

MONDAY, AUGUST 23, 2004, P.M.

**SESSION 1: FOURTH INTERNATIONAL SYMPOSIUM ON ADVANCES IN
REFRACTORIES FOR THE METALLURGICAL INDUSTRIES**

STEELMAKING (I)

Sponsors: Materials Science and Engineering, The Metallurgical Society of CIM, The Refractory Ceramics Division of the American Ceramic Society and The Canadian Ceramic Society.

Room: Webster A

Chairmen: T. VERT, Dofasco Inc., Hamilton, Ontario, Canada, and
R. CROLIUS, TRI, Pittsburgh, Pennsylvania, U.S.A.

PAPER 1.1 — 14:00

OPTIMIZATION AND IMPROVEMENTS IN DOFASCO'S 165 MT EAF LADLE DESIGN.

S. SAGAR, Dofasco Inc., Hamilton, Ontario, Canada

In September 1996, Dofasco commissioned a 165 Mt twin shell EAF furnace and an associated ladle fleet. During and after this startup, refractory performance in the ladles was optimized on a holistic approach through several initiatives that increased ladle refractory retention times from 7000 to over 16000 mins (160 heats). This dropped the overall refractory costs by 40% while ensuring a consistent and predictable ladle performance.

One initiative that drove enhancements was the proper brick selection for each particular refractory area and its process conditions. The work concentrated on the selection of a resin bonded alumina magnesia carbon (AMC) brick in the barrel area of the ladle, upgrades to the 2 piece monolithic alumina cast ladle bottom and increasing the slagline refractory brick quality with the appropriate zoning/paneling. The adoption of a magnesia alumina carbon (MAC) brick in the transition area of the barrel/slagline has also improved performance and predictability. The design developments have lowered the overall wear rates and balanced the service life of the entire ladle.

Safety was improved and breakout potential reduced by changing the safety lining from a high alumina brick to a state of art technology - monolithic shotcrete lining. This initiative decreased the overall manpower required to brick a ladle and increased shop ladle availability. The ladle bricking area environment was also improved by adopting a post combustion device to burn phenol fumes from ladle preheating practices. This has improved the overall health & safety of the reline teams.

The consistent and predictable performance of the ladle on a whole has allowed the shop to decrease the number of working ladles in operation from 5 to 4. This further decreased wear rates from over-oxidation and excessive thermal cycling, saving approximately \$500,000 in natural gas from pre-heater operations.

PAPER 1.2 — 14:25

THE LADLE REFRACTORY IMPROVEMENT EXPERIENCED IN MOBARAKEH STEEL COMPANY.

M. BAVAND-VANDCHALI, N. KHALILI, S. ROWSHANFEKR-FALLAH, Pars

Refractories Co., Tehran, Iran, and

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In the secondary metallurgy of steel, the availability of ladles plays an important role in decreasing the production cost. The refractory lining, therefore, should satisfy optimized quality to grant higher heats. This paper reports the results of an investigation carried out in Iranian Mobarakeh Steel Company in order to increase the lining life of ladles by employing different types of MgO - C and Al₂O₃ - MgO - C. The zoning concept was used in replacing the conventional refractories either in slag line or the lower parts of ladle. The number of heats could be improved to almost two times as before. The results are explained in terms of refractory quality as well as zoning approach. The economical impact of this improvement will also be analyzed.

PAPER 1.3 — 14:50

INNOVATIVE FIBRE FREE STEEL LADLE PREHEATERS AT CORUS STEELWORKS IJMUIDEN.

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T. DE WIT, Corus Staal, IJmuiden, Netherlands,

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The introduction of the near net-shape casting process at CORUS Staal IJmuiden in January 2000 required changes of secondary metallurgy processes including a development towards more aggressive slag compositions in the steel ladle. Therefore the steel ladle lining has been changed from fired andalusite bricks to magnesia-carbon bricks and, most recently, to fired spinel bricks to withstand the severe slag conditions. In comparison to the andalusite bricks the new steel ladle linings have a higher thermal conductivity. This requires the capability to keep the lining warm by ladle preheaters to sustain the overall thermal stability of the steel ladle in case of interruptions during hot cycling of the ladles. New high performance ladle preheaters have been installed with a focus on fibre free linings. Fibre linings have the advantage of low density and a resulting low weight of the refractory lining. The alternative monolithic lining therefore needs to have a low density and a low thermal conductivity to keep the hydraulic power for lifting the lid within reasonable limits. After 39 months of successful industrial application experiences the paper describes the fundamental properties of the new fibre free steel ladle preheater technology.

