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Gasification of Oil Palm Shells and Empty Fruit Bunches to Produce Gas Fuel

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Abstract. National energy needs have been met by non-renewable energy resources, such as natural gas, petroleum, coal and so on. However, non-renewable energy reserves are depleting and there will be an energy crisis. Conversion of biomass into energy is one solution to overcome this. Indonesia, with its biodiversity, has enormous biomass potential, especially from oil palm plantations and also sugar cane plantations. From the oil palm plantation point of view, oil palm shells and oil palm empty fruit bunches are side products. These wastes can be treated with gasification technology to produce gas fuel. The gasification tool model used in this study is a downdraft gasifier equipped with a cyclone to separate gases with solids or liquids resulting from the gasification process. The results of the gasification process show that the more feeds are introduced, the more syngas is produced during the gasification process. The more feeds, the longer the syngas release time. The two variables have a correlation, that is, between the weight of syngas and the time for syngas removal to increase in line with the addition of the amount of feed entered. Syngas analysis of oil palm empty fruit bunches contains 4.959% H_2 and 5.759% CO. Whereas the analysis of syngas of oil palm shells contained 2.524% H_2, 6.391% CO, and 0.895% CH_4.

Introduction

Along with economic and population growth, the energy demand is always increase yearly in all sectors. So far, national energy needs are met by non-renewable energy resources, such as natural gas, petroleum, coal and so on. The depletion of energy reserves is forcing the Indonesian government and society to look for other alternatives as an energy source.

Indonesia is a tropical country, so it has huge biomass potential. Agriculture and plantation industries such as oil palm plantations, coconut plantations, sugar cane plantations, industrial timber plantations, and produce a lot of biomass waste. Oil palm plantations (*Elaeis guineensis*) is a large source of biomass waste in the form of dry palm waste consisting of oil palm empty fruit bunches and oil palm shells [1].

Empty bunches are the biggest waste compared to other solid wastes. Oil palm empty fruit bunches (EFB) represent waste generated as much as 23% of fresh fruit bunches (FFB) [2]. Most areas in Indonesia produce oil palm. Such as in the areas of Riau, Lampung, Palembang, Aceh, the east coast of Sumatra, Java, Kalimantan, Sulawesi. Most oil palm producing areas do not utilize solid waste from oil palm such as empty fruit bunches, palm shells, and palm leaf.

Oil palm empty fruit bunches are the largest waste produced by oil palm plantations. The number of empty bunches reaches 30-35% [3] of the weight of fresh fruit bunches per harvest. However, until now, the utilization of oil palm empty fruit bunches has not been used optimally. At the palm oil mill, oil palm empty fruit bunches have only been burned and have now been banned due to environmental pollution concerns, or discarded causing complaints / problems because it can reduce the ability to absorb water. In addition, oil palm empty fruit bunches that decompose on the spot will attract the arrival of certain types of beetles that have the potential to damage the rejuvenated oil palm trees in the land around the landfill [4]. The composition of oil palm empty fruit bunches shown in Table 1.

Table 1. Composition of oil palm empty fruit bunches [3]

Component	Dry weight [%]
Ash	6.04
Lignin	15.70
Cellulose	36.81
Hemicellulose	27.01

From Table 1, the main component in oil palm empty fruit bunches are cellulose and hemicellulose. Those components will be converted through gasification process become carbon monoxide, methane, and hydrogen. Carbon monoxide, methane, and hydrogen can be gas fuel.

The shell is a waste produced from the processing of the kernel of the palm kernel with a shape like a coconut shell, having heat from 3500 kcal/kg to 4100 kcal/kg. Palm shells are palm trees with pisifera shell type which are sterile female so that they rarely produce fruit bunches and in the production of superior seeds are used as male elders [1]. With a very large potential, empty fruit bunches and palm shells will be able to meet current energy needs. Several treatments that can be used in processing biomass especially thermal conversion are pyrolysis [5–8] and gasification [9-11]. In this research we used gasification process to convert empty fruit bunches and oil palm shells become gas fuel.

Gasification is defined as the thermo-chemical conversion of carbon-based solid or liquid materials (feedstock) into combustible gas products with a supply of gasification aids in the form of other gases [12]. Thermo-chemical conversion changes the chemical structure of biomass at high temperatures. Gasification aids encourage carbon-based materials to be converted quickly into gas through various heterogeneous reactions [12, 13].

The gasification unit consists of two types of updraft and downdraft. This type of updraft, which experiences a counter-current flow between gas and solid material, is more suitable for the conversion of char (char) which is less reactive to gas. Nearly 90% of the world's coal is classified using this configuration [13, 14]. While the type of downdraft experiences a concurrent flow between the solid material being fed and the gas, which is less flexible for water content and size. However, this type of downdraft is preferred for small scale processes because it provides cleaner gas yields and results in uncomplicated cleaning or purification processes [13].

The main purposes of this research are wanted to know the relationship between weight of materials and weight of syngas produced and the syngas composition that produced through gasification process.

Research Methodology

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.

Research Materials. Materials used in this research are oil palm shells and empty fruit bunches obtained from oil palm plantations in Lampung.

Research Tools. 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.

