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Metallurgical and Materials Transactions B, August 2016

Formation mechanism of CaS-bearing inclusions and the rolling deformation in Al-killed, low-alloy steel with Ca treatment. G. Xu, Z. Jiang, Y. Li

The existing form of CaS inclusion in Ca-treated, Al-killed steel during secondary refining process was investigated with scanning electron microscopy and an energy-dispersive spectrometer (EDS). The results of 12 heats industrial tests showed that CaS has two kinds of precipitation forms. One form takes place by the direct reaction of Ca and S, and the other takes place by the reaction of CaO in calcium aluminates with dissolved Al and S in liquid steel. Thermodynamic research for different precipitation modes of CaS under different temperature was carried out. In particular, CaO-Al2O3-CaS isothermal section diagrams and component activities of calcium aluminates were calculated by the thermodynamic software FactSage. By thermodynamic calculation, a precipitation-area diagram of oxide-sulfide duplex inclusion was established by fixing the sulfur content. The quantity of CaS, which was precipitated in a reaction between [Al], [S] and (CaO), can be calculated and predicted based on the precipitation-area diagram of oxide-sulfide duplex inclusion. Electron probe microanalysis and EDS were used for observing rolling deformation of different types of CaS-bearing inclusions during the rolling process. Low modification of calcium aluminates wrapped by CaS has different degrees of harm to steel in the rolling process.

Thermodynamics of complex sulfide inclusion formation in Ca-treated Al-killed structural steel. Y. Guo, S. He, G. Chen, Q. Wang

Controlling the morphology of the sulfide inclusion is of vital importance in enhancing the properties of structural steel. Long strip-shaped sulfides in hot-rolled steel can spherize when, instead of the inclusion of pure single-phase MnS, the guest is a complex sulfide, such as an oxide-sulfide duplex and a solid-solution sulfide particle. In this study, the inclusions in a commercial rolled structural steel were investigated. Spherical and elongated oxide-sulfide duplex as well as single-phase (Mn,Ca)S solid solution inclusions were observed in the steel. A thermodynamic equilibrium between the oxide and sulfide inclusions was proposed to understand the oxide-sulfide duplex inclusion formation. Based on the equilibrium solidification principle, thermodynamic discussions on inclusion precipitation during the solidification process were performed for both
general and resulfurized structural steel. The predicted results of the present study agreed well with the experimental ones.

**Sulfide capacities of CaO-MgO-Al2O3-SiO2-CrOx slags.** L. Wang, Y. Wang, K. Chou, S. Seetharaman
The sulfide capacities of CaO-MgO-Al2O3-SiO2-CrOx slags were measured by gas–slag equilibration method in the temperature range of 1823 K to 1898 K (1550 C to 1625 C) to reveal the effect of CrOx on the sulfide capacities of slags. Both higher basicity and temperature enhanced sulfide capacities. The CrOx additions in the range of 0 to 5 mass pct increased the sulfide capacity, but, further increase of CrOx contents to 7 pct was found to lower the sulfide capacity. Utilizing the relationship for estimating the ratio of Cr(II)/Cr(III) put forward by the present authors, the influence of Cr(II) on the sulfide capacities of the slags studied is discussed.

**Multiphase flow modeling of slag entrainment during ladle change-over operation.** R. Morales, S. Garcia-Hernandez, J. Barreto, A. Ceballos-Huerta, I. Calderon-Ramos, E. Gutierrez
Steel transfer from the ladle to a single-strand tundish using a conventional ladle shroud (CLS), and a dissipative ladle shroud (DLS) is studied during the transient period of ladle change-over operation. Fluid velocities and fluid flow turbulence statistics during this unsteady operation were recorded by an ultrasound velocimetry probe in a 1/3 scale water–oil–air analog model (to emulate steel-slag-air system). Reynolds stress model and volume of fluid model allow the tracking of water–oil, water–air, and oil–air interfaces during this operation. Velocity measurements indicate a very high turbulence with the formation of a water–air bubbles-oil emulsion. Flow turbulence and the intensity of the emulsification decrease considerably due to an efficient dissipation of the turbulent kinetic energy employing the DLS instead of the CLS. The modeling results indicate that DLS is widely recommended to substitute flow control devices to improve the fluid dynamics of liquid steel during this transient operation.

