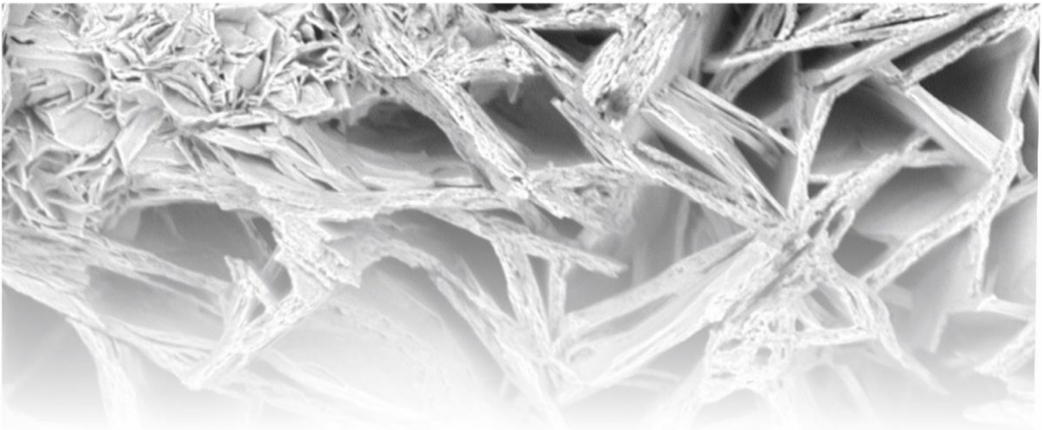

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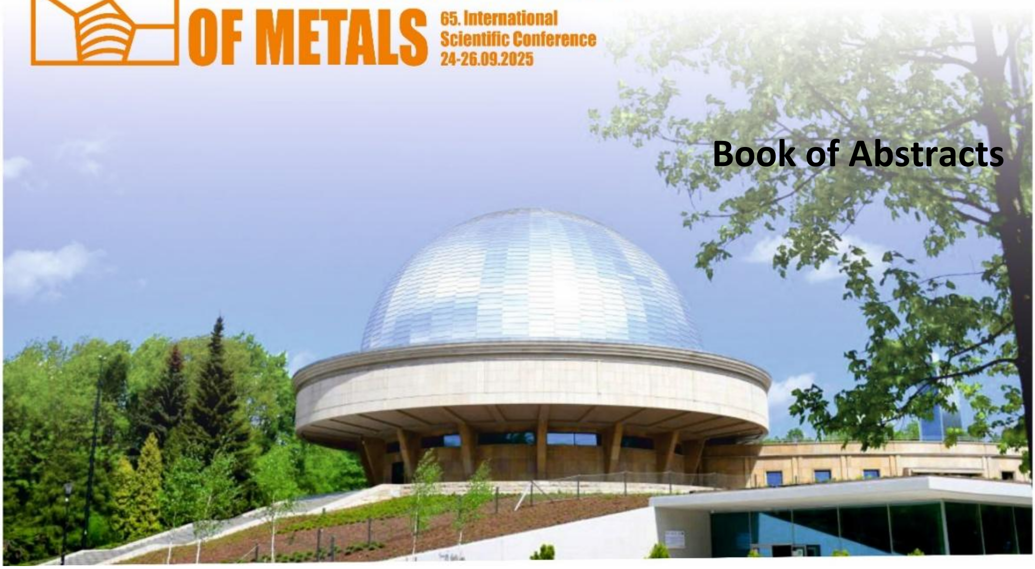

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[c] G.S. Pysarenko Institute for Problems of Strength of the National Academy of Sciences of Ukraine,
[d] National University of Life and Environmental Sciences of Ukraine, Ukraine

Influence of Structure on Wear Resistance of Cast High-Speed Steel of M2 Type

The paper investigates the process of structure formation of M2 high-speed steel at cooling from liquid state. The pairwise influence of the average values of grain sizes and the amount of eutectic, the average values of grain sizes and the amount of alloying elements in grains, the amount of eutectic and alloying elements in grains on the wear resistance of steel was determined. The analysis of the analytical dependences of such an influence showed that the effectiveness of the influence of grain sizes is of 33%, and the amount of eutectic - 67%; the amount of eutectic - 47%, and the amount of alloying elements in grains - 53%; the average values of grain sizes - 41%, and the amount of alloying elements in grains - 59%. It was also established that with a decrease in the distance between carbides in the eutectic, as well as their thickness and length, the abrasive wear resistance of steel increases. An increase in the content of elements in the grain in the order of V, Cr, W, Mo, C increases steel wear resistance.

Nurdan Alkan, Ümit Kutsal, Murat Çolak
Bayburt University, Cevher Wheels, Turkey

Investigation of Fluidity Properties at Varying Fe and Mn Ratios in Casting of A356 Aluminum Alloys

The final product properties in aluminum alloys emerge during the solidification process, and the elements that are intentionally added to the alloy or subsequently transferred to the alloy depending on the production process affect the final product properties. In this context, one of the most harmful impurities is the Fe element, and its amount in the alloy has an important role. Fe, which has low solid solubility in aluminum, forms intermetallic compounds that cause various brittle phases by bonding with other impurities or other elements in the alloy. In this context, studies are ongoing on eliminating the harmful effects of the Fe element and making castings with different alloy element additions depending on the increase in quality expectations from the alloys. In this study, casting experiments were carried out in fluidity molds by adding Mn (%0.05, %0.1 and %0.2) to A356 scrap alloy with different Fe (%0.1, %0.15 and %0.2) contents at varying rates. In the experiments, a spiral and 8-channel fluidity mold with a section thickness ranging from 0.5 mm to 8 mm was used. Thus, the effects of Fe and Mn on the fluidity properties of the A356 alloy were evaluated. The Fluidity Index values of the samples were determined depending on the section thickness in the test samples. Melting, permanent mold casting, liquid metal cleaning, metallography processes, RPT test, macro examination, image analysis techniques were used in the study. When the results were examined, it was observed that the fluidity properties of the alloy changed depending on the Fe and Mn content in the alloy. It was also determined that the liquid metal advancement distances increased depending on the increase in section thickness.

Michał Angrecki, Jarosław Jakubski, Jadwiga Kamińska,
Łukasiewicz Research Network – Krakow Institute of Technology, Poland

Technological Properties of Ceramic Moulds Containing Reclaimed Furan Resin Sands as a Substitute Fresh Ceramic Material for Subsequent Layers of Ceramic Moulds

The study presents the results of investigation of the strength properties of ceramic materials used for ceramic layered moulds. The aim of the studies was to determine the possibility of using the reclaimed spend moulding sand as a full-value ceramic material for making the successive layers of multi-layer ceramic moulds. The reclaimed spent moulding sands were obtained from domestic foundries and subjected to additional reclamation processes to examine how the degree of reclamation affected the strength properties of the test materials. The ceramic reference material was prepared from fresh ceramic ingredients. The first layer of a ceramic moulds was always made of fresh ceramic materials, while the remaining layers were made of reclamation sands.

