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Performance of a Power Generator System Using Crude Plant Oil Blend with Diesel Fuel

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Abstract**—**Under the variation of crude oil price and the impact of greenhouse effect, it is urgent to find a potential alternative fuel. Among these alternative fuels, non edible plant oils are the most potential ones, because they don't have the problem of food and cropland competitions. Among the non-edible plant oils, Jatropha oil is the most potential one. Jatropha oil is non-eatable oil and has good oil quality and low temperature performance. It has potential to become one of the most competitive biomass crude oils. The crude plant oil will be blended with diesel fuel to be tested in a power generator. The international collaboration between Taiwan and Indonesia on the production of Jatropha in Indonesia will also be presented in this study.

Keywords**—**Jatropha, plant oil, oil blend, diesel, power generator.

I. Introduction

FROM bureau of energy, the international price of crude oil are unstable from the year of 2000, the price increased year by year, and reached the new record in 2008, the average price of the crude oil almost near 100 USD per barrel at that year, especially in July, the average price of the crude oil is 130 USD per barrel, but it decrease to 40 USD per barrel in the end of that year, the difference between these two prices is around 90 USD. It's not only effect the economy trend in the word, but also the life of ordinary citizens. And, the wide applications in fossil fuel, cause climate and geographic environment changed by greenhouse effect. From the point of view of global environment protect and energy sustainability, it is urgent to find a new alternative fuel. And the alternative fuels should have the characteristics of low cost and friendly to the environment [1].

In many developed countries, they already had some examples of using alternative fuels, and it can mitigate the problems of fossil fuel's depletion and environmental pollution. Now, the whole world are focus on preventing the extend of greenhouse effect and finding a new alternative fuel, resulted in this topic been noticed again, among these, plant oil is the most potential one to mitigate fossil fuel's depletion[1]. Plant oil has many advantages, like: renewable, produce less pollutants, also has almost the same fuel property with fossil diesel.

There are two types of plant oil, one is edible oil, another one is non-edible oil, among these two types, non-edible plant oil have more potential than edible one, this is because they don't have the problem of food and cropland competitions.

Most of the plant oils can be used as a fuel in engine for short term operation, even though it will result in more fuel consumption, but will produce almost the same gas emissions with fossil diesel. For long term operation, many problems should be solved, like: injector deposits, ring sticking, gum formation, pipe clogging, etc, and this is because plant oil's large molecular weight and molecular structure, resulted in higher viscosity and lower volatility. Higher viscosity will cause pump's inadequate work, and result in the problems that we mentioned. And lower volatility will cause inadequate atomization, result in incompletely combustion, among these two disadvantages, higher viscosity is the most crucial one. Because higher viscosity usually followed with lower volatility [2-4].

From the results we know that it is unfeasible to use straight plant oil, we should do some modification to lower the viscosity. Normally, there are three ways to reduce plant oil's viscosity, let the combustion property more near fossil fuel, including: heating, blending, and transesterification. Of course transesterification is the most efficiency way, however, it is the most expensive one if we compare with the other two ways, because it needs extra chemicals and energy inputs. In this study, we'll focus on oil blending, with this way, we can save more cost, we don't have to use extra energy or extra chemicals.

II. Experimental Section

A. Materials

Jatropha curcas oil in this study is from India, and fossil diesel is from gas station in Taiwan, named "super diesel".

B. Apparatus

The diesel generator for electrical power in this study is from Yanmar Company, it's an air cooled diesel generator, and the model is YDG2700E.E. There are two Halogen lights that we use is for the engine load, and with an electric meter to measure the generator's power output. Other apparatus that we use for

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physical property test, like calorimeter, to measure fuel's heat value, the model is C200, kinematic viscosity meter from Koehler can get fuel's kinematic viscosity, model is KV4000, we use an automatic cold filter plugging point analyzer to get the cold filter plugging point (CFPP), which is from Herzog, and model is HCP842, with Herzog's Flash point tester, we can get fuel's flash point, and use front view distillation apparatus to get fuel's boiling point, the model is K45200 and from Koehler, the Portable density/specific gravity meter that we use is from KEM, and the model is DA-130N.

