ENERGY FUELS ENVIRONMENT 2020

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Preamble

AGH University of Science and Technology is the technical university that deals with scientific topics important for Poland, which fit in with the latest global trends.

Energy sector is exercising changes and challenges that never occurred in the past. They extend over various matters, such as for example, there is a continuous process going on related to limiting of pollutants emissions. This is especially of importance 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 analyzes of available techniques, forces power plants to invest in emissions abatement installations, which, however, leads to higher costs of the generated energy. Basically in the same direction go efforts directed to combat climate changes. After over two decades from the Kyoto protocol, an agreement on global efforts was reached during the 21st Conference of the Parties. Although it does not impose decisive limits on greenhouse gases emissions, it creates voluntary obligations to undertake actions that will lead to the decrease of GHG emissions. Two countries, USA and China, which are responsible for almost 40% of global GHG emissions, have ratified COP21 Paris agreement. And while the recent USA declarations do not follow the strict climate policy, the ongoing changes in the energy mix, coal replaced by natural gas, etc., lead to lower carbon dioxide emissions. General improvements in efficiency and technological changes in the industry would also contribute to the lower GHG emissions. European ambitions are that in year 2050 renewable sources should dominate energy supplies, and dissemination of these technologies is indeed observed. One, however, should not forget about the abundant reserves of cheap coal, which has no economic competitor. Despite relatively high emissions, and its impact on environment and human health, coal will still have a role in the energy supplies. However, only clean coal technologies would be acceptable, with improvements in efficiency and abatement technologies constituting a plausible path for the coal employment.

Air quality seems to be one of the most important factors, considering recent environmental activities in Poland. While emissions from the 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, especially in winter season, when allowed concentrations are often largely exceeded. Many Polish cities are among the ones of the poorest air quality. The Polish society has become aware of the related 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 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 the 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 the disappearing supplies. Development of high capacity storage technologies could help to overcome the balancing problems.

The Conference is organized 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 the discussed processes, as well as allow to find the means to solve both large and small problems of the fuels and energy sectors.

Monika Motak
Dean of Faculty of Energy and Fuels

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FROM GREEN DEAL TO TRANSFORMATION OF POLISH POWER GENERATION SECTOR

Maciej Chorowski[1,*]

Keywords: Green Deal, power sector, climate policy, energy mix

ABSTRACT

A Green Deal policy will influence the transformation of Polish power generation system on an unprecedented scale. We observe the change of approach toward environment protection. Traditional environment protection has been focused on the activities aimed at repairing environmental damage or preventing such damage, maintaining the status quo. Climate policy, the aim of which is to take measures to adapt to the ongoing climate change and to try to prevent such changes, has the ambition to achieve dynamic goals. Currently, the environmental policy is changing to climate policy. The tool for achieving the goals of the climate policy is the transformation of the energy sector. Energy policy aims to achieve climate goals, but must, in principle, ensure energy security. Achieving dynamic climate goals requires a huge energy investment and transition to a new energy mix, guaranteeing both stable energy supply and Green Deal. The goal is ambitious and difficult but hopefully not impossible.

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RE-PURPOSING EUROPEAN COAL POWER PLANT DURING ENERGY TRANSITION

Stanisław Tokarski[1,*]

Keywords: Green Deal, RECPP, coal power plant

ABSTRACT

The EU has over 300 power plants (as of July 2016) with 738 separate generating units. These are not evenly distributed across the individual member states and those most reliant on coal are Poland, Germany, Bulgaria, the Czech Republic and Romania. Germany and Poland alone are jointly responsible for 51% of the EU's installed coal capacity and 54% of emissions from coal.

According Green Deal vision, European economy should be carbon neutral in 2050. It means that all coal fired power plant should be decommissioned at this time. How can be re-used assets and infrastructure of phase-out power plants?

Re-Purposing Coal Power Plants During Energy Transition (RECPP) is an accompanying measures project funded by European Funds under the Research Fund for Coal and Steel Programme. RECPP is about the status, mapping, and screening of the re-purposing potential of coal power plants (coal regions in transition - countries, type, age, etc). The main goal of the project is to assess the potential of assets leftover decommissioned power plants/combined heat and power plants, along with accompanying infrastructure, and part of the decommissioned infrastructure inactive plants. Thus, RECPP aims to illustrate the challenges and opportunities in re-targeting the potential of coal-fired power plants and their infrastructure.

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RENEWABLE ENERGY SYSTEMS: CURRENT STATUS IN THE WORLD AND PROSPECTS

Soteris A. Kalogirou[1,*]

Keywords: renewable energy sources, climate change, conventional resources of energy

ABSTRACT

This presentation examines the current status of renewables in the world. This is based on various international reports and refers to the year 2019. The presentation starts with some facts about the climate change, global warming and the effects of human activities such as the burning of fossil fuels on the climate problem. It then examines the current status of conventional resources of energy such as oil, coal and natural gas and their reserves based on current consumption and known resources, followed by a general outline of the status of renewables in the world, which includes the shares with respect to conventional fuel use for electricity and power and jobs created. Then the basic forms of renewables are examined in some detail, which include solar thermal, both for low and high temperature applications, photovoltaics, hydro power, onshore and offshore wind energy systems and biomass/biofuels. In all these the basic overview of the technology is presented followed by the current status as well as the prospects of the technology and new research findings.

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PATHWAYS FOR A LOW-CARBON ENERGY TRANSFORMATION IN THE CITY OF RIGA

Fabio Fava[1], **Duarte M. Sousa**[1,*], **Nika Kotoviča**[2]

Keywords: Urban energy planning, emission reduction, pathways, renewable energy measures

ABSTRACT

The city of Riga, being at the forefront of fighting climate change, is in the process of updating their energy planning document, the Riga Smart City Sustainable Energy Action Plan, for the planning period 2020–2030. As Riga surpassed the emission reduction target of the EU for 2030, there is an opportunity for a new ambitious goal and innovative actions to accomplish it (suitable targets for Riga are a reduction by 61% (2030) and 70% (2050), respectively, compared to 1990 levels). This paper presents pathways that contain measures that are complementary to the planned actions of Riga and focus on three thematic areas:

- green hydrogen (Fig.1, as example),
- solar engagement, and
- modern transportation.

The measures consist of successful European actions modified and applied to the characteristics of Riga.

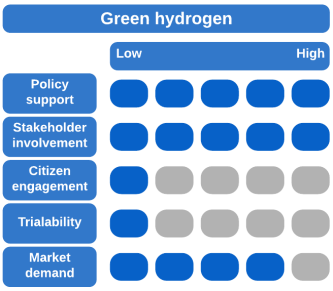

Figure 1. Indicator score pathway "Green hydrogen".

The production of green hydrogen is economically feasible for the city of Riga, achieving a Levelized Cost of Electricity of 0.0395 EUR/kWh and a Levelized Cost of Hydrogen of 3.62 EUR/kg_{H2}. Rooftop solar PV systems are an attractive option for the citizens of Riga if a feed-in tariff of 0.1 EUR/kWh is granted, and including citizens in renewable projects in the form of voucher return packages is a welcomed alternative loan scheme benefiting both the municipality and the citizens. The paper discovered the economic feasibility for the deployment of a renewable hydrogen production facility and confirmed that the employment of PV systems for citizens as an attractive option. Furthermore, the development of a microalgae carbon capture pilot project could leverage Riga's role as an innovation hub. The creation of a fossil-free last-mile delivery zone in the city centre would tackle the challenge of reducing road emissions as electric cargo bicycles have the potential of decreasing emissions by around 99% per trip.

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ASPECTS OF CONTROL AND SYSTEMS THEORY FOR ENERGY EFFICIENT PNEUMATICS

Oliver Sawodny[1,*]

Keywords: energy efficient, pneumatics drives

ABSTRACT

The efficient use of resources and energy is a key factor in achieving global climate protection goals, where the industry has an essential role to fulfil. A remarkable proportion of the energy consumption in the field of handling and automation technology originates from the generation of mechanical translations. The focus of this talk is on pneumatic drives which, on one hand are widely used, but on the other hand cause considerable energy consumption if the parameters are set unfavorably. To reduce this consumption, methods for design and efficient control are being investigated.

However, in production plants, pneumatic drives are used in larger numbers and not individually. In general, a plant manufacturer will not be able to search for the optimal solution of each drive by means of detailed simulation models. Instead, simple applicable approaches are necessary to achieve energy savings in practice. Therefore, in the next step, an optimized adjustment of the supply pressure, a cascaded air usage, and an automated adaptive control pattern are derived. Thus, care is taken to ensure that the measures are applicable without the knowledge of detailed simulation models or parameters, which need to be determined experimentally. Using those measures for pneumatic drives in groups, energy savings in the dimension of 50% are shown experimentally at a demonstrator.

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FOSTERING COOPERATIVE EDUCATION AND RESEARCH BETWEEN AFRICA AND EUROPE TO MUTUALLY MITIGATE THE RISKS OF POWER SYSTEM TRANSITION IN A DISRUPTIVE TECHNOLOGY CONTEXT

Louis Jestin[1,*], Sandile Peta[2]

Keywords: CO_2, Paris agreement, Africa

ABSTRACT

Globally, Digitization, Decarbonization, Decentralization and Deregulation are major disruptors driving changes in the energy sector. Without energy savings, the global energy demand is expected to more than double during the period between 2020 and 2040. Between 2012 and 2035, it is expected that the power sector will add more than 4TW of net capacity globally compared to the 2.8 TW global installed capacity in 2012. This will result in electricity related CO2 emissions increasing from 13.2 gigatonnes (Gt) in 2012 to 15.4 Gt in 2040. This while Paris Agreement signatories continue to work together to limit the effects of climate change which does not respect geographical country boundaries.

Without concomitant action to back the Paris agreement paperwork, it is expected that the average global surface temperature will exceed 3 °C relative to pre-industrialization levels during the current century. This is widely accepted as the critical limit at which irreversible damage to the planet will occur. It is expected that people in the poorest and most vulnerable countries, which are characterised by high levels of inequality (gender parity, housing, education, mobility, energy access and environmental protection) will be the most affected by the effects of climate change. This could further exacerbate the already existing global immigration problems which are in part driven by large inequalities between developed and developing nations.

This urgent situation is driving a transformation of the power sector enabled by the disruptive technologies of the fourth industrial revolution (4IR). For some decades now, Europe has been a global leader in pursuing actions to reduce the impacts of climate change. The lessons learnt present an opportunity to foster cooperative education and research between Africa and Europe in order to implement new solutions that will give electricity access to Africans that are most in need while simultaneously mitigating the climate change risks.

This presentation discusses the above different aspects and suggest areas for cooperative activities that can enable upskilling of people and transfer of knowledge and technology. The presentation also discusses how use can be made of CO2 trading between Signatory Parties of the Paris agreement to develop common projects in this framework

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FRAMEWORK FOR ASSESSING THE SUSTAINABILITY OF END-OF-LIFE MANAGEMENT ALTERNATIVES FOR CRYSTALLINE SILICON PHOTOVOLTAIC PANELS

Kishore Ganesan[1], **César Valderrama**[1,*]

Keywords: PV panel Recycling, Multi Criteria Decision Analysis, stakeholder survey, sustainability, SDGs

ABSTRACT

Solar Photovoltaic systems create a positive impact by bringing energy equity, security, and environmental sustainability to societies across the World. Given the volume of installations currently and those expected in the future, there is an undeniable need to manage the end of life solar panels sustainably. PV recycling technologies are still in their nascent stage with their validation in lab and pilot scales. There is also dearth of data available on PV panel processing at the end of life stage. The existing Life Cycle Analysis (LCA) framework is mostly retrospective with the expectance of detailed data, which is obtainable only from mature systems/technologies.

Anticipatory Life Cycle Analysis (a-LCA) accommodates the uncertainty involved with an emerging technology and utilizes stakeholder engagement throughout the analysis. Anticipatory LCA is carried out to identify the most sustainably preferred waste management option for crystalline silicon Solar PV panels in India by ranking among options like landfilling, mobile or decentralized recycling, centralized recycling and high value recycling that enables close to 100% material recovery. The ranking is carried out through Multi Attribute Value Theory using environment, economic and social indicators developed from Sustainable Development Goals (SDGs).The indicators are then prioritised through stakeholder consultations via online survey and quantified through LCA, literature review, and expert interviews as shown in Figure 1. The online survey was conducted with a diverse group of stakeholders representing the solar PV supply chain with an aim to understand the drivers, barriers and enablers for end of life management of PV panels along with the design and market trends affecting the same.

The a-LCA analysis suggested that high-value recycling is preferrable among the various other waste management options. High-value recycling is high rated among social and environmental criteria but lacks in economic criteria. A sensitivity analysis was performed to analyze the robustness of the developed model. The subjectiveness of the stakeholder preferences in the survey was reflected in the delicate nature of the model. The results from this a-LCA analysis can be used to provide feedback to recyclers, technology developers and research funders to re-orient R&D strategies and sustainably develop end of life management of PV panels.

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THE USE OF HYDROGEN FOR VEHICLE PROPULSION

Marek Brzeżański[1,*]

Keywords: hydrogen fuel cells, Toyota Mirai, ambient temperature

ABSTRACT

The presentation presents various possibilities of using hydrogen as a fuel to drive motor vehicles. The results of the tests of hydrogen fueled combustion engines are discussed. The first in Poland operational tests of a Toyota Mirai powered by hydrogen fuel cells was presented. The results of tests of the Toyota Mirai car carried out in a thermoclimatic chamber at low ambient temperature are discussed.

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SEASONAL THERMOCHEMICAL HEAT STORAGE SYSTEM FOR LOW – TEMPERATURE SPACE HEATING BASED ON RENEWABLE ENERGY (SEASTOR)

Łukasz Bondar[1,]*, Anna Włodarczyk[1]

Keywords: heat storage, thermochemical reactions, seasonal storage, solar collectors

ABSTRACT

The SEASTOR project was performed under the Measure 1.2: Sectoral R&D programmes of the Smart Growth Operational Programme 2014-2020 co-financed by the European Regional Development Fund, by a consortium composed of: Instytut Chemicznej Przeróbki Węgla (Consortium Leader) and PGE Polska Grupa Energetyczna S.A. (member of the Consortium). The aim of the project was to develop an innovative technology that allows storing of excess solar radiation energy in the summer and its utilizing during the heating season by using a thermochemical heat accumulator operating in seasonal cycles. The completed and planned R&D works included, among others: development of heat storage material, development of a reactor for the material, development of the SEASTOR system integrating the reactor with a solar collector system and a ventilation heating system for a single-family house, construction of a pilot scale installation with its tests and development of guidelines for serial production. As part of the project, a technical and economic analysis of the solution was performed, supplemented with a comparison of the estimated CAPEX and OPEX costs of the SEATOR system with alternative widely used heating technologies for single-family houses (heat pump, system heat, electric heater). In order to achieve profitability for the end user, it is recommended to conduct further research on increasing the relative storage capacity of the material, which may contribute to reducing the cost and overall dimensions of the reactor, as well as expanding the potential market for the discussed solution.

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LONG TERM PROSPECTS of ENERGY SYSTEMS

Wojciech Suwała[1,*]

Keywords: Environmental policy, European Green Deal, Impact assesment

ABSTRACT

The paper discusses the selected aspects of European Green Deal, especially for the vulnerable energy and fuels sectors. The Green Deal refers not only to these sectors but as emissions from fuels and energy production as well as impact on environment are considerably larger than in other sectors they would be affected most. Reaching the targets of Green Deal, especially carbon neutrality, requires significant changes in the energy production. The number of papers and studies have undertaken the quantitative evaluation of such a radical change as decarbonisation of energy production. The aim of the paper is to review results of these works to present estimates of potential increases of costs of energy and environmental effects e.g. reduction of emissions of majority of pollutants.

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ENERGY FUELS ENVIRONMENT 2020
AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY, CRACOW UNIVERSITY OF TECHNOLOGY
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ANALYSIS OF SECTORAL ENERGY CONSUMPTION COEFFICIENTS IN THE POLISH REGIONS

Janusz Sowiński [1,*]

Keywords: energy consumption, forecasting

ABSTRACT

The structure of the power industry is extremely complex today, with a number of qualitatively different elements tied on many levels [1]. With respect to economic and technological criteria, it is possible to substitute one kind of fuel or energy by another at the stage of the final consumption. Owing to easy access to modern technologies and a wide supply of power devices and electrical appliances on the market, consumers can avail themselves of different forms and carriers of energy to fulfill their needs. When analyzing energy consumption in a region, it is therefore essential to take into account price relations among energy carriers, development in the technology of obtaining and transforming energy, as well as problems resulting from the increasing popularity of distributed electricity generation based on renewable energy sources. These factors, encumbered with high uncertainty, have impact on the future demand for energy. To fulfill that demand, power industry companies have to plan future investment, keeping in mind that insufficient infrastructure both in power plants and networks may significantly hamper development and progress in regional economy, leading to far-reaching consequences. The market principles of regional economy, including power industry, call for specific functions to model energy balance. Classic analytical methods are no longer applicable, since forecasts have to include uncertainty and various forms of risk [1].

Statistical report published by Główny Urząd Statystyczny (Statistics Poland, abbrev. GUS), concerning power use in Poland [2], comprises four main sectors of electricity consumption: industry, transport, agriculture and households, apart from other use. The data published by GUS form Bank of Local Data [2]. They are grouped according to the division of the country into units (voivodeship) and according to the category, such as natural resources and power industry. In the latter category, the data include total installed power capacity, power generated in plants, electricity generation from particular sources and electricity consumption in the sectors of economy. It also states basic energy consumption rates, such as total consumption per capita or industrial consumption per 1 m. PLN of added value. These rates are indispensible for monitoring power consumption and managing it in a way ensuring sustained development. The analysis of power consumption rates of various degrees of aggregation is also necessary for forecasting energy consumption by means of *end-use* type models [1, 3-5].

Variations of power consumption rates are dynamic processes with random perturbations. They can be modeled by means of stochastic differential equations [6]. Some results of simulation with comments and conclusions are presented.

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The emerging hydrogen economy in UE countries

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Keywords: hydrogen, fuel cells, electric cars, energy carrier

ABSTRACT

The increasing climate changes cause the shift towards low-emission energy systems. Hydrogen and fuel cells are the most important branches of the development of renewable energy sources. The present status of hydrogen as a clean, flexible energy carrier is discussed. Special attention is paid to advances in the field of hydrogen production, storage, and utilization involving conventional and emerging technologies. The emerging hydrogen industry demands safety considerations, potential regulations, the development of new fields of study, and education. Hydrogen is used for stationary applications CHP systems, transport applications such as electric cars, heavy-duty transport, marine ships, drones, aircraft, and other aviation as well as for applications in special services. Emerging technology needs the development of new: (i) materials for electrochemical process; (ii) chemical compounds; (iii) methods of fabrication enabling improvement of durability and reduction of costs; (iv) nanomaterials; (v) new composite materials; (vi) analytical methods and techniques for the characterization of compounds. The current status of hydrogen economy development in the UE countries as well as in Poland will be discussed.

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PRIMARY ENERGY CONSUMPTION IN SELECTED EU COUNTRIES COMPARED TO GLOBAL TRENDS

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Keywords: primary energy, consumption, energy policy

ABSTRACT

The consumption of primary energy was once seen as a determinant of the state's civilizational development. The economic progress of individual countries was measured in terms of both primary and secondary energy consumption, the use of coal and steel and electricity. In later years, it was realized that such a constant drive for development through an unrestricted increase in the use of natural resources is inefficient and harmful to the world around us. Therefore, actions are taken to protect natural resources through their efficient use. Why obtain more and more resources from the environment when you can use what you have more efficiently? The article shows the consumption of primary energy carriers in selected European Union countries, including Poland. The trend of consumption of primary energy carriers was compared with the global trend which is different from that observed in the European Union. The consumption of primary energy sources has been increasing steadily for many decades due to the growth of the world population and the aspirations of developing countries to raise the standard of living of their citizens. In the European Union, the opposite trend has been observed since 2007, i.e. a decrease in primary energy consumption. The article presents tables and graphs showing these phenomena. The authors tried to answer the following questions: (a) What influences the decrease in demand for primary energy in highly developed countries? (b) Why the demand in less-developed countries is constantly growing? The trends in countries such as Germany, France, Great Britain, Italy, and Poland, i.e. countries with the most developed economies in the European Union and the home country of the authors of the article, were analyzed.

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COMBINING LONG AND SHORT-TERM PLANNING METHODS TO DESIGN A PATHWAY TO CARBON NEUTRALITY IN A COAL-BASED POWER SYSTEM

Artur Wyrwa[1,*], Wojciech Suwała[1], Marcin Pluta[1], Stanisław Tokarski[2], Janusz Zyśk[1], Maciej Raczyński[1]

Keywords: power system, modelling, capacity expansion, unit commitment and economic dispatch, carbon neutrality

ABSTRACT

Achieving carbon neutrality requires a deep transformation of power systems in the next 20-30 years. This constitutes a real challenge, especially in power systems that are still dominated by coal power plants. The development of a robust plan for the transformation of such systems into sustainable RES-based systems requires the use of both: long-term strategic planning and short-term operational planning methods. The former should take into account a number of conditions that shape the future structure of electricity generation, such as climate and energy policy objectives, macroeconomic factors, the economics of power generation, RES potentials, changes in demand and load profile of end-use sectors, etc. Most often the strategic planning problems are tackled with the use of capacity expansion optimization models. Such models provide results including quantities and timing for new electrical capacity additions as well as retirement plans for existing generation assets. Unfortunately, these types of models, due to computational burden associated with their large size, neglect the system dynamics and detailed technical operation constraints. They can be, however, complemented by the latter, i.e. short-term operational planning methods addressing the unit commitment and economic dispatch problems. This paper proposes an approach in which long and short-term planning models are combined into a one modelling system to validate whether the results of the capacity expansion models ensure a proper functioning of power system impacted by the RES intermittency. The capabilities of this system were demonstrated for the Polish power system, which has been chosen for several reasons. Firstly, Poland is the only EU Member Stated that has not yet shared the EU objective of reaching carbon neutrality by 2050 agreed by the European Union Council. Secondly, still approx. 77% of electricity in Poland is produced from hard coal and lignite. Thirdly, in the period 2021-2035 a permanent decommissioning of about 16.5 GW of electrical capacities mostly in coal units is planned. Taking into account the electricity demand forecasts, this means that nearly 33.5 GW of new electrical capacity (i.e. ca, 70 % of total electrical capacity installed in 2020) has to be restored in low-carbon and renewable technologies until 2035. Three scenarios for the transition of the Polish power system towards carbon neutrality have been elaborated in the paper. First one was coherent with the Polish Energy Policy until 2040 (PEP40). After that period, the target was set of 85% cuts in CO_2 emissions from power sector by 2050 compared with 2005. The second scenario had a similar target but assumed delayed construction of nuclear units foreseen in PEP40. Finally, the third scenario assumed reaching carbon neutrality of the Polish power sector by 2050. The overall result of the study is that the targeted reductions in CO_2 emissions were achieved in all the scenarios with moderate increase of electricity generation costs.

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THERMOCHEMICAL CONVERSION OF SELECTED REFUSE DERIVED FUELS IN THE PROCESS OF STEAM CO-GASIFICATION TO HYDROGEN-RICH GAS

Adam Smoliński[1,]*, **Natalia Howaniec**[2], **Rafał Gąsior**[3]

Keywords: waste utilization; waste valorization; hydrogen; energy; coal; flotation concentrate; municipal waste

ABSTRACT

Low rank coals may be considered as by-products of coal extraction. Since the economic attractiveness of such coals is limited they are commonly stored at excavation heaps causing additional costs and risk of an endogenous fire occurrence. Flotation concentrates are also a waste material related to coal production. The municipal waste constitute another abundant and problematic waste material related to human activity. All of them are however also valuable carbonaceous materials. The environmental friendly and economically sound options of their utilization should be developed. In the paper several low rank coals, flotation concentrates and a municipal refuse derived fuel were tested in terms of their reactivity in the process of steam gasification. The reactivity of studied low rank coals and flotation concentrates at 50% of carbon conversion, R_{50}, varied between $1.46 \cdot 10^{-4}$ and 2.39·10-4 s^{-1}, whereas the maximum reactivity, R_{max}, changed from $3.28 \cdot 10^{-4}$ to 4.62·10-4 s^{-1}. The mathematical models were developed to investigate the similarities and dissimilarities between studied fuels as well as the relations between physical and chemical parameters and reactivates of fuels chars in steam gasification. On this basis a low rank coal was selected and applied in fuel blend with 20%w/w of municipal refuse derived fuel and tested in co-gasification experiments focused on hydrogen-rich gas production, as an energy carrier applicable in power and in transportation sectors.

