Experimental Study of Oil Purification from Plastic Waste with Distillation System Using Fractionation Column

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Abstract- ***Plastic waste is a global environmental problem. Plastic waste has a negative impact on the environment if it is not processed further, including being a problem in Indonesia. One way is by converting plastic waste into oil. This can be done because basically plastic comes from petroleum, so it just needs to be returned to its original shape. In addition, plastic also has a relatively high calorific value, equivalent to fossil fuels. This study aims to determine the performance of an alternative fuel purification fractionation column distillation apparatus from LDPE type plastic waste to reduce a large amount of plastic waste. Various studies have been carried out to reduce plastic waste into something useful, one of which is converting plastic waste into an energy source. The method and process used is pyrolysis (thermal cracking). Fractionated column distillation is a method of separating a mixture of solutions using a vapor/gas phase which is then condensed into a pure solution. The purification distillation equipment consists of a heater, reactor tube, fractionation column, condenser, thermometer, inlet and outlet hoses. The distillation solution is an alternative fuel from LDPE type plastic waste. Of the five tests of alternative fuels from LDPE type plastic waste, the first test produced 1370 mL, the second test produced 1230 mL, the third test produced 1490 mL, the fourth test produced 1400 mL, the fifth test produced 1610 mL, and the overall results of the five tests is 7100 mL. Refined oil has an average density of 694 – 736 [kg/m³].***

Indexed Terms- ***Plastic oil, Pyrolysis, Fractionated column distillation***

I. INTRODUCTION

Plastic waste is an environmental problem on a global scale. In Indonesia, plastic waste is the biggest problem, because it has advantages such as being strong, light and stable. However, the plastic currently circulating in the market is a synthetic polymer made from petroleum which is difficult to decompose. From survey data from one "greenliving" account posted on online mass media, if in one day the amount of waste produced per individual is 9 plastic, 3 styrofoam and 1 single-use bottle, assuming that there are around 228 million people in Indonesia. So in a day Indonesia produces 2,052,000,000 plastic bags, 684 million Styrofoam and 228 disposable bottles. (Source: detikforum.com/greenliving members).

In general, single-use plastic waste will be burned, considering that single-use plastic waste is very difficult to decompose. Plastic bags take 10-12 years to decompose, while Styrofoam takes 500 years to decompose properly. For handling plastic waste, it has not yet reached a perfect point that can preserve and sustain the earth. So it is necessary to develop long-term solutions that can reduce waste. while at the same time producing useful products. The process of recycling (recycling) is becoming very popular today. However, only certain recycling has been carried out so far. Even though there are many promising alternative recycling processes and prospects for the future.

II. LITERATURE REVIEW

Rahyani Ermawati, (2011), The use of plastic waste is a possible alternative as an energy-producing material. The cracking process is a process for

converting plastic waste from long alkyl chains of polyolefins into hydrocarbons.

Panda, (2011) Conversion of plastic waste into fuel oil Converting plastic waste into fuel oil includes tertiary recycling. Converting plastic waste into fuel oil can be done by the cracking process. Cracking is the process of breaking polymer chains into lower molecular weight compounds. The result of this plastic cracking process can be used as a chemical or fuel.

According to Kadir (2012), in the journal "Study of the Utilization of Plastic Waste as a Source of Liquid Fuel" said that plastic is a material that has been widely developed and used since the 20th century which has grown tremendously in its use from only a few hundred tons in 1930- an, to 220 million tons/year in 2005. Plastic is the main packaging material today. One type of plastic is polyethylene (PE). Polyethylene can be divided according to its density into two types, namely Low Density Polyethylene (LDPE) and High Density Polyethylene (HDPE). LDPE has a density of between 0.91-0.94 gmL-1, half of which is crystalline (50-60%) and has a melting point of 115oC.

Mustofa K, Fuad Zainuri (2014), said in the journal "Pyrolysis of Plastic Waste Up to 900oC as an Effort to Produce Environmentally Friendly Fuel", one of the alternatives for handling plastic waste which is currently being extensively researched and developed is converting plastic waste into fuel.

