V INTERNATIONAL CONFERENCE OF CASTING AND MATERIALS ENGINEERING ICCME 25
KRAKOW, POLAND, OCTOBER 27-28, 2025

BOOK OF ABSTRACTS

FACULTY OF FOUNDRY ENGINEERING
AGH UNIVERSITY

Lightweight innovations for a better climate

ICCME25

V International Conference of Casting
and Materials Engineering ICCME 25
Krakow, Poland, October 27-28, 2025

BOOK OF ABSTRACTS

It is my great pleasure to welcome all participants to the 5th International Conference of Casting and Materials Engineering (ICCME 2025), organized by the Faculty of Foundry Engineering at the AGH University of Krakow.

The main theme of this year's conference, "Lightweight Innovations for a Better Climate," is both timely and highly relevant, reflecting current global trends in the development of lightweight components and the increasing use of environmentally sustainable materials.

I am pleased that this year's scientific program features four distinguished keynote speakers, representing a diverse spectrum of expertise in casting technologies, additive manufacturing, simulation, and process optimization.

Dr. Susana Mendez, Director of Casting Technologies at AZTERLAN Metallurgical Research Centre (Spain), will deliver a lecture entitled Application of Hybrid Models to the Foundry Manufacturing Process. Professor Maurizio Vedani from Politecnico di Milano (Italy) will discuss Solidification in Metal Additive Manufacturing: Similarities and Differences with Welding and Metal Casting. Mr. Young-Hoon Yim, Director of Overseas Business at AnyCasting Software Co., Ltd. (Korea), will present Metamodeling Approach to Predict Microstructure and Mechanical Properties in Aluminum Alloy Casting and Heat Treatment Processes. The plenary session will conclude with Dr. Wojciech Kowalczyk, who will share insights on the influence of casting parameters on the quality and efficiency of high-pressure die casting processes. His presetation title is High-pressure die casting in the face of global industry change. Opportunities and threats.

This year, we are honored to host participants and speakers from South Korea, Italy, Finland, France, Germany, England, Türkiye, Sweden, the Netherlands, and Poland. Among them are not only renowned scientists and industry experts but also PhD students and young researchers, for whom ICCME provides an excellent opportunity to present their work, exchange ideas, and establish international collaborations.

The International Conference of Casting and Materials Engineering has always been more than a scientific meeting – it is also a celebration of the Faculty of Foundry Engineering, its alumni, and its friends. It is a platform for sharing experience, inspiration, and innovation that strengthen the European foundry community.

Next year, the Faculty of Foundry Engineering at AGH University of Krakow, will celebrate its 75th anniversary. As the only academic center in Poland with comprehensive competence in foundry engineering – encompassing metallurgy, mould and process technology, modeling, and corrosion studies – the Faculty continues to expand international cooperation and serve as a center of knowledge for the casting industry.

I would like to express my sincere gratitude to the Organizing Committee for their dedication and effort in preparing this conference.

Special thanks are also extended to our co-organizer, the NetCastPL4.0 Project, funded by Horizon Europe (Networking for Advancing Excellence and Capacity in Lightweight Castings for Foundry 4.0 in Poland), and to our sponsors: CPP Poland, Foseco, Brembo, LENAAL, KPR Prodlew-Kraków, and Alu4Ceed, for their valuable support in organizing ICCME 2025.

Finally, I wish all participants an inspiring and fruitful conference, filled with constructive discussions, new ideas, and memorable experiences.

May ICCME 2025 strengthen our shared pursuit of excellence and innovation in the foundry and materials engineering community.

Prof. Marcin Górny

Dean, Faculty of Foundry Engineering, AGH University of Krakow

Organizational Committee

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27.10.2025 (Monday)

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

08:30	09:30	**REGISTRATION**
09:30	10:00	**OFFICIAL OPENING**
PLENARY SESSION | Main Hall		
Chairmen: G. Angella, R. Dańko		
10:00	10:30	S. Méndez (Azterlan, Spain) Application of hybrid models to the foundry manufacturing process
10:30	11:00	M. Vedani (Politecnico di Milano, Italy) Solidification in metal additive manufacturing: similarities and differences with welding and metal casting
11:00	11:30	Y.H. Yim (AnyCasting Software Co., Ltd., South Korea) Metamodeling Approach to Predict Microstructure and Mechanical Properties in Aluminum Alloy Casting and Heat Treatment Processes
11:30	12:00	W. Kowalczyk (Frech, Poland) High-pressure die casting in the face of global industry change. Opportunities and threats
12:00	13:30	**LUNCH**
13:30	14:30	**DISCUSSION PANEL** (Chairmen: K. Jalava, M. Górny) Lightweight Innovations Panellists: S. Mendez, R. Dańko, J. J. Sobczak, G. Angella, M. Łuszczak

SCIENTIFIC SESSION A | Main Hall		
Chairmen: P. Jacquet, R. Cygan		
14:30	14:45	T. Tokarski (AGH University of Krakow, Poland) Spheroidal graphite in ductile iron: morphology, growth, and distribution
14:45	15:00	N. Sobczak (Polish Academy of Sciences, Poland) Effect of calcium alloying on the wettability and interfacial reactions between liquid Mg and a Ti substrate under different atmospheric conditions
15:00	15:15	U. Gürol (Foseco, Türkiye) Alloy and Process Optimisation of High-Manganese Steels: Linking Microstructure to Industrial Performance of Track Shoe Castings
15:15	15:30	N. Roudbarian (Aachen University, Germany) Integrated Design Optimization for Thin-Walled Cast Automotive Components
15:30	15:45	K. Jalava (Aalto University, Finland) Experimental Comparison of Al-Si and Al-Cu Alloy Fluidity in Thin-Walled Sand Castings Supported by Numerical Simulations
15:45	16:00	G. Angella (CNR-ICMATE, Italy) Specimen geometry and tensile testing system effects on the ausferrite stability
16:00	16:30	COFFEE BREAK

SCIENTIFIC SESSION B &D | Conference Room (1 Floor)		
Chairmen: M. Vedani, D. Myszka		
14:30	14:45	**Ł. Rakoczy** (AGH University of Krakow, Poland) As-cast microstructure, strength and steam oxidation resistance of René 125 nickel-based superalloy fabricated via lost-wax casting
14:45	15:00	**B. Cygan** (Teksid Iron, Poland) ADI cast iron production at Teksid Iron Poland – opportunities and challenges
15:00	15:15	**A. Świątkowski** (AGH University of Krakow, Poland) Influence of growth velocity v and temperature gradient G on the interlamellar spacing λ of FeC eutectic
15:15	15:30	**A. Kmita** (AGH University of Krakow, Poland) Modern Materials and Additive Manufacturing (3D Printing) Technologies for Foundry Molding Sands – Toward Reducing Environmental Impact
15:30	15:45	**J. Piątkowski** (Silesian University of Technology, Poland) What has the main influence on the shrinkage porosity of castings from secondary Al-Si alloys?
15:45	16:00	**M. Kawalec** (AGH University of Krakow, Poland) Hybrid Crusher Hammers: Improved Durability and Efficiency Through High-Carbide Alloyed Iron Inserts Cast into a Manganese Steel Matrix
16:00	16:30	**COFFEE BREAK**

Chairmen: A. B. Vieira Moreira, K. Major-Gabryś		
16:30	16:45	J. Marosz (AGH University of Krakow, Poland) Si-Mo Composite Reinforced with (Ti,Mo)C in Ultra-Thin-Walled Castings
16:45	17:00	K. Morgiel (AGH University of Krakow, Poland) Mechanism of SiMo DCI HT oxidation based on complementary LM/SEM/TEM and XRD methods
17:00	17:15	A. Fijołek (AGH University of Krakow, Poland) Archaeometallurgy using modern research techniques and reverse engineering. Results obtained and prospects for the future
17:15	17:30	P. Stręk (LedaVi.com, Poland) Determination of the heat transfer coefficient in the isothermal quenching process of ADI cast iron cooled with water mist
17:30	17:45	K. Chrzan (AGH University of Krakow, Poland) The influence of induction melting parameters on the structure of ingots made of high-entropy alloys from the AlCoCuFeNi family
17:45	18:00	D. Halejcio (AGH University of Krakow, Poland) The influence of furfuryl resin type – classical and designed for sand 3D printing, on cast iron castings microstructure and surface roughness
18:00	18:15	M. Bork (AGH University of Krakow, Poland) An insight into high-nickel austenitic ductile cast iron

SCIENTIFIC SESSION C & E | Pub (-1 Floor)		
Chairmen: T. Tokarski, M. Kawalec		
14:30	14:45	D. Halejcio (AGH University of Krakow, Poland) The effect of microwave curing on selected properties of molding compounds with inorganic binders intended for 3D printing of sand molds and cores
14:45	15:00	N. Anwar (Aalto University, Finland) Evaluation of Sodium Metasilicate Pentahydrate Powder as Foundry Sand Binder
15:00	15:15	A. Sepiał (AGH University of Krakow, Poland) Influence of strand width and layer height on porosity in FDM 3D printed parts
15:15	15:30	O. Asghar (University of Padova, Italy) Raw Material Criticalities And Furnace Selection Choices In Aluminum Casting: A Pathway To Sustainable Foundries
15:30	15:45	K. Major-Gabryś (AGH University of Krakow, Poland) The use of green molding materials in the production of advanced lightweighting castings
15:45	16:00	A. Szczęsny (AGH University of Krakow, Poland) VR, AR, and MR in casting and materials engineering – opportunities and possibilities
16:00	16:30	**COFFEE BREAK**

Chairmen: S. Mendez, B. Cygan		
16:30	16:45	B. Milewski (AGH University of Krakow, Poland) Challenges facing the composite abrasives industry in the era of Energy consumption reduction
16:45	17:00	A. Burbelko (AGH University of Krakow, Poland) Modeling interaction of particles with crystallization front in in-situ nanocomposite using cellular automaton
17:00	17:15	K. Lemonnier (ENSAM, France) Differential Scanning Calorimetry of grey cast iron: Presence of iron nitrides after casting
17:15	17:30	P. Paczkowski (AGH University of Krakow, Poland) Optimizing Crystallization Control and Waste Heat Recovery in Foundries for Sustainable Electricity Generation
17:30	17:45	G. Szczurek (AGH University of Krakow, Poland) Evaluation of Carbide Eutectic in Castings of High-Chromium Cast Iron Grade EN-GJN-HV600 (XCr18)
17:45	18:00	K. Bracka-Kęsek (AGH University of Krakow, Poland) Coatings obtained in a zinc bath with Ti addition observed by TEM
18:00	18:15	Ł. Gondek (AGH University of Krakow, Poland) TiFe derivatives for cost-efficient hydrogen storage
19:00	24:00	**BANQUET**