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DEEP BIOGAS CLEANING FOR EXPLOITATION IN HIGH TEMPERATURE FUEL CELLS: THE DEMOSOFC PROJECT EXPERIENCE

Marta Gandiglio[1,*], Massimo Santarelli[1]

Keywords: biogas, fuel cell, cleaning, purification, contaminants removal

ABSTRACT

The presented work aims at describing the biogas cleaning system designed, tested and analyzed within the DEMOSOFC project. The biogas cleaning unit was designed to feed a 150 kW Solid Oxide Fuel Cell system and was operated for more than 10'000 hours in a real industrial environment in the framework of the DEMOSOFC EU project [1], where the first industrial size biogas-fed SOFC system in Europe was installed. The biogas is produced onsite from the wastewater treatment, through the anaerobic digestion of primary and secondary sewage sludge. The cleaning system is based on adsorption on activated carbons and it was designed, in terms of material selection, after a one-year experimental campaign devoted to the analysis of the adsorption capacity of different commercially available sorbents: the materials were selected by doing a cost-performance comparison. The key contaminants to be removed are sulphur and silicon molecules, H_2S and siloxanes. The cleaning unit was constructed by the Italian company Biokomp srl. A continuous online gas analyzer was also installed to detect the raw and clean biogas composition. After more than 10'000 hours of operation results have been analyzed and are here presented: the system has not yet reached breakthrough time, and the sorbents are still operating according to the initial specifications. The current loading rate of the first two vessels is 35% of the maximum value measured in the experimental phase for H_2S and 1.8% for siloxanes, confirming the optimal design of the cleaning unit. Future scenarios were the system cost can be reduced of 50% by optimizing the design are also presented.

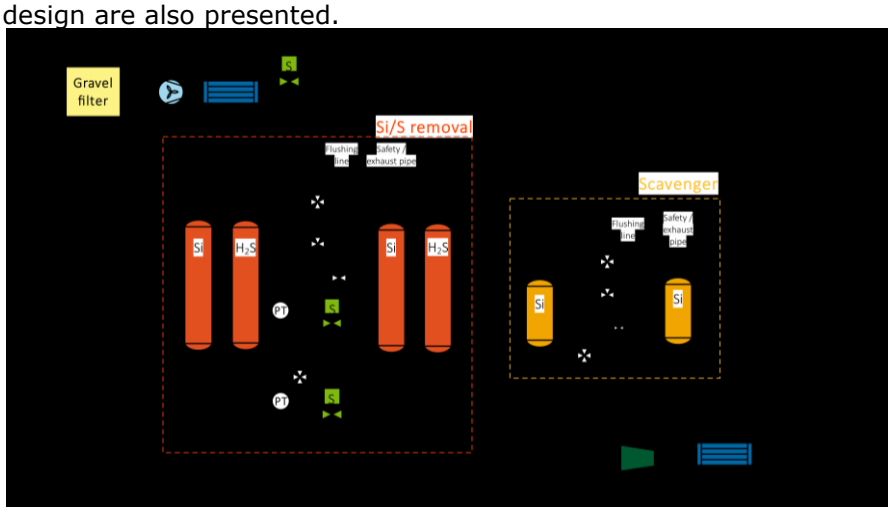

Figure 1. Biogas cleaning unit for exploitation in the SOFC system.

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MERCURY DISTRIBUTION IN THE PROCESSING OF NON-FERROUS METAL ORES

Krzysztof Kogut[1,*], Barbara Tora[2], Adrianna Bigaj[1]

Keywords: mercury, flotation, non-ferrous metal, copper, zinc, lead

ABSTRACT

Non-ferrous metallurgy is one of the main sources of anthropogenic mercury emissions. It is responsible for about 4% of mercury emissions in the European Union. In the case of Poland, this share is about 9%, but it is still the second largest source of mercury emissions. This is due to the high mercury concentration in non-ferrous metal ores.

The following processes are carried out during the preparation of non-ferrous metal ore for smelting: grinding, milling, enrichment, and drying of the concentrate. Enrichment has the greatest influence on the mercury content of the product to be smelted. During this process, materials that deteriorate the properties of the ore are removed. One of the enrichment processes is flotation, whose influence on the mercury content has been studied.

During the experiments, 2 types of copper ores and 2 types of zinc and lead ores were examined. Mercury concentration in the feed, products and waste was determined. The flotation process was also checked and on this basis process balances were made: mass, mercury and metals. Mercury concentrations in non-ferrous metal ores are several times higher than in other raw materials. In copper ores they are about 800–1000 μg/kg and in zinc and lead ores they are up to 10 mg/kg.

During the research, a different behaviour of mercury in the flotation process was also found. In the case of the examined copper ores, the mercury content in the concentrate increased significantly (up to even 9000 μg/kg) and decreased in waste (concentration of 230 μg/kg). The concentration of copper changed in a similar way: about 9% in the feed, 45% in the concentrate, and 2% in the waste.

In the case of zinc and lead ore, the situation was different. In concentration, the mercury content decreased slightly (by about 4–12% depending on the ore), with slight changes in metal content. In waste, the mercury content was not clear and depended on the ore. Both a decrease in concentration by about 25% and an increase by about 60% were observed. With similar nature of metal content changes.

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ASSESSMENT OF THE CATALYTIC EFFECT OF VARIOUS BIOMASS ASHES ON CO_2 GASIFICATION OF TYRE CHAR

Grzegorz Czerski[1], **Katarzyna Śpiewak**[1,*], **Przemysław Grzywacz**[1], **Faustyna Wierońska-Wiśniewska**[1]

Keywords: tire-char, CO2 gasification, biomass ashes as catalysts, TGA

ABSTRACT

Waste tyres are a growing, global environmental problem. At the same time, they are characterised by high calorific value and a high potential for thermochemical processing, e.g. pyrolysis, the main products of which are oil and char. The oil from pyrolysis can be used as low-grade fuel in boilers or can be fractionated to gasoline, diesel and heavy oil. The use of tyre char, however, is much more challenging due to its low reactivity. Therefore, the aim of this study was to determine the effect of various biomass ashes, comprising catalytically active components, on tyre char reactivity during the CO2 gasification process. Ashes from the combustion of corn cobs, beet pulp, sunflower husks and beech chips were selected for the research. Moreover, industrial fly ash from a coal-fired power plant was used as a reference. The tyre char-ash blends with different content of ash were gasified in CO2 atmosphere under non-isothermal conditions using dynTHERM Rubotherm thermobalance. The results obtained showed that the addition of biomass ashes enhanced the reactivity of tyre char, and the magnitude of these changes was dependent on both quantity and type of the additive. In turn, reference fly ash from a power plant hardly affected the course of CO2 gasification of tyre char.

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CURRENT TRENDS IN THE CHEMICAL UTILIZATION OF CARBON DIOXIDE CO_2

Bogdan Samojeden[1,*], **Teresa Grzybek**[1], **Monika Motak**[1]

Keywords: carbon dioxide, utilization, CCS, CCU

ABSTRACT

The harmful influence of CO_2 on climate is generally recognized. There are two strategies to deal with the problem: CCS – CO_2 Capture and Storage and CCU – CO_2 Capture and Utilization. The latter can lead to added-value products, thus treating carbon dioxide not as a pollutant but valuable resource. This may be especially beneficial in case of production of fuels or their precursors, both gaseous and liquid. However, CO_2 is a very stable molecule and therefore its processing requires catalytic methods, with catalysts both active and stable. The presentation discusses the current literature trends in production of methane, methanol and syngas, with main attention paid to new catalysts, as well as industrial application perspectives.

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FLUIDISED BED OF LIGHTWEIGHT EXPANDED CLAY AGGREGATE DEDICATED TO COMBUSTION OF LOW-DENSITY WASTE

Gabriela Berkowicz-Płatek [1], Witold Żukowski [1], Krystian Leski [1,*]

Keywords: fluidisation, lightweight expanded clay aggregate, thermal degradation

ABSTRACT

Generally, the waste management industry and the scientific literature use fluidised beds (made of materials such as sand and alumina) that are not suitable for combustion of low-density waste. Low-density wastes float on the fluidised beds surface and, consequently, their combustion takes place in the freeboard [1,2]. Therefore to take advantage of the properties of the fluidised state in full, it is necessary to adjust the bed density to the density of the degraded waste. Furthermore, the new bed material must also be resistant to the intense movement of grains and high temperatures.

The aim of this study is to create a space of fluidised bed where low-emission combustion of low-density materials (such as polyolefins) could be carried out. An innovative idea of the study is to use a lightweight expanded clay aggregate (LECA) as fluidised bed material. The LECA is a lightweight construction aggregate made of expanded clay [3]. The material grains with a size of 4 mm have a loose bulk density of 480 kg/m^3 [4]. This study determines the ability of the LECA material to fluidise. The grain sizes were defined. The minimum fluidisation velocities were examined experimentally, and the obtained values were compared with the values calculated from the correlation known from the literature. The terminal fluidisation velocity was determined based on the Rozumov correlation [5]. The shape of the grains was examined using scanning electron microscopy, and their density was determined using a helium pycnometer.

The validity of using the LECA material for fluidised bed combustion of low-density materials was tested on the burning polyolefins. It has been proven that the polymer pellets freely sink into the fluidised bed, and the ongoing process takes place inside the bed.

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THE CCUS CHAIN EVALUATION IN CASE OF REDUCTION OF CO_2 EMISSION IN POLAND

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Keywords: carbon capture storage and utilization, climate change, CO_2

ABSTRACT

Climate changes are one of the most important worldwide issues. Especially today, all available tools and technologies should be developed towards the reduction of CO_2 emission. The ambitious goal set by the Paris Agreement in 2016, to keep the temperature rise well below 2°C, can be met only using Carbon Capture Storage and Utilization (CCUS) technology. This approach relies on capturing the CO_2 from stationary sources and distributes it to different utilization or storage options. Also, the CO_2 Capture and Utilization (CCU) technology already offers resource conservation by reducing the need for extracting CO_2 from other sources. A wide range of literature studies have been undertaken, reviewing the latest global reports and the newest articles. The primary focus of this paper is to evaluate the CCUS chain, as a tool to address the climate changes. This critical review also discusses issues of technology maturity and availability, its costs and optimization of the CCUS chain. Moreover, it outlines potential environmental and economic benefits for Poland from applying CCUS technologies.

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DEPENDENCE OF THE MOLECULAR COMPOSITION OF THE GAS EMITTED DURING SELF-IGNITION PROCESSES ON THE TEMPERATURE IN THE COAL WASTE DUMP: EXAMPLE FROM UPPER SILESIA, POLAND

Dariusz Więcław[1,*], Krzysztof Jurek[1], Adam Kowalski[1], Monika Fabiańska[2], Justyna Ciesielczuk[2], Magdalena Misz-Kennan[2], Adam Nádudvari[2]

Keywords: coal waste, gaseous pollutants, self-heating, Upper Silesia

ABSTRACT

Coal waste dumps have become a part of the Upper Silesian Coal Basin (USCB) landscape, where mining has been carried out for over a century. Deposited coal wastes are subjected to secondary processes that may result in the formation of harmful gases and odors during self-heating and self-ignition becoming a large environmental problem.

The study was conducted in a coal waste dump located in the Bytom city (USCB, Poland) [1]. Twenty gas samples were collected with a soil gas probe from a depth between 0.5m to 1.0 m to 1-Liter Tedlar® sample bags from the non-heating, currently burning, and overburnt dump parts. The temperature measurements on the ground and 0.5-1 m subsurface were conducted. Identification of gaseous pollutants (CO_2, CO, hydrocarbons (HC), H_2S, COS, thiols and organic sulphides) was carried out using a set of gas chromatographs equipped with FID, TCD and FPD detectors.

The dump temperature increased from 21°C in the non-heating zone to 457°C in the currently burning part and it ranged from 50 to 375°C in the overburnt material.

CO_2 is the main pollutant: its content in gases occurring within dump varies from 0.05 to 9.45% (av. 2.64%). The highest concentration was recorded usually in the pre-burning (self-heated) parts at temperatures ca. 60-150°C and locally in overburnt areas. Methane is the second important pollutant with concentrations up to 2.37% (usually above 0.5%) in the pre-burning zone. The presence of the H_2 (up to 0.98%) and CO (up to 0.57%) in the pre- and currently burning areas is not only the result of the incomplete combustion of the organic material but also the gasification process ($C+H_2O=CO+H_2$). In the pre-burning zones, saturated and unsaturated hydrocarbons up to C_7 were recorded indicating pyrolysis of coal before the main phase of burning. The sulphur-containing compounds (H_2S, COS, mercaptanes and organic sulphides) occur in variable amounts. The highest concentrations of H_2S (from 14.8 to 1052 vol. ppm) and COS (from 0.52 to 12.6 vol. ppm) were recorded in the direct vicinity of the burning area. Mercaptanes and organic sulphides were recorded only in this zone. The presence of the S-compounds in zones below 100°C is the result of their migration from a burning area.

Presented results helped to understand and evaluate the emission of organic and inorganic pollutants during self-heating and self-ignition of the stored coal wastes. The most dangerous for the environment is the pre-burning phase connected with the emission CO_2 as well as hydrocarbons and S-containing compounds.

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ENVIRONMENTAL CHARACTERISTICS OF MARINE DIESEL ENGINE FUELED BY BUTANOL

Tomasz Kniaziewicz[1,]*, Ryszard Zadrąg[1], Artur Bogdanowicz[1], Paweł Wirkowski[1]

Keywords: combustion engines, exhaust emission, biofuels

ABSTRACT

Recently, recession in global economy might be observed. It is related to a disturbance in the international logistic system mainly caused be the Covid-19 pandemic. Fortunately, this does not apply to sea transport. Despite some turbulences, dynamic development of this economy branch can still be observed. However, this has an impact on the natural environment, as ships are rapidly becoming the largest source of air pollution in the EU. By the end of 2020, emissions of sulfur dioxide and nitrogen oxides from ships are estimated to exceed land-based emissions in Europe. Therefore, it becomes imperative to take the steps necessary to solve this problem. The activities are carried out in two ways. Firstly, efforts are made to develop more and more perfect technologies to reduce pollutant emissions. Secondly new energy sources are sought, including fuels from renewable sources. This group includes biobutanol as a product of biomass fermentation. Some of its physicochemical features, such as the ability to mix with hydrocarbon fuels, predestine it to be used as a fuel component to power piston engines, including marine diesel engines.

The article presents ecological characteristics of the Sulzer 6AL20/24 marine diesel engine fueled by a mixture of n-butane and diesel fuel. An important issue is the selection of the composition and methods of producing this mixture. The problems which have to be solved during selection of n-butanol content in the fuel mixture for a specific engine (with specific features of the operation), is selection in such a way that, at the desired level of toxic compounds emission and particulates will be achieved. Moreover, the impact on the engine operation parameters have to be as small as possible. The mixture composition selection problem was solved by analyzing the experimental data. On this basis a multiple regression models were built. It enabled the study of the effects and interactions between the model input values and the output variable.

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CATALYTIC TRANSFORMATON OF BIO-BUTANOL DERIVED FROM BIOMASS TO BUTENE ISOMERS

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Keywords: biomass, bio-alcohol, bio-butanol, catalysts, heteropolyacid

ABSTRACT

The idea of this study was the application of bio-butanol (bio-BuOH), produced from biomass, as a substrate in the catalytic and photocatalytic reaction. The Clostridium bacteria are used to convert biomass-derived raw materials to saccharides or polysaccharides which then are fermented to bio-BuOH - an environmentally-friendly substrate for alcohol conversion over acidic catalysts. The desired reaction products are cis-, trans-2-butene, and di-n-butyl ether (DNBE). Both butane isomers are commonly produced petro-chemically by catalytic cracking of crude oil. Therefore, the catalytic production of these olefins from biomass seems to be environmentally beneficial.

Our research aimed to design the efficient supported catalyst- heteropolyacid/TiO_2 for n-butanol conversion. The TiO_2 powders -hydrophilic P25 (Evonik) as well as the hydrophobic T805 (Evonik) were applied as supports. As an active phase of the catalyst, the heteropolyacid $H_3PW_{12}O_{40}$ (HPW) with a low surface area (5 m^2/g) was used. The supports were impregnated by an HPW solution, obtaining the high surface area catalysts: HPW/P25 (54 m^2/g), HPW/T805 (32 m^2/g), HPW/Fe-P25 (57 m^2/g). Each of them was tested in a gas-phase bio-butanol conversion at 120-200°C and their catalytic activities were compared (Figure 1). Additionally, the catalytic process was slightly enhanced by the photocatalytic effect due to the use of UV irradiation.

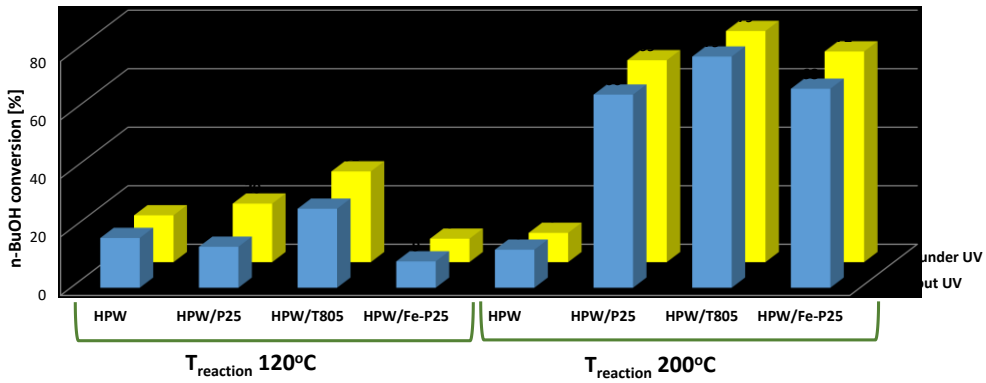

Figure 1. n-butanol conversion for particular catalysts at reaction temperature of 120°C and 200°C. Two series of catalytic data: without light and under UV light are presented.

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MODEL TESTS OF A MARINE DIESEL ENGINE POWERED BY A FUEL-ALCOHOL MIXTURE

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Keywords: mathematical modelling, marine diesel engine, fuel-alcohol mixture

ABSTRACT

The paper presents results of model and empirical tests of the marine diesel engine powered by a mixture of n-butyl alcohol, and diesel fuel. The research was aimed at assessing the adequacy of the mathematical model of a diesel engine developed by the authors. The model was originally created for the purpose of developing new diagnostic methods, and was adapted for the needs of research on fuelling marine engines, with mixtures of fossil and renewable fuels.

The researches were carried out according to the elimination plan in accordance with the theory of the experiment, where the input parameters were: rotational speed of the crankshaft, torque and concentration of the fuel-alcohol mixture. The analysis of the research results made it possible to conclude, that the model is adequate to the extent assumed by the authors in almost the entire scope of the research. The model inadequacy occurred only in a range of low engine loads with a torque not exceeding 10% of the nominal torque. As a result of the model tests, the following engine operation parameters were obtained as a function of the crankshaft rotation angle: indicated pressure, temperature inside the cylinder, torque, indicated power, crankshaft rotational speed. Moreover, the values of unitary and hourly fuel consumption, and the excess air coefficient were obtained.

As a result of the conducted research, the authors concluded that the developed mathematical model can be used in further work on the use of mixtures of fossil and renewable fuels in shipbuilding.

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MODIFICATION OF THE BIOBUTANOL PRODUCTION PROCESS FOR TRANSPORT APPLICATIONS

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Keywords: biobutanol, fuel, transport

ABSTRACT

The authors propose to investigate the possibility of replacing gasoline with biobutanol, which they synthesize. For this purpose, several methods of producing biofuel as fuel for internal combustion engines have been proposed. Biobutanol was obtained in the process of alcoholic fermentation with the use of selected substrates and bacterial strain.

For fermentation, a suitable strain of bacteria is required that is able to produce the desired product. Unfortunately, butanol is not the only product in the process, so it must be extracted using appropriate filtration and distillation techniques.

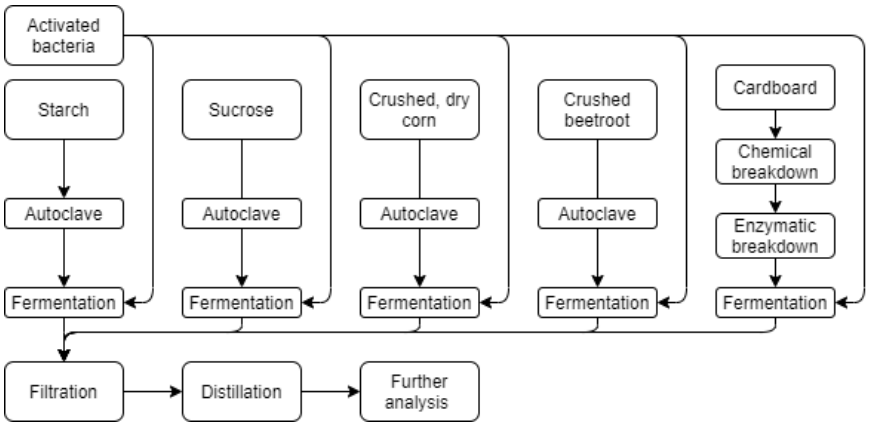

Figure 1. Modifications of biobutanol preparation

Obtaining this fuel is an inherently ecological process, as plant products are used. It is therefore a fuel similar to gasoline obtained with a significantly lower carbon footprint.

The choice of butanol as a fuel is motivated by its ecological nature. Both the process of obtaining fuel and the use of fuel are beneficial for the environment. Alcohol as a fuel is easy to transport and store. Butanol has transport advantages over the existing pipeline network compared to other alcohols used as fuel. Another advantage is the analogy to petrol for engines, so it does not require modification of its accessories.

The fuel must have appropriate properties, including energy storage, and the possibility of easy and beneficial conversion into mechanical energy. Butanol fits these criteria due to its similarity to the commonly used gasoline.

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MANAGING GREENHOUSE GAS EMISSIONS IN THE LIFE CYCLE OF MOTOR FUELS. REFINERY STAGE

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Keywords: greenhouse gases, refining industry, fuels, emission

ABSTRACT

Nowadays reduction of GHG (greenhouse gases) emission is crucial problem, mainly due to an extraordinary rise in the average temperature of the Earth which is observed in recent years. It seems that only effective way to reduce GHG emission is reducing it at each stage of life cycle, not only at final using stage. Crude oil refining industry and using of motor fuels contribute significant amount of GHG emission.

Therefore, there is a need to develop a tool to manage life cycle GHG emission. The lecture will present a way on how to identify GHG emission sources, allocate it to fuels, taking into account the complexity of refineries and the fact that one factor (e.g. yield) affects others.

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MODELLING OF A STAND-ALONE H2-BASED ENERGY STORAGE SYSTEMS FOR ELECTRICITY PRODUCTION AND H_2 MOBILITY

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Keywords: hydrogen, energy storage, power-to-power, power-to-hydrogen

ABSTRACT

The application of renewable energy sources (RES) during the last decades is increasing, with the aim to reduce carbon dioxide emissions and develop more sustainable energy systems. Referring to isolated microgrids and off-grid remote applications, because of the non-continuous RES production, energy storage systems (ESSs) are necessary to make the energy supply reliable and reach the energy self-sufficiency. Among the possible EESs, hydrogen-based storage solutions integrating electrolysers to produce hydrogen from surplus renewable energy and fuel cells to generate power from the stored hydrogen (called Power-to-Power systems) can represent a promising solution. The present study has the aim to analyse, from a technical and an economical point of view, a hybrid Power-to-Power and Power-to-Hydrogen system for a mountain off-grid village. The hydrogen is utilized in fuel cells for power generation to provide the electrical load of the site and also for mobility for fuelling a FCEV minibus line. The aim of this work is to find the optimal system configuration, with the minimum Net Present Value (NPV) at the end of system lifetime. The Levelized Cost Of Energy (LCOE) and the Levelized Cost Of Hydrogen (LCOH) are also computed, to understand the economic viability for electricity and mobility loads, respectively. These values were derived using cost inputs from literature, and a comparative analysis is performed for different system configurations. Results from the energy simulations revealed that the need for an external source is significantly reduced thanks to RES together with the hydrogen-based storage system, with zero emission respect to diesel solution and a cost of electricity slightly higher. Moreover, considering also a biomass-based CHP system as energy source, the cost is reduced more than three times. The cost of hydrogen for mobility instead, is still highly influenced by the lower development status of hydrogen technologies in the mobility sector.

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DEVELOPMENT OF AN ELECTROCHEMICAL MODEL OF AN ENERGY SOURCE MADE OF AN ELECTROCHEMICAL BATTERY AND HT-PEMFC FUEL CELLS POWERED BY PROCESS GAS FROM METHANOL REFORMING

Magdalena Dudek[1], Bartlomiej Lis[1], Andrzej Razniak[1], Mariusz Walkowiak[2], Rafal Grzeszczyk[3], Adam Wrona[3], Pawel Imilkowski[4], Jacek Madry[4], Jaroslaw Markowski[4,*]

Keywords: fuel cell, HT-PEMFC, battery, methanol reforming

A typical source of electricity for city cars are electrochemical batteries, where the available energy is typically 10 to 30 kWh and the range does not exceed 300 km. In this case, the challenge is to provide all electric vehicles equipped with electrochemical batteries with a source of electricity needed to charge the battery. One of the solutions to the above problem may be the use of fuel cell generators, apart from the electrochemical battery, whose task is to recharge the electrochemical battery in order to increase its range.

