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Metallurgical and Materials Transactions B, June 2017
Experimental and theoretical studies on the viscosity-structure correlation for high alumina silicate melts. T. Talapaneni, N. Yedla, S. Pal, S. Sarkar
Blast furnaces are encountering high Alumina (Al2O3 > 25 pct) in the final slag due to the charging of low-grade ores. To study the viscosity behavior of such high alumina slags, synthetic slags are prepared in the laboratory scale by maintaining a chemical composition of Al2O3 (25 to 30 wt pct) CaO/SiO2 ratio (0.8 to 1.6) and MgO (8 to 16 wt pct). A chemical thermodynamic software FactSage 7.0 is used to predict liquidus temperature and viscosity of the above slags. Experimental viscosity measurements are performed above the liquidus temperature in the range of 1748 K to 1848 K (1475 C to 1575 C). The viscosity values obtained from FactSage closely fit with the experimental values. The viscosity and the slag structure properties are intent by Fourier Transform Infrared (FTIR) and Raman spectroscopy. It is observed that increase in CaO/SiO2 ratio and MgO content in the slag depolymerizes the silicate structure. This leads to decrease in viscosity and activation energy (167 to 149 kJ/mol) of the slag. Also, an addition of
Al2O3 content increases the viscosity of slag by polymerization of alumino-silicate structure and activation energy from 154 to 161 kJ/mol.

**Phase equilibria in the system “FeO”-CaO-SiO2-Al2O3-MgO at different CaO/SiO2 ratios.** K. Jang, X. Ma, J. Zhu, H. Xu, G. Wang, B. Zhao

The “FeO”-containing slags play an important role in the operation of an ironmaking blast furnace (BF), in particular the primary slags such as the system “FeO”-CaO-SiO2-Al2O3-2 mass pct MgO with CaO/SiO2 weight ratios of 1.3, 1.5, and 1.8 saturated with metallic iron. To investigate the characteristics of such a slag system and its behavior in BF, the phase equilibria and liquidus temperatures in the slag system have been experimentally determined using the high-temperature equilibration and quenching technique followed by an electron probe X-ray microanalysis (EPMA). Isotherms between 1553 K and 1603 K (1280 C and 1330 C) were determined in the primary phase fields of dicalcium silicate, melilite, spinel, and monoxide [(Mg,Fe2+)O]. Pseudo-ternary phase diagrams of (CaO + SiO2)-Al2O3-“FeO” with a fixed MgO concentration at 2 mass pct and at CaO/SiO2 ratios of 1.3, 1.5, and 1.8 have been discussed, respectively, simplifying the complexity of the slag system for easy understanding and applying in BF operation.

**Effect of Al2O3 concentration on density and structure of (CaO-SiO2)-xAl2O3 slag.** R. Rajavaram, H. Kim, C. Lee, W. Cho, C. Lee, J. Lee

The effect of Al2O3 concentration on the density and structure of CaO-SiO2-Al2O3 slag was investigated at multiple Al2O3 mole percentages and at a fixed CaO/SiO2 ratio of 1. The experiments were conducted in the temperature range of 2154 K to 2423 K (1881 C to 2150 C) using the aerodynamic levitation technique. In order to understand the relationship between density and structure, structural analysis of the silicate melts was carried out using Raman spectroscopy. The density of each slag sample investigated in this study decreased linearly with increasing temperature. When the Al2O3 content was less than 15 mole pct, density decreased with increasing Al2O3 content due to the coupling of Si (Al), whereas above 20 mole pct density of the slag increased due to the role of Al3+ ion as a network modifier.

**Iron & Steel Technology, May 2017**

**Gas odorization technology for toxic gas leak detection.** M. de la Aleja

Hazards are ever-present in the steel plant environment, and a heightened awareness and emphasis on safety is a necessary priority for our industry. This monthly column, coordinated by members of the AIST Safety & Health Technology Committee, focuses on procedures and practices to promote a safe working environment for everyone.

**ISIJ International, April 2017**

**Degradation behavior of coke reacting with H2O and CO2 at high temperature.** P. Wang, Y. Zhang, H. Long, R. Wei, J. Li, Q. Meng, S. Yu

The degradation behaviors of coke which reacts with CO2 and H2O were explored in self-made gas-solid reacting apparatus. It was observed that the temperature loss of coke with H2O in initial and violent solution were about 37°C and 125°C lower than that with CO2 respectively. The gasification rate of coke with H2O was about 1.27–3.16 times faster than that with CO2. But the difference of gasification rate will reduce with the lower temperature. The coke strength after reaction (CSR) with H2O was lower than with CO2 at 950°C–1 100°C, but higher at 1 200°C. The coke’s apparent porosity and changing rate after reacting were both smaller with H2O than with CO2. It is mainly due to the reaction that occurred closer to the coke particle surface with H2O than with CO2.
Development of new charging technique for mixing coke in ore layer at blast furnace with center feed type bell-less top.


