Contribution ID: **27** Type: **Keynote Presentation**

Optimization of electric arc furnace refining via CFD simulation of steel, slag, and freeboard dynamics

Monday 11 May 2026 14:10 (20 minutes)

In recent years, the steel industry has increasingly adopted electric arc furnaces (EAFs). Currently, more than 70% of steel production in the United States is achieved through EAFs. In addition to their energy efficiency and operational flexibility, EAFs can reduce carbon emissions by up to 55% compared with the blast furnace–basic oxygen furnace route, making them a key technology for achieving the steel industry's decarbonization goals. The EAF process consists of melting and refining operations. During melting, electrodes and burners are activated to melt the scrap charge through a combination of arc and chemical heating. In the refining stage, burners switch to lance mode, and oxygen is injected into the molten steel. This oxygen reacts with the steel to reduce carbon content, form oxides, and remove impurities. At this stage, the desired chemical composition and temperature of the steel bath are achieved before tapping. EAF operations involve complex physicochemical phenomena occurring under harsh conditions, making direct data collection extremely challenging. Computational fluid dynamics (CFD) provides a powerful tool to analyze EAF behavior by describing flow dynamics, reaction rates, phase changes, and thermal characteristics throughout the system. However, proper modeling of EAF processes at an industrial scale requires advanced CFD frameworks to capture these strongly coupled phenomena. In this study, a state-of-the-art CFD methodology is developed to simulate the refining stage of industrial EAF operations. The CFD model extends a previous approach that coupled a coherent jet model with a refining model. Namely, the coherent jet model is used to obtain the velocity and mass flow rates of oxygen jets impinging on the molten bath, which are then used to determine the cavities formed by the jets in the liquid steel. The updated CFD methodology, based on the volume-of-fluid approach, incorporates these cavities into the computational domain and includes the molten steel, slag, and gas (freeboard) regions. The updated model accounts for oxide formation in the molten bath during oxygen injection and the migration of oxides into the slag and gas phases. Validation against theoretical data demonstrates accurate prediction of decarburization as well as FeO and MnO generation in both high- and low-carbon regimes. The validated model is then applied to optimize oxygen injection parameters to enhance control over decarburization of the molten steel while preventing excessive FeO generation during refining operations.

Speaker Country

United States

Speaker Company/University

Purdue University Northwest

Primary author: UGARTE, Orlando (Purdue University Northwest)

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

Presenter: UGARTE, Orlando (Purdue University Northwest)

Session Classification: Automation and Digitalization in Electric Steelmaking I

Track Classification: EEC 2 - Process Optimization: EEC 2.A Energy efficiency and consumption reduction strategies