Design and Operational Analysis of Integrated Gasification and Steam Methane Reforming

The demand for hydrogen in industries continues to rise with increased plant capacities and is currently met by steam reforming or gasification of carbonaceous feedstock. The most preferred feedstock for the steam reforming process has been natural gas, while for gasification it has been coal. Steam reforming of natural gas is a highly endothermic and catalytic process that requires external heat to drive the reforming reactions, orthodoxly supplied by combusting fossil fuels in a furnace chamber. On the other hand, gasification in entrained flow gasifiers is a high temperature process where the product synthesis gas exits the gasifier at a temperature of around 1300 °C to 1400 °C. The coal-derived synthesis gas, with a low molar H_2/CO ratio of 0.75-1.1, needs to be cooled down to 150 °C for downstream acid gas treatment. Conventional methods employ radiant coolers with tubes for steam generation and quench cooling to provide the required cooling duty. This work presents the model development and design options of a hybrid system that integrates gasification with catalytic natural gas steam reforming by utilizing the heat duty available from the hot coal-derived syngas to drive the endothermic reaction inside the tubes of the radiant cooler. The advantages of the proposed system are process intensification by integrating two independent processes, production of a more valuable product using available exergy, improving the molar H_2/CO ratio of coal-derived synthesis gas and ability of a gasifier to respond to transient demands of a polygeneration plant.

Systems level analysis by Adams and Barton [1] has shown that the new cooling strategy is both profitable and technically feasible. However, the design and operational stability of the proposed system has to be studied in detail under transient operating conditions. A multi-scale, dynamic, heterogeneous, two-dimensional model of the radiant syngas cooler and steam methane reforming has been developed that can track temporal and spatial variations in concentration and temperature at the catalyst particle level. This work will discuss model development and validation approach adopted for a new system without supporting experimental data, associated computational complexities and the procedure to design an integrated system that meets the operating constraints. Simulation results show that the process is feasible providing the required cooling duty to the coal-derived synthesis gas and at the same time, achieving a higher conversion of methane at par with conventional reforming reactors. Also, an analysis of different design configurations considered will be presented with optimal design parameters for each of the case.

REFERENCE:

[1] T. A. Adams II and P. I. Barton, “Combining coal gasification and natural gas reforming for efficient polygeneration,” *Fuel Process. Technol.*, vol. 92, no. 3, pp. 639–655, Mar. 2011.