separation, one of them is flue gas purification by CO_2 capture through adsorption [2]. Advantages of adsorption methods include ready availability, flexible operating conditions, automated processing, and the production of pure final products. Furthermore, in comparison to chemical absorption, the investment and operational costs of adsorption methods are much more competitive, especially in case of for a medium size installation [3].

For the purpose of experiments two polish brown coals were selected. Selected coal samples were subjected to an activation process in the laboratory reactor designed at Faculty of Energy and Fuels, AGH, under a CO_2 atmosphere. Activation was conducted for 15 and 30 min at a temperature of 1123 K. To determine the impact of impregnation on the adsorption of CO_2, low-pressure sorption measurements were performed using an accelerated surface area and porosimetry system. Measurements were carried out at 298 K at pressures up to 1 atm. For the purpose of comparison CO_2 sorption experiments were performed with the use of activated carbon.

The results of experiments indicate that it is possible to perform synthesis of low cost sorbents in simplified process using brown coal as a raw material.

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MODIFICATION OF GEOPOLYMERS FROM FLY ASHES IN TERMS OF IMPROVING OF INSULATING PROPERTIES

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Keywords: geopolymer, fly ash, perlite, compressive strength, thermal conductivity

ABSTRACT

The Polish energy sector is mainly based on coal. The growing demand for electricity makes it necessary to look for new solutions for the management of coal combustion residues. One of the possibilities of using fly ash is to use it for the synthesis of geopolymers. Geopolymers can be an interesting product that can be used in the construction industry. The paper presents the results of synthesis of geopolymer samples subject to modification to improve insulation parameters. Expanded pearlite was used as an additive. Compressive strength tests were carried out. It was found that already a small addition of pearlite causes a significant reduction in the thermal conduction coefficient, without significantly reducing the strength parameters.

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DEVELOPMENT OF TEMPERATURE-INDUCED STRAINS IN COAL-CH_4 AND COAL-CO_2 SYSTEMS

Paweł Baran[1,*], Katarzyna Zarębska[1], Agnieszka Ćwik[1,2], Katarzyna Czerw[1]

Keywords: coal, carbon dioxide, methane, sorption, swelling

ABSTRACT

Expansion/contraction of coal induced by the sorption of carbon dioxide and methane in isothermal and non-isothermal conditions was measured. The investigation is of great importance in the context of validation of the potential CO_2 sequestration in unmined coal seams. Changes of the temperature in underground coalbeds can influence the sorption balance, resulting in the strains in coal strata that could lead to desorption of gas and leaks to the ground surface. The research shows that the strains induced by the CO_2 sorption are about twice the size of those resulting from the sorption of CH_4. The linear strains are anisotropic, greater in the direction perpendicular to the bedding plane. The results of the non-isothermal experiments show that the temperature increase give rise to the sample swelling in the presence of methane but a different pattern is observed for the coal-CO_2 systems, where the sample contraction occurs. This behavior is explained by the different mechanism of CH_4 and CO_2 deposition and by the diversity in the maceral composition of the samples.

