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Institute for Technology of Nuclear and Other Mineral Raw Materials
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MME SEE 2017

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PREFACE

The Third Metallurgical & Materials Engineering Congress of South-East Europe (MME SEE 2017), organized by Association of Metallurgical Engineers of Serbia and Faculty of Technology and Metallurgy University of Belgrade, takes place in Belgrade, Serbia, 01-03 June 2017. This is a biannual meeting of specialists, scientists and professionals working in the field of metallurgical and materials engineering. The aim of the congress is to present current research results related to processing/structure/property relationships, advances in processing, characterization and applications of modern materials.

The Congress is aided by the Metallurgical Academic Network of SEE Countries, SEE Associations of Metallurgical Engineers and Chambers of Commerce of SEE Countries, Serbian Foundrymen's Society, Institute for Technology of Nuclear and Other Mineral Raw Materials, Institute of Chemistry, Technology and Metallurgy and Vinca Institute of Nuclear Sciences.

The Congress involves together a wide range of related topics and presents the views from both academia and industry. Future of metals/materials industry in South-East European countries; Raw materials; New industrial achievements, developments and trends in metals/materials; Ferrous and nonferrous metals production; Metal forming, casting, refactories and powder metallurgy; New and advanced ceramics, polymers and composites; Characterization and structure of materials; Recycling and waste minimization; Corrosion, coating, and protection of materials; Process control and modelling; Nanotechnology; Sustainable development; Welding; Environmental protection are all covered in the Book of abstracts.

The Editors hope that the Congress will stimulate new ideas and improve the knowledge in the field of metallurgical and materials engineering.

The Editors would like to thank the Scientific and the Organizing Committee, the Congress Secretariat - CONGREXPO d.o.o. and all those who helped in making the Congress a success.
Exceptionally grateful to the sponsors without whom our Congress would not be possible:
1. *General sponsor*: HBIS GROUP Serbia Iron & Steel llc Belgrade
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We would like to express sincere appreciation to the Ministry of Education, Science, and Technological Development of the Republic of Serbia for their endeavor to make this Congress successful.

Editors

Content

Plenary lectures

FURTHER DEVELOPMENT OF SERBIA STEEL MILL UNDER HBIS GROUP OWNERSHIP

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Abstract

This article reviews traditional friendship between China and Serbia and introduces the propose of "One Belt, One Road" which will be of great importance to the long-term healthy growth of the world economy, also, the article illuminates purpose and significance of HBIS Group's acquisition of Serbia steel plant. The article introduces company profile, technical feature and operation principle of HBIS Group, focus on HBIS Group Serbia Company's current situation of production technology and products; also, the article highlights major measures taken since HBIS Group took over Serbia steel plant. The article shows HBIS Group Serbia Company's medium and long term development program and investment plan in terms of output, products structure, quality, energy conservation, environmental protection ,customer development , market exploitation and so on, HBIS Group Serbia Company will strive to enhance product s' quality and service level through efforts to improvement of technology and management , moreover, the article shows that HBIS Group Serbia is willing to strengthen sincere mutually beneficial cooperation and common development with iron and steel enterprises in central and east Europe or even whole Europe

Keywords: take over, operation, development, cooperation

TEXTURE ENGINEERING OF LEAD-FREE PIEZOELECTRIC CERAMICS

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Lead-free ceramics have been receiving especial attentions as promising piezoelectric materials to replace $Pb(Zr,Ti)O_3$ (PZT)-based piezoelectric ceramics. Although $Bi_{0.5}(Na,K)_{0.5}TiO_3$ (BNKT)- and $(K,Na)NbO_3$ (KNN)-based ceramics are reported to be promising for piezoelectric applications, their piezoelectric properties must be further improved before they can replace PZT. The piezoelectric properties of BNKT- and KNN-based ceramics can be improved through compositional modification by preparing solid solutions. Further improvement in the piezoelectric properties can be achieved by controlling the grain orientation through texture engineering using anisotropic templates with plate-like shapes. Through the growth of aligned templates, texture engineering can produce samples containing grains aligned along certain crystallographic orientations instead of randomly distributed matrix grains. One of the most important parameters in texture engineering is the role of the template. Plate-like $Bi_4Ti_3O_{12}$ (BiT) (or BNT) and $NaNbO_3$ (NN) are generally used as templates for texturing of BNKT and KNN ceramics, respectively. These templates are prepared by molten-salt synthesis using NaCl (or NaCl+KCl) flux. In this study, we investigated the role of templates in texture engineering of BNKT- and KNN-based lead-free piezoelectric ceramics.

Keywords: piezoelectric ceramics, lead-free, texture engineering, template

TEXTURE ENGINEERING OF LEAD-FREE PIEZOELE EMERGING HYDROMETALLURGICAL METHODS FOR A BETTER RECOVERY OF VALUES FROM OUT-OF-BALANCE COPPER ORES AND ACCOMPANYING WASTEWATERS

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Mining of heavy metal ores comprises the devastation of large areas of land at the mine surroundings by depositing huge amounts of out-of-balance material on dumps, prior reaching the main ore body. Dumps contain significant amount of oxide and oxide-sulphide minerals (oxide cap- not suitable for mineral processing operations), which could be processed by dump or heap leaching to remove valuable metals from. On the other hand, acid mine drainages (AMDs), originating as a rule, either from so formed dumps or from active or abandoned heavy metal mines, contain considerable amount of heavy metal ions and sulphuric acid and represent a significant potential of metals. AMDs make a significant ecological threat to rivers, wells and land downstream to mine site and huge problems for companies' management. Besides mine waters, there are numerous other metal bearing effluents from extractive, metal working-, electronic-, or metal finishing industry, needing to be purified prior their discharging in water recipients. So far, there is no unique technology, able to accept and process metal bearing solutions in a wide range of metal ions concentration and to achieve a high removal efficiency of the targeted metal from, to an extent in which they will meet the required water quality standards to be safely discharged either into a natural water recipients, or to be recycled into the existing mining or metallurgical plants as industrial water.

Through this lecture will be considered three main topics usually consisting every hydrometallurgical technology process, i.e.: dump and heap leaching of oxide-sulphide ores and advanced novelties in this area for enhancing the process rate and metal recovery degree; recent separation and concentration techniques - their advantages and limitations to be employed for treating leach liquors and similar effluents from mining, extractive or metal working industry of copper; electrochemical reactors for direct electrowinning of copper ions from dilute solutions; hydrometallurgical processes created by combining of different separation and concentration techniques, which will appear based on the recent research in copper hydrometallurgy- their ability to be applied on an economically and ecologically sustainable industrial scale.

Keywords: copper ores leaching; leach liquors; ions separation; electrowinning

Invited lectures

THE EFFECT OF SILICON AND COPPER ON THE FEEDING CHARACTERISTIC OF CAST Al-Si-Cu ALLOYS

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Abstract

Al-Si-Cu casting alloys in the past several decades have been widely used in automotive industry due to their extraordinary mechanical, thermos-physical and metallurgical properties. Chemical compositions of those alloys have a significant impact on their all previously mentioned properties. Silicon is added to improve castability and fluidity, as well as to reduce shrinkage and to give superior mechanical and physical properties. The Copper is the second major alloying element in these alloys. It has great impact on the strength and hardness of AlSiCu alloys in as cast and heat treated conditions. This element is also responsible for the reduction of casting characteristics, especially feeding ability of Al-Si-Cu alloys. During solidification those alloys reduced volume in the ranges between 4 to 8 % (depends on their chemical compositions), which need to be feed with extra volume of liquid melt in order to fulfill volume deficit and prevent formation of shrinkage porosity in as cast parts. Shrinkage porosity is a common and sever defect encountered in cast products. Once it occurs, the casting has to be repaired or scraped resulting in significant loss.

According to Campbell during solidification of those alloys can be recognized five characteristic feeding regions such as: liquid, mass, interdendritic, burst and solid feeding. Those regions are affected by alloy composition as well as processing conditions and variables. Characteristic solidification temperatures such as: liquidus, dendrite coherency, rigidity and solidus temperatures, which limiting these regions, can be determined using cooling curve analysis. This work focused on two major issues: (i) to quantify characteristic solidification temperatures and at the same time calculate the amount of fraction solid for each feeding regions, applying cooling curve analysis, and (ii) to analyze how different contents of silicon and copper influence five feeding regions.

Keywords: Aluminum cast alloys, feeding regions, Thermal analysis, Coherency and rigidity temperatures

HIGH-THROUGHPUT METHODS FOR ACCELERATED MATERIAL DISCOVERY

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Metals and alloys have the highest impact on technological progress of humankind over the past 10,000 years than. The metallurgy has evolved over millennia to become a highly sophisticated research field that influences almost all sectors of industry including energy, aeronautics, automotive, space, chemical, machinery, electrical, scientific equipment, construction, packaging, computing and health. Without metals and alloys the modern world would be inconceivable and could not function successfully. Also, metal industry is one of the largest sectors in the European Union. The combination of primary metal production, alloy creation, downstream processing, integrated metal products and alloy recycling, accounts for 46% of all EU manufacturing value and 11% of the EU's total gross domestic product (GDP). In order to maintain this strategic industrial strength in the European Union the greatest challenge for scientific and industrial communities is to continue making new metallurgical discoveries at higher pace. To compete successfully with the US the rest of the world and claim patent priority on new formulated products, European companies must be able to significantly accelerate the pace of material discovery and optimization. Failure to do this will put Europe at a disadvantage, technologically and economically. The only way to accelerate the discovery of smarter, safer, more sustainable, more recyclable, energy-efficient alloys is to put emphasis on new High-Throughput Techniques (HTT).

The development and improvement of materials have always been demanding, time-consuming, and costly processes. Throughout history, scientists and engineers have relied on the slow and serendipitous one-at-a-time process for discovering and developing new materials. Therefore, materials research is expensive and time-consuming, with estimates for the time from discovery of new advanced materials in the laboratory to the commercial market place often taking 10 to 20 years, and with R&D costs often in excess of $20 M per new material product. In order to accelerate materials research, combinatorial materials science (CMS) and high-throughput (HT) technologies, which promise to speed up the discovery and development processes, have been introduced and will be reviewed in the lecture. Finally, a novel method for accelerated alloy fabrication named Additive Alloy Melting (ADAM) will presented with its basic characteristics, advantages and drawbacks.

Keywords: High-throughput methods, Casting, Compositional spreads, Alloys libraries

MODELING OF HEAT TRANSFER PARAMETERS IN THE MELT-SPINNING PROCESS

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Abstract

Purpose In the case of continuous casting of metal ribbons with the melt-spinning process on the industrial scale, larger quantity of melt could lead to a slow excessive warming of the chilling wheel, which would further lead to solidification of a ribbon at non-uniform conditions and increased wearing of the wheel. Primary goal of our work was to determine to what extent the release of heat during contact of the melt/ribbon on the circumferential surface of the chilling wheel affect its surface temperature rise, and inversely how much elevated temperature of the chill wheel surface affects on metal ribbon cooling rate and its solidification velocity.

Design/methodology/approach On the basis of developed mathematical model, a computer program was made and used for analyses of heat transfer in the melt-spinning process.

