Abstracts for Oral Presentations

SESSION 1: KEYNOTE LECTURES

INNOVATION IN NITRIDING

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ABSTRACT

Society has, over the last twenty years, gained immensely from the emerging global knowledge economy. In the modern world there is a relatively easy flow of knowledge and the International Federation for Heat treatment and Surface Engineering (IFHTSE) has a vitally important role to play in providing a global platform for the dissemination and generation of knowledge intensity in Heat Treatment and Surface Engineering. If we invest time, money and human capital wisely we can look optimistically to an even brighter, more sustainable future. The suggestion implicit in this paper is that if we stand on the shoulders of giants, such as, for example, Professor Tom Bell, we can be successful in areas of technology that might be considered mature. We have selected, by way of example, two areas of technology with which Professor Bell was closely associated over his long career, namely, nitrocarburising and plasma nitriding, where innovation has opened up scientific, technical and commercial pathways.

IFHTSE PROJECT TO HELP PLANNING IN THE HEAT TREATMENT AND SURFACE ENGINEERING INDUSTRY

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ABSTRACT

The concept behind the IFHTSE initiative Global 21 is to create a framework for continuous study on the state of the art and expected development trends in heat treatment and surface engineering in the first decades of the 21st century. Beginning with the Congress in Vienna (2006) a number of papers were presented at IFHTSE events and published in the International Heat Treatment and Surface Engineering and future expert contributions are under preparation.
The paper presents a synthesis of the work done so far and considers the necessary corrections on some of the conclusions due to the drastic changes in the World economy in the current global financial and economic crisis. The expected impact of the technological development is briefly outlined emphasizing also the importance of dedicated training and education in critical periods.

MODELING AND SIMULATION OF HEAT TREATMENT AND SURFACE ENGINEERING PROCESSES FOR PROCESS DEVELOPMENT AND OPTIMIZATION

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ABSTRACT

Physics-based models of heat treating processes are becoming very important tools in the development and optimization of thermal and metallurgical processes. These models can be simple calculations, thermodynamic analysis, finite difference (FD) or finite element analysis (FEA), computational fluid dynamics (CFD) or an integrated software system of several of these methods. When these models are developed and verified they become a powerful tool for heat treatment process development and optimization. The need for enhanced databases with the thermal, physical and mechanical properties will be discussed. In this paper a series of case studies will be presented to illustrate the development, verification and application of these tools for heat treating age hardenable aluminum alloys, gas and vacuum carburization, nitriding and the distortion and residual stresses associated with quenching. These results will demonstrate the power of these tools to enhance part quality while saving energy and money in heat treating processes.

NEW TOOL STEELS AND THEIR INTERRELATIONSHIP WITH MODERN HEAT TREATMENT PROCESSES

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ABSTRACT
Several new tool steel grades as well as optimised modifications of standard grades have been developed by special steel producers during the last one to two decades. These steels offer the potential for better properties and tool performance, but only if the heat treatment is performed with an optimum combination of parameters. The achievement of this potential is supported by advanced heat treatment equipment and processes.
This paper gives an overview of the possibilities, requirements and optimum heat treatment parameters of these new tool steels based on the examples of cold-work tool steels, hot-work tool steels and tool steels for plastic moulding. Not only are the requirements of these grades and the rising demands regarding work piece size discussed herein, but their correlation with developments in the field of heat treatment processes for tool steels are also examined.
Optimized combinations of alloy composition, steel production and heat treatment process offer not only significantly improved material properties such as hardness, strength, wear resistance or toughness, but lead to significantly prolonged life cycles of the tools, thereby justifying the higher nominal cost of these steels and the advanced equipment for the heat treatment processes.

Keywords*:* Tool steels, Heat treatment processes, Material properties

COMPUTER SIMULATION OF MECHANICAL PROPERTIES OF QUENCHED AND TEMPERED STEEL SHAFT

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ABSTRACT

Prediction of working stress of quenched and tempered steel workpiece has been investigated. The working stress was characterized by yield strength, fracture toughness and fatigue threshold. The method of computer simulation of working stress was applied in workpiece of complex form. Fracture toughness and fatigue limit are depending on microstructural constituents, and distribution of the usual intermetallic particles and non-metallic inclusions. Fatigue resistance of quenched and tempered steel is achieved by eliminating coarse alloy carbides present in steel. Properties of matrix may also have an important influence on fracture and fatigue proper behaviour. Most high-strength materials are fracture and fatigue limited. Fatigue strength is directly proportional to the difficulty of dislocation cross slip. Grain size has its greatest effect on fatigue life. The algorithm of estimation of yield strength and fracture toughness was based on steel hardness, HV. Numerical modelling of hardness distribution in quenched and tempered steel has been performed by involving the results of simple experimental test, i.e., Jominy-test. Yield strength and fracture toughness distributions have been predicted using the Hahn-Rosenfield approach. Fatigue threshold was estimated based on predicted microstructure and hardness. It can be concluded that working stress of quenched and tempered steel workpiece can be successfully predicted by proposed method. The further experimental investigations are needed for final verification of established model. The mathematical model has been applied in failure analysis of a quenched and tempered steel shaft. For efficient estimation of fatigue resistance, additional data about microstructure are needed.

Keywords:Heat treatment, Computer simulation, Microstructure, Yield strength, Fracture toughness

SESSION 2

COMPARISON OF THE MICROSTRUCTURE, MECHANICAL AND CORROSION PROPERTIES OF DUPLEX AND SUPER DUPLEX STAINLESS STEELS SUBJECTED TO AGEING IN THE RANGE 475-950^{O}C.

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ABSTRACT

Duplex and superduplex stainless steels are used widely due to their high mechanical properties and corrosion resistance. These steels are mainly used in the temperature range from -50 ^{o}C to 300 ^{o}C because they are susceptible to brittleness at lower and higher temperatures. Faults in temperature control may occur during welding, hot forging of large pieces, heat treatment, and in service conditions leading to precipitation of brittle phases. The aim of this work is to study the embrittlement of these steels as a result of heating to the temperature range from 475 to 950 ^{o}C for 10, 30, and 60 minutes, the relationship between the obtained microstructure, mechanical properties, and pitting corrosion resistance and to determine the most optimum means of following-up any embrittlement that may occur due to over heating. Ferrite content measurements, microstructure, tensile test, impact test, hardness test, X-ray diffraction, scanning electron microscope, and pitting corrosion tests were used. Results showed that mechanical properties, microstructure and pitting corrosion resistance are all tightly related to remaining ferrite content, which may be used as good indicator of the degree of embrittlement that may occur during fabrication or service. Maximum embrittlement occurs at the range from 875 to 900 ^{o}C. At 950 ^{o}C less embrittlement and precipitates were observed than at the range from 875 to 900 ^{o}C.

Key words: Duplex; Superduplex; Stainless steel; Sigma –Phase; Ageing; Microstructure; Toughness; Pitting corrosion

THE CONCEPT OF CREATION MULTIFUNCTIONAL ECONOMIC METASTABLE ALLOYS OF NEW GENERATION, WHICH SELF-ORGANIZATION DURING OPERATION

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ABSTRACT

This work is a generalized study of conformity to the law of forming of the various metastable conditions for the management of properties of multifunctional metastable alloys realized in the process of tests and operation due to the deformation induced phase transformations (DIPT), such as deformations during $\gamma \rightarrow \alpha'$ or $\gamma \rightarrow \varepsilon'$ deformation induced martensite transformations (DIMT), dynamic deformation aging (DDA) and transformation of carbides.

Conceptual positions of creation of multifunctional economical metastable alloys of a new generation, self-organized in the process of tests and operation, are developed.

Basic physics and chemical mechanisms and factors of stabilization of austenite are systematized. On the basis of which it is possible by the methods of heat treatment, thermo-chemical treatment and other types of treatments, to develop the metastable conditions in the alloys and provide their mechanical properties. The possible morphological types of metastable austenite are first classified: basic phase concomitant (or inferior), primary, eutectic, reversive, remaining, oversaturation, etc.

The DIPT realization on optimum kinetics allows considerably not only to promote separate indexes, but also - that it is very important – complex of strengthening, ductility, toughness and the special properties, which it is impossible to get in the known phase-stable materials.

The basic principles and scientific positions in creation of a new generation of alloys with the promoted properties and new strengthening technologies were theoretically formulated and experimentally tested.

The models of evolution of the phase-structural condition and self-organizing of metastable alloys during their life cycle are developed (production, heat and another treatment, strengthening, tests, operation, destruction and utilization). They show advantages of metastable alloys of a new generation over phase-stable, allow to forecast the rise of complex of physico-mechanical and operating properties.

In the basis of designing a new alloy, the forming and adjusting of the metastable conditions of austenite and the DIPT management is a necessity. This is needed for the alloys of a different functional setting (high-strength, wear-proof, corrosion-resistant, heat-resistant, construction and so on.). It is widely used in industry standard steels and cast-irons – construction, instrumental, wear-proof and also superficial layers of the wares, consolidated by the methods of thermo-chemical treatment, plasma, electron-beam, laser treatments and by surfacing of metastable metal.

The developed new generation of alloys for different applications, with their complex of properties (at times it is difficult to combine in one material), considerably excel their analogues of more expensive alloys containing scarce and very expensive elements – Ni, Mo, V, Nb, W, Co, etc.

Key words: Conception, Alloy, Metastable austenite, Martensite, Strengthening, Heat treatment.

