MONDAY, AUGUST 25, 2003, A.M.

POSTER SESSION

Room: Pavilion Ballroom
Chairman: Rizhi Wang

POSTER 1

KINETICS AND MECHANISM OF LEAD OXIDATION.

D. VINEBERG, K. WING NG and R. HARRIS, Department of Mining, Metals and Materials Engineering, McGill University, Montréal, Québec, Canada

A reliable method to study the interfacial behaviour during lead softening and the kinetics of oxidation has been developed to facilitate the improvement of commercial operations that have been found to be unreliable and unpredictable in their performance and behaviour. Pb samples containing Sb, As and/or Sn weighing 6.25 g were heated to 500-650 °C in high-alumina crucibles that were suspended in a homemade thermogravimetric furnace in an argon atmosphere. Once at temperature, the samples were skimmed and the melt exposed to pure oxygen at a volumetric flow rate of 100 mL/min for a period of 60 minutes. Experimental trials were simultaneously filmed to allow for visual evaluation of the oxidation processes. Large differences in the observed behaviour and rate of mass gain during oxidation were observed with varying amounts of As, Sb and/or Sb. XRD and EDX analyses of the products of oxidation found a range of complex oxides whose morphology, crystal structure and growth pattern appeared to play a significant role in controlling the rate of oxygen mass transport to the gas/liquid interface.

Results for studies of the effects of: (i) wt % As, (ii) wt % Sb, (iii) wt % Sn, and (iv) temperature are presented.

POSTER 2

INHIBITION OF 316L STAINLESS STEEL CORROSION IN ALKALINE HYDROGEN PEROXIDE BLEACHING ENVIRONMENTS.

O. TANANE, A. IRHZo, Department of chemistery, Hassan II Unniversity, Casablanca, Morocco

The corrosion of 316L stainless steel in alkaline hydrogen peroxide environments has been studied by a combination of experiments utilizing weight loss measurements, potentiodynamic current-potential curves, and electrochemical impedance spectroscopy (EIS). Tri-amino-propanol and calcium were investigated as corrosion inhibitors. The effectiveness of calcium over extended time periods was found to be questionable. Tri-amino-propanol behaved as a more stable corrosion inhibitor than calcium. Raising the Tri-amino-propanol concentration decreased the corrosion rate.

POSTER 3

SCALING OF DSA ANODES IN COBALT ELECTROWINNING FROM CHLORIDE SOLUTIONS

T. ÅKRE, G.M. HAARBERG, J. THONSTAD, Department of Materials Technology, Norwegian University of Science and Technology,Trondheim, Norway
O.M. DOTTERUD, Technology Department, Falconbridge Nikkelverk A/S, Kristiansand S, Norway

Cobalt metal is produced electrolytically from an all-chloride electrolyte at Falconbridge Nikkelverk A/S, Kristiansand, Norway. The principal anode reaction is chlorine gas evolution, which takes place on DSA-type anodes consisting of a titanium substrate coated with an active layer of noble metal oxides. In the cobalt tankhouse some trivalent cobalt oxides are precipitated on the anodes. The formation of this unwanted scale, which has to be removed regularly, was examined in the laboratory by electrochemical techniques and SEM. The effect of key parameters was evaluated. The extent of scaling was found to be strongly dependent on electrolyte pH.

POSTER 4

NUMERICAL MODELING OF THE SMELTING PROCESS IN THE REVERBERATORY FURNACE

S.M. HOSSEINI SARVARI, S.H. MANSOURI, Department of Mechanical Engineering, Shahid Bahonar University of Kerman, Kerman, Iran
E. NIKNEJAD, Department of Pyrometallurgical Dept., R&D Center, National Iranian Copper Industries, Sarcheshmeh Copper Complex, Rafsanjan, Kerman , Iran

The smelting process in the reverberatory furnace is simulated numerically. The radiative heat transfer in the gas zone and the transient conductive heat transfer in the solid zone of the sidewall banks are solved by the discrete transfer and the finite element methods, respectively. The phase change problem through the moving surface between gas and solid zones is considered to be an ablation phenomenon. Since the domain of interest is changed by time, the spatial mesh is modified at each time step. The performance of the present technique is investigated by some numerical experiments.

POSTER 5

DIOXIN RESEARCH IN PYROMETALLURGICAL PROCESSES

BUEKENS, Department of Chemical Engineering, VUB, Brussels, Belgium

The authors have studied numerous pyrometallurgical processes with the aim of defining their tendency to form dioxins and related chlorinated aromatics. Factors of influence have been identified using both the analysis, chemometric study, and simulation of full plant data and dedicated laboratory research. Tests were developed especially for this purpose of simulating the reactions of dioxin formation at small scale.

Case studies will be selected from ongoing studies. A first possibility is the manganese ore fines sintering, but several other ongoing studies are of interest and can be related.

POSTER 6

ARE COOPERATIVE RESEARCH CENTRES THE WAY OF THE FUTURE FOR THE MINERALS INDUSTRY?

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The Parker Centre was established in 1992 under the Australian Government's Cooperative Research Centre program to encourage collaboration between hydrometallurgy researchers and industry. With 85 staff and 45 postgraduate students, it is now regarded as an excellent example of how a CRC should operate. This Paper outlines the key initiatives taken to address the challenges of developing a joint venture between industry, universities, state-funded research organisations and government. The changing nature of the international minerals industry, the consequent changes in companies' relationships with research providers and the ever-more demanding government expectations of taxpayer-funded research organisations are examined to develop a hypothesis for the future direction of minerals industry research. Attracting undergraduates into minerals industry-related courses and postgraduate students is an important aspect of the Centre's Education Program when such enrolments are falling internationally.

POSTER 7

METALLURGICAL OPTIMIZATION OF SELENIUM PRODUCTION AT THE PRECIOUS METALS PLANT OF MEXICANA DE COBRE

O. RODRÍGUEZ-HOYOS, A. ROBLES-VEGA, Complejo Metalúrgico La Caridad, Mexicana de Cobre, S.A. de C.V.

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Selenium production at the Precious Metals Plant (PMP) of Mexicana de Cobre began in 1999. This process involves the volatilization of selenium as SeO_2 during the conversion and refining of molten decopperized anodic slimes, absorption of selenium in water and finally elemental selenium precipitation using $SO_2(g)$ injection. During the initial operation of the PMP, a 94.9% selenium product was obtained, making difficult its commercialization in the international market.

As a result of this work, various changes in the operation routines were recommended. Modifications were performed in the following operations: filtering of the solution containing the captured selenium, pregnant solution purification, selenium precipitation, and product washing. Finally, a product containing at least 99.5 % Se is now obtained.

POSTER 8

STUDIES ON FROTH ZONE RECOVERY IN COLUMN FLOTATION

J. TORTORELLI, DEPARTMENT OF MATERIALS SCIENCE & ENGINEERING, UNIVERSITY OF TORONTO

The froth zone is of paramount importance to the operation of a flotation column. However, froth zone recovery can be quite low, in many cases less than 50%. This investigation aims to provide a better understanding froth zone dynamics by employing a modified flotation column to directly measure froth zone particle detachment and drop-back. The commonly identified problem in the plant of low coarse particle recovery is addressed. As well, the function that finer particles may play in stabilizing or destabilizing the froth is examined at great depth. Operational variables considered include wash water rate, frother dosage, solids flux, collector dosage, conditioning method, bubble velocity and fine particle shape, size and hydrophobicity. It was confirmed that the poor coarse particle column recovery is a result of significant detachment and drop-back of these particles within the froth. The main cause of this was froth instability in the middle and upper regions of the froth. It was found that the presence of non-hydrophobic solids with a wide particle size distribution in the 5-45 ìm range help stabilize the froth and promote a higher froth zone recovery of coarse particles. It is concluded that the results indicate these interstitial solids act to deter bubble coalescence by hindering drainage and increasing viscosity in the Plateau borders. Other key findings include wash water bias in the froth is an important parameter, drop-back at the pulp-froth interface is not significant, and independent conditioning of coarse size fractions is favorable due to the increased susceptibility of larger particles to insufficient collector adsorption.