Findings The calculations show that contact resistance between metal melt and chilling wheel has a great influence on melt/ribbon cooling and chill wheel heating rate, and must not be neglected in numerical calculations, even if its value is very low. In the case of continuous casting, significant “long term” surface temperature increase may take place, if the wheel is not internally cooled. But inner cooling is effective only if wheel casing thickness is properly chosen.

Research limitations/implications Influence of process parameters and chill wheel cooling mode on cooling and solidifying rate over ribbon thickness are outlined.

Practical implications Directions for the chill wheel cooling system design are indicated.

Originality/value New method for determining contact resistance through variable heat transfer coefficient is introduced which takes into account physical properties of the casting material, process parameters and contact time/length between metal melt/ribbon and substrate and enables cooling rate prediction before the experiment execution. In the case of continuous casting, heat balance of the melt-spinning process is calculated and influence of the chill wheel cooling mode on cooling rate of metallic ribbon is analyzed.

Key words: *Modeling, Heat Transfer, Melt-spinner, Metallic Materials, Rapid Solidification, Heat Transfer Coefficient*

BIOBASED POLYMERS: A STEP FURTHER TOWARD SUSTAINABILITY

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With the continuous depletion of fossil fuels, dramatic fluctuations in the price of oil, and serious environmental concerns, the chemical industry is faced with real issues associated with the use of an essentially non-renewable feedstock for the majority of its products. The transfer from a petroleum-based to a bio-based industry provides a sustainable and economically viable solution. A slow shift to bio-based production has been observed in many fields, but one of the most promising areas is chemically manufactured products for wide consumption, i.e. polymers. Bio-based polymers offer important contributions by reducing the dependence on fossil fuels and through related positive environmental impacts such as reduced carbon dioxide emissions. The legislative landscape is also changing where bio-based products are being favored through initiatives.

Unsaturated polyester resins (UPRs) are important cross-linkable polymeric materials with excellent mechanical performance, easy processability, low density, high chemical resistance and, most of all, low cost. UPRs are widely used in building and construction, the automotive, marine, electrical, decorative, and aerospace industry. In industrial process, UPRs are produced with two components: prepolymer and reactive diluents (RD) as the cross-linker. Nowadays, the most frequently used raw materials for the production of UPRs originate from petrochemical sources. As UPRs are an important sector of the polymer industry, scientists dedicate significant attention to the research of an adequate replacement for petrochemical raw materials. The majority of studies investigated UPRs prepared from bio-based prepolymers. Some studies showed promising results, achieving features comparable or even better than commercial resins. Styrene was used as the reactive diluent. Although styrene has excellent properties, it is highly volatile and has been identified as a hazardous air pollutant and been anticipated to be a human carcinogen. Therefore, to replace styrene in UPRs with reactive diluents derived from renewable or sustainable resources represents a challenge from both the industrial and research point of view.

This paper reports the development of new fully bio-based unsaturated polyesters resins (UPRs). A series of prepolymers were synthesized by varying saturated di-acids (oxalic, succinic and adipic acid), itaconic acid, and 1,2-propandiol. Dimethyl itaconate was used as a reactive diluent (RD). UPRs based on itaconic acid can be tailored during synthesis of the prepolymer to meet the needs of different property profiles.

The authors acknowledge the financial support of the Ministry of Education, Science and Technological Development of the Republic of Serbia through project no 172062.

Oral presentations

BAYESIAN COGNITIVE MODELLING OF SCRAP-INTENSIVE WROUGHT ALUMINIUM ALLOYS

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The successful industrial modelling of scrap-intensive wrought aluminium alloys with the desired combination of properties is based on a precise correlation of the properties of the final product and the technological path (concentrations of the individual alloying elements as well as various processing parameters) capable of providing it (and vice versa).

The correlation-finding methodology used in this work is the Bayesian computational cognitive algorithm.

The inductive learning of the algorithm was performed by applying the experimentally confirmed equivalency of different technological paths, able to provide the same combination of properties.

In the first step, by practicing the data “mining”, a data matrix was created consisting of the results of standard, room-temperature tensile tests and the corresponding technological paths for different production lots of the AA 6110 alloy.

Next, by cognitive processing of the accumulated data, the most probable technological path-property correlations were identified.

Finally, various standard and some non-standard alloy compositions, derived from the alloy AA 6110, and the processing parameters were cognitively inducted to provide the desired combination of properties.

The validation of the above-described methodology was performed through the regular production of a limited number of cognitively computed alloys and their detailed characterization. It was found that by applying the cognitive-computing methodology on a sufficient number of experimentally determined values, either the chemical composition or the mechanical properties can be predicted with high accuracy, sufficient for most industrial applications.

Keywords: Aluminium, Wrought Alloys, Modelling, Composition-Properties, Cognitive Computing

CAN QUASICRYTALLINE ALLOYS BE OF ANY USE?

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Quasicrystals became interesting for researchers mainly because of their unique properties, such as: high absorption of infra-red light, reduced adhesion and friction, heat insulation and as reinforcement component in composites for mechanical devices.

In order to obtain good mechanical properties the homogeneous dispersion of iQc phases with equiaxed shape is preferred. With an increase in the volume fraction of the iQc phase the yield strength of alloy is also increased. Alternative way of producing durable light-weight, high-strength alloys containing QC phases in via solidification and in-situ growth of QC phases. This route can provide composite-like materials with tunable mechanical properties and great potential for wider use.

Keywords: Al-based alloys, quasicrystals, use, synthesis

ACCESS THE MARINE MARKET THROUGH MATERIAL CERTIFICATION

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The marine sector can only use materials that are certified to relevant international standards and norms. This applies for ship building structures and all the machinery within the vessel (valves, gears, shafts, etc.). The relevant standards must be maintained not just for new builds but also for any modification or repair, conversion, or replacement parts throughout the vessel's lifetime.

Manufacturers in South East Europe intending to sell materials for marine service can be approved and certified by a marine classification society. These are authorized third parties and their approval facilitates the access of the manufacturers to the market. The authorization given to manufacture products is done in accordance with the Rules and Regulations under survey, by verifying compliance with international and/or national statutory regulations.

Manufacturers who are considering trying to access these markets need to understand the steps and the requirements involved. This paper will outline the process and help companies assess if this is a viable opportunity.

Keywords: certification, materials, quality, rules, survey.

NEW PRODUCTION METHODS FOR OPTIMAL SCRAP CONSUMPTION IN WROUGHT ALUMINIUM ALLOYS

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The recycling level in wrought aluminium alloys production is generally affected by the quality achievements of aluminium scrap sorting, chemical composition limits of alloys, preparation process variation and melting solutions.

Linear modelling with Simplex method increases the preparation process reliability in aluminium scrap application and has the possibility to manage the optimal consumption of different input materials. The linear model includes also relations between quality properties of scrap storage and their prices, which is solved by using a revised Simplex method. Such program syntax restrictions represent most advantages resulting from practical principles in casthouse production.

In the study, the optimal scrap preparation for modificated alloys EN AW 6082 with Simplex determination is presented. New Simplex data mining matrix was made with consideration on the optimal algorithm calculation of chemical alloy composition with optimal performance due to quality vs. price. The result from different portions of individual chemical composition in scrap is presented like the distribution of average composition of mixture and the standard deviation of each accessible material.

The program shows high demand of necessary preparation and significant precision by definition of scrap quality (chemical composition, impurity level, geometry and density of material, contamination level, etc…) in physically separated boxes. Such variables between chemical composition and production process determine the final mechanical properties of wrought aluminium alloys.

The correlation between input material and process variables has very high future advantages due to consistency of casting series and furthermore define stochastic or cognitive modelling principles.

Keywords: Aluminium, Wrought Alloys, Simplex Modelling, Chemical Composition, Correlation

SYNTHESIS OF GOLD NANOPARTICLES THROUGH ULTRASONIC SPRAY PYROLYSIS AND ITS APPLICATION IN PRINTED ELECTRONICS & BIO-MEDICAL

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This abstract presents a review of Ultrasonic Spray Pyrolysis (USP) as a technique for the synthesis of gold nanoparticle (AuNPs). The synthesis mechanism involved the preparation of the precursor solution with insoluble gold salts and the study of the process parameters i.e. chemical (initial concentration, solubility and purity of the precursor) physical (ultrasonic frequency, droplet size, evaporation and sintering temperature) and kinetic (flow rate of carrier and reducing gases). In the second step the USP parameters` effects on AuNPs` morphology (size and shape), final concentration of AuNPs, purity and crystal structure, functional characteristics (stability, degree of agglomeration and absorption spectra of AuNPs) have been studied extensively. We would like to introduce AuNPs` future applications, which could be in printed electronics with conducted patterns and in different bio-medical fields.

Keywords: Ultrasonic Spray Pyrolysis, Gold Nanoparticles, Synthesis Mechanism, Printed Electronics

TRIBOLOGICAL BEHAVIOUR OF CHROMIUM NITRIDE BY PVD COATINGS UNDER CONSTANT LUBRICATED CONDITION

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The wear behavior of the chromium nitride (CrN) coating on piston ring material against liner material was investigated under lubricating conditions at room temperatures according to need of a better efficiency and higher performance under environmentally friendly aspects is an actual trend for automotive applications and machine components. Cast iron alloy, widely used in manufacturing of piston rings and cylinder liners, further it was coated by physical vapour deposition method. Wear tests were carried out on a Pin on Disc tribometer on dry and lubricating conditions, Simultaneous effect of sliding velocities (1,2 & 3 m/s) and corresponding loads (50, 60, 70 & 80,90,100 N) on wear rate, friction coefficient and temperature were analyzed. In conclusion, Specific wear rate is decreasing by increase in load and velocity. The rise of temperature in dry condition at the wear track resulted in a reduced coefficient of friction (COF) when the increase of load from50 to 70N. The wettability of the PVD coatings with lubricants is characterized by means of wear behavior and it's mechanism. The wear mechanism is mixed mode such as three body abrasion and oxidation wear for dry conditions and adhesive wear in flooded condition.

Keywords: Physical vapour deposition (PVD), Chromium Nitride (CrN), Wear mechanism, Effect of Lubricant, Effect of temperature

USAGE OF 100% PELLETS IN THE BLAST FURNACE ORE BURDEN PART

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Using 100% pellets in the blast furnace ore burden part is not the common practice in Europe. During January and February 2016. we have been testing Smederevo Steel plant Blast Furnace 1 by decreasing sinter percentage in the ore burden from usual 40% to the full stop of sinter usage. We had different test periods with different sinter ratio usage, and no period was shorter than 4 days. During each test period, blast furnace was operating with the same technological and operational parameters.

Goal of each test period was to determine and compare technological and economical parameters of blast furnace operations.

A blast furnace 1 operation with usage of 100% of pellets was organized in the period between January 20th, and January 31th, 2016.

It was the first time in 45 years long tradition of Smederevo iron making that blast furnace is charged with pellets only.

Achieved Blast furnace 1 technological parameters during this period did not deviate from parameters achieved with normal burden structure.

Total fuel consumption was 542.78 kg/thm, Fe content in the burden was 63.59%. Fluxes consumption (limestone and gravel) in the blast furnace, in order to achieve required slag basicity was around 90 kg/thm, and the slag volume was 270 kg/thm. Thermal condition of blast furnace was normal (top temperature was averaging 134 °C), and without cooling system elements heat overloading. BF gas utilization (ETA CO) was above expected level and it was around 48%.

