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PERFORMANCE AND EMISSION EVALUATION OF CASTOR BLENDS BIODIESEL IN SINGLE CYLINDER DIESEL ENGINE DYNAMOMETER

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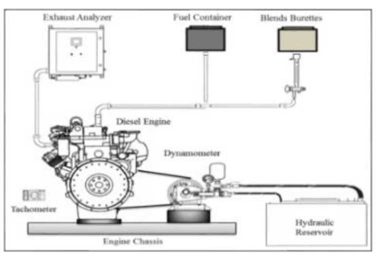
Graphical abstract



Abstract

This study presents a preliminary investigation of engine is running on petro-diesel in order to determine the engine's operating characteristics and exhaust emission levels, constituting the base line that is compared with corresponding cases when using second generation biodiesel that used castor biodiesel consists of 5%, 10% and 20% blends. The engine coupled to hydraulic dynamometer through belting connection for load measurement. The same method will be repeated for each fuel blend by keeping the same operating condition. The present studies contribute as an alternative fuel by using biodiesel fuels from non-edible for diesel engines with standard engine parts.

Keywords: Biodiesel; castor oil; engine dynamometer; emissions

Abstrak

Kajian ini membentangkan penyiasatan awal ke atas enjin yang menggunakan petro-diesels sebagai bahan api asas bagi menentukan ciri-ciri operasi enjin dan tahap pelepasan asap lalu dibandingkan dengan kes-kes yang sama apabila menggunakan biodiesel generasi kedua iaitu minyak kastor yang juga terdiri dengan campuran 5%, 10% dan 20%. Enjin digandingkan bersama dinamometer hidraulik melalui sambungan tali sawat bagi tujuan untuk pengukuran beban. Kaedah yang sama akan diulang bagi setiap campuran bahan api dengan mengekalkan keadaan operasi yang sama. Kajian ini telah menyumbangkan bahawa bahan api biodiesel daripada sumber yang tidak boleh dimakan mampu untuk dijadikan sebagai bahan api alternative dalam operasi enjin biasa. .

Kata kunci: Biodiesel; minyak kastor; dinamometer enjin; pelepasan

1.0 INTRODUCTION

Recently, crisis about fossil fuel depletion and environmental pollutants already got a people attraction. Air pollution is one of the most dangerous environmental problems all over the globe. Continuously increasing use of oil will intensify local air pollution and accelerate the global warming problems caused by CO_2. One of the environmental problems are most widespread in the whole world is air pollution. Production of CO_2 gasses accelerates that's global warming and the resulting pollution improving local air from the use of petroleum [1]. Thus, our nation needs to worry and that need to explore for alternative fuels are urgent to meet the demands of transit and industrial power generation. That needs to find way by utilizing alternative fuels, which are preferably renewable and also could give off low levels of gaseous and particulate pollutants in internal combustion engine [2]. Nowadays, most researches on biodiesel utilize food based-ingredients as a mixture of the fuel such as palm oil, corn, soy bean and maize, which are also consumed as food. Even though, the effectiveness of those developed biodiesel has been proven to be used as the alternative fuel, it has ignited a conflict between food requirements and fuel necessity. Of this problem, a based non-food ingredient by using *Ricinus Communis L* (Castor) oil is proposed as the blend of the biodiesel. For the purpose of the observation, a direct-injection diesel engine is used to examine the usability and the performance of the proposed biodiesel in term of BSFC, power output, torque and emission produced by the engine [3]. So that, the objectives of this research to studies the direct injection engines performance and emissions of second generation biodiesel of Castor oil and its blends i.e. B5, B10 and B20. As a result, the objective of this study was to explore the utility of Castor oil as a potential source of biodiesel. Hence, the role of non- edible oils such as Castor would be more sustainable for biodiesel production [4].

