The Effect of Mixing Diesel Fuel with Cottonseed Oil and Coconut Oil on The Performance of 4-Stroke Diesel Engine

Adhi Iswantoro[1], Aguk Zuhdi Muhammad Fathallah[2], Semin[3], Ramdhan Febrianto Saputra[4]

(Received: 23 January 2018 / Revised: 27 February 2019 / Accepted: 26 March 2019)

***Abstract*— research on biodiesel as an alternative fuel has been widely carried out. Such as mixing one type of oil mixed with diesel fuel with a certain composition. In this research, biodiesel was made by mixing two types of oil and then mixed with diesel fuel with a composition of 30:80, where 30% for mixed oil that is cottonseed oil and coconut oil, then 80% for diesel fuel. And then in this research, the composition between cottonseed oil and coconut oil must be found, so that it will get the best composition between cottonseed oil and coconut oil. For comparison in performance between mixed biodiesel with 4 cSt and 6 cSt, and in the mixing process, using mathematical calculation methods, then the mixing results must meet SNI standards (Standard Nasional Indonesia / Indonesian National Standards). In this research, 4-stroke diesel engines with one cylinder were used. From the experiments and data analysis, biodiesel with 6 cSt more powerful, torsion and BMEP better than mixed biodiesel 4 cSt.**

Keywords—biodiesel, coconut oil, cottonseed oil, performance.

I. Introduction

Energy availability has become a very important discussion topic in recent years. We know that fossil energy includes non-renewable energy. The availability of fossil energy that continues to decrease makes us look for other energy as an alternative and besides, it is also expected to be more environmentally friendly than fossil energy. One of them is energy derived from plants and animals. This can be used as fuel that can be used for diesel engines which are applied in several vehicles and power plant. And the alternative fuel from plants includes renewable energy [1].

It is these energy needs that make today's challenges where energy needs are increasing but it can be renewed and used in the long term. Dependency on petroleum fuels can be reduced by utilizing biodiesel fuel. Where the use of this biodiesel raw material abundant and feasible to be developed. Biodiesel itself is a diesel fuel derived from vegetable oil and animal oil. Biodiesel itself has some characteristics that are more advantageous than fossil fuels that are biodegradable, non - toxic, has low CO2 emissions and sulfur gas and is classified as safe to the environment. The use of biodiesel mixed with diesel fuel is obtained with a result of higher viscosity condition [2,3].

Adhi Iswantoro, Department of Marine Engineering, Institut Teknologi Sepuluh Nopember, Surabaya 60111, Indonesia, Email: adhi.iswantoro@gmail.com
Aguk Zuhdi Muhammad Fathallah, Department of Marine Engineering, Institut Teknologi Sepuluh Nopember, Surabaya 60111, Indonesia, Email: fathalaz@its.ac.id
Semin, Department of Marine Engineering, Institut Teknologi Sepuluh Nopember, Surabaya 60111, Indonesia, Email: seminits@gmail.com
Ramdhan Febrianto Saputra, Department of Marine Engineering, Institut Teknologi Sepuluh Nopember, Surabaya 60111, Indonesia, Email: ramdhanfebri87@gmail.com

One of the challenges in the application of biodiesel fuel is the price of raw materials that are still considered high and in non-industrial level consumption. Until now the most perceived raw materials are palm oil. This is because Indonesia is one of the largest palm oil producers in the world. but the availability of oil palm and soil are also limited so it needs other plants as a companion.

Therefore one of the solutions can use biodiesel that does not consist of one type of biodiesel only. In addition to these reasons, one of the challenges is that some biodiesel that has been developed not all meet SNI standards, such as candlenut oil, which in the previous research obtained viscosity values that do not meet the SNI standards. Then there is also a caster oil whose viscosity value is under SNI standards and a cottonseed oil whose heating value does not meet SNI standard. So to know the feasibility of using mixed biodiesel fuel and to get the best mixing formula according to SNI [1-3].

