ICCME23

IV INTERNATIONAL CONFERENCE OF CASTING AND MATERIALS ENGINEERING ICCME 23
KRAKOW, POLAND, NOVEMBER 6–7, 2023

BOOK OF ABSTRACTS

AGH
FACULTY OF FOUNDRY ENGINEERING
AGH UNIVERSITY

Energy and Military Industries

ICCME23

IV International Conference of Casting and Materials Engineering ICCME 23
Krakow, Poland, November 6-7, 2023

BOOK OF ABSTRACTS

The 4th International Conference of Casting and Materials Engineering ICCME 23 is organized by the Faculty of Foundry Engineering at AGH University of Krakow. Main topic of ICCME 23 is materials and technologies for Energy and Military Industries. We will be proud to listen to the lectures of four invited keynote speakers. Among them we have two distinguished professors, i.e. Prof. Maria Losurdo from CNR-ICMATE, Instituto di Chimica della Materia Condensata e di Tecnologie per l'Energia and Prof. Krzysztof Wojciechowski from Faculty of Materials Science and Ceramics, AGH University of Krakow, who will present lectures on Metals for energy, security and thermoelectric materials. The two other Invited keynote speakers are John Bradley from Bitech, UK and Dr. Dominik Kawalec, from APTIV Poland, who represent the Advanced materials industry from England and Poland. I am delighted that among the participants and speakers we will be hosting representatives of universities, research units and industry representing Italy, Finland, Romania, France, India, Czech Republic, Germany, England and Poland. Among the participants will also be doctoral students and young scientists. This is an excellent opportunity for them to present their work in such an respected group of scientists and representatives of European industry.

The International Conference of Casting and Materials Engineering is also traditionally a celebration of the Faculty of Foundry Engineering, its graduates and friends, accompanied by an inspiring exchange of ideas, thoughts and research projects. I wish all of you, that this year's conference will bring many creative discussions, ideas and opportunities to celebrate together.

The Faculty of Foundry Engineering is the only academic center with broad competence in foundry engineering, which includes metallurgy, mold technology, modelling of foundry processes, corrosion studies, etc. It continuously develops partnerships with scientific, research units in Europe and around the world. It also serves as a knowledge center for the foundry industry. It is worth mentioning that there are more than 460 foundries in Poland and almost 6,000 in Europe. 70% of them are small enterprises, the number of people employed in the European foundry industry is 260,000. It is also worth noting, that 14 million tons of castings are annually produced in Europe. Today, castings account for more than 90% of all machine and equipment parts globally.

In particular, I would like to thank all the Organizing Committee for all their efforts to prepare the conference. Co-organizer of GREEN CASTING panel is GREEN CASTING LIFE project, co-funded by European Union's LIFE program and headed by Prof. Rafał Dańko. My sincere thanks to all event sponsors (Hermex, ASK Chemicals Polska, Kom-Odlew, HA Polska, CPP Poland, LENAAL, KPR Prodlew-Kraków, Odlewnia Żeliwa "DRAWSKI", Frech Polska) who supported the organization of ICCME 23.

I would like to thank all ICCME 23 participants for attending the conference and wish you fruitful deliberations, creative discussions and unforgettable impressions.

Marcin Górny
Dean of the Faculty of Foundry Engineering AGH University & Chairman of the ICCME 23 Conference

Organizational Committee

Marcin Górny – Chairman
Katarzyna Major-Gabryś – Vice-Chairperson
Rafał Dańko – Co-organizer of GREEN CASTING panel
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Jan Marosz

Sponsors

Scientific partner

Co-organizer of GREEN CASTING panel

GREEN CASTING LIFE project is co-funded by European Union's LIFE program under grant agreement LIFE21-ENV-FI-101074439 and co-funded by National Fund for Environmental Protection and Water Management under grant agreement 276/2023/Wn-06/OZ-PO-LF/D.

NATIONAL FUND FOR ENVIRONMENTAL PROTECTION AND WATER MANAGEMENT

With the contribution of the LIFE programme of the European Union
LIFE21-ENV-FI. Project 101074439

GREENCASTING

Green Casting LIFE Project:

Towards Zero Emissions in European Ferrous Foundries Using Inorganic Binder Systems
Duration: 09.2022 - 02.2026
Professor Rafał Dańko (AGH University of Krakow)
Professor Angelika Kmita (AGH University of Krakow)
www.green-casting.agh.edu.pl

Green Casting LIFE European project aims to demonstrate the technical and environmental feasibility of using inorganic binders, instead of traditional organic ones, in European ferrous foundries. The **Green Casting LIFE** consortium is constituted by **16 partners from 8 countries: Finland, Spain, Poland (AGH University of Krakow, Odlewnie Polskie S.A.), Italy, Czech Republic, Germany, France and Estonia.** Under the LIFE project, 6 European flagship ferrous foundries will implement at industrial scale the inorganic binder system on their production process implying major changes, starting with selection of the suitable **inorganic binder system**, changes in processes and investments in new equipment. In parallel different sand reclamation methods will be demonstrated. Based on the results obtained, the foreseen techniques will present an outstanding knowledge for **BAT** technologies participating to tackle environmental problems and to produce greener products to European market.

CONFERENCE PROGRAMME

6.11.2023 (Monday)
'STUDIO' CLUB, AGH University of Krakow CAMPUS (Budryka 4, Krakow)

09:00	10:00	REGISTRATION
10:00	10:30	OFFICIAL OPENING
PLENARY SESSION | Main Hall | Chairmen: J. Rozmund, M. Górny		
10:30	11:00	**Maria Losurdo** (CNR-ICMATE, Instituto di Chimica della Materia Condensata e di Tecnologie per l'Energia, Italy) *Metals for energy and security: needs of databases and opportunities from chemical processing*
11:00	11:30	**Krzysztof T. Wojciechowski** (Faculty of Materials Science and Ceramics, AGH University of Krakow, Poland) *Thermoelectric materials and devices for recovering heat generated in technological processes*
11:30	12:00	**John Bradley** (MD Bitech Training Limited, UK) *The journey to develop the Metalcasting Engineering MSc*
12:00	12:30	**Dominik Kawalec** (Signal and Power Solutions APTIV, Poland) *Advanced materials in electric car high-voltage architecture*
12:30	13:30	LUNCH

CONFERENCE PROGRAMME

GREEN CASTING PANEL | Main Hall | Chairmen: P. Jacquet, K. Major-Gabryś		
13:30	14:00	**R. Dańko, A. Kmita, J. Dańko, M. Holtzer** *Key assumptions for Green Casting Life Project: Towards zero emissions in European ferrous foundries using inorganic binder systems*
14:00	14:15	**A. Kmita, R. Dańko, M. Holtzer, J. Dańko, D. Drożyński, M. Skrzyński, A. Roczniak, D. Gruszka, J. Jakubski** *Emission measurements of new inorganic binder systems for the production of molds and cores*
14:15	14:30	**R. Dańko, J. Dańko, A. Kmita, M. Holtzer, D. Drożyński, D. Gruszka, M. Skrzyński** *The influence of aqueous protective coatings on permeability of samples of the selected sand kinds – in the context of the environment protection by controlling the emission of process gases*
14:30	14:45	**K. Jalava, N. Anvar** *Evaluation of 3D printed pattern material for heat-hardened inorganic molds*
14:45	15:00	**St. M. Dobosz, J. Kozień, D. Drożyński, M. Hosadyna-Kondracka** *New Pro-Ecological Alkyd Binder for Molding Sands with Limited Solvent Content*
15:00	15:15	**D. Halejcio, K. Major-Gabryś** *The influence of γ-Al_2O_3 nanoparticles in the binder composition on the chosen properties of inorganic molding sands prepared in different technologies*
15:15	15:30	**J. Wielgosz, A. Vaucheret, P. Jacquet, R. Chiriac, F. Toche, J. F. Carton** *A Comparative Study of the Atmosphere in Green Sand Molds Produced from New and Reclaimed Sand*
15:30	16:00	COFFEE BREAK

CONFERENCE PROGRAMME

SCIENTIFIC SESSION A | Conference Room | Chairmen: K. Naplocha, M. Szucki		
13:30	13:45	**A. Fijołek, A. Garbacz-Klempka, P. Żak** *Application of reverse engineering and virtualization tools to recreate bracelet casting technology*
13:45	14:00	**A. Pierwoła, J. Lelito** *Analysis of the crystallization kinetics in biomedical MgZnPt-metallic glass during annealing*
14:00	14:15	**M. S. Khan, M. Szucki** *Advancements in the PU Cold Box Curing Process*
14:15	14:30	**E. Proniewicz, A.M. Vijayan, O. Surma, A. Szkudlerek, M. Moledna** *Plant-assisted green synthesis of MgO nanoparticles as a sustainable material for bone regeneration: spectroscopic properties and photocatalytic and SERS activity*
14:30	14:45	**J. Marosz, M. Górny, E. Olejnik, M. Kawalec** *TiC ceramic phase reinforced "in situ" composite, based on Si-Mo cast iron obtained by SHSB reaction*
14:45	15:00	**A. Bitka, M. Górny, G. Angella, B. Cygan** *Mechanical properties of thin-walled austempered ductile iron (TWADI) castings*
15:00	15:15	**S. K. Kolparambath, M. Szucki** *Numerical Studies on the Recycling of Aluminum Matrix Composites using Rotational Assisted Filtration Technique*
15:15	15:30	**K. Chrzan, B. Kalandyk** *Abrasive wear resistance of AlCoCuFeNi high entropy alloy*
15:30	16:00	COFFEE BREAK

CONFERENCE PROGRAMME

SCIENTIFIC SESSION B | Main Hall | Chairmen: G. Angella, T. Hoblea		
16:00	16:15	**B. Gracz, G. Piwowarski, W. Krajewski** *AlZnCu-based cast composites reinforced with Ti aluminides*
16:15	16:30	**P. Jacquet, A. Vaucheret, M. Souetre, J. F. Carton** *How to improve the precision of numerical simulation in casting?*
16:30	16:45	**S. Terlicka, K. Janus, N. Sobczak, J.J. Sobczak, E. Ziółkowski** *Investigation of wetting behavior of molten magnesium with titanium, niobium and titanium-niobium substrates as a potential materials for medical implants*
16:45	17:00	**M. Łuszczak** *Challenges and opportunities of cars electrification for HPDC foundries*
17:00	17:15	**A. Dmitruk, N. Raźny, J. Grzęda, K. Naplocha** *Manufacturing of cellular structures to absorb impact energy*
17:15	17:30	**K. Janus, S. Terlicka, J.J. Sobczak, N. Sobczak, E. Olejnik, W. Maziarz** *High-temperature interaction of liquid aluminium with compacted titanium-carbon powder substrate as a key factor for in-situ fabrication of aluminium matrix composites reinforced with TiC*
17:30	17:45	**E. Olejnik, P. Kurtyka, W. Maziarz, R. Chulist** *Exploring the effect of TiC nanoparticles on in situ Al-based cast composites: microstructure, properties, and prospects for electromobility applications*
17:45	18:00	**A. Łukaszczyk, B. Grysakowski, F. Kuśmierczyk, T. Moskalewicz** *Corrosion Resistance of Multicomponent PEEK-based Coatings on Zirconium Alloy in Ringer's Solution*
18:00	18:15	**Z. Szklarz, A. Garbacz-Klempka, M. Bisztyga-Szklarz** *Multi-component metallic alloys produced by electrochemical methods - properties and applications*
19:00	24:00	BANQUET

