（＊掲載記事題目及び掲載頁は変更になる場合があります。）

Fundamentals of High Temperature Processes

Wettability effects on liquid flow characteristics in a bubbling wall jet along a vertical flat plate

M.IGUCHI et al.

A bubbling wall jet was generated along a vertical flat plate with different wettability by using a single-hole nozzle. Water flow characteristics in the jet were measured with a laser Doppler velocimeter. Effects of the wettability of the plate emerged on the water flow characteristics primarily in the momentum region near the nozzle tip where the inertia force of injected gas governed the flow field. In the buoyancy region located above the momentum region, the horizontal distributions of the vertical mean velocity and the root-mean-square value of the vertical turbulence component of water flow were hardly dependent on the wettability of the plate and followed their respective similar distributions.

(cf. *ISIJ Int.*, **40** (2000), 1)

Reduction of FeO in slag with coal char

K.SEO et al.

Recently, many blast furnaces have increased pulverized coal injection. Unburnt coal char is generated from pulverized coal injection and a portion of it remains in the slag. This interferes with tapping by increasing slag viscosity, and can make blast furnace operation unstable. Reduction of FeO with different types of coal was measured in simulated blast furnace slags at 1 450°C, using a constant volume pressure increase (CVPI). The reaction rate of FeO was observed to be independent of the type of coal used regardless of different components such as volatile matter and ash. The measured rates at 1.0% and 3.0% of FeO in the slag were 2.77×10^{-7} and 1.58×10^{-8} mol/cm^2 s respectively. The overall rate is controlled by a series of processes such as the reaction of CO_2 with C, CO with FeO in slag, liquid phase mass transfer of FeO in the slag, and gas phase mass transfer. For low FeO contents, when the gas evolution rate is low, liquid phase mass transfer is the primarily controlling mechanism. A model to predict the amount of char in the slag at tap based on these results is presented.

(cf. *ISIJ Int.*, **40** (2000), 7)

Ironmaking

Fluidization characteristics of iron ore fines of wide size distribution in a cold tapered gas–solid fluidized bed

H.G.KIM et al.

The effects of taper angle on the particle size distribution in a tapered gas–solid fluidized bed was experimentally investigated using two different iron ore fines (–5 mm and –8 mm) of wide size distribution. From the analysis of axial and radial particle size distribution of iron ore fines taken from the bed, it was found that the taper angle is the most critical parameter to minimize the size segregation along the fluidized bed level and there is a downward flow of finer particles along the walls. The effect of superficial gas velocity on the particle size distribution in fluidized bed and the effect of ore size on the taper angle required for minimizing the size segregation are also discussed. The present study has endeavored to obtain fundamental data for an effective plant operation and design of a fluidized-bed reduction furnace using sinterfeed through fully understanding the effects of taper angle and the gas velocity on the particle size distribution in a cold tapered gas–solid fluidized bed.

(cf. *ISIJ Int.*, **40** (2000), 16)

Steelmaking

Characteristics of jets from top-blown lance in converter

K.NAITO et al.

It is important to know the behavior of jets from a top-blown lance in order to control the reactions in the converter. However, there are few studies on the jet characteristics under incorrect expansion and the interference behavior of multiple jets.

In this study, the characteristics of jet under incorrect expansion and the interference behavior of multiple jets were investigated by experiments using a cold model. Furthermore, hot model experiments using a 6 t converter were conducted in order to investigate the correlation between the velocity of jet and dust generation.

There is good correlation between dust generation and the velocity of jet, and dust decreases by utilizing incorrect expansion for soft-blow.

(cf. *ISIJ Int.*, **40** (2000), 23)

Casting and Solidification

Improvement of castability and quality of continuously cast steel

D.JANKE et al.

Thermodynamic fundamentals on the systems Fe–Al–O and Fe–Al–Ca–S–O being important to metallurgy of Ca-treated Al-killed steels are analysed and discussed. The formation of liquid Ca aluminates for the improvement of castability is pursued in view of the production of Ca-treated Al-killed steels. The "Liquid window" is theoretically analysed and experimentally investigated. The top slag is formed after tapping and its composition is fairly constant during ladle treatment for both with and without RH treatment, respectively. However, the top slag of the degassed heats shows a lower oxygen level compared to the non-degassed heats. It is found that there exists an "einclusion path" during the ladle treatment. The inclusion path for the heats with RH treatment considerably differs from that of the heats without RH treatment and it greatly influences the efficiency of Ca treatment.

(cf. *ISIJ Int.*, **40** (2000), 31)

Reoxidation behavior of molten steel in tundish

K.SASAI et al.

It is necessary to clarify the reoxidation factors and quantitatively determine the contribution of each factor to the reoxidation of the molten steel to prevent the contamination in the tundish. In this study, the molten steel in tundish has been sampled in production scale experiment and from the composition change of the molten steel the amount of reoxidation of the molten steel teemed from the first ladle into an actual tundish has been quantified by factor as divided into initial teeming stage and stable casting stage. By applying the reaction rate model of oxidation by air which was developed on the basis of the basic experiment, the amount of oxidation by air in the tundish has been predicted successfully. Comparison of the amounts of oxidation by air calculated from the change in the N content with the experimentally determined amounts of oxidation has shown that it is difficult to judge whether or not the molten steel is oxidized from the N absorption behavior alone.

(cf. *ISIJ Int.*, **40** (2000), 40)

Numerical modeling of deflected columnar dendritic grains solidified in a flowing melt and its experimental verification

S.Y.LEE et al.