At the end of test period of 100% pellets usage in blast furnace burden, it has been concluded that excellent balance between operating parameters and hot metal and slag chemical composition.

During the test period there were no observed anomalies in blast furnace operations. It has been confirmed that blast furnace can, without issues, operate by using 100% pellets in the ore burden part.

Keywords: Pellets, sinter, burden

ANALYSIS OF THE INFLUENCE OF VGS STRUCTURE ON MECHANICAL PROPERTIES OF Ti-12Mo ALLOY

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Titanium alloy with 12 mass % Mo was produced by crucible levitation melting (CLM) technique. Swirly Mo segregation occurred during hot caliber rolling was named VGS, after famous Vincent van Gogh's Sky pattern. Nanoindentation testing was performed in order to determine influence of the VGS structure on the hardness and elastic modulus of Ti-12 Mo alloy. Two sides of hot-rolled samples were observed: in transverse direction (TD) and along the rolling direction (RD). Microstructural characterization and analysis of indents was done by scanning electron microscopy (SEM) equipped with energy dispersive spectroscopy (EDS). Obtained results show that side of sample (TD or RD) has negligible influence on observed mechanical properties. On the other hand, Mo segregation show great effect on hardness and elastic modulus. Absence of Mo segregation induces the heterogeneous precipitation of the ω-phase. Consequently, regions with higher amount of Mo show lower values of hardness and elastic modulus.

Keywords: Ti-beta alloy, ω-phase, nanoindentation, hardness, elastic modulus

NATURAL AGING BEHAVIOR OF COMPOSITES CONTAINING A HIGH-STRENGTH ALUMINUM ALLOY MATRIX AND TITANIUM DIBORIDE PARTICLES

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Heat treatment and ceramic particle content are among the important parameters that have a great influence on the mechanical properties of the ceramic reinforced composites with a heat treatable metal matrix. In this work the metal matrix composites, reinforced with ceramic TiB_2 particulates having a mean size of ~16 µm, have been manufactured by the conventional powder metallurgy technique namely, cold pressing and sintering operations. The elemental powders have been used to get a heat treatable aluminum alloy matrix bearing Zn, Cu and Mg as alloying elements. Initially, the characterization of powders has been made to determine the average powder sizes and the powder shapes. And then the powders in certain proportions have been blended and mixed in a mixer to get uniform powder distribution. The volumetric fractions of the titanium diboride constituent in the composites have been selected to be in the range of 5% to 20%. Next, the green density variations as a function of compaction pressure for the composite powders have been found. After the cold pressing the samples at ~ 300 MPa, the sintering process has been carried out at 590 ºC for 15 minutes in an atmosphere controlled furnace using the inert argon gas to complete the production phase. In the precipitation hardening step, the composite materials have been solutionized at 480 ºC and subsequently water-quenched. As a last step, they have been subjected to the aging treatment naturally at room temperature for a duration period of 60 days in order to obtain the hardness variation with respect to the aging time. The experimental results have showed that the compaction pressure up to ~ 200 MPa has led to a rapid increase in the green density of the composite samples. In addition, the hardness of the composites has increased very rapidly in the first few days and almost stabilized with further increments in the natural aging period. Furthermore, the peak hardness of 145 Brinell has been recorded for the composite reinforced with 20% TiB_2 particles.

Keywords metal matrix composite, natural aging, powder metallurgy

METHODS IN OPTIMIZATION, SYSTEM THEORY AND NETWORK FOR THE MATHEMATICAL MODELING OF MATERIALS

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In this talk, firstly I will present my latest results on areas that I currently work on such as optimization, fractional operators, networks etc. Then we will discuss how these results can be applied into mathematical models related to materials, image processing, and power systems.

Keywords: optimization, fractional, discrete, systems, networks

OPTIMIZATION OF PROCESS PARAMETERS TO MINIMIZE ANGULAR DISTORTION, SHRINKAGE STRESS AND BENDING STRESS IN GAS TUNGSTEN ARC WELDED STAINLESS STEEL PLATE USING TAGUCHI METHODOLOGY

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Abstract

The effects of process parameters of TIG welding on distortion, shrinkage stress and bending stress of welded joints of stainless steel plate of SS304 grade has been studied. The optimum combination of process parameters has been suggested to achieve minimum distortion, shrinkage stress and bending stress. Design of experiment (DOE) was used to plan and design the experiment to study the effects of parameter on these stresses. The input parameters considered in present investigation were welding current, gas flow rate, root face and welding speed. L9 Orthogonal Array (OA) technique was used to formulate the experimental layout. It was concluded that the minimum distortion, shrinkage stress and bending stress were found at optimal setting of parameters of welding current, 90 amp, gas flow rate, 2.0 liters/min, root face, 2mm and welding speed, 15.384 mm/min.

Keywords: DOE, OA, S/N ratio, Taguchi method, shrinkage stress, distortion, shrinkage stress, bending stress etc.

MICROSTRUCTURAL PHASE TRANSFORMATION EVOLUTION OF Ti-6Al-4V ALLOY IN SELECTIVE LASER MELTING PROCESS

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Abstract

Ti-6Al-4V alloy is being widely used to produce the functional customised metal components of aerospace, automobile and load-bearing implant due to its competent mechanical properties with effective martensitic grain structure. In this investigation, microstructural properties have been explored of Ti-6Al-4V alloy products manufactured in deferent energy densities (EDs) in selective laser melting (SLM) process. To observe the microstructure, the scanning electron microscope (SEM) is used after etched by the Kroll's reagent on the polished surfaces. Additionally, the changes of the microstructure are also investigated in the sample after controlled heat treatment of the SLM product. Theoretical concepts of heat transfer, selective laser sintering process and continuous cooling transformation diagram have been applied to evaluate the behavior of the microstructures. Tensile tests and hardness tests are done to compare and establish the characteristic changes of the microstructures. An efficacious behavior in microstructures has been noticed in the SLM products fabricated in different EDs.

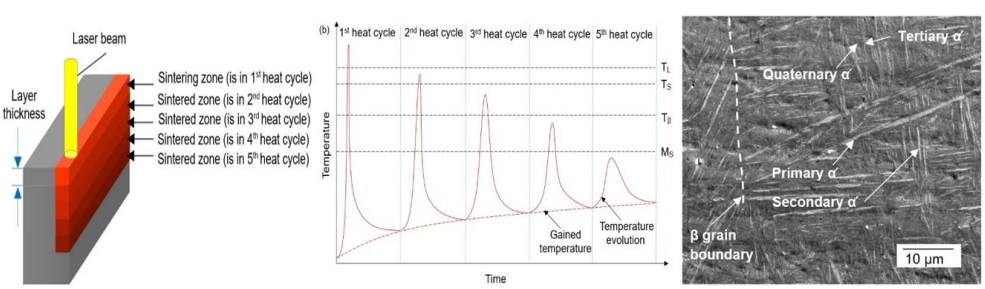

Figure: Graphical abstract - phase transformation in selective laser melting process

Keywords: Microstructure; Ti-6Al-4V alloy; Selective laser melting; Tensile strength; Hardness

USE OF RETURN MATERIALS IN SINTER PRODUCTION

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Use of return materials formed in production processes – blast furnace dust and sludge, pellet fines, BOP sludge, C scrap, mill scale, is necessery because of material losses and enviorment endangering by their storage inside ironworks area. Using certain return materials in ore mixture (blast furnace sludge, C scrap) is limited due to containment of harmful elements (zinc and phospfor) and it directly depends on amount of sinter in backfilling of blast furnace.

Zinc in sintering mixture comes from ore and blast furnace dust. Reduction of zinc content in mixture is possible only if ZnO is reduced to metalic zinc. New-formed zinc evaporates, extent of zinc removal due to sintering process depends on sintering-layer temperature, respectively of coke content in mixture. In blast furnace, zinc is reduced, evaporates and condenses on higher zones, on a revetment walls and on backfilling material. This condensation causes revetment destruction. Condensed zinc drops to lower zones of blast furnace, evaporates again wich slows down work of blast furnace and increases coke consumption.

According to modern knowlage, regarding blast furnace processes, amount of zinc input is 200-250g/t of Fe.

During sintering process, all the phosphor goes to sinter, and also due to melting inside the blast furnace it goes into iron. Removing of phosphor during basic-oxygen process is aggravate when iron contains increaset percentage of Mn. C scrap is a bearer of phosphor. While balance sheet was being made, base parametars were structure of blast furnace backfilling, amount of sinter in it, as well as the phosphor limit of 0,075%.

With defining ratio of sinter and pellets in backfilling of blast furnace, it is possible to determine amount of sludge and C scrap, by applying methods for eliminating bad compounds on stock supplies.

It is necesarry to monitor the content of Fe, P and Zn in return materials and ore and preform optimization of pyramides, based on this contents.

In the first half of 2016. the content of C scrap was 32kg/t, and BOP sludge 11kg/t. Since august, these amounts were increased, C scrap – 119kg/t and BOP sludge – 44kg/t of sinter. Goal was not to jeopardize quality of sinter (especially content of Fe), wich was achieved. Content of Fe was increased from 49.7% up to 52% of Fe. Price of sinter was significantly decreased.

Keywords: return materials, sinter, C scrap, BOP sludge.

UTILIZATION OF BLAST FURNACE SLAG AS A RAW MATERIAL FOR CEMENT CLINKER PRODUCTION WITH THE AIM OF IMPROVING TECHNO-ECONOMIC PARAMETERS AND REDUCING CO_2 EMISSION

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Abstract

Recent practice in cement production is the utilization of blast furnace (BF) slag as an additive to cement clinker. By using that practice, all the advantages arising from characteristics of BF slag are insufficiently used from the aspects of techno-economic parameters, as well as environmental protection. Advantages of BF slag resulting from the favorable chemical and mineralogical composition have a particular influence on the reduction of energy consumption. In addition to these advantages and compared to the use of natural raw materials (marl, limestone, sand), the utilization of BF slag as a raw material for clinker production reduces the formation of deposits of low-temperature melting phases on kiln walling. In this research, the results of reducing energy costs and CO_2 emissions when BF slag is used directly as raw material for the production of cement clinker, and not as an additive, are presented. On the basis of the material and heat balance, and comparative values of energy consumption when utilizing BF slag as the additive to clinker and as raw material for the production of clinker, it was concluded that energy costs of clinker and cement production can be reduced by up to 15 % and CO_2 emissions up to 25 %.

Keywords: BF slag; cement clinker; energy; CO_2 emission

Poster presentations

STABILITY OF GOLD COMPLEX BASED ON MERCAPTOTRIAZOLE IN ACID AND NEUTRAL ELECTROLYTES

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Abstract

This work presents results of the investigation of the gold complex based on mercaptotriazole stability in one neutral and two acid electrolytes. It was predicted to conduct the investigations for a period of one year, or until the first visible signs of complex decomposition. Visual monitoring and some electrochemical techniques have been used to detect those signs. Electrochemical characterization included open circuit potential measurement, cycling voltammetry method and recording the polarization curves, with measurement the pH values of electrolyte before and after each electrochemical experiment. These tests were carried out at different starting pH values: 2, 4 and 7 at concentration of gold in electrolyte of 2.5 g/dm^3, previously determined as optimal. For all investigated electrolytes, the first visible signs of complex decomposition have appeared three months after synthesis.