OPTIMISING HEAT TREATMENT REQUIREMENTS FOR IMPROVED TOUGHNESS OF V-CONTAINING 3%NiCrMo-STEEL

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ABSTRACT

Medium carbon low alloy steels are extensively used in applications where mechanical strength and good resistance to dynamic forces are needed. One major field of these applications is the military industry, specially the production of mortars. In this work steel type 4337V known in defense standard as gun steel (3%NiCrMo-steel) is investigated to study the combined effect of V level and heat treatment cycle on the achievement of the required strength/toughness necessary for this specific application. Vanadium is added to these steels mainly, to act as a grain refiner, but V is also a strong carbide former, and then likely to cause some drop in toughness when present. In this work an investigation on the effect of different heat treatment cycles on the mechanical properties of steel grade 4337V was carried out. The investigated heat treatment cycles are as follows: conventional heat treatment CHT (normalizing at 900 ^{0}C followed by quenching from 850 ^{0}C), modified heat treatment MHDN (double normalizing treatment was first carried out at 900^{0}C and 800^{0}C, successively, before the conventional treatment), and thermomechanical treatment TMT (where the part was quenched in oil directly from the forging temperature at about 800-850 ^{0}C). All the specimens were then tempered at 600^{0}C for 3 hrs. The results showed that for all heat treatment cases a marginal content of 0.08 – 014 % V should not be exceeded for maximum toughness. Using other heat treatment cycles rather than the conventional one made it possible to accommodate the presence of V on the upper range. Thermomechanical treatment causes an increase in the strength of the alloy but a slight increase in toughness, whereas, using double normalizing caused an improvement in both strength and toughness compared to those achieved through conventional heat treatment.

Keywords: Heat treatment of CrNiMo steels, Vanadium, Thermo-mechanical treatment.

CRACK IDENTIFICATION BY SOUND EMISSION DURING STEEL QUENCHING

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ABSTRACT

Quenching and tempering often represent almost the final stage in the production of machine components of manufacturing process. Only the most exacting piece of work like grinding, polishing etc. follows. Final mechanical properties, such as residual stresses and hardness layer, therefore depend on optimum parameters of a quenching process and monitoring of the process itself. Even then happens that some work-pieces failed also due to cracking of the material. Detecting such faults in the due time may reduce unnecessary costs due to final machining of the machine part or even due to damage of the machine occurred due to machine part breakdown. The paper treats an experimental setup comprising detection of sound emission in the course of quenching process. Due to heat transfer from a specimen's surface to a quenching medium, film boiling and nucleate boiling occur round a heated specimen, which strongly affects quenching. Cracking due to high internal stresses causes sound signal which differ from regular sound emission by intensity and by frequency as well. High internal stresses encountered are caused by local deviations due to a vapor - film formation and due to too severe quenching agent chosen. An investigation of sound emission in the quenching process was carried out with cylindrical specimens made of heat-treatable steel quenched in water and salt solution. Analysis of sound emission signals and selection of certain signals which differ from the regular sound emission can provide useful information regarding cracking with certain step of probability and confirm the differences occurring in quenching with different quenching conditions. The results lead to the applicability of the new approach to the control of the hardening processes of steels.

Keywords: Acoustic spectrograph, Cracking, Internal stresses, Quenching, Sound emission, Sound pressure level

HEAT TREATMENT OF DUPLEX STAINLESS STEELS SAF 2205 WELDED JOINT

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ABSTRACT

The heat treatment plays an important role in final properties of welded joint. In fact, it may give unwanted structure changes in joint. The duplex stainless steel SAF 2205 welded joint has been heat treated in the temperature range 780-880 for times between 15-45 min. The influence of heat treatment on microstructure of fusion zone, heat affected zone, and base metal has been investigated. It was found that Chromium nitride precipitated dissolved and density of secondary austenite phase increased in fusion zone and heat affected zone. The sigma phase precipitated in different zones of joint. The grain size and volume fraction of sigma phase was measured. It was found that the volume fraction of it increased in the direction of base metal.

INFLUENCE OF HEAT TREATMENT ON MECHANICAL PROPERTIES OF STAINLESS STEELS

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ABSTRACT

New austenitic stainless steels have been developed through partial and total replacement of nickel by nitrogen. Stainless steels with different combinations of nickel and nitrogen were produced in 10kg induction furnace under different nitrogen pressures. The produced stainless steels were cast and hot forged and the total nitrogen was determined. Furthermore, the produced forged steels were subjected to either only solution treatment or solution treatment followed by ageing process. The microstructure of produced stainless steels was observed and the grain size was measured. The tensile properties at room temperature were determined. The influence of grain size, total nitrogen, insoluble and soluble nitrogen on tensile strength was investigated. All produced stainless steels as-quenched were aged at temperatures range from 350^{o} C to 950^{o} C for different times. Hardness testing was carried out for aged stainless steels and the optimum ageing conditions were determined. The contributions of different strengthening mechanisms to the yield strength were analyzed. The phase transformations of all stainless steels were investigated. The yield strength and ultimate tensile strength of the aged stainless steels were found to increase at average rates of 706 MPa/1 mass % nitrogen and 723 MPa/1 mass % nitrogen, respectively. On the other hand, the increase of nitrogen content deteriorates the steel ductility. Stainless steels, which have nickel content less than 4%, exhibit lower strength compared with stainless steels containing higher nickel content (>5% Ni). From the present article, it can be concluded that partial and total replacement of nickel by nitrogen produce stainless steels with stable phase as well as it improves the mechanical properties of austenitic stainless steels at room temperatures·

EFFECT OF NIOBIUM AND NITROGEN ADDITION ON SECONDARY HARDENING TEMPERATURE OF SUPER HARD AISIM41 HIGH SPEED TOOL STEEL

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ABSTRACT

High speed steels are high alloyed carbon steels with a complex pattern of carbides. They are employed in cutting tools operating at high speeds. These quality steel grades require sophisticated production technology. The properties of high speed steels depend to a large extent on the production and refining technology which affect the morphology, size and distribution of carbides of the produced steel. In this work, effect of niobium and nitrogen on morphology of carbides and secondary hardening temperature of investigated steels were studied. The experimental result shows that, nitrogen alloying increases the hardness of air induction melting ingot by about 6.5 HRC compared with 10 HRC for niobium alloyed steel. This result also shows that, the conventional ingots have many types of carbides of different shapes and sizes precipitated on the boundary together with thick needle like carbide. On the contrary, for both nitrogen and niobium steels, the nitrogen and niobium alloying lead to formation of dense, fine and well distributed microstructure. From the tempering result, it is clear that both nitrogen and niobium alloying improve the hardness profile and achieve the best secondary hardening effect, the highest hardness at elevated temperature (600 ^{O}C) as well as minimum softening is produced by un-alloying steel. It has been found that with addition of 0 - 0.5% Nb, the steels investigated have the highest secondary hardness after austenitizing at 1220°C and tempering at 500–600°C. The investigated steel after heat treatment (austenitizing and tempering) acquires the highest secondary hardness of about 60 HRC of all of the niobium alloyed steels. The main reason for the secondary hardness effect in all of the steels investigated is the precipitation of the dispersive M_4C_3 carbides in the martensite matrix and the martensitic transformation of the residual austenite.

Key Words : High speed steel – Carbide – Nitrogen - Niobium – Mechanical properties – Hardening - Tempering – Secondary hardening – Nitride – Eutectic carbide

EFFECT OF AlN PRECIPITATION AND HOT ROLLING PROCESS ON THE MICROSTRUCTURE AND PROPERTIES OF LOW-CARBON STEELS PRODUCED THROUGH EAF-THIN SLAB CASTING TECHNOLOGY AT EZZ FLAT STEEL

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ABSTRACT

The much faster cooling rate and rapid solidification in association with liquid core reduction in thin slab casting process result in finer grains in the slabs as compared to the conventional process. Hot strips produced by CSP process from these slabs also undergo a different thermo-mechanical treatment. First, there is no γ to α transformation as the slabs enter into the tunnel furnace in austenitic temperature for reheating. Secondly, some AlN precipitates in the slabs before these enter into the tunnel furnace. Even after holding about 25 minutes inside the furnace at 1150^0 C, some of these finer AlN particles may remain undissolved in the slab and restrain the growth of recrystallized austenite grains. Further precipitation and growth of AlN during subsequent hot rolling in roughing and finishing mills and cooling at run-out table as well as after coiling, significantly affect the final properties of steel such as strength, ductility, formability, grain size, strain aging index (SAI) etc. Ezz Flat Steel (EFS) is regularly producing low carbon Al-killed hot-rolled coils for cold rolling, direct forming and galvanizing applications from the similar steel chemistry. The typical chemistry of these steels are: C 0.025 to 0.05%, Mn 0.15 to 0.22%, Si 0.035% max., P 0.004 to 0.012%, S 0.001 to 0.006%, Al 0.025 to 0.04% and nitrogen 60 to 80 ppm. The desired mechanical and microstructural properties of hot bands for different applications are achieved through control of hot rolling parameters, which in turn control the precipitation and growth of AlN in steels at different stages of processing. Soluble nitrogen in steel has a strong influence on the yield strength, ductility and strain aging index. The equilibrium solubility of AlN in austenite at various temperatures (Roughing mill exit, finishing mill entry and finish rolling) and isothermal precipitation of aluminium nitride have been evaluated to understand the precipitation kinetics of aluminium nitride. To achieve the desired formability properties in hot band for cold forming application, most of the nitrogen in solid solution is fixed as AlN by coiling at higher temperature in the range of 690 to 700^0 C. This resulted in superior formability properties of hot bands as measured by YS/UTS (≤ 0.8), SAI (6 to 10%) and grain size (ASTM No. 8.5 to 9.5). The deleterious effect of nitrogen has been further reduced by addition of boron in cold forming steels. Boron in the range of 50 to 60 ppm (just below the stoichiometry) is being added for stringent forming such as compressor shell. The addition of boron has resulted in dramatic improvement in the formability properties. For production of cold rolled and annealed deep drawing sheets, the two utmost requirements of low carbon hot bands are higher strain aging index (i.e., more nitrogen in solid solution) and fine grain microstructure. Nitrogen and aluminium retained in solid solution are precipitated during annealing after cold rolling, but before recrystallization to develop the desired {111} texture in fully processed CR sheets.