By comparing the properties of the ceramic test materials and reference material, it was possible to determine the extent to which reclaimed moulding sands with furan resin binder could be used in the technology of making multi-layer ceramic moulds.

Dariusz Bartocha, Jan Jezierski, Marcin Kondracki
Silesian University of Technology, Poland

The Influence of the Purity and Microstructure of the AiSi7 Alloy on the Natural Frequency of Casting Vibration

The main objective of the study was to determine the impact of the quality of charge materials on the properties of the AlSi7 aluminum alloy. A unique method was proposed and tested to evaluate the alloy's properties based on the natural frequency of a test casting. The test melts included materials of varying purity, such as circulating scrap and chips. The test castings were subjected to a wide range of analyses, including mechanical property testing, chemical composition analysis, and microstructural examination. Furthermore, the geometry of the castings was precisely determined using 3D scans, and the natural frequency was calculated through Fourier transformation of the sound wave generated by the vibrating test casting after excitation. The accurately determined geometry and density of the test castings enabled modal analysis and the determination of Young's modulus by solving the inverse problem. The data obtained during the study were subjected to statistical analysis to explore the possibility of developing quantitative relationships between chemical composition, natural frequency, and the properties of the alloy, as well as between mechanical properties and their relationship to natural frequency. Based on the analysis of the experimental results and calculations, appropriate conclusions were formulated.

Dana Bolibruchová, Martina Sýkorová, Marek Matejka
University of Zilina, Slovakia

Influence of Beryllium on the Microstructure and Properties of a Cast Aluminum Alloy with Low Silicon Content

Currently, with high demands on structurally complicated castings with high demands on mechanical characteristics, microstructure but also physical properties, current alloys in many cases are no longer able to achieve the required properties, especially for electromobility, ultra-large castings, etc. Therefore, many teams are dedicated to searching for non-standard elements that could meet the above requirements by forming intermetallics and dispersoids.
Therefore, the work is devoted to the influence of beryllium on the AlSi5Cu2Mg alloy within the framework of crystallization processes, the influence of non-standard heat treatment on mechanical and physical properties, microstructure. It points out the possibilities of using non-standard alloys in industrial practice.

Omar Choukri, Ezzine Mohsine, Souadi Taibi
Mohammed V University , Rabat, Morocco

Industrial Recycling of Used Copper Cables and Wires: Combination of Cold and Hot Treatment for Maximum Recovery and Minimum Emissions

This study introduces an innovative and environmentally sustainable technique for recycling copper conductors coated with grease-laden insulation. The process integrates cold mechanical treatment with pyrolysis conducted in an inert atmosphere at temperatures ranging from 500 to 600 °C. This approach effectively inhibits copper oxidation while enabling the thermal decomposition of insulating materials. Processing a 100 kg batch at 540 °C resulted in a copper recovery efficiency of 99.5%, yielding oxygen-free copper bars with a high electrical conductivity of 98.2% IACS (International Annealed Copper Standard), appropriate for electrical applications. Compared to traditional incineration methods, this technique markedly diminishes the emission of hazardous pollutants. Overall, the results demonstrate the method's high efficiency and environmental compatibility, providing a viable solution for high-value copper recovery, especially for small and medium-sized enterprises.

Ümit Kutsal, Murat Çolak, Yiğit Sağnak, Serhat Bardakçı, Gizem Ammas, Güney Sarper
Bayburt University, Cevher Wheels, Turkey

Investigation of the Effect of Rotary Degassing Parameters on Melt Cleanliness in A356 Aluminum Alloy

Melt cleanliness is a critical parameter that directly influences casting quality and gains even greater importance in recycling-oriented production processes where high levels of scrap utilization are targeted. The increase in scrap content raises the risk of inclusions, oxides, and gas porosity accumulating within the molten metal; therefore, the implementation of effective refining methods is essential. In this study, the effects of rotary degassing process parameters—including rotor speed, rotation time, and gas flow rate on melt cleanliness in A356 aluminum alloy were systematically investigated. Experimental samples were prepared with 20% primary and 80% scrap content, and various combinations of degassing parameters were applied in conjunction with a commercially available cleaning flux. The experiments were evaluated using multiple characterization techniques such as the Reduced Pressure Test (RPT), bifilm analysis, K-mold fracture surface analysis, fluidity test, microstructural examinations, tensile tests, and Brinell hardness measurements. The findings revealed that increasing the rotor speed from 200 rpm to 500 rpm significantly enhanced melt cleanliness, and that gas flow rate and rotation time were also significantly associated with this improvement. As a result, optimization of the rotary degassing process parameters was shown to positively affect not only melt cleanliness but also casting quality and mechanical performance. In this context, the study provides important contributions to process control in recycling-based production of aluminum alloys.

Adrian Dąbrowski, Maria Maj
AGH University of Science and Technology, Poland

Analysis and Improvement of the Model and Casting of the Cylinder of the S-38 Engine

This publication presents a cylinder casting for the S-38 engine, designed as part of A. Dąbrowski's master's thesis, conducted under the supervision of prof. M. Maj. The cylinder was manufactured using a cast-in-place technique using gypsum mass. A detailed analysis of commercially available S-38 engine cylinders was conducted and compared with the developed part. The alloy used (Alusil) and its characteristic machining processes were also described. The gypsum masses were then characterized, distinguishing between conventional, foamed gypsum, and vacuum methods. Consequently, an exhaust system was designed to closely interface with the cylinder, and an engine simulation with this system was conducted, demonstrating that the 50 cc engine would generate 18.1 hp and 8.8 Nm.

After describing the cylinder production process, a verification casting was made, demonstrating the validity of the selected technology. Defects in the verification casting necessitated testing of the thermal decomposition of the model materials, the permeability of the gypsum masses, and the flow of the alloy under difficult conditions. Spectrometric analysis of the chemical composition of all input materials was also conducted. Furthermore, a gas furnace was constructed to allow for drying and firing of the molds under controlled conditions. To enable casting using negative pressure, a vacuum chamber with a perforated casting sleeve was also constructed. Using this equipment, tests were conducted to select the appropriate casting method using gypsum masses. The negative pressure method demonstrated the best results and was used to produce the final casting, which was correctly made, with high surface smoothness and high accuracy in model detail. After mechanical processing, the completed casting was successfully installed in the engine.

subsidy number 16.16.170.654/B507

Anna Dolata
Silesian University of Technology, Poland

Castability of the AlSi Alloy Matrix Composites with Silicon Carbide Particles

The introduction of silicon carbide particles (SiCp) into aluminum alloys (AlSi) and the formation of a composite system improves their properties, primarily by increasing dimensional stability, hardness, and wear resistance under frictional conditions. The most important issues for casting technology are the flow of the composite suspension (AlSi/SiCp) in the mold channels and the assessment of its fluidity and degree of gasification. The volume fraction of reinforcement particles and the chemical composition, refining, and modification of the matrix alloy are significant factors influencing the viscosity, and thus the flowability of the suspension. The modifying effect of Mg and Sr on the castability of a composite suspension based on an aluminum alloy (A365) containing 10 vol.% SiCp were determined. Additionally, the density index of the composite materials was determined and compared with the base alloy.