A two-dimensional, coupled, cellular automaton-continuum model was developed to model the evolution of solidification grain structures and the deflection behavior of the columnar dendritic grains solidified in a flowing melt. Al–Cu alloys were solidified on an inclined Cu chill in order to investigate the deflection behavior of columnar grains. The growth velocity of a dendrite was determined by the KGT (Kurz–Giovanola–Trivedi) model based on the calculated temperature and solute profiles around a dendrite tip during solidification. The deflection behavior of the growing grains in a flowing melt was studied by the macroscopic observation of the solidified shell on the inclined Cu chill plate, and the interpretation of this phenomenon was made with the aid of numerical calculation, including Cu solute redistribution and velocity vector profile around dendrite tips during solidification, with various solidification parameters. Effects of flow velocity and solute content on the deflection angle of the columnar grains were investigated through experiments, and the results were compared with the numerical simulations.

(cf. *ISIJ Int.*, **40** (2000), 48)

Forming Processing and Thermomechanical Treatment

Effect of initial sheet thickness on shear deformation in ferritic rolling of IF-steel sheets

K.-K.UM et al.

The effect of sheet thickness on shear deformation and texture for the ferrite rolling has been studied. The shear deformation was estimated from the distorted shape of inserted wire before rolling and FEM simulation. The deformed shape of inserted wires and FEM results showed that the shear strain decreased with increasing initial sheet thickness. The measured and simulated textures also showed that the Goss component changed to Dillamore component as the thickness increased. From rolling simulation of 20% reduction, the minimum shear deformation was found to exist for the given roll

bite geometry and friction coefficient.

(cf. *ISIJ Int.*, **40** (2000), 58)

FE-based analysis for the microstructure evolution in hot bar rolling

J.YANAGIMOTO et al.

A new FE-based analysis model for the microstructure evolution in hot rolling is proposed. Incremental formulations for the prediction of microstructure evolution are coupled with three-dimensional finite element method for the analysis of plastic deformation and temperature. By using an integrated FE-based model for the evolution of microstructure in hot rolling, cross-sectional grain size distributions after hot bar rolling are successfully simulated. Change in grain size of bar rolled by two-roll mill and three-roll mill, and microstructure evolution related to grain coarsening in bar sizing mill are shown and discussed.

(cf. *ISIJ Int.*, **40** (2000), 65)

Welding and Joining

Some basic aspects of geometrical characteristics of pulsed current vertical-up GMA weld

H.S.RANDHAWA et al.

The performance of pulsed current gas metal arc welding (GMAW) in vertical-up position has been studied in reference to thermal behaviour of the droplet at the time of deposition affecting the geometrical characteristics of weld deposit. A more realistic estimation of heat generation at tip of the filler wire has been worked out by modifying its resistive heating component using effective current (RMS value) of the pulse current wave. The estimated rate of heat generation and measured burnoff rate of the filler wire are correlated to a factor ϕ defined as summarised influence of pulse parameter such as peak current, base current, pulse duration and pulse frequency. Analysis of heat balance in between the heat generated at tip of the filler wire and heat consumed in melting the volume of filler wire fed to the arc indicates that the temperature of droplet decreases with the increase of both ϕ and mean current. The variation in pulse parameters affects the weld geometry by maintaining a good correlation with factor ϕ. In consideration of these correlations, a qualitative understanding over the control of pulse current GMAW process in vertical-up position, affecting weld geometry has been developed.

(cf. *ISIJ Int.*, **40** (2000), 71)

Effects of aluminum on weldability of nonoriented electrical steel sheets

Y.KUROSAKI et al.

The effects aluminum has on the weldability of nonoriented electrical steel sheets as related to blowholes and welding bead width was studied. The addition of aluminum to steel sheets decreased the numbers of blowholes and widened the welding bead width in Gas Tungsten Arc Welding. The following effect of aluminum in steel sheets on welding blowholes was observed. The organic components in the inorganic-organic coating applied on steel sheets gasified due to welding heat and CO gas was generated. The gas dissolved in weld pool and CO gas became dissolving C and O. Aluminum acted as a deoxidizer and decreased dissolving oxygen. CO gas which generated at solidification of the weld pool was decreased. As a result, the addition of aluminum in steel decreased blowholes. The effect of aluminum in steel sheets had on welding bead width was as follows. Oxygen has been known to make the shape of welding bead deep and narrow. In the case of welding after consumer annealing, oxide film formed on the cut surface during consumer annealing. Aluminum deoxidized the dissolved oxygen which penetrated from the oxide film into the weld pool at the time of welding. As a result, the addition of aluminum in steel made the shape of welding bead shallow and wide. The driving force of convection in the weld pool of nonoriented electrical steel sheets was the surface tension because the penetration changed by the presence of oxide film on the surface in Al-free specimens even in laser welding in which electromagnetic force did not work.

(cf. *ISIJ Int.*, **40** (2000), 77)

Mechanical Properties

Description of stress–strain curves based on thermal activation models for a Ti–Fe–O alloy at 77 to 296 K with strain rates from 10^{-9} to 10^{-2} sec^{-1}

N.TSUCHIDA et al.

Using two thermal activation models for dislocation motion, we analyzed experimental data for a Ti–Fe–O alloy. One is the Kocks–Mecking model and the other is the Ogawa model. These two models differ from each other in the determination of athermal stress component and the modeling of work hardening. The Kocks–Mecking model is found to describe well the measured flow curves in a temperature range between 77 and 296 K and in a strain rate range between 10^{-5} and 10^{-2} sec^{-1}. The so-called base curve is found to be a flow curve at the strain rate of approximately 10^{-9} sec^{-1} by the calculations using the Kocks–Mecking model. In actual, the strain rate of 10^{-9} sec^{-1} is approximately the minimum strain rate obtained by the crosshead displacement dwell test. The Ogawa model was found to be insufficient to describe the above flow curves for the Ti–Fe–O alloy.

(cf. *ISIJ Int.*, **40** (2000), 84)