CONFERENCE PROGRAMME

SCIENTIFIC SESSION C | Conference Room | Chairmen: R. Cygan, K. Jalava		
16:00	16:15	**J. Grzęda, A. Dmitruk, N. Raźny, K. Naplocha** *Precision-cast metal spatial structures for thermal energy storage applications*
16:15	16:30	**A. Świątkowski, A. Szczęsny, E. Guzik, K. Piotrkowski, D. Kopyciński** *Evaluation of microstructure of large-size gray iron castings*
16:30	16:45	**A. Szczęsny, A. Burbelko, D. Kopyciński** *Crystallization of primary austenite in chromium cast iron*
16:45	17:00	**M. Królikowski, A. Zaczyński, M. Sokolnicki, A. Nowak, E. Guzik, A. Burbelko** *Control of melting and secondary processing of liquid alloy dedicated to ductile iron castings*
17:00	17:15	**K. Bracka-Kęsek, A. Szczęsny, M. J. Skuza, A. Bigos, D. Kopyciński** *Influence of Ti addition to the zinc bath on the microstructure of the coating formed in the dip galvanising process*
17:15	17:30	**D. Kopyciński, P. Paczkowski** *Control of the casting structure by means of a chill with thermoelectric modules*
17:30	17:45	**M. Bork, M. Górny, M. Kawalec, G. Palumbo, Ł. Gondek** *Structure and thermal stability of austenitic ductile iron castings*
17:45	18:00	**T. Wiktor, A. Burbelko, A. Garbacz-Klempka, E. Ziółkowski** *Method for quantitative evaluation of EN-AC46000 alloy phase composition from EDS measurements*
18:00	18:15	**W. Kwilosz, M. Królikowski, A. Zaczyński, M. Sokolnicki, A. Nowak, E. Guzik** *Tests of mechanical, fatigue and fracture toughness of high Silicon ferritic ductile iron EN GJS 600-10*
19:00	24:00	BANQUET

CONFERENCE PROGRAMME

7.11.2023 (Tuesday)
ACMiN, AGH University of Krakow (Kawiory 30, Krakow)

09:30	10:00	REGISTRATION
10:00	10:15	OFFICIAL OPENING
10:15	10:45	**Tiberiu Victor Hoblea** (Foundry consultant, Romania) *Feeding and Gating Tool*
STUDENTS SESSION A Chairmen: H. Dorożyński, J. Lelito		
10:45	11:00	**P. Tomal, C. Leinenbach, A. Baganis, G. Michta** *Fabrication, microstructure analysis and mechanical testing of aluminum based metal-metal composites*
11:00	11:15	**T. Galwas** *Development of technology for producing fiber composites by infusion and RTM process*
11:15	11:30	**K. Morgiel, Ł. Dyrlaga, A. Świątkowski, D.Kopyciński** *Overview of SiMo 1000 cast iron microstructure*
11:30	11:45	**M. Cużytek** *Analysis of the selected factors on the 3-D printed models made of PLA material quality*
11:45	12:00	**K. Kuglarz** *28 years and still works*
12:00	12:15	**B. Ślęzak, P. Zieliński** *Developing own technology of manufacturing climbing holds*
12:15	12:30	**K. Liszka** *STOP - cooperation, integration and tradition* - Polish Foundrymen's Association
12:30	13:00	COFFEE BREAK

CONFERENCE PROGRAMME

STUDENTS SESSION B Chairmen: G. Matysik, K. Kaczmarska		
13:00	13:15	**B. Moćko** *Comparison of photovoltaic cells lamination methods*
13:15	13:30	**S. Żołynia** *Numerical simulation and experimental validation of the heat treatment of a steel casting*
13:30	13:45	**J. Cupek, J. Walek, M. Tkadlečková** *Numerical modeling of steel flow in the tundish with different casting conditions*
13:45	14:00	**N. Mordyl** *Analysis of the structure of casting made as a result of combining two non-ferrous metal alloys – CuSi3Zn3Mn1 and AlSi7Mg*
14:00	14:15	**A. Dąbrowski** *Design of the new cylinder of S-38 engine and development of its production technology*
14:15	14:30	**E. Bartosik** *3D printing of conductive carbon materials*
14:30	14:45	**A. Bryłka** *Where does the biggest DISA hide?* - Lisie Kąty Foundry
15:15	16:00	CONTEST RESULTS ANNOUNCEMENT
16:15	19:00	STUDENTS SOCIAL MEETING

KEYNOTE SPEAKERS

Maria Losurdo
CNR-ICMATE, Instituto di Chimica della Materia Condensata e di Tecnologie per l'Energia, Italy
Metals for energy and security: needs of databases and opportunities from chemical processing

Krzysztof T. Wojciechowski
Faculty of Materials Science and Ceramics, AGH University of Krakow, Poland
Thermoelectric materials and devices for recovering heat generated in technological processes

John Bradley
Bitech, UK
The journey to develop the Metalcasting Engineering MSc

Dominik Kawalec
Signal and Power Solutions APTIV, Poland
Advanced materials in electric car high-voltage architecture

INVITED LECTURER

Tiberiu Vicktor Hoblea
Foundry consultant, Romania
Feeding & Gating Tool

BIOSKETCH

Maria Losurdo

Before joining ICMATE as Director, Maria Losurdo served CNR since 1996. She brings more than 25 years of experience in research and higher education to the role. Losurdo received her Chemistry degree from University of Bari and her doctorate in Chemistry and Material Science. She was Adjunct Professor at ECE Department -Duke University, NC, USA and Visiting Scientist at several International Universities, including the Dept of Chemistry at University of North Carolina at Chapel Hill -US, Universidad Autónoma de San Luis Potosi-Mexico, the Dept. Of Materials Engineering – Shandong University – China and the Department of Chemistry at Seoul National Univ. Korea. She teaches Master and PhD courses on materials processing, engineering and characterization. Losurdo is Elected Member of the IUPAP Committee C10- Structure and Dynamics of Condensed Matter. She is part of the Horizon Europe EIC-Women Leadership Programme and as of 2008 she has been coordinating several European projects (FP7, H2020, HE) on innovative materials. Losurdo's work focuses on materials growth and characterization, for applications from photonics and optics to sals, and low salso rę plasma processing of materials with over 400 publications in various journals. Her current research also looks at how to integrate plasmonic systems with chemical, catalytic, sensing, sals and photonic systems. Her work Her most downloaded book, "Ellipsometry at the Nanoscale" was published in 2010 by Springer-Verlag.

BIOSKETCH

Krzysztof T. Wojciechowski

Prof. Krzysztof T. Wojciechowski, Ph.D., is a member of the Faculty of Materials Engineering and Ceramics at the AGH University of Science and Technology in Cracow. He is the founder and head of the Thermoelectric Technology Laboratory of the AGH Energy Centre. He has been working on thermoelectric materials and devices for more than 20 years. He has co-authored more than 90 publications in scientific journals, about 300 scientific presentations and more than 20 invited conference presentations in this field. Prof. Wojciechowski and his team are widely involved in the R&D and implementation of thermoelectric technologies. He has carried out projects with industrial partners such as Honda Ltd, Sasol Technology Ltd, EDF Poland, Synthos S.A., Collins Aerospace Poland, General Electric Aviation Poland, Mesko S.A. and others. He is co-author of more than 15 patents and patent applications. He has been awarded several gold medals for his inventive activities, including the International Invention Show & Technomart (INST) in Taipei and the National Research Council of Thailand; a salso medal at the International Warsaw Invention Show; and an award from the Minister of Higher Education of the Republic of Poland. Prof. Wojciechowski is a member of the boards of the most important international scientific societies in the field of thermoelectric technology, viz: International Thermoelectric Society and European Thermoelectric Society and salso an Academician of the International Thermoelectric Academy.

BIOSKETCH

John Bradley

Director of Epsilon International UK India Private Limited: An International Educational Company. Managing Director of Bitech Group Limited: An International Educational Company. Managing Director of Bitech Training Limited: A business to skills company advisory consultancy Company. Non-Executive Chairman of Results Consortium Limited: A UK Education and Training Company. Director of BIIDEA Limited: A UK Iranian Trading Consultancy Company. Over 50 years' experience in International Engineering, Business and Training. John has worked as the, Regional Director, London & East of England for the Sector Skills Council for Science Engineering Manufacturing Technology Association (SEMTA), National Skills Academy for Manufacturing (NSA-M), & Automotive Academy, MD BICERA British Internal Combustion Engine Association an international powertrain development Company. Engine R&D manager at Ethyl Petroleum an oil additive research and development Company. Engine Development manager at Holset a Turbochager manufacturing Company owned by Cummins Diesel Engine. An International diesel engine manufacturing Company. Apprenticeship and degree with Thomas Broadbents, an advanced manufacturing Company.

John's companies are now International business to skills advisors specialising in getting the right skills and training for the workplace. Ensuring the skills and training help the organisation successfully develop. John has developed training programs for Advanced Manufacturing and particularly Engineering and Business Improvement Techniques. Working with UK Universities to get the right undergraduate and post graduate developing suitable curriculum educational skills and training. Working closely with Industry and Academia matching skills and training fit for purpose.Bitech have developed a Casting & Pattern Making Apprenticeship delivered in companies. Working closely with Cast Metal Federation & Institution of Cast Metal Engineering to develop to Casting and Pattern Making Apprenticeship. Developing specialised under & post graduate engineering programmes with Foundry Faculty AGH Krakow University. John works closely with companies in a Non-Executive Director role developing their strategic business development, learning and skills to continuously improve with sustainable growth and profitability. I completely believe through learning and skills businesses/organisations will see transformational change.

BIOSKETCH

Dominik Kawalec

Dominik Kawalec is a graduate of the Faculty of Physics of AGH University of Kraków. He completed his doctoral studies in the field of air conditioning devices using CFD (computational fluid dynamics) simulations under the supervision of Professor Witold Krajewski from the Faculty of Foundry Engineering. For 10 years he worked as a Thermal Simulation Engineer at APTIV (formerly Delphi) in the Signal and Power Solutions department. During this time he developed a thermal simulation methodology for Electrical Centers and Electric Vehicles inlets. Dominik holds 9 patents in the field of electrical engineering and cooled cables technology. He is currently working in a new area of activity in the field of optical simulation as a Senior Simulation Engineer.

BIOSKETCH

Tiberiu Vicktor Hoblea

He graduated from the Bucharest Polytechnic Institute, Faculty of Metallurgy in 1979. Between 1979 and 1994, he worked in two of the most modern foundries at that time in Romania, Tractorul UTB SA, which produces tractors, and Roman SA, which produces trucks, as foundry engineer, shift foreman, head of the melting department and also within the Chef Metallurgist Department as metallurgical engineer.In 1994, he received and accepted the offer to work for a year at a newly built foundry in Egypt. Upon his return in 1995, he goes to Roman SA and fills the position of Deputy Manager of the Cast and Forged Parts Factory. From this new position, he will visit the foundries all over Europe, including foundries of the Daewoo company in South Korea. He remained in office until 2006, when he resigned and started working as consultant for foundries at Huttenes - Albertus Romania. With HA Romania he visits and collaborates in various projects with all cast iron and steel foundries in Romania until 2022. In 2022, the company HA Romania is sold and the author leave the company and for a period of one year he takes the job of consultant for the last one large foundry still in operation in Romania, SATURN SA.

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STUDENTS SESSION B

PLENARY SESSION

Abstract title:

Metals for energy and security: needs of databases and opportunities from chemical processing

Authors:
M. Losurdo*

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Institute of Condensed Matter Chemistry and of technologies for Energy ICMATE-CNR Corso Stati Uniti 4, Padua, Italy; *maria.losurdo@cnr.it

Key words:
Casting materials, plasmachemistry processing, microstructure, characterization, properties database

Abstract:
Foundry products are fundamental in numerous energy production and security applications, involving, for instance, metal alloys such as, nickel based superalloys for high temperature applications, ferrous alloys such as steels and cast irons for structural components and nuclear waste storage, or aluminum alloys to minimize emissions in order to comply with global and European emission regulations. The ability to develop innovative, high-performance and value-added alloys and treatments constitute the basis for generating new entrepreneurial initiatives, even in sectors related to the foundry, outlining prospects for economic and social development. In this context, chemistry plays a fundamental role: for instance, the request to use a greater quantity of scrap in the charging of foundry alloys in the circular economy requests requires greater control of the chemical compositions of the materials, cause of the deleterious effects that trace elements from scarps may have on the materials properties, while the reduction of critical elements for geopolitical and supply problems is always actual. In this talk, the interlink between plasmachemical processing for passivating defects in metals and for changing their mechanical properties and extensive characterization of the microstructure will be discussed in light of enabling predicting the behavior of structural and functional components. Furthermore, the relevance of updating metal properties databases will be discuss also in light of training Artificial Intelligence and machine learning approach to perform grain orientation mapping in metal alloys to advance the design of next-generation, high-performance materials.

