

Effect of Variations in Pyrolysis Reactor with Glass Wool Equipped and Without Glass Wool on the Weight of the Oil Produced

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ABSTRACT

Currently, plastic waste is a very serious threat because plastic waste pollution can harm all living things around and also harm the environment. The increasing volume of plastic waste is due to the lack of processing technology, so that the volume of plastic waste is increasing day by day. Plastic is a material that is difficult to decompose because it is non-biodegradable. One application of plastic waste processing technology offered in this study is to use the pyrolysis principle. Pyrolysis is a method of converting plastic into fuel oil through a thermal decomposition process without the use of oxygen. The pyrolysis process used with a variety of reactors equipped with glass wool and reactor variations without glass wool. The purpose of this study was to compare the yield of pyrolysis oil with a variety of reactors equipped with glass wool and reactors without glass wool. The plastic used is OPP (oriented polypropylene), with a constant reactor heating temperature of 200° C. The pyrolysis process is carried out for 1 hour each test, and the condenser cooling temperature is 28° C. Based on the results of the research, the reactor variation with glass wool got the highest oil weight of 175 grf, while the reactor variation without glass wool got the lowest oil weight of 17 grf. With a variety of reactors equipped with glass wool, the heat generated is more concentrated into the reactor core, resulting in higher oil weight and a more efficient pyrolysis process.

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I. Introduction

Currently, plastic waste is the most abundant waste because every tool/ item can be made of plastic, such as transportation equipment, household, technology, and so on. Plastic is a material that is cheap, light, flexible, and strong, but the increasing use of plastic materials also has an adverse impact on the environment, such as plastic waste pollution [1]–[3]. Plastic is a type of material that is difficult to degrade by the environment, which is called non-biodegradable material. As much as 60-70% of the waste generated from human activities is organic waste, while the remaining 30-40% is classified as non-organic waste, 14% of the non-organic waste is a plastic waste [4], [5]. Various efforts have been made by the community to eradicate the pile of plastic waste, which is increasing day by day, but the efforts made have triggered new problems such as blockage of flow and also combustion exhaust gases [6], [7]. Increasing population growth causes energy consumption to increase as well. Therefore, solutions are needed to find alternative energy sources. One of the methods offered is to utilize plastic waste to be used as fossil fuel through the pyrolysis process [8]–[10]. Generally, plastic waste management techniques are only through open dumping, sanitary landfill, and composting. In this study, we introduce a plastic waste management technology with easy operation and feasible to develop called the pyrolysis technique. Pyrolysis is the process of decomposition of a material at high temperatures that



takes place in the absence of oxygen. The products produced by the pyrolysis can be used in various needs. The types of fuel phases produced from the conversion process of plastic waste into fuel include a solid/charcoal phase, a liquid/tar phase, and a gas flammable phase, where the fuel can be converted again into heat energy and electrical energy [11], [12].

Handling plastic waste using the pyrolysis technique is expected to overcome the problem of environmental pollution caused by plastic waste. Besides, the pyrolysis method is able to produce products in the form of fuel oil. Previous research [13] carried out the pyrolysis process using plastic waste with the addition of twig waste. The pyrolysis temperature was maintained at 450° C for 10 min. Based on the results of the study, the best liquid smoke was obtained from PP gr and guava 34.2 ml. The optimum charcoal was produced at 75 gr HDPE and 25 gr mango, which was 95.56%. Previous research [14] carried out a pyrolysis technique using LDPE and PET plastic waste, which aims to determine the results of the comparison of oil volume and the quality of the fuel produced. The pyrolysis process was carried out within 2 hours with a constant temperature of 250° C. The results showed that the volume of oil produced from LDPE plastic was 525 ml, while PET plastic obtained 368.47 ml. The resulting density of these two types of plastic is close to the density value of kerosene. The calorific value of LDPE plastic is similar to the calorific value of diesel oil, while the calorific value of PET plastic is close to the calorific value of kerosene. Research has been carried out [15], which aims to determine and compare the ability of plastic pyrolysis oil with kerosene and diesel in terms of density, duration of combustion, water temperature and volume of water lost (evaporated) when cooked using the oil. Based on the results of the study showed that the density of the pyrolysis oil was 0.8 g/ml. Cooking water using pyrolysis fuel oil produces a temperature of 75°C at a cooking time of 4 minutes with a volume of water lost (evaporating) of 12.6 ml. The time it takes to burn down an object is 4.02 minutes. From the 4 parameters observed, the quality of pyrolysis oil is below kerosene but above diesel oil.

Based on the description above, the pyrolysis technique is determined as a method of processing plastic waste. It is expected to be a solution to the problem of plastic waste and an alternative fuel source in the form of oil as a substitute for fossil fuels. This study aims to determine the ratio of the weight of the pyrolysis oil in a variety of reactors equipped with glass wool and reactors without glass wool.

