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High-Temperature Electrolysis Integrated With Direct Reduced Iron Process for Producing Low-Carbon Steel

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ABSTRACT

High-temperature electrolysis (HTE) of steam is one of the most energy-efficient techniques for producing hydrogen. Coupling the process with a direct reduced iron (DRI) plant can help the steel industry lower its carbon footprint by using the low-carbon hydrogen as a reducing agent and fuel, instead of synthesis gas derived from either natural gas or coal. In this study we aim to predict the performance of an integrated DRI plant via process modelling and simulation. The integration of HTE significantly reduced the CO_2 intensity of steel production.

Keywords: Hydrogen, Electrolysis, Direct Reduced Iron, Process Modelling, Decarbonization

INTRODUCTION

Iron and steel industries generate about 7% of the CO_2 energy related emissions as referenced by the International Energy Agency.[1] Most of the companies of the sector have thus made announcements to reach net zero between 2045 to 2050. Accordingly, the iron and steel industry decarbonization path[2] will at least comprise: (i) steel processes and materials optimization, (ii) developing CO_2 capture technologies and CO_2 utilization options, and (iii) feasible and economic low carbon hydrogen production. In addition, this technology and innovation journey will be combined with proper digital tools for measurements and evaluation purposes.

Manufacture of steel involves several high-temperature processes: (i) conversion of iron ore into steel, (ii) ladle refining and casting into multiple forms, (iii) heat treatment (e.g., quenching, annealing, and tempering) and (iv) chemical processes (e.g., galvanization). Among them, the direct reduced iron (DRI) process is one of the major steps of the steel making chain. The DRI allows to convert iron ore into sponge iron using a reducing agent such as synthesis gas (mixture of hydrogen and carbon monoxide) derived from either natural gas or coal. Pure hydrogen is also a fair option as reducing agent.[3]

Hydrogen is usually produced by methane reforming and coal gasification. Low-carbon hydrogen can also be produced by electrolysis technologies using water and renewable energy sources (such as solar, wind, hydraulic, and biomass). High-temperature electrolysis (HTE) of steam is one of the most energy-efficient techniques for producing hydrogen.[4]

