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K.01

The Foundry Processes. From Art to Science

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ABSTRACT

The manufacture of cast components is a complex process that involves a large number of variables. Additionally, to obtain a component that meets the specified requirements, it is necessary to avoid the formation of defects that may render its commissioning unusable. defects may invalidate the functionality of the component.
Generally, in the foundry world, the rejection of castings is measured in percentage. This carries the risk that an unsuitable component may be sent to the final customer. Unfortunately, due to the fact that, currently, the scrap is measured in percentage, it is needed tsee the problem in a different way and, with the aim to produce perfect components generated tools such as Smart Manufacturing, Digital twin, permanent auditors' techniques, among others.
This work shows how it is possible to reduce the internal and external scrap rate dramatically by applying Artificial Intelligence techniques, also combining the expert knowledge, data collection, prediction tools, and being managed by a digital twin. All this ecosystem will identify on the production line molds that do not fulfill the requirements, avoiding deviations and, finally, reducing drastically customer complaints.

Keywords: Artificial intelligence, smart manufacturing, digital twin, permanent auditors, perfect component

K.02

Powertrain Trends: The Outlook for Cast Iron

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ABSTRACT

Media reports often suggest that the automotive industry will be all-electric, tomorrow. Sometimes sooner. But over the past year, as sales slow in both the US and Europe, the narrative has started to evolve from euphoria to realisation. New development is rarely fast or easy. Electrification still needs to overcome challenges related to raw materials, charging infrastructure, driving range, total cost of ownership, government subsidies and consumer acceptance. The size of these challenges increases as the size of the vehicle and the demand of the duty cycle increase from cars to pick-up trucks and commercial vehicles.
The presentation will provide an overview of recent legislation in Europe and America, and how the legislation influences the development of new powetrain technologies, new fuels, and the demand for cast iron cylinder blocks and heads.

Keywords: Automotive industry, powetrain, cast iron

K.03

Time-resolved X-ray Imaging and Diffractometry of Ferrite-Austenite Transformation Following Ferrite Solidification in Steels

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ABSTRACT

Unevenness and cracks in the solidifying shell are the recognized casting defects in the peritectic steels. The formation of these defects has been discussed on the basis of the peritectic reaction/solidification, where the growth of the austenite (FCC) was controlled by carbon diffusion in the ferrite (BCC) and/or the liquid. Recently, our X-ray imaging using synchrotron radiation X-rays has demonstrated that the ferrite massively transformed in the austenite even in the steady state growth even at a rate as low as 0.05 mm/s, producing the fine austenite grains through this transformation (referred to as massive-like transformation). Understanding the solidification phenomena and the formation mechanism of casting defects in steel is of great interest because a deep understanding can contribute to the improvements in casting/solidification processing. This presentation will cover the solidification, the massive-like transformation and the austenite grain coarsening. We have performed time-resolved X-ray transmission imaging and time-resolved tomography with X-ray diffractometry. According to the observations, once the austenite nucleated at temperatures below the peritectic temperature during/after the ferrite solidification, the ferrite massively transformed into the austenite and the remaining liquid rapidly solidified in the solidification of carbon steels and Fe-Cr-Ni alloys. The austenite grains coarsened immediately after the massive-like transformation. The volumetric strains in the solidifying shell were evaluated based on the observations. The model revealed a sharp peak in the volumetric strains caused by the massive-like transformation at hypo-peritectic compositions. The results suggest that the massive-like transformation is crucial for understanding the solidifying shell deformation in peritectic steels.

