The Influence of Wood Pellet Feedstock Water Content on Tar Component in Biomass System Using Downdraft Gasifier

Rizqi Fitri NARYANTO※1※3†, Hiroshi ENOMOTO※1, Noburu HIEDA※1, Yoshikazu TERAOKA※1, Chuntima CHUNTI※2, Reiji NODA※2

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Biomass gasification is a promising technology on the improvement of a worldwide green energy system. Biomass gasification is a thermal procedure where solid fuel changed over into a valuable gas using several gasifying agents, for example, air and steam. Tar is inevitable byproduct during biomass gasification process and needs to be reduced because it will disrupt the performance of other systems. This research had done on utilizing the dryer to change the moisture content of wood pellet to an arbitrary value. This experiment inspects the impact of the water substance on woody biomass in order to know the gasification efficiency. The tar sampling with various humidity pellet feedstock will be analyzed applying Gas Chromatography-Mass Spectrometry. It was found that generally, many compounds such as acetic acid, propanoic acid, phenol, benzene, toluene, xylene and naphthalene contained in tar composition. This research indicated the rising value of moisture content had influenced effects of the gasification efficiency.

Key Words
Tar, Water Content, Gas Chromatography-Mass Spectrometry, Downdraft Gasifier

1. Introduction

Biomass gasification is a promising technology on the improvement of a worldwide green energy system. Biomass gasification is a thermal procedure where solid fuel changed over into a valuable gas using several gasifying agents, for example, air and steam. Tar is inevitable byproduct during biomass gasification process and needs to be reduced because it will disrupt the performance of other systems. This research had done on utilizing the dryer to change the moisture content of wood pellet to an arbitrary value. This experiment inspects the impact of the water substance on woody biomass in order to know the gasification efficiency. The tar sampling with various humidity pellet feedstock will be analyzed applying Gas Chromatography-Mass Spectrometry. It was found that generally, many compounds such as acetic acid, propanoic acid, phenol, benzene, toluene, xylene and naphthalene contained in tar composition. This research indicated the rising value of moisture content had influenced effects of the gasification efficiency.

Biomass gasification process was affected with various aspects such as equivalence ratio, gasification temperature, fuel type, moisture content, and gasifying agent 5). The effects of various parameters on gasification performance, which use wood pellet had been done based on the gasification condition. Some values of moisture content parameters are used in this experiment. Conventional tar sampling methods are typically based on cold trapping followed by solvent extraction 6), evaporation 7) and final determination by Gas Chromatography as we have been done. This research had done in order to investigate the impact of moisture content modification of wood pellet feedstock towards the cold gas efficiency and chemical tar composition.

2. Experimental

Wood pellet was chosen as feedstock because it contained lignin component compared to other kind of feedstock. In this experiment we used wood pellet with 6 mm diameter and 790 kg/m³ of bulk density. Woody biomass typically contained more than 25% lignin and 70% cellulosic carbohydrate. Lignin acts as bonding agent
for hydrocarbon products and it causes tar production. On the other hand, the amount of wood pellet can be accommodated much more compared with a wood chip in the same reactor gasifier volume. Wood pellet has low of moisture content and has denser composition than wood chips. Moisture content that being used are around 2 wt%, 4 wt%, 6 wt%, 8 wt% and air flow rate 80 L/min, which characteristics of wood pellet shown in Table 1.

Fig. 1 apparent diagram of the downdraft gasifier system manufactured in this experiment. Reactor was made from stainless steel with 500 mm length and 120 mm inner diameter. Another parts were being used, are Soot Remover, Cooler, Suction Pump. Gas Chromatography-Mass Spectrometry (GC-MS) was applied in the function to separate, identify and quantify component in bio syngas.

Collection of tar was carried out using the apparatus of Fig. 2. This device used three tar sampling bottles with 300 mm long and 24 mm diameter and Cold Solvent Trapping (CST) method use in this research. Syngas from reactor heated with 250 °C and ethylene glycol was used to freezing tar sampling in the bottle with -20 °C setting temperature. The procedure that had been executed has a different way with the procedure from Kamp, et al., because in this experiment only produces one type of organic compound named ‘tar’.

