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Experimental results of gasification of waste tire with air&CO_2, air&steam and steam in a bubbling fluidized bed gasifier

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ABSTRACT

Gasification is one of the thermochemical conversion methods to produce both product gas and solid char. The quality of the product gas widely differs depending on the type of the gasification agent used in the gasification process. Therefore, one of the important parameters in the design phase of the gasification system is the gasification agent. In the present study, a laboratory scale bubbling fluidized bed gasifier was used to gasify the waste tire with the gasification agents of air&CO_2, air&steam and steam. Within this frame, the effects of gasification agents, bed material particle size, CO_2 to air ratio, steam to air ratio, steam temperature and steam to fuel ratio on the quality of the product gas were investigated. In order to determine the composition of the product gas, an online gas analyzer, which can measure CO, CO_2, CH_4, H_2 and O_2 components, was used. By using the measured gas compositions, the lower heating value (LHV) was calculated to represent the quality of the product gas. Comparing the gasification agents of air&CO_2, air&steam and steam, the LHV of the product gas was obtained 9.59, 7.34 and 15.21 MJ/Nm^3, respectively. The repetition and uncertainty calculation of the tests were performed.

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1. Introduction

Management of waste tires has become a serious environmental problem through the increase in the number of vehicles. One solution to this problem is to dispose waste tire thermally because waste tire has a high heating value, high volatile and low ash contents. There are three main thermochemical conversion methods: combustion, pyrolysis and gasification. Both in pyrolysis and gasification, the main objective is to obtain solid, liquid or gas products. However, pyrolysis and gasification are substantially different processes in terms of the types and the ratios of the yields. In combustion, on the other hand, the objective is to generate heat for different applications.

When the solid tire material is gasified, both solid and gas yields are generated. The gas yield is called product gas. The product gas is mainly composed of CO, CO_2, CH_4, H_2, O_2 and N_2. However, there are particulates, tars, and contaminants in minor amounts in the product gas as well. In order to generate electrical energy from the product gas, the aforementioned minor components must be removed from the product gas. After the removal process, the product gas is burned in a gas turbine or a gas engine to produce electricity. On the other hand, the solid yield of the gasification of the waste tire can also be used as a carbon source in industrial processes.

Because thermochemical conversion methods have many advantages in the disposal of waste tire, they have been extensively studied by researchers. Several studies have been performed to investigate the pyrolysis of waste tire. Williams et al. [1] studied the effects of temperature and heating rate on pyrolysis yields in a fixed bed reactor. Lee et al. [2] studied the pyrolysis of waste tire in a fluidized bed reactor. They found that the feeding rate of tire did not affect the output parameters of pyrolysis. Dai et al. [3] investigated the pyrolysis of waste tire in a circulating fluidized bed reactor. They obtained that the oil yield in pyrolysis process increased as the temperature and the heating rate increased. Chang [4] studied the pyrolysis of waste tire in a thermal gravimetric analyzer. He found that the degradation rate was sharply affected by temperature below 400 °C. Zabaniotou and Stavropoulos [5] performed experiments on the gasification of pyrolysis char. They found that the pyrolysis char presented higher reactivity with steam than CO_2. Ko et al. [6] conducted an economic analysis and found that the production of activated carbon from waste tire appeared to be more attractive than the production of activated carbon from coal, in terms of return on investment value.

Singh et al. [7] performed experiments on co-firing of tire and coal. They obtained that the co-firing of tire with a lower volatile coal provided a greater amount of NO removal than the co-firing of tire with a higher volatile coal. Song and Kim [8] reported that the calorific value

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