28.10.2025 (Tuesday)

AGH Faculty of Foundry Engineering (Reymonta 23, Krakow)

09:30	10:00	**REGISTRATION**
10:00	10:15	**OFFICIAL OPENING**
10:15	11:00	**INVITED LECTURE** **A. Kang** (AnyCasting Software Co., Ltd., South Korea) **Desing and Review of Battery Pack Housing Parts for Electric Vehicles with Thin Sectioned Die Casting**
STUDENTS SESSION A		
Chairmen: N. Mordyl, P. L. Żak		
11:00	11:15	**P. Paszek** (AGH University of Krakow, Poland) **Assessment of the influence of die casting machine chamber filling parameters on the stability of HPDC quality** Supervisor: M. Brzeziński
11:15	11:30	**J. Jaworowski** (AGH University of Krakow, Poland) **Project of Manufacturing a High-Pressure Die-Casting of an Oil Sump from AlSi9Cu3(Fe) Alloy** Supervisor: Ł. Jamrozowicz
11:30	11:45	**J. Juszczyk** (AGH University of Krakow, Poland) **Model of a robotic production line for the assembly of a selected gearbox assembly component** Supervisor: M. Łucarz

11:45	12:00	**K. Adamiec** (AGH University of Krakow, Poland) **Design of a prototype lightweight brake caliper for motorbikes based on additive technology** Supervisor: J. Augustyn-Nadzieja
12:00	12:15	**M. Jaroszewski** (AGH University of Krakow, Poland) **The Influence of Electrochemical Cadmium Plating Technology on Hydrogen Embrittlement Phenomena in the Aerospace Industry** Supervisor: G. Michta
12:15	12:45	**COFFEE WITH NETCASTPL4.0 PROJECT**
STUDENT SESSION B		
Chairmen: P. Paszek J. Jakubski		
12:45	13:00	**J. Druciarek, K. Zaruczyński** (AGH University of Krakow, Poland) **Metallographic Studies of 3D-Printed Metal Alloys for Industrial Applications** Supervisor: G. Michta
13:00	13:15	**J. Lach** (AGH University of Krakow, Poland) **Advanced Optimization and Numerical Simulation of the High-Pressure Die Casting (HPDC) Process for the Automotive Industry** Supervisor: P. L. Żak
13:15	13:30	**M. Prażanowski** (AGH University of Krakow, Poland) **Implementation of rapid prototyping methods in process of manufacturing foundry wax models characterized by extremely thin walls** Supervisor: P. L. Żak
13:30	13:45	**A. Miśta, K. Machowska** (AGH University of Krakow, Poland) **Minimalizing the mass of a solar-powered racing boat, through the use of 3D printing, aluminum and composite materials** Supervisor: K. Sornek

13:45	14:00	**M. Majcher** (AGH University of Krakow, Poland) **Development of technology for the casting of the pump housing from ductile iron GJS-400-15** Supervisor: Ł. Jamrozowicz
14:00	14:15	**I. Herman** (AGH University of Krakow, Poland) **Designing the technology for making a casting using AnyCasting software** Supervisor: J. Lelito
14:15	14:30	**CLOSING OF THE CONFERENCE**
15:00	19:00	**STUDENTS SOCIAL MEETING** **FILUTEK Club, AGH University Campus, Rostafińskiego 10**

KEYNOTE SPEAKERS

Suzana Méndez
AZTERLAN, SPAIN
Application of hybrid models to the foundry manufacturing process

Maurizio Vedani
POLITECNICO DI MILANO, ITALY
Solidification in metal additive manufacturing: similarities and differences with welding and metal casting

Young-Hoon Yim
ANYCASTING SOFWARE, SEOUL KOREA
Metamodeling Approach to Predict Microstructure and Mechanical Properties in Aluminum Alloy Casting and Heat Treatment Processes

Wojciech Kowalczyk
FRECH POLSKA, POLAND
High-pressure die casting in the face of global industry change. Opportunities and threats

INVITED LECTURER

Andy Kang
ANYCASTING SOFTWARE CO., LTD., SOUTH KOREA
Desing and Review of Battery Pack Housing Parts for Electric Vehicles with Thin Sectioned Die Casting

Suzana Méndez

Dr. Susana Méndez is Director of Casting Technologies at AZTERLAN Metallurgical Research Centre (Spain).

During her career of more than 25 years, she has been working leaded in industrial and research activities related to casting processes and, in this context, she completed her PHD at the University of Toulouse (France). She currently leads a team of researchers focused on metallic materials, processes, and smart manufacturing technologies, aimed at developing new technologies and transferring them to foundry industry.

During the V International Conference of Casting and Materials Engineering ICCME 25 Dr. Susana Méndez will present the work titled:
"Application of hybrid models to the foundry manufacturing process"

Maurizio Vedani

Maurizio Vedani is full professor of Metallurgy at Politecnico di Milano and chief of the Material Section at the Department of Mechanical Engineering.

The main subjects of his scientific activity concern research on microstructure and mechanical behaviour during manufacturing and service of several metals and metallic alloys, ranging from structural steels to non-ferrous alloys such as aluminium alloys, metal matrix composites, titanium and magnesium alloys.

Specific subjects of his research activity in recent years cover degradable Magnesium and Zinc alloys for biomedical applications, novel alloys for additive manufacturing and multi-materials produces by the same techniques. He authored or co-authored more than 250 papers since 1989. Current research tracks given by Scopus based on data updated to May 2025, provide a total of 7300+ citations from the indexed papers and an h-index of 42.

During the V International Conference of Casting and Materials Engineering ICCME 25 Professor Maurizio Vedani will present the work titled:
"Solidification in metal additive manufacturing: similarities and differences with welding and metal casting".

Young-Hoon Yim

Mr. Young-Hoon Yim is Director of Overseas Business at AnyCasting Software Co., Ltd. (Korea).

With more than 28 years of experience in casting design and simulation, he has worked across various processes including cast iron, steel, aluminum, and magnesium alloys, covering both gravity casting and high-pressure die casting.

During the V International Conference of Casting and Materials Engineering ICCME 25, Mr. Yim will present the work titled:
"Metamodeling Approach to Predict Microstructure and Mechanical Properties in Aluminum Alloy Casting and Heat Treatment Processes".

Wojciech Kowalczyk

Wojciech Kowalczyk is working for one of the leading hardware suppliers for die casting technology. In his career of more than 25 years, he has mainly focused with issues related to the hardware side of HPDC technology. With particular attention on the influence of casting parameters on casting quality and process optimization in terms of both economic and quality efficiency.

During the V International Conference of Casting and Materials Engineering ICCME 25 Dr. Wojciech Kowalczyk will present the work titled:
"High-pressure die casting in the face of global industry change. Opportunities and threats".

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PLENARY SESSION

Abstract title:

Application of hybrid models to the foundry manufacturing process

Author:

S. Méndez [1*]

Affiliation:

[1] Azterlan - Centro de Investigación Metalúrgica

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Abstract:

The foundry industry is undergoing a digital transformation, driven by the need to improve process efficiency, product quality, and sustainability. In this context, hybrid modelling approaches—combining physical models based on metallurgical principles with data-driven models powered by machine learning—are emerging as powerful tools to optimize complex manufacturing processes. This presentation explores the application of hybrid models to key stages of the foundry process. The talk will highlight the strategy being developed for the integration of knowledge with artificial intelligence, which will enable more precise control of processes, reduce trial and error cycles, and facilitate real-time decision-making.

The challenges of implementing hybrid models in industrial environments and the prospects for their integration into Industry 4.0 frameworks will be evaluated.

Abstract title:

Solidification in metal additive manufacturing: similarities and differences with welding and metal casting

Authors:
M. Vedani [1*]

Affiliation:
[1] Politecnico di Milano, Department of Mechanical Engineering

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Key Words:
Additive manufacturing; solidification; microstructure; Al alloys; alloy steels

Abstract:
The contribution aims at reviewing the complementarity between metal additive manufacturing and casting, summarizing the opportunities offered by the former technology and the unsurpassed advantages of the latter for larger scale industrial production. From the scientific perspective, the peculiar solidification conditions encountered in additive manufacturing (especially focussing on Laser powder bed fusion) are compared to those met in fusion welding and in sand rather than permanent mould casting.

As a result of the different solidification rates and thermal gradients measured for the different processes, solidification microstructures are generated with distinctive features such as: grain shape and size, grain substructure, elemental segregations, crystal anisotropy, and solidification defects. These features are discussed, taking as examples a set of aluminium alloys and of alloy steels.

Finally, the relation between the microstructure discussed above and the resulting mechanical performance is discussed.

Abstract title:

Metamodeling Approach to Predict Microstructure and Mechanical Properties in Aluminum Alloy Casting and Heat Treatment Processes

Authors:
Y.H. Yim [1*]

Affiliation:
[1] AnyCasting Software

* yhyim@anycasting.com

Key Words:
metamodeling, mechanical property, Orthogonal Latin Hypercube Design, Kriging

Abstract:

1. Introduction

Through thermodynamic database calculations for aluminum alloys, the microstructure and mechanical properties in the as-cast state are first determined, followed by the calculation of microstructure and mechanical properties after heat treatment under specific conditions. When applying the analysis results to cast components, the microstructure and mechanical properties are estimated through sampling, then mapped using metamodeling. These results are compared with experimental data to verify accuracy and assess reliability.

2. Experimental procedure and workflow

The major mathematical formula was used to calculate the yield strength for the as-cast state and after heat treatment respectively. The calculation is performed based on the solute profile and the fraction of secondary phases through thermodynamic database. The metamodeling in the numerical analysis was performed using the Kriging method, and the sampling for calculating mechanical properties was conducted based on the Orthogonal Latin Hypercube Design (OLHD).

To obtain mechanical properties based on differences in cooling rates, a stepped test specimen was designed. The experimental results in the as-cast were compared with the simulation results. Furthermore, the experimental results after T6 heat treatment were compared and analyzed against the simulation results.

3. Result and discussion

Yield strength of the AC4CH alloy was compared for regions of the stepped test specimen using the as-cast microstructure, along with the results obtained after T6 heat treatment, in both experimental and simulation analyses. The yield strength showed over 95% agreement between the experimental and simulation results. A microstructure prediction method for aluminum alloys was developed, and its effectiveness was verified in regions with different cooling rates.

Abstract title:

High-pressure die casting in the face of global industry change. Opportunities and threats

Authors:
W. Kowalczyk [1*]

Affiliation:
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Key Words:
die casting, HPDC, giga casting, die casting industry, rheocasting

Abstract:
High-pressure die casting (commonly known as HPDC) of aluminum alloys is widely used wherever large quantities of components are required. The main customer of European pressure die casting foundries is the automotive sector, which accounts for up to 80% of foundry production capacity.