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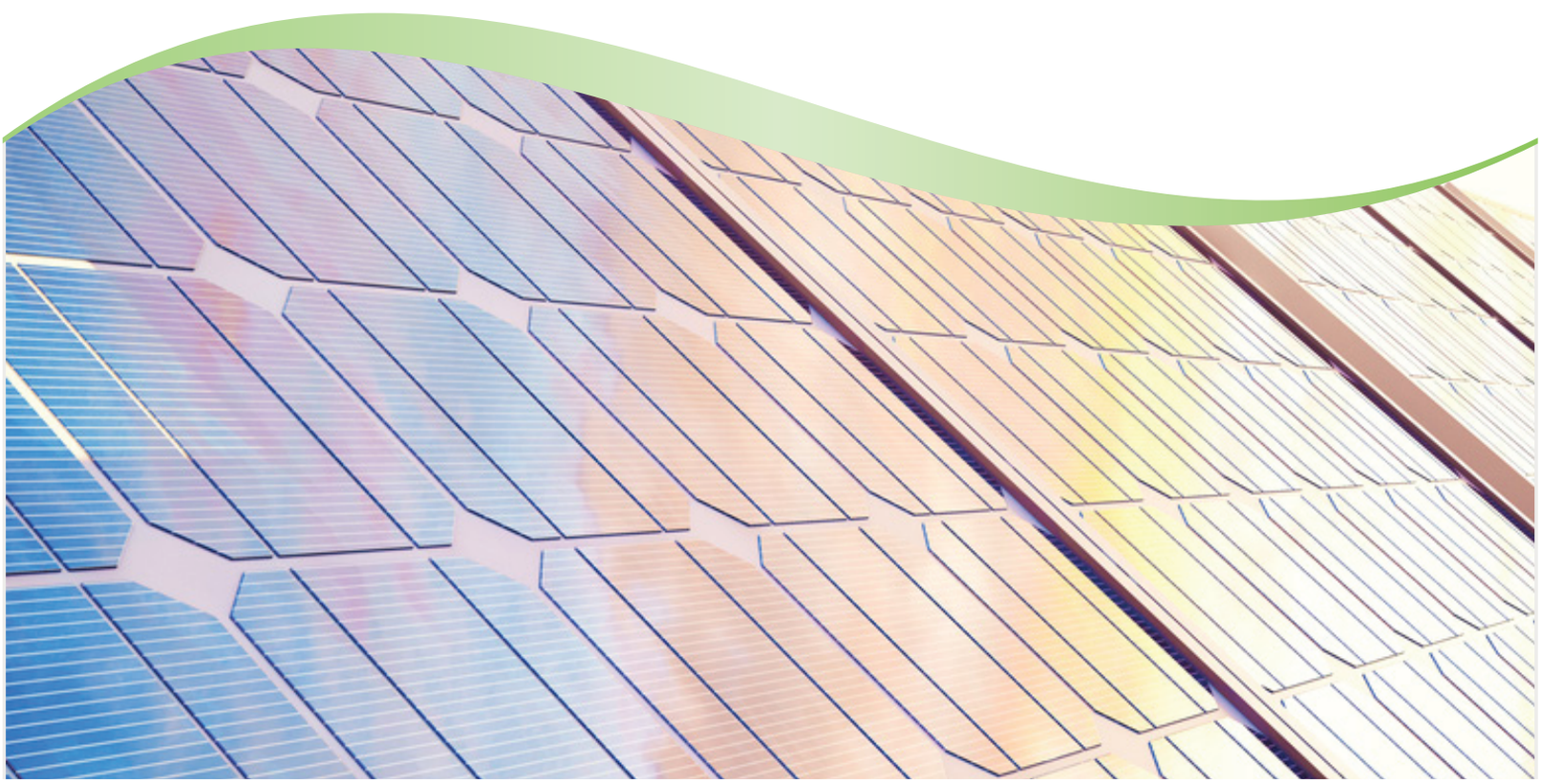

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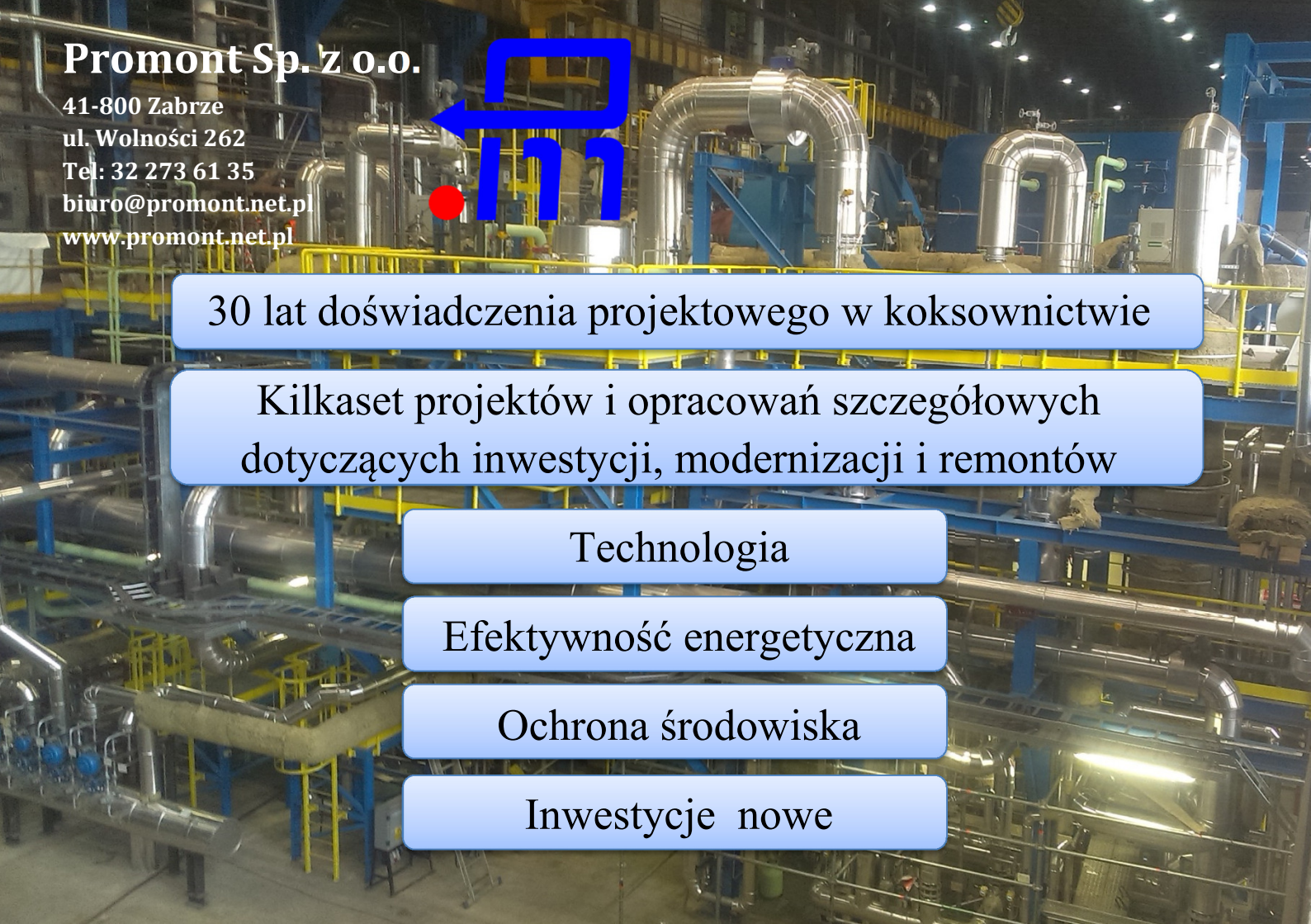