Improved permeability and increased gas utilization have been desired in order to achieve low coke rate operation of blast furnaces. Coke mixed charging in the ore layer is one of the effective measures for realizing these improvements. A new charging technique for mixing small coke in the ore layer at a blast furnace with a center feed type bell-less top was developed and investigated in an experiment with a 1/18.8 scale model of an actual blast furnace at JFE Steel. By the new charging technique that small coke was charged in the determined port of the upper bunker before ore was charged in the upper bunker, the discharge pattern of the mixed small coke discharged from the bell-less top was improved, and the radial distribution of the mixed small coke ratio at the furnace top after the mixed materials were charged in the blast furnace was also improved. The new charging technique was applied to an actual blast furnace at JFE Steel, and improvement of gas permeability and a decrease in the coke rate were confirmed.

Speciation of PM2.5 released from iron ore sintering process and calculation of elemental equilibrium.

Z. Ji, X. Fan, M. Gan, Q. Li, X. Chen, Y. Tian, T. Jiang

The aim of this study was to elucidate the speciation of PM2.5 and proportion of each typical speciation via calculation of chemical mass balance. The results from elemental and morphological analyses showed that PM2.5 consisted of diverse components mainly including O, Fe, Ca, Al, Si, and trace elements K, Na, Pb, S, and Cl. These components mainly existed in spherical, cubic, polyhedral, flake-like and bulk-like particles. Through examining the chemical composition and distribution property of main components in typical particles, Fe, Ca and O were determined to present in the speciation of Fe2O3–CaO from melting process, while Al, Si and O existed in the speciation of xAl2O3–ySiO2 from fuel fly ash. K, Na, Pb and Cl could exist in the speciation of KCl, NaCl and PbCl2 respectively from chlorination reactions. Moreover, Ca, K, Pb, O and S could form sulfates of CaSO4, K2SO4 and PbSO4 respectively. Calculation of O, S and Cl equilibrium in PM2.5 indicated that Fe2O3–CaO accounted for about 30.63%, xAl2O3–ySiO2 accounted for about 7.02%, K(Pb/Na)Clx accounted for about 41.29%–49.77%, and K2(Ca/Pb)SO4 accounted for about 21.05%–12.57%.

Reducibilities of wüstite and calcio-wüstite in terms of high temperature x-ray diffraction analysis.

B. Cai, T. Watanabe, C. Kamijo, K. Sunahara, M. Susa, M. Hayashi

Reducibilities of wüstite and calcio-wüstite have been examined using high temperature X-ray diffraction analysis including the effect of hydrogen on the reducibility. Fe2O3 reagent powders and hematite ore powders were used for reduction of wüstite (denoted as FeO) and sintered ore powders were used for reduction of FeO and calcio-wüstite (denoted as CW). High-temperature X-ray diffraction was applied to these samples in a flow of CO–CO2–He mixtures with and without 3.9 vo% of hydrogen during the heating cycle which simulates a blast furnace condition. The diffraction angle was scanned in the range from 33° to 55°. In experiment on sintered ore powders without hydrogen, the main peak around 48.5° shifted to lower angles with increasing temperature. This shift also continued while temperature was kept at 1 000°C where wüstite was saturated with iron; on the contrary, the peak shift did not take place for hematite ore powders. This main peak is associated with wüstite (200), which is actually composed of peaks due to FeO and CW for sintered ore powders.

46th Ironmaking Seminar – ABM Week 2016, October 2016

Influence of Ferrous Raw Materials in the TKCSA Blast Furnaces Operation.

Geovane Viturino da Silva, Bruno Pinheiro da Silva, André Wulff Hirano
The stable operation with high production and low fuel consumption depend on the ferrous materials used. In view of the current challenge in the markets of ferrous raw material due to the worsening of the quality, the development of new solutions of charge has been an important issue to keep stability and high productivity. Thus, the phenomena comprehension is the key to make the operational model suitable. The aim of this paper is presents a review of the phenomena caused by a variation in the chemical composition of the sinter and the consequences in the process of the TKCSA Blast furnaces. It was found that the Al2O3 and SiO2 content rose, which have strong influence in the physical, metallurgical, and melting properties of the sinter. In the Blast furnace the sinter analyzed has caused a variation of 200°C in the melting point of the slag, great variations in the ETA CO and in the CO/CO2 deviation, reaching 4% and 70%, respectively.

From Run of Mine to Steel Holistic Approach to Process Optimization. Reinhard Redl, Christoph Aichinger, Bernhard Hiebl
The optimization and improvement of a modern integral iron and steel works gets more and more difficult as each individual plant is already operated at its best efficiency and at the lowest operational expenditures. However very often the individual plants are considered as stand-alone units and there are losses and inconsistencies on interfaces and take over points, which could be avoided and by that improving the overall performance of the iron and steel works as a holistic unit. Primetals Technologies looked into this subject extensively in the recent years and is now ready to offer new tools and services in order to assist operators to find further potential for improvement in processes, which seem to be fully developed at first sight.

