ABSTRACT

The microstructural aspects of cast A356/357 alloys are strongly dependent on the magnesium content, modification, grain refinement, cooling rate, porosity and heat treatment. On the other hand, the fracture behavior of these alloys depends on the size and shape of eutectic silicon particles and iron-rich intermetallics. Magnesium content increases both the matrix strength and eutectic particle size but decreases the ductility. The combined effect of modification and grain refinement improves the overall mechanical properties. Increasing the cooling rate refines the eutectic Si particles, iron-rich intermetallics, aspect ratio and improves ductility. Porosity defect is detrimental to mechanical properties and an increased level of porosity is reported to accompany the modification of A356/357 cast alloys. Cast A356/357 aluminium alloys are strengthened by heat treatment processes to attain desirable mechanical properties. The fracture behavior of Al-Si-Mg alloys depends on silicon particle cracking. The damage process takes place due to particle cracking, microcrack formation and growth and local linkage of microcracks. This paper presents an overview on the microstructural aspects and fracture behavior of A356/A357 alloys.
EXPERIMENTAL INVESTIGATION OF STRAIN HARDENING BEHAVIOUR OF SINTERED ALUMINIUM PREFORMS

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ABSTRACT

Cold upset – forming, densification and strain hardening behaviour of sintered aluminium preforms were investigated. Cylindrical preforms of four initial theoretical densities 82, 86, 89 and 92 percent with aspect ratio 0.75, were prepared using a suitable die, a punch and a die bottom insert on a 1.0 MN capacity hydraulic testing machine. The instantaneous strain hardening exponent $n_i$ and strength coefficient $k_i$ of the aluminium preforms were calculated and found to have reached the peak value when the deformation or packing density was at low value. Further, it has been observed that the value of $n_i$ and $k_i$ decreased and settled to a constant value for both of the fractional densities of the preforms tested irrespective of the lubricant.

Key words: Sintering, Compression test, aluminium, plastic deformation, lubricants
AN ANALYSIS OF THE MICROINDENTATION DATA OBTAINED FROM A THERMOMECHANICALLY PROCESSED MULTIPHASE MICROALLOYED STEEL

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ABSTRACT

The indentation experiments using Vickers micro- and macrohardness tester at various loads ranging from 50 mN to 98 N were performed on a multiphase (ferrite-bainite-martensite) microalloyed steel. The hardness response could be classified into three stages. At loads higher than 10 N a load independent hardness (4.74 GPa) was obtained. In the load range of 10 N to 1 N an indentation size effect (ISE) i.e., an increase in the hardness with the decrease in the load was observed, whereas, in the load range of 1 N to 50 mN a reverse ISE i.e., a decrease in the hardness with the decrease in load was observed. The experimental data were analysed using the energy balance and strain gradient plasticity (SGP) models. The energy balance model was able to predict the load independent hardness as well as both the ISE and the reverse ISE. On the other hand, the SGP model could predict only the ISE but not the reverse ISE. A modified SGP model was proposed to explain the ISE and the reverse ISE. The hardness calculated based on the proposed model compares well with the experimental data. The mathematical equivalence between the modified SGP and the energy balance models has been established.
WEAR RESISTANCE OF RS-D2 STEEL REINFORCED ALUMINIUM COMPOSITES

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ABSTRACT

Rapidly solidified (RS) D2 steel particle reinforced aluminium matrix composites have been fabricated using powder metallurgy technique involving sintering and hot pressing. Density of the composites has been found to be almost 100% that of the theoretical value. The composite containing even 0.9 vol% particles could exhibit a hardness of 116 BHN as against 40 BHN of aluminium matrix. EDX analysis and microhardness measurements indicate the presence of (Fe,Cr)2Al5 at the particle-matrix interface. The effect of RS-D2 particles on the wear resistance of aluminium against 600 grit bonded SiC countersurface has been studied using Pin-on-Disc type wear set up. The wear resistance of the composites has been found to increase remarkably with the concentration of RS-D2 particles. The abrasive wear resistance ($\Omega$) shows a positive deviation from the rule of mixture. A five fold improvement in $\Omega$ with respect to aluminium matrix has been achieved by incorporating only 2.8 vol% of RS-D2 reinforcement.
BIOLOGICAL REMOVAL OF SULFUR FROM COAL
FLOTATION CONCENTRATE BY CULTURE
ISOLATED FROM COAL WASHERY PLANT
TAILING DUMP

