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Characteristics of Synthetic Fuel from Plastic Waste by Gasification Method

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Abstract: This study discusses about the synthetic fuel made from plastic waste using gasification method. The instrument used is a simple one phase distillatory. Sample has been tested and analyzed at PT. Pertamina RU V Balikpapan laboratory and Department of Transportation Banjar District. The result shows that this fuel is more alike to diesel fuel type according to its Final Boil Point and density. The smoke result shows that synthetic fuel has 19.73% and diesel fuel has 29.67%. The gas analyses also showed the carbon monoxide of synthetic fuel is 0% and the carbon monoxide of diesel fuel is 0.01%. Both of smoke and gas analyses test of synthetic fuel are less than diesel fuel. Since the distillation process has been done for four to five hours, and the ratio of plastic bucket waste (PP) and plastic bottle waste (PET) is 3:1 (PP:PET) so the pressure vessel capacity is 800 grams. 4000 grams of plastic waste is required to produce 1000 mL of synthetic fuel. The cycle time was approximately 20 hours. The sample testing using ASTM D.1298 method showed that the fuel condition is good and the density 15oC of temperature of 0.8031 g/mL. The result using ASTM D. 85 method shows the Initial Boil Point (IBP) is 60°C, and the Final Boil Point (FBP) is 345°C.

Key Words: distillation, synthetic fuel, diesel, smoke and gas analyses, boil points

1 Introduction

GLOBAL warming issue had been discussed on June 1992 at Rio de Janeiro, Brazil. This issue was mainly discussed on High Level Convention about Environment and Development. Indonesia was one of those countries whose there became an active member on some of this meeting [1]. Global environment has suffered from air pollution that impacted the global climate change. Since industrial revolution, the industry was built using an energy which made from coal, oil and greenhouse gases, such as carbon dioxide, methane and nitrous oxide. Recently, the topic that has been discussed is plastic waste. Its role has a huge impact (in negative way) to air pollution. Over 599 billion pounds of Plastic is the polymerization of crude oil [2]. The most familiar resin from its polymerization is poly(ethylene) terephtalate (PET) and polypropylene (PP) [3]. To produce plastic, it is required about 12 million barrel of crude oil and 14 million trees per year [4]. Plastic can not be decomposed and during this time plastic were pulling out the greenhouse gases (due to the sun light). Actually, greenhouse gases are useful for the Earth to cover it from ultraviolet radiance.

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Some of the radiance can not be coming back to the outside of Earth surface. This radiation caused the greenhouse gases. The most common gas is dioxin which will be dangerous not only for the environment, but also for the human being [2]. The impact of energy crisis is always huge. Both of the economics and politics value will be impacted [5]. Most of the environment will be destroyed because people keep searching another energy sources on Earth. Beside the negative side of plastic waste, it is also has the positive side as an alternative energy which more beneficial for environment and human being. The plastic waste can be used as an alternative energy sources by gasification method. This study will explain about the characteristics of synthetic fuel and compare it to diesel fuel.

2 Literature Review

OVER 500 billion pounds of new plastic in manufactured each year and roughly 33% of that is single use and thrown away [6]. The US patent 6,902,711 B1 [7] mentioned to provide a method and apparatus for treating wastes by gasification. This can recover and resources of the wastes, open up a road to separation and reuse of the resources. This is also can produce synthesis gas having desired components for the use synthesis of ammonia (NH_3) by partial combustion. Solving various problems caused by incineration or dumping of organic wastes, and obtain low-cost hydrogen (H_2) which is used for synthesis of MMONI. The apparatus contains of: a) a fluidized bed reactor for partially combusting wastes at a temperature of from 450°C to 650°C; b) a combustor that separated from fluidized bed reactor and operable at a temperature sufficient to melt an ash content of char, for receiving the gaseous material and the char from outlet of fluidized bed reactor and for gasifying the gaseous material and the char to form synthesis gas; c) a cooler to cool the synthesis gas to form cooled synthesis gas; d) a CO converter to receive the cooled H_2 and CO_2; e) a separator to separate H_2 from the CO_2. In this patent, does not mentioned the amount of synthesis gas that can be produced. According to US patent 5,369,947 [8], the high energy content of mixed plastic waste of any composition could be efficiently converted into power in the form of electricity. At the same time, it would enable the plastic waste to be disposed of completely and