Table 1 Important Fuel Properties

Properties	Units	Diesel	Castor Oil	Standard Value biodiesel BIS:15607
Density@ 15 ˚C	kg/m^3	800	878	860-900
Flash point	˚C	47	125	< 120
Kinematic Viscosity @ 40 ˚C	mm^2/s	2.27	5.5	2.5-6.0
Cetane No.	N/A	47	48	<45
Calorific Value	MJ/kg	42.5	39.5	40
Iodine Value	N/A	N/A	80	>120

2.0 METHODOLOGY

The experiment was conducted using biodiesel and diesel blends on single cylinder engine. The setup consists of a single cylinder, air-cooled four strokes direct injection diesel engine KIPOR KM 170F that had power of 2.6 kW at 3000 rpm as shown in Fig. 1. The engine performance test was taken using the SAE Standard Engine Power Test Code for diesel engines (SAE, 1983) as a guideline. Granting to the standard, engine power is determined as the product of engine speed and torque that obtained at wide open throttle. The exhaust gas analyzer SV-YQ type was used to measure the concentrations of carbon monoxide (CO), carbon dioxide (CO_2), hydrocarbons (HC) and nitrogen oxides (NOx) of the exhaust gas of engine. Throughout all tests, this engine was set at full load condition at variable engine speed from 1500 rpm to 3000 rpm. Experimental set up was indicated in different blend ratios, these were regular diesel, and then using castor oil blended mixing with diesel at 5% (B5), 10% (B10) and 20% (B20). Moreover, the important fuel properties were stated in Table 1.

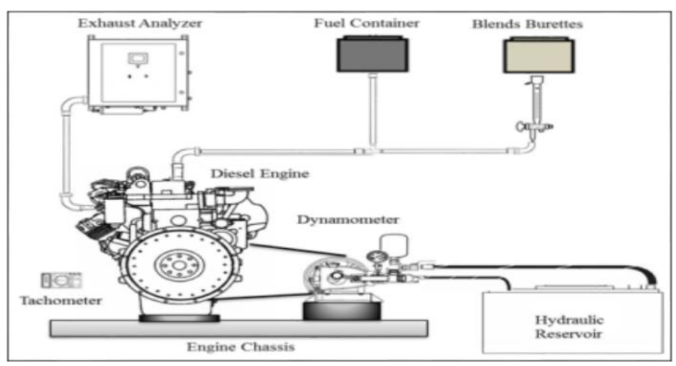


Figure 1 Schematic Diagram of Experiment Setup

Based on values obtained from generated pressure of hydraulic, it allows to obtain power and torque required. In this case, the engine efficiency was assuming without any losses occurred.

3.0 RESULTS AND DISCUSSION

3.1 Performance Parameter

3.1.1 Brake power

Figure 2 show a comparison between a regular diesel and several biodiesel of B5, B10, and B20 at 100% load condition. As illustrated in Fig.1 that graph shows relationship between brake power and engine speed using different blends of biodiesel castor. As the result, the brake power is increasing steadily for regular diesel and all biodiesel blends. The maximum power of engine was recorded at 3000 rpm, and it produced about 2.29 kW, 2.18 kW, 2.07 kW, and 2.18 kW for diesel, B5 castor, B10 castor and B20 castor, respectively. It is clearly shown that the castor blends produced a lower value compared than regular diesel accordingly to lower calorific values and higher viscosities of biodiesel blends that affected in combustion chamber and cause unusual combustion criteria [5].

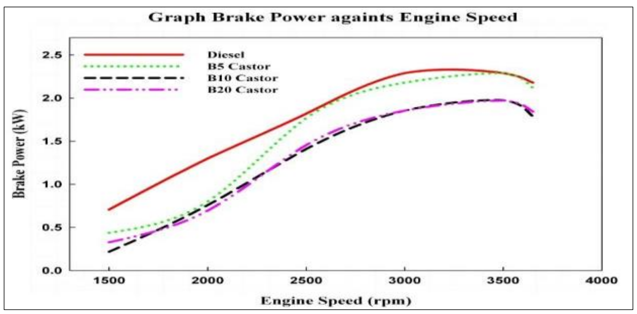


Figure 2 Variation of Brake Power respect with Engine Speed

3.1.2 Engine Torque

The relationship between engine torque against engine speed can be illustrates from Fig. 3. It can be seen that biodiesel blends of B5, B10, and B20 have a similar trends compared to regular diesel. The regular diesel produced about 7.29 Nm at 3000 rpm, B5 about 6.95 Nm, B10 about 5.95 Nm and B20 about 5.95 Nm. Biodiesel produced less value of torque because it related to higher calorific value and higher cetane number of blends [6].