The objective of this thesis was to develop a model of electricity demand for various profiles of electric car use. Based on the developed model for the construction of the energy source, an electrochemical battery with a capacity of 20 kWh and a 5kW HT-PEMFC fuel cell stack powered by hydrogen gas from methanol reforming were selected. For this source, the analysis of individual profiles of electricity demand, expected hydrogen gas and methanol consumption was carried out. The charge-discharge curves for a 20 kW electrochemical battery were experimentally determined, as well as the operating parameters of the HT-PEMFC fuel cell stack powered by hydrogen from methanol reforming under static and dynamic conditions. The analysis of the distribution of electricity and heat from an energy generator with fuel cells depending on the electric power was performed. The preliminary studies of the charging process of the electrochemical battery with the current generated from a fuel cell powered by a methanol solution were carried out. The consumption of methanol solution during the battery recharging and the efficiency of the process of converting the chemical energy of the fuel into electricity stored in the electrochemical battery were determined. The efficiency of electricity converters was determined, which made it possible to recharge the electrochemical battery in a controlled and safe manner.

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ASSESSMENT OF THE TUG'S ENERGY DEMAND IN THE ASPECT OF ALTERNATIVE ENERGY SOURCES APPLICATION

Ryszard Zadrąg[1,*], Leszek Wontka[1], Jarosław Markowski[2], Paweł Wirkowski[1]

Keywords: ship, hybrid end electric vehicles, renewable energy

ABSTRACT

Ships are rapidly becoming the largest source of air pollution in the EU. It is estimated that by 2020 emissions of sulfur dioxide and nitrogen oxides from ships will exceed land emissions in Europe. It is necessary to develop technologies that will reduce emissions. Such technology will be an innovative hybrid energy generation system for the needs of ships. So far, no practical design for fuel cells on board of ships has been developed and almost no hydrogen fuel ships have been presented. The main obstacle is the immaturity of modern design solutions. The next drawback is the need to install large-capacity power plants on the facilities, which, in connection with ensuring the planned autonomy, raises further problems.

The aim of the project is to develop an innovative system for generating electricity using fuel cells, dedicated to supply vessels displaying operational parameters of high variability and a relatively short period of work with maximum load. A vessel that undoubtedly corresponds to this type of use is a port tug. The key element of the hybrid system will be the low-temperature fuel cells (Polymer Membrane Fuel Cell) powered by hydrogen produced on board in the methanol reformer. The use of the proposed energy system will help relieve the power grid by supplying floating vessels with methanol - liquid fuel, which is considered a "hydrogen carrier" or "chemical energy storage" that can be easily distributed using the existing distribution network of hydrocarbon fuels.

For the correct selection of individual components of the planned hybrid drive system, it is necessary to estimate the power required for the operation of "future electric tug". For this purpose, measurements of the propulsion system parameters of two "classic" port-shore tugs used in the Navy were made. Investigated vessels were, type H-900 / II tugs with a standard displacement of 185 t and tugs type H-960 with a standard displacement of 310 t. Both types of ships have a propulsion system consisting of a marine diesel engine driving through a reduction gear a variable-pitch propeller working in the Kort nozzle. Measurements of propulsion system parameters, including these tugs have been systematically made by the scientists employed in the Shipbuilding and Operation Institute of the Naval Academy from 1996. Results were used to prepare the propulsion characteristics of these tugboats with the Silukov method. Such characteristics are the basis for determining required useful power of similar units, equipped with any main propulsion system operating in all sailing conditions.

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POLARIZATION RESISTANCE ESTIMATION ALGORITHMS APPLICABLE TO THE ASSESSMENT OF THE STATE OF HEALTH IN LEAD-ACID BATTERIES

Piotr Ryś[1], **Krzysztof Kaczor**[1], **Michał Piszcz**[1], **Jacek Lipkowski**[1], **Piotr Biczel**[2], **Maciej Siekierski**[1]

Keywords: batteries, storage systems

ABSTRACT

Lead-acid batteries are commonly used in uninterrupted power supply (UPS) and other guaranteed voltage fed systems. Applications of this kind play a very important role in ensuring the operational reliability and safety of key infrastructure elements during short power shortages, or in providing time needed for the diesel generators to start up in the case of longer blackouts. However, for these solutions to work properly, the batteries that are their crucial part of should remain reliable during their whole operational time. As during their lifetime, batteries suffer progressive deterioration of capacity their State of Health must be periodically monitored. On the other hand they can, as well, suffer a sudden catastrophic failure (typically occurring upon load engagement). The latter failure mode if not predicted in advance (e.g. during the periodic check-ups) can lead to a severe consequences of an unexpected operational breakdown of the protected infrastructure happening in the course of the power shortage. A typical and commonly used method of the batteries assessment is based on their periodic controlled discharge by means of the external loads. This leads to either discontinuation of the infrastructure protection for the time of the check-up or creates a need of a costly system redundancy. Therefore, a need for a field applicable on-line test methods arise.

A common problem with lead-acid battery management is the difficulty in monitoring the said internal deterioration over time. A figure of merit - "State of Health" (SoH) was devised, which tries tie a numeric value with the progression of the ageing processes in the battery. Several methods have been devised that calculate the SoH and using such try to monitor the progression of the ageing process during the battery's life. The technique that was devised and is presented here is the "polarization resistance method". The key output of such technique is the polarization resistance of the battery estimated during the battery's partial discharge-charge sub cycle and then compared with both the reference values gathered for the just installed battery, as well as, with the values registered during all previous check-ups of the battery (or batteries) monitored. The resistance in the said method is calculated as the difference between the open circuit voltage and the voltage under a given load registered with the use of an intermittent current pattern.

This method at the current state has several flaws, one of which is lack of a proper algorithm for the assessment of the internal resistance. This disqualifies the usage of the graphical method in places with large amounts of batteries due to how time consuming the method is. To counteract this, an algorithm was devised capable of estimating the battery's internal resistance, dubbed the 'numerical method'. In turn these lead to a possible automation of the process and its viability to in-situ industrial applications in battery monitoring systems. A comparison of both methods was needed and an answer whether the 'graphical' and 'numerical' one produce similar results deeming them interchangeable. The further research tested the applicability of use of the 'numerical method' for a variety of lead-acid battery types and classes and it was found that the method was applicable for both the MF or VRLA batteries. Moreover, a model allowing to correlate the changes of the internal resistance of the battery with the deterioration of its capacity was built upon the data gathered.

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FORMAL, LEGAL AND TECHNICAL ASPECTS OF THE PROCESS OF PUTTING BACK INTO SERVICE OF BATTERIES WITHDRAWN FROM ELECTROMOBILITY

Mariusz Kłos[1,*], **Michał Piszcz**[2], **Martyna Smolarek**[2], **Krzysztof Zgrajek**[1], **Maciej Siekierski**[2]

Keywords: batteries, storage systems

ABSTRACT

The paper presents the formal, legal and technical aspects of the possibility of the reuse of the lithium-ion batteries withdrawn from the electric vehicles propulsion systems.

It describes the methodologies used to carry out diagnostics of the lithium ion batteries considered, as well as, an expert evaluation of the results of the analyses carried out on a sample lot of the said cells, defining finally the electrochemical conditions of the cells tested.

Carrying out in-depth electrochemical analyses of these cells makes it possible to assess the level of advancement of aging processes of active cell materials (mainly electrodes and electrolyte) and to select these cells in ordering them according to the depth of their wear and tear level, and therefore, to evaluate the level of their retained usefulness.

We also present and discuss the potential application areas of the selected batteries that can be put back into service according to the new second-life recycling standards.

The main suggested areas of application are stationary battery systems commonly referred to as battery storage systems, which enable the improvement of the functioning of the power grid infrastructure as a whole, as well, as assuring the auxiliaries of the particular sub-sectors of the economy being nowadays significantly dependent on electricity.

Their usefulness is particularly noticeable in the process of satisfying the current and future energy needs related to the new social ideas developed towards the fulfilment of the requirements of the green deal concept on the side of the end user of the electric energy.

Current trends related to the digitization of the successive areas of live force us to treat an increasing number of electricity receivers as the priority ones as they are the ones that ensure the stability of modern industrial and municipal and commercial processes.

It seems that the power supply to such receivers will be provided by means of dedicated local power microsystems with UPS functionality. The executive element determining the stable operation of such microsystems will be the electricity storage facilities integrated with them.

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PROTONIC TRANSPORT PROPERTIES OF THE PHOSPHSILICATE GLASS BASED COMPOSITES WITH HYDROGEN URANYL PHOSPHATE AND ARSENATE

M. Mroczkowska-Szerszeń[1*], R. Letmanowski[2], P. Ryś[2], M. Piszcz[2], W. Pudełko[2], A. Krztoń-Maziopa[2], A. Zalewska[2], M. Dudek[3], M. Siekierski[2]

Keywords: hydrogen uranyl phosphates (HUP), hydrogen uranyl arsenates (HUAs)

ABSTRACT

Hydrogen-fed fuel cells are promising but technologically demanding sources of electric power. For low power range devices, proton-exchange membrane fuel cells (PEMFCs) are nowadays attracting the greatest deal of interest, as they are capable of producing high power densities while operating at low temperatures. However, the operation of a miniature fuel cell at temperatures significantly exceeding 100 °C would be an attractive technological solution due to the higher tolerance of platinum catalysts for carbon monoxide (CO) and sulphur-containing hydrogen contaminants, faster electrode kinetics, greater energy efficiency and simplified heat management. It is believed that for an operational temperature above 150-170 °C, the first of these features will allow for utilization of a hydrogen fuel originating from an on-site reformer fed with natural gas. The increase of temperature operation of hydrogen-oxygen fuel cells is also important for the development of m-CHP units involving fuel cells for stationary and mobile applications. Amongst various materials tested as electrolytes working in the said temperature range, an inorganic glassy conductor comprising interpenetrating networks of poly-silicate and poly-phosphoric acids seems to be highly promising due to its extreme electrochemical stability under operational conditions.

On the other hand, uranospinite type materials such as hydrogen uranyl phosphates (HUP) and hydrogen uranyl arsenates (HUAs) are crystalline materials known for exhibiting rotational and translational diffusion of water and oxonium ions and, therefore, able to provide protonic conductivity according to the Grotthus mechanism present, as well, in the above-mentioned glasses. It should also be noted that, in spite of the outstanding protonic properties of HUP and HUAs, studies devoted to their utilization have stopped due to their uranium content. The eventual release of this element can be significantly hindered by the encapsulation of the HUP/HUaS grains in a chemically inert matrix. Therefore, it was worth investigating the properties and application potential of a composite material comprising the glassy matrix and the dispersed crystalline phases, both being protonic conductors in the desired temperature range.

HUP and HUAs were synthesized by means of wet synthetic route while the phosphor-silicate glass was obtained according to the previously described synthetic route. The composites were prepared through mechanosynthesis performed in an ultra-high velocity planetary mill by Fritsch (Pulverisette 7 Premium Line) by a high energy grinding technique. The resulting powdered materials contained form 10 to 80 % of the crystalline phase. They were later examined employing DSC, XRD and FT-IR. The latter two techniques were applied both to the just-synthesized materials, as well as to the samples annealed previously at 250 °C, finally delivering the characterization of the thermal stability of the materials studied. On the other hand, the immittance properties were investigated after pressing the composites into thin pellets. Both the ionic conductivity and the dielectric relaxations occurring in the material were investigated in the temperature range spanning from ambient to 250 °C, thus, slightly above the limit of the applicability of the material. Interesting phenomena related to the interphase charge transport were found in the materials studied, being dependent on both temperature and the composition of the samples under investigation.

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REVERSIBLE SYMMETRICAL SOLID OXIDE ELECTROCHEMICAL CELLS FOR ENERGY STORAGRE AND CONVERSION

Kun Zheng[1,2,*]

Keywords: solid oxide electrochemical cells, reversible SOFCs, symmetrical SOFCs, redox-stable electrode materials

ABSTRACT

The energy generation by combustion of fossil fuels brings many serious environmental problems, and the depletion of those fuels urgently requires the development of new, alternative clean and green energy production means. Solid Oxide Cells (SOCs) are among the most promising technologies for both, electrical power generation from renewable and traditional energy sources (by operation in fuel cell mode), and clean efficient fuel production (in electrolysis mode). Reversible SOCs can produce/consume a wide variety of fuels including hydrocarbons, which can be provided in the existing infrastructure - not only hydrogen, unlike most other types of reversible fuel cells. The symmetrical SOC configuration with the same electrode material simultaneously applied at both, cathode and anode, is very promising, due to numerous advantages including a reduced number of different cell components, a considerable simplification of the manufacturing process, and alleviation of the problems associated with the chemical stability of materials. This should allow reducing the production costs and ensuring stable, long-term operation of the symmetrical SOCs. Also, one of the most important advantages associated with the application of symmetrical cells is the possibility to address problems related to sulfur poisoning and carbon deposition, by simple reversing of the gas flows to clean the system, which is especially suitable in the case if the cells are fueled by uncleaned and lower quality non-hydrogen fuels [1-3].

In this study, Fe- and W-containing perovskites were systematically investigated as novel redox-stable electrode materials for reversible symmetrical SOCs. Phase composition, crystal structure, oxygen content, transport properties, chemical stability in relation to electrolyte, and chemical stability of the proposed materials under reducing/oxidizing atmospheres were studied. Good electrochemical properties were recorded for the constructed reversible symmetrical SOCs.

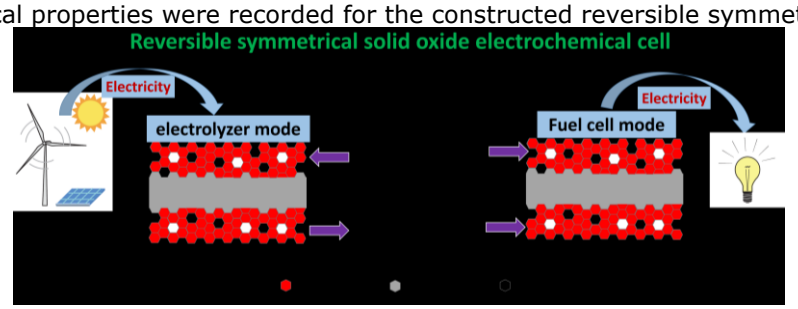

Fig. 1. Reversible symmetrical solid oxide electrochemical cells for energy storage and conversion.

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TOWARDS THE STABILITY OF AIR ELECTRODE IN SOLID OXIDE CELLS BY BSCF INFILTRATION INTO MICROPOROUS SDC BACKBONE

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Keywords: Solid oxide cells, Oxygen electrode, BSCF, SDC porous backbone, infiltration

ABSTRACT

Reaching the ambitious net-zero greenhouse gas emissions objective by 2050 will require the use of several cost-effective new technologies. With the widespread diffusion of renewable energy sources, the conversion of excess power into fuels and chemicals is considered one of the most promising schemes where solid oxide cells (SOCs) are a key point due to their high versatility and efficiency.

Barium strontium cobaltite-ferrite ($Ba_{1-x}Sr_xCo_yFe_{1-y}O_{3-\delta}$, BSCF) is a widely studied mixed ionic-electronic conductor material used as oxygen electrode in solid oxide cells to perform the reduction and evolution of oxygen. Despite having excellent features as electrocatalyst, favoring the oxygen reaction, *i.e.* rapid oxygen bulk diffusion and surface exchange kinetics, it lacks long-term stability due to mismatch between the thermal expansion coefficient (TEC) of the electrolyte and the electrode, which leads to electrode delamination [1,2], and to structural transformation at temperature lower than 900 °C [3] which increase electrode polarization.

In this work, the cell stability was studied by adding a thin porous samarium-doped ceria ($Ce_{0.8}Sm_{0.2}O_{2-\delta}$, SDC) backbone on top of the dense SDC electrolyte. The porous SDC backbone was then infiltrated by $Ba_{0.5}Sr_{0.5}Co_{0.8}Fe_{3-\delta}$ precursor nitrates. Symmetrical cells were prepared and studied in the 400-700ºC temperature range and under anodic/cathodic polarisations. Ageing test showed high material stability for over 100 hours at 600 °C under a switched current load of ±0.2 $A \cdot cm^{-2}$ coupled with remarkable electrocatalytic very good mechanical properties.

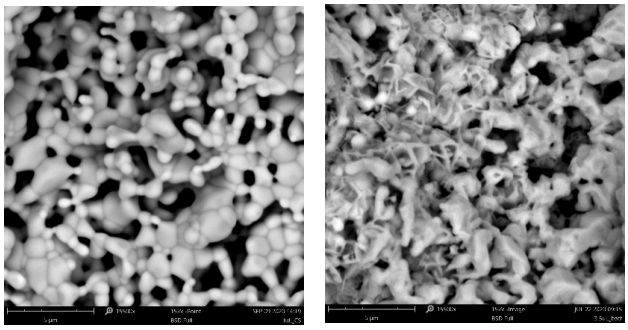

Figure 1. SEM micrographs before (a) and after (b) infiltration

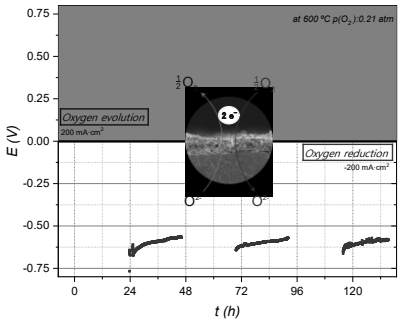

Figure 2. Degradation test under anodic and cathodic polarization.

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NOVEL, Cu-CONTAINING AIR ELECTRODE MATERIALS FOR REVERSIBLE SOLID OXIDE ELECTROCHEMICAL CELLS

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Keywords: Reversible Solid Oxide Cells, air electrode materials, Cu-containing perovskites

ABSTRACT

Reversible solid oxide electrochemical cells (rSOC), in which the generator is able to either utilize chemical energy of the fuel and oxidizer to produce electricity and heat or to operate in the reversed mode, generating e.g. hydrogen with the usage of surplus electrical energy, has become of the special interest [1-4]. Most of the developed air electrode materials for such cells are Co-based, despite that deposits of Co are limited, sources are localized in regions with volatile economic and unstable political situation, and cobalt is classified as carcinogenic. Unfortunately, replacement of Co by other 3*d* elements has not been fully successful, especially considering performance of the air electrodes at lowered temperatures.

In this work fundamental issues concerning development of novel, Cu-containing air electrode compounds are discussed, with focus on cation-disordered and cation-ordered $RE_{1-x}A_xM_{1-x}Cu_xO_{3-\delta}$ (RE: selected rare-earth elements, A: selected alkaline-earth metals, M: selected 3d metals) perovskite-type oxides, showing possibility to access previously unexplored modification range of the mean electronegativity, ionic radii and charge state of elements in the considered materials. The obtained perovskites at the working temperatures of reversible SOCs exhibit desired physicochemical characteristics, including mixed Cu^{2+}/Cu^{3+} states (leading to the increased oxygen reduction/oxygen evolution reactions activity), stabilized crystal structure (source of the enhanced transport properties), and controlled presence of the oxygen vacancies (allowing to balance high effectiveness of Zener mechanism and enabling high ionic conductivity). As shown for the constructed laboratory-scale button-type cells, low electrode polarization resistance values can be achieved, with the best recorded power density outputs exceeding 1 W cm^{-2} at 900 °C. The results unambiguously document that development of the effectively working Cu-rich air electrode materials is feasible.

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INFLUENCE OF THE RARE-EARTH RADIUS ON REACTIVITY WITH OXYGEN IN HEXAGONAL $Y_{1-x}R_xMnO_{3+\delta}$ OXIDES

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Keywords: oxygen storage materials, *in-situ* X-ray diffractometry, rare-earth manganites, temperature swing absorption, gas separation

ABSTRACT

In the need of discovering a new air-operating oxygen storage material (OSM) dedicated for oxygen production, a performance-structure relation has been discovered in the group of $RMnO_{3+\delta}$ (R – rare earth elements) oxides. OSMs are already being applied in many technologies (automotive catalysts, fuel cells, chemical looping combustion, etc.), and also may have some new applications – one of those is oxygen production via temperature swing absorption (TSA), which is a promising alternative to cryogenic distillation of air. Great advantage of $RMnO_{3+\delta}$ is the ability to operate at significantly lower temperatures (ca. 200-300 °C) compared to other groups of OSMs (e.g. 600-800 °C). However, a majority of already reported $RMnO_{3+\delta}$ operate effectively only in pure O_2 – only a few are able to absorb reasonable amount of oxygen in air [1-2]. Our recent research involved the series of $Y_{1-x}R_xMnO_{3+\delta}$, where Y is substituted with a small amount ($x \leq 0.1$) of other rare-earth element (Yb, Gd or Pr). We have discovered that by manipulating the mean value of ionic radius of $Y_{1-x}R_x$ we can enable these OSMs to operate in air and increase their OSC (Fig. 1 a and 1b). Among examined OSMs, incorporation of 5 mol.% of Pr showed the best results – $Y_{0.95}Pr_{0.05}MnO_{3+\delta}$ operates in air reaching OSC close to the OSC recorded in pure O_2, and comparable to the best reported OSMs.

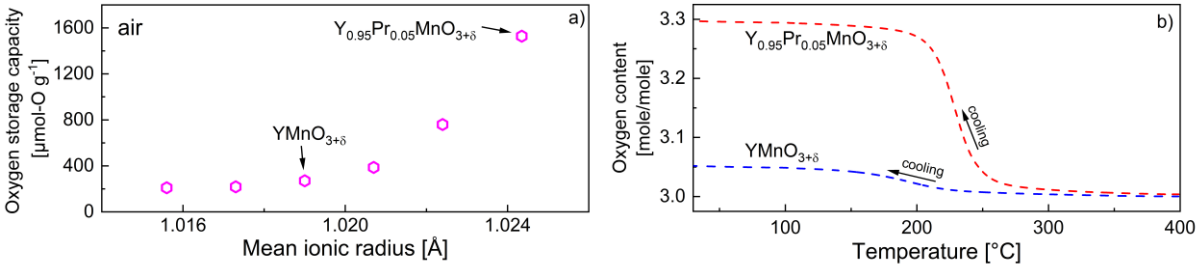

Figure 1. OSC in air of Y1-xRxMnO3+δ as a function of ionic radius (a), and oxygen content change upon cooling of unmodified YMnO3+δ and Pr-substituted material in air (b)

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SOL-GEL SYNTHESIS AND EVALUATION OF ELECTROCHEMICAL PROPERTIES OF $NaFeTiO_4$ – A LOW-COST ANODE MATERIAL FOR Na-ION BATTERIES

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Keywords: Na-ion batteries, anode, sol-gel synthesis, low-cost

ABSTRACT

To counteract worsening environmental issues and growing industrial dependence on lithium-ion batteries (LIBs), it is necessary to develop inexpensive and efficient sustainable energy storage technologies. Sodium-ion batteries (SIBs) are considered an attractive alternative to LIBs due to the possibility of replacing lithium with abundant and low-cost sodium [1]. Unfortunately, graphite – the most common anode material in LIBs – can not be applied in SIBs due to a significant mismatch between the ionic radius of Na ions and interlayer distance of graphite. Here, we would like to propose $NaFeTiO_4$ as an anode material for SIBs.

$NaFeTiO_4$ was synthesized via a citrate-assisted sol-gel method, accompanied by annealing at 700°C for 6h in synthetic airflow. Such an approach allowed us to reduce the synthesis temperature by 200°C in comparison to the solid-state reaction route [2]. XRD analysis confirmed that material is single-phased and all diffraction peaks belong to the orthorhombic *Pnma* space group. Lattice parameters calculated by the Rietveld refinement method were equal to a = 9.1810(3) Å, b = 2.96679(9) Å, c = 10.7424(4). The unit cell is comprised of Fe/Ti octahedra and one-dimensional tunnels occupied by Na ions, which serve as a pathway for rapid diffusion of sodium ions. SEM analysis revealed rod-like sub-micro particles about 600 nm long and 150 nm wide. The discharge/charge experiments were carried out in $Na/Na^+/NaFeTiO_4$ cells at various current in 0.01 – 2.5 V range. Obtained charge capacities were equal to 141, 113, 80, 54, 33, mAh g^{-1} for C/20, C/10, C/5, C/2, 1C current rates with mid-point voltage around 1.2 V. Diffusion coefficient of sodium calculated from the Randles-Sevcik equation was equal to 1.52 x 10^{-16} cm^2 s^{-1}. Ex-situ XRD measurements on completely discharged electrodes revealed that a new unknown phase is formed during intercalation. Finally, ionic conductivity was measured using the EIS technique in $Pt|NaFeTiO_4|Pt$ setup and was equal to 3.6 x 10^{-6} S cm^{-1}. We believe that $NaFeTiO_4$, due to abundance and low-cost Na, Fe and Ti, may find application in large-scale energy storage systems in the near future.

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NiO-$Ba_{1-x}M_xCe_{0.9}Y_{0.1}O_{3-\delta}$ – BASED ANODES FOR CERAMIC PROTON FUEL CELLS, WHERE M = Ca, Sr

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Keywords: ceramic proton conductor, anode supported fuel cell, solid oxide fuel cell, barium cerate

ABSTRACT

Ceramic proton-conducting materials involving $Ba_{1-x}M_xCe_{0.9}Y_{0.1}O_{3-\delta}$ where M=Sr, Ca are considered promising electrolytes for the construction of intermediate-temperature solid oxide fuel cells (IT-SOFCs) operating in the temperature range 500–700 °C.

Reduction of the electrolyte thickness leads to lower cell ohmic polarization and improve SOFC performance. Reduction of the electrolyte thickness under 100 μm makes it necessary to transfer mechanical loads through other component layers of the fuel cell.

Reducing the thickness of the electrolyte is possible by the use of the anode as the supporting layer of the cell which could be made e.g. by ceramic tape casting.