Keywords: Peritectic steels, ferrite-austenite transformation, X-ray imaging

K.04

Graphite Nucleation on Silicate Phases

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ABSTRACT

The present investigation is undertaken with the objective of studying nucleation of graphite in cast irons. Graphite is found to nucleate heterogeneously on non-metallic micro-particles such as oxides, sulphides, and nitrides. After inoculation by ferrosilicon-based alloys it has been found that specific alumino-silicate phases are formed on the surface of magnesium-containing particles from the nodularising treatment. Calcium, strontium and barium silicates produced from the inoculant have crystal structure resembling the graphite. Highly coherent lattice match is found between the silicates and graphite providing favourable conditions for nucleation at small undercoolings.
Due to the very small nature of these silicate phases, it has proven difficult to detect their presence in conventional cast irons even by advanced high resolution electron microscopy. In the present investigation, attempts have been made to produce synthetic specimen of the favourable silicate substrates. Such substrates subsequently have been exposed to solidifying cast iron to facilitate nucleation and growth of graphite on their surfaces. Finally, scanning and transmission electron microscopy investigations of graphite-silicate interfaces have been made to reveal their crystalline characteristics.

Keywords: Inoculation, graphite nucleation, micro-particles, silicates

K.05

The Fracture of Metal Castings

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ABSTRACT

Nearly all our engineering metals are filled with cracks by our turbulent casting processes. This gives rise to the various fracture modes, including simple tensile fracture, fatigue, creep, stress corrosion cracking, and hydrogen embrittlement. All are caused by turbulent casting. Some, particularly the vacuum arc remelting process appears to cause cracks so serious as to bring down aircraft, especially helicopters. The helicopter failure modes from etch pits in drive trains is a common VAR failure causing tragedies. New technology to reduce turbulence will be outlined, and results illustrating the improvement to Ni alloys and steels will be presented.

Keywords: Fracture modes, turbulence, Ni alloys, steels

L.01

The Foundry Processes. From Art to Science Slightly Irregular Spheroidal Graphite (Type-V, ISO) - Typical Graphite Morphology for High-Si Ductile Cast Irons

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ABSTRACT

Recent experiments pointed out that the deviation, using a sphere as reference for graphite particles was noticeably increased by Si-alloying, at a larger real perimeter, resulting in a large category [IV, V, VI forms, ISO 945]. Several influencing factors were experimented on the graphite characteristics, such as the alloying grade, solidification cooling rate (metal mould-MM vs. sand mould-SM; solidification on the metallic chill) and inoculation/inoculating elements.
In a 4.5%Si iron, the graphite shape factor RSF (involving area and maximum size) had higher values in the MM (0.68-0.7 vs. 0.59-0.64), with the graphite real perimeter at 41-43% lower and a higher nodularity (NG) (75.5% vs. 67.4%). The solidification on the metallic chill affects RSF and NG more for 5.25%Si vs. 4.55%Si iron, with the maximum influence for 4.8%Si-2.3%Mo iron and by the imposed RSF=min.0.8 (especially for 5.25%Si). Inoculation has a specific position, to avoid free carbides at higher cooling rate (MM, metallic chill or less than 3mm wall thickness in SM), by improving the graphite morphology and nodularity, and by reducing the casting skin thickness. Ca,Ba-FeSi appears to be better than simple Ca-FeSi, while Ca,RE-FeSi led to higher graphite real perimeter and with lower shape factors.
Type V-ISO, slightly irregular spheroidal graphite morphology usually characterises High-SI Ductile Iron, typical for RSF=0.6-0.8 range. The shape factor involving the graphite real perimeter (instead of its maximum size, stipulated in ISO 945-4-2019) appears to be better in nodularity calculus.

Keywords: Ductile cast iron; Si and Si-Mo alloying; nodular graphite; metal mould; sand mould; metallic chill; ferrite; carbides; graphite size; graphite shape factors; graphite nodularity

L.02

Cast Structures and Their Susceptibility to Failure

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ABSTRACT

Finding the root cause of failure in industrial components can be sometimes more akin to the art of forensic metallurgy than technology, given that the root cause can be rather hidden in the processing history of the material. As it happens, the process of casting and the solidification laws are a large contributor to these causes. This paper brings forward a few examples of cast structures that, directly or indirectly, became root causes of failure. These examples belong to four large classes of failures: a) due to material defects; b) wrong design/ components used inappropriately; c) environmental failure; d) root cause of secondary failures. Several materials were investigated, such as iron alloys, aluminum alloys, copper alloys and brazing alloys. Failure mechanisms encountered in these failures were fatigue, overload, corrosion, dealloying, liquid metal embrittlement, and wear. Characterization methods included microscopy (optical and electron microscopy), analytical methods (energy dispersive spectroscopy and X-Ray fluorescence), and non-destructive techniques (X-ray imaging and ultrasound).