Initiatives Thyssenkrupp CSA Sintering to Reduction Phosphorus Content in Hot Metal. Wagner Luis Garcia Silveira, Maxwell Pereira Cangani, Cristiane Vilma Rocha Galiazzi, Marilene Aparecida Ennes Landin, Daniel Augusto Godinho de Carvalho
In the last years thyssenkrupp Companhia Siderúrgica do Atlântico - CSA has been undergone a number of changes regarding the quality profile of raw materials, especially in relation to the worsening of quality of ore mined in Iron Ore Quadrangle Minas Gerais, that makes up 100% of the metallic burden used by the company. One of the main changes observed was the increase of phosphorus content in the metallic burden (Sinter Product, Pellet and Lump Ore), becoming necessary studies to mitigate the impact of the increasing phosphorus content in hot metal, such as development of new fluxes and additives. Phosphorus is an element that brings few changes in ironmaking process (Sintering, Coke Plant and Blast Furnace) and there are effective methods of reducing these changes [1], but it is extremely detrimental to the quality, productivity and cost of Steelmaking, mainly in steel production requiring low phosphorus content in your composition [2]. This paper aims to present the Sintering efforts to reduction phosphorus content in the sinter product and consequently in Hot Metal by means of quality simulations involving new fluxes and additives.

How to Double the BF Volume and Production with Limited Changes to Plant Infrastructure. A PW Experience. Sunil Katharia, Nagendra Kumar, Mirko Bassetti, Marco Perato, Jaipal Yadav, Antonio Maestri, Roberto Cambria
In February 2016, the upgraded Blast Furnace 1 of JSW Steel Limited (JSW) at its Vijayanagar Steel Plant was blown in after a 6 months shutdown in which the whole furnace was rebuilt on the existing foundation and within the existing tower structure. Despite several plant constraints it was possible to increase the furnace inner volume by 85% - reaching 2307 m3 from existing 1250m3. The upgradation project covered the stockhouse and its dedusting system, top charging system, furnace profile, furnace cooling system, casthouse and its dedusting system, slag granulation plant,pulverized coal injection plant, hot blast system and gas cleaning plant – with major interventions in order to cope up with the changed operating conditions. The total scope of the
The project was split by JSW into several packages, all based on design data provided by Paul Wurth. JSW was responsible for coordinating the local subcontractors along with Paul Wurth which has been appointed as main technology supplier in charge of complete basic and selected detail engineering in the key areas and of the supply of core equipment such as the Bell-less Top®, copper staves, GCP key items and TMT casthouse machines. The main design concept and the key points of the project such as optimization of project ROI, advanced erection concepts as well as a summary of the operating results are presented confirming JSW “BF1” upgradation as one latest examples of the current state of the art in the revamping projects.


Compliance with environmental standards in the various processes of steelmaking plants in Brazil, more than a legal requirement, should be a company commitment to its employees, customers and society. The correct design of the gas cleaning system and the application of horizontal bag filters is certainly an effective alternative to solve adequately the special characteristics and needs of several steelmaking processes.

SEAISI Quarterly Journal, September 2016
Hot Metal Process Technologies and Plant Engineering. Reinoud Van Laar, Jacques Pilote, Koen Meijer

The blast furnace has been an efficient technology for producing hot metal using pellets, sinter, lump ore, coke, coal and natural gas. The technology has been continuously improved and a modern blast furnace can produce 1,000 to more than 10,000 tonnes hot metal per day. The liquid hot metal is normally further processed by oxygen steelmaking, but could also be charged to an electric arc furnace to reduce the scrap input. Alternatively pig iron or iron granulates can be produced at the blast furnace for storage and transportation to other places. Hismelt is an alternative to the blast furnace for typical production levels of 1,000 - 3,000 tonnes hot metal per day. The main advantages of Hismelt process technology are the fact that ore and coal can be directly processed without the need for pellets, sinter or coke. This introduces significant transformation cost savings, environmental benefits and a strategic advantage by its raw material flexibility. Hismelt has been first operated at the Australian industrial demonstration plant, which is currently reconstructed in China. Hismelt technology has been further developed and integrated with Converter Cyclone Furnace technology resulting in the Hlsarna process using pure oxygen instead of heated air and using fine ore injection instead of pre-heated ore. This simplifies the flow sheet, reduces the investment costs and introduces additional transformation cost savings. The Hlsarna pilot plant has been constructed in the Netherlands and the first test results have been exceeding expectations. This paper will discuss the blast furnace, Hismelt and Hlsarna process technology and plant engineering characteristics.