The tape casting method was used to elaborate NiO – ceramic proton conductor composite as an anode support layer for IT-SOFC. The A – sublattice of barium cerate doped with yttria was modified by alkaline earth cation substitution (Ca or Sr). Proton conducting electrolyte powder was mixed with nickel oxide, graphite, and an organic binder to form homogenous slurry. Casted slurry was cut to disk-shaped substrates and sintered. Samples of raw ceramic tape, sintered substrates, and electrode-electrolyte half-cell were studied using SEM, DTA-TG. Electrochemical impedance spectroscopy was applied to measure anode support conductivity over a temperature range of 400–750 °C in a hydrogen-rich atmosphere.

Based on performed experiments we can stand that elaborated composite anode materials appear to be suitable for anode-supported solid oxide fuel cells with ceramic proton conducting electrolytes.

Some of the measurements were performed using scientific equipment belonging to the laboratories of the AGH-UST Energy Centre, Cracow, Poland.

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ENVIRONMENTAL SAFETY OF THE USE OF GRANULATED FERTILIZER PRODUCED FROM MUNICIPAL SEWAGE SLUDGE

Marcin Głodniok[1,]*, **Katarzyna Styszko**[2]

Keywords: sewage sludge management, pharmaceutics, environmental safety, granular fertiliser

Many of human activities are sources of pharmaceutical residues which can have a significant impact on human health and the state of ecosystems. The intensive agriculture, the high expansion of urban areas and the use of fertilizers based on sewage sludge may cause the entry of contaminants into the environment. One of the main sources of a wide mixture of compounds origins from sewage treatment plants (WWTP), from which emerging contaminants are discharged with effluents, directly into surface waters [1]. Pharmaceuticals are an important problem that may affect the limitation of the use of sewage sludge as fertilizer products, thus raw sewage sludge require certain processing to minimize their environmental impact.

For the case of stabilized sewage sludge and their applicability as potential soil improvers or fertilizers results from both the presence of organic fraction and the mineral content (nitrogen and phosphorous).

The recent method elaborated, patented [2] and described [3] by the Katowice GIG (gold medal at IWIS Warsaw 2020) [4] allows for production of variant bio-based fertilizer products. The novel organo-mineral granulated fertilizer is a mixture of municipal dewatered stabilized sewage sludge (19-20% of d.m.) collected from municipal WWTPs, dolomite, lime and microcrystalline cellulose. The final product is generated as non-dusting, irregular-shape granulate 1–6 mm in diameter. The granulation process is a key sequence of unit operations involving grain formation from either a powdery or solid substance of appropriate physico-chemical properties.

Fertilizer environmental safety was examined by analysis of the pharmaceutical compounds leaching to proof maximizing their decomposition at the production stage with is important from the point of view of processing sewage sludge into fertilizer products. As a study results it was noticed that in water extracts after 27 days, the majority of substances except ibuprofen were practically undetectable [5].

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SEWAGE SLUDGE MANAGEMENT IN TERMS OF THE CIRCULAR ECONOMY IN POLAND

Wioleta Bolesta[1,3], Marcin Głodniok[2], Michał Pieczonka[1], Katarzyna Styszko[3,*]

Keywords: sewage sludge management, circular economy, thermal treatment, granular fertiliser

ABSTRACT

The economical and ecological way to dispose of the generated sewage sludge is an eternal problem of entities dealing with sewage treatment. Traditional methods can't solve the problem no longer, because the sewage treatment plants record more and more sludge formation every year [1], which makes high costs for WWTP operators. What is the most significant, the protection of nature are extremely important, if not the most important aspect.

The aim of the work is to present innovative directions of sewage sludge management in the near future, which perfectly fit into the trend of the circular economy. Currently, the most promising ways to remove sewage sludge are thermal methods such as incineration or drying [2]. For several years now, sludge incinerators have been operating in Poland.

Sewage sludge can be used as a raw material to implement a closed cycle of sludge components [3]. In the process of downdraft gasification, the resulting gas will be used to dry the sewage sludge. It is similar with the process of pyrolysis of sewage sludge, the product of which will be biochar. A promising way to use sludge is to use it as a component in the production of biodiesel. In addition, the resulting ash from sludge incineration can be used in construction or in the process of phosphorus recovery. The first tests on the above-mentioned solutions are currently underway.

The undoubted advantage is the transformation of the sludge into completely safe and rich in phosphorus and nitrogen mineral-organic fertilizers or plant cultivation agents. The resulting sewage waste becomes a raw material in another production line and the resulting products, such as fertilizers, can be successfully sold after prior detailed research. The first installations in Poland for the production of the so-called granular fertilizers are already being developed, and the effects of their work go through the next stages of legalizing their use [4,5].

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THE STABILITY STUDIES OF SELECTED HYDROXY-DERIVATIVES OF POLYCYCLIC AROMATIC HYDROCARBONS IN WASTEWATER BY USING HIGH-PERFORMANCE LIQUID CHROMATOGRAPHY WITH THE UV-VIS DETECTOR

Justyna Durak[1], **Katarzyna Styszko**[1,*], **Dariusz Wideł**[2], **Elżbieta Sochacka-Tatara**[3]

Keywords: hydroxy derivatives of polycyclic aromatic hydrocarbons, biomarker, stability, wastewater-based epidemiology, treated wastewater

ABSTRACT

Polycyclic aromatic hydrocarbons (PAHs) belong to the group of chemical compounds responsible for environmental pollution, while their hydroxy derivatives (OH-PAHs) are considered to be markers of PAHs exposure.

In the conducted research, a methodology for the determination of three OH-PAHs (1-hydroxypyrene, 2-hydroxyfluorene, 2-hydroxynaphthalene) was developed by using HPLC/UV-Vis - Varian Star liquid chromatograph equipped with a spectrophotometric detector and a Kinetex C18 column. It was expected that the concentration of OH-PAHs in wastewater would be at the level of ng/L, so it was assumed that the analysis of real samples would require the use of solid phase extraction (SPE). SPE efficiency tests were carried out for cartridges filled with various sorbents. The column filled with silica gel modified with octadecyl groups showed the highest recovery (75-95%). The last stage of the research was to assess the stability of selected OH-PAHs in order to determine whether any transformation is possible during their transport to the sewage treatment plant from the moment they leave the human body. It was decided to simulate the conditions in the sewage system during the summer and winter periods by conducting an experiment at a temperature of 22°C and 4°C. In addition, the analyzes were carried out in parallel on two matrices with the addition of analytes standards: deionized water and real sewage, which made it possible to check whether the stability of OH-PAHs is influenced by the diversity of compounds in the sewage. The performed stability test showed that within 72 hours, regardless of the prevailing conditions, all analyzed OH-PAHs remain stable, which means that no hydraulic retention occurs in the analyzed period. What's more, no differences between the used matrices were noticed, which proves that the chemical diversity of wastewater does not accelerate their degradation in the sewage system.

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EMISSION OF MICROPLASTICS FROM COMMUNICATION ROUTES

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Keywords: microplastics, environmental pollution, tire rubber

ABSTRACT

Plastics have been mass-produced since the mid-twentieth century. Despite their negative impact on the environment noticed already in the 70s, production is still growing due to a very wide range of applications, availability and low production costs. Recently, the scientific community has shown a special interest in the so-called microplastic. These are plastic particles, the size of which does not exceed 5 mm. Currently, microplastics can be found in the farthest corners of the Earth. The purpose of this paper is to present information on the sources of emissions from traffic routes, i.e. emissions from abrasion of car tires, brake blocks and road markings, and to characterize them. Attention has also been focused on the multi-country tire wear statement, which shows a large spread of the mass emissions per capita, ranging from 0.2 to 5.5 kg/year [1]. The percentage share of individual microplastic sources from communication routes has been determined. The substances that can be released by microplastics from communication routes, adversely affecting living organisms, have been characterized.

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A REVIEW OF TECHNOLOGIES RELATED TO THE UTILIZATION OF BY-PRODUCTS OF THE FUEL INDUSTRY USABLE TOWARDS THE PRODUCTION OF LACTIC ACID

Edyta Strzelec[1,]*, Grzegorz S. Jodłowski[1]

Keywords: biotechnology, gliceryn, molasses, lactic acid

ABSTRACT

Lactic acid is a naturally existing organic acid, which may be applied in many different branches of industrial application, for example cosmetics, pharmaceutics, chemicals, food, and nowadays also in medicine. It can be made in sugar fermentation process from renewable raw materials, which means, that is the ecological product that has enjoyed great popularity in recent years. In 2010, the US Department of Energy published a report, which means about lactic acid as a potential building element for the future technology, and demand on that product is still growing year by year [1, 2].

The lactic acid molecule naturally exist in plants, microorganisms and animals and can also be produced by carbohydrate fermentation or chemical synthesis from coal, petroleum products or natural gas. In industry, lactic acid can be produced by chemical synthesis or fermentation.

Although racemic lactic acid is always produced chemically from petrochemical sources, optically pure L(+) – or D(-) – lactic acid form can be obtained by microbial fermentation of renewable resources when the appropriate microorganism is selected. Depending on the application, one form of optically pure LA is preferred over the other. Additionally, microbial fermentation offers benefits including cheap renewable substrates, low production temperatures and low energy consumption. Due to these advantages, the most commonly used biotechnological production process with the use kind of biocatalysts – that is lactic acid bacteria [3, 4].

The cost of raw materials is one of the major factors in the economic production of lactic acid. As substrate costs cannot be reduced by scaling up the process extensive research is currently underway to find new substrates for the production of LA [5].

These searches include starch raw materials, lignocellulosic biomass, as well as waste from the food and refining industries. Here, the greatest attention is still drawn to molasses and whey as the largest sources of lactose, vitamins and carbohydrates, as well as glycerin – a by-product of biodiesel component production process [6].

Focusing on the importance of lactic acid and its subsequent use as a product, but also a valuable raw material for polymerization (exactly to PLA), this review summarizes information about the properties and applications of lactic acid, as well as about its production and purification processes.

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LONG REACH DIRECTIONAL DRILLING TECHNOLOGY – AN EFFECTIVE WAY OF GAS DRAINAGE AND MITIGATION OF GHG EMISSION: CASE STUDY OF MURCKI-STASZIC HARD COAL MINE

Grzegorz Leśniak[1,*], Bartłomiej Jura[2], Renata Cicha-Szot[1], Mirosława Bukowska[2], Tomasz Topór[1], Grzegorz Plonka[3], Radosław Surma[3], Marcin Karbownik[2], Paweł Budak[1]

Keywords: LRDD, CMM, gas drainage, GHG emissions abatement, safety in the mine

ABSTRACT

Methane emissions are the second largest contributor to climate change next to carbon dioxide. The estimated direct and indirect forcing effects of methane is on the level of 58% of the value of CO_2. Although annual emissions are only 3% w/w of those associated with CO_2, it is much more harmful cause its radiative forcing is approximately 120 times more than CO_2 immediately after it is emitted [1,2].

In Poland, nearly 29% of total methane emissions into the atmosphere are related to the direct hard coal mining process. They include ventilation emissions and emissions from methane drainage systems. In 2018, the total methane emissions reported for the Polish hard coal mines amounted to 919.1 million m^3 CH_4, from which almost 65% of methane was emitted into the atmosphere [3].

The application of novel technology based on long-reach underground directional boreholes drilled above-mined coal seams can increase methane capture and improve methane pre- and post-drainage processes [4]. However, to ensure process effectiveness, it is necessary to optimize boreholes' location and length, considering both geological and petrophysical properties.

Preliminary studies were performed in Murcki-Staszic hard coal mine on part C of the coal seam 501, where a combined methane drainage strategy, including conventional and directional boreholes, was implemented as a part of the DD-MET project. The DD-MET is a European Pilot and Demonstration project co-financed by Research Fund for Coal and Steel (RFCS). The obtained results come from the first in this field project in Europe.

The five horizontal boreholes were drilled from the ventilation gallery F to access the clay/sandstone layers deposited above the 501-coal seam. The efficiency of CH_4 intake of directional boreholes was on the ca. 70% level, while conventional boreholes only 30%. The average methane intake was in the range of 5-4 m^3/min. Moreover, post-exploitation drainage is observed from some boreholes with a cumulative flow rate of 3.0 m^3/min from TM2 and TM4 boreholes and 0.2 m^3/min from TM2 borehole. The methane concentration was in the range of 50% for TM2 borehole to 74% for TM4 borehole. The total methane intake from the boreholes drilled on part I-C was nearly 1.8 million m^3CH_4.

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POTENTIAL FOR USING SOLAR ENERGY TO GENERATE ELECTRICAL ENERGY IN LEBANON

Bogusław Podhalański[1,*]

Keywords: solar energy, photovoltaic, Lebanon, Chile

ABSTRACT

Lebanon has been facing disruptions in electrical energy supply for years, which constrains its development potential. To reduce Lebanon's growing energy deficit, electricity is produced using ship-based power plants anchored near existing conventional plants, located near the shore and use liquid fuel—oil or mazut. This energy is very expensive. One solution to the problem could be the large-scale use of photovoltaic cells and wind farms. However, neither are popular in this country. Their popularisation could considerably aid in balancing the country's energy mix. Chile possesses an appropriate supply of electrical power generated using hydropower plants. Renewable energy production using wind is also developed, as is solar power, although to a lesser extent. Both countries do not have nuclear power plants.

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THE MAIN DIRECTIONS OF KHK S.A. DEVELOPMENT

Wojciech Wróbel[1,*], **Jakub Bator**[1]

Keywords: environmental protection, thermal waste treatment

ABSTRACT

The establishment of Krakowski Holding Komunalny S.A. resulted from the concept of tax activities of the capital group (PGK) of Cracow municipal companies, developed by the Council and Board of the City of Cracow. Currently, its main task is the operation of the Thermal Waste Treatment Plant in Cracow. According to the PKD 2007 classification, the main activity of this plant is the treatment and disposal of non-hazardous waste (PKD 38.21.Z). The purpose of the Thermal Waste Treatment Plant is environmentally safe thermal treatment of municipal waste from the area of Cracow, as well as the generation of electricity and heat during this process. The operation of the Eco-Incineration Plant fully complies with the provisions of the European Union regulations and Polish law. In the field of environmental protection, particular attention should be paid to the activities related to: recovery of raw materials and reuse of waste as energy sources, environmentally friendly disposal of waste, reduction of the amount of municipal waste deposited in landfills, as well as reduction of the amount of biodegradable waste intended for landfilling. These activities play a special role in the process of reducing greenhouse gas emission. The Eco-Incineration Plant in Cracow manages 220,000 tonnes of waste annually, and its thermal treatment is much more beneficial for the environment than its management. There is also an educational campaign aimed at increasing the ecological awareness of the residents and promoting the idea of selective waste collection and their thermal treatment.

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OIL AND GAS IN POLAND: LICENSING PROCEDURES AND PETROLEUM PROSPECTIVES IN 2021

Krystian Wójcik[1,*], Jowita Kumek[1], Ewelina Krzyżak[1], Joanna Roszkowska-Remin[1], Piotr Słomski[1], Łukasz Smajdor[1], Marcin Wesołowski[2], Grzegorz Jagielski[2]

Keywords: crude oil, natural gas, concessions, procedures

ABSTRACT

There are two ways to get the concession for prospection, exploration and production of hydrocarbons in Poland: tender procedure and open door policy. On June 26, 2020 the Polish Minister of the Environment announced the areas dedicated to the 5th tender round for hydrocarbon concessions in Poland, planned in 2021 [1]: Gryfice, Gorzów Wielkopolski S, Kartuzy and Siedlce W (Fig. 1). The main exploration target of the Gryfice and Gorzów Wielkoposlki S areas is related to conventional accumulations of oil and gas in the Permian Main Dolomite dolomites and limestones and Rotliegend sandstones. On the other side – in the Kartuzy and Siedlce W areas – the shale-gas and shale-oil discoveries in the Lower Paleozoic shale formations, as well as conventional and tight-gas/tight-oil accumulations in the Cambrian sandstones are expected. These four areas have been selected from 24 proposals indicated by the Polish Geological Survey as the most prospective areas for petroleum exploration in Poland [2]. Anyway, according to the open door policy, an entity may apply for a concession for an any area that is not a subject of a tender or other concession, but the area cannot be greater than 1200 km^2.

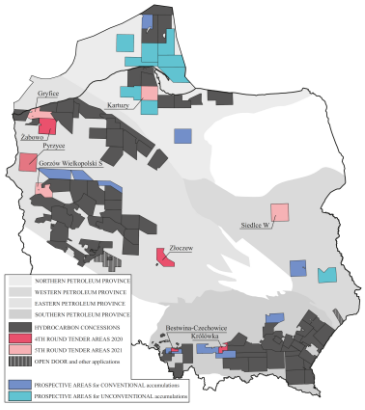

Fig. 1. Petroleum subdivision of Poland in relation to hydrocarbon concessions, pending applications, tender areas, and prospective areas. [2]

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THERMAL WASTE TREATMENT WITH AN ELEMENT CLOSING THE SYSTEM

Jakub Bator[1,*], Wojciech Wróbel[1]

Keywords: circular economy, environmental engineering

ABSTRACT

The verified CEWEP calculations suggest that a capacity of residual waste treatment of 142 million tonnes will be required to achieve the European Union's established municipal waste management goals, assuming that the recycling goals will be achieved in the context of commercial and industrial waste. The current capacity of thermal conversion of waste into energy is 90 million tonnes. Co-combustion systems have a treatment capacity of approximately 11 million tonnes per year. At the moment, this leaves a gap of 40 million tonnes.

At present, in Poland, the share of selective collection of municipal waste is at the level of 32-34%. It should be borne in mind that only separately collected waste can be recycled. By 2020, municipalities are required to achieve a 50% recycling rate. The stream of the so-called mixed residual waste goes mainly to more than 170 MBP installations, where 3 fractions are separated: oversize (combustible) fraction - the so-called Pre - RDF, RDF, biodegradable fraction - for composting and mineral fraction (ballast) - for landfilling.

Taking into account both environmental and economic factors, the current works aim at determining the possibility of managing the generated waste in line with the concept of circular economy.

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THERMOMODERNISATION OF BUILDINGS ACCORDING TO THE REQUIREMENTS OF THE UE DIRECTIVE 2010/31/EU

Tomasz Sumera[1,*]

Keywords: energy auditing, thermomodernisation, heat recovery, BMS

ABSTRACT

The article [2] shows problems project-makers face when trying to implement the directive [1] and Polish regulations [3] in buildings of great internal volume factor compared with the heated space. The analysis of technical solutions - based on an example of such a building - was performed to show that using such technical solutions not only will allow to satisfy those requirements after the year 2020 but will also enable the use of surplus energy produced in the building to supply another one.

The Polish Buildings Performance Act [3] and further regulations connected with the act require that the energy used for heating space and domestic hot water in a new building owned by the community council after 2020 cannot increase more than E_{PH+W}=45kWh/m^2.Similar low values are set for lighting (E_{PL}=50kWh/m^2) and cooling (E_{PC}=25kWh/m^2). These limits pose the same problems to project makers, because the limits are set for 1m^2 independent of the height of the building. For example if the internal height of the storey is 2,5m then E_{PH+W}=45kWh/m^2 means 18kWh/m^3. By the storey height of 16m (like in the sports halls) the same factor is 2,81kWh/ m^3.

To reach such a low factor it is not sufficient to insulate the walls and roof, even by the standard of passive houses, and use low emission windows. Most of the energy in insulated houses goes to heating the air during the ventilation process, especially if the volume of the building is significant, e.g. sports halls. To solve this problem a complex solution is necessary, including, but not limited to: heat recovery using heat pumps in ventilation systems, renewable energy sources like photovoltaics, heat pump or HCP systems for space heating, building management system which automatically controls space heating based on the weather forecast, lighting depending on the natural sunlight levels in the building. Heat recovery from other sources can be used where possible, for example waste heat from factory production can be used for space heating in factory buildings, heat recovered from an artificial ice rink can be used to heat the swimming pool etc.

Reaching the goal set by the directive 2010/31/EU therefore requires that the energy auditor think in a more interdisciplinary manner.

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A COMPUTER SYSTEM FOR ON-LINE MONITORING THE OPERATION OF A THERMAL WASTE TREATMENT PLANT

Marcin Trojan[1,*], Jan Taler[1], Krzysztof Smaza[2], Wojciech Wróbel[3], Piotr Dzierwa[1], Dawid Taler[1], Karol Kaczmarski[1]

Keywords: thermal waste treatment plants, on-line monitoring, computer system, mathematical modelling

ABSTRACT

The thermal waste treatment plants are of great importance for the management of municipal waste. The primary purpose for which waste incineration plants are built is:

- to reduce the volume of waste to about 10% of the original volume
- to reduce waste up to about 30% of the original weight.

Waste incineration also protects the environment against the uncontrolled entry of toxic organic substances that can be leached from the waste through water (precipitation). It should be noted that the operation of waste incineration plants is much more complicated than the operation of a power plant. High variability of the chemical composition of the fuel (municipal waste) supplied to the boiler causes that the plant operation must be controlled continuously. This article presents a system for monitoring the operation of a thermal waste treatment plant allowing to determine the efficiency of the plant in on-line mode. The computer program is based on measurements of pressure, temperature and mass flow rate of the working medium. The boiler efficiency is calculated using an indirect method based on the energy balance of the boiler. Thermal calculations of the boiler combustion chamber in the on-line mode make it possible to determine the heat flow rate to the evaporator. Based on the energy balance of the boiler evaporator, the superheated steam mass flow rate is determined, taking into account the mass flows of water injected into steam attemperators. By comparing the calculated and measured value of steam mass flow rate, the calorific value of the fuel fed is determined. The developed system enables monitoring of energy distribution in individual elements of the power unit, taking into account losses in the boiler and turbine condenser. It is planned to expand the system by further modules, allowing, among others, to monitor the fouling degree of individual heating surfaces of the boiler or to monitoring the tube walls temperature of the steam superheater.

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CATALYTIC METHODS FOR THE ABATEMENT OF N_2O EMISSION FROM NITRIC ACID PLANTS

Marek Inger[1,*], Monika Ruszak[1], Jakub Rajewski[1], Bartosz Moszowski[2], Marcin Wilk[1]

Keywords: greenhouse gas, N_2O abatement, nitric acid

ABSTRACT

Nitrous oxide (N_2O) is a greenhouse gas with a much higher global warming potential than a carbon dioxide. One of the largest stationary emitters are the nitric acid plants, where N_2O is formed as a by-product of NH_3 oxidation reaction. Due to the legal regulations in force, it is highly desirable to find technologies enabling effective reduction of N_2O emission from nitric acid plants. Among the potential catalytic technologies, the following are of practical importance: decomposition from the nitrous gas stream at a high temperature downstream of ammonia oxidation reactor (secondary abatement technology) and N_2O decomposition or N_2O reduction with hydrocarbon from the tail gas stream at a low or medium temperature (tertiary abatement technology).

In Łukasiewicz-INS, the catalysts for both technologies (secondary and tertiary) were developed. The results of the activity tests, carried out under real process conditions indicate, that the use of both types of catalysts, after meeting the relevant conditions (process temperature, residence time), allow for the effective N_2O decomposition. Due to the internal diffusion resistance, the reaction rate of N_2O decomposition observed for the shaped catalyst is lower than in case of the catalyst in the form of grains. Kinetic parameters, determined on the basis of the activity tests on the shaped catalyst can be directly used to calculate the volume of the catalyst bed or the size of the industrial reactor for N_2O decomposition in the nitric acid plant.

The selection of the optimal variant for the abatement of N_2O emission depends on the individual characteristics of the nitric acid plant, such as pressure and temperature in the ammonia oxidation unit and the tail gas parameters upstream of the expansion turbine. In some cases the optimal solution is the combination of this both technologies. This solution is ecologically beneficial and may be economically advantageous, regarding the high prices of CO_2 emission allowances.

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EFFECT OF BOILER OPERATION ON THE LIFETIME OF SCR INSTALLATION EQUIPPED WITH V_2O_5-WO_3/TIO_2 CATALYST

Maciej Żyrkowski[1]*, **Bogdan Samojeden**[1], **Monika Motak**[1]

Keywords: SCR, Catalyst, Lifetime, Industrial boiler, Deactivation,

ABSTRACT

Commercial SCR (Selective Catalytic Reduction) flue gas denitrification system, while operating in industrial conditions, has a limited lifetime. Its loss is derived from decrease in catalyst activity, which can be expressed as the ability to reduce nitrogen oxides. For SCR installations working on power units equipped with solid fuel boilers, the impact of boiler operation parameters on the catalyst lifetime is significant. Fluctuating exhaust gas temperatures and flow, as well as the sulfur and mineral content in the fuel. In order to determine the influence of individual factors on this undesirable phenomenon, a detailed analysis of the literature was made in terms of deactivation of V_2O_5-WO_3 / TiO_2 catalysts. In addition, an analysis of the operating conditions of the pulverized coal boiler was performed and key factors influencing the SCR installation and catalyst life were identified. The analysis showed that the loss of the SCR catalyst lifetime is primarily the result of the interaction of the catalytic surface with compounds of alkali metals and sulfur, dust accumulation as well as the operating temperature of the system. Another factor described, is the formation of ammonium bisulfate, resulting from high concentration of sulfur trioxide in flue gas as well as high level of ammonia slip from the SCR reactor. It is highly undesired and influence catalysts fast deactivation, therefore, it is important to understand its origin.

