ABSTRACT BOOK

IRAN INTERNATIONAL ALUMINIUM CONFERENCE

22 - 23 April 2009
Tehran, Olympic Hotel

Edited by
Dr. Mansour Soltanieh
In the name of God

Abstract book of

Iran International Aluminium Conference

22-23 April 2009

Tehran, Iran

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Dr. Mansour Soltanieh
Preface

Before the human experiences his perpetual will, i.e., the sweet taste of a safe and repeatable flight, higher weight, thickness and volume were thought as great advantages for structures. This perception implicated also for ancient ship industry. However, it was not so irrational thought; before achieving the production of sound parts it was the simplest way to gain strength and durability. With beginning of “Aerospace era”, demand for strong but light structures arose. Although light metals and their foregoing, aluminium, had been introduced formerly, the new era sparkled extensive researches on production of strong parts using these metals. Gradually, international concerns on energy and fuel shortage caused more interest to use light alloys more and more in transportation industries. Thus, one may entitle the light metals as a basis of new era. Among this group, aluminium was dedicated more attention mainly due to mass production in lower cost by the invention of Hall-Heroult process. Within years, worthwhile researches on this metal lead to the wide development of aluminium knowledge and related industries. Nevertheless, it is fair to say that there are still important contexts in the field of aluminium to be scrutinized.

It seems that the most important challenge of aluminium industry (and maybe all industries) is ENERGY. What distinguishes this industry among the others is the high share of energy in production costs of primary aluminium.

Thus, it is expected that aluminium industry to be concentrated in regions with inexpensive energy as well as growing demand. Iran bears these advantages where it carries the second rank in gas resources and has a low capital consumption of aluminium. Supposing this point, Iran International Aluminium Conference (IIAC2009) is to provide a suitable context to collect aluminium experts in domestic and international scale and present the latest progresses in science and technology of aluminium to create a new stimulus in aluminium related industries in Iran as a country with geographically proper situation for aluminium industries.

In addition to article presentations, IIAC2009 comprised specialized courses in the field of aluminium presented by outstanding international professors and experts. An exhibition besides IIAC2009 also appeared as a great opportunity to famous industrials and researchers to conduct beneficent dialogues.

This scientific-industrial event which experienced its first round, got executed by intensive help of a group of university professors, researchers and graduate students of Iran Aluminum Research Center (IARC) along with invaluable support of Iranian Mines & Mineral Industries Development & Renovation Organization (IMIDRO) and close cooperation of Iranian aluminium industries. The event has aimed to be the first sparkle for a series of international aluminium conferences to play a major role in monitoring current status and discussing future trends of domestic industries in terms of
international progresses. I hereby like to give my intimate thanks to all who did their best to hold this event successfully whom all the beneficiaries of IIAC2009 owe. I wish them prosperity in either stage of their life.

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CASTING
Modern Concepts for Defect-Free Cast Aluminium.

J. Campbell
Department of Metallurgy and Materials, University of Birmingham, B15 2TT, UK

Abstract

Our current foundries and cast houses are required to be re-engineered to take account of the latest findings that the pouring of melts can introduce defects into the metal that reduce properties. The damage caused by oxides is well known. However, it is not generally known that all oxides entrained by pouring are double (known as bifilms). Bifilms have an unbounded central interface that acts as a crack in the liquid, and this liquid crack can survive to form a crack in the final solidified alloy. The nature and importance of oxide bifilms are presented together with methods to avoid such damage. The prospects for greatly enhanced strength and fatigue performance from existing alloys at no extra cost represents the next major challenge and incentive to the Al industry.
Melt Quality Related, Aluminium Casting Defects

A. Nouruzi Khorasani
ROH Automotive, P.O. Box 2466, Regency Park, SA 5942, Australia

Abstract

Al-Si casting alloys are used extensively in automotive and aerospace industries; this is primarily due to the excellent casting characteristics and good mechanical properties. There are extensive combinations of aluminium-silicon casting alloys, which have been developed in years for many different applications. Within Al-Si group of casting alloys, elements such as copper, magnesium and zinc are added to enhance certain characteristics. Casting parts depending on the application and the cost targets are made by methods such as high pressure, gravity and low-pressure die-casting. In the case of parts that are used for critical applications and require high integrity plus mechanical strength usually are manufactured by low-pressure die-casting. The advantage of being heat-treatable plus minimum turbulence gives extra benefit from strength point of view. In this article we will be reviewing some common low-pressure die casting faults. Some of these defects are melt quality related and can be reduced by following certain procedures. Machines and methods that can be utilised to improve melt quality are discussed and some explanation and theories behind the concept will be presented.

Key words: Aluminium, low pressure, casting defects, melt treatment.
Numerical simulation of effective parameters on fluidity of semisolid A356 aluminium alloy

A. M. Parvanian, A. Kermanpur, B. Niroumand

Department of Materials Engineering, Isfahan University of Technology, Isfahan 84156-83111, Iran

Abstract

Semisolid metal processing is a new technology for producing metallic components with high integrity, improved mechanical properties, complex shape and tight dimensional control. In this study, effects of fraction of solid ($f_s$) and centrifugal force on the fluidity of A356 aluminium alloy were investigated using finite difference method. The sand mould consisted of four straight channels of 250 mm long with square cross sections of 3, 6, 9 and 12 mm width. Numerical simulations were performed using commercial Flow3D package. Simulation results were compared to the experimental findings of the Al-7%Si aluminium alloy and a good agreement was achieved. The results showed a linear relationship between alloy fluidity and square fraction liquid. On the other hand, while the fluidity of the alloy was improved by applying a centrifugal force, it was more effective for thicker sections.

Keywords: Semisolid processing, Numerical simulation, Finite volume method, Fluidity.
Effect of temperature and pressure of squeeze casting on porosity and density of AA2024 alloy

V. Ashofte, D. Sadat Safanama, P. Marashi, A. Jahangiri
Mining and Metallurgical Engineering, Amirkabir University of Technology, Tehran, P.O. Box: 15875-4413, Iran

Abstract

This paper investigates the effect of pressure and temperature of squeeze casting on the porosity and density of AA2024 alloy. Due to the effect of these parameters on the mechanical properties and crack formation mechanism, it is important to reduce the porosity and minimize the difference between the measured density and the theoretical value (2.7 g/cm$^3$ for Aluminum). In this research, 3 samples were prepared under various temperatures (700, 750 and 800 °C) and pressures (0, 70, 105 and 140 MPa). Metallographic samples were studied and it was observed that at atmospheric pressure, by increasing the temperature from 700 to 800 °C, the mean diameter of porosity in the center of samples increased from 1.5 μm to 2.5 μm. At 750 °C, increasing the pressure from atmospheric pressure to 140 MPa, decreases the mean diameter of the porosity from 1.3 μm to 0.3 μm. The effect of temperature is negligible at pressures above 70 MPa. Moreover, at pressures above 70 MPa, the density remains almost constant, near its theoretical value of 2.7 g/cm$^3$, which proves that the porosity is almost eliminated.

Keywords: Squeeze Casting, AA2024 alloy porosity, AA2024 alloy density.
Gas Behavior in Aluminum and Steel Lost Foam Casting

M. Khodai¹, S. Ghadiani², N. Varahram², N. Parvin²

¹ Islamic Azad University, Majlesi, Iran
² Department of Material Science and Engineering, Sharif University of Technology, Tehran, P.O. Box: 11365-9466, Iran

Abstract

In lost foam casting process, volume and properties of foam degradation products have significant effects on mold filling and formation of defects. Gas generation capacity and gas gap length are two important parameters in lost foam casting models. In this research, metal front behavior and gas gap length in A356 aluminum alloy and 42CrMo4 steel lost foam casting are investigated using in situ photographic technique. Gas generation capacity in aluminum and steel lost foam casting are investigated using a plunger system. Results indicated that gas gap length and mold filling time increase with coating thickness or foam density. The generated gas gap length in aluminum lost foam casting was about 5 mm whilst measured up to 600 mm in steel lost foam casting. Results of gas capacity measurement indicated that gas generation capacity in steel lost foam casting was about 40 times higher than that of aluminum. Thus high permeability coating should be used in steel lost foam casting.

Keywords: lost foam casting, photographic technique, gas generation capacity.
Effect of process pressure on mechanical properties of semisolid extruded 7075 aluminum alloy

M.A. Shafaat, M. Ketabchi, Z. Makhdumi, M. Gholizadeh

Department of Mining and Metallurgy, Amirkabir University of Technology, Tehran, 424 Hafez Ave., Iran

Abstract

Semisolid extrusion of metals involves extruding metallic alloys within their solidification range, between the solidus and liquidus. In this process, microstructure of extruding billets must consist of spherical solids in liquid matrix. Recrystallisation and partial melting (RAP) is one of the several methods usually used for conditioning microstructure. In this study microstructural conditioning was performed with RAP method and two extrusion pressures were applied to investigate related mechanical properties. Tensile properties of semisolid extruded rods in T6 condition were compared. It was seen that increasing pressure has decreased shrinkage porosities in boundaries of globules and improved yield and tensile strength as well as elongation.

Keywords: Semisolid extrusion, Extrusion pressure, Recrystallisation and partial melting (RAP), Mechanical properties.
The effect of cooling rate and refining elements on the microstructure and tensile properties of a new developed super high strength Al-alloy

N. Pourkia, M. Emam, H. Farhangi and S.H. Seyed Ebrahimi

Center of Excellence for High Performance Materials, School of Metallurgy and Materials, The University of Tehran, Tehran, P.O. Box: 11365-4563, Iran

Abstract

The effect of cooling rate and refining elements on the newly developed super high-strength Al-12Zn-3Mg-2.5Cu alloy was studied. Microstructural examinations by optical and scanning electron microscopy showed that in the absence of refining elements, increasing cooling rate through reduced sections, decreases grain size and proportionally reduces dendrite arm spacing. Constituents were identified as η-MgZn₂, T-Al₃Mg₃Zn₃ and S-Al₃CuMg phase. The optimum level of Zr as a grain refiner was found to be 0.3 wt.%. But, the use of only small amount of Al-5Ti-1B (0.05 wt% Ti) showed refined structure in optimum condition. After solution heat treatment at 455 °C for 2 hours, specimens were aged at 120 °C for 24 hours. It was also found that by the addition of grain refiners and increasing cooling rate, higher strength could be obtained. Data scatter of tensile tests attributed to casting defects. Fractographic studies of tensile specimens revealed a predominantly transgranular fracture.

Keywords: refinement, cooling rate, super high-strength, tensile properties, Al-Zn-Mg-Cu alloy.
Effect of melt super heat on hot tearing of A206 Aluminum alloy

M. Nasr Esfahani, B. Niroumand
Department of Materials Engineering, Isfahan University of Technology, Isfahan, 84156-83111, Iran

Abstract

Effect of melt superheat on the hot tearing susceptibility of A206 aluminum alloy was investigated. For this purpose a hot tearing test apparatus was designed and built which enabled real-time measurements of the contraction load applied on the casting and the temperature as a function of time. Critical temperatures and points during solidification of a casting were extracted from these data. The maximum load developed at the coherency point of the castings was identified as a comparative criterion for predicting the hot tearing susceptibility of the alloys which could be utilized even when no visual tearing had occurred. The results showed that hot tearing susceptibility increased with the melt superheat. This was associated with the reduced cooling rate, increased solute segregation and more localized hot spot formation at the T-junction areas.

Keywords: Super heat, T-shaped casting, Hot Tearing, Aluminium, A206.
Effects of pouring temperature on the structure, density, soundness and hardness of a Semi-Solid Rheocast part made of A356 alloy

M. T. Seyyed Beigi, B. Niroumand
Department of Materials Engineering, Isfahan University of Technology, Isfahan, Iran 84156-83111

Abstract

In this study, effects of pouring temperature on the structure, soundness, density and hardness of a cup-shaped SSR processed casting made from A356 alloy were investigated. Results showed that with increase in the solid fraction, roundness and average grain size of primary solid particles increased. Solid fraction of the primary particles at the bottom of the castings was more than other points due to the liquid segregation which also resulted in non-uniform hardness in different parts of the castings. Densities of the components produced in semi-solid state were more than the one formed in the liquid state. SSR processed castings were less susceptible to hot tearing than the conventionally processed squeeze casting. Hardness of the castings was affected by primary particles size, liquid segregation and section thickness. In general, low fraction solid slurries appeared more suitable for squeeze casting than high fraction slurries because of less liquid segregation and better mechanical properties of the castings.

Keywords: SSR process, pouring temperature, structure, density, liquid segregation, hardness.
Effect of Al-5Ti-1B and Al-5Zr master alloys on structure and tensile properties of A713 alloy

A. Razaghian¹, M. Saghaﬁ², M. Emamy², A. Sadeghi², Sh. Zangeneh¹

¹ Imam Khomeini International University, Qazvin, Iran
² Department of Metallurgy and Materials, Faculty of Engineering, University of Tehran, Tehran, Iran

Abstract

The present study was carried out to investigate the effect of Al-5Ti-1B and Al-5Zr as grain refining elements on the microstructure and tensile properties of 713 aluminum alloy. The results showed that an increase in the percentages of Al-5Ti-1B master alloy would result the average grain size decreased from 370 µm to 40 µm. It was also found that Ti addition changes the morphology of grains from dendritic to rosette type and globular, but the addition of Zr did not show any considerable changes on morphology of grains. Further work on UTS and elongation percentage measurements of the alloy after T5 heat treatment showed that grain refining by Ti improves tensile properties of the alloy.

Keywords: 713 alloy, Grain refiner, Grain size, DAS, Tensile properties.
Effect of refined structure on semi-solid microstructure of A6070 Al alloy during SIMA process

M. Karshenas, M. Emamy
Department of Metallurgy and Materials Engineering, University of Tehran, Tehran, Iran

Abstract

In current research the macro and microstructure of grain refined A6070 aluminum alloy prepared by strain-induced melt activation (SIMA) process was studied. First, different concentrations of Ti (0.003, 0.005, 0.01, 0.02, 0.05, 0.1) and Zr (0.05, 0.1, 0.2, 0.3, 0.4, 0.5) were used for grain refining of the alloy. Then, the cast specimens were rolled (subjected to deformation ratios of 10, 20 and 30%) and heat treated at a constant temperature (625 °C) and time (10 minutes) for altering dendritic structure to globular morphology. The results showed that the additions for best grain refinement were 0.3 wt% Zr and 0.02 wt% Ti. The optimum amount for each grain refiner was selected for SIMA process. Further results of microstructural studies showed that fine and globular structures are obtained after 20% reduction of 0.02% Ti-refined specimens.

Keywords: A6070 aluminium alloy, SIMA process, semi-solid microstructure.
Microstructure Evaluation of Semi-Solid Metal Processed 7075 Aluminium Alloy by SIMA Process

A. Bolouri, M. Shahmiri

School of Material Engineering and Metallurgy, Iran University of Science and Technology, Tehran, 16844, Iran

Abstract

The effects of cold work and heat treatment cycles on the microstructural features of semisolid processed-SIMA are investigated and present in this report. The specimens were subjected to different deformation ratios and various heat treatment cycles (between solidus and liquidus). The optical microscopy were employed to study and characterize the samples subjected to various deformations and heating cycles, and the effects of process parameters on the microstructure evaluation of semi-solid Al 7075 were investigated using Image Analyzer. The results indicated that the processing parameters must be selected properly to obtain the fine, uniform and spheroidal microstructure by SIMA and with increase of strain sphericity of particles increases, their size will decrease and sphericity takes place in less reheating time.

Keywords: SIMA Process, Aluminium 7075, Heat Treatment, Semi-Solid Processing.
Nucleation Effect of Ti-6Al-4V Powder on Grain Size and Tensile Strength of Al-Si Eutectic Alloy

Z. Sarajan, B. Torange

*Department of Material Engineering, Islamic Azad University-Yazd Branch, Safaeeyeh, Yazd, I.R of IRAN, P.O.Box: 89195/155

Abstract

In this research nucleation effect of Ti-6Al-4V powder on grain size and tensile strength of Al-12.1% Si eutectic alloy was studied. Metal powder produced from Ti-6Al-4V machining chips by meshes of 50 and 140 and weight percentages of 0.1, 0.15, 0.2 and 0.25 were used. The microstructure by mesh 50 with 0.15 wt% consists of grain with average size of 6 µm, tensile strength and elongation equal to 492 MPa and 9.6%, respectively. By mesh 140 with 0.15 wt% the considered values are equal to 10 µm, 540 MPa and 8.82%, respectively. Before refinement the needle-plate like eutectic silicon is distributed arbitrarily, which dissevers the Al matrix seriously. The morphology of the eutectic silicon is changed from needle-plate to a fibrous form with addition of 0.15 wt. % of mesh 50 and finally changes its morphology from a needle-plate to a globular form after adding 0.15 wt. % of mesh 140, which is full modified. SEM/EDX micro-analyzing shows that TiAl3 compound has been formed which is the major factor in grain size modification and tensile strength increasing. This phase is formed prior to solidification of Al-Si alloy makes it an efficient nucleation site for aluminum grains upon solidification.

