Pyrolysis of Plastic Waste into The Fuel Oil

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Abstract. Plastic distillation with pyrolysis method is one of the ways that can be used to convert plastic waste into useful chemicals and fuel oil. The purpose of this research is to design a simple plastic waste distillation design model, knowing the oil yield that can be obtained and the calorific value of oil from plastic distillation. The distillation device consists of a 12-liter volume reactor and a condenser with 0.5-inch copper pipe formed spiral with a total length of 1.5 meters and liquid cooled. The test was carried out with 2 kg Polyethylene Terephthalate type plastic material per process with 3 variations of temperature of 300 ° C, 350 ° C, 400 ° C and using LPG as fuel. The test results, the highest amount of oil produced is 49 gr at a pyrolysis temperature of 400 ° C with the heating value obtained from the distillation oil is 1537 J / gr.

Keywords: Pyrolysis, destilation, plastic waste.

1 Introduction

Indonesia is ranked second in the world producing plastic waste into the sea which reached 187.2 million tons after China which reached 262.9 million tons. Every year, plastic production produces around eight percent of world oil production or around 12 million barrels of oil, equivalent to 14 million trees.[1] Most of the product packaging used today is made of plastic. Around the world, nearly 280 million tons of plastic material is produced every year, eventually being wasted on land or sea [2].

Uncontrolled disposal of plastic waste causes the environment to become carcinogenic to humans, birth defects, immune disorders, endocrine disorders, damage to the reproductive system [3]. Microplastic has been found in the sea around the world, suspected sea salt contains microplastic, because they are directly supplied by sea water. **Figure 1.** shows the test results for 15 brands of sea salt, lake salt, and rock / salt from supermarkets throughout China, found microplastic 550−681 particles / kg in sea salt, 43−364 particles / kg in lake salt, and 7−204 particles / kg in rock / salt. most microplastic particles are less than 200, contributing 55% of the total microplastic, and the most common microplastic are polyethylene terephthalate, followed by polyethylene and cellophane in sea salt [4].

Conventional hydrocarbon production in the world will soon decline. Hydrocarbon deficiency cannot be avoided unless there is a drastic change in demand or unconventional supply of hydrocarbons. Global conventional oil supplies are currently at political risk. This is because of the amount of conventional oil production of all countries in the world, except for the five major Middle Eastern suppliers, the maximum limit is limited by the limits of physical resources. If Middle Eastern suppliers decide to reduce supply substantially, deficiencies cannot be replaced by conventional oil from other countries. The world's conventional oil

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supply will soon be physically at risk. Middle Eastern countries only have a small reserve operational capacity, and this will be increasingly demanded because oil production decreases.

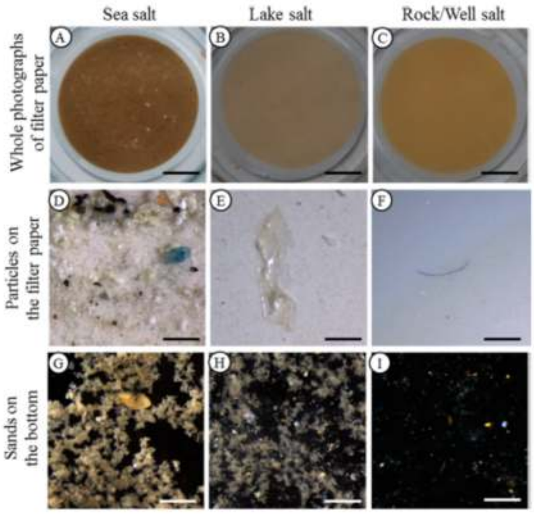

Fig.1. Photographs of the total particles isolated from table salts. A−C, the particles in the salt solution without separation; D−F, the particles in the supernatant of the salt solutions. More particles were observed in sea salts (D) than lake salts (E) and rock/well salts (F); G−I, the particles at the bottom of the bottle after removal of the supernatant [4].