**Influence of the mold current on the electroslag remelting process.** M. Hugo, B. Dussoubs, A. Jardy, J. Escaffre, H. Poisson
The electroslag remelting process is widely used to produce high value-added alloys. The use of numerical simulation has proven to be a valuable way to improve its understanding. In collaboration with Aubert & Duval, the Institute Jean Lamour has developed a numerical transient model of the process. The consumable electrode is remelted within a mold assumed to be electrically insulated by the solidified slag skin. However, this assumption has been challenged by some recent studies: the solidified slag skin may actually allow a part of the melting current to reach the mold. In this paper, the evolution of our model, in order to take into account this possibility, is presented and discussed. Numerical results are compared with experimental data, while several sensitivity studies show the influence of some slag properties and operating parameters on the quality of the ingot. Even, a weakly conductive solidified slag skin at the inner surface of the mold may be responsible for a non-negligible amount of current circulating between the slag and crucible, which in turn modifies the fluid flow and heat transfer in the slag and ingot liquid pool. The fraction of current concerned depends mainly on the electrical conductivities of both the liquid and solidified slag.

**Multivariate analysis of ladle vibration.** J. Yenus, G. Brooks, M. Dunn
The homogeneity of composition and uniformity of temperature of the steel melt before it is transferred to the tundish are crucial in making high-quality steel product. The homogenization process is performed by stirring the melt using inert gas in ladles. Continuous monitoring of this process is important to make sure the action of stirring is constant throughout the ladle. Currently, the stirring process is monitored by process
operators who largely rely on visual and acoustic phenomena from the ladle. However, due to lack of measurable signals, the accuracy and suitability of this manual monitoring are problematic. The actual flow of argon gas to the ladle may not be same as the flow gage reading due to leakage along the gas line components. As a result, the actual degree of stirring may not be correctly known. Various researchers have used one-dimensional vibration, and sound and image signals measured from the ladle to predict the degree of stirring inside. They developed online sensors which are indeed to monitor the online stirring phenomena. In this investigation, triaxial vibration signals have been measured from a cold water model which is a model of an industrial ladle.

Metallurgical and Materials Transactions B, June 2016

Ladle furnace is a key unit in which various phenomena such as deoxidation, desulfurization, inclusion removal, and homogenization of alloy composition and temperature take place. Therefore, the processes present in the ladle play an important role in determining the quality of steel. Prediction of flow behavior of the phases present in the ladle furnace is needed to understand the phenomena that take place there and accordingly control the process parameters. In this study, first a mathematical model is developed to analyze the transient three-phase flow present. Argon gas bottom-stirred ladle with off-centered plugs has been used in this study. Volume of fluid method is used in a computational fluid dynamics (CFD) model to capture the behavior of slag, steel, and argon interfaces. The results are validated with data from literature. Eye opening and slag–steel interfacial area are calculated for different operating conditions and are compared with experimental and simulated results cited in literature. Desulfurization rate is then predicted using chemical kinetic equations, interfacial area, calculated from CFD model, and thermodynamic data, obtained from the Thermo-Calc software. Using the model, it is demonstrated that the double plug purging is more suitable than the single plug purging for the same level of total flow. The advantage is more distinct at higher flow rates as it leads higher interfacial area, needed for desulfurization and smaller eye openings (lower oxygen/nitrogen pickup).

