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# The Effect of Plastic Type and Temperatures on Oil Fuels Produced by The Pyrolysis Method

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**Abstract.**Pyrolysis is one of methods to process plastic waste into fuel oil through the process of decomposing chemically organic matter by heating without or little oxygen or other reagents. The purpose of this study is to determine the effect of plastic type and temperature on the amount (volume) of oil fuel produced using the pyrolysis method. Plastic waste pyrolysis was performed by bait namely bottled plastic waste water (Polyethylene Terephthalate), black plastic bags (Polypropylene) and styrofoam food packaging (Polystyrene).The device used for testing was a series of pyrolysis and cooling back devices. Tests were performed 3 times on each type of plastic with temperature variations of 500<sup>0</sup>, 600<sup>0</sup>C, and 700<sup>0</sup>C with a weight of 500 grams for 60 minutes per process. The results of the test, the amount (volume) of oil produced was most obtained at 600<sup>0</sup>C reactor wall temperature in bottled water plastic bottles (Polyethylene Terephthalate) of 250 ml, while the density with the highest value produced by styrofoam plastic (Polystyrene) of 2.1672 gr/ml.

**Keywords:** pyrolysis, polyethylene terephthalate, polypropylene, polystyrene, density

## 1. Introduction

The depletion of fossil fuel reserves and the increasing human population are very contradictory to the energy needs for human survival along with their economic and social activities [1]. The increase in population rises along with the need for means of transportation and industrial activities. This has resulted in an increase in the need and consumption of fuel oil which is a non-renewable natural resource. Therefore, it is necessary to find alternative energy sources that are environmentally friendly. Increased use of plastic is a consequence of the industrial technology development as well as population numbers [2]. Plastic waste throughout the world is increasing especially in the sea. [3] In Indonesia, plastic needs continue to grow to an average increase of 200 tons per year. In 2002, it was recorded at 1.9 million tons, in 2003 it rose to 2.1 million tons, and then in 2004 it rose again to 2.3 million tons per year. In 2010, 2.4 million tons, and in 2011, has increased to 2.6 million tons. As a result of the increased use of plastic, plastic waste is also added. "Based on the assumption of the Ministry of Environment (KLH), every day the Indonesian population produces 0.8 kg of waste per person or a total of 189 thousand tons of garbage/day. Of that amount, 15% is plastic waste or 28.4 thousand tons of plastic waste/day.

Plastics are a type of non-biodegradable material that is difficult for nature to decipher. This creates a new problem in processing the waste. To overcome this problem, a plastic waste recycling program is held. However, this seems to be increasingly ineffective, only about 4% can be recycled, the rest mounts in a garbage shelter. Given the increasing amount of plastic waste, an alternative promising and prospective prospecting process is needed. Some known types of plastic packaging are PE (Poly Ethylene), PP (Poly Propylene), PET (Poly Ethylene Terephthalate), PVC (Poly Vinyl Chloride), and PS (Poly Styrene) [4].

One method to use plastic waste is to process plastic waste into an alternative energy source. This can be possible because basically the plastic comes from the petroleum fraction. In addition plastic also has a high enough heating value, equivalent to fossil fuels such as gasoline and diesel. Many efforts have been made to convert these plastic waste materials to produce fuel because of the nature of the constituent plastic waste, which is in the form of hydrocarbons [2] and also some studies around the conversion of plastic waste into quality liquid fuel products have been performed and show results

prospective enough to be developed [5]

Liquid hydrocarbons are chemical compounds that are needed by many chemical industries and the petroleum industry. In addition, this liquid hydrocarbon can also be used as a source of liquid fuel replacing fossil fuel sources that are beginning to deplete in the world due to a human population increase [6]. Therefore, liquid hydrocarbons produced from plastic waste are expected to be a new innovation to overcome the problem of non-renewable liquid fuel sources. Pyrolysis products can be utilized more flexibly and easier to handle. This pyrolysis technique is capable of producing combustion gases that are useful and safe for the environment. This technique can be regarded as an environmentally friendly method because the end product produces CO<sub>2</sub> and H<sub>2</sub>O which are toxic gases [7].

## 2. Research Methodology

The pyrolysis scheme in this study can be seen in Figure 1. In the pyrolysis process three types of product classification are produced, namely: First, the gases released in the carbonization process are mostly CO<sub>2</sub> gas and some are flammable gases such as CO, CH<sub>4</sub>, H<sub>2</sub> and other low-level hydrocarbons. Distillate in the form of liquid smoke and tar. Second, the main composition of liquid smoke is liquid hydrocarbons ranging from C<sub>1</sub> to C<sub>4</sub> and long chain compounds such as paraffin and olefins. Other parts are minor components namely phenol, metal acetate, formic acid, butyric acid etc. Vaporized liquid products contain tar and polyaromatic hydrocarbons. The last group is, the residual (carbon) content of cellulose, hemicellulose and lignin in materials varies depending on the type of material used.

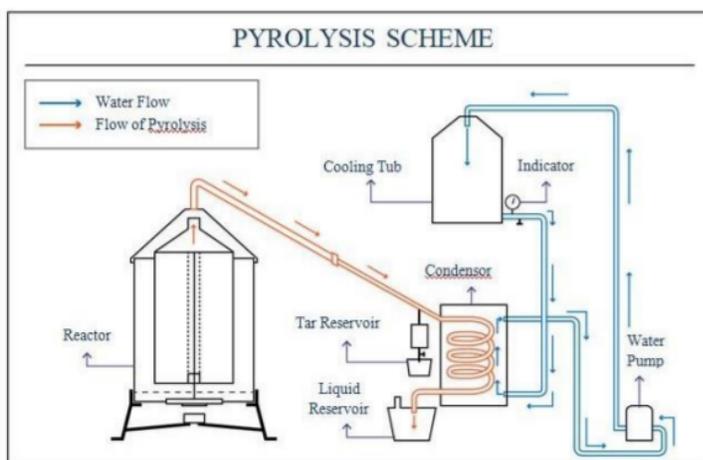


Figure 1. Pyrolysis Device Series Scheme

The raw material for plastic waste was cleaned and then grouped according to its type and then it was dried. The type of plastic waste used was PET plastic (Polyethylene Terephthalate) using bottled water (Aqua), Polystyrene plastic used styrofoam food packaging, PP plastic (Polypropylene) used black plastic bags.

