Book of Abstracts of 17th International Foundrymen Conference: Hi-tech casting solution and knowledge based engineering

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BOOK OF ABSTRACTS

17th INTERNATIONAL FOUNDRYMEN CONFERENCE

Hi-tech casting solution and knowledge based engineering

PROCEEDINGS BOOK

with papers *in extenso* included on CD-ROM

Opatija, May 16th – 18th, 2018

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PROCEEDINGS BOOK
17th INTERNATIONAL FOUNDRYMEN CONFERENCE
Hi-tech casting solution and knowledge based engineering

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PREFACE

Foundry industry as a base branch represents an important factor contributing to the economic potential of each country. Current market development as well as technical and economic objective, the production of high-quality, low-cost and environmentally friendly casting, requires application of recent and advanced materials, as well as production technologies, followed and supported by understanding of production process.

Production imperative is pointed into the recent technologies and improved materials for everyday usage in our homes, workplaces, as well as materials with special requirements for specific applications such as those for the automotive or space industry. Industrial activities, which are defined as strategic activities in the Republic of Croatia are Metal Casting and Production of Final Metal Products, recognized as "economic growth drivers" because they are expected to realize higher rates of growth and employment.

What does knowledge based engineering actually means? The following abstract indicate the definition:

"The handling of knowledge represents the key to competitiveness, with company-specific product and process knowledge marking a unique position with respect to competition. Knowledge-based engineering (KBE) is a comprehensive application of artificial intelligence in engineering. It facilitates new product development by automating repetitive design tasks through acquisition, capture, transform, retention, share, and (re-)use of product and process knowledge. The idea behind KBE is to store engineering knowledge once by suitable, user friendly means and use it whenever necessary in a formal, well documented, repeatable and traceable process. It works like design automation. This chapter begins with the definition of knowledge in an engineering context and subsequently addresses the state-of-the-art in KBE research. Three particular areas of research are discussed in detail: knowledge structuring, maintainability of knowledge and KBE applications, and the technological progress and weaknesses of commercial KBE applications like KBE templates. From case study examples, various recent developments in KBE research, development and industrial exploitation are highlighted. By the resulting sequence optimization of the design process a significant time saving can be achieved. However, there are still notable drawbacks such as the complexity of KBE implementation and the adaptability of developed applications that need to be researched and solved. A view on KBE systems within the Concurrent Engineering context is synthesized, leading to the identification of future directions for research."
[J. Stjepandić, W. J. C. Verhagen, H. Liese, P. Bermell-Garcia, Knowledge-Based Engineering, in Concurrent Engineering in the 21st Century Foundations, Developments and Challenges; J. Stjepandić, N. Wognum, W. J. C. Verhagen (Editors) Springer International Publishing Switzerland, 2015, DOI 10.1007/978-3-319-13776-6, Chapter 10, pp. 255 – 286]

Hi-Tech casting solution comprehends to recent technology and educated and skilled engineers. The Conference topics were designed as presentations of the current "state of the art" research in collaboration with industry, and production innovation with the aim to improve the competitiveness.

The scope of ***17th International Foundrymen Conference (IFC)*** covers scientific, technological and practical aspects concerning research, development and application of casting technology with the common perspective – increase of competitiveness. Special attention will be focused towards the competitiveness ability of foundries, improvement of materials features and casting technologies, environmental protection as well as subjects connected to the application of castings.

During this Conference 44 papers will be presented. Book of Abstracts of the 17th International Foundrymen Conference includes summaries of the papers. The Proceedings book consists of papers *in extenso* published in electronic format (CD). Full length papers have undergone the international review procedure, done by eminent experts from corresponding fields, but have not undergone linguistic proof reading. Sequence of papers in Proceedings book has been done by category of papers in following order: plenary lectures, invited lectures, oral and poster presentation, and inside the category alphabetically by the first author's surname.

Within the Conference Student section is organized. This is an opportunity for industry to meet and recruit human resources as a main potential for business development. Correlation of material knowledge based engineering and technology improvement known as Hi-Tech solutions, represent a knowledge transfer between industry and higher education institutions. Higher education at the Faculty of Metallurgy (HEI), conceived through the program and the learning outcomes, is based, inter alia, on promoting students' scientific and research work on applied topics, enabling ambitious and creative young people to become independent problem solvers, developing and supporting their curiosity, analytics and communication: Graduates like the labour market need!

This occasion represents the opportunity to discuss and increase the mutual collaboration between HEIs' and industry with the aim of information exchange related to advanced experience in foundry processes and technologies, gaining the new experience in presentation and / or teaching process within lifelong learning process.

The organizers of the Conference would like to thank all participants, reviewers, sponsors, auspices, media coverage and all those who have contributed to this Conference in any way.

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Assoc.Prof. Zdenka Zovko Brodarac, PhD

THE HEAD OF ORIENTAL GOD (ATIS?)
bronza
2nd century AD
SISCIA (modern Sisak, Croatia)

ILLYRIAN HELMET
iron
6th century BC

UNDER THE HIGH AUSPICES

President of Croatia
Kolinda Grabar – Kitarović

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FUNDAMENTAL QUALITY ISSUES IN CASTINGS

John Campbell*

University of Birmingham, Department of Metallurgy and Materials, Birmingham, United Kingdom

Plenary lecture
Subject review

Abstract

Traditionally some of the main quality problems in castings were described as porosity (gas and shrinkage types), hot tears, cracks and poor and variable mechanical properties. All these defects occur because of the presence of more fundamental entities: *entrainment defects* in the form of bifilms and bubbles. During the surface turbulence associated with stirring and pouring of liquid metals, the oxide surface is *entrained* into the bulk liquid. The entrainment mechanism involving the impingement of drops or splashes is one which guarantees that the top dry oxide surface on one liquid mass impinges on a similar top dry oxide surface of another liquid mass, with the result that a non-bonded interface consisting of a double oxide film (a 'bifilm') is formed between them. Bifilms act as cracks in the liquid. Turbulent pouring fills the liquid with bifilm cracks and air bubbles. Air bubbles are very damaging to the liquid as a result of the long oxide trails which they leave behind. However, bubbles can at least be easily seen. Bifilms are often so thin (although relatively large area) that they are often invisible, being only nanometers thick. The bifilms degrade properties, but can also be expanded by diffusion of gas to form gas porosity, or expanded by strain to form shrinkage porosity. They are the universal initiators of tears and cracks. Interestingly, there is evidence that the bifilm is the most important, and possibly the only, crack-initiating mechanism in metals. Novel casting techniques to eliminate entrainment defects have been proven to deliver essentially defect-free, consistent and reliable castings. A revolution in metallurgy and engineering now seems within the control of the foundry industry.

Keywords: *bifilm, casting, entrainment, defect, properties*

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TOWARDS STRUCTURAL AND DIMENSIONAL STABILITY OF SELECTED AlZn-BASED CAST ALLOYS

Witold Kazimierz Krajewski[1]*, Alan Lindsay Greer[2], Paweł Krzysztof Krajewski[1]

[1] AGH University of Science and Technology Faculty of Foundry Engineering, Krakow, Poland
[2] University of Cambridge, Department of Materials Science & Metallurgy, Cambridge, United Kingdom

Plenary lecture
Original scientific paper

Abstract

The present paper is devoted to modification of the AlZn based cast alloys aimed at improving their mechanical properties and structural stability. The examined alloys belong to high aluminium-zinc group represented here by Zn-(20-30) wt% Al – 1-3 wt% Cu (HAl-Zn) and to high zinc-aluminium group represented here by Al-(20-30) wt% Zn – 1-3 wt% Cu (HZn-Al). It was stated that reducing Cu content to 2-2.5 wt% and/or its partial replacing by Ti in the HAl-Zn alloys or with Mn in the HZn-Al alloys allows avoiding dimensional changes long time after supersaturation and quenching.

Keywords: *AlZn-based foundry alloys, structure modification, grain refinement, dimensional changes*

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HIGH Si / Si-Mo DUCTILE CAST IRONS

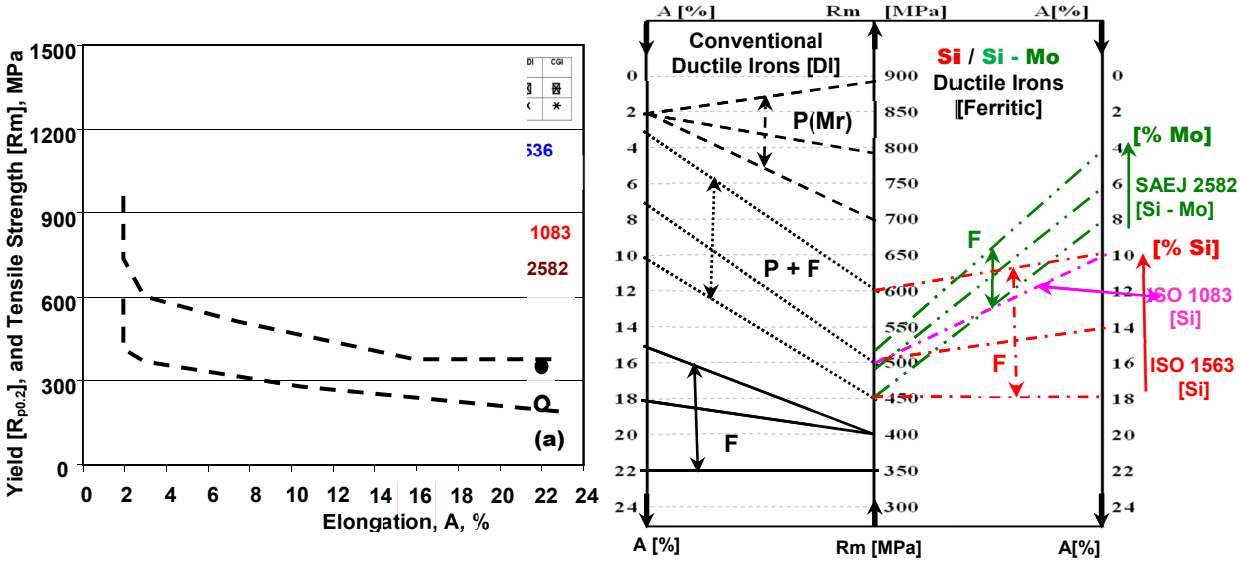
Iulian Riposan*, Stelian Stan, Mihai Chisamera

Politehnica University of Bucharest, Bucharest, Romania

Plenary lecture
Subject review

Abstract

A review of Si / Si-Mo alloyed ductile iron data in the first part of the paper shows that Si promotes ferrite, increases the strength and reduces the elongation and toughness by solid solution hardening. The instability of a mixed ferrite-pearlite matrix (Si < 3%), could be replaced with more predictable and controllable ferritic grades (3.2 – 4.3%Si), with reduced hardness variation (± 4HB), increased cutting tool life, and consistently better mechanical properties (R_m=450-650MPa; $R_{p0.2}$=350–500MPa; A=10-20%). Mo additions in high Si ferritic grades (3.5–5.5%Si, 0.2–2.0%Mo) favours superior mechanical properties (R_m=450-550MPa; $Rp_{0.2}$=275 – 440MPa; A=4 – 10%) and improved resistance to oxidation and corrosion at high temperatures. Some important new knowledge was identified: Si segregation pattern and typical content to reach the maximum strength and ductility; graphite degeneration (Si & Al effects); tolerance levels for other elements; increasing the strength and maximum working temperature up to 900-1000°C (Al, Ni, Co, Cr, V, Ti, Zr, etc supplementary alloying); carbides and phases characteristics; effects of Si and Al on transformation temperature and the oxide layer thickness; CGI–SiMoAl efficient application; specific corrosion and fatigue behaviour in different media; crack growth mechanisms, etc.
Experiments studied the solidification pattern of three ductile iron compositions [2.5%Si; 4%Si and 4%Si-1.6%Mo (Si:Mo=2.5)], for 0.35–0.45%Mn and controlled on minor elements content. The influence of Si and Si-Mo content and inoculation on the representative temperatures and undercooling during the eutectic reaction and at the end of solidification was observed. Without inoculation a supplementary high Mo addition decreased the beneficial effect of Si on decreasing undercooling. Despite that, Si is known to favour chunky graphite formation, effective inoculation decreased the sensitivity to form a dark coloured porous region in the thermal centre of castings and ensured desirable graphite nodularity and nodule count. It was found that inoculation is important for high-Si but particularly so for Si-Mo alloyed irons, requiring a high efficiency inoculation.



Keywords: *ductile iron, Si, Si-Mo, alloying, inoculation, thermal analysis, structure, graphite, ferrite*

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THE GLOBAL CASTINGS INDUSTRY

Andrew Turner*

The World Foundry Organization Ltd., United Kingdom

Plenary lecture
Subject review

Abstract

This paper will give an overview of the World Foundry Organization and how it works with member associations from around the world, covering the working groups and the World Foundry Congress and Technical Forum.
It will then give a comment on the global industry and in particular the production output from the worlds leading foundry nations, looking at the individual countries production and their challenges and opportunities.
Finally there will a look at the global challenges that face the industry in particular reference to macro economics and geopolitical instability.

Keywords: *production, WFO, challenges*

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OPTIAL-AN INDUSTRIAL GENERIC TOLL FOR DATA-DRIVEN MODELLING OF PRODUCTION CHAIN AND PROPERTIES OF THE END-PRODUCTS APPLICATION IN WROUGHT ALUMINIUM ALLOYS DEVELOPMENT AND PRODUCTION OF SEMIS

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Invited lecture
Preliminary note

Abstract

Prior to the successful industrialization of the new recycling-friendly wrought aluminium alloys it will be necessary to develop and apply advanced tools and techniques for their virtual modelling.
An industrial tool developed within the Impol Aluminium Group for such modelling is OPTIAl. It is the cognitive computing algorithm for (i) **extracting structured data** (process parameters, concentrations of alloying elements, and mechanical properties), (ii) **finding the correlations** between the individual processing paths and the end-product properties, and (iii) **performing the predictions** on the composition of new alloys and the processing parameters for matching the required mechanical properties.
The algorithm was validated in an industrial environment by ***predicting the properties*** of more than 250 production lots of the alloy AA 6110 processed by the different technological paths, and by ***predicting the processing paths*** for the production of semis with required mechanical properties. In both cases the matching was better than 90%.
In the case of the non-standard compositions derived from the alloy AA 6110, it was found that either the processing paths or the mechanical properties can be predicted with a typical accuracy of 60 to 80%, which is a promising starting point for further optimizations and development of new alloys.

Keywords: *data-driven modelling, OPTIAl, correlations, prediction of properties, prediction of processing paths*

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INDUSTRY CHALLENGES CONNECTED WITH DIGITAL TRANSFORMATION

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Mecas ESI as subsidiary of ESI GROUP, Plzen, Czech Republic

Invited lecture
Subject review

Abstract

The next several years will be about the "digital Transformation" of manufacturing industries. This will touch nearly every aspect of business as existing systems, jobs, and business processes are instrumented, redefined, and optimized with artificial intelligence. This transformation will be widespread and far reaching. Information technology (IT), operational technology (OT), engineering technology (ET), supply chain, asset management, services, and customer-facing systems will all be impacted. Discrete manufacturing, process industries, utilities, energy, infrastructure, and more are already beginning the transformation.
The transformation will affect all stages from product development, manufacturing processes and also product in operation. In order to develop smarter products, and the emerging class of autonomous products, designers and engineers must anticipate multiple unknowns and associated risks. Among these are the somewhat unclear ways different sensors and systems, upon which "intelligent" products rely, may interact and function/dysfunction together. Furthermore, it becomes increasingly critical to be able to predict system faults, that can result from design weaknesses, fabrication defects, or wear and tear, and to mitigate detrimental consequences right from the conception phase.
There are the main points which are going to be a momentum for an industrial transformation:

- autonomous robots,
- simulation,
- horizontal and vertical system integration,
- industrial internet of things,
- cybersecurity,
- cloud,
- additive manufacturing,
- virtual and augmented reality,
- big data and analytics.

All mentioned aspects will be discussed in relation to manufacturing processes including foundry technology.

***Keywords**: digital transformation, simulation, Industry 4.0*

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INCREASING THE VALUE OF CASTINGS BY APPLYING SURFACE ENGINEERING PROCESSES AND KNOWLEDGE BASED ENGINEERING

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Invited lecture
Preliminary note

Abstract

The paper presents the concept of application of surface engineering on castings and permanent metal molds. The procedures for modifying and coating the surface of castings and permanent metal molds have been mentioned and the effects of their application on increasing durability and lowering production costs. The importance of the application of knowledge based engineering and materials selection in the design of castings and molds for application of surface engineering processes has been described. For a practical example, a duplex process with plasma nitriding and PACVD coating has been applied to extend the exploitation life of the die-cast mold.

Keywords: *knowledge based engineering, material selection, surface engineering, PACVD coating*

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EXPERIMENTAL AND NUMERICAL MODELING OF HETEROGENEOUS MATERIALS

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Invited lecture
Original scientific paper

Abstract

Heterogeneous and composite materials are nowadays widely used for engineering applications. Nodular cast iron is used as a material of many engineering structural components due to its high strength and ductility. The realistic description of its deformation responses demands an accurate modeling at both macroscopic and microscopic scales. In this paper experimental and numerical modeling of nodular cast iron is conducted by investigating the influence of the microstructure on the overall mechanical behaviour. In the experimental measurements, comprehensive study of the nodular cast iron fatigue behaviour is performed, for various production techniques. For numerical modeling a two-scale computational approach employing the homogenization scheme based on the small strain nonlocal continuum theory is presented. Discretization of the macro- and microstructure is performed by means of the C^1 continuity finite element based on the nonlocal continuum. Basic relations of the scale transition procedure, and the homogenization procedure performed at the microlevel are described. The results obtained are employed at each material point of the macroscale model predicting the structural deformation response. All algorithms derived have been embedded into the finite element program ABAQUS. The performance and accuracy of the proposed numerical method has been verified in an example, where the microstructure of a nodular cast iron is modeled by an academic representative volume element.

***Keywords**: heterogeneous materials, nodular cast iron, second-order homogenization, C^1 finite element, nonlocal continuum theory*

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EVALUATION OF MICROSTRUCTURE AND TRANSFORMATION TEMPERATURES OF THE Cu-Al-Mn SHAPE MEMORY ALLOYS

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Invited lecture
Original scientific paper

Abstract

Four ternary Cu-Al-Mn shape memory alloys with 10.0-13.4 wt.% of aluminium and 3.6-7.8 wt.% of manganese were prepared by arc melting. Microstructures of the bulk alloys were investigated in the as-prepared state and after homogenization annealing at 850 °C followed by slow cooling using SEM-EDS technique. Transformation temperatures of the investigated alloys were analyzed using DSC technique. The results of present study represent contribution to the better understanding of the properties of investigated alloys in different thermal conditions.

Keywords: *shape memory alloy, Cu-Al-Mn alloy, microstructure, martensitic transformation*

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MASTER OF THE COMPLEX CASTINGS IN THE TECHNOLOGY OF HIGH PRESSURE DIE-CASTING

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Invited lecture
Subject review

Abstract

In contemporary high pressure die casting (HPDC) foundries the mastery of each sequence in production cycle is the most important, where the strive to reliable master, as well as planning of composed molten metal, pouring and solidification process, ejection of castings, transport to the cooling place and cutting of gating system and overflows were done. For castings with a complex geometry and dimensional accuracy, the appropriate planning of pouring and feeding elements according to a heat economy of casting, rapid tooling and prototyping and then reliable manufacturing which includes the mastery of all the edge conditions in the process chain. In the work the example of virtual analysis of casting from Al alloy will be presented with choosing of appropriate foundry technology HPDC, calculation of casting process which includes the filling process of cold chamber, model description of three phases at HPDC, flow of molten metal, solidification with considering the temporary air gap formation between the casting and tool, formation of stress and relaxation of it into deformations in each sequence, cooling in water or on air and after cutting off the gating system. It is not always possible to produce the castings according to the principle of unidirectional solidification with a traditional approach, for the individual areas, the local squeezing process is performed in the sequence of the semi-solid state of the region. The location of the impression is marked by a local increase of pressure and a plastic deformation of the already solid part of the casting (solid shell). Comparisons will be made with calculations of volume defects, casting dimensions and deformations with experimentally obtained castings produced from LTH Castings' industrial technology practice. Proven complete master of high-pressure die-casting have the result an important financial effect and decreasing of required time to start of serial production of castings.

Keywords: *aluminium alloy, high pressure die casting (HPDC), complex geometry, virtual analysis, squeezing process*

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FROM IDEA TO PATENT: DEVELOPMENT OF INNOVATIVE BIOMEDICAL MATERIAL FOR DENTAL IMPLANTS

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Invited lecture
Subject review

Abstract

One of the main issues concerning dental, but also all other implants, arises from their Young's modulus being considerably higher than that of bone. This can lead to stress shielding, bone resorption, and poor osseointegration of dental implants. Therefore, intensive activities are directed to lowering Ti implants Young's modulus while preserving sufficient values of other mechanical properties. Most of them are oriented at β-type Ti alloys, but recently some other metal matrix composites appear as a possible solution.
This presentation report on the development of the titanium-magnesium (Ti–Mg) bioactive metal-metal composite designed concretely for a fabrication of dental implants. The biomedical Ti-12vol. %Mg composite is manufactured using a cost effective approach, where a mixture of elemental Ti and Mg powders is extruded at low temperature to sound profiles. Microstructure of composite comprises filaments of biodegradable Mg component, which are arrayed along extrusion direction and are homogenously distributed within permanent, bioinert Ti matrix. Compared to Ti Grade 4, the reference material used for dental implants, the properties of as-extruded composite include significantly reduced Young's elastic modulus (92.1 GPa) and low density (4.12 g/cm^3), while the mechanical strength of Ti Grade 4 is maintained (at values required for dental implants). Dynamic testing of dental implants fabricated from as-extruded composite, realized to follow the ISO 14801 standard for endosseous dental implants, confirms fatigue performance of Ti-Mg implants equal to the one of the reference material. Exposure of as-extruded composite samples to Hank's solution, realized to simulate behavior in human body over the time after implantation, yields gradual dilution of Mg from composites surface and volume. Corroded Mg leaves at prior Mg filament sites pores within Ti matrix, which remains intact. This provides further decrease of Young's modulus and enhances macro and micro roughness at implants surface. As a result, newly developed Ti-Mg composite shows improved mechanical compatibility (i.e., reduction of stress-shielding) and better osseointegration potential.

Keywords: *dental implants, powder metallurgy, Ti-Mg composite, low modulus of elasticity*

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COMPUTER SIMULATION OF CONTROLLED COOLING OF CONTINUOUS CASTED AND ROLLED STEEL BAR

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Invited lecture
Original scientific paper

Abstract

Numerical model of controlled cooling in production of steel continues casting hot rolled bars was developed. By numerical model of controlled cooling is possible to predict a transient temperature field, microstructure evolution and hardness of rectangular steel bars during their cooling in cooling beds.
The numerical model of transient temperature field is based on control volume method. The algorithm for prediction of hardness and microstructure distribution in steel bars is based on continues cooling transformation (CCT) diagrams and real chemical composition. The numerical model and algorithm is completed to solve problems in controlled cooling of hot rolled bars in cooling beds. The controlled cooling is performed by special placement of hot rolled bars on cooling beds.
Numerical model and computer program was experimentally verified by simulation of real industrial production of low-alloyed steel bars. The verification of developed numerical model was performed by comparison of simulated hardness with experimentally evaluated results.

Keywords: *computer simulation, controlled cooling, continuous casting, rolling, steel, hardness, microstructure*

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INFLUENCE FACTORS ON STORAGE ABILITY OF INORGANIC CORES

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Invited lecture
Original scientific paper

Abstract

Use of inorganic binders based on alkali silicate solutions for core and mold production in the foundry industry represents the most environmental friendly technology. During the core and mold production or during the casting no odors and emissions are released, which is compared to the organic binder systems the great advantage. Nevertheless, the use of inorganic binders based on alkali silicate solutions brings along some technological drawbacks. In this paper the effect of storage conditions of cores with alkali silicate binder cured by dehydration is evaluated as well as the influence of sand granularity on storage ability. Test bars made with different mixtures were stored in climatic chamber with three different storage condition set ups. Bending strength of test bars was measured in certain time interval within 24 hours, free water content in test bars was also measured by the use of halogen moisture analyzer in order to express reverse reaction. From the obtained results, storage conditions with absolute humidity of 9,21 g/cm^3 were evaluated as ideal, storage conditions with absolute humidity 14,97 g/cm^3 were evaluated as critical with limited storage time and storage conditions with absolute humidity 27,31 g/cm^3 as not suitable storage conditions for inorganically bound cores and mold. Results also showed that finer sands are more sensitive for storage conditions with higher air humidity.

Keywords: *inorganic binders, storage ability, granularity, sand core, automotive industry*

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HOT TEARING TESTING OF ALUMINIUM ALLOYS USING RING CASTING METHOD

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Oral presentation
Preliminary note

Abstract

Hot tearing is a serious and quite common casting defect therefore they are a good indicator of an alloy's castability. Most significant factors that influence overall susceptibility to hot tearing of an alloy are: chemical composition, grain size, pouring temperature and cooling rate. Ring casting test in green sand mould was carried out to determine susceptibility to hot tearing for AlSi12, AlSi9Mg and AlMg1 alloys. Outer ring diameter was kept constant in every trial while the ring width that defines the test severity varied depending on a metal core dimension. A steel core was used to inhibit ring shrinkage and therefore inducecrack occurrence. At the same time mould filling and ring solidification simulations were conducted. AlMg1 alloy showed high susceptibility to hot tearing and should not be cast using permanent moulds that that doesn't allow for shrinkage during solidification. Alloys AlSi12 and AlSi9Mg showed no tendency to hot tearing.

Keywords: *aluminium alloys for casting, hot tearing, ring casting method*

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INFLUENCE OF MEDIUM AND MICROSTRUCTURE ON CORROSION BEHAVIOR OF GRAY CAST IRON

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Oral presentation
Original scientific paper

Abstract

This paper investigated the corrosion resistance of gray cast iron in the medium of artificial rain and 0.5 M H_2SO_4 medium and the effect of microstructure on its corrosion behavior in the mentioned media. By Tafel's extrapolation of the polarization curves, it was found that the examined gray cast iron shows an extremely high corrosion rate in the acidic medium, as opposed to the artificial rain test, where the corrosion rate is much lower. However, compared with the results of earlier researches obtained for nodular cast iron these values are three times higher, indicating that the nodular cast iron is more corrosion-resistant to atmospheric corrosion and therefore more acceptable for the manufacture of parts for agricultural machines. The obtained results were confirmed by the method of electrochemical impedance spectroscopy, where in the medium of artificial rain lower value of charge transfer resistance of gray cast iron was registered in opposite to nodular cast iron. These points to the fact that a thin layer formed on the gray cast iron, which represents a weak barrier to penetrating aggressive ions from the solution. The corrosion behavior of the gray cast iron in the tested media can also be related to its microstructure. Namely, aggressive ions from the applied media attack the metal matrix of the examined materials, while the graphite retains its original form. When compared to nodular cast iron, the nodules seems to be a more favorable form of precipitated graphite due to better sample surface covering and therefore the insulation in electrochemical corrosion process.

Keywords: *gray cast iron, corrosion rate, impedance, artificial rain, microstructure*

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TOOL STEELS - CLASSIFICATION AND BASIC PROPERTIES

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Oral presentation
Review

Abstract

This paper presents an overview of metallurgical processes of advanced metallic materials. The thermodynamic characteristics of the process include the conditions under which it is possible to follow the process in the desired direction and kinetics of the process. Tool steels belong to a group of advanced metallic materials, which are required by special properties such as high hardness and wear resistance, high strength stability at elevated temperatures, good behavior during heat treatment, high corrosion resistance etc. Achieving good properties is enabled by alloying with chromium, tungsten, vanadium, molybdenum or cobalt. It is very important to what extent the alloying elements are added and how the process of production proceeds, because the compounds formed during the production can be altered, and thus affect the transformation processes, and secreted in an undesirable form. Alloying elements are most often combined with carbon in carbides but can also be partially substituted in the iron crystal lattice and create undesirable intermetallic compounds. In order to improve the properties of tool steels, the aim is to find an adequate chemical composition to enable obtaining stable thermodynamic parameters.

Keywords: *tool steels, metallurgical processes, thermodynamics, kinetics, alloying elements*

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HARDNESS AND FRACTURE TOUGHNESS OF A CEMENTED CARBIDE

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Oral presentation
Original scientific paper

Abstract

In this paper the hardness and fracture toughness values for nanostructured cemented carbides were tested and analyzed. The experimental part included the testing of three samples: WC with 5% cobalt (WC-5Co), WC with 10% cobalt (WC-10Co) and WC with 15% cobalt (WC-15Co). Hardness was tested by Vickers method (HV30) according to HR EN ISO 6507-1: 2005, and fracture toughness was determined by the Palmqvist method according to ISO 28079: 2009. Palmqvist's method uses the length of cracks that propagate from the tip of the Vickers pyramid imprint to determine fracture toughness. The results show that by increasing the amount of cobalt in cemented carbides hardness values drop, and the fracture toughness increases. They also indicate that using nanostructured cemented carbides increases hardness with a slight change in toughness.

***Keywords**: nanostructured cemented carbides, hardness, fracture toughness*

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COMPARISON OF PHOTOCATALYST PREPARATION BY TiO_2 DEPOSITION ON A SUPPORT USING DIFFERENT METHODS

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Oral presentation
Original scientific paper

Abstract

The issue of water protection has long been one of the most important environmental issues. When it comes to the micropollutants, one of the greatest problems is pharmaceuticals. Their detection is not only a consequence of the development of analytical methods but also of the massive use of pharmaceuticals and their increasing concentration in the environment. In this paper, advanced photocatalysts were prepared and characterized by two different processes of titanium dioxide immobilization (TiO_2) on the support through sol-gel method. Immobilization was performed by the classical and microwave-assisted drying, and the catalysts were characterized by scanning electron microscopy (SEM), energy dispersion X-ray spectrometry (EDS) and X-ray diffraction analysis (XRD). The photocatalyst activity was tested through the photocatalytic degradation of salicylic acid (SA) in the pilot reactor, monitoring the degradation by the UV-vis spectrometry.

Keywords: *titanium dioxide, imobilization, sol-gel, photocatalysis*

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ANALYSIS OF THE LOW ENERGY LAYERING FRACTURE IN Al-2.5Mg-0.7Li ALLOY

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Oral presentation
Original scientific paper

Abstract

The mechanism of nucleation and propagation of low energy layering fracture, observed during thermo-mechanical testing of Al-2.5Mg-0.7Li alloy in as cast condition, was analyzed. Since the low energy layering fracture is affected by Li segregations and microstructural constituents' development, solidification sequence of Al-2.5Mg-0.7Li alloy was investigated in equilibrium and non-equilibrium conditions. Results of the investigations have shown that Mg has more pronounced effect on low energy layering fracture due to reducing solubility of Li in liquid phase and α_{Al}, maximizing precipitation of hardening (Al_3Li) δ' phase, ternary (Al_2LiMg) T phase and (Al_8Mg_5) β phase, and reducing ductility by solid solution hardening.

Keywords: *Al-Mg-Li alloy, phase precipitation, Li solubility, solidification sequence, low energy delamination fracture*

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GRAPHITE SHAPE DETERMINATION BY ELECTRICAL RESISTIVITY MEASUREMENTS OF CAST IRONS

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Oral presentation
Preliminary note

Abstract

The paper describes the possibility of electrical resistivity measurement in order to determine the state of the microstructure of grey cast irons.
Electrical resistivity is a property of materials which is changed by temperature and it depends also on microstructure. In cast irons the microstructure first consists from austenite dendrites and eutectic graphite which can be lamellar, nodular etc. Austenite is later transformed to pearlite and ferrite. The involved phases and amounts of phases and also the shape of graphite have big influence on electrical resistivity of material. In this manner it is possible to determine the solidification path of melt and the state of microstructure of cast irons.
Electrical resistivity measurements were performed on lamellar and nodular cast iron melts. A four probe technique was applied for the measurements of electrical resistivity in a sand mould made through Croning process. The temperature was measured simultaneously. Microstructures were investigated by optical microscopy to determine the shapes and amounts of graphite and to determine the matrix as well.
Results are showing that electrical resistivity of nodular cast iron is decreased during solidification but in lamellar cast iron it is rising during the solidification and decreasing after the solidification. From such phenomena one can conclude that such measurements are appropriate for graphite shape determination.

Keywords: *grey cast iron, electrical resistivity, graphite shape*

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MICROSTRUCTURE CHARACTERISTICS OF GOLD ALLOYS AND PROCEDURES FOR CORROSION PROTECTION

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Oral presentation
Original scientific paper

Abstract

The aim of this work is to present the microstructure characteristics and microhardness of different gold alloys (yellow, white and rose). This is connected closely to achieving proper coatings on these alloys with the goal to protect their surface against corrosion. We show some results of development in coating production, where it is extremely important that the difference in the colour of the gold alloy and the applied coating is not noticeable to the naked eye. Particular attention was focused on 2 production approaches of coatings: Electro-galvanization and the PVD process, in order to avoid different effects of reflection and inappropriate aesthetic performance (colour mixing). For this purpose, we show the results of colour measurements of different produced coatings on Au alloys with the use of the CIELAB system.
The assessment of the resulting coatings` layers is performed with FIB analysis, which was used to measure the deposited layers on various gold alloys. Investigations showed that the thickness of coatings layers varies according to the process, from 800 nm obtained by electro-deposition to 50 nm obtained by the PVD process.

Keywords: *gold alloys, galvanic layers, corrosion protection, colour stability*

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WEAR BEHAVIOUR OF TiAlN COATING DEPOSITED ON DEEP CRYOGENIC TREATED HIGH SPEED STEEL SUBSTRATE

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Oral presentation
Original scientific paper

Abstract

The aim of the research was to investigate the influence of deep cryogenic treatment on the load-carrying capacity of the high speed steel substrate and the wear resistance, hardness and coefficient of friction of the PVD TiAlN hard coating. Deep cryogenic treatment in combination with classic heat treatment shows a significant improvement in wear resistance of high speed steel tools. Also extending tool durability by reducing friction and wear is achieved by applying hard thin coatings to the tool surface. The results showed that deep cryogenic treatment influenced the properties of the substrate which resulted in higher hardness, reduction of friction coefficient and better wear resistance of the deposited TiAlN coating.

***Keywords**: deep cryogenic treatment, PVD coating, load-carrying capacity, coefficient of friction, wear resistance*

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INFLUENCE OF THE DIAMETER OF THE BORE OF THE COMBUSTIBLE MIXTURE ON THE TEMPERATURE FIELD IN THE AGGREGATE FOR THE MELTING OF ALUMINUM WASTE – SKIMS

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Oral presentation
Original scientific paper

Abstract

At the present time aimed at increasing the use of recycled material and reducing waste generation, specific aggregates are used to achieve this goal. Efforts to increase the efficiency of the facility lead to improvements in heat exchange in the system the flue gases – the batch – the lining. When heat is exchanged, the temperature of the heat source, its distribution in the working space, the way of the flue flow around the batch and others are decisive. The paper deals with the influence of the diameter of the combustion outlet of the combustible mixture for the temperature distribution in the working space, which is realized using mathematical modeling in the ANSYS simulation program. Based on the realized modeling, it is possible to predict the possibilities of adjusting the burner system to improve the heat exchange, thus shortening the heating time, respectively melting aluminum waste.

***Keywords**: combustion, heat exchange, skims, tilting rotary melting furnace*

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THE INFLUENCE OF TIRON ON THE RHEOLOGICAL PROPERTIES OF ALUMINA SUSPENSIONS WHICH CONTAIN WASTE ALUMINA POWDER

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Oral presentation
Original scientific paper

Abstract

Ceramic materials are already a well-known and widely used group of technical materials. Convenient properties such as density and strength, high hardness as well as high temperature and corrosion resistance provide the ability to use ceramic materials for many technical purposes. During the green machining of the green body, a certain amount of waste ceramic powder is generated which remains unused. In addition, the waste ceramic powder should be disposed as a non-hazardous waste in a legally prescribed manner.
In this paper, the commercial dispersant 'Tiron' is investigated for the stabilization of highly concentrated alumina suspensions with three different composition of waste (secondary) alumina powder. The dispersant amount was varied and the rheological curves were recorded, in order to determine the optimal amount of the dispersant. The amount of the dispersant required for the minimum viscosity to obtain stable alumina suspensions with different addition of waste alumina powder was determined to be in range from 0.05 to 0.06 expressed on dry weight basis (dwb %) of alumina powder for each suspension.
The viscosity of all suspensions suggests that the waste alumina powder may be used to prepare new ceramic products, like less complex shapes produced via the direct casting process. According to the measured viscosity, the amount of waste alumina powder of 15 % wt., with the optimal amount of the dispersant, indicates possible applications in the production of new ceramics products, with acceptable properties.

***Keywords**: alumina suspensions, waste alumina, slip casting, rheology*

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PREVENTION OF CHUNKY GRAPHITE FORMATION AND OPTIMISING THE PRODUCTION OF FERRITIC DUCTILE CAST IRON WITH HIGHER CONTENT OF SILICON

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Oral presentation
Professional paper

Abstract

In this paper, the optimisation of production for ferritic ductile cast iron with higher content of silicon is presented. Due to problems with achieving mechanical properties and achieving proper microstructures for material qualities EN-GJS-500-14 and EN-GJS-600-10 possible affecting factors were researched. In the beginning-as it also says in this paper-insufficient mechanical properties were connected with chunky graphite in the microstructure. Further, carried out a couple of experiments were carried out with different additions into the melt to try to avoid chunky graphite.

Keywords: *ductile iron, chunky graphite, high silicon content, ferritic ductile iron*

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ATMOSPHERIC CORROSION OF CORTEN STEEL IN THE RURAL, INDUSTRIAL AND MARINE ATMOSPHERE

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Poster presentation
Professional paper

Abstract

Corten steel is a trade name for a group of low alloy structural steels, which have an increased resistance to atmospheric corrosion. The carbon content for these steels is not greater than 0.2 % and the amount of alloying elements is not more than 5 %. Corten steel does not belong to a group of corrosion-resistant steels, but at exposure to atmospheric conditions as a corrosion product creates a surface oxide layer, which to some extent, protects the base material against further corrosion propagation. Due to the presence of alloying elements, especially copper, the oxide layer evenly covers the surface and has an attractive, red-brown color that takes darker tones over time. For this reason, Corten steel is very interesting to the architects and artists who use it in their projects.
The paper presents the results of the comparison of the oxide layers formed on the surface of the Corten steel plates after 200 days of exposure to the rural, industrial and marine environment. The thickness, homogeneity and color of the resulting oxide layers on the surface of the samples were significantly different. The thinnest oxide layer was measured in the sample exposed to the rural atmosphere, and the surface was uniformly covered with oxides. The sample exposed to marine atmosphere was most damaged by corrosion. In this sample, the largest thickness of the oxide layer and the greatest inequality of propagation of corrosion by depth were measured. Furthermore, surface was unevenly covered with oxides and had the darkest shades of brown-red color. For samples exposed to the industrial atmosphere, the surface coverage of oxides is similar to that of rural atmosphere and the thickness of the oxide layer is about 30 % higher.

Keywords: *Corten steel, atmospheric corrosion, microstructure, oxide layer*

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COMPARISON OF BRASS YOUNG'S MODULUS TESTING RESULTS OBTAINED THROUGH CONVENTIONAL AND INDENTATION METHODS

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Poster presentation
Preliminary note

Abstract

Elasticity modulus (Young's modulus) is a constant of the material which depends on bonding strength between atoms and/or molecules in the crystal lattice or amorphous structure. Determination of the elasticity modulus is a very difficult task from the measurer's perspective. In this work, a short overview of the modern applicable methods for the determination of elasticity modulus is discussed. In the experimental part, a comparison between the elasticity modulus testing results of brass samples performed by two different methods is also discussed. Testing methods included a tensile testing method with the use of a contact extensometer and an instrumented indentation method. Testing and statistical analysis of the obtained results showed a significant correlation between the results and several factors, such as extonsemeter's accuracy, load measurement range, sample preparation (material homogeneity) and linearization of elastic (Hook's) line, among others.

Keywords: *Young's modulus of elasticity, extensometer, instrumented indentation method, brass*

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THE MECHANISM NUCLEATION AND PROPAGATION OF HOT TEARING DUE TO THE FORMATION OF INITIAL MICROPORES ON THE TRIPLE JUNCTION OF GRAIN BOUNDARIES IN THE ALLOY AlMgSi

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Poster presentation
Original scientific paper

Abstract

The formation of pores on the triangular joints of the grain boundaries during the solidification of the aluminum alloy of the billet by the Direct Chill drilling can propagate into the microcrack. The mechanism of propagation of hot cracks for the alloys of the EN AW series 6XXX has described by two superponed processes: (1) the nucleation of the pore at the grain boundaries due to shrinkage during solidification and (2) the thermal contraction due to rapid cooling of the alloy. For this purpose, the areas of early phase formation and morphology of pores were analysed in the EN AW 6060 alloy microstructure in as - cast state produced by Wagsstaff AirSlip. Microscopic investigation using electron microscope confirmed the combined mechanism of the generation and propagation of microcracks from the series of micropores formed on the triple grain boundary joints and micropores along the grain boundaries formed by interdendritic separation before completion of solidification process.

Keywords: *triple point boundary, hot tearing criteria, pores nucleation, aluminium alloy 6060*

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INFLUENCE OF THE TOOL TRAVEL SPEED AT FRICTION STIR PROCESSING OF ALUMINIUM ALLOY AlCu4Mg1 ON TEMPERATURE FIELD AND MACROSTRUCTURE DEVELOPMENT OF THE WELDED JOINT

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Poster presentation
Original scientific paper

Abstract

This paper investigates the influence of the tool travel speed on the temperature field developed inside EN AW 2024 plate during the Friction Stir Processing. Different measuring systems were used to obtain temperatures on the tool and processed plates. Measured temperatures differ according to the features and characteristics of the used measuring equipment. The heat input has been calculated and compared with temperatures of the tool and the workpiece using heat input model from the literature. Influence of the tool travel speed on the weld defects was examined using macrostructure analysis of the produced runs. Higher tool travel speed creates less heat input and developed temperatures are lower, but the probability of a wormhole defect in the processed material is high.

Keywords: *friction stir processing, friction stir welding, tool speed, temperature measuring system, heat input*

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HEAT EXCHANGE DURING MELTING OF Al - SCRAP IN SAS FURNACE

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Poster presentation
Original scientific paper

Abstract

Generally, it is possible to increase the efficiency of the plant through the knowledge and improvement of the heat exchange in the working space of the respective aggregate between flue gases - batch - lining. In this paper, the determination of heat exchange in the Al-scrap melting process as a basis for controlling the melting process, based on information on the amount and composition of the scrap in terms of the batch mass, is described. It was explained how to determine the heat transfer coefficient *K* (W/K) from the data obtained from the operational temperature measurements in the kiln, batch and other necessary parameters of the furnace. The obtained coefficient *K* is used in the mathematical model of heating and melting in order to determine the expected heating time and melting of Al - scrap from the input data and the kiln operation data.

***Keywords**: melting, Al-scrap, SAS furnace, heat exchange*

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TESTING OF ABRASION WEAR RATE ON TECHNICALLY PURE ALUMINUM AND Al ALLOY AA 2024

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Poster presentation
Original scientific paper

Abstract

The purpose of this paper is to determine the influence of abrasive size on wear rate of Al-alloy AA 2024 and technically pure aluminum. Abrasive wear test was performed on Taber abrader, on abrasive papers of different quality (from P80 to P600).
Abrasive wear rate was given like volume lost per abraded surface unit.
It was determined that the abrasive size has a great influence on abrasive wear. Wear rate of technically pure aluminum is higher than the wear rate of Al-alloy AA 2024. Critical particle size – CPS is noticeable for both materials. Due to different microstructures and properties, Al-alloy has a higher value of critical abrasive size (≈ 125μm) than technically pure aluminum (≈ 82μm).

***Keywords**: abrasion, CPS -critical particle size, aluminum, Al alloy 2024, Taber abrader*

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OPTIMIZATION OF CASTABILITY TEST FOR GRAY IRON USING FEM CALCULATION

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Poster presentation
Professional paper

Abstract

The aim of investigation was to make and optimize new castability test for grey iron. For this purpose, new measuring test cell for castability test was constructed. The development and construction were based on numerical simulations of casting processes which was calibrated with experiment. In the castability cell also the cup for thermal analysis was integrated. For experimental calibration of the castability test cell spheroidal grey iron EN-GJS-500-7 was used. The geometry in the optimized castability test cell is constructed in this way that we can determine castability for different thermal modulus regarding same pouring conditions. Considering this with this castability test we can determine the casting technology for complex castings with different wall thickness more accurate.

Keywords: *castability test, grey iron, ProCAST, FEM*

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PROPERTIES OF CONTINUOUSLY CASTED Cu-Al ALLOY

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Poster presentation
Original scientific paper

Abstract

In this work are shown properties of continuously casted Cu – 9.1Al alloy before and after heat treatment. The continuously cast cylindrical bar with 8 mm diameter was produced using the device for the vertical continuous casting which is connected with the vacuum induction furnace. Heat treatment was consisted of annealing at 900 °C/30 minutes and water quenching. Microstructural analysis was performed by optical microscopy (OM), scanning electron microscopy (SEM) equipped by device for energy dispersive spectroscopy (EDS) and using differential scanning calorimeter (DSC). Also, hardness and mechanical properties were measured. EDS analysis confirmed that as-cast state of Cu – 9.1Al alloy is successfully done and alloy with homogeneous composition was produced. Optical and scanning electron microscopy showed existence of dual-phase α+β microstructure, which keeps after heat treatment but with certain sporadic changes of α - phase shape. DSC analysis on all samples presented one endothermic change of the heat flow during the heating, which probably represents α→β transformation and one exothermic change of the heat flow during the cooling which probably represents β→α transformation. The effect of heat treatment on the hardness and yield strength values is insignificant, while the tensile strength decreases with annealing.

***Keywords**: Cu-Al alloy, heat treatment, microstructure, mechanical properties, hardness*

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INFLUENCE OF GRAPHITE NODULARITY ON PLASTIFICATION AROUND CRACK TIP OF DUCTILE IRON

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Poster presentation
Original scientific paper

Abstract

The dependence of plastic zone magnitude around crack tip on graphite nodularity of cast iron was considered in this paper. Mechanical properties of four different samples of cast iron as a function of graphite nodularity (21%, 52%, 77% and 95%) were taken from available literature. At plastic deformation, the cast iron is nonlinearly hardened in accordance with the Ramberg-Osgood equation. Those data was fitted with nonlinear Ramberg-Osgood equation, where material parameters were determined using least-squares method. Thin infinite plate with straight crack was loaded perpendicularly to the crack plane. Plastic zone magnitude around the crack tip was determined according to the Dugdale model. A nonlinear isotropic strain hardening of a plate material was assumed. The stress intensity coefficient from the cohesive stresses was calculated using Green functions. The analytical methods, assuming small plastic zone around a crack tip, were used in the analysis. The results were obtained by means of commercial software package and presented in the form of diagrams.

***Keywords**: graphite nodularity, Ramberg-Osgood equation, strain hardening exponent, Dugdale model, plastic zone magnitude around crack tip*

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** Professor in retirement

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MONITORING OF RADIONUCLIDES IN STEEL SCRAP INTENDED FOR RECYCLING IN STEEL MILLS AND FOUNDRIES

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Poster presentation
Review

Abstract

Production of steel by the recovery of steel scrap today represents a very important industrial activity worldwide, and its social and ecological utility has been contributed to the preservation of natural sources of ore and energy savings. However, over the last 30 years, a number of unlucky cases have been reported in this activity with radioactive sources that were unintentionally found in recycled steel scrap. The consequences of these incidents were very serious in terms of protecting people and the environment from the harmful effects of ionizing radiation, as well as from an economic point of view.
The purpose of this paper was to point out the need to introduce radionuclide monitoring and monitoring systems in steel and steel casting processes in steel mills and foundries to improve the quality and environmental management system without which no modern steel and steel casting manufacturer can be imagined. The construction of a monitoring system for radionuclide monitoring in steel and casting production processes simultaneously represents a guarantee of the competitiveness of their products on the European and world market which is increasingly demanding in terms of the quality of these products and increasingly requires a certificate of radionuclide content.
This paper presents the basic types of radionuclide monitoring and monitoring system, the most common requirements to be met by such devices, and the process of measurement and imaging monitoring of radionuclide in steel waste.

Keywords: *radionuclides, monitoring, steel, steel mill, foundry*

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MICROSTRUCTURE AND THERMAL ANALYSIS OF THE LOW MELTING Bi–In EUTECTIC ALLOYS

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Poster presentation
Original scientific paper

Abstract

Microstructure and thermal properties of the low melting Bi–In eutectic alloys were investigated in this work. Three eutectic alloys (Bi–47.44 at.% In, Bi–66.33 at.% In, Bi–77.92 at.% In) were prepared by induction melting of pure elements. Microstructure of the alloys was analyzed using scanning electron microscopy (SEM) with energy dispersive X-ray spectrometry (EDS) and identification of co-existing phases was done. Differential scanning calorimetry (DSC) was applied for determination of melting temperatures and latent heats of eutectic melting. Experimentally obtained results were compared with the results of thermodynamic calculation according to CALPHAD (calculation of phase diagram) method and good mutual agreement was observed.

***Keywords**: Bi-In system, eutectic alloy, latent heat of melting, microstructure*

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COMMON FAILURES IN ALUMINOTHERMIC WELDING PROCESS AND PROPOSAL FOR THEIR PREVENTION

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Poster presentation
Preliminary note

Abstract

Aluminothermic welding of rail is still a unique method for joining the rails because of its flexibility and ease of performance, both during the reconstruction and construction of a new track, as well as in the ongoing maintenance of the continuity of the track. Although this procedure is applying for almost hundred years with constant improvements, it still has serious shortcomings. The shortcomings primarily relate to quality variability, which directly dependent on the training of the operator and their compliance with the prescribed instructions and procedures, during the welding process. The most common working mistakes are very similar to the casting failures that occur during the usual casting of steel. The process is susceptible because the welded joint is in constant strain condition caused by the structural differences between primary material and filler material (thermite steel). This paper presents some working failures on the samples from the track in exploitation, as well as the analysis of the causes of their formation. Also, the innovative way of performing aluminum welding of the rail was shown, which minimizes working mistakes and prevents working failures. The results of the quality testing of welded joints are done according to the EU standards. They pointed out that the implementation of this procedure provides greater safety of rail transport as well as its coherence because it significantly reduces the impact of faults of welding teams.

Keywords: *aluminothermic welding, rails, failures, porosity*

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ALUMINIUM ALLOY AS CAST MICROSTRUCTURE OBTAINED UNDER THE INFLUENCE OF ELECTROMAGNETIC FIELD

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Poster presentation
Preliminary note

Abstract

Aluminium alloys are characterized by a number of defects that occur during the solidification process such as: porosity, hot cracks, non-uniform grain size and crystal segregation. Since the quality of final product is directly affected by these defects it is necessary to prevent or reduce their appearance by the choice of the appropriate process and optimal parameters of casting. The application of electromagnetic field during the vertical continual casting process can be a very useful tool in reducing these errors. The results presented in this paper were obtained from examination of 7075 Al alloy samples cast with and without electromagnetic field. The microstructure was analyzed by optical microscope. The characterization shows that it is possible to obtain finer and more homogeneous microstructure through the entire cross section of ingots cast with electromagnetic field, compared to ingots cast without electromagnetic field. The grain size measuring is also done and the dependence between grain size and electromagnetic field frequency is given. As the consequence of microstructure-mechanical properties correlation, the use of electromagnetic field improved the mechanical properties, as well.

Keywords: *Al alloy, electromagnetic field, microstructure*

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EXPERIMENTAL STUDY OF THE TERNARY Ag-Ge-In SYSTEM

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Poster presentation
Original scientific paper

Abstract

Some selected alloys from the ternary Ag-Ge-In system have been experimentally examined by using few different experiment techniques. Used experimental techniques are differential thermal analysis (DTA), scanning electron microscopy (SEM) with energy dispersive spectrometry (EDS), and X-ray powder diffraction (XRD) analysis. Investigated ternary alloys were from three vertical sections Ag-GeIn, Ge-AgIn, and In-AgGe and two isothermal sections at 200 and 400 °C. Temperatures of four invariant reaction and liquid temperatures have been determined with DTA. By EDS and XRD test, phases which are in equilibrium have been determined. By EDS analysis did not detect new compound and large solubility of the third element into the binary compounds.

Keywords: *ternary system Ag-Ge-In, phase equilibria, DTA, SEM, XRD*

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CASTING AN Al ALLOY 2024 + 4% FLY ASH COMPOSITE SUITABLE FOR PROCESSING BY PLASTIC DEFORMATION

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Poster presentation
Original scientific paper

Abstract

Fly ash appears as a by-product of the coal combustion in thermal plants and it presents a serious ecological problem. It is a low density material that consists of spherical micro particles, which are by its constitution basically metal oxides. Fly ash micro-particles can be incorporated as reinforcement into a metal matrix based on aluminium or Al alloy. Developing this composite achieves two basic aims: a) resolving the problem of disposal of the fly ash, and b) providing a lower price material suitable for production of light components which are usually made from Al or Al alloys.
This paper describes producing an Al alloy 2024 + 4% fly ash composite by casting method. The gained composite as well as the non fly ash aluminum alloy 2024 was subsequently subjected to plastic deformation of 25%. We performed a comparison of microstructure of cast and deformed composites, and 2024 alloy without fly ash by *Olympus GX51F-5* microscope.

***Keywords**: composite, fly ash, Al alloy 2024, casting, deformation*

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A COST EFFECTIVE APPROACH TO PRODUCTION OF INVESTMENT CASTING WAX MODELS BY ADDITIVE MANUFACTURING

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Poster presentation
Professional paper

Abstract

Production of precise cast parts is often be accomplished by investment casting process. Within this process molten metal is poured into molds produced around wax models of the final part. In this process models and molds, which may be costly or time consuming to create, can be used one time only.
Investment casting is well established process in production of metal castings with complex or thin walled shapes or patterns. In this paper application of desktop size 3D printer for production of wax models is presented as fast and low-cost method of model production. The goal of this investigation was to test the possibility of the use of open source printer and software for wax pattern manufacturing for educational and training purposes. The use of a 3D printer allows rapid production of a part from a CAD image as well as the ability to create many copies of the same wax model. The surface quality of models was analyzed regarding to print parameters (layer thickness vs time) and some of typical wax models' defects and reparation method are shown.

***Keywords**: investment casting, rapid prototyping, 3D printing, additive manufacturing*

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EFFECT OF ANNEALING ON HARDNESS AND TOUGHNESS OF DUPLEX STAINLESS STEEL

Zrinka Švagelj[1]*, Iva Karačić[2], Damir Muslić[3]

[1] University of Zagreb Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia
[2] Ivičeki 21, Lučko, Croatia
[3] "E-PRO" Ltd. for designing, engineering and technical consulting, Bihać, Bosnia and Herzegovina

Poster presentation
Original scientific paper

Abstract

The aim of this work was to investigate the effect of 475 °C embrittlement on microstructure and properties of duplex stainless steel X2CrNiMoN 22-5-3 (1.4462). Microstructural changes that occur by annealing at 475°C for 3 hours cannot be clearly visible under a light microscope. The maximum magnification of 1000x and the maximum resolution of 0.4 µm are not enough to clearly distinguish small clusters of alpha-prime-phase formed in Fe-Cr alloys with 13%-90% Cr during ageing at temperature between 350 and 525 °C.
It was observed that the sample annealed for the longest time (3 hours) had 2 % higher austenite content in comparison with the untreated sample and the sample annealed for 1 hour. It was found that the hardness increases with increasing annealing time at 475°C and decreasing load. The toughness of duplex stainless steel decreases with increasing annealing time.

Keywords: *duplex stainless steel, embrittlement 475, hardness, toughness*

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INFLUENCE OF GRAIN REFINEMENT STRUCTURE ON THE INOCULATION EFFICIENCY IN WROUGHT AA 6182 ALLOY

Maja Vončina[1]*, Jožef Medved[1], Lina Jerina[1], Irena Paulin[2], Peter Cvahte[3], Matej Steinacher[3]

[1] University of Ljubljana Faculty of Natural Sciences and Engineering, Ljubljana, Slovenia
[2] Institute of Metals and Technology, Ljubljana, Slovenia
[3] Impol Group, Slovenska Bistrica, Slovenia

Poster presentation
Preliminary note

Abstract

Al–Ti–B refiners perform adequately for wrought aluminium alloys whereas the efficiency is various. It is in general believed that the poisoning elements interact with the grain refining constituents of the Al–Ti–B master alloys (Al_3Ti and TiB_2) and make them ineffective or less effective. Also, the quality of grain refiner is utmost important, whereas the size, shape and distribution of particles influence on the inoculation efficiency.
In our case three different grain refiners were investigated using thermal analysis (TA) to establish the inoculation efficiency in AA6182 alloy. Furthermore, optical microscopy and scanning electron microscopy (SEM) with energy dispersive spectroscopy (EDS) was used in order to analyse the structure of TiB_2 and Al_3Ti particles in the microstructure of grain refiners for three different manufacturers.
The potency of TiB_2 and Al_3Ti particles changed regarding the size, shape and distribution of particles in the grain refinement master alloy. It was established that the most favourable refinement was shown for a grain refiner with more evenly distributed Al_3Ti particles with a flake-like shape and smaller TiB_2 particles fragmented in-between Al_3Ti particles.

***Keywords**: grain refinement structure, nucleation potential, TiB_2 particles, Al_3Ti particles*

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ANCIENT LEAD METALLURGY AND THE APPLICATION OF LEAD ARTIFACTS IN ANCIENT TIMES

Irena Žmak*, Krešimir Grilec

University of Zagreb Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia

Poster presentation
Review

Abstract

The paper describes the typical applications of lead and its compounds, which have been used since 8 000 years by many civilizations. Products such as cosmetics, a medicine, pottery glazing, and as a food additive were commonly accepted for far too many centuries. Different engineering applications were made possible due to the easily available large amounts of the lead-containing ore, and to the simple metallurgical production technology, with lead having a relatively low melting point. The remains of one of the first human attempts to melt the lead-rich ore galena was found in today's Bosnia, which is described in the paper. Lead is a soft and easily malleable metal, which has allowed lead to be used in many engineering applications that require high plasticity. Besides art figures, and value-expressing Roman tesserae, one of the lead usage examples explained in the paper is the Roman water supply system found in the Sisak area in Croatia. In addition, numerous lead engineering applications found on ancient Roman ships are discussed in the paper

***Keywords**: lead, melting, ancient Rome, applications.*

*Corresponding author (e-mail address): *irena.zmak@fsb.hr*

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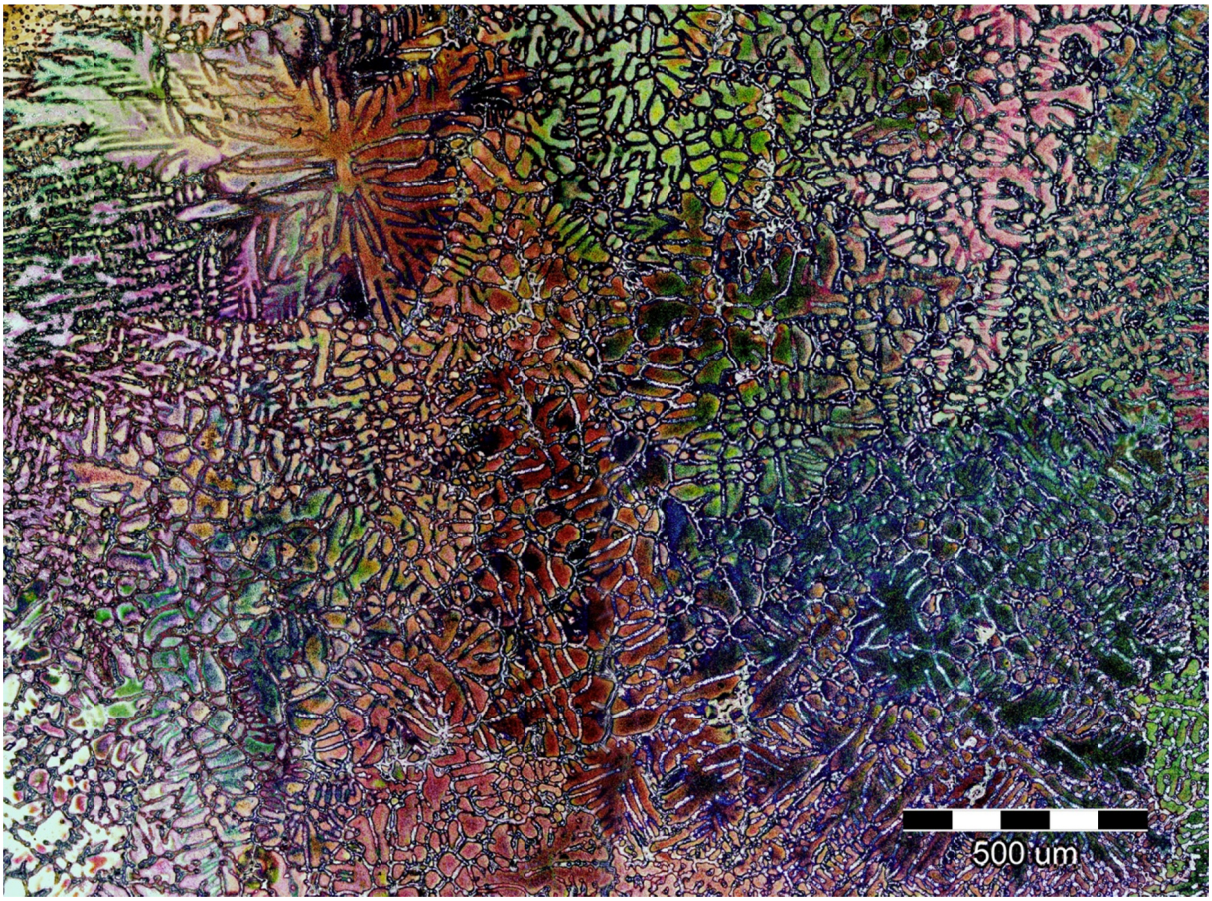

Dendritic network development in Al-2.5Mg-0.7Li alloy
F. Kozina, Z. Zovko Brodarac, M. Petrič, P. Mrvar, T. Rupčić,
Innovative Al-Mg-Li alloy with improved properties for aero - and space industry,
15. International fair of innovation ARCA 2017, October, 19 - 21, 2017, Zagreb

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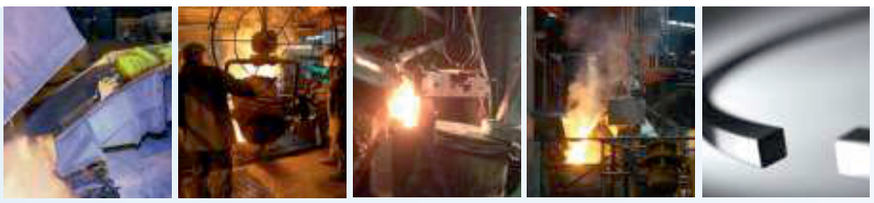

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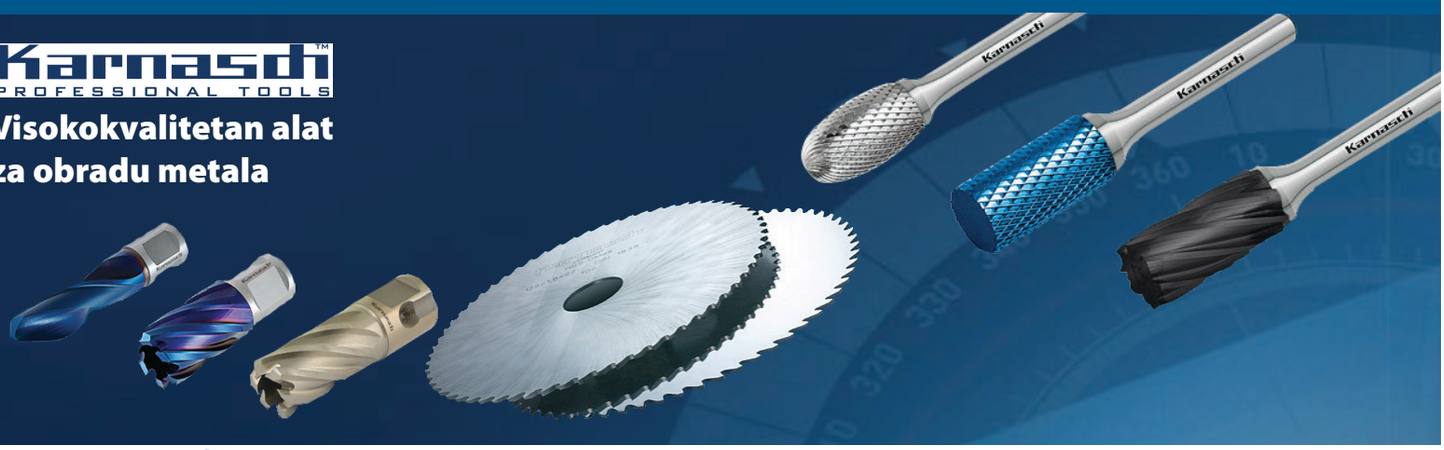

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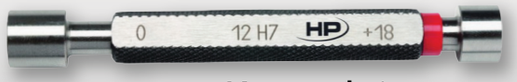

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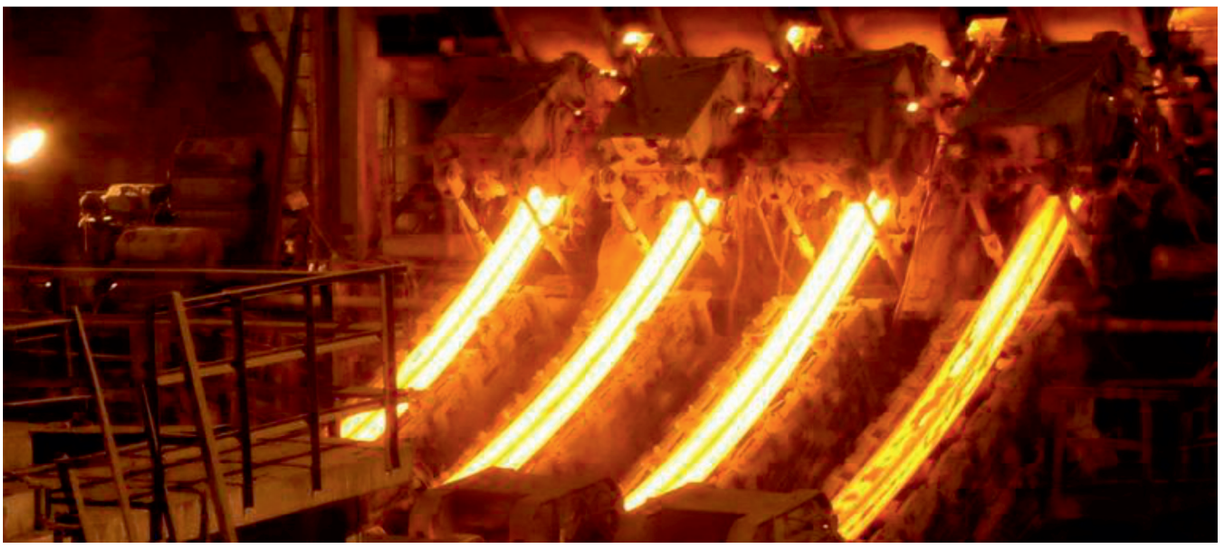

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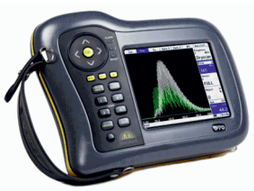

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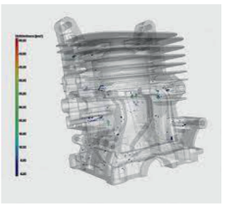

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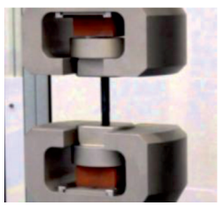

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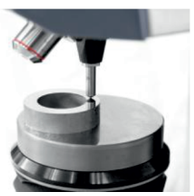

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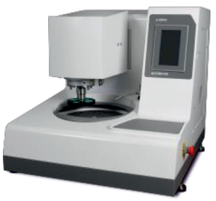

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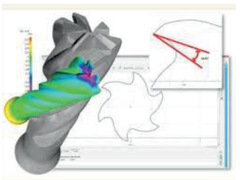

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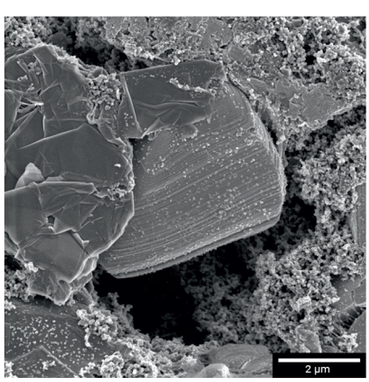

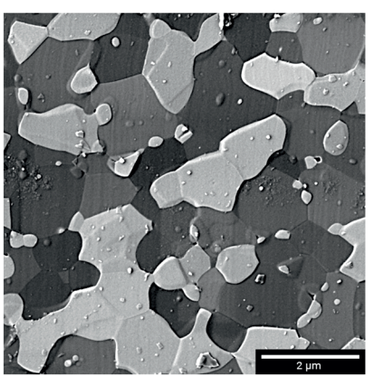

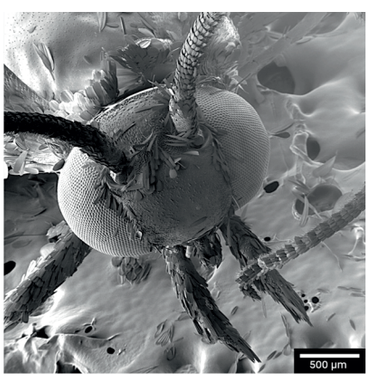

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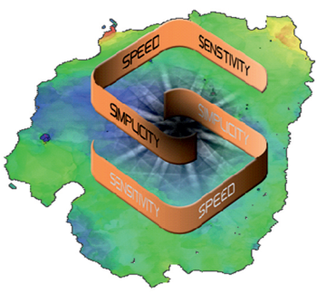

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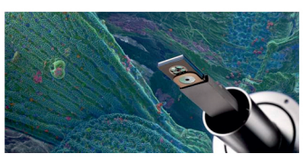

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