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Biuro Projektów KOKSOPROJEKT Sp. z o.o., z siedzibą Biura w Zabrzu i Oddziałem w Krakowie, jest wyspecjalizowanym biurem inżynierskim istniejącym od 1953 roku. Posiada wysokokwalifikowany zespół, doświadczony w projektowaniu i realizacji obiektów (również "pod klucz") dla przemysłu koksochemicznego oraz przemysłów pokrewnych. Realizacja obiektów odbywa się zarówno w kraju (ostatnie realizacje: bateria w WZK Victoria i Węglopochodne JSW KOKS Radlin -2017) jak i za granicą (płuczka benzolu i regeneracja oleju AM Seremange Francja -2017)
Oferuje, w oparciu o własne know-how oraz posiadane i opatentowane rozwiązania, nowoczesne technologie i rozwiązania techniczne o światowym standardzie, zgodne z kryteriami „najlepszych dostępnych technik" (BAT), wymaganymi dyrektywami w krajach UE. Zostały one wdrożone i z powodzeniem pracują w koksowniach, zapewniając Biuru czołową pozycję na rynku dostawców rozwiązań technologicznych dla koksowni, tak po stronie baterii jak i węglopochodnych. Zawierają one również kompleksowe rozwiązania w zakresie ochrony środowiska a ponadto zapewniają wysoką efektywność wykorzystania energii przy umiarkowanych nakładach inwestycyjnych i niskich kosztach eksploatacyjnych.

Biuro dysponuje zespołami specjalistów i rzeczoznawców, którzy oprócz dokumentacji technicznej realizują specjalistyczne opracowania w zakresie analiz ekonomicznych i ekologicznych dla zamierzeń inwestycyjnych i rozwojowych. Są również autorami raportów i studiów analitycznych, biznes planów, badań statystycznych, opinii, itp.
Dla zapewnienia wysokiego poziomu opracowań, Koksoprojekt stosuje najnowsze systemy wspomagania komputerowego oraz, od 1997 roku, roku System Zarządzania Jakością zgodny z PN EN ISO 9001. Jest laureatem wielu konkursów w zakresie technologii i biznesu.
Koksoprojekt nieprzerwanie od roku 1999, dla Ministerstwa Energii i Eurostatu, prowadzi specjalistyczne badania statystyczne w przemyśle koksowniczym.
Koksoprojekt jest autorem Programu Restrukturyzacji Polskiego Przemysłu Koksowniczego, przyjętego do realizacji przez Radę Ministrów RP w październiku 2000 roku.
W roku 2015, staraniem Koksoprojektu, ukazała się monografia pt. *„Historia przemysłu koksochemicznego na ziemiach polskich".*

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