Similarly, more deformation bands are produced during cold rolling of fine grained hot bands, which act as nuclei for the development of {111} texture. In view of these, higher finish rolling temperature (880 to 900^0 C) and lower coiling temperature (600 to 640^0 C) are used for processing of low carbon hot rolled coils for cold rolling application. The strain aging index in these coils has been found to be in the range of 12.5 to 18% depending on the coiling temperature. The microstructures of these coils have also shown fine polygonal ferrite grains of ASTM No 10 to 11. These coils have given very good formability properties as measured by average plastic strain ratio and strain hardening exponent (n) after fully processing to cold rolled and annealed sheets at customer's end.

Keywords: Solubility of aluminum nitride, Finishing and coiling temperatures, Cold rolling, Aluminum nitride precipitations, Boron nitride precipitations, Texture development, Deep drawing and Cold forming.

THERMO-MECHANICAL PROCESSING OF 42CrMoS4 STEEL

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ABSTRACT

The $42CrMoS_4$ steel is one of the widely used heat-treatable / or surface hardened medium carbon low alloy steels for vehicles and machinery construction. The conventional heat treatment of this steel consists of hardening and tempering. In this work billets of $42CrMoS_4$ steel were subjected to a program including further forging and rolling to achieve different reduction ratios, followed by quenching and tempering in order to simulate online thermo-mechanical treatment TMT during rolling of these steels. The microstructure and mechanical properties were compared to those obtained by conventional heat treatment CHT of this steel (quenching from 860 ^oC and tempering). It was found that increasing the hot reduction ratio from 18% to 60% enhance mechanical properties such as tensile and yield strength while the elongation was reduced. At 60 % hot deformation, a further enhancement for all mechanical properties was obtained by decreasing the rolling finishing temperature from 900 to 750 ^oC. It was also found that the CHT provides higher hardness for the alloy whereas TMT provides higher impact toughness.

Keywords: Medium carbon - low alloyed steel, $42CrNiMoS_4$, Thermo-mechanical treatment.

SESSION 3

WAYS TO ACCELERATE THE KINETICS OF NITROGEN MASS TRANSFER PROCESS AT NITRIDING

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ABSTRACT

Operating in low temperatures, the nitriding by definition involves long periods of treatment cycle. The paper presents theoretical reasons that lead to accelerated kinetics of mass transfer processes both in nitriding media and metallic matrices in contact with them. Resuming, the idea according to which, in the atmosphere used for nitriding, the coexistence of ions, molecules, atoms etc., and the presence of some electrical and electromagnetic fields or substrates with a role of catalyst increase the concentration of nitrogen adsorbed in the nitrided layer is shown. Starting from the conclusions of theoretical analysis possible ways to apply for decreasing the time of nitrogen saturation cycle and the modeling of phase's composition of the nitrided layers are also presented.
Keywords: Nitriding, Modeling, Kinetics, Chemical activation

MECHANICAL PROPERTIES OF PVD COATINGS ON TiC-BASED CERMETS

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ABSTRACT

Thin hard coatings are currently being used in a large number of important metal processing applications, such as metal cutting and forming tools, as well as in tribological applications such as sliding bearings, seals, engine parts and other machine elements. The present study was to investigate and compare different thin coatings produced by Physical Vapor Deposition (PVD) technique on TiC- NiMo cermets. The substrates with varying binder ratio were produced by conventional powder metallurgy (PM) techniques applying Sinter-HIP. The surfaces of the samples were prepared with varying roughness values and the surface roughness parameters were studied using nanoindentation techniques in scanning mode. The hardness and topography of the substrate materials was studied using nanoindentation technique using loads in the range 200 mN to 500 mN. The abrasive wear resistance was studied using modified block-on-ring test setup. Several hard coatings (TiN, TiCN, TiAlN, AlTiN, nACo®) were deposited on the cermets. The chemical and phase composition, microstructure and morphology of the coatings were assessed using scanning electron microscopy. All coatings were characterized with respect to their hardness, cohesion/adhesion and abrasive wear resistance. Surface topography, hardness and scratch resistance of the coatings were investigated by means of nanoindentation. Relationships between the mechanical properties of the coatings, and the substrate surface roughness values of TiC-NiMo cermets were proposed.

Key words: Cermets, PVD coating, Nanoindentation, Surface roughness, Hardness

ROLE OF ACTIVATORS ON THE THERMOCHEMICAL STABILITY OF ALUMINIDE COATINGS OF LOW CARBON STEEL

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ABSTRACT

Many metallic components used in chemical industries are exposed to aggressive corrosion. One of the methods used widely for corrosion control is the pack cementation process. This study aimed to improve the stability of aluminide coatings on low carbon steel. Powdered pack consists of Al and Al_2O_3, in addition two types of activators (NH_4F and NH_4CL) were separately used. The diffusion coating was carried out at two different temperatures, 900°C and 1100°C. Appropriate microstructure examinations and surface morphologies analysis were conducted by SEM and EDS to study stability of aluminide coatings. The obtained results show that the pack aluminized steel substrates at 900°C using NH_4F activator exhibit good compact and more adherent coating layer, and that pack aluminized at 1100°C using NH_4Cl give embrittle Al_5Fe_2 and Al_3Fe phases tend to spalling.

Keywords*:* Aluminum diffusion coating, Thermochemical Stability, Microstructure and surface morphology.

WEAR PROPERTIES OF DUPLEX TREATED SURFACES

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ABSTRACT

Advantages of hard coatings and deposition technologies such as PVD and HVOF have opened new possibilities for production of wear parts operating in abrasive environment. Thin hard PVD coatings are excellent for strengthening of hardmetals and high-speed tool steels, but are not useable by low-temperature tempering tool steels as well by constructional steels. Thermally sprayed hardmetal coatings are used widely in many industrial applications for wear, but not usable at impact wear conditions. To widen the application areas of thin as well as of thick hard coatings the following coatings and surface treatment technologies were studied: duplex coatings on nitriding steels (hardening + plasma nitriding + PVD), duplex treatment of surface of high-speed steels (PVD + laser hardening) and powder spray-fused coatings (thermal spray + laser cladding). The microstructure of coatings and influence of the heat treatment to the structure of substrate as well to the coatings were studied. The duplex treated surfaces and duplex coatings were tested under the conditions of abrasive impact wear and surface fatigue wear and mechanisms of surface degradation were studied. Prospectivity was demonstrated of duplex coatings on nitriding steels and thermal spray-fused iron-based metal-matrix WC-Co hardmetal consisting coatings for abrasive impact wear conditions. Based on comparative abrasive and surface fatigue wear resistance studies the recommendations for materials and coatings are offered.

Key words: Duplex treatment, Duplex coatings, Thermal spray, Plasma nitriding, Laser cladding, Abrasive wear, Surface fatigue

ESTIMATION OF FRACTURE TOUGHNESS OF NITRIDED LAYERS ON TOOL STEEL BY APPLICATION OF THE VICKERS INDENTATION METHOD

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ABSTRACT

Nitriding and nitrocarburising treatments are established methods of improving the wear performance of tool and die steels. However, our understanding of the relationship between nitriding process parameters, and microstructure and fracture behavior of the surface layers is far from complete. Vickers hardness indentations generate radial fractures in brittle surface layers, and it has been shown that the length of these cracks can be used to provide valuable information about the fracture toughness of these layers. This paper describes an investigation of the application of indentation fracture testing to nitrided and nitrocarburized H11 hot work tool steel. The results suggest that where a sufficiently thick compound layer has formed, this method has the potential to be applied as a pseudo non-destructive method of monitoring the fracture properties of treated surfaces on actual tool parts. However, the validity of the method appears to be a function of the presence and thickness of the compound layer, and possibly the mechanical properties of the diffusion layer. The effect of such factors has not been quantified and further work is required to establish the sensitivity of the method for fracture toughness calculations.

Keywords: Nitriding, Nitrocarburizing, Fracture toughness, Indentation fracture, Hardness testing, Palmqvist Cracks

EFFECT OF THERMAL OXIDATION TO THE SUBSTRATE ON PROPERTIES OF THE RuO_2-TiO_2 COATED TITANIUM ANODE

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ABSTRACT

Titanium coated RuO_2-TiO_2 anode is an important electrode material in electrochemical industries. The pure titanium substrate (TA2) was thermal-oxidized at the temperature range of 400°C ~ 800 °C for 1 h before applying the 30% RuO_2 - 70% TiO_2 (mol%) coating, which was coated on TA2 by thermal decomposition method. The structural changes on the titanium substrate after thermal oxidation were studied by the X-ray diffraction (XRD) and the Scanning electronic microscopy (SEM). The electrode properties of the anodes treated with different thermal oxidation procedures were investigated by the electrochemical tests. It was found that the phase structure and the morphology on the TA2 surface did no change much by thermal oxidation at temperatures lower than 600°C. Treated at temperatures higher than 700°C, thick TiO_2 were formed. The electrochemical tests revealed that, the overall properties are improved after the thermal oxidation at the temperature lower than 600°C. Both electrocatalytic property and the anticorrosive property would be destroyed by the thermal oxidizing at 700°Cor 800°C .

