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Insights into Electric Arc Furnace Behavior: A Practical Simulation Approach

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The Electric Arc Furnace (EAF) has become increasingly popular in the industrial metal production sector in recent decades, undergoing substantial growth. At present, over 30% of steel production relies on electric arc furnace technology. In light of the harsh conditions surrounding the electric arc, numerical modeling emerges as a valuable tool for examining its behavior throughout the process. The objective of numerical modeling is to bring industrial enhancements in furnace design and facilitate the integration of new, environmentally friendly technologies, such as the utilization of hydrogen within the EAF.
The current study presents a model capable of simulating the thermal and flow dynamics of an industrial-scale EAF. The model couples the very rapid dynamics of the arc with flow inside liquid slag and metal. The model possesses the capability to forecast the behavior of the electric arc, including its interaction with the liquid pool underneath and its impact on the furnace's refractories thermally through radiation and mechanically through arc shear flow, all at an industrial scale. The arc shear flow and the electro-vortex flow inside the slag and liquid metal ensure sufficient mixing inside the slag layer and liquid metal. The model predicts the slag temperature to be higher than the liquid metal temperature which is in line with experimental measurements. The presence of an external axial magnetic field alters the flow and produces flow in the azimuthal direction. For a low axial magnetic field in a range of the earth's magnetic field, a rope tornado flow can be observed. With the increase in axial magnetic field, the flow transitions into a tornado-like flow. These simulations play a crucial role in advancing our comprehension of the electric arc furnace process. Additionally, they offer valuable insights into phenomena occurring inside EAF such as heat transfer to refractory walls and the erosion rate.

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