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Composition of Syngas from Gasification with Variations in Oxygen Flow Rate (Gas Agent) in Up-Draft Type Gasification

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ABSTRACT: Gasification is a thermochemical process that converts solid fuel into gas fuel through a combustion process with limited air supply. Gasification generally consists of 4 process zones, namely drying, pyrolysis, oxidation, and reduction. The drying, pyrolysis and reduction processes are endothermic, while the exothermic oxidation process functions as a heat provider for the three processes. The biomass gasification process in this study used horse manure which is livestock waste with a gas agent in the form of oxygen. The gasification reactor used in this study has a reactor diameter of 600 mm and a reactor height of 1500 mm. The study was conducted using the thermal decomposition method where the gas agent used was oxygen with various flow rate variations (10, 15, 20 and 30 lt/min). Furthermore, the effect of the gas agent flow rate on the gasification process on the composition of the gas produced will be studied. The results of the research that has been conducted show that with the increasing flow rate of the gas agent, it will be followed by an average decrease in CO gas of 18.4%, an average increase in CH_4 gas of 8.8% and an average increase in CO_2 gas of 14.5%.

KEYWORDS: gasification, horse manure, syngas, oxygen, flow rate

I. INTRODUCTION

Research conducted by Gunawan [1] through the coconut shell gasification process using an updraft gasifier produces combustible gas CO = 13.32%; CH_4 = 1.52%; H_2 = 4.68%; N_2 = 37.09% and CO_2 = 38.21%. Research on coconut shell gasification using an updraft gasifier was also conducted by Yuono [2] at an AFR of 15%, the composition of the syngas produced was H_2 = 2.67%; CO = 40.70%; CH_4 = 1.7% and LHV of 5.53 MJ/m^3. Therefore, the resulting calorific value can be used as a substitute for conventional fuels. Research on the gasification process of coconut shells and palm oil shells using a downdraft fixed bed reactor with variations in material size found that the composition of syngas at a material size of 11 mm with a combustion temperature of up to 900°C in coconut shells was H_2 = 13.3%; CO = 17.4%; CO_2=16.7% and CH_4=4.23% [3].

The study was conducted to compare coconut shell and oil palm frond biomass fuels in terms of flammability and tar content. The fuel was burned in an updraft type gasification reactor until syngas was produced. The results of the study showed that the flammability of coconut shell biomass lasted for 43 minutes 14 seconds while oil palm frond biomass lasted for 10 minutes 26 seconds. The weight of dry tar from the gasification process weighed using a digital scale on coconut shell biomass was 8.99 gr, while on oil palm frond biomass was 4.62 gr. The mass of tar in each liter of gas sampled from Coconut Shell Biomass was 0.064 gr/lt while Oil Palm Frond Biomass was 0.034 gr/lt [4].

Gasification is a process of converting carbon-containing compounds to convert liquid or solid materials into combustible gas fuels (CO, H_2, CO_2, CH_4 and H_2O) through a combustion process with a limited air supply of between 20% and 40% stoichiometric air. The reactor where the gasification process occurs is called a gasifier. During the gasification process, a process area will be formed which is named according to the temperature distribution in the gasifier reactor. These areas are: Drying, Pyrolysis, Reduction and Combustion. Each area occurs at a temperature range between 25^{o}C to 150^{o}C, 150^{o}C to 600^{o}C, 600^{o}C to 900^{o}C, and 800^{o}C to 1400^{o}C. The gas resulting from the gasification process is called producer gas or syngas. Advantages and disadvantages of each reactor and the types of

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reagents commonly used for the gasification process. In addition to the available advantages, it turns out that the biomass thermal gasification process still has challenges in terms of excessive tar and char formation and low syngas calorific value if the operating conditions do not match the characteristics of the biomass being processed [5].