POSTER 9

ORGANIC EXTRACTION OF MOLYBDENUM (VI) AND COBALT (II) FROM ELECTRODEPOSITION EFFLUENTS

C. KARGL-SIMARD, R. WU and A. M. ALFANTAZI, Department of Metals and Materials Engineering, University of British Columbia, Vancouver, B.C., Canada

Cobalt-molybdenum bearing effluents which are being generated from electrodeposition of nanocrystalline cobalt alloy coatings present an environmental challenge, but fortunately comprise great recovery potential. Experiments were carried out in solutions containing 12.5 g/L Mo (VI) in the form of sodium molybdate, and 12.5 g/L Co (II) in the form of 10 g/L cobalt sulfate and 2.5 g/L cobalt chloride. Different organic extractants including Cyanex 923, Aliquat 336 and Hostarex A327 were used and diluted in kerosene. Based on the results obtained, Mo (VI) was preferentially extracted over Co (II) for all the organic extractants between pH 2 to 4. The percentage of extraction increased with decreasing pH over the acidic range. Aliquat 336 and Hostarex A327 maintained 99% Mo (VI) extraction between pH 2 to 5. Loading curves were constructed for all organic extractants at pH 2 and 3 between an A/O ratio of 0.5 to 16. At pH 2, the Mo (VI) loading capacity was 39 g/L for Hostarex A327, 30 g/L for Cyanex 923 and 26 g/L for Aliquat. Co (II) loading was very low at any A/O ratio; all organic solvents had Co (II) loading below 10 g/L. Aliquat 336 was found to be the most selective organic extractant for Mo (VI) loading over Co (II).

POSTER 10

EXTRACTION OF ALUMINA FROM CLAY

V. OUELLET, C. BAZIN, K. EL OUASSITI, Metallurgical, mining and materials engineering department, Laval University, Pavilon Pouliot, Cité universitaire, Sainte-Foy (Québec)

The Quebec province in Canada is a major producer of aluminum through electrolysis of alumina. The alumina that feeds the electrolysis cells is mainly imported from foreign countries, where it is extracted from bauxite. Other alumina sources, such as clays may be used as potential substitutes for bauxite.

An hydrometallurgical extraction process has been developed to extract alumina from a large clay deposit in the area of Murdochville in Quebec. The process includes:

Pretreatment of clay (crushing, calcination)

Acidic leaching of clay

Production and purification of aluminum chloride by HCl gas injection to leachates

Pyrohydrolysis of aluminum chloride to produce electrolytic grade alumina

This process is costly and the clay found in the Murdochville area has a high iron content. High cost operations such as calcination of the clay have to be eliminated to reduce the overall cost. However, bypassing the calcination step will lowered the amount of aluminum in leachates.

Iron and impurities are currently eliminated at the aluminum chloride production step but a significant effort was made to reject it at the acidic leaching step. Purification eliminate the impurities before the pyrohydrolysis step in order to produce the electrolytic grade alumina.

In the pyrohydrolysis step, time and temperature have to be controlled to give to the alumina good physical properties and to eliminate associated water.

Various options have been made and are currently studied to reduce the capital and operating costs of the process and to eliminate or reduce the need for the iron removal in the purification step of the process. Some of the results obtained so far and the work currently in progress are discussed in this poster.

POSTER 11

CHARACTERIZING ZINC STOCKS AND FLOWS: MATERIAL FLOW ANALYSIS AT REGIONAL AND GLOBAL LEVELS

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Material Flow Analysis (MFA) is a useful tool for examining the interactions between the natural environment and the technosphere. At the global and continental level MFA can provide an indication of intensity of usage trends and a gross snapshot of how materials are used and where they tend to reside. Data available at the country level can be used to model material flows across the life cycle, and thus provide rough indicators of usage and recycle patterns, which can then be used for guiding national policy on materials management. Country level flows can be aggregated into continental and global cycles, the results of which can show trends in resource management and economics. At the micro scale material flows are directly useful for assessing environmental risks and impacts.

This poster examines the zinc technological cycle at country, continental, and global levels. A comprehensive contemporary cycle for stocks and flows of zinc is characterized and presented, incorporating information on extraction, processing, fabrication, use, discard, recycling, and dissipation. The analysis is performed on an annual basis, ca. 1994, at three discrete governmental unit levels –countries or country groups that comprise essentially all anthropogenic zinc stocks and flows, nine world regions, and the planet as a whole. We also examine metrics on the per-capita level within different countries for the defined continents. Inter and intra-continental scale comparisons reveal global and local disparities in material usage, they also provide a gross indication of in-use materials stocks available for future use, which is important for guiding waste management decisions. The regional material stock and flow (STAF) model was developed at Yale University as part of the stocks and Flows project, whose objective is to track the pathway of important metals utilized in the 20th century. The model applies MFA.

The collection of multi-level cycles shows that most primary zinc is mined, then exported as concentrate from North and South America, Oceania, and central and Southeast Asia. Europe and Japan import the majority of the metal as concentrate, then smelt and refine it domestically for their fabrication and manufacturing industries. While zinc's residence time can be high for many of its applications in the building and construction sector, since the majority of it is used as an anti-corrosion coating, there are dissipative losses occurring during the lifetime of products and infrastructure containing zinc. This study and others suggest that zinc losses from use over the last century are significant in magnitude and should be thus examined historically.

POSTER 12

ATTRITION SCRUBBING YIELDS BENEFITS IN FLOTATION PROCESSES

M.J. PRESTON, D.A. ADAMS, M.A. GIRALICO, LIGHTNIN

Minerals recovery is dependent on accurate and as complete as possible separation of the mineral specie from waste ores that become tailings. A primary method of recovery involves the Flotation process where ore slurry is treated with chemical reagents and aerated to separate the desired minerals in a froth overflow.

Assuming all chemical and mechanical aspects of the process are optimized, success of this process also depends on surface characteristics of the ore. Chemical reagents that preferentially select specific minerals depend heavily on the mineral surface being exposed to and contacted by the reagents prior to frothing and separation.

Many industrial and precious minerals experience oxidation or scaling while in a slurry environment. Vigorous contacting (scrubbing) prior to addition of flotation reagents has been used to "wash" the mineral surface free of impurities, scale and oxides to allow the reagent to more effectively select the proper specie for froth flotation.

Effective "washing" action is characterized by high shear gradients and particle collisions that physically scrub the surface and expose more mineral surface for recovery. By utilizing significant mixing knowledge and experience, LIGHTNIN has modified key components inside the equipment to increase the amount of shear within a given volume and installed power. Pilot testing and full scale installations have proven the enhancements as successful. Recovery, economics and ROI will be shown in addition to equipment schematic.

POSTER 13

HYDROGEN INHIBITOR APPLICATIONS IN FUEL CELLS AND BASE METAL ELECTROWINNING

B.W. DOWNING, MagPower Systems Inc., Delta, BC
E. GYENGE, J. LU, and D.B. DREISINGER,University of British Columbia, Vancouver, B.C.
J. JUNG,BC Research Inc. , Vancouver, B.C.

MagPower has developed methods to control the detrimental formation of hydrogen that occurs in electrochemical reactions in numerous commercial applications such as the Magnesium-Air Fuel Cell, electrowinning, zinc alkaline batteries, hydrogen embrittlement, waste water/ metal recycling and coolants. The company's approach to an alternative energy source is the development of an environmentally friendly non-toxic alternative power source that generates electricity through a combination of magnesium, oxygen and a saltwater electrolyte with *MagPower's* patent pending hydrogen inhibitors. The magnesium-air technology has never reached the commercial stage due to its limiting power output caused by hydrogen generation. *MagPower* has solved this problem and has patents pending on its intellectual property; the Hydrogen Inhibitors and has developed several consumer power units for a variety of applications through licensing agreements. The company has also shown that the inhibitors have an impact on zinc electrowinning through laboratory test work where current efficiency was improved. This will significantly reduce power consumption and increase the efficiency of the electrowinning process, as well as reduce the potential acid mist hazards associated with electrowinning.

POSTER 14

APPLICATION OF SOLID-PHASE CHLORINATION FOR PARTING THE CONCENTRATES OF NOBLE METALS FROM IMPURITIES

V.P. GORBATENKO, InfoGrupp, Russia, Minsk's rep. office, Minsk, Republic of Belarus

The paper identifies a possibility of parting a multicomponent concentrate of platinum metals from Sn, Sb, Se, and Te and As impurities by the solid-phase chlorination method.

