Mathematical Modelling and Experimental Validation of Steam Gasification of Coal and Biomass Chars

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Abstract

Gasification of biomass is a promising technology to convert renewable resources to energy and fuels. However, the high costs for transporting the low density biomass is a barrier for constructing a large scale bioenergy plant. From feasibility studies, co-gasification of blended biomass and coal has shown advantages to reduce the costs. There are uncertainties and lack of information in literature on the gasification performance of the blended biomass and coal. In this work, fundamental studies were conducted to develop a mathematical model which simulates the key part of the gasification process, e.g., the gasification of solid chars generated from initial devolatilization. This process is slow thus dominating the whole gasification process. Difference in microstructure among biomass and coal chars causes dissimilarity in steam gasification characteristics. The developed model is based on reaction kinetics and gas transportation of both the producer gas (H_2, CO, CO_2, H_2O) and the gas agent (steam). Mass conservation equations are also developed for each of the gas components and carbon involved in the process. This has resulted in a set of highly-nonlinear differential equations which were solved using a numerical method to predict gas production, gas composition and carbon consumption during the gasification.

Experiments were performed in a bench scale gasifier in which biomass chars, coal chars and blended chars were gasified using steam as gasification agent while nitrogen was used as a carrier. The gasification temperature was controlled at 850 to 950°C. Gas produced was analysed using a micro-GC from which the carbon consumption was also determined. From the experimental investigations, it has been found that the biomass and coal chars have distinct gasification characteristics and the overall reaction rate decreases as the increased coal to biomass blend ratio. The experimental results were used to validate the developed model, which shows close agreement between the simulation results and the experimental data.