In this paper, the small oxygenated hydrocarbons (acetic acid, propanoic acid, and phenol) and small aromas (benzene, toluene, xylene, and naphthalene) were measured quantitatively with GC-MS (Shimadzu QP2010) in order to verify the amount of these compositions.

### Results and Discussion

The first step of this experiment is to prepare feedstock conditions by drying with the following methods, feedstock has an initial value of moisture content around 8 wt%. Wood pellet dried with four different temperature conditions 70 °C, 60 °C, 50 °C, 40 °C. The interval for moisture content measurement was every 2 hours during 48 hours which was divided into 4 measurement sessions. From the result, the value of the moisture content changes significantly in the first 12 hours. This value will decrease gradually during drying occur, and the percentage of moisture content are stable after 12 hours. The sessions were exhibited in Fig. 3.

In this result, other parameters to be examined are cold gas efficiency to measure performance of gasifier. Cold gas efficiency can be defined as the ratio between the flow of energy in the gas and the energy contained with the fuel, as shown in Fig. 4. From the graph, it can be seen, cold gas efficiency decreases from 0.69% (2 wt% of moisture content wood pellet) to be 0.59% (8 wt% of moisture content wood pellet). This condition indicated that wood pellet with low moisture content has a better value of fuel conversion.

In the gaseous tar condensation, oxygenated

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**Table 1** Characteristics of wood pellet

| Ultimate analysis (wt%, dry basis) JIS M 8813 |
|----------------|
| C | 49.75 |
| H | 6.40 |
| N | 0.09 |
| S | 0.09 |
| O (balance) | 43.14 |
| Ash | 0.53 |

| Proximate analysis (wt%, dry basis) JIS M 8812 |
|----------------|
| Ash | 0.53 |
| Volatile Matter | 81.82 |
| Fixed carbon | 17.65 |

| Heating value (MJ/kg-dry) JIS M 8814 |
|----------------|
| Lower heating value (LHV) | 15.37 |

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Fig. 2 Tar sampling

Fig. 1 Diagram system of downdraft gasifier
hydrocarbons, e.g., acetic acid or phenol, are significant because they work as a surfactant between oil-like tar composition and the moisture content.

Tar sampling was taken in the position after the reactor with operating temperature average 400°C - 700°C. This temperature is known to generate increased amounts of light tar and then analyzed using GC-MS and calibrated using standard reagents with high purity 94% to 99% of phenol, benzene, m-cresol, toluene, styrene, p-xylene, m-xylene, o-xylene, indene, naphthalene, 2-methylnaphthalene, 1-methylnaphthalene, acenaphthylene, acenaphthene, benzophenone, fluorene, anthracene, phenanthrene, pyrene, fluoranthene, acetic acid, propanoic acid, 2-pentanone. Product quantification was determined based on compound peaks with similarity index greater than 80 on the Total Ion Chromatogram (TIC) using 23 standards. Firstly, the repeatability had been executed to evaluate the accuracy of the methodology. After that, the moisture content of pellet effects is revealed.

Fig. 5 describes the tar composition of wood pellets with different moisture content conditions. The condition with 2 wt%, 4 wt%, 6 wt%, 8 wt% of moisture content found in wood pellet was contained the small oxygenated hydrocarbons as well as acetic acid, propanoic acid, 2-pentanone. In this research we found that the element of
Naphthalene and phenol are mostly contained on all wood pellets. The compound of acenaphthylene and naphthalene arises when the moisture contents decrease.

4. Conclusion

The process of drying pellet by varying moisture content would be stable in the first of 12 hours, and after that, the moisture content would reach a constant value. The increasing of moisture content affected to the decreasing of cold gas efficiency because of effect from decreasing temperature gasification process. The other hand the water contents on wood pellet feedstock resulted in tar production from downdraft biomass gasifier. The research confirmed that generally, many compounds such as acetic acid, propanoic acid, phenol, benzene, toluene, xylene and naphthalene content in the tar composition. The compound of acenaphthylene and naphthalene arises when the moisture contents decrease.

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