Initial wetting and spreading rates between SiC and CaO-SiO2-MnO slag. J. Park, J. Jeon, K. Lee, J. Park, Y. Chung

The wetting of CaO-SiO2-MnO slag on silicon carbide was studied with a variety of slag compositions at 1823 K (1550 C). Wetting experiments were performed by the dispensed drop technique. We observed complete wetting of the slag on SiC (within 1 second) without a bubble reaction regardless of the basicity (=CaO/SiO2 = C/S ratio). However, after 8 seconds, the bubble reaction was observed under conditions of C/S = 0.8 and 1.1, whereas it was not observed at temperatures lower than 1823 K (1550 C). The contact angle was independent of MnO content, while the spreading rate increased with the increasing MnO content at the early stage of wetting. Inertial force acts on the early stage of spreading, and viscous force acts with lower MnO content due to higher viscosity. The low-viscosity slag did not fit with the nonreactive viscous model. However, the high-viscosity slag fitted the model well.

Deoxidation equilibria of manganese, silicon, and aluminum in iron-nickel-chromium melts. V. Dashevskii, A. Aleksandrov, A. Kanevskii, L. Leont’ev

Oxygen solution in Fe-Ni-Cr melts containing manganese, silicon, and aluminum has been thermodynamically analyzed and experimentally studied at 1873 K (1600 C). The Fe-10 pctNi-20 pctCr and Fe-40 pctNi-15 pctCr compositions were studied as examples of the most frequently used alloys. Manganese is not a deoxidizer in these alloys, since manganese and chromium have similar affinities for oxygen. At low contents, silicon is
also not a deoxidizer. However, above 0.358 pct for the Fe-10 pctNi-20 pctCr alloy and 0.261 pct for the Fe-40 pctNi-15 pctCr alloy, silicon decreases the oxygen concentration in the melts. Aluminum is an effective deoxidizer in the Fe-Ni-Cr melts. It decreases the oxygen concentration when its content is higher than 2.914 x 10^{-4} pct in the Fe-10 pctNi-20 pctCr alloy and 2.109 x 10^{-3} pct in the Fe-40 pctNi-15 pctCr alloy. Minimum oxygen concentrations are observed at aluminum contents of about 0.24 pct in the Fe-10 pctNi-20 pctCr alloy and at about 0.23 pct in the Fe-40 pctNi-15 pctCr alloy. The combined deoxidation of Fe-10 pctNi-20 pctCr and Fe-40 pctNi-15 pctCr alloys with silicon and manganese and also with aluminum and silicon was studied. The lower oxygen concentrations were reached as a result of complex deoxidation in comparison with the cases when deoxidized separately by each element at the same concentration levels.

**Effect of non-metallic inclusions in Fe-Al-Ti-O-N-S alloy on grain size.** W. Choi, H. Matsuura, F. Tsukihashi  
The effect of characteristics of non-metallic inclusions in Fe-Al-Ti-O-N-S alloys with various compositions at 1473 K (1200 C) on the microstructure was studied. The ASTM grain size number was determined in as-cast and heated samples by the optical microscopy, and the inclusion types in each sample were determined from composition analysis by field-emission scanning electron microscope with energy-dispersive spectroscopy. The TiN-based inclusions certainly had a positive effect on the grain refinement. On the other hand, TiS-based inclusions exhibited no influence on the decrease of grain size. In addition, the formation and evolution behavior of inclusions by heating solid-state Fe-Al-Ti-O-N-S alloys with those locations were clarified. A different change of inclusions in alloys was observed depending on the distribution and composition of inclusions.

**Motion behavior of nonmetallic inclusions at the interface of steel and slag. part i: model development, validation, and preliminary analysis.** C. Liu, S. Yang, J. Li, L. Zhu, X. Li  
The motion behavior of nonmetallic inclusions at the interface of molten steel and slag fundamentally affects the removal of inclusions. Therefore, from an analysis of forces, this study constructed a mathematical model of inclusion movement. Compared with other models that only consider the forces acting on nonmetallic inclusions at the interface, the proposed model considers not only cases in the inclusions which enter the slag interior and rebound into the molten steel, but also the effect of fluid flow containing the inclusions with different Re numbers on the drag force. The application of this established model has not taken Reynolds number of fluid flow into consideration. The model can predict the motion of inclusions at the interface and in nearby areas and provide a curve of inclusion displacement vs time. The mathematical model was verified with a physical model, with the curve of displacement vs time obtained from physical experiment being consistent with the calculated curve. The preliminary calculation results show that inclusions having liquid film at their surfaces are rebounded into the steel when they have size within a certain range but enter the slag phase directly when they are beyond that size range.

