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Tar Content Evaluation of Produced Gas in Downdraft Biomass Gasifier

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Abstract: Gasification offers a combination of flexibility, efficiency and friendliness to the environment that these are important in meeting the energy needs to overcome impurities or contaminants and organic particles, such as tar. In fact tar is a serious problem that must be considered in the process of gasification, especially for an internal combustion engine application. Gas cleaning system is one the methods to reduce the tar produced in gasification process. This study aims to evaluate the content of tar before and after the ventury scrubber. Gasification air flow rate was 189.6 lpm; the water flow rates through the venturi scrubber were in the range of 10 to 30 lpm. The tar contents of the produced gas before and after cleaning were 675 and 125 mg/m^3, respectively.

Key words: Coconut Shell; Gasification; Downdraft gasifier; Venturi scrubber; Tar

INTRODUCTION

Energy is needed for human life which may assist in the modernization of social life. The increase in world oil prices, reduced world oil resources and environmental problems (global warming) has become a particular concern.

Gasification offers a combination of flexibility, efficiency and friendliness to the environment. Gasification is a thermochemical process that converts solid fuel into a combustible gas which is processed in a reactor called a gasifier. In addition to the resulting of fuel gas (produced gas) also produces particles and tar. Tar which is produced from the gasification process, can reach of 50 mg/Nm^3 to 2 g/Nm^3 at downdraft gasifier [1].

Impurities or contaminants and organic particles, such as tar created a serious problem during the process of gasification. This may affect the the utilization produced gas, especially for applications in internal combustion engines where is the requirements of tar that is lower than 100 mg/Nm^3 [2].

Several studies have been conducted to evaluate the performance on the downdraft gasifier. Phuphuakrat *et al*. [3] have conducted an investigation on the tar content in gas cleaning and the results showed, that the tar content reduced while the increasing gasification process equivalence ratio from 8.11 to 6.59 g/m^3. Kitapong *et al*. [4] have conducted a study on the comparison of tar at throatless downdraft gasifier with singles and double air supply position where the tar content decreases from 114 to 43.2 mg/Nm^3. While, Ueki *et al*. [5] have conducted an experiment on the tar content produced gas at throatless downdraft gasifier which was 32.3 g/Nm^3. Barrio *et al*. [6] have conducted a study on throttles downdraft gasifier performance resulted in the amount of tar 3- 5 g/Nm^3 [6]. The tar content produced by downdraft gasifier varies greatly depending on the design of the gasifier.

In the present study evaluates the resulting tar content of fuel downdraft gasifier using coconut shell as fuel.

MATERIALS AND METHODS

The study uses as the gasification system is shown in Figure 1, which was developed by laboratory of thermodynamics, department of mechanical engineering, The University of Indonesia which is the type of gasifier used downdraft. The gasifier had diameter of 30 cm, throat diameter of 10 cm and height of 50 cm. The solid fuel used for the gasification process was coconut shell, fuel capacity of about 5 to 6 kg per hour. Combustion air used was 189.6 lpm. Air and gas flow rate was measured using an orifice plate with U tube manometer. The gas cleaning was used in a venturi scrubber that was supplied with water at flow rate of 10, 20 and 30 lpm.

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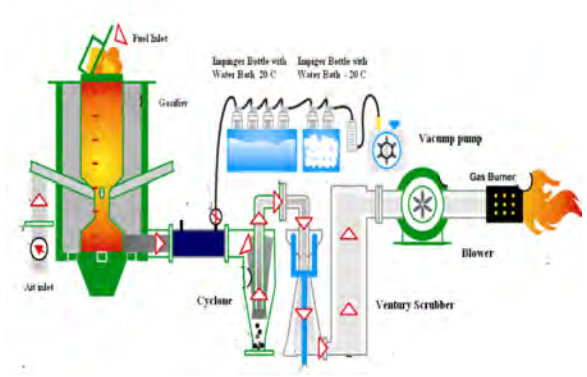

Fig. 1: Experimental Set Up

Fig. 2: Flame of gas combustion

Tar was trapped inside of six impinger bottle that filled with acetone as solvent, four of impinger bottle was lied over coolbath with temperature of 20 °C and two impinger bottles with temperature of -20 °C. The solvent that contained tar was heated at temperature 80 °C. The tar was analyzed by gravimetric after all solvent was evaporated. The tar weight was calculated by counting the weight differences of impinger bottle with and without tar content.

RESULTS AND DISCUSION

Testing the stability of the gas flame in the initial stage was conducted in order to observe stability of produced gas. Gasification process that occurs in the reactor in which the amount of fuel used is approximately of 8.5 kg using air flow rate of 189.6 lpm. The starting time from start-up condition until a combustible gas is produced was around 15 minutes. The time length of all amount of solid fuel is gasified was about 105 minutes. The rate of fuel consumption was 4.85 kg/h. The produced gas flame existed around of 88 minutes as shown in Figure 2. The temperature distribution inside the reactor at combustion zone is shown in Figure 3, which the maximum temperature reached in the combustion reactor around 800°C.

The results of measurements of tar before venturi scrubber at constant combustion air flow rate of 189.6 lpm shown the tar content about 675 mg/m^3. The content of tar after venturi scrubber showed that the increasing venturi scrubber water flow rate (VR) may created a decrease in tar content of the produced gas. That was due to an increase in flow rate of water, it would generate more breadth contact zone between the gas and water that makes the duration of residence time of gas into water longer so that it leads to an increase in the droplet formation of tar in the water. Tar after through venturi

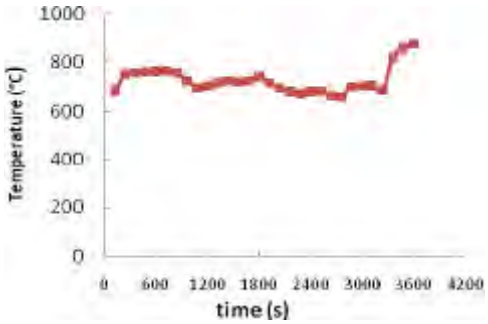

Fig. 3: Temperature of combustion zone against time operation

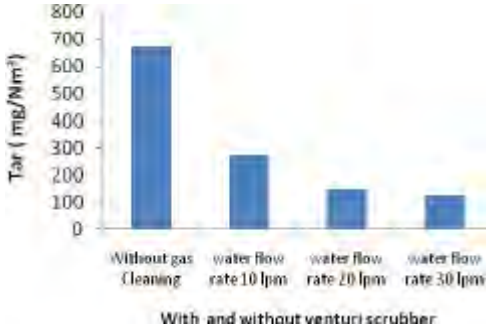

Fig. 4: Tar content

scrubbers between 125 to 275 mg/Nm^3. Absorption capacity of the venturi scrubber tar was about 60%. The increasing water flow may reduce tar content in the produced gas. The amount of tar produced had nearly met the criteria of internal combustion applications.

CONCLUSION

Testing results showed that the tar produced after passing through the venturi scrubber was in the range of 125 to 275 mg/Nm^3. This mean the capacity of

the absorption venture scrubber has reached to 60%. An increase in water flow rate would reduce the tar content of the produced gas;

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