Project co-financed by the National Centre for Research and Development under the 5th Polish-Turkish Cooperation Call; total investment value: PLN 957,062.50; grant amount: PLN 841,562.50 (project no. POLTUR5/2022/39/ALU-Wheel/2023).

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Agnieszka Dulska, Natalia Przyszlak
Silesian University of Technology, Poland

Computational Analysis of Solidification in Layered Castings

The purpose of this study was to investigate the mechanisms of surface layer solidification using computer simulation methods. The research focused on how pouring temperature affects the temperature distribution within the casting mold and the joint area of the applied titanium insert, as well as the resulting structure of the alloyed surface layer formed on the cast iron casting. The analysis was carried out with the use of the MAGMASOFT simulation software. Individual model sets were parameterized according to actual casting process conditions, with boundary conditions for FEM and technological parameters—such as pouring temperature and material properties—defined in the system. The results demonstrated that the solidification of the layered casting, composed of a cast iron base and a pure titanium working insert, is most stable when the insert has the thinnest connector wall, owing to improved temperature equalization. Nevertheless, this configuration was found to be less favorable in terms of mechanical performance compared to, for example, inserts with medium connector wall thickness. The study confirmed that connector wall thickness has a direct impact on the temperature distribution across the insert's surface and in the surrounding region near its connection with the casting.

Aldona Garbacz-Klempka[1], Łukasz Kowalski[2], Jędrzej Kubiak[2]
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Bronze Casting Technology in the Context of a Hoard from Papowo Biskupie, Poland

The discovery of a wetland site in Papowo Biskupie, northern Poland was one of the most notable advancements in European archaeology of 2023. The archaeological research revealed that between 1000 and 400 BC, local groups of the Lusatian culture sacrificed humans and offered hundreds of bronze objects, including jewellery, horse gear elements and weapons, at the site. A hoard of bronze objects was also discovered in the same location during the 1870s. The assemblage includes five solid necklaces, four hollowed anklets, a large pin, and three phalerae. To date, these artefacts have not been analysed in terms of metal analysis. The objective of the research is to determine the foundry technology characteristics of the artefacts from Papowo Biskupie, in terms of the mould construction and the properties of the materials utilised. A range of analytical and imaging techniques were applied in the study. The chemical composition of the alloys was determined, and the technologies used were analysed. The interdisciplinary approach to archaeological artefacts and the application of metallurgical research are instrumental in elucidating ancient foundry technologies and the scope of prehistoric metalworking focuses.

This work was supported in part by National Science Centre, Poland (NCN) under grant agreement No. 2022/45/N/HS3/04212 and by the Ministry of Education and Science, grant number AGH 16.16.170.654/B507.

Aldona Garbacz-Klempka[1], Karolina Marlicka[1], Marcin Piękoś[1], Janusz Kozana[1], Andrzej Fijołek[1], Daniel Wałach[2], Grzegorz Kaczmarczyk[2]
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[2] AGH University of Krakow, Faculty of Civil Engineering and Resource Management

The Use of Reverse Engineering and Metal Science Analysis in the Research of Historic Foundry Processes

A unique historical casting is the subject of comprehensive metallographic and technological research conducted by a team of scientists from the AGH University of Science and Technology in Krakow. The research combines material analysis with modern diagnostic techniques to reconstruct the manufacturing process and material properties of this historical artifact.
The research included non-invasive tests, including macroscopic observations revealing complex decorations and traces of patina on the surface. Chemical composition analysis using X-ray fluorescence spectroscopy (ED-XRF) showed that the object was made of brass. Scanning electron microscopy (SEM-EDS) allowed for a detailed examination of the microstructure, revealing the characteristic alpha phase of brass and intermetallic phases containing tin and lead. Trace amounts of other elements were also identified in the material, which are technological traces of metallurgical processes. The presence of sulfur phases suggests the use of sulfide ores during smelting.
Computed tomography (μCT) was used to examine the internal structure, identifying small porosities formed during the casting process. The research was supplemented by the preparation of a model alloy with a composition similar to the original, which was analyzed for crystallization using the ATD method.
Macroscopic analyses confirmed that the object was made using the lost wax technique. The decorations were initially made in beeswax and beef fat, and then carved out of the finished casting. A review of the literature showed that the casting mold consisted of a limestone core and mortar, surrounded by a coating of clay and powdered charcoal.
Computer simulations using MAGMASOFT software recreated the pouring and solidification processes, with particular emphasis on ceramic molds heated to 800°C. A comparison of the simulation results with tomographic images showed good agreement, confirming the historical production methods.
The research provided valuable information about historical metallurgical practices, demonstrating a high level of technological advancement in casting. The analyzed object is an example of a combination of technical precision and artistic craftsmanship.
The research was carried out subvention no. 16.16.170.654/B507.

Małgorzata Grudzień-Rakoczy [1], Konrad Chrzan [1], Wacław Oleksy [1], Robert Żuczek [1], Łukasz Rakoczy [2], Rafał Cygan [3]
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Microstructural Characterization of GTAW-Deposited Clads on Preheated Ni-Based Superalloys

