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Integrated Multi-institutional Approach to EAF bottom blowing technology development: Scaled Physical Model Verification, CFD Simulation, and Industrial Application

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Electric arc furnace (EAF) steelmaking represents a critical pathway toward achieving carbon neutrality in the steel industry by 2050, as it significantly reduces CO_2 emissions compared to blast furnace and basic oxygen furnace processes. However, the localized heating from the electric arc limits the stirring efficiency of molten steel, necessitating enhanced mixing strategies. Bottom blowing technology has emerged as a proven solution to enhance fluid flow, accelerate melting and decarburization rates, and improve molten steel quality. This study presents a comprehensive multi-institutional collaborative framework integrating theoretical modeling, advanced computational analysis, and industrial-scale validation to optimize EAF bottom blowing technology. The research methodology comprises three complementary approaches: (1) University-led scaled physical modeling provides theoretical verification of CFD simulation through the experimental validation using water model and PIV observation, establishing the scientific foundation for the phenomena of fluid dynamics. (2) Specialized simulation company develops high-fidelity CFD models to generate comprehensive simulation datasets characterizing fluid dynamics, gas bubble behavior, and mixing efficiency in bottom blowing systems. (3) Steel industry partner conducts full-scale industrial demonstration to validate laboratory and computational findings, ensuring practical applicability and operational feasibility in conventional EAF furnace. This integrated approach bridges the gap between academic research and industrial implementation, combining the rigor of physical modeling verification with computational precision and real industrial validation. The collaborative methodology establishes a reasonable framework for understanding bottom blowing hydrodynamics and optimizing operational parameters for enhanced energy efficiency and product quality in conventional EAF steelmaking.

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