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SOURCE CONTRIBUTIONS TO RURAL CARBONACEOUS WINTER AEROSOL IN NORTH-EASTERN POLAND

Adam Kristensson[1,*], **Stina Ausmeel**[1], **Julija Pauraite**[2], **Erik Ahlberg**[1], **Steigvilė Byčenkienė**[2], **Anna Degórska**[3]

Keywords: source apportionment, domestic, aerosol

ABSTRACT

Coal and wood is widely used in Poland for domestic heating, and is a challenge for air quality. However, the air quality problem and the sources of aerosol particles in ambient air is rarely presented in scientific literature.

Measurements in rural north-eastern Poland, at the Diabła Góra field site (54° 07′ N, 22° 02′ E) ([1]) were conducted during the 2018 EMEP intensive winter campaign to estimate the source contribution to rural background aerosol particle carbonaceous mass concentration below 2.5 µm diameter. The aethalometer light absorption measurements in seven wavelengths and levoglucosan concentrations were used to apportion traffic exhaust, and domestic coal and wood combustion sources.

The concentrations varied quite much between days, and wood, coal, and traffic contributed on median to 21, 44 and 35 % to the mass concentration of carbonaceous aerosol of 7.5 µg m^{-3} (Figure 1a). The highest contributions of wood and coal combusted aerosol were from the Katowice and Krakow region (Figure 1b), despite that this region is about 500 km away from Diabła Góra. The results are published in Kristensson et al. [2].

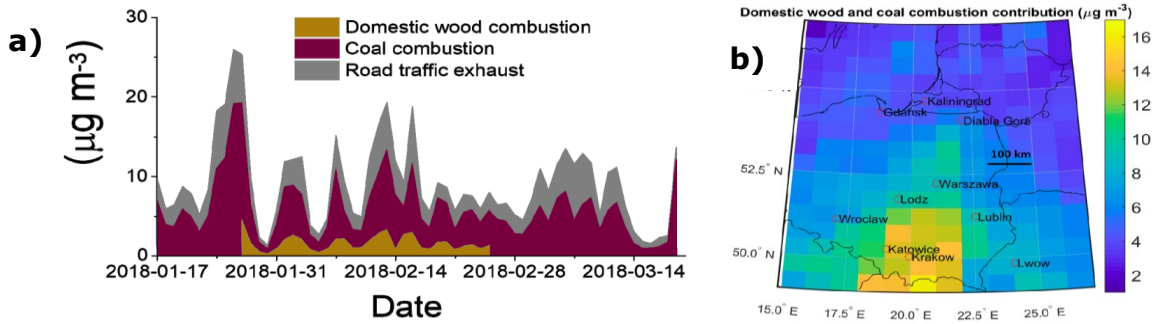

Figure 1. (a) The source apportionment of the carbonaceous aerosol PM2.5 mass concentration at the Diabła Góra site (Domestic wood combustion contribution was missing in the beginning and end of the period), and (b) the contribution from the domestic wood and coal combustion sources as function of air mass origin [2].

The source apportionment agrees well with a similar, but independent study for a Lithuanian rural site, and the results indicate that there is work to be done to decrease the air pollution coming from wood and coal combustion in Poland.

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IN SITU AEROSOL OBSERVATIONS IN LILLE, NORTHERN FRANCE: OVERVIEW OF 2016-2019 CHEMICAL COMPOSITION DATA

Véronique Riffault[1,*], **Joel Brito**[1], **Emmanuel Tison**[1]

Keywords: submicron aerosols, source apportionment, aerosol mass spectrometer, aethalometer

ABSTRACT

A research site dedicated to atmospheric observations is located in a suburban area, on the rooftop of a building on the University of Lille campus in Villeneuve d'Ascq, France. It is only 4 km apart from the closest monitoring network station defined as an urban background site and about 80 km apart from five rural sites (2 in France, 3 in Belgium), 200 km from Paris and 100 km from Brussels. A large panel of active/passive remote sensing instruments deployed there, including Sun/sky photometer and LIDAR, has been dedicated to aerosol property retrievals for decades as part of several networks (AERONET, EARLINET, ACTRIS, etc.).

Near-real time in situ measurements of the submicron (PM_1) fraction of aerosols have started on October 2016, in order to better assess the temporal variability of the chemical composition of aerosols at the ground level. An Aerosol Chemical Speciation Monitor (Q-ACSM) measures the mass concentrations of non-refractory constituents (organics, sulfate, nitrate, ammonium, chloride) every 30 min while an Aethalometer provides Black Carbon (BC) measurements at a time resolution of 1 min.

The spatial representativeness of the measurements was assessed by comparison of the sum of these constituents with ground-level mass concentrations of $PM_{2.5}$ at surrounding sites. Furthermore, source apportionment of the BC data (road traffic vs biomass burning) [1] and of the organic fraction (primary emissions and processed aerosols) [2] was performed for the warm and cold periods.

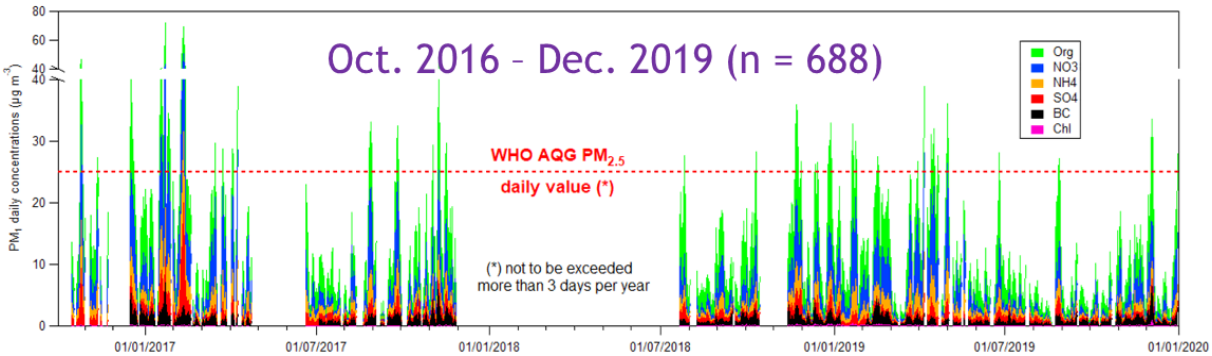

Figure 1. Chemical composition of the daily mass concentrations of PM_1 aerosols in the Lille area between Oct. 2016 and Dec. 2019

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LONG-RANGE TRANSPORT AND LOCAL AEROSOL IMPACT ON INDOOR AIR QUALITY

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Keywords: Air quality, indoor, outdoor, aerosol, environment

ABSTRACT

High levels of air pollutants worldwide rise environmental and health issues which largely depends on energy use in both local and distant areas. In order to improve policies and actions in reducing personal exposure, the assessment of emissions sources and measurement of outdoor and indoor concentrations of pollutants are essential.

From 30th September to 10th November, 2020, 7-wavelenght Aethalometer (Magee Scientific AE31) and Aerodynamic Particle Sizer (APS) (TSI 3321) were deployed in the building of FTMC main campus (urban background environment) and were operating for both outdoor and indoor measurements. Campus air is treated with HEPA filters, building belongs to B energy class. 'Aethalometer model' was applied to separate black carbon (BC) released from biomass burning (BC_{bb}) and fossil fuel combustion (BC_{ff}). It was found that both BC_{bb} and BC_{ff} were observed in indoor air with the same ratio as in outdoor air. Furthermore, poor air filtering (<44.1%) for smaller than 1 μm diameter was observed in indoor air comparing to outdoor (Figure 1). Since long-range transport aerosol is rather larger in size comparing to local, it has a lower impact on indoor air quality.

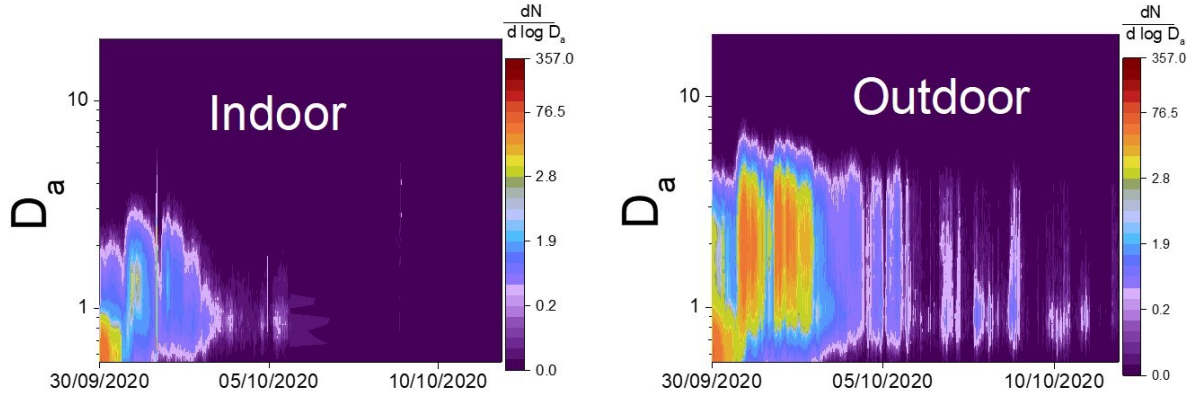

Figure 1. Size distribution for indoor and outdoor air

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SEASONAL CHANGES IN THE COMPOSITION AND CONCENTRATION OF SELECTED CHEMICAL COMPOUNDS IN THE PM_1 AND PM_{10} FRACTIONS OF PARTICULATE MATTER COLLECTED IN KRAKOW IN 2018-2019

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Keywords: particulate matter, organic carbon, elemental carbon, ions, carbohydrates

ABSTRACT

Particulate matter (PM) is a complex mixture of solid and liquid particles suspended in air. It consists of both organic and inorganic compounds (organic and elemental carbon, ions, carbohydrates, polycyclic aromatic hydrocarbons etc.). The results of analyzing the composition of PM allow to obtain, among others, the information about sources of its formation - it might lead to the improvement of air quality in the future.

The work focused on determining the chemical composition of the collected atmospheric aerosols (PM_1 and PM_{10} fractions) in Krakow during selected months of 2018 and 2019, with particularly emphasis the concentrations of ions, carbohydrates, carbonaceous fraction and their seasonal differences.

The analyses of ions was performed using isocratic ion chromatography on an ICS-1100 instrument (Thermo Scientific) equipped with an AS-DV autosampler, conductometric detector and ion exchange columns: Ion Pac AS22 (4 × 250 mm) for anions (NO_2^-, NO_3^-, SO_4^{2-}, PO_4^{3-}, Cl^-, Br^-) and CS16 analysis (5 × 250 mm) for cations (Na^+, NH_4^+, Mg^{2+}, K^+, Ca^{2+}). Thermal-optical analysis with a Sunset carbon analyzer, (Sunset Lab. Inc.) was used to obtain the information about OC/EC concentration, while to determine 14 carbohydrates (Xylitol, Levoglucosan, Arabitol etc.) authors used HPAE-PAD Dionex ICS 3000 Analysis.

On the basis of the analyses, seasonal differences in the concentration of chemical compounds and differentiation of the share of sources in the analysed periods were discussed.

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TARGETED MITIGATION OF THE POTENTIALLY NEGATIVE ENVIRONMENTAL IMPACT OF FLY ASHES FROM ENERGY SECTOR BY USING THEM FOR SYNTHESIS OF FUNCTIONAL MATERIALS OF CATALYTIC IMPORTANCE

Paweł Rybowicz[1,*], Michał Mochnaczewski[1], Barbara Gil[1], Wiesław Roth[1], Artur Łagosz[2], Andrzej Adamski[1]

Keywords: circular economy, fly ash utilization, environmental impact, synthesis of catalytic materials

ABSTRACT

Fly ashes belong to principal by-products of energetic combustion of fuels. They are produced mainly during coal combustion (global production ~600-700 mln t/y), but also during combustion of biomass or crude/heavy oil. When stored, ashes can have a negative impact on the environment as a source of dust and harmful substances such as heavy metals, unburned residuals and noxious components as e.g. NH_3. The ashes and flue gases accompanying fuel combustion usually undergo cleaning processes, e.g. denitrification. The removal of NO_x with using ammonia as a reducing agent (cases of both SCR and SNCR), poses however the serious risk of a so called ammonia slip, responsible for releasing NH_3 into the environment due to its partial adsorption on the collected ash grains (mainly in a form of ammonium salts). The way to reduce the potentially negative environmental impact of fly ashes is to reuse them in a controlled manner. In line with the principles of the circular economy, new methods of ash reusing are constantly being sought. One of them is the use of fly ashes for synthesis of zeolites and other functional materials. Fly ashes are usually rich in Si and Al. These elements are present mainly in a form of aluminosilicate glassy phases, building spherical grains called cenospheres, and also in the form of crystalline phases of quartz and mullite. Thus, due to their composition, high availability and relatively low prices, fly ashes can be considered as substrates for the synthesis of zeolites: structuralized aluminosilicates with a wide range of possible functional modifications and, with such applications as those in adsorption and catalysis. Another option can be synthesis of oxide catalysts.

This paper reports the results of determination of ammonia concentration in fly ash leachates using the spectrophotometric method and analyzes possible environmental consequences of the presence of ammonia in the ashes generated from the energy sector for their storage and re-management. The dedicated methods reducing negative environmental impact of fly ashes by their use for synthesis of zeolites and heterogeneous catalysts will be discussed. The final products have been characterized in terms of their chemical composition as well as structural and textural properties by using X-ray fluorescence and diffraction, SEM and DRIFT spectroscopy, respectively.

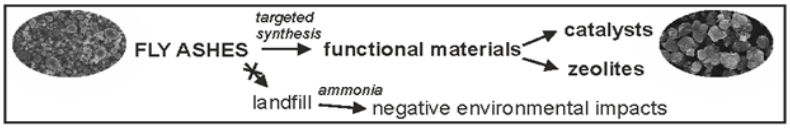

Figure 1. General concept of fly ash management

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IMPACT OF HEAVY METALS PRESENT IN FLY ASHES ON ZEOLITE SYNTHESIS

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Keywords: fly ash, zeolite synthesis, heavy metals

ABSTRACT

The synthesis of zeolites from fly ashes is very promising method of using waste generated by coal combustion. In recent years, many articles have been written to improve the methods of synthesizing zeolites from fly ash. One of the problems in effective synthesis is the heterogeneous composition of the ashes. The presence of heavy metals is particularly troublesome.

The conducted research covers the process of zeolite synthesis using the own designed method of their preparation, through the variable composition of the starting reagents, with particular emphasis on the use of oxides of selected metals. The author used the hydrothermal method, modifying the composition of the starting mixture. Such an experiment was proposed to verify the effect of the individual composition on the type of zeolite material obtained. Ten zeolite samples were synthesized, they were analyzed, determining the specific surface area and the type of material obtained. Based on the obtained results, the influence on the physicochemical properties of the synthesized product of the type of individual metal oxide was determined.

Appropriate selection of raw material composition in the process of zeolite synthesis in terms of metal oxides can help us in selective zeolite synthesis. The division of fly ashes due to the composition of the metal oxides they contain may in the future be used to categorize fly ashes as a raw material for the synthesis of zeolites.

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MULTI-OBJECTIVE OPTIMIZATION OF A SOLAR-ASSISTED STIRLING HEAT ENGINE SYSTEM USING ELITIST RAO ALGORITHMS

R. Venkata Rao[1,*], **Hameer Singh Keesari**[1], **Dawid Taler**[2], **Jan Taler**[2], **Paweł Ocłoń**[2]

Keywords: Multi-objective optimization, Rao algorithms, elitist Rao algorithms, decision making, solar-assisted Stirling heat engine

ABSTRACT

Renewable energy resources are significant sources of contribution to clean energy demands. In the last few decades, researchers have focused on development of new techniques and tools that could harvest energy from renewable energy sources. However, to meet energy demands and reduce investment, a rigorous study of energy extraction systems is required. Identifying, analyzing, and optimizing the effect of various parameters of a renewable energy system contribute significantly in assessing the system's performance. Furthermore, it is always not preferable to present the optimum system parameters considering only a single objective as these systems have multiple objectives such as power output, system efficiency, investment cost, economic and ecological factors. Hence, this work proposes improved versions of the Rao algorithms named as elitist Rao (ERao-1, ERao-2, and ERao-3) algorithms for multi-objective optimization of a solar-assisted Stirling heat engine system. The multi-objective elitist Rao algorithms have no algorithm-specific control parameters and this features reduces the burden of tuning the parameters for optimum results. The proposed algorithms are developed by implementing the elitism concept in the basic Rao algorithms. The proposed algorithms use the elite population and duplicate solutions removal to avoid premature convergence and trapping into local optima. The performances of the proposed algorithms are tested using a case study of a solar-assisted Stirling heat engine system and are compared with those of the NSGA-II, Jaya, adaptive multi-team perturbation guiding Jaya (AMTPGJaya), self-adaptive population Rao (SAP-Rao), and Rao algorithms. The efficiencies of the proposed elitist Rao algorithms are evaluated in terms of spacing, hypervolume, and coverage metrics. The computational results obtained by the proposed algorithms are superior to those achieved by the well-established non-dominated sorting genetic algorithm.

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THE DIRECT METHOD FROM FINITE SPEED THERMODYNAMICS USED FOR ISENTROPIC EFFICIENCY EVALUATION OF QUASI-CARNOT IRREVERSIBLE CYCLES

Cătălina Dobre[1], Mihaela Constantin[1,*], Cristi-Emanuel Iolu[1]

Keywords: Finite Speed Thermodynamics, Direct Method, irreversibility, isentropic efficiency

ABSTRACT

The paper presents the analysis of the influence of irreversibility in a reversed quasi-Carnot vapor cycle. The present computation scheme is based on recent developments of the Direct Method of Finite Speed Thermodynamics (FST). The Direct Method consists in analyzing any irreversible cycle, step by step, by writing the corresponding equation of the First Law of Thermodynamics for finite speed processes and integrating it on the whole cycle, for each process. The First Law expression for finite speed processes includes three of the main sources of internal irreversibility, namely: finite speed interaction between the piston and the gas/vapor, friction due to the finite piston speed within the cylinder, throttling processes in the valves.

The study aims to take into account the essential differences between the behavior of perfect gases and vapors, and to analyze the changes necessary to develop a methodology for fully analytical calculating the isentropic efficiency. The principal objective of this approach is to avoid the use of property tables, by replacing them with a fully analytical calculation scheme for the irreversible cycle, in a manner similar to the development available in Classical Reversible Thermodynamics.

The analytical results were applied to a particular set of operating parameters for which the optimum piston operating speed corresponds to the minimum refrigerating power and maximum operating efficiency. Corroborating the variation of the performances (COP and power) and the evolution of the isentropic efficiency, the results show the designer what the losses are during the operation of a machine and allow it to "see" where it is necessary to intervene in order to increase the performance of refrigeration machines and heat pumps.

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PERFORMANCE CALCULATIONS OF THE STEAM REHEATER IN LARGE POWER BOILER USING THE NUMERICAL-ANALYTICAL METHOD

Katarzyna Wrona[1], **Dawid Taler**[1], **Magdalena Jaremkiewicz**[1], **Jan Taler**[1], **Mateusz Marcinkowski**[1]

Keywords: Reheater, two-pass cross-current heat exchanger, superheater, complex flow systems

ABSTRACT

The paper presents a mathematical model of a steam reheater in a steam boiler installed in a power unit of 1000 MW. A new numerical-analytical method was used to determine the temperature distribution of steam, flue gas and tube walls of the reheater. Even if the whole superheater is divided into a small number of elements, very high accuracy of calculations is achieved. The analyses were carried out at different divisions of the whole reheater into finite volumes. The reheater is a two-pass cross-current heat exchanger. There are 44 panels of tubes on the width of the boiler. The steam flows parallel through 20 pipes in each pass. The results of the first and second pass steam temperature calculations were compared using the ε-NTU (Effectiveness - Number of Transfer Units) method. A perfect match between the steam temperature and the average temperature of the flue gas at the outlet of the reheater was found. The advantage of the developed method of superheaters modelling is the possibility to calculate superheaters with complex flow systems.

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ENERGY BALANCE OF THE GROWTH CHAMBER IN THE INSTALLATION FOR THE PRODUCTION OF VEGETABLE GERM

Klaudia Zolińska[1,*], **Paweł Mirek**[2], **Marcin Panowski**[3]

Keywords: heat exchange, heat recovery, sprout production, waste heat

ABSTRACT

The development of seeds in the growth chambers plays an important role in the production of vegetable sprouts after the imbibition phase. It forms a growth stage lasting dozens of hours in which heat is released as a result of metabolic processes [1] according to the reaction equations of catabolic (1) and anabolic (2) [2]:

$$substrate + O_2 + x\ ADP + x\ Pi \rightarrow CO_2 + H_2O + x\ ATP + heat \quad (1)$$

$$substrate + y\ ATP \rightarrow growth + y\ ADP + u\ Pi + heat \quad (2)$$

where: Pi - inorganic phosphate, ADP - adenosine diphosphate, ATP - adenosine triphosphate

In the germination phase, the amount and frequency of water supply are crucial. On the one hand, it is necessary in the growth process, on the other hand, it protects against overheating of plants and damaging the crops. In traditional installations, the heat removed from the biological mass is irretrievably lost due to its low exergetic value. However, according to the own research, the heat flux is high enough to be an efficient source necessary to cover a large part of the energy needs of the crop.

The article presents the energy balance of the Mung bean grains growth chamber carried out on an industrial installation for the production of vegetable sprouts (Fig. 1).

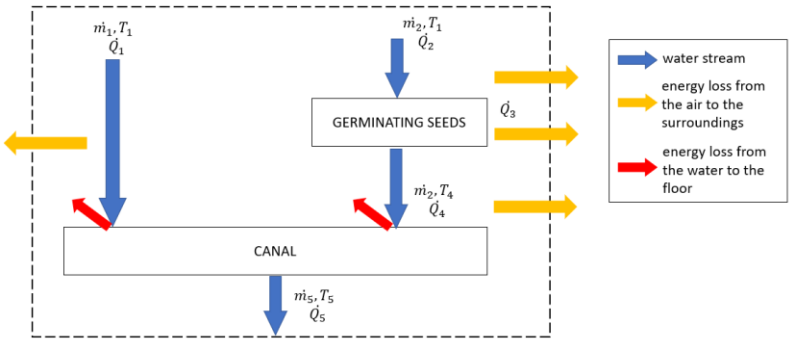

Figure 1. Diagram of the growth chamber of vegetable sprouts.

Based on the performed measurements, the heat flux removed from the growth chamber was determined, taking into account the variable production parameters. The performed analyzes allowed to identify the places of potential energy losses and to improve the efficiency of heat recovery from the growth chambers, as well as to propose a technological system based on a thermal energy storage cooperating with a membrane heat exchanger.

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MODELING OF THE HEAT EXCHANGER IN THE ADSORPTION CHILLER BED WITH DESALINATION FUNCTION

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Keywords: adsorption, absorption chiller, desalination

ABSTRACT

According to a report by the International Refrigeration Institute in Paris, the refrigeration sector uses around 20% of the cost of producing electricity. The estimates of IEA (International Energy Agency) show that about 10% of the demand for electrical energy is consumed for cooling of buildings. The air conditioning installations of buildings mainly use compressor chillers where electricity is employed to supply them. The real alternatives to compressor chillers is the adsorption chiller is used hot water having a temperature of 55C derived from waste heat from technical processes or water from the district heating network. Adsorption chillers are characterized by a low coefficient of cooling efficiency of COP, about 0.6, and are large dimensions of the device. One way to increase the efficiency of the device is to optimize the exchanger in the bed for increase of heat exchange between silica gel and the exchanger surface.

The main purpose of the work was to present the procedure for creating a computer model of the heat exchanger included in the adsorption chiller, to show the process of creating a numerical grid and the settings of the solver used to calculate the model. The calculation will be performed in the ANSYS CFX software.

The key point of the work is to show the results of a computer simulation in terms of the flow of the medium through the exchanger as well as the distribution and pressure drop in the device. After receiving the results, their analysis was carried out and the model was parameterized in order to find changes in the geometry of the exchanger that may positively affect the improvement of the heat exchange process and thus the efficiency of the device. The final part of the work was devoted to considerations on the obtained results as well as suggestions and recommendations of ways to further increase the efficiency of heat transfer in the tested device.

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MATHEMATICAL MODELLING OF SUDDEN REDUCTION IN WATER FLOW RATE IN A PLATE-FIN AND TUBE HEAT EXCHANGER

Anna Korzeń[1,*], **Dawid Taler**[2]

Keywords: heat exchanger, numerical modelling,experimental study, transient response

ABSTRACT

The article presents a mathematical simulation of plate fin and tube heat exchanger. Water flows inside the pipes and air perpendicular to their axis. The transient operation of the heat exchanger was performed using general numerical model developed in [1]. Water-side Reynolds number was between 4000 to 12,000. A transient response was modelled for sudden reduction in the water volume flow rate in time.

