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Biofuel production from rubber by pyrolysis method

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Abstract

The production of biofuel from rubber by pyrolysis method and study the properties of bio-oil test by engine The experiment includes the starts from study of the basic physical of lump rubber study the bio-oils properties and study the engine test. The investigated factor was pyrolysis temperature (include 400, 500 and 600°C). The characteristic of lump rubber studied include, moisture content, heating value, decomposition temperature. The moisture content of the lump rubber is 7.64%wb, the heat value is 40682 kJ/kg, and the thermal degradation of the rubber began rapidly at 300°C The flash point, viscosity, specific gravity, cetane index of bio-oil were determined. The result shows that the specific gravity of biodiesel was 0.85. The effective pyrolysis temperature was 500°C due to the got the highest percent of bio-oil. In the preliminary engine testing of biodiesel, it was found that gasoline can run both low rpm (at 3800 rpm) and high rpm at 5,600 rpm. For, low cycle got the better than high rpm. For biodiesel, run low rpm (1,200 rpm) and high rpm (2,000 rpm). Biodiesel run at low rpm can get the better performance than that of high rpm. The experiment of biodiesel blended with diesel oil and biodiesel from rubber found that the proportion of blended biodiesel of less than 40%, the engine can run smoothly.

Keywords: Pyrolysis, Biofuel, Rubber

1. Introduction

At present, the world's technological development tends to increase rapidly. As a result, there is an increase in energy use and resources. Because the population has increased demand for resources and the use of facilities. As a result, resources are rapidly depleted. causing the resources needed to be used to be insufficient Thailand's ultimate energy consumption during the 10 months of 2019 was 72,502 thousand tons, equivalent to crude oil. An increase of 3.9% from the same period last year, equivalent to a value of more than 1,030,016 million baht [1]. Energy use continues to increase. According to economic growth, Refined oil is still energy. That is the most used, accounting for 48.2% of final energy use, followed by electricity and renewable energy. Traditional renewable energy coal/lignite and natural gas accounted for 20.1, 10.0, 8.4, 6.8, and 6.5%, respectively. Using alternative resources is therefore one option that will help solve the problem. which will provide the required amount of energy Thailand used renewable energy at 11,917 thousand tons of crude oil equivalent, an increase of 11.7% from the same period last year. The proportion of energy use to gross product tends to decrease. Continuously compared to the year 2010, which is the base year for the implementation of the 20-year energy conservation plan (2011 - 2030) and the energy conservation plan 2015 – 2036 [2] use renewable resources Therefore, it is one option to help solve this problem. Biomass is therefore used as an alternative energy source for fuel production. Appropriate technology for use in transforming raw materials Biomass is a fuel for use in various processes. There are many methods such as physical methods. biological method and thermochemical methods Pyrolysis process is a technology classified as a thermochemical process that converts raw materials in the solid state into fuel. that has a higher heat value [3].

Rubber is one raw material that can be turned into renewable energy. The total rubber plantation area in Thailand is approximately 20 million rai, producing approximately 4.9 million tons of latex per year. Rubber exports in January-July 2020 were valued at 1,885.64 million US dollars, decreasing 27.25% from the period. same as last year Export volume Jan. July 2020 totaled 1,497,798 metric tons, a decrease of 23.00%, divided by type as follows: Concentrated latex 666,860 (2.10%), Block rubber 583,846 (-40.10%), Rubber sheets 222,446 (-21.90%) Rubber Others 24,646 (-22.10%) Rubber export situation in January-July 2020 has decreased due to the COVID-19 situation causing various industrial sectors around the world to halt [4]. The trend of rubber plantation areas is continuously increasing. The most is grown in the southern region, followed by the northeastern region, where the 10 provinces that grow the most rubber are Surat Thani, Songkhla, Nakhon Si Thammarat, Trang, Yala, Narathiwat, Phang Nga, Rayong, Krabi, and Bueng Kan, in that order rubber prices the average price of cup lump in 2012 was 40 baht/kg. The average price of cup lump rubber in 2019 was 20 baht/kg, which decreased from the previous amount by 50% [5]. The use of latex to produce as an alternative fuel. Must go through a pyrolysis process. which the pyrolysis process There are many forms and factors that affect the resulting product. Here, we study the most suitable temperature that affects the distillation of biological water from rubber lumps used in pyrolysis to obtain an efficient oil