II. Method

In this research, using experiment method and data calculation. Before the experiment is carried out, the first process will be made of fuel in the form of pure biodiesel from coconut oil and cottonseed oil. the process is as follows:

A. Biodiesel Production

In the process of making biodiesel, it requires preparation of equipment. The equipment required are laboratory scale equipment consists of trans esterification equipment, that is:

a. Stove
b. Thermometer
c. Measuring Cylinder
d. Glass Cylinder
e. Stirrer
f. Then the materials needed in this research that is:
g. Fat Oil
h. Aquades

i. Methanol
j. KOH
k. H2SO4
l. H3PO4

The first step of Biodiesel production is the process of degumming for cottonseed oil only, this process is to make sure for purify the oil. The degumming process using H3PO4 in 0.1% of volume oil. And then settling for 2 days and remove "gum" and proceed to the next step. Heating oil in the stove, the oil is heated to a temperature of about 45o to 50o C, followed by the addition of a strong KOH base. Heating each session with a volume of 1000 mL coconut oil, added 500ml methanol and 3.5 gr KOH and for cottonseed is every 1000 ml used 500 ml methanol and 7 gr KOH. Followed by mixing methoxide and waste cooking oil for 1 hour. After it is well-mixed, the next step is the settling process. This process is used to separate biodiesel and glycerol [4]. Settling process takes about 8 hours (minimum) or 24 hours for the best result. The settled glycerol will be separated elsewhere, the next is biodiesel washing process using aqueous liquids. The washing is done 3 times to make sure the biodiesel is clearly separated with glycerol. After the washing process, the final step is the drying process. This step is to ensure that no water exists in biodiesel that has been cleared during the manufacturing process. Final step mixed both of biodiesel with the composition where the experiment conducted. The biodiesel product can be seen in Figure 1.

Figure. 1. Cotton seed oil and Coconut oil product

B. Biodiesel Testing

After biodiesel is complete in production, the next step is oil testing with a sample in laboratories to know the properties of biodiesel, like viscosity, density, flash point, and low heating value. From this test, we can know the biodiesel meet with SNI standard or not [5,6].

1) Viscosity
   Viscosity is a measure of the viscous that expresses the magnitude of friction within the fluid viscosity is very influential on the performance of the diesel engine, especially in the injection process. Which if the viscosity is too high it will give low atomization so the engine will be difficult to start. If the viscosity too low it will impact the leakage on the fuel pump and accelerate the wear on the pump components and fuel injectors.
2) Density
   Density is defined as the ratio of weight (kg) per unit volume (m^3) of fuel. Density can be affected by changes in temperature and pressure. The higher in pressure, so density will high too. While the higher in temperature, the density will be low.
3) Flash Point
   Flashpoint is the lowest temperature of fuel when heated, thus the vapour from the heating mixed with air will ignite on high compression. Flashpoint on biodiesel standard has a minimum value limit of 100°C.
4) Low Heating Value
   The value of heat (value of combustion) or Heating Value is the amount of heat released by the fuel in 1 kg of fuel if the fuel is burned. In combustion gas, there is H2O in the steam or liquid form. There are two kinds of combustion values that is the up burning value or High Heating Value (HHV) and lower burning value or Lower Heating Value (LHV). HHV is the value of the combustion when inside the combustion gas there is H2O in the liquid form, whereas LHV is combustion value when inside the combustion gas there is H2O gas.

C. Engine Set-up

In this step, will be prepared equipment and installation of tools that will support the data collection of the experiment results. Such as the installation of sensors consisting of Vibrasindo TMR-Card Board and TMR-Crank angle Rotary Encoder Hardware on diesel engine YANMAR type TF 85 MH-di. In addition, there is also a test tool in the form of Electric Dynamo to know the engine performance. In the engine set up is done, running tests the initial conditions of YANMAR diesel engine to determine the initial characteristics.

In this step is expected all have been available and ready to do experiments because if the initial set up is not perfect and found error later when the test took place then the results obtained are certainly not optimal. The engine set-up scheme can be seen in Figure 2.