Keywords: complex stability, gold, mercaptotriazole, electrolytes, electrochemical characterization

COMPARISON OF CAVITATION EROSION RESISTANCE OF MULLITE AND ZIRCON SAMPLES BASED ON NON DESTRUCTIVE CHARACTERIZATION

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Mullite and zircon are widely used for different applications for refractory materials. In this paper their cavitation erosion resistance will be investigated. Cavitation erosion resistance testing will be applied using standard the ultrasonic vibratory cavitation set up with stationary specimen. Weight loss, image analysis, and ultrasonic measurements (Dynamic Young modulus of elasticity) will be used for determination of the effects of cavitation.

In this paper image analysis will be implemented for monitoring degradation level during the testing, as well as number of formed pits and their characterization (average diameter and area). Ultrasonic measurements will be related to the determination of Dynamic Young modulus of elasticity. Ultrasonic velocities will be measured and used as controlling factor for degradation level during the cavitation erosion testing.

Obtained results will be discussed in order to compare and analyze resistance of the different materials (mullite and zircon) to cavitation erosion as well as strengths and weaknesses of the used methodology.

Keywords: mullite, zircon, wear resistance (cavitation erosion), image analysis, level of degradation, UPVT

ESTIMATION OF PHOSPHORUS PARTITION COEFFICIENT IN BOF PROCESS

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Abstract

Long time ago phosphorus is recognized as a deleterious (harmful, negative, unwanted) trace element in steel, which must be strictly controlled. The removal of phosphorus in steelmaking is more difficult than is the case with sulfur. The BOF process offers the conditions conducive to oxidation of phosphorus-oxidizing atmosphere and high slag basicity. On the other hand dephosphorization in a BOF vessel is necessary not only to meet the increasing demand for low-phosphorus steel, but also to compensate for increasing phosphorous in hot metal caused by high [%P] ore.

Reducing phosphorus content in the steel is one of the critical factors to enhance the steel properties. In the recent times, lowering of phosphorus content has become a highly critical requirement for steels used in thin sheets for deep drawn applications, automobile exteriors, pipe lines for transportation of natural gas and petroleum products or heavy plate for shipbuilding.

It is well known that, the dephosphorization efficiency in steelmaking process is related to the different models of equilibrium phosphorus partition ratio (L_P) available in the literature. Because of this, the goal of this work was to compare results given by applying common acceptable Healy's, Young's, Suito-Inoue's, and Turkdogan's models for prediction of phosphorus partition coefficient between slag and steel. The present paper is focused on the basic thermodynamics calculation of dephosphorization. Twenty heats were employed in this study. The samples of liquid steel and slag were collected at the end of blowing process before tapping in real production conditions. It was found that Suito-Inoue's model gives a better prediction of phosphorus partition ratio (Lp) in comparing to others (Lp) prediction models.

Key words: Phosphorus, BOF-Slag, oxygen activity, L_P-phosphorus partition coefficient

THE EFFECT OF SLAG OXYGEN POTENTIAL ON FINAL SULFUR STEEL LEVEL AT THE END OF VACUUM LADLE TREATMENT

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Abstract

Production of low sulfur steel is a challenging problem due to fact that there is an increasingly demand for clean steel. Except in free-cutting steels, sulfur is considered to be a harmful impurity since it has an important influence on the mechanical properties such as impacts ductility, toughness, weldability and hot shortness in steels. The steelmaking technology has always been focused on the removal of sulfur from metal to slag during the steelmaking operation to the lowest possible level. With rising demand for high quality 'clean steel' modern steelmaking technology has been faced with the requirement to produce steel with the fewest ppm of sulfur possible. Based on the production route and the type of steel products, desulphurization could be done at different points in the steelmaking processes. It is well known that an important thermodynamic parameter which influences on the desulphurization process apart from the slag composition is the oxygen potential of the slag-steel system. Because of this the aim of this work is to show whether the oxygen potential of 31 analyzed ladle slag-steel heats has influence on the final steel sulfur level. The effect of slag oxidation potential on the final sulfur level after deep vacuum ladle treatment is investigated using thermodynamic calculations and industrial test. The results show that to obtain steel sulfur content $[\%S]_{max}$=0.001, the ($\%Fe_{tot}$.+%MnO) content in the ladle slag should be less than 0.9% , the sulfur distribution coefficient (Ls) higher than 1000 and the sulphide capacity in the range Cs=0.0161-0.0287.

Key words: Sulfur, Slag, oxygen activity, Ls-sulfur distribution coefficient, ladle treatment

OPTIMIZATION OF TENSILE STRENGTH USING RESPONSE SURFACE METHOD FOR PdNi5 WIRE

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The aim of this work was to assess the optimal conditions for PdNi5 wire processing parameters, based on factorial design applied to experimentally obtained data. Six important factors of thermo-mechanical treatment with three factor level were used as the input variables and experimentally obtained tensile strength of PdNi5 wire was taken as the output variable. The optimum operating parameters were predicted using the RSM method and confirmed through experiment. It was found that the linear and quadratic coefficient of the final wire diameter had the strongest effect on the tensile strength of PdNi5 wire in order to make Pd catalysts-catchers

Keywords: PdNi5 alloy, tensile strength, catalysts-catchers, factorial design

THE EFFECT OF ALLOYING ELEMENTS ON CREEP RATE AND TEARING TIME OF PLATINUM AT HIGH TEMPERATURES

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The unique complex of physical-chemical and mechanical properties – the increased corrosion resistance in different environments, catalytic activity, stable electrical, thermoelectric and emission characteristics - make the tripartite system alloys Pt-Rh-Pd as irreplaceable construction materials in the modern industries. The alloys of this triple system are primarily used in the conditions of high temperatures and stresses.

This work presents the results of creep rate and tearing time the alloys of the system Pt-Rh-Pd, with platinum as the basic element and alloying elements: Rh up to 15% and Pd up to 60% by weight. Tests were carried out in the temperature range from 20 to 1700 °C and stresses of 2-13 MPa. It is shown that the increase in rhodium content in the alloy, at constant content of palladium, causes a noticeable drop in the value of creep rate with simultaneous increase of tearing time.

Keywords: Pt-Rh-Pd system alloys, creep rate, tearing time, high temperature, stress

OPTIMIZATION OF HEAT TREATMENT PARAMETERS IN RETROGRESSION AND REAGING TREATMENT OF ALLOY EN AW 7075-T6

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Retrogression and reaging heat treatment (RRA) process is applied to the high strength aluminum alloy 7075 in the T6 state, to improve its toughness without or with small loss of maximum strength acquired from the initial T6 state. The retrogression treatments are performed at different temperatures and holding times, and the subsequent reaging is preformed at 120 °C for 26 hours. Mechanical properties (hardness, tensile strength and toughness) of the alloy EN AW 7075 are studied depending on the temperature and the holding time of the retrogression heat treatment. Compared to initial T6 state, after applied RRA treatments, it was shown that with increasing temperature and holding time of the retrogression hardness reduces, maximum strength reduces slightly and increases toughness.

Keywords: Aluminium alloy EN AW-7075, Retrogression and reaging heat treatment, hardness, strength, toughness.

HARDNESS AND ELECTRICAL CONDUCTIVITY PROFILES OF Ag-Bi-In ALLOYS AT 100^{O}C

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In the past decade a lot of research work has been done in order to find promising lead-free solder materials. The studies published so far suggest that an adequate replacement for classical lead solders may be found within Sn based alloys. At present, some of the quaternary Sn-Ag-Bi-In alloys seem to be the best alternative among the selection of other Pb-free solder systems. Accordingly, in recent years ternary sub-systems (Ag-Bi-In, Ag-Bi-Sn, Ag-In-Sn and Bi-In-Sn) of the Ag-Bi-In-Sn system have been attracting a lot of attention. In view of potential applications and insufficiency of literature data, in the present study the Ag-Bi-In system was investigated in terms of mechanical and electrical properties of ternary alloys from an isothermal section at 100^{o}C. Phase diagram of the Ag-Bi-In ternary system at 100°C was predicted using thermodynamic calculation of phase equilibriums based on CALPHAD method and latest thermodynamic parameters from COST 531 database. The calculated isothermal section was corroborated by results of X-ray diffraction analysis and additionally by the results of microstructural analysis carried out by using scanning electron microscope with energy dispersive spectrometer. Information about the hardness of the alloys of the ternary Ag-Bi-In system was obtained using Brinell test method while electrical conductivity was measured using eddy current instrument. Studied alloy samples were selected from three vertical sections Bi-$Ag_{0.25}In_{0.75}$, Bi-AgIn and Bi-$Ag_{0.75}In_{0.25}$ of the ternary Ag-Bi-In system. On the basis of the experimentally obtained results iso-lines of Brinell hardness and electrical conductivity for all ternary alloys of the Ag-Bi-In system at 100^{o}C were calculated by applying appropriate mathematical model. The obtained results represent rather important information from the application point of view as they provide direct insight and enable evaluation of these ternary alloys in terms of their possible application as environmentally acceptable electronic materials.

Keywords Ag-Bi-In system, phase composition, Brinell hardness, electrical conductivity

Acknowledgement

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INVESTIGATION OF MECHANICAL AND MICROSTRUCTURE CHARACTERISTIC OF MICROALLOYED SHIPBUILDING STEEL AH36 IN DIFFERENT WELDING METHODS AND POSITIONS

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In this study, grade A ship steel having chemical composition of 0.125% C, 0.71% Mn, 0.149% Si and 98.85% Fe has been employed to transverse dual-phase steel. In order to produce the dual-phase steel, Grade A steel was accomplished by intercritically annealing at intercritical temperatures area (730-760-800 ^{o}C and 900 ^{o}C) and following by water quenching. It was determined how the martensite volume fraction (MVF) depending on the intercritical annealing temperatures can change. The results show that the tensile strength and elongation of dual phase steels is higher and lower than that of the original (as-recieved) Grade A steels, respectively. While the martensite volume fraction of dual phase steel increase, also the tensile strength increases but the elongation decreases.

Keywords: Grade A ship plate, Dual-phase steel, Tensile properties, Martensite volume fraction (MVF)

SHINING PROPERTIES AND ABILITY FOR LASER WELDING OF COLD ROLLED STRIPS FROM 585 GOLD ALLOY

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Abstract

Noble metals are, however, non-oxidizing elements and obviously possess high reflectance. Their products must have at least the minima contest of used noble metals, as it was defined by all national standards and trade regulations. Jewels alloys from relatively soft noble metals should be enough strong and hard. In jewelry, from golden products&coatings commonly is expected to be shine, as a visual quality. In many production methods of jewels, as casting, rolling, drawing, hammering, etc., the question of shining of working material is inferior but for final jewel product this demand is strongly emphasized.
In most welding techniques of golden products, especially in long term used techniques-one of them is gas welding, the high reflectance (shining) of the surface before welding (or brazing) practically does not represent an important factor. But, during laser welding of noble metals, the high shining property is just undesirable. Laser beam in its nature is high energy beam and is subjected to optical laws, what is of importance for manipulations.