Keywords: Casting defects, failure analysis, microscopy, Widmanstätten graphite, cold drop, cold shut, dendritic orientation, fatigue, corrosion, dealloying, liquid metal embrittlement, wear

L.06

Microstructure and Wear Behavior of the Ti-alloyed Gray Irons

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ABSTRACT

Gray iron has been the conventional material for automotive brake discs due to its thermal conductivity and production cost. Achieving optimal wear resistance is crucial for ensuring performance and durability in this application. This investigation focused on the effect of titanium on the microstructure and wear characteristics of gray iron. Various amounts of titanium ranging from 0 to 0.349 wt% were introduced into hypereutectic gray irons. It was found that the addition of 0.132 wt% titanium resulted in the lowest specific wear rate recorded at 3.16 x 10^{-5} mm^3/Nm. This improvement in wear resistance can be attributed to a combination of matrix structure and a reduction in the friction coefficient. Additionally, titanium significantly increased the tensile strength by refining graphite and reducing primary graphite formation. However, exceeding the optimal level of titanium did not yield further improvements in both tensile strength or wear properties. Cooling curve analysis revealed that titanium has an effect of lowering the eutectic composition of Fe-Graphite system.

Keywords: Microstructure, wear rate, wear resistance, titanium, gray irons, cooling curve analysis

L.07

Multiscale Simulation of Directed Energy Deposition (DED) for Duplex Stainless Steel

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ABSTRACT

Ferritic/austenitic duplex stainless steel (DSS) contains a substantially equal ratio (50/50) of ferritic phases (α) and austenite. DSS generally provides high resistance to corrosion and has excellent mechanical properties. However, the precipitation of secondary phases, especially sigma (σ) phase, during heating or cooling might cause the deterioration of mechanical property and corrosion resistance. Direct energy deposition (DED) is a 3D printing technique that is particularly effective for repairing or adding material to existing components. It involves melting a feedstock material, typically metal powder or wire, using a focused energy source like a laser or electron beam, which is deposited layer by layer. This process implies a complex temperature history and successive heat and cooling at high temperature. The power source shape, power and path will affect the final properties.
The present work aims at establishing a framework to study this problem by combining a process modelling tool (Abaqus), a Thermodynamic software (ThermoCalc), and a precipitation model based on JMAK approach. We will present the methodology to couple these software as well as the calibration procedure for the precipitation model. Then, the effect of the main process parameters is simulated and correlated to the final microstructure.

Keywords: Additive manufacturing, Direct Energy Deposition, duplex steel, microstructure, precipitation

L.08

Modelling of Ferro-Silicon-Magnesium Dissolution in Iron Melt

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ABSTRACT

Ductile cast iron, also known as nodular cast iron, is a type of graphite-rich cast iron with high impact and fatigue resistance, due to its nodular graphite inclusions. Ductile cast iron is produced by incorporating additives (mainly FeSi alloys) to the iron base metal at different production steps to obtain the desired graphite shape. A crucial step is the addition of Magnesium to promote the spheroidization of graphite. The most common method is by adding Ferro-Silicon-Magnesium (FSM). The alloy composition, particle sizes, and packing are affecting the key parameters of this reaction, namely, reactivity, recovery, and slag formation.
The present work aims at understanding and modelling the dissolution of the major phases during the melt treatment. This study will consider only an isolated FSM particle containing multiple phases. Two approaches have been used: phase field modelling using MICRESS coupled with Thermo-Calc solver and multi-physics modelling using COMSOL. The models aim at covering the diffusion of chemical elements and phase changes during dissolution and melting of the FSM in the iron melt. The simulation results provide estimates for temperature and concentration gradients, an indication of the sequence of dissolution, and highlight the instability related to Mg release.