II. Material and Methods

The tools used in this study include 3 kg LPG gas cylinders, gas stoves, digital thermometers, digital LPG scales, digital scales, pyrolysis equipment, as shown in Figure 1. The material used in this research is OPP (oriented polypropylene) type plastic, as shown in Figure 2.

The research procedure included preparing tools and materials by cleaning plastic, weighing it to 500 grams, and designing a pyrolysis device with glass wool and without glass wool. The pyrolysis reactor equipped with glass wool is made of stainless steel with a diameter of 20 cm and a height of 30 cm, consisting of three main components: a heating reactor, a condenser, and a filter equipped with activated carbon. A bimetal thermometer is attached to the pyrolysis reactor component to determine the temperature during heating. The reactor was covered with glass wool so that not much heat was wasted, and the reactor was connected by 80 cm long connecting pipes to the condenser. The condenser is made of an iron plate with a capacity of 10 liters. Next for the design of the pyrolysis device without

glass wool has the same design, but it is not covered with glass wool. After completion of the device design process, 500 grams of OPP plastic is inserted into the pyrolysis reactor, which will experience a heating process when the burner is turned on with a fuel source of 3 kg LPG gas, and a process of change of state in the reactor from solid to gas occurs. The condenser tube has previously been filled with water as a cooling medium, which is called the liquification process, which is the process of changing the form of gas to liquid. In this condensation stage, a distillation process occurs to produce pure pyrolysis oil. The temperature of the cooling water in the condenser was found to be 28°C. The pyrolysis process was carried out within 1 hour of each test, with a reactor temperature of 200°C. After the testing process is complete, the results of the weight of the pyrolysis oil are compared to the reactor variations equipped with glass wool and without glass wool.



Fig. 1. Pyrolysis device



Fig. 2. OPP (oriented polypropylene plastic)

III. Results and Discussions

From the retrieval of test data, namely the pyrolysis process using OPP type plastic at a constant reactor temperature of 200°C, the results obtained by weight of pyrolysis oil for each variation of the pyrolysis reactor equipped with glass wool and without glass wool as described in Figure 3. The pyrolysis process is a conversion process, in this case, plastic

material into fuel oil with high temperatures and without the use of oxygen. Incomplete combustion of OPP plastic causes complex carbon compounds not to be oxidized to carbon dioxide, and this is called pyrolysis [15].

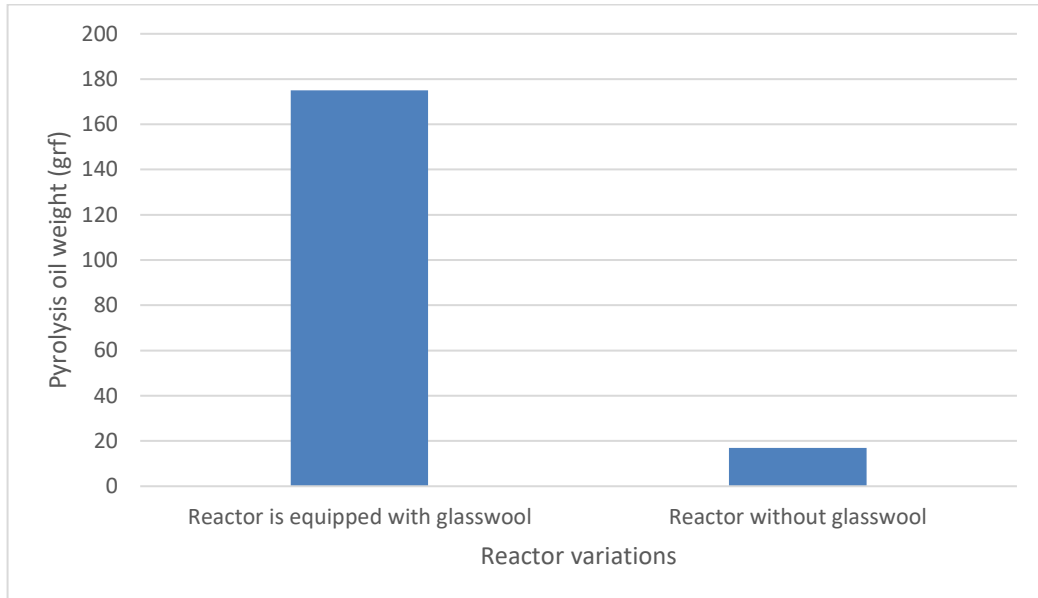


Fig. 3. Oil weight of each reactor variation

The increase in condenser temperature every 10 minutes in the variation of the pyrolysis reactor can be seen in Figure 4.

