Fundamentals of High Temperature Processes

Determination of aluminum and oxygen contents in liquid iron in equilibrium with α-alumina and hercynite
K.WASAI et al.

The constitution of $\underline{Al}$ and $\underline{O}$ at 1 873 K at the co-existing point, at which the Fe–Al–O system was in equilibrium with both of $FeO \cdot Al_2O_3$ and $\alpha\text{-}Al_2O_3$, was investigated, and the measured $\underline{Al}$ and $\underline{O}$ contents were found to be 0.072 mass% $\underline{O}$ and 0.0018 mass% $\underline{Al}$. The $\underline{O}$ content of this point agrees well with other measured values. The $\underline{Al}$ content of this point is two orders of magnitude larger than the activity of $\underline{Al}$ but agrees fairly well with the $\underline{Al}$ content predicted by an associated solution model and that measured by Novokhatskiy *et al.* This result reveals that the equilibrium curve (E.C.), which indicates the $\underline{Al}$ and $\underline{O}$ contents in liquid Fe in equilibrium with $\alpha\text{-}Al_2O_3$, is a concave curve in the low $\underline{Al}$ region that extends to the coexisting point. However, the E.C. calculated using the interaction parameters and deoxidation constant K is almost a straight line. This discrepancy indicates that the use of the interaction parameters reported for this system is probably inappropriate in the concave E.C. region. The interaction parameters and thermodynamics of this system should be reexamined.

Swirl motions in a cylindrical bath induced by gas injection under reduced pressure on surface
M.IGUCHI et al.

Swirl motions occurring in a bottom blowing water bath of an aspect ratio between approximately 0.2 and 1.0 were observed by eye inspection and with a high-speed video camera. The aspect ratio is defined as a ratio of the bath depth to the bath diameter. Effects of reduced pressure on the period, amplitude and some related aspects of the swirl motions were investigated. Measured values of these quantities for gas injection under the reduced pressure on the bath surface agreed with their respective measured values for gas injection with the same volumetric gas flow rate under the atmospheric pressure on the bath surface. Empirical equations for these quantities were proposed.

Steelmaking

A model of an induction-stirred ladle accounting for slag and surface deformation
J.ALEXIS et al.

A 3 dimensional 2-phase model of an induction stirred ladle has been developed. The model is based on fundamental transport equations and includes the solution of steel- and slag-phase. Predicted velocities are in very good agreement with experimental data. Predicted velocities and turbulent kinetic energy dissipation from the model are shown to have linear relationships with input stirring force for different cylindrical ladles. Linear equations for these relations are presented. Further calculations have shown that these linear equations also are able to predict velocities for a conical ladle.

Back-attack phenomena of gas jets with submerged horizontally blowing and effects on erosion and wear of refractory lining
J.-H.WEI et al.

Taken the refining process in an 18 t AOD vessel for example, the "back-attack" phenomena of the horizontal rotating and non-rotating gas jets and their effects on the erosion and wear of the refractory lining were investigated in a water model. For this refining process, the two-tuyere (lance with constant cross-sectional area) blowing of gas is operated using the annular-tube type tuyere. The geometric similarity ratio of the model unit (including the tuyere) with its prototype was 1/3. The relations of the gas blowing rate, blowing pressure, angular separation between the two tuyeres, type of tuyere and other operation parameters with the back-attack action of the gas jet and the refractory lining erosion and wear were examined under the different operating modes. The appropriate back-attack frequencies and pressures were continuously monitored and measured by means of a dynamic resistance strain-meter of YD-21 type with an anti-water pressure sensor made specially. A light-beam oscilloscope of SC16A type recorded simultaneously the back-attack waves. Also, the modeling experiment on the erosion and wear of the refractory lining was carried out. The results indicated that the back-attack phenomena of the horizontal rotating and non-rotating gas jets have respectively the different features from that in a bottom blowing. On the back-attack phenomena of these two kinds of jets, the gas streams of the inner tubes (main-tuyeres) have all a governing bearing, and the annular slit pipe (sub-tuyere) streams show an evident alleviation and suppression effect. The circulative motion of the liquid in the bath would be another important reason to bring about the back-attack phenomenon of a submerged gas jet. The buoyancy force gives a considerable influence; it is able not only to increase the back-attack intensity of a horizontal gas jet, but also to enlarge the locally eroded and worn zone of the refractory lining. The influence of the tuyere position (the angle included between the two tuyeres) is not so remarkable in the conditions of the present work. The rotating motion of a horizontal gas jet may decrease the frequency and intensity of the back-attack action and reduce the eroded and worn rate and area of the refractory lining under a same blowing pressure. The annular-spiral tube type tuyere with a reasonable structure may be expected to have a good latent using power and composite effectiveness.

Casting and Solidification

Design and plant experience using an advanced pouring box to receive and distribute the steel in a six strand tundish
J.MADIAS et al.

Based on water and math modeling work, a refractory device was designed aiming to improve the liquid steel flow in the tundish of the ACINDAR #2 billet, bloom and minislab caster. The simulation work took into account sequence start, ladle change and steady state.

The device improved flow behavior for the inner strands and helped minimizing slag emulsification and the contact of the steel with the air, especially at ladle change.

Better inclusion counts and temperature homogeneity throughout the sequence were obtained when using APB in the tundish.

Influence of injected Ar gas on the involvement of the mold powder under different wettabilities between porous refractory and molten steel
Z.WANG et al.