Keywords: Cast iron, FSM, dissolution, melt treatment, phase field, microstructure

L.10

Thermal Analysis – Yesterday and Today

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ABSTRACT

Thermal Analysis (TA) is only a short seven years away of the respectable age of 100, as its first bibliographic mention by Esser and Lautenbusch dates from 1931. In the late-1960s, TA began to be used in iron foundries for the rapid estimation of carbon equivalent and phosphorus content, making it possible the on-time monitoring of transformations during cooling of alloys. Today, it is widely used for process control in the manufacturing of all types of cast irons and other alloys, as it is the only tool that provides on-time information on graphite nucleation and growth, thus saving significant costs with process waste. Its use in solidification simulation permits a more accurate description of solidification patterns, casting soundness, and even an estimation of mechanical properties. After a short review of the current techniques and mathematical interpretation, this work will present some examples of more recent practical foundry applications.

Keywords: Cast iron, solidification, thermal analysis, mechanical properties

L.11

Effect of Centrifugal Casting Parameters on Microstructure of Stainless-Steel Tube

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ABSTRACT

Laboratory prototype of the machine for vertical centrifugal casting in vacuum was developed in cooperation with FRIPOL d.o.o. company from Ljubešćica, Croatia. Vertical centrifugal casting process is used for producing pipes, tubes or a shapes connected to a pipe. This casting process is very complex and requires a lot of knowledge and skills. Casting of stainless-steel EN 1.4301 tube with an outer diameter of 84 mm, a height of 42 mm and thickness of 7 mm was simulated using ProCAST software. Subsequent, effect of process parameters on microstructure was determined on experimental casted tubes. After visual control a metallographic analysis was made and the hardness of the casting was tested. Chemical composition was also determined. Simulation results showed shrinkage porosity on inner side of the casting, at the place of last solidification, which was also confirmed with experimental results. This can be reduced by choosing correct casting parameters but can't be avoided. Coated graphite crucible and hybrid graphite/SiC crucible caused carburization of the molten metal during melting and an increased appearance of carbides in the microstructure, which could lower the corrosion resistance of the casting. Carburisation didn't occur with the use of ceramic Al_2O_3 crucible.

Keywords: Centrifugal casting, stainless steel, microstructure

L.12

Characterization of Cast Co-Cr-Mo Alloys for Medical Devices

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ABSTRACT

Co-Cr-based alloys are a type of superalloys that are composed of a cobalt matrix, which is strengthened by a high chromium concentration. Chromium (Cr) provides two important properties: hardness, achieved by the generation of carbides, and corrosion resistance, achieved by the growth of a spontaneous Cr_2O_3 passive oxide layer. In some applications, a third significant component, such as Mo, is included. CoCrMo alloys find extensive use in aerospace, gas turbines, and dental and orthopedic implants according to their exceptional properties such as high hardness, strength, wear resistance, and corrosion resistance. The characteristics of these alloys are determined by its chemical composition, as well as the methods used in its production and heat treatment.
The primary objective of this work was to analyze the microstructure, corrosion behavior and microhardness of two cast heat treated Co-Cr-Mo alloys. The purpose was to provide medical professionals with valuable information to anticipate the behavior of these alloys in the human body. In order to achieve this objective, a series of metallography tests, scanning electron microscopy tests, X-ray diffraction tests, corrosion tests and microhardness tests were conducted.
It was determined that the cast alloys experience spontaneous passivation as a result of the formation of a passive layer on their surface. The passive potential range has a significant magnitude, and the alloys demonstrated excellent resistance to pitting corrosion. The thickness of the passive layer is directly proportional to the potential and exhibits a capacitive response throughout a broad frequency spectrum. The manuscript elements have been formatted for you through the “styles” capability of the software. To use the styles, select the text you wish to apply a style to, then, using the mouse, point to the style box on the toolbar. Click once on the downward pointing arrow to the right and select the appropriate style.