COFFEE BREAK — 15:15 – 15:45

PAPER 1.4 — 15:45

CORROSION MECHANISMS OF HIGH ALUMINA REFRACTORIES IN STEEL LADLES.

J. POIRIER, F. QUAFSSAOUI, J.P. ILDEFONSE, Polytech' Orléans, Orléans, France, and

P. HUBERT, DAMREC, Glomel, France

Corrosion tests by corrosive alumina-lime slags were carried out on commercial high alumina bricks used in steel ladle linings and model refractories (with different raw materials : bauxite, andalusite, and different microstructures). Using (SEM) scanning electron microscope and (EDS) energy dispersive spectroscopy, microstructures of slag-corroded refractory interfaces were studied in detail. The monomineral and glassy phases, the composition of reaction products and chemical profiles were determined.

A thermochemical analysis based on phase equilibrium diagrams has permitted to estimate the proportion and the composition of the high temperature intergranular liquid phase. These data were compared to the experimental microanalysis results. The viscosity of the high temperature liquids were calculated according to Urbain 's model and the relationship between the viscosity and the penetration of liquid phases were discussed.

These theoretical and experimental results were used to understand the complex phenomena of slag penetration and corrosion of andalusite and bauxite refractories at high temperature and to propose new ways of improvements for the formulation of high alumina refractories.

PAPER 1.5 — 16:10

THERMAL STRESSES IN THE WORKING LINING OF A LADLE DURING THE STEEL REFINING PROCESS.

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E. BLOND, Polytech' Orléans, Orléans, France

Working lining of steel ladles progressively damages during the steel manufacturing process due to both severe thermomechanical and chemical stresses. In the framework of the coupling scheme proposed by Blond et al.,¹ this study examines more particularly the effects of the thermomechanical loading on the onset of microcracking by considering that the complex microstructure of the slag impregnated brick is fixed during the steelmaking process. Numerical simulations of a simplified geometry of the lining subjected to cyclic thermal loadings at the inner side are shown. The behaviour of the refractory was identified by using a thermoelastic-(asymmetric) viscoplastic constitutive equation.² Two cases are analysed, namely, i) the material is a homogeneous continuum with a thermoelastic-(asymmetric) viscoplastic behaviour, ii) the material is porous and saturated by liquid slag, and the skeleton has the previous non-linear behaviour. The stress and strain fields are shown and for the porous medium the interstitial pressure of slag too. Comparisons between these assumptions are made to better assess the role of the slag pressure on the degradation of the working lining.

PAPER 1.6 — 16:35

EFFECTS OF DOLOMITE ADDITION ON DURABILITY OF COATING MATERIALS FOR BOF.

G.-G. HONG and M-K. CHO, Research Institute of Industrial Science and Technology, Pohang, Korea

In order to evaluate the properties of coating materials for BOF, the effects of dolomites(dolomite and light burned dolomite) addition on durability of coating materials were investigated. In all coating materials, matrix was dicalcium ferrite(C_2F) and both free MgO and dicalcium silicate(C_2S) were precipitated. Fe_2O_3 content must be controlled to improve the adhesion and durability of coating materials for BOF during oxygen blowing process. The amount of dolomites added to BOF slag must be controlled in optimum condition with high refractoriness of C_2S to improve the

adhesion of coating materials for BOF. The weight ratio of converter slag to dolomite must be below 8 to improve the adhesion and durability of coating materials simultaneously.

PAPER 1.7 — 17:00

EFFECT OF ADDITIVES ON HYDRATION RESISTANCE OF DOLOMITE REFRACTORIES

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The use of dolomite refractories in steel making and cement industries has advantages over other basic products particularly in countries where this type of refractories is produced. Due to existence of high-quality dolomite deposits in many regions of Iran, there is a good potential for producing dolomite refractories in the country. This study focuses on the effect of such additives as iron oxide and alumina on hydration resistance and density of Iranian dolomite. It was found that addition of Fe_2O_3 is more effective than Al_2O_3 on increasing density as well as resistance to hydration of dolomite.