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Biomass Gasification of Sengon Sawdust to Produce Gas Fuel

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Abstract. Indonesia is a country with extensive agricultural and plantation areas that produce abundant biomass, some of which are rice husks, coconut shells, corn cobs, and wood waste. Wood waste itself has a very large number of species, for example, Sengon sawdust, Teakwood, Mahogany wood, Lamtoro wood and so on. Sengon wood is usually used as material for craftsmen and furniture, but with advanced technology, it can be done using sengon sawdust to produce syngas with the gasification process. The gasification process uses a gasifier tool. In this study, an independent variable was used in the form of sengon sawdust. While the dependent variable that will be obtained is in the form of syngas output, gasification temperature and time needed to produce syngas. The results showed that the more bait sengon sawdust, the more syngas was produced and the longer the time needed. Based on syngas analysis, CO results were obtained 17.235%; CH_4 3.446%; H_2 5.089%. It can be concluded that sengon wood powder waste is one of the biomass that can be used as a gasification raw material to meet energy needs.

1. Introduction

Biomass is a renewable fuel and generally comes from living things (non-fossil) in which is stored energy or in other definitions, biomass is the whole material that comes from living things, including living and dead organic matter, both above ground surface or below the surface of the land. Biomass is a photosynthetic product where the energy absorbed is used to convert carbon dioxide with water into carbon, hydrogen, and oxygen compounds. Biomass is easy to obtain, environmentally friendly and renewable [1]. In general, the potential for biomass energy comes from the waste of seven commodities from the forestry, plantation and agriculture sectors. The biggest potential of biomass waste is from forest wood waste, then followed by the waste of rice, corn, cassava, oil palm, and sugar cane. Overall, the potential for biomass waste energy in Indonesia is estimated at 49,807.43 MW. Of this total, installed capacity is only around 178 MW or 0.36% of the existing potential (Hendrison, 2003). Household waste such as waste cooking oil can be processed into biodiesel which can be used as liquid fuel [2]. the byproducts of processing waste cooking oil into biodiesel produce glycerol which can be processed into triacetin that can be used as a bio additive [3, 4]. Inorganic waste such as plastic can also be processed into liquid fuel through the pyrolysis process [5-7].

Biomass is considered an alternative source of renewable energy for fuels that makes it possible to reduce greenhouse gas emissions. Biomass can be farmed sustainably through a process of fixation cycles and CO_2 release, thereby reducing the problem of global warming. Energy can be obtained by burning biomass directly, it can also be by pyrolysis (without oxygen) or gasification (with limited oxygen) to produce liquid fuel or gas fuel [8-11]. Biomass gasification is one of the most promising technologies because of its ability to quickly convert large quantities and various types of biomass into gas or fuel. The process of biomass gasification is by converting it into a mixture of gases such as carbon monoxide, hydrogen, and hydrocarbons, along with with carbon dioxide and nitrogen [12].

Sengon is a member of the Fabaceae family and is one of the tree species that grows very fast. Its growth for 25 years can reach a height of 45 m with a trunk diameter reaching 100 cm. Given its rapid growth, sengon has been dubbed the miracle tree. At the age of 6 years, the sengon tree can produce 372 m^3 / ha of round wood [13].

The general characteristic of Sengon wood is the color of the terrace wood which is almost white or light brown where the sapwood is generally not different from the terrace wood, the texture is rather rough and evenly distributed, the direction of fibers is straight, wavy wide or combined, the impression of touch on the surface of the wood is rather slippery or slippery, specific gravity 0.33 (0.24-0.29) and strong class IV - V with shrinkage up to furnace 2.5% (radial) and 5.3% (tangential) [14].