The profound changes currently affecting the global automotive industry have a direct impact on the current condition and future of European foundries.

The decline in car production volumes in Europe has caused a 20% drop in foundry capacity utilization compared to the record years of 2018/2019. This means that there are several hundred HPDC casting cells installed in Europe too many in relation to demand.

In addition, the growing market share of electric cars, which use far fewer castings, has only amplified the shortage of orders in foundries.

At the same time, the BEV revolution has created a new branch of die casting. Giga, Mega... casting. The design of BEV cars has made it possible to use very large Al castings in the car's body structure, eliminating hundreds of steel sheet stamped parts joined together with thousands of welds.

Paradoxically, despite the declining number of castings, the weight percentage of Al castings in cars is increasing. This means that the automotive industry needs fewer but larger castings. This phenomenon is not only related to the emergence of mega castings, but also to the integration of many castings into single, larger ones combining various functions.

These phenomena are strongly linked to the geopolitical situation and the shift of the market towards China.

In the field of "old" HPDC casting, there are high hopes for new applications and technologies. These include: Rheocasting, Thixomoulding, and Al wheels by HPDC.

DISCUSSION PANEL

Panellists: S. Mendez, R. Dańko, J. Sobczak, G. Angella, M. Łuszczak

SCIENTIFIC SESSION A

Abstract title:

Spheroidal graphite in ductile iron: morphology, growth, and distribution

Author:
T. Tokarski [1*]

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Key Words:
ductile iron, Nodular graphite, particles inhomogeneity, Transmission Kikuchi Diffraction, TEM diffraction

Abstract:
Ductile iron is a class of cast iron distinguished by its excellent combination of mechanical strength, ductility, toughness, and wear resistance. Its ability to be cast into complex shapes with both thin and thick sections makes it highly suitable for demanding engineering applications. These superior properties are primarily governed by the presence of graphite nodules, whose size, distribution, and morphology play a crucial role. Despite extensive research, the mechanisms controlling graphite crystallisation remain incompletely understood, particularly the influence of various alloying elements acting directly on spheroidal graphite (SG) formation or through the creation of nucleation sites.

This presentation introduces a novel approach for quantifying SG inhomogeneity and provides new insights into the mechanisms of SG formation. In the first part, a statistical method is proposed that defines a single parameter to describe the inhomogeneity distribution of SG particles. The method will be demonstrated using ductile iron castings with varying wall thicknesses. In the second part, the relationship between SG microstructure resulting from nucleation and growth processes will be examined. The complex nature of SG nodules and the intricate graphite/matrix/nucleus interfaces present significant experimental challenges. By employing advanced sample preparation techniques and high-resolution analytical methods such as Transmission Electron Microscopy and Transmission Kikuchi Diffraction, a detailed characterisation of the SG microstructure will be presented. The analysis will highlight local variations in crystallinity, ranging from amorphous regions to turbostratic structures and fully crystalline graphite.

Funding/Acknowledgments:

NetCastPL4.0 - NETWORKING -

The research is co-financed within NetCastPL4.0 project. The project is funded by the European Union under the Horizon Europe programme, Grant Agreement No. 101159771.

Abstract title:

Effect of calcium alloying on the wettability and interfacial reactions between molten Mg– Ca alloy and Ti substrates under two different atmospheric conditions

Authors:

J. J. Sobczak [1*], K. Janus [1], S. Terlicka [2], N. Sobczak [2], A. Jarzębska [2]

Affiliation:

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[2] Institute of Metallurgy and Materials Science, Polish Academy of Sciences, Reymonta 25, 30 059 Krakow, Poland

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Key Words:

Wettability; Mg-Ca alloy; Titanium; Microstructure; Sessile drop method, Capillary purification procedure, Contact angle.

Abstract:

Mg and Ti alloys are considered promising candidates for biodegradable orthopedic implants due to their favorable mechanical strength and deformation behavior. However, the high elastic modulus of Ti alloys compared with natural bone and the limited corrosion resistance of Mg alloys restrict their individual biomedical applications. Combining these materials through liquid-state processing could yield bioresorbable joints, but such integration requires a detailed understanding of wettability and interfacial reactivity.

The sessile drop method [1] was applied to study the high-temperature interaction between molten Mg–10Ca alloy (10 wt% Ca) and a pure Ti substrate, using non-contact heating to the test temperature and in-situ capillary purification of the alloy drop from its native oxide film directly within the high-temperature chamber prior to testing. Experiments were conducted isothermally at 700 °C under two flowing gas atmospheres: (i) pure argon and (ii) a mixture of Ar + 5 wt% H. The time-dependent contact angle (θ) was measured from the drop images captured by two high-speed CCD cameras to assess wetting kinetics.

In a pure Ar atmosphere, the Mg–10Ca/Ti system exhibited non-wetting behavior with an average contact angle of ~90°, accompanied by interfacial discontinuities and an absence of metallurgical bonding. Conversely, under Ar + 5 wt% H, excellent wetting occurred, with θ ≈ 11° after 180 s. The presence of hydrogen significantly improved the wettability by controlling the physicochemical reactions at the drop/substrate interface and simultaneously promoting the formation of a permanent bond at the Mg–10Ca/Ti interface. Based on the comparative characterization of

the structure and chemistry of the interfaces formed in the drop/substrate couples, the positive effects of alloying Mg.

[1] N. Sobczak, J. Sobczak, R. Asthana, R. Purgert, The mystery of molten metal, China foundry 7 (4), 425-437 (2010)

[2] S. Terlicka, K. Janus, N. Sobczak, J.J. Sobczak Effect of atmosphere on the high-temperature interaction of molten Mg-10Ca alloy with steel substrates. Arch. Civ. Mech. Eng. 24, 160 (2024)

Acknowledgments:
This research was supported by the National Science Centre of Poland within OPUS 21 under Project No. 2021/41/B/ST5/02787.

Abstract title:

Alloy and Process Optimisation of High-Manganese Steels: Linking Microstructure to Industrial Performance of Track Shoe Castings

Authors:
U. Gürol [1,2*], S. Can Kurnaz [1]

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Key Words:
High-manganese steel, microstructure, alloying design, casting parameters, wear resistance

Abstract:
High-manganese austenitic steels are distinguished by their unique combination of toughness, work-hardening ability, and wear resistance, making them critical for mining and heavy-duty applications. However, their performance is highly dependent on alloy design and process parameters. This study investigates the influence of carbon, manganese, and titanium additions, together with heat treatment and pouring temperatures, on the microstructural evolution and mechanical response of ASTM A128 E-1 type steels.

Systematic trials with different C–Mn ratios showed that increasing Mn content to 17 wt.% stabilized the austenitic phase and suppressed carbide precipitation. The 1.0C–17Mn alloy solution-treated at 1100 °C exhibited refined grain structure and significant property improvements compared to the baseline alloy (1.0C–13Mn): +5% yield strength, +19% elongation, and +21% impact toughness. Titanium microalloying promoted the precipitation of nano-scale Ti(CN) particles, which refined the grain structure and enhanced wear resistance by up to 40%. However, local embrittlement effects led to reduced impact toughness, with the best compromise observed in the 1.0C–17Mn–0.05Ti alloy.

Microstructural analyses revealed that property optimization is strongly linked to controlling carbide networks and promoting uniform Ti(CN) dispersion. In addition, pouring temperature was identified as a decisive factor for thick-section castings.

To validate laboratory-scale findings, a real track shoe casting part (~3.5 tons gross weight) was successfully cast using the optimized 1.0C–17Mn composition without Ti addition. By optimizing pouring conditions, particularly lowering the pouring temperature to 1420 °C, both the microstructural homogeneity and mechanical performance were significantly improved. Most importantly, service life under severe wear was extended by approximately 30% compared to the standard reference alloy, confirming the direct link between alloy/process optimization and industrial performance.

Abstract title:

Integrated Design Optimization for Thin-Walled Cast Automotive Components

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Key Words:
Topology Optimization, Shape Optimization, Thin-walled Casting, GJS-400, Casting Constraints

Abstract:
Lightweight design of cast automotive components plays a vital role in reducing CO emissions while maintaining structural integrity. Sand casting of nodular cast iron (GJS 400) offers a cost-effective route for manufacturing geometrically complex structures, yet the realization of thin walled castings remains challenging due to incomplete mold filling, limited core removability, and defects caused by rapid solidification. This study presents an integrated workflow that combines topology optimization, redesign, and shape optimization to develop a thin walled castable demonstrator for a trailer component. Beginning with a simplified bulk design space, topology optimization was applied to determine an efficient load carrying layout. The resulting configuration was then redesigned to satisfy essential casting requirements such as minimum wall thickness, draft angles, and core removability. A subsequent shape optimization step refined the geometry of the core removal holes to reduce local stress concentrations, while casting simulations were performed to assess manufacturability and detect potential defect zones. The proposed workflow provides a practical route for translating topology optimized concepts into manufacturable thin walled cast components. By integrating structural optimization with process-based design constraints, the approach achieves a balanced combination of lightweight efficiency and casting feasibility. The final design was successfully realized through sand casting trials, demonstrating the robustness and applicability of the developed optimization to manufacturing methodology for future lightweight automotive applications.

Abstract title:

Experimental Comparison of Al-Si and Al-Cu Alloy Fluidity in Thin-Walled Sand Castings Supported by Numerical Simulations

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Key Words:
Thin-walled casting, Al-Si alloy, Al-Cu alloy, fluidity, experimental validation

Abstract:
This study presents an experimental comparison of the fluidity and casting behavior of Al-Si (AlSi10Mg) and Al-Cu (AlCu4Ti) alloys in thin-walled sand castings, in addition to some numerical simulations for optimizing the process. The main objective was to evaluate the influence of temperature and wall thickness on the achievable flow lengths and casting soundness for both alloys. Experiments were performed using Archimedes spiral molds with wall thicknesses ranging in between 1 mm and 5 mm. The results showed that AlSi10Mg exhibited higher fluidity and more complete filling across all tested conditions, while AlCu4Ti displayed limited flow length. The effect of pouring temperature was also studied, revealing that higher temperatures improved the flow in Al-Cu alloy during the experiments. Numerical simulations using MAGMASOFT® were performed in parallel to analyze the impact of different gating configurations, runner tapering, and filter placements on flow uniformity and porosity formation. These simulations provided valuable insights into how design modifications influence metal flow and defect distribution, supporting the interpretation of experimental results. Overall, the findings confirm that Al-Si alloys offer superior castability and fluidity under thin-walled conditions, whereas Al-Cu alloys require careful optimization of temperature and gating design to achieve defect-free filling.