Keywords: Thermal oxidation, Titanium substrate, RuO_2-TiO_2

APPLICATION OF PHOTONIC CRYSTAL CONCEPT IN DESIGNING OF OPTICAL THIN FILM FILTER

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ABSTRACT

Photonic crystal is a kind of dielectric media with periodic refractive index change in the scale of wavelength. This periodicity is responsible for the complex dispersion band diagram that characterizes these structures, in which forbidden frequency bands may appear. These forbidden bands, the so-called band gaps, are one of the unique properties of photonic crystals. The concept of photonic crystal was first put forward in 1987 by E.Yablonovitch and S.Johnin, respectively, when studying the influence of periodic dielectric materials to light transmitting performance. Photonic crystals were regarded as counterpoint of electron in optics field. The properties of photonic crystal are photonic energy and frequency forbidden band, and the photons located in forbidden area were prohibited to transmit within photonic crystal. The behavior of photons in this structure is just like that of electrons within semiconductor, and this structure of photonic crystal was named photon band gap. While in the process of designing of optical thin films, the obtained result may be very difficult for deposition, or it may be very hard to obtain a reasonable result for some requirement by conventional method. It is possible to design optical thin filter by concept of photonic crystal. In answering to demand of a project, a dual band thin film filter was designed with photonic crystal concept. Some simulation research was carried out, and the regular pattern of filtering properties of one dimensional photonic crystal was obtained by numerical calculating on defect modes and analyzing of the defect mode characteristics in detail by the optical transmission matrix method. The result shows that the layers of thin film filter is much less than that obtained by conventional optical thin film design method, and the result is much easier to realize by deposition. The filter was prepared by Ion Beam Assisted Deposition method, and the performance is in good accordance with the designed result. So it is possible to design dual band filters using one-dimension photonic crystals concept.

Keywords: One-dimension photonic crystal, Dual-band filter, Optical thin film

EVALUATION OF FATIGUE RESISTANCE OF LOW-CARBON STEEL UNDER EFFECT OF CARBURIZING MEDIA.

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ABSTRACT

This research is concerned with the effect of different carburizing media on fatigue strength of low carbon alloy steel for its wide industrial applications. All fatigue tests of rotating bending were made in laboratory, the mean stress was zero. Carburizing was made in the three media (pack, gas and liquid) under different conditions of time or duration of pack (solid) carburizing. Heat treatment after carburizing included quenching in water and tempering. Carburizing in the three media (pack, gas and liquid) contributed to the improvement in fatigue strength in different proportions. The degree of improvement depended on the depth (thickness) of the hardened layer and on the microstructure of a carburized steel. It was found that the fatigue strength of low alloy steel with pack carburizing was higher than that of steel with gas and liquid carburizing at 925˚C for 8hr.

Keywords: Carburizing , Fatigue Strength , Steel, Hardness , Case Hardening .

TECHNIQUE OF CALCULATION OF THE ECOLOGICAL INDICES OF METAL HEATING IN FUEL FURNACES

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ABSTRACT

An efficiency of the environmental policy implemented at the enterprise under ISO 14000 can be evaluated using environmental indicators of production process. A list of environmental indicators gives a priority to the specific resource consumption and specific wastes generation. A method to calculated specific environmental indicators of thermal metal treatment in fuel heating furnaces is provided and an analysis of the influence of different factors on the value of the indicators is given in the paper.

SESSION 4: KEYNOTES LECTURES

PREPARATION AND CHARACTERIZATION OF SURFACE TREATED AND COATED STEELS

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ABSTRACT

A wide variety of surface treatments and coatings are applied to metals to enhance their performance, for example, to improve fatigue resistance, increase wear resistance, corrosion or oxidation resistance. Some of these treatments involve diffusion of one or more elements into the metal or alloy followed by post heat treatments. These processes included the familiar processes of carburizing, nitriding, and carbonitriding but also included less familiar processes such as ion nitriding and boriding. There are also a wide variety of coatings that are deposited by hot-dipping, electroless or electrolytic means, by physical or chemical vapor deposition, or by thermal or plasma spray. The technological significance of these processes is enormous .
Keywords: Surface treatments, Metallography, Specimen preparation, Case depth, Microstructure

SESSION 5

ADVANCES IN THE HEAT TREATMENT OF AUSTEMPERED DUCTILE CAST IRON

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ABSTRACT

The as-cast mechanical properties of ductile iron can be significantly improved through an austempering heat treatment. This has led to the birth of a new member of the cast iron family, the asutemepered ductile iron (ADI) with its unique microstructure; spheroidal graphite in an ausferritic matrix. The excellent property combination of ADI has opened new horizons for cast iron to replace steel castings and forgings in many engineering applications with considerable cost benefits. Thanks to the extensive research efforts made allover the world over the past few years, new processing techniques have opened even more opportunities for this very prospective material to acquire better combinations of strength, ductility, toughness, wear properties as well as machinability. This review describes the key features of those novel processing techniques and the resulting new applications of ADI. The recent developed techniques include ausforming, cold rolling, two-step austemepring, ADI with mixed ferritic – ausferritic structures, austenite free (ferritic) ADI, carbidic / martenisitic (B/M) ADI as well as thin-wall castings. Throughout this review, special focus will be made on the research work done at CMRDI over the past few years. As a consequence of these developments, ADI currently offers high levels of mechanical properties at a competitive cost. This material can successfully compete with lightweight alloys due to the lower weight of ADI required to give unit strength. The enhanced strength and toughness of ADI are related to the asuforming, cold-rolling, two-step austempering as well as squeeze casting. Superior wear resistance, combined with reasonable toughness can be offered by carbidic as well as bainitic / martensitic ADI. Machinability of ADI could be considerably improved by the mixed (ferritic – ausferrtic) and austenite – free grades of ADI. The machinability improvement looks rather vital for the future of this material.

INFLUENCE OF LASER REMELTED MICROSTRUCTURE OF CAST IRONS ON RESIDUAL STRESSES

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ABSTRACT

The presence and amount of residual stresses is very important in dynamically loaded machine parts. In designing dynamically loaded parts designers very frequently demand the presence of compressive residual stresses in the surface after the process of heat treatment and finish grinding of the surface, since this increases the fatigue strength of the material and reduces the danger of fracture. In this investigation, the size and variation of residual stresses after laser surface remelting were measured as a function of the modified layer depth on flat specimens from nodular iron. Optimal laser remelting conditions were chosen, while only the overlapping of the remelted traces was varied. To measure the residual stresses, the relaxation method was used, including gradual electro-chemical removal of the modified layer in which the deformation of the specimen was measured by resistance strain gauges. The results of the measured residual stresses confirm that the stresses strongly depend on the presence and quantity of the microstructure constituents in the remelted surface layer.

Keywords: Laser surface remelting, Nodular cast iron, Residual stresses, Constituents.

EFFECT OF HEAT TREATMENT AND TITANIUM ADDITIONS ON ABRASION RESISTANCE AND IMPACT TOUGHNESS OF WHITE CAST IRON

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ABSTRACT

This work studies the influence of heat treatment on microstructure and hence the wear resistance of high chromium white iron alloyed with titanium. The austenitizing temperatures of 980 °C and 1150 °C for 1 hour followed by tempering at 260 °C for 2 hours have been performed and the effect of those treatments on the wear resistance / toughness combination has been reported. The microstructure of irons austenitized at 1150 °C showed fine precipitated secondary carbides (M_6C_{23}) in a matrix of eutectic austenite and carbides (M_7C_3). Meanwhile, the structure of irons austenitized at 980 °C consisted of spheroidal martensite, small amounts of fine secondary carbides (M_6C_{23}) and eutectic carbides (M_7C_3). In both cases, particles of titanium carbides (TiC) with cuboidal morphology were uniformly distributed in the austenitic matrix. Irons austenitized at 980 °C showed relatively higher tensile strength compared to those austenitized at 1150 °C, whereas the latter showed higher impact toughness as a result of larger amounts of austenite reinforced with secondary carbides existing in matrix. For both austenitizing treatments, optimum tensile strength values were found with irons alloyed with 1.31% Ti, whereas the maximum impact toughness was obtained for the irons with no Ti-addition and decreased with Ti-additions and reached a minimum at 0.93% Ti and then became almost constant till 1.78% Ti. Higher wear resistance obtained for the samples austenitized at 980 °C compared for the irons treated at 1150 °C due to the existence of hard martensite phase and lower amounts of austenite. For both austenitizing treatments, optimum wear resistance was obtained at 1.3% Ti where TiC particles were homogenously distributed throughout the matrix. TiC agglomerates at higher Ti-contents (1.78%) impaired the wear resistance as they fractured into small particles and then pulled out from the matrix during the wear test.

Keywords: Abrasion resistance, Impact toughness, White iron, Titanium, Heat treatment.

MICROSTRUCTURE, MECHANICAL PROPERTIES, WEAR CHARACTERISTICS AND FRACTURE TOUGHNESS OF AUSTEMPERED AND LOW ALLOYED SPHEROIDAL GRAPHITE CAST IRON

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ABSTRACT

Successful endeavors were done to obtain conventional sg-iron (DI) and austempered sg-iron (ADI); by austempering heat treatment. Successful addition of alloying elements; Ni, Mo, Cr and Mn were achieved to get as-cast low alloyed sg-iron (LADI). Applying austempering heat treatment for as-cast LADI we obtained as-treated LADI. The hardness values (HB) of the ADI alloys were lower than that of LADI alloys. A macro-hardness conversion table was deduced for irons investigated by showing the values in HV, HB and HRA and HRC. DI delineated lowest tensile strengths; whereas, it exhibited highest ductility and toughness compared to that of ADI and LADI alloys. Moreover, highest values of calculated quality index (QI) was for ADI alloys at austempering temperature 673 K which, indicated a combination of higher strength and elongation and therefore, higher material performance. The difference in the impact energy between highest value of DI and lower value of ADI alloys was attributed to the nature of microstructure and properties. However impact results showed superiority of ADI over LADI. Wear characteristics of some ADI alloys were comparable with LADI. Additionally, the micro-hardness values were decreasing with increasing distance from the worn surface to bulk matrix hardness and then steady state values were observed for all types. The present results indicated generally that the higher combination of strength and ductility revealed ductile mode for ADI alloys, while, brittle mode was observed for LADI alloys. Due to higher toughness, and cheaper production price, it is suggested in the present study that rolling mills may be produced from ADI instead of LADI.