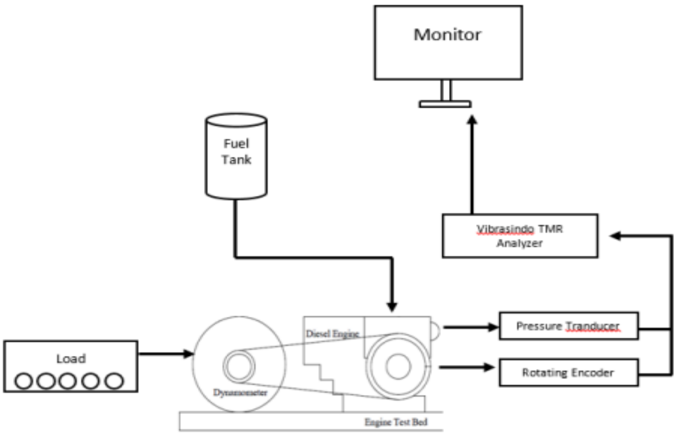

Figure. 2. Engine set-up scheme

D. Experiments

The experiments doing after the previous steps have been accomplished. These experiments used Yanmar engines TF85-MH 4-strokes 1 cylinder. The purpose of the experiments is to know the engine performance that can be seen in the engine power, torque, and BMEP.

III. RESULTS AND DISCUSSION

A. Calculating of Mixed Biodiesel

For the mixing process, is done directly without addictive substances because, in the mixing process, two biodiesel can mix perfectly. For the calculation formula using Bloomfield method (1971) [7]. The Bloomfield approach is to correlate the viscosity of mixture with properties of pure components and with the characteristics of the thermodynamic parameter of intersection between the components, so the formula becomes:

$$\ln \eta = X_1 \ln \eta_1 + X_2 \eta_2 \quad (1)$$

Where:

η : viscosities

X : mol fraction

From the calculation, the result of the calculation shown in Figure 3. It shows the Bloomfield method result and the experimental result. Figure 3 compares the calculation with the Bloomfield method with an experiment where the error value is 1.1 %. And in Table 1 shows the comparative value of each composition and its viscosity value to the results of the experiment. So from that formula, the mixed fuel will use a formula based on the Bloomfield method which has error value 1.1 %. The mixture used for the experiment is that has viscosity 4 cSt and 6 cSt. The reason is 4 cSt because engine to be used as experiments using solar fuel which has viscosity 2 – 4 cSt, and 6 cSt based on maximum standard biodiesel in Indonesia. So the composition in 55% coconut and 45% cottonseed oil for 6 cSt and 85% coconut oil and 15 % cottonseed for 4 cSt. And for the experiment all biodiesel using B30, with composition 30% for mixed biodiesel and 70% for diesel fuel [8-10].

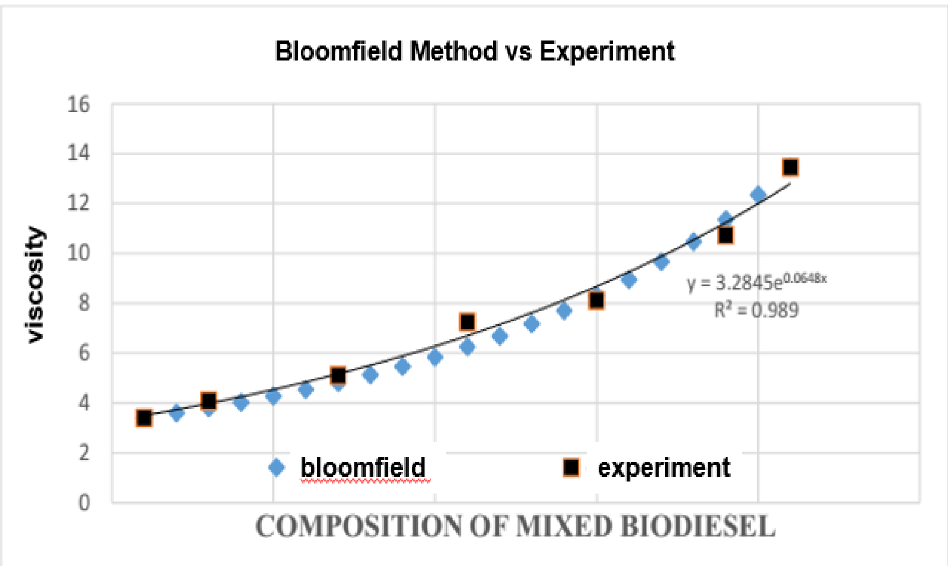

Figure. 3. Viscosity graph between Bloomfield method and experiment

TABLE 1.
VISCOSITY COMPARISON OF MIXED BIODIESEL BETWEEN BLOOMFIELD METHOD AND EXPERIMENT

Composition Mixed Biodiesel	Bloom Field Result	Experiment Result
100%	3.41	3.41
95%:5%	3.60	
90%:10%	3.81	4.08
85%:15%	4.03	
80%:20%	4.28	
75%:25%	4.54	
70%:30%	4.82	5.11
65%:35%	5.14	
60%:40%	5.47	
55%:45%	5.84	
50%:50%	6.25	7.25
45%:55%	6.69	
40%:60%	7.18	
35%:65%	7.71	
30%:70%	8.30	8.12
25%:75%	8.95	
20%:80%	9.67	
15%:85%	10.47	
10%:90%	11.36	10.73
5%:95%	12.35	
100%	13.46	13.46