**Investigation on the effect of nozzle number on the recirculation rate and mixing time in the RH process using VOF + DPM model.** H. Ling, F. Li, L. Zhang, A. Conejo  
A mathematical model has been developed to explain the effect of the number of nozzles on recirculation flow rate in the RH process. Experimental data from water modeling were employed to validate the mathematical model. The experimental data included the velocity fields measured with a particle image velocimetry technique and mixing time. The multiphase model volume of fluid was employed to allow a more realistic representation of the free surface in the vacuum chamber while injected argon bubbles were treated as discrete phase particles and modeled using the discrete phase model. Interfacial forces between bubbles and liquid phase were considered,
including the lift force. The simulations carried out with the mathematical model involved changes in the gas flow rate from 12 to 36 L/min and a number of nozzles from 4 to 8. The results indicated a logarithmic increment in the recirculation rate as the gas flow rate increased and also corresponded with an exponential decrease in mixing time. The plume area and liquid velocities resulting from individual nozzles were computed. A maximum optimum recirculation rate was defined based on a mechanism proposed to explain the effect of gas flow rate and the number of nozzles on the recirculation rate.

Attachment of alumina on the wall of submerged entry nozzle during continuous casting of Al-killed steel. Z. Deng, M. Zhu, Y. Zhou, D. Sichen
The mechanisms of the formation of different attachments on the walls of submerged entry nozzle (SEN) were studied for the processes of Al-killed steel (Ca-treated, HSLA) and ultra-low carbon Al-killed steel (ULC). To understand the mechanism, the types of inclusions in the steel taken in tundish and in bloom (or slab) were identified. In the case of ULC, the reoxidation product, micro-alumina particles were found to be the source of attachment on the inner wall of the SEN. To avoid reoxidation of the steel by the top slag, removal of the slag could be considered in order to improve the situation. No attached layer was found on the outer surface of the SEN after casting of the ULC steel. In the case of HSLA steel, an attached layer composed of plate-like alumina crystals was found in some trials. The entrainment of oxygen through the mold powder due to improper operation would be the reason for the formation of this type of attachment. The formation of the plate-like crystals was discussed with the help of CFD calculation.

ABM Week – Automation Seminar, August 2015
The project goal was to optimize the availability and the uptime of the equipment responsible for the secondary refining of liquid steel on CSN, the RH Vacuum Degasser. This optimization has occurred over the monitoring of events generated by sensors installed in the device to determine when it has started operation and which was the time required to complete the process. The Availability of RH Vacuum Degasser is a management tool that performs the full mapping production in the Degasser for twenty four hours a day, capable of mapping processing time based on the standard grade steel time and downtime of the equipment, pointing out all the problems affecting production.

New level 2 automation systems for JSW Steel Toranagallu. R. Hubmer, J. Weiss, N. Desai
In October 2013 JSW Steel decided to place an order to Primetals Technologies Austria (former Siemens VAI Metals Technologies) for the installation of a comprehensive Level 2 process optimization system for more than 20 existing production facilities of various suppliers. For SMS-I new L2 systems are provided for two hot metal pretreatment stations, three hot metal desulphurization stations, three ladle furnaces, two 1-strand slab casters, a ladle tracking system as well as a shop supervisory system. Additionally the existing L2 system for one 1-strand slab caster is being upgraded in the course of the project. In SMS-II new L2 systems for the 7 hot metal desulphurization stations, 4 ladle furnaces, 1 new RH vacuum degasser, ladle tracking system and a shop supervisory system are supplied. Despite of the challenging time schedule the commissioning of the single facilities started within less than 12 month after contract effectiveness. The installed Level 2 process optimization systems together with the achieved results are described in this paper.