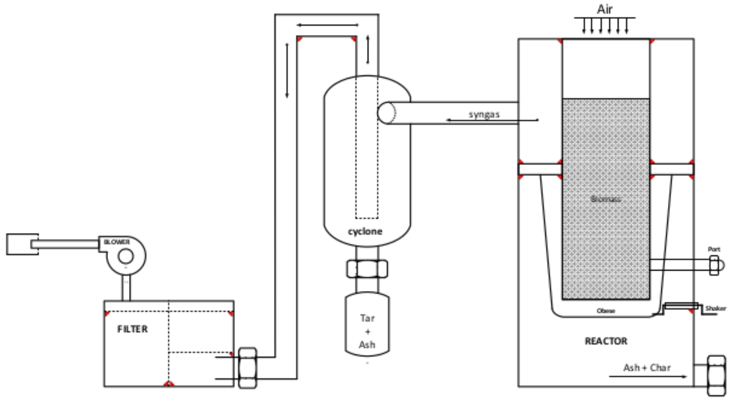

Fig. 1. A series of dry palm waste gasification tools

This biomass gasification research began by preparing biomass raw materials by drying the raw materials under the hot sun followed by reducing the size of the raw materials to 2-4 cm. Weighing biomass using a digital balance.

Biomass gasification begins by introducing biomass feedstock into the gasifier, using blower to drain air into the gasifier. The biomass was ignited through the combustion pit. The temperature recorded 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 [11].

Results and Discussion

Effect of material weight on the syngas weight produced. In this research, raw materials such as empty fruit bunches and oil palm shells are used. The cellulose content in shells is around 45% and empty bunches around 36.81%. the biomass is put into the gasifier and ignited. 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 which are the weight of the residual ash and the weight of tar. From these two data we will get the effect of biomass weight on the resulting syngas. The following are data on the effect of the weight of the empty bunches and oil palm shells on the syngas weight presented in graphical form in Fig. 2. and Fig. 3.

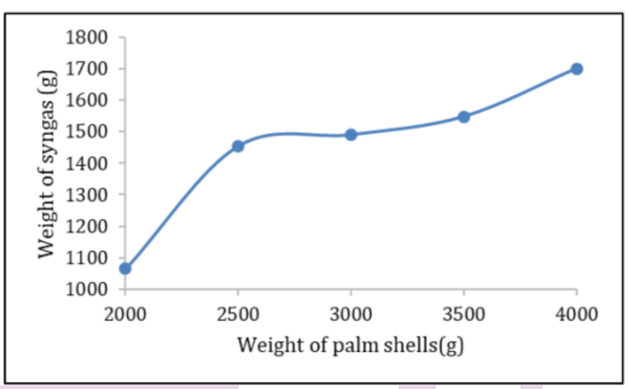

Fig. 2. Correlation between weight of palm shells and weight of syngas produced

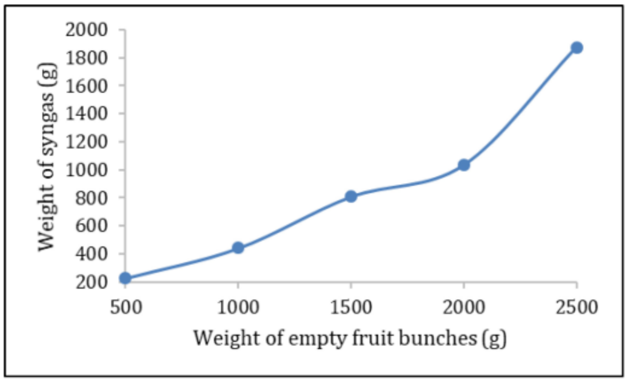

Fig. 3. Relationship between weight of empty fruit bunches and weight of syngas produced

Syngas composition. Gasification is the process of converting solid fuels through combustion with limited air supply to combustible gas in the form of CO, CH_4 and H_2. To determine the concentration of these compounds in the syngas from the gasification of oil palm empty fruit bunches and oil palm shells, sampling was carried out into a 10 ml vacuum tube and gas chromatographic analysis. Following are the results of the syngas analysis on the gasification of oil palm empty fruit bunches and oil palm shells contained in Table 2.

Table 2. Syngas composition

Component	Syngas composition [%]	
	Empty fruit bunches	Oil palm shells
H_2	2.524	4.959
CO	6.391	5.759
CH_4	0.895	0

From Table 2. for syngas composition of empty fruit bunches, CO has the highest concentration in the analysis of syngas with a concentration of 5.759% in other words CO has the biggest role in producing flammable or syngas gas. Then, H_2 was 4.959% and there was no CH_4 content in syngas. Based on the analysis, CH_4 at retention time, 3727 minutes can be seen the presence of CH_4 in syngas but the concentration is too small. From these data, it can be seen that CO has the highest concentration in the analysis of syngas with a concentration of 6.391% in other words CO has the biggest role in producing flammable or syngas gas. Then, H_2 is 2.524% and CH_4 content is 0.895%.

Summary

Palm shells and empty fruit bunches are good enough raw materials to be processed by gasification and produce syngas that can ignite when triggered by fire. The results of the gasification process show that the more feeds are inserted, the more syngas is produced during the gasification process. The two variables have synergy, that is, between the weight of syngas and the time for syngas removal to increase in line with the addition of the amount of feed entered. Syngas analysis of oil palm empty fruit bunches contains 4.959% H_2 and 5.759% CO. Whereas the analysis of syngas of oil palm shells contained 2.524% H_2, 6.391% CO and 0.895% CH_4.

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