International Journal of Scientific Engineering and Technology ISSN : 2277-1581
Volume No. 7, Issue No. 1, PP : 7-12 1 Jan. 2018

Characteristics Investigation of Biodiesel-Diesel (B50) Blend with Ethanol Additive as C I Engine Fuel

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Abstract: Biodiesels are being utilized as renewable, alternative energy resource of fuels and also the best substitute for continuously depleting mineral diesel as they have similar characteristics of combustion. The use of pure biodiesel as a fuel for diesel engines is presently limited due to problems relating to biodiesel fuel properties. By the addition of additive to biodiesel fuel properties can be improved to the acceptable range. In the present work, the test fuel was prepared with B50 blend fuel (50% palm oil methyl ester + 50% diesel) and ethanol additive at different percentages (0, 4, 8, 12, 16 and 20%) and investigated for their properties. The results revealed that by increasing the quantity of additive in B50 improves in density, viscosity, pour point and cloud point and with slight decrease in energy content. For the test fuel viscosity and density are decreases by 41%, 2.73%, respectively with 20% ethanol in blend fuel. The flash and fire points are 51ºC and 54ºC slightly lower than the flash and fire points of the conventional diesel and 18.3% of energy content decreases as compared to the blend fuel. All the test fuels (B50 blend fuel with ethanol additive) samples meet the requirements of ASTM D6751 biodiesel.

Keywords: **Biodiesel, Properties, Ethanol, Blend fuel (B50), Viscosity, Additive, Test fuel**

I. Introduction

Fast depletion of petroleum resources, increasing fuel price, continuous addition of vehicles on road and accumulation green house gases are the main reasons for the development of best alternative and renewable fuels. To overcome these difficulties, several researchers recommended the usage of transesterified vegetable oils with reduced viscosity by some commonly used chemicals, which is termed as biodiesel [**1-2**]. Biodiesel can be used in any diesel automotive engine almost without modifications in its pure form or blended with petroleum diesel fuel. It is a biodegradable, nontoxic, clean burning alternative fuel, produced from domestic, renewable resources [**3**]. The fatty acid composition of soy soapstock is quite similar to that of commercial biodiesel produced from refined soybean oil. The ester product has properties similar to provisional biodiesel specifications such as flash point, water and sediment, carbon residue, sulfated ash, density, kinematic viscosity, sulfur, cetane number (CN), cloud point, copper corrosion, acid number, free glycerine and iodine number values. The emissions profile of biodiesel from soapstock was quite similar to that of biodiesel produced from refined soy oil. Emissions of total hydrocarbons, particulates, and carbon monoxide were reduced considerably with neat soapstock biodiesel as compared with petroleum diesel fuel [4]. Experimental investigations on the fuel properties of biodiesel and its blends at various temperature revealed that the fuel properties of different biodiesels can be enhanced by blending with diesel fuel. The undesirable properties of different biodiesels can be reduced by decreasing acid value as well as density of different biodiesels [**5-6**].

Additive in the biodiesels improve the properties of blend fuels which enhance the ability to vaporize completely that leads to proper combustion there by increases the engine output [**7**]. The fuel properties results show slight improvement in density and acid value with a significant reduction in viscosity and volatility when ethanol additive quantity is increased. Further the test fuel pour point was reduced with ethanol additive. However, the fuel energy content was slightly affected with increasing ethanol additive ratio in the test fuel compared with diesel fuel [**8-9**].The properties of the blend fuel change with the amount of fuel blended with the biodiesel and hence there is a need for the development of suitable models for the prediction of various properties of the blends. A correlation between cloud point and total unsaturated fatty acid methyl ester and similarly correlation between pour point and total unsaturated fatty acid methyl ester were obtained. Using these four correlations, cloud and pour points of different biodiesel blends can be determined [**10**].

Some properties of biodiesel are very close or sometimes even better when compared to diesel fuel. These are better ignition quality, comparable energy quantity of content, higher density, flash point, almost zero sulphur and cleaner burning of fuel [**11-13**]. Biodiesel has a calorific value which is about 12% lower than diesel that means biodiesel has lower energy content. This leads to a higher consumption of biodiesel in order to achieve same power that of diesel in the engine [**14**]. Cetane number measures the readiness of fuel to ignite that injected into the engine. This usually depends on the fuel composition and can impact on engine in the relation to noise level, performance and exhaust emissions. A high value of cetane number indicates that the fuel ignite at faster rate [**15**]. Hence, biodiesel could be a most reliable alternative fuel for emissions reduction in diesel engine applications. Vegetable oils such as rapeseed, soybean and palm oil, algae oil and animal fats which are primarily composed of triglycerides, and are used to produce biodiesel, is also known as fatty acid methyl ester. Knocking can be prevented by the addition of additives in biodiesel fuel. Triacetin additive can be used as an antiknock agent to reduce engine knocking, to improve cold flow and viscosity properties of biodiesel. From the experiments it was concluded that 10%

International Journal of Scientific Engineering and Technology ISSN : 2277-1581
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of triacetin with biodiesel gives encouraging results (**16-17**). Addition of DEE to diesel fuel improves thermal efficiency and reduces in smoke, carbon monoxide and hydro carbon emissions in the diesel engine [**18**].