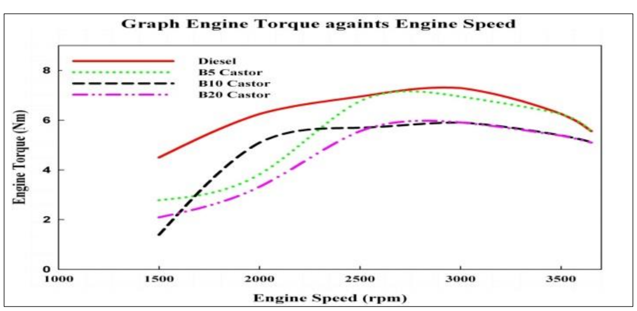


Figure 3 Variation of Engine Torque respect with Engine Speed

3.1.3 Brake Specific Fuel Consumption (BSFC)

The relationship between BSFC against engine speed can be illustrated from Fig. 4. It can be seen that biodiesel blends i.e. B5, B10 and B20 Castor have a similar trends compared to regular diesel whereas BSFC decreases with increasing engine speed. As can see, the graph showed that BSFC for regular diesel is lower, and for biodiesel produces a higher value. It is due to the calorific value of biodiesel that has less value compared to regular diesel, which has affected by the quantity of fuel consumed at higher engine speed [7].

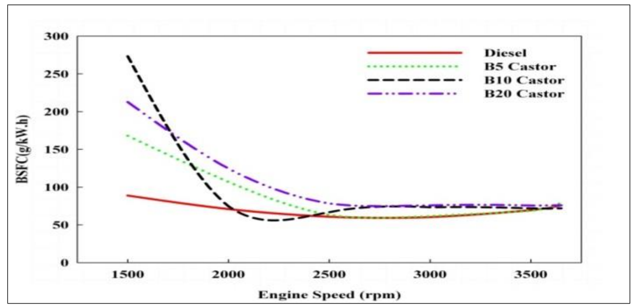


Figure 4 Variation of BSFC respect with Engine Speed

3.2 Emission Parameter

This assessment is to address a measurement of exhaust gas concentration with applying the load distributed about 100 % conditions. The exhaust gas composition was measured using exhaust gas analyzer SV-YQ. That measured NOx, HC, CO and CO_2

3.2.1 Nitrogen Dioxides

Figure 5 illustrates the variation of Nitrogen oxides emissions from castor oil and its blends with respect to regular diesel at 100% load condition. The NOx is increased with the increasing the engine speed at beginning after 3000 rpm engine speed then it dropped due to higher combustion temperature and amount of oxygen content. It can be seen that maximum NOx were produced from B20 followed by B10, B5 and a regular diesel that the NOx values are 172 ppm, 170 ppm, 79 ppm and 62 ppm, respectively. This is happen due to higher amount of oxygen that occurred in the combustion chamber that resulted in higher NOx formation in biodiesel-fueled engine [8].

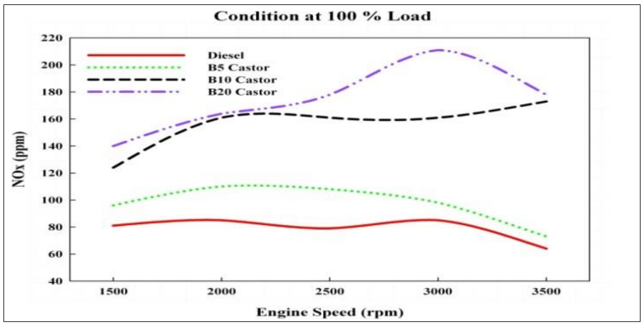


Figure 5 Variation of Nitrogen oxides with engine speed

3.2.2 Hydrocarbon

The variation of Hydrocarbon emissions from castor oil and its blends with respect to regular diesel are illustrated at varying engine speed with 100% load condition in Fig. 6. It was observed that HC emission of B20 Castor biodiesel was lowest compared to other biodiesel blends and regular diesel. It can be seen that B5, B10 and B20 castor were produced less HC emission compared regular diesel about 17 ppm, 8 ppm, and 6 ppm at maximum engine speed while regular diesel produced about 75 ppm. The biodiesel is found that produced lower HC emission primarily due to relatively oxygenated compounds that improved the fuel oxidation. Within it, biodiesel blends have a higher cetane number than the regular diesel, whereas in the combustion chamber it can occur before the air and fuel are properly mixed and can result in incomplete combustion and smoke that related to reduce in HC emission [9].