Keywords: Nucleation, Ti-6Al-4V Chips, Eutectic Al-Si, Grain size, Tensile strength.
Effect of ultrasonic treatment on the microstructure of AZ91 magnesium alloy

M. Khosro Aghayani, B. Niroumand

Department of Materials Engineering, Isfahan University of Technology, Isfahan, 84156-83111, Iran

Abstract

In this study the influence of ultrasonic treatment on the microstructual features of AZ91 magnesium alloy was investigated. Melts were subjected to ultrasonic waves of different powers using an ultrasonic device with frequency of 20kHz and maximum nominal power of 600W. The results showed that ultrasonic treatment of the melt prior to casting had a strong effect on the size and roundness of α-Mg dendrites as well as on the size, roundness and distribution of intermetallic phases formed during solidification and cooling of the alloy including Mg$_2$Si, Mg$_{17}$Al$_{12}$ and MnFeAl(Si) particles. Increasing the applied ultrasonic power generally resulted in smaller, more round and better distributed grains and particles. The effects were mainly attributed to the cavitation phenomenon that takes place during ultrasonic treatment.

Keywords: Ultrasonic treatment, AZ91 magnesium alloy, Ultrasonic power, Microstructure.
Influences of TiH$_2$ Content and Holding Temperature in Foamed Pure Aluminum

Z. Sarajan, M. Sedigh

Department of Material Engineering, Islamic Azad University- Yazd Branch, Safaeeyeh, Yazd, I.R of IRAN, P.O.Box:89195/155

Abstract

In this study the parameters which affecting on foaming process of pure commercial aluminum for preparing of light products are investigated. Titanium hydride (TiH$_2$) powder as a foaming agent (0/5 to 2/5 wt %) added to the aluminum melt. The temperature range of 620 to 660 °C was selected. The proper holding temperature and foaming agent content lead to production of foamed aluminum with high porosity percentage and cell structure uniformity. Results show that by adding one wt % of TiH$_2$ at foaming temperature of 640 °C, cells with 2-6 millimeter in diameter and uniform distribution with 86% porosity are achieved.

Keywords: Metal foam, Aluminum foam, Titanium hydride, Casting, Foaming characteristic
The microstructures and mechanical properties of a new super high strength aluminum alloy with Zr addition


Department of Materials and Metallurgy Engineering, University of Tehran, Tehran, P.O. Box: 14395-515, Iran

Abstract

This research is based on the addition of zirconium to a new super high strength Al-Zn-Mg-Cu alloy. The microstructural investigations were made on the specimens by using scanning electron microscopy and optical microscopy. Studying the mechanical properties was carried out in the extruded and T6 heat treated samples. The results showed that Zr addition decreases average grain size and introduces proper distribution of the second phase. Furthermore, improvement of the hardness and tensile properties of the alloy was seen.

Keywords: Wrought alloys, Grain refining, Extrusion process, Microstructure, Mechanical properties.
Effect of temperature and pressure of squeeze casting on porosity and density of AA2024 alloy

V. Ashofte, D. Sadat Safanama, P. Marashi, A. Jahangiri
Minning and Metallurgical Engineering, Amirkabir University of Technology, Tehran, P.O. Box: 15875-4413, Iran

Abstract

This paper investigates the effect of pressure and temperature of squeeze casting on the porosity and density of AA2024 alloy. Due to the effect of these parameters on the mechanical properties and crack formation mechanism, it is important to reduce the porosity and minimize the difference between the measured density and the theoretical value (2.7 g/cm³ for Aluminum). In this research, 3 samples were prepared under various temperatures (700, 750 and 800 °C) and pressures (0, 70, 105 and 140 MPa). Metallographic samples were studied and it was observed that at atmospheric pressure, by increasing the temperature from 700 to 800 °C, the mean diameter of porosity in the center of samples increased from 1.5 μm to 2.5 μm. At 750 °C, increasing the pressure from atmospheric pressure to 140 MPa, decreases the mean diameter of the porosity from 1.3 μm to 0.3 μm. The effect of temperature is negligible at pressures above 70 MPa. Moreover, at pressures above 70 MPa, the density remains almost constant, near its theoretical value of 2.7 g/cm³, which proves that the porosity is almost eliminated.

Keywords: Squeeze Casting, AA2024 alloy porosity, AA2024 alloy density.
COMPOSITE
The influence of Cu on the microstructure and mechanical properties of Al-15% Mg2Si composite

M. Emamy, N. Nemati, M. Dadashipour, F. Hassan Abadi
School of Metallurgy and Materials, University of Tehran, Tehran 11365-4563, Iran

Abstract

Al-based composites, reinforced with particulates of Mg2Si have been introduced as a new material that offers attractive advantages such as good castability, low density and good wear resistance. In this research, the effect of Cu on the microstructure, hardness and tensile properties of cast composite with the chemical composition of (9.5% Mg, 6.5% Si and 84% Al) has been investigated. Further study was made on the fractured surfaces of the composite by scanning electron microscopy. The results showed that both primary and secondary Mg2Si phases are seen in as-cast structure and the addition of Cu (0 to 5% wt.) results in Mg2Si particle refinement and relative change of Mg2Si morphology. The results showed an increase in UTS and hardness but reduction in elongation values with the addition of Cu. Study of fractured surfaces obtained from tensile test showed that at high Cu concentrations (>3%) the presence of new intermetallic compounds play an important role in altering the fracture behavior from ductile to brittle.

Keywords: Al-based Composite, Cu addition, hardness, UTS, Mg2Si par.
An Investigation on the Applicability of In situ Powder Metallurgy (IPM) Method for Processing of Hybrid Al/SiC/Gr Composites

S. Mahdavi, F. Akhlaghi

School of Metallurgy and Materials Engineering, Faculty of Engineering, University of Tehran, P.O. Box: 11365-4563, Tehran, Iran

Abstract

Aluminium matrix composites reinforced with SiC and Graphite (Gr) particulates are a unique class of advanced engineered materials that have been developed for use in tribological applications. The conventional techniques used for producing these composites have some drawbacks. In the present study for the first time a new method, namely "in situ powder metallurgy (IPM)" is applied for consolidating these hybrid composites. In this method, the stir casting and the P/M synthesizing processes were combined into an integrated net shape forming process. 40 vol. % of SiC particles within three different sizes ranges, together with 13 vol.% of uncoated graphite particles were introduced to 6061Al melt and the slurry was stirred in a specified time–temperature regime resulting in a mixture of graphite, SiC and aluminium powder particles. The powder mixtures were cold pressed and sintered resulting in Al/SiC/Gr composites. The applicability of the IPM method for processing of such hybrid composites was demonstrated and the effect of SiC particle size on the microstructure of the composites was investigated.

Keywords: Hybrid composites, Al/SiC/Gr composites, In situ powder metallurgy (IPM), SiC particle size, Distribution of the reinforcing particles.
Effects of Reinforcement (TiB$_2$) Adding Temperature on Properties Of Al /TiB$_2$ Composite

F. Abdi $^1$, H. Abdizade $^2$, K. Shirvani Moghaddam $^1$

$^1$ Azad University of South Tehran, Tehran, Iran.
$^2$ School of Materials Eng, University of Tehran, Tehran, Iran

Abstract

Cast metal matrix composites fabricated through stir casting method have the cost advantages over the composites made by other processing techniques. These kinds of composites have a good wear resistance, hardness and thermal properties. In this study, mechanical behavior and physical properties of aluminum matrix composites reinforced by TiB$_2$ under different temperature conditions has been investigated. Samples were made using aluminum alloy A356.1 as matrix metal and TiB$_2$ particles (1 micron size) as reinforcement ceramic material in different casting temperatures (750, 850, 950 °C) with 5 % volume percent of TiB$_2$ particles. The microstructure and mechanical behavior of composite samples were studied. Results showed that TiB$_2$ particles are homogeneously dispersed throughout the matrix metal. The hardness and tensile strength of the composites are higher than those of the monolithic aluminum; and the best processing temperature in this study seems to be 950 °C.

Keyword: Aluminum Matrix Composites, Reinforcement, TiB$_2$, Microstructure, Mechanical Behavior.
The effect of recycling process on tensile properties of A357-Al₂O₃ cast composites

N.Nasiri, M.Emamy, A.Gholami
Department of Metallurgy and Materials, University of Tehran, 11365-4563, Iran

Abstract

In this study, the effects of reinforcement material volume fractions and heat treatment on tensile properties of A357-Al₂O₃ cast composite were investigated. A comparison was made on tensile properties of A357-Al₂O₃ cast composite between primary and recycled ingots. Tensile specimens were cast in CO₂ sand mould in separated pieces and tested after T6 heat treatment. Tensile test results showed that recycled specimens have ultimate tensile strength and elongation less than the primary specimens. Fractographic observation by SEM showed some defects on the fractured surface. Oxide films and micro shrinkage had a significant role in strength and ductility reduction. More oxide films were found in recycled specimens compared to the primary specimens.

Keywords: A357-Al₂O₃, recycling process, tensile strength, oxide films.
The effect of strontium and calcium on the tensile properties of cast Al-Mg$_2$Si metal matrix composite

N.Nasiri, M.Emamy

School of Metallurgy and Materials, University of Tehran, 11365-4563, Iran

Abstract

In current research, the effects of Sr and Ca modification on the microstructure and tensile properties of Al-15%Mg$_2$Si composite have been investigated. The results showed that, with the increase of Ca content, primary Mg$_2$Si morphology changed and the average size of Mg$_2$Si particles decreased. Also, with addition of Sr, the primary Mg$_2$Si morphology changed from polygonal to quadrangle shape. The results showed that the optimum amount of Sr and Ca are 0.1% and 1% respectively. Also addition of Sr and Ca showed marginal effect on ultimate tensile test values, however, the effects on percentage of elongation were significant. Furthermore, the fracture surface study of modified and unmodified Al- Mg$_2$Si composite was made to understanding the failure mechanism.

Keywords: Al/ Mg$_2$Si composite, Tensile properties, Modification, Casting.
Investigation on wear properties of cast AL matrix composites containing SiC and Al₂O₃ reinforcing particles

N. Nasiri, M. Emamy, H. Hosseinzadeh, A. Sohrabi
School of Metallurgy and Materials, University of Tehran, 11365-4563, Iran

Abstract

During last decades, particle particulate metal matrix composites have found special industrial applications in producing wear-resistance components. One of the most cost-effective processes for manufacturing such materials is stir casting in which the composite is produced by adding ceramic particles to the matrix alloy. In current study, the pin on disk method was used to investigate the wear properties of SiC and Al₂O₃ containing composite materials. Further investigation on studying wear mechanism was carried on using Scanning Electron Microscopy (SEM). Wear rate was calculated by measuring the amounts of weight losses of samples subjected to wear. It was found that the addition of SiC and Al₂O₃ particles to the matrix alloy (A356) can improve the wear properties considerably, but according to microstructural investigations, these particles showed different wear mechanisms and behaviour.

**Keywords**: metal matrix composites, A356 aluminum alloy, Al₂O₃ and SiC particles, wear properties.
Effect of Sr and Na on the microstructural features of alumina containing metal matrix composites

A.A. Najimi, M. Emamy, J. Rasizadeh, H.R. Lashgari
School of Metallurgy and Materials, The University of Tehran, Tehran, Iran

Abstract

Sr and Na are considered as well-known modifiers of Al-Si alloys. In current research effort was made to investigate the effect of Sr and Na (separately and simultaneously) on the microstructure of the matrix alloy and A357-20vol% Al₂O₃ composites. The modification of silicon eutectic was seen in both materials with the application of Sr and Na. Individual addition of Sr showed a higher incorporation of alumina particles in the matrix while Na addition had no influence on it. It was also found that combined addition of Sr and Na did not show improvement in modification of eutectic silicon and distribution of alumina particles. A negative interaction between Sr and Na was observed in the surface layer during melt holding. The presence of Sr in the surface dross of molten material, detected by XRD, shows that Na addition may promote Sr oxidation kinetically.

Keywords: Metal matrix composite, Strontium, sodium, Modification, Microstructure.
The influence of iron intermetallic compounds on the microstructure and tensile properties of Al-Mg$_2$Si composite

S.Ghaiour, M.Emamy, P.Vahdati, N.Nasiri

School of Metallurgy and Materials, University of Tehran, 11365-4563, Iran

Abstract

The microstructure and tensile properties of an in-situ composite Al-Mg$_2$Si have been investigated after adding different Fe contents (Fe varies from 0.5-3 wt %). It was found that the morphology of intermetallic compounds strongly depends on Fe contents and it changes from polyhedral (1.5%Fe) to star-like or plate-like (>2%Fe). The study of tensile properties of metal matrix composite showed that plate-like intermetallics have negative effects on ultimate tensile strength and elongation results, but the composite with polyhedral intermetallic showed optimum tensile properties.

Keywords: Al-Mg$_2$Si composite, iron intermetallic.
Effect of SiC Content and Stirring Velocity on Hardness and Tensile Strength of SiC/Al_{cp} Composite

Z. Sarajan, M. Sedigh
Department of Material Engineering, Islamic Azad University- Yazd Branch, Safaeeyeh, Yazd, I.R of IRAN, P.O.Box:89195/155

Abstract

In this research the application of SiC particles to improve hardness and tensile strength of Al_{cp} produced by vortex method is investigated. 5-25 wt% of SiC particles were added to the melt and through the stirring velocity of 400, 800 and 1200 rpm; the aluminum matrix composites were prepared. Hardness increases by increasing the SiC content up to 15-20 wt%. The maximum hardness is obtained by using 15 wt% of SiC and 1200 rpm and increases to about 48 HRB. The maximum strengths are obtained by 20, 15 and 10 wt% of SiC, 700, 1250 and 1450 N/cm² at the mentioned velocities, respectively. The microstructure consists of the SiC particles that are homogeneously dispersed in the matrix with nearly equiaxed grains for the specimens with 15 to 20 wt% of SiC. The uniformity in distribution of SiC particles improves in the specimens with 20 wt% and stirring velocity of 1200 rpm.

Keywords: Metal-matrix composites (MMCs), Strength, Stress concentration, Hardness testing, Melt-spinning.
CORROSION

AND

SURFACE TECHNOLOGY
Self Cleaning Coatings on Al Surface: Surface Treatment, Deposition & Photocatalytic and self cleaning Properties

H. Yaghoubi ¹, N. Taghavinia ²,³, E. Keshavarz Alamdari ¹,⁴

¹ New Material Department, Material & Energy Research Center, Iran
² Institute for Nanoscience and Nanotechnology, Sharif University of Technology, Tehran, Iran
³ Physics Department, Sharif University of Technology, Tehran, Iran
⁴ Material & Metallurgical Engineering Department, Amir Kabir University Of Technology, Tehran, Iran

Abstract

In the proposed work, surface of aluminum substrates were treated and began through dipping in a H₂SO₄/K₂Cr₂O₇ chemical solution. Surface wetting characteristics changed as a result of this rapid and easy treatment process, from hydrophobic to hydrophilic. The contact angle (CA) measurement before and after treatment was 90° and 0°, respectively. Furthermore, the effect of aging during 30 days on stability of contact angle was investigated and after this period, contact angle reached to 14.8° and remained constant. For evaluation of chemical bonding on the surface X-Ray Photoelectron Spectroscopy (XPS) was carried out. Topographic images by Atomic Force Microscopy (AFM) showed that rms roughness of the surface changed slightly from 3.1 nm to 3.6 nm after chemical treatment. Reflectance spectra before and after treatment demonstrated that the treatment process has not changed the appearance of substrates. TiO₂ self cleaning coatings were prepared on the substrates by dip coating a sol containing TiO₂ nanoparticles of 28.2 nm size. Scanning Electron Microscopy (SEM) images showed the granular structure of the TiO₂ coating surface. The surface roughness of the coatings was about 13.6 nm, as determined by AFM. Photo catalytic properties of the coatings were measured through decomposition of stearic acid and methylen blue (MB) under UV irradiation. As a result of photo catalytic properties of the films, almost 50% of MB was decomposed when the coated substrates were exposed to UV irradiation for 100 min.

Keywords: Photo catalyst, stearic acid, Self Cleaning, TiO₂, Methylen Blue.
Structure and properties of oxide ceramic coating formed by plasma electrolytic oxidation on Al5083

H.A. Dehghanian, M.H. Shariat, A. Dehghan

Department of Materials Science and Engineering, Shiraz University, Shiraz, Iran

Abstract

An aluminum oxide ceramic coating using plasma electrolytic oxidation (PEO) on Al5083 was achieved. The composition and structure of the cross section and surface of the coating were studied by XRD and SEM respectively. The results showed that the coating is composed of dense and porous layers of α and γ alumina. A significant improvement was observed through evaluation of corrosion and wear properties of the coating. The micro-hardness test was shown that the surface hardness of the material has increased significantly.

