Materials Science and Engineering Thesis Defense

Laboratory-Scale Simulation of Slag Foaming: Method Development and Evaluation of Different Carbonaceous Materials

School for Engineering of Matter, Transport and Energy

Isaac Rhoden
Advisor: Terry Alford

Abstract

Electric arc furnace (EAF) steelmaking is the primary method of steel production in the USA. Efficient and stable operation of an EAF relies heavily on slag behavior, and more specifically, slag foaming to ensure that electrodes are protected and insulated. Slag foaming is a result of gas bubble formation from reactions between FeO in the molten slag and added carbon. To be able to effectively anticipate and control slag foaming behavior is of industrial interest to select the appropriate sources of carbon. This study focuses on a novel laboratory testing method as well as the application of that method to assess the suitability of multiple carbon sources for slag foaming behavior. The laboratory testing method involves using a confocal laser scanning microscope (CSLM) to get high-fidelity video observation of slag/carbon interactions, and specifically the gas formation behavior between carbon particles and 10 wt.% FeO synthetic slag. This was done under controlled conditions meant to closely replicate EAF conditions, including similar operating temperatures and feedstock chemistries. An experiment-specific data analysis methodology designed to get quantitative data from the video was designed using Meta's Segment Anything Model (SAM3). This experimental model was suitable for comparative assessment between carbon sources, and the data analysis methodology enabled the extraction of quantitative information such as bubble count, lifetime, and size. This experimental method was used to comparatively analyze multiple carbon sources (anthracite, calcined biocoke, and green biocoke). It was found that green biocoke demonstrates inconsistent particle-to-particle behavior, making it unsuitable for industrial use despite the low production costs associated with it. Additionally, it was found that the calcined coke has an extremely high reactivity with slag and will often react 1.15-2.2 times as quickly compared to a comparable mass of a conventional carbon species (anthracite). These findings indicate that the proposed method is not only capable of distinguishing differences between different carbon sources but has promise as a practical testing method for informing decisions related to carbon source selection and slag foaming behavior in EAF steelmaking.

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