The objective of this work is i) To produce biodiesel from palm oil by transesterificaton process ii) To compare the biodiesel properties with diesel fuel iii) To prepare biodiesel-diesel blend fuel B50 by volume iv) To prepare test fuels with ethanol and B50 at various proportions by volume v) To study the properties variation of diesel, ethanol, biodiesel and test fuels [E0BF100, E4BF96, E8BF92 E12BF88 E16BF84 and E20BF80] and vi) To compare the results obtained with diesel fuel. These properties provide important data for further investigation of the engine operation with those fuels in terms of performance, combustion and emissions.

II. Material and Methodology

MAKING OF BIODIESEL

Biodiesel refers to a vegetable oil or animal fat based fuel consisting of long chain alkyl esters. Biodiesel is made by chemically reacting lipids with alcohol producing fatty acid esters. It can be used in diesel engines directly or blended form with the petro-diesel at various proportions by volume. ***Transesterification*** process is the best method to produce biodiesel from crude oil. It is a process of chemical reaction between triglycerides and alcohol in the presence of catalyst to produce mono-esters that are termed as biodiesel **[19-20]**. Transesterification process consists of the following steps in making biodiesel.

- i) Acid treatment
- ii). Sodium methoxide preparation
- ii) Base treatment
- iv). Water washing

i) Acid treatment: *Palm* oil is heated to 110°C in order to remove any water particles from the oil in order to complete the reaction. Heated oil is cooled and filtered to remove dust particles. 120ml of methanol is added to the solution and stirred with constant heating for about one hour. At about 60°C, 2ml of H_2SO_4 (99% pure) is added to the solution and stirred continuously with constant heating. Ensure that the temperature is not to exceed 65°C because at this temperature methanol will evaporate (Fig. **1**). The solution is allowed to settle in a separating flask. A two layer glycerol and oil solution is formed depending on the content of the acid the glycerol may separate on top layer or bottom layer (Fig. **2**). The separated glycerol is removed to collect oil in the base treatment.

Fig. 1 Acid treatment

Fig. 2 Glycerin separation

ii). Sodium methoxide preparation*:** Methanol of 200ml with 99% pure and 6.5gms of sodium hydroxide mixed in a conical flask and shaked well to dissolve completely. Sodium hydroxide acts as a catalyst in the base treatment. The formed solution is called ***sodium methoxide.

iii) ***Base treatment:*** Sodium methoxide is mixed with the acid treated oil and stirred well in by heating up to 60°C in a conical flask for a period of one hour to complete chemical reaction (Fig. **3**). The solution is allowed to settle down in separating flask (Fig. **4**). A two layer solution is formed after settlement. The top layer indicating the oil and bottom layer is glycerol which is to be removed. The obtained oil from base treatment is poured in to the flask for bubble washing process.

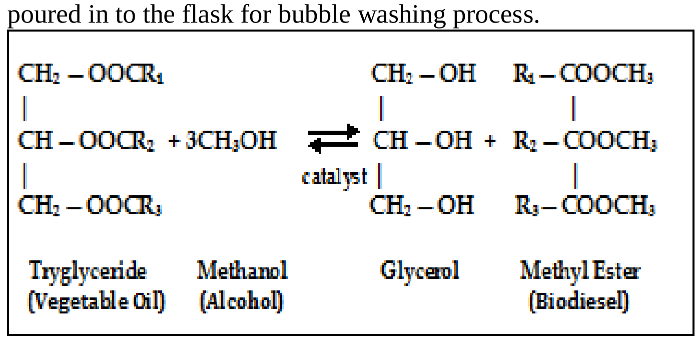

Fig.3 Biodiesel Reaction

iv). Water washing: Base treated solution is added with half volume of water and four drops of ortho-phosphoric acid (H_3PO_4) for water wash in order to remove soaps from the biodiesel. The solution is bubble washed for half an hour and allowed to settle. Water along with the soap is settled at the bottom of oil which is to be removed (**Fig. 5**. The process is repeated till the clean water settled at the bottom of oil (Fig. **6**). After separation the oil is heated to 110°c to remove water traces (**Fig. 7**). Thus the formed oil is called as Palm Oil Methyl Ester ***(POME)*** or Biodiesel which is used for experimental work.

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Fig. 4 Glycerin separation

Fig. 5 Separation of soap

Fig. 6 Clear water in water washing

Fig. 7 Biodiesel heating

MATERIALS AND METHODS

Test fuels preparation: Equal quantities of biodiesel prepared by transesterification process and diesel are mixed together to form a blend fuel of B50. From this blend fuel, test fuels are prepared at various proportions of ethanol. The test fuels prepared with blend fuel B50 were at different ratios (E0BF100, E4BF96, E8BF92 E12BF88 E16BF84 and E20BF80) on the basis of volume at 100%, 96%, 92%, 88%, 86% and 80% of blend fuel mixed with 0%, 4%, 8%, 12%, 16% and 20% of ethanol as additive respectively as shown in Table 1. The test fuels (Fig. **8**) under consideration to determine properties are like density, viscosity, calorific value, flash point, fire point, cloud and pour point and cetane index. To get accurate a result stirring is used to ensure uniform mixing and to prevent phase separation of blend fuel with 99.9% pure ethanol additive in the process of making of test fuels.

Table 1 Test Fuels (Percentages of BF + Ethanol