Nickel-based superalloys are widely used in high-temperature turbine components due to their excellent creep strength and oxidation resistance. However, their applications can be limited by welding issues, particularly the development of heat-affected zone (HAZ) liquation cracking during gas tungsten arc welding (GTAW). This study investigates the impact of preheating on the microstructural changes and susceptibility to cracking in GTAW-deposited clads on cast nickel-based superalloys. Preheating treatments were performed at high homologous temperatures, followed by autogenous bead-on-plate GTAW. The resulting microstructures were analyzed using light microscopy, scanning electron microscopy (SEM), transmission electron microscopy (TEM), and scanning transmission electron microscopy with energy-dispersive X-ray spectroscopy (STEM-EDX) techniques. The findings indicate that preheating has a significant impact on the stability and morphology of the strengthening precipitates. As the preheat temperature increases, secondary γ' precipitates progressively dissolve, reducing their volume fraction. This dissolution is accompanied by splitting phenomena and increased dislocation activity at the γ/γ' interfaces. Microstructural analysis of the HAZ revealed that at lower preheating temperatures, constitutional liquation of γ' precipitates, along with contributions from carbides and borides, led to the formation of thin liquid films along grain boundaries. These films facilitated the initiation and propagation of liquation cracks, although their extent was notably reduced compared to non-preheated conditions. Notably, preheating above 1000°C eliminated liquation cracks. This improvement is attributed to the increased volume of non-equilibrium liquid available for a self-healing mechanism, where micro-fissures were filled and arrested during cooling, as demonstrated by the γ–γ' eutectic re-solidification and the presence of liquid film migration (LFM) zones. Overall, the results demonstrate that carefully optimized preheating before GTAW deposition is an effective strategy for reducing liquation cracking in nickel-based superalloys. These microstructural insights provide a mechanistic foundation for selecting preheat parameters that balance precipitate stability, thermal stress relaxation, and crack-healing potential, ultimately enhancing the weldability and service life of nickel-based superalloy components.

Acknowledgements:

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Grzegorz Gumienny, Tomasz Szymczak
Lodz University of Technology

As-Cast Ausferritic Cast Iron

The paper presents the technology of various types of ausferritic cast iron obtained without heat treatment. Nodular or compacted graphite cast iron was obtained using Inmold technology. Ausferrite in the matrix was obtained by modifying the chemical composition of the cast iron. The crystallization process was examined using thermal and derivative analysis (TDA). The microstructure and properties of the cast iron was tested too. Wear resistance was compared with other types of cast iron, including ADI (Austempered Ductile Iron). Application possibilities were indicated.

Hao Yue, Zhengwei Yang, Bo Lin, Yan Chen, Chao Zhou, Xiaohong Ji, Rong Li
Guizhou Normal University, China

Research on the Investment Casting Process of Irregular Lining Plates for Electrolyte Cleaning Machine

In order to manufacture qualified non-standard liners for self-grinding machines, three different pouring system were designed and simulated by ProCAST. The simulation results indicate that in the dual-piece side gate ribbed pouring system, the presence of ribs allows for a smoother flow of molten metal, resulting in a uniform temperature distribution of the casting and minimizing the volumes of porosity and shrinkage defects. It can effectively reduces the degree of casting deformation. Additionally, by optimizing the pouring system through the addition of risers, the occurrences of porosity and shrinkage defects were further reduced. Based on the simulation results, a dual-piece side gate ribbed pouring scheme was selected to prepare the corresponding foam molds, and after coating and drying, qualified self-grinding machine protruding non-standard liners were obtained through investment casting. This study further demonstrates the rationality and feasibility of the investment casting process for non-standard liners.

Aleš Herman, Zdenek Kopanica, Michal Jarkovsky
Czech Technical University in Prague, Faculty of Mechanical Engineering

Research on Increasing the Proportion of Regenerate in A Self-Bonding Moulding Mixture Based on Water Glass

From the current status on the implementation of the requirements of the new BAT for foundries and forges (2024), where a higher recovery rate (above 90%) is required for moulding sands, a ban on the use of furan resin binder is required and emission reductions, relatively large changes in the production of large cast iron castings have to be implemented. This paper will focus on a study of the proportion of regenerate in the mould and cores for a moulding sands based on water glass binder and esterol hardener for both model sand and core sand. The model moulding mix is currently blended from two types of sands and 75% regenerate is currently used for mould making. However, the moulding mix for cores is 100% pure sand, with no regenerate. The aim of this study is to create a test casting for castings with flake graphite, including cores, and to evaluate experimentally for different sand ratios the effect on the surface and internal quality of the castings. From the results of this study, it appears that it is possible to achieve very similar surface quality castings even when using a proportion of 95% regenerate in the model moulding sands and 90% regenerate in the core moulding sands.

Łukasz Jamrozowicz
AGH University of Science and Technology, Poland

The Role of Air Movement over the Mold in the Drying Process of Protective Coatings

The paper presents the results of measuring moisture migration in the surface layer of a sand mold during the soaking and drying process of protective coatings. During the study, a bench was used to measure the resistance of the porous medium as a result of moisture migration. An alcoholic zirconia coating with a conventional viscosity of 20s was used in the study. The viscosity of the coating was determined using a Ford cup with a mesh clearance of 4mm. Cores for the tests were made of molding compound on phenol-formaldehyde resin. The average grain size of the sand matrix was dL = 0.25 mm. During the study, the course and kinetics of the process of moisture migration in the top layer of the core after the protective coating was applied to it were determined. The tests were conducted when there was no air movement over the surface of the core and when air flow was forced over the cores. The air movement over the mold was constant and of a certain flow rate. The tests were conducted in a climate chamber with constant air temperature and humidity.

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Evaluation of Carburization Efficiency by Measuring the Specific Resistivity of Coke and Graphite Carburizers Used in Foundry

This article will present the results of studies on the resistivity of carburizing materials used in the cast iron smelting process. The measurements will include the resistivity of granular carburizers made from synthetic graphite, petroleum coke, and pitch coke. These can include materials specifically designed for cast iron carburizing processes, as well as carburizers obtained from recycled electrodes used in various industrial processes. Increased demand for carburizers occurs in the smelting of cast iron in electric induction furnaces, when the share of pig iron in the charge is reduced or completely eliminated and replaced with steel scrap. This aligns perfectly with the sustainable development goals of managing and efficiently using natural resources, reducing waste through prevention, reduction, recycling, and reuse. The resistivity test results will be correlated with carburizing efficiency measurements obtained in laboratory and industrial settings.

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Characterization of the Microstructure and Selected Properties of C101 Nickel-Based Superalloy Manufactured by Investment Casting

Nickel-based superalloys play a critical role in the aerospace and power generation industries due to their exceptional mechanical strength, creep resistance, and thermal stability at high temperatures. Among these materials, the C101 alloy stands out, offering enhanced performance under demanding service conditions. This study presents a comprehensive characterization of the microstructure and selected properties of the C101 nickel-based superalloy, which was manufactured using vacuum investment casting (also known as lost-wax casting). Microstructural investigations were conducted with light microscopy, scanning electron microscopy, and energy-dispersive X-ray spectroscopy to assess the phase constitution, morphology, and distribution of the alloy. The as-cast alloy displayed a typical dendritic microstructure with noticeable segregation of alloying elements between the dendritic cores and the interdendritic regions. The γ matrix was reinforced by a high volume fraction of cuboidal γ′ precipitates, with secondary γ′ phases observed along the interdendritic zones. The presence of eutectic γ–γ′ colonies and carbides (predominantly of the MC type, enriched with Ta, Hf, and Ti) was confirmed, along with boride precipitates decorating the interdendritic areas. Microhardness measurements and tensile tests highlighted the significant contribution of the γ′ precipitate morphology and volume fraction to the alloy's strength, which is comparable to that of high-performance nickel-based superalloys designed for turbine blade applications. The findings demonstrate that careful control of investment casting parameters results in well-developed γ/γ′ microstructures with minimal casting defects. The strong precipitation hardening effect of γ′, in combination with the stability of MC carbides and borides, contributes to the alloy's excellent potential for high-temperature applications. Importantly, insights into solidification and microsegregation behavior guide optimizing casting practices and post-casting heat treatments to enhance alloy homogeneity and performance further. In summary, this work establishes a detailed connection between the solidification behavior, microstructural features, and mechanical response of the C101 superalloy produced by investment casting, highlighting its suitability for manufacturing advanced turbine components.