With the purpose of forecasting the variants of processing the raw stuff a thermodynamic analysis of the Au—Ag—Pt—Pd—Sn—Sb—Se—Te—As—Cu—S—Cl—O system has been carried out. Calculations were performed with the help of *ASTRA.3/pc*, version 2/24*,* a multi-purpose software complex for simulating chemical and phase transformations developed by the team of Moscow State Technical University named after N.E.Bauman.

The analysis of thermodynamical calculations has revealed a possibility of a low-temperature chlorination of the concentrate that can ensure an efficient parting of the raw staff from impurities.

The optimal calculated parameters of the process have been tested at the laboratory batch plant.

The indices of the concentrate chlorination have confirmed the results of the thermodynamic calculations and the efficiency of parting the raw stuff from Sn, Sb,Se,Te and As impurities.

POSTER 15

RECOVERY OF NICKEL IN THE ELECTROLESS NICKEL PLATING BATHS

MIKIYA TANAKA, National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki, Japan,

With increasing importance of the electroless nickel plating technology in many fields such as electronic and automobile industries, the treatment of the spent baths is becoming a serious problem. The spent baths are currently treated by the conventional precipitation method, and nickel in these baths is not recycled. Therefore, a method to recycle nickel without sludge generation should be developed. This presentation outlines our attempt to establish a recycle process of nickel in the spent baths from electroless nickel plating plants using solvent extraction. Nickel in the actual spent baths is efficiently extracted by a hydroxyoxime extractant such as LIX84I at a pH greater than 6 and is readily stripped with sulfuric acid. The application of acidic organophosphorus extractants to selectively remove impurity metal ions (iron and zinc) from actual spent baths before extracting nickel leads to the finding that PC88A and Cyanex272 effectively remove iron and zinc without pH adjustment leaving nickel in the raffinate. Based on these results, a flowsheet for the recycling nickel from the spent baths has been proposed.

POSTER 16

NOVEL METHODOLOGY FOR SEPARATION AND PURIFICATION OF PLATINUM GROUP METALS (PGMS).

W. PAL SINGH and H. LEE, Lynntech Inc., College Station, TX, U.S.A.

Over the past several years the PGM market has been showing a continues imbalance between the supply of PGMs vs market needs, where supplies have always fallen short of the demand. This has resulted in constant increase of price for PGMs. Availability of an efficient and cost effective method for recycling PGMs will help shorten this gap and will reduce constant pressure on the price of PGMs. A number of very complex separation methods are currently utilized in the production of PGMs and these add additional costs to the purified metals. Thus, more efficient and cost-effective materials and processes are in need, especially for PGMs recycling market. Lynntech has been focusing on designing a series of extremely efficient metal extraction products (MEPs) with tailor-made properties for specifically extracting and purifying platinum group metal (PGM) anions from acid solutions. Lynntech's novel MEPs extract PGMs with high efficiency as well as selectivity, outperforming well-known commercial products. In addition, Lynntech's MEPs can be reused through multiple cycles of extraction without significant loss of efficiency. Several different back-extraction methods have been evaluated to strip extracted PGMs from MEP solutions. The stripped PGMs can be recovered as zero-valent PGMs by conventional electrochemical methods. Conclusively Lynntech's unique process can convert low value PGMs in acidic waste stream to priceless PGMs economically and efficiently. The research will expand the scope of the work to launch the technology into PGM recycling market at the end of the study.

POSTER 17

MAGNETIC GOLD – LOSSES FROM THE MUSSELWHITE ELUTION-ELECTROWINNING CIRCUIT

S.,AREDES, H.,GHAFFARI, F. MELO, B.KLEIN, University of British Columbia, Mining Engineering

A study was conducted to characterize gold losses from the elution / electrowinning circuit at Placer Dome's Musselwhite Mine. The plant metallurgist identified the loss by inserting a magnet into the fines settling tank overflow stream and assaying the magnetic fraction which graded up to 7000 g/t Au.

Solid and solution samples collected from the circuit were analyzed chemically and using SEM + EDX. Three main forms of gold were identified:

Gold cemented to iron oxide and iron silicate grains

Colloidal gold adsorbed to the oxidation rim of iron sulfides

Dendritic free gold

The circuit conditions were reviewed to speculate the where these forms of gold were created. The poster presents the results of the study and makes recommendations to reduce these gold losses.

POSTER 18

Condition Of Al 6061 Substrate As A Quality Factor In Manufacturing Of Highly Reflective Optical Mirror

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Silver-based reflective coatings are appealing in optical systems because of their inherently high reflectance over a wide spectral range. Coating quality has been observed to be greatly related to the quality of diamond turned aluminum substrate which is characterized by its conditions (microstructure, inclusions, heat treatment) of the aluminum 6061 alloy prior to machining. Aluminum 6061 with different impurity levels has been analyzed. We found that different impurity levels (Fe, Mn, Cu, Ni, Cr, Mg) caused inclusions (FeSiAl5,

(Fe,Mn)xSiyAlz, CuAl2, Mg2Al) of both different geometry (needle-shaped, Chinese hieroglyphic, rounded) and hardness to form, affecting the quality of the diamond turned substrate responsible as a result for the lifetime of the reflective coatings.

POSTER 19

Investigation On Non-Metallic Oxide Inclusions In Different Steps Of Steelmaking

M. SOLTANIEH, Y. PAYANDEH, Department of Materials and Metallurgical Engineering, Iran University of Science & Technology, Narmak, Tehran, Iran

In all of the steelmaking processes, oxygen is used to remove impurities, therefore, in the end of steelmaking process, molten steel contains around 1500 ppm of dissolved oxygen. In the next step to reduce the dissolved oxygen content of steel, usually deoxidizers are used. Some of the product of deoxidizing process remain in the molten steel that are the origin of native inclusions. Native and foreign inclusions have a deep effect on the quality of steel.

In this research the trend of the formation of oxide inclusions in different steps of the production of the carbon steel in the Mobarakeh steel company were investigated. Several samples of arc furnace, ladle furnace, tundish, continuous casting mould were taken. After solidification a number of samples of slab and hot rolled sheet were prepared. Samples were investigated by the optical microscope and by the scanning electron microscope. It was found that the number and chemical composition of the inclusions were totally depending to the steel production conditions and the inclusions were different from each other.

POSTER 20

Thermo-Chemical Modeling Of The Smelting Processes In The Reverberatory Furnace

S. H. MANSOURI, A. ALIZADEH, H. NAMAVARI, Department of Mechanical, Sarcheshmeh Copper Complex of Iran, Kerman, Iran

In this paper, a thermo-chemical model has been developed to optimize the performance of a reverberatory furnace, in which, all parameters and compounds that affect the processes have been taken into account. The results of this model can be used to obtain technical and economical characteristics for sizing and rating of an energy efficient furnace. A sample calculation has been carried out for Sarcheshmeh Copper Complex Reverberatory furnace. Parametric studies have been carried out to investigate the effects of (1) the excess air, (2) the type of charge, (3) the furnace temperature, and (4) the excess Oxygen on the matte, the slag and gases outflow compositions. This study is of great importance in predicting the optimum operational condition and the maximum yields of products.

POSTER 21

HIGH TEMPERATURE WEAR CHARACTERISTICS OF A NEW HOT WORK DIE STEEL CH95

X.-H. CHENG, C.-H. WANG, C.-Y. XIE, School of Mechanical Engineering, Shanghai Jiao Tong University, Shanghai, China

High temperature wear characteristics of a new hot work die steel CH95 doped with a small amount of rare earth and boron have been investigated and compared with that of conventional steel H11 at series temperatures and loads. Worn surfaces of CH95 steel and H11 steel were analyzed with a scanning electron microscope. It is found that high temperature mechanical properties of CH95 steel are much better than that of H11 steel. The oxide layer formed on the worn surface plays an important role in wear resistance at high temperature. When the load is less than 63 N, the surface oxide layer keeps integrate and the effect of load on high temperature wear is very little. When the load is higher than 63 N, supporting ability of matrix to the oxide layer decreases, which results in the increase of wear rate. Wear resistance of CH95 steel is much better than that of H11 steel and its worn surface is smoother. It is easier for CH95 steel to form a compact and integrate surface oxide layer at high temperature, which protects the worn surface and reduces the wear.