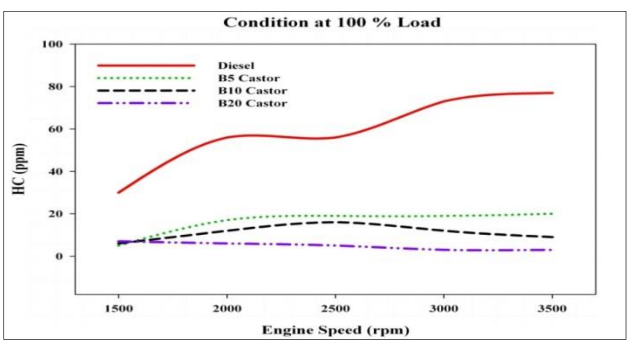


Figure 6 Variation of Hydrocarbon with engine speed

3.2.3 Carbon Monoxide

Figure 7 illustrates the variation of carbon monoxide emissions from castor oil and its blends with respect to regular diesel at varying engine speed with 100% load condition. It was observed that biodiesel that are B5, B10, and B20 castor blends were produced lower CO emission compete than the regular diesel. There are 0.03 %, 0.02 %, and 0.02 %, respectively at maximum engine speed while regular diesel produced about 0.11 %. This is because higher cetane number of biodiesel blends resulting in the lower possibility of the establishment of a rich fuel zone and thus decreases CO emissions. On the other hand, the biodiesel and its blend have some more oxygen contents that cause the better combustion process. Thus, CO can be converted into CO2 gasses [10].

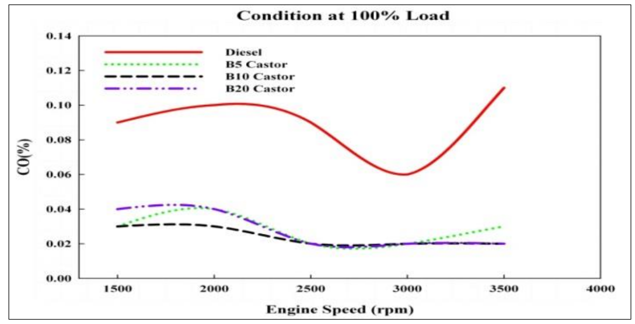


Figure 7 Variation of Carbon monoxide with engine speed

3.2.4 Carbon Dioxide

Figure 8 depicts the variation of Carbon dioxides emissions from castor oil and its blends with respect to regular diesel at varying of engine speed with 100% load condition. The CO_2 emission increased a maximum value at B20 and followed by B10, B5 Castor, and regular diesel. As illustrates biodiesel blends produce higher CO_2 than the regular diesel. Meanwhile, at maximum engine speed, the biodiesel blends i.e. B20, B10, B5 Castor and the regular diesel produce 4.5%, 3.2 %, 1.6 % and 1.4 % of CO_2, respectively. This may occur due to the oxygen content in biodiesel, which is, it can react with carbon atoms in combustion chamber section and indirectly increases the CO_2 emissions formation. Furthermore, the primary factor that occurred with increasing of biodiesel blends is the extra carbon dioxides content amounts in exhaust emission, and that can led to complete combustion of fuel [11].