46º Seminário de Aciaria, August 2015
The fully automated meltshop: better safety, control and savings. J. Vasquez, F. Memoli
During the last years Riva Acciaio Verona has taken the decision to invest in the route of a fully automated meltshop. The aim is to reduce at the minimum the operator’s intervention from the bucket preparation till the ladle transfer to the continuous casting bay. The foundation for achieving the goal is the introduction of innovative technological solutions (fully automated cranes for bucket charge in the EAF, robots for sampling, etc. The paper underlines how the different solutions are based on the best practices to improve operator’s safety and describes the different steps of the project, the different solutions adopted and the results in terms of production, energy savings, cost reduction and improved safety. Details are presented for: scrap yard management and bucket preparation, EAFs centralized controls and related robots for auxiliary operations (sampling, EBT cleaning, scraper for slag door automation, complete mass & energy balance based on process control), LF’s centralized controls and process integration.

Reduced cost of manufacturing steel for the construction by increasing the specification limits. V. Stricker, P. Torrico, F. Casarini (in Spanish)
Acerbrag is an Argentine steel company over 50 years of experience that since 2007 belongs to the steel unit of the Votorantim group of Brazilian origin. It is dedicated to the production of long steel for construction. The industrial plant has an integrated steelmaking process, electric furnace, ladle furnace and continuous casting machine. The raw material of this mill is 100% scrap, different characteristic from other mills in the country. Given that the raw material is 100% scrap the primary focus of this project is to reduce the manufacturing cost through a “impoverishment” of the metal loading from flexible specification limits. Increase the specification limits for closer monitoring of the performance of processes to detect possible deviations that lead to refuse material breaches of technical specification, for it was necessary to implement the use of statistical and graphical tools for monitoring. Changes in the mix of production did not show significant changes in mechanical properties and chemical compositions of products, favorable situation for the continuation of this project. It is observed besides the expected cost reduction, an advantage in operating the scrap yard and mill process as well as the possibility of using scrap with high levels of waste such as Cr - Ni.

A CFD model to simulation of steel desulphurization in RH degasser. L. Costa, R. Tavares (in Portuguese)
A mathematical model was set-up to simulate and investigate the desulfurization process on the RH degasser. It was considered a top slag layer over steel, added at the vacuum chamber after the gas hold-up. The model was built considering the LaSIP (Process Simulation Laboratory) scaled 1:5 model of a industrial Brazilian plant. The model validation was performed through circulation rate of the water model and mathematical 1:5 model. The steel desulfurization was carried out in the CFD model for the industrial conditions and some parameters such chemical composition and slag volume were investigated. The model came out with consistent results which fits at the literature data and shown a great reliability to predict the sulfur evolution during the process. Therefore, the desulphurization in RH degasser can be performed at industrial installations whit good gains expectations and a additional/alternative route is now available to the steel production chain.

Through the mathematical modeling of desulfurization processes in pig iron and steel, this paper is focused in establish routes for steel production in integrated steel framework regarding productivity and cost reduction. So on, the following production shifts were evaluated: only steel desulfurization, only pig iron desulphurization and desulfurization on both steel and pig iron. The treatment conditions and route to obtain steel sulfur at levels below 20 ppm were also defined. In addition, it was
developed a sulphur balance for the BOF process to study the parameters that can promote or not the desulphurization in this reactor. Finally, the way these three treatment stations are used (KR, BOF and Ladle Furnace) makes a integrated model for sulphur evaluation in steel chain production, which can be applied to different plants with different operating processes and is suitable to provide good results.

**Thermodynamic evaluation of non-metallic inclusions on high silicon dual-phase steels production.** J. Beltrami, W. Bielefeldt, A. Vilela (in Portuguese)

This work evaluates the formation, slag interaction and solidification of inclusions generated during the processing of dual-phase steels with high content of silicon (<1% wt). The composition of these steels, if not properly controlled, can produce solid silica inclusions during continuous casting. For the thermodynamic calculations, the commercial software FactSage 6.4 was used. The results show that for the initial composition of inclusion, the most important factors are the %Mn/%Si ratio and the aluminium content of steel. When interacting with the slag, the tendency of the inclusions composition is to equal the slag composition over time. During solidification most of the inclusions presented deformable and low fusion temperature phases, except for inclusions without CaO and with 25%Al2O3 and intermediate CaO content, which formed tridymite, corundum and gehlenite, all phases with high fusion temperature and non-deformable.