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ABSTRACT

A combination of flotation and microbial leaching processes was used to achieve acceptable level of sulfur and ash in Tabas coal sample of Iran. Representative sample of the minus 500 micron size fraction was subjected to flotation separation for the removal of ash and sulfur. The final concentrate with recovery, combustion value and sulfur content of 86.03, 86.45 and 1.35 % respectively were achieved at pH: 8 and following reagent dosage and operating conditions: collector: diesel oil (1200 g/ton), frother: MIBC (5%) + pine oil (95 %) with concentration of 120 (g/ton), depressant: sodium silicate (1000 g/ton), particle size: <500 µm and pulp density: 7 %. Because of fine distribution of sulfur on Tabas coal macerals and lithotypes, high percentage of total sulfur (79.9%) is distributed in flotation concentrate and only 20.1 % is yielded in the tails. So microbial leaching using a species isolated from coal washery plant tailing dump was used in batch system to remove sulfur from flotation concentrate. The conditions were optimized for the maximum removal of sulfur. These conditions were found to be pH of 2, particle size less than 0.18 mm, pulp density: 8 %, temperature: 30 °C, shaking rate: 150 rpm conditions. Total sulfur and ash content was reduced by bioleaching from 13.55 and 1.35 in flotation concentrate to 9.47 and 0.55 in the final leached concentrate, a reduction of 35 and 61.9 % respectively. Sterilization of coal adversely affects the sulfur reduction. The results suggest that the isolated culture is sufficiently effective for depyritization of Tabas coal flotation concentrate in stirred system.
THE INFLUENCE OF PRECIPITATION HARDENING ON THE RECIPROCATING WEAR BEHAVIOUR OF METALLIC MATERIALS

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ABSTRACT

The main objective of the present investigation is to evaluate the influence of precipitation hardening on the reciprocating wear behavior of metallic materials. Towards that purpose, three different alloys, which can be hardened by precipitation hardening method, have been selected as test material. The reciprocating wear rates of these materials have been evaluated at three different loads. The morphology of the worn surfaces and polished section surfaces beneath the worn surfaces have been examined under SEM. The results indicate that the reciprocating wear rate in solution treated condition is higher than peak aged conditions for a Cu-based and Ni-based alloy. In contrast, in Al-based alloy, higher wear resistance can be seen in peak-aged condition. It is also noted that in reciprocating wear crack generates from the surfaces.
FLEXURAL BEHAVIOUR OF 2D SILICA – SILICA CONTINUOUS FIBRE-REINFORCED, CERAMIC-MATRIX COMPOSITES

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ABSTRACT

Advanced materials, such as continuous fiber-reinforced ceramic-matrix composites offer significant enhancements in a variety of properties, as compared to their bulk, monolithic counterparts. These properties include primarily the flexural and compressive strength and fracture toughness / energy. However, till date, there are hardly any scientific studies that are reported in case of the silica based fiber reinforced advanced ceramic composites, which bring out the effects of various experimental conditions on these properties. Some of these experimental conditions become very important as they simulate nearly the service conditions of components that are made from these materials. In the present study, the effects of various test conditions on the flexural strength of 2D woven silica continuous fiber-reinforced, (silica) ceramic-matrix composite (CFCC) materials have been comprehensively evaluated and reported. These conditions include the span length (effectively the specimen dimensions), strain rate, test temperature, high temperature exposure and finally the thermal shock. The results obtained are discussed and rationalized in terms of the material characteristics and the mode of failure. The study reveals that the material exhibits a well defined critical span length \( L_c \), beyond which the mode of failure is tensile (fully bend or flexural loading) and also the fact that \( L_c \) depends on the strain rate and test temperature.
FRETting Fatigue of Biomaterials