Abstract title:

Thermoelectric materials and devices for recovering heat generated in technological processes

Authors:
K. Wojciechowski[1], T. Parashchuk[1], A. Kosonowski[1], K. Zazakowny[1], R. Knura[1,2], O. Chernioshok[1], A. Lis[1], M. Maksymuk[1], A Wilmanski[1]

Affiliation:
[1]AGH University of Krakow, Faculty of Materials Science and Ceramics, A. Mickiewicza 30, 30-059 Krakow
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Key words:
energy conversion, thermoelectric modules

Abstract:
Waste heat recovery is a promising method to enhance the energy efficiency of various metallurgical processes, leading to a substantial reduction in fuel consumption and CO2 emissions. Currently, thermoelectric devices are the most advanced technology for waste heat recovery. Due to their solid-state construction, thermoelectric generators (TEGs) are simpler in design than comparable mechanical systems. The lack of moving parts in thermoelectric converters makes them silent, robust, and highly reliable. The Thermoelectric Research Laboratory team is developing technology for a new class of converters that are more efficient in energy conversion, cheaper to produce, and environmentally friendlier than commercial modules. Novel strategies utilizing advanced electronic structure and phonon engineering were employed to achieve a high average thermoelectric figure of merit, ZTaver. Our projects included the development of the Double Tuned Functionally Graded Thermoelectric Material (DT-FGTM) concept, which underwent experimental testing on PbTe and Bi2Te3 solid solutions. Our approach involves tuning two electronic parameters simultaneously, namely the bandgap (Eg) and the Fermi level (EF), to achieve a high averaged figure of merit (ZTave) over the operational temperature range. We also propose using resonance effects in PbTe and adjusting EF with selected donor and acceptor impurities. We have demonstrated that with the developed DT-FGTM approach, energy conversion efficiency of at least 15% can be achieved. The best materials were selected for the construction of prototypical thermoelectric converters designed for the recycling of low-parametrical heat. The TE modules were applied in the laboratory thermoelectric generator for the recovery of heat from exhaust gases of automotive engines. The determined power density exceeds 3.2 kW/m2 which makes developed thermoelectric converters elements attractive both for industrial and military applications.

Abstract title:

The journey to develop the Metalcasting Engineering MSc

Authors:
J. Bradley*

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Key words:
UK foundry, apprenticeship, metalcasting engineering MSc

Abstract:
The presentation describes the journey to develop the blended learning part time in English post graduate Metalcasting Engineering MSc. This was developed with the Foundry Faculty, AGH, Krakow University, several advanced manufacturing UK Foundry mainly defence and military casting companies, Maycast Nokes, Finecast & AATi together with Bitech Training Limited over the last five years. This program enables Foundry Engineers to have a career progression from an Apprenticeship right the way to a foundry post graduate qualification. Meeting one of the Foundry Industries biggest challengers of shortage skills.

Abstract title:

Advanced materials in electric car high-voltage architecture

Authors:
D. Kawalec*

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Key words:
electric car, charging, new materials, electrical architecture

Abstract:
Handling high voltages is currently one of the most important challenges for electric car designers. The article presents sample aspects of the challenges facing the developing electric car industry. To meet the demanding automotive market, new materials with conflicting requirements and methods for their mass production must be developed and implemented. The main aspects of this work concerned the problems of the electrical conductor and its insulator, thermal aspects are also important in this respect, as high current causes excessive heating during charging. In each of these cases there is room for new materials with unique properties. This work contains examples of new materials that APTIV and electrical architecture companies are working on. The work also shows development trends and solutions that have not yet been implemented.

GREEN CASTING PANEL

Abstract title:

Key assumptions for Green Casting Life Project: Towards zero emissions in European ferrous foundries using inorganic binder systems

Authors:
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Key words:
foundry, moulding sand, environmental protection, best available techniques

Abstract:
Green Casting LIFE European project (duration: 09/2022-02/2026) aims to demonstrate the technical and environmental feasibility of using inorganic binders, instead of traditional organic ones, in ferrous foundries.
• To successfully use inorganic binder systems on an industrial scale in 6 flagship ferrous foundries, including necessary equipment investments, in five European countries.
• To develop tailor-made inorganic binder systems solutions for iron and steel foundries, in cooperation with the flagship foundries.
• To demonstrate different type of sand reclamation methods for inorganic binder system sands (thermal, mechanical and wet methods).
• guiding and testing inorganic binders in 15 selected follower pilot foundries in Europe.
• providing new results and experiences for the preparation of the Reference Document on Best Available Techniques in the Smitheries and Foundries Industry (BREF document).
Expected results
• Experiences and know-how from six flagship foundries for implementing inorganic binders in their production.
• Step-by-step implementation plans for flagship foundries for the full-scale implementation of inorganic binders.
• Emission reductions after changing from organic binder systems to inorganic binder systems.
• To reduce total hazardous airborne emissions by 80-95% (VOC, SO2, NOx, Particulate Matters…) in the production lines using inorganic binders compared.
• To create a healthier environment for the workers by improving indoor air quality in foundries.
• To reduce the harmful substances in waste sand by 80-90% (DOC, phenols, fluoride, BTEX concentrations).
• To decrease the amount of waste sand to be landfilled by 90% in the partner foundries.
• After 5 years from the end of the project 300 ferrous foundries in EU are expected to change from current organic to inorganic binder systems.

Funding/Acknowledgments

Funded by the European Union

With the contribution of the LIFE programme of the European Union LIFE21-ENV-FI Project 101074439

GREENCASTING

NATIONAL FUND FOR ENVIRONMENTAL PROTECTION AND WATER MANAGEMENT

The research is financed within GREEN CASTING LIFE project. GREEN CASTING LIFE project is co-funded by European Union's LIFE program under grant agreement LIFE21-ENV-FI-101074439. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them. GREEN CASTING LIFE project (LIFE21-ENV-FI-101074439) is co-funded by the National Fund for Environmental Protection and Water Management (NFOŚiGW) under grant agreement 276/2023/Wn-06/OZ-PO-LF/D.

Abstract title:

Emission measurements of new inorganic binder systems for the production of molds and cores

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Key words:
Inorganic binders, environmental protection, emission, BTEX, PAHs

Abstract:
Molding sands subjected to high temperatures of liquid metal generate a number of harmful and even dangerous substances eg. from the group of benzene, toluene, ethylbenzene and xylenes (BTEX) and polycyclic aromatic hydrocarbons (PAHs). Research carried out as part of the GREEN CASTING LIFE (LIFE21 ENV/FI/074439) concerned the analysis of various types of molding sands in terms of emissions of BTEX and PAHs gases and other compounds (SO2, CO, CO2 and NOx) formed in the process of pouring the mold with liquid metal. In the article, particular attention was paid to the differences in the amount of emitted BTEX (Fig.1) and PAHs compounds for two types of sands with organic and inorganic binders. This project is an initiative to assess the potential benefits of using inorganic binder systems in European ferrous alloy foundries. The GREEN CASTING LIFE project aims to improve the environment and working conditions in European iron alloy foundries by introducing cleaner and ecological production methods using innovative inorganic binders. The GREEN CASTING LIFE Consortium includes 16 partners from European countries including 6 flagship foundries. The work carried out as part of the GREEN CASTING LIFE project will enable the implementation and validation at the industrial level of the use of inorganic binder systems for the production of molds and cores in iron alloy foundries, reaching the TRL8 (*Technology Readiness Level*) level. Moreover, the new knowledge obtained will be used to update the *Reference Documents on Best Available Techniques for Forging and Foundries* (BREF document).

Funding/Acknowledgments
The research is financed within GREEN CASTING LIFE project. GREEN CASTING LIFE project is co-funded by European Union's LIFE program under grant agreement LIFE21-ENV-FI-101074439. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those

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Abstract title:

The influence of aqueous protective coatings on permeability of samples of the selected sand kinds – in the context of the environment protection by controlling the emission of process gases

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Key words:
foundry, protective coatings, gas emissions, environmental protection

Abstract:
Investigations performed within the GREEN CASTING LIFE PROJECT revealed significant differences in amounts and contents of harmful gases occurring during the thermal influence of ferrous alloys on samples of the tested sand kinds. In the emission of gases generated from moulding and core sands it is possible to separate the initial period of a significant intensity of emissions and the period of low emission of gases, which – regardless of their kinds -requires a prolongation of the work time of technological devices (usually of constant parameters). The possibility of utilizing traditionally determined permeability results in elaborating guidelines related to engineering of taking over and controlling process gases as well as in adjusting the operations of the gases exhaust system to the required level of TVL range by directing the air-flux and gases flow into their exhaust, is presented.The study explores innovative approaches to lower energy usage without compromising performance. Through a combination of advanced control algorithms, energy-efficient materials, and system redesign, the paper proposes feasible solutions for reducing the carbon footprint associated with ventilator operations. The findings not only contribute to sustainable industrial practices but also underscore the importance of addressing energy consumption in critical systems to achieve a more environmentally responsible and resource-efficient future. Investigations of the free permeability and possibility of its stimulation by the presence and influence of protective coatings of a membrane character, are described in the hereby paper. These coatings were illustrated for cylindrical and conical samples made of the sand treated as a reference with pep-set binder and for 4 selected kinds of the sand with binders, for which aqueous coatings can be proposed. Averaged values of the obtained permeability values concerned the same sands for both kinds of samples with binders applied to determine amounts of gases, within the realised Green Casting Life Project. Permeability indicators of protective coating, determined by the percentage average value of permeability of the sample of sand with the coating in relations to the sample without a coating were

accepted. The sample permeability with the coating layer deposited individually (SPI) or twice (SPII), is taken into account. Cylindrical samples without a coating indicated the average permeability values 301.975 Pu [x10^{-8} m^2/Pa·s] (standard deviation), while conical samples: Pu 807 [x10^{-8} m^2/Pa·s] (standard deviation), which in both cases was accepted as 100%. In a similar way determined Pu value after deposition of the first layer and then the second layer of coating equalled respectively: Pu = 4.72 and 1.46 [x10^{-8} m^2/Pa·s] – for cylindrical samples and: Pu = 17.825 and 4.95[x10^{-8} m^2/Pa·s] – for cylindrical samples and in turn: Pu = 55.85 and 16.6 [x10^{-8} m^2/Pa·s] – for conical samples.

Funding/Acknowledgments

The research is financed within GREEN CASTING LIFE project. GREEN CASTING LIFE project is co-funded by European Union's LIFE program under grant agreement LIFE21-ENV-FI-101074439. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them. GREEN CASTING LIFE project (LIFE21-ENV-FI-101074439) is co-funded by the National Fund for Environmental Protection and Water Management (NFOŚiGW) under grant agreement 276/2023/Wn-06/OZ-PO-LF/D.

Abstract title:

Evaluation of 3D printed pattern material for heat-hardened inorganic molds

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Key words:
solid silicate, inorganic binder, additive manufacturing, patternmaking, heat hardening

Abstract:
Inorganic binders for sand moulding are currently of high interest due to needs for lesser environmental impact and emissions. In this study, a heat hardened solid inorganic sodium silicate binder was tested with a 3D printed resin material to see how the use of such material affected a silica mould's quality, e.g. surface roughness. Results were compared to moulds made with metallic patterns. The unmodified binder had sticking issues when used with a metallic pattern, resulting in a rough as-moulded surface. Such issues were not seen with the printed resin patterns, hinting also at good performance with binders that contain performance increasing additives. The resin pattern material has Heat Deflection Temperature (HDT) of 230°C, enabling use of inorganic binders that require temperatures between 160 - 200°C to harden and dry. Additive manufacturing of such materials also allows designs for other hardening techniques than furnace heating, such as microwave heating. Moulds hardened with microwaves did not exhibit sticking issues. Additive manufacturing of tooling is a potential source of geometrical variation in final castings, studied also in this work. In general, switching from traditional sand moulding patterns used with organic binder systems to inorganic systems, the patterns and core boxes need to be replaced by new ones made of metallic or other heat resistant material. The studied material is a promising option for such a switch, especially when also the complex shaped enabled by additive manufacturing is required.