Large investments in Middle Eastern production can increase production, but only to a certain extent. If demand persists, and if investment in large capacity in the Middle East is not made, the world will face the prospect of shortages in the near future. Even with large investments, the resource limit will force Middle Eastern production to decline rapidly, as well as conventional oil production globally. Estimates of global conventional oil production peaks between 5 and 10 years from now.

The world contains large amounts of non-conventional oils and various oil substitutes. But the rate of decline is very high. Conventional oil production causes these unconventional sources not to increase fast enough. The result is a continuing global oil shortage. For conventional gas, the world's original endowment may be almost the same, in terms of energy, as its endowment from conventional oil [5].

As an optimum waste-to-energy converter, the MSW pyrolysis system has experienced a recent increase in demand as a distributed MSW processing method. Pyrolysis is very different from gasification where it does not need oxygen at all. However the gasification with very low oxygen supply can significantly increases the heating value of the gas products as proven by Simanjuntak, et al (2015). By using a newly developed gasifier, they conducted gasification with a very low equivalence ratio (ER) where it’s not possible with a conventional one [6].

Literature studies and technologies related to MSW pyrolysis have shown that most industrial pyrolysis facilities are combined with gasification or combustion processes and are all equipped with gas scrubber.[7]. In the same thermal cracking parameters were applied, different volatile and residue fractions could be observed. As can be found, the yield of residue from virgin plastics was significantly lower at about 1.50 wt % compared to waste PP and waste LDPE, which gave 19.55 and 7.33 wt % residue, respectively. The results are also in good agreement with TG analysis, which also can be obtained in TG curves. However, the yield of gases obtained from cracking of plastics both in virgin and waste was approximately equal changing from 13.67 to 15.60 wt % [8].

The conclusion of experiment [9], when the same thermal cracking parameters were applied,different volatile and residue fractions could be observed. As can be found, the yield of residue from virgin plastics was significantly lower at about 1.50 wt % compared to waste PP and waste LDPE, which gave 19.55 and 7.33 wt % residue, respectively. Sequential pyrolysis and catalytic improvement of Indonesian municipal plastic wastes have been done over Y-zeolite and natural zeolite catalysts. The results of the report [10] show that the feedstock types in a powerful manner affect the product yields and the quality of liquid and solid products. HDPE waste produced the highest liquid fraction. However, the heavy oil fraction was still high in the oil from HDPE waste. The highest diesel fraction has been produced in PE bag 2 while PE bag 1 produced highest gasoline fraction.

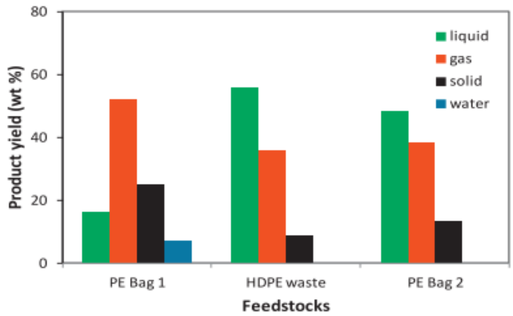

Fig.2. Effect of different types of feedstocks on the product yields [10].

2 Methodology

2.1 Material

The plastic used in this research is PET, which is a plastic water bottle that uses very much in Indonesia. They were obtained from the final disposal site and the small plastic recycling company in Medan city, Indonesia. Plastic bottles are chopped into 2-3 cm chips, then washed and dried in the sun for 5 hours.

2.2 Manufacturing of Pyrolysis Reactors

The experiment was started by designing a plastic pyrolysis reactor (Figureure 1), the reactor was made of 30 cm diameter iron pipe, 15 cm long, 3 mm thick. The condenser is made of iron pipe with a diameter of 20 cm, 30 cm long, 3 mm thick.

