Fundamentals of High Temperature Processes

Prediction of generation rates in "reactive arc plasma" ultrafine powder production process
A.M.FUDOLIG et al.

The vaporization rates of several metal beads subjected to transferred arc plasma impingement were calculated based on combined mathematical models of the arc plasma and the metal bead. Predictions of vaporization rates are made by solving conservation equations of mass, momentum and energy of the arc and the metal target. As a result of examination of three vaporization models, vaporization rate of metals in transferred arc plasma impingement is described well by a combined Langmuir vaporization and mass transfer through the anode concentration boundary layer. The vaporization rate of metals at the molten pool surface increases with the use of nitrogen gas over argon, increasing arc current, shorter arc lengths, or a higher gas inflow rate.

Ironmaking and Reduction

Thermal stress analysis of coking behavior of the packed bed of coal in oven chamber — effects of creep, dilatation and reaction fraction dependence of thermophysical properties of coal —
K.GOTO et al.

The internal stress of a lump coke in a coke oven chamber is analyzed using a creep model, which can represent a deformation behavior of the lump coke. The thermal stress analysis, which has been previously developed by authors to estimate the stress distribution within the lump coke in the laboratory scale oven, is improved with considering the creep characteristics of the plastic and semi-coke layers, dilatation of the plastic layer and the pyrolytic reaction fraction dependence of thermophysical properties. The effects of the above-mentioned models on the stress distribution and deformation behavior within the lump coke are discussed in this study. The calculated stress distribution and deformation behavior within the lump coke leads to the following conclusion: 1) The pyrolytic reaction fraction dependence of the thermophysical properties influences on the results of the heat transfer within the lump coke and the heating rate at the region near the coke oven center is estimated to be higher than one calculated with the properties which are measured in the constant heating rate condition. 2) The y-directional tensile stress at the center of the lump coke, which is calculated with the creep analysis, is half of the one of the elastic analysis. 3) The clearance which is defined as a distance between heated wall and lump coke is smaller because of considering the dilatation of the plastic layer. 4) The model used in this study can more accurately predict the formation/propagation of transverse fissure within the lump coke. Thus the creep model would be an effective tool to investigate the coking process.

Casting and Solidification

Asymmetry and oscillation of the fluid flow pattern in a continuous casting mould: a water model study
D.GUPTA et al.

The fluid flow pattern inside the continuous casting mould is mostly asymmetrical about the central plane and oscillating. Present work studies the frequency of flow oscillation for different mould dimensions, SEN position and its configuration, fluid inlet condition into the mould etc. A time average symmetry has been observed in the prevailing flow pattern inside the mould. However, this symmetry is disturbed when the SEN is displaced from its symmetrical position by more than four percent of the mould width. An upward SEN port angle and increase of flow rate increase the frequency of flow oscillation significantly. The use of a buffer over the continuous casting mould does not reduce the frequency of flow oscillation.

Numerical analysis of the influences of operational parameters on the fluid flow and meniscus shape in slab caster with EMBR
Y.-S.HWANG et al.

A package of computer programs which can calculate fluid flow, induced current, argon gas fraction in molten steel, and meniscus shape was developed and applied to the numerical study on the effects of EMBR. In the numerical analysis of the fluid flow, BFC (Body Fitted Coordinate) was implemented into FVM (Finite Volume Method) to consider complex geometry of the SEN (Submerged Entry Nozzle) and irregular shape of the meniscus.

In investigation about the influence of important operating parameters on the effect of EMBR, several useful standards like the followings were used as evaluation standards: average velocity beneath the meniscus, the shape of the meniscus, and the standard deviation of velocities of each grid plane along the casting direction. In spite of general stabilizing effect of EMBR, it was found that the molten steel stream spouted from the SEN makes bypasses to avoid strong magnetic field region under particular conditions: such bypasses act as channels and prevent uniform distribution of the flow. A mechanism and conditions for the formation of them were suggested in the discussion.

Grain refinement during melt-spinning of dilute Cu-base and Ni-base alloys
R.MATSUKI et al.