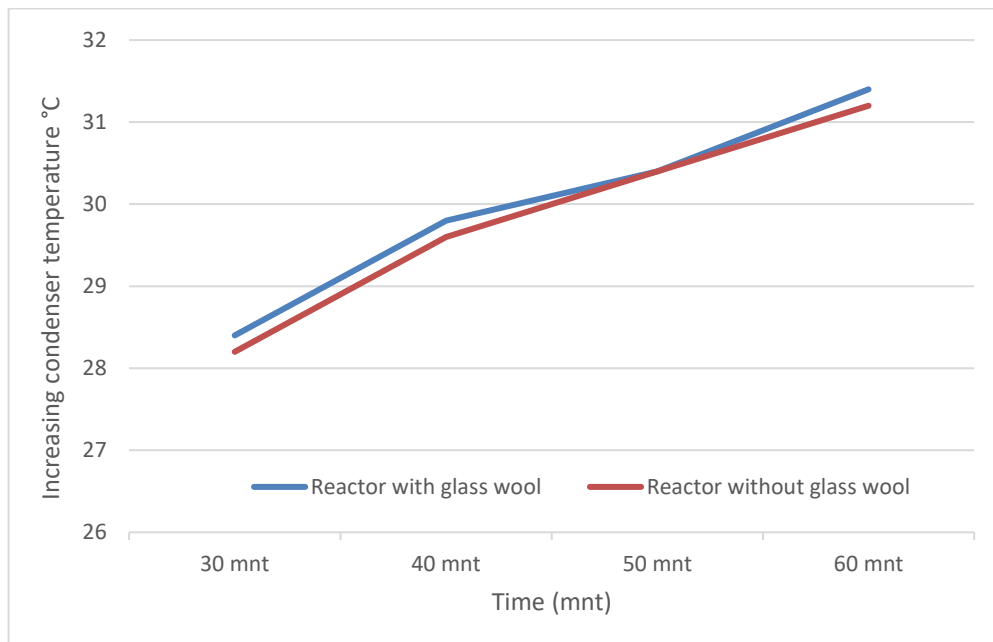


Fig. 4. Temperature increase in condenser

The phenomenon that occurs in pyrolysis is that when OPP plastic is heated in a pyrolysis reactor with temperatures reaching 200°C, the plastic will melt by changing its state from solid to gas. In the heating process, heat energy encourages oxidation which causes complex carbon molecules to decompose, most of which will become carbon or charcoal. Hot gas from the plastic conversion process in the reactor will be flowed into the condenser tube through the connecting pipe between the reactor and the condenser. In the condenser tube, the hot gas will be cooled by the water in the condenser. The phenomenon that occurs in the condensation process is the change of gas into a liquid. In this case, the hot gas is cooled so that the gas will melt into fuel oil. Figure 3 describes the results of the pyrolysis oil weight test in each reactor variation. Reactor equipped with glass wool produces oil with the highest weight of 175 grf, while the reactor variation without glass wool produces the lowest oil with a weight of 17 grf. This is because the reactor equipped with glass wool produces heat that is more concentrated in the reactor core so that the heat that is wasted out is not so much, and the reactor reaches a temperature of 200°C faster. Meanwhile, the reactor without glass wool takes a longer time to reach a temperature of 200°C, because the heat generated is not concentrated in the reactor core, so it takes a longer time to reach a temperature of 200°C than a reactor equipped with glass wool. Previous studies have carried out the pyrolysis process using plastic waste with a stainless steel-based reactor, with a reactor heating temperature of 606.9°C and a condensation temperature of 17°C. From the results obtained, the weight of the oil produced is 460 grf [16]. In the pyrolysis process, in addition to the low condensation temperature, the parameter to produce high oil is the reactor heating temperature. The higher reactor temperature, the higher and faster the process of converting solid to gas.

Figure 4 describes the increase temperature in the variation of the reactor equipped with glass wool and reactor without glass wool. In reactor with glass wool, it can be seen that at the 40th minute, the temperature increased to 29.8°C, while at the 50th minute, the temperature increased by 30.4°C. At the final minute of 60 minutes, the temperature was found to be 31.4°C. Meanwhile in reactor without glass wool, it can be seen that at the 40th minute the temperature increased to 29.6°C, while at the 50th minute, the temperature became 30.4°C. At the 60th minute, the temperature increased to 31.2°C. The increase in temperature in the condenser is caused by hot steam originating from the solid to the gas conversion process in the pyrolysis reactor. This hot steam flows through the connecting pipe to the condenser to be cooled so that the hot steam is converted into liquid fuel oil. As the condensation process progresses, the coolant temperature in the condenser increases. The limitation of this research is that the maximum reactor temperature only reaches a temperature of 200°C. In the pyrolysis process, it is suggested that the reactor temperature can reach temperatures above 200°C. At the condensation temperature, it reaches below 20°C so that the pyrolysis process becomes more efficient and produces a higher weight of pyrolysis oil.

IV. Conclusions

Based on the research, it can be concluded that the variation of the reactor equipped with glass wool produces the highest oil weight of 175 grf, while the variation of the reactor without glass wool produces the weight of oil the lowest is 17 grf. The addition of glass wool material to coat the reactor can cause the heat generated to concentrate to the reactor core so as to produce more fuel oil and the pyrolysis process becomes more efficient.

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