Keywords: CoCrMo cast alloys, microhardness, corrosion rate, EIS, SEM

L.13

Effect of Niobium Content and the Inoculation on the Microstructure and the Thermal Analysis of a Hipoeutectic Cast Iron

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ABSTRACT

The effect of niobium and the inoculation on graphite flakes' type and size distribution and eutectic cell count was examined. The impact of these variables on the solidification characteristic temperatures was also assessed.
Thirty-two kg of base metal was first elaborated with concentrations of main elements within the compositional range of a hypoeutectic iron. Subsequently, small batches of material, 1.6 kilograms per melt, were remelted, in which the Nb concentration was modified to 0, 0.2, and 0.4%Nb. The temperatures reached during refusion were higher than 1500 ºC, searching for damage to the graphite morphology. From the material thus prepared, thermal analysis cups inoculated with 0.1% Superseed or without this inoculant were poured. Then, metallographic observations were performed on these cups.
It was observed that remelting of the metal at such high temperatures affected the quality of the graphite lamelles. The best type A graphite flakes were observed in the base metal, a cast material without any inoculant addition. In the non-inoculated remelted cast iron, the increase of Nb contents favors the formation of type A graphite. Additionally, the proportion of type A graphite is further increased with the inoculation. This effect of the inoculation is more critical in the case of metal without any Nb addition than in metal with 0.4%Nb. On the non-inoculated samples, the minimal temperature of the eutectic plateau, TEmin, diminishes as Nb content increases; that effect could promote the undesirable formation of carbides. Inoculation allows for the decrease of this effect of Nb addition, but TEmin is still lower on the cast irons tested with Nb than with cast iron without this element.

Keywords: Graphite flakes morphology, inoculation, Nb addition, thermal analysis

L.14

Assessment of Section Sensitivity of 4.2%wt. Si Ductile Iron Based on Tensile Flow Behavior Analysis

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ABSTRACT

Defects and metallurgical discontinuities affect significantly the magnitude and the variability of mechanical properties of materials, which can be very significant in castings because of sensitivity to chemical composition and section thickness. Conventional testing techniques such as ultrasounds, fractography or metallography cannot always quantify defects in materials, and only more elaborate techniques like computer micro tomography can, even if these techniques are too expensive to be used as standard quality control procedures. Indeed, it would be desirable if the indicators of materials quality could be obtained from the tensile mechanical properties, which has been attempted in the past with uncertain success. Indeed strain hardening analysis of tensile flow curves could give additional information of the materials defectiveness, with the possible production of material quality indexes. A new procedure to assess the DIs casting integrity has been proposed based on the tensile strain hardening analysis, through modeling the experimental tensile flow curves with the constitutive equation of Voce. The goodness of this approach is based on the unexpected regular strain hardening behavior of defective materials that has been called as Defects-Driven Plasticity (DDP), which gave rise to the definition of a new Material Quality Index (MQI). The tensile flow behavior and the microstructure analysis on 4.2%wt. Si ductile irons produced in different Y-blocks are reported to support the rationalization of DDP, and the use of the new MQI.

Keywords: Tensile Strain Hardening; Defects-Driven Plasticity; Material Quality Index.

L.16

Structural Refinement of Austempered Ductile Iron (ADI)