This research studied the involvement of mold powder and the influence of argon gas injection by means of a silicon oil–water model experiment and a 3-D numerical model. In this experiment argon gas was injected into the submerged entry nozzle through two kinds of cylinder-like porous refractory with and without wax film on inner surface. Investigation indicates that injected argon influence the involvement of silicon oil by give rise to a strong fluctuation on the interface between the water and the silicon oil layer that was used to simulate the mold powder of the continuous casting process. Silicon oil was involved more easily when the porous refractory with wax film was used than that as the porous refractory without wax film was used. This is because injected argon gas through the porous refractory with wax film produced a gas curtain inside the nozzle and in turn caused unstable water flow inside the mold and a strong fluctuation of the silicon oil–water interface. The results of experiment and numerical simulation agree with each other when gas injection rate is small. The involvement behavior of the mold powder the continuous casting process is thought to be similar to that as porous refractory with wax film was used because in both cases the wettability between the liquid and the porous refractory is poor.

Prediction of slag pool thickness in continuous casting mould
N.PRADHAN et al.

Physical properties of mould powder control the surface equality of the continuously cast products. Formation of mould slag of specific quality in caster mould requires correct formulation of melting rate property so that molten slag of adequate thickness is continuously generated. The melting of the casting powder, apart from mineralogical composition, is influenced by caster application conditions such as casting speed, oscillation parameters etc. The known melting rate tests are not amenable for quantitative prediction of slag pool thickness since they do not consider all the application conditions together.

Present work describes a methodology predicting slag pool thickness based on melting rate measurements using various known experimental techniques. The measured melting rate data has been combined to generate acceleration coefficients incorporating effect of slag consumption and mould oscillation on powder melting. An effective melting rate parameter (EMR) has been formulated using these coefficients. Measured slag pool thickness (d) during actual casting correlates well with the de-

fined EMR in the speed range of 0.55 to 1.5 m/min.

$$d = 35.70 \cdot EMR \cdot V/(a \cdot b) + 2.1, \quad R^2 = 0.94$$

The high confidence level of this correlation indicates applicability of effective melting rate parameter (EMR) concept for prediction of slag pool thickness.

Welding and Joining

Effects of oscillation on impact property of weldments
S.P.Tewari

The present paper deals with the effects of oscillation on impact property of mild steel weldments. Mild steel plates were welded at different frequencies and amplitudes of longitudinal and transverse oscillation. Frequencies and amplitudes of oscillations were varied in the ranges of 0 to 400 Hz and 0 to 40 μm respectively. Impact test specimens were made out of the stationary and oscillatory welded workpieces and were tested on Izod testing machine.

The absorbed energy of the welds prepared under oscillatory (longitudinal and transverse) conditions show significant increase in comparison to absorbed energy of stationary prepared welds. It was observed that 80 Hz–40 μm and 400 Hz–5 μm oscillatory condition gave best results, at 80 Hz and 400 Hz frequencies respectively. At lower frequency higher amplitude and at higher frequency lower amplitude produce maximum percentage increase. However, best results are obtained at 400 Hz–5 μm oscillatory condition where the percentage increase in absorbed energy may be attributed to grain refinement which is caused by the initiation of dendrite fragmentation and grain detachment mechanisms in the weld pool because of its oscillation.

Transformations and Microstructures

The influence of the substitution of Si by Al on the properties of cold rolled C–Mn–Si TRIP steels
M.D.Meyer et al.

The effect of the substitution of silicon by aluminium on the mechanical properties and the microstructure of cold rolled C–Mn–Si TRIP steels was investigated for different continuous annealing cycles.

The mechanical properties were evaluated using tensile testing. It was seen that the Al alloyed steel had very good mechanical properties with an improved formability compared to the conventional C–Mn–Si TRIP steel. The strain hardening behaviour was studied in detail. All the investigated specimens showed a very high n value but their strain dependence was different. For the conventional C–Mn–Si TRIP steel the maximum n value was reached at low strain, while the Al substituted TRIP steel showed a gradual increase of the n value. The latter effect resulted in a larger uniform elongation for the C–Mn–Al–Si TRIP steel.

Investigation of the microstructure using color etching and scanning electron microscopy revealed that the Al alloyed steel composition contained a larger amount of bainite with a finer structure than the C–Mn–Si TRIP steel. Furthermore, XRD measurements showed that the Al substitution resulted in a larger volume fraction of retained austenite.

Mechanical Properties

Fatigue of martensite–ferrite high strength low-alloy dual phase steels (Review)
Z.G.Wang et al.

Fatigue tests were carried out with as-rolled and heat-treated Si–Mn–Cr–Mo martensite–ferrite dual-phase steels at room temperature in air and 3.5% NaCl solution. The effects of duplex microstructural morphologies, martensite contents and environmental conditions on fatigue stress-life, cyclic deformation behavior, fatigue crack initiation and near-threshold fatigue crack growth were investigated. The influence of prestrain and ageing on fatigue threshold was also studied.

Mechanisms of surface deterioration of high-Ni grain roll for hot strip rolling
J.-W.Choi et al.

Wear test was carried out by using the two disc type wear testing simulator to clarify the effects of the following factors on the surface deterioration in high alloyed grain cast irons. Namely, contact stress, microstructures, high temperature wear behavior and initiation and propagation of the surface microcrack which is generally occurring during the hot rolling were studied. The test conditions are as follows; mated specimen temperature of 850°C, contact stress of 200 and 250 MPa and up to 1.25×10^4 revolutions with slip rate of 0.4 m/s. The mechanism of the deterioration of roll surface was discussed. During the early stage of hot rolling, surface of work roll is covered with the black film evenly formed by oxidation of roll material at high temperature, followed by the banding of black film. The wear resistant carbides initially surrounded with matrix are emerged by being worn out of the matrix during successive rolling. The emerged carbides induce the sticking phenomena by the evolution of uneven friction heat, and then the particles stuck on the roll surface disappear by the successive wear during hot rolling.