Keywords: ADI, Heat treatment, Mechanical properties, Microstructure, Wear characteristics, Impact toughness.

THE CREATION OF A NEW ECONOMICAL (NICKEL FREE) POWDER-LIKE WIRE FOR SURFACING MADE OF META-STABLE METAL, SELF-STRENGTHENED DURING WEARING

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ABSTRACT

The work is devoted to the urgent problem – saving of alloying components (Ni, Mo, Nb), very scarce in Ukraine and other countries and increase in physical, mechanical, technological and operational properties, while designing a new surfacing material. The purpose of the work is development of the composition of economical powder-like (nickel free) wire of PP-Np-20Cr_8Mn_6SiTiV and investigation of welding and surfacing characteristics for electrode-arc surfacing, the structure and physical and mechanical properties of deposited meta-stable metal, capable of self-strengthening in the surface layer during the process of wearing, due to the development of deformation induced martensite $\gamma \rightarrow \alpha'$ transformation (DIMT).

Metallographic, durometric, x-ray structural methods were employed in the research, as well as impact energy tests and wear tests, during dry sliding friction and impact-abrasive wearing. Electrode-arc surfacing was carried out on basis of steel of St. 3 grade, in one, two and three layers, in cast-iron shot. The changes in the panorama of microstructure of the deposited metal (alongside with various space and technological schemes) were investigated with the changes in hardness in horizontal and vertical directions, micro hardness of the structural components (martensite, austenite, carbides), changes in impact energy (KCU) and relative wear resistance on sliding friction and impact-abrasive wearing (ε and $\varepsilon_{i.a}$) depending on the temperature of quenching of 950 and 1150 °C.

It was found that the deposited metal is characterized by its good alloyability with the base metal (St. 3 steel grade), absence of pores, gas bubbles, non-metallic inclusions, hot or cold cracks. The microstructure of the deposited metal consists of martensite, meta-stable austenite and carbides of $Cr_{23}C_6$, TiC and VC. Depending on the temperature of quenching, number of deposited layers the correlation between martensite and austenite is changed, thus influencing the properties. The highest value of impact-abrasive wear resistance ($\varepsilon_{i.a.}$= 9,8) and impact energy (KCU=15,4 MJ/m^2) of deposited metal was achieved after quenching at 1150 °C, when the microstructure is mainly austenite (with small quantity of quenching martensite and carbides). The highest value in sliding friction wear resistance (ε = 4, 2) with satisfactory impact energy value (KCU = 8, 5 MJ/m^2) was achieved after quenching at 950 °C, when the structure of deposited metal is martensite-austenite-carbides with meta-stable retained austenite.

An important role in the increase of properties belongs to meta-stable austenite DIMT during the process of wearing and dynamic investigations, this being an additional factor of self-strengthening of deposited meta-stable metal. The developed and investigated

surfacing material seems to be promising for substitution of expensive and scarce chromium-nickel analogues (contained 9-11%Ni).

Key words: Powder-like wire, Surfacing, Meta-stable austenite, Martensite, Quenching, Wear resistance.

ADVANCED HIGH STRENGTH STEELS FOR AUTOMAKERS

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ABSTRACT

The advanced high strength steels (AHSS) help automakers meet proposed stringiest fuel and emissions requirements.
World Autosteel, the automotive group of the world steel association continually explores steel innovation in automobiles, and continues to lead the materials revolution through projects sponsored by the global steel industry for example Ultra Light Steel for Autobodies-Advanced Vehicle Concepts (ULSAB-AVC) and the present program Future Steel Vehicle (FSV).
These programs focused attention on advances of lightweight design concepts and more extensive use of (AHSS). About half of the family cars"S" class's bodies are made of AHSS which have minimum tensile strength of 500-800 MPa. This class of steel is lighter, stronger, and easier to form and has better crash energy absorption. The principal difference between conventional (HSS) and (AHSS) is their microstructure. (AHSS) has a structure of ferrite, pearlite, and martensite, bainite, austenite, and / or retained austenite.

SESSION 6

SUSTAINABLE SUBSTITUTION OF TRADITIONAL HEAT TREATMENT PROCESSES BY PLASMA ASSISTED SURFACE TREATMENT - A VISION OR STATE OF THE ART?

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ABSTRACT

Nowadays plasma treated parts have been successfully introduced for various applications in different industries. The industrial plasma surface treatment has been growing over 300% since 2000. In future, economical and ecological process chains demand integration of heat- and surface treatment into typical machining production flows. Compared to traditional well known treatment methods there is a need for reliable fatigue data from optimized material-plasmanitriding-coating-combinations. To generate such fatigue data in a fast and cost effective way, a step by step approach with specially designed specimens and test procedures has been chosen. The first part of this investigation focuses on bending fatigue strength, while other failure modes, such as pitting, will be tested in the second part of the project. The paper additionally shows innovative ways for component design combining the influence of hardness, residual stress, and surface conditions on fatigue strength and tribological behavior. Quite promising results will be presented, giving also an outlook for further developments.
Key words: Plasma nitriding, Coating, Fatigue data, Component design, Residual compressive stresses

AN ALL-SOLID-STATE ELECTROCHROMIC DEVICE FOR THERMAL CONTROL OF SPACECRAFT

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ABSTRACT

Electrochromic materials can change their optical properties under the action of an applied voltage pulse. These materials can be made for active thermal control device based on their electrochromic properties. This device is light in weight, small of volume, low energy consuming and has highly controlled precision. An all-solid-state electrochromic device was designed to be used on thermal control of spacecraft. The structure of device is ITO/WO_3/Ta_2O_5/NiO/Ag/ Glass. Thin films of ITO, WO_3, Ta_2O_5, NiO and Ag were made by magnetron sputtering. The ITO thin films have surface resistance of about 100 - 120 Ω/cm, the absorptivity is less than 5% in the wavelength range of 200-2500 nm. The average transmittance of WO_3 thin films is about 83% in bleach state, and it decreased to 3% when the films were colored; the transmittance value decreased by nearly 80%. The Ta_2O_5 thin films have good ion conductive properties; NiO thin films have the average transmittance of 88% (bleached) and 15% (colored) respectively, and the change value is 73%. The average reflectivity of Ag thin films is more than 90%. We successfully produced all-solid-state electrochromic device with structure of ITO/WO_3/ Ta_2O_5/NiO/Ag/Glass.

STUDY ON THE HARDFACING OF THE LOW ALLOY STEEL SCREW CONVEYOR

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ABSTRACT

A low alloy steel screw conveyor was exposed to an extensive wear at the top and the side surfaces of the teeth. The microstructure of the base metal is martensitic structure. Welding procedure specification (WPS) and Process Qualification Record (PQR) were carefully performed using a scraped part from the screw conveyor. The preheating temperature of 300 to 400 °C was applied and the SMAW process was selected as selected as a welding process.

Three types of electrodes were selected which mainly wear and corrosion resistance type. Using chromium Carbide electrodes resulted in a significant appearance of cracks at the weld surface that extended to the heat affected zone. However, Using martensitic electrodes resulted in a crack free weld metal with a significant improve of the wear resistance of the base metal.

The effect of applying cushion layer between the base metal and hardfacing layer were studied using two kinds of covered electrodes. The hair cracks that observed using the hardfacing electrodes were greatly reduced using these cushion layers.

The results were discussed on the basis of microstructure and the wear resistance of the base metal and the hardfacing layers.

TECHNICAL AND ECONOMICAL STUDY ON HARDFACING TECHNIQUES

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ABSTRACT

In this research, a comparative study has been carried out to investigate the effectiveness of using different methods for hardfacing; namely surface treatment and welding. In surface treatment method, quenching techniques was employed where specimen were heated and then quenched directly in a proper medium. Heating temperature and quenching medium were varied. The applied heating temperatures were 500, 700 and 927 ^{o} C and water and oil were applied as quenching medium. Effects of each parameter on hardfaced surfaces were investigated .

Welding processes were varied and investigated through the application of SMAW and TIG welding processes. Depositing techniques for hardfacing layers were also varied. Single, parallel double and crossing double layers were employed for depositing techniques comparison. Microhardness measurements and microstructure examinations for the hardfaced groups were carried out. It was found that using welding in hardfacing can raise the hardness of the surface to reach abt. 340 % of its original raw material value. It is expected to have better wear resistance for the hardfaced surfaces by welding. Surface treatment by quenching in water after heating to 927 ^{o} C could raise the hardness values to about 200 % of its original raw material value. Economic study was made to calculate and determine the point at which the cost of using special high strength steel and the cost of using soft steel with hardfacing breakeven. This point was found to be located at material thickness of 13.5 mm; above this value the application of hardfacing by SMAW is economic.

Keywords: Hardfacing, SMAW, TIG Welding, Surface treatment, Microhardness, Microstructure, Economic study.

MECHANIC PROPERTIES OF TI-DOPED DLC MULTILAYER BY PULSE CATHODIC ARC DEPOSITION

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ABSTRACT

The Ti-DLC/DLC multilayer films were prepared on GT35 substrates by arc ion plating, the main body of the films were made of Tix-DLC /DLC multilayer, and the surface is carbon (DLC), which was deposited by arc technology with Ar ion intermittent sputtering and etching. The thickness, hardness, friction coefficient, adhesion and structure of multilayer films were characterized by Dektak 8 Stylus Profilometer, nano-hardness tester, reciprocating sliding wear tester, pull tester, X-ray photoelectron spectroscopy (XPS), transmission electron microscopy (TEM), Raman spectroscopy, and X-ray diffractometry (XRD), respectively. Result shows that the thickness, hardness, friction coefficient, and the adhesion are 2.2 μm, 5200 Hv, 0.09, and 40 N/mm^2, respectively. The internal stress calculated by Stoney's equation, is 2.2 GPa, and the stress of carbon films is as high as 4.5 GPa.