safely without any formation pollutants. It would be saved a high percentage of fossil raw materials to preserve raw material resources and the environment. Thus problem has been solved by coupling a plasma pyrolisis process with a combines gas or steam turbine processes, so that both processes together in their coupled form represent a highly effective "plastic-driven power generator". The plastic waste is reacted in a plasma reactor under reducing conditions in a plasma containing substoichiometric oxygen at temperatures above 1200°C to form a plasma pyrolisis gas consisting of low molecular weight carbon fragments which is then cooled to temperature below 1500°C. It is then delivered in compressed form as a fuel of high calorific value and high temperature to a gas turbine for generating power. The waste heat of this gas turbine is used to generate steam which is fed into a steam turbine for generating more power. The calorific value of this gas is 37,000 kJ/m^3. The process of apparatus on this patent is too complex. It needs reacting the plastic waste in a plasma reactor (temperature of >1200°C), cooling it (temperature of <1500°C), compressing it (pressure of > 10 bar). It needs a steady state cycle. If the pressure is less than 10 bar, it would not be produces the heat and if it is more the max pressure standards (which is not mentioned in the patent), it will blow up the apparatus. US patent 5,470,361 [9] is explained about the process of municipal plastic waste materials by gasification in Germany. A dual system effort is made to collect the plastic waste separately from the common components of the garbage and to recycle or reutilize them. Thus waste are contains carbon and hydrogen (as same as heavy heating oil heat contents). It is obvious to use the energy content of the plastic waste by combustion to produce heat, as is done in the garbage incineration plant. But this is a dangerous method, thus waste is contains halogen substances. When this substances are released to the atmosphere through the exhaust gases and the exhaust process is interrupted during the operation, these substances will be harmful. To provide a process for working up municipal plastic waste is by gasification which avoids the above-described disadvantaged and provide an environmentally friendly utilization of plastic waste. By this method, the plastic waste will be compressed and heated at pressure of from 40 to 80 bar until at temperature from 230°C to 300°C. then it is heated again from 400°C to 500°C to produced a melt plastic waste. It will be form as crude gas when it is heated from 1300°C to 1600°C, then cooled it by the heat exchanger to 220°C to produces 20 mg/Nm^3 of desulfurized crude gas. The patent is not mentioned how long the process will took and also it is not mentioned how many plastic waste can be turned into a gas. Bordynuik [6] studied that thick HDPE plastic can be vaporized into a cleaner burning two fuel. The result is a fuel with the same characteristics of a diesel, light naphta and gases such as methane, ethane, butane and propane. About 8.3 pounds of plastic is turned into 1 gallon of fuel. This study does not explain the method to produce these fuels.

3 Experimental Method and Facility Needed

QUANTITATIVE research was used. Three liter of synthetic fuel was collected to be a sample for both type of fuel (distilling) and gas emission (smoke) test. Both of synthetic and diesel fuel were tested to be known for their boil points, density and gas emission. The ASTM section D was used to be a method for distilling test. The smoke and gas emission were being tested using a gas analyzer. A pilot testing of the gas emission using a diesel car was performed to test suitability of the fuel on street. The raw materials were plastic waste from the black bucket waste and bottle waste. Poly (ethylene) terephtalate and poly propylene were two specific types for this plastic waste. Those materials were being mixed in 3:1 of ratio. The flow chart of methodology is depicted in Figure 1.

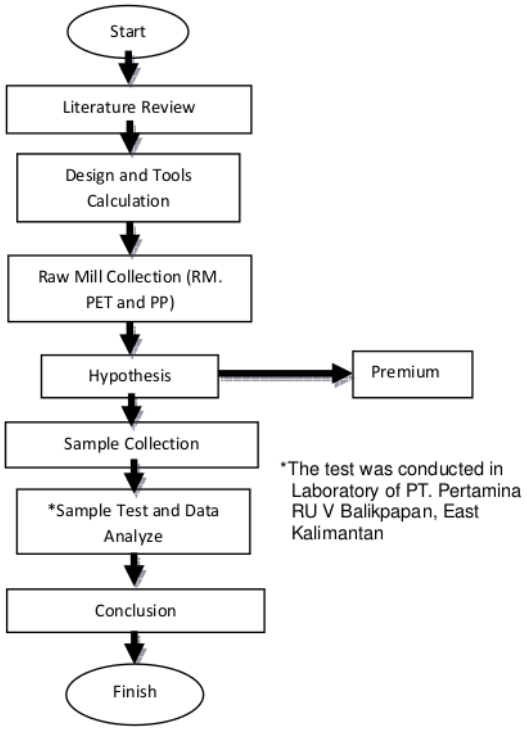

Figure 1 Flow Chart of Methodology

4 Results

The result showed that the hypothesis was unlike the tested result. It is showed that the synthetic fuel is more alike to diesel fuel. This conclusion is obtained from the final boil point (FBP) and the density of this fuel that are close to diesel fuel. The result data of synthetic fuel and diesel fuel distilling using the ASTM method are shown on Tables 1 and 2.