Abstract title:

New Pro-Ecological Alkyd Binder for Molding Sands with Limited Solvent Content

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Key words:
pro-ecological molding sand, innovative binder, alkyd binder, solvent content, properties of molding sand

Abstract:
The alkyd binder consists of an alkyd resin modified with drying oil and a liquid hardener based on polyisocyanate. Molding sands with an alkyd binder are used primarily in the production of massive castings, mainly of cast steel, but they can also be used for castings made of other alloys. Molding sands with an alkyd binder compete with self-hardening sands with phenolic and furfuryl resins. They have several advantages in common with furan molding sands, such as excellent knock-out properties and very good quality of the casting surface. Additionally, alkyd molding sands do not contain nitrogen, sulfur, formaldehyde and water, various sands can be used as a matrix: quartz, chromite, zircon or olivine and a high proportion of reclaimed material (up to 90%), moreover the molding sand has high plasticity. The disadvantages of this technology include limited ability to adjust the hardening time, high binder viscosity and high sensitivity of the molding sand to the matrix and the ambient humidity. The Prec-Odlew company is a Polish manufacturer of this type of resins for the foundry industry. As part of the project: "Development and implementation of technologies for obtaining ecological binders (systems) for bonding highly refractory ceramic materials" (RPMP.01.02.01-12-0636/18 of the Regional Operational Program of the Małopolska Voivodeship for 2014-2020) under the leadership of Prof. Stanisław M. Dobosz DSc. PhD. Eng., two new alkyd resins was developed with a reduced amount of solvents - SL 2017 and SL 2019. So far, resins of this type contained approximately 40 - 50% of solvents, including aromatic ones. The newly developed resins have a reduced amount of solvents in their composition - they contain from 20 to 30% and are mainly non-aromatic solvents. The SL 2019 resin contains solvents that do not contain any aromatic compounds in the form of hydrocarbons. This article presents the results of testing the properties of molding sands using the standard SL 2002 alkyd resin and the newly developed SL 2017 and SL 2019 resins. The obtained results confirmed the possibility of making molding sands with innovative binders, and even higher strength values were observed than in the case of the reference molding sand with the SL 2002 binder.

Abstract title:

The Influence of γ-Al_2O_3 nanoparticles in the binder composition on the chosen properties of inorganic molding sands prepared in different technologies

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Key words:
environmental friendly molding sands, inorganic binder, γ-Al_2O_3 nanoparticles, self-hardening, thermal hardening, viscosity

Abstract:
Research on the possibility of replacing molding and core sands with organic binders used in foundry practice with environmentally friendly inorganic compositions have been conducted for many years in many domestic and foreign scientific and research centers. Molding / core sands with inorganic binders based on modified thermally hardened water glass are currently successfully used in the production of aluminum castings for the automotive industry. These mixtures are characterized by good strength properties at ambient temperature and, due to their characteristic low retained strength at a temperature close to the temperature of pouring aluminum, good knockout properties. Unfortunately, the use of inorganic sands is still a problem in the production of cast iron castings because of the high pouring temperature of these alloys. As a part of this work, research covering the effect of the addition of γ-Al_2O_3 on selected properties of molding sands with both a binder based on thermally hardened water glass and water glass cured in ester technology were carried out. Viscosity and contact angle tests of the obtained binding materials were tested. Water glass with the addition of 5.0% of γ-Al_2O_3 nanoparticles were used as binders for sands compositions. Nanoparticles were also added to the matrix. Thermally hardened molding sands with 1.5 and 2.0 mass parts of a new binder were tested. Self-hardened molding sands with 2.5 and 3.0 mass parts of a new binder were tested. Thermally hardened molding sands were cured at the temperature of 140°C for 7 minutes. Self-hardened molding sands properties were tested after 2, 4 and 24 h of hardening in ambient temperature. Retained strength at the temperature of 800°C was tested. It was proved that thermally hardened molding sands with γ-Al_2O_3 nanoparticles and reduced amount of the binder are characterized by better properties than self-hardened sands. The addition of nanoparticles decreased retained strength of molding sands, which means that knockout properties were improved at the temperature of conducted tests.

Acknowledgements
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Abstract title:

A Comparative Study of the Atmosphere in Green Sand Molds Produced from New and Reclaimed Sand

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Key words:
steelcasting, mold's atmosphere, green sand, gas analysis, mold-metal interactions

Abstract:
The composition of the mold atmosphere is a crucial parameter influencing mold-metal interactions in steelcasting. Despite its significance, studying the mold atmosphere presents challenges due to technical obstacles associated with gas extraction from sand molds and the demanding environment of the metal casting process. In this study, we propose a novel gas analysis system for real-time, in-situ examination of the mold atmosphere. This system is currently under development through a collaboration between ENSAM Cluny and the industrial partner – Castmetal Development. The presentation will also delve into preliminary experiments aimed at identifying gases present in green sand molds produced using new and reclaimed sand. The practice of using a blend of new and reclaimed sand is prevalent in the industry to optimize production costs. However, the utilization of reclaimed sand can potentially alter the evolving atmosphere within the sand mold. In our initial experiments, gas samples were extracted from various sections of a sand mold and collected in sample bags. Subsequently, a GC/MS analysis was performed in The Laboratory of Multimaterials and Interfaces in Lyon, France. The study not only confirmed gases commonly reported in the literature for green sand molds but also identified additional gas species specific to molds produced with reclaimed sand. This research sheds light on the gas composition variations in green sand molds concerning the sand type used, providing valuable insights for a comprehensive understanding of mold atmospheres in steelcasting.

SCIENTIFIC SESSION A

Abstract title:

Application of reverse engineering and virtualization tools to recreate bracelet casting technology

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Key words:
archaeometallurgy, casting technology, 3D scanning, CAD design, CAE software

Abstract:
The use of modern engineering tools in the form of 3D scanning, CAD (Computer Aided Design) software for designing individual 3D objects and CAE (Computer Aided Engineering) software for computer-aided engineering work create the possibility of reconstructing prehistoric objects as recreated 3D elements. Additionally, the use of CAE software using previously designed 3D model allows for the reconstruction of the casting technology used in those years.
The aim of the work was to design the casting technology of a prehistoric bracelet in a CAD program and using the 3D scanning technique. Developed 3D model and designed casting technology with its subsequent verification of the prepared project in the CAE program. The artifact comes from the village of Uścikówiec in Greater Poland. The bracelets are part of a treasury of bronze items from the Bronze Age. The design of the 3D model of the bracelet was prepared based on 3D scans. Then, the 3D geometry was imported into the CAD program, where the casting technologies were designed. Then, a numerical simulation of the casting and solidification process was performed using MAGMASOFT software. The performed numerical simulation showed where casting defects may occur in the proposed casting technology.

Acknowledgments:
The financial support of the National Science Centre, Poland under the grant numbers 2017/26/E/HS3/00656.

Abstract title:

Analysis of the crystallization kinetics in biomedical MgZnPt-metallic glass during annealing

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Key words:
metallic glass, $Mg_{72}Zn_{27}Pt_1$, Avrami exponent, activation energy, non-isothermal annealing

Abstract:
Recently, Mg-based metallic glasses have been gaining interest for the purpose of biomedical materials, especially in the form of temporary biodegradable implants, that crystallize and dissolve in the human body over time. The phenomena of crystallization and dissolution of metallic glasses occur at different rates, depend strictly on the chemical composition and are still not well understood. This work aims to understand the mechanism of the crystallization process in potentially biomedical amorphous $Mg_{72}Zn_{27}Pt_1$. The amorphous ribbons were non-isothermal annealed in Differential Scanning Calorimetry (DSC) with various heating rates: 5, 10, 20, 40 and 80 K/min. The glass transition (T_g), the onset crystallization (T_x), and the crystallization peak (T_p) temperatures are strongly dependent on the heating rate. The activation energies for these temperature points were calculated using Kissinger method and equal 114.56 kJ/mol, 102.52 kJ/mol and 95.01 kJ/mol, respectively. Although the activation energies decrease, which means that the system tends to crystallize, the difference between E_g and E_x indicates the temporary stability of this metallic glass. This confirms the assumption that due to differences in the size of the atomic radius compared to Mg and Zn, platinum will hinder atomic order, which facilitates vitrification and increases the stability of the amorphous structure. Moreover platinum allows T_x to be moved towards higher temperatures (about 50 K) compared to the binary $Mg_{72}Zn_{28}$ metallic glass. The Matusita model was used to calculate the local Avrami exponent. Values n >2.5 indicate diffusion-controlled three-dimensional grain growth with increasing nucleation rate. This is also confirmed by the SEM observation of numerous very small grains in the annealed samples. Moreover, although energetically crystallization occurs in the form of one peak, SEM observation suggests the presence of five phases in the microstructure.

Abstract title:

Advancements in the PU Cold Box Curing Process

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Key words:
phenolic urethane cold box system, curing process, simulation, sensor system, amine detection

Abstract:
The PU (phenolic urethane) Cold Box system is a leading sand core-making technology. Sand cores are used for producing metal castings with complex internal structures. The core-making process involves two crucial steps: sand shooting and curing. In this study, the main focus is on the curing stage. The input parameters such as amine quantity and curing time are selected based on a trial-and-error approach or the experience of the machine operator. This is due to the lack of monitoring and control systems in the core-making machine. This is negatively affecting the efficient use of expensive amine and other resources, and it can also have a negative impact on the environment. To address these issues, authors have developed an In-Situ monitoring concept using a hybrid sensor system. The current research involves simulation and experiment trials, focusing on a simplified core curing setup consisting of a gas detection sensor incorporated with a volumetric flow measurement device. The result outcomes indicate the possibility of detecting the presence of amine and its concentration. Additionally, this system is now able to differentiate between curing sub-processes such as amine dosing and air purging. The above findings are significant for improving the cold box curing process. The results show that the hybrid sensor system is a promising solution for On-Line process monitoring, control, and optimization of the curing step in the machines. This can eventually reduce environmental impact and increase cost efficiency in sand core-making using the PU Cold Box system.

Abstract title:

Plant-assisted green synthesis of MgO nanoparticles as a sustainable material for bone regeneration: spectroscopic properties and photocatalytic and SERS activity

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Key words:
green chemistry synthesis; Magnesium oxide nanoparticles, MgONPs; Thermogravimetric analysis, TGA; Scanning electron microscopy with energy dispersive X-ray spectroscopy, SEM-EDS; Dynamic light scattering, DLS; Ultraviolet-visible spectroscopy, UV-Vis; X-ray powder diffraction analysis, XRD; Raman scattering spectroscopy, RS; Surface-enhanced Raman scattering spectroscopy, SERS; Methyl orange, MeO; photocatalytic activity; L-phenylalanine, Phe

Abstract:
This work is devoted to magnesium oxide (MgO) nanoparticles (NPs) for their use as additives for bone implants. Extracts from four widely used plants, including *Aloe vera*, *Echeveria elegans*, *Sansevieria trifasciata*, and *Sedum morganianum*, were evaluated for their ability to facilitate the "green synthesis" of MgO nanoparticles. The thermal stability and decomposition behaviour of the MgONPs were analysed by thermogravimetric analysis (TGA). Molecular spectroscopic characterisation was performed by X-ray diffraction (XRD), scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDS), UV spectroscopy, dynamic light scattering (DLS) and Raman scattering spectroscopy (RS). The photocatalytic activity of MgO nanoparticles was investigated using methyl orange (MeO) degradation by UV-visible spectroscopy. Surface-enhanced Raman scattering spectroscopy (SERS) was used to monitor the adsorption of L-phenylalanine (L-Phe) on the surface of MgONPs. This is the first work showing the SERS spectra of a chemical compound immobilised on the surface of MgO nanoparticles.

Abstract title:

TiC ceramic phase reinforced “in situ” composite, based on Si-Mo cast iron obtained by SHSB reaction

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Key words:
“in situ” composites, Si-Mo cast iron, titanium carbides, molybdenum carbides, SHSB reaction, Vickers hardness

Abstract:
This paper presents a method for the synthesis of a new composite material based on an alloyed iron, Si-Mo CGI (Compacted Graphite Iron). Si-Mo cast iron belongs to a family of high-quality and modern cast iron grades, in which the microstructure consists of spherical graphite (or vermicular graphite) and a ferritic metallic matrix with a small proportion of carbides such as M_6C and Fe_2MoC. Si-Mo cast iron differs from typical ductile iron by having a higher content of silicon (4 - 6%) and molybdenum (0.5 - 2%), resulting in a maximum operating temperature of 850 - 860°C. The main objective of the research presented here was to transform this grade of cast iron into a castable composite of the MMCs (Metal Matrix Composites) type using the “in situ” method The transformation of this material into a composite is carried out by a SHSB (Slef-propagating High-temperature Synthesis metal Bath reaction). This procedure enriches the matrix of this material with a TiC ceramic phase, which is formed in a one-step casting process, Its volume and weight share can be assumed “a priori”, this phase being uniformly distributed throughout the casting volume. In this paper, the chemical composition, Vickers hardness and microhardness, SEM and EDX results and EBSD imaging are presented. The structures of the composite material and the reference material, a classic Si-Mo cast iron, are also compared.