In the beginning, heat transfer correlations for air and water were established using the experimental data. Unknown parameters occurring in the relationships for the Nusselt numbers on the air and water-sides were estimated using the least-squares method. The power-type form of the relationship was used for the air-side Nusselt number. Two correlations of different form were chosen for the water-side Nusselt number. The mathematical model of the heat exchanger was built and these correlations were used for the simulation of its transient operation.

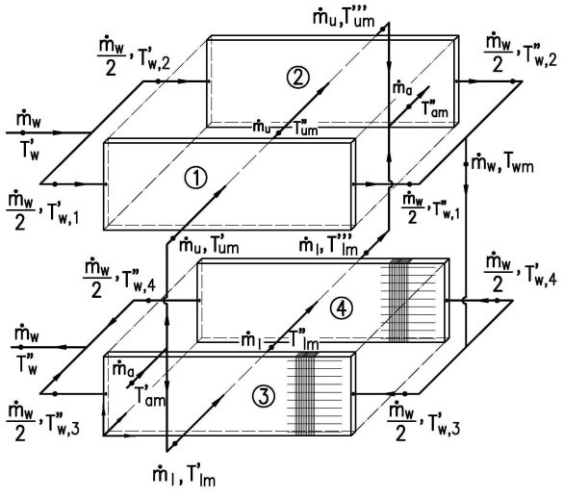

Figure 1. The modelled heat exchanger flow diagram.

The outcomes of the mathematical simulations of a heat exchanger using experimentally determined air and water-side heat transfer formulas for calculation of heat transfer coefficient were compared with the measurement data. Compatibility of computation results (i.e. air and water temperature at the outlet of the heat exchanger) with the experimental data was excellent.

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CFD MODELLING AND EXPERIMENTAL TESTING OF AN AIR HEATER IN A POWER BOILER FIRED WITH VARIOUS GASEOUS FUELS

Tomasz Sobota[1,]*, Mariusz Granda[1], Magdalena Jaremkiewicz[1], Dawid Taler[1]

Keywords: CFD modelling, ε-NTU (Effectiveness-Number of Transfer Units) method

ABSTRACT

In the operation of the boiler, the air heater and the water heater below it are seriously damaged. Since various fuels, such as natural gas, blast furnace gas or coke oven gas, or a mixture of the three, are burned in the boiler, there is a danger of corrosion caused by sulphuric acid. These fuels contain sulphur, from which sulphur dioxide is produced after combustion. This, in turn, together with water from condensation of water vapor from flue gases on cold pipe surfaces, forms sulphuric acid. Sulphuric acid solution flowing down the vertical pipes of the air heater causes corrosion not only of the air heater pipes but also of the horizontal water heater pipes located below.

A simulation of the flow and heat exchange on the flue gas and air sides was performed to determine the areas of the air heater where the temperature of the air heater pipes is low and where condensation may occur. Based on the measured air and flue gas mass flows and the measured flue gas temperatures behind the heater and the air temperature at its inlet, the flue gas temperature before the air heater was determined using the ε-NTU (Effectiveness-Number of Transfer Units) method.

Knowing the temperature and velocity of the flue gas and air at the inlet to the air heater, CFD modelling was carried out.

On the basis of CFD modelling and experimental research, the areas in the heater where sulphuric acid can form at given outside air temperatures were determined.

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THE IMPACT OF CHOSEN ENVIRONMENTAL POLLUTION ON SOLAR ENERGY SYSTEM EFFICIENCY

Stanisław Gumuła[1], Krzysztof Pytel[1,*], Małgorzata Paiskowska-Silarska[2], Wojciech Kulinowski[2]

Keywords: Sustainable Development and Sustainability, climate change, energy use and consumption, pollution reduction, renewable energy

ABSTRACT

This study presents an approach to estimating the impact of air pollution obtained by using air pollution measurements for the proposed inclination angles of the PV panel. Many factors have an impact on the performance of a PV system, but air pollution and the angle of the panels are one of the most important factors. The deposition of airborne contaminants on the PV panels, and other air pollutants associated with PV setup at a selected location and at different periods allows the estimation of the PV system performance decline and allows for the development of a cost effective PV setup angle constraint. Electricity generated by photovoltaic power plants can be considered ecological, but the analysis was undertaken due to the fact that photovoltaic installations should work the longest and most efficiently so that the energy expenditure and raw materials used in their production should be maximized. The results were analyzed for the selected location in Poland for 2020. The object of research is a photovoltaic micro installation with a rated electric power of 1200 Wp that is located on a flat roof in a city with a high degree of pollution. A photovoltaic installation equipped with modules using a monocrystalline silicon photovoltaic cell works continuously, regardless of weather conditions, external power source or other external factors. The positive aspects of the impact of renewable energy on the environment resulting from the use of photovoltaic energy conversion systems are presented. The final effect of air pollutions, which was estimated as a loss on the obtained power, was calculated at the maximum level of 17% for the selected working conditions.

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ENERGY FUELS ENVIRONMENT 2020
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FORCED VERTICAL MOVEMENT OF THE ATMOSPHERE TOWARDS AIR QUALITY IMPROVEMENT

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Keywords: air quality, particulate matter, atmosphere, shock wave generator

ABSTRACT

Outdoor air pollution affects human health and activity significantly. According WHO data 90% of population lives in polluted area, what causes 4.2 million death each year [1]. Poland also struggles with poor air quality, especially with large exceedances of the outdoor concentration of particulate matter (PM) and carcinogenic benzo(a)pyrene (B(a)P) contained in them. The cause of poor air quality are anthropogenic and natural emissions of pollutants released to the atmosphere. However, meteorological conditions such as lack of winds, no vertical movement of the atmosphere or absence of precipitation causing high and long-lasting pollution concentrations, which directly affects the quality of life and health of the inhabitants. The unnatural forcing of atmospheric movements may induce a significant and rapid reduction in the concentration of pollution in a relatively large area i.e. covering a city such as Krakow.

Krakow is one of the most polluted cities in the world, and the specificity of its location also affects air pollution. The city is located in the Vistula valley and is surrounded on the north and south by hills - this in turn causes poor air circulation. The development of a smog removal methodology in Krakow will allow the creation of a model for other cities on a similar location.

This work describes the operation of the invention reducing PM concentrations in the atmosphere and preliminary analysis of the results of its operation. The invention creates a cycle of shock waves by exploding a mixture of combustible gases and air. The result of shock waves impact is destruction the structure of the atmospheric temperature inversion layer, which enables the formation of vertical movements of the atmosphere, leading to reduce air pollution concentration. The invention is mobile, it can be used anywhere, it is equipped with an air quality monitoring system, including contamination detection system mounted on drones and an operational algorithm that determines the need to generate a shock wave, the number and strength of an explosion.

The initial results of the device operation show an average reduction of PM10 concentration of near 20% in the atmosphere layer at a height of up to 100 m (vertical measurements every 1m) at a distance of 10 m from the axis of shock wave generation in a cycle of 11 minutes consisting of 110 explosions.

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BLACK CARBON, ELEMENTAL CARBON AND ORGANIC CARBON AS EMISSION FACTORS OF BIOMASS AND FOSSIL FUEL COMBUSTION

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Keywords: black carbon, elemental carbon, organic carbon, soot, carbonaceous matter

ABSTRACT

Atmospheric aerosol is an extremely important research object due to its negative impact on human health and the environment [1]. Atmospheric dust affects human morbidity and contribute to the increase in premature mortality, mainly due to the effects on the respiratory and circulatory systems [2]. In the context of environmental impact, a very important component of aerosols is the carbonaceous substance due to its ability to absorb solar radiation [3]. The content of carbon matter is dominant in the fine fraction of dust and it has been estimated that in the case of $PM_{2.5}$ it constitutes about 20–50% of the mass concentration and less (20–35%) in PM_{10} [4,5,6].

In this work, two research methods were used to test the carbon substance: thermo-optical and optical. As a result of the application of the thermo-optical method, two main parts of total carbon (TC): organic and elemental carbon (OC and EC, respectively) were obtained from three dust fractions (PM_1, $PM_{2.5}$ and PM_{10}). In addition, the concentrations of black carbon (BC) and its components: BC_{ff} (BC from fossil fuels combustion) and BC_{bb} (BC from biomass burning), were also obtained. The measurements concerned the urban station in Zabrze in southern Poland and covered the non-heating season 2019 (from April 1 to September 30, 2019).

Statistical analyzes showed very strong correlations between the indicators obtained from the thermo-optical and optical methods. The strongest correlations were found for BC and EC obtained for the fine dust fraction (PM_1) and this correlation weakens with increasing dust fraction ($PM_{2.5}$ and PM_{10}). The same relationship was noted for BC_{ff}/EC. In the case of BC and OC, the correlation was very strong for both the PM_1 and $PM_{2.5}$ fractions. A different situation was noticed for BC_{bb}/OC because the strongest correlation was noted for the $PM_{2.5}$ fraction.

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CITIES PROBLEM WITH AIR POLLUTION - CHEMICAL CHARACTERISTICS OF PARTICULATE MATTER PM2.5

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Keywords: polycyclic aromatic hydrocarbons, mercury, ions, trajectory model

ABSTRACT

The objective of this research is to evaluate the seasonal variation of the chemical composition of PM2.5 collected in Krakow, district Kurdwanow (50°00'38.1"N 19°56'57.1"E, South Poland) from February 2014 to January 2015. During the campaign, 192 samples were collected with 24h resolution using Low-Vol samplers. Chemical characterization was performed using the following analytical techniques: gas chromatography coupled with mass spectrometry (GC/MS), ion chromatography (IC), thermal-optical analysis using Sunset Laboratory Inc. Analyzer, thermal decomposition with the MA-3000 mercury analyzer. The modeling tool Hybrid Single-Particle Lagrangian Integrated Trajectory model (HYSPLIT), developed by NOAA's Air Resources Laboratory, was used to investigate the possible source region of air pollutants.

The research showed significant seasonal variation between the heating season and the non-heating season. PM2.5 daily mean concentrations ranged from 6 μg/m^3 (summer) to 206 μg/m^3 (winter). The lowest total mean concentration of polycyclic aromatic hydrocarbons occurred in summer, the highest in winter (14,8 ng/m^3 and 52,6 ng/m^3, respectively). The mean annual concentration of benzo(a)pyrene was 2,4 ng/m^3. The range of organic and elemental carbon values was 2,7-105,2 μg/m^3 and 0,7-11,7 μg/m^3 respectively, while mercury concentrations ranged from 0,3 pg/m^3 to 287,1 pg/m^3. IC analyses showed the highest contribution of ammonium, sodium, nitrates, sulphates and chlorides. Trajectory model (HYSPLIT) showed that the highest concentrations of PM2.5 were recorded mostly on days when air masses were moving from the south-west range.

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A COMPARISON OF TWO MOUNTAINOUS LAKES ON THE BASIS OF THE VERTICAL DISTRIBUTION OF RADIONUCLIDES (A CASE STUDY OF THE TOPOROWE STAWY LAKES, TATRA MOUNTAINS)

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Keywords: sediments, Toporowe Stawy Lakes, artificial and natural radionuclides, chemometric analysis, ^{210}Pb dating

ABSTRACT

Sediment plays an important role in aquatic radioecology. They act as a tank for different kinds of compounds including radionuclide. Sediments constitute naturally occurring material that is formed by the process of weathering and erosion. Small particles are transported with wind or water and they settle into the aquatic environment. The presence of radionuclide in sediments is an effect of their natural distribution in every part of the environment. The natural radioactivity in soils and rock sediments is mainly due to ^{238}U and ^{232}Th and primordial ^{40}K radionuclide. The concentration varies considerably, depending on the geological characteristic of the area. Additionally, human activity has caused an increase in the radioactivity in the environment. Huge amounts of artificial radionuclides, such as ^{137}Cs or ^{241}Am, were introduced into the environment during the Chernobyl accident (1986) and nuclear weapons tests [1,2]. The aim of this work was to estimate preliminary distribution of radioactivity in the sediment core taken from Toporowe Stawy Lakes (Niżni (TSN) and Wyżni (TSW), the Tatras). Radionuclides were used to find differences and similarities in the studied lakes. For this purpose, cluster analysis was used. The sampling was done using Limnos corer. After preparation of the physical sample, gamma measurements were executed in hermetically closed vessels. The ^{210}Pb radionuclide was determined via it's daughter radionuclide ^{210}Po, by applying the alpha spectrometry. The level of radioactivity in both lakes was quite similar but the sediments were characterized by different distribution of the chosen radionuclides. The mean values for TSN are as follows: ^{137}Cs~123 Bq·kg^{-1}; ^{40}K~389 Bq·kg^{-1}; ^{228}Th~55 Bq·kg^{-1}; ^{226}Ra~86 Bq·kg^{-1}; ^{241}Am~5 Bq·kg^{-1}; ^{210}Pb~200 Bq·kg^{-1}. For TSW the radioactivity levels of ^{226}Ra and ^{241}Am are comparable to the TSN. The mean values of ^{137}Cs, ^{40}K, ^{228}Th and ^{210}Pb are almost twice as high as in TSN. Using chemometric tools similarities in the layers were found in both lakes. The source of material supply to the lake and differences in the sedimentation process were estimated on the basis of radionuclide distribution and geochronology by means of CRS (Constant Rate of Supply) model (^{210}Pb method).

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ASSESSMENT OF MERCURY CONTAMINATION OF LANDFILLED AND RECOVERED FOUNDRY WASTE - A CASE STUDY

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Keywords: foundry waste, mercury, landfilling, recovery, soil

ABSTRACT

Environmental pollution by mercury is a local problem in Poland and concerns industrial sites, mainly those close to mines, coal power stations, transport routes [1-3]. Foundry waste is not included in the source of mercury in the environment. This wastes are usually characterized by low mercury content in contrast to other heavy metals. For this reason, in the toxicity assessment of this waste the content of this metal is not analysed [4-5]. However, due to Hg toxicity, even a minimal content may have a negative impact on biota. The toxicity of foundry waste is usually assessed on the basis of total content and leachability of heavy metals and toxic organic compounds from binders origin [6-8]. This study focuses on assessing the mercury content of foundry waste. The results were compared with the mercury content of local soils to assess the degree of waste pollution compared to the reference level. Waste samples were taken from six piles located in the landfill. Piles was formed from recovered waste, which are used to road aggregates production. Primary samples were taken from each pile, which were averaged and reduced to a laboratory sample. The mercury content and fractional composition (particle–size), organic matter (OM), total organic carbon (TOC), pH and elementary composition of waste were analysed. It was found that the mercury content in foundry wastes was very low, at the level of natural content in soils and did not pose a threat to the environment. Based on the fractional analysis of the waste, it was found that the main component of the waste was the sand fraction. Larger fractions (>5.6 mm) were diverse material, consisting of metallic sinters, slag, refractory materials and others. The content of organic matter in the tested waste was higher than the content in soils. Organic binders are the main component of the organic matter in foundry wastes. No statistically significant correlation between the mercury content and the content of organic matter, total carbon (TC) and total organic carbon (TOC) and the waste fraction of tested waste was found. Low correlation between particle size and OM, TOC, TC of waste were determined. Whereas, a positive correlation between soil organic matter (SOM), TOC and mercury content for soil samples was found.

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OBJECTIVIZATION OF CARBON DIOXIDE DURING THE TEACHING PROCESS

Ivana Tureková[1,*], Jozef Harangozó[1], Iveta Marková[2]

Keywords: carbon dioxide, indoor environment, concentration

ABSTRACT

Carbon dioxide belongs to chemical factors whose concentration in the classroom environment does not have a strict concentration limit determination in the Slovak Republic. For this reason, the general criterion of its concentration acceptability is the recommended limit value of 1000 ppm, introduced by Max Joseph von Pettenkofer. However, it is not possible to maintain this value nor at the 0,5–fold air circulation. The majority of school buildings are built without ventilation systems, predominantly with insulated outer cladding and plastic windows, as we could see in the case of the building we evaluated. Our research aimed to monitor the increase in carbon dioxide concentration during a daily teaching cycle at the 52-70 % seat-occupancy of the classroom by students in November. The variable parameters were the thermal – humidity microclimate and various educational activities – workshops, lectures and seminar lessons. With a questionnaire, we focused on obtaining subjective opinions of respondents about the influence of indoor environment factors (temperature, humidity, air circulation), as well as the dustability, carbon dioxide and possible symptomatic manifestations caused by the microclimate. Based on the comparative analysis of obtained results and subjective evaluation, we found out that 63 % of requested respondents correctly identified the carbon dioxide concentration as unsuitable. However, they were not able to evaluate correctly the humidity which achieved the required parameters.

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ASSESSMENT OF DISPOSAL TECHNIQUES FOR END OF LIFE BATTERY STORAGE SYSTEMS

Ravindrane Padma[1,*], Arango-Muñoz Melisa[1]

Keywords: batteries, battery recycling, disposal, re-use, energy

ABSTRACT

The current climate situation and worldwide implementation of compromises to reduce the damage in earth's environment inevitably requires the reduction of emissions obtained from fossil fuels and hence, transitioning to renewable energy sources. Integrating renewable energy generation to the electric grid depends largely on energy storage systems for stabilized and reliable power distribution, owing to the intermittent state of such resources. Another major contributor to the rapid growth in the production of battery storage systems are electric vehicles, that play a crucial role in reducing green-house gas emissions impacting global temperatures and air quality. The battery market is expected to grow at a Compound Annual Growth Rate (CAGR) of more than 12.13% during 2020 to 2025[1]. This accelerated advancement poses challenges in processing at the battery end of life. Development of methods and technologies that enable in recovering the raw materials from the disposed batteries for further manufacturing will rectify the limited availability of scarce elements[2] for production and also reduce the environmental impacts throughout the battery life cycle. The current available approaches for battery recycling and re-use are assessed and the areas of improvement are discussed in this study.

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PHOTOVOLTAIC THERMAL SOLAR COLLECTORS – AN OVERVIEW

Maciej Szram[1,*]

Keywords: PVT Collector, Solar Energy, Photovoltaics, Solar Collectors

ABSTRACT

The rise of energy demand and the need to decrease carbon dioxide emissions worldwide led to a rapid development of renewable energy technologies, including solar energy systems. As PV panels and solar collectors become cheaper and more popular, a technology combining these two into a single device may appear to be a viable solution. The purpose of this study is to present the overview of Photovoltaic-Thermal Solar Collectors and investigate the potential of this technology. Laboratory measurements were made in order to determine the parameters of an exemplary PVT collector. The study measured these results and compared them with literature data. Technical parameters of an exemplary collector turned out to be low due to a poor condition and years of exploitation. The literature research proves that the use of PVT collectors is less effective than using PV and solar heating systems separately. The study shows that the technology of PVT collectors has little chance to become widely used for the production of electricity and heat in the nearest future. Further studies are needed to explore possible technological advancements of PVT collectors.

Figure 1. Photovoltaic Solar Collector

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ENERGY TRANSITION PERFORMANCE IMPERATIVES – ANALYSIS OF THE POLISH ENERGY SECTOR OPERATING FRAMEWORK

Mariusz Badura[1,*], Jakub Strąg[1]

Keywords: energy, transition, sector, Poland

ABSTRACT

Energy Transition is currently the key aspect of the sustainable energy sector development. While the purpose of the process is globally acknowledged, it is crucial to conduct it properly in order to meet its presumptions. A successful energy transition model for different stakeholders can be distinguished by considering various performance factors, such as: "Energy Security and Access", "Environmental Sustainability" and "Economic Growth and Development", which were thoroughly examined in this analysis. The scale of the energy system, energy demand, different fuel sources and affordable technologies - all these variables had to be considered in order to create the objectives aimed at ensuring an effective energy transition framework.

The aim of this study is to evaluate the efficiency of the Polish energy sector transition plan considering the ETI (Energy Transition Index) imperatives [1] and compare the actions undertaken to fulfill them and the results obtained to chosen European countries. The analysis has been conducted in accordance with the major aspects of the energy transition index, which consist of: "Energy System Structure", "Capital and Investment", or "Infrastructure". The results obtained in the research show that the Polish energy transition plan can be improved in the economical and ecological areas of the country's infrastructure development program. The suggestions and general ways of improvement in the Polish energy sector planning were presented in the conclusions of this paper.

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ELECTROCHEMICAL CHARACTERISATION OF LOW AND NON-PLATINUM CATALYSTS FOR FUEL CELL APPLICATIONS IN GAS DIFFUSION ELECTRODE SETUP

Talal Ashraf[1,2], Lusia Martins[1], Serhiy Cherevko[3], Konrad Ehelebe[3], Magdalena Dudek[2,*]

Keywords: Oxygen reduction reaction, Non-PGM catalyst, Platinum confinement, Gas diffusion electrode, AEMFC, PEMFC.

ABSTRACT

In this research work, an optimised gas diffusion electrode GDE half-cell setup is used to determine the ORR activity of electrocatalysts and aimed to bridge the gap between fundamental and applied electrochemical methods such rotating disk electrode and membrane electrode assembly. Various parameters were investigated to optimise the catalyst layer for commercial Pt/C catalyst, advanced Pt/HGS catalyst and non-PGM Fe-N-C catalyst in proton and alkaline exchange membrane fuel cell conditions (PEMFC & AEMFC). The Pt/C showed high performance with ECSA of 66.59 m^2/g_{pt} approaching the current density of 2 A/cm^2 at 0.63 V_{RHE} in 1.0 M $HClO_4$ but suffered from severe degradation in 1.0 M H_2SO_4. The addition of membrane to commercial Pt/C in both electrolytes to mimic the conditions of PEMFC results with comparable activity. The performance of Pt/C in alkaline was superior with the current density of 2 A/cm^2 at 0.8 V_{RHE}, which was highest in comparison to the acid electrolyte. Advanced platinum catalyst activity improved by stress cycling to 10,000 and 30,000 cycles, the ORR activity enhanced up to 50 mV. AEMFC conditions were also be mimicked in GDE cell with non-PGM catalyst Fe-N-C in 1.0 M KOH for the stability, ionomer activation and reproducibility. The catalyst layer was optimised with the ion exchange ionomers with the enhanced improvement to 80-100 mV by several breaking and time-based (max 48 hours) ionomer activation procedures. This shows the versatility and advantage of GDE half-cell to optimise the single catalyst layer properties. Thus, GDE is proved to be a very effective method for quicker, reliable optimisation of electrocatalyst performance but with several challenges need to be addressed in the future work.

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SPONTANEOUS VIOLATIONS OF THE CLAUSIUS-DUHEM INEQUALITY

Martin Ostoja-Starzewski[1,*]

Keywords: Clausius-Duhem, continuum mechanics, Couette flows

ABSTRACT

Already in the 19th century, J.C. Maxwell recognized that "*the second law is of the nature of strong probability … not an absolute certainty*". However, it has only been in the past three decades that theoretical, simulation, and experimental results in physics in support of that old statement have been obtained. Fundamentally, there is a non-zero probability of negative entropy production rate on very small length and time scales. Thus, the Second Law needs to be replaced by the fluctuation theorem [1]. First, we discuss the consequences of these results for the axioms of continuum mechanics, arguing in favor of a framework relying on stochastic functionals of energy and dissipation [2,3] with random field coefficients of non-conservative responses which are required to satisfy the positive definiteness only on average. With the microstructure-based fluid mechanics (classical and micropolar), this framework is then employed to examine the violations of Clausius-Duhem inequality in Couette flows of molecular [4,5] and granular media [6]. The boundary between regimes of violations and non-violations is mapped in the parameter space. Extensive sampling of LAMMPS-generated realizations of Couette flows of granular media allows determination of the dissipation function as a wide-sense stationary random process with near-Gaussian properties and non-trivial fractal and Hurst properties.

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EVALUATING THE CYCLIC VARIABILITY OF A MULTI-CYLINDRE FLEX FUEL ENGINE BY USING WAVELETS

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Keywords: Flex-fuel, Cycle-to-cycle variations, wavelet analysis

ABSTRACT

In Brazil, the Flex-fuel vehicles are able to run on any proportions of commercially available Brazilian fuels. The engine performance can be affected greatly by in-cylinder combustion variability. Usually, the cyclic variations are evaluated by acquiring the in-cylinder pressure, combustion and emission data which are then used to carry out conventional statistical analysis. The in-cylinder pressure data and combustion durations were acquired by carrying out the experiments with Brazilian commercial fuels (i.e., gasohol, E27 and hydrous ethanol, E95h) for the engine speed of 4000rpm at full engine load. The commercial flex-fuel naturally aspirated engine (see specifications in Table 1) was used to carry out the experiments [1]. Numerous, studies have been published incorporating the evaluation of in-cylinder cyclic variations by conventional methods. In the present work, the wavelet analysis is adopted for the evaluation of cyclic variability [2-3]. The acquired data of 300 consecutive engine cycles was then used to carry out wavelet analysis. The wavelet power spectra (WPS) of indicated mean effective pressure (IMEP) series are evaluated for each cylinder. The results obtained by carrying out the wavelet analysis are consistent with respect to the conventional statistical analysis [4]. The interdependence of IMEP and combustion durations is evaluated by cross wavelet transform. The anti-phase relationship expressed by cross wavelet spectra (XWS) of IMEP and combustion durations affirm the interdependencies.