According to Sulaiman [15] gasification is an alternative in the framework of energy-saving and diversification programs. Besides gasification will help overcome the problem of handling and utilizing waste from wood products. Gasification is the process of converting solid or liquid fuels to gas fuels without producing waste or solid carbon residues. Gasification is a very important form of conversion because it can be effectively utilized for the decentralization of power generation and the application of heat utilization. Gasification is also an energy conversion technology that can be used for a variety of biomass fuels [16]. Gasification is a process of converting solid fuel to combustible gas (CO, CH_4, and H_2) through the combustion process with a limited air supply (20% - 40% stoichiometric air) [17].

The gasifier is an instrument that can convert various solid or liquid materials such as biomass into gas fuels as shown in Figure 1. The gasifier is a reactor where various complex chemical and physical processes can occur such as drying, heating, pyrolysis, partial oxidation, and reduction. Through gasification carbonate, the solid material is broken down into basic materials such as CO, H_2, CO_2, H_2O, and CH_4. The gases produced can then be used directly for the combustion process or stored in gas cylinders [16].

According to Higman [18], the stages of the gasification process are: Drying, the water content in solid fuels is evaporated by heat absorbed from the oxidation process. This reaction is located at the top of the reactor and is the zone with the lowest temperature in the reactor that is below 150 °C. The drying process is very important so that ignition on the burner can occur faster and more stable. In this reaction, fuel containing water will be removed by evaporating and it takes about 2260 kJ of energy to carry out the process so that it takes up a lot of operating time. Pyrolysis or devolatilization is also called partial gasification. A series of physical and chemical processes occur during the pyrolysis process which starts slowly at T <350 °C and occurs quickly at T> 700 °C. The composition of products arranged is a function of temperature, pressure, and gas composition during pyrolysis. The pyrolysis process starts at a temperature of about 230 °C, when components that are thermally unstable, such as lignin in biomass, break and evaporate together with other components. The vaporized liquid product contains tar and PAH (polyaromatic hydrocarbon). Pyrolysis products generally consist of three types, namely light gas (H_2, CO, CO_2, H_2O, and CH_4), tar, and charcoal. Reduction or gasification involves a series of endothermic reactions whose heat is supplied from the heat of the combustion reaction. The products produced in this process are combustible gases, such as H_2, CO, and CH_4. Oxidation or burning of charcoal is the most important reaction that occurs in the gasifier. This process provides all the heat energy needed for endothermic reactions. The oxygen supplied to the gasifier reacts with flammable substances. The results of these reactions are CO_2 and H_2O which are subsequently reduced when in contact with charcoal produced in pyrolysis.

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2. Research Methodology
The research methodology consists of materials used in research, research tools, steps in data retrieval during the gasification process, and gas analysis of the results of gasification.

2.1. Research Materials
Materials used in this research are sengon sawdust obtained from the furniture industry in Kulonprogo.

2.2. Research Instruments
The research tool used in this study is shown in Figure 1 which consists of a gasification reactor equipped with a cyclone and filter, a blower, a high-temperature thermometer, and a scale.