Abstract title:

Mechanical properties of thin-walled austempered ductile iron (TWADI) castings

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Key words:
thin-wall, austempered ductile iron, alloying elements, mechanical properties

Abstract:
In this study the influence of nodule count and alloying elements addition on mechanical properties of austempered ductile iron (ADI) castings was investigated. 3, 6 and 13 mm wall thickness castings were made of four alloys containing additions of Cu, Ni, both Cu-Ni, and one alloy without any additions. The spheroidal graphite morphology was determined. In thin-walled castings (3 mm) there was a great number of graphite spheroids in the range of 1100 – 1300 per mm^2, which is over two times higher than in castings with thicker sections. It was found, that such great number of graphite precipitations has detrimental effect on elongation and toughness, but has no significant impact on tensile and yield strength as well as on hardness. It was also found that shorter times of austenitization and austempering transformations may improve toughness of thin-walled castings. The chemical composition of ductile iron doesn't have considerable effect on tensile strength and hardness of ADI castings used in this study. On the other hand with the single addition of Cu the best yield strength and toughness were obtained. The single addition of Ni gave the highest elongation for every thickness of a casting.

Abstract title:

Numerical Studies on the Recycling of Aluminum Matrix Composites using Rotational Assisted Filtration Technique

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Key words:
aluminum matric composites (Al-MMC), silicon carbide (SiC), Rotational-Assisted Filtration and Flow 3D simulation

Abstract:
Aluminum matrix composites (Al-MMC) are widely used in the aerospace and automotive industries. They offer a combination of high strength-to-weight ratio and enhanced mechanical strength due to the reinforcing Silicon Carbide (SiC) particles. With the increasing production of Al-MMC, there is a growing accumulation of scrap. To maximize resource recycling and reduce waste it is essential to reuse this material. However, remelting this material results in the formation of agglomerates which affect the properties of the casting. Therefore, it is important to reuse the aluminum matrix by separating SiC particles and agglomerates from the Al-MMCs. To separate SiC particles, a preliminary investigation was carried out using a horizontal filter chamber geometry. The experiment revealed that an incomplete filling of mould in some cases, this is due to blockage in the filter pores by SiC agglomerates. Therefore, a new filtration technique called rotational-assisted filtration is proposed with the help of computational fluid dynamics (CFD) simulations. Initially, an experiment was performed using Duralcan Al-MMC containing 20% SiC particles. This material matrix is melted twice in a loop to analyse the size and formation of SiC agglomerates. The metallographic analysis revealed that SiC particles tend to aggregate and form significant agglomerates with sizes ranging from 50 to 500 µm. The obtained data was used for performing CFD simulations using Flow-3D. Next, a Rotational-assisted filtration housing is developed which consists of a tangential inlet to create centrifugal motion expecting to separate bigger SiC agglomerates. Additionally, a cylindrical filter is incorporated to capture smaller/single SiC particles. To evaluate the efficiency of the proposed technique, the number of particles passing through the inlet and outlet of the housing are compared. The simulation results show a considerably smaller number of SiC particles exiting from the filter housing, highlighting the effectiveness of the rotational-assisted filtration technique.

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Abstract title:

Abrasive wear resistance of AlCoCuFeNi high entropy alloy

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Key words:
high entropy alloy, abrasive wear resistance, mechanical properties, SEM, surface topography

Abstract:
Two variants of high entropy alloys based on AlCoCuFeNi system, were produced by induction melting. After casting process, materials have been heat treated to homogenize. Previous research has revealed that Al and Cu content change, lead to significant changes in microstructure and mechanical properties. Comparing equiatomic variant and alloy with twice reduction of Al and four-fold reduction of Cu, leads to hardness decrease (from 403 HV5 to 133 HV5) and improvement of plasticity and tensile strength. Fabricated alloys have been subjected to resistance to abrasive wear according to ASTM G75 standard in mixture of water and SiC particles in 16 hours. Research have been shown that alloy wit reduced concentration of Al and Cu subject to higher degradation than equiatomic alloy, what is connected with hardness difference between these alloys. Equiatomic variant, after 16 hours of test had loss of weight at 1.6 g level, while alloy with reduced Al and Cu had loss of weight at 1.1 level. Research conducted with using SEM on surfaces which were subjected to abrasive wear, revelated that booth alloys have plastic type of deformation with smmal regions were chipping could occur, but it may be the result of occurrence small SiC particles. In case of equiatomic variant, very visible is appearance of two types of phases (visible in bright and dark colour) which differ in chemical composition. Surface topography tests revelated that alloy with reduced Al and Cu have bigger difference between maximum an minimum value on the height profile. In connection with obtained results, it was concluded that reduction of Al and Cu have negative impact on abrasive wear resistance.

SCIENTIFIC SESSION B

Abstract title:

AlZnCu-based cast composites reinforced with Ti aluminides

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Key words:
cast composites, reinforcement, Ti aluminides, grain refinement, strength properties, structure stability

Abstract:
The European Commission identified critical raw materials, in this number the following alloy components: Antimony, Beryllium, Cobalt, Gallium, Germanium, Indium, Magnesium, Niobium, Silicon Metal, Tungsten, Platinum Group Metals, Light Rare Earths and Heavy Rare Earths, Bismuth, Hafnium, Phosphorus, Scandium, Tantalum, and Vanadium. Foundry industry needs alloys com-posed of available and comparatively cheep components, e.g. Aluminium, Zinc and Copper. Production of the AlZnCu-based alloys is still very small in Poland as compared to the Fe one, though Po-land produces significant amount of pure zinc and copper. Replacing some amount of Fe-based castings with the AlZn-based one is very important for environmental protection, because the AlZn-based alloys are called pollution-free alloys. They are also relatively cheaper as they have a low melting point, which allows saving on energy costs. Within the range of Al products, the global pro-duction of Al-based cast alloys continues to increase. Rather little attention has been paid to Al-Zn based alloys with high Zn and Cu content of 10 – 40 wt. %. Yet this group of high-zinc aluminium alloys possesses a special set of properties which allow for their usage for shape castings with good mechanical and damping properties. However, wider implementation into practice requires improvement of their rather low ductility. This improvement can, for instance, be achieved through inoculation of the melt before pouring into foundry moulds, especially sand moulds or by fast cooling/rapid quenching, e.g. in a copper mould, or by matrix reinforcing. The paper presents research aimed at developing Al-Zn-Cu-X based cast composites, of high mechanical properties (strength, ductility, damping & tribological properties) and stable structure, reached after implementing processes of melt purification, grain-refinement and addition of fourth reinforcing elements.

Abstract title:

How to improve the precision of numerical simulation in casting?

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Key words:
steelcasting, numerical simulation, database, material properties, cooling curve.

Abstract:
In order to improve the results of numerical simulation applied to steel foundry, interventions can be made at various levels: using advanced simulation models, employing high-quality meshing, using appropriate numerical methods, or enhancing input data. We chose to work on the latter aspect by accurately measuring the changes in physical parameters (thermal conductivity, specific heat, and density) of both steel and mould sand (green sand) as a function of temperature. Various experimental techniques were utilized, including differential scanning calorimetry (DSC), spark spectrometry (GDOES), Laser flash, etc. This approach is valuable as it can be applied to any simulation software that allows for modification of data within its database. The software used for this study is NovaFlow&Solid®. A specific experimental setup was developed to record the cooling of a steel cylinder from the liquid state to 500°C. The experimental cooling curve was compared with the simulated cooling curve using, firstly, the initial data from the NFS database and, secondly, the data corrected based on our measurements (thermal conductivity, density, and specific heat of both the sand and steel). The results show a significant improvement compared to the simulation curve obtained with the initial data provided by the NFS software and are close to the experimental curve.

Abstract title:

Investigation of wetting behavior of molten magnesium with titanium, niobium and titanium-niobium substrates as potential materials for medical implants

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Key words:
magnesium-based alloy, sessile drop method, capillary purification procedure, wettability, contact angle, biodegradable Mg alloys

Abstract:
Pure Ti and its alloys are the most commonly used materials for medical implants due to their appropriate biocompatibility and mechanical properties. However, they have a relatively high elastic modulus compared to a human bone. Thus, β-Ti alloys containing non-toxic β-stabilizing elements, i.e., Nb or Ta, which have a lower elastic modulus, are now widely investigated. Among such alloys, Ti-Nb alloys have excellent corrosion resistance, biocompatibility, and super-elastic properties. Since after implantation, the implant surface is in a direct contact with the tissue, the surface properties are one of the most important aspects in osteointegration, which is influenced by the corresponding biological interactions caused by the surface roughness and chemical composition. Therefore, surface modifications such as ion implantation are performed to improve the biomedical performance of implants. Ti alloys implanted with Mg show, for example, better adhesion. Also, the alloying Ti with Mg can reduce the density and elastic modulus because of the low elastic modulus of Mg that is comparable to a human bone (~40 GPa). Moreover, Mg can precipitate from the matrix during sintering, and its degradation in a human body will create pores and increase surface roughness, which will promote the biocompatibility of the Ti implant. Thus, Ti-Nb-Mg alloys have great potential as future materials for medicine. In this study, the sessile drop method was applied to examine the high-temperature wetting behavior of liquid Mg drop on different substrates: pure titanium, niobium and Ti-Nb alloy (26 at. %Nb). The capillary purification procedure was used to eliminate the heating history of the Mg/substrate couples and the presence of the native oxide film on the Mg samples. All tests were conducted under isothermal conditions (700°C) using a gaseous mixture of Ar + 5 wt.% H_2 as a protective atmosphere. The images of Mg/substrate couples recorded during the high-temperature measurements were used for determination of the contact angle

values (θ) formed between the liquid metal and the investigated substrates. The obtained Mg/Ti, Mg/Nb and Mg/Ti-Nb alloy couples were subjected to detailed structural characterization by scanning electron microscopy combined with energy-dispersive X-ray spectroscopy. Under the present testing conditions, liquid magnesium exhibited non-wetting behavior (θ>90°) and no permanent bonding between liquid magnesium and the examined substrates. Following the available phase diagrams for the Mg-Nb and Mg-Ti systems, this behavior can be attributed to the nonreactive and immiscible nature of these systems caused from the negligible solubility of Nb and Ti in liquid Mg, and the fact that Mg does not form compounds with either Nb or Ti.

Abstract title:

Challenges and opportunities of cars electrification for HPDC foundries

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Key words:
high pressure die casting, electric cars, battery housings, electric motor housings

Abstract:
Worldwide introduction of electric platforms by OEMs opens a huge new market for the aluminum high pressure die casting foundries. However, with the whole new groups of products like battery housings, electric motor housings and new body-in-white and structural castings comes also new challenges and requirement that must be met by the casting industry. Not only need for big aluminum HPDC castings means introduction of so-called Gigapress HPDC Machines but it also brings changes in the productions process, quality control and logistics. Topics like leak tightness, straitening, assembly, adhesive joining and weldability becomes more relevant then ever before.
Additionally progressing lightweighting of cars calls for more holistic approach to the analysis of the mechanical properties of castings, defects detection and finally design of the part itself. Building competence in the component level testing becomes necessary requirement for the success. With long flow length during filling, thin walls and new alloys systems, virtual development phase is crucial to smooth and low-cost launch of the new projects. Especially with the shortening time dedicated for the development of the new project that can be observed in the last few years.

Abstract title:

Manufacturing of cellular structures to absorb impact energy

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Key words:
investment casting, 3D printing, energy absorber, lightweight metal alloys, cellular structures

Abstract:
Cellular castings are hereby proposed to be utilized for energy-absorbing applications. Various types of constructs were considered, such as foam-like or honeycomb, which can be cast from lightweight metal alloys e.g. aluminum or magnesium. Metallic foams characterized with open porosity were fabricated on the basis of PUR patterns via replica technique, while honeycomb structures were produced with the use of models originating from additive manufacturing. By the means of two combined technologies: 3D printing (FDM, Fused Deposition Modelling) and subsequent investment casting, it is possible to quickly and reproducibly prototype thin-walled complex structures with a shape that can be easily customized according to the current requirements and subjected to topology optimization. Parameters of the elaborated technological processes were adjusted and evaluated in detail. Castings prepared in this way are supposed to find their application in various sectors: kinetic energy absorbers (e.g. in the automotive or sports industry), bone implants (biomedical industry) etc. Manufactured structures were tested in a static mode, which allowed a preliminary assessment of their behavior during compression. Failure mechanisms were identified and interpreted in relation to the direction of the applied load. Additionally, perspectives for dynamic testing and performance of cast open-porous foams will be discussed in terms of the usage in e.g. ballistic shields.