Table 1. Engine specifications [1]

Engine displacement	***cm³***	**1199**
Stroke	***mm***	75
Bore	***mm***	90.5
Compression ratio	-	12.5:1

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ENERGY FUELS ENVIRONMENT 2020
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AN INVESTIGATIVE STUDY OF THE GUEYMARD DI MODEL APPLICABILITY AT ANNABA CITY (ALGERIA) LOCATION

Fethi Bennour[1,*], Hocine Mzad[1]

Keywords: Gueymard DI model, optimal solar radiation, PVGIS-SARAH, irradiances gap differences, Annaba city

ABSTRACT

In order to preserve our planet and by the way to fight against the climate change, all of us must use renewable energies and also having in mind that hydrocarbons resources are in depletion, in Algeria, the solar energy is the most available and in the coast can reachs I_T=1050 W/m^2 .

This paper intends and tries to present, first, a comparative study between the global radiations reckoned by the Gueymard daily integration model using a Matlab® code and the hourly global horizontal radiation values extracted from PVGIS website which has been processed in a Excel spreadsheet, from the sunrise to the sunset for both, In this work , we have undertaken a calculus of the global radiations on various slope angles based on a isotropic model for the typical days of the year 2016 in Annaba city location.

Secondly, an evaluation was carried out of the prediction of the Gueymard model during the 03 principal hours of the typical days for all the months of the year 2016 and was compared to the picked PVGIS values for the zero azimuth surface angle, the calculation were achieved for tilts from 10° up 40° .

Generally , the outcomes seem to be interesting especially those obtained at noon time ,otherwise,in winter months, discrepancies have been revealed, and the computed values from the model don't match with calculated irradiances in the dedicated Excel spreadsheet from PVGIS values , differently,in summer,spring and autumn months, the differences are less than ±30% (as mentioned in several related handbooks), in the other hand and according to the two approaches, the best concordance along the year 2016, has been highighted at noon hours (-20 to 27%) in terms of irradiance gap differences.

Similarly, the curves potted by the two methods, agreed that the optimum tilts are the same.

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THE THERMAL COLLECTORS SLOPE AND SURFACE AZIMUTH OPTIMAL ANGLES DETERMINATION BY GUEYMARD DAILY INTEGRATION MODEL

Fethi Bennour[1,]*, Hocine Mzad[1]

Keywords: Gueymard DI model, optimal slope angle, solar radiation, PVGIS-SARAH, Annaba city

ABSTRACT

Solar energy is free, inexhaustible and available in different countries at various intensity levels ,in order to harness this potential in an efficient way , one must identify the best surface azimuth and tilt angles to harvest the maximum power by the solar thermal or PV collectors on each month of the year.

The interest of this study has an important significance getting the solar energy efficiently in winter to heat water or air , or utilizing the maximum irradiation to feed a absoption cooling machine fitting a building for air conditioning purpose, has become,now, so overriding.

In this paper, we present a graphical method, based on the Gueymard daily integration model, implemented in matlab® software ,in fact, curves of global irradiance on tilted surface have been plotted from the sunrise to the sunset ,and different slope and surface azimuth angles have been applied ,hence, the optimal angles have been determined when the maximum irradiation was generated and the bell like-shape from the sunset to the sunrise appeared more important ,furthermore, with this approach, interesting results were obtained, this technique has been applied to Annaba city (Algeria).

Our findings explicit that the south-facing angle is the more appropriate in this location,besides ,to obtain the maximum intensity irradiation such as 1020 W/m^2 in July , the slope of the collector must be ajusted at 15° , and therfore for every month, the inclination can take value from 40° to 10°, according to the curves drawn.These angles are also useful to make a trade-offs when installing or mounting the solar collectors in Annaba city and to correct the inclination from time to time.

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TRANSIENT CFD SIMULATION OF CHARGING HOT WATER TANK

Piotr Dzierwa[1,*], Jan Taler[2], Patryk Peret[1], Dawid Taler[1], Marcin Trojan[1]

Keywords: stratification, hot water tank, CFD modelling, energy storage

ABSTRACT

Heat accumulation in vertical, cylindrical hot water tanks is one of the methods of increasing the total efficiency of a combined heat and power (CHP) plant, which causes a decrease in the unit cost of produced electricity and heat [1]. Furthermore, it allows to maximize the production of electricity in case of lack of simultaneous peak demand for electricity and heat [2]. Accumulated heat can be used at another convenient time, for example: peak demand for domestic hot water. Moreover, the lifetime of energy devices is increased [1].

This study concerns a numerical analysis based on an axially symmetrical model of a hot water tank using commercial software. The simulation was done for a ten-hour process of charging the heat storage tank. The initial water temperature distribution in the tank was determined based on twenty temperature measurements along the height of the heat store. What is more, the inlet parameters such as water temperature and mass flow as well as ambient temperature were assumed to be transient in time using measurement data obtained from the SCADA at a frequency of one minute. Effects of mesh density on the solution were also analyzed. The results were compared graphically with the data taken from the cogeneration plant after every full hour of this process. In addition, heat loss from hot water tank has been included and the fluctuations of the heat flux depending on the height and time are also presented.

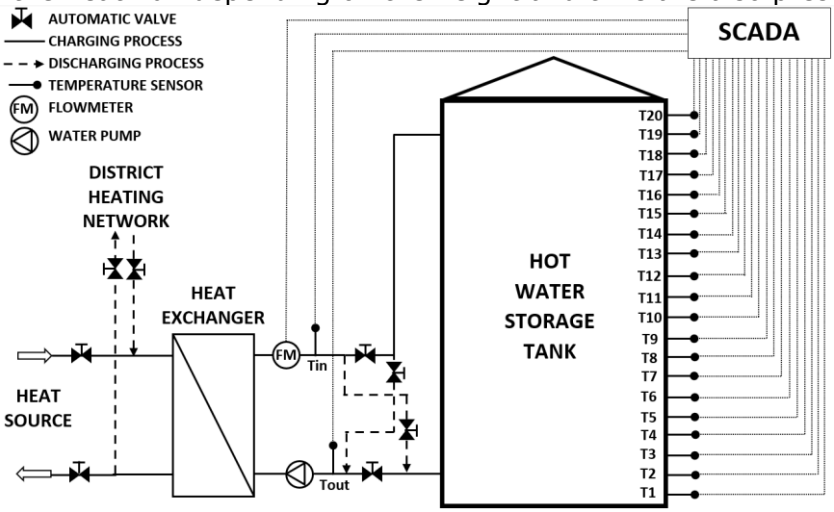

Figure 1. Schematic diagram of heat storage system

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METHODOLOGY FOR IDENTIFYING THE ENERGETIC PARAMETERS OF THE SHIP MAIN PROPULSION TURBINE ENGINE UNDER OPERATING CONDITIONS

Paweł Wirkowski[1,*], Ryszard Zadrąg[1], Artur Bogdanowicz[1], Jarosław Markowski[2]

Keywords: gas turbine, ship, exhaust emission, road tests

ABSTRACT

The issue taken in the article concerns the assessment of the environmental impact of vessels equip with marine turbine engines in propulsion systems. The aim is to determine the impact of the operation of a frigate class warship on the natural environment in terms of ecological characteristics. As part of the research, measurements of the concentration of harmful compounds in engine exhaust gases were carried out during a cruise, with simultaneous recording of engine operation parameters. The obtained results were comparative analyzed with the engine load. The compilation of obtained data made it possible to assign the concentration of individual harmful compounds to the appropriate engine load during the cruise. On the basis of the analyzes carried out, emission factors for harmful exhaust emissions were determined. These factors allow determining the mass of harmful compounds emitted to the atmosphere from marine gas turbine engines during the operation of the Oliver Hazard Perry frigate.

During operation of warships, change of some the model input parameters directly affect the emission of harmful components in the exhaust gas change. while their values are not the same. These changes can be different. The concept of the sensitivity of ecological parameters to the same extortion from external conditions but implemented in other load states is introduced. In the case when the set of parameters is numerous and the values of these parameters are similar, there is a real problem with their correct classification, often based on the discretion of the researcher. In the paper, the authors propose a methodology for classifying the obtained ecological parameters using the Hellwig information capacity indicator method, which is the basis for building a ranking of ecological parameters based on the zero unitarisation method.

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ACOUSTIC AND VIBRATION CHARACTERISTICS OF MARINE ENGINE USING DIFFERENT BUTANOL-DIESEL OIL FUEL BLENDS

Marcin Kluczyk [1,*]

Keywords: Vibrations, noise, butanol, diesel engine

ABSTRACT

One of the main sources of noise and vibrations in a working marine diesel engine are the phenomena accompanying the combustion process of fuel injected into the cylinders. Therefore, the course of the injection process as well as the quality and type of fuel supplied to the engine may also change the parameters of the combustion process. If combustion parameters will change also values describing noise and vibration may change.

The analysis of literature, on the discussed issues, indicates that in this area some research has been conducted, but mainly concerning small engines used in the automotive industry [1-3]. While in recent years there has been an increased interest of manufacturers in the electrification of vehicles used in road transport, this tendency has not been observed with regard to sea transport. The main reason for this is usually the very large required range of vessels. It might be assumed that the use of liquid fuels in shipbuilding will be continued to grow. The majority of marine fuels used today are fossil fuels, the resources of which are constantly diminishing. Potential widespread use of alternative fuel additives such as butanol can significantly reduce the consumption of fossil fuels. One of the conditions to be met by a new commonly used fuel for marine engines are its good properties in terms of limiting the parameters of accompanying processes.

The article presents a comparison of parameters values describing noise and vibrations of a marine engine fueled with different blends of butanol and diesel oil. The measurements were carried out in laboratory conditions on a six-cylinder marine engine loaded with a water brake. The tests were carried out for various engine loads, which allowed to recreate the real operating conditions of the engine.

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OPTIMISATION OF HEATING AND COOLING OF PRESSURE THICK-WALLED COMPONENTS OPERATING IN THE SATURATED STEAM AREA

Dawid Taler[1], **Piotr Dzierwa**[1], **Karol Kaczmarski**[1,*], **Jan Taler**[1]

Keywords: Optimum fluid temperature, thick-walled element, equivalent stress

ABSTRACT

The paper presents a new method of determining optimum temperature variations of the fluid during heating and cooling of cylindrical thick-walled components weakened by holes. The temperature of the factor located or flowing through the pressure component is equal to the saturation temperature.

The stress concentration factors at the edges of the holes were determined using the Finite Element Method (FEM) to represent the real construction of the junction between the element and the spigot.

Optimum fluid temperature variations were determined so that the maximum equivalent stress at the edge of the opening is equal to the permissible stress determined with regard to thermal fatigue. The equivalent stress at the hole edge at the point of its concentration includes thermal stress and stress due to pressure.

Optimum temperature changes of hot water and steam-water mixture were determined during heating up and cooling down of the boiler drum, i.e., during boiler start-up and shutdown.

Three-dimensional computations of the transient field of temperature and stress were carried out for the junction of the drum and downcomer to show that the equivalent stress at the edge of the hole does not exceed the allowable stress if the optimum temperature of the fluid was estimated in accordance with the proposed method.

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SYSTEM OF STORAGE AND USE OF COMPRESSED AIR ENERGY PRODUCED IN RENEWABLE ENERGY MICRO-INSTALLATIONS

Dominik Gryboś[1,*], Jacek S. Leszczyński[1], Bartosz Kozera[1], Jan Markowski[1]

Keywords: Renewable energy, Compressed air energy storage, Energy efficiency, Micro-installation

ABSTRACT

The European Union's energy policy consistently focuses on renewable energy sources. This is related to the urgent development of electricity storage methods, especially distributed one, which would support micro PV installations or micro wind turbines [1]. One of the methods of storing energy is to convert it into compressed air in compressed air energy storage (CAES) system [2]. Its advantages are long service life, length of the charging/discharging cycles and relatively environmental friendliness [3].

The paper presents a micro compressed air energy storage system (μCAES) connected mechanically directly to the wind turbine (Figure 1a).

a) b)

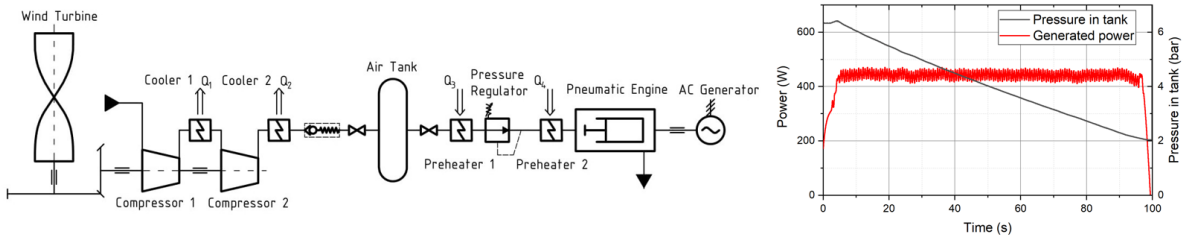

Figure 1. Wind turbine with compressed air energy storage system: a) Layout; b) Electrical power and gauge pressure in the tank during discharge.

The wind turbine drives a two-stage compressor with intercooling that charges the high-pressure tank with air (50-100 bar). The key to the entire solution is the unloading of the high-pressure tank with a pneumatic motor at a slight overpressure of 1.5 - 3 bar. Figure 1b shows the results of an experiment in small scale involving the discharge of a compressed air tank (500 l) with an overpressure of 6.2 bar by own design pneumatic motor [4] operating at gauge pressure 2 bar. An average power of 460 W was achieved during 97 s. On the basis of the constructed mathematical model of the micro CAES, the analysis of the entire system in different scales will be performed.

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ENERGY BUDGET IN THE CASE OF MAGNETICALLY MODIFIED FORCED CONVECTION

Łukasz Pleskacz[1], **Elżbieta Fornalik-Wajs**[1,*]

Keywords: computational fluid dynamics, strong magnetic field, forced convection, heat transfer modification, Nusselt number

ABSTRACT

Nowadays, the energy savings become one of the most demanding challenges, present in all of the engineering fields. It can be realized in the large scale, referring to whole energy systems and significant increase of their efficiency, but also in the small scale systems, in which an efficiency increase can be of moderate level.

Presented paper is dedicated to an issue of magnetically enhanced heat transfer in the modified Graetz-Brinkman problem. This problem considers forced convection through the channel of circular cross-section with various thermal boundary conditions along its wall occurring in the strong magnetic field. Such system was numerically analyzed by Ozoe [1] and then compared with the classical Graetz solution [2]. It was found that the radial component of velocity increased due to the effect of magnetizing force and the vertical velocity profile was modified. Further analyses conducted by Pleskacz and Fornalik-Wajs [3] exhibited 3D flow structure modifications and, what is more important, the heat transfer enhancement. The main scope of current research is related to a modification of energy budget implied by the presence of strong magnetic environment on the forced convection of paramagnetic fluid. The information, whether the local heat transfer intensification results in overall increase of heat transfer performance, is very important for evaluation of energy savings.

In the paper, the numerical dimensionless approach to the given problem is discussed. The similarity parameter, namely magnetic Richardson number, is introduced to simplify mathematical description and to give it more general view.

The results confirm an ability of the magnetic field to increase the overall heat rate in non-invasive way. They also identifies the ranges of similarity numbers values, which assure the energy savings.

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NUMERICAL ANALYSIS OF ENTROPY GENERATION IN A PLUG-FLOW STEAM REFORMING REACTOR

Kamil Oliwko[1], Marcin Moździerz[1,*], Marcin Pająk[1], Grzegorz Brus[1]

Keywords: entropy, steam reforming, numerical simulation

ABSTRACT

Nowadays, steam reforming of hydrocarbons is a primary method of hydrogen production. Considering that the classical steam reforming of methane requires a vast amount of natural gas, it becomes crucial to make it as effective as possible. Entropy generation minimization is one of the possibilities to increase process efficiency. This study aims to analyze the entropy generation rate in a methane/steam reforming reactor through numerical simulation. In the current study, the mathematical model of entropy generation in the small-scale methane/steam reformer is developed. The total entropy generation rate was obtained as a sum of three main components — entropy generation due to heat transfer, chemical reactions, and viscous flow in porous media. The study presents how the external wall temperature, steam-to-carbon ratio, porosity, and other factors influence an entropy generation field inside the reactor. It was shown that the total generation of entropy achieves its peak mainly at the inlet of the reactor, near its axis, but in several conditions, for instance, in lower working temperature, the noticeable amount of entropy is generated near the outlet, further from the reformer center. It indicates that in cases where heat transfer is less intensive, factors like viscosity and reaction rate significantly influence the final distribution. Obtained results could become a solid foundation for process optimization.

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ANALYSIS OF ENERGY FLOW IN RENEWABLE ENERGY SYSTEMS IN TERMS OF THE CONSEQUENCES OF THEIR USE

Mateusz Grzelczak[1], **Jaroslaw Markowski**[2], **Jacek Madry**[2], **Pawel Imilkowski**[2,*]

Keywords: energy flow, analysis, systems, energy conversion

ABSTRACT

The wide use of renewable energy sources is considered crucial in the implementation of one of the European Union's postulates for the coming years to reduce CO2 emissions. The so-called "Green Deal" postulate is placed on all areas of social life of the inhabitants of EU countries and constitutes a challenge for the functioning of the economy in terms of industry and transport. Such action forces the development of zero-emission technologies aimed at obtaining and using energy from sources other than fossil fuels. This action is aimed at obtaining and processing solar energy, wind energy, water energy, and relatively focusing on the short carbon cycle - obtaining energy from biomass.

The challenge posed as zero-emissivity can be implemented with the wide application of electromobility not only in terms of transport means, but it should be understood in a much broader sense - as energy mobility. In this sense, the challenge is the acquisition and processing of energy, as well as its distribution and storage. Therefore, it is crucial to analyze energy flows in different structures of renewable energy systems. These flows determine the scope of energy inputs related to the transformation of energy from the moment of its generation to the moment of its use in accordance with its intended purpose. Energy transport, storage processes and infrastructure must be considered in flow streams. These components of the system structure are currently a great technological challenge and at the same time are the direction of many development works. The conducted analysis indicates the scope of activities and the direction to rational solutions.

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BATTERY SUPPLY NEEDS AND STRATEGY IN THE OPERATING CONDITIONS OF AN ELECTRIC VEHICLE EQUIPPED WITH A CONTINUOUS POWER SUPPLY SYSTEM

Magdalena Dudek[1], Bartlomiej Lis[1], Andrzej Razniak[1], Mariusz Walkowiak[2], Rafal Grzeszczyk[3], Adam Wrona[3], Pawel Imilkowski[4], Jacek Madry[4], Damian Olejniczak[4], Marcin Nowacki[4,*], Jaroslaw Markowski[4]

Keywords: power strategy, energy demand, battery, electric vehicle

ABSTRACT

The market success of electric vehicles is closely dependent on the ability to meet the vehicle operation conditions resulting from the individual needs of users. Therefore, it is crucial to assess the operating conditions in which the electric vehicle could potentially be used. The operating conditions of the vehicle together with its design and function of intended use determine the operating conditions of the electric energy supply system, in particular the conditions of battery use. The current solutions of electric vehicles and the energy accumulators used by them provide a range of electric vehicles from 100 to 500 km depending on the energy capacity of the battery and the operating conditions of the vehicle. As a consequence, electric vehicles are most often used in medium and large cities, depending on the potential number of electric vehicle charging points and their availability.

By introducing solutions that extend the energy capabilities of electric vehicles in the form of own emergency energy sources of the "range extender" type, there is an interference in the vehicle's power supply system in the form of additional energy during its operation. This changes the operating conditions of the vehicle's energy system components. These changes take place in a wider range when we introduce the idea of supplementary power supply in a continuous mode during the operation of the vehicle. The introduction of such a power supply system requires the assessment of operational changes of the system components in terms of energy demand, energy flow streams and the development of a strategy for managing the flow of energy streams depending on the vehicle operating conditions. These activities require the development of strategy models that are a multi-criteria function of the operational parameters of the vehicle itself and the components of the energy system. These actions were taken as part of the ongoing work and the results are published in the article.

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ENERGY MANAGEMENT AS A WAY TO IMPROVE THE ENERGY EFFICIENCY OF THE FACILITY

Sławomir Sowa[1,*]

Keywords: energy management, energy efficiency, saving in energy consumption

ABSTRACT

The energy efficiency of facilities is a significant factor that allows to determine the amount of electricity and heat consumed in the context of the facilities demand for these media. The aim of increasing and improving the energy efficiency of the facilities is to introduce solutions aimed at reducing the electricity and heat consumption in the facility while ensuring its full functionality and comfort of use. Many ways can lead to savings in energy consumption. The implementation of proper solutions to reduce energy consumption depends on the size, type, and manner of use of the facility. In facilities that consume large amounts of electricity and heat, the introduction of savings in their consumption can also be realized by introducing an energy management system. Several different strategies are being developed to reduce energy consumption in companies and thus reduce the emission of harmful substances into the atmosphere [1]. Monitoring of the demand and control of the consumption of the energy carriers allows to select places and develop solutions leading to the reduction of electricity and heat consumption. Apart from the obvious solutions, i.e. thermal insulation of the building or the use of energy-efficient lighting sources, other solutions led to the reduction of energy carriers' consumption in the facility. Ensuring the improvement of energy efficiency of the facility does not come down to one-off actions, but should be a continuous process of monitoring and improving the implemented solutions limiting the consumption of energy carriers. One of the energy management systems is the ISO 50001 standard. The base of the management system, including energy, is Deming's PDCA cycle, which indicates continuous control and verification of the effectiveness of implemented solutions. Thanks to such solutions it is possible to work out optimal methods of energy management, which will result in significant savings in energy consumption, which will improve the energy efficiency of the facility. The article presents the real effects of lowering costs for heat consumption in one of the trained facilities operating in the district of Poznań. The forecast of energy consumption reduction in lighting installations, thanks to the introduction of a lighting control system, which uses daylight [2] is also presented.

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THE STUDY OF THE STRUCTURAL AND SURFACE PROPERTIES OF COALS OF VARYING DEGREES OF METAMORPHISM AND ACTIVATED CARBON.

Agnieszka Orzechowska-Zięba[1], **Eliza Wolak**[1], **Stanisław Kozioł**[1]

Keywords: sorption, coal, water vapours isotherms

ABSTRACT

The study of the porous structure, determination of the surface properties of coal and the resulting sorption properties are of great importance when assessing the sorbents tested for their characteristics and applications.

The paper characterized three coals (WKB, WKV, WKW) of varying degrees of metamorphism and activated carbon (WA) which is a sorbent rigid microporous structure.The characteristics of the carbons structure were presented on the basis of densimetric measurements, and the pore volume distribution was determined by high-pressure mercury porosimetry.

Water adsorption isotherms were determined by volumetric method using liquid microburettes to assess the surface polarity of the tested carbons. Measurements were carried out at 298K. The water adsorption isotherms were analyzed basing on the description proposed by Dubinin and Sierpiński. The number of primary centers of adsorption in the form of surface oxygen groups was calculated. The Boehm method was used for the quantification of surface functional groups.

Interpreting the water sorption isotherm observe that with increasing metamorphism of coal decreasing its sorption capacity in relation to water vapor. The number of determined primary centers of adsorption and the content of oxygen and nitrogen decreases linearly with the increase of coal metamorphism.

Activated carbon with a developed microporous surface, has the greatest absorption capacity with respect to water vapor and the greatest amount of surface functional groups which also confirms result the number of primary centers of adsorption from equation Dubinin-Sierpinski.

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ENERGY FUELS ENVIRONMENT 2020
AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY, CRACOW UNIVERSITY OF TECHNOLOGY
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OPPORTUNITIES AND CHALLENGES FOR THE DOMESTIC NATURAL GAS SECTOR DURING THE TRANSITION TO A LOW-CARBON ECONOMY

Rafał Biały[1,*], Aneta Korda-Burza [1], Adam Szurlej [1], Przemysław Wnęk [1]

Keywords: natural gas, gas market, hydrogen, low-carbon economy

ABSTRACT

In recent years, the natural gas market in Poland has been characterised by dynamic development compared to other gas markets in the EU. This development has been influenced by the need for energy transformation of the Polish economy and the EU policy on the implementation of the *European Green Deal*. This strategy aims, among other things, at sustainable industry, mobility and the promotion of clean energy in order to reduce pollutant emissions quickly and effectively. Achieving such an ambitious goal by 2020 requires the use of natural gas as a "transition fuel" [1]. In the case of Poland, the recent years have seen the growing importance of natural gas in the fuel and energy balance (Table 1).

Table 1. The importance of natural gas in Poland's energy balance [3] [4]

	2010	**2015**	**2018**	**2019**
Consumption, bcm	16.2	17.1	19.9	20.4
Share of natural gas in the primary energy,%	14.2	15.4	16.4	17.2
Share of natural gas in the electricity production,%	2.6	2.6	5.8	7.6

The main goal of Poland's energy policy in the area of natural gas is the diversification of natural gas supplies. Over the past decade, the implementation of this priority goal has translated into the expansion of gas interconnections with EU countries, and above all, the commissioning of the LNG terminal in Świnoujście in 2016. Currently, the most important investment in gas interconnection projects is the *Baltic Pipe* project which will have a transport capacity of up to 10 billion m^3 of natural gas annually to Poland and up to 3 billion m^3 of natural gas to Denmark annually; underway are also gas interconnections: Poland - Slovakia and Poland - Lithuania.

The infrastructure investments under way are essential to ensure energy security. These investments will translate into ensuring the increased use of natural gas as an energy resource towards a low-carbon economy, enabling greater integration of unstable sources (RES).