Keywords: PEO, Aluminum alloy, wear, corrosion, surface protection.
An Approach to Predict Galvanic Corrosion Using Identical Couple Electrodes; Investigation of Weld Zone and Parent Alloy in AA6xxx Welded through FSW Technique

M. Amini, F. Kazemzade, M.H. Moayed, M. Haddad-Sabzevar

Department of Materials and Metallurgical Engineering, Ferdowsi University of Mashhad, P.O. Box 91775-1111, Iran

Abstract

The technology requires fabrication, utilization; maintenance and repairing of structures, causing different materials contact each other in operational environments. Therefore, galvanic corrosion has a great significance. The present work is an approach to investigate the occurrence of galvanic corrosion by applying identical couple electrodes. In this work, an AA6xxx specimen was welded by FSW method. The parent alloy and the weld zone were investigated by various electrochemical examinations including potentiodynamic, potentiostatic and corrosion potential monitoring in 3.5% NaCl solution at room temperature. The results revealed no significant difference in corrosion behavior of WZ and PA. Further investigations on the occurrence of galvanic corrosion carried out over nonidentical and also identical couple electrodes from WZ and PA using ZRA technique. The comparison of mean couple current density showed that the amount in PA/WZ was approximately twice PA/PA and five times WZ/WZ indicating the occurrence of galvanic corrosion between WZ and PA.

Keywords: aluminum alloy, galvanic corrosion, friction stir welding, identical couple electrodes, nonidentical couple electrodes.
Nano-scale localized corrosion studies of EN AW-3003 Al alloy by SEM-EDS, SKPFM and in-situ AFM

A. Davoodi 1,2, J. Pan 2, C. Leygraf 2, G. R. Ebrahimi 1, M. Javidani 1

1 Department of Materials Science and Engineering, Tarbiat Moallem University of Sabzevar, Sabzevar, P.O. Box: 397, Iran
2 Division of Surface Chemistry-Corrosion Science, Royal Institute of Technology, Stockholm, P.O. Box: 10044 SE, Sweden

Abstract

Localized corrosion of aluminum alloys is often triggered by intermetallic particles, IMP’s. To understand the role of IMP’s in corrosion initiation of EN AW-3003, efforts were made to combine nano-scale ex-situ analysis of the IMP’s by SEM-EDS, SKPFM and in-situ AFM monitoring of the localized attack in chloride containing solution. The results showed that two distinct types of eutectically-formed constituent IMP’s exist; the $\alpha$-Al(Mn,Fe)Si and the Al(Mn,Fe) phases. However, the exact chemical composition of the IMP’s varies with the particles size. Volta potential difference of surface constituents revealed that IMP’s have a higher Volta potential compared to the matrix, indicating the cathodic characteristic of the IMP’s. Noticeably, the boundary regions between the matrix and IMP’s exhibited a minimum Volta potential probably the sites for corrosion initiation. Localized corrosion attack monitored by in-situ AFM clearly showed the trench formation occurrence around the large elongated IMP’s in the rolling direction.

Keywords: Localized corrosion, Aluminum alloys, SEM-EDS, SKPFM, in-situ AFM.
The effects of heat treatment on structure and corrosion behavior of electroless Ni-P deposits on Al5083 alloy

S. Ahmadizadeh¹, S. M. Monirvaghefi¹, A. Saatchi¹, A. Heidary Moghadam²

1. Material Science Department, Esfahan University of Technology, Esfahan, Iran
2. School of engineering, Eslamic Azad University, Dezful Branch, Dezful, Iran

Abstract

In this work, electroless Ni-P deposits of approximately 20 μm in thickness with a medium phosphorous content of approximately 6.73 wt.% were attained on Al5083 substrates, and the effects of heat treatment on structure and corrosion behavior of the deposits were investigated. Deposits were heated at temperatures ranging from 200 to 400 °C for 1 h. Structural characterization was done with X-ray diffraction studies. Deposited coatings exhibited broadened X-ray reflections indicative of a semi-amorphous structure. Heat treatment decreased the amorphous phase and after heat treatment at 400 °C for 1 h, the final equilibrium phases contained Ni₃P and Ni crystals of 32 and 18 nm, respectively. Corrosion resistance was evaluated in 3.5 wt.% NaCl solution by potentiodynamic polarization and electrochemical impedance (EIS) methods. The corrosion resistance increased at 240 °C, but decreased at higher temperatures. The decrease in corrosion resistance after heat treatment at 400 °C was attributed to crystallization of the amorphous phase that created grain boundaries that were highly prone to corrosion.

Keywords: Electroless plating, Heat treatment, Structure, Corrosion, Al5083.
Study on corrosion properties of plasma nitride pure aluminium

A.Yazdani, H.Aghajani, M.Soltanieh

Department of material and metallurgical engineering, Iran University of Science and Technology, Tehran, Narmak

Abstract

In this research plasma nitriding of pure aluminium and effect of iron elemental alloy on the formation and growth of aluminium nitride was investigated. Also corrosion properties of formed AlN were investigated. After preparation, the samples were plasma nitrided at 550°C, for 6, 9 and 12 h and a gas mixture of 25%H2-75%N2. The microstructure and phases analysis were investigated using Scanning Electron Microscopy and X-ray Diffraction techniques. Moreover corrosion resistance of samples was investigated using polarization techniques. The results showed that only a compound layer was formed on the surface of samples and no diffusion zone was detected. Dominant phase in compound layer was AlN. Scanning Electron Microscopy results showed that nitride layer has particulate structure. These nitried particles have columnar growth and are perpendicular to the surface. It was also observed that the existence of iron in the samples increases the nitrogen diffusion and growth rates. Corrosion tests results showed that formation of an aluminium nitride layer on the surface of aluminium decreases the corrosion resistance of aluminium significantly. This is due to propagation of cracks in the surface layer and thus increasing in local and pitting corrosion.

Keywords: Aluminium, Aluminium nitride, Plasma nitriding, Corrosion.
Improvement corrosion behavior of pure Aluminum by applied TiO$_2$ nanoparticle coating with sol gel method

A. Shanaghi, A. R. Sabour Rouhaghdam, M. Velashjerdi

Faculty of Engineering, Materials Engineering Department, Tarbiat Modares University, Tehran, Iran, P.O.Box: 14115-143

Abstract

TiO$_2$ nanoparticle coating possess good thermal and electrical properties and they are more resistance to oxidation, corrosion, erosion and wear in some severe environments that this is very important factor in the applications such as pipeline, casting and auto industrial. In this present investigation a uniform and TiO$_2$ nanoparticle coating on pure Aluminium has been prepared using Sol-gel method. The coating was deposited on a pure Aluminium substrate by a dip coating technique. The morphology and structure of the coating were analyzed using SEM, AFM and X-ray diffraction. The anticorrosion performances of the coating have been evaluated by using electrochemical technique. It is worthy to note that the film uniformity was retained in high temperature; no crack and flaking off from the substrates were observed. The tafel polarization measurements provide an explanation to the increased resistance of TiO$_2$ nanoparticle coated Aluminum against corrosion.

Keywords: TiO$_2$ nanoparticle coating, Pure Aluminium, Corrosion protection.
Deposition of nano sized iron nitride on aluminium substrate using active screen plasma nitriding method

A.Yazdani, H.Aghajani, M.Soltanieh
Department of material and metallurgical engineering, Iran University of Science and Technology, Tehran, Narmak

Abstract

Active screen plasma nitriding (ASPN) is an emerging surface engineering technology that offers many advantages over the conventional DC plasma nitriding (DCPN). In this research plasma nitriding of pure aluminium, using iron active screen was investigated. Samples were plasma nitrided at 550 °C, for 2.5, 5 and 7.5h with a gas mixture of 25%H2-75%N2. The coating microstructure and phase analysis were investigated using Scanning Electron Microscopy and X-ray Diffraction technique. Moreover corrosion resistance of samples was investigated using polarization technique. The dominate phase in compound layer was Fe3N. With increasing processing time, the layer thickness was increased. According to Scanning Electron Microscopy results, the sample surface was formed of nano sized iron nitride particles. The corrosion tests results showed that the formation of an iron nitride layer on the surface of aluminium deteriorated the corrosion resistance of aluminium significantly.

Keywords: Aluminium, Iron nitride, active screen plasma nitriding, corrosion.
Surface precipitation hardening of aluminium alloys through mechanochemical process at ambient temperature

P. Valizadeh, M. Sheikhamiri, J. Vahdati Khaki
Metallurgical and Material Engineering Department of Ferdowsi university of Mashhad, Iran

Abstract

A novel method for precipitation hardening of aluminium alloys has been introduced in this research. In this new method, some of heat treatment cycles have been eliminated and, therefore, a considerable amount of time and cost is spared. In this method, the desired surface of the aluminium part (which has been solid solution treated) is subjected to mechanical milling and, therefore, its surface is locally precipitation hardened. The activation energy required for the formation of the precipitates is provided by the mechanical milling energy and the precipitates form through a mechanochemical process at room temperature. This method was applied to two different aluminium alloys, A356 and 2024. The results obtained from hardness tests and X-ray diffractions confirmed the integrity and practicality of this method. Compared to samples obtained from traditional methods, the samples processed in this new way have higher hardness and strength properties. Moreover, the method allows a surface precipitation hardening of aluminium alloys.

Keywords: precipitation hardening, milling, process activation energy, mechanochemical process, hardness measurement, aluminium alloy.
The impact of impurities in billet shell on surface quality of profiles after anodizing.

P. Dastoorani

Quality control manager, Abeskoon Aluminum Ind., Amol, Iran.

Abstract

In Aluminum industry it is very seen that produced raw profiles are very shiny and there is no line on their surfaces. But after anodizing some lines and elongations appear and the face and quality of profiles become unfavorable. These lines are usually wide and extensive and are seen in the end of each cutting length. It is specified that the main cause of these lines are the great presence of impurities in the shell of billet. These impurities are not seen in raw profiles but the selective work of etch both, resulted to differences in surface and impurities appear. Even anodizing can’t create a suitable coating on it. Duration experiments we changed percent of butt thickness. This point had straight influence on intensity of impurities appearance. Yet decrease of temperature difference between container and billet causes the increase of intensity of impurities appearance.

Keywords: Shell of billet, Impurities, Butt, Temperature, Extrusion.
HEAT TREATMENT
Prediction of bake hardenability of Aluminum alloys Al5052 and Al7075 using neural network

A. Nekahi, K. Dehghani, N. Kamkar
Department of Mining, Metallurgy and Oil Engineering, Amirkabir University of Technology, Tehran, Iran

Abstract

Using artificial neural network (ANN), the effect of composition on bake hardenability of two aluminum alloys 7075 and 5052 was studied and verified based on experimental data. Following these, the bake hardening and final yield stress values were predicted. Samples were prepared from the as received sheets. They were then subjected to different aging conditions in temperature range of 150-250°C, following different amounts of pre-straining for 15-30 minutes. Test results show that the bake hardenability increased with increasing ageing time and temperature and prestrain amount, as well as Zn content. By comparing the predicted values with the experimental data, it is demonstrated that the ANN model is a useful and practical tool for prediction of bake hardenability and mechanical properties of these two alloys.

Keywords: artificial neural network, prediction, aluminum alloys, bake hardening, yield stress.
The effect of aging treatment on mechanical properties of AA6082 alloy: Modeling and Experiment

N. Anjabin, A. Karimi Taheri

Department of Materials Science and Engineering, Sharif University of Technology, Tehran, P.O. Box: 11365-9466, Iran

Abstract

A novel constitutive equation has been proposed to predict the effect of ageing treatment on mechanical properties of AA6082 aluminum alloy. Considering that aging phenomenon affects the distribution of alloying element in matrix, and the fact that different distribution of alloying elements has different impediments to dislocation movement, a material model based on microstructure, has been developed in this research. A relative volume fraction or mean radius of precipitations is introduced into the flow stress by using the appropriate relationships. The GA-based optimization technique is used to evaluate the material constants within the equations from the uniaxial tensile test data of AA6082 alloy. Finally, using the proposed model with optimized constants, the flow behavior of the alloy at different conditions of heat treatment is predicted. The results predicted by the model, showed a good agreement with experimental data, indicating the capability of the model in prediction of the material flow behavior after different heat treatment cycles. Also, the calculated flow stress was used for determination of the material property in Abaqus Software to analyze the uniaxial compression test. The force-displacement curves of the analysis were compared to the experimental data obtained in the same condition, and a good agreement was found between the two sets of results.

Keywords: Aluminium alloys, Heat treatments, Mechanical properties, FEM analyze.
Characterization and Evolution of grain boundary phases during the homogenization of AA7020 Aluminium Alloy

A.R. Eivani 1,2, H. Ahmed 1, J. Zhou 2, J. Duszczyk 2

1 Materials Innovation Institute, Mekelweg 2, 2628 CD Delft, The Netherlands
2 Department of Materials Science and Engineering, Delft University of Technology, Mekelweg 2, 2628 CD Delft, The Netherlands

Abstract

The presence of large particles decreases the strength and hot workability of aluminium alloys especially when they are located in the grain boundary regions. Therefore, the evolution of these particles is a major issue in the homogenization process of these alloys. The grain boundary (GB) phases constitute more than 70% of all the secondary phases present in the microstructure of AA7020 aluminium alloys. The dominant GB phase is identified to be $\text{Al}_{17}(\text{Fe}_{3.2}\text{Mn}_{0.8})\text{Si}_2$. In the present research, a comprehensive study on the effect of the homogenization treatment on the evolution of the $\text{Al}_{17}(\text{Fe}_{3.2}\text{Mn}_{0.8})\text{Si}_2$ particles during homogenization was conducted. The analysis shows that the evolution of this phase is largely dependent on temperature, which ranges from sheroidization with insignificant dissolution at low temperatures to full dissolution during homogenization at high temperatures.

Keywords : AA7020 aluminium alloy, Homogenization, $\text{Al}_{17}(\text{Fe}_{3.2}\text{Mn}_{0.8})\text{Si}_2$ particles.
Evaluation of dislocation structure and crystallite size in worn Al-Si alloy by X-ray diffraction

M. Zand Rahimi, A. Rezvanifar

Department of Materials Science and Engineering, Shahid bahonar university of Kerman, Kerman, Iran

Abstract

Diffraction peak profile analysis has recently been developed to such an extent that it can be applied as a powerful method for the characterization of microstructures of crystalline materials in terms of crystallite size and dislocation structures. In this paper the effect of the sliding on the microstructure of A356 for both as-cast and heat treated conditions are studied, The X-ray phase analysis shows with increasing applied load, the dislocation density is increasing, whereas the crystallite size is decreasing. It has found that heat treatment cause to raise dislocation density during wear. The screw or edge character of dislocations in worn specimens were determined by analyzing the dislocation contrast factors, it was demonstrated that the character of the prevailing dislocations in high loads is nearly pure screw.

Keywords: Severe wear, Peak profile analysis, Crystallite size, Dislocation structure.
Effect of Ti and Zr on solution heat treatment behavior of thin section 319 aluminum cast alloy

M. J. Shabani, M. Emamy, J. Rasi Zade

Department of Materials Science and Engineering, University of Tehran, Tehran, P.O. Box: 14395-515, Iran

Abstract

Heat treatment of Al-Si-Cu alloys has been the subject of many researches because of its important effect on mechanical properties of these alloys, which are widely used in automotive industry. The present research is focused on solution heat treatment of 319 aluminum alloy. Specimens including base alloy, Ti added and Zr added were heat treated at 505 °C in different solutioning times. At each time, the amount of remained Al₂Cu phase was measured using scanning electron microscopy. Further microstructural study was carried out by an optical microscope coupled with an image analyzing software. Results showed that dissolution of Al₂Cu intermetallic has not been occurred perfectly in any of the specimens even after 32 hours. Moreover, in Ti and Zr containing specimens, dissolution was found to be less complete and more remained Al₂Cu phase was detected. Microstructural observations also showed that Si particles undergo fragmentation, spheroidization and then coarsening. Thin section specimens showed more spherodized Si particles in comparison with thick section castings.

Keywords: 319 aluminum alloy, Solution heat treatment, Al₂Cu dissolution, Si particle characteristics.
Improving Mechanical and Fatigue Properties of Forged Aluminum Alloy 7075 by Retrogression and Re-Aging Heat Treatment

V. Tari, A. Kermanpur

Department of Materials Engineering, Isfahan University of Technology, Isfahan

Abstract

The high strength 7075 aluminum alloy in the T6 condition is widely used for aerospace and automotive applications. It represents high mechanical properties but low stress corrosion cracking resistance (SCC). The T7 heat treatment has been successfully applied to the alloy to improve SCC resistance with the expense of mechanical properties. Recently, the retrogression and re-aging (RRA) treatment has been introduced to simultaneously improve mechanical properties and corrosion resistance. In this work, effect of the RRA parameters on the mechanical and fatigue properties of the forged 7075 aluminum alloy was investigated. Several RRA heat treatments were carried out at 180, 200, 220 and 240 °C for 5, 10, and 20 min. Hardness, tensile and fatigue properties of the specimens along with their microstructures were evaluated and compared with the T6 condition. The fracture surfaces of the fatigue samples were also studied by scanning electron microscopy. The results showed a reasonable improvement in the tensile and fatigue properties of the RRA treatment against the T6 ones.