Key words: DLC; multilayer; Ti-doped.

STRUCTURES AND ACCELERATED LIVES OF $Ru_xIr_{1-x}O_2$ COATINGS PREPARED BY A PECHINI METHOD

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ABSTRACT

$Ru_xIr_{1-x}O_2$/Ti coating is considered a prospective anode with a high anticorrosive property for some electrochemical industries of oxygen evolution reaction (OER). A series of anode coatings $Ru_xIr_{1-x}O_2$ (x=1, 0.7, 0.5, 0.3, and 0) were deposited onto titanium substrate (TA2) by a Pechini method using commercial $IrCl_{3\cdot3}H_2O$ and $RuCl_{3\cdot3}H_2O$ as source chemicals. The prepared samples were heat treated at 450 °C for 1 hr. The phase structures, crystal sizes, microstructures and morphologies were analyzed by DSC-TG-DTA, XRD, TEM and FT-IR techniques. The X-ray diffractometry revealed well the rutile structure, which is the common phase for both Ru and Ir oxides. A great amount of metallic Ru could be detected in the coating without Ir (x=1). For x = 1, the crystallite sizes of Ru and a small quantity of RuO_2 are around 20 nm and 10nm, respectively. The crystallite sizes of $Ru_xIr_{1-x}O_2$ (x= 0.7, 0.5, 0.3 and 0) are rather similar. The finest average size of roughly 6–7 nm was observed. The cyclic voltammetry indicates that a highest active area of the electrode could be achieved when x=0.5. The Tafel plots normalised by the voltammetric charges revealed the true electro-catalytic effect of the RuO_2 for the oxygen evolution reaction (OER). In fact, the combination of electro-catalytic effects and surface roughness made $Ru_{0.7}Ir_{0.3}O_2$ coating the most effective for the OER. The Tafel slope values changed from 40 mV sec^{-1} for pure RuO_2 coatings to 60 mV sec−1 for pure IrO_2. In general, the anticorrosion property increased with increasing IrO_2. However, the accelerated test performed at 2000 mA cm^{-2} in 2M H_2SO_4 showed the longer life-time was obtained using $Ru_{0.3}Ir_{0.7}O_2$/Ti.

Keywords: Electrocatalysis, Pechini method, Oxygen evolution, $Ru_xIr_{1-x}O_2$

SESSION 7

LASER SURFACE HARDENING OF TOOL STEELS EXPERIMENTAL AND NUMERICAL ANALYSIS

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ABSTRACT

Laser Surface Hardening (LSH) of High Speed Steel (HSS) AISI M2 was studied. The investigation was made by Continuous wave Neodymium Yttrium Aluminum Garnet (CW Nd:YAG) laser method. Based on the orthogonal experimental design method, only a few experiments needed to be carried out to obtain the optimum processing parameters for the laser surface hardening of the tested tool steels.

The present investigation had been done to obtain and predict suitable and appropriate methods and to get optimizing the laser surface hardening of tested tool steels. Using Ashby and Easterling heat-transfer model, a considered hardened zone, of hardened depth, width, surface hardness and temperature, can be obtained, according to the tested tool steel.

Laser surface hardening process parameters were numerically simulated by DESIGN-EXPERT software to optimize, and predict the laser process parameters with an average accuracy from 88 to 99.96 % comparing to experimental work. The analysis enables the determination of surface temperature, hardened depth and also the temperature profiles.

Key wards : Laser surface hardening, Nd/YAG laser, High speed steel M2, Ashby and Easterling heat-transfer model ,Design Expert software.

RESEARCH ON DEPOSITION TECHNOLOGY OF SIO2 FILM WITH GOOD ABRASION RESISTANCE AND HIGH TRANSMISSION BY ION-ASSISTED METHOD

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ABSTRACT:

SiO_2 film has been widely applied in surface engineering area for its good characters of chemical stability, abrasion resistance and wide transparent spectrum range. For example, it can be used in multi-layer optical film applied in ultraviolet, visible and infrared spectrum range, and also used as protection film in order to resist abrasion, deliquescence and erosion. Several methods are usually adopted to prepare SiO_2 film, such as PECVD (Plasma Enhanced Chemical Vapor Deposition), ion-assisted e-beam evaporation, sol-gel method and so on. Usually, the abrasion resistance characters of SiO2 film prepared by the three methods are different. PECVD is the best, ion-assisted next and sol-gel worst. But the character of SiO_2 film prepared by PECVD is very sensitive to the technology process. In the paper, ion-assisted e-beam evaporation method was used to deposit SiO_2 film on calcium aluminate substrate with good abrasion resistance and high optical transmission in spectrum range of 3.0~5.0 μ m, and the technology was studied. The result has shown that ion power, base temperature and evaporating rate were key factors which affected the abrasion resistance and transmission of SiO_2 film seriously. At the end, we succeeded in preparation of good abrasion resistance and high transmission SiO_2 film on special glass base by this method.

Keywords: Ion-assisted deposition, SiO_2 film, Abrasion resistance, High transmission

SURFACE MODIFICATIONS AND AMORPHIZATION INDUCED BY HIGH-ENERGY ION IRRADIATION OF THE SEMICONDUCTOR INDIUM PHOSPHIDE COMPOUND

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ABSTRACT

Indium phosphide (InP) is one of the most promising compound semiconductor materials for optoelectronic and photonic industries. The effect of ion beams on this material is considered to be paramount as ion beams are important tools for processing and tailoring semiconductor materials. In this investigation we report the effect of high energy ion beams on InP (001) surfaces, these were irradiated with 200 MeV Au ion beams to different fluences. The surface nanotopographical changes due to increasing fluence of swift heavy ions were observed by atomic force microscopy (AFM) where the onset of large increase in surface roughness for fluences sufficient to cause complete surface amorphization was observed. Transmission Electron Microscopy (TEM) was also used to observe the formed agglomeration of defects along the ion path in the crystalline matrix known as ion tracks. High resolution TEM (HRTEM) revealed that the impact of each individual ion leads to single ion track with a core of ~ 5 nm width this core might not be amorphous in nature. Nevertheless, the accumulation and overlap of these individual tracks lead to the observed large increase in surface roughness represented as Root Mean Square (RMS) surface roughness after the onset of complete surface amorphization. Rutherford backscattering (RBS) was utilized to follow the formation of disorder to complete amorphization of the irradiated surface. The surface ion tracks were observed by AFM in the form of ill defined pits of ~ 12 nm in width. However, the observation that the onset of large increase in surface roughness commences only with the complete surface amorphization as confirmed by both TEM and RBS analyses may be attributed to the associated plastic phenomena induced by the change of states from crystalline to amorphous states.

MODIFYING PdO COATING BY PT NANO-PARTICLES TO IMPROVE ELECTROCHEMICAL PROPERTIES

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ABSTRACT:

PdO is an excellent electrocatalyst but the drawback of lower anticorrosion limits its widespread applications in many electrochemical industries, including brine electrolysis, water electrolysis, electrochemical cells and super capacitors, etc. In this paper, nano-phase Pt as a modifier was employed to improve the properties of PdO anode coating. In the experiments, a PdO-Pt composite coating with the Pd:Pt molar ratio being 60:40 was prepared by thermal decomposition onto a pure Ti plate (TA2). A PdO/Ti sample was also prepared as a contrast sample. Both samples were annealed at 450℃ for 1 hr in a furnace. Their crystal structures were defined by X-ray diffraction (XRD). It is showed that the PdO/Ti coating examined is mainly composed of PdO. There is about 5-7 mol% metallic Pd. In the coating of PdO-Pt/Ti, the phases are PdO and metallic Pt, whereas the metallic Pd is not detected. The average crystal size in coating of PdO/Ti was calculated about 22nm. After introducing the Pt, the average crystal sizes of PdO and Pt in coating were calculated about 16 and 30 nm, respectively. It suggests that the formation of the Pt nano-particles would greatly hinder the growth of the PdO grains. The active surface area of the samples was conducted by cyclic voltammeter. The active area of the new type of PdO-Pt/Ti is 1.35 times than that of PdO/Ti. The accelerated life test at 1000 mA cm^{-2} in 2 M Na_2SO_4 was used to characterize the anticorrosive property of samples. It was found that owing to the addition of the highly anticorrosive Pt nano-particles in PdO coatings, the lifetime of PdO-Pt/Ti would be increased to10 times.

Keywords: PdO, Pt particles, Modifying, Electrochemical properties

CARBON NANOPARTICLES COATED TiO_2 NANOFIBERS AND ITS PHOTOCATALYTIC ACTIVITY

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ABSTRACT

This study investigates the fabrication of the ultrafine fibers by polyvinylpyrrolidone (PVP) sol/titanium n-butyloxide ($Ti(OC_4H_{9n})_4$) using the electrospinning technique. The bicomponent fibers of PVP/TiO_2 are heat treated at 250℃ and calcined at 550℃. TiO_2 nanofibers with a diameter of 60-300 nm were fabricated. Thin carbon films were deposited on the surface of the TiO_2 nanofibers by chemical vapor deposition(CVD). The morphological structure of the ultrafine fibers has been studied by means of infrared (FT-IR) spectrum, scanning electron microscopy (SEM), transmission electron microscopy (TEM), and X-ray diffraction (XRD). Comparing with TiO_2 nanofibers the carbon film deposited TiO_2 fibers exhibit higher photo-catalytic activity toward the degradation of methylene blue.