Funding/Acknowledgments:

NetCastPL4.0 - NETWORKING -

The research is co-financed within NetCastPL4.0 project. The project is funded by the European Union under the Horizon Europe programme, Grant Agreement No. 101159771.

Abstract title:

Specimen geometry and tensile testing system effects on the ausferrite stability

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Key Words:
Thin-walled castings; ausferrite; tensile geometry effects; tensile testing rig effects

Abstract:
As in thin-walled foundry products the skin layer becomes dramatically significant respect to the component bulk, defects and metallurgical imperfections can affect the whole component microstructure and properties. This might be even more serious in Austempered Ductile Irons (ADIs), where the main concern of their use is the ausferrite stability, as during thermal and mechanical loading the retained austenite may transform into martensite, causing rupture. In fact, the ausferrite stability depends on chemical segregations and metallurgical defects. So, as the assessment of the ausferrite stability in thin-walled ADI components is paramount, in ICMATE the sensitivity of ausferrite stability to thin-walled tensile specimen geometry has been assessed. Tensile strain hardening analysis has been proved to be a useful tool to assess the ausferrite stability in ADIs. The results of the investigation on the effect of tensile specimen geometry and tensile gripping system on the tensile mechanical properties of ADIs are reported. Round and flat tensile specimen geometries were used in combination with thread, pin-hole and wedge grips. A Digital Image Correlation (DIC) system was used to collect local information on the stress–strain conditions during tensile testing of flat geometries. Moreover, XRD measurements were carried out to follow the austenite-to-martensite transformation during straining.

Funding/Acknowledgments:

NetCastPL4.0 - NETWORKING -

The research is co-financed within NetCastPL4.0 project. The project is funded by the European Union under the Horizon Europe programme, Grant Agreement No. 101159771.

SCIENTIFIC SESSION B

Abstract title:

As-cast microstructure, strength and steam oxidation resistance of René 125 nickel-based superalloy fabricated via lost-wax casting

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Key Words:

aerospace, Rene 125, investment casting, gamma prime, as-cast microstructure

Abstract:

Recent advancements in the design, optimization, and manufacturing of turbine engine hot-section components have significantly improved the power output and efficiency of gas turbine systems. For long-term operation in extreme environments, it is essential to use materials that combine high mechanical strength with excellent microstructural stability. Nickel-based superalloys meet these requirements and are thus widely used in aerospace and power applications, especially in components produced through vacuum investment casting. René 125, a high-performance nickel-based superalloy commonly utilized for turbine blades and vanes, requires precise heat treatment procedures to achieve optimal service properties. Understanding its as-cast microstructure and solidification characteristics is crucial for developing and controlling these post-casting processes. This study focuses on characterizing the solidification behavior, microstructural evolution, mechanical strength, and steam oxidation performance of René 125 in its as-cast state. The alloy, produced via investment casting, was analyzed using a combination of thermodynamic simulations, differential thermal analysis, synchrotron X-ray diffraction, light and scanning electron microscopy, energy-dispersive X-ray spectroscopy, scanning-transmission electron microscopy, tensile testing, and steam oxidation measurements. The as-cast microstructure comprised a γ matrix reinforced with cube-like secondary γ' precipitates, which accounted for over 45% of the total volume. Distinct variations in the morphology, size, and distribution of the intermetallic γ' phase were observed between dendritic and interdendritic regions, which can be attributed to elemental segregation. The

limited solubility of carbon, zirconium, and boron in the γ and γ' phases promoted the formation of secondary phases, including MC carbides, M_5B_3 borides, and $Ni_7(Hf,Zr)_2$ intermetallic phase. Steam oxidation testing showed minimal mass gain (less than 0.2 mg/cm²), indicating the development of a protective oxide layer primarily composed of Cr_2O_3, Al_2O_3, and TiO_2.

Acknowledgements

The authors gratefully acknowledge the funding by National Centre for Research and Development, Poland, under grant FENG.01.01-IP.01-000E/23. This research was partially conducted within Horizon Europe Project No. 101159771 — NetCastPL4.0.

Abstract title:

ADI cast iron production at Teksid Iron Poland – opportunities and challenges

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Key Words:

ductile iron, heat treatment, mechanical properties, impact strength

Abstract:

Austempered Ductile Iron (ADI) is a well-known and increasingly used material. This type of cast iron is characterized by attractive mechanical properties (Rm, Rp0.2, A5) that significantly exceed those of conventional pearlitic ductile irons. However, the production of ADI requires a strictly controlled process for the base ductile iron — starting from the composition of the charge materials, through melting, metal treatment (spheroidization and inoculation), controlled cooling of castings in the mold, and finally heat treatment.

ADI cast iron is widely used in the automotive, railway, machinery, agricultural, and energy industries, and increasingly in the defense sector, particularly for castings subjected to high loads. To meet the growing demands of these markets, an attempt was made to produce ADI cast iron at Teksid Iron Poland that would satisfy these requirements.

Within the scope of this study, trial melts were carried out under production conditions at the Teksid Iron Poland foundry in Skoczów. The obtained castings (Y-block I and Y-block II) were then subjected to heat treatment to produce ADI. The results indicate that, under strictly controlled melting, metal treatment, and heat treatment conditions, it is possible to obtain ADI castings with a stable microstructure and attractive mechanical properties, while maintaining high values of elongation (A5) and impact toughness (KC).

Therefore, based on the results, it can be concluded that the production of ADI cast iron at Teksid Iron Poland is feasible. Such production presents both an opportunity — enabling access to new markets — and a challenge, due to the need for tight process control and the importance of operator expertise and experience.

Funding/Acknowledgments:

The research is co-financed within NetCastPL4.0 project. The project is funded by the European Union under the Horizon Europe programme, Grant Agreement No. 101159771.

Abstract title:

Influence of growth velocity v and temperature gradient G on the interlamellar spacing λ of Fe-C unidirectionally crystalilized eutectic

Authors:

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Key Words:

Unidirectional crystallization, Bridgman furnace - LMC, Fischer-Kurz model, growth velocity (v), temperature gradient (G), interlamellar spacing (λ).

Abstract:

The paper presents results of investigations concerning the influence of the growth velocity (v) and temperature gradient (G) on the interlamellar spacing (λ) in an irregular iron-carbon (Fe-C) eutectic unidirectionally crystalized. The aim of this study was to verify the growth model of D.J. Fisher and W. Kurz and to determine the relationship λ = f(v, G) based on experimental and numerical analysis. The crystallization process was carried out using the Bridgman-Stockbarger method with liquid metal cooling (LMC), and the structure was studied using optical microscopy. In parallel, numerical simulations were performed in ProCAST to determine the temperature gradient in the liquid at the crystallisation front. The results showed that increasing the growth velocity at constant G leads to a decrease in the interlamellar spacing λ, while at constant velocity a decrease in G results in an increase in λ. The experimental data obtained showed good agreement with the results of mathematical modelling, confirming the suitability of the W. Kurz and D.J. Fisher model in describing the crystallisation of irregular Fe-C eutectics alloys. Part of the research was carried out as part of the European Funds for a Modern Economy project with the SMART path - FENG.01.01- IP.01-A0EZ/24-00, in which Krakodlew S.A. Company is the consortium leader.

Abstract title:

Modern Materials and Additive Manufacturing (3D Printing) Technologies for Foundry Molding Sands – Toward Reducing Environmental Impact

Authors:

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Key Words:

advanced materials, 3D printing, molding sands, environmental protection.

Abstract:

The development of advanced materials and additive manufacturing (3D printing) technologies is creating new opportunities for the design and production of molds and cores, representing an important step toward the sustainable development of the foundry industry. This paper presents an overview of modern materials and technological solutions that help reduce the environmental impact of foundry processes. The discussion includes the use of environmentally friendly binders, low-VOC (volatile organic compound) materials, and approaches that enable broader implementation of ecological binders in the production of iron castings. Current research directions and challenges related to the adoption of innovative materials and 3D printing technologies in foundry applications are also highlighted within the context of the circular economy.

Acknowledgements:

This research is partially financed by the National Science Centre (NCN), Grant number 2021/41/B/ST5/02632 and partially financed within the UE GREEN CASTING LIFE project under grant agreement LIFE21-ENV-FI-101074439.

Abstract title:

What has the main influence on the shrinkage porosity of castings from secondary Al-Si alloys?

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Key Words:
Al-Si alloys, shrinkage porosity, iron phases, microstructure of Al-Si alloys

Abstract:
This paper discusses the causes of shrinkage porosity in castings of AlSi7Mg alloy obtained from secondary raw materials. The research aims to prove the validity of one of two hypotheses. The first hypothesizes that shrinkage porosity in Al-Si alloy castings is caused by the presence of brittle, plate-like b-Fe phase precipitates. The second hypothesizes that shrinkage porosity is caused by the presence of two-layer, thin oxide films (called "bifilms"), which assume a spherical or flattened shape during casting. The research was conducted on an AlSi7Mg alloy gravity-cast into a metal mold under low pressure (up to 0.15 MPa) on a casting machine at the Superior Industries Production of Poland foundry in Stalowa Wola.

It has been shown that the main factor determining which hypothesis is correct is the method of introducing the liquid alloy into the mold cavity (casting method). During gravity casting and slow heat removal, the b-Fe phases are the determining factor for shrinkage porosity. This applies primarily to Al-Si-Mg alloys with iron contents from 0.4 to 0.79 wt.% (pre-eutectic crystallization of b-Fe phases) and above 0.8 wt.% Fe (primary crystallization of b-Fe phases). However, during pressure casting, oxide films play a dominant role in the development of shrinkage porosity. This is due to the turbulent metal flow, which causes entanglement and folding. In this case, the contribution of iron phases (especially the b-Fe phase) to the development of shrinkage porosity is insignificant. Therefore, the allowable iron content in pressure-cast Al-Si alloys is higher (up to 1.6 wt.%) compared to gravity-cast Al-Si alloys.

Abstract title:

Hybrid Crusher Hammers: Improved Durability and Efficiency Through High-Carbide Alloyed Iron Inserts Cast into a Manganese Steel Matrix

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Key Words:

Mining technology; Crusher hammers; Wear resistance; Manganese cast steel; High-alloyed cast iron; Hybrid materials; Casting technology

Abstract:

The continuous advancement of technology in the mining industry necessitates the use of increasingly durable and wear-resistant working components in machinery, particularly crusher hammers. These components operate under extreme conditions, including high impact loads and intense abrasion, rendering traditional construction materials inadequate. While manganese cast steel is widely used due to its high toughness and strain-hardening capability, it often fails to provide sufficient abrasion resistance in specific working areas.