Fig.3. The experiment Aaparatus

2.3 Experimental Set-up.

A 3 kg of plastic is inserted into the reactor, the pump is turned on to drain the water through the condenser pipe, then the LPG heater is turned on to heat the reactor tube, the processing time is measured with a stopwatch, the condensation is held in a measuring cup, the remaining crust in the furnace is weighed, the rest LPG gas is weighed. This process is carried out at temperatures of 300, 350 and 400 ^{o}C.

3 Result and Discussion

In the Figure. 1 and 2 it can be seen that the increase in temperature is proportional to the increase in oil produced, the test is not passed to a higher temperature, because according to [11] the temperature of 500 ^{o}C, the percentage of oil will decrease, while the percentage of gas will increase.

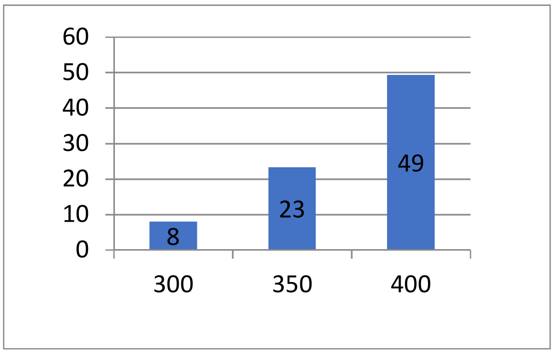

Fig.4. Effect of Reactor Temperature on Liquid oil produc yield

This is in line with the results obtained [12], that the volume of oil increases on increasing the temperature from 450 to 500 °C with no wax component present in oil (density 0.71–0.73), while on further rise in temperature to 600 °C there was no increment in oil volume but increase in yield was obtained by increase in density from 0.73 to 0.79 caused by formation of heavier hydrocarbons in form of aromatics.

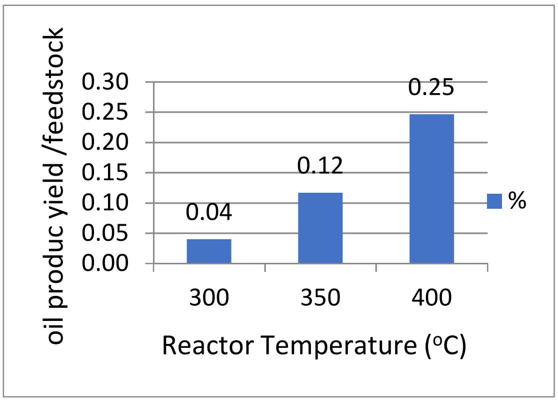

Fig.5. Effect of Reactor Temperature on oil produc yield /feedstock

Eqivalent to oil produced, an increase in reactor temperature is also followed by an increase in HHV (**Figure. 3**), but according to [11] the temperature of 500°C HHV decreases, so that the experiment is not continued to a higher temperature

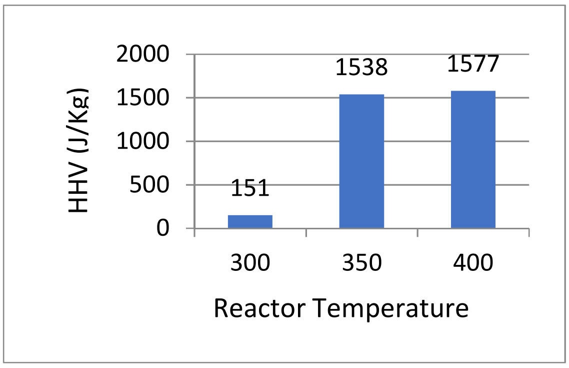

Fig.6. Effect of Reactor Temperature on HHV

4 Conclusion

A small pilot scale batch pyrolysis reactor has been used to convert PET plastic waste into liquid oil. The effect of process temperature on yield of liquid oil was studied. The results showed that at lower temperatures (300 °C), liquid oil yield was low. The optimum conditions for maximum liquid oil yield / feedstock of 0,25% and HHV of 1577 J/kg were achieved at 400°C.

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