**Description of inclusion size for a LCAK steel with the generalized extreme value distribution.** E. Cedeño, M. Trejo, M. Roman, M. Cornejo, F. Uresti (in Spanish)

In the production of clean steels inclusion control is critical for the manufacturing of a product which complies with the required quality specifications. The analysis of the size distribution of inclusions with the use of statistical models allows to estimate the incidence of inclusions in the solidified product from a relatively small metal samples. For six heats of low-carbon aluminum-deoxidized steel, liquid metal samples were taken in the ladle furnace and continuous casting mold. The samples were polished and analyzed by metallographic inspection to determine inclusion sizes in the sample. The measurements of inclusion size were analyzed by means of a statistics of extremes approach in which the Gumbel distribution (which is part of the ASTM E-2283 norm) and the Generalized Extreme Value (GEV) distribution are compared with each other. Using the Anderson-Darling hypothesis test, quantile analysis and the survival function it is shown that the estimations made by the GEV model are more representative than the Gumbel model. Finally, an estimate of the probable incidence of inclusions in the solidified product is given.

**Study of inclusion removal in the ladle by inner gas injection by physical modeling.** P. Silva, T. Cardoso, A. de Mendonça, A. Nascimento, R. Tavares (in Portuguese)

Inclusions are particles that usually have deleterious effects on steel quality. The present work had the objective of evaluating the effects of different variables on the efficiency of the gas bubbling treatment during the drainage of the ladle in the continuous casting process. A physical model in a 1:5 scale of a 180 metric tons ladle was used in the experiments. The APS sensor was used to count and determine the size distribution of the particles used to simulate the inclusions. The results indicated that there is an optimum treatment time for each gas flow rate and that lower gas flow rates gave better results. These conclusions could be explained by the reversion and floatation phenomena.

**Partial deoxidation with coke of aluminum killed low carbon steels.** J. de Athayde Júnior, A. Jorge, I. Alves, S. de Alcântara Filho (in Portuguese)

The deoxidation practice of steel during the tapping, which aluminum is used as a deoxidizer, is widespread among steelmakers. However, alumina is generated as deoxidation product: 2Al + 3O =Al2O3(s). Most of the times, alumina is a problem for the
internal quality of the product and also for the castability of liquid steel. Those nonmetallic inclusions promote clog formation at submerged entry nozzle (SEN). This study evaluated the partial replacement of aluminum by coke in deoxidation of Alkilled low carbon steels during the tapping. After the methodology and the operational procedures development, coke was used as a pre-deoxidizer in 868 heats, from 09/2014 to 02/2015, without the occurrence of reactions during the addition of coke in the tapping and without compromising the accuracy of the chemical composition.

Mathematical model of flow in the RH degasser: analysis of behavior of slag by system air/oil/water. L. Neves, R. Tavares (in Portuguese)
In this paper a study of multiphase flow in the RH degasser was developed. The mathematical simulations in physical model were performed using the Eulerian approach to simulate the flow rates employed in the industry to predict the behavior of slag. For the validation of the mathematical model, tests were made in these physical models in the scale of 1:5 to the industrial equipment. The flow monitoring was done by using ordinary camera. The results of the oil thickness obtained in the physical model could validate the results obtained in mathematical modeling. The results showed that the oil thickness near the ladle wall have the least thickness of the oil layer. And the oil between the upleg and the ladle wall were smaller and decrease as the gas flow increases.