Table 1 Distillation Data of Synthetic Fuel

No.	Analysis	Methods	Results
1.	Density at 15 ℃	ASTM D. 1298	0.8031
2.	Distillation:	ASTM D. 86	
	- IBP		60
	- 5% vol. Rec. At		104
	- 10% vol. Rec. At		119
	- 20% vol. Rec. At		133
	- 30% vol. Rec. At		150
	- 40% vol. Rec. At		164
	- 50% vol. Rec. At		187
	- 60% vol. Rec. At		218
	- 70% vol. Rec. At		237
	- 80% vol. Rec. At		278
	- 90% vol. Rec. At		334
	- FBP		345

Table 2 Distillation Data of Diesel Fuel

Analysis	Methods	Results
Density at 15 ℃ kg/m³	D. 1298-99	845.9
Color	D. 1500-98	1
Cetane Number	D. 613	
Cetane Index	D 4737	50
Visco. Kin, at 40 ℃ mm²/s	D 445-01	3.8
Pour Point ℃	D 97-96a	12
Sulphur Content % m/m	D 2622	0.07
Copper Strip Corr. (3hrs 50 ℃)	D. 130	Class 1
Conradson Carbon Res. % m/m	D 189	<0.1
Sediment % m/m	D 473-95	<0.01
Ash Content % m/m	D 482-00a	<0.01
Strong Acid Numb. mgKOH/gr	D 664	Nil
Total Acid Numb. mgKOH/gr	D 664	0.2
Water Content ppm	D 1744	110
Flash Point PMcc ℃	D 93-00	58
Appearance	Visual	C & B
Distillation	D 86-01	

(to be continued)

Table 2 (continued)

IBP		156
- 10% vol. Rec. At		212
- 20% vol. Rec. At		240
- 30% vol. Rec. At		255
- 40% vol. Rec. At		266
- 50% vol. Rec. At		277
- 60% vol. Rec. At		287
Density at 15 ℃ kg/m³	D 1298-99	
- Upper		840.9
- Middle		847.9
- Lower		848.7
- 80% vol. Rec. At		312
- 90% vol. Rec. At		345
- 70% vol. Rec. At		300

From the tables above, it can be seen the differences of both synthetic fuel and diesel fuel in the form of chart. Figure 1 shows the comparison of boil point between those two types of fuel.

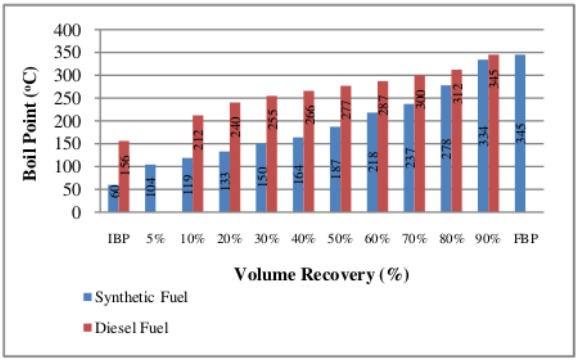

Figure 1 Boil Point Comparison Chart

Figure 2 shows the comparison of density between synthetic and diesel fuel.

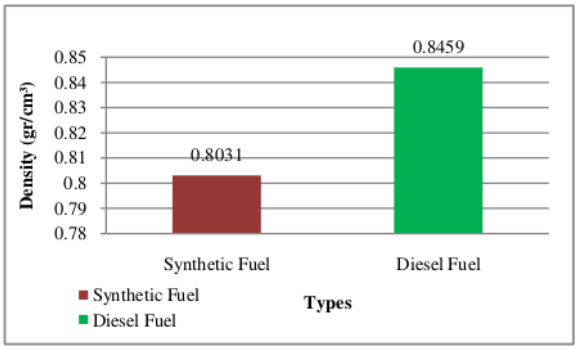

Figure 2 Comparison Chart of Density

The gas emission has been tested, too. It was tested at Department of Transportation, Banjar District. The result smoke of synthetic fuel and diesel fuel are shown Tables 3 and 4. The gas analyses of synthetic fuel and diesel fuel are shown on Tables 5 and 6.

Table 3 Smoke Result of Synthetic Fuel

TESTS	RESULTS
Test 1	25.2%
Test 2	21%
Test 3	12.7%
Result	19.73%

Table 4 Smoke Result of Diesel Fuel

TESTS	RESULTS
Test 1	34.9%
Test 2	32.6%
Test 3	21.5%
Result	29.67%

Table 5 Gas Analyses of Synthetic Fuel

Parameters	Results	Parameters	Results
CO	0%	O2	25%
CO2	1.7%	λ	2
HC	28 ppm	AFR	0

Table 6 Gas Analyses of Diesel Fuel

Parameters	Results	Parameters	Results
CO	0.01%	O2	25%
CO2	1.7%	λ	2
HC	11 ppm	AFR	0

From tables 3 and 4, it shows that smoke result of synthetic fuel is less than diesel fuel based on the average of the tests. The carbon monoxide of synthetic fuel is also less than diesel fuel (Tables 5 and 6). Carbon monoxide is the most poisonous gas on air, because it was came from an imperfect combusted of vehicle gases.

5 Conclusion

The conclusion of this study is that plastic waste beside its negative impact for the environmental, it is has a beneficial impact as synthetic fuel. Synthetic fuel is more alike to diesel fuel according to its FBP and density. This synthetic fuel is friendlier than diesel fuel and it is viable to be use in diesel vehicles.

6 Acknowledgment

This study has been published in JSME-SNTTM XII Lampung 2013 proceeding, paper no. 48, page 1370 to 1373.

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