Numerical simulation of biomass steam gasification (oil palm empty bunches) using a thermodynamic equilibrium model. From the simulation, it can be seen that hydrogen production increases with increasing temperature. At low temperatures, hydrogen production is low and increases with increasing temperature until it reaches a peak and then hydrogen production decreases again [6]

The composition of syngas varies depending on the biomass raw material, but on average it can produce syngas with H_2 content of 18-20%, CO of 18-20%, CH_4 of 2-3%, CO_2 of 12%, H_2O of 2.5% and the rest N_2, with a gas calorific value of around 4.7 - 5 MJ/m^3 [7]. Gasification that we have known so far is gasification with coal and agricultural waste as feed, however gasification with livestock waste as feed, especially horse manure (biomass), has never been done, even though horse manure has great potential to be developed as a raw material for gasification. In this study, the use of horse manure as a feed material in the gasification process will be developed by considering the fine grain size, carbohydrate, fat and crude fiber content which is quite high so that it can increase carbon production which will indirectly increase the production of methane and carbon monoxide gas. Horse manure (feces) has various shapes and sizes as well as fine grain sizes. In addition, horse manure also has a high water content. As a gasification feed, if used directly, horse manure will be difficult to process and can interfere with gasification performance. Therefore, initial processing of horse manure needs to be done. The initial processing is in the form of reducing the water content in horse manure (feces). While the ratio of horse manure (feces) waste production reaches 5.5 tons/year/head with an energy conversion coefficient of 14.9 Gjoule/ton [8].

II. RESEARCH METHOD

The research method that will be used to achieve the research objectives is to test the potential of horse manure as a feed material in a gasification reactor using the thermal decomposition method with oxygen as a gas agent, then test the composition of syngas.

In this study, the variables used are:
Fixed variables

- Syngas composition consisting of a mixture of CO, CO2, CH4 gases
- Updraft type gasification reactor

Changing Variables

- agent gas flow rate: 10 lt/minute; 15 lt/minute; 20 lt/minute; 30 lt/minute
- agent gas: oxygen

The gasifier used in this study has a reactor diameter of 600 mm, and a reactor height of 1500 mm (figure 1). The main material needed in this study is horse manure, horse manure has a high water content. As a gasification feed, if used directly, horse manure will be difficult to process and can interfere with gasification performance. Initial processing of horse manure needs to be done through a drying process first. The study was continued with the process of making syngas with horse manure as feed material, in this case an updraft type gasification reactor was used and using a thermal decomposition method with a gas agent media in the form of oxygen and flowed using a compressor. The gas agent flow rate was varied at 10, 15, 20 and 30 lt/minute respectively. Furthermore, the composition of the resulting syngas will be studied.

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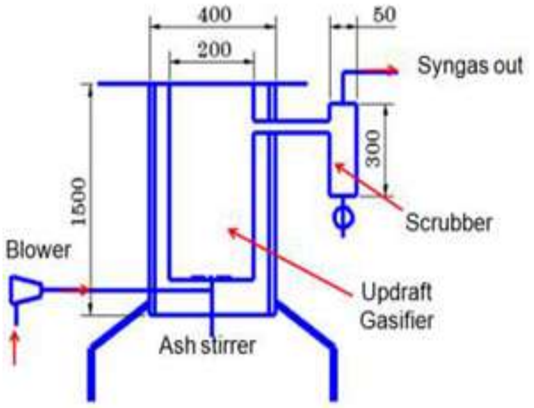

Figure 1. Gasification Reactor Test Installation

III. RESULTS AND DISCUSSION

The results of the research that has been done show that during the gasification process, an endothermic chemical reaction occurs. This reaction requires external heat during the process. The temperature that occurs in the gasification reactor increases along with the increasing rate of oxygen flow to the gasifier. Sihotang [9] stated that increasing the air flow rate increases the temperature in the reactor, gas composition, gas flow rate and gasification efficiency. High temperatures of around 900oC will result in the combustion process of horse manure biomass in the gasifier becoming more perfect. Therefore, the CO gas produced can be seen in Figure 2. If the heat produced in the oxidation process is higher, the heat will affect the pyrolysis process. The higher the reactor temperature, the better the pyrolysis process will be and more carbon will be formed. The greater the flow rate of the gas agent, the lower the CO gas produced. The decrease that occurs is around an average of 18.4%.

