REFRACTORY MATERIALS FOR METALLURGICAL USES

Refractory Materials for Metallurgical Uses

CAMILLE FLEURIAULT,^{1,3} JOSEPH GROGAN,¹ and JESSE WHITE²

1.—Gopher Resource, Eagan, MN 55121, USA. 2.—Elkem Carbon AS, Kristiansand, Norway.
3.—e-mail: camille.fleuriault@gopherresource.com

Refractory selection plays a fundamental part in optimization of pyrometallurgical processes. Refractory materials are made of high-temperature-resistant minerals, binders, and additives, being dedicated to provision of insulation and protection of reactors from corrosion and physical wear. This topic brings together five articles highlighting the influence of proper refractory selection and management during a furnace campaign life.

In the first article of this issue, “Variables Applicable to Benchmarking of Tap-Hole Life Cycle Management Practices in Coke-Bed Based Ferroalloy Production,” Joalet Dalene Steenkamp et al. identify and validate key factors influencing the tap-hole life cycle of submerged arc furnaces (SAFs). Based on literature reviews and plant personnel interviews, relevant independent variables are highlighted and divided into the four main functions associated with the tap-hole life cycle: operation, relining, maintenance, and repair.

The following three articles of this series are dedicated to refractory wear in the copper industry. The article “Copper Anode Furnace: Chemical, Mineralogical and Thermo-Chemical Considerations of Refractory Wear Mechanisms” by Dean Gregurek et al. describes the mechanisms associated with the wear of magnesia–chromite and alumina–chromia bricks. Post mortem analysis of such bricks reveals infiltration and corrosion of the slag components on the refractory, as well as physical wear phenomena such as hot erosion and spalling. Thermochemical modeling is used to explain the different behavior between the two brick types.

The next article is “Post-mortem Study of Magnesia–Chromite Refractory Used in a Submerged Arc Furnace in the Copper-Making Process” by Ismael Perez Pina et al. This study also details the post mortem study of a magnesia–chromite lining, which was sampled across its entire area of

contact with the slag. Scanning electron microscopy (SEM) energy-dispersive spectroscopy (EDS) analysis revealed that the spatial distribution in the furnace did not affect the wear pattern. However, the formation of a reaction layer was identified, subsequently leading to weakening of the brick and spalling, forming a new fresh surface to come into contact with the slag.

The third article relating to the copper industry is “Chemical Degradation Mechanisms of Magnesia–Chromite Refractories in the Copper Smelting Furnace” by Mao Chen et al. The authors used both post mortem samples and static laboratory tests to characterize the degradation mechanisms within the lining of a bath smelting furnace. Magnesia corrosion by silica and copper oxide from the slag led to formation of new, unstable phases within the brick. The newly formed phases compromised the refractory integrity and led to brick damage.

To conclude this topic, Aidong Hou et al. use finite element modeling for enhancing refractory efficiency in “A Method for Steel Ladle Lining Optimization Applying Thermomechanical Modeling and Taguchi Approaches.” This case study presents an a priori method for furnace lining design, using orthogonal arrays, analysis of variance, and signal-to-noise ratio as tools. After designing the refractory, the Taguchi finite element method is used to determine temperature and stress factors. Factors such as thickness, thermal conductivity, and Young’s modulus were tested and ranked to optimize the furnace design.

The following papers published under the topic “Refractory Materials for Metallurgical Uses” in the November 2018 issue (vol. 70, no. 11) of *JOM* can be accessed via the *JOM* page at <http://link.springer.com/journal/11837/70/11/page/1>:

- “Variables Applicable to Benchmarking of Tap-Hole Life Cycle Management Practices in Coke-Bed Based Ferroalloy Production” by J.D. Steenkamp, W.G. Bam, and S.P. Tsebe.
- “Copper Anode Furnace: Chemical, Mineralogical and Thermo-Chemical Considerations of

Camille Fleuriault, Joseph Grogan, and Jesse D. White are the *JOM* advisors for the Pyrometallurgy Committee of the TMS Extraction and Processing Division, and guest editors for the topic Refractory Materials for Metallurgical Uses in this issue.

- Refractory Wear Mechanisms” by D. Gregurek, J. Schmidl, K. Reinharter, V. Reiter, and A. Spanring.
- “Post-mortem Study of Magnesite–Chromite Refractory Used in a Submerged Arc Furnace in the Copper-Making Process” by I. Pérez Pina, I. Morento-Ventas Bravo, R. Parra Figueroa, and G. Ríos Ransanz.
 - “Chemical Degradation Mechanisms of Magnesite–Chromite Refractories in the Copper Smelting Furnace” by M. Chen, Y. Jiang, Z. Cui, C. Wei, and B. Zhao.
 - “A Method for Steel Ladle Lining Optimization Applying Thermomechanical Modeling and Taguchi Approaches” by A. Hou, S. Jin, H. Har-muth, and D. Gruber.