Metallurgical demands (melting, alloying, working processes) about some noble metals were studied pretty well but not so much their optical properties, i.e. reflectance. Here are discussed the shining properties of golden alloy 585 in a strip form, further intended to laser welding. This golden alloy previously is cold rolled and then laser welded. For achieving the better results of laser welding those gold rolled strips are coated with an absorption layer for decreasing the high level of reflectance. The reflectance is measured by using a mineralogical microscope at daily light. Welding of cold rolled 585 gold alloy strips is provided by using Nd^{3+}:YAG laser system, with wavelength of λ=1,06μm.

Keywords: 585 gold alloy, surface properties, reflectance, laser welding

SURFACE DAMAGES AND FRACTURE OF CRANK SHAFT FROM ONE FAST PRESS FOR DEEP DRAWING OF CANS

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Abstract

Presses for deep drawing commonly operated in slow regime. Here, fast deep drawing machine means that drawing of orthosymetric cans is provided in regime of more than 300 pieces per minute. Only from this point of view becomes clear that crank shaft of a drawing machine/press is highly loaded element. Next characteristic of this shaping method is large serial production of cans, because the drawing press is engaged 0-24h a day, over months and a year. Such deep drawing regime produces high dynamical stresses. Torsional stiffness is one of the most important facts in crankshaft design, it means that forces imposed on a crank-shaft must be well studied. At those working circumstances, the crank shaft of this deep drawing press should be designed very carefully. Metallurgical and/or servic-ing demands for choosing an appropriate material for manufacturing the crankshaft are reasonable. Steel for examined crank shaft belongs to a group of medium carbon (≈0.4%) structural steels, alloyed with chromium and molybdenum. But, instead of design and material selection the crank shaft also must be very carefully heat treated.

So, damage even a fracture of this type of machine element in de-scribed working conditions may be expected. Here will be shown some examples of surface damages and fractured surface at the end of crank shaft. Checking of cracks is inspected by using a magnetic particle method. Main journals are rotate causing rotation of rod journals. Fracture was initiated and finally is happened at main journal, which outer diameter was 101,6mm, and surface hardness values were in range 330±25HRB2.5. Pretty small radii at main journal is one of reasons for fracture appearance at this position. The fatigue strength of crank-shafts usually is increased by using a larger radius at the ends of main or bearing journals, for the same heat treating regime.

Keywords: crank shaft, magnetic particle inspection, cracks, fracture.

THERMODYNAMIC ANALYSIS ON COPPER(II) HYDROXIDE PRECIPITATION IN THE SYSTEM OF Cu-Cl-H_2O

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Abstract

Using HSC Chemistry software and its database, the potential-pH diagram of Cu-Cl-H_2O system has been constructed. It was constructed with fixed value of chloride ions activity corresponding to 3.5% NaCl solution. The solution is standard replacement for seawater in corrosion, reverse osmosis and environmental investigations. It was discussed using the available thermodynamic and electrochemical data. Equilibrium of Cu(II) hydroxide in water has been analyzed with different literature data. Different values of solubility product constant changes the stability areas of the spices. Correction of the diagram was performed manually based on calculations in the present study. It was shown that stability area of Cu(I) chloride complex ion should be extended.

Keywords: thermodynamic, Eh-pH diagram, copper(II) hydroxide, solubility

SOME POSSIBILITIES OF COST REDUCTION IN BOF STEELMAKING

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Abstract

The sustainability on the market requires from steel producers permanent activities to reduce production costs. These activities can be simply classified into the following three groups: a) the modernization of metallurgical equipment and technology, b) continuous improvement, and c) optimization within the existing technological practices. The subject of this paper is a consideration of the two examples of possible optimization in the BOF steel shops, depending of its metallurgical equipment. In shops with hot metal desulphurization and without possibility of deep removing of sulfur from liquid steel in the ladle, the desired effect of the desulphurization can be optimized by a choice of the relationship between the content of the remaining sulfur in hot metal after desulphurization and the degree of its removal in the BOF process by manganese from the hot metal. The reason for this is well known positive impact of manganese on the sulfur distribution coefficient in the converters. In shops without static dynamic models for BOF control (SDM), and without a device for liquid steel heating, the largest effects in terms of cost reduction can be achieved by optimizing the target temperature at the end of oxygen blowing. The optimization is based on a comparison of the positive effects of lower temperatures at the end of oxygen blowing and negative effects of the re-blowing and cold heats (costs of repeated process, interruptions of casting sequences, etc.). For those shops where the standard error in the temperature control at the end of the blowing is very large, the techno-economic justification of the transition to the “Intermediate Stop Practice” (ISP) should be considered.

Key words: BOF steelmaking, cost reduction, optimization, sulfur, temperature

INTELLIGENT SYSTEM FOR AUTOMATIC CONTROL OF THE PROCESS FILLING THE MOLD

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Abstract

This paper show an fuzzy and neuro – fuzzy intelligent systems for automatic control of mold filling employed in casting plants. The concept of precision mold filling presupposes three key points in the process i.e. precise pouring of the stream into the basin, maintaining constant level of molten metal in the basin and finally, elimination of overflow of molten metal from the mold. Fuzzy and neuro-fuzzy control of casting process was tested through many experimental attempts which have confirmed the possibility of application of these methodologies in the control of gravity casting process.

Keywords: Casting, Molten Metal, Simulation Fuzzy Logic Control, Neuro-fuzzy Control

THERMODYNAMIC CALCULATIONS AND CHARACTERIZATION OF THE Bi-Cu-Ni TERNARY ALLOYS

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The Bi-Cu-Ni ternary system is a very significant, because its alloys belong to the group of potential Cu-Ni-based advanced lead-free solder materials for high temperature application. This system represents environmental friendly alternatives to Sn-based solders which has been examined recently in the frame of COST MP0602 “HISOLD” project [1] and has been described in two recent references [2,3]. The results of thermodynamic predicting using general solution model and experimental investigation of thermal, structural and electrical properties based on DSC, SEM-EDS and electroconductivity measurements of the alloys selected in the Bi-CuNi section from bismuth corner with molar ratio Cu:Ni = 1:1, are presented in this paper.

The results of thermodynamic predicting, including integral molar Gibbs excess energy and calculated bismuth activities at the temperature of 1273K, are shown in this paper. Also the results of thermal analysis, performed using DSC and measured during the heating stage, are presented. Structural analysis was done using SEM-EDS method confirmed that the Bi–Cu–Ni system consists of five phases (liquid, RHOMBO_A7 (Bi), FCC_A1 (Cu,Ni), BiNi and Bi3Ni), which is in accordance to its crystallographic data, given in [4]. From the results of electrical conductivity measurements it can be noticed that increase of bismuth content influences decrease in electrical conductivity for all samples in the investigated section.

Keywords: Bi-Cu-Ni ternary alloys; lead-free solders; thermodynamic predicting; characterization

Acknowledgements

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ION CONDUCTIVE GLASS-CERAMICS IN THE SYSTEM $Li_2O{\cdot}Al_2O_3{\cdot}GeO_2{\cdot}P_2O_5$

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Abstract

Lithium based solid electrolytes are mainly useful for utilization in high energy density batteries, supercapacitors, sensors, displays and electrochemical devices. They generally crystallize in rhombohedral R3-c(167) space group related to open structures and the monovalent Li^+ cation can easily migrate in lattice with low activation energy. These materials are usually obtained by powder sintering route and the crystallization of these glasses.

The studies of crystallization of $Li_2O–Al_2O_3–GeO_2–P_2O_5$ glasses showed that one of dominant crystal phase precipitated in glass matrix is NASICON - type $LiGe_2(PO_4)_3$ crystals. It was detected that this glass crystallizes by the volume crystallization mechanism. The enthalpy of crystallization ΔH_{cryst}= -48.36 kJmol^{-1} was determined. The density of the crystalline phase was ρ=3.52 gcm^{-3} and molar volume V_m = 121.09 ·10^{-6} m^3. The ionic conductivity of the test phase which belongs to the solid solutions is about 6.2· 10^{-6} Scm^{-1} at room temperature.

It may be considered that the structure of this glass consists of GeO_6 octahedra and PO_4 tetrahedra. The basic unit of this glass consists of two GeO_6 octahedra and PO_4 tetrahedra corresponding to $[Ge_2(PO_4)]$. Each GeO_6 octahedron is connected to three PO_4 tetrahedra, each of which is linked to four GeO_6 octahedra.

These units in turn are connected to form ′ribbons′ along the *c*-axis and the ribbons are joined together along the *a*-and *b*-axis by PO_4 tetrahedra. This structure results in cavities where lithium ions reside and in bottlenecks in which they pass through.

Keywords: glass, glass-ceramics, nasicon, crystallization

SPHALERITE PASSIVATION DURING THE LEACHING IN SODIUM NITRATE AND SULPHURIC ACID SOLUTION

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Zinc is extracted from sphalerite and complex concentrates by pyrometallurgical or hydrometallurgical processes, whereby the hydrometallurgical processes have received considerable attention in recent years. Thair application provide better metal recoveries and reduced emission of gaseous and toxic agenses in the environment. This paper studies the leaching process of the sphalerite with sodium nitrate in sulphuric acid solution. Chemical reactions of leaching and their thermodynamic probabilities are predicted based on the calculated Gibbs energies and analysis of E-pH diagrams. Thermodynamic analysis, experimental data, chemical, XRD, TG/DTA, and SEM/EDX analyses for the phases present in both the complex concentrate and leach residue were performed to determine the leaching process. Elemental sulphur is the main solid product of reaction, and a minor amount of sulphide sulphur is oxidized to sulphate during the leaching. It also indicates that the sulphur precipitated at the particle surfaces, and slowed down the rate of the leaching process.

Keywords: leaching; sphalerite passivation; elemental sulphur; sulphuric acid; sodium nitrate

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AGRICULTURAL WASTES AS LOW COST MATERIAL FOR HEAVY METALS REMOVAL

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Removal of Pb(II), Cu(II) and Zn(II) from aqueous solutions by low cost agricultural wastes was investigated.

The effect of the initial pH value, biomass dosage, initial metal concentration and contact time was investigated in batch system. It is found that metal uptake increased with increasing the initial pH value, initial concentration and contact time but decreased with increasing biomass dosage. The optimum pH value for biosorption process of the metal ions was found to be ranged from 5.0 to 6.0 for all investigated materials.

The experimental data well fitted to the Langmuir isotherm model. The maximum biosorption capacities of investigated agricultural waste materials followed the order: Pb(II) > Cu(II) > Zn(II). Kinetic data well fitted to the pseudo-second-order kinetic model. The kinetic study revealed that biosorption process is fast.

Desorption study was done due to of the need to recycle metal loaded materials and dispose them. Obtained results revealed that investigated agricultural wastes after biosorption process can be efficiently recovered with diluted HNO_3.

From obtained results and their comparison to different biosorbents reported in literature it can be concluded that investigated agricultural wastes can be used as natural, low cost, effective and ecofriendly materials for heavy metals removal from water solutions.

Keywords: agricultural wasters, biosorption, heavy metals, desorption study

RESEARCH FOR BETTER Al ALLOYS MICROSTRUCTURE

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The as cast ingots quality is of great importance because it implies a greater efficiency of Al alloys production process. Al alloys are characterized by a number of defects that occur during the solidification process such as: porosity, hot cracks, non-uniformal grain size and crystal segregation. The application of electromagnetic field during the vertical continual casting process can significantly reduce the occurrence of these errors. The presented results were obtained from examination of 7075 Al alloy samples cast with and without electromagnetic field.

