Alert Billet Casting (January 2017)

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Mixing and residence time distribution in an inert gas-shrouded tundish. S. Chatterjee, A. Asad, C. Kratzsch, R. Schwarze, K. Chattopadhyay
Tracer dispersion experiments were carried out in a multi-strand tundish by injecting 1 (N) NaCl solution into water. The variation of dimensionless concentration–time curves known as C-curves and mixing times with different gas flow rates were studied. The proportions of dead, mixed, and dispersed plug volumes were calculated using the ‘modified mixed model.’ The observations were explained by analyzing the behavior of the bubble plume, incoming jet velocity, and turbulent kinetic energy within the tundish.

Effect of fluid bypassing on the experimentally obtained Darcy and non-Darcy permeability parameters of ceramic foam filters. S. Akbarnejad, M. Pour, L. Jonsson, P. Jonsson
Ceramic foam filters (CFFs) are used to remove solid particles and inclusions from molten metal. In general, molten metal which is poured on the top of a CFF needs to reach a certain height to build the required pressure (metal head) to prime the filter. To estimate the required metal head, it is necessary to obtain permeability coefficients using permeametry experiments. It has been mentioned in the literature that to avoid fluid bypassing, during permeametry, samples need to be sealed. However, the effect of fluid bypassing on the experimentally obtained pressure gradients seems not to be explored. Therefore, in this research, the focus was on studying the effect of fluid bypassing on the experimentally obtained pressure gradients as well as the empirically obtained Darcy and non-Darcy permeability coefficients. Specifically, the aim of the research was to investigate the effect of fluid bypassing on the liquid permeability of 30, 50, and 80 pores per inch (PPI) commercial alumina CFFs. In addition, the experimental data were compared to the numerically modeled findings. Both studies showed that no sealing results in extremely poor estimates of the pressure gradients and Darcy and non-Darcy permeability coefficients for all studied filters.

Study of the viscosity of mold flux based on the Vogel–Fulcher–Tammann (VFT) model. L. Zhou, W. Wang
Viscosity is one of the most important properties of mold flux and affects the process of continuous casting significantly. In order to describe the variation of viscosity of mold
flux accurately in a wide range of temperature occurring in the casting mold, a non-Arrhenius Vogel–Fulcher–Tammann (VFT) model was adopted in this study. The results showed that the adjusted coefficient of determination (Adj. R²) of non-Arrhenius VFT Model ranges from 0.92 to 0.96, which suggests this model could be well adapted to predict the relationship between viscosity and temperature of mold flux. The temperature at which viscosity becomes infinite, TVFT, increased with the addition of Cr₂O₃ and improvement of basicity, while it decreased with the addition of B₂O₃, as it was determined by both the degree of polymerization of the melt structure and crystallization behavior of the melt. Also, the pseudo-activation energy, EVFT, of Samples 1 to 5 was 60.1 ± 3.6, 94.7 ± 14.9, 101.7 ± 19.0, 38.0 ± 4.8, and 32.4 ± 4.0 kJ/mol, respectively; it increased with the addition of Cr₂O₃ and B₂O₃, but decreased with the increase of basicity.

Center segregation with final electromagnetic stirring in billet continuous casting process. D. Jiang, M. Zhu

With a multiphase solidification model built, the effect of F-EMS parameters on center segregation was investigated in 160 mm × 160 mm billet continuous casting process. In the model, the initial growth of equiaxed grains which could move freely with liquid was treated as slurry, while the coherent equiaxed zone was regarded as porous media. The results show that the stirring velocity is not the main factor influencing center segregation improvement, which is more affected by current intensity and stirring pool width. Because solute transport is controlled by solidification rate as stirring pool width is 73 mm, center segregation declines continuously with current intensity increasing. As liquid pool width decreases to 61 mm and less latent heat needs to dissipate in the later solidification, the center segregation could be improved more obviously by F-EMS. Due to center liquid solute enrichment and liquid phase accumulation in the stirring zone, center segregation turns to rise reversely with higher current intensity and becomes more serious with stirring pool width further decreasing to 43 mm. As the stirring pool width is 25 mm, the positive segregation has already formed and solute could still concentrate with weak stirring, leading to center segregation deterioration. With the optimized current intensity (400 A) and stirring pool width (61 mm) set for continuous mode, center segregation improvement is better than that of alternative mode.