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ABSTRACT

Since the first industrial application of ADI was announced in the last decade of the 20th century, there has been some sort of explosion of R&D projects that nominated this material to replace steel castings and forgings.
This report reviews some processing techniques adopted at CMRDI to refine the microstructure of ADI in trials to further enhance its strength as well as tribological properties.
Structural refinement of ADI was achieved through ausforming introduced in the austempering cycle just after quench but before any substantial transformation of austenite, which resulted in dramatic increases of 70% and 50% in yield and ultimate tensile strength respectively. Similar effect was noticed when ADI was subjected to cold rolling as a result of the formation of deformation bands and twins as well as deformation induced martensite formation. Thin-wall ductile iron castings with increased undercooling were found to have increased graphite nodule count and considerable refinement of austenite dendrites. Increased graphite / austenite area enhances austempering transformation kinetics and promotes austemperability.
Recently, ultrasonic treatment of solidifying ductile iron melts resulted in the formation of a new grade of ultrafine ductile iron with more than 2000 nodules /mm^2. Dilatometric studies showed that the time required for complete austempering of this material was just 25% of that required for statistically solidified iron. SEM micrographs showed an extremely fine and short ausferrite structure. Furthermore, a dual phase intercritically austempered ductile iron (IADI), where austenite + ferrite + graphite coexist showed that introducing free ferrite in the matrix provides additional refinement of ausferrite. Thermomechanical treatment in different phases of austempering was effective in refining ADI microstructure.

Keywords: Austempered ductile iron, ultrasonic treatment, thermomechanical treatment.

L.17

The use of thermal analysis for generation of fraction solid evolution in Al-Si alloys

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ABSTRACT

Solidification shrinkage induced defects, generally referred to as shrinkage cavities and shrinkage porosities, have negative consequences ranging from high rework costs to casting rejection that produce significant negative economic impact. Recently developed simulation tools used to predict porosity distribution in casting alloys rely on the calculation of fraction solid during solidification, which is highly dependent on the local solidification rate. Predicting such rates with standard solidification software is insufficient as most software are unable to include in the calculation the real solidification kinetics that is highly dependent on the nucleation and growth of phases. The solution is to use fraction solid based on the experimental local solidification conditions. The goal of this work is to develop a TA method/equipment that can record and generate in-time evolution of fraction solid for local casting conditions in any casting shape or size. To this goal results obtained on a designed experiments are analyzed and compared through Newtonian and Fourier calculations.

Keywords: Aluminum alloy, microshrinkage, microporosity, thermal analysis, cooling curves

L.18

Effect of Solidification Time and Carbon Content on Microstructure, Thermal Conductivity and UTS of Lamellar Graphite Iron

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ABSTRACT

Lamellar graphite iron (LGI) is used in the automotive industry as well as in a variety of other industries for geometrically complex components with demands on good balance between mechanical and thermal properties. Carbon content and cooling conditions influence the fraction and coarseness of the primary and eutectic microstructure that defines the mechanical and thermal properties. A wide range of carbon contents and cooling rates utilised in this work to produce LGI with ultimate tensile strength (UTS) and thermal conductivity (λ) that range from 200 to 350 MPa and 31 to 63 $Wm^{-1}k^{-1}$ respectively. The microstructure was extensively studied, and the results shows that UTS and λ are highly correlated with many different microstructural features. There is a strong correlation between the length scale of the primary austenite phase, as it is expressed by the interfacial area factor, and the eutectic cells count, regardless of the carbon equivalent and solidification time. This dependency indicates that the morphology of the dendrite structure effect the eutectic cells count, most probably due to the increased number of carbon rich regions available for graphite nucleation. Finally, the unique partial effect of carbon equivalent and solidification time on the UTS and λ have been estimated.

Keywords: Gray iron, tensile strength, thermal conductivity, microstructure, component castings