In this work the attention is given to microstructure characterization using optical microscope and SEM. The samples obtained by electromagnetic casting process, especially with frequency of 20 and 30 Hz, have finer and more homogenous microstructure than the sample obtained without electromagnetic field influence.

The grain size measuring is also done and the relation between electromagnetic field frequency and grain size is given.

The results of electrical conductivity test reveal the higher conductivity of samples obtained with influence of electromagnetic field in comparison with sample obtained by conventional casting process.

Keywords: Al alloy, electromagnetic field, microstructure

MICROSTRUCTURAL CHARACTERIZATION OF Cu-Al-Mn SHAPE MEMORY ALLOY AFTER ROLLING

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In this paper, the microstructure of Cu-8.3%Al-9.4%Mn (in wt%) shape memory alloy after cold and hot rolling was investigated. The Cu-Al-Mn alloy was produced by vertical continuous casting method in form a cylinder rod of 8 mm in diameter. After the casting the cold and hot rolling was performed. Hot rolling obtained the strip with thickness of 1.6 mm, while cold rolling produced strip with thickness of 1.0 mm. After rolling process the heat treatment was performed. The heat treatment was carried out by solution annealing at 900 °C held for 30 minutes and water quenched immediately after heating. The microstructure characterization of investigated alloy was carried out by optical microscopy (OM), scanning electron microscopy (SEM) equipped by device for energy dispersive spectroscopy (EDS) and thermal analysis (DSC). The homogenous martensite microstructure was confirmed by OM and SEM micrographs. Phase transformations temperatures were determined by differential scanning calorimetry (DSC).

Keywords: shape memory alloy (SMA), continuously casting, microstructure, heat treatment, rolling

WASTE WATER TREATMENT: RHODAMINE ADSORPTION BY GRAPHENE OXIDE NANOMATERIAL

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Carbon exists in different forms such as graphite, diamond, graphene, carbon nanotubes etc. These different forms of carbon have entirely unique properties and thus find ample diverse applications in various technological devices. It is known that, crude form of graphite, called charcoal, is used in mass separation technologies since centuries. Graphite and charcoal has important applications in waste water treatment. This paper reports the study of the synthesis of graphene oxide by means of modified Hummer's method and it's applications in waste water treatment for eradication of Rhodamine 6g dye. The study reports the adsorption capacity of such is dye analyzed by means of UV spectroscopic techniques. The characterizations are carried out by means of XRD, FTIR so as to know crystalline nature and functional groups. It is reported that Graphene oxide synthesized in lab had shown to provide more than 85% Rhodamine adsorption capacity. Graphene oxide is found to be suitable for selective adsorption and seems to be ideal material for waste water treatment particularly for the adsorption of hazardous dyes.

Keywords: Graphene oxide, Rhodamine 6g, Waste water treatment

AN ANALYSIS OF INTERMETALLIC BONDING BETWEEN A RING CARRIER AND ALUMINUM PISTON ALLOY

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Abstract

This paper presents the results of an analysis of the formation of an intermetallic bond between a ring carrier and an aluminum piston alloy. A metallographic investigation using an optical microscope in combination with the SEM/EDS analysis of the quality of the intermetallic bonding layer was done. The test results show that if the proper conditions are met, the preparation of the ring carrier can be made successfully, as can the formation of the metal connection between the two materials of different qualities.

Key words: piston alloys, ring carrier, intermetallic bond, Ni-Resist, Al-Fin process

LEACHING OF NICKEL FROM RŽANOVO'S LATERITIC ORE

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The subject of this research is characterization of low-grade nickel-bearing lateritic ore originated in Ržanovo near Kavadarci, R. Macedonia and leaching of nickel. Characterization of the ore was studied by means of XRF spectroscopy, X-ray diffraction, AT-FTIR spectroscopy, thermal (TG and DTG) analysis, SEM observation and measurement of the Zeta potential. Ni content in the used ore was 0.85 %. After crushing and milling, sieve analysis has shown that the highest content of Ni (0.92 %) was concentrated in the lowest size fraction of –0.037 mm. To reduce the content of Fe, magnetic separation was performed. Non-magnetic fraction (94.3 %) contained 1.03 % of Ni and 16.76 % Fe. Thus the treated ore was leached in sulfuric acid with different concentration and different temperatures. The highest extraction of Ni of 84.2 % was achieved using 3 M H_2SO4 at 363 K for 120 min. Kinetic of the leaching process was analyzed using results obtained in 3 M H_2SO4 at different temperatures: 298, 323, 348 and 363 K. A few models corresponding to chemical reaction or diffusion through product layer were tested. The Jander model has shown the best fitting of the experimental results indicating diffusion control of the nickel dissolution from the studied lateritic ore. Activation energy of leaching process was calculated to be 42.65 $kJ \cdot mol^{-1}$ and corresponds to the rate of limiting diffusion process.

Keywords: lateritic ore, nickel, leaching, kinetic study.

CONTRIBUTION TO THE STUDIES OF CHEMICAL PROCESSES OCCURRING AT CONTACT SURFACE LIQUID METAL-MOLD

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During the casting of metals at the interface between metal and mold, or contact surface metal-mold, some chemical reactions occur. Reaction products penetrate or move toward the mold as well as toward the castings.

In this work the chemistry at the contact surface between the metal and mold was studied. The objective of the work was better understanding of the chemical reactions that occur, at the interfaces, during the casting processes. All experiments were performed, both, on a laboratory and industrial scale, using the steel samples DIN; the steel samples came from the steel casting industrial plant production list. The molds were made using the CO2 procedure. Some active components were added to the mold mixture.

During the casting process, while liquid metal enter into the mold vacancy, a kind of intensive reaction of liquid metal with quartz sand and added active components occur thus forming a new chemical compounds. These compounds have an important influence on the steel castings quality, and consequently on the production economy.

Keywords: reactions; surface; contact; metal; mould

HEAT BALANCE CALCULATION FOR FREEZE LINING SMELTING PROCESS

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Abstract

Simulating the furnace processes can lead to the minimal energy loses and optimal temperature distribution through the system. Freeze lining is a result of balance between the heat input from liquid bath and heat removal from outer layer. In that manner, solid slag crust is formed with good mechanical properties. At this paper freeze lining for the plasma smelting process was simulated using COMSOL software package. For smelting material corundum with the addition of other materials was used. Smelting is possible if the heat balance is properly calculated. Colling rate will control the layer thickness and inner temperature.

Keywords: Heat balance; freeze lining; COMSOL.

REVALORIZATION OF FOOD INDUSTRY WASTE

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Various industries, such as mining, smelting, electroplating, energy and fuel production, etc., produce and discharge waste containing different heavy metals into the environment. This presents serious threat both to environment and human health. Heavy metal pollution is one of the most important environmental problems today because of non-biodegradability and possibility of metal accumulation in living organisms. Most commonly used techniques for removing heavy metals from wastewater have certain limitations which have induced necessity for developing low-cost processes. Application of cheap and abundant low-cost polymers in sorption process represents one of the promising techniques for heavy metal removal, especially at its low concentrations.

On the other hand, worldwide depleting of non-renewable energy sources are causing a serious economic and environmental threats, leading to intensive research and investments in renewable resources. The most important source of renewable energy in Serbia represents biomass, where almost half of this potential is agricultural and industrial waste. Most of these wastes are disposed at open landfills with negligible revalorization. On the other hand, electricity production in the Republic of Serbia is still based on the combustion of low – rank domestic coals in thermal power plants and utilization of available hydro potential.

Peach (*Prunus persica* L.) has an important role in Serbia's fruit production with average annual production in 2016 of 96502 t that generates more than 18000 t peach stone (PS) waste. This kind of lignocellulosic waste has been proven as renewable source of many chemicals, components and biofuels.

For all the reasons previously described, the authors have investigated the possibility of application of this cheap, wasted material from food industry in sustainable manner-first as heavy metal sorbent and later as fuel based on energy renewable source. For this purpose, sorption experiments with different heavy metals (Cu, Pb, Zn, Cd) were conducted, and after desorption process, the exhausted sorbent was thermally degraded. Sorption and energetic characteristic were investigated using FTIR, SEM and TG techniques. Obtained equilibrium results confirmed possible application of this waste material as a heavy metal sorbent, while the kinetic parameters calculated from thermal degradation results, confirmed its possible application as a fuel.

Keywords: heavy metals pollution, sorption, desorption, thermal degradation, fuel

EFFECT OF MICROSTRUCTURE AND MECHANICAL PROPERTIES OF AUSTENITIZING TEMPERATURE AND COOLING CONDITIONS OF FERRITIC/PERLITIC BORON ALLOY STEELS

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Results showed that hot stamping process transformed the ferritic-pearlitic microstructure in the as-received state into martensite or martensite-bainite after press hardening and caused substantial increase in the strength in expense of ductility and impact strength. The aim of this study is determine both the mechanical properties and transition temperature. The microstructure analysis and hardness measurement was realized. Also, charpy test was performed at temperature range from (-60^{o}C) to (+60^{o}C) for establishing the transition temperature of the material.

Keywords: Hot stamping, 22MnB5 steel, phase structure, hardness, charpy test

ROOT CAUSE AND ORIGIN OF DEFECT “GREASY STAINS”ON TINPLATE, ANNEALED AT BATCH ANNEAL (BA)

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Abstract

In the metallurgical process of the tinplate final production (rolling, electrolytic cleaning, annealing), different surface defects can occur, which degrade quality of the strip. All known defects are systematized and processed (by description, place of origin and cause of defects) in the Catalogue for cold–rolled products, where corrective measures are listed for the purpose to eliminate them. In this study the research carried out for completely unknown defect, called “greasy stains”, which appeared on the tinplate, after electrolytic cleaning, during annealing on the Batch Anneal. It was found that (for reason of improving the dirty strip) Electrolytic cleaning line changed cleaner solution which, unlike the previous one, contained silicate additive inside. Therefore it was no longer a need for the use of inhibitors, whose role was to prevent the diffusion of carbon and graphite during the process of recrystallization annealing low carbon steel, by Surface Unsuitable for Tinning, (SUFT) mechanism. Lack of inhibitor, in combination with the increase of content dirties (especially oil), into the cleansing solution, created the conditions for the occurrence of defect during the process of annealing on the BA. Increase dirties is the results changes of concentration, depending on the operating mode of the CAL. Adding additives, which chemical reaction binds to carbon and evaporates in the process of annealing, and changing process of CAL (they are equal concentrations of cleaning solution, whatever mode CAL), the defect is eliminated.

Keywords: Inhibitor, additive, diffusion of carbon, recrystallization annealing

POTENTIAL ACHIEVEMENT OF LOW CONTENT OF S IN STEEL INTERNAL QUALITY KJ02, EXTERNAL QUALITY S235J2+N AND S235J2C+N

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ABSTRACT

One of the most important trends in steelmaking development is to produce as cleaner metal as possible, together with improvement of its properties. Content of Sulphur plays one of the most significant roles among properties that define "pure steel", but it is also valuable condition for reaching high ductility steel that enables construction of lighter steel structures and higher load capacity. That is why actual S contents in trial production of KJ02 internal steel quality grade can contribute to reviewing and estimating of potentiality and reliability of large-lot production, economy efficiency of production and potential extension of product assortment of Hesteel Serbia Iron & Steel, for those markets where there is strong demand for such kind of product.