Effects of CaO/SiO₂ ratio and Na₂O content on melting properties and viscosity of SiO₂-CaO-Al₂O₃-B₂O₃-Na₂O mold fluxes. L. Wang, C. Zhang, D. Cai, J. Zhang, Y. Sasaki, O. Ostrovski

This paper investigated the effects of CaO/SiO₂ ratio (0.8 to 1.5) and Na₂O concentration (6 to 9 wt pct) on melting properties and viscosity of SiO₂-CaO-Al₂O₃-B₂O₃-Na₂O mold fluxes with a fixed B₂O₃ content. Melting properties of fluxes (softening temperature Ts, hemispherical temperature Th, and fluidity temperature Tf) were determined by the hot-stage microscopy method. Viscosity was measured using a rotating cylindrical viscometer, and structure of quenched fluxes was studied using Raman spectroscopy. Equilibrium phases in the SiO₂-CaO-Al₂O₃-B₂O₃-Na₂O system were calculated using FactSage. It was found that Th decreased with increasing CaO/SiO₂ ratio from 0.8 to 1.0 and increased with a further increase in the CaO/SiO₂ ratio to 1.5. The effect of Na₂O content in the range of 6 to 9 wt pct on Th of the flux with a fixed CaO/SiO₂ ratio at 1.3 was marginal. Increasing CaO/SiO₂ ratio and Na₂O content increased the break temperature and reduced the value of viscosity at 1673 K (1400 ºC). Viscosity of liquid fluxes was discussed in the relationship with the flux structure. Melting properties and viscosity of boracic fluxes were compared with those of industrial fluorine-containing mold fluxes.

Application of time-series analysis for predicting defects in continuous steel casting process. A. Rodziewicz, M. Perzyk

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The purpose of this paper was testing suitability of the time-series analysis for quality control of the continuous steel casting process in production conditions. The analysis was carried out on industrial data collected in one of Polish steel plants. The production data concerned defective fractions of billets obtained in the process. The procedure of the industrial data preparation is presented. The computations for the time-series analysis were carried out in two ways, both using the authors’ own software. The first one, applied to the real numbers type of the data has a wide range of capabilities, including not only prediction of the future values but also detection of important periodicity in data. In the second approach the data were assumed in a binary (categorical) form, i.e. the every heat (melt) was labeled as ‘Good’ or ‘Defective’. The naïve Bayesian classifier was used for predicting the successive values. The most interesting results of the analysis include good prediction accuracies obtained by both methodologies, the crucial influence of the last preceding point on the predicted result for the real data time-series analysis as well as obtaining an information about the type of misclassification for binary data. The possibility of prediction of the future values can be used by engineering or operational staff with an expert knowledge to decrease fraction of defective products by taking appropriate action when the forthcoming period is identified as critical.

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In order to achieve a higher steelmaking productivity and product yield while retaining world leading product quality across a wide range of engineered steel, TimkenSteel decided to install a vertical continuous casting machine (VCCM) in the premises of their Faircrest steel plant (Canton - OH, USA). The caster has been designed, supplied and commissioned by SMS-Concast (part of SMS Group) and put in operation in the last quarter of 2014. The TimkenSteel quality and size program required a unique custom designed caster. The special design incorporates a large (46Ox610mm) and a medium section (280x430) and features a special tundish design, a new designed vertical roll layout with CONCOR rolls and advanced technological packages, such as echanical soft reduction, bloom quenching, M-EMS, advanced stopper rod controls, hydraulic oscillator, on-line solidification model, and on-line breakout prevention system. The vertical nature of this caster required tailored engineering solutions for the bloom elevator, dummy bar car, and bloom inclined car. Capacity and utilization requirements necessitate numerous operational modes, such as dual casting, link casting, and a top/bottom feeding dummy bar, to ensure a high utilization and capacity of the caster as well as a highly flexible production. L1 and L2 automation complete the caster scope of supply in order to achieve a reliable and controlled process. TimkenSteel and SMS Concast worked in close cooperation throughout the Project to satisfy the design, operational, safety, and constructions challenges to ensure the highest surface and internal quality required by a demanding product mix. Special design solutions and initial results after CCM commissioning are presented in this publication.