A Regenerative Process for CO2 Removal and Hydrogen Production in Integrated Gasification Combined Cycle (IGCC) Processes

Advanced power generation technologies, such as Integrated Gasification Combined Cycles (IGCC) processes, are among the leading contenders for power generation conversion because of their significantly higher efficiencies and potential environmental advantages, compared to conventional coal combustion processes. Although the increased in efficiency in the IGCC processes will reduce the emissions of carbon dioxide per unit of power generated, further reduction in CO2 emissions is crucial due to enforcement of green house gases (GHG) regulations. In IGCC processes to avoid efficiency losses, it is desirable to remove CO2 in the temperature range of 303°C to 503°C, which makes regenerable MgO-based sorbents ideal for such operations. In this temperature range, CO2 removal results in the shifting of the water-gas shift (WGS) reaction towards significant reduction in carbon monoxide (CO), and enhancement in hydrogen production. However, regenerable, reactive, and attrition resistant sorbents are required for such application. This paper discusses the development and evaluation of a highly reactive and attrition resistant regenerable MgO-based sorbent is prepared through dolomite modification, which can simultaneously remove carbon dioxide and enhance hydrogen production in a single reactor. The results of the experimental tests conducted in a high-pressure Thermogravimetric Analyzer (HP-TGA) and a high pressure packed-bed reactor indicate that, in the temperature range of 303°C to 503°C at 2 atm, more than 90 molar percent of CO2 can be removed from the simulated coal gas, and the hydrogen concentration can be increased to above 7 percent. Based on the physical and chemical analysis of the sorbent, a two-zone expanding grain model provides an excellent fit to the carbonation reaction rate data at various operating conditions. The modeling results indicate that more than 91 percent purification of hydrogen is achievable. The preliminary economical assessment of the MgO-based process indicates that this process can be economically viable compared to commercially available processes for combined CO2 removal and enhancement of hydrogen production.
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