Ironmaking and Reduction

Reduction properties of sinter with fine dispersed pores at high temperatures of 1 273K and above

Y.HOSOTANI et al.

The change in the particle size distribution of limestone and coke breeze has been investigated to determine its effects on the sintering rate, sinter quality, sinter bed heat pattern and other parameters by the use of the sintering pot test. Furthermore, the sinters produced in the sintering pot tests have been evaluated as to their reducibility at 1 273 to 1 573 K in a high-temperature reduction test apparatus. If the particle sizes of both limestone and coke breeze are simultaneously adjusted, it is possible to improve the permeability of a raw mix and control the pore size distribution of the sinter product.

Simultaneous removal of a -1.0mm fraction from the limestone and a -0.5mm fraction from the coke breeze improves the granulation index and permeability of the raw mix, and is considered effective in shortening the high-temperature holding time in the sinter bed. Such removals also suppress the shrinkage of sinter cake, and also improve the pore network of the sinter cake to assure a uniform gas flow in the sinter bed and increase the sintering rate.

Fine pores can be prevented from coalescing into coarser pores if expansion of the heat pattern in the sinter bed is suppressed.

This study suggests that the number of fine pores in the sinter can be increased by reducing the small fractions of the limestone and coke breeze used in the raw mix and coalesced fine pores can increase the surface area of sinter to achieve a substantial improvement in its high-temperature reducibility.

Steelmaking and Refining

Processing of Fe_3Al based intermetallic alloys through electroslag remelting

R.G.BALIGIDAD et al.

A process comprising air induction melting (AIM) and electroslag remelting (ESR) for production of iron aluminides based on Fe_3Al is reported. Extensive hydrogen gas porosity is observed in air induction melted electrodes. Electroslag remelting of AIM electrode results in ingots free from gas porosity. Possible mechanisms for elimination of gas porosity during electroslag remelting are discussed. The cast ESR ingots exhibit a marked susceptibility to cracking at high power inputs due to high thermal gradients prevailing in the ingot. This may be attributed to the relatively low thermal conductivity and high coefficient of thermal expansion of Fe_3Al. At very low power levels the ESR ingots exhibited poor surface quality. Proper selection of process parameters during electroslag remelting of air induction melted electrodes results in sound ingots free from thermal cracks and exhibiting good surface quality.

Effect of carbon content on mechanical properties of electroslag remelted Fe_3Al based intermetallic alloys

R.G.BALIGIDAD et al.

The effect of carbon content (0.013 to 0.50 wt% C) on structure and mechanical properties of electroslag remelted iron aluminides based on Fe_3Al containing approximately 16 wt.% (28 at%) aluminium alloy has been studied. At low carbon contents (0.031 wt% or less) the ESR ingots suffer from hydrogen embrittlement which results in poor mechanical properties. At high (0.074 wt.% or more) carbon contents the hardeness and strength of ESR ingots increase with increasing carbon content without significant change in ductility. This is attributed to the solid solution strengthening arising from interstitial carbon present in the Fe_3Al matrix as well as to the increased amount of Fe_3AlC (perovskite) precipitation. The mechanical properties of these high carbon ESR cast alloys are comparable or superior to those reported for high purity wrought alloys with similar aluminium contents. The machinability of ESR ingots improves with increase in carbon content. This is attributed to the presence of uniformly distributed Fe_3AlC precipites in the ingots which allow formation of small and uniform size chips during machining.

Recycling of superalloy scrap through electro slag remelting

V.V.SATYA PRASAD et al.

Electro Slag Remelting (ESR) with a water cooled copper electrode has been used for recycling machined superalloy scrap. Careful electrode design and optimization of process parameters are necessary to achieve target composition and mechanical properties. The design criteria are discussed in detail. Coolant water flow rate and velocity need to be carefully chosen to ensure adequate cooling to the electrode. It is necessary to adopt liquid start technique while using the electrode. It is also essential to provide refractory metal (molybdenum) tips at the bottom of the electrode. These tips help in initiating and sustaining the ESR operation. The copper wall thickness should allow formation of a solid slag skin around the copper portion of the electrode to prevent electrode erosion as well as melt contamination. The superalloy scrap was charged through the annular gap between the mould and the electrode. Considering ingot chemistry, soundness and surface finish as the main criteria, ESR process parameters were optimized. Superalloy scrap of composition close to that of Nimonic 80A was remelted using the water cooled electrode. The process has potential for recycling a range of superalloy scrap and scaling up to produce large diameter ingots.

Liquidus relationships in the CaO-angle of the ternary system $CaO-Al_2O_3-SiO_2$

M.GÖRNERUP et al.

Saturation lines of CaO, $2CaO-SiO_2$ and $3CaO-SiO_2$ in the system $CaO-Al_2O_3-SiO_2$ were determined at 1 600 and 1 700℃ using a technique of solid phase dissolution in a liquid slag phase. The liquidus surface of $3CaO-SiO_2$ phase was found to be larger than expected. The solubility of $2CaO-SiO_2$ was found to be higher, especially at 1 700℃, and the CaO solubility was found to be lower then previously known. Finally, the solubility of $2CaO-SiO_2$ in the binary system $CaO-SiO_2$ was determined to be 2.5-3 wt.% higher than in the currently accepted system.

Casting and Solidification

Design of electromagnetic dams for the containment of metal melts, application to the belt/roll casting process

S.M.HASHEMI et al.

