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Towards Smarter EAF Steelmaking: AI-Powered Slag Optimization with Real-Time Process Adaptation

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In our previous work, we developed an AI-driven system to optimize slag quality in Electric Arc Furnace (EAF) steelmaking. The system utilized neural networks trained on harmonic signal data to assess slag conditions and recommend optimal carbon and oxygen injection profiles. By reducing reliance on operator estimations, this approach improved slag control and process efficiency. However, the initial model focused primarily on harmonic-based slag assessment without accounting for key process variables such as feedstock composition and manually controlled additives.

This study advances the AI system by incorporating Direct Reduced Iron (DRI) composition and lime and dolomite additions—critical parameters that influence carbon and oxygen demand. Since these factors impact slag chemistry, foaming behavior, and impurity removal, their inclusion refines injection strategies to ensure both optimal slag properties and target melt specifications, such as phosphorus reduction and carbon content control.

To achieve this, a deep learning framework leveraging multi-modal data fusion was developed to analyze the complex interactions between harmonic signals, feedstock composition, and additive inputs. The AI dynamically adapts its recommendations in real-time, ensuring that carbon and oxygen injection profiles align with both slag optimization and evolving furnace conditions. The system now integrates operator-controlled variables, allowing for greater adaptability based on real-time process decisions.

Currently undergoing industrial validation, the enhanced system extends harmonics-based slag monitoring by incorporating real-time process data, reducing variability, and improving melt consistency. By expanding AI-driven control to broader operational factors, this work further advances intelligent process optimization in EAF steelmaking, leading to improved efficiency and energy saving, reduced material waste, and more consistent metallurgical outcomes.

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