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ABSTRACT

The use of metals and materials for replacement and repair of human body parts are attracting more attention in recent times. Like any other components in service, biomaterials also undergo degradation due to fretting, wear and corrosion. Fretting wear, fretting fatigue and fretting corrosion are the three main areas of concern for the orthopedic surgeons. This paper reviews fretting fatigue along with various methodologies and mechanisms. Fretting of materials is controlled by several sets of variables working synergistically, making the process difficult to quantify. A fretting test rig for biomaterials has been developed simulating the conditions of the actual implants as close as possible. Fretting fatigue life is also controlled by contact geometries, which delay or accelerate the crack initiation. Several contact geometries have been mentioned which can influence the fretting life of the materials. Fretting conditions are also governed by normal pressure and slip amplitude regime in fretting maps. Physiological medium may aggravate or reduce the fretting failures depending on the nature of surface and the medium. Titanium alloys have been established as the most suitable materials for bio implants due to their attractive properties within the body environment. Some important aspects of the fretting damage of these alloys are mentioned in this paper. Fretting fatigue life of these alloys can be significantly improved by surface modification with specialized techniques such as plasma nitriding, ion implantation and Physical Vapour Deposited TiN coatings. The paper describes details of these methods as well.
KINETICS AND MECHANISM OF IRON ORE – COAL COMPOSITE PELLETS REDUCTION

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ABSTRACT

Composite pellet contains mixture of fines of iron bearing oxide and carbonaceous material (coal, coke etc), which has been imparted sufficient green strength for subsequent handling by cold bonding technique. The composite pellets offer the advantage of reduction rate, utilization of fines and pollution control.

During non-isothermal reduction of composite pellets, it is found that degree of reduction varies from 46 to 99 pct, depending upon pellets composition and heating rate. It is also observed that devolatilization of coal generates reducing gases (such as H₂, CO etc). A significant quantity (approximately 10 to 20 pct of pellet weight) of extraneous H₂O and CO₂ are retained by oven-dried pellets as chemically combined or strongly adsorbed species. These gases, liberate during heating to high temperature, react with carbon and hydrocarbon to generate additional quantities of CO and H₂. The paper analyses the non-isothermal kinetics data and discusses the mechanism of iron ore – coal composite pellets reduction. Activation energy values obtained for final stage reduction, vary from 183 to 268 KJ/ mol. Hence, it can be concluded that the overall rate of reduction of composite pellets is controlled by the rate of gasification reactions.
METAL FORMING WITH EXPLOSIVES

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ABSTRACT

The paper describes the development work on explosive forming of sheet metals. Various shapes such as cones with an apex angle of 48°, domes, hemispheres etc., were successfully formed in different materials like iron, stainless steel, copper, titanium, aluminium and nimonic 75 alloy. Scaling laws were applied for forming the shapes of size larger than 300 mm in diameter. Metallic dies were fabricated from reusable low melting kirksite alloy for shapes less than 200 mm diameter while concrete/epoxy coated dies were used for larger shapes in order to make the process economically attractive for producing even a few components of large size. Microstructural studies of the samples from the above components showed that metals with fcc structure work harden more readily than the bcc ones. The study has further confirmed that the deformation mechanisms such as slip, twinning and grain distortion operative in explosive forming are akin to that encountered in conventional metal forming. Apart from the processing aspects, the potential advantages of explosive forming have also been briefly highlighted in this paper.
DETERMINATION OF CRYSTALLOGRAPHIC
TEXTURE OF ZIRCONIUM ALLOY COMPONENTS
USING XRD PATTERNS