Abstract title:

High-temperature interaction of liquid aluminium with compacted titanium-carbon powder substrate as a key factor for in-situ fabrication of aluminium matrix composites reinforced with TiC

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Key words:
aluminium matrix composites, wettability, contact angle, reinforcement, microstructural characterization

Abstract:
Aluminum matrix composites are very attractive for commercial applications in various industries, including aerospace and automobile, due to their light weight, high strength-to-weight ratio, high stiffness, low cost, and high dimensional stability. Among different processing techniques, the liquid state fabrication route (in-situ techniques) is the most commonly used for fabrication because of its low cost, availability, and possibility to produce large complex structural components. However, to obtain the homogeneous distribution of reinforced particles in the metal matrix, the wettability of the matrix/particle interfaces must be characterized. Hence, this research is focused on investigating the role of the high-temperature interaction of liquid Al with Ti-C compacted powders. The high-temperature behaviour between liquid aluminium and the solid substrate was studied using a sessile drop method combined with a capillarity purification (CP) procedure. The experiment was conducted under isothermal conditions at 800°C in a high vacuum atmosphere (10 - 6 mbar). During these measurements, the images of the couple were recorded by two high-speed monochromatic CCD cameras and used to determine the values of contact angles vs. time. For the interpretation of the wetting and spreading behaviour of solidified couples, the advanced scanning equipped with energy-dispersive X-ray spectroscopy and transmission electron microscopies were used for detailed microstructure observations. Based on these results, the mass transport to the Al drop direction from compacted Ti-C powder and simultaneous precipitation of Al_3Ti intermetallic phases were observed.

Abstract title:

Exploring the effect of TiC nanoparticles on in situ Al-based cast composites: microstructure, properties, and prospects for electromobility applications

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Key words:
Al-based alloys, TiC, nanoparticles, MMCs, properties

Abstract:
This study investigates the effect of TiC nanoparticles on the microstructure, properties, and prospects for electromobility applications of Al-based cast composites. The TiC particles were fabricated in situ via the casting process. The high-purity, particle-matrix boundary is the main advantage of this method. The incorporation of TiC nanoparticles in Al-based cast composites has gained significant attention due to their potential to enhance the mechanical and functional properties of these materials. The phase analyses of composites materials were investigated at DESY synchrotron in Hamburg Germany. Microstructure and chemical composition of the materials ware investigated by means of a Leica DM IRM light microscope, FEI ESEM XL30 scanning electron microscope equipped with X-ray energy dispersive spectrometer EDAX GEMINI 4000, dual beam high-resolution SEM FEI Quanta 3DFEGSEM integrated with the EDAX Trident system, Hikari EBSD camera and Tecnai G2 transmission electron microscope with an Energy Dispersive X-ray microanalyzer and High Angle Annular Dark Field Detector. The hardness and wear were determined by means of Vickers and Ball-on-disc methods. The microstructural analysis reveals that the addition of TiC nanoparticles promotes grain refinement and hinders grain growth during the solidification process. This refined microstructure leads to improved mechanical properties, including enhanced strength, hardness, and wear resistance. The presence of TiC nanoparticles also acts as a barrier to dislocation movement, resulting in increased tensile and yield strength. Considering the prospects for electromobility applications, the enhanced mechanical properties using TiC-reinforced Al-based cast composites are promising candidates for lightweight structural components e.g., auto wheels, heat sinks, and electrical connectors in electric vehicles. In conclusion, this study highlights the positive influence of TiC nanoparticles on the microstructure, properties, and potential applications of Al-based cast composites in the field of electromobility. The findings provide valuable insights for researchers and engineers working towards the development of advanced materials for sustainable transportation systems.

Abstract title:

Corrosion Resistance of Multicomponent PEEK-based Coatings on Zirconium Alloy in Ringer's Solution

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Key words:
corrosion resistance, multicomponent coating, electrophoretic deposition, zirconium alloy, sulfonated PEEK.

Abstract:
The multicomponent Cu/HA/ZnS/PEEK coatings were electrophoretically deposited (EPD) on Zr-2.5Nb alloy substrates. The microstructure, roughness, surface properties, and adhesion strength of the coatings were studied. The coatings were characterized by a limited number of pores and the presence of HA agglomerates on their surface. All of the obtained coatings exhibited significant roughness and mild hydrophilicity, as well as high adhesion to the alloy substrates. Electrochemical investigations were performed in Ringer's electrolyte at 37°C. The corrosion measurements were performed using electrochemical techniques like open circuit potential (OCP), linear sweep voltammetry (LSV), and electrochemical impedance spectroscopy (EIS). The corrosion studies demonstrated that the multicomponent Cu/HA/ZnS/PEEK coatings have a significant improvement in terms of corrosion resistance compared to the uncoated Zr-2.5Nb alloy in an aggressive Ringer's electrolyte solution.

Funding:
The SEM and coatings adhesion studies were supported by AGH-UST (project no. 16.16.110.663).
The corrosion resistance (OCP, LSV, EIS) study was supported by AGH-UST (project no. 16.16.170.7998).

Abstract title:

Multi-component metallic alloys produced by electrochemical methods - properties and applications

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Key words:
high entropy alloys, electrodeposition, layers, cyclic voltammetry, corrosion

Abstract:
Typical metallic alloys bases on one major alloying component, where the addition of other elements is intended to improve or modify certain properties, most of all the mechanical properties. However, in 1995 a new concept of metallic alloys was described and defined. High Entropy Alloys (HEA) contains at least five alloying elements in an amount from 5 to 20 at.%. A common feature this type of alloys is an absence of intermetallic phases, high homogeneity of the microstructure and unique chemical composition, what leads to obtaining materials with very high strength indicators, stable structures (also at high temperatures) and excellent corrosion resistance. Hence, HEA can be successfully used as a substitutes for typical metallic alloys.
For fabricating HEA, a few ways are applied: 1/ from liquid phase i.e. casting (usually arc melting); 2/ from solid phase i.e. powder metallurgy (sintering methods preceded by mechanical synthesis) and 3/ from gas phase e.g. sputtering or 4/ other deposition methods like electrodeposition from liquids. Application of different production methods creates different microstructures of HEA, which can entail differences in their properties. The last two methods also allows to obtain coatings with HEA structures, hereinafter referred to as High Entropy Films (HEF). With reference to above, the crucial aim of this work was the optimization of the manufacturing process of the multi-component metallic layers (HEF) by the electrochemical deposition (ED). The proper electrochemical parameters and chemical elements concentration allowed to obtain homogeneous and equimolar composition of HEF as far as it possible. The deposition process was carried out in organic electrolyte to avoid hydrogen evolution. The basic chemical composition of the coatings was CoCrFeMnNi system (known as Cantor's alloy). In order to analyse the microstructure of HEF, the optical, confocal, SEM/EBSD, and XRF techniques were employed. Moreover, the corrosion resistance of the CoCrFeMnNi layers in non-organic liquids was also determined.

Acknowledgements
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Research has been also supported by subsidy no.: 16.16.170.7998.

SCIENTIFIC SESSION C

Abstract title:

Precision-cast metal spatial structures for thermal energy storage applications

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Key words:
heat storage, solar energy, PCM's

Abstract:
Due to humanity's growing interest in sustainable energy generation and renewable energy, intensive efforts can be observed in the area of providing new, more effective and ecological energy solutions. This means the energy production, but also the accumulation of energy, especially solar energy. Storing solar energy in the form of heat is widely used in households and industrial areas. One of the promising methods of storing thermal energy is the use of phase transformation of storage materials (PCM's). This technology exhibits ability to store more heat energy compared to classic sensible heat storage systems with the same storage volume, which makes it a promising solution wherever it is necessary to increase the energy density of the heat storage. The development of this type of heat storage technology is widely undertaken by researchers and engineers around the world. One of the key issues is to ensure the best possible heat transfer into the storage bed. The paper will discuss the solutions being developed to accelerate the energy exchange process in phase change deposits in terms of adapting them to the specific nature of the daily supply of solar energy.

Abstract title:

Evaluation of microstructure of large-size gray iron castings

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Key words:
large-size castings, heavy-weight castings, grey cast iron, inoculation, microstructure.

Abstract:
The research presents characteristics of the inoculation and metallographic assessment for two experimental melts of grey cast iron where the overheat temperature was 1450°C and 1500°C. Metallographic analysis was performed using a LEICA optical microscope. Quantitative analysis of the test specimens were performed using Leica QWin computer software. In order to determine the size of graphite separations and perlite dispersion and the proportion of perlite in the matrix samples were collected from the center of the casting with wall thickness of 100 mm. The research presents the effect of overheating temperature on the effects of inoculation with the Zircinoc inoculant, in which it was shown that increasing the temperature by fifty degrees increased the amount of eutectic grains by around 11 – 15%. The inoculation had positive effects by reducing the proportion of undesirable D-type graphite, increasing the proportion of A-type graphite and the number of grains. The inoculation reduced the length of graphite precipitates which also has a positive effect on metal properties. The obtained high-quality gray cast iron with flake graphite will be the starting material for further research on large-scale castings intended for wind turbine components. That cast iron will be nodularized and then heat treatment to obtain Austempered Ductile Iron (ADI). By replacing standard ductile cast iron, with ADI, the weight of castings can be reduced and strength can be increased.

Abstract title:

Crystallization of primary austenite in chromium cast iron

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Key words:
EBSD, ProCAST, high chromium cast iron, primary grains

Abstract:
Castings made of high-chromium iron are characterized by a very good abrasion resistance. At the same time, a large amount of carbides in the microstructure may result in the appearance of hot cracks. One way to eliminate this defect is to carry out an inoculation that will increase the number of primary austenite grains. Measuring the number of primary grains in the entire volume of the casting requires preparing a series of samples tested using the electron backscatter diffraction method. This method of measurement is time-consuming and cost-intensive. The examination time could be simplified and shortened by using the ProCAST program. This program makes it possible to simulate crystallization with a given number of austenite nucleation sites. In the tests carried out, plates made of high-chromium cast iron with a thickness of 20, 30 and 40 mm were made in one melt. The samples were cut out and examined using a scanning microscope with an EBSD detector. Then, a series of simulations was performed in the ProCAST program with different numbers of primary austenite nucleation sites. The number of grains has been calculated. Comparison of the number of primary grains revealed by the EBSD method and in the ProCAST simulation showed that with an appropriately selected number of nucleation sites, the results obtained are similar.

Abstract title:

Control of melting and secondary processing of liquid alloy dedicated to ductile iron castings

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Key words:
ductile cast iron, ATAS thermal analysis, dynamic modification, eutectic crystallization

Abstract:
The share of shrinkage defects in castings (% and PLN) in the annual production of the foundry was presented. The causes were analyzed, indicating the lack of stability of the parameters of the liquid alloy during its keeping in a furnace with a capacity of 7 Mg (up to 1.5 h) and during its pouring into molds from a ladle with a capacity of 1 Mg (up to 12 min). Changes in the physicochemical state of the alloy were controlled based on the values of the ATAS MetStar 10.3 thermal analysis parameters. Combined with the results of spectral analysis, it was possible to select base cast iron in real time for a known casting modulus by ACEL (Active Carbon Equivalent) correction. Also in real time of the process, an indication from the control system (Optimizer Ductile Iron) about the amount of spheroidizer introduction in the Tundish Cover method was obtained. Thermal analysis made from 6 consecutive portions from a 7-Mg furnace indicates the optimal amount of modifier administered per stream of liquid alloy introduced into the casting molds (Dynamic Inoculation Ductile Iron Optimizer). The parameters of the ATAS system indicated that the first 3 ton portions of the poured alloy should be modified in the amount of 0.15% of the modifier in relation to the amount of cast iron introduced into the molds, and the next 3 portions of the liquid alloy (kept in the induction furnace for over 0.5 hour) require modification. in the amount of 0.20%. In special cases, the control system recommended modifying the second portion of melt taken from the furnace at the level of 0.20%. The analysis results were obtained 90s after taking a sample from the ladle transporting cast iron to the pouring machine, and the pouring machine and the modification system were started after approximately 2 minutes. from the system indicating the amount of optimal modification. It was possible to correct the value of modifier feeding into the stream for subsequent poured molds. The optimal spheroidal graphitization ability was maintained for castings with a known thermal modulus, preventing under- or over-modification of the cast iron throughout the entire period of pouring the cast iron from the 7-ton furnace.

