Contribution ID: **49** Type: **Poster Presentation**

Optimizing Biomass Gasification-Driven Carburization for Carbon-Neutral Hydrogen-Based Steelmaking

Tuesday 7 October 2025 19:02 (1 minute)

Global steel companies are shifting from coal and natural gas-based production methods to hydrogen-based systems in pursuit of carbon neutrality. However, transitioning from coal to hydrogen significantly increases electricity consumption. To address this challenge, it is imperative to expand renewable energy resources, promote the supply of green hydrogen, and reduce its cost. In this context, we propose the development of a carbon-neutral carburization process that utilizes biomass to support the expansion of renewable energy. The carburization process is critical to the production of direct-reduced iron (DRI), as the carbon in the DRI provides chemical energy input to the electric arc furnace (EAF), thereby reducing the electric power requirements. Specifically, the carburization process in the form of cementite has been shown to yield a higher recovery in the electric arc furnace (EAF). The presence of high-carbon DRI in the cementite form has been shown to enhance DRI stability and EAF productivity.

In this study, we employed biomass gasification which does not produce carbon footprint of product(CFP) within carburization technology. Hydrogen-reduced pellets were carburized using bio-syngas, and we examined both the carbon content and its form (cementite/graphite) in accordance with the influencing factors associated with carburization.
It was observed that the temperature dependency of the carburization process varied with the contents of the primary carbon-based gases in the bio-syngas, attributable to differences in the reaction heat. Additionally, byproducts such as H_2 and CO_2 were found to influence the carburization process differently.

The study also revealed that both the carbon deposition and form were strongly dependent on the reaction time. Prolonging the deposition time beyond the optimal duration led to cementite decomposition reactions, resulting in the formation of graphite (i.e., dust). Consequently, optimal operating conditions were derived to maximize carbon yield while effectively suppressing cementite decomposition reactions.

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Session Classification: Poster Session

Track Classification: Hydrogen-based Steelmaking