Acknowledgements:

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Application of the Moulding Sand with a Mixed Matrix in Layered Castings Technology

The paper concerns the technology of layered castings made with a system where the base part is made of grey cast iron with flake graphite, and the working part is made of high-chromium steel X46Cr13. The castings were produced using a mould cavity preparation method utilising a moulding sand with a mixed matrix, i.e. SiO2 and SiC in proportion 7:3. The idea of the research was to perform heat treatment of X46Cr13 steel directly in the casting mould, with the success of this approach guaranteed by selecting moulding sand with appropriate physicochemical parameters. During the pouring and cooling of the mould, the temperature on the outer surface of the steel insert was recorded to check if it reached the required austenitization temperature. The castings were then examined for the quality of the bond between the grey cast iron base part and the steel working part, microstructure studies were conducted using light optical and scanning microscopes, and hardness was measured on the surface of X46Cr13 steel. Based on the conducted research, it was found that the molding sand with a mixed matrix disqualifies it for use in the analyzed technology of integrating heat treatment of X46Cr13 steel with the process of producing a bimetal system with gray cast iron, because a satisfactory increase in the hardness of the working surface compared to the hardness obtained after classical heat treatment, i.e. hardening in air of X46Cr13.

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Production Technology of Spheroidal Cast Iron with Enhanced Strength and Thermal Shock Resistance Using In-Mold Nodularization

High-grade cast iron, due to its very good mechanical properties, is widely used in various industries. Currently, the production process of high-grade cast iron strengthened by alloying additives through solid solution is usually carried out outside the mold, most often in the pouring ladle.
This publication presents a method of in-mold nodularization of cast iron, implemented under operational conditions at the KAW-MET Foundry. The in-mold nodularization method, with proper selection of the chemical composition of the cast iron and pouring temperature, enabled the production of an alloy with improved strength parameters and simultaneously increased resistance to thermal loads.
The paper presents the results of microstructural and mechanical property tests of ductile iron castings with increased silicon content and alloying additions of Cu and Ni, produced using in-mold nodularization technology.

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The Influence of Manufacturing Technology (DMLS vs. Casting) on the Structure and Functional Properties of Metal Alloys

Manufacturing technologies, such as 3D printing (including DMLS), are revolutionizing the production of metal components by offering distinct possibilities for shaping material structure and properties compared to casting methods. This article compares thin-walled 316L steel elements manufactured using DMLS 3D printing and casting. Differences in microstructure, mechanical properties, and accuracy were investigated. Thin-walled samples were prepared and subjected to tensile and impact tests, metallographic analysis (optical microscopy, SEM), and phase identification (EDX). The results revealed significant differences in microstructure (porosity, homogeneity), mechanical properties (strength, ductility), and manufacturing precision, confirming the influence of the technology on the obtained properties. This article provides valuable information on the advantages and limitations of both methods for thin-walled 316L steel products, indicating optimal application areas.

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The Influence of Casting Design on Knock-Out Properties from Ceramic Moulds Made Using an Improved Technology

The article discusses the influence of casting design on the knock-out properties from ceramic molds produced using an improved technology.

It presents an innovative solution in the construction of ceramic moulds, developed to improve the knock-out process for castings with complex geometries. Due to design features such as holes, enclosed spaces, sharp edges, varying cross-sections, or corners, these castings tend to sinter or become stuck in the mould.

Traditional molds, although mechanically strong, often hinder the removal of castings, leading to damage and increased cleaning costs. The improved technology involves the use of a hybrid mould structure, incorporating special layers based on an organic binder in the central zone. These layers exhibit reduced final strength after firing. Depending on the casting design, these layers are selectively placed to improve knockout properties and facilitate the removal of residual ceramic material.

The conducted research confirmed that proper mould adaptation to the casting geometry, combined with the use of layers with controlled strength, effectively eliminates knock-out problems—particularly for castings with complex designs. This technology shows high implementation potential in industrial sectors such as aerospace, automotive, and energy, where precision and casting quality are of critical importance.

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Indirect Method of Quality Assessment for Aluminium Alloys Solidifying Under Low Pressure

This paper presents the assumptions and methodology for quality evaluation of aluminium alloys used in the production of low-pressure castings. The method is based on linking qualitative and quantitative relationships between the alloy structure and discontinuities with the acoustic characteristics of the casting. A method for making a test casting, sample size, and its geometrical features were selected. A simplified casting technique combining the characteristics of low-pressure casting with centrifugal casting was also employed. A mould for the test castings was designed and manufactured, and preliminary tests were performed. To eliminate potential errors in alloy quality assessment resulting from manufacturing accuracy, the geometric characteristics of the test castings were analysed using 3D scanning and computer simulations, including experimental validation.

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Analysis of the Impact of Selected Alloying Additives and Refining Processes on the Quality of Tin Bronze Castings

The research conducted and the results obtained and compiled concern cast tin bronzes. The elements introduced and the refining processes carried out are aimed at reducing the tin content while maintaining the properties of the CuSn10 alloy. The presented results include research experiments in the field of smelting and casting of bronzes, as well as crystallisation analysis, optical and scanning metallography, and tests of the technological and mechanical properties of selected copper-tin alloys.

The results obtained indicate the possibility of replacing CuSn10 bronze with an alloy with a significantly lower tin content, while maintaining or even improving selected casting and mechanical properties.

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Processing Aspects and Characteristics of In-Situ A356/TiC Composites

Increasing demands for material efficiency and sustainable development drive the search for lightweight and high-strength structural materials. This study evaluated the potential of in-situ synthesized A356/TiC composites for laboratory and pilot-scale castings, with additional assessment of secondary alloys obtained from remelting aluminum chips and wheels. Ti+C substrates in the form of UCP compacts were introduced into the molten alloy during casting. The produced composites exhibited satisfactory fluidity and a low porosity index. Microstructural analyses (LM, SEM) revealed the presence of iron-rich phases in the secondary alloys and a uniform distribution of TiC particles within the composites. Mechanical and tribological tests confirmed that the incorporation of TiC particles enhanced strength and wear resistance, albeit at the expense of ductility. The highest UTS values and the most favorable tribological performance were obtained for the composite based on pure A356 alloy.

