Contribution ID: **62** Type: **Oral Presentation**

Temperature-Dependent Carburization Kinetics and Carbon deposition of iron in CO-H2-CH4 Gas Mixtures

Tuesday 12 May 2026 09:30 (20 minutes)

The global steel industry's transition toward low-carbon ironmaking is driving the expanded utilization of direct reduced iron (DRI) and hot briquetted iron (HBI). During the DRI process, carburization occurs concurrently with iron ore reduction in gas mixtures containing CO-H2-CH4, and it is critical for reducing the melting point of the product, thereby enhancing the energy efficiency and operational stability of subsequent steelmaking operations. Among commercial DRI processes, Energiron and Midrex are the most widely applied. Energiron operates at carburization temperatures above 1273 K, whereas Midrex proceeds at relatively lower temperatures below 1173 K. As a result, the two technologies show clear differences in carburization kinetics arising from variations in temperature, pressure, and gas composition. Accordingly, systematic comparative studies are needed to optimize process time and energy consumption.
This study investigated the carburization kinetics of pure Fe at 1073 K and 1273 K, corresponding to typical Midrex and Energiron carburization conditions, under various CO-H2-CH4 gas compositions, using thermogravimetric analysis (TGA). Carbon/Sulfur analysis and optical microscopy were conducted to determine the carburization behavior and the extent of carbon deposition.
The results demonstrated that the influence of the carbon source on carburization is significantly dependent on temperature. At the low temperature of 1073 K, CH_4 was negligible due to its limited capacity for C-H bond cracking. However, at 1273 K, the surface reaction rate of CH_4 was found to be more than three times faster than that of CO, indicating that CH_4 is highly effective in enhancing the overall carburization rate. Crucially, CH_4-rich, high-temperature gas compositions were found to cause severe carbon deposition concurrent with rapid carburization kinetics. Tablet-specimen experiments demonstrated that CH_4 conditions induced pronounced structural degradation and significantly accelerated carbon deposition. This behavior is interpreted as a result of excessive carbon precipitation driven by elevated carbon activity, causing internal stress and fragmentation. Furthermore, thin-foil experiments revealed that the extent of carbon deposition is strongly influenced by the initial surface roughness and specific surface area of the Fe substrate. Therefore, while CH_4 is favorable for achieving fast carburization kinetics at high temperature, controlling carbon precipitation and soot formation is essential for ensuring the stability of CH4-based processes.

Speaker Country

Korea South

Speaker Company/University

Inha university

Primary author: DAHAN, Jo (Inha university)

Co-authors: Prof. YOUNGJAE, Kim (Inha university); Ms YUBIN, Lee (Hyundai steel)

Presenter: DAHAN, Jo (Inha university)

Session Classification: Process Control and Quality Improvement

Track Classification: EEC 2 - Process Optimization: EEC 2.C Process control and quality improvement techniques