POSTER 22

OBSERVATION OF TWINNED MARTENSITE IN THE WELD HEAT-AFFECTED ZONE OF GRADE 100 LOW CARBON MICROALLOYED STEEL

K. POORHAYDARI, B.M. PATCHETT and D.G. IVEY, Dept. of Chemical and Materials Engineering, University of Alberta, Edmonton, Alberta, Canada

The effect of applying a low nominal heat input of 0.5 kJ/mm on the microstructural changes of the CGHAZ in Grade 100 microalloyed steel is demonstrated. Microhardness measurements suggested that the CGHAZ was martensite of maximum theoretical hardness for the carbon content of the steel.

The bulk of the CGHAZ was lath martensite containing none of the small and medium sized Nb precipitates responsible for strength and grain size control in the steel plate. Twinned martensite was unexpectedly observed in the local areas of the CGHAZ. The formation of twins, which are normally seen in steels with higher level of carbon, is explained by a combination of the rapid heating rates, high peak temperatures, precipitate dissolution and dispersion, and rapid cooling rates.

POSTER 23

NUCLEATION AND SHORT FATIGUE CRACK GROWTH BEHAVIOR OF 2024-T3 ALUMINUM ALLOY

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A. MERATI, Institute for Aerospace Research, Structures, Materials, and Propulsion Laboratories, Ontario, Canada

Due to economic factors, many aircraft flying today are nearing (or over) 30 years of age even though they were initially designed with a design service objective of 20 years. Improved damage management models, therefore, are needed for use in life prediction and management of aging fleets of aircraft.

Currently, life prediction models utilize long crack growth data in conjunction with the fatigue life to back-calculate the hypothetical initial flaw size. However, considerable metallurgical studies and coupon fatigue tests have shown that the role of the Initial Discontinuity State (IDS) on crack nucleation have not been appropriately modeled or considered in the overall life prediction methodology to date. These findings are that constituent particles were the sole microstructural discontinuity controlling the crack origins in new, bare 2024-T3 and nucleation and early (short) crack growth made up the major portion (e.g. up to 95%) of the fatigue lives. The discontinuity (nucleation sites) sizes found in these studies are in the range of short cracks.

In the short crack growth regime, local microstructural features such as grain boundary and size, inter-particle spacing, and texture play the primary roles. These features affect the local stress field in the front of the crack tip and hence control the crack growth. Furthermore, concepts of Linear Elastic Fracture Mechanics and ΔK_{th} are not applicable to short fatigue crack analysis.

A study has been carried out to evaluate the various crack detection and monitoring techniques in short crack regime in AA2024-T3. These techniques are direct current potential drop (DCPD), alternating current potential drop (ACPD) and replication. Fatigue samples were also prematurely overloaded at different stages of the fatigue life in order to help develop a more basic understanding of the microstructural features that influence the growth rate and pattern of short cracks in the aluminum alloy. This knowledge can then be used to help develop an improved methodology for the estimate of the fatigue life of aircraft components.

POSTER 24

THE EFFECT OF DWELL TIME ON THE FATIGUE CRACK GROWTH BEHAVIOUR OF IMI834 AT ROOM TEMPERATURE

P. AU, C. CHANG, D. DUDZINSKI AND P.C. PATNAIK, Structures, Materials and Propulsion Laboratory, Institute for Aerospace Research, National Research Council Canada, Ottawa, Ontario

It has been reported in the literature that the presence of hold periods at peak stress during low cycle fatigue testing can dramatically reduce the fatigue life of titanium alloys, even in a room temperature environment. In fact, in-flight failure of RB 211 fan discs in the 1970s was thought to be associated with this “cold dwell” or “cold creep “effect. During subsequent laboratory studies on titanium alloys IMI 834, IMI 685, Ti-6Al-4V and Ti-6Al-2Sn-4Zr-6Mo, it was found that their low cycle fatigue lives were sensitive to cold dwell, and that the factors affecting this phenomenon include microstructure, texture, hydrogen content in the material, the level and state of applied stress, test temperature and environment. The cold dwell effect has also been observed under certain conditions during fatigue crack growth rate testing; however, the amount of information is relatively limited. The objective of this work is therefore to investigate the cold dwell effect on the room temperature fatigue crack propagation behaviour of an IMI834 titanium forging. The effect of different hold times on crack growth rate and fracture morphology will be presented.

POSTER 25

HOMOGENISATION FURNACES OPTIMISATION

G. CHIASSON, Ste-Foy, Québec

S. LECLERC, Cap-Rouge, Québec

Some products of the aluminum industries have to undergo a heat treatment for certain specific applications. The homogenisation is used to put in solution the silicon in the aluminum matrix, to turn the βAlFeSi phase into αAlFeSi and to ease the extrusion of aluminum billets for the 6063 alloy family. This poster is a summary of an internship done at the Alcoa plant in Baie-Comeau.

The objective of this project was to characterise and optimise the operations of three homogenisation furnaces: one recent (furnace #1), supposedly better, and two older (furnaces #2 and 3). The homogenisation treatment is divided in three steps: the heating of the charge (minimum of 12 hours), the soak time (4 hours) and the cooling time which should be as quick as possible. The characterisation was done using thermocouples installed in strategic places in the billets charge, more specifically in the hottest and coldest points of the three furnaces. Although the #1 furnace was expected to give the best performance, the results of the furnace #1 have showed that some parts of the billets charge had not reached the minimal temperature of operation. After 12 hours, the coldest point’s temperature ought to be 571°C, but for #1 furnace, this same point was only 550°C. Moreover, after 16 hours of treatment (heating and soaking), the temperature of the coldest point was still under 571°C. Since the control method of the #1 furnace is different form that of the other furnaces, the problem had not been detected before. In the 213, the measurements were taken with thermocouples fixed on the lateral walls, while in the old furnaces, the thermocouples were in the billets charge. Furthermore, the internal design did not allow an efficient air circulation. In fact, no baffles were installed on the walls and the base of the furnace was not appropriate for the type of wagon used. Consequently, the method of collecting data of the #1 furnace ought to be reviewed and the internal design must be changed to allow a better air circulation in the billets charge.

This study showed also that after having analysed the results, we recommend to start the soaking time as soon as the temperature of the billets charge’s coldest point is 571°C (whitch is the minimal temperature of operation) and remove the 12 hours minimum heating time.

POSTER 26

COMPARISON OF WC-CO-CR COATED FLAT AND CYLINDRICAL SPECIMENS AFTER ASTM B117 SALT FOG CORROSION

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Electrolytic hard chrome (EHC) plating has been used to provide corrosion and wear resistance for structural applications, including aircraft landing gears. It is typically applied in the hexavalent state (Cr^{+6}) on new and refurbished parts. However, Cr^{+6} is carcinogenic and as a result, the Environmental Protection Agency (EPA) in the USA has issued a Permissible Exposure Limit (PEL) of 100 mg/m^3 for Cr^{+6} and is considering reducing this level further. The cost of complying with a lower PEL level is significant and therefore, selecting a suitable replacement is desirable.

The Canadian National Defence has considered using HVOF thermal sprayed WC-10Co-4Cr coating as a replacement. An ASTM B117 salt fog test was carried out to compare the corrosion resistance of the HVOF WC-10Co-4Cr with that of the EHC plating on both cylindrical and flat geometry specimens. In addition to geometry, the test matrix includes the comparison of 3 coating conditions: HVOF, EHC, and bare substrates; 2 coating thickness values; and 2 high-strength steel alloy substrates. Corrosion resistance of the coating systems was rated in accordance with ASTM B537, and post-test metallographic analysis was conducted with a view to understanding the failure mode. In this poster the corrosion test results and metallographic analysis are presented and discussed with reference to the effect of specimen geometry.

POSTER 27

INFLUENCE OF WELDING PROCESSES ON THE CORROSION BEHAVIOR OF WELDED 304 AUSTENITIC STAINLESS STEEL

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This work is intended to reveal the relationships among the welding thermal cycle, metallurgical changes and pitting resistance for welded 304 stainless steel. The scanning reference electrode technique (SRET) was used to monitor the real-time activity of pit initiation and growth in different weld zones. It was found that laser-welded (LBW) specimens exhibit more resistance to pitting corrosion than those with gas tungsten arc welds (GTAW). A duplex microstructure observed in the weld metal (WM) of laser-welded specimens could account for the different corrosion behavior

POSTER 28

PHOTO RESPONSE OF PASSIVE FILMS ON X70 MICRO-ALLOYED STEEL

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In situ potentiostatic investigation show that hydrogen ingression results in an increase in anodic dissolution of the passive films on X70 micro-alloyed steel which however resumed after the hydrogen charging was stopped. Whereas concurrent photoelectrochemical experiments reveals, surprisingly, that the increased photocurrent of the film arising from hydrogen ingression would not recover to the state prior to hydrogen charging after the external hydrogen source was cut off. This irreversibility of hydrogen effect on the optical and electronic properties of the passive film on X70 steel is first discovered in our experiments. Existing theories could not explain the complexity of the effects satisfactorily. Future work is needed to explore the responsible mechanism.