Abstract title:

Influence of Ti addition to the zinc bath on the microstructure of the coating formed in the dip galvanising process

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Key words:
hot-dip galvanization, corrosion protection, titanium in zinc bath, HDG with addition titanium, intermetallic phase Zn-Fe-Ti.

Abstract:
Dip galvanisation is an effective, efficient, and low-cost method of protecting steel products against corrosion. However, this technology must face the inevitable raw material crisis caused by the shortage of zinc resources. Consider the possibilities of modifying the immersion metallisation technology leading to a reduction in zinc consumption in the process or the obtaining zinc coatings with higher corrosion resistance. The aim of this study was to observe and analyse the microstructure of zinc coatings obtained in Ti-containing baths. The machined steel substrate was cleaned, degreased in alcohol, etched, and subjected to a fluxing process. Subsequently, immersion galvanisation of steel samples was carried out in pure zinc and in 0.01%Ti - 0.5%Ti baths at 450°C and 550°C under laboratory conditions. Zinc bath immersion times of 60, 180 and 360s were used, followed by cooling in water to freeze crystallisation. Metallographic scans of a cross-section of the coatings from the substrate to the surface layer were taken. SEM microstructure images were obtained together with EDS chemical composition analysis, through which Ti segregation was determined. In addition, a detailed phase analysis was performed using TEM, which allowed the phases present in the coating to be identified and their elemental structure to be determined. The study showed clear differences not only in the thickness of the coatings but also in the phase composition. Nanocrystalline structures that occur between the Zn-Fe-Ti phase separations were also identified. The experiments carried out are a prelude to the development of an optimal immersion metallization technology in Ti-containing baths.

Abstract title:

Control of the casting structure by means of a chill with thermoelectric modules

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Key words:
crystallization of the casting, technological process control, waste heat recovery, energy efficiency of the foundry, thermoelectric generators.

Abstract:
Specificity of high temperature liquid-phase technologies enables effective formulation of the correlation between the use of waste heat and the course of the process. In metal foundries, it is possible to use the heat released during the crystallization process in a useful way. In the era of energy transformation, one of the postulates of sustainable development is to increase energy efficiency in heavy industry. In foundries, this postulate can be implemented using waste heat generated during the foundry process. The result of the research is the to develop of foundry mould construction that enable the modification of the crystallization process in the castings using a correlated system of thermoelectric generators and local cooling of the casting with the use of chills enabling control of the cooling intensity. Thermoelectric generators are devices that directly convert heat into electricity. Thermoelectric generators can be used wherever waste heat can be used to increase energy efficiency and, as a consequence, to reduce the consumption of energy from other sources. At the conference will be presented the results of research on the influence of cooling intensity on the structure of the casting combined with the production of electricity and studying the possibility of increasing the energy efficiency of the foundry process by analyzing the course of electricity production from pouring the alloy to cooling the casting.

Abstract title:

Structure and thermal stability of austenitic ductile iron castings

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Key words:
austenitic ductile iron, thermal stability, corrosion resistance, EBSD

Abstract:
In the present study, the influence of increased nickel content on castings structure formation and thermal stability has been investigated. For the research, the high-nickel ductile cast iron based on EN GJSA XNi22 and EN GJSA XNiSiCr35 5 2 grades were chosen, which are commonly in use for pumps and turbocharger parts. Due to the austenitic metallic matrix, their operating service temperature ranges from -200 up to 650°C. Two alloys have been investigated for each grade. For cast iron based on EN GJSA XNi22 first sample contains 21 whereas the second contains 28 wt. % of nickel. For cast iron based on EN GJSA XNiSiCr35 5 2 first sample contains 25 whereas the second contains 35 wt. % of nickel. Metallographic examinations were carried out to determine the role of nickel in shaping the primary structure (austenitic dendrites) and graphite nodules. The quantitative metallographic analyses using scanning electron microscopy (EBSD) and optical microscopy were performed to describe the austenite dendrites and graphite morphology. Also, X-ray diffraction (XRD) investigations with changing temperature were performed between 25 up to + 900°C. A corrosion study of the four samples was also carried out in the presence of 3.5 wt.% of NaCl at room temperature. The results showed that nickel and chromium additions have significant influence to corrosion resistance and thermal stability.

Abstract tit;e:

Method for quantitative evaluation of EN-AC46000 alloy phase composition from EDS measurements

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Key words:
quantitative metallography, phase identification, EDS

Abstract:
Measurement of the volume fractions of the phases or structure components is often used for quantitative evaluation of the microstructure of multiphase alloys. For stereological measurements, the use of selective etching of the metallographic specimen is required. Proper surface preparation should make it possible to unambiguously identify properly the affiliation of measurement points to a specific phase. For this purpose, special etching and observation methods must be used to ensure that contrastingly differentiated coloration of the grain surfaces of the different phases on the specimens is obtained. For systems of automatic stereological analysis, the variation in the coloration of the grain surface of each phase must be brought to a minimum at the same time. For multiphase alloys, such as Al-Si-based technical alloys used in high-pressure die casting, it may not be easy to meet the above requirements. As a result of the large variation in the cooling rate of areas of castings with different wall thicknesses in metal molds and the high variation in the rate of solidification on the cross-section of such castings, the type of grain surface coloring of the same phase in different areas of the casting may be non-uniform. This often limits the capability and accuracy of stereological methods used in automated metallographic analysis, performed on the images in the visible light band. This publication attempts to use the results of local chemical composition measurements by energy-dispersive X-ray spectral microanalysis (EDS) as primary data for estimation the phase fraction in a sample of HPDC casting from Al-Si-based multicomponent alloy EN-AC46000. There is segregation of components in the grain areas of each phase. Besides, the area of generation of the measured characteristic X-rays, can cover grains of several phases. Therefore, the method of mathematical nonlinear optimization with constraints was used to determine the fraction of selected phases in a multicomponent alloy based on the results of EDS measurements. The system of limiting conditions in this model was determined by the limiting concentrations of the components in each phase obtained using the Thermo-Calc thermodynamic database.

Abstract title:

Tests of mechanical, fatigue and fracture toughness of high Silicon ferritic ductile iron EN GJS 600-10

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Key words:
high silicon ferritic ductile iron , fatigue testing, fracture toughness, silicon reinforced ductile iron products, fatigue limit, fracture toughness

Abstract:
Ferritic cast iron reinforced with silicon (Si>4%) grade EN-GJS-600-10 according to EN 1563 was smelted in an induction furnace. The liquid alloy was subjected to a selected extra-safety treatment consisting in the process of spheroidization with nodularizer with rare earth elements, modified with antimony additives and graphitizing modification with Ultraseed. Mechanical properties and structure were evaluated in test samples made of ingots according to EN 1563 with a thickness of 12.5, 25, 50 and d=25 mm. Over 400 $1/mm^2$ of ductile graphite precipitates were obtained in the ferritic structure in the 12-25 mm wall and over 200 precipitates in the 50 mm ingot wall. The mechanical properties met the requirements of the standard (Rm > 600 MPa, A5 > 15%). The resistance of this cast iron to brittle cracking according to ASTM E1820-18 was assessed as part of subcontracting (Kielce University of Technology); 2018, KJC > 80 $MPa*m^{1/2}$, compared to the minimum required by EN1563 as min. 65 $MPa*m^{1/2}$. Fatigue tests were performed on smooth cylindrical samples and with a sharp concentrator to obtain the Wohler relationship (stress – number of cycles, σ – logN). Cyclic rotational load tests at a given stress level were performed until the sample was destroyed or discontinued if the sample was not destroyed after 107cycles. Average values of Z G = 173.75 MPa (according to EN 1563 ZG min 165 MPa) were obtained for samples without notch, and for samples with notch Z G = 299.15 MPa (according to EN 1563 ZG_{min} 275 MPa), as well as the value of the modulus E = 177 GPa against the required value of 170 GPa for this cast iron grade.

INVITED LECTURER

Abstract title:

Feeding & Gating Tool

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Key words:
feeder design, cast iron, shrinkage, modulus, feeder, solidification

Abstract:
The paper describes a calculation software for the design of feeders for cast iron using two methods of feeder calculation. One developed by Centre Technique des Industries de la Fonderie, (CTIF - France) and another by Cast Metal Institute, (CMI - USA). Soundness requirements of the casting, casting geometry and the casting production conditions are elements considered in the software design. The software is operated on Excel and is an excellent option for small foundries that cannot afford the acquisition and operating costs of major simulation software such as Magma soft, SOLID cast, Nova cast etc. The software is also an aid for young enngineers and operators of simulation software programs with little or no metallurgical and foundry expertise. The geometric modulus of the casting, the shrinkage of the iron, can be easily calculated and the optimum feeder will be calculated. The software can be used as an optimization tool for chemical composition of 10 types of cast iron. Correlation between iron chemical composition and mechanical properties, images of graphite shape and matrix, dimensions and shapes of graphite are also presented. Main input parameters are: modulus value, iron metallurgical quality, mold strength and pouring temperature.
Validation/interrogation of the software was done through the comparison between the present software results and SOLID cast simulation software results.

STUDENTS SESSION A

Abstract title:

Fabrication, microstructure analysis and mechanical testing of aluminum based metal-metal composites

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Key words:
additive manufacturing, laser powder bed fusion, metal-metal composite, casting, mechanical testing of materials

Abstract:
The goal of the project was to produce composites with minimized porosity and crack formation, testing the ability of this production route to fabricate structures with mechanical performance overpassing single materials and the one of cast aluminium, proving the ability of additive manufacturing to provide reinforcing structures with unique geometrical freedom. Three types of powders were proposed: 316L, Ti6Al4V, and AlSi10Mg. Subsequently, two pairs of metal-metal composites were created, namely 316L/AlSi10Mg and Ti6Al4V/AlSi10Mg. The samples were 3D printed using the Sisma MySint 100 machine through the L-PBF method, utilizing 316L and Ti6Al4V powders. An innovative casting process was conducted using AlSi10Mg powder. The main characterization methods for the metal-metal composites were microstructural and mechanical properties analysis. Metal-metal composites 316L/AlSi10Mg and Ti6Al4V/AlSi10Mg exhibited approximately half the Young's modulus value compared to the AlSi10Mg cast- Ti6Al4V/AlSi10Mg cast (Young's modulus of 17,61 GPa), 316L/AlSi10Mg (Young's modulus of 26,41 GPa), AlSi10Mg cast (Young's modulus of 41.5 GPa), 316L lattice (Young's modulus of 14,28 GPa), and Ti6Al4V lattice (Young's modulus of 10,50 GPa). This underscores the excellent mechanical properties of metal-metal composites and demonstrates the effectiveness of the casting technique in producing structures with mechanical properties surpassing those of individual materials. It also paves the way for further research to exceed the properties of conventional aluminum castings. Furthermore, it showcases how additive manufacturing enhances the mechanical properties and structural integrity of components, while simultaneously offering exceptional design flexibility. In the case of the Ti6Al4V/AlSi10Mg composite, the absence of cracks indicates robust structural integrity. Conversely, in the case of 316L/AlSi10Mg, cracks were identified in the microstructure at the interface of the two materials (AlSi10Mg and 316L). Nanohardness testing confirmed the increased hardness of the composites due to the presence of intermetallic phases at the interface of the two materials.

Abstract title:

Development of technology for producing fiber composites by infusion and RTM process

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Key words:
fiber composites, epoxy resin infusion, Resin Transfer Molding (RTM), development

Abstract:
The paper will present the process of developing the technology for producing fiber composites using the vacuum infusion method at the AGH Eko-Energy Scientific Club. The speech will present the lamination process and highlight the problems that this process generates, and the methods of dealing with them developed within the team will be presented. The second part of the speech will present RTM technology, i.e. resin transfer molding. The assumptions of the technology and the results it allows to achieve will be explained. The end of the presentation will be devoted to the interpretation of this technology developed in the scientific group and the results achieved. The last one presents an example of the use of the obtained panels.