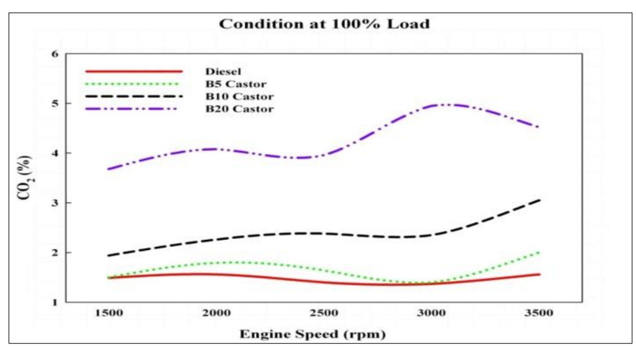


Figure 8 Variation of Carbon dioxides with engine speed

4.0 CONCLUSION

The recent study was focusing on the standard diesel engine and the primary aim of the present study was to investigate the suitability of Castor and its blends as a fuel for diesel engine in term of performances and emissions. The outcome study indicates that the engine performance and emissions with biodiesel of Castor and its blends were comparable to the operation with regular diesel. From the experiments, it can be concluded that the biodiesel fuel gives brake power and engine torque, lower than the regular diesel due to a higher volume flow rate of fuel. The specific fuel consumption was observed with the blend B20 is more depressed compared with other blends and regular diesel. Meanwhile, biodiesel has decreased the amount of CO emissions due to higher oxidation rate that increases the concentration of O_2 in fuel molecules. The hydrocarbons for biodiesel blends are delivered lower than regular diesel due to relatively oxygenated compounds that improved the fuel oxidation and higher cetane number. The castor biodiesel produced higher NOx emission, but somehow it produced lower CO, CO2 and hydrocarbon compared regular diesel.

Biodiesel castor oil is suitable alternative fuel for diesel engine without major adjustment of engine parts. It suggests that biodiesel from non-edible oil like castor oil could be a full replacement for diesel engine and can play a vital part in the near future particularly for meeting energy requirement in agriculture, industrial and shipping sectors. With comparable engine performance and reduction of Hydrocarbon, CO and with penalty of increased NOx emissions in comparison to regular diesel fuel, it can be concluded that biodiesel derived from castor oil and its blends could be applied in a formal diesel engine without any alteration. Nevertheless, the optimization of suitable blend can be subjected to future work with regard to engine parameters.

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References

[1] Arisel Corro, N. T., Edgar Ayala, Alma Marinez-ayala. 2010. Two-step biodiesel production from Jatropha curcas crude oil using SiO2.HF solid catalyst for FFA esterification step. *Fuel*. 89: 2815-2821.

[2] Liaquat, A. M., Masjuki, H. H., Kalam, M. A., Fattah, I. M. R., Hazrat, M. A., Varman, M., Mofijur, M. & Shahabuddin, M. 2013. Effect of Coconut Biodiesel Blended Fuels on Engine Performance and Emission Characteristics. *Procedia Engineering*. 56: 583-590.

[3] Demirbas, A. 2009. Progress and recent trends in biodiesel fuels. *Energy Conversion and Management*. 50: 14-34.

[4] Chauhan, B. S., Kumar, N., Cho, H. M. & Lim, H. C. 2013. A study on the performance and emission of a diesel engine fueled with Karanja biodiesel and its blends. *Energy*. 56: 1-7.

[5] Campos-Fernandez, J., Arnal, J. M., Gomez, J., Lacalle, N. & Dorado, M. P. 2013. Performance tests of a diesel engine fueled with pentanol/diesel fuel blends. *Fuel*. 107: 866-872.

[6] A. E. Pillay, S. C. F., M. Elkadi, S. Stephen, J. Manuel, M. Z. Khan & S. Unnithan. 2012. Engine Emissions and Performances with Alternative Biodiesels: A Review. *Journal of Sustainable Development*. 5: 59-73.

[7] Silitonga, A. S., Masjuki, H. H., Mahlia, T. M. I., Ong, H. C. & Chong, W. T. 2013. Experimental study on performance and exhaust emissions of a diesel engine fuelled with Ceiba pentandra biodiesel blends. *Energy Conversion and Management*. 76: 828-836.

[8] Virender Singh, S. S., Shibayan Ghosh, Ankit Agrawal 2013. Study of Performance Characteristics of Diesel Engine Fuelled with Diesel, Yellow Grease Biodiesel and its Blends. International *Journal of Scientific Engineering and Technology*. 2: 524-527.

[9] Kousoulidou, M., Fontaras, G., Ntziachristos, L. & Samaras, Z. 2010. Biodiesel blend effects on common-rail diesel combustion and emissions. *Fuel*. 89: 3442-3449.

[10] Radha, K. K., Kumari, A. A., Sarada, S. N., Nagesh, E. L. & Rajagopal, K. 2008. Alternative Fuels for a Single Cylinder Direct Injection Diesel Engine. *Emerging Trends in Engineering and Technology, 2008. ICETET '08. First International Conference* on, 16-18 July 2008. 1083-1088.

[11] Buyukkaya, E. 2010. Effects of biodiesel on a DI diesel engine performance, emission and combustion characteristics. *Fuel*. 89: 3099-3105.