This work addresses the issue by proposing an innovative hybrid material solution: the design of crusher hammers made from a manganese steel matrix with cast-in inserts of high-alloyed iron. The iron inserts, rich in carbide-forming elements, offer superior abrasion resistance, while the manganese steel maintains the necessary high impact toughness. This combination aims to achieve optimal operational properties.

The paper describes the design process for these innovative hybrid hammers, based on real-world industrial crusher hammer designs. Furthermore, it details the developed casting technology for these components, utilizing the innovative KALPUR direct pouring system by Foseco, which significantly simplifies the production process and increases casting yield. The study also includes analyses to determine the potential benefits and limitations of this novel solution.

SCIENTIFIC SESSION D

Abstract title:

Si-Mo Composite Reinforced with (Ti,Mo)C in Ultra-Thin-Walled Castings

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Key Words:

Titanium-molybdenum carbides, SHSB reaction, ductile iron, cast iron, Si-Mo cast iron, thin-walled castings

Abstract:

This study focuses on the development and characterization of ultra-thin-walled Si–Mo ductile iron castings reinforced with titanium–molybdenum carbides synthesized in situ via the Self-propagating High-temperature Synthesis in Bath (SHSB) reaction. The objective was to enhance the ductility, toughness, and high-temperature performance of Si–Mo iron by eliminating detrimental eutectic M_6C carbides and introducing thermodynamically stable (Ti,Mo)C particles. Castings with wall thicknesses as low as 1 mm were successfully produced using the investment casting technique. Metallographic, EDS, and EBSD analyses confirmed the presence of uniformly distributed faceted carbides and excellent casting surface quality. The results indicate that the incorporation of in-situ synthesized (Ti,Mo)C significantly refines the microstructure and opens new possibilities for ultra-thin-walled castings intended for high-temperature applications. Additionally, the obtained phases exhibited high thermodynamic stability, which potentially translates into improved resistance of the material under high-temperature operating conditions.

Funding/Acknowledgments:

NetCastPL4.0 - NETWORKING -

The research is co-financed within NetCastPL4.0 project. The project is funded by the European Union under the Horizon Europe programme, Grant Agreement No. 101159771.

Abstract title:

Mechanism of SiMo DCI HT oxidation based on complementary LM/SEM/TEM methods

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Key Words:
SiMo DCI, TEM, M_6C, Fe_2O_3, Fe_3O_4

Abstract:
Cast irons intended for high temperature (HT) applications like the SiMo family are widely used in automotive industry, however further progress in that area requires a thorough understanding of their oxidation behavior. Improvement of combustion engines efficiency and reduction of CO2 emissions can be achieved mainly by raising the working temperature which forces the use of materials with higher corrosion resistance. Previously published papers often contradicted each other and contained incorrect interpretations of some results. In the present work, measurements of weight gains during cyclic HT exposition (1000°C in air) of the SiMo5-1 (5 wt. % Si, 1 wt. % of Mo) were explained by microstructure investigation with light, scanning and transmission electron microscopy. The results showed that ferrite areas and regions filled with carbides promoted two different oxidation paths. First one triggered formation of amorphous SiO2 layer covered with Fe3O4, while the latter restricted development of the silica diffusion barrier, leading to an accelerated growth of globular Fe2O3 crystallite agglomerates. With time, the oxide scale over ferrite areas thickened and transformed into a mixture of Fe3O4 and a-SiO2 phases, eventually surrounding the globules and slowing down their expansion. The acquired data allowed to devise a new, complete mechanism of SiMo5-1 HT oxidation in air.

Abstract title:

Archaeometallurgy using modern research techniques and reverse engineering. Results obtained and prospects for the future

Authors:
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Key Words:
Archaeometallurgy, casting technology, 3D scanning, CAD design, visualization

Abstract:
The use of modern engineering tools, such as 3D scanning and CAD (Computer Aided Design) software, for the design of individual 3D objects, as well as reverse engineering, which enables the reconstruction of Bronze Age objects in 3D geometry. Furthermore, the use of reverse engineering software allows for the detailed visualization and reconstruction of casting technology. Our team represents the AGH University of Science and Technology in the consortium "Polish Infrastructure for Cultural Heritage Research – E-RIHS PL." This national research infrastructure contributes to an international project.

The aim of this work is to present the results obtained so far for Bronze Age artifacts. The work presents, among other things, the use of CAD software and reverse engineering techniques to reconstruct the geometry of the studied objects. The developed 3D geometry of the artifacts allowed for visualization, preparation of the casting technology, and numerical simulations of the pouring and solidification processes. Furthermore, the work includes information on future research prospects and plans, including the use of modern research equipment to achieve further goals.

The use of diverse techniques broadens the scope of research and the opportunities for its dissemination and collaboration across numerous interdisciplinary Polish and European research communities, which is particularly important for the partnership within the ERIHS (European Research Infrastructure for Heritage Science) and ESFRI (European Strategy Forum on Research Infrastructures).

Acknowledgments
Polish infrastructure for cultural heritage research – ERIHS.PL FENG.02.04-IP.04-0006/24-00.

Abstract title:

Determination of the heat transfer coefficient in the isothermal quenching process of ADI cast iron cooled with water mist

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Key Words:
ADI cast iron, austempering, water mist, heat transfer coefficient, heat treatment

Abstract:
Isothermal quenching of austempering cast iron (ADI) castings requires that, after austenitization, the casting must be rapidly cooled to the temperature of isothermal austenite decomposition. The cooling rate throughout the entire volume of the heat-treated product must be high enough to prevent pearlitic transformation. At the same time, the temperature of the cooled surface must not decrease below the martensitic transformation start temperature Ms. The cooling rate is determined by factors such as the temperature difference between the surface of the cooled casting and the cooling medium, the thermal conductivity of cast iron, and the heat transfer coefficient. In the case of cooling with water mist, the heat transfer coefficient depends on the temperature of the cooled surface. To control the cooling process of castings using water mist, information about this relationship for the temperature range of 200–800°C is needed. Available scientific publications on this subject contain contradictory data. Therefore, a measuring station was built with the ability to set the temperature of the cooled surface. The station includes a measuring system that allows the measurement of the heat flux flowing from the heating element to the environment. The result of the research is the measurement of the relationship between the temperature of the cooled surface and the heat transfer coefficient. The values obtained will be used in the future to build a numerical model of ADI castings heat treatment. This work may contribute to the future replacement of salt baths (currently used for fast cooling and austempering) with water mist spraying. In this case, low-temperature operation of austenite decomposition can be performed without the use of salt bath.

Abstract title:

The influence of induction melting parameters on the structure of ingots made of highentropy alloys from the AlCoCuFeNi family

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Key Words:
HEA, AlCoCuFeNi, induction melting, microstructure, computed tomography

Abstract:
High-entropy alloys (HEAs) from the AlCoCuFeNi family were produced using electric induction furnaces. Materials of this type are characterized by a tendency toward chemical segregation within the ingot due to their complex chemical composition. In the literature, the most common reports describe studies in which such materials are produced using laboratory arc furnaces. In these cases, the alloys typically require multiple remelting steps and prolonged heat treatment in order to obtain a homogeneous structure.

In the present study, the materials were fabricated by melting in electric induction furnaces. Two types of units were employed: an open furnace with a capacity of approximately 3 kg of molten alloy, operating under an inert gas atmosphere, and a vacuum furnace with a capacity of about 1 kg of molten alloy. During melting in the open furnace, a specific procedure was applied, involving the sequential addition of alloying components in a defined order and the use of mechanical stirring to accelerate the mixing process of the alloying elements.

For the vacuum furnace process, several parameters were found to be critical for achieving proper melting. These included the appropriate arrangement of charge materials, ensuring sufficient free space within the crucible to prevent charge suspension and control of the internal pressure within the chamber.

Casting was performed into ceramic step molds, which were preheated to a temperature of 900 °C. Computed tomography (CT) scans of the ingots revealed the presence of internal defects in similar locations for both the vacuum- and open-furnace-cast materials. The size of the largest internal defects was also comparable between the two variants. To further investigate potential differences, microstructural analyses were carried out; however, these examinations did not reveal any significant distinctions between the two processing routes.

Abstract title:

The influence of furfuryl resin type – classical and designed for sand 3D printing, on cast iron castings microstructure and surface roughness

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Key Words:
thin-walled castings, cast iron, molding sand, furfuryl resin, 3D printing

Abstract:
3D printing technologies are classified as innovative additive production methods. In the production of foundry molds and cores, the binder jetting technology is used. It is a modern technology that enables the production of molds and cores with shapes and layout impossible to obtain using traditional molding methods. The method involves binding layers of sand grains (with or without hardener) together using binders and/or other agents.

The production of thin-walled iron castings with complex shape, characterized by high quality while maintaining the required properties, involves many steps in the production process. One of them is the appropriate selection of the mold technology including molding materials.

Resin-based binders are one of the main materials used in foundry molding and core sands. Self-curing sands with furfuryl resin dominated the production of large-size castings and are also successfully used in the production of sand 3D printed molds and cores, especially for aluminum castings manufacturing.

This work is part of the research on new molding sands for molds and cores 3D printing. The work concerns the influence of furfuryl resin type (classical and designed for 3D printing) on cast iron castings properties. The pouring parameters were elaborated on the basis of MAGMA software. The microscopic observations of castings, produced in classical and 3D printed molds were conducted as well as roughness of the samples assessment.

It was proved that the type of resin does not affect the microstructure of the cast iron while - due to a greater amount of gas emitted from molds made using conventional technology, it affects the surface quality of castings,

Funding/Acknowledgments:

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Abstract title:

An insight into high-nickel austenitic ductile cast iron

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Key Words:

Ni-resist ductile iron; thermal stability; electric conductivity; thin-walled castings; TEM

Abstract:

The present study focuses on high-nickel ductile cast iron, which is known as Ni-Resist cast iron. The nickel addiction in amount starting from 18 wt.% allows obtaining austenitic metallic matrix into cast iron. Ni-Resist ductile cast iron exhibits combination of the superior properties among which the following must be underlined: possibility to operate in a wide range of temperatures: starting form -200 °C, reaching 1050 °C for grades with spheroidal graphite, corrosion and erosion resistance exceeding unalloyed cast irons and relatively good mechanical properties, especially its plasticity reaching 40%. In the present study the high-nickel ductile cast iron with changing nickel content: 21, 25, 28 and 35 wt.% was examined. Two series having the same nickel content were prepared, where for second series also chromium on the level 2.5 wt.% was added. The micro- and macrostructures were deeply investigated using optical microscopy, scanning electron microscopy including EBSD technique and transmission electron microscopy. The thermal stability experiments were performed in low and high temperatures by X-ray diffraction (XRD), including cryogenic temperatures. The electrical conductivity of investigated cast irons was examined, science this property is important for some of the applications of Ni-Resist cast iron. Additionally, the mechanical properties of analyzed cast irons were investigated. After that, the chemical composition having 21 wt.% of nickel was selected for section-sensitivity experiments, which were focused on investigations of thin-walled castings. The results showed predomination of the highly branched dendritic microstructure, with graphite nodules present in the interdendritic regions and along austenite grain boundaries. The conducted research showed that it is possible to obtain a cast iron with elongation reaching 45%, which from point of view of other cast irons grades is unreachable. Also, it was proved that a nickel content on the level 25 wt.% is sufficient to ensure structural

stability at cryogenic temperatures.