B. Engine Performance

After B30 biodiesel has finished laboratory tests to find out and meet SNI standards, then the next step is conducting experiments. Experiments were carried out with progressive engine load levels. In Figure 4 show a 100% power ratio resulting from a fuel variation at each RPM [11-13]. The result is the use of either pure or mixed biodiesel B30 fuel produces better power than conventional fuels for this research is dexlite (diesel fuel), and also for better-mixed coconut and cottonseed oil owned by higher viscosity mixtures but, nevertheless with viscosity increases the higher does not increase the performance to be better as can be seen in the RPM 2100 increase in viscosity is higher in the B30 cotton seed even make the engine performance to go down.

This performance increase factor can also be caused by higher energy value content due to higher capacity, this can be seen from the value of B30 cotton seed power which has the highest value compared to other fuels. Similarly, Figure 5 and 6 are directly proportional to the results as in the power graph that is the addition of biodiesel fuel increase the value of torque and also BMEP. A better comparison of viscosity mixtures 4 cSt or 6 cSt can be seen from each round versus RPM, for B30 coconut and coconut viscosity 6 cSt performance is better than viscosity 4 cSt because it produces slightly higher power, torsion and BMEP than the viscosity mixture 4 cSt.

Figure 4 is a graph of power ratio performance against RPM on fuel mixed variables B0 and B30 with mixed variations. The results can be obtained from the graph is either B0 or even B30 various fuel variations have values that coincide with each other, producing power that is almost similar in each RPM. For an initial RPM of 1800 RPM, almost every mixed variable of B30, both mixed coconut and B30 cotton seed mixture and mixed B30 mixed biodiesel from coconut and cottonseed both viscosity 4 and 6 have a higher power value than B0 or dexlite of 0.85% or of 0.0213 kW for B30 coconut, 1.38% or 0.0349 kW for B30 cottonseed, 0.46% or 0.0116 kW for B30 coconut and cottonseed mixture with a viscosity of 4 cSt (mixture of coconut and cottonseed before mixed dexlite), and 1.6 % or 0.04 kW for B30 coconut and cottonseed mixture with a viscosity value of 6 cSt (mixture of coconut and cottonseed before mixed dexlite).

Even in 1900 RPM, the power value is still greater on the mixed variation compared with pure dexlite or B0 which is around 0.53% - 1% or equivalent with 0.0147 kW - 0.0281 kW. However, when the RPM reaches 2000 and 2100 differences begin to occur, for RPM 2000 the value of pure dexlite or B0 is still below the B30 value except for B30 coconut, where the difference between B30 coconut and B0 is 0.0063 kW or 0.2% smaller than B0 and farthest namely B30 coconut and cottonseed mixture with viscosity 6 which is 0.0141 kW or 0.45%. Lastly at RPM 2100 the dexlite value is better than the B30 cottonseed value and also the B30 value of coconut and cottonseed mixture at viscosity 6, where the B30 coconut has the best power with the difference from dexlite is 0.0225 kW or 0.67% while the worst is B30 cottonseed with difference under dexlite of 02091 kW or 6%. From the graph, it can be concluded the addition of biodiesel either pure or that has been mixed can increase the power of diesel engine but for certain RPM give the little impact of power decline as in RPM 2100. And also with the higher viscosity then the resulting power impact tends to decrease.