for use in the future. Other factors depend on the pyrolysis model chosen. Thailand currently has a large amount of renewable energy being used, which can reduce the amount of depleted resources. In addition, remaining resources can be used to maximize benefits and also help reduce costs for importing resources and fuel. which leads to creating sustainability in energy and resource management for the country's economic system.

The pyrolysis process therefore plays an important role in producing alternative energy from rubber. The pyrolysis process is a thermochemical process that Transforms biomass, plastics, and used rubber. It is a fuel that has Higher calorific values include charcoal, bio-oil and non-condensing gas. (non-condensable gas) by heating at a medium temperature of 500-800°C in an environment without oxygen. The proportion of products from the pyrolysis process depends on several factors, including the reaction conditions. Characteristics of raw materials used as starting materials Type of reactor, etc. Pyrolysis process It is divided into two types: slow pyrolysis and fast pyrolysis. The production of alternative fuel energy from rubber requires a fast pyrolysis process. It is a process that produces oil as the main product. The reaction is carried out at a moderate temperature of 400-650°C, has a high heating rate (more than 1,000°C/s), and has a very short vapor time in the reactor (less than 2 s) when using biomass raw materials. The proportion of the product in the liquid state, called bio-oil, will be about 60-75%, 15-25% solid and 10-15% non-condensing gas, and there will be 10-30% water content in the bio-oil, depending on the moisture content. contained in the starting biomass The most important aspect of the rapid pyrolysis process is to design the reactor to have a high heat transfer rate and to design the vapor to condense into liquid as quickly as possible to obtain 70-80% oil content [3].

2. Materials and methods

The first step in the experiment is Study the basic properties of rubber, namely moisture, heat, and thermal decomposition. The humidity value will be tested by putting the latex cubes into an oven at a temperature of 105 °C for 24 hours, then calculating the humidity value. The experimental heat value was obtained by water entering the Bomb Calorimeter and the thermal decomposition value was obtained from the TGA machine. The second step was to put the rubber into a pyrolysis furnace as shown in Figure 1 at temperatures of 400, 500 and 600 °C.

Figure 1 A pyrolysis furnace for the test

Then the crude oil enters the distillation furnace for a final quenching. The third step is to test the properties of the oil, namely flash point, viscosity, cetane index, and specific gravity. The fourth step is testing the engine. Biogasoline will be tested with a Honda Gx 120 engine as shown in Figure 2, and diesel fuel will be tested with a Kubota RT100 engine. The final step is to find the right mix of biodiesel and diesel for running the engine.

Figure 2 Gasoline test

3. Results and Discussion

Results of testing of the preliminary properties of para rubber. The moisture value of the rubber lump is 7.64 %wb. The heat value of the rubber is 40,682 kJ/kg or 40.6 MJ/kg. If comparing the heat value with other biomass such as rice husks, rice straw, coconut shells, the heat value is 13.52. MJ/kg, 12.33 MJ/kg, 17.93 MJ/kg, respectively and the thermal decomposition values found that rubber will begin to decompose rapidly at 300°C. The results of study of temperature effects on products from rubber pyrolysis. Shown as in Table 1.

Table 1 Quantity of biofuel obtained from pyrolysis.