The model is presented for designing electromagnetic dams for the containment of metal melts. It is applied to compute side dams for the casting of steel strip with the belt / roll process. The electromagnetic field was obtained with the mutual induction method. Optimization algorithms were applied to determine the inductor configuration and to calculate the final shape of the melt. Experiments with Wood's metal have been conducted demonstrating that the designed inductor functioned as predicted.

Forming Processing and Construction

High-strain-rate superplasticity in metallic materials and the potential for ceramic materials (Review)

K.HIGASHI et al.

High strain rate superplasticity (*i.e.*, superplastic behavior at strain rates over $10^{-2}s^{-1}$)has been observed in many metallic materials such as aluminum alloys and their matrix composites and it is associated with an ultra-fine grained structure of less than about 3 μm. Its deformation mechanism appears to be differ ent from that in conventional superplastic materials. Experimental investigations showed that a maximum elongation was attained at a temperature close to the partial melting temperature in many superplastic materials exhibiting high-strain-rate superplasticity. Recently, a new model, which was considered from the viewpoint of the accommodation mechanism by an accommodation helper such as a liquid or glassy phase, was proposed in which superplasticity was critically controlled by the accommodation helper both to relax the stress concentration resulting from the sliding

at grain boundaries and/or interfaces and to limit the build up of internal cavitation and subsequent failure. The critical conditions of the quantity and distribution of a liquid phase for optimizing superplastic deformation was discussed and then applied to consider the possibility of attaining high-strain-rate superplasticity in ceramics materials.

Microstructure

Effect of initial grain size on the static recrystallization kinetics of Nb microalloyed steels

G.LI et al.

The static recystallization kinetics of a 0.08%C-0.055%Nb steel were investigated at 950℃ by means of interrupted hot compression tests; the results obtained in this way were analyzed using three different methods for assessing the fractional softening. In particular, the effect was studied of varying the initial grain size from 12 to 83μm. The exponent relating initial grain size to the time for 50% recrystallization was found to be about 1.7. This is somewhat less than the exponent of 2.0 conventionally employed for plain C-Mn steels, and which is often quoted in the literature as applicable to Nb grades. In addition, by means of comparison with previous work on grades with lower levels of Nb and Mn, it is shown that higher levels of Mn make significant contributions to the retardation of static recrystallization in Nb steels.

Continuous cooling transformation behaviour of microalloyed steels containing Ti, Nb, Mn and Mo

P.A.MANOHAR et al.

Continuous cooling transformation diagrams are determined for microalloyed steels containing Ti, Nb, Mn and Mo in undeformed as well as in thermomechanically processed conditions using dilatometry. Effects of thermomechanical processing, cooling rate and Nb content on γ/α transformation kinetics are presented. Thermomechanical processing is found to accelerate the onset of γ/α transformation (γ transformation start temperature, Ar_3, is raised). However, the progress of γ/α transformation is retarded considerably in deformed samples. Increase in cooling rate lowers Ar_3 significantly and accelerates the progress of transformation. Nb lowers Ar_3 of undeformed austenite but raises Ar_3 of thermomechanically processed austenite.

Physical and Mechanical Properties

Solid solution hardening of austenitic stainless steel single crystals with high nitrogen content

O.V.IVANONA et al.

A dislocation model is proposed, that describes the orientational and the temperature dependence of the critical resolved shear stress (CRSS) and the anisotropy of CRSS depending on the sign of the applied stress in single crystals of austenitic stainless steel with nitrogen impurities (interstitial atoms). This model explains that the solid solution hardening by the interstitial atoms is large in comparison to those by the substitutional atoms. The model takes account of the following: the change of the interstitial atom position in the lattice from octahedral interstice to tetrahedral site owing to passage of a leading Shockley's partial dislocation; the change in the separation width between two partial dislocations in external stress field; the relationship between the width of the extended dislocation and the elastic interaction of the extended dislocation with the impurity atoms.

Mathematical modeling of the mean flow stress, fractional softening and grain size during the hot strip rolling of C-Mn steels

F.SICILIANO JR. et al.

The logs for plain C-Mn grades from four different hot strip mills were analyzed in order to calculate the mean flow stress developed at each stand. The calculation, based on Sims's equations, takes work roll flattening, redundant strain, and the forward slip ratio into account. The stresses are compared with the predictions of a model based on an improved Misaka mean flow stress equation in which strain accumulation as well as the kinetics of static and dynamic recrystallization are fully accounted for. A good fit is observed between the model predictions and the mill data, with agreement generally falling within the interval ± 15%.

Mathematical modeling of mean flow stress during the hot strip rolling of Nb steels

K.MINAMI et al.

The mean flow stresses developed during the hot strip rolling of nine grades of Nb steel have been examined. For this purpose, log data obtained from four different strip mills were converted to mean flow stress using the Sims approach. The results are analyzed and compared to the predictions of a mathematical model that takes microstructural evolution into account. The model is based on the Misaka equation, but incorporates the effects of dynamic, metadynamic, and static recrystallization, and also takes the accumulated strain and Nb content into account. Excellent agreement between measured and predicted mean flow stress values is obtained over the whole range of rolling temperatures. In addition, the predictions indicate that dynamic, followed by metadynamic, recrystallization takes place in the latter passes of the finishing rolling of some Nb grades. This generalization applies particularly to the low Si and high Mn grades, indicating that the Si and Mn concentrations and not only the Nb level, determine whether or not dynamic and metadynamic recrystallization are observed under hot strip rolling conditions.