Synthesis Gas Production of Municipal Solid Waste in a Fluidized Bed Gasifier using Thermodynamic Equilibrium Model

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Abstract:

The increment of municipal solid waste (MSW) generation nowadays is due to fast growing population, urbanization and industries in Malaysia as well as their impact towards environment and human health has been a biggest concern nowadays [1]. In addition, the dramatic increase of the depletion of fossil fuels over the years has rising up the awareness and accelerated the current research about the utilization of MSW into energy recently. Abundant of MSW at the landfill sites and improper management of the particular waste could provide a favorable alternative supply of renewable energy sources due to its energy content and low carbon dioxide emission to the atmosphere [2]. Gasification is one of the technology that can be used to transform waste into an energy supply. Gasification is the thermochemical process of conversion of solid feedstock into useful gaseous that involving burning under limited amount air or oxygen. The gasification process is conducted at high temperature (>650°C) and the product of gasification process is called as synthesis gas which consists of hydrogen, carbon monoxide, methane and carbon dioxide. The synthesis gas can be directly used as a gaseous fuel and can be processed further to produce electricity and heat. Hydrogen is part of the synthesis gas which is one of the clean energy sources and a potential alternative fuel [3]. The combustion of hydrogen does not negatively affect the environment. In terms of simulation model, technically there are two groups of biomass gasification models to represent gasification process which are equilibrium approach and kinetic approach [2]. The comparison between both types of the models show the most effective and applicable model is the equilibrium model due to its simplicity, behaviour and operation system. The equilibrium model based on the minimization of Gibbs free energy and equilibrium constant to analyse the gasification process and also to solve the optimization and non-linear equation problems based on the gasification process. Therefore, the objective of this study is to predict the production of synthesis gas from MSW using thermodynamic equilibrium model. In this work two types of MSW will be used which are food waste and wood waste considering boths are the highest composition of MSW in Malaysia. The synthesis gas predicted from thermodynamic equilibrium model will be validated using food waste as biomass feedstock with the data from literature. Next the sensitivity analysis for gasification process using food waste and wood waste will be implemented by varying the gasification temperature, moisture content and equivalence ratio. This analysis is important in order to study the effects of operating conditions on the synthesis gas production. As conclusion, the proposed thermodynamic equilibrium model will be applicable for modelling of gasification process and can be used for pre-analysis in determining the hydrogen gas production for MSW before a full scale experiment can be implemented.