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ABSTRACT

Preferred orientation in zirconium alloy components, namely pressure tube, fuel cladding tube and calandria tube, which are used in Pressurized Heavy Water Reactor (PHWR), was determined using 2θ XRD scans method. XRD patterns of specimens from three well-defined directions in the tubes e.g., rolling direction (RD), transverse direction (TD) and radial or normal direction (ND) were analysed to get preferred orientation factors \( f_R \), \( f_T \) and \( f_N \) which represent the fraction of grains with their basal poles oriented in rolling direction, transverse direction and normal (radial) direction of the tube respectively. Results showed strong radial basal pole texture in the cladding tubes. The values of preferred orientation factors \( f_R \), \( f_T \) and \( f_N \) for PHWR cladding tube were found to be 0.11, 0.24 and 0.67 respectively. The samples of Zr-2.5%Nb pressure tube were analysed at three laboratories. The results obtained at the three laboratories were comparable. The mean values of preferred orientation factors \( f_R \), \( f_T \) and \( f_N \) for Zr-2.5%Nb pressure tube were found to be 0.06, 0.51 and 0.41 respectively. The values of \( f_R \), \( f_T \) and \( f_N \) for zircaloy-2 calandria tube were found to be 0.17, 0.29 and 0.57 respectively.
FOAMING OF COMMERCIAL PURITY ALUMINUM USING ZIRCONIUM HYDRIDE

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ABSTRACT

Foaming in commercial purity aluminum was obtained by two techniques using different concentrations of the foaming agent, zirconium hydride. The densification of the mixed powders of aluminum and zirconium hydride was obtained by (i) compacting in uniaxial press and (ii) by the powders rolling in sealed aluminum cans. The foaming was obtained by heating the pressed compacts in a furnace under argon flow and the rolled sheets under oxygen-butane flame in air. The compacts obtained using uni-axial press did not give good products while the rolled sheets showed good foaming behavior. The foamed parts (from rolled sheets) were characterized by measuring the pore size, distribution, bulk density and compression tests. The pore size increases, bulk density and compression strength decrease with increase in the concentration of the hydride powder.
MODELLING OF TIME–TEMPERATURE EVOLUTION DURING HEATING OF STEEL INGOTS AND SLABS

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ABSTRACT

Embodying the commercial software package, Fluent®, a computational procedure has been developed to mathematically model heating of steel ingot and slab in a furnace. Parallel to this, experiments were also carried out in a laboratory scale set-up wherein, temperature of both the furnace and the solid was monitored as a function of time through two independent thermocouples. In general, reasonable agreement between experimental measurement and numerical predictions was observed. Extensive numerical calculations also were carried out to assess the sensitivity of predicted results to various model parameters and it was shown that time step size ($\Delta t$), emissivity ($\varepsilon$) as well as the ambient temperature are critical and influence the accuracy of the predicted results significantly. The mathematical model was extrapolated to deduce “complete thermal homogenisation period” of industrial scale ingots in a reheating furnace. It was found that steel ingots, initially at room temperature, and weighing typically 4 to 5 tons require almost 5 to 6 hrs. of heating time to become practically thermally homogeneous.
SYNTHESIS AND PHYSICAL PROPERTIES OF ZEOLITE FROM COAL ASH AND ITS APPLICATION FOR ENVIRONMENTAL PROTECTION

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ABSTRACT

The hydrothermal synthesis of zeolites from coal fly ash was carried out using NaOH and KOH as an alkali source. The cation exchange properties and the simultaneous removal of NH$_4^+$ and PO$_4^{3-}$ were investigated for the zeolites thus obtained from coal fly ash. The effective use of these zeolites was evaluated from the viewpoint of environmental protection.

Na type zeolite P (NaP) and potassium-chabazite (K-CHA) are mainly formed as zeolite species in NaOH and KOH solutions at 393K. CaP zeolite (CaP) with high substitution percent can be obtained by Ca substitution operation from NaP. As indicated by the X-ray diffraction intensities, NaP, CaP and K-CHA deteriorate with a decrease in pH by acid dissolution of zeolite crystals, when they are used as a cation exchange material. The Ca substitution ratio of CaP increases with an increase in the number of substitution operation and Ca$^{2+}$ concentration, and the cation exchange reaction between Na$^+$ and Ca$^{2+}$ is essentially reversible. The phosphate species, PO$_4^{3-}$ is removed by Ca$^{2+}$ supplied from CaP into aqueous solution by a cation exchange reaction. The CaP can simultaneously remove NH$_4^+$ and PO$_4^{3-}$ in aqueous solution. The zeolite obtained from coal ash can be used as the material for cation exchange and soil improvement, an environmentally friendly use of coal fly ash.