POSTER 29

FUNDAMENTAL STUDY ON THE CORROSION BEHAVIOR OF NANOSTRUCTURED WC PARTICLES DISPERSED IN POLYMER COATINGS

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The composite coating systems consist of nanostructured WC particles dispersed in a polymer phase were studied in this work. The corrosion property of composite coatings of polymer with nanostructured WC particles has shown promising outcome. The nanostructured WC particles were dispersed in the Xylan 1810 polymer using an ultrasonic device before spin-coated on carbon steel. Spin-coated samples were tested under corrosive environment by using electrochemical technique to better understand the fundamental processes of corrosion. The experimental results showed that the nanostructured WC particles-enhanced polymer composite coatings exhibit a better or at least equivalent corrosion resistance than the pure polymer coating.

POSTER 30

MICRO-POROUS ELECTRODE PRODUCED BY CURRENT OSCILLATIONS OF IRON-BASED MATERIALS

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It is first time reported that micro-porous electrode may be produced by current oscillations for iron-based materials in phosphoric acid solution. The porous electrodes find wide application in the field of batteries, fuel cells, electrocatalysis and sensors. Electrochemical techniques were used to investigate the electrochemical behavior of porous electrodes and electrodissolution processes and charge transfer process at the pore surface.

POSTER 31

INVESTIGATION OF EROSION-CORROSION IN SLURRY OF CARBON STEEL BY ROTATING CYLINDER ELECTRODE

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Erosion, corrosion and the synergistic effect between erosion and corrosion are primary concerns in oil sand slurry transport system. The slurry–erosion behavior of carbon steel was investigated using rotating cylinder electrode (RCE) system. The influences of flowing parameters and sand concentrations are investigated. Weight loss measurements and electrochemical measurements were conducted to differentiate the different components

POSTER 32

THE INFLUENCE OF HOT ROLLED MICROSTRUCTURE ON THE PROPERTIES OF ALUMINUM-ALLOYED, COLD ROLLED AND ANNEALED TRIP STEELS.

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Since high silicon content in TRIP steels can cause poor surface quality and coatability, aluminum-alloyed multiphase TRIP steels, in which aluminum substitutes for silicon, have been recently developed to overcome these disadvantages. It has been known that, although aluminum is a ferrite stabilizing element under equilibrium conditions, it is effective as far as retention of metastable austenite is concerned. But, because of the weak solid solution hardening effect of aluminum, aluminum-alloyed multiphase TRIP steels show low strength levels compared to that of silicon-alloyed TRIP steels. This study was carried out in order to investigate whether the hot rolled microstructures would affect the strength of aluminum-alloyed TRIP steel used in the cold rolled and annealed condition. Steels were hot rolled under several rolling schedules to generate different as-hot rolled microstructures, and then cold rolled and TRIP heat treated. To examine the changes in the characteristics of retained austenite, microstructure and mechanical properties, several analyses, including tensile tests, microscopy, X-ray diffraction were done.

POSTER 33

EFFECT OF INTERCRITICAL STRAIN IN HOT ROLLED C-MN-AL TRIP STEELS.

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To be included as a future structural steel in automobile industry, TRIP steels, which have high strength and good formability, must solve the drawbacks associated with the alloying addition of more than 1% silicon. Recently C-Mn-Al TRIP steels, as a substitution of high silicon TRIP steels, have been under investigation. The aim of this work is to try to improve the as-hot rolled strength of these alloys. In this paper, the approach is to investigate deformation in austenite plus ferrite two-phase region. A number of mechanisms could then contribute to strengthening including refining austenite grain and work hardening of ferrite. These may also affect the retained austenite characteristics. Two different C-Mn-Al TRIP aided steels with aluminum contents of 1.5% and 2.0 wt % were investigated and compared to a typical 0.2 wt% C-Mn-1.5Si TRIP aided steel. To determine the phase transformations during cooling, a CCT diagram was obtained by dilatometry. Using these data, hot deformation experiments, to incorporating, intercritical deformation were designed to investigate the influence of the intercritical conditions on the microstructure of all three steels.

POSTER 34

PRECIPITATION AND ITS STRENGTHENING OF A STATE-OF-THE-ART TI-NB HSLA STEEL.

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The entire hot strip rolling process, starting from reheating, has been simulated employing an HT100 hot torsion test system. The effect of on line accelerated cooling patterns on the final microstructure was studied. Aging tests were carried out to evaluate the precipitation kinetics in detail in the thermomechanically processed samples. Microhardness measurements were performed for mechanical property evaluation. Transmission electron microscopy was used to investigate the individual phases of the microstructure and the nature of the precipitates, focusing on size and morphology and chemistry. The strengthening mechanisms of the particular state-of-the-art HSLA steel was discussed. The substantial strengthening due to the precipitation in ferrite is emphasized in this work.

POSTER 35

THE STRESS-STRAIN BEHAVIOUR OF AN INTERCRITICALLY ANNEALED DUAL PHASE STEEL AS FUNCTION OF MARTENSITE VOLUME FRACTION.

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Ferrite-martensite dual-phase steels with a good combination of high strength and high ductility are of great importance to industry, particularly the automotive sector. The aim of this research was to evaluate the effect of martensite volume fraction on the stress-strain behaviour of low carbon cold-rolled C-Mn-Mo dual-phase steel. The heat treatments required to produce dual-phase steel samples with different martensite contents were conducted using the Gleeble machine. Three dual-phase steel samples with 26, 39 and 78% martensite were produced at three different intercritical annealing temperatures, i.e. 740, 780 and 810ºC, respectively. The relationship between properties and the fraction martensite was more complicated than initially expected. When martensite content increased from 26 to 39%, the strength increased but the uniform elongation remained almost constant. In addition, the increase in martensite content from 39 to 78% martensite has only a small effect on the overall stress-strain response. This unusual result could be due to the fact that the carbon content of martensite phase in these steel samples is relatively low and decreases with increasing the volume fraction of martensite resulting in a relatively low flow stress for the martensite. Finally, an initial attempt to model the stress-strain relationship of dual-phase steel with 26% martensite was made using a modeling approach based on the Eshelby approach, and using stress-strain relations for the constituent phases obtained from literature. A relatively good agreement was found between the experimental and calculated stress-strain curves.

POSTER 36

THE INFLUENCE OF THE MICRO-ALLOYING ELEMENTS ON MECHANICAL PROPERTIES OF COLD ROLLED CMNALSIP TRIP-AIDED STEELS.

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The effect of the addition of micro-alloying elements, such as Nb, Ti and V on the mechanical properties and the microstructure of cold rolled CMnAlSiP TRIP steels was investigated in detail for different continuous annealing conditions. The mechanical properties of the obtained TRIP steels were evaluated by means of tensile testing. It was found that the CMnAlSiP reference material due to a synergetic effect of Si and P excellent mechanical properties were achieved, in particular a high strength level (>800MPa) in combination with good formability properties. The addition of the micro-alloying elements increased the tensile strength by about 200 MPa at the total elongation of at least 20%. The pronounced effect of Nb on a increase of the mechanical properties was due to the precipitation of NbC during intercritical annealing. This was in contrast to Ti, which formed carbides at temperatures higher than 1000°C. The strain hardening behavior was studied in detail. For both reference and micro-alloyed grades the clear TRIP effect was revealed with the retained austenite volume fraction about 10% as estimated by XRD measurements.

POSTER 37

CHARACTERIZATION METASTABLE AUSTENITE FECMNSI TRIP-AIDED STEEL BY NEUTRON DIFFRACTION.

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The detailed analysis of X-ray diffraction data obtained from intercritically annealed and isothermally transformed low-alloy FeCMnSi TRIP-aided steels reveals that the microstructure contains athermal plate martensite and Fe_2C η carbide in addition to ferrite, bainite and residual austenite. Neutron diffraction shows that athermal plate martensite can be formed at room temperature in the isolated austenite phase. Whereas the formation of athermal martensite leads to compressive strains in the austenite, the formation of strain-induced martensite results in tensile straining of the austenite. The strain-induced transformation leads to the formation of a martensite of low tetragonality. Low temperature annealing leads to the formation of η carbide in both the athermal and strain-induced martensite.