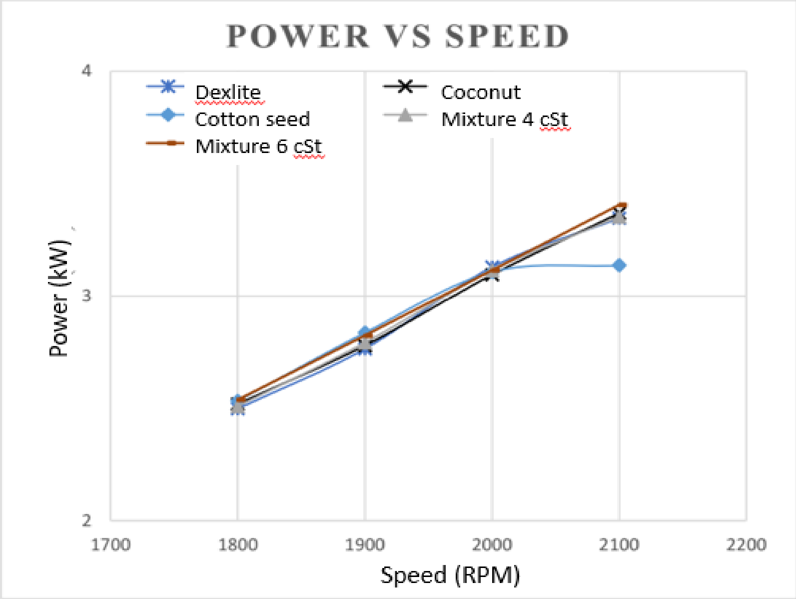

Figure. 4. Performance result: power vs speed

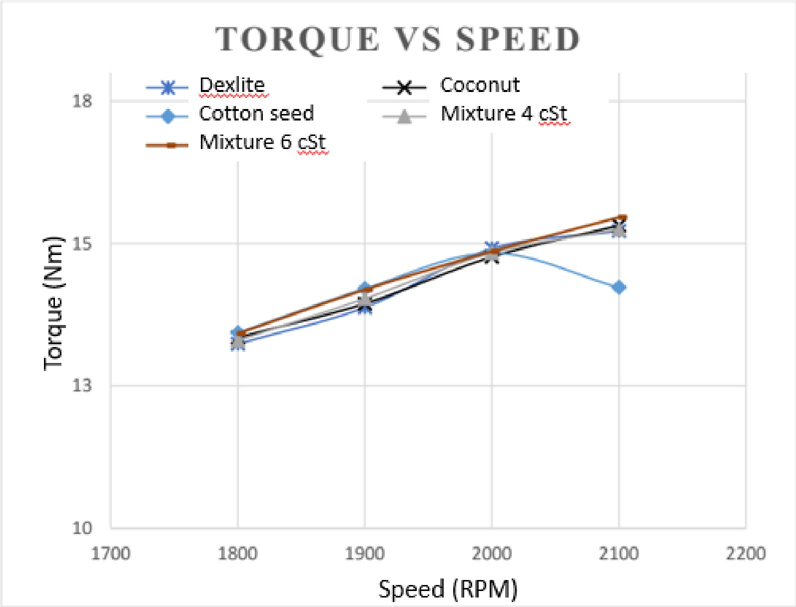

Figure. 5. Performance result: torque vs speed

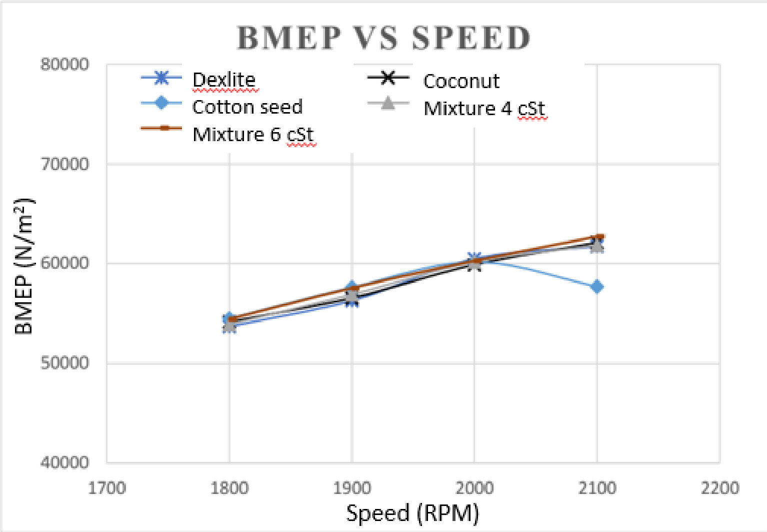

Figure. 6. Performance result: bmep vs speed

IV. Conclusion

Based on the calculation, experiment and data analysis, the diesel engine performance from using mixed biodiesel, some conclusions can be taken:

Mixing of biodiesel with the value not meet the standard SNI can be done to get the value of SNI, wherein this study coconut that has the viscosity of 3.41 cSt and cottonseed with viscosity 13.46 cSt can be mixed and got a value of SNI by mixing certain level. For mixing alone the approach used is Bloomfield formula with error value is 1.1%.