Keywords: Retrogression and re-aging, Aluminum 7075, Mechanical properties, fatigue, Thin-walled components.
Microstructural characteristics of Al-12Zn-3Mg-2.5Cu alloy in the as-cast and homogenized condition

N. Pourkia, M. Emamy, J. Rasi Zadeh, S. H. Seyed Ebrahimi

Center of Excellence for High Performance Materials, School of Metallurgy and Materials, the University of Tehran, Tehran, P.O. Box: 11365-4563, Iran

Abstract

Microstructural characteristics of the Al-12Zn-3Mg-2.5Cu alloy have been studied in both as-cast and homogenized conditions by using optical microscopy, scanning electron microscopy coupled with energy dispersive spectrometry and X-ray diffractometry. Due to the higher amounts of alloying elements and so great tendency for segregation, the microstructure of as-cast specimens showed a complicated structure including α (Al) dendrites, inter-dendrite lamellar eutectic phase, η-MgZn2, with "Chinese script" morphology and isolated T-Al2Mg3Zn3 and S-Al2CuMg phases with spherical morphology. After homogenizing, the eutectic phase was completely eliminated. T-phase was dissolved partially and replaced by Zn-free S phase with the same spherical morphology, due to the lower diffusion coefficient of Cu. Also, due to the little amount of Fe impurity, which is almost always accompanied Al-alloys, a little amount of Al7Cu2Fe phase was observed in the grain boundary regions of both as-cast and homogenized alloy. The morphology of Al7Cu2Fe phase was almost irregular.

Keywords: homogenizing, microstructure, super high-strength, 7XXX series, Al-Zn-Mg-Cu alloy.
Using Artificial Neural Network to Optimize the Aging Behaviors and Bake Hardening of Al2024 and Al6110

N.Kamkar-Ze, K.Dehghani, A.Nekahi, S.S. Tayarani Bathaie

1 Department of Mining and Metallurgical Engineering, Amirkabir University of Technology, Tehran, Iran
2 Department of Electrical Engineering, Amirkabir University of Technology, Tehran, Iran

Abstract

In the present work, the response of two aluminum alloys (Al2024 and Al6110) to strain aging and bake hardening (BH) was investigated. After the primary heat treatments, they direct chilled ingots were subjected to laboratory cold rolling. Various treatments and different testing conditions were used to evaluate the aging and baking behaviors. The different strains were applied so that to attain different dislocation densities required for attaining various aging and baking values. The results show that the higher the strain, the greater the strain aging and bake hardening amounts. Experimental data was used for the training of ANN and a multilayer cascade forward back-propagation neural network was designed. The optimization was performed by minimizing the generalized interval between the predicted values and the optimized ones that were obtained experimentally. The predicted values obtained from the trained ANN are found to be in close agreement with the experimental results.

Keywords: Aluminium 2024, Aluminum6110, Bake Hardening, Neural Network, Back Propagation.
Investigation on the aging behavior of AA6061-SiC cast composite and the influence of T6 heat treatment on its mechanical properties

A. Pakdel, M. Emamy, H. Farhangi

School of Metallurgy and Materials Engineering, University of Tehran, Tehran, P.O. Box: 11365-4563, Iran

Abstract

Aluminum and its alloys are considered suitable choices for use in metal matrix composites, since they provide good strength and ductility, satisfactory resistance to corrosion, and reasonable cost. Among them age hardenable alloys such as Al-Si-Mg series, whose strength increase after application of heat treatment, have become noticed to a greater degree. In this research an AA6061-10Vol. %SiC composite was produced by the vortex method and several testing methods including tensile and hardness tests were utilized to investigate the aging behavior and influence of T6 artificial aging on the mechanical properties of this material. Results showed that the addition of SiC particles to the aluminum matrix did not affect the sequence of aging, but influenced the magnitude of the hardness achieved. Moreover, hardness, yield stress, and ultimate tensile strength of the composite increased considerably after heat treatment, but ductility reduced as expected.

Keywords: Artificial Aging, Al-SiC composite, Vortex Method, Mechanical Properties.
Artificial Overaging Heat Treatment of Al 7075-T6 Alclad Alloy: Microstructural and Mechanical Characterization

M. Meratian, M. Askari.
Department of Materials Engineering, Isfahan University of Technology, Isfahan 84156-83111, Iran

Abstract

The 7xxx series Al alloys have found a vast variety of applications in automotive and aerospace industries. The T6 heat treatment on 7075 Al alloy causes an increase in tensile strength and decrease in strength of stress corrosion. The T7 heat treatment is usually applicable in order to increase the corrosion strength. In this research work, the 7075-T6 Alclad specimens, heat treated under T7 overaging. The microstructures obtained by this treatment were characterized by optical and scanning electron microscopy (SEM-EDS). The applied T7 heat treatment caused formation of some fine transgranular and light gray (FeAl₃) precipitates. Based on optimum mechanical properties obtained by different heat treatments, the exact temperatures and times for appropriate T7 heat treatment cycles were selected. In this regard a temperature of 470°C for 80 minutes were suggested for solutionizing and 107°C for 7 hours as well as 170°C for 19 hours for the first and the second aging steps found to be of appropriate.

Keywords: Al 7075 Alclad, Artificial overaging T7, Microstructure, Mechanical properties.
Effect of heat treatment on the structure and mechanical properties in an Al-Li-Cu-Mg base alloy

S. Nouri 1, Sh. Mirdamadi 1, M. Hadavi 2, S. Ahmadi 3, H. Mehrjou 1

1 Department of Materials Science and Engineering, Iran University of Science & Technology (IUST), Tehran, Iran
2 Department of Materials Engineering, Amir Kabir University of Technology, Tehran, Iran
3 Department of Materials Science, Faculty of Engineering, Tarbiat Modares University, Tehran, Iran

Abstract

Increased strength to weight ratio of aluminium -lithium alloys has attracted materials scientists to develop these for aerospace applications. Varied temper conditions such as T4 (solution treated and natural aged), T6 (solution treated and artificial aged) and T8 (solution treated, cold worked and artificial aged) have been used to improve mechanical properties of Al-Li (8090) alloy. In the present research, mechanical properties of A.A.8090 sheet including hardness and tensile properties were evaluated in T6 and T8 temper conditions. Owing to use of T6 temper condition , there was an increase in hardness and strength with a concomitant considerable reduction in ductility toward witness specimen (the specimen without implementation of heat treatment). T8 temper condition results in increase of hardness and strength, while decrease of ductility toward T6 temper condition. The grain structure and fractography examinations of heat-treated specimens were carried out using optical microscope (OM) and scanning electron microscope (SEM) respectively.

Keywords: Al-Li (8090), precipitation hardening heat treatment (T6), Thermomechanical process (T8), Strengthening precipitates.
JOINING AND WELDING
Hardness evaluating of submerged friction stir processed Al-6061-T6 plate by a novel artificial neural network model

A. Ebnonnasir, F. Karimzadeh, M. H. Enayati
Department of Materials, Isfahan University of Technology, Isfahan, P.O. Box: 8415483111, Iran

Abstract

The aluminum (Al) alloy 6061-T6 was friction stir processed at submerged condition and different tool rotation speeds (w) and processing speeds (V). The effect of processing parameters on hardness of stir zone was investigated. In order to derive out the relationship between the hardness of stir zone and processing parameters and optimizing them, some test was done and a matrix of variation parameters of process was filled and used for training of an artificial neural network (ANN) model. A sensitivity analysis was carried out using the ANN model. It is shown that, among two process parameters, the processing speed (V) is more important on stir hardness. In addition, a safe zone can be defined by ANN model in which superior hardness can be achieved.

Keywords: Submerge friction Stir Processing, Artificial Neural Networks (ANN), Al-6061-T6.
Effect of Friction Stir Welding parameters on mechanical properties and fatigue life of Al 5083

A. M. Nasiri, A. R. Sadeghi, A. H. Kokabi

Materials Science and Engineering Department, Sharif University of Technology, Tehran, P.O. Box: 11365-946, Iran

Abstract

The effect of processing parameters on fatigue and mechanical properties of Al 5083 joints produced by Friction Stir Welding was analyzed in the present study. Different samples obtained by employing rotating speeds of 500, 800 and 1000 rpm and welding speeds of 40, 56 and 80 mm/min were produced. The mechanical properties of the joints were evaluated by means of tensile tests at room temperature. Fatigue tests on the welds were carried out by using a resonant electro-mechanical testing machine under constant loading control up to 250 Hz sine wave loading. The low cycle (LCF) and high cycle (HCF) fatigue tests were conducted in the axial total stress-amplitude control mode with $R = \sigma_{\text{min}}/\sigma_{\text{max}} = 0.1$, for all the welding and rotating speeds used in the present study. It was observed that the specimens welded at 56 mm/min showed the best behavior in the low cycle regime.

Keywords: Friction Stir Welding, Processing Parameters, Fatigue, Tool Rotation Rate, Tool Travel Speed.
Bonding mechanism in the aluminum roll-cladding

M. Soltan Ali Nezhad 1, A. Haerian Ardakani 1, T. Azim zadegan 2

1 Ferdowsi University of Mashhad, Department of Materials Science and Engineering, Mashhad, Iran.
2 Sharif University of Technology, Department of Materials Science and Engineering, Tehran, Iran.

Abstract

In this investigation, steel strip was coated by 1xxx series aluminum at different roll-cladding parameters. The separation of roll-claded strips was performed by peeling test. Weld interface and peeled surface of two metals were examined by optical microscopy, SEM and EDS analysis to evaluate the metallurgical effects of cladding and bonding mechanism. Micrographs showed cracks on the brittle surface of the two materials. These points are extruded areas of virgin substrate which facilitate intimate contact and ultimately bonding between the two metals. By increasing the temperature and total thickness reduction (%R) cracks number, size, open proliferates and therefore extruded new metal increases. According to analysis results it is obvious that there are the extruded aluminum in the cracks of peeled surface of steel and extruded steel in the cracks of peeled surface of aluminium.

Keywords: Bonding Mechanism, Roll-cladding, Aluminum, SEM.
The effect of post weld heat treatment on the properties of 2024 friction stir welded joints

M.A. Safarkhanian, M. Goodarzi, S. M. A. Boutorabi
Metallurgy and Materials Engineering Department, Iran University of Science and Technology, Tehran, Iran

Abstract

A 2024-T8 aluminum alloy was friction stir welded, and the effect of post weld heat treatment on the structure and tensile properties of joints was investigated. Abnormal grain growth usually happens during post-weld heat treatment. It found that for this alloy if this phenomenon completely happens in stir zone, tensile strength of the joint will increase significantly. On the other hand stable grains in the stir zone have no effect on tensile strength of heat treated joint, because broken intermetallics are retained in grain boundaries.

Keywords: Friction stir welding, Aluminum alloy, Post weld heat treatment.
Scarf welding of Aluminium to Copper plates by explosive welding and investigation of interface properties

S. M. Bagheri, J. Zamani, A. Mehdipour Omrani

Mechanical Engineering Department, K. N. Toosi University of Technology, Tehran, P.O. Box: 13448-47153, Iran.

Abstract

The purpose of this study is to produce scarf joint through explosive welding process (EXW). The scarf weld is a process in which the final bond interface is oblique. With applying the explosive welding technique, this type of joint can be used to create a metallic bond between similar or dissimilar metals. In this study, chamfered end of aluminum and copper plates were joined explosively and named scarf joint, employing changes in chamfered angle at different stand-off distance and explosive loading. The geometry of scarf joint enables consideration of both flyer and base plate thickness and explosive loading and the effects on mechanical properties of interface such as bond shear strength and micro-hardness can be investigated. Mathematical models developed for the interface properties of scarf joint to make relationship between the bond shear strength and explosive loading ratio. To check the adequacy of developed models, mechanical properties of interface, such as bond shear strength, predicted and compared with actual values in explosive cladding process. The results show reasonable agreement with theoretical predictions. Consequently, mathematical model which is based on scarf joints, can predict bond shear strength of cladding metals under desired explosive loading and flyer plate thickness.

Keywords: Explosive welding, Scarf Joint, Shear strength, Micro-hardness, loading ratio.
Cracking behavior in pulsed laser welding of AA2024 is investigated. It is established that the weld metal can be divided in two zones with respect to cracking behavior. The first zone corresponds to the weld metal nucleated and grown on the wrought base metal. The second zone corresponds to that part of the weld pool which is grown on the weld metal of the previous spot. It is established that the partially melted zone between the weld metal and the wrought base metal acts as a strong initiation site for solidification cracks. However, the partially melted zone of the fusion line between two consecutive weld spots is immune to acting as initiation site for solidification cracking. Overall, the study shows that partially melted zone microstructure and its relation to the welding stresses has an overriding effect on what is known as solidification cracking in the weld metal of AA2024.

**Keywords:** laser welding, solidification cracking, partially melted zone, liquation cracking, wrought aluminium alloy.
Effect of accumulative roll bonding process on microstructure and mechanical properties of Al 5083 alloy

S. Akhavan, M. R. Toroghinejad, F. Ashrafizadeh
Department of Materials Engineering, Isfahan University of Technology, Isfahan, 8415683111

Abstract

Accumulative roll bonding (ARB) process is severe plastic deformation (SPD) process that has been used for Al 5083 alloy. The ARB process up to 6 cycles was performed at room temperature under unlubricated conditions. Sample properties were studied by employing hardness measurements, tensile test, SEM and TEM characterizations. The specimens after 6 cycles showed a microstructure covered with ultra-fine grains with an average diameter 150 nm. The tensile strength and hardness of the ARB processed aluminum alloy was increased by 200% in comparison with initial value. On the other hand, the elongation dropped abruptly at the first cycle and then increased slightly. Strengthening in ARB processed aluminum may be attributed strain hardening grain refinement.

Keywords: Accumulative roll bonding, Severe plastic deformation, Al 5083 alloy.
Investigations on the effects of process parameters for Nd:YAG pulsed laser welding of 7075 aluminium alloy

A. R. Sufizadeh, S. A. A. Akbari Mousavi, F. Hasanabadi, M. Moradian
School of Metallurgy and Materials Engineering, University College of Engineering, University of Tehran, Iran, P.O.Box: 11115-4563

Abstract

Pulsed Nd:YAG laser beam (LB) welding is conducted on 7075 aluminium alloy sheets under different welding parameters. In this study, the effects of laser power on the geometry of the welds were investigated. Microstructures of the welded joints were investigated by the optical microscopy (OM), scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDS) and micro hardness test. Very fine dendritic microstructure was achieved in the weld zone. The reason is attributed to the higher cooling rate in the laser welding process. The EDS results show that the percentages of Zn and Mg are reduced due to high vapor pressure. In the PMZ region (partial melting zone), micro crack was detected. The study shows that the PMZ and micro cracks are eliminated by reducing the heat input. The results show grain growth in the HAZ region.

Keywords: laser welding, laser power, microstructure, Al7075.
Investigation on roll bonding behaviour of Al3003/Al4043 and Al3003/Zn sheets

M. Movahedi, A. H. Kokabi, H. R. Madaah Hosseini, M. Hajizadeh

Department of Materials Science and Engineering, Sharif University of Technology, Tehran, P.O. Box 11365-9466, Iran

Abstract

In present study, the roll bonding behaviour of Al-3003/Al-4043 and Al-3003/Zn sheets were compared. The bi-layer sheets were produced via roll bonding process at different reductions in thickness and room temperature conditions. The joint strengths of the sheets were measured by peel test before and after supplemental annealing treatment. The peeled surfaces were examined using a scanning electron microscope. The results indicated that Al-3003/Al-4043 sheets were bonded with higher joint strength and lower threshold reductions in thickness with respect to the Al-3003/Zn sheets. In contrast to Al-3003/Zn sheets, significant improvement was observed on the joint strength of Al-3003/Al-4043 sheets after annealing treatment. Moreover, electron microscopy examinations showed that the fracture type of Al-3003/Al-4043 and Al-3003/Zn sheets were predominantly ductile and brittle, respectively.

Keywords: Al-3003, Al-4043, Zn, Roll bonding, Bond strength.
Optimization the Exothermic Welding Process for Aluminum Parts

H. Ayazian Mavi 1, H. Madanipour 1, M. Mirjalili 1, M. Soltanich 1, G. H. Khakian 2, H. Goodarzi 2

1 Department of Materials and Metallurgical Engineering, Iran University of Science and Technology, Tehran P.O. Box: 16844, Iran
2 Almahdi Aluminum Inc, Bandar Abbas, Iran.

Abstract

In this work, the possibility of welding aluminum parts by self propagating high-temperature synthesis technique is investigated. Metallic compounds (such as sulphates and fluoride compounds) and aluminum are used as the precursor combustion powders to perform the exothermic welding process. Aluminum as a reducing agent reacts with metallic compound to release heat for melting the remained aluminum. A proper flux such as CaF2, MgF2, cryolite, alkali silicates and fluorosilicates suggested to be used to improve the fluidity of produced slag. Weld powder mixture composition have to be controlled exactly since the molten pool adiabatic temperature is highly dependent in composition. So the current work propose an optimum powder composition to form a high quality weld with the lowest aluminum powder consumption, as the most expensive used powder.