The clean plastic raw material was cut by an average size of 1-2 cm<sup>2</sup> so that the contact surface area that occurs is greater so that the results of this process are more maximal.

The procedure in the pyrolysis process was performed through several stages of the process including checking the pyrolysis device to be used. After that, PET plastic waste raw material was weighed at 500 grams. The plastic raw material which has been cut and weighed was inserted into the reactor feedstock. Then pumped and ran the reactor heater to a temperature of 500°C on Thermocouple. After reaching the temperature determined by keeping the temperature for one hour, then the pump and reactor heater were turned off, then the next pyrolysis process was prepared.

Repeat the above steps with Polystyrene plastic and PP plastic with reactor temperatures of 500°C, 600°C, and 700°C. After all the pyrolysis oil samples were successfully obtained, the characteristics of each sample were tested.

### 3. Results and Discussions

After the pyrolysis process was performed on several types of plastic, the results were obtained as in the table below:

**Table 1.** Pyrolysis results in various temperatures and volumes (ml)

Eksperiment		Temperature (°C)			
		500	600	700	
PETPlastic	Trials	1.	53,1	250	205,2
		2.	52,8	249,7	204,6
		3.	52,5	249,0	204,5
PPPlastic	Trials	1.	72,0	150,2	110,0
		2.	71,9	149,6	109,5
		3.	71,7	149,3	109,3
PolystyrenePlastic	Trials	1.	31,9	69,4	80,9
		2.	31,5	69,3	80,6
		3.	30,8	69,1	80,2

From the results of the pyrolysis process from the table above, data analysis was then performed using the factorial design. The results of the arian analysis (ANOVA) were obtained as in table 2.

**Table 2.** Variation Analysis

Source of Variation	df	JK	KT	F <sub>count</sub>	F <sub>table</sub> α=0,01
Average	1	346482,74	346482,74		
Treatment					
Plastic Type	2	53218,36	26609,18	181885,54	5.85
Temperature	2	53369,89	26684,94	182403,41	5.89
Interaction of Types of Plastics and Temperatures	4	23516,92	5879,23	40187,14	4.43
Error	18	2,63	0,15		
Total	27	35,47			

From table 2 Anova above, the hypothesis testing results are:  
 $H_0^I =$  rejected, which means that there was a significant influence on the plastic type on the fuel volume, with a confidence level of 99%  
 $H_0^{II} =$  rejected, which means that there was a significant influence on treating temperature on volume with a confidence level of 99%, and  
 $H_0^{III} =$  rejected, which means there was an influence of the interaction between the plastic type and the temperature on the fuel volume with a confidence level of 99%  
 Based on the hypothesis testing, all  $H_0$  were rejected, which means that there was a significant influence on the plastic type and temperature on the fuel amount (volume) produced.

**Table 3.** Testing of fuel density (gr / ml)

Eksperiment		FACTOR B			Total	Average	
		Temperature					
		500	600	700			
PETPLAS TIC	Trial	1	0,533	0,533	0,533		
		2	0,531	0,532	0,532		
		3	0,533	0,533	0,533		
Total			1,596	1,597	1,597	4,79	
Average			0,532	0,53	0,53	0,53	
FACTOR A PPPLASTI C		1	1,046	1,194	1,194		
		2	1,043	1,196	1,192		
		3	1,044	1,199	1,189		
	Total			3,133	3,589	3,575	10,297
	Average			1,04	1,20	1,19	1,14
PSPLASTI C		1	2,056	2,167	2,164		
		2	2,068	2,167	2,168		
		3	2,102	2,169	2,173		
	Total			6,226	6,503	6,505	19,234
	Average			2,08	2,17	2,17	2,14
Total			10,955	11,689	11,67896814	34,3255	
Average			1,22	1,30	1,30	1,27	

**Table 4.** Analysis of variations in fuel density testing

Source of Variation	df	JK	KT	F <sub>count</sub>	F <sub>table</sub> $\alpha=0,01$
Average	1	43.63	43.63		
Treatment					
Plastic Type	2	11,81	5,90	87445,46	5.85
Temperature	2	0,04	0,02	290,78	5.89
Interaction of Types of Plastics and Temperatures	4	0,02	0,01	84,21	4.43
Error	18	0,00	0,00		
Total	27	35,47			

From the Anova table above, the Hypothesis testing results:  
 $H_0^I =$  rejected which means that there was a significant influence on the plastic type on fuel density, with a confidence level of 99%

$H_0^{II}$  = rejected which means that there was a significant effect of treating temperature on fuel density with a confidence level of 99%, and

$H_0^{III}$  = rejected which means there was an influence of the interaction between the type plastic and the temperature on the fuel density with a confidence level of 99%,

Based on hypothesis testing, all  $H_0$  were rejected, which means that there was a significant influence on the plastic type and temperature on the fuel density produced.

#### 4. Conclusions

The highest volume of oil output is at 600°C reactor wall temperature, in PP plastic and at 700°C reactor wall temperature on Polystyrene plastic. The average mass of pyrolysis oil in PET, PP and Polystyrene plastic is 0.53 gr/ml, 1.14 gr/ml, and 2.14 gr/ml respectively.

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