In order to obtain a fine and equiaxed grain structure in a casting, grain formation has been examined in past work in terms of undercooling of the melt, promotion of heterogeneous nucleation and remelting or fragmentation of dendrites. Some techniques to obtain grain refinement are commercially used, but the mechanism is not fully understood. The addition of a second element to a pure metal is one of the possible ways to obtain grain refinement in bulk samples. In the present work, this approach was taken with a melt-spinning method, which allows for an extremely directional and rapid heat extraction.

Dilute Cu-base and Ni-base alloys with selected solute additions were studied to examine the operating mechanism of the grain refinement in melt-spun alloys. In melt-spun Cu-base and Ni-base binary alloys, it was found that the type of solidification structure (columnar or equiaxed) can be predicted by the constitutional undercooling parameter, P, in most alloy systems as well as the case of bulk samples. There were some cases in which the melt-spun grain structure was not consistent with the P parameter prediction. In all cases, however, the final solidification temperatures of the alloys appear to be correlated to the development of grain refinement. As a result, to explain all the results in the present work, a model has been proposed which considers the effects of the parameter P, dendrite fragmentation and final solidification temperature concurrently and offers useful guidance in alloy design for optimum grain refinement.

The δ to γ transition in Fe-Cr-Ni alloys during laser treatment
S.FUKUMOTO et al.

Laser remelting experiments have been performed with Fe-18%Cr-Ni alloys to evaluate the effects of composition (Cr/Ni ratios between 1.30 and 1.83) and growth velocity (0.9 to 50 mm/s) on the microstructure selection during solidification between primary δ-ferrite and primary γ-austenite. The experimental results are compared with theoretical predictions from a dendrite growth model. The experimental transitions from ferrite to austenite are in good agreement with theory for both an increase in Ni content and increase in growth rate. The transitions from austenite to ferrite are found to occur at lower Ni contents than predicted. It is thought that the δ-γ transition shows no nucleation barrier and is controlled by dendrite growth kinetics and the γ-δ transition is controlled by nucleation of ferrite.

Surface Science and Technology

Corrosion inhibition on iron with propargylic alcohol in acid solutions
M.GOJIC et al.

The corrosion inhibition of iron by propargylic alcohol (PA) in sulphuric acid was discussed by correlating the corrosion kinetics obtained by DC polarization measurements with surface structure obtained from AC impedance spectroscopy and IR spectroscopy. Both anodic and cathodic reactions were affected primarily by the addition of the inhibitor. Therefore PA can be appreciated as a

mixed type inhibitor. The inhibition process was recognized as the substitution adsorption process. The number of water molecules replaced by one molecule of PA was 3. Standard free energy of adsorption, calculated at the corrosion potential E_{corr} on the basis of Langmuir type isotherm, was -31.2 kJmol^{-1}.

Impedance spectroscopy revealed that the inhibitor adsorption was nonuniform and led to decreased surface heterogeneity and formation of the protective surface film. IR-spectra of PA-inhibited specimens suggested that the inhibiting film formed after prolonged immersion time at E_{corr} was composed of mainly fully saturated hydrocarbons. The stable species of iron carboxylate and alcoxide contributed to strong adhesion of the film to the iron surface as well as to the protective properties of the film.

Development of corrosion data system for maritime steel structures
M. YAMAMOTO et al.

A corrosion data system for maritime steel structures has been developed. This system is designed not only for retrieving the measured date of corrosion but also for analyzing large amounts of measured data to help derive corrosion mechanisms for steel in a marine environment. The system is based on RDBMS and is integrated with statistical analyzing package, graph plot software and an image handling program. The graphical user interface helps users to carry out complex query procedures easily. The data model using a classification of material data was employed and this data model has been effective for analyzing input data.

The results obtained by the present system have included much new corrosion information for maritime steel structures. Especially, if the exact environment factors were not measured, the data are estimated using a classified key word. In this point of view, the present system is a very useful tool for corrosion science.