Temperature (°C)	Oil (g)	Rubber (g)	Gas (g)
400 °C	788±57.17	35.75±3.27	176.25±55.49
%/w	78.80%	3.58%	17.63%
500 °C	866.5±18.42	32.75±4.21	100.75±18.18
%/w	86.65%	3.28%	10.08%
600 °C	851.75±43.61	30.75±1.92	117.5±43.76
%/w	85.18%	3.08%	11.75%

The amount of bio-oil that can be distilled from 1 kilogram of rubber pyrolysis furnace is shown in Table 1. If you look at the amount of bio-oil obtained from pyrolysis, it is found that at the pyrolysis temperature of 500°C, the highest amount of bio-oil was obtained. This is because the temperature increases in pyrolysis. The resulting product will be more liquid and gas, but the solids will decrease [6]. At a pyrolysis temperature of 600°C, the bio-oil will be less than at 500°C because at 600°C it is a point beyond the breaking of the first bond. This causes a second breakage of the bonds, resulting in more gas and less oil [6]. The results of the biofuel properties test for biodiesel and biogasoline are shown in Table 2 and Table 3, respectively.

Table 2 The properties of biodiesel

Temperature (°C)	Properties of biodiesel			
	Flash point (°C)	Viscosity (cSt)	Specific gravity	Cetane index
BR 400 °C	29.17	1.39	0.85	30.88
BR 500 °C	28.50	1.32	0.85	30.88
BR 600 °C	31.56	1.21	0.85	26.85

Table 3 The properties of biogasoline

Temperature (°C)	Properties of biogasoline	
	Viscosity (cSt)	Specific gravity
BR 400 °C	0.68	0.8
BR 500 °C	0.68	0.8
BR 600 °C	0.65	0.8

Engine test results for gasoline and diesel are shown in Table 4 and Table 5, respectively, mixed diesel fuel test results are shown in Table 6, and oil consumption for diesel are shown in Table 7.

Table 4 Results of testing of gasoline engines using biogasoline

Temperature (°C)	BR 400 °C		BR 500 °C		BR 600 °C		Gasoline	
	5600 rpm	3800 rpm	5600 rpm	3800 rpm	5600 rpm	3800 rpm	5600 rpm	3800 rpm
Fuel Temp (°C)	118.23	77.70	113.83	83.73	116.3	72.3	104.40	65.10
CO_2 (%)	1.79	1.63	1.73	1.65	1.72	1.62	1.77	1.68
Effn (%)	68.17	77.33	66.83	76.50	67.5	75.58	74.60	86.10

Table 5 Diesel engine test results using biodiesel oil

Temperature (°C)	BR 400 °C		BR 500 °C		BR 600 °C		Diesel	
	1200 rpm	2000 rpm	1200 rpm	2000 rpm	1200 rpm	2000 rpm	1200 rpm	2000 rpm
Flue Temp (°C)	262.30	432.75	288.27	456.00	270.10	444.97	298.17	453.20
CO_2 (%)	4.09	7.255	4.82	8.26	4.17	9.05	6.46	8.93
Effn (%)	66.00	59.1	68.13	70.57	65.90	73.60	75.30	71.00

Table 6 Test results for mixed biodiesel oil

Temperature (°C)	B20		B40		B60		B80	
	1200 rpm	2000 rpm	1200 rpm	2000 rpm	1200 rpm	2000 rpm	1200 rpm	2000 rpm
Flue Temp (°C)	72.80	99.60	74.30	108.43	75.10	112.77	75.80	114.67
CO2 (%)	1.58	1.65	1.77	1.81	1.79	1.79	1.71	1.75
Effn (%)	83.37	72.27	83.21	72.03	82.93	71.23	79.70	68.67

Table 7 Oil consumption rate

Diesel	Low RPM (ml/min)	High RPM (ml/min)
-	5.0	10.0
B20	5.0	10.1
B40	5.1	10.2
B60	5.3	10.3
B80	6.0	10.8

4. Conclusions

From the experiment of pyrolysis of rubber lumps into bio-oil and testing the properties of the bio-oil, it was found that the properties of the oil were still lower than the specified standard values and when tested with the engine, it was found that it was still unable to work smoothly. It must be Adjust quality and refine by mixing with common oils.

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