C. Experimental Process

Our study is to make sure the maximum percentage that Jatropha oil blends can let diesel generator run and has a stable power output for at least 1 hour under different conditions, therefore, we blended Jatropha oil with diesel fuel follow these volume ratio: 10% , 30%, 50%, then we compared the physical properties like: flash point, CFPP, kinematic viscosity, heat value, gravity (API), boiling point with super diesel and crude Jatropha oil to find the difference between different ratio.

In oil property measurements, there is an important value in alternative fuel research, it shows fuel's ignition property (i.e. the cetane number). And the way that we use to calculate the cetane number is follow ASTM D976-91 [5], we called it cetane index, we use fuel's mid boiling point [6] and gravity, then follow the equations and figure provided to calculate cetane index.

The performance test of the diesel generator was conducted after finishing the physical property study of oil blends. Before the experiment, we tried a very short term test, two halogen lights were used as an engine load, then tried six different fuels, including super diesel, 10% Jatropha blends till 50% Jatropha blends for 30 minutes, and calculated the combustion efficiency follow the literature [2], Lertsathapornsuka and his colleagues used heat value and fuel consumption to calculate combustion efficiency. For heat value we can get by the instrument that we mentioned in last part, and for fuel consumption, we measure test fuel's consumption under 1000w load after ran for 30 minutes. From the result, we found that they showed almost the same efficiencies, so we moved to 1 hour test.

Because from the results we already found that even Jatropha oil blends, can show similar efficiency with diesel, so, in order to make sure if the Jatropha oil blends can conform the laws of National Fire Agency, to be an alternative fuel for diesel generator and offer stable power output for 1 hour in emergent situation. And this is one of our research goals, we'd like to know how many percent Jatroph blends is, can let diesel generator offer stable power output for 1 hour.

In 1 hour operation, we chose super diesel, and Jatropha oil blends as a test fuels in diesel generator and run for 1 hour with the same engine load, and measure power output.

III. Results and Discussion

In this study, the physical properties of oil blends were measured, like: kinematic viscosity, flash point, CFPP, gravity, heat value, mid boiling point, and cetane index, to see the difference between different percentage of Jatropha oil blends, also compare the value with super diesel.

The kinematic viscosity of the fuels was shown in Table I, it showed different kinematic viscosity between different percentage of Jatropha oil blends. In order to see how temperature effect fuel's kinematic viscosity, the different temperature's kinematic viscosity were measured. From the results, we found that kinematic viscosity increase with the percentage of Jatropha increase in the oil blend, especially in 50%, the value increase significantly, this is because Jatropha oil's high kinematic viscosity, so, if Jatropha blends more, kinematic viscosity increase more hardly.

On temperature side, we can found that when temperature increased, kinematic viscosity decrease, this phenomenon is more evident in higher Jatropha percentage in the oil blends. About temperature effect, especially in 40°C, it's the most important index in research, because when generator start to run, these's some heat release from engine or pipe, and these heats will indirectly preheat oil tank, let fuel's temperature higher than room temperature, even reach to 40°C when it flow into the combustion chamber, so this is the reason why we have to do kinematic viscosity tests at 40 °C. Another reason is that, during oil extraction process, because extract solvent's boiling point is quite low, the reaction temperature usually set at 40°C, so, it is important to see the relation between oil's kinematic viscosity and flow rate in the pipe during oil extraction process. If we can use waste heat to preheat fuel, then Jatropha oil can blend more, like Agarwal's literature in 2007[1], with this way, not only can save more energy, but also can use higher percentage of Jatropha in oil blends.

TABLE I
KINEMATIC VISCOSITY OF OIL BLENDS WITHI DIFFERENT PERCENTAGE OF JATROPHA

@ 30℃				
Diesel	90%D/10%CJ	70%D/30%CJ	50%D/50%CJ	Jatropha Oil
3.3	4.3	6.3	11.7	40.7
@ 40 ℃				
Diesel	90%D/10%CJ	70%D/30%CJ	50%D/50%CJ	Jatropha Oil
2.9	3.6	5.0	8.8	30.0

Unit of Kinematic viscosity: cSt
D: Diesel Fuel
CJ: Crude Jatropha Oil

Table II showed fuel's flash point and CFPP, for flash point, we found that with Jatropha percentage in the oil blends increase, flash point also increase, this is because Jatropha oil's high flash point, and higher flash point represent more saver when we storage the fuel, but relatively, higher flash point means fuel's combustion property more worse, because it's ignition temperature more higher, that's why when we increase Jatropha oil's ratio, the engine's performance more unstable.