Keywords: Electrospinning; Fiber;Carbon; TiO_2; Chemical vapor deposition

SESSION 8

STUDY OF ANISOTROPY OF TWO ALUMINIUM ALLOYS OBTAINED BY TWO METHODS OF RAPID SOLIDIFICATION

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ABSTRACT

The aim of this research work is concerned with the study of thermal expansion coefficient of two aluminium alloys. These alloys are studied by two methods of rapid solidification. The first method is: Twin Roller Melt Spinning (TRMS) whereas the second is: Direct Chill Casting (DCC). The presence of the anisotropy was concluded on the basis of the thermal expansion coefficient which depends upon the laminate directions. However, measured along the radial direction appeared to be inferior to the measured one along the axial direction in both as cast and homogenised alloy.
Keywords: Aluminium alloys, Rapid solidification, Thermal expansion coefficient, Anisotropy

INFLUENCE OF ANNEALING TEMPERATURES ON STRUCTURE FORMATION AND MECHANISMS OF DC CONDUCTION IN THERMALLY EVAPORATED NANOCRYSTALLITE STRUCTURE $ZnIn_2Se_4$ THIN FILMS

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ABSTRACT

$ZnIn_2Se_4$ is of polycrystalline structure in as synthesized condition. It transforms to nanocrytallite structure of $ZnIn_2Se_4$ film upon thermal evaporation. Annealing temperatures influenced crystallite size, dislocation density and internal strain. The hot probe test showed that $ZnIn_2Se_4$ thin films are n-type semiconductor. The dark electrical resistivity versus reciprocal temperature for planar structure of Au/$ZnIn_2Se_4$/Au showed existence of two operating conduction mechanisms depending on temperature. At temperatures > 365K, intrinsic conduction is operating with activation energy of 0.837eV. At temperatures < 365K, extrinsic conduction takes place with activation energy of 0.18eV. The operating conduction mechanism in extrinsic region is variable range hopping. The parameters such as: density of states at Fermi level, hopping distance and average hopping energy have been determined and it was found that they depend on film thickness. The dark current-voltage characteristics of Au/n-$ZnIn_2Se_4$/p-Si/Al diode at different temperatures ranging from (293-353)K have been investigated. Results showed rectification behavior. At forward bias potential <0.2V, thermionic emission of electrons from $ZnIn_2Se_4$ film over a potential barrier of 0.28V takes place. At forward bias potential > 0.2V, single trap space charge limited current is operating. The trap concentration and trap energy level have been determined as $3.12\times1019cm^{-3}$ and 0.24eV, respectively.

Keywords: $ZnIn_2Se_4$; Electrical properties; Heterojunction diode

ALUMINUM QUENCHING BY ARRAY OF WATER JETS

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ABSTRACT

The primary heat removal technique in metal casting process for Aluminum ingots produced through Direct Chill (DC) casting method in which direct contact between hot surface and coolant takes place, quenching can be defined as, cooling of metals at a rate faster than cooling in the still air which is widely used for controlling the mechanical and metallurgical properties in the metal manufacturing and material processing industries. The hot metal is suddenly reduced into atmospheric conditions by means of coolants and the complete process will end up within 4-7 seconds. The heat leaving from the hot surface is the primary interest in the metal quenching process for the prediction of temperature, hardness, microstructures, residual stresses and deformation. Based on the region of temperature, the heat transfer mechanism during quenching will also change, i.e., film boiling, transition boiling and nucleate boiling. The present research work deals with the impact of the quenching water velocity parameter on the heat flux and wetting front movement during array of jets quenching. A thin hot metal plate is exposed to array of water jets on one of its surfaces. Aluminum Al2024 material considered for the study and the coolant used is de-ionized water. The temperature at the other side is measured through the infrared camera. The measured temperature data are further processed through the inverse finite element technique for the estimation of heat flux leaving from the quenched surface. The significance of experimental temperature measurement is discussed in detail. The change in coolant velocity strongly affects the heat flux and wetting front movement. In this work, nine different coolant velocities are employed and the influence of coolant is studied more elaborately.

Keywords: Aluminum DC casting, Critical heat flux, Leidenfrost point, Inverse heat conduction problem, Rewetting front velocity,

THERMO MECHANICAL BEHAVIOUR MODELLING OF THE SHAPE MEMORY ALLOYS AND ESTIMATION OF THEIR ABSORPTION CAPACITY OF THE STRAIN ENERGY

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ABSTRACT

The shape memory alloys (SMA) are relatively new materials having remarkable mechanical properties such as the super elasticity and the memory of shape. These properties enable them to find their initial form by a simple heating or a simple reversible stress or strain application. In this article, some definitions concerning the effect of super elasticity and the shape memory of these types of materials are presented. Also, predictive models of beam behavior in SMA material, induced by simple mechanical requests such as the flexion and the traction are considered. This behavior is broken up into two linear parts with two different elastic modules. The analytical model is built up in order to estimate the ability of these alloys to absorb the strain energy induced by a simple external loading. However, the thermo mechanical parameters of these SMA are determined experimentally.

The obtained results reveal differences in level of the strain energy absorption according to the state at which the memory alloy material is, i.e.: in austenitic or martensitic phase, and whatever is the type of their loading. Also, they allowed us to determine their transformation temperatures and their Young modules on one hand, and to validate the model of their stress - strain behavior law, on the other hand. The quantification to evaluate this capacity for absorption of the strain energy of the SMA is essential in order to improve the mechanical performances and to optimize the design of these types of materials known as "intelligent materials", so that to increase and to widen their application fields.

Keywords: Shape memory alloy, Martensitic transformation, Thermo mechanical properties, Strain energy, Stress and strain.

STUDY OF THE PRECIPITATION AND THE EFFECT OF NATURAL AGING AND SUBSEQUENT ARTIFICIAL AGING ON THE RESISTIVITY EVOLUTION OF AL-MG-SI ALLOYS

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ABSTRACT

It is very essential to improve electrical and mechanical properties of Al-Mg-Si alloys by adding other elements and/or by different heat treatments. It is well known that the addition of transition metals is useful to refine the grain size, and the addition of Cu to Al-Mg-Si alloys increase the strength and hardness of the materials. And the electrical and mechanical properties of the Al-Mg-Si alloys can be changed by heat treatment. We studied in this research work the effect of natural aging on the aging response of the Al-Mg-Si alloys by using low-temperature electrical resistivity measurements. We examined two experimental conditions; natural aging for one month followed by artificial aging in the temperature range of 20–200°C and natural aging for variable periods followed by aging at 180°C. The influence of aging (artificial aging) on tensile (yield strength) properties of Al-Mg-Si alloys has been investigated. Tensile properties have been estimated for aging temperatures between 20-250°C.

Key words: AlMgSi alloys, Precipitation, Resistivity, Natural aging, Artificial aging.

16,00 – 17.00

ATON HALL 1

WORK SHOP / PANEL DISCUSSION

Global 21, IFHTSE Project to Help Planning in the Heat Treatment and Surface Engineering Industry.

Prof. Z. KOLOZSVARY

After almost two years from launching the IFHTSE initiative of "Global 21" significant progress has been made in collecting and publishing the contribution of specialists to the survey study. The new IFHTSE journal, International Journal of Surface Engineering is on its way due to the tremendous effort, devotion and professionalism of the late Professor Tom Bell. The work is continued and the contribution of world leading specialists is even more important. To generate a new impetus a Workshop is organized in the framework of the First Mediterranean Conference on Heat Treatment and Surface Engineering

The objective of this IFHTSE study is to show the state of the science, practice and business of *heat treatment and surface engineering at the beginning of the 21st Century* and to try to outline what reasonably is to be expected in the field over the next decades. Progress in fundamental science considered, but global trends, world economic shifts, energy and environmental concerns with their effect on heat treatment and surface engineering are also outlined. Energy and the environment can be identified as the main drivers governing innovation in industrial practice and development.

The Workshop is aiming to cover:

- what has been achieved in the years since the initiative was launched;
- what has to be changed or completed in the structure of the survey study;
- what is the impact of regional development on the heat treatment industry;

Discussions are considered to be focused on the problems of:

- vocational training and education in heat treatment and surface engineering;
- impact of the Far East development with a special emphasis on Japan, China and India
- specific development trends and problems in the Mediterranean area

Abstracts of Poster Presentations

WELDABILITY OF BRITTLE MATERIALS TOUGHENED BY DUCTILE REINFORCEMENTS

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ABSTRACT

The effect of introducing ductile reinforcements on microstructure and mechanical properties is investigated for weld gray cast iron specimens. The present work was carried out on annealed specimens after and before welding process to study the influence of heat treatment on mechanical properties. Correlation of microstructures and their hardness were characterized by using optical microscope and microhardness testing set. The results show that hardness increased in heat affected zone of cast iron due to form structure of a fine acicular martensite. The results indicated that, the formation of phosphide eutectic free zone located at the interface between the ductile reinforcement and the matrix of gray cast iron.

Keywords: Ductile reinforcements, Microstructure, Heat treatment, Microhardness, Martensite, Phosphide eutectic.