Beside very efficient technology for desulphurization of hot metal by injecting magnesia (Mg) and lime in certain ratio, as well as through series of processes for desulphurization of steel in a steel ladle, final extremely important fact is amount of S brought into BOP Shop process and the level of its transfer to slag and gases.

To measure efficiency of reaching required low content of S in metal at the end of melting process, the following facts were considered: S content in hot metal, technical capabilities of Desulphurization station and the level of desulph process, efficiency of skimming BF slag from a ladle after desulphurization of hot metal and before it is prepared for BOP. HM preparation and efficiency of BOP directly impact S content at the end of melting process, in steel samples before teeming, actual transfer of S from metal to slag (Ls) during melting of heats and alloying in a steel ladle. For overall estimation of potential success of managing with S content and reaching its low content in steel (taking into consideration levels and variation of bringing S with other components of a charge apart from hot metal), content of S in hot metal prior desulphurization and BOP Shop process must be prescribed.

This study presents results of trial production of KJ02 internal steel quality grade, with low S content (max 0.006%).

Keywords: Sulphur, Magnesium, Desulphurization

IMPROVEMENT OF MECHANICAL PROPERTIES AND IMPACT RESISTANCE OF ZrO_2/PMMA NANOCOMPOSITE BY DIFFERENT SURFACE TREATMENT OF ZIRCONIA OXIDE

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Dental nanocomposites based on poly(methyl methacrylate) (PMMA) matrix reinforced with zirconia oxide nanoparticles (ZrO_2) were prepared by in-situ free radical polymerization. Surface functionalization of ZrO_2 was performed by using silane coupling agents with vinyl and methacryloxy organo-functional groups. Nanocomposites based on 1, 3 and 5 wt.% of nanoparticles were processed and characterized. FTIR spectrometry was employed in order to characterize functionalized surface of zirconia oxide and to evaluate chemical interactions between the fillers and matrix in nanocomposites. Micro Vickers hardness showed significant improved resistance to indentation of dental nanocomposites when modified nanoparticles were employed. Obtained SEM images showed that silane coupling agents enabled effective dispersion of nanoparticles in matrix. Thermal properties of nanocomposites were analyzed by thermogravimetric analysis (TGA). Low energy impact test was performed in order to determine the mechanical properties of nanocomposites. The use of modified ZrO_2 in fabrication of nanocomposites led to improved thermal, mechanical properties and resistance to impact compared to the nanocomposites reinforced with unmodified particles.

Keywords dental nanocomposites, impact resistance, silane coupling agent, surface functionalization, zirconia oxide

POLYMER COMPOSITE FILM ON THE METAL SURFACE ADHESION TESTING

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Abstract

Adhesion of composite films on metal support is a very important parameter in various fields of materials science research. Classical pull tests for adhesion are sometimes unavailable as they have limits in terms of chemical composition of the adhesive and the strength of adhesion force. Alternative methods to measure adhesion in function of the composition of the film are used in those situations. The objective of this study is to investigate quantitative assessment of the strength of adhesion between the composite films composed of UV-light curing (BisGMA (bisphenol A glycidyl methacrylate), 49.5% TEGDMA (triethylene glycol dimethacrylate), 49.5% CK (Camphorkuinone) 0.2% of a 4EDMAB (ethyl-4-dimethilaminobenzoate), 0.8%) polymer and the aluminium oxide based particles as a filler and reinforcement on metallic surfaces. Composites were made with different content of inorganic particles 3, 5 and 10% of the particles respectively. Films were subjected to cavitation that is a non-stationary process by which the material is separated from the solid surface. This is called cavitation erosion and the resulting damage is termed cavitation damage. The progression of damage observed in films is considered to be in correlation to the adhesion force between the film and the substrate.

Keywords: Dental ceramics, Adhesion, Cavitaion erosion

EVALUATION OF CORROSION AND MECHANICAL PROPERTIES OF BIOPOLYMERS COATED POROUS MAGNESIUM SCAFFOLDS

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Abstract

Porous Magnesium scaffolds are recently being used as a biodegradable implant material as tissue engineering scaffolds. The main problem of using Mg scaffold in medical applications is its rapid corrosion rate. The present work, gives brief review about corrosion rate of biopolymer coated Mg scaffolds. To analyse the patterned layers, SEM images and X-ray diffraction (XRD), Energy Dispersive X-ray Spectroscopy (EDX) and Fourier Transformed Infrared Spectroscopy (FTIR) measurements were carried out. Corrosion behaviour was assessed by electro-chemical studies in Simulated Body Fluid (SBF) at 37°C. The results indicate that the Mg scaffold coated biopolymers exhibit excellent mechanical properties and corrosion resistance compared with that of Mg scaffold. The coatings formed the apatite layer on the surface and controlled the degradation rate of the Mg Scaf-folds. The biopolymer coating played a promising role in reducing the corrosion rate and enhancing the mechanical properties which further helped the scaffolds to withstand the compressive loads after invitro tests.

Keywords: *Mg scaffold, Invitro tests, biopolymers, mechanical properties, Electro-chemical studies.*

INVESTIGATION OF ABRASION PROPERTIES OF AGGREGATES USING IMAGE PROCESSING TECHNIQUE

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Abstract

Aggregates are widely known to be used as concrete and road building materials. Therefore, determining the chemical and physic-mechanical properties of aggregates plays an important role in the selection of aggregates.

This study was carried out on aggregates obtained by using jaw crusher in the laboratory within the scope of evaluation of natural building block wastes. Rocks of different origins are used. The abrasion characteristics of the aggregates were determined using a micro-dewal abrasion tool and image processing technique.

The relationship between the abrasion characteristics of aggregates and the properties of hardness, uniaxial compression strength hand indirect tensile strength are explained by statistical methods.

The success of the image processing technique to determine the abrasion properties of aggregates has been investigated.

Keywords: image processing, abrasion, aggregate, uniaxial, roundness.

MEASUREMENTS OF TECHNOLOGICAL PARAMETERS OF GAS FIRED CHAMBER FOR HAVY STEEL ROLLS HEAT TREATMENT

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Abstract

Within the sphere of work experimental activities, technical measurements of gas fired chamber furnace Bosio PP CP-70/1150, through the entire heat treatment process of HCS rolls was carried out. Measurements were performed in an industrial environment in the company Valji Štore d. o. o.

The main purpose of the work was to assess the operation of the gas fired chamber furnace Bosio PP-CP 70/1150 and its impact on the performance of demanding heat treatment.

Temperature measurements were taken during heat treatment process with additional thermocouples in different areas on the surface of the rollers, and at the same time temperatures were monitored in all heating zones of the furnace. With finite difference method and computer simulation we calculated temperature profile across the roll cross section. As regards the assessment of the furnace efficiency, temperature of all external walls of the furnace were measured. As part of the experimental activities were also carried out measurements of CO and NOx emissions to evaluate ecological integrity.

SURFACE MORPHOLOGIES AND TEXTURE OF OPAL MINERAL PARTICLES FROM KÜTAHYA AND ESKİŞEHİR DISTRICTS, NW TURKEY

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Abstract

This paper reports the relationships found between surface morphologies and texture of opal mineral particles. In this study three different opal mineral taken from different locations situated in around Eskişehir and Kütahya district, NW Turkey. The one and other outcrops in southeast of Sofça and east of Gökçekısık from Eskişehir. The last one outcrops in northeast of Belkavak from Kütahya. The XRD analyses revealed pseudocrystalline cristobalite (opal – CT) and pseudocrystalline tridymite (opal – C) as main mineral components of opals from Sofça, Gökçekısık and Belkavak districts. SEM images show that sphere texture and fibrous texture are found in the Sofça and Gökçekısık opals, on the other hand sphere texture in the Belkavak opal.

Considering that total average area of particles and average diameter in the medium for each opal, total average area of particles and ranked as Gökçekısık > K16 (Sofça)>K5(Belkavak) and average diameter as Gökçekısık>K16(Sofça)>K5(Belkavak). On the other hand, considering that roundness of particles and flatness in the meium for each opal, roundness of particles ranked as K16(Sofça)>K5(Belkavak)>Gökçekısık and flatness as Gökçekısık>K5(Belkavak)>k16(Sofca).

Keywords: Opal, texture, roundness, particle, sphere .

PRODUCTION OF DOUBLE REDUCED TIN PLATE THICKNESS 0.14mm AND 0.15mm

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Abstract

The world trend in the production of "light" cans imposed on us the obligation to manufacture sheet material thickness 0.14 and 0.15 mm. By 2015, we worked on trials and test production at our plants (Tandem Mill and DCR), and in 2015 we began with the regular production. In 2015 and 2016 the production of this material was at a level of 25.13% of the total production. Production of this material requires additional costs due to increased rolling oil consumption and reduced yield, but the final calculations of total costs and the price of this product showed the economic viability.

In 2015 19.278 t of this material was produced, and in 2016 28.042 t was produced.

In 2016, we went a step further and made a trial production of thickness 0.13 mm. In our facilities, the production was estimated as successful, and we now expect feedback from the customer who is testing this material on their production lines.

Keywords: tin plate double reduced, thickness 0.14 and 0.15 mm

SOLVOTHERMAL SYNTHESIS AND CHARACTERIZATION OF NANO-CRYSTALLINE NICKEL-FERRITE

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A solvothermal method has been investigated for the synthesis of nano-crystalline nickel-ferrite powder under mild conditions. The proposed method is based on the use of inorganic metal salts (nitrates) as precursors for metal oxides and ethanol as a solvent. The reaction was carried out in a stainless steel auto-clave at 200^{o}C and under 33.7 bar. Phase composition and crystallite size, mor-phology and magnetic properties of the obtained powder were determined by X-ray diffraction method (XRD PAN analytical X'Pert PRO MPD with CoKα radiation, using Full Prof software and ICDD database), ^{57}Fe Mössbauer spectroscopy, scanning (SEM) and transmission electron microscopy (TEM) and vibrating sample magnetometer (VSM). It was found that under the investigated conditions the obtained powder is still partially amorphous and that it contains traces of precursor salts. The powder is also characterized by very fine primary particles (10 nm) agglomerated in larger structures. After additional annealing at 900^{o}C the crystal-line structure was formed which corresponds to nickel-ferrite. These findings were additionally supported by the results of phase analysis and room temperature magnetic measurements.

Keywords: Nickel-ferrite, solvothermal reaction, nano-crystalline powder

Acknowledgement

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THERMODYNAMIC AND KINETIC INVESTIGATIONS OF THE SULFIDE COPPER CONCENTRATE ROASTING WITH AN INCREASED NICKEL CONTENT

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Sulfide copper concentrates represent a mixture of copper sulfides and other metal sulfides, which have to be removed during pyrometallurgical copper production. Thermodynamic prediction of the behavior of each concentrate component and kinetic analysis of the oxidation is essential for the sucessful managing of the roasting process.

