Contribution ID: **203** Type: **Oral Presentation**

Hydrogen Reduction of Manganese and Iron Oxides in a Commercial Manganese Ore: Thermochemistry and Kinetics

Tuesday 7 October 2025 16:40 (20 minutes)

Abstract:

The transition from solid carbon to hydrogen gas in ferromanganese production represents a transformative strategy for reducing carbon emissions in the ferroalloy industry. The HAlMan process, an innovative hydrogen-based reduction method, has advanced from laboratory-scale research to pilot-scale validation, demonstrating significant potential for decarbonizing ferromanganese production. This breakthrough technology could reduce CO2 emissions by approximately 1.5 tonnes per tonne of ferromanganese produced, marking a critical step toward sustainable metallurgy.

This study examines the thermochemical behavior and the reaction kinetics of a commercial manganese ore during hydrogen pre-reduction in a laboratory-scale vertical thermogravimetric furnace under isothermal conditions. Experiments were conducted at temperatures ranging from 600℃ to 900℃ to assess the reduction behavior and determine the rate-limiting mechanisms. Thermogravimetric analysis (TGA) was employed to monitor weight loss, enabling precise reduction rate measurements. Reduction progression was evaluated using XRF, XRD, BET, and SEM analyses to investigate compositional, mineralogical, and microstructural transformations.

The results indicate that the simultaneous hydrogen reduction kinetics of manganese and iron oxides in the ore are strongly temperature-dependent, with higher temperatures facilitating faster reduction and phase transformations. Complete reduction to metallic Fe and MnO was achieved at 800℃ and 900℃ within two hours, whereas lower temperatures required extended holding times to reach similar extents of reduction. Additionally, sintering effects were observed above 700℃, as evidenced by a decrease in BET surface area and pore volume.

These findings provide valuable insights into the hydrogen reduction mechanisms of manganese ore, supporting the development of an environmentally sustainable pathway for ferromanganese production.

Keywords: Hydrogen reduction, Thermogravimetry, Isothermal reduction, Thermochemistry, Kinetics, Manganese ore, Porosity, Surface area.

Primary author: SARKAR, Alok (Norwegian University of Science and Technology (NTNU), Norway)

Co-author: Prof. SAFARIAN, Jafar (Norwegian University of Science and Technology (NTNU), Norway)

Presenter: SARKAR, Alok (Norwegian University of Science and Technology (NTNU), Norway)

Session Classification: Hydrogen-Based Steelmaking Technologies

Track Classification: CO2 mitigation in iron and steelmaking