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Experimental investigation of whole tires and biomass mixed firing in reverse burning fixed-bed gasifier

Kai Wu[a], Tianqi Ren[a], Haijun Chen[b1*],Yuezhao Zhub[2*]

[a]college of Mechanical and Power Engineering, Nanjing Tech University, No.30 Pu Zhu South Road, Nanjing 211816, China
[b]Jiangsu Key Laboratory of Process Enhancement and New Energy Equipment Technology, School of Mechanical and Power Engineering, Nanjing Tech University, No.30 Pu Zhu South Road, Nanjing 211816, China

Abstract

The experiment researched on the gasification of the branch straw and whole tires as raw materials in reverse burning fixed-bed gasifier. The results of the process have shown us the temperature in the gasifier heated-up and the efficiency of the gasifier increased. The temperature in the gasifier can reach up to 750℃ and the heat value of the gas is 4.86MJ/m^3. The heat value of the gas was 5.34 MJ/m^3 and thermal efficiency of the gasifier could reach up to 60.21% when the tire biomass ratio was 44%. The speed of gasification layer is 140mm/min. ER have great impacts on gasification temperature, gasification is efficient when ER is at 0.3.

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Keywords: reverse burning; pyrolysis; tires; biomass; gasifier

1. Introduction

With the development of the society, more and more fossil fuels are used to meet the demands of economy growth. The fossil fuels are dominant energy on one hand and bring lots of environmental problems while burning on the other hand. Therefore, searching for renewable and clean energy in the future have become more and more important. Biomass, a natural fuel, will be endless for using in a proper way. Wasted tires, synthetic rubbers, they will do harm to the environment if mishandled. Thus, the purpose of the study is to validate the feasibility of mixed burning of tires and biomass.

* Corresponding author. Tel.: +86 13814502232 (Haijun Chen).
E-mail address: chenhj@njtech.edu.cn (Haijun Chen).
* Corresponding author. Tel.: +86 13505199993 (Yuezhao Zhu).
E-mail address: zyz@njtech.edu.cn (Yuezhao Zhu).

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Tires contains more half of carbon; the pyrolysis process produces more tar. The research concerning the gasifier compared to the pyrolysis of tire powder in the laboratory has been limited. Although the tire crusing step was eliminated in this process, the poor heat mass transferring performance still existed. So, the mixed burning way of tires and biomass was focus on research.

The mole ratio formula of the biomass based on the ratio of H and O to C, equation of the biomass is ($CH_{1.4}O_{0.6}$) [1]. Biomass was used to improve the quality of the gas production. And the biomass is stacked between the tires, which promoted utilization of the gasifier. In addition, biomass can be easily ignited than tire, which means the time to ignition reduced, and the consumption of the fuel also decreased. In a word, it is suitable for industrial production.

In previous work, it was confirmed that tires powder and biomass in tube furnace could acquire heat value of gas about 6.7MJ/Nm^3 and the efficient of the gas yield could be achieved 66% [2]. But the tire which divided into powder needed much mechanical energy. And the pre-treatment was difficult, additional energy such as man powers and electrical power was needed, because the sizes of the tires powder has a great impact on the outcomes. Co-gasification of the whole tires and the biomass without complicated pre-treatment could reduce the previous problems.

2. Experimental

2.1. The reverse burning fixed-bed gasification principals

The process was applied to whole tire pyrolysis in the reverse burning fixed-bed gasification, which different from other burning fixed-bed gasification, and can avoid trouble of burn-through and bypass phenomena. Biomass and waste tire was blended in the gasifier before gasification. In the process of gasification, the blend will be formed in ash layer, reduction layer, gasification layer, pyrolytic layer and dry layer spontaneously. The primary air enters the gasification chamber from the bottom of the gasifier, then passes through each layer with the reaction. In pyrolytic layer, much tar produced, then the air enters into the gasification layer, main reaction in this layer is the gasification of the C, H. In the reserve burning gasifier, the reduction layer exists above the gasification layer, so the useful gas produced in this layer and the rest of the tar will be cracked again. The ash layer purifies the gas at last, some tar will be absorbed by ash.

2.2. Design of the gasifier

A gasifier Lei Ning in Nanjing Tech University [2] designed as shown in Fig. 1. It is made up of 6mm thick mild steel sheet. The inside diameter of the gasifier is 650mm, with a water leg. The volume is 0.332m^3. The total height of the gasifier is 1600mm. The gasifier can hold 50kg raw materials about two whole tires. Biomass was filled in the rest zones of the gasifier. The diameter of the tires is 630mm with 113mm thickness. The biomass consisted of straw and branch.

The energy content of the biomass was 19.14MJ/kg and the tire was 38.52 MJ/kg. The proximate and ultimate analysis of wasted tire and pine sawdust as shown in Table 1. We can appropriately calculate the equation of the tire($CH_{1.12}S_{0.006}O_{0.011}$). Three thermocouples were set in 100mm, 300mm and 500mm height of gasifier. Under the reactor was an air grate and a constant 1.5KW blower was set to supply air. Air and gas flows were measured with flowmeter which the accuracy was 1.5. The gasifier is shown in Fig 1.