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A Study on the Selected Properties of Al-Si-Cu Alloy Containing Tungsten

Progression in materials engineering is critically dependent on the development of new alloys through the controlled addition of alloying elements. Aluminum alloys, due to their advantageous properties such as low weight and good workability, are frequently utilized in the automotive and aerospace industries. Tungsten represents a particularly interesting alloying element because of its high melting point and strength at elevated temperatures, which suggests potential for property improvement. For this reason, this study investigates the effect of graded tungsten additions (0.05, 0.10, and 0.15 wt.%) on the microstructure and selected properties of Al-Si-Cu based aluminum alloys. The goal is to understand how tungsten modifies the internal structure and consequently the material's strength. Microstructural analysis using SEM and EDS is performed, along with tests to determine selected characteristics based on tungsten concentration. The results yield new insights into tungsten's potential as an alloying element. This knowledge contributes to the optimization of Al-Si-Cu alloys for demanding industrial applications and the expansion of their utilization possibilities.

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AlSiMg Alloys Microstructure Determined by Flow Effect During Slow Solidification

The presence of gravity during pouring, causes the flow of the alloy in the gating system and the mold cavity, as well as the phenomenon of natural convection at the stage of solidification of the casting. However, the developed casting technologies also use the phenomenon of forced convection, which can be generated by mechanical or electromagnetic mixers. The effect of stirring with electromagnetic coils on the microstructure of Al-Si-Mg alloys was analyzed, based on slowly solidifying small cylindrical samples. In tested Al-Si-Mg alloys, melt flow led to microstructure modification: changed amount, dimension, and location of magnesium-rich Mg2Si precipitates, secondary dendrite arm spacing SDAS, specific surface and grain size of α-Al phase and finally modified eutectic spacing for observed binary and ternary eutectics. Flow produced more and larger blocky shaped and Chinese script phases and significantly reduced amount and dimension of dispersed Mg2Si in the alloy where Mg2Si grow as first phase. By co-precipitation of α-Al and Mg2Si with a basically dendritic shape and internal form of Mg2Si, forced flow increased its SDAS, produced globular forms, whilst did not change the internal spacing. In the alloy where α-Al and Si crystals co-precipitate, stirring caused formation of characteristic eutectic-enriched regions separated from α-Al rich regions. In the alloy where Mg2Si and Si co-precipitate before eutectic growth, stirring caused distinct appearance of dendritic Mg2Si and α-Al. The observed structural modifications are new and can help in assessing of convection effect on microstructure of industrial alloys and support the design of casting processes in which mechanical or electromagnetic stirring is the main phenomena determining microstructure and mechanical properties of cast parts.

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Application of Medium-Entropy Alloys for Anticorrosive Coatings

Anticorrosive coatings are used in various industrial sectors, especially in the automotive, machinery, construction and military to protect the base material from the effects of chemically aggressive environment. In recent years, there has been a continuous increase in interest in medium- and high-entropy alloys, which results from their exceptional properties like high strength at variable temperature as well as resistance to abrasive wear and corrosion. Medium- and high-entropy alloys are classified as materials with potential use for protective coatings. The aim of the study was to develop CoFeNi, CoFeMn, CoMnNi and FeNiMn medium-entropy coatings by the electrodeposition method with increased corrosion resistance in 3.5% sodium chloride aqueous solution.

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Effect of the Secondary Aluminum Ingots on the Distribution of TiC Nanoparticles and the Mechanical and Functional Properties of In-Situ Cast A356-Based Composites

This study presents the results of research on the influence of the share of secondary aluminum ingots on the distribution of TiC nanoparticles and the mechanical and functional properties of cast composites based on the A356 alloy. The composites were produced by the in-situ method through the introduction of 10 wt.% TiC reactants into the molten alloy, with a variable proportion of secondary aluminum ingots. Microstructural analyses using LM, SEM, and XRD showed that, for the investigated variants, TiC particles and their agglomerates were mainly located in the Al-Si eutectic regions. With a lower share of secondary ingots, the particle distribution was more uniform, whereas with a higher share an increase in agglomeration and the formation of compact TiC clusters was observed. These changes significantly affected the mechanical properties: the highest relative increase in tensile strength was recorded for composites with a low content of secondary aluminum ingots. In contrast, a higher content resulted in a smaller strength increase but wear resistance. Tensile strength tests, and ball-on-disc wear testing confirmed the findings.

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Analysis of the Aluminum Improvement Process Using Powdered Additives Introduced by Barbotage

The refining of aluminum is a crucial stage in ensuring the high quality of alloys applied in the aerospace, automotive, and construction industries. One of the most effective methods of improving melt cleanliness and controlling its microstructure is barbotage refining, which combines efficient degassing with the removal of non-metallic inclusions. This study analyzed the possibilities of intensifying the process through the introduction of powder fluxes directly into the molten metal via the refining gas stream. The developed experimental setups enabled the injection of powdered additives through the rotor channel, allowing precise dosing deep into the melt. Special attention was given to the role of in situ reactions, leading to the formation of alumina particles and other compounds that may act as nucleation sites, thereby inhibiting grain coarsening during solidification. Although barbotage refining has been applied in industrial practice for many years, it remains an evolving technology with significant potential, stemming from its ability to simultaneously purify and modify molten aluminum. Leading companies in the foundry sector have developed a variety of solutions in this area. For example, Pyrotek applies equipment from the Rotary Degasser (RotoDegas™) STAR 3500 series, utilizing rotating impellers for intensive melt agitation and uniform distribution of refining gas. Foseco, in turn, offers the MTS 1500 system, which combines rotary gas refining with controlled addition of grain refiners and modifiers. STAS Inc. (Canada) has developed ADL – Aluminium Degassing and Launder Systems, enabling continuous melt treatment directly in the metal stream. Companies such as ALTEK and NOVELIS have also implemented hybrid solutions, integrating conventional barbotage degassing with automated, pulsating injection of fluxes or powdered refiners. The results of the study demonstrate that the synergistic combination of rotary gas refining with precise, fluidized powder flux injection opens up new prospects for the further development of the technology. This approach enables more effective control over the properties of molten aluminum, the production of a more homogeneous microstructure, reduction of porosity, and the manufacture of castings with enhanced quality parameters, fully meeting the stringent requirements of modern industrial applications.