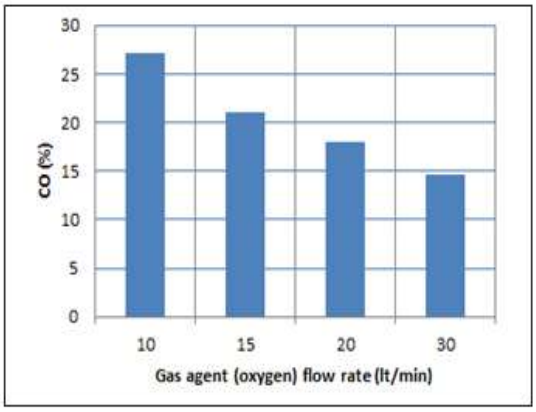

Figure 2. Relationship between gas agent flow rate and CO gas composition.

High temperature in the gasification process causes easier combustion, therefore this process produces higher levels of CO_2 gas in the syngas. Because most of the CO gas produced in the oxidation process has become CO_2 gas (figure 3), only a small proportion of CO gas is contained in the syngas and experiences an average decrease of 18.4% (figure 2). This result is consistent with the research results of Pacioni et al. [10]. They said that high air velocity results in a decrease in CO gas content.

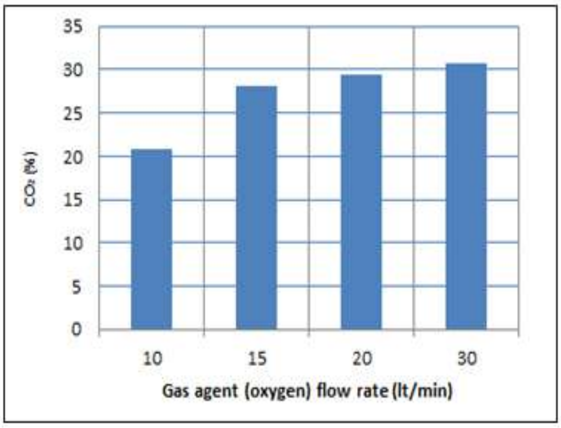

Figure 3. Relationship between gas agent flow rate and CO_2 gas composition.

Furthermore, the methane process is a reaction of methane gas formation where H_2 gas will react with carbon and form CH_4 gas. H_2 gas is formed in the carbon monoxide reduction reaction process. Figure 4 shows that the CH_4 gas formed will increase along with the increasing speed of the agent gas (oxygen) flowing with an average increase of around 8.8%.

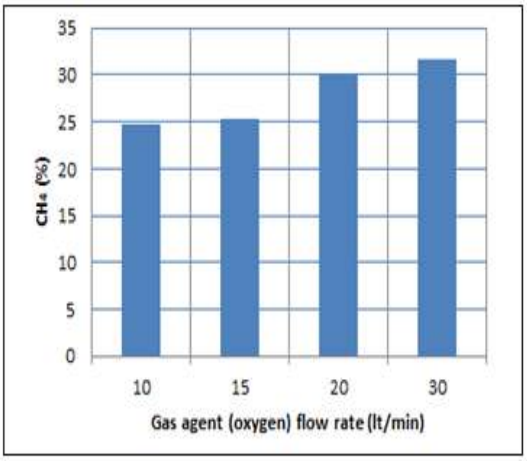

Figure 4. Relationship between gas agent flow rate and CH_4 gas composition.

IV. CONCLUSION

The conclusion that can be drawn from the results of this study is that the gasification process can not only be carried out with agricultural waste and coal as feed materials but also for solid livestock waste can also be carried out with good results. The effect of the increasing flow rate of the gas agent (oxygen) has an impact on the average decrease in CO gas by 18.4%, an average increase in CH_4 gas by 8.8% and an average increase in CO_2 gas by 14.5%.

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