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Numerical Analysis of Gasification and Emission Characteristics of a Two-Stage Entrained Flow Gasifier

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Abstract

A two-stage dry-feed oxygen-blown entrained flow gasifier of HNCERI (Huaneng Clean Energy Research Institute) has been numerically studied through an integrated CFD-ROM approach, in which computational fluid dynamics (CFD) simulation is employed to investigate the detailed flow, temperature and composition fields, as well as to provide necessary information for the construction of reactor network-based reduced order model (ROM). A ten-step gasification chemistry together with an eight-step pollutant formation model optimized for the HNCERI gasifier have been constructed to investigate the gasification characteristics and emission of NO_x, NH_3, HCN, COS, SO_2 etc. Computational results show that a ROM consisting of two perfectly stirred reactors and one plug flow reactor can accurately reproduce the available gasification and emission industrial data in minutes on a PC and thus is suitable to integrate with process flowsheet simulation. Heterogeneous reactions are found to dominate the gasification process in the second stage of the gasifier. The CO/H_2 distribution in product syngas is determined by the water gas shift reaction at the downstream of the second stage where it reaches equilibrium. A sensitivity analysis shows that the coal and oxygen feed rates have pronounced effects on gasification characteristics while the effects of the steam feed rate and pressure are minimal. In addition, the decrease in the ratio of the coal feed rate of the second stage to the total coal feed rate may further increase the gasification efficiency, the effective gas production rate and carbon conversion with slight decrease in the temperature within the gasifier.

Keywords: coal gasification; numerical simulation; reduced order model; CFD