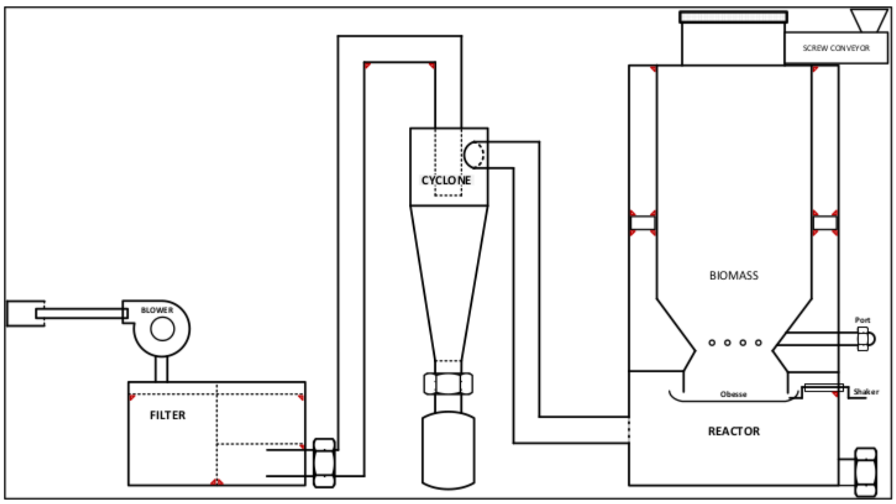

Figure 1. Unit of biomass gasification

This biomass gasification research began by preparing biomass raw materials by drying the raw materials under the hot sun. Weighing biomass using a digital balance sheet. Biomass gasification begins by introducing biomass feedstock into the gasifier. Turn on the blower to drain air into the gasifier. Light the biomass through the combustion pit. Record temperature changes every minute during the gasification process.

The final gasification results in the form of gas coming out of the blower, tar which is accommodated under the cyclone and ash mixed with charcoal retained under the gasification reactor. A mixture of ash and charcoal is taken, then weighed and recorded by weight. The gas (syngas) produced is partially taken with a vacuum and put into a sample tube for gas content testing.

3. Result and Discussion
The results of the research are correlation data on the change in the amount of raw material and the amount of syngas. The other results are in the form of correlation data of changes in the amount of raw material with syngas flame time. Gasification syngas analyzed carbon monoxide, methane, and hydrogen content with gas chromatography-mass spectrophotometry.

3.1. Effect of material weight on the syngas weight produced
The cellulose content in sengon sawdust is around 56.90%. First, the material is put into the gasifier and starts burning. The results of combustion in the form of gas and byproducts in the form of tar. If the gas is able to burn when ignited by fire, then this shows that there is syngas in the gasification gas

output. To find out the amount of syngas produced, we need some data taken in the study, namely the weight of the residual ash and the weight of tar. From the two data, we will get the effect of bait weight on the syngas produced as shown in Figure 2.

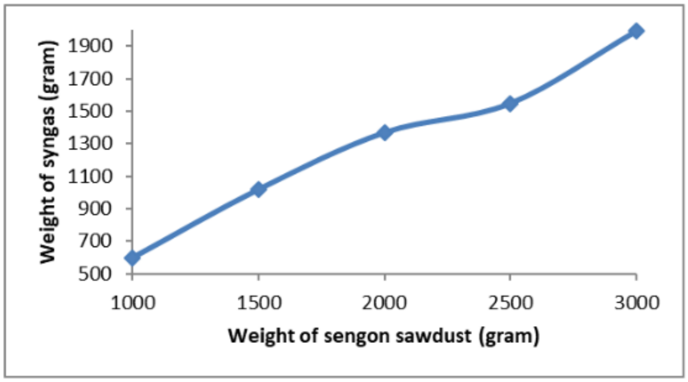

Figure 2. Correlation between the weight of sengon sawdust and weight of syngas produced

From Figure 2 about the effect of sengon wood waste weight on syngas weight with a variable weight of 1000 grams; 1500 grams; 2000 grams; 2500 grams; and 3000 grams produce syngas weight, which is 598,815 grams; 1019,106 grams; 1368,468 grams; 1548,138 grams; and 1991,731 grams. From Figure 6 it can be concluded that the more sengon sawdust waste that is used, the more syngas is produced.

3.2. Effect of material weight on long time the syngas is on

In addition to the residual ash weight of the combustion and the weight of tar, other data taken during this study were the time when the combustible gases were able to ignite when ignited by fire. From this time data, it will be known the effect of sengon wood waste feed on the time which shows there is syngas in the combustion gas as shown in Figure 3.

