The Effect of Air Flow Rate on the Production of Active Charcoal from Palm Oil Shells with Partial Oxidation Method

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Keywords: Activated Charcoal, Oil Palm Shell, Air Flow Rate, Partial Oxidation, Pyrolysis.

Abstract: Palm kernel shell is one of the palm oil processing wastes which is quite large, reaching 6.5% of 1 ton of palm oil. This shell can be used as an ingredient for making activated charcoal. Activated charcoal is widely used as an adsorbent, gas purification, water purification and so on. The palm kernel shell (PKS) is the hardest part of the components found in oil palm. Oil palm shell contains 26.6% cellulose and 27.7% hemicellulose which are good for making activated charcoal. This study aims to determine the effect of air flow rate on activated charcoal according to SNI No. 06-3730-1995. Carbonization and activation are carried out using pyrolysis with the principle of partial oxidation. The pyrolysis process was carried out at air flow rates of 20, 25, 30, 35 and 40 L/ min for 5 hours. The best results were shown at an air flow rate of 35 L / min with a product yield of 20%, water content of 5.82%, ash content of 7.51%, volatile matter content of 8,73%, fixed carbon 77,94%, and absorption. iodine of 750,1403 mg / g. These results have met the SNI 06-3703-1995 standards.

1 INTRODUCTION

Oil palm shells contain 26.6% cellulose and 27.7% hemicellulose which are good for making activated charcoal. The average annual production of oil palm fruit is 5.6 million tons, which means that around 364,000 tons of shells are produced. This number will continue to increase in line with the increase in palm oil production. With the availability of this waste, a further process is needed to convert palm oil shell waste into a product that has high economic value such as activated charcoal (Yuliusman, 2015).

The development of industry is increasing along with the development of science and technology, so that industry is one of the important sectors that supports the Indonesian economy. However, there are several industries that are developing slowly, in this case the charcoal and activated charcoal manufacturing industry. Activated charcoal is widely used as adsorbent, gas purification, water purification and so on. Activated charcoal can be made from all materials containing charcoal, both organic and inorganic, provided that the material has a porous structure.

Activated charcoal is a porous solid containing 85-95% carbon, produced from carbon-containing materials by heating at high temperatures. Charcoal is a porous solid material which is the result of combustion of materials containing carbon elements, while activated charcoal is charcoal that is activated by immersion in chemicals or by flowing hot steam into the material, so that the pores of the material become more open with a surface area range from 300 to 2,000 m2/g. The wider surface of activated charcoal has an impact on the higher absorption of gas or liquid materials. The methodology used includes the process of preparing activated charcoal, absorption and testing.

Research on the manufacture of activated charcoal with the pyrolysis method conducted by Hasan et al., 2020 which the study varied the addition of the amount of N2 gas, namely without the addition of nitrogen gas, the addition of nitrogen gas in batches, and the addition of nitrogen gas continuously with air flow rates of 0.5 L/min and 1 L/min. The best pyrolysis conditions are with nitrogen gas flowing continuously at 1 liter/minute. characteristics of activated charcoal with a yield value of 42%, water content 3.23%, ash content 2.73% volatile substances 28.37%, fixed carbon 66.16%. Research on the pyrolysis mechanism namely the production of pilot scale activated charcoal from oil palm shells

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(cks), the study varied the pyrolysis time and temperature. In this variation, the yield is 33-52%, water content 2- 5%, volatile matter 20-70%, ash content 2-10% and fixed carbon 22-70%.

Yuliusman, 2015 conducted research with the title of making activated carbon from palm oil shells with KOH and N2/CO2 as activating ingredients. Chemical activation with KOH 75% and physical activation at a temperature of 850°C using N2 gas for 1 hour followed by CO2 gas for 1 hour. Characteristics produced by the activation process at a temperature of 850°C have an iodine number of 884 mg/g with a water content of 13.6%, an ash content of 9.4% and a concentration lost on heating of 23.1%. In this study using the pyrolysis method with the principle of partial oxidation with a pilot plant scale with a raw material capacity of 5 kg/batch, physically activated not using pure N2 gas and CO2 but utilizing excess N2 gas in the air by limiting the air flow rate which aims to increase the pores. so that activated charcoal has a high absorption capacity. The advantage of this method is to use internal heat or heat generated from the oxidation reaction that arises by limiting the air flow rate in the raw material combustion process so that it can reduce combustion efficiency. In addition, with the air flow rate, biomass can create new porosity which can affect the combustion process and the resulting liquid smoke.

The purpose of this study was to determine the effect of air flow rate on activated charcoal using oil palm shells with a pyrolysis process using the principle of partial oxidation in a pilot plant scale with a raw material capacity of 5 kg/batch, and to determine the quality of charcoal produced by pyrolysis of oil palm shells. One of the advantages of making activated charcoal with the partial oxidation method is that at the activation stage it does not use chemicals but utilizes nitrogen gas in the air as an activator by limiting oxygen entering through the air flow rate.