POSTER 38

STRAIN INDUCED AUSTENITE-TO-FERRITE TRANSFORMATION BEHAVIOUR OF PLAIN CARBON STEELS THROUGH SINGLE PASS ROLLING.

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As is well established, a proper combination of strength and ductility is achieved through micro components refinement in steels. This is particularly emphasized with ferrite refinement in ferrite-pearlite microstructures. In this regard, different methods have been developed from which strain induced transformation (SIT) has shown spectacular capabilities. In the present study, to address the effect of thermomechanical processing parameters on the (SIT) behaviour, two plain carbon steels were studied through single pass rolling. This was carried out at the corresponding (Ar3+20)ºC temperature of the steels. The results indicated that the amount of strain and carbon content strongly affect the transformation behaviour and ferrite morphology. Furthermore, a high volume fraction of very fine ferrite with mean grain size of less than 2 µm was obtained. This was attributed to the ferrite nucleation at deformation bands and serrated austenite grain boundaries.

POSTER 39

ROOM TEMPERATURE CREEP BEHAVIOUR OF X-100 PIPELINE STEEL.

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In this research, room temperature creep deformation of a X-100 pipeline steel was studied under various loading conditions including static, cyclic, and a combination of static and cyclic loading. A burst of creep deformation was observed during static loading following the initial cyclic loading. The burst required an incubation period that increased with the number of cycles prior to static loading. Higher yield strength and lower work hardening rate were observed after room temperature creep deformation. The possible dislocation mechanisms related to the pre-cyclic-load-induced burst of creep deformation is also discussed in the presentation.

POSTER 40

REFINEMENT OF THE SCALE OF MICROSTRUCTURE IN DUAL PHASE STEELS.

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Dual phase steels are traditionally produced by annealing in the intercritical α and γ range and cooling to produce a mixture of ferrite plus a complex hard constituent. This hard constituent characterizes properties such as the work hardening rate, the magnitude of the Bauschinger effect and the fracture behaviour. The constitutive laws for dual phase steels are usually expressed in terms of the volume fraction of the non ferritic phase without regard to its scale. However, the scale can be reduced markedly by utilization of prior cold rolling and very rapid anneal cycles. This work outlines an initial exploration of the changes in microstructure and properties, which can be attained by these refining treatments.

POSTER 41

EXPLORATIONS OF RAPID HEAT TREATMENT PROCESSES IN STEELS.

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Although much previous work has explored the basic transformations which occur when either austenite or mixtures of austenite and ferrite are cooled at various rates, relatively little effort has been made to explore the reverse process of rapid heating to produce fine scale microstructural products. This poster shows the results of an exploratory study using a variety of heating systems including rapid (ferrite-second) laser pulses to heat a range of steels into both the austenite and austenite plus ferrite range. The products have been characterized both by optical and electron metallography methods and instrumental indentation testing.

POSTER 42

RESEARCH ON HOT-ROLLED TRIP STEEL WITH SUPER FINE GRAIN SIZE

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The advanced hot-rolled TRIP steel with the characteristics of retained austenite (11.0%vol), super fine grain size (3.0μm) and integrated or purified grain (less interstitial atoms or dislocation), has been developed successfully by simply adding common elements of carbon (0.19%wt), silicon (1.50%wt) and manganese (1.90%wt), as well as by controlling hot-rolling and cooling processes in a mill after simulating experiment in Gleeble 2000.

The mechanical test results showed the well balanced properties of the steel with high tensile strength 775MPa, low ratio of yield strength to tensile strength 0.72, appropriate elongation 29%, especially low ductile brittle transmission temperature -80□, which is usually obtained by adding expensive elements like nickel in conventional steels for low temperature pressure vessel, for example.

According to microstructure analyses by using of Electron Probe JXA8800, TEM JEM-2000FX□and x-ray diffraction RIGAKU D/Max-3, it can be concluded that silicon plays a dual-role both on retaining austenite and purifying ferrite grain. Firstly, silicon expels carbon atom from ferrite into austenite during the transformation $\gamma \rightarrow \alpha$, which increasing carbon content in untransformed austenite, consequently improving austenite stability and enhancing retained austenite fraction that leads to higher elongation in spite of high tensile strength. Meanwhile, as silicon purifying ferrite grain and lessening interstitial atoms like carbon in integrated or purified ferrite grain, low ratio of yield strength to tensile strength and low ductile brittle transmission temperature are obtained easily for the steel.

Further, the energy depressive analysis revealed that manganese content between integrated grain and common grain was significantly different, with the former 1.83%, approaching to the matrix 1.90%, while the latter as high as 2.84%. It means that the integrated grain may form firstly in high temperature and the common grain in low temperature.

Besides, the controlled processing including rolling reduction in higher finishing temperature also extremely affected the amount of dislocation and integrated grain formation.

As for the super fine grain size in the experiment, it mainly depends on the newly processing without specially rolling requirements for conventional HSLA steels with large amount of rolling reduction in low finishing temperature region, and a patent about the processing was applied last year.

Furthermore, a new finding was obtained by TEM observation that micro texture with certain orientation existed in the microstructure, which might be contributed to high silicon content like Silicon-contained Electric Steels and could partially explain the reason for the high formability in TRIP steels in spite of low r value or weak beneficial texture. The further research about the micro texture should be carried out in order to make new progress for TRIP steels.

POSTER 43

EFFECTS OF MOLYBDENUM AND NICKEL ADDITIONS ON THE STRUCTURE AND PROPERTIES OF CARBURIZED AND HARDENED LOW CARBON STEELS

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The effects of molybdenum and nickel on the microstructure and properties of low carbon steels in the carburized and hardened condition were studied by means of optical microscopy, surface hardness and micro-hardness measurements, X-ray diffractometry and impact tests.

It was found that molybdenum produces fine martensite and nickel has no effect in refining the size of martensite. Molybdenum with nickel is more effective than molybdenum without nickel in refining the size of martensite. Molybdenum and nickel enhance the formation of retained austenite in the case of carburized and hardened low carbon steels but nickel is more effective than molybdenum in enhancing the formation of retained austenite.

Molybdenum improves and nickel reduces the maximum case hardness of the steels. The presence of nickel decreases the effect of molybdenum in the increment of maximum case hardness. Molybdenum and nickel both increase the core hardness but molybdenum is more effective than nickel in increasing the core hardness. Molybdenum and nickel both reduce the toughness of the core of the steels. Nickel is more detrimental to toughness than molybdenum.

POSTER 44

EFFECT OF RECLAMATION ON THE MECHANICAL PROPERTIES OF 18NI (300) MARAGING STEEL.

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An 18Ni maraging steel scarp has been used to study the effect of reclamation process on the mechanical properties of the product. For this, the early processed 18Ni(300) maraging steel scrap, was melted in a Lab. scale vacuum induction furnace using alumina type rammed crucible and cast into iron mold. The cast ingot was soaked at 1523 K for 10.8 ks then hot forged to 12 by 30 mm plate. Solution annealing was performed at 1100 K for 3.6 ks followed by air cooling. Half size tensile and Charpy impact specimens were prepared from the solution annealed material according to ASTM A370 and age hardened at 723 K for 10.8 ks in a neutralized salt bath. Tensile properties and impact toughness were determined in the aged condition and fractographic features were studied by a scanning electron microscope. The chemical analysis showed a minor reduction in Ti content during melting which was balanced to standard composition by addition of required ferrotitanium. Mechanical properties of the reprocessed material were as follow: YS= 1760-1860 MPa, UTS= 1810-2000 MPa, EL%=10-16 in 25 mm, RA%=53-62% and CVN=20 J. It has been found that reprocessing resulted in an increased tensile ductility but the same strength and impact toughness as compared to standard 18Ni(300) maraging steel. Fractography of impact specimens shows ductile dimpled fracture.

POSTER 45

MODIFICATION OF HIGH CARBON LOW ALLOY STEEL MELTS.

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Because of proper wear resistance at hot rolling condition, high carbon low alloy steels are used as rolling mill rolls and rings' material. The as cast microstructure of these steels include, basically, closed networks of carbides in an austenitic matrix and some martensite. Improper distribution of carbides in matrix and existence of residual retained austenite may significantly reduce mechanical and wear properties. Basically, carbide dissolution and proper redistribution in matrix, and converting the retained austenite to perlite or beinite recover these properties, all by heat treatment. Dissolution of the carbides networks require high temperature and prolonged heat treatment time while carbides do not dissolve completely, therefore, an alternative treatment is needed to be presented. The objective of this work is to introduce a liquid metal processing treatment as chemical modification of liquid metal. The results show that besides improving carbide morphology and distribution in matrix, inclusions and microporosity distributions and morphologies improve significantly in as cast condition. Although, modified samples still need heat treatment, but the treatment period is remarkably shorten while mechanical properties are comparable with those of heat-treated.

POSTER 46

EFFECT OF TWO STEPS AGING ON THE KINETICS OF PRECIPITATION HARDENING OF COBALT FREE T-300 MARAGING STEEL.

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Cobalt free maraging steels have a low carbon, iron-nickel lath martensite matrix which are strengthened significantly by the precipitation of intermetallic compounds in conventional aging process at temperature of about 480°C. The most common precipitates which form in aging process of these steels are hexagonal (Ni3Ti) and (Fe2Mo). In this research a cobalt free maraging steel with 0.02C-18Ni-3.8Mo-1.9Ti-1.01Mn-0.009S-0.01P(Wt%) were used to study the effect of conventional and two steps aging on the kinetics of precipitation hardening of the steel. Conventional aging was carried out at 480°C, while two steps aging was done at 400°C as first step and 480°C as second step. The hardness test results of conventional aging show that the precipitation time interval of Ni_3Ti and Fe_2Mo is so short that it is rather difficult to distinguish the exact nucleation and growth of each precipitate separately. However, two steps aging reduces incubation time of Ni_3Ti formation without any major impact on the kinetics of Fe_2Mo precipitation in which two different hardness curves can be clearly seen. In addition, two steps aging shows a minor effect on the hardness peak of the steel.

POSTER 47

INTERFACIAL REACTIONS IN B_4C-NI AND WC-NI FOR WEAR APPLICATIONS

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Wear of materials is a significant industrial problem. Wear reduction can be accomplished by using materials able to absorb impact without failure. This is often achieved through the application of metal matrix composite (MMC) coatings consisting of a hard reinforcing phase and a tough metal matrix such as WC and Ni respectively. The interfacial behavior between metal and reinforcement is key to the performance of the MMC. In this case, the interfacial behaviors in the B_4C-Ni and WC-Ni systems will be compared. The reaction mechanisms are studied with solid and liquid nickel. Characterization techniques such as Wavelength Dispersive Spectroscopy and X-Ray Diffraction will be discussed.

POSTER 48

HUMIDITY SENSITIVE CHARACTERISTICS OF CASNO3 HUMIDITY SENSOR

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CaSnO3 ceramic humidity sensors were prepared by solid-state oxide synthesis processing and their humidity sensitive characteristics have been investigated. The impedance of CaSnO3 humidity sensor decreases with increasing relative humidity and changes by about three orders of magnitude in an exponential manner over the whole humidity region. The humidity sensitivity of the sensor depends on the applied frequency and the activation energy for conduction is reduced with water adsorption. CaSnO3 humidity sensors show a negligible hysteresis under cyclic humidity changes with a good long term stability and fast response time.

POSTER 49

Novel Surface Coating Materials For Endodontic Dental Implant

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The aim of this study was to design and produce novel coating materials in order to obtain two goals including; improvement of the corrosion behavior of metallic dental endodontic implant and the bone osteointegration simultaneously. Stainless steel 316L (SS) was used as a metallic substrate and a novel Hydroxyapatite/Titanium (HA/Ti) composite coating was prepared on it. Structural characterization techniques including XRD, SEM and EDX were utilized to investigate the microstructure and morphology of the coating. Electrochemical tests were performed in physiological solutions in order to determine and compare the corrosion behavior of the coated and uncoated specimens as an indication of biocompatibility. Two types of endodontic implants including; SS with and without (HA/Ti) coating were prepared and subsequently implanted in the mandibular canine of 20 cats after completion of root canal treatment and osseous preparation. After a healing period of 4 months, osteointegration evaluation and histopathological interpretation was carried out using SEM and optical microscopy.

Results indicate that the novel HA/Ti composite coating improves the corrosion behavior and biocompatibility of SS endodontic dental implant. The clinical evaluation (in vivo test) results showed that there was significant difference in ossointegration between coated and uncoated endodontic dental implants and average bone osteointegration of coated implants were more than uncoated implants. The histopathological results and bone tissue response to the coated implants was acceptable and it was concluded that HA/Ti composite coated SS could be used as an endodontic implant.

POSTER 50

THE EFFECT OF POLISHING TIME ON THE SHEAR BOND STRENGTH OF RESIN COMPOSITE AND COMPOMER TO DENTINE

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The aim of this study was to evaluate the effect of polishing time on the shear bond strength of resin composite and compomer to dentine of tooth.

Truncated cone cavities were prepared in the horizontal coronal occlusal dentinal sections of 48 human molar teeth. Specimens were randomly divided in 4 experimental groups. The specimen cavities of the group 1 and 2 were filled with rein composite and the specimen cavities of the group 3 and 4 were filled with compomer. The specimens of the group 1 and 3 were polished immediately after filling the cavities and the specimens of the group 2 and 4 were polished after 24 hours storage of samples in normal saline at 37 ˚C. After that procedure, all of the groups were stored in normal saline at 37 ˚C for one week. The push out test was used to evaluate the shear bond strength of resin composite and compomer to dentin and the mean values of shear bond strength of four groups were determined. The results were analyzed with t-student test.

The results showed statistically significant differences between the mean shear bond strength values of the group 1 and 3, the group 2and 3, and the group 3and 4. The group 4 possesses the highest shear bond strength and the group 3 possesses the lowest shear bond strength.

It was concluded that hygroscopic expansion of compomer and improvement of bond strength of the compomer during the storage time (one-week) increases the shear bond strength between compomer and dentine. Because the type of setting reaction of the resin composite is polymerization, the time of polishing had no significant influence on the shear bond strength between resin composite and dentine.

POSTER 51

RECENT PROGRESS ON CHEMICALLY BONDED COMPOSITE SOL-GEL CERAMIC/PMPS BOND COATINGS

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A novel chemically bonded composite sol-gel (CB-CSG) coatings has been researched at the UBCeram. This essentially "ceramic paint" technology operates with the composite sol-gel (CSG) slurries formulated to contain a sol-gel "glue", e.g. hydrated alumina sol, and inert filler, e.g. alpha alumina or zirconia, suspended in water or other solvent. The CSG is spray-deposited on the metallic surfaces, and heat-treated at about 400°C to partially dehydrate the gel-derived hydroxides. The CSG film is subsequently chemically bonded (CB) through the reactions of the gel-derived active alumina with metal phosphates, such as aluminum phosphate. To address the issue of coating porosity and coating corrosion resistance, a novel process is under development to the impregnation of monomeric MPS (methylphenylsiloxane) into the micro-pores of 5-10 μm thick CSG alumina primer, and polymerization of MPS to form an impermeable inorganic polymer/ceramic composite bond coat connected with a 40-50um CB-CSG top coat after. The coatings have been deposited on a variety of metallic substrates to produce protective barriers against the wet corrosion. The coatings micro-structure has been studied. The ASMC bond coat essentially relaxed the thermal stress during heat treatment and cooling down.

POSTER 52

LIFE CYCLE INVENTORY ANALYSIS OF BIO-BASED POLYESTER PRODUCTION BY GENETICALLY ENGINEERED BACTERIA FROM RENEWABLE CARBON SOURCES

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Polydroxyalkanoates (PHAs) are bio-based polymer produced by a wide variety of microorganisms and used as biodegradable thermoplastic. Large-scale fermentative production of PHA copolymer, poly(3-hydroxybutyrate-*co*-5mol% 3-hydroxyhexanoate) (P(3HB-*co*-5mol% 3HHx)), from soybean oil as sole carbon source is simulated using a recombinant strain of *Ralstonia eutropha* harboring a PHA synthase gene from *Aeromonas caviae*. Its production costs, life cycle inventories (LCI) of energy consumption and carbon dioxide emissions from the cradle-to-factory gate are calculated and compared with the counterparts for microbial production of poly(3-hydroxybutyrate) (P(3HB)) from glucose as sole carbon source. In addition, the values of bio-based polymers are compared with those of petrochemical polymers. Annual production of 5,000 tonnes of P(3HB-*co*-5mol% 3HHx) is estimated to cost from 3.5 to 4.5 US$/kg, depending on presumed production performances. Similar scale production of P(3HB) from glucose is estimated to cost 3.8-4.2 US$/kg. In contrast to the comparable production costs between P(3HB-*co*-5mol% 3HHx) and P(3HB), life cycle inventories of energy consumption and carbon dioxide emissions favor the former product over the latter, reflecting smaller inventories and higher production yields of soybean oil compared to glucose. The life cycle inventories of energy consumption and carbon dioxide emissions of bio-based polymers are markedly lower than those of typical petrochemical polymers.

POSTER 53

PROCESS ENGINEERING OF THICK DIELECTRIC FILMS ON ALUMINUM FOR HEATING ELEMENTS BY CHEMICALLY BONDED COMPOSITE SOL-GEL

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A thick dielectric coating on aluminum was successfully made via chemically bonded composite sol-gel (CB-CSG) by spray coating and its dielectric breakdown voltage was measured at room temperature. Currently, aluminum is not available for heating systems on markets due to thermal mismatch between ceramic materials and aluminum. However, use of aluminum has some benefits, such as lightweight and high thermal conductivity (~150W/m·K) leading to energy savings. In this study, process engineering is introduced in order to reduce thermal mismatch between ceramics and aluminum and to make a dense and thick coating. Furthermore, the coating process is more focused to increase an insulation property. The breakdown voltage of $2KV_{AC}$ is required to pass the safety standards.

POSTER 54

THE EFFECTS OF ADDITIVES ON MICROSTRUCTURE EVOLUTION OF ECD CU FILMS

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The integration of a low resistivity metal wiring and a low-k interlevel dielectric is crucial for the high performance interconnects with low resistance-capacitance delay which are required in advanced chip technologies with further decreased feature sizes. Thus, copper metallization is rapidly being introduced as an advanced interconnect material to replace the traditionally used aluminum. To fabricate copper interconnects, electroplating has emerged as the deposition method of choice. The electroplating solution contains additives, e.g. organic compounds, which aid the deposition process to obtain high-quality Cu interconnects.

This work presents an investigation of the effects of additives on microstructure evolution of Cu films which were electrochemically deposited (ECD) on Au substrates. Four additives were used in the Cu bath solution: Potassium Chlorine (KCl), Poly ethylene glycol (PEG), Bis-(sodium-sulfoprophl)-disulfide (SPS), and Jannus Green B (JGB). The rate of bulk Cu deposition was quantified with cyclic voltammetry. The self-annealing of the as-deposited Cu films was recorded at room temperature with resistivity measurements. Further, the grain size evolution during self-annealing was characterized by X-ray diffraction (XRD). The challenges associated with these measurements are discussed in detail.

A systematic variation of the additive concentrations confirms that additives affect self-annealing rates markedly. The presence of sufficient quantities of KCl, PEG and SPS is required to obtain self-annealing while JGB affects just the kinetics. This suggests a synergistic effect of these additives. An optimum additive composition is approximately given by a bath chemistry of KCl=50mg/l, PEG=300mg/l, SPS=1mg/l and JGB=1mg/l where the maximum self-annealing rate has been observed in this study. Increasing the additive levels further increases also the required annealing times.

POSTER 55

CORROSION RESISTANCE OF DIAMOND-LIKE CARBON COATINGS ON 316L STAINLESS STEEL FOR BIOMEDICAL APPLICATIONS

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The corrosion resistance of diamond-like carbon (DLC) coatings deposited by plasma-assisted chemical vapor deposition (PACVD) on 316L stainless steel was investigated in the simulated body fluid environment. Three kinds of a-C:H were prepared as a function of bias voltage and Si incorporation. The corrosion behavior of DLC coatings was studied using electrochemical corrosion tests and surface analyses. Electrochemical polarization measurements demonstrated that the Si-C:H coating had a lower porosity than a-C:H coatings. Porosity of the coatings was studied on films by measuring polarization resistance on the coated and uncoated substrate. Electrochemical impedance measurements explained the effect of bias voltage and Si incorporation on the corrosion resistance in terms of charge transfer polarization resistance and delamination area of the coatings. In conclusion, the DLC coating provided an increased corrosion performance with higher bias voltage and Si incorporation.

POSTER 56

FRICTION BEHAVIOR OF NANO-UNDULATED DLC FILMS

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Frictional behavior of nano-undulated diamond-like carbon (DLC) films deposited by plasma assisted chemical vapor deposition (PACVD) process was investigated. In order to prepare the nano-undulated DLC film, a Si wafer with nano-sized Ni dots was prepared by rapid thermal annealing of Ni thin films. Since the structure of DLC film deposited by PACVD was independent of the substrate materials and that the size of Ni nano dots could be controlled in a systematic way by changing the thickness of the Ni film, we could investigated the effect of nano-scale surface roughness on the tribological behavior of DLC films. The friction coefficient between steel ball and undulated DLC films of the roughness varying from 0.6 to 13.7 nm was measured by using a ball-on-disk type wear rig in ambient environment. The friction coefficients were in the range from 0.15 to 0.2, independent of the surface roughness. Wear of the steel ball was much enhanced with higher content of Fe in the debris as the roughness increased. However, the size of the debris decreased with increasing roughness. Raman spectrum analysis revealed that the chemical bond structure of the debris is significantly dependent on the surface roughness. The friction behavior was discussed in terms of the chemical compositions and the agglomeration behavior of debris.

POSTER 57

NOVEL HYDROXYAPATITE COATING ON STAINLESS STEEL CORONARY STENT

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Various coating materials have been studied in order to improve the biocompatibility of the coronary stents. Few of the studied coating materials have been able to fully prevent the side effects of the stent implantation, mainly thrombosis and restenosis. Lack of biocompatibility and the adverse reaction of the biological environment toward the implant has been the main cause of failure for the most of these materials. This research work presents the application of hydroxyapatite as a biocompatible coating on the coronary stainless steel stents by using a novel sol-gel synthesis of hydroxyapatite and method for its deposition.

POSTER 58

A METHOD TO MITIGATE ERROSION-CORROSION IN SLURRY PIPELINES

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Transportation of oil sand by hydro transport is a more recent development and a promising method to transport oil sand. Corrosion and corrosion due to erosion called erosion-corrosion is a significant concern in oil sand transportation in long pipelines.

This research investigates the various effects on a pilot scale slurry flow loop. This includes quantitative measurements, temperature and velocity effects, electrochemical and microscopic analysis. This also proposes a method to mitigate erosion corrosion.

POSTER 59

PREDICTION OF MICROPOROSITY IN AL-SI CASTINGS USING CRITERIA FUNCTIONS

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Microporosity in Al-Si castings is a serious defect responsible for more than 50% of the scrap loss in production of commercial castings, and it severely prevents the widespread use in many critical load bearing applications. Research on prediction of microporosity has been a long term task since 1950's. A promising method is to use criteria functions to quantitatively predict microporosity level. To date, an ideal one has not yet been obtained. Based on these considerations, the objective of this research is to develop criteria functions for predicting microporosity level in Al-Si alloys under the low pressure casting conditions by correlating results of numerical simulation studies to those obtained experimentally.

In the research, several new criteria functions have been developed by multivariable regression analysis to predict the microporosity content in 319, 356 and 332 alloys with strontium modification.

POSTER 60

ELECTRODEPOSITED ALUMINA-POLYMER COMPOSITE COATINGS WITH INCREASED ABRASION RESISTANCE

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Polymer E-coat has been a common method of protecting automotive body panels and many other accessories for outdoor use against corrosion. Typically, the polymer is composed of epoxy or acrylics in a water based suspension. This work focuses on increasing the coating properties such as scratch and wear resistance, with the addition of fine dispersed ceramic into the suspension, creating a polymer matrix with reinforced ceramic particles as finish product. Also, there has been no alteration of the processing technique, which signifies a good method of improving the mechanical properties of this auto body coat. The coating chemistry and microstructure have been studied. The essential mechanical properties of the coatings have been evaluated. It is shown that by introducing the ceramic reinforcement phase, the scratch and wear resistance is increased significantly without influencing bonding properties.