Funding/Acknowledgments:

The research is co-financed within NetCastPL4.0 project. The project is funded by the European Union under the Horizon Europe programme, Grant Agreement No. 101159771.

SCIENTIFIC SESSION C

Abstract title:

The effect of microwave curing on selected properties of molding compounds with inorganic binders intended for 3D printing of sand molds and cores

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Key Words:
innovative technology, 3D printing, molding sand, microwave curing, inorganic binder

Abstract:
Microwave curing is becoming increasingly popular in the field of thermal curing of molding compounds, especially those with inorganic binders. Microwave-cured molding sands have better strength properties than chemically cured compounds with the same binders. It is therefore possible to reduce the amount of binder used while maintaining the high properties of molds and cores. In addition, the composition of the mixture intended for microwave curing does not contain an organic hardener, which is beneficial from both an ecological and economic point of view.

Currently, there are printers on the market for 3D printing of casting molds and cores equipped with microwave curing systems. The direction of research aimed at developing inorganic binders for this technology is therefore fully justified.

As part of the work, tests were carried out on molding sands intended for microwave curing using new inorganic binders developed on the basis of commercial binders. FTIR tests were carried out on classic binders and binders modified for 3D printing. The effect of the new binders on selected properties of molding mixtures was determined. Tests were carried out on thermal deformation (hot distortion parameter), gas emission, and residual strength. SEM images of bonding bridges were analyzed.

The conducted tests showed that it is possible to use new inorganic binders intended for 3D printing in microwave curing technology.

Abstract title:

Evaluation of Sodium Metasilicate Pentahydrate powder as foundry sand binder

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Key Words:
sodiuma metasilicate pentahydrate, sand molding, binder optimization, mold strength, metal casting

Abstract:
Sodium silicates are among the most widely used inorganic binders in sand molding for metal casting, yet significant differences in handling, curing, and final casting performance persist across available forms. Liquid sodium silicate binders dominate in current foundry practice, but they pose challenges in transport, storage, and mixing uniformity. To address these limitations, dry silicate powders like sodium disilicate powder has been researched in prior studies, demonstrating favorable molding and final casting characteristics. Building upon this approach, the present study examines sodium metasilicate pentahydrate ($Na_2SiO_3 \cdot 5H_2O$) powder as an alternative binder for sand molding applications. This compound offers several potential advantages like ease of handling, reduced dust generation tendency, rapid solubility in water and better pH regulation ability. Experimental mixtures were prepared using reclaimed silica sands, with systematic variation in both water content and binder concentration to assess their effect on mold strength. In addition, selected formulations were subjected to small-scale casting trials to evaluate mold integrity, dimensional accuracy, and surface finish. The results indicate that sodium metasilicate pentahydrate can achieve high mold strength through thermal hardening, providing performance comparable to that of conventional industrial binders. These findings suggest that this powder represents a promising alternative for inorganic sand molding in metal casting.

Funding/Acknowledgments:

NetCastPL4.0 - NETWORKING -

The research is co-financed within NetCastPL4.0 project. The project is funded by the European Union under the Horizon Europe programme, Grant Agreement No. 101159771.

Abstract title:

Influence of layer height and strand width on the porosity of 3D printed parts produced using FDM technology

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Key Words:
FDM 3D printing, porosity, strand width, layer height, polypropylene filament

Abstract:
The presentation will outline the methodology and results of a study aimed at evaluating the influence of printing parameters, such as layer height and extrusion width, on the porosity of polypropylene specimens fabricated using Fused Deposition Modeling (FDM). To determine the porosity of the investigated samples, their density was measured by means of the immersion method, based on Archimedes' principle. Acquired data enabled the calculation of open, closed, and total porosity in the tested specimens. The results served as the basis for drawing conclusions regarding the influence of extrusion width and layer height on porosity. Three parameter sets were then selected for further investigation. New specimens were printed for uniaxial tensile testing and cross-sectional analysis. A methodology was developed to obtain fracture surfaces suitable for cross-sectional observation, enabling clear visualization of porosity differences among the tested specimens. The final step involved mechanical testing of the specimens to evaluate their tensile properties, followed by drawing conclusions based on all the investigations presented in this thesis.

Abstract title:

Raw Material Criticalities And Furnace Selection Choices In Aluminum Casting: A Pathway To Sustainable Foundries

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Key Words:

Critical Raw Materials; Embodied Energy; Carbon Footprints; Furnaces; Sustainable Foundries

Abstract:

The aluminum casting industry plays a pivotal role in modern manufacturing, contributing to sectors such as automotive, aerospace, and construction. However, the increasing demand for aluminum, coupled with environmental concerns, necessitates a critical evaluation of its raw material sourcing and energy-intensive casting processes. This study will explore the dual challenges of raw material criticalities and furnace selection choices in primary and secondary aluminum casting, aiming to chart a pathway toward more sustainable foundry practices. The study will based on definition of criticality and environmental indexes to provide the sustainability index of aluminium alloys for more circular and climate-resilient future. Raw material criticality index (referring to designing phase of aluminium casting) will be assessed through factors: 1) Abundance of elements in earth crust, 2) Sourcing and geopolitical risk, 3) Environmental country risk, 4) Supply risk, 5) Economic importance and 6) Recycling input. While environmental impact index values (referring to processing phase of aluminium casting) will be assessed through factors: 1) Embodied energy and 2) carbon footprints. A comparative analysis of common furnace types—such as crucible, induction, reverberatory, and stack furnaces will be carried out to study the trade-offs in performance and considered sustainability metrics. The findings of proposed work will emphasize the importance of material and process selection in foundries to save the reserves of critical raw materials (who has no viable substitutes), better closed-loop recycling systems, renewable energy integration, and smart furnace operation to minimize environmental footprints. This comprehensive approach is vital for transitioning the foundry industry toward a more circular and climate-resilient future.

Abstract title:

The use of green molding materials in the production of advanced lightweighting castings

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Key Words:
thin-walled castings, environmental protection, molding sand, resin, inorganic binder

Abstract:
The production of thin-walled iron castings with complex shape, characterized by high quality while maintaining the required properties, involves many steps in the production process. One of them is the appropriate selection of the technology of molding and core sands, taking into account strict environmental requirements. The need to meet high environmental standards is currently the dominant factor in the development of molding sands technologies is. It's even being done at the expense of reducing the technological properties of the materials.

As part of the development of molding compounds for thin-walled castings, two compounds with organic binders and two compounds with inorganic binders were tested. Tests were carried out on the tensile and bending strength, permeability, and friability of the compounds. For selected molding sands, tests were carried out on their thermophysical properties (hot distortion parameter), gas emission, and thermal degradation. Molds were also made using 3D printing technology and no-bake system.

The tests carried out on the molding sands showed that all the proposed mixtures have the appropriate properties for the production of thin-walled castings. Sands with inorganic binders are characterized by lower gas emission, which is important both from the point of view of environmental protection and the quality of the castings obtained.

As part of the work, a mold for the production of thin-walled castings was designed. The molds were made from molding compounds selected for testing. Four castings with different wall thicknesses were made in each mold. The feeding system was designed on the basis of computer simulation.

Funding/Acknowledgments:

NetCastPL4.0 - NETWORKING -

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Abstract title:

VR, AR, and MR in casting and materials engineering – opportunities and possibilities

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Key Words:
virtual reality, augmented reality, material engineering, casting, manufacturing

Abstract:
Virtual, augmented, and mixed reality (VR, AR, and MR) are expanding their capabilities and finding new fields of application every year. It is best known for its entertainment applications, much like PCs were 30-40 years ago. And just as in those days the use of computers in foundry or materials engineering was not common, today working without computers and specialised software is practically impossible. Will history follow the same path for VR, AR, and MR? It is very possible. Fully automated and robotic manufacturing plants exist, but they are not feasible in all industries due to the specificity of the product and the cost of the equipment. It is also crucial that such factories are usually focused on a single type of product and any changes to the production process must take into account the specifications of the equipment on the production line. This essentially means that it is easier and cheaper to build a new plant focused on a new product than to modernise an old one. This leads to the fact that certain production processes are still easier and cheaper to be performed by humans rather than machines. Furthermore, even in a fully robotic factory, humans will be needed both as operators in abnormal situations and as service technicians. Due to increasingly affordable and advanced hardware and software (VR, MR, AR), combined with pressures to optimise production, rising labor costs, and increasing employee training costs, the use of VR, AR, or MR is becoming an increasingly attractive way to increase employee productivity and accelerate training.

SCIENTIFIC SESSION E

Abstract title:

Challenges facing the composite abrasives industry in the era of energy consumption reduction

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Key Words:
abrasives, composite, tools, grinding, cutting

Abstract:
Throughout the almost 150-year history of the modern abrasive industry, constant development has been driven by the need to improve the quality of manufactured abrasive tools . The main goals have been to increase longevity of the tools, shorten machining time, or improve machined surface quality. Often, all these targets have been achieved simultaneously, resulting in the abrasive products currently available on the market.

Over the decades, the thickness of common cutting disks has been reduced repeatedly. It has always been a challenge, both from the materials engineering and technological perspective. Nowadays, in the era of battery-powered power tools and the global need for energy savings, the abrasive industry faces another challenge – the need for manufacturing of high performance thin grinding disks and ultra-thin cutting disks with a thickness less than the now standard 1mm.

This study analyses the material solutions used in the production of modern, energy efficient abrasive tools. It contains a historical overview of the changes in abrasive materials and tools available on the market over the last decades and shows their impact on longevity of the tools. It presents how the introduction of successive generations of abrasive tools impacted specific power consumption during cutting operations. Innovative cutting disks with thickness of 0.9, 0.8 and 0.6 mm, brought to the market over the past few years are evaluated. Challenges in the upcoming abrasive materials and technological solutions, that manufacturers must face in the era of energy consumption reduction and the environment care, are shown.