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Using the Rheocasting Technology to Cast Electric Motor Gearbox Housing

Given the rapidly evolving global landscape, the automotive industry faces numerous challenges. Globalization, increasing competition and rapid technological advancements necessitate the pursuit of innovative solutions. In response to these challenges, trials utilizing Rheocasting technology were conducted. The trials involved a mass-produced cover for the electric motor gearbox, installed in models such as VW ID.3, ID.Buzz, and ID.7. During the trials, several key aspects of Rheocasting technology were examined, such as process stability and maintaining the required alloy temperature, stress measurement of the casting machine columns confirming the possibility of applying approximately 20% less clamping force for the tested component. Additionally, the reduction of metal speed in the gap from approximately 70 m/s in high-pressure casting to 15 m/s for Rheocasting indicates the elimination of cavitation issues. Despite initial positive results, further tests and analyses are necessary to fully assess the potential of Rheocasting technology.

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The Influence of Heat Treatment Parameters on the Microstructure and Hardness of High-Chromium Alloy Steel X46Cr13

This study presents the results of research on the influence of heat treatment parameters namely, temperature, holding time, and quenching medium (air, water, oil) on the microstructure and hardness of high-chromium alloy steel X46Cr13. The research included hardening heat treatment of X46Cr13 steel, hardness measurements, and mi-crostructural analysis using light microscopy and scanning electron microscopy (SEM), supported by EDS chemical composition analysis. Based on the conducted studies, it was found that increasing the austenitizing temperature and time results in higher hardness of the X46Cr13 high-chromium alloy steel, regardless of the quenching me-dium used. Due to the negligible influence of the quenching medium on the hardness of the steel under the analyzed heat treatment conditions, air hardening is recommended, as it reduces quenching-induced stresses compared to water quenching.

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Machinability of Lead-Free and Low-Lead Casting Brasses. Cutting Forces and Surface Roughness

In this article, a comparative analysis of the machinability of cast brasses with different lead contents was carried out, namely lead-free alloy CB771 (<0.1% Pb), low-lead CB771 (approx. 0.2% Pb), and leaded CB770 (approx. 0.8% Pb). The aim of the study was to assess the influence of lead content on key machining parameters, such as cutting forces and surface roughness. Milling experiments were conducted on a vertical machining centre, with the cutting force components Fx and Fy measured using a piezoelectric dynamometer. Surface quality was evaluated using a profilometer, analysing the parameters Ra, Rz, and RSm.

The results showed that as feed per tooth increased, cutting forces rose for all tested alloys, which is consistent with expectations. It was found that the brass with the highest lead content (CB770) exhibited the lowest cutting forces and the lowest surface roughness values (Ra, Rz), which translates into better machining quality. In the case of the CB771 alloy with the lowest lead content, the highest cutting forces and poorer surface roughness were observed. Moreover, during the machining of this alloy, internal defects in the form of porosity were revealed, which disrupted the measurement process.

The conclusions confirm the crucial role of lead in improving the machinability of brasses, acting as both a lubricant and a chip breaker, while also highlighting the need for further research on optimizing the chemical composition and technological parameters of lead-free alloys.

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The Effect of Sr Modification on the Microstructure and Mechanical Properties in AlSi12(Fe) HPDC Alloy

High-pressure die casting (HPDC) is a widely used method for producing Aluminum – Silicon alloys. These alloys are commonly used in automotive components. Maintaining uniform cooling of the end-cast part is crucial for preventing the formation of coarse, and acicular eutectic Si in the section. Coarse, and acicular eutectic Si can lead failure due to acting as a potential stress concentration site. Modifying the eutectic Si phase to fine, and fibrous form via Sr is widely used for improving the mechanical properties of the alloy. In this study, changes in microstructure and mechanical properties of AlSi12(Fe) HPDC alloy based on modification via different amounts of Sr were investigated. In the liquid phase, by the addition of different amounts (0, 40, and 160 ppm) of Sr, tensile test bars were injected with cold-chamber die casting injection machine. X-Ray radiography technique was used for viewing porosities and their distribution in the tensile test bar. Microstructural investigation, tensile, impact and hardness tests were performed for understanding the effect of Sr addition on the both microstructural and mechanical properties of casting. SEM imaging was performed for the intermetallic formed in the microstructure due to the increasing amount of Sr, and point, linear, and areal EDX analyses were performed on the relevant phases. As a result, it was determined that Sr modification is influenced the Si morphology and has a significant effect on tensile properties of the alloy.

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Effect of Nb Addition on the Selected Properties of AlSi5Cu2Mg Aluminum Alloy

The article focuses on investigating the effect of niobium (Nb) on selected properties of the AlSi5Cu2Mg aluminum alloy. The aim of the study is to determine the influence of Nb addition on the mechanical and physical properties of the AlSi5Cu2Mg alloy. A complete microstructural analysis of the Nb-alloyed AlSi5Cu2Mg will also be conducted. Particular attention will be paid to evaluating the potential grain-refining effect of Nb and to the characterization of thermally stable Nb-based dispersoid particles. The effect of heat treatment on selected properties and the microstructure of the aluminum alloy will also be evaluated. The main objective of the study is to develop an aluminum alloy suitable for applications in the production of large-scale castings.

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Effect of Freezing Temperature on the Volume Fraction and Hardness of Retained Austenite in Cast GX70CrMnSiNiMo2 Alloyed Tool Steel

The abrasive wear resistance of cast steel strictly depends on its hardness, microstructural constituents and homogeneity. Commonly used in heavy industry for thick-walled castings, cast GX70CrMnSiNiMo2 steel after heat treatment has a martensitic structure with a certain content of retained austenite (RA), which depends on the carbon content and the content of alloying elements. It is generally believed that, being the cause of accelerated wear of components, retained austenite is not a favourable constituent of the structure, and one of the methods to reduce its amount is heat treatment consisting in freezing. In this study, the results of research on the changes in hardness and volume fraction of RA and martensite as a function of the freezing temperature are presented. It was found that lowering the freezing temperature has only an insignificant effect on the volume fraction of RA and the measured hardness of the examined phases.

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In Situ Carbides Transformation in High Chromium Cast Iron Under Industrial Conditions

In this article, the authors describe the in situ transformation of M_7C_3 -> $M_{23}C_6$ carbides in high-chromium cast iron containing 32% chromium, obtained under industrial conditions at a Polish foundry. The paper focuses on the obtained properties of such cast iron, including hardness and wear resistance in the Miller test. Images of the cast iron's microstructure are also presented.

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Results of Commissioning an Automated Molding-Sand Processing Station at GZUT Odlewnia Sp. z o.o.