2 METHODOLOGY

A total of 5 kg of PKS shells are dried and cleaned then the pyrolysis process will be carried out using a pyrolysis device which is assembled consisting of a raw material sleeve, combustion chamber, compressor and condenser. The pyrolysis combustion process uses coals that are inserted through the bottom hole of the pyrolysis and held for ± 10 minutes. Then the compressor is turned on and adjusts the air flow rate on the flow meter according to the air flow rate used. Cooling water is run in the condenser section. The process runs for 5 hour. The resulting charcoal is then analyzed for absorption of iodine by the SNI method No. 06-3730-1995 Calculate the absorption of activated charcoal against iodine using the following formula:

$$\text{Iodine NUmber } I_2 = \left(\frac{\left(10 - \frac{V_{tio} \text{ x } N_{tio}}{N_{tio}}\right) \text{x} 126{,}9 \text{ x fp} \times \text{N}}{\text{W}}\right)$$

Keterangan:

Vtio = Required volume of sodium thiosulfate solution (ml)

Ntio = Normality of sodium thiosulfate (N) solution

Niod = Normality of I2 solution

126,9 = Iodine atomic weight

W = Sample mass (grams)

3 RESULT AND DISCUSSION

The yield of activated charcoal produced relatively decreases as air is added or flowed into the reactor during the pyrolysis process.

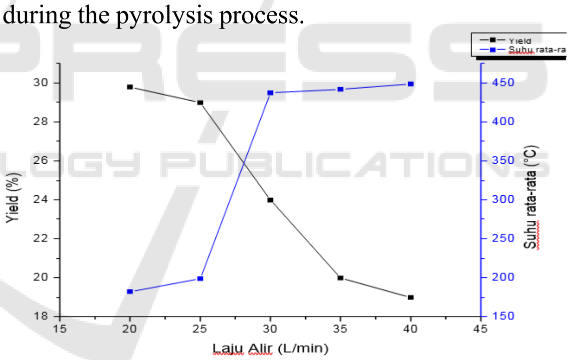

Figure 1: The relationship between the air flow rate and the average temperature of pyrolysis with the yield of activated charcoal produced.

In Figure 1 it can be seen that at a flow rate of 20 L/min the activated charcoal product produced is at the maximum yield, which is 29.8%, while at a flow rate of 40 L/min the minimum yield of activated charcoal product is 19%. . It can be seen that the yield continues to decrease along with the addition or flow of air into the reactor, namely the more oxygen and nitrogen gas that is circulated, the yield of activated charcoal obtained is also relatively decreased (Hasan et al., 2020). In addition, temperature is also very influential on the pyrolysis process. The higher the temperature, the better the decomposition/decomposition process, but the less amount of charcoal obtained while the more liquid and gas results, due to the large amount of decomposed and evaporated substances. The maximum yield was obtained at an average temperature of 182.68 °C at 29.8% and the minimum yield was obtained at a temperature of 448.98 °C at 19%, this is in accordance with the statement of Haji et al., 2010 that due to the high temperature some charcoal turns into ash and volatile gases, so the yield tends to be low. It can be concluded that the oxygen and nitrogen that are flowed into the reactor help the pyrolysis process occur perfectly, the incoming oxygen reacts with the activated charcoal to become CO_2 which causes the amount of solids to decrease. The function of oxygen here is to oxidize the material while nitrogen is a physical activating agent. The absorption of iodine (iod adsorption) indicates the ability of activated carbon to adsorb components with low molecular weight. Activated carbon with high Iodine absorption microstructure and pores.

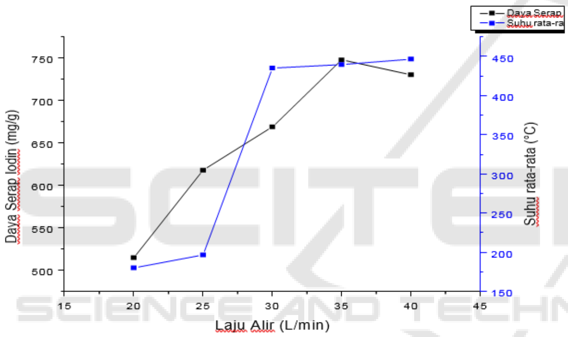

Figure 2: The relationship between the air flow rate and the average temperature of pyrolysis on the absorption of iodine in activated charcoal.

The absorption of iodine (iod adsorption) indicates the ability of activated carbon to adsorb components with low molecular weight. Activated carbon with high Iodine absorption means it has a larger surface area and also has a larger microstructure and pores.

Figure 2. It can be seen that the higher the air flow rate used in the pyrolysis process, the higher the temperature rise and the higher the iodine absorption. This is because the higher the air flow rate used will reduce volatile substances and increase the amount of fixed carbon in activated charcoal, the more iodine will be adsorbed so that the greater the reduction in the concentration of iodine solution which causes the higher the absorption of iodine. From Figure 2. the air flow rates are 20 L/min, 25 L/min, and 30 L/min with an average temperature of 182.68 °C, 199.12 °C, 437.50 °C, the results of absorption analysis are obtained. Iodine of 517,0282 mg/g, 620,1861 mg/g, and 671,1982 mg/g that have not yet entered the standard, this is due to the oxygen and nitrogen entering the pyrolysis process has not been maximized which causes the pyrolysis process to not run properly. The best results for the absorption of iodine by activated charcoal in this study were shown at the air flow rate of 35 L/min of 750.1403 mg/g, these results met the quality standard of activated charcoal according to the SNI 06-3703-1955 standard, which was 750 mg /g.

4 CONCLUSIONS

1. The air flow rate reaches the optimum condition at a speed of 35 L/min. At the above optimum conditions, the activated charcoal has already experienced a saturation point.
2. The best results are shown at the air flow rate an iodine absorption capacity of 750.1403 mg/g. This result has met the standard of SNI 06-3703-1995.

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