Abstract title:

Overview of SiMo 1000 cast iron microstructure

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Key words:
SiMo cast iron, metallography, molybdenum carbide, SiMo ductile iron

Abstract:
The material known under the trade name of SiMo is a silicon-molybdenum cast iron with spheroidal graphite. This low cost material is an alternative for steel in applications involving machining and heat treatment. It is characterized by high both hardness and resistance to high-temperature corrosion (up to 1000°C) also in an acidic atmosphere. Its applications are covering combustion engine blocks and turbocharger housings as well as a range of similary mechanically and termally loaded parts.The standard SiMo cast iron specifying maximum and minimum content and ratio of respective alloying addition allows to test various chemical compositions aimed at choosing the most appropriate one. Therefore, within this work alloys having following nominal compositions were prepared: Fe5Si1Mo2,5Cr3,5Al (no 1), Fe5Si1Mo2Cr2,5Al (no 2), Fe5Si1Mo1,5Cr1,5Al (no 3) with P, S, Mg, and other minor alloying additions <0,1 (in wt. %) and their microstructures were compared. The investigation performed with light microscopy (LM) showed that the alloy no 2 is characterized by a highest volume of spheroidal graphite. The scanning and transmission eletrontron microscopy (SEM/TEM) backed by X-ray energy dispersive spectroscopy (EDS) revealed that the grain boundaries are decorated with colonies of M23C6 carbides (~20Cr, ~12Mo, ~3Si, ~1Mn, rest Fe).

Abstract title:

Analysis of the selected factors on the 3-D printed models made of PLA material quality

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Key words:
additive manufacturing, PLA filament, FDM technology, product quality

Abstract:
The purpose of my work titled Analysis of the selected factors on the 3-D printed models made of PLA material quality was to examine chosen factors that impact quality of the surface of the 3D models made with PLA in 3D print. Theoretical part of work contains knowledge about 3D print technology it beginnings and different technologies used today. Additionally few of the most popular and most used materials in 3D printing were described. Also CAD software, STL format and G-code were mentioned as they're important element in function of 3D printer. In later parts factors that impact quality of 3D printing were described and how carry quality check of them. In research part model used in research was shown. Test were conducted on 3D printer in FDM technology. In first step carried on 3D print of the model in standard setting slowly raising temperature to maximum limits in next step cooling of the models was reduced to partial and in final step it was fully reduced. In the next part model was prepared in 3 different software used to prepare models for 3D print using the same parameters and observed how it impacted the final model. In the last part of the research the top of the 3D printer was covered with prepared chamber and models were printed with same parameters like in the first part and it was compared how closed environment impacted quality of the models. At the end all of data was collected and after analysis best parameters for printing on this material were chosen.

Abstract title:

28 years and still works

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Key words:
steel K18, steel P265GH, repair welding, degradation processes, steel corrosion

Abstract:
The paper presents the material used in construction of conventional power plants, which is P265GH steel. The characteristics and requirements of such materials are described. Macro and microscopic research were carried out on samples taken from the working CHP plant, which allowed to show the effect of 28 years of operation at elevated temperature. The characteristic features of the microstructure, therefore the type of materials are presented. Degradation processes arising during long-term operation are discussed. Attention was paid to the resulting cracks on the inside and outside of the tubes tested. Microscopic examination was also carried out on a long-operated pipe which was subjected to repair welding after the perforation had occurred. In addition, the study was extended to include chemical composition analysis and hardness testing. The results obtained were referenced to standards and literature, which allowed to draw unambiguous conclusions.

Abstract title:

Developing own technology of manufacturing climbing holds

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Key words:
climbing, holds, 3D printing, new technology

Abstract:
Climbing has been gaining popularity in recent years. Lots of people who wants to try it begins on climbing wall. The authors are AGH students and climbers at once. That is why we would like to connect and improve that two things. Climbing holds mostly are made by resin founding and then screw to the wall. Manufacturer attempts to make their products lighter (it makes easier to screw holds to the wall), moreover they try to create original shape to keep eyes on it. Purpose of our project is devise new manufacturing technique which include polyurethane resin founding with special 3D printed framework in FDM technology. Deployment the framework will let us to curb usage of resin and production costs. During The accomplishment we reached; devise manufacturing technique of making climbing grips by resin founding, creating work frame and die plate and connect into composite, which help us safe up to 38% of climbing holds weights.

STUDENTS SESSION B

Abstract title:

Comparison of photovoltaic cells lamination methods

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Key words:
solar panels encapsulation, solar cells, light transmittance

Abstract:
Issues related to the process of lamination of photovoltaic cells are one of the biggest challenges facing the Eko-Energia student research group in the ongoing project of the "Perła" solar car.Due to the regulations of the competitions in which the design of the car is ultimately to participate, it was necessary to optimize in terms of cost, dimensions, as well as resistance to shocks caused by conditions on the roof of the vehicle. This presentation presents the results of a year's research in this area. Three methods of laminating photovoltaic cells were presented, and the technological advancement of the developed methods was compared. The first method mentioned was the use of PTFE films. Films made from the fluoropolymer family, along with a cheaper substitute in the form of PET film, are currently the most widely used alternative to glass in photovoltaic panels. The second method was to laminate the panels using fiberglass and epoxy resin. The last encapsulation method mentioned was the use of highly transparent silicone. The effects of the work are shown in the photo documentation. On the basis of the collected data, the selection of the optimal lamination method for the "Pearl" project was presented, taking into account all the mentioned factors.

Abstract title:

Numerical simulation and experimental validation of the heat treatment of a steel casting

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Key words:
heat treatment, numerical simulation, cast steel, VisualWeld, Sysweld

Abstract:
The problem of preparing the heat treatment technology of cast steel with the use of modern simulation tools is important to the today's engineer. The main purpose of the thesis was experimental verification of the numerical simulation results of L500-II carbon cast steel heat treatment, which is similar in chemical composition to CF35 steel. In accordance with the assumption, a computer simulation of the heat treatment process was carried out using the VisualWeld (Sysweld) software. Experimental tests, during which the cooling curves were recorded, were carried out simultaneously. After conducting quenching in water, the hardness distribution on the cross-section of the sample was examined, as well as the microstructure in selected areas, using a light microscope and ImageJ software. It was shown, that the results of the numerical simulation are different from those obtained in the experiment.

Abstract title:

Numerical modeling of steel flow in the tundish with different casting conditions

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Key words:
numerical modeling, tundish; steel flow, casting speed, temperature

Abstract:
Numerical modelling is currently an essential part of metallurgical research. In the case of numerical modeling, the prototype is replaced by partial differential equations. Numerical modeling can solve a wide range of events, such as the flow of liquids and gas, heat transfer or the course of chemical reactions. To describe the numerical model, it is necessary to understand the flow regimes (laminar and turbulent). These modes are described using the Navier-Stokes equation along with the continuity equations. The partial differential equations are solved on a computational mesh that covers the constructed geometry. The most important part of continuous steel casting is the tundish. supplies liquid steel during the ladle change and distributes steel between casting strands. During casting steel, the tundish is the last reactor where it is possible to influence the quality and purity of the cast steel. In the presented paper, the effect of flow at different casting speeds is evaluated. The influence of the temperature field in the tundish and wear of the refractory material of the lining is evaluated. The influence of the used model was also assessed within the paper. The k-epsilon and k-omega models were evaluated. Ansys Fluent software was used for numerical simulations.

Abstract title:

Analysis of the structure of casting made as a result of combining two non-ferrous metal alloys – CuSi3Zn3Mn1 and AlSi7Mg

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Key words:
metallographic examination, bimetal casting, structure analysis, CuSi3Zn3Mn1, AlSi7Mg

Abstract:
The aim of this study was to analyze the structure of the casting made as a result of combining two non-ferrous metal alloys CuSi3Zn3Mn1 and AlSi7Mg. The study was carried out on a cuboid plate with dimensions of 100x100x10 mm. The casting was made by a modified method of producing liquid-liquid casting bimetals. It involved simultaneous filling of the sand mold cavity with both alloys from separate gating systems. The dimensions of the elements of the gating systems were selected in accordance with the Polish Standards. As a result of the difference in density of CuSi3Zn3Mn1 and AlSi7Mg, a layered casting was obtained - bronze occupied the lower part and aluminum occupied the upper part of the plate. The study of the structure of the resulting casting included metallographic microscopy using an optical microscope and a scanning electron microscope (SEM) including point analysis of the chemical composition of individual phases. It was deduced from the study that the casting consisted of three layers - a layer of aluminum alloy, a layer of bronze and a transition layer separating the two alloys. As a result of the experiment, a casting bimetal was obtained with different contents of copper, aluminum and silicon in each layer. As a result of diffusion, the silicon bronze structure transformed into a multiphase structure characteristic of aluminum bronzes, depending largely on the elements present in the resulting alloy and the crystallization conditions. In the AlSi7Mg layer, it was observed that the main phase (α(Al)) was transformed into copper-rich multicomponent phases. The effect of diffusion phenomena resulted in the formation of brittle CuxAly-type precipitates. The high porosity - resulting from aluminum's high propensity to absorb hydrogen and the brittle phases observed in casting are features that prevent this bimetal from being used as a material of engineering significance.

Abstract title:

Design of the new cylinder of S-38 engine and development of its production technology

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Key words:
cylinder design, two-stroke engine, aluminum alloys, development of casting technology, simulation of cylinder operation, simulation of pouring and solidification process, lost wax technology

Abstract:
The paper aims to present the process of designing a new cylinder for the S-38 engine, and then to develop the technology of making this cylinder in investment casting technology. In the theoretical part of the work, the functions and requirements of the cylinders of two-stroke engines are presented at the introduction. The properties of aluminium alloys were then discussed. The cylinder will be made of aluminum alloy with copper and magnesium with the designation 390. For the production of the cylinder, investment casting technology was chosen. The paper presents in detail the process of mold manufacturing, materials used for models and molds, as well as disadvantages, advantages and application of technology. The course of the technology design process was also analyzed, i. e. how to select processing allowances, compensate for shrinkage and shape errors, design and calculate the filling and feeding system. In the practical part, the 3D cylinder design was developed as a fusion of solutions from the D50B0 engine and the S-38 engine. The engine equipped with this cylinder was then simulated. Subsequently, studies were carried out on the integrity of materials used in 3D printing with binders used in investment casting technology and an illustrative model of the designed cylinder in 3D printing technology was made. Having developed the cylinder body, we proceeded to the design process of the filling and feeding system starting from the required calculations. On the basis of the calculations, three variants were designed, taking into account the different orientation of the cylinder and the different places of supply of the liquid alloy. In the final stage, a simulation of pouring and solidification was performed for all prepared variants. Based on the results of the simulation, the casting system was selected to ensure the highest quality of the casting.

Abstract title:

3D printing of conductive carbon materials

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Key words:
printing, conductive carbon materials, Direct Ink Writing, functional devices, rheology, spectroscopy

Abstract:
Conductive materials are promising candidates in diverse applications including energy conversion and storage, bioelectronics, sensors, and so on. Carbon-based materials have gained significant attention due to their abundance, safety, exceptional electrical conductivity, mechanical properties, and chemical stability. The versatility and adaptability of 3D printing have spurred extensive interest in the production of complex, custom-designed electrodes. Here we introduce 3D printable inks based on toxic-free materials for Direct Ink Writing. This work provides a comprehensive overview of the formulation and optimization of these conductive inks, addressing crucial aspects such as material selection, rheological properties, and the role of additives and solvents. In addition, it elucidates the printing techniques and strategies employed for precise deposition, layer-by-layer construction, and post-processing methods to achieve functional and intricate electrode designs. The effects of filler content on printing parameters and the influence of heat treatment are thoroughly discussed. The structural changes and bonding configurations of materials are shown using spectroscopy techniques. The rheological analysis reveals the relationship between the ink composition and its deposition. We demonstrate that carbon materials impact the ink's viscosity, yield stress, and shear-thinning behavior. These findings are critical for optimizing the printability and precision of 3D printing processes, ultimately ensuring the fabrication of intricate and high-resolution structures. This research signifies a pivotal step towards advancing the field of electrode production, offering innovative solutions for emerging technologies while reducing the environmental footprint through sustainable materials and processes.

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