Keywords: Thermite Welding, Aluminum Welding, Combustion Synthesis, Exothermic Welding.
METALWORKING

AND

MECHANICAL PROPERTIES
Achenbach Buschhütten, a more than 555 year old family-owned German company, is the only rolling mill supplier in the world today being specialized on rolling of nonferrous metals and the market leader in this field. A close co-operation of the rolling mill supplier and the aluminium strip and foil producers combines modern research and development efforts with long decades of practical experiences and was the basis for more than one century of rolling mill development which leads to an outstanding level of new technologies today. Only the best combination of most advanced components of mechanics, electric, electronics, engineered by experienced specialists, finally guaranties the necessary reliability of a successful operation. Experiments should be done in laboratories and test fields but not on site. Big investments like rolling plants in competitive markets require serious and reliable partners with the complete know-how of the total technical environment.
Numerical inspection of compound extrusion process in Aluminium-Copper and comparison of experimental results and analysis of upper bound.

M. Naghdian, O. Nikfarjam, V. Baratloo, M. Rasouli Mir, M. Saket

Iran University of Science and Technology (I.U.S.T)
Iran Khodro Company (I.K.CO)

Abstract

In this article, by using of ABAQUS software, the process of widthwise extrusion of composite rod through conical die in symmetrical axis form has been modelled. The modelled composite rod consist of aluminum core and cupper shell. Effect of reduction in area on forming force and radius ratio has been inspected in this model. Afterwards, the results of Finite Element model have been compared with the experimental data, based on upper bound analysis method.

Keywords: Extrusion, Finite Elements Analysis, Composite rod, upper bound theory, Experimental Approach.
Experimental estimation of fatigue crack growth rate in thin aluminium alloy plates

A. R. Shahani, H. Moayeri Kashani, M. Rastegar, M. Botshekanan Dehkordi

Department of Applied Mechanics, Faculty of Mechanical Engineering, K.N. Toosi University of Technology, Tehran, P.O Box 19395-1999, Iran

Abstract

In this paper Fatigue Crack Growth Rate (FCGR) is expressed in terms of $\Delta J$ (cyclic $J$-integral), $\Delta CTOD$ (cyclic crack tip opening displacement) and $\Delta CMOD$ (cyclic crack mouth opening displacement) instead of $\Delta K$ (cyclic stress intensity factor) in the well-known Paris equation. Conducting several tests on CT specimens made of aluminium alloy with specific chemical composition and having 2.9mm thickness according to standard test method ASTM E647, the proposed model is examined. The experimental results show that $\Delta J$ and $\Delta CTOD$, contrary to $\Delta K$ and $\Delta CMOD$ which are constant in $R$-ratio variations, vary with the variations of $R$-ratio in the range $R=0.3$ to $R=0.6$. Therefore, there is no need to enter $R$ parameter directly in the well-known Paris equation if $\Delta J$ or $\Delta CTOD$ parameter is used instead of $\Delta K$ in this equation. The constants of these equations are independent of loading unlike the constants of Paris equation. Meanwhile, the presented relations also cover Elastic-Plastic Fracture Mechanics (EPFM) assumption in fatigue crack growth. Finite element analysis is also performed and the results are compared with the experimental results.

Keywords: Fracture Mechanics, FCGR, cyclic $J$-integral.
An investigation into the effect of ECAE process on mechanical and microstructural properties of middle layer in copper clad Aluminium composite

B. Tolaminejad ¹, A. Karimi Taheri ², H. Arabi ¹, M. Shahmiri ¹

¹ Department of Metallurgy and Materials Engineering, Iran University of Science and Technology, Narmak, Tehran, Iran.
² Material Science and Engineering Department, Sharif University of Technology, Azadi Ave., P.O.Box11365-9466, Tehran, Iran.

Abstract

Equal channel angular extrusion (ECAE) is a promising technique for production of ultra fine-grain (UFG) materials of few hundred nanometers size. In this research, the grain refinement of aluminum strip is accelerated by sandwiching it between two copper strips and then subjecting the three strips to ECAE process simultaneously. The loosely packed copper-aluminum-copper laminated billet is passed through ECAE die up to 8 passes using the B₄ route. Then, tensile properties and some microstructural characteristics of the aluminum layer are evaluated. The scanning and transmission electron microscopes, and X-ray diffraction were used to characterize the microstructure. The results show that the yield stress of middle layer (Al) is increased significantly by about four times after application of ECAE throughout the four consecutive passes and then it is slightly decreased when more ECAE passes are applied. An ultra fine grain within the range of 500 to 600 nm is obtained in the Al layer by increasing the thickness of the copper layers. It was observed that the reduction of grain size in the aluminum layer is nearly 55% more than that of a ECA-extruded single layer aluminum billet, i.e. extruding a single aluminum strip or a billet without any clad for the same amount of deformation. This behavior was attributed to the higher rates of dislocations interaction and cell formation and texture development during the ECAE of the laminated composite compared to those of a single billet.

Keywords: Severe plastic deformation, Laminated composite, Equal channel angular extrusion, UFG materials, Aluminium/Copper.
Effect of Impurities on Microstructure, Mechanical and Fatigue Properties of Aluminum Alloy 7075-T6 and 7075-RRA

A. Kermanpur, V. Tari, E.H. Dehkordi

Department of Materials Engineering, Isfahan University of Technology, Isfahan 84156-83111, Iran

Abstract

Two extruded aluminum alloy 7075 with different impurity levels were forged followed by aging heat treatment under T6 temper and retrogression-reaging (RRA) conditions. Microstructures, mechanical and fatigue properties of the samples were characterized and compared with each other. The results showed that although the apparent chemical composition of the alloys were in the standard range, the values of Si and Fe impurities could make significant effects on the mechanical and fatigue properties of both T6- and RRA-treated samples. The alloy with lower amounts of Si and Fe impurities showed higher values of hardness, tensile properties and fatigue strength in both forged and aged conditions.

Keywords: Aluminum alloy 7075, Impurity, Mechanical properties, Fatigue, T6 temper, Retrogression and re-aging.
The use of the SHPB technique and FEM to determine the dynamic behavior of Al5083 alloy at high strain

B. Davoodi ¹, A. Gavrus ², E. Ragneau ³

¹ Department of Manufacturing Engineering, Faculty of Mechanical Engineering, University of Tabriz, P.O.Box 51665, Tabriz, Iran
² The Civil and Mechanical Engineering Laboratory (LGCGM), INSA de Rennes, 35043 Rennes Cedex, France

Abstract

The Split Hopkinson Pressure Bar (SHPB) technique is extensively used to characterize material behavior at high strain rates. This paper deals with an experimental and numerical analysis of the SHPB test applied to obtain dynamic stress-strain data for Al5083 and the strain rate sensitivity of this aluminum alloy at room temperature. The specimen in the form of halter was set between the incident and transmitted bars and impacted at high strain rate (1000s⁻¹ to 2500s⁻¹). Starting from the variation of the stress with the strain and strain rate, we can obtain constitutive parameters. The parameters for a Johnson–Cook constitutive equation are determined from the test results. A non-linear parameter identification technique is used. This constitutive model is introduced into a numerical model developed with the explicit code Abaqus®. The results indicate that the J–C constitutive equation is suitable for expressing the dynamic behavior of the Al5083.

Keywords: Al 5083, Split Hopkinson Pressure Bar, Constitutive equation, High Strain Rate, FEM.
AUTOMATIC DIE CLEANING AND CAUSTIC SODA RECOVERY PROCESS

W. Dalla Barba
ITALTECNO S.r.l., Modena, ITALY – www.italteco.com

Abstract

The process described is a new plant design for cleaning extrusion dies in a more ecological, faster and fully automatic way compared to conventional methods in use even today. The new process guarantees that the caustic soda solution used for dissolving the aluminium metal in the dies is always transferred into an holding tank before any opening of the covers of the treatment tank so that no caustic soda fumes can be released in the working environment or outside. During the cleaning phase (treatment) the process is “fumes free” since hydrogen and caustic fumes can be sent away through a “hood” and treated separately (scrubber, etc). The agitation of the solution through pumps offers 20 – 25% faster process than the conventional methods.

All the plant is automatically operated by a programmable PLC so that operators have only to place the dies before cleaning in suitable baskets in loading positions and to take out the cleaned dies from same baskets located in unloading positions after been transferred automatically from the treatment tank. The die cleaning plant may be completed with a special saw for cutting and recovering part of the aluminium metal left in the bottom of the extrusion dies before the automatic cleaning and with an optional caustic soda recovery system. With the caustic soda recovery plant it is possible to almost totally recover the caustic soda, reducing almost to zero its consumption. The only by-product of the process is simply a very dry mud composed of aluminium hydroxide, which can even be sold, eliminating therefore the necessity of disposing of toxic harmful substances. Other than the evident economical advantages, the described process is highly ecological for the environment and it also allows to recycle the used chemical products.

Keywords: extrusion, die, ecology, automatic.
Effect of Initial Microstructure on Liquid Segregation during Back Extrusion of A356 Alloy

S. Ghadiani, J. Mola, M. Khodai, N. H. Aashuri, N. Parvin

Department of Material Science and Engineering, Sharif University of Technology, Tehran, P.O. Box: 11365-9466, Iran

Abstract

Segregation is an integral phenomenon accompanied by thixoforming processes, which leads to heterogeneity of products in terms of microstructure and properties. Segregation intensity is closely connected to processing parameters as well as initial microstructure. In order to evaluate effect of initial microstructure on the degree of phase segregation during back extrusion, A356 alloy slugs with different initial microstructures were prepared through different routes namely sand casting with high and low superheatings, cooling slope and electromagnetic stirring, and subsequently back extruded at very high ram speeds provided via a Drop Extruder Apparatus (DEA). The sample prepared by cooling slope route exhibited the best thixoformability and the least pronounced segregation. On the other hand, three other samples with microstructures consisted of large irregular particles underwent significant phase segregation and displayed much lesser thixoformability. Furthermore, it was revealed that no constant relationship between thixoformability and homogeneity of back extruded products could be established.

Keywords: Semi-Solid Processing, Cooling Slope, Electromagnetic Stirring, Liquid Segregation, Backward Extrusion, A356 Alloy, Globular Structure.
Distribution of TiH₂ and cell morphology in closed-cell aluminum foam produced by ARB process

M. Khalkhali, A. Akbarzadeh, A. Saeghi, M. A. Sadeghi

Department of Materials Science and Engineering, Sharif University of Technology, Tehran, P.O. Box: 11365-8639, Iran

Abstract

Closed-cell aluminum foam was manufactured from preformed Al-TiH₂ composite which was produced through ARB (Accumulative Roll Bonding) process. The effect of number of ARB cycles on distribution of TiH₂ particles in aluminum matrix is investigated. It is observed that severe plastic deformation during high number of ARB cycles, leads to a homogenous distribution of TiH₂ particles. This is due to increase in TiH₂ containing interfaces and crumble of particles along the rolling direction. It is also shown that the TiH₂ containing interfaces experience remarkable bonding quality in the last ARB cycles. Closed-cell foam was fabricated by annealing of preformed composite at appropriate temperature. It is observed that the number of ARB cycles and the foaming temperature, have considerable effect on porosity and cell morphology of produced foam.

Keywords: Metal foam, aluminum, TiH₂, Composite, ARB.
Investigation of mechanical properties and SCC resistance of cryorolled and aged Al-7075

H. Fooladfar, B. Hashemi, M. Younesi
Department of material science and engineering, Shiraz University, Shiraz, Iran

Abstract

Al-7075 is widely used in aerospace industries because of its high strength and low density. But sometimes the parts under tension in confrontation with atmospheric corrosive environment can not show an acceptable strength against stress corrosion cracking (SCC). In this research we have studied a modified method of T8 heat treatment including cryorolling and aging at low temperature on this alloy and investigated its mechanical properties and its SCC resistance by hardness, tensile tests and micro structural evidences. In addition to the high increase in the yield strength and UTS of the alloy, its resistance to SCC had also a great improvement. Furthermore the uniform elongation of the cryorolled and aged alloy was almost two times more than that of the cryorolled nano structured sample. High density of secondary phase precipitates enabled effective dislocation pining and accumulation, leading to simultaneous increase in strength and ductility. The improvement of resistance to SCC was due to superior dispersion of secondary phase precipitations which doesn’t allow precipitation free zones to develop.

Keywords: cryorolling, age hardening, SCC, Al-7075.
The effect of punch radius and preheat temperature on the billet temperature during hot backward extrusion of Al 2124 by finite element method

S. M. Ebrahimi, M. Belbasi, A. A. Akbari Mousavi, S. Enayati, Mohammad Mastoori

Material Engineering, Iran University of Science and Technology, Tehran, P.O. Box: 16844, Iran

Abstract

In this study, the hot backward extrusion process of Al-21204 was simulated with the finite element analysis and their results were compared with experiments. The effects of punch radius and the preheat temperature on the billet temperature, on the load required and on the flow behavior of the Al-2124 during the process were considered. The results suggest an optimum punch radius. If the punch radius is smaller than the optimum value, the high localized temperature will be produced at the interface of punch and material. Moreover, the high temperature may result in producing melt at the grain boundaries. In addition, it may cause non-uniform strain distributions near the punch radius, so that material may shear off by the punch. If the punch radius exceeds the optimum value, the material loss will increase and make the process uneconomical.

Keywords: Backward extrusion, Punch radius, Incipient melting temperature, Punch load.
Effects of preheat temperature and punch shape on the mechanical properties of the Al7075 in the hot backward extrusion process

S. M. Ebrahimi, M. belbasi, A. A. Akbari Mousavi, M. Bayazidi, M. Mastoori

Material Engineering, Iran University of Science and Technology, Tehran, P.O. Box: 16844, Iran

Abstract

The Al7075 has extensive use in the aerospace industry due to its good mechanical properties and formability. The backward extrusion process is one of the best methods for forming Al7075 alloys since it effectively reduces the pressure required for extrusion, due to the elimination of the friction at the container wall. The control of operational parameters such as punch diameter, punch conical angle, applied reduction, forming temperature results in producing the products with good strength and proper dimensions. The aim of this study is to consider the effects of the process parameters on the final shape of the products using the ABAQUS finite element software. The dimension of the punch and its conical angle were obtained by the simulation process. The optimum preheat temperature to obtain the best mechanical properties was achieved by the experiments. The three temperatures of 430°C, 440°C and 450°C were used. The samples were subjected to mechanical testing. The results of the simulations and experiments show that the optimum punch conical angle and process temperature are 5.5°, 430°C, respectively. The ultimate strength of 620MPa and elongation of 13% was achieved by using the optimum extrusion parameters.

Keywords: Hot backward extrusion process, punch conical angle, preheat temperature, microhardness test.
Comparison between Aluminium panel and Steel panel on Dent Resistance

M. Aghamirzaie 1, M. Alijanpour 1, S. H. Masoud 2, S. M. Razavi 2

1 CAE Engineer, Department of R&D Center, Iran Khodro Company, Tehran, Iran
2 Design Engineer, Department of R&D Center, Iran Khodro Company, Tehran, Iran

Abstract

The use of thinner sheets and the introduction of new materials have meant that the dent resistance of exterior panels has become more focused in the automotive industry during the last years. The objective of this study was to investigate the influence of material choice and the effect of thickness on the static dent resistance of automotive panels. The experiments were performed on a flat circular panel. Two materials were included in the study: aluminum and steel. Dent resistance is quality criteria for automotive body panels which should be considered in design. A computer simulation technique was developed for dent resistance prediction, which can potentially be used in the early design stages before panels are produced. Simulation techniques are discussed using implicit (FEA) for denting simulation. Dent resistance for this study is measured at the centre of circular panel.

Keywords: Dent resistance, thin sheet, finite element, yield strength, aluminum.
Investigation and evaluation of Computational Simulation of 7075 Aluminum Flat Rolling Technology

A. A. Mottahedi

Industrial Metallurgy and New Processing group, Department of Advanced Materials and Renewal Energies Iran Research Organization for Science & Technology (IROST), Ferdosiss Sq., Forsat St.71, Post O Box: 15815/3338, Tel/ Fax: +98-21-88826692,

Abstract

Production tonnage and high productivity of rolling process make it a very important process in metal forming of wrought metals. Hence, any interruption in rolling line or wastage has large costs. So, technological research or any change in rolling process is difficult along with a high risk of cost in industrial scale. Thus, rolling simulation by computer and using of software could make rolling research easier. The paper is extracted from a project in the field of computational simulation of Aluminum strip rolling and making software by using theoretical aspect of flat rolling and also experimental data and industrial technology experience in a 20 thousand tons Aluminum rolling mill manufacturing Company. Analysis of force, pressure profile on rolls, neutral point, and other useful information and computation of strip rolling process which are significant in controlling of force, power, torque, rolls, crown, quality of plate and so on, are analyzed by this computer program. This paper is written to exhibit the computer code and its usage in R&D, Quality Control, Planning and Technology of Flat rolling process of Aluminum industry. The software results are validated by 2 tons 7075 Aluminum slabs in an industrial rolling mill company. 7075 Aluminum alloy is using in aerospace.