L.19

Preventing Graphite Degeneration with Fluorine-Free Feeders

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ABSTRACT

Increasingly, in modern foundries, the application of precise feeders helps designers to prevent porosity in nodular graphite iron castings, ensuring the structural integrity and mechanical performance required by the client. However, at the same time the metallurgical aspect can be affected by the use of these feeders. Indeed, the presence of abnormal or even degenerated graphite is often found in the surrounding area of sleeves and mini-risers, leading to a loss of the mechanical properties to the point of scraping the casting. The aim of this study was to evaluate the effect of exothermic sleeves, both in terms of graphite morphology in the casting skin, and of the presence of fish-eye defect. The investigation was carried out by comparing different types of feeders, such as insert sleeves and mini-risers. Especially, the graphitic structure was analyzed in the presence of innovative fluorine-free exothermic material and compared with classical exothermic materials available on the market.
For the implementation of the project, a model plate was designed with cubes featuring different thermal moduli calculated by using NovaFlow&Solid simulation software: 1.6cm, 1.9cm and 2.3cm. The experimental test was carried out in a real foundry by casting standard ductile iron grade EN-GJS-500-7. The entire melting process was monitored by using ATAS MetStar 10.1 adaptive metallurgical process control system based on thermal analysis. It was found that fluorine-free exothermic feeders can guarantee the fully integrity of casting skin as well as complete nodularity below the feeder neck and immediately close to its fracture surface.

Keywords: Feeders, degenerated graphite, fish-eye defect, exothermic sleeves, fluorine-free

L.20

Effect of the Ni Content on Structure and Magnetic Properties of Austenitic Ductile Iron Castings

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ABSTRACT

In the present study, the influence of nickel content on phase structure, chemical order and magnetic properties in high-nickel castings has been investigated. Ductile austenitic cast irons are a series of cast irons that include nickel from 18 to 36 percent of weight. Its addition in an amount higher the 18 wt. % allows obtaining austenitic metallic matrix in castings. As a consequence, the material has relatively good mechanical properties with elongation even exceeding 40% and can operate in a wide temperature range from –200 up to 850 °C. High-nickel cast iron is commonly used e.g. for pumps and turbocharger parts. In the present study, austenitic ductile iron with the addition of 21, 25, 28 and 35 wt.% of nickel with and without the addition of chromium at the level of 2.5 wt.% was investigated. Materials characterization was carried out by means of optical and scanning electron microscopy including EBSD technique, XRD (synchrotron radiation), mechanical and magnetic properties. The role of nickel and chromium content in the process of shaping the primary structure (austenitic dendrites) including lattice parameters, chemical ordering and graphite nodules was described. The investigation of magnetic properties revealed that nickel content strongly influences the magnetic characteristic of analyzed ductile cast iron. Finally, it was proved that by changing the combination of nickel and chromium content, the mechanical and physical properties of high nickel austenitic cast iron can be tailored.

Keywords: Austenitic ductile iron, magnetic properties, structure, EBSD

L.21

Austempered Ductile Iron Castings Reinforced with TiC Particles Obtained by SHSB Reaction

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ABSTRACT

The aim of the presented research was to produce a new cast composite material based on the widely known and used ADI (Austempered Ductile Iron). The transformation of classic ADI cast iron into a composite material was based on SHSB (Self-Propagating High-Temperature Synthesis in Bath) reaction. This was a "solid Ti" – "solid C", which ensures that TiC particles are obtained in the microstructure of the alloy. The titanium carbides are thermodynamically stable as a result of their covalent bonding nature, so they do not undergo transformation during the heat treatment process. In the present work castings with different wall thicknesses ranging from thin-walled, i.e. 3 mm, up to 25 mm were attained. The study showed that it is possible to produce a ductile iron using the SHSB reaction with a titanium content of 2% mass, in which titanium carbides of up to 5µm in size are evenly distributed in metallic matrix. Heat treatment was carried out to attain upper and lower ausferrite, reinforced with titanium carbides. The characterization of an attractive engineering material in terms of mechanical and performance properties was carried out using XRD (synchrotron radiation), light microscopy, scanning microscopy and mechanical properties. Finally it was shown that ADI strengthened with TiC using SHSB synthesis makes it possible to obtain an attractive material that can be used in the areas such as defense, railroad or automotive.

Keywords: ADI cast iron, heat treatment, "in situ" composites, MMCs composites, SHSB reaction, titanium carbides

L.22

Laboratory Production and Characterisation of Composed Foam Casts Made of Biodegradable Zn Alloy and NaCl Salt

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ABSTRACT

As part of our research into biodegradable materials, we have produced complex composed casting foams from a zinc alloy alloyed with 1.5 wt.% Mg, whereby the complex internal macrostructure was created by a salt core.
The solid salt used was NaCl, a precise granular composition with a high degree of uniformity. For the casting we used the following casting techniques: Vacuum process to fill the casting cavity, complex gravity casting with 3D centrifugal casting on a vibrating table. In the first phase, each salt granulate was sintered in a previously prepared quartz tube (cell), then the casting cavity was instrumented with a thermocouple.
The melt was prepared in an electric resistance furnace, then the quartz tube (cell) was heated to the desired temperature at which the casting was carried out. In this way, we were able to produce the composite casting foams studied. The last technique used was virtually optimised by numerical simulations of the casting process. The finite element method (FEM) was used to calculate the filling and solidification process.
The complete characterisation of the metallic foam structures was carried out at macro and micro level using computed tomography (CT), optical and electron microscopy with energy dispersion spectrometer (SEM, EDS), chemical analyses and simultaneous thermal analyses (STA).
One possible application in medicine is in connection with the production of complex structures with a large specific surface area. After incorporation and the corrosion process in the body, useful reaction products are formed for the cells. It is suitable for use in traumatological connections of broken bones. In connection with similar systems, it is assumed that the above findings would be useful to shorten the recovery time after surgery and that no additional surgical intervention would be required in the event of the removal of connecting elements.

Keywords: Foam casting, ZnMg alloy, NaCl core, casting, biodegradability, characterization

L.23

Comparative Study of the Metallurgical Quality, Microstructure and Mechanical Properties of Primary and Secondary AlSi7Mg(Fe) Aluminium Alloys

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ABSTRACT

The use of secondary aluminium is increasingly being promoted in the automotive industry for environmental reasons.
The purpose of this work is to demonstrate that it is possible to obtain a recycled AlSi7Mg(Fe) aluminium alloy with as good metallurgical quality as that of a primary AlSi7Mg alloy when an adequate melt treatment is applied.
The melt treatment applied consisted of deoxidation, degassing and skimming in accordance with the detailed procedure described in this article. The metallurgical qualities of one primary and three secondary alloys have been assessed by thermal analysis, density index test, macro inclusion test before and after melt treatment.
The thermal analysis allows to compare the variables of the solidification cooling curve (Al primary temperature and its undercooling; Al-Si eutectic temperature and its predictive modification rate); Density Index test is used to evaluate the hydrogen gas content in the melt; Macro inclusions test is used for melt cleanliness evaluation.
Finally, the metallurgical analysis and mechanical properties of the different samples were made to show the feasibility of manufacturing aluminium components by using 100% secondary aluminium alloy returns through the gravity die casting technology.

Keywords: Secondary alloys, thermal analysis, density index

L.24

Preliminary Study of High Alloyed Cast Irons with High Entropy Design Concept

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ABSTRACT

Many grades of high alloyed cast irons with carbidic structure have been developed and used over the past decades for various applications, especially where wear or corrosion-wear resistance is needed. The general types of abrasion resistant cast irons are covered by major materials standards such as ASTM A532. In recent years, the concept of high-entropy alloy was proposed and explored in many alloy systems. However, the original definition of high-entropy alloy challenges the conventional principles typically used in alloy development. As a result, high-entropy alloy research done in carbidic cast iron system is rather limited.
The present experimental study examines an Fe-C-Cr-V-Mo-Mn-Si cast alloy system in which at least five of the elected seven elements meet the 5% (atomic) concentration requirement, and the ones not meeting are still at five percentage or higher concentration level by weight. Induction melting and sand casting processes were used to produce relatively large samples. In addition to microstructure analysis, hardness and abrasion resistance were also evaluated using hardness testers and the ASTM G65 testing method, respectively. Test results showed rather high hardness and abrasion resistance even in as-cast condition, as compared some conventional white cast iron grades, perhaps, indicating a complex mechanism of carbide formation and high-entropy solution and lattice distortion effect.

Keywords: High entropy alloy, carbidic structure, cast, iron, abrasion resistance