Performance from the B30 biodiesel fuel mixture of coconut and cottonseed has slightly better results compared to conventional fuels. Based on the Power, Torque, and BMEP mixed biodiesel fuel has a better value. For the comparison of mixed fuels with viscosities 4 and 6, it can be seen that B30 mixtures that have greater viscosity in terms of performance are slightly less than those of viscosity 4 but for fuel consumption more wasteful than B30 viscosity 4.

References

[1] Semin, Adhi Iswantoro, Gage Cendekiaji Hadi, "Biodiesel Cotton Seed Oil Performance Analysis on Diesel Engine", International Journal of Marine Engineering Innovation and Research, 2018, Vol. 2, No. 4, ISSN: 2548-1479, page 235-241

[2] Beny Cahyono, Aguk Zuhdi Muhammad Fathallah, Vianto Ilham Pujinaufal, "Effect of Model from Candlenut Seed (Aleurites Moluccana) to NOx Emission and Combustion Process on Single Cylinder Diesel Engine", International Journal of Marine Engineering Innovation and Research, 2018, Vol. 3, No. 1, ISSN: 2548-1479, page 1-8

[3] Bello,E.I. & A.A., Aldesuru. (2015). Cottonseed (Gossypium arboretum) Oil Biodiesel. Department of Mechanical Engineering, the Federal University of Technology. Akure Nigeria.

[4] Kareem , S.O., Falokun , E.I.., Balogun S.A., Akinloye, O.A., Omeike , S.O.. (2016), Enzymatic biodiesel production from palm oil and palm kernel oil using free lipase. Egyptian Journal of Petroleum.

[5] SNI, Standar Nasional Indonesia. http: //sispk.bsn.go.id/SNI/ICS_Detail_list/1053

[6] Barabás, István. & Todoruţ, Ioan-Adrian. (2011). Biodiesel Quality, Standards and Properties. Technical University of Cluj-Napoca. Romania.

[7] Bloomfield, Victor A. (1971), Viscosity of Liquid Mixture. The Journal of Physical Chemistry, vol 75 no 20, 1971 pg 3113 -3119

[8] Nariati, Susi. (2016). Influence Analysis of The Iodine Number on Motor Performace with B20 and B30 Biodiesel Fuel from Waste cooking oil. Institut Teknologi Sepuluh Nopember. Surabaya.

[9] Nair, Jayashri N., Deepthi, J., Kalyani, K. Siva. (2013), Study of Biodiesel Blends and Emission Characteristics of Biodiesel. International Journal of Innovative Research in Science, Engineering and Technology, vol 2, Issue8, August 2013.

[10] Amin, A. Gadallah, A., Morsi, A.K.El., El-Ibiari, N.N., ElDiwani, G.I. (2015), Experimental and empirical study of diesel and castor biodiesel blending effect, on kinematic viscosity, density, and calorific value. Egyptian journal on Petroleum. 25,509-514.

[11] Anantharaman, Gopinath., Krishnamurthy, Sairam., Ramalingam, Velraj. (2013). A Review on Combustion, Performance, and emission characteristics of Fuels derived from oil seed crops (biodiesel). Australian Journal of Crop Science, AJCS 7(9):1350-1354 (2013).

[12] Mofijur, M., Masjuki, H.H., Kalam, M.A., Atabani, A.E., Shahabuddin, M., Palash, S.M., Hazrat, M.A..(2013). Effect of Biodiesel from various Feedstocks on Combustion characteristics, engine durability, and materials compatibility: a review. Department of Mechanical Engineering, University of Malaya. Kuala Lumpur Malaysia.

[13] Bhangale, J.H.& Kulkarni, A. B. (2017), A Review of the Effects of Biodiesel from Different Feedstocks on Engine Performance and Emissions. International Research Journal of Engineering and Technology (IRJET), volume :04 Issue:07 July 2017.