Keywords: 7075 Aluminum Rolling, Metal Forming, Flat Rolling Simulation, Aluminum Rolling, Rolling Software, Strip Rolling, Rolling Process.
Influence of Rolling on the Microstructure and Hardness of Aluminum 1100 Previously Subjected to Twist Extrusion

S. Ranjbar Bahadori, S. A. A. Akbari Mousavi, A. R. Shahab

School of Metallurgy and Materials Engineering, University College of Engineering, University of Tehran, Tehran, Iran, P.O. Box: 11155-4563.

Abstract

Interest in processing of bulk ultrafine-grained materials has grown significantly over the last years. Severe plastic deformation processes such as twist extrusion (TE) have been the essence of these researches and used to decrease the bulk grain size. The bulk structure grain size can reduce if twist extrusion process combines with a conventional forming technique. In this study, the effects of reduction by employing the rolling process after the twist extrusion process are considered. The T.E process of Al1100 was carried out using a twisted die with 60° die angle and the samples were processed through rolling subsequently. As a result of rolling, average microstructure grain size decreases significantly and the hardness magnitude increases accordingly.

Keywords: Severe plastic deformation, Ultrafine-grained, Twist extrusion.
Springback simulation of friction aided deep drawing process

M. Kadkhodayan and R. Pourhasan

Department of Mechanical Engineering, Ferdowsi University of Mashhad, P.O. Box: 91775-1111, Mashhad, Iran

Abstract

In the recent years the friction-actuated blank holding technique has been developed for drawing cylindrical cups. A new technique on friction aided deep drawing using tapered blank holder divided into eight segments has already been proposed. A metal blank holder was designed to be of two layers: stationary layer or base with 5 degree taper angle and moving layer divided into eight tapered segments. The main function of this developed blank holding device is adopting the frictional force between the blank and the blank holder to work in the useful drawing direction. Using this method, successful deep cups with high drawing ratio up to 3.67 can be produced without any defect only in one die set. This paper discusses a finite element analysis of springback and the effects of different process parameters in the friction aided deep drawing process of an aluminium alloy sheet. Effects of different process parameters such as initial sheet thickness, punch profile radius, blank holder force, friction coefficient and hardening models on springback prediction are studied. Simulation of springback is performed by the ABAQUS software.

Keywords: Friction aided deep drawing, Springback, three-Dimensional simulation, ABAQUS /Explicit.
Effect of extrusion variables on tensile fracture of AA6061-SiC composites

A. Pakdel, M. Emamy, H. Farhangi

School of Metallurgy and Materials Engineering, University of Tehran, Tehran, P.O. Box: 11365-4563, Iran

Abstract

Vortex method was carried out to fabricate an AA6061 aluminum matrix composite reinforced with 10 Vol. % SiC particulates. It was then extruded at 450°C, 500°C and 550°C with the extrusion ratios of 6:1, 12:1 and 18:1 to reveal the effect of extrusion variables on the tensile fracture of the material. Tensile testing and SEM fractography were used to characterize the fracture behavior of the composite. The as-cast samples had very low ductility and their fracture surfaces revealed agglomerations of reinforcement particles leading to brittle fracture of the material. However, these clusters were eliminated after applying the extrusion process and a more ductile fracture behavior was observed as the extrusion ratio or the extrusion temperature increased.

Keywords: Metal Matrix Composite, Extrusion, Fracture, Ductility, Fractography.
Investigation of friction condition effects in isothermal closed die forging process of Aluminium AA7075

S. Zare Chavoshi, M. Tajdari
Department of Engineering and Hi Tech, Iran University of Industries and Mines, Tehran, P.O. Box: 14395-518, Iran
Department of Mechanic & Manufacturing Technologies, Malek Ashtar University of Technology, Tehran, Iran

Abstract

Aluminium alloys are important construction materials in the automotive industry, in racing and aerospace due to their low specific weight, their corrosion resistance and their ability to achieve high strength with certain alloying additions. Aluminium AA7075 is one of these alloys which is used for the above applications. In production of complex aluminium parts by forging process, the friction is a major factor in determining the characteristics of metals. In this study, the effects of friction conditions on the forming forces, effective stress and strain rate of Aluminium AA7075 in isothermal closed die forging process have been considered by the finite volume method. The results show the remarkable differences between forming forces and effective strain rate in different friction conditions, while there aren’t considerable differences between the effective stresses.

Keywords: Friction conditions, Aluminium AA7075, Isothermal closed die forging, Finite volume simulation.
NANOTECHNOLOGY
Fabrication and tribological properties of bulk nanostructured Al2024 alloy

M. Jafari Bahramabadi, M. H. Abbasi, M. H. Enayati, F. Karimzadeh

Materials Engineering Department, Isfahan University of Technology, Isfahan, P.O. Box: 84156-83111, Iran

Abstract

Tribological properties of nanostructured Al2024 alloy prepared by mechanical milling and hot pressing methods were investigated. Al2024 powders were subjected to high-energy milling for 30h to produce nanostructured alloy. 30h-milled Al2024 powders were compacted at 450°C under 200MPa in a uniaxial die. Consolidated sample had a hardness and relative density values of 205HV and 99%, respectively. For determination of the effect of nanocrystalline structure of Al2024 on wear behavior, two samples of traditional Al2024-O (annealed) and Al2024-T6 (age-hardened), were analyzed. The wear behavior of the samples was investigated using a pin-on-disk technique under an applied load of 20N. Worn surfaces and the wear debris were analyzed by scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS) and X-ray diffraction (XRD). Nanostructured Al2024 revealed a lower friction coefficient and wear rate compared with Al2024-O and Al2024-T6. This enhanced wear resistance is mainly due to the effect of nanocrystalline structure of Al2024 alloy.

Keywords: Nanostructured Al2024 alloy, Hot pressing, Tribological properties.
The effect of milling time on tribological properties of Al6061-Al₂O₃ nanocomposite prepared by milling and hot pressing methods

N. Hosseini, M. H. Abbasi, F. Karimzadeh, M. H. Enayati
Materials Engineering Department, Isfahan University of Technology, Isfahan, P.O. Box: 84156-83111, Iran

Abstract

In this paper, the effect of milling time on tribological properties of bulk Al6061-Al₂O₃ nanocomposite prepared by mechanical milling and hot pressing was studied. Al6061 chips were milled for 30h to achieve a homogenous nanostructured powder with a grain size of approximately 35nm. 3vol% Al₂O₃ nanoparticles were added to the Al6061 after 15h and 30h from beginning of milling. The milling time of Al6061 with Al₂O₃ in these two samples was then 15h and 30min, respectively. Hot pressing of milled samples was executed at 400°C under 128MPa in a uniaxial die. The hot pressed samples were characterized by micro-hardness test, bulk density measurements, pin on disc wear test, and finally SEM observations. 15h-milled nanocomposite showed improvement in wear resistance and bulk density compared with that of 30min-milled nanocomposites due to its better interfacial cohesion between Al₂O₃ nanoparticles and the matrix. Moreover, there would be a good dispersion of Al₂O₃ nanoparticles after 15h of milling.

Keywords: Milling, Hot pressing, Nanocomposite, Wear.
Fabrication of nanocrystalline Al matrix hybrid composite by mechanical milling

E. Mohammad Sharifi, F. Karimzadeh, M. H. Enayati

Department of Material Science, Isfahan University of Technology, Isfahan, P.O. Box: 84154, Iran

Abstract

Fabrication and characterization of aluminum matrix composite reinforced by Al₂O₃–AlB₁₂ particles were investigated. Al₂O₃–AlB₁₂ composite powder was first synthesized by mechanochemical route starting from Al and B₂O₃ powder mixture. Then, prepared Al₂O₃–AlB₁₂ powder was mixed with pure aluminum powder and ball milled in order to produce Al–20 wt.% (Al₂O₃–AlB₁₂) composite. The structural evaluation of powders was studied by X-ray diffraction (XRD), scanning electron microscopy (SEM) and microhardness measurement. The aluminum crystallite size estimated with broadening of XRD peaks by Williamson–Hall formula. The results showed that through ball milling process a homogeneous distribution of Al₂O₃–AlB₁₂ particles in nanocrystalline Al matrix was obtained. This structure exhibited good thermal stability and high hardness value of 190 HV which is significantly higher than 33 HV for pure Al.

Keywords: Aluminum matrix composite, Mechanical milling, Nanostructured materials.
Formation of nano-structured Aluminum 6056 using severe plastic deformation (SPD)

S. Yoonesian, K. Dehghani, M. Arab
Faculty of metallurgy, Amirkabir university of Technology, Tehran, Iran

Abstract

Wire brushing is used for different purposes such as removing metal oxides, increasing surface brightness, improving fatigue properties and surface activation before coating. The wire brushing severely scratches and stirs the metals in the surface layers, so that complicated metal flow gives rise to very large amount of plastic strain and increases dislocation density into the surface layer. After recovery, subdivision grains and nanocrystalline structure are formed. Formation of nanocrystalline structure on the surface of material was investigated by using atomic force microscopy and X-ray pattern. The results showed that the severe plastic deformation decreased the surface grain size to 30-70nm.

Keywords: Wire brushing, Severe plastic deformation, Nanocrystalline grains, Atomic Force Microscopy.
Microwave induced solution combustion synthesis of nanocrystalline alumina powder, comparison with conventional heating

S. Saket\textsuperscript{1}, S. Rasouli\textsuperscript{2}, K. Tahmasebi\textsuperscript{3}, E. Ghasemi\textsuperscript{2}

\textsuperscript{1}Department of Metallurgy and Materials Science, School of Eng, Maybod University, Yazd-Iran
\textsuperscript{2}Institute for Colorants, Paints and Coatings, Tehran-Iran
\textsuperscript{3}Department of Metallurgy and Materials Science, School of Eng, Shiraz University, Shiraz-Iran

Abstract

The combustion synthesize is one of the economical methods for nanometric powders production due to low energy and time required. The aim of this study is to obtain of nanocrystalline $\alpha$-Alumina and investigation on the combustion temperature and comparing the combustion process in furnace and microwave. For this, the aluminum nitrate as alumina source, the urea as fuel, aluminum acetate as fuel aid was used. The process was done for composition in the furnace and microwave separately. The XRD, SEM, STA and PSA were used for powders characterizations. Results showed that using the furnace the combustion at 400°C lead to nanocrystalline $\alpha$-Alumina. Increasing the combustion temperature lead to growth of nanocrystals. Moreover using the microwave the product of combustion is amorphous and need to heating process at about 900°C. both process lead to flake-like agglomerated particles.

Keywords: combustion synthesis, nanocrystal, alumina.
Effect of Milling Time on Crystallite Size and Morphology of Al / Al₂O₃ Nano Composite Powder Prepared by Mechanical Alloying

S. S. Moosavifar, S. Heshmati Manesh, M. Heydarzadeh Sohi

School of Metallurgy & Materials Engineering, University of Tehran, Iran

Abstract

In this study preparation of Al / Al₂O₃ nano composite powder by mechanical alloying technique was investigated. Micron sized powders of Al and Al₂O₃ with commercial purity were milled in a pure argon atmosphere using a high-energy planetary ball mill, operated in a constant rotation speed of 350 rpm and a ball to powder weight ratio of 30:1. Scanning electron microscopy revealed that a homogeneous and uniform distribution of Al₂O₃ particles, as reinforcement phase in the Al matrix may be obtained during the milling operation. Effect of milling time on morphology and microstructure of the milled powder was investigated. The mean crystallite sizes of Al and Al₂O₃ particles calculated by Williamson-Hall method using XRD pattern showed that they became approximately as fine as 20 and 100 nm respectively after 9 hours of milling. Prolonged milling time resulted in ultra fine particles in the product, crystallite size reduction and peak broadening in XRD patterns, but no phase transformation was determined.

Keywords: Mechanical Alloying, Al₂O₃ particles, microstructure.
Synthesis of Aluminum Nanopowder through Evaporation-Condensation Method

S. H. Hosseini 1, S. Sheibani 2, Z. Valefi 1

1 Malek Ashtar University of Technology, Tehran, P.O. Box: 16765-3454, Iran.
2 School of Metallurgy and Materials Engineering, University of Tehran, Tehran, P.O.Box: 14395-553, Iran.

Abstract

In this paper aluminium nanoparticle production was investigated using evaporation-condensation method. The feasibility of this method was demonstrated and preliminary results were presented. Aluminium nanoparticles were formed by evaporation or sublimation of metal at high temperatures, 1400 °C, and subsequent cooling in inert gas atmosphere. Possible mechanism for explaining nanoparticle formation was discussed. The morphology and structure of aluminium nanopowders were studied using X-ray diffraction and scanning electron microscopy. The as-produced nanoparticles had a mean diameter of 60 nm. Additionally, nanoparticles were covered by an oxide layer i.e. alumina. Also, the specific surface area of the nanopowder was measured by BET method as 26.227 m²·g⁻¹.

Keywords: Aluminium, Nanopowder, Evaporation-Condensation.
Manufacturing and investigation on the mechanical properties of Al products with bimodal nanocrystalline microstructure

A. R. Jangjou 1, M. H. Paydar 2, A. Honarbakhsh 1

1 Department of Materials Science, Semnan University, Semnan, P.O. Box: 7461749733, Iran
2 Department of Materials Science, Shiraz University, Shiraz, P.O. Box: 7134851154, Iran

Abstract

In this study, microstructure, mechanical properties and deformation behaviour of bimodal nanocrystalline aluminium samples produced by P.M method were investigated. Nanocrystalline Al powders achieved by attrition-milling of atomized commercially pure aluminium powders for different milling times. Bulk samples were produced through cold pressing followed by hot extruding the mixture of nanocrystalline powders milled for 20h (with an average crystalline size of 37nm) and 0, 15, 30 and 50 wt.% unmilled coarse Al grain powders. To investigate mechanical properties of the samples, tensile and hardness test were used. The results showed that by increasing nanocrystalline particles in the microstructure of raw material, in the range of 0 to 100%, tensile strength and ductility increase and decrease in the range of 120 to 520Mpa and 22 to 5 percent, respectively, and the hardness also increase in the range of 34 to 175Hv. This results suggest a good balance between tensile strength and ductility for the samples including appropriate amount of nanocrystalline and coarse-grain particles

Keywords: Nanocrystalline powder, Pure aluminium, Bimodal, Attrition-mill, Hot-extrusion.
SMELTING

AND

RAW MATERIALS
(Keynote Lecture)

Research Cooperation between Norwegian Primary Aluminium Industry and The Norwegian University of Science and Technology and SINTEF

H. A. Øye

Department of Materials Science and Engineering, Norwegian University of Science and Technology, 7491 Trondheim, Norway

Abstract

Norway has 7 primary aluminium plants with a total production of 1.36 M ton. Norway has a well established culture for a close cooperation between the industry and the Norwegian University of Science and Technology. An example of a very successful cooperation was EXPOMAT. The program was part of the export industries’ business strategy and industry was responsible for planning, management and reporting. The research was, however, mainly carried out at universities and research institutions. The total budget for primary aluminium was 132 M NOK = 20 M USD over 5 years with industry paying 56 % and The Norwegian Research Council 44 %. The chief executives of the 3 companies were participating actively in the program. In order to have a proper blend of applied and fundamental research the budget was divided as follows:

- Research which is directly applicable if successful: 60 %
- Long-term or high risk projects: 25 %
- Institute initiated research to be reported afterwards: 15 %.

The program was successful both industrially and scientifically.

Some research examples are also presented: Long life for aluminium cells, Standardization of test methods (ISO), Automatic pore analysis of baked carbon materials, TiB₂ coating on cathodes and 3-D modeling of thermal and sodium expansion in aluminium cells.

Keywords: Aluminium Industry, Research Program, R and D Process.
(Keynote Lecture)

Pleasures and Pitfalls in Amperage Increase Projects on Aluminium Electrolysis Cells

H. Kvande¹, B. Moxnes²

¹ Hydro Aluminium, Drammensveien 211, NO-0240 Oslo, Norway
² Hydro Aluminium Process Optimization, NO-6601 Sunndalsora, Norway

Abstract

During the last decade Hydro has increased its primary aluminium production volume by 25% by increased potline amperage in its Norwegian smelters. With very low investment cost this capacity creep programme has been implemented mainly to increase the metal production, but it has also reduced the specific energy consumption and increased the manning productivity. Both energy and manning costs are high in Norway, so the programme has been an important contribution to improve the competitiveness of the company. Valuable lessons have been learned about how to avoid pitfalls, and the experience makes it plausible to assume that similar amperage increase programmes will be successful also in the future.

Keywords: amperage increase, prebake cells, booster cells, cell operation.
Influence of Anode Baking Process on Smelter Performance

M. Meier
R&D Carbon Ltd., P.O. Box 362, CH-3960 Sierre, Switzerland

Abstract

The baking process is the most expensive step in the anode manufacturing chain due to the investment cost of the bake furnace and the energy consumption required for baking. As the baking process decisively influences the anode quality, the performance of the anodes in the pots has a strong effect on the overall smelter performance. In this context, the bake furnace firing system is a key element and must be well adapted to the design of the bake furnace. The design criteria and related performance figures of the bake furnace firing system are discussed in this document.