Microstructure

Influence of ferrite rolling temperature on microstructure and texture in deformed low C and IF steels
M.R.BARNETT et al.
Single pass rolling experiments were carried out on two low carbon steels and an IF grade at temperatures between ambient and 700°C. The main aim was to investigate the transition from the well known behavior observed under cold rolling conditions to the less understood warm rolling behavior. Three aspects of the

deformed state were examined: the occurrence of in-grain shear banding at angles of 30°-35° (and 17°-20°) to the rolling plane; the stored energy of deformation; and the final texture. These were chosen because of their effect on recrystallization. In-grain shear bands were evident, to one degree or another, in all samples. Their sensitivity to deformation temperature, however, was markedly different in the two low C grades compared to the IF grade. In the low C material, the frequency of banding was high at low temperatures but virtually nil at high temperatures. The degree of banding remained constant with temperature in the IF steel. These observations are explained in terms of strain rate sensitivity differences. The stored energy measurements were consistent with results in the dynamic strain aging literature. The deformation textures obtained were also in line with typical ferrite rolling textures. The overall sharpness of the rolling textures of the low C grades, however, increased markedly with temperature. This is ascribed to a drop in the texture weakening caused by in-grain shear banding.

Influence of ferrite rolling temperature on grain size and texture in annealed low C and IF steels
M.R.BARNETT et al.

Single pass rolling experiments were carried out on two low carbon steels and an IF grade at temperatures between ambient and 700°C. These were followed by salt bath annealing treatments. The main aim was to investigate the effect of the transition from cold to warm rolling on annealing behavior. Three aspects of annealing were examined: the kinetics of recrystallization; the final grain size; and the resulting texture. The sensitivity of these to the deformation temperature was markedly greater in the low C grades than in the IF grade. In the low C material, changing the rolling temperature from cold to warm resulted in an increase in time to 50 % recrystallization of about 11/2 orders of magnitude, a two-fold increase in final grain size and a remarkably different texture (i.e. one composed of a partial RD fibre instead of the typical ND fibre). By comparison, recrystallization was only slightly influenced by deformation temperature in the IF steel. These observations are explained in terms of the influence on nucleation of the stored energy and the degree of in-grain banding. In particular, the present results suggest that in-grain shear bands play a larger role in the formation of ND fibre grains than previously thought. From an industrial standpoint, IF steels clearly

lend themselves more readily to the replacement of cold by warm rolled material than do low C grades.

Mechanism of isothermal eutectoid transformation in high carbon stainless steels
T. TSUCHIYAMA et al.

Morphology and growth mechanism of eutectoid structure were investigated in 12 mass % Cr steels with various carbon content, by means of microstructural examination with optical and electron microscope. The alloys were once subjected to full solution treatment at a high temperature, and then held at a lower temperature to perform eutectoid transformation isothermally. 12% Cr-0.7% C steel can complete eutectoid transformation, and carbide particles are dispersed homogeneously. On the other hand, in the low carbon steels (the 0.3 % C and 0.15 % C), eutectoid transformation occurs only at the first stage of isothermal aging, and then γ-α transformation follows at the later stage. This results in the formation of an inhomogeneous structure composed of a cellular eutectoid structure and ferrite in the low carbon steels. The growth rate of eutectoid structure in the 0.7 mass % C steel is controlled by the lattice diffusion of carbon in austenite, and it can be evaluated theoretically as a function of the lattice diffusion coefficient of carbon in austenite and the thickness of diffusion layer.

Physical and Mechanical Properties

Mechanical properties of M7 high speed cast steel modified with niobium
S.KHEIRANDISH et al.

Some parts of W and V in a high speed M7 steel were replaced by Nb to improve the mechanical properties. Microstructure and mechanical properties of as-cast and heat treated samples of this modified steel were investigated by both light microscope and electron microscope coupled with an EDX analyser. Various heat cycles were applied in order to optimize the mechanical properties of this cast steel. The properties were compared with those of a standard cast and a wrought M7 and a wrought M2 high speed steels for better understanding of the effects of alloy modification.

It was shown that high temperature hardness and cutting performance of the modified cast steel in a properly heat treated condition, are about 95 and 70 % of those of a standard wrought M7 and a wrought M2 steel, respectively.