PREDICTION OF OVER-TEMPERING DURING RAPID INDUCTION HEATING

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ABSTRACT

The present work concerns the kinetics of hardness loss during induction heat treating of a AMS6414 steel. Induction hardening is used in industry as it is a "green" manufacturing process that allows local superficial hardening. The vast majority of induction hardening is done on normalized ferrite-pearlite structures with low core hardness. However, in the present study, the core material is a tempered martensite with hardness of 450 HV for aerospace mechanical application. Metallurgically, there is a big difference between these two cases as ferrite-pearlite structure are thermodynamically stable, where as martensite is metastable. Because of the high temperatures seen by the region just below the transformed region, martensite softens and this region is called "over-tempering." Indeed, this layer (martensitic) is heated to very high temperatures without being austenitized and return to a more stable state, i.e., ferrite with dispersed carbides. This return to equilibrium leads to loss of hardness. The aim of this study is to predict the depth and final hardness of this zone according to the specific thermal cycle of induction hardening, i.e. very short times, and high temperatures. The specific influences of time, temperature and initial hardness / microstructure on the kinetic tempering alloy were investigated and analyzed with regards to the over-tempering phenomenon.

Keywords: Tempering, Martensite, Over-tempering, Induction, Surface hardening.

ELECTROCHEMICAL BEHAVIOR OF ALUMINIZED STEEL IN SALINE ELECTROLYTES

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ABSTRACT

Low carbon steel was coated by pack aluminization at process temperatures 900°C and 1100°C. Two types of activators (NH_4F and NH_4CL) were used separately. The thermally treated steel substrates were examined in saline electrolytes such as static saline solution as well as saline slurry in erosion corrosion process. The techniques of OPC, LPR and EIS (Nyquist and Bode plots) were used to measure the corrosion resistance. The obtained results show that specimens treated at aluminizing temperature of 900°C show in general higher corrosion resistance (2-3 mpy) during both static as well as erosion corrosion tests, as compared to specimens treated at 1100°C aluminizing temperature (5-16 mpy). Moreover, it was found that aluminizing process with NH_4F activator give better corrosion resistance compared with that of NH_4Cl activator.
Keywords: Aluminum diffusion coating, Static Corrosion, Erosion Corrosion, .

QUALITY ASSESSMENT OF 12 Ni MARAGING STEEL AFTER POWDER LASER SURFACING AND SUBSEQUENT HEAT TREATMENT

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ABSTRACT

In the mass production of dies in die-casting industry, the use of reliable technology for fast and efficient repair of die-casting tools is required. Surface repair experiments with Nd:YAG coaxial laser cladding of NiCoMo maraging powder were made on specimens from maraging steel (EN 10027-2, mat. no. 1.2799). The influences of different modes of laser-beam guidance with various powder mass flows and with different degrees of overlapping of individual traces on the dilution and the repair area were determined. The micro and macroscopic analyses of microsections of fusion zone (FZ), heat affected zone (HAZ) and through-depth microhardness were analysed after cladding and after subsequent solution and precipitation annealing. The microchemical (EDS) analysis was performed at various depths. The residual stresses in the clad face and in the clad toe were determined and compared, using the hole-drilling method.

Keywords: Laser cladding, Surface integrity, Maraging steel, Microhardness, Residual stress

EFFECT OF CASE HARDENING PROCESS OF ALLOYSTEELS ON THEIR CHARACTERISTICS

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ABSTRACT

Cane chains are very important transmission elements which are carefully designed according to fatigue strength and wear resistance. To increase the life of cane chains, the resistance of the surface failure should be increased. In this investigation experiments were carried out to evaluate the wear resistance using wear test rig designed and manufactured for this purpose. Three types of materials were used, namely 16MnCr5, 17CrNiMo6, and 18MnCrB5. Discs manufactured from steels were carburized for different periods of time (6, 10, and 12 hours). Tempering process was carried out at different temperatures to obtain hardness values of 48, 52, and 56 HRC. The accumulated loss of weight was measured and the wear rates were determined for each case hardened material at constant normal test load of 800 N. The accumulated loss of weight was measured as a function of the number of revolutions. Wear rate was calculated and presented with case depth and case hardness for all materials. The hardness distribution and carbon content of carburized layer presented with distance from the surface, microstructure and carbides percentage are presented and measured. From test results, it was concluded that the wear rate for all materials under investigation decreases with increase of their case hardness. Minimum wear rate was obtained at hardness 56 HRC. Wear rate for all materials decreases with increase of carburizing time tending to reach a minimum at carburizing time 10 hours. Wear rate for material 16MnCr5 is less than that of the wear rate for 17CrNiMo6 and 18MnCrB5 by about 15 and 45% respectively under the same testing conditions. Carburized layer, carbon content and case depth increases with increase of carburizing time.

Keywords: Heat treatment, Carburizing, Case hardening, Cane chain Hardness, Wear rate, Microstructure, Carbide, X - Ray diffraction

EXPERIMENTAL STUDY OF END-MILLING OF STEEL AISI 1060 FOR OPTIMUM SURFACE ROUGHNESS

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ABSTRACT

Taguchi optimization methodology was applied to optimize cutting parameters in end milling operation. Machining carbon steel AISI 1060 with high speed steel tool under finishing conditions with coolant is used in this study. The experimental work has been conducted on CNC milling machine tool, and the experiments carried out by using orthogonal array as suggested by Taguchi. The milling parameters are cutting speed, feed rate, depth of cut and cutting tools with different number of flutes were used as additional factor in cutting conditions. An orthogonal array, signal-to-noise (S/N) ratio is employed to analyze the effect of these milling parameters on surface roughness. The results show that the optimum parameters of machining is obtained at a depth of cut 0.3 mm, cutting speed 1000 rpm, feed rate 50 mm/rev and number of flutes four. Confirmation tests with the optimal levels of cutting parameters are carried out in order to illustrate the effectiveness of Taguchi optimization method. Taguchi method has been found very efficient tool to obtain an optimum surface roughness or by other meaning a smaller surface roughness.

Keywords: Taguchi Method; Cutting Tools;; Surface Roughness; CNC Milling Machine; Optimization.

THE EFFECT OF THE DISPERSOID ON THE RECRYSTALLIZATION BEHAVIOUR IN ALMGSI ALLOYS

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ABSTRACT

The addition of small amounts of the transition elements such as Zr, Mn and Cr to AlMgSi alloys showed that these elements inhibit recrystallization when the alloys are pre-heated prior to deformation. The transition elements produce fine dispersoid particles which retard the crystallization and increase the microstructure stability at high temperature due to their low solid solubility and diffusivity in aluminium. The formation of the coarse particles during casting is mainly due to the presence of Fe. These particles are found in samples, even, after solution treatment. The particles having a diameter exciding 3μm accelerate the recrystallization as they are good sites for nucleation of recrystallization. Precipitate free zones (PFZ's) developed around the coarse particles favour nucleation of recrystallization by subgrain growth. Intermediate annealing before deformation allowed achieving a high rate of cold rolled deformation due to the remove of the solute from the matrix by the formation of the hardening phases. Optical and transmission electron microscopy, hardness measurements were used to study the kinetics of recrystallization of the AlMgSi alloys.

keywords: AlMgSi alloys, precipitation, nucleation, recrystallization, dispersoid.

OXIDATION BEHAVIOR OF Fe_3Al-5Cr- (0, 0.5, 1.5) Ti ALLOYS AT TEMPERATURE RANGES FROM 800^{O}C TO 1200 ^{O}C

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ABSTRACT

As cast Fe_3Al-5Cr- (0, 0.5, 1.5) Ti alloys were isothermally oxidized at temperature ranges from 800 to 1200 ^{0}C in air, and their oxidation characteristics were studied using thermogravimetric analyzer, X-ray diffractometer, optical microscope and scanning electron microscope. It was found that Ti increased the oxidation resistance of Fe_3Al- Cr alloys to a certain extent. The oxide scales that formed on the unalloyed Fe_3Al alloys consisted primarily of α-Al_2O_3 containing a small percentage of dissolved iron and chromium ions. The experimental result of unalloyed Fe_3Al alloy shows also, an Al-free, Fe-enriched zone was formed beneath the oxide scale, owing to Al consumption to form the oxide scale. The oxide scale on unalloyed Fe_3Al alloy had poor adherence. On the other hand, the result shows that, the oxidation rate decreased for titanium alloyed Fe_3Al alloy, which has been explained by a change in the nature of the surface scale. Analysis of the oxidation product revealed that the presence of titanium as alloying elements change the nature of formed oxide scale and protect the bulk alloy from further oxidation.

Keywords: Intermetallic compound – Fe_3Al – Scale – Oxidation resistance – High temperature

CONCEPT OF REAL TIME QUALITY CONTROL ON THE INDUCTION HARDENING MACHINES

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ABSTRACT

The goal of surface hardening of steel or cast iron parts using induction heating is to develop a martensitic layer of a specified thickness. Due to this layer, the work piece will present the requested hardness on the surface, but the core remains elastic and tenacious. To harden by quenching, the work piece must be heated into the austenitic crystal phase and then fast cooled. The requirements for this process are more and more complex, especially for car industry.

In the same time, high production rate and the high cost of the work piece demand a quick and cheap quality control during production. Though the test laboratory, integrated in heat treatment line, can be completed with high performance equipment, still the controlled pieces are generally destroyed and the measurement takes long time.

A good approach for real time quality check of the induction heat treatment is to control and record the parameters of the process. This can be done using the higher processing capability and larger memories of today's industrial control units included in the machine. This way, the process will have high throughput without the risk of producing defective parts.

This paper presents solutions for real time quality control of the hardening process implemented on a machine made by AAGES Ltd, Tg. Mures - Romania. For each work piece, the total transferred heating energy, the working frequency, the temperature and quality of the quenching liquid is measured and compared to expected values. In case of a difference, the defective piece can be automatically excluded from production chain. This method will make the production stable any nonconformity is immediately removed. The maximum allowed difference between recorded and expected parameters are stored along the program for the heat treatment process and the user sets these values. The measured values for each work piece can be transmitted to external computer for data acquisition and processing. In this way, the system allows not only a close control of the quality, but also a statistical analysis of the process and further enhancement of the quality.