Keywords: Baking, bake furnace firing system, furnace performance, anode quality and consistency.
Alumina Fines and their impacts on Smelter Operations

L. Perander, J. Metson
Light Metals Research Centre, The University of Auckland, Private Bag 92019, Auckland, New Zealand

Abstract

Smelter grade alumina particles are typically aggregates of smaller particles with a complex internal structure which has significant impacts on behaviour in the smelter. Phase changes in the calcination of gibbsite to from SGA cause significant c-axis shrinkage, the opening of significant internal porosity and particle cracking along grain boundaries. Fines are produced through the fracture of these aggregated particles and from the particle size distribution carried through from filtration in the refinery. These fines invariably have a phase composition and microstructure which is different from that of the bulk material. These differences have impacts on the behaviour of alumina in the dry-scrubber, in dissolution and in the further attrition of the alumina.

Keywords: Alumina, Phase composition, Microstructure, Fines.
Successful Commercial Operation of NEUI400 Potline

Q. Xiquan, L. Dingxiong, W. Youwei, M. Jihong, W. Dequan, D. Hui,
M. Yu, L. Bin
Northeastern University Engineering & Research Institute (Ltd. Co.), No. 73, Xiaoxi Rd., Shenhe Dist.,
Shenyang City, PR China, 110013

Abstract

Development of large aluminum reduction technology belongs to a complex system engineering. While overcoming the core technologies, more attentions shall be paid to structure optimization, environmental protection and energy saving. As a professional engineering and research institute in light metals industry, NEUI has overcome successfully, by carrying out self-developing and joint operation, some bottle-neck technologies which affect the development of high amperage aluminum reduction technologies, such as MHD simulation technique of high amperage reduction cell, simulation technique of triaxiality thermoelectric field, simulation technique of flue gas fluid dynamics inside the cell, etc. Simulated and optimized with multi-advanced technologies, NEUI400 (I) aluminum reduction cells have been put into normal operation rapidly after startup, and the technical parameters are close or over the design values. Thus, all the simulation technologies of NEUI are proved as mature and reliable.

Key word: Electric balance, MHD, thermoelectric field, stress field, hooding structure.
Total Amount Control Technology on Aluminium Reduction Pot Fume Treatment

L. Dingxiong, Y. Qingchen, M. Jihong, L. Bin, W. Xingming
Northeastern University Engineering & Research Institute Co., Ltd, No.73, Xiaoxi Road, Shenhe District, Shenyang, Liaoning Province, PR China

Abstract

In the course of industrialization, environmental issues have become a restriction factor for the sustainable development. Comprehensive treatment on pot fume, control of every tache that affects fume emissions and realization of controlling total amount emitted to the environment have become the path of meeting requirements of relative environmental protection standards which appear to be more and more strict. This paper introduces in detail contents, principles and effects of the comprehensive pot fume treatment technology which help control of total amount emitted to the environment. The comprehensive pot fume treatment technology includes the technology of pot fume capture in the following sections: dual-duct fume emission technology, indirect fume cooling technology, new type two-stage counter current dry scrubbing technology and dust collector technology with alumina separated dynamically, etc. By using these technologies, hooding efficiency of a reduction pot is over 99%, total fluoride scrubbing efficiency of the scrubbing system over 99.5% and dust collection efficiency over 99.99%. For a 400kA reduction pot, the total fluoride emitted is less than 0.6kg/t. Al and total dust emissions is less than 1.02kg/t.Al.

Keywords: aluminium electrolysis fume clean, aerodynamics simulation, fume emission, waste heat recovering.
Value Added Product from Bauxite Residue

M. Ghiafeh Davoodi \(^1\), H. Nikraz \(^2\)

\(^1\) Lycopodium Minerals Ltd Pty, Process Department, Perth, Australia
\(^2\) Curtin University of Technology, Department of Civil Engineering, Perth, Australia

Abstract

Alcoa World Alumina Australia (Alcoa) produces more than 8 million tonnes of alumina annually at its Western Australia refineries located at Kwinana, Pinjarra, and Wagerup. These refineries utilise the vast resources of Bauxite located in the Darling Ranges south of Perth. This ore is low grade by world standards containing high levels of quartz and resulting in a coarse residue fraction. Alcoa has been working to develop coarse bauxite residue (Sand >100 µm) by a process of neutralization and washing to a product standard in conjunction with the Centre for Sustainable Resource Processing (CSRP). Further processing using a magnetic separator has demonstrated the ability to form different fractions such as High and Low Iron Sand. These fractions have different properties and hence different potential applications. Preliminary investigations have demonstrated that this residue sand is of little difference physically to crushed rock; hence it can potentially be used as a substitute for natural yellow sand in concrete mix design. This paper describes investigations into the potential to achieve low strength concrete mixtures using coarse bauxite residue as a fine aggregate. Physical, chemical and mineralogical properties of different segments of coarse bauxite residue were tested and compared with those of natural sand. Various combinations of these sands (fine aggregates) were used in concrete mixtures in order to verify their effects on strength and other properties. The results were promising in terms of mechanical properties and indicated that concrete mixes made using residue sand are likely to be effective in place of fine aggregates for practical use. From the results obtained, it can be deduced that this material can be used in a wide range of concrete applications in construction industry.

Keywords: Bauxite Residue, Red Mud, Utilisation, Construction Industry, Bayer Process.
The Continuous Development of SAMI’s Pot Technology

S. Kangjian, Z. Jiaming, Y. Xiaodong, L. Wei

Shenyang Aluminium & Magnesium Engineering & Research Institute (SAMI); 184 Hepingbei St. Shenyang China

Abstract

Starting from 1996, the Shenyang Aluminium & Magnesium Engineering & Research Institute (SAMI) developed a series of prebaked pot technologies ranging from 160kA, 190/200kA, 230/240kA 280kA, 300kA, 350kA to 400kA pots. All of them have been applied to the industry field, which gives rise to total capacity of 12Mt of aluminium. These pot technologies were developed through effective numerical simulation modelling and by learning the success and failure of the engineering and operation of previous pot technologies. Numerical modelling, pot design, pot measurements and process control will be described in this article. The SY series pot technology has been validated for its technical performance and economy. SAMI is launching a new campaign to reduce more investment and improve pot performance.

Keywords: reduction pot, high amperage, SY300, SY350, SY400.
A new Approach for Design and Development of Wear Resistance Silicon Carbide Blocks for use in Aluminum Electrolysis Cell Walls

M. Hosseinzadeh ¹, N. Khalili ¹, A. Samani ², M.N. Batoie ² ¹ MehrGodaz Refractories Co., Shahr-e-kord, Iran ² Almahdi Aluminum Corporation, BandarAbbas, Iran

Abstract

Having 240 aluminum electrolysis cells, Almahdi Aluminum Corporation is one of the biggest producers of primary aluminum in Iran. Aluminum has been produced by electrolysis of alumina (Al₂O₃) dissolved in molten cryolite (Na₃AlF₆)-based bath at temperature about 970°C. Aluminum is deposited molten onto a Carbon cathode, which also serves as the melt container. Simultaneously, oxygen is deposited on and consumes the cell's carbon anodes. In the current research, the effect of different phenomena in the cells such as oxidation, wear, thermomechanical stresses, chemical and operational conditions on the each component of refractory side wall has been investigated. The expecting properties of the refractory working layer were studied and finally, the design and development of the related refractory was performed. For that matter, a high temperature reaction occurred between silicon metal powder and thin layers of carbon which had covered the surface of silicon carbide grains in the main matrix. This reaction gave rise to SiC formation along with bonding the particles together. To reinforce the particles bonding, a mixture of pseudo-SIALON and synthetic SiC bonding was created by firing the blocks in coke bed at high temperatures. Experimental testes including CCS, HMOR, Density and porosity were measured according to JIS standard. The microstructural properties were studied by optical microscope and phase characterizations were done by XRD instruments. At last 50 blocks were fabricated in industrial scale and installed in two electrolysis cells of Almahdi Aluminum Corporation. According to Almahdi's Reports, there is not any sign of corrosion after one year of their operation, leading to Almahdi’s satisfaction.

Keywords: Silicon carbide, Aluminum Electrolysis Cell, Wear, Refractory.
Restarting Frozen Aluminum Pots with Cold Metal Method

G. H. Khakian\textsuperscript{1}, B. Bahr Vand\textsuperscript{1}, B. Samdani\textsuperscript{1}, M. Soltanieh\textsuperscript{2}

\textsuperscript{1} Almahdi Smelter- Bandarabbas- Iran- P.O. Box: 79171-7-6385
\textsuperscript{2} Dept. of Materials and Metallurgical Eng., Iran Univ. of Sci. & Tech.

Abstract

Aluminum is produced by electrical electrolysis in molten electrolyte by passing electrical current. The main part of aluminum production operation is performed in reduction pots at 960°C. If power cut-off lasts longer than 3 hours, most probably the pots will get cold so continuing the process will be impossible. In this case cut out pots from the production cycle will be urgent and removing the electrolyte and molten metal will be impossible because of the number of pots. The reasons of power cut-off can be failures that take place in power supply; rectifier department or electric network. The process of restarting these pots with cold metal layer, called Cold Metal Method, is very complex and needs fast reaction in operation, experience and safety precautions, especially at the first 24 hours. In this method of restarting pots, at first the electrolyte and metal is removed from the pot completely, then preheating is done by a resistance layer (resistor). The pot is then returned to the producing cycle. 87 pots were restarted by this method. The average cell life of restarted pots was more than 738 days. About 15 pots are still in operation after the restarting cycle.
The calcium removal from diasporic bauxite ore by acid leaching

S. M. J. Koleini, M. Abdollahy, R. Khormali
Department of Mineral processing, Faculty of Engineering, Tarbiat Modares University, Tehran, P.O. Box: 14115-143, IRAN

Abstract

The calcium removal from diasporic bauxite ore by acid leaching in order to bauxite enrichment was investigated in this research. The results of XRD, XRF, ICP and chemical studies indicated that Diaspore (AlO(OH)) is the major mineral phase and Hematite (Fe$_2$O$_3$), Quartz (SiO$_2$), Anatase (TiO$_2$), Calcite (CaCO$_3$) are minor phases in the sample ore. At first, calcination experiments were carried out to optimize calcination parameters. The experimental results suggested 900ºC and 60 minutes as optimizing calcination parameters; subsequently leaching tests with hydrochloric acid were performed and 90ºC, 30 min, 3 M acid concentration, solid liquid ratio of 1:6, 300 rpm agitation speed and 150 – 500 µm particle size as optimizing leaching parameters were obtained. Temperature and acid concentration showed strong effect on the calcium removal. In the optimum conditions removal of more than 95.45% of calcium content was achieved from basic mineral and the calcium content was decreased below 0.05% within the residue bauxite and made it desirable for refractory and abrasives industries.

Keywords: Bauxite, Calcination, Acid Leaching, Calcium Removal.
Effective Parameters in Digestion Efficiency of Jajarm Bauxite

R. Salami, M. Khani, S. Rezvani

Iran Alumina Complex, P.O.Box 94415-1135, Iran

Abstract

Alumina production process consists of 5 main steps as following: crushing and milling, digesting, red mud settling, precipitating and calcinating. Digestion is one of the most important steps in Alumina production using the Bayer process. Hence, in this paper the effective parameters are studied. These parameters are as follow: digesting temperatures, caustic concentration, lime, and bauxite grain size. By modifying the above mentioned parameters, we could obtain the optimized efficiency in digestion.

Keyword: digestion, bauxite, optimize, alumina.
Computational Process Simulation of Aluminum Reduction Cell for Operational Enhancement

H. H. Rad ¹, A. Seyyedi, A. H. Saghaﬁ ²

¹ M.Sc. Student, Metallurgy Department, Sharif University, Tehran, Iran
² Arad Engineering Consultant Co., Tehran, Iran

Abstract

The design and operation of an aluminum reduction cell is a complex task requiring a detailed understanding of the behavior of the cell. Process Modeling Tools are useful when designing new and retrofitting existing aluminum reduction cells. Based on mathematical simulation that describe thermal behavior and time-depending response of reduction cells, realistic prediction of cell behavior will be achieved. Heat balance of a reduction cell has a large impact on lining life and it also plays a significant role in the cost of aluminum production. It is the aim of this paper to study different process simulation of aluminum reduction cell and a program was developed to model the steady state behavior of an aluminum reduction cell. The program simulates the electrolytic process by solving the heat and mass balance equations that characterizes the behavior of different chemical species in the system in order to calculate actual energy requirements, energy efficiency, ledge profile, heat loss measurement etc.

Keywords: Aluminum Reduction Cell, Process Simulation, Mass Balance, Energy Balance.
Electrolytic recovery of gallium from alkali stripping solution from Jajarm Bayer process liquor

M. Abdollahy, H. Naderi
Mining Engineering department, Tarbiat Modarres University, Tehran, P. O. Box: 14115-111, Iran

Abstract

Electrolytic recovery of gallium from alkali stripping solution produced at purification processing of Jajarm Bayer process liquor was investigated. A 3 N NaOH solution contains 3414 ppm Ga and 1.42 ppm Al were obtained using solvent extraction method. In order to recover gallium metal from solution, electrolytic process was carried out using copper and titanium plates as cathode and anode. The effects of current density, temperature and time were studied. Optimum conditions were determined as current density 35 mA/cm$^2$, temperature 40 $^\circ$ C and time 10 hours. Under these conditions 95.26% of gallium was recovered from solution as metallic gallium. SEM analysis showed that gallium weight percent at cathode surface was 97.85%.

Keywords: Gallium, Bayer process liquor, electrolytic recovery.
Optimizing the acid dissolution of sodalite scale in alumina complex

R. Salami ¹, H. Pahlavanzadeh ², M. Khani ², S. Rezvani ², A. Yektaniya ²

¹ Department of Chemical Engineering, Islamic Azad University, South of Tehran Branch, Iran
² Iran Alumina Complex, P.O.Box 94415-1135, Iran

Abstract

Aluminum metal is produced by the electrolytic reduction of aluminum Oxide (Al₂O₃), mainly extracted from bauxite ore digested in a hot caustic soda solution. This solution is supersaturated with respect to sodium aluminate and silicate, which react together to form sodalite (3[Na₂O.Al₂O₃.2SiO₂.2H₂O].Na₂CO₃) at high temperature. Heat exchanger tubes are scaled with this compound, which seriously reduce heat transfer coefficient, thus increasing energy costs. Heat exchanger tubes are cleaned periodically with a sulfuric acid solution that contains a corrosion inhibitor. In digestion unit in alumina complex we have performed a number of tests that have become a foundation for industrial incorporation of tube digestion and have allowed selection of the most efficient mixtures of acids and inhibitors for chemical cleaning of heating surfaces. An investigation was undertaken in order to study the parameters affecting sodalite scale dissolution by H₂SO₄ and H₃PO₄: temperature, solution concentration, flow rate, etc. It was found that by increasing the temperature, the flow rate, the acid concentration, and the scale dissolution rate increase. This result was further investigated by adding organic compounds to the sulfuric acid solution. In this research we could finally obtain the optimized acid mixture for descaling with high efficiently which has the least effect on metal corrosion.

Keyword: Sodalite Scale, Chemical cleaning, Bauxite, Alumina.
Soda Recovery from Red Mud in Alumina Complex

R. Salami ¹, M. Khani ², S. Rezvani ², A. Yektaniya ²

¹ Department of Chemical Engineering, Islamic Azad University, South of Tehran Branch, Iran
² Iran Alumina Complex, P.O.Box 94415-1135, Iran

Abstract

Jajarm Alumina factory is the only producer of Alumina from Bauxite using the Bayer process. In this process, at the digestion step, existing Al2O3 in Bauxite enters the liquid phase and impurities in the form of solid enter the solid phase. Separation of the liquid phase from the solid one (Red Mud) is fulfilled in the thickeners and red mud is finally sent to the disposal. Red mud with the rate (50 ton/hour) which weighs 70% coming Bauxite is produced including (5 % of Na2O). Due to the much soda consumption and high cost, recovery of soda has become very important. In this research, for soda recovery from red mud disposal and recycling, several different tests have been done. Recovery has been fulfilled by mixing red mud and lime milk and for each test, efficiency has been calculated. Finally we could obtain the best efficiency for soda recovery. Through this research, 50% of soda loss was recycled to the Bayer cycle.

Keyword: Red mud, Soda, Recovery, Alumina.
TECHNICAL
New Concepts for Bulk Materials Plants for the Aluminium Producing Industry: From Raw Materials Receiving to Electrolysis Cells

S. Skirde
Coperion GmbH, Niederbieger Str. 9, 88250 Weingarten, Germany

Abstract

The demand for aluminium is steadily rising. Today’s new smelters are often built at remote places with ever increasing plant capacity for which an efficient bulk material handling system is of great importance for a continuous production. The various plant layouts require different solutions for an economic transport method for the raw material delivery, its in-plant conveying & storage as well as the distribution to the electrolysis cells. A very common way for the receipt of raw material delivered by Panamax sized ships such as alumina and petrol coke is with a vacuum ship unloader. The product is conveyed at high capacities with a pipe conveyor directly to a big storage silo which can hold at least one complete ship load. Further transports can be of pneumatic or mechanical nature depending on its best suitability. The electrolysis cell is the core element of the smelter where the raw material is transformed to valuable metal. The automatic and reliable feed of alumina in a dense mode is of greatest importance.