This work aims at the use of literature models thermodynamics and computational thermodynamics in the study of hot metal desulfurization through CaO-Fluorspar and CaO-Sodalite mixtures. Experiments were performed with the addition of different mixtures from these systems in molten hot metal at a temperature of 1,400°C. The test results were analyzed and compared with those obtained by the literature models thermodynamics and computational thermodynamics software program ThermoCalc. Through literature models were calculated optical basicity, sulfide capacity (Cs) and sulfur partition (Ls). By software ThermoCalc were calculated the equilibrium sulfur content in the metal, solid phases, and the amount of liquid in each desulfurizing mixture used in the process at a temperature of 1,400oC. ThermoCalc showed up more accurate than literature model of Cs and Ls in analysis of desulfurizing efficiency of the mixtures used in this paper.

Using the DMAIC methodology for transformation cost reduction at Votorantim’s meltshop in Resende. P. Coutinho, A. Santos, J. Cerqueira, P. Franco, E. Gomes, J. Navarro, M. Radich (in Portuguese)
The objective of this work was the reduction of transformation cost at Votorantim’s Meltshop in Resende-RJ, aiming decrease the billet Cash Cost, important point in current economic scenario of Brazilian steel industry. The DMAIC methodology was used to prioritize the actions, optimize resources and manage the issue in a structured way. As a result there was a reduction of the transformation cost achieved by improvements in Electrical Energy, Alloys, Electrodes and Other Costs.

In order to obtain good results in industrial scale of steel destined to mechanical engineering, the practices in the company’s process has been constantly analyzed to avoid wastes due to defects on products. Based on this concept, this paper seeks to analyze the process control to optimize the secondary steelmaking throughout the analysis of effective deoxidation and alloy yield with the inert gas stirred ladle system’s parameters of a low carbon steel produced at Gerdau Riograndense steel mill. From
the results found, it may be stated that obtaining low oxygen levels in the melt is due to the correct operational practice implemented. Yield alloy is an adequate tool to predict the melt’s oxidation levels, the influence on the slag performance and that the inert gas stirred ladle system’s parameter during secondary steelmaking influences the performance of yield alloy and deoxidation in the melt.

The use of numerical simulation tools in slide gate mechanisms’s design optimization. L. Teixeira, R. Freire, F. Silva, M. dos Santos (in Portuguese)
The use of numerical tools in structural analysis has grown in recent years, specially using the finite elements method. In this work, the design optimization of two slide gate system components are shown, performed by Magnesita Refratários S.A. Starting from the initial geometry until the final product, the adequacy of the stress fields to allowable values is analyzed as design is modified. Finally, the importance of this kind of study to achieve more reliable and safe mechanical design is established.

China’s Refractories, October/December 2014
Development and Application of Chrome-free Refractory Materials for RH Degasser
Li Hongxia, Liu Jun, Feng Haixia, Zhang Lixin
The research progress and industrial application of chrome-free refractories for RH degasser were introduced in the paper. It is proved that unburned magnesia – spinel refractories used for RH throat and snorkel in Baosteel have longer service life compared with traditional direct bonded fused magnesia - chrome materials. The new developed chrome-free unburned magnesia - spinel composite can fully meet the present demand for RH operation and can be applied extensively for RH processing. At present, instead of chrome-containing materials, chrome-free refractories have been applied widely for RH in Baosteel. Super low carbon MgO - C material with high mechanical properties at mild and high temperatures can be an alternative chrome-free material for RH.

Preparation of Nanoporous Thermal Insulating Materials and Their Application as Ladle Linings. Yu Jingkun, Han Lu
The nanoporous thermal insulating material was prepared by using firmed silica, Sic powder and glass fiber as starting materials, the appropriate thickness of the nanoporous thermal insulating material lined in ladle was discussed by the simulation method, and the effect of its application as ladle lining was investigated. The results show that the thermal conductivity of the nanoporous thermal insulating material prepared in composition of fumed silica: SiC powder: glass fiber = 75: 20: 5 (in mass) is 0.023 W.m⁻¹.K⁻¹ at 1 000 °C , the appropriate thickness of the nanoporous thermal insulating material lined in ladle is ≤5 mm and the average temperature of the ladle outside surface when lined with the nanoporous thermal insulating material is 95 °C lower than that with the ordinary thermal insulating material.