In view of the actions planned and taken in the field of hydrogen economy, both in the EU and in Poland, it can be assumed that the role of natural gas will increase. The pace of changes in the domestic natural gas market will depend on how the hydrogen market will be developing in the short, medium and long term [2]. The key document that will significantly determine the integration of the hydrogen and gas sector will be the Polish hydrogen strategy.

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EVALUATION OF THE POSSIBILITIES TO IMPROVE AIR QUALITY IN POLISH HEALTH RESORTS BY USING RENEWABLE ENERGY SOURCES

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Keywords: air quality, health resort, renewable energy sources, sustainable development

ABSTRACT

For a long time Poland has been regarded as one of the most polluted countries in the European Union. In 2019 the World Health Organization published a list of the 50 most polluted cities in Europe, the majority of which (36) being located in Poland. One of the main reasons of the poor quality of air is the inefficient combustion of solid fuels with bad quality leading to the formation of ground level emission. The paper presents the characterization of Polish health resorts, discussion about air quality and analysis of possible solutions based on renewable energy sources that can contribute to the improvement of air quality.

In Poland, the status of health resort can be received by areas with natural resources of therapeutic mineral waters, peloids and confirmed therapeutic properties of climate. According to the data provided by the Central Statistical Office [1], in Poland one can find 45 operating health resorts. Based on their geographical location, they can be divided into: lowland resorts constituting 38% of all the health resorts, submontane resorts – 31%, mountain resorts – 18% and seaside resorts – 13%. The analysis of air quality in polish health resorts was carried out on the bases of monitoring in the years 2010-2018 [2]. The results of the monitoring provide a framework for the assessment of healing properties of the health resort climate. In addition, the episodes of heightened air pollution may evoke doubts concerning validity and effectiveness of treatment offered in health resort areas. The violation of a 35-day limit with exceedance of the permissible level of concentration of PM10 occurred in ten of the twenty eight analysed health resorts. The European Union annual limit value of concentration of PM10 and PM2.5 was not exceeded. Nevertheless, the WHO air quality standards were exceeded in almost all analysed cases. One of the major problems in Polish health resorts is the annual level value of concentration of benzo(a)pyrene. The concentration of this toxic substance was exceeded even 8 times the annual limit value in some places.

In order to assess the possibility of reducing emissions in spa areas, a comparative analysis was performed for a coal-fired boiler and a heat pump. Moreover, the environmental effect of the photovoltaic installation was also analysed. Implementation of renewable energy source solutions is to achieve the basic objectives of improving air quality in the health resorts treatment areas, making the local governments and the local communities aware of the importance of the problem, as well as to increase the environmental values of the health resorts.

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ELEMENTAL CONCENTRATION OF PM10 AIR SAMPLES COLLECTED IN TWO SMALL TOWNS IN SOUTH POLAND

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Keywords: PM10, air pollution, ED-XRF fluorescence

ABSTRACT

Air pollution is one of the scourges of the 21st century and while it is now common knowledge that large cities are highly polluted areas, the situation in smaller towns is also alarming. In Poland, the air pollution level has been constantly monitored in big cities while monitoring in small towns has become more popular in recent years. The purpose of this study is to analyse the concentration of chemical elements and PM10 in air samples gathered in two small towns - Skala and Wadowice located in southern Poland in the winter of 2017/2018 and to compare them with the results of concentration in the city of Cracow from earlier years. The chemical elements were identified for each sample using the EDXRF method. Spectrometer was equipped, among other, with an X-ray tube which was the source of photons and the Si(Li) detector. The following chemical elements: Cl, K, Fe, Ca, Zn, Pb, Br, Ti, Cu, Mn, V, Co, Rb, Ni, Sr and Cr were identified in the samples. It was observed that the results were significantly higher than the EU limit value for PM10. Moreover, the high concentration of, among others, K, Pb, Cl or Zn, is likely to be linked with fossil fuels combustion and biomass burning. The levels of element concentrations in Wadowice and Skała resemble the levels observed several years before in Krakow.The results clearly demonstrate that the element and PM10 concentration is alarmingly high and, perhaps even more surprisingly, that it is not much different to the level of pollution occurring in large cities.

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CARBON NANOTUBES MODIFIED WITH Fe, Mn AND Ce AS SCR CATALYSTS

Joanna Burek[1,*], Anna Dudek[1], Marzia Faedda[1,2], Bogdan Samojeden[1], Monika Motak[1]

Keywords: iron, cerium, manganese, selective catalytic reduction of NOx

ABSTRACT

The development of industry, which is taking place in an uncontrolled manner and the very rapid progress of civilization, are a serious threat to the natural human environment. One of the aspects of environmental protection is the reduction of gaseous pollutants emitted into the atmosphere. The basic gaseous pollutants of the atmospheric air include nitrogen oxides, due to their increasing emission various ways of its reduction are applied, one of them is selective catalytic reduction [1]. Due to its excellent catalytic activity and high resistance to sulphur poisoning, V_2O_5-WO_3/TiO_2 is still the most commonly used catalyst for SCR-NH_3 in industry. However, the problems associated with its use and narrow operating temperature range (300-400°C) are still very noticeable. Due to the disadvantages of V_2O_5-WO_3/TiO_2, work on obtaining new and better materials has begun. Currently carbon nanotubes are considered as an attractive catalyst due to their unique structure and thermal stability. Most catalysts based on CNT are highly active in in the medium temperature range (200-300°C) [2].

The aim of this work was to obtain bimetallic catalysts based on carbon nanotubes. For this purpose a number of Mn, Fe and Ce modified catalysts were prepared. The active materials were applied by two methods: incipient wetness impregnation method and solution adsorption method. The obtained catalysts were characterized by FTIR, UV-Vis and XRD methods. The activity and selectivity of the catalysts were tested in catalytic tests at the flow of 100 ml/min with the use of the reaction mixture with the following composition: 800 ppm NO, 800 ppm NH3, 3.5% O_2, filling with helium inert gas, catalyst weight 200 mg. The selectivity of the process was tested by recording the amount of N_2O produced.

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CLINOPTILOLITE MODIFIED WITH IRON AND COPPER AS CATALYSTS FOR SELECTIVE CATALYTIC REDUCTION OF NITROGEN OXIDES WITH AMMONIA

Agnieszka Szymaszek[1,]*, Bogdan Samojeden[1], Monika Motak[1]

Keywords: clinoptilolite, iron, copper, selective catalytic reduction of NO_x

ABSTRACT

Nitrogen oxides (NO_x) are one of the most harmful contaminants of the environment. The majority of NO_x is emitted to the atmosphere as the result of energy production and transportation. The most common technology used for their reduction in the exhaust gases is selective catalytic reduction with NH_3 (NH_3-SCR) [1,2]. Nevertheless, the method is not free of some disadvantages, mainly related to the commercial catalyst, V_2O_5-WO_3-TiO_2 [3,4]. Therefore, in recent times, novel materials have been searched. The potential substitutive catalyst should exhibit high acidity, thermal stability and reducibility. Zeolites modified with iron and/or copper are confirmed to be promising replacing materials for vanadium-based catalyst and their application could restrain the operating problems with NH_3-SCR installations [5].

In this work, natural zeolite (clinoptilolite) was modified with copper or/and iron and tested as the catalyst for NH_3-SCR. The active phase was deposited on the support by impregnation, co-precipitation or citric acid method. Structure of the materials and its changes after catalytic reaction were characterized by XRD, while characteristic groups of the support and their reconstruction during NH_3-SCR were determined by FT-IR. Additionally, it was observed that raw clinoptilolite exhibits relatively high NO conversion of 57%, which suggests that it contains compounds that are catalytically active in high-temperature range of NH_3-SCR. What is more, coexistence of iron and copper extended the temperature window of the catalyst which proved synergistic effect of these elements in NH_3-SCR catalysts.

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MODIFIED ZEOLITE CATALYST FOR A NO_x SELECTIVE CATALYTIC REDUCTION PROCESS IN NITRIC ACID PLANTS

Magdalena Saramok[1,*], Marek Inger[1], Katarzyna Antoniak-Jurak[1], Agnieszka Szymaszek[2], Monika Motak[2]

Keywords: selective catalytic reduction, zeolite catalyst, nitric acid plant

ABSTRACT

Nitrogen oxides (NO_x) are dangerous gases that contaminate the environment and affect negatively on human health. They also contribute to the formation of acid rain and photochemical smog. Hence, there is a high need to reduce their emission. Except of the mobile and stationary sources, large amount of NO_x are produced by nitric acid plants. Several methods of NO_x emission abatement from the tail gases (the temperature range of 200-450°C) in nitric acid plants are known. One of the most common is selective catalytic reduction with ammonia (NH_3-SCR). Many different catalysts are commercially used in this process. However, the operating temperature range, at which these catalysts work efficiently is usually 200-350°C. Therefore, at the higher tail gas temperature not all of the commercial catalysts are effective.

In the following research, the new formula of the catalyst for NH_3-SCR operating in wider temperature window than the commercial ones has been developed. The studies were performed as a part of the cooperation between Ł-INS and AGH. The novel catalyst was supported on the zeolite of a heulandite type and doped with iron as an active phase. The material was prepared on a laboratory scale in a powder form. Then series of experiments of its shaping into tablets was conducted. Physicochemical studies of the catalyst (FT-IR, XRD, UV-VIS, low-temperature nitrogen sorption) were performed to determine the textural and structural properties and to identify the surface functional groups. The activity tests for the shaped catalyst were performed under real conditions using tail gases from the pilot nitric acid plant. The influence of a temperature, catalyst loading and the amount of reducing agent (NH_3) on the NO_x reduction process were investigated. Additionally, the operating conditions under which high efficiency of NO_x reduction (>90%) can be obtained and negligible formation of N_2O occurs were determined.

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LIFE CYCLE ASSESSMENT OF OXYGEN SUPPLY TO HOSPITALS

Ryszard Bałys[1], Anna Korzeniewska[1,*], Ewelina Brodawka[1], Jakub Szczurowski[1], Katarzyna Zarębska[1]

Keywords: oxygen supply, LCA analysis, COVID-19, environmental impact

ABSTRACT

In this paper authors perform a comparative Life Cycle Assessment (LCA) to evaluate the environmental and economic impacts of three scenarios (oxygen cylinders, liquid oxygen in tanks and on-site oxygen production) of local oxygen supply to hospitals in Poland [1,2]. Two of the analysed options (the liquid oxygen in tank scenario and the on-site oxygen production scenario), have a lower level of Greenhouse Gas (GHG) emissions and terrestrial acidification (TA) compared to the oxygen cylinders scenario. The greatest GHG emission reductions may be observed when the liquid oxygen in tank scenario is applied. However, the greatest terrestrial acidification reductions can be achieved when applying the on-site oxygen production scenario. Based on the analysis of local demand, with respect to oxygen therapy and the number of ventilators, an economic analysis and LCA was performed. The results show that hospitals would sustain the lowest costs when using the on-site oxygen production scenario.

Authors also built fourth scenario- mixed scenario, in which authors assumed that the oxygen supply would be a combination of two of the previously analysed scenarios. The aim of this attempt was to create the most suitable solution for each hospital battling against COVID-19. For this purpose, the ways of oxygen supply to hospitals in Poland was analyzed. Then, the most flexible scenario was developed, which would allow for a cheaper and more "green" oxygen supply to most of the analyzed hospitals in Poland.

Medical oxygen is the key to survival for COVID-19 patients. The WHO estimates that the world needs about 620,000 cubic metres of oxygen a day (about 88,000 large cylinders) if the number of newly infected people remains at the current level of one million a week. To meet the demand spike, local hospitals began searching for a suitable medical oxygen delivery system. When considering how to increase access to medical oxygen, it is useful to undertake studies of the available sources and storage possibilities of medical oxygen. Among the studies published on the impact of COVID-19 on many aspects of life, including the global economy and the environment, no study has been conducted on the environmental impact of medical oxygen supply to hospitals under epidemic conditions [3].

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LOW-COST ARDUINO-BASED AUTOMATION SYSTEM FOR PSA UNIT AS A RESPONSE TO 2020 GLOBAL CORONAVIRUS OUTBREAK

Mieczysław Bałys[1,]*, Adrian Lubecki[1], Ewelina Brodawka[1], Jakub Szczurowski[1], Katarzyna Zarębska[1]

Keywords: PSA, coronavirus, oxygen, Arduino

ABSTRACT

In 2020 global coronavirus (SARS-CoV-2) outbreak has shown how unprepared we are, as humanity, to fight global infectious diseases. World Health Organization (WHO) for coronavirus disease patients recommended oxygen therapy as one of the treatment methods [1]. This recommendation has had a strong impact on the medical oxygen market. It is estimated that by 2026 this market will be worth almost three times more than in 2019 [2]. There are known several technologies for the production of medical oxygen. One of them is pressure swing adsorption (PSA). PSA is a cyclic process based on the use of adsorbents that selectively adsorb components of separated gas mixtures [3]. In response to the growing interest of the medical oxygen market and emerging challenges related to the coronavirus outbreak, we analyzed the role of PSA in the production of medical oxygen. PSA is considered as a mature and well-known technology but still requires improvement and innovation [4]. In this paper we proposed low-cost automation system for PSA unit. The main part of the system is Arduino (open-source microcontroller board). Arduino is responsible for control valves and collecting data from sensors. To obtain remote access to the PSA unit we implemented solutions used in intelligent systems. Moreover, for testing purposes we carried out air separations. Using the specially designed cycle, we obtained a continuous stream of a product containing no less than 93% oxygen. We believe that our project will allow scientists to advance their works on the field of PSA for medical oxygen production. In the next step, we are going to make efforts to design a more efficient way to carry out PSA separation including cycle optimization and development of new adsorbents. These improvements could reduce the high PSA energy requirement – one of the main challenges and limitations of this technology [5].

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MERCURY AND SULPHUR CONTENT IN ALTERNATIVE FUELS IN COMPARISON WITH SELECTED SOLID FUELS

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Keywords: mercury, sulphur, alternative fuels, solid fuels

ABSTRACT

The decarbonization currently being implemented will gradually reduce coal consumption as well as substitute it with other types of fuels, including waste-derived alternative fuels. Nevertheless, these fuels are characterized by a large variation in mercury content and their co-combustion with coal may contribute to exceeding the mercury emission standards and increasing its emissions. In the paper, a comparison of mercury content in alternative fuels with other fuels was presented. The sulfur content was also compared.

The research was carried out on samples of alternative fuels (RDF, waste paper, textiles, foil, tires and its char, sewage sludge), forest and agri-food waste, samples of biomass and conventional fuels currently used in the power sector. Another analyzed group of fuels was forest waste and agri-food waste. For the plant-derived biomass, the samples of firewood, wood pellets and energy crops were examined. In the case of wood-derived biomass, wood pellets, hard coal, lignite, anthracite and coke, samples of commercial products were selected. In the samples the mercury and sulphur content and calorific value were determined.

The alternative fuels analyzed were characterized by significant differences in mercury contents from 0.4 to 92.0 μg/MJ, with an average of 22.3 μg/MJ. The fuels with the highest mercury content were RDF (2.0-79.3 μg/MJ) and sewage sludge (44.8-92.0 μg/MJ). The other waste-derived fuels were characterized by a much lower mercury content from 0.4 to 4.3 μg/MJ, with an average of 2.0 μg/MJ. However, it was noticed that the average mercury content in the alternative fuels was at the same level as for lignite (22.3 μg/MJ). The clean coals were characterized by a much lower mercury content than raw hard coals (0.2-10.3 μg/MJ). Coke and biomass fuels had the lowest mercury content.

Sulphur content in alternate fuels was at the level as in lignite and was higher than in hard coal and much higher than in biomass and coke.

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HIGH-ENTROPY OXIDES AS ANODE MATERIALS FOR Li-ION CELLS

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Keywords: High-entropy oxides, Rock salt structure, Spinel structure, Li-ion cell anode

ABSTRACT

Nowadays, the need to design and manufacture electrical energy storage systems with higher capacity, energy density and extended lifespan is indisputable. However, commercial Li-ion technology, which is usually based on lithium metal oxide cathode and graphite anode has already reached its theoretical limits [1,2]. Among alternative anode materials, transition metal oxides have been proposed, for which conversion-type reaction with lithium occurs. While high capacity could be obtained for various studied compounds, until now, issues related to the significant capacity fade on cycling have not been fully solved. As an answer to this problem, in 2018 a material from a novel class of compounds, the so-called high-entropy oxides, has been proposed as a candidate anode material [3]. The tested half-cell containing (Co,Cu,Mg,Ni,Zn)O active material exhibited extraordinary cycling stability due to the occurrence of a new conversion mechanism, with the stable high-entropy matrix being retained for the whole time.

In order to further explore the prospect of application of high-entropy oxides as the anodes in Li-ion cells, the two most promising groups of these materials were chosen: rock salt-structured and spinel-structured ones. For synthesis, the classical solid-state route was used for selected compositions from the Li-Co-Cu-Cr-Fe-Mn-Ni-Mg-Zn-O system. The obtained materials were assembled in half-cells and comprehensively studied, proving that both types of oxides are promising anode materials for future Li-ion batteries. For example, for cell with the spinel-type $(Co,Cr,Fe,Mn,Ni)_3O_4$ electrode material, although not being optimized, the specific capacity reached at 2nd lithiation at C/2-rate was equal to 439 $mAhg^{-1}$, which is higher than the theoretical capacity of commerially used graphite anode (372 $mAhg^{-1}$ [1]). In the case of rock salt-type anode material, the specific capacity at 2nd lithiation was equal to 363 $mAhg^{-1}$ at the specific current of 100 mAg^{-1}.

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MoS_2 AS POTENTIAL ANODE MATERIAL FOR SODIUM-ION BATTERIES

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Keywords: anode, Na-ion batteries, MoS_2

ABSTRACT

Nowadays a considerable growth in renewable energy, electric vehicles, and portable electronics is being observed. A reliable energy storage system is playing a key role in clean transformation. Currently, the most popular energy storage technology is lithium-ion batteries, based on rocking-chair mechanism, due to their high energy density (both gravimetric and volumetric). However, obstacles like the high price of lithium and limited resources on Earth make the search for other technologies still ongoing. One of the proposed solutions is sodium-ion batteries, with the same principle of operation as mentioned before. Lack of anode material constitutes a bottleneck issue for the application of sodium-ion batteries and their further improvement. Graphite, the most commonly used negative electrode in Li-ion batteries, does not intercalate properly sodium ions into its structure, which disqualifies it from being used in sodium batteries. Molybdenum disulfide is considered an anodic material due to its desired layered structure and high theoretical capacity of around 668 mAh/g. Additionally, MoS_2 is distinguished by a two-stage mechanism during the sodiation/desodiation process: intercalation and conversion depending on the operation voltage window [1].

The work presents the idea of the operation of sodium-ion batteries, the process of synthesis of molybdenum disulfide, and modification like the addition of reduced graphene oxide. The X-ray diffraction and scanning electron microscopy were conducted to specify the structural properties of materials. Moreover, the electrochemical properties of the batteries assembled with the use of the obtained materials are also presented. The cells were assembled in CR2032 cases, in which metallic sodium acted as a counter-electrode, and then they were subjected to electrochemical tests to determine the operating parameters.

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CATHODE MATERIALS FOR NA-ION BATTERIES BASED ON SODIUM MANGANESE LAYERED OXIDE

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Keywords: Na-ion batteries, layered transition metal oxides, energy storage

ABSTRACT

Na-ion batteries are a promising candidate to replace Li-ion batteries in some applications. Sodium is commonly available element and the work mechanism based on the intercalation process is similar for both Li-ion and Na-ion batteries. Cathode materials based on the layered Na_xMnO_2 system draw attention due to high capacities, low harmfulness to the environment, availability, and low cost. The typical operation mechanism of $Na/Na^+/Na_xMnO_2$ cell is based on transition metal redox reaction; however, some recent papers report the possibility of also oxygen taking part in such a process. It is suggested that some elements, such as Mg, can activate oxygen redox reactions, thus lead to capacity increase [1,2].

$Na_{0.67}MnO_2$ (NMO) was synthesized via low temperature sol-gel method while $Na_{0.67}Mg_{0.2}Mn_{0.8}O_2$ (NMMO) was prepared in solid state reaction route. Powder X-ray diffractometry (XRD) confirmed that obtained materials were single-phased and allowed to describe their crystal structure. Morphology and chemical composition were investigated by means of scanning electron microscopy (SEM/EDS). Electrochemical impedance spectroscopy (EIS) was used to measure the conductivity of the samples. Cathode layers based on NMO and NMMO were used to assembly CR2032-type coin cells in the glovebox in argon atmosphere. Electrochemical tests, such as cyclic voltammetry and cyclic charge/discharge under various current densities were then carried out. Ex-situ XRD measurements were performed as well.

Cyclic charge/discharge tests allowed to find optimal voltage range. Extra capacity, far beyond theoretical value connected with Mn^{3+}/Mn^{4+} redox couple, was obtained in $Na/Na^+/Na_xMg_{0.2}Mn_{0.8}O_2$ cell. This effect may indicate the oxygen activity in redox process. Thanks to ex-situ XRD measurements, better understanding of intercalation mechanism was possible.

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INVESTIGATION OF FOLW NON-UNIFORMITIES IN THE HEAT EXCHANGER

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ABSTRACT

W wymiennikach ciepła, zwłaszcza o przepływie krzyżowo-prądowym, uzyskanie równomiernego rozpływu czynnika roboczego w przestrzeni rurowej, przy stosowanych obecnie rozwiązaniach komór: wlotowych i wylotowych, a także w niektórych konstrukcjach również nawrotnych, jest praktycznie niemożliwe do osiągnięcia. Aby uzyskać wysoką sprawność cieplną i hydrauliczną w wymiennikach ciepła, stosuje się rury eliptyczne. Znalazły one szerokie zastosowanie w przemyśle motoryzacyjny, energetycznym czy chłodniczym. Główną zaletą rury eliptycznej jest korzystna wydajność hydrauliczna w porównaniu z rurą okrągłą. Dlatego do przepływu gazu przez wiązkę rur nie są potrzebne duże strumienie ciepła. W tym względzie szczególnie istotny jest przepływ o charakterze przejściowym w przestrzeni rurowej wymiennika ciepła, którego zjawiska są złożone i trudne do modelowania matematycznego. Dlatego konieczne jest dokonywanie weryfikacji eksperymentalnych. Stanowisko doświadczalne zbudowane w Instytucie Maszyn i Urządzeń Energetycznych Politechniki Krakowskiej służy do doświadczalnych badań rozkładu przepływu wody w wymienniku ciepła. Wymiennik złożony jest z 20 eliptycznych rurek, ustawionych przestawnie w dwa rzędy. Pozostałe elementy stanowiska badawczego stanowią: zbiornik wody obiegowej (czynnik roboczy), kształtki, armatura i aparatura pomiarowa. W pracy przedstawiono wyniki pomiarów i ich analizę. Zbadano rozkład przepływu w wymienniku ciepła z kolektorami w kształcie prostego odcinka rurowego przy przekątnej zabudowie króćców: zasilającego i odpływowego. Pomiaru przepływu czynnika roboczego w poszczególnych rurkach wymiennika ciepła krzyżowo-prądowego, wykonano w zakresach przepływów: laminarnym, przejściowym i turbulentnym. Każdy pomiar wykonano dla określonego sumarycznego natężenia przepływu czynnika jakim była woda, zmienianego w zakresie od 1 [m^3/h] do 5 [m^3/h]. Otrzymane wyniki pomiarów potwierdzają tezę o nierównomierności napływu czynnika do poszczególnych rurek urządzenia.

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SIMULATION OF CRUDE OIL FOULING FORMATION

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Keywords: crude oil, fouling, deposits

ABSTRACT

The accumulation of undesirable solid or semi-solid substances on the heat transfer surfaces (e.g. in heat exchangers) is called fouling. Fouling reduces heat transfer and equipment thermal efficiency. Fouling remains one of the main cost drivers in oil refineries. The substances responsible for fouling are either directly present in the process fluid or are formed from precursors by chemical or physical processes. In the refining industry, the most common causes of fouling are the presence of incompatible and insoluble asphaltenes, inorganic substances, coke formation, corrosion products, polymerization of olefins after thermal conversion, and the formation of oil-water emulsions. Fouling deposits are the result of chemical reactions and physical changes that occur when crude oil comes into contact with the high temperature of the metal surface in the heat exchanger. Chemical analyzes of such deposits show that they mainly consist of non-melting coke, asphaltenes and inorganic materials. The unique chemical composition of crude oil, the type and amount of asphaltenes present, and the compatibility of crude oil composition may determine the fouling potential.

The fouling of crude oil was simulated on a constructed test stand. The operating principle of the simulator was based on the flow of oil through a model heat exchanger (test plate), which was dismantled after the test and the deposits were assessed directly on the test plate surface. The apparatus had a closed circuit of oil in the flow loop and the ability to control the heat exchanger temperature and the oil flow rate. On the test stand fouling tendency was evaluated for selected three crude oil samples, previous tested for basic physico-chemical properties (including distillation range, group composition, asphaltene content, colloidal instability factor). The changes that occurred during the simulation in the form of fouling deposits on the test plates were assessed by means of an optical microscope. For each of the tested crude oils, a different type of deposit was obtained on the test plate - in the form of rust, inorganic salts and organic sediment.

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