MONDAY, AUGUST 23, 2004, P.M.

SESSION 6: INTERNATIONAL SYMPOSIUM ON LIGHT METALS AND METAL MATRIX COMPOSITES

PROCESS MODELING AND SIMULATION

Sponsor: Light Metals Section, The Metallurgical Society of CIM
Room: 203
Chairmen: R. GUTHRIE, McGill University, Montréal, Québec, Canada, and
D. GALLIENNE, Aluminerie Alouette, Sept-Iles,Québec, Canada

PAPER 6.1 — 14:00

COMPARISON FOR 6061 MATERIALS EXTRUSION ANALYSES BY FEM AND TRADITIONAL APPROXIMATIVE METHODS.

H.J. MCQUEEN and Y. YAO, Mechanical and Industrial Engineering Concordia University, Montréal, Québec Canada

The modeling of the extrusion of 6061 alloy and its composites with 10, 15 and 20 vol% Al2O3 or SiC is examined by two techniques. The unaxial finite element method FEM (DEFORMtm) provided force-stroke curves and temperature rise over the ranges: billet temperatures 450-500°C, ram speeds 2.61-5.1mm/s and extrusion ratios of 31 and 64. The traditional technique considers both ideal and redundant work as well as friction and uses average temperatures and strain rates. The two techniques are used to clarify each other and to extend the analysis to 400 and 350°C. The calculated efficiencies are compared to measured values in extrusion trials and to values derived for 7075 extrusion analyses. The analyses are based on constitutive equations determined by hot torsion tests.

PAPER 6.2 — 14:25

MODELING EXTRUSION OF ALUMINA AND SILICON CARBIDE REINFORCED ALUMINIUM METAL MATRIX COMPOSITES.

A. SAIGAL and B. BOGALE, Tufts University, Medford, Massachusetts, U.S.A.

A finite element analysis based investigation using DEFORM software was undertaken to model the extrusion of 15% alumina and 15% silicon carbide reinforced aluminum metal matrix composites. The study dealt with predicting the extrusion load as a function of ram displacement and initial billet temperature. The finite element simulation was also used to determine the maximum extrusion load, temperature distribution, maximum temperature, strain rate, velocity and stress distributions in the billet during the hot extrusion process. The constitutive equation used was of the type: $Z = \dot{\varepsilon} \exp(Q / RT) = A\{\sinh(\alpha\sigma)\}^n$ where Z is the Zener-Hollman parameter (temperature compensated strain rate), $\dot{\varepsilon}$ is the strain rate, Q is the activation energy, R is the gas constant, T is the absolute temperature, σ is the flow stress and A, α and n are constants. Based on the work of Davies et al and McQueen and Konopleva, the values of Q (KJ/mol), α (MPa-1), n and A for aluminum 6061 composites reinforced with 15% alumina and 15% silicon carbide used are 181, 0.024, 4.15 and 1.33x1012 and 233, 0.052, 2.60 and 1.26x1014, respectively.

Even though the individual parameters are quite different, it was found that the predicted maximum extrusion load, temperature distribution, maximum temperature, strain rate, velocity and stress distributions are quite similar and differ by no more than 1-2 percent between the two composites indicating that the deformation behavior is primarily controlled by the matrix material.

PAPER 6.3 — 14:50

FEM ANALYSIS OF PLASTIC DEFORMATION IN BRINELL HARDNESS TESTING: CORRELATION BETWEEN STRENGTH AND HARDNESS IN ALUMINUM ALLOYS.

S. MALEKSAEEDI and M.M. ALIPOUR, Shiraz University, Shiraz, Fars, Iran

On-site evaluation of strength using hardness is common for different materials. The lack of such relation for aluminum alloys has always been felt. In this work, a finite element analysis of plastic deformation and its distribution in Brinell hardness test is presented. The analysis has been performed for different strength levels of aluminum alloys. By utilizing the equivalence of Von Mises equivalent strain in hardness and tensile tests, it is tried to derive a correlation between hardness and strength values for the alloys under consideration. The derived correlation is further extrapolated using the experimental values available in literature.

COFFEE BREAK — 15:15 - 15:45

PAPER 6.4 — 15:45

NUMERICAL SIMULATION OF COUPLED FLUID FLOW AND SOLIDIFICATION IN A SINGLE-ROLL CASTER.

S.H. SEYEDEIN, A. JAFARI and R. ABOUTALEBI, Iran University of Science and Technology, Tehran, Iran

A mathematical model was developed to study fluid flow and solidification in a single-roll casting system. Fluid flow coupled with energy equations were solved numerically using a finite volume method. A body-fitted coordinate transformation technique was adopted to handle the irregularly shaped domain. In order to couple the continuity and momentum equations, a SIMPLEC algorithm was used. A fixed- grid enthalpy method was considered to model the solidification in the system. The model developed in this work was further run under various conditions to optimise the operating parameters of the process.

PAPER 6.5 — 16:10

MODELING OF ELECTROMAGNETIC SEPARATION OF INCLUSIONS FROM MAGNESIUM MELT.

M.R. ASFHAR, R. ABOUTALEBI, Iran University of Science and Technology, Tehran, Iran,
R.I.L. GUTHRIE and M. ISAC, McGill University, Montréal, Québec, Canada

In this work a mathematical model was developed to study the effect of electromagnetic force on the magnesium melt containing nonmetallic inclusion in an isolated vertical channel. The Archimedes electromagnetic force exerted on the inclusion induced by DC current as well as DC magnetic field was calculated. The 3-D velocity field within the channel was computed numerically by solving the Navier- Stokes equations. On the basis of computed velocity and magnetic fields, the trajectories of inclusions were calculated using the equations of motion for inclusions. Parametric studies were carried out to evaluate the effect of various parameters such as inclusion size, channel diameter; current density and magnetic intensity on the removal efficiency of inclusions from magnesium melt.