Contribution ID: **109** Type: **Oral Presentation**

CFD modeling of supersonic jet impingement on molten bath during electric arc furnace refining

Wednesday 13 May 2026 09:10 (20 minutes)

Electric arc furnaces (EAFs) have become a key steelmaking technology in recent years. Today, more than 70% of steel produced in the United States comes from EAFs, which can reduce carbon emissions by up to 55–60% compared with the traditional blast furnace–basic oxygen furnace route. This makes EAFs a critical pathway for decarbonizing the steel industry. Despite these advantages, further improvements in refining efficiency and process understanding are essential to meet increasingly stringent sustainability and productivity goals. During the refining stage of EAF operation, supersonic oxygen injection is employed to enhance molten steel stirring, control steel composition, and promote slag foaming, which shields the electric arc and improves thermal efficiency. The behavior of these supersonic jets governs cavity formation, momentum transfer, and bath circulation, all of which influence refining performance. However, these jet–bath interactions occur under extreme thermal and chemical conditions, making direct experimental measurements inside industrial furnaces extremely difficult. Computational fluid dynamics (CFD) has therefore become an indispensable tool for studying complex phenomena such as supersonic injection in actual EAFs. Modeling supersonic injection in EAFs poses significant challenges, including compressible turbulent flow, free-surface deformation, multiphase interactions among gas, molten steel, and slag, and highly transient behavior. These complexities demand advanced numerical methods, careful mesh design, and robust solution strategies to maintain stability and accuracy. In this study, an advanced CFD framework based on the volume-of-fluid (VOF) formulation is developed to examine coherent jets injecting oxygen at different Mach numbers during the refining stage. The simulations are based on the geometry and operating conditions of an actual industrial furnace. To balance computational cost with realistic representation, the model focuses on a section of the furnace rather than the full geometry. Jet angle and position, as well as stand-off distances are selected according to typical industrial practice to ensure relevance. Simulations are used to evaluate coherent jet performance at Mach 1 and Mach 2, providing insights into their effects on cavity dynamics and molten steel mixing. The findings contribute to a deeper understanding of supersonic injection behavior and support the development of industry-relevant guidelines for refining-stage optimization.

Speaker Country

United States

Speaker Company/University

Purdue University Northwest

Primary author: SCHULMAN, Jacob (Purdue University Northwest)

Co-authors: UGARTE, Orlando (Purdue University Northwest); OKOSUN, Tyamo (Purdue University Northwest); PRETORIUS, Eugene (Nucor Steel Berkeley); MAIOLO, Joe (Linde); ZHOU, Chenn (Purdue University Northwest)

Presenter: UGARTE, Orlando (Purdue University Northwest)

Session Classification: Automation and Digitalization in Electric Steelmaking III

Track Classification: EEC 6 - Research and Development: EEC 6.B Collaboration between academia and industry