Arif Setyo Nugroho, Rahmad Rahmad (2017) To get engineering solutions for plastic processing technology that are appropriate and can produce renewable energy sources to produce alternative energy and make it possible as alternative fuels.

Jatmiko Wahyudi, (2018), Pyrolysis is a thermal cracking process, namely the process of cracking or breaking polymer chains into simpler compounds through a thermal process (heating/combustion) with no or little oxygen. Pyrolysis is an endothermic process meaning that the pyrolysis process can only occur when the system is given heat energy.

III. RESEARCH METHODOLOGY

- Design Process of Oil Purification Distillation System from Plastic Waste

The design of a distillation system for refining oil from plastic waste is made using stainless steel materials, to produce quality oil compared to traditional equipment which only uses materials that are easily corroded and less hygienic.

- Materials and tools

The main ingredient in this research is oil from LDPE plastic waste.

Figure 1. The raw material is oil from LDPE plastic waste before being refined

- Tool

The tools used to conduct this research are:

- Pyrolysis equipment is used to carry out purification distillation.

Figure 2. Pyrolysis Equipment

- Thermocouple, to measure temperature during testing and data collection.
- Digital scales are used to measure the mass of oil produced.
- Measuring cup, to measure the results obtained from each test in ml units.

- Research design

Testing of purification distillation by burning plastic waste with a distillation system process.

- Process steps for testing distillation purification systems

To carry out the manufacture and testing of the reactor with the distillation system process is carried out in several steps, namely:

a. Make preparations in the form of collecting data on the results of previous evaluations from comparative studies and literature studies.
b. Prepare materials and equipment needed.
c. Testing the purification distillation system with the combustion process.
d. Recording/retrieving data.
e. The data analysis stage in this stage the researcher tested the tool and collected the necessary data. The researcher also made comparisons on the data and results obtained during the testing.

- Research Plan

The process of testing the performance of the distillation system for purifying alternative fuels from plastic waste is as follows:

- Collecting plastic waste as the main ingredient in making alternative fuels
- Sorting LDPE type plastic waste.
- Time meter in the form of a clock.
- Prepare a measuring instrument in the form of a thermometer to be used in research.
- Put alternative fuel from plastic waste into the pyrolysis tube.
- Setting up a gas stove for burning.
- Prepare a container for the oil that comes out after going through the condenser.
- After the process is complete, turn off the fire and take measurements for the results obtained.

- Types of research

The research conducted to solve the problem is a type of experimental research in which the author examines and determines the process of purifying distillation systems to become fuel oil (bbm) from plastic waste as an alternative fuel to replace kerosene and also determines the density of the oil produced from processing plastic waste

- Research variable

The research variable is the meaning of the variable which is expressed in the definition of the concept practically, operationally, and actually within the scope of the research studied. The variables used in this research are independent variables.

a. Independent variable

The independent variable is the influencing variable, which causes the emergence or change of the dependent variable. The variables used in this study are temperature and the amount of fuel yield obtained (mass and volume).

b. Dependent variable

This variable is the result that arises from the independent variable. This variable is a direct result of the influence of the independent variables. So the dependent variable in question is research or data collection to solve the causes of the independent variables, namely the type of plastic being tested and the time/duration of data collection, which is every 15 minutes

- Sample/Subject/Object of Research

The samples/subjects/objects in this study were temperature data taken during the testing and combustion process in the pyrolysis device within a period of every 15 minutes while replacing the plastic fuel sample bottles.

IV. RESULTS AND DISCUSSION

Table 1. Comparison of fuel yields during testing.