For CFPP result, we can find that when Jatropha percentage in oil blends increase, CFPP decrease, and it's a

good phenomenon for the fuel property, because lower CFPP can avoid engine pipe's clog when the weather is very cold.

For heat value, we can also check back to Table II, from the result we can easily found that their value are almost the same, only when the proportion come to 50%, the difference between super diesel is near 5000J per gram, But from later generator test we can find that they all can let diesel generator have stable power output for 1 hour.

To get cetane number we follow the literature that we mentioned in last section, called it cetane index, with this value, we still need two data, they are gravity and mid boiling point. Table II showed cetane index's result, including gravity and mid boiling point. From the data, also we can find out that with the Jatropha oil blends increase, cetane index decrease lightly, and they lowest one is 50%, the difference between super diesel near 6, but also, from later generator test we can find that they all can let diesel generator have stable power output for 1 hour.

TABLE II
PHYSICAL PROPERTIES OF OIL BLENDS WITH DIFFERENCT PERCENTAGE OF JATORPHA

	Flash point	CFPP	Heat value	Gravity	Mid boiling point	Cetane number
Super diesel	76	-7	46077	36.27	278	51.6
D90/CJ10	77	-7	45360	34.72	282	49.73
D70/CJ30	80	-9	43288	31.69	306	48.31
D50/CJ50	89	-13	41866	28.66	330	45.73
Jatropha oil	244	-	39373	22.46	-	-

Units: flash point, CFPP, mid boiling point: ℃, heat value: J/g

Before 1 hour generator test, we already did 30 minutes test, and we found that for Jatropha blends in 10% and 20%, they all showed almost the same efficiency with super diesel, so, in 1 hour test, we start from 30% Jatropha blends. Fig. 1 showed the results of frequency, ampere, power and voltage at 30 ℃. From the results we found that, all the test fuels can have the same power output, even at 50%, so, it seems if the fuel can let generator run successfully, then it can provide stable power output, the values that they showed are almost the same. In order to know the limit of Jatropha oil blends, we tried the proportion to 60%, but unfortunately it failed. The reason is that 60% Jatropha blends already close to crude Jatropha oil's property, so, higher kinematic viscosity and higher flash point we'll get, and these kinds of inferiority property appeared, resulted in inadequately combustion, and even let generator unstable after it ran after 10 minutes.

IV. Conclusion

With oil blending process, we can slightly lower kinematic viscosity, and improve the situation of incompletely combustion. The major objectives of this study is to find out whether Jatropha oil blends can let diesel generator run and has a stable power output. From the results, we found that crude Jatropha oil blends, even 50% can let Yanmar diesel generator has a similar power output with fossil diesel, including voltage, frequency, ampere, power, and run for 1 hour. We all know it is necessary to do oil degumming process, in order to protect engine. Therefore, we will conduct the studiy of purified Jatropha oil blends' performance at the same conditions in the future.

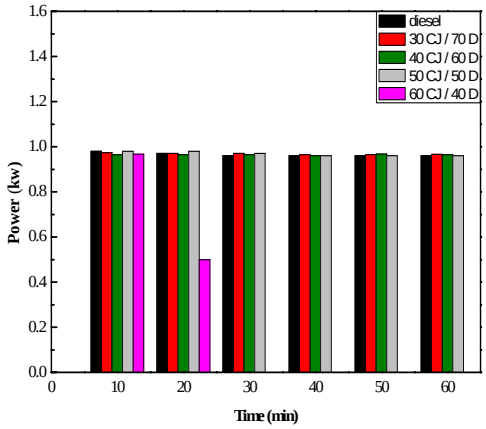

Fig. 1 Diesel generator power output of different Jatropha oil blends

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