Project "Implementation of the production of significantly improved castings by enhancing molding-sand properties and automating its preparation" was co-financed by the European Funds for Silesia 2021–2027. It encompassed the design, construction, and commissioning of a modern bentonite-bonded molding-sand preparation plant, focused mainly on sand reclamation. The aim of the project was to launch the production of new castings that had previously been impossible to manufacture due to the inability to ensure molding sand with top, stable properties. The article presents the installation's design assumptions, the stages of its implementation, and preliminary outcomes, which indicate a major success for the project. High quality of the return molding sand was achieved and, most importantly, high stability of its properties. Initial results point to a significant improvement in the quality of castings produced using sand supplied from the modernized preparation plant, especially in the as-cast surface finish.

This article was co-financed by the European Union under the European Funds for Silesia 2021–2027 programme.

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Optimization of Mould Technology in CuSn10 Bronze Green Sand Castings- Influence of Insulating Sleeves, Risers and Chills on Leak-Tightness.

CuSn10 bronze castings, due to their wide solidification range, are particularly susceptible to microsegregation and shrinkage defects, which may significantly impair their leak-tightness.
The aim of this study was to evaluate the effectiveness of selected mould technology variants on the leak-tightness of castings produced in green sand moulds. Three solutions commonly applied in foundry practice were analysed: insulating sleeve, riser and chill. These solutions can contribute to the mitigation of shrinkage-related defects either by providing additional feeding of the casting or by promoting directional solidification. Each variant was examined separately, which enabled a direct comparison of their effectiveness in reducing shrinkage porosity and improving leak-tightness. The experiment included the production of a series of castings in green sand using CuSn10 alloy (EN 1982, PN-91/H87026), followed by microstructural analysis, nondestructive testing and leak-tightness evaluation.
The results revealed clear differences in the effectiveness of the analysed technological solutions. The most favourable outcomes were obtained in variants employing insulating sleeves and chills. Appropriate selection of the gating system may play a key role in improving the leak-tightness of CuSn10 bronze castings and in reducing the proportion of defective products.
The research was carried out subvention no. 16.16.170.654/B507 and the doctoral grant no. 68.10.170.07250/B148.

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The Influence of Ni on the Hardness and Impact Resistance of Manganese Cast Steel in Applications for Cast Elements of Railway Infrastructure

This paper presents the results of research obtained under the POIR.01.01.01-00-0060/21 project carried out by Huta Małapanew Sp. z o.o. as part of the National Centre for Research and Development: Szybka Ścieżka competition and co-financed by the European Union from the European Regional Development Fund. The aim of the research was to determine the effect of Ni addition on the usable properties, i.e., hardness and impact resistance of manganese cast steel for cast components of railway crossovers. The scope of the research included making test castings with a unit weight of 1.5 kg in molds from molding sand prepared using Alphaset technology on a chromite sand matrix. The technological process of the test castings included heat treatment, i.e., oversaturation in water from a temperature of 1050°C. The effect of Ni addition from approx. 0.5 to approx. 1.5 wt.% on the usable properties of manganese cast steel were assessed through impact resistance tests performed in a railway impact bending test, Brinell hardness measurements, and microstructure analysis using light optical and scanning electron microscopy. Analysis of the obtained test results allowed for the optimization of the chemical composition of manganese cast steel for cast elements of railway infrastructure

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Krakodlew S.A, Poland

Manufacturing of Cores Using SMS Technology with a Hybrid Protective Coating Supported by Forced Air Flow for Massive Large-Sized Slag Ladles

Self-hardening bulk sand (SMS) technology produces medium-sized or large cores. Furan sand cores dominate current practice. This article presents the results of research on the technology for producing hybrid coatings on cores subjected to high thermal stress, as well as the results of research on the possibility of significantly shortening the initial curing time of the sands in the core box. Hybrid coatings according to the solution (PL 435747 A1) are coatings with a mineral glass nonwoven fabric incorporated into their structure. Such coatings have been tested for their performance and effectiveness on a large industrial scale. To achieve this shortened curing time, a technique called forced air flow through the layer of furan sand cured in the core box was used. This new solution allows for a reduction in the initial curing time (until the core is removed from the core box) from several dozen minutes, sometimes over an hour, to several or a dozen minutes. The initial curing time was reduced several times. This allows for increased core box utilization and core production efficiency. The article presents examples of industrial use of the new solutions at Odlewnia Krakodlew S.A.
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Integration of 3D Scanning and Digital Twin Verification in the Casting Shot Blasting Process

Large-scale casting removal stations for molding sand residue are exposed to factors harmful to human resources. The design assumptions regarding the use of a blasting chamber and the validation of a digital twin with the unprocessed part based on visual imaging indicate a potential reduction in casting abrasive processing time by 30%.
Numerical allowances and textural verification of casting surface images will allow for the identification of areas for intensified blasting. A dedicated robotic arm will simplify the 3D scanning process, and after preparing numerical paths for the blasting head, it will support abrasive processing. After process optimization, the process chain from scan to 3D model to blasting head will be integrated, eliminating human decision-making.
The AUTOWIND project no. 1/Ł-KIT/CŁ/2023 "Automation of production processes of wind tower elements together with recycling and post-production waste management technologies" leads to the development of a prototype of a cleaning chamber for large-size castings.

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Effect of Sc Addition on the Mechanical Properties and Thermodynamic Properties

In recent years, the addition of rare earth elements to aluminum alloys has emerged as a significant research focus aimed at improving casting quality and structural integrity. Among these, scandium (Sc) stands out for its ability to refine grain structure, suppress the formation of detrimental phases, and enhance mechanical properties. Sc addition promotes controlled and homogeneous solidification of the molten metal, reducing porosity and bifilm formation, and thereby improving the overall quality of the final product. In recycling-based manufacturing, Sc also plays a key role in mitigating microstructural disadvantages caused by scrap-derived impurities. Fluidity is a critical parameter in casting alloys, particularly for the defect-free filling of molds with thin sections or complex geometries. Alloying elements directly influence molten metal characteristics such as viscosity, surface tension, and solidification behavior, thereby affecting fluidity. In this study, the effects of different Sc addition levels (0.1%, 0.2%, and 0.3%) on melt quality and fluidity behavior of A356 aluminum alloy were systematically investigated under recycling-oriented casting conditions. The alloy composition was maintained at 20% primary and 80% scrap, with a fixed iron (Fe) content of 0.2%. Melt refinement was performed using a commercial flux through rotary degassing at 7 L/min gas flow rate, 500 rpm rotor speed, and 10-minute treatment time.

Samples were characterized using multiple techniques including the Reduced Pressure Test (RPT), bifilm index analysis, K-mold fracture surface evaluation, and eight-channel fluidity tests. The results revealed that Sc addition significantly altered the alloy's fluidity characteristics, enhancing mold filling capability. Furthermore, Sc was found to reduce the impact of harmful Fe phases and contribute to the formation of more desirable microstructures. This study provides comprehensive insights into the influence of Sc on casting quality, melt cleanliness, and fluidity performance of aluminum alloys produced from recycled raw materials.