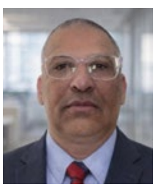
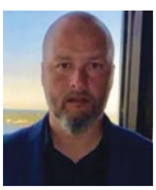
Predictive Modeling for Slidegate Refractory Wear: A Machine Learning Approach for Enhanced Condition Monitoring in Steelmaking Processes







In this work, the wear of the ladle slidegate plate was modeled and optimized to ensure operational safety, process stability and cost reduction associated with premature plate replacement. Adhering to established standards, such as limiting the maximum center hole size and maintaining crack-free conditions, prevents jamming and ensures steel flow control, thereby protecting both personnel and equipment. Premature replacement increases refractory, maintenance and labor costs while decreasing ladle availability. To address these challenges, a predictive tool was developed using a machine learning approach to estimate and track the wear of the center hole diameter and crack formation in the slidegate plate.

Authors

Franz Ramstorfer (top left), Process Senior Manager, Ternium Brasil, Rio de Janeiro, RJ, Brazil
franz.ramstorfer@ternium.com.br

Donaldo Silva Orosimbo (top right), Advisor Refractory Inspection, Ternium Brasil, Rio de Janeiro, RJ, Brazil
donaldo.orosimbo@ternium.com.br

Ricardo Pereira Dias (center left), Production Coordinator, Ternium Brasil, Rio de Janeiro, RJ, Brazil
ricardo.dias@ternium.com.br

Gilvan Nascimento De Souza (center right), Process Manager, Ternium Brasil, Rio de Janeiro, RJ, Brazil
gilvan.souza@ternium.com.br

Leandro Silvino Crivellari (bottom), Operations Senior Manager, Ternium Brasil, Rio de Janeiro, RJ, Brazil
leandro.crivellari@ternium.com.br

Introduction

In the continuous casting process, the ladle slidegate mechanism is the essential component for controlling the steel flow from the ladle to the tundish. Mounted at the bottom of the ladle, this mechanism consists of refractory plates, one of which can be opened or closed hydraulically to regulate the flow of liquid steel. The ladle shroud, a refractory tube that prevents reoxidation of the steel as it flows from the ladle slidegate to the tundish, is attached to the ladle slide mechanism via a collector nozzle or a dedicated shroud holder. Fig. 1 shows a schematic sketch of a slidegate mechanism and its main components (a), as well as an opened slidegate mechanism during maintenance operations (b).

The importance of the ladle slidegate mechanism cannot be overstated, as it plays a critical role in ensuring both safety and quality throughout the continuous casting process. Safety is paramount in steelmaking operations, and the ladle slidegate mechanism significantly contributes to maintaining a safe working environment by providing precise control over the flow of liquid steel, minimizing the risk of accidents such as spills, splashes or overflows. Thus, ensuring the proper functioning and maintenance of the ladle slidegate mechanism is essential for steel manufacturers striving to achieve excellence in safety, quality and efficiency.

A key challenge in maintaining the slidegate mechanism's performance is the unavoidable wear of the refractory plates. During operation, these plates are exposed to sudden thermal shocks when the ladle is opened for casting, as well as physical abrasion and chemical corrosion from the liquid steel and slag. The wear and condition of the refractory plates are limiting factors for safe operation and directly impact production costs and output. The lifetime of slidegate plates, defined by the number of hot cycles from receiving liquid steel from the basic oxygen furnace (BOF) or electric arc furnace (EAF) until emptying at the continuous caster, is determined by crack formation and the steady increase of the center hole diameter due to corrosion. Depending on operating conditions, the plates must be replaced after one to five cycles. Fig. 2 shows the working surface of the movable slidegate plate after its last hot cycle, indicating surface abrasion, crack formation and a significant increase in the center hole diameter.[1–3]

Slidegate plates are typically made of alumina-graphite or magnesia-graphite. Alumina-graphite has the