No.	Jenis plastik	Hasil(ml)
1	LDPE	1370
2	LDPE	1230
3	LDPE	1490
4	LDPE	1400
5	LDPE	1610
Jumlah Keseluruhan		7100

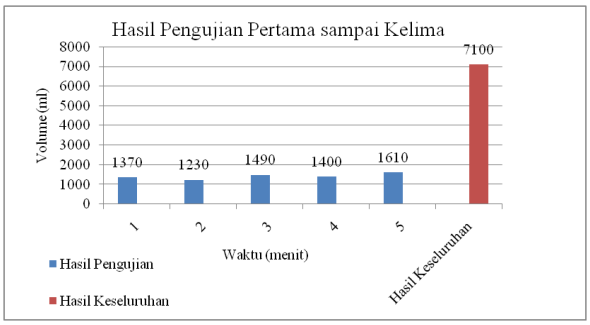

Figure 1. Graph of test results from start to finish.

Graph 3 shows that in the first test it obtained 1370 ml of fuel oil, in the second test it obtained 1230 ml of fuel oil, in the third test it obtained 1490 ml of fuel oil, in the fourth test it obtained 1400 ml of fuel oil , and in the fifth test obtained as much as 1610 ml of fuel oil. Then the total of fuel oil is 7100 ml.

- Calculation of the density of fuel oil from the resulting plastic waste

To calculate the density of oil produced from plastic waste, a calculation is carried out by entering:
Given : V = 230 mL = 230 [cm³] = 0.00023 [m³]
m = 150 gr = 0.150 kg
density (ρ) = m/V
= 0.150/0.00023= 652.1 [kg/m³]
Then the density of the oil produced by processing plastic waste is 652.1 [kg/m³].

Table 2. Testing of five samples of oil density from plastic waste.

No.	Sampel pengujian	Volume [m³]	Massa [kg]	ρ [kg/m³]
1	1	0,00035	0,250	714,28
2	2	0,00035	0,250	714,28
3	3	0,00036	0,250	694,44
4	4	0,00036	0,250	694,44
5	5	0,00034	0,250	735,29
ρ rata-rata				710,54

So the fuel oil produced from the processing of LDPE type plastic waste has an average density of 694 – 736 [kg/m³]. If we compare it with the density of kerosene, which is 800 [kg/m³], then the density of kerosene is heavier than fuel oil from LDPE plastic waste. Meanwhile, if we compare it with the density of gasoline, which is 710 – 770 [kg/m³]then the density of fuel oil from LDPE plastic waste is almost like gasoline.

Table 3. Comparison Table

No.	Zat Cair	MassaJenis [kg/m³]
1	Minyak Tanah	780 -800
2	Bensin	710 -770
3	Minyak Sampah Plastik	694 – 736

Density is a measurement of the mass per unit volume of an object. The higher the density of an object, the greater the mass of each volume. The average density of each object is the total mass divided by the total volume. An object that has a high density has a lower volume.

CONCLUSION

Based on the research that has been done, it can be concluded several things, namely :

From the five times of oil refining from LDPE type plastic waste, it produced (1) 1370 ml, (2) 1230 ml, (3) 1490 ml, (4) 1400 ml, (5) 1610 ml oil, and the total amount of oil produced was 7100 ml. The average gain is 1420ml. Oil processing from LDPE plastic waste is carried out by means of pyrolysis, where the plastic will be heated in a reactor which is heated by a gas burner. After the oil from the LDPE type plastic waste is heated to a temperature above its boiling point, it will become polymer vapor which passes through the steam pipe leading to the cooler or condenser and a condensation process occurs to produce alternative fuels.

Oil produced from the processing of LDPE type plastic waste has an average density of 694 – 736 [kg/m³]. The combustion temperature in the reactor is very influential on the time / length of combustion and the amount of alternative fuel produced from plastic waste.

SUGGESTION

After conducting the research, the suggestions given for further research are: Before carrying out the test, you should check each pipeline in the pyrolysis tool to find out leaks in the welded joints and find out that there are no clogged drain pipes, because if they are clogged the gas will not come out and produce fuel but the pressure inside the reactor becomes large. This can cause a leak in the reactor and will emit gas and fire.

Further research needs to be carried out using oil from plastic waste types PET, PP, HDPE, PVC, PS, OTHER.

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