Keywords: Bulk Materials Plants, Vacuum Ship Unloader, Pipe Conveyor, Storage Silo, Pot Feeding System.
OUTOTEC Rodding Shop Solutions

M. Beilstein ¹, T. Evans ²

¹ Outotec GmbH, Albin Köbis Str. 8, D-51147 Cologne, Germany
² Outotec (Canada) Ltd., 1551 Corporate Drive, Burlington, Ontario L7L 6M3, Canada

Abstract

Outotec, with its headquarters in Espoo, Finland, is a worldwide technology leader in minerals and metals processing, providing innovative and environmentally sound solutions for a wide variety of customers in minerals processing, iron and steel, aluminium and non-ferrous metals industries. Through the former organisations of AISCO Systems Inc. of Burlington, Canada, and KHD Aluminium Technology GmbH of Cologne, Germany, both now being part of Outotec, Outotec has more than 30 years experience in the design and supply of equipment and plant for anode rodding shops. The company offers the full range of process equipment for the anode rodding shop and the ancillary shops for carbon scrap (“butt”) crushing and bath processing. The state-of-the-art equipment and systems, as supplied by Outotec for these plant areas, are described.

Keywords: Rodding shop, Anode rods, Bath cleaning, Butt stripping, Casting station.
Aluminum: Market and Development

M. Aghajanlou, M. Goudarzi
Iranian Mines and Mining Industries Development and Renovation Organization (IMIDRO)

Abstract

Possessing qualities such as superior corrosion resistance, bank of energy and most importantly being light in weight, Aluminum has been labeled as the “sustainable development metal”. In the Aluminum market competition rather than being based on innovation, is dependent on reducing the cost of production and investment. Currently 80% of the expenses of Aluminum’s global production are dependent on the price of alumina, electricity and carbon materials. The rest includes repair and spare parts, labor and other consumable raw materials. In comparison to 2007, the total primary global Aluminum production increased in 2008 by about 3.6%, to reach 38,759KT. China with the production of about 13,105KT was the leading Aluminum producing state. Russia and Canada came second and third respectively. In the recent years, the production of the metal has witnessed a swift growth, resulting in a huge increase in worldwide statistics. As the leading producer country, China’s annual production hit a 27% increase. The country’s fellow nations in the Asian continent observed an 11% growth, making Asia the world’s chief Aluminum producing area. The current paper attempts to review the history and current state of Aluminum’s production, consumption and price throughout the world. The authors will also delve into major development projects in Iran and the Persian Gulf area and the effects of the worst global financial crisis in sixty years on these projects.

Keywords: Primary Aluminum, Production, Consumption, Statistics.
Aluminium Industry: Raw Materials

P. Geramishoar¹, S. Pirmoradi²

¹ Iranian Mines and Mining Industries Development and Renovation Organization (IMIDRO)
² Nonferrous Metals Department

Abstract

In this paper bauxite and alumina market structures are going to be discussed. Statistics of production, consumption and prices is analyzed to make it possible to predict the direction of the market in medium and long term. Also the main bauxite/refining projects are brought here in order to show most of the ore planned would be consumed by predetermined refineries plus there's going to be mega alumina capacity increases so the Bauxite subject would be a tough one.

Keywords: Bauxite, Alumina, Production, Consumption, Trend.
MISCELLANEOUS
Trends of aluminum applications in the Iran automotive industry

M. Zarghami, H. Rahmani, J. Rahimi
Materials Research Center of SAPCO

Abstract

Recently there have been developments in application of aluminum in the automotive industry. Aluminum has now exceeded iron to become the second most used automotive material worldwide. Aluminum alloy parts weigh 1/3 the weight of steel parts. Use of this high tech, high strength, low weight metal is increasing rapidly because it offers consumers safety, environmental and driving performance at a cost-effective value. This growth is observed in applications across all vehicle segments in engines, transmissions, wheels, brakes, body closures, instrument panels etc. Compared to heavier steel, aluminum can provide better stability and response, and reduced noise /vibration /harshness (NVH) due to reduced vehicle weight combined with high structural stiffness – this also leads to improved stability and turning response. This paper reviews the detailed developments in aluminum applications in global automotive industry. Moreover the trend of aluminum application in the vehicles produced in Iran khodro will be presented and analyzed.
Synthesis of Elevated-Temperature Iron Aluminide Intermetallic Powders by Novel Hot Ball Milling Method

M. Fourjanizadeh, M. Panjepur, M. Meratian
Materials science, Isfahan University of technology, Isfahan, P.O. Box: 84154, Iran

Abstract

The synthesis of elevated-temperature iron aluminide intermetallic powders was carried out using a novel hot milling technique. In comparison to the conventional mechanical milling, the direct formation of submicron-sized elevated-temperature intermetallic powders such as Fe$_2$Al$_5$, FeAl, and Fe$_3$Al, at relatively low temperatures and less time can be obtainable. A stoichiometric portion of Fe and Al powders were mixed and milled at 700°C for different times. The final FeAl alloy powders with the submicron size were produced.

Keywords: Iron Aluminide, Intermetallic, Solid-Liquid Reaction, Hot Ball Milling.
Activation of Alumina Industrial Waste for Environmental Proposes

K. Badii ¹, F. Doulati Ardejani ², S. Norouzi ²

¹ Department of Environmental Researches, Institute for Colorants, Paints and Coatings, Tehran, Iran.
² Faculty of Mining and Geophysics, Shahrood University of Technology; Shahrood, Iran.

Abstract

Alumina waste is a by product of aluminium reduction industry. There is a large pond of this by product near aluminium industrial sites and there is little known application for it. In this research, it was found that this material could have been used as a pollutant adsorbent after activation process. It has been shown that the application of heat in acidic environment can change the structure and material percentage of alumina industrial waste and increase its adsorbent capacity. The comparison of SEM, XRD and BET tests of raw and activated waste material has shown this big difference that has been caused by activation process. This activated waste material can remove colorants and heavy metals from industrial and mining waste waters.

Keywords: Alumina industrial waste, Waste water treatment, Adsorbent, Activation, Acid washing
Kinetics of TiAl₃ Formation in Molten Aluminum-Solid Titanium Interface

R. Khoshhal, M. Mirjalili, M. Soltanieh
Iran University of Science and Technology, Department of Materials and Metallurgical Engineering

Abstract

In this work, the kinetics of intermetallic compounds formation in Ti/Al system was studied by immersing titanium plates in molten aluminum at 750 °C, 850 °C and 950 °C. According to Scanning Electron Microscopy and X-Ray Diffraction Analysis results TiAl₃ is the only phase which forms in different temperatures. At 750 °C, thickness of TiAl₃ layer increases slowly to 20 µm. After 3 hours, TiAl₃ thickness quickly increases to about 500 µm. Presumably reaction starts with solving titanium in molten aluminum and then TiAl₃ layer forms. Different molar volume of Ti and TiAl₃ causes in tensile stresses in the Ti-TiAl₃ interface which leads to TiAl₃ layer disruption. This disrupted layer causes molten aluminum to be in contact again with titanium surface and therefore TiAl₃ thickness starts to increase significantly. Also activation energy of intermetallic layer formation and growth was calculated by measuring Ti thickness decrease by time. Calculated activation energy is 110.8 KJ/mol which roughly equals to sum of activation energies of TiAl₃ formation and aluminum diffusion through the TiAl₃ layer.

Keywords: titanium aluminide, TiAl₃, combustion synthesis, SHS, kinetics.
Numerical simulation of combustion synthesis of Ni-Al intermetallic compounds: the effect of porosity

M. Shekari, S. H. Seyedein, M. R. Aboutalebi, M. Adeli
School of Materials & Metallurgical Eng., Iran University of Science and Technology, Narmak, 16846-13114 Tehran, Iran

Abstract

Combustion synthesis is a special thermophysio-chemical process of producing intermetallic compounds. In this research a reaction–diffusion numerical model of nickel-aluminides combustion synthesis by self-propagating high temperature synthesis process was developed. By comparison with experimental data and evaluation of model reliability, the developed model was used to analyze temperature profile. Also the effect of compact density (porosity) on combustion temperature and wave propagation velocity has been studied.

Keywords: Combustion Synthesis (CS), Ni-Al Intermetallic Compounds, Modelling, Porosity.
A novel method for manufacturing aluminum foam sandwich panels

A. Nabavi, J. Vahdati Khaki

Department of Materials Science and Engineering, Engineering Faculty, Ferdowsi University, Mashhad, Iran

Abstract

In recent years the attentions are focused on using light weight constructions. Metallic sandwich panels are constructions with high strength to weight ratio that can be used in a wide range of industries. In this research a novel method for manufacturing aluminum foam sandwich panels via self-propagating high temperature synthesis was introduced. In this method aluminum and NaCl powders are mixed with specified weight ratio. Then the mixed powder was pressed and formed in a mold. A mixed powder of aluminum and copper oxide with stoichiometric ratio was covered over both surfaces of preformed shape. The covered perform was placed between two aluminum sheets and heated under static pressure. During heating SHS reaction (3CuO + 2Al = Al₂O₃ + 3Cu, ∆H<0) occurs in the interface of sheet and the perform core. The resulting heat of this exothermic reaction causes to join the sheets to the core by melting the interface and nearby. In order to evaluate the shear strength of the interface, the shear test was applied to sandwich panels and the results were compared with sandwich panels produced with other methods. Furthermore by the aid of EDS and XRD analyses, the formation of copper in the core/sheet interface and its diffusion into the sheets and the core were observed. These observations approve the occurrence of reduction reaction of copper oxide with aluminum in the interface. The results show that metallic sandwich panels produced by using SHS method have high joint strength than those which has produced by diffusion and adhesive bonding process and the maximum shear strength of the interface is reached in shorter heating time. Therefore, this innovating method for production of metallic sandwich panels can be applied as a proper and alternative method.

Keywords: sandwich panels, self-propagating high temperature synthesis, diffusion bonding, aluminum foam.
The study of environmental effects of aluminum factory activities on physiological and biochemical parameters of five plant species growing in Arak city.

M. Mashhadi Akbar Boojar ¹, E. Pajooheshfard ²

1 Department of Biology, University of Tarbiat Moalem, No: 49. Dr. Mofateh Avenue, Tehran, P.O.Box: 15614, Iran.
2 Faculty of agriculture, center of research complex, Azad University. Tehran. Iran

Abstract

In this study we evaluated the environmental effects of aluminum on growth parameters, physiological and biochemical factors in 5 plant species including; Velvet Ash, Elm, Fles, Poplar and White Mulberry. The samples of soils, leaves and stems were collected from eastern part of aluminum factory in vicinity of Arak city (B) and from Amir Kabir Park located in this city (A). The level of aluminum was considerably high and contents of Chlorophylls (a and b), dry weight, nitrogen percent, total protein and relative water capacity decreased in samples of (B) site with respect to (A) site. On the other hand, membrane resistance of leaves was higher in (B) site with respect to (A) site. Activity of CO₂ assimilation also showed decrease in samples of (B) site as compared with (A) site, however, the levels of Proline and Abscesic acid as anti-tension parameters in plants raised considerably in samples of (B) site as compared with (A) site. Accordingly, we conclude that plants exposure to aluminum caused metal tension on plants growing in vicinity of aluminum factory, leading to decrease in their growth, photosynthesis and defense parameters. The development of aluminum accumulator plants in contaminated zones is highly recommended.

Keywords: aluminum, Arak, accumulation, CO₂ assimilation, resistance.
Formation of intermetallic compounds in early stage of immersion of solid iron in liquid aluminium

A. Shahbazi, H. R. Shahverdi

Materials Science Department, Tarbiat Modares University, Tehran, P.O.Box: 14115-333, Iran

Abstract

In this article the interaction between solid iron and liquid aluminium by immersion of solid iron in liquid aluminium in 700, 750, 800 and 850 °C was studied. For this purpose, high purity iron wires and aluminium were used. The results of metallographic images of cross section of wires using optical microscope were used to obtain time dependent diagrams. The results show that with increase in temperature of liquid aluminium, intermetallic compound forms at shorter times. Also, increasing the immersion time causes to increase in the amount of intermetallic compound. Intermetallic phases that formed in this research were Fe$_2$Al$_5$ and FeAl$_3$, and the volume fraction of Fe$_2$Al$_5$ phase was more and formed earlier.

Keywords: Solid iron, Liquid aluminium, Nucleation.
Design Improvement of Automotive Front Bumper Beam Behavior, made of Steel & Aluminum Subjected to Low-Velocity Impacts

M. Alijanpour¹, M. Aghamirzaie ¹, S. M. Razavi ², S. H. Masoud ²

¹ CAE Engineer, Department of R&D Center, Iran Khodro Company, Tehran, Iran
² Design Engineer, Department of R&D Center, Iran Khodro Company, Tehran, Iran

Abstract

In this paper, a commercial front bumper beam of an automotive is studied and analyzed with using finite element method, when impacts with a barrier in low-velocity. A good design of this part of automotives must prepare safety of passengers and pedestrians meanwhile should have low weight. Beside the roles of safety, fuel efficiency and emission gas regulations are being more important in recent years that encourage manufacturer to reduce the weight of passenger cars by using the aluminum instead of steel. The effects of material type, thickness and impact condition are studied here using explicit dynamic FEM according to the E.C.E. (1994) standard. Here, those different mentioned factors are investigated and the results are compared to find the better characteristics. The front bumper beam of a sedan car subjected to low velocity impact are modeled and analyzed in FEM software to determine the deflection, impact force and energy absorption behavior. Time history of the calculated parameters is showed for comparison. The results show the high strength aluminums have better impact properties against steels.

Keywords: Bumper beam, Passenger car, Low velocity Impact, Passenger
A new and rapid Conductometric Determination of Aluminium Using Hydrochloric Acid Solution as Titrant

R. Hazrati, S. Rostami

Lab. Of production of alumina from nepheline syenite pilot plant, Azarshahr, East Azarbayjan, Iran. Tel: 0412-4226305

Abstract

A simple and sensitive conductometric method for the determination of Aluminium ion with hydrochloric acid solution is described. The recovery and standard deviation are determined. The shape of titration curve is studied. The proposed method shows good agreement with the conventional EDTA titration using Xylenol orange indicator and gravimetric determination of aluminium content. The advantage over the conventional methods is discussed.

Keywords: Aluminium, Conductometric, Titration, Hydrochloric acid, Determination.
Aluminium Determination in Food by Using Spectrophotometric Alizarin Red S and AES methods

S. Rostami, R. Hazrati

Lab. Of production of alumina from nepheline syenite pilot plant, Azarshahr, East Azarbayjan, Iran. Tel: 0412-4226305

Abstract

Results of aluminium determination obtained by employment of N\textsubscript{2}O-C\textsubscript{2}H\textsubscript{2} flame AES method and spectrophotometric Alizarin Red S (SA) method in various foods were compared. The sample were digested for few hours in Teflon beakers using a mixture of concentrated acids (H\textsubscript{2}SO\textsubscript{4}+HNO\textsubscript{3}+HClO\textsubscript{4}), and then transported for final destruction into platinum dishes and burned. The obtained stock sample solutions were used for examination by both methods. Food products containing higher levels of aluminium can be determined directly by employment of AES method using 1-2g of samples for decomposition, while foods containing low levels of aluminium need use of larger samples for decomposition (i.e. 5-20g) and the obtained ash should be dissolved as low as possible of final volume of stock sample solution. Limits of detection, sensitivity and validity of beer’s low and precision study for each of both methods were studied.

Keywords: Aluminium, Alizarin Red S, Food, EAS method, Determination,
Elemental Combustion Synthesis of Titanium Aluminides,
Pre-Combustion Reactions Effect

R. Khoshhal, M. Mirjalili, M. Soltanieh

Iran University of Science and Technology, Department of Materials and Metallurgical Engineering

Abstract

In this work, reactions between titanium and aluminum powders were studied at temperatures lower than aluminum melting point. Different Ti/Al ratio as the precursor powders were prepared for combustion synthesis at 620 °C for different times. For this purpose titanium and aluminum powders by 1:3, 1:1 and 3:1 molar ratio were pressed to form cylindrical tablets with 1 mm diameter. Two samples of each ratio put into a controlled-atmosphere furnace for 10 minutes and 15 hours. For exact determination of pre-combustion reactions temperature, powder mixtures were DTA analyzed. According to Scanning Electron Microscopy and X-ray Diffraction Analysis the first phase forms in the Al-Ti interface is TiAl₃ for all of powder mixtures. However, with the complete consumption of Al, Ti₃Al is the second intermetallic phase forms in the TiAl₃-Ti interface. Also type and amount of intermetallic compounds were considered by the time. Finally, effect of pre-combustion reactions on the high-temperature combustion synthesis products was studied. Results indicated that pre-combustion products have no negative effect on amount and type of final intermetallic compounds.

Keywords: titanium aluminide, combustion synthesis, SHS, TiAl₃.