Spring 4-11-2016

Combined magnesium oxide/water gas shift-based CO2 capture process

Santosh Ganwal
Southern Research, sgangwal@southernresearch.org

COMBINED MAGNESIUM OXIDE/WATER GAS SHIFT-BASED CO_2 CAPTURE PROCESS

Santosh K. Gangwal, Southern Research
sgangwal@southernresearch.org
Andrew J. Lucero, Southern Research
August Meng, Southern Research

Key Words: CO_2 capture, MgO sorbent, Water-gas shift, IGCC

Southern Research is developing a combined magnesium oxide (MgO) CO_2 sorbent/water gas shift (WGS)-catalyst-based CO_2 capture process for integrated gasification combined cycle (IGCC) power plants. A heat-exchanger reactor with a highly efficient heat management capability is being developed for simultaneous CO_2 capture and WGS to convert CO to CO_2 and H_2 and capture more than 90 % or more of the carbon from coal gasifier syngas. Simultaneous heat management and reaction allows the maintenance of thermodynamically favorable reaction temperatures for both steps. Also, by simultaneously converting the CO to CO_2 over the shift catalyst, the overall reaction thermodynamics is shifted allowing greater carbon capture by the MgO sorbent than if the two steps were carried out separately. The ultimate project goal is to capture > 90 % CO_2 and to reduce the cost of electricity by 30% over IGCC plants employing conventional methods of CO_2 capture.

Extensive thermodynamic analyses from multiple sources of thermodynamic data have been completed for simultaneous CO_2 capture and water-gas shift reactions. Based on these analyses, optimum temperature and CO_2 partial pressure windows have been established for reactor design. A thorough analysis of the literature has been conducted for preparation of MgO sorbents with excellent multi-cycle durability and high CO_2 capture capacity. An appropriate commercial water-gas shift catalyst has been obtained from a reputable catalyst manufacturer. Several MgO-based sorbents with and without promoters have been synthesized and have been tested using a thermo-gravimetric analyzer (TGA) at various temperatures and CO_2 partial pressures determined from the thermodynamic analysis. The best performing sorbents have shown CO_2 capture capacities greater than 20 wt %.

Present sorbent development/synthesis efforts are concentrating on (i) achieving excellent multi-cycle durability for these high capacity sorbents over 100s of cycles and (ii) mechanical forming of the sorbent in appropriate form for use in the heat-exchange reactor along with the WGS catalyst. A laboratory scale CO_2 capture/ WGS process skid has been designed and constructed to test sorbents under relevant gasifier conditions in a ½ inch diameter, 18 inch long reactor. Following sorbent development and completion of laboratory scale experiments, the sorbent and process will be scaled up to bench-scale. Simultaneous heat management, CO_2 capture and WGS will be demonstrated with high capacity and durability over 1000 cycles. A techno-economic evaluation will be conducted to demonstrate the potential of the process to achieve the required reduction in cost of electricity.