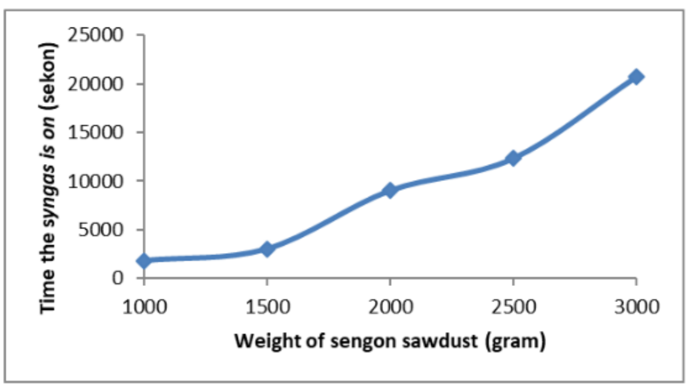

Figure 3. Correlation between the weight of sengon sawdust and time the syngas is on

From Figure 3 about the effect of sengon wood weight on syngas removal time with a variable weight of 1000 grams; 1500 grams; 2000 grams; 2500 grams; and 3000 grams produce syngas with a long time in a row, which is 1800 s; 3000 s; 9000 s; 12300 s; and 20700 s. From these data, graphs can be made of sengon wood powder weight vs. syngas weight. Figure 7 shows that the weight of sengon powder is directly proportional to the time of gas release. The more sengon sawdust used, the longer the time spent on gas.

3.3. Syngas composition

Gasification is a thermochemical conversion process that converts solid fuels to gas in a combustion reactor with an amount of oxidant that is less than needed. Some parameters used to determine the composition of the gas are CO, CH_4, and H_2. To find out the concentration of these compounds in the syngas from sengon wood powder gasification, sampling was carried out in a 10 ml vacuum tube and gas chromatography analysis. Syngas composition shows in Figure 4.

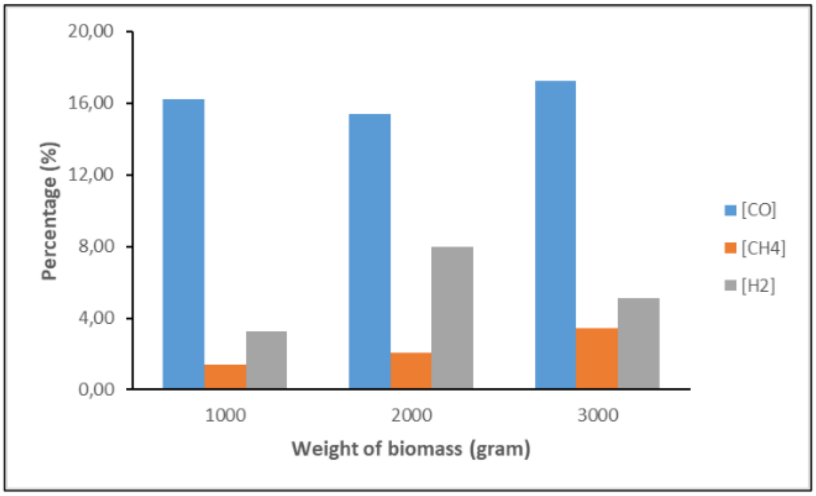

Figure 4. Syngas composition

4. Conclusions

From the research that we have done regarding gasification of biomass from sengon wood waste with the variable in the form of feed weight, it can be concluded that sengon wood waste is one of the biomass that can be used as raw material for gasification in meeting energy needs. This is indicated by the emergence of fire when the combustion gas is able to ignite when triggered by the fire.

The weight of the feed of sengon wood waste which is an independent variable in this study affects other variables in the form of a dependent variable. Some dependent variables in this study are the weight of the syngas produced and the flame time of the syngas. Table 4 shows that the more sengon sawdust waste feed, the more syngas is produced during the gasification process. Figure 7 shows that the more sengon sawdust waste feed, the longer the syngas removal time. In the analysis of syngas 1000 gr samples, it is known that 10 ml of syngas contains 16.214% CO; 1,382% CH_4; 3.244% H_2. For the analysis of 2000 gr syngas samples, it is known that 10 ml of syngas contains 15.402% CO; 2,058% CH_4; 8.002% H_2. While for the analysis of syngas 3000 gr samples it is known that 10 ml of syngas contains 17.235% CO; 3.446% CH_4; 5,089% H_2.

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