Abstract title:

Modeling interaction of particle with crystallization front in in-situ composite using cellular automaton

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Key Words:
metal matrix nanocomposites, nanoparticles engulfment, Brownian motion, cellular automata

Abstract:
Ceramic nanoparticle reinforced metal-matrix composites (MMNC) are an area of intensive research. MMNC castings can be made using suspensions containing ceramic nanoparticles. The properties of MMNC depend on spatial distribution of particles in the metallic matrix of composites.

The interphase energy levels at boundaries liquid – solid metal, liquid – ceramic, and solid metal - ceramic indicates that the absorption of ceramic nanoparticles by the growing grains of solid phase should cause an increase in the free energy of the system. For this reason, in the case of low cooling rate and low crystallization front migration speed, surface forces cause repulsion of ceramic particles into the liquid. The result is the accumulation of nano-particles in the interdendritic space, their aggregation and highly uneven spatial distribution.

It is known that increasing the cooling rate promotes absorption of ceramic nano-particles by the front of the growing solid phase. Numerous mathematical models are known in the literature, which use the migration velocity of the solid-liquid interface as the criterion for transition from particles pushing to their engulfment.

The proposed model for analyzing interactions between nanoparticles in the liquid phase and the solidification front is based on the dendritic crystallization model using a cellular automaton. The model takes into account that nanoparticles located in the liquid phase participate in chaotic motion, known as passive Brownian motion.

In this model, the basis for deciding whether a particle will be absorbed or repelled by the crystallization front is the kinetic energy of the particle in active Brownian motion. The particle will be absorbed if the part of its kinetic energy associated with the component of the particle's velocity vector in the direction of the solid phase surface exceeds a critical level.

The results of a computer simulation of MMNC solidification for a range of cooling rates are presented.

Abstract title:

Differential Scanning Calorimetry of grey cast iron: Presence of iron nitrides after casting

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Key Words:

Grey cast iron, DSC, Iron nitride, Cast iron aging, Age strengthening

Abstract:

In order to understand the mechanisms behind the aging phenomenon of grey cast irons, Differential Scanning Calorimetry (DSC) was chosen to monitor the evolution and quantity of iron nitride precipitates responsible for aging. Grey cast irons were produced with varying nitrogen contents (from 50 ppm to 150 ppm) in an induction furnace and then poured into green sand molds. DSC samples were prepared from the raw castings successively by turning, micro-sectioning and polishing. The first challenge was to make visible, through an adapted protocol, the exothermic phase transition of iron nitrides from $\alpha"Fe16N2 \rightarrow \gamma'Fe4N$ near 200°C, which is masked by the exothermic Curie temperature of cementite at 210°C. The nitrogen content in the cast irons was varied to observe differences in the amplitude of the exothermic signal, in order to demonstrate that the observed transition is indeed the phase transition of iron nitrides $\alpha"Fe16N2 \rightarrow \gamma'Fe4N$. This transition was established at 169°C. Aging monitoring tests using DSC were conducted in parallel with free resonance measurements on cast irons produced and poured simultaneously. However, the changes in Young's modulus occurred by the ageing observed through free resonance test were not reflected in the evolution of the DSC thermograms.

Abstract title:

Optimizing Crystallization Control and Waste Heat Recovery in Foundries for Sustainable Electricity Generation

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Key Words:
controlling solidification, thermoelectric generators, industrial process control, waste heat recovery, foundry energy efficiency

Abstract:
In an effort to reduce the environmental impact of foundry operations, this study explores the dual potential of controlling casting solidification and recovering waste heat. Controlling solidification is crucial in foundries because it determines the microstructure — and thus the mechanical properties — of castings. This makes controlling crystallization a cornerstone of quality management. Meanwhile, the research also examines the substantial yet underutilized energy resource of waste heat generated during foundry processes.

It examines how cooling intensity influences the microstructure of castings and enables electrical energy to be generated from waste heat. The primary objectives are to quantify the relationships between cooling rate, microstructural evolution and electricity output, and to evaluate integrated systems that combine active solidification control with power generation.

Experimental molds were designed with controlled cooling setups integrated with thermoelectric generators to convert thermal gradients into electrical energy. A series of casting experiments were conducted under specified cooling conditions. Microstructural analyses of ZnAl4Cu1 and ZnAl11Cu1 alloys produced at different cooling rates are presented alongside measurements of the electrical energy generated during the casting process. The findings demonstrate that cooling intensity significantly affects the microstructure of castings, with electrical output showing a clear correlation to the cooling regime.

The results demonstrate that actively adjusting the cooling intensity enhances product quality and facilitates on-site energy recovery. This study successfully integrates crystallization control with thermoelectric energy harvesting, thereby aligning the optimization of the metallurgical process with the clear ecological goal of promoting more sustainable foundry practices.

Abstract title:

Evaluation of Carbide Eutectic in Castings of High-Chromium Cast Iron Grade EN-GJNHV600 (XCr18)

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Key Words:
High-chromium cast iron, chromium carbides, M7C3, microstructure analysis, cast iron inoculation

Abstract:
High-chromium cast irons are exceptionally hard and corrosion-resistant materials, primarily used in the mining, energy, and construction industries. Their main technological challenge is the susceptibility to hot cracking and porosity, resulting from the high casting shrinkage of chromium. This study presents the results of investigations on high-chromium cast iron specimens subjected to alloy inoculation and heat treatment. The research included quantitative analysis of carbide precipitates and their surface fraction, as well as microstructural examinations using SEM combined with EDS analysis. Wear resistance tests were also conducted on a 3-POD Tribotester to evaluate the influence of inoculation and heat treatment on the measured parameters. The results demonstrated that minor additions of Fe-Nb and Fe-Ti effectively mitigate technological defects and enhance wear resistance. Furthermore, heat treatment was shown to positively influence the functional properties of the material. The research was conducted at the Faculty of Foundry Engineering in Kraków and at the Świdnica Foundry.

Abstract title:

Coatings obtained in a zinc bath with Ti addition observed by TEM

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Key Words:

Intermetallic phase Fe-Zn, Transmission Electron Microscopy, zinc coatings, Hot-Dip Galvanizing, corrosion resistance

Abstract:

Zinc coatings provide excellent corrosion protection for iron-carbon alloys. There are several methods of applying such coatings, which ultimately differ in the structure of the protective layers obtained, their thickness, but also in their varying effectiveness of corrosion protection over time. The hot-dip galvanising method allows for the creation of a metallic layer that protects against corrosion for much longer than protective painted coatings or enamels. The literature [1] pays particular attention to the industrial application of the process due to the relatively low cost of obtaining such durable corrosion protection. The zinc coating obtained in a zinc bath is characterised by a layered structure composed of Fe-Zn intermetallic phases. The authors describe the structure of these intermetallic layers in detail, also from the point of view of the morphology of the precipitates and the reactions leading to their formation [2 - 4]. One of the ways to further improve the properties of the zinc coating obtained by immersing a steel component in a zinc bath is to use an alloying additive dissolved in liquid zinc. The paper describes how the addition of Ti to the zinc bath results in a different structure of the coating obtained: in addition to the alloy layer consisting of the ζ and δ phases, a zone of additional phase precipitates is formed in the coating. The results of the analysis of intermetallic phases performed using a Transmission Electron Microscope are presented, which made it possible to identify the crystalline structure of the coating. The zinc coating obtained in experimental baths with Ti, by which the precipitation of an additional phase and the presence of a nanostructure, is characterised by better corrosion resistance. Analysis of the chemical composition confirmed the segregation of Ti in the coating and the enrichment of all intermetallic phases with this element.

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Abstract title:

TiFe derivatives for cost-efficient hydrogen storage

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Key words:
Metal hydrides, Hydrogen storage, TiFe alloys, X-ray diffraction, Mössbauer spectroscopy

Abstract:
Solid-state hydrogen storage in metal materials is extremely important for the wide application of hydrogen energy systems. The current bottlenecks in this field are the cost of catalyst metals (e.g. platinum) for fuel cells and the lack of cost-effective materials for hydrogen storage. In this contribution, we address the problem of safe, low-pressure, and affordable hydrogen storage systems based on metallic hydrides. Commercially available materials like LaNi5 or TiMn2, have reasonable properties for stationary storage or application in heavy transportation (trains, ships), where the relatively high mass of the hydrogen storage container is not of the highest importance. Currently, the derivatives of magnesium and Ti-Fe alloys are widely researched for the sake of price of the raw materials and for achieving a high gravimetric hydrogen density. However, Mg-based alloys suffer from poisoning effects (surface oxidation) and high operating temperatures, as well as low kinetics. On the other hand, alloys based on the Ti-Fe system exhibit severe activation pressure and temperature. In our contribution, the results of comprehensive research on modification of the TiFe alloy by various transition elements are presented. Namely, results of structural (X-ray diffraction) and microstructural studies (electron microscopy) combined with investigation of sorption properties, cycle-life, and finally, electronic structure (Mössbauer spectroscopy) are presented. The results provide insight into mechanisms of facilitating the activation, which are related to structural disorder arising from doping the parent TiFe alloy by transition metals. It is shown that appropriate choice of doping elements can reduce the activation temperature by a factor of two, while the cycle life performance remains on the high level.

INVITED LECTURE

Abstract title:

Assessment of the influence of die casting machine chamber filling parameters on the stability of HPDC quality

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Key Words:
HPDC, process parameters, porosity, process stability, quality management

Abstract:
The study presents an assessment of the influence of chamber filling parameters on the quality stability of aluminium high-pressure die castings (HPDC). The research was conducted in the context of a quality management system, with particular attention paid to the relationship between process stability and the occurrence of internal defects.

The analysis was based on data obtained from an industrial HPDC production process involving several thousand production cycles. The study evaluated the relationship between the degree of chamber filling and the geometry of the biscuit – the first element of the gating system formed in the shot sleeve. This element reflects injection conditions and shows a strong correlation with the occurrence of quality-related defects recorded during routine process control. Statistical Process Control (SPC) methods were applied, including XmR control charts, distribution analysis, and variability measures of key process parameters.

The results confirmed that monitoring and controlling the chamber filling parameters significantly influence the reduction of casting porosity and the improvement of HPDC process stability. The application of SPC tools within the Quality Management System (QMS) enables the identification of process trends and the implementation of corrective actions in line with the principle of continuous improvement. The obtained results demonstrate the integration of process analysis methods with quality management practices, providing an effective approach to improving efficiency and product quality in high-pressure die casting operations.

Abstract title:

Project of Manufacturing a High-Pressure Die-Casting of an Oil Sump from AlSi9Cu3(Fe) Alloy

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Key Words:
aluminium alloy, automotive, high pressure die casting, simulation

Abstract:
This presentation focuses on the comprehensive technological project of manufacturing an oil pan casting, intended for the automotive industry, using the aluminum alloy AlSi9Cu3(Fe) and the High-Pressure Die Casting (HPDC) technology. The structural analysis of the casting was undertaken to assess its feasibility using the HPDC technique. Detailed technological calculations necessary for designing the gating system were performed, including the dimensioning of the gate slot, runner, and the shot sleeve. A key stage involved the development and verification of three different casting technology variants, which were subsequently subjected to Computer-Aided Engineering (CAE) simulation.

Abstract title:

Model of a robotic production line for the assembly of a selected gearbox assembly component

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Key Words:
3D printing, automotive, CAD, robot programming

Abstract:
This engineering thesis presents the design and implementation of a comprehensive assembly station, in which an industrial robot performs the process of mounting a gear shift knob onto a previously designed gear lever. The gear knob model used in this project was developed in an earlier engineering thesis. For the purposes of the current work, a new gear lever was designed and manufactured using CAD software (SolidWorks) and 3D printing technology based on the FDM/FFF method.

The practical stage of the project involved preparing physical models of both components and developing a complete assembly process utilizing an industrial robot. The programmed robot is responsible for gripping the gear knob and precisely mounting it onto the gear lever, as well as testing it in an element imitating the gearbox transfer environment, simulating real-world production conditions. This thesis also includes an analysis of gearbox construction, gear shifting mechanisms, and the impact of robotics and additive manufacturing technologies on the efficiency of production processes in the automotive industry.

Abstract title:

Design of a prototype lightweight brake caliper for motorbikes based on additive technology

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Key Words:
3D printing, Ti alloys, structural optimization, stress simulation

Abstract:
The paper presents design process of a prototype brake caliper intended for a motorcycle, developed with additive manufacturing in mind using the SLM technology and the Ti6Al4V alloy. The objective of the project was to achieve maximum weight reduction compared to the original caliper body while maintaining the required strength under operational conditions. The design was based on an existing brake caliper, manufactured using traditional methods, designed for a sport-touring motorcycle. As part of the work, reverse engineering was utilized with the application of 3D structured light scanning technology, ensuring compatibility with the previously selected motorcycle. The geometry of the prototype caliper was developed based on finite element method (FEM) stress simulation analyses and optimization, considering the calculated load system under maximum braking conditions. A total of 15 iterations of FEM analyses were conducted to design and refine the caliper body geometry in CAD software. The result of the work is a computer model of a prototype brake caliper body, whose mass constitutes 39% of the original design's mass, along with the fabrication of a non-functional prototype made of plastic. The paper outlines the design process based on structural optimization for additive manufacturing techniques, demonstrating an approach that can be adapted to the production of a broader range of automotive components.

Abstract title:

The Influence of Electrochemical Cadmium Plating Technology on Hydrogen Embrittlement Phenomena in the Aerospace Industry

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Key Words:
hydrogen embrittlement, cadmium electroplating, AISI 4340 steel, hydrogen diffusion, coating microstructure, current density, surface preparation, SEM analysis, fracture surface, electrochemical processes

Abstract:
Hydrogen embrittlement (HE) remains one of the key challenges in the aerospace industry, particularly for high-strength steels subjected to electrochemical processes such as cadmium electroplating. The conducted research evaluated the influence of selected technological parameters of the cadmium electroplating process on the susceptibility of AISI 4340 steel to hydrogen embrittlement. The analysis included the effects of cyanide module composition, surface preparation (sandblasting combined with oscillation), and current density during deposition, considering hydrogen diffusion phenomena and coating microstructure. Additionally, the influence of the shape of the cadmium-plated surface was examined, with particular emphasis on the effect of local current density in the context of developing technologies for coating aerospace components. Scanning electron microscopy (SEM) was used to observe fracture surfaces and to characterize the cadmium coating and substrate. Comparative mechanical testing allowed for the identification of correlations between process parameters and the intensity of hydrogen embrittlement. The results indicate critical process conditions that affect hydrogen ingress and deterioration of mechanical properties. The research concludes with insights into technological optimization and discusses the challenges of direct hydrogen quantification in cadmium coatings, an area requiring further investigation to enhance safety in aerospace applications.

STUDENTS SESSION B

Abstract title:

Metallographic Studies of 3D-Printed Metal Alloys for Industrial Applications

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Key Words:
3D printing, Ti alloys, structural optimization, stress simulation

Abstract:
The project focused on the development and implementation of additive manufacturing technologies for the production of metal parts and components intended for the chemical, energy, and metallurgical industries, as well as for manufacturers of research equipment.

The main objective of the project was to leverage the advantages of additive manufacturing such as weight reduction, minimization of the number of components, high precision, and process repeatability and apply them in new industrial sectors, including automotive, medical, aerospace, and space industries.

As part of the project, detailed metallographic studies were conducted, encompassing both quantitative and qualitative assessments of the produced materials. These analyses made it possible to determine the microstructure, porosity, and potential material discontinuities, which enabled the optimization of printing process parameters and confirmed the high quality of the manufactured components.

As a result of the project, a comprehensive methodology was developed and the manufacturing process was optimized, allowing for the production of components with high strength, reduced weight, and no need for mechanical joints, while also shortening production time and lowering costs. The final outcome included the development of a design methodology and forming technology, the fabrication of demonstrator components, and the simulation of their performance, which facilitated the implementation of the developed solutions into industrial practice.

Abstract title:

Advanced Optimization and Numerical Simulation of the High-Pressure Die Casting (HPDC) Process for the Automotive Industry

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Key Words:
simulation, HPDC, automotive industry, technology optimisation, CAD

Abstract:
In an increasingly fast-changing world, mankind requires reliable technologies more than ever to foster economic growth, enhance quality of life, and promote social progress. In industrial production planning, due to rising energy costs, minimizing casting weight and reducing energy consumption are becoming increasingly important.

High Pressure Die Casting (HPDC) effectively meets these requirements by enabling the production of metal components with moderate costs, excellent mechanical properties, and complex geometries for wide-ranging industrial and commercial applications. One of the most direct ways to analyse various technological parameters and their impact on the final product quality without incurring additional costs is through numerical analysis and computer simulation.

Therefore, this study focuses on the modeling and optimization of the HPDC process for an automotive component. The performed simulations enabled detailed analysis and optimization of key technological parameters, including pouring temperature, overflow design, and solidification behavior. Optimized conditions ensured smooth cavity filling and eliminated porosity formation, which is crucial for mechanical strength. Lower pouring temperatures and the use of overflows effectively reduced porosity and improved process efficiency, while also providing economic and energy-saving advantages.

The validated heat balance confirmed the reliability of the simulations and indicated that the applied improvements can increase productivity and reduce costs. It is worth noting that the selected topic is particularly relevant to Poland's highly developed pressure die casting industry, which includes numerous metal casting facilities, such as META-ZEL (Głogów Małopolski), Nemak (Bielsko-Biała), LIMATHERM (Limanowa), LENAAL (Radom), and Norlys (Nowy Sącz).

Abstract title:

Implementation of rapid prototyping methods in process of manufacturing foundry wax models characterized by extremely thin walls

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Key Words:
3D printing, wax models, casting patterns, CAD design

Abstract:
The development of rapid prototyping technologies has significantly influenced modern foundry practices, particularly in the production of complex wax models used for investment casting. This study presents the implementation of selected rapid prototyping methods in the process of manufacturing foundry wax models characterized by extremely thin walls. The project focused on developing an efficient workflow that combines casting simulations, 3D design, 3D printing of master patterns, creation of silicone molds, and wax casting. During the process, several technical challenges were addressed, including the closed air bubbles, wax flow, and fragility of sections with high wall thickness difference. The results confirmed that the integration of rapid prototyping with traditional foundry methods allows for a significant reduction in preparation time, and enhanced flexibility in prototype production. The developed approach demonstrates the practical potential of RP technologies as a reliable and cost-effective solution for manufacturing delicate wax models intended for investment casting applications.

Abstract title:

Minimalizing the mass of a solar-powered racing boat, through the use of 3D printing, aluminum and composite materials

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Key Words:
3D printing, CAD design, composite materials, rapid prototyping, metals and alloys

Abstract:
For a racing boat's performance to be as high as possible, its mass must be taken into consideration during each step of the design process. At AGH Solar Boat, besides using less material through geometry optimization, we focus on using the lightest materials. 3D printing, aluminum and composite materials allow us to approach the limits in mass reduction. Real-world solutions used by us for manufacturing a bulkhead, hull and other components will be discussed.

Abstract title:

Development of technology for the casting of the pump housing from ductile iron GJS-400-15

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Key Words:
Heini's feeder, chiller, simulation, nodular cast iron, pomp housing

Abstract:
The presentation concerns the development of the casting technology for a pump housing made of ductile iron GJS-400-15, designed to operate with heating oil, diesel fuel, or water. The main objective of the project was to design and optimize the pouring and solidification process for a series of six castings produced on an automatic molding line with a horizontal parting plane.

The study presents the design assumptions as well as the 3D model of the pump housing created in SolidWorks, which served as the basis for further technological analyses. Subsequently, three variants of the casting technology were examined based on the results of computer simulations carried out using MagmaSoft software. The analyses included

the occurrence of shrinkage porosity and other casting defects.

The implementation of a ceramic filter in the gating system ensured a laminar flow of the molten metal, effectively reducing turbulence and inclusions. Properly designed Heini's feeders and top feeders minimized shrinkage porosity, while the use of chillers accelerated solidification in critical areas, preventing structural defects.

The simulation results confirmed that the applied technological modifications significantly improved the quality of the castings, ensuring proper mould filling, uniform material structure, and absence of major defects. The developed technology provides a solid foundation for potential industrial implementation and serial production of the pump housing.

Abstract title:

Designing the technology for making a casting using AnyCasting software

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Key Words:
simulation, metal casting, modelling, aluminium alloy, AnyCasting software

Abstract:
This work focuses on the development of a casting technology for a gear shift knob made of AlSi6Cu4 alloy. Both numerical simulations and experimental trials were applied in order to compare theoretical predictions with real casting results.

In the first part, a casting model was designed in CAD software, and a gravity casting simulation was carried out using AnyCasting. The obtained results enabled the identification of potential casting defects and assessment of casting quality before conducting experimental tests.

The second part included the preparation of sand molds and the casting of the component under laboratory conditions. The comparative analysis showed a general agreement between the simulation outcomes and the actual casting process. Ultimately, the study confirmed the usefulness of numerical simulations as a supporting tool in designing casting processes and in reducing the number of necessary technological trials.


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