

TUESDAY, AUGUST 23, 2005, A.M.

SESSION 15: INTERNATIONAL SYMPOSIUM ON LIGHT METALS

CASTING AND SOLIDIFICATION OF ALUMINIUM

Sponsor(s): Light Metals Section, The Metallurgical Society of CIM

Room: Neilson 2

Chair(s): J-P. MARTIN, CNRC- Aluminium Technology Centre, Canada and
M. SAHOO, CANMET-Materials Technology Laboratory, Canada

PAPER 15.1—8:30

RHEOLOGICAL CHARACTERISTICS OF HYPEREUTECTIC AL-SI (A390) ALLOY IN THE SEMI-SOLID STATE.

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Hypereutectic Al-Si alloys are used in applications that require high resistance to wear and corrosion, hardness and low coefficient of thermal expansion. To maximize the properties of these alloys, semi-solid processing can be utilized to modify the solidification structure of the primary silicon crystals as well as to reduce microsegregation and porosity. The transformation and spheroidization of primary Si crystals by shearing in the semi-solid state are not fully understood as they precipitate in the presence of other alloy phases. The objective of the present work is the determination the rheological characteristics of A390 (Al-17%Si-4.5%Cu-0.5%Mg) alloy using a Couette type (Haake RV12) viscometer and examining the microstructural evolution during continuous cooling and isothermal shear rate experiments. The effect of shear rate, solid fraction (temperature) and morphological evolution of the silicon crystals are investigated.

PAPER 15.2—8:55

EFFECT OF MG AND SR ADDITIONS IN 319-TYPE ALUMINUM CASTING ALLOYS.

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F.H. SAMUEL, Université du Québec à Chicoutimi, Canada

S. VALTIERRA, Corporativo Nematik, Mexico and

H.W. DOTY, Metal Casting Technology Inc., U.S.A.

In this paper, the effect of magnesium and strontium additions on the heat treatment behaviour of cast A319.2 alloy was investigated. Permanent mold samples were heat treated at 495 °C for 4 and 24 h, then quenched in hot water and aged at 180 °C and 220 °C for different temperatures. It is found that multiple aging peaks are present in the age-hardening curves of Al-Si-Cu alloys, mainly when Mg and Mg-Sr are added. The results of electron probe microanalysis (EPMA) observations reveal that the age-hardening behaviour is related to the precipitation sequence of alloys. For the Al-Si-Cu alloy, the first aging peak is the result of the high-density GP zones, while the subsequent peaks arise from metastable phases. Obvious intervals during the transition from GP zones to metastable phases may be the main reason of the formation of multiple aging peaks. It is seen that addition of Mg (~0.40 wt %) leads to the precipitation of coarse $Al_5Mg_8Si_6Cu_2$ particles. When modifying the high Mg alloys, Cu-intermetallics segregate in areas away from the growing Al-Si eutectic regions. Modification with strontium retards the precipitation of the silicon out of the matrix.

PAPER 15.3—9:20

SIMULATION OF MICROPOROSITY IN A356 ALUMINUM ALLOY CASTINGS: THE ROLE OF HYDROGEN TRANSPORT.

S.L. COCKCROFT, J.D. ZHU, B. ZHANG and D.M. MAIJER, University of British Columbia, Canada

A numerical model for predicting microporosity formation in aluminum castings has been developed, which describes the redistribution of hydrogen between solid and liquid phases, the transport of hydrogen in liquid by diffusion and Darcy flow in the mushy zone. One of the key features of the model is that it uses a two-stage approach for porosity prediction. In the first stage, the volume fraction of porosity is calculated based on the reduced pressure, whereas, in the second stage, at fractions solid greater than the liquid encapsulation point, the fraction porosity is calculated based on the volume of liquid trapped within the continuous solid network, which is estimated using a correlation based on the Niyama parameter. The porosity model uses thermal data calculated using the commercial finite element package ABAQUSTM. The model has been applied to examine the evolution of porosity in a series of experimental samples cast using unmodified A356 in which the initial hydrogen content was varied from 0.048 to 0.137 [cc/100g]. A comparison between the model predictions and the experimental measurements indicates good agreement in terms of the variation in porosity with distance from the chill and the variation resulting from initial hydrogen content.

PAPER 15.4—9:45

APPLICATION OF RHEOLOGICAL STUDY TO CHARACTERIZE THE MICROSTRUCTURE OF SSM RHEO-CAST BILLETS.

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Manipulation of pouring temperature is an efficient way to produce different microstructural features. In order to characterize the microstructure of rheocast billets due to different superheats of 615-695 °C, the parallel plate compression method was employed. Foundry 356 Al-Si alloy with different morphologies of primary α -Al particles were tested at different initial pressures of 4.8, 11.2 KPa. The resulted strain-time graphs were further treated mathematically to calculate viscosity of SSM billets. The interrelationships of viscosity, the microstructure and primary phase flow during compression are discussed. It is shown that the dendritic primary α -Al structure has the highest viscosity number which is almost three orders of magnitude greater than those for globular morphology. The current research have, for the first time, shown the validity and reliability of “parallel plate compression viscometry” method in characterizing microstructural evolution of Rheocast SSM billets.

COFFEE BREAK—10:10–10:40

PAPER 15.5—10:40

DEVELOPMENT OF A NEW CRITERIA FUNCTION TO PREDICT MICROPOROSITY IN 319 AL-SI CASTING.

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The 319 Al-Si alloy is one of the most prominently used aluminium-based alloys in motor vehicle and engine applications. Microporosity present in 319 alloy castings reduces the load bearing capacity of the castings. The quantitative prediction of microporosity levels in Al-Si castings has been a subject of much interest for several years. In this research a new criteria function, $t_f^{1.98} R^{1.30}$ (t_f : local solidification time, R: cooling rate) was developed by multiple regression analyses, correlating thermal data from simulation studies to experimentally obtained microporosity values. This new criteria function gives a general prediction of microporosity in 319 Al-Si castings.

PAPER 15.6—11:05

DYNAMIC WETTING SPREAD FACTORS AND INTERFACIAL HEAT TRANSFER COEFFICIENTS IN THE SOLIDIFICATION OF ALUMINUM DROPLETS ON COPPER SUBSTRATES.

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L. KISS, Université du Québec à Chicoutimi, Canada

Dynamic wetting spread factors and interfacial heat transfer coefficients were determined for aluminum droplets solidifying on copper substrates. The spread factors were determined from the droplet geometries while the heat transfer coefficients were obtained by solving inverse heat conduction problems. 1-D and 2-D heat transfer models are presented and the results they provided are compared. For the latter, a sensitivity analysis was also performed to determine the influence of thermophysical properties and boundary conditions. Experiments were alternatively carried out with three different gaseous atmospheres and the dynamic wetting spread factors were correlated to the interfacial heat transfer coefficients.