This paper presents the results of thermodynamic analysis of the sintetic mixture of sulfide copper concentrate from the ore body "Veliki Krivelj" (Serbia) with 7 % Ni in the form of Ni_3S_2 (heazlewoodite). Prior to thermodynamic and kinetic investigations, chemical analysis of the initial concentrate, and quantitative mineralogical and XRD analyses of the initial mixture were done. Also XRD analysis was done for the roasting products, heated at 650 °C.

As a theoretical background for the obtained experimental results, phase stability diagrams for the Cu-O-S and Ni-O-S systems as functions of temperature were calculated and drawn. Possible reactions in the Ni-O-S system were determined for which were obtained the values of Gibbs free energies at 650 and 900 °C. Equilibrium composition diagrams for the molar ratios between gas and batch of 5:1 and 20:1 were constructed, according to which the behavior of the concentrate components was discussed and the reaction mechanism was proposed.

Kinetic analysis was done in the isothermal conditions using Sharp's method of reduced half-time reaction. It was found that the roasting process most closely matches with the kinetic function $\alpha^2 = k \cdot \tau$. Reaction rate and kinetic equation were also determined. The activation energy was found to be 49 $kJ \cdot mole^{-1}$, which indicates that the roasting process of the copper concentrate with an increased nickel content is a chemically controlled process, i.e. is carried out in the kinetic field.

Keywords: roasting, heazlewoodite, equilibrium diagram, oxidation, reaction rate

Acknowledgement

Authors are grateful to the Ministry of Education, Science and Technological Development for financial support of this research, which was done in the frame of the Project No. TR 34023.

IMPACT PROPERTIES OF HYBRID WOOD COMPOSITES

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Abstract

This paper investigated the processing of hybrid Wood-Plastic Composites (WPC), the moisture resistance, tensile and impact properties. Hybrid composite panels of WPC were made by pressure molding. Toluene-2,4-diisocyanate (TDI) and Fusabond® Du Pont WPC-576D (FB) were used as cross-linking bonding agents for modification of wood fibers. The hybrid composites were built by using PMMA to the wood pulp mass was 2:1. Influence of composite structure and the moisture absorption on mechanical properties was investigated. Moisture absorption was lower for composites with bonding agents. Mechanical testing revealed that modulus of elasticity and absorbed energy of deformation increased with bonding agents.

Keywords: Hybrid Wood-plastic composites; Compression molding; Moisture absorption; Mechanical properties

EFFECT OF MECHANICAL ALLOYING TIME ON CAVITATION EROSION BEHAVIOR OF COPPER MATRIX COMPOSITES HARDENED WITH VARIOUS PERCENTAGES OF ZrB_2 PARTICLES

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The hardening of copper and copper matrix composites by using powder metallurgy (PM) techniques as well as analysis of their single and combined effects on mechanical and physical properties of obtained material at room temperatures have been presented and discussed. Mechanically alloyed powders Cu-Zr-B were consolidated by hot pressing (HP) in order to obtain copper matrix hardened with various percentages of ZrB_2 particles. Optical, scanning electron microscopy (SEM) equipped with an energy dispersive X-ray spectroscopy (EDAX) and X-ray diffraction (XRD) were used for characterization of morphological and elemental properties of treated compacts. Changes in mechanical alloying time show strong influence on mechanical properties and cavitation erosion resistance of Cu–ZrB_2 alloy. Cavitation erosion resistance was investigated with standard test method for cavitation erosion using vibratory apparatus. Obtained results using mass loss analysis and image analysis for level of degradation measurements confirmed strong influence of the activation time on cavitation resistance. Longer time of mechanical alloying provides a better distribution of micro and nano ZrB_2 particles which results in improved mechanical properties. After 120 minutes of cavitation testing, samples for MA 30 h (with 1 vol. % ZrB_2) reduces level of degradation for almost 50% comparing to starting Cu samples, but the highest reduction of degradation level (over 75%) reached the samples for 30 h MA (with 7 vol. % ZrB_2). Accordingly, compacts obtained with longer time of mechanical alloying show excellent cavitation erosion resistance.

Keywords: mechanical alloying, metal-matrix composite, hardness, cavitation erosion, surface analysis.

BFC® SOFTWARE FOR RAW-MATERIALS OPTIMIZATION IN BLAST-FURNACE SMELTING

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Abstract

BFC® is a mathematical model developed to design techno-economic parameters of a blast furnace process, both for current and strategic requests of a production and procurement manager. In addition to features provided by conventional models for similar purposes, BFC® enables the following: online calculation of required fine coke and fluxes quantities when preparing sinter or pellet for the designed blast furnace process; from different minerals or fuels that are available for purchase or for ongoing blast furnace operation, BFC® compiles a mixture that enables lowest production costs and technological requirements fulfilling; calculation of a minimal possible and an ideal coke consumption in order to select a coke reserve in the blast furnace more accurately. The developed software is suitable for application in the blast furnace modernization, when switching from mechanism management level to process management level. In the present paper, each ore, returning iron-bearing material and fuel is metallurgically-economically evaluated and ranked, in three Levels of Detail for metallurgical requirements (according to Fe content, global and complex evaluation). Afterwards, it was presented how to prepare optimized batch for blast furnace from a complex-evaluated material. Reduction of costs, which can be achieved by using BFC application for the complex evaluation, is considerably higher than in the case of utilization of present calculation methods for the burden materials.

Keywords: blast-furnace smelting; mathematical modeling; smelting parameters; iron-ore-bearing raw materials

MECHANICAL PROPERTIES OF TWO Al-Mg ALLOYS MANUFACTURED BY ACCUMULATIVE ROLL BONDING (ARB) PROCESS

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Abstract

The influence of alloying on the mechanical properties of AA5083 type Al-Mg alloy sheets produced by accumulative roll bonding (ARB) process was studied. Two investigated Al-Mg alloys: commercial AA5083 alloy with 4.2% Mg, and modified AA5083 alloy with 5.1% Mg and addition of 0.5% Zn, were supplied by Impol-Seval Aluminium Mill (Sevojno, Serbia) as hot rolled thick plates. Hot rolled plates were further laboratory cold rolled up to 1 mm in thickness, and ARB processed at room temperature with ~ 50% reduction per each ARB cycle. It was possible to conduct up to maximum 6 ARB cycles for a commercial AA5083 alloy and 4 ARB cycles for modified AA5083 alloy.

Hardness and tensile properties of ARB processed multilayered sheets were significantly improved with Mg and Zn addition. In the initial annealed state, before ARB processing, yield strength of the modified AA5083 alloy was only 15-20 MPa higher than for a commercial AA5083 alloy. However, flow stress level and tensile strength became higher for nearly 100 MPa after each ARB cycle for the modified AA5083 alloy in comparison with standard AA5083 alloy. The elongation decrease value was high after the first ARB cycle, while after subsequent passes it stayed almost constant, and slightly improved with Mg and Zn addition. Resistivity level was also affected by chemical composition of the tested alloys. Higher resistivity level obtained for the modified AA5083 alloy was attributed to higher Mg content and addition of Zn.

Despite the fact that addition of Mg and Zn limited the possibility of joining through ARB processing, mechanical properties of the modified AA5083 alloy were superior over a commercial AA5083 alloy.

Keywords: Accumulative Roll Bonding; Al-Mg alloys; mechanical properties;

INTERMETALLIC PHASES IN THE AS-CAST MICROSTRUCTURE OF Al4Mg0.7Mn TYPE ALLOY WITH ZINC ADDITION[1]

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Abstract

Aluminium alloys with magnesium as the major alloying element constitute a group of non-heat treatable alloys with medium strength, high ductility, excellent corrosion resistance and weldability. Al–Mg alloys are used as structural materials in marine, automotive, aircraft and cryogenic applications.

The chemical composition of tested alloy is: 3.98%Mg, 0.08 %Si, 0.27 %Fe, 0.27 %Cu, 0.7 %Mn, 0.07 %Cr, 1.59 %Zn, 0.017 %Ti and 0.18 %Zr. The structure of Al-Mg-Mn alloy with Zn addition consists of grains of α - solid solution of aluminum with a dendritic-cell substructure, and a variety of intermetallic phases. The distribution of the various alloying elements on the microstructural scale is very inhomogeneous in the alloy. Enrichment of Mg and Zn, depletion of Mn and precipitates of different intermetallic compounds have been observed at the interdendritic regions of this alloy.

The dominant intermetallic phases formed during solidification of tested alloy have been identified to be Al-Fe-Mn, Al-Zn-Mg and Al-Zn-Mg-Cu. SEM/EDS analysis revealed that the Mg_2Si and β phases do not form during nonequilibrium solidification in this alloy.

The zinc addition in tested Al-Mg-Mn alloy precludes the formation of β-phase precipitates, resulting instead in the formation of a chemically and structurally distinct Al-Mg-Zn phase at grain boundaries and interdendritic regions.

While the τ -phase has been reported in 7000 series alloys containing high levels of Zn, this study indicates that the τ -phase can also form extensively in Al-Mg-Mn alloy with Zn addition.

Keywords: Al4Mg0.7Mn type alloy, zinc addition, τ phase

[1] Acknowledgment

This research was supported by the Ministry of Education, Science and Technological Development, Republic of Serbia, and Impol-Seval Aluminum Mill, Sevojno, under Contract Grant No. TR 34018.

INFLUENCE OF IRON CONTENT ON THE VOLUME FRACTION, MORPHOLOGY AND DISTRIBUTION OF α-AlFeSi INTERMETALLIC PHASE IN THE AS-CAST MICROSTRUCTURE OF AA6026 ALLOY[2]

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Abstract

The 6xxx series aluminum alloys are well known for desirable combinations of high strength, weldability, corrosion resistance and formability.

Depending upon the alloy composition and solidification condition, various types of the intermetallic phases are formed in tested AA6026 alloys: α_c – $Al_{19}(FeMnCr)_4Si_2$, β –Al_5FeSi, Mg_2Si, $Al_5Cu_2Mg_8Si_6$ (*Q*), $CuAl_2$ (Θ), Si, α – Pb, β –Bi, Mg_3Bi_2 and Pb_3Bi.

Predominant intermetallic compounds are of the AlFe(Mn)Si type. The concentrations of Mn and Fe in the alloy determine the fractions of the β-Fe and α -Fe phases, as well as the concentration of Mn in solid solution. Iron has an extremely low solid solubility in aluminum and virtually all of it appears as intermetallic phases. During solidification Fe segregates to cell or dendrite arm boundaries where it takes part in eutectic or peritectic reactions. The α_c – $Al_{19}(FeMnCr)_4Si_2$ phase is hard to dissolve and virtually unaffected by homogenization treatment.

The results reveal that the α -Fe phase has a Chinese script or blocky morphology in tested alloys with higher iron content (0.35–0.50 wt.%). On the other hand, if the Fe concentration is low (<0.1 wt.%), the irregular plate-like or rod-like α -Fe particles are observed in the as-cast microstructure.

The α_c – $Al_{19}(FeMnCr)_4Si_2$ intermetallic particles are coarse in the microstructure of tested alloy with higher iron content, and become smaller as the iron content decreases.

The volume fraction, size and morphology of α -AlFeSi particles may influence the materials' properties during subsequent fabrication steps and play a crucial role for the material quality.

Keywords: AA6026 alloy, α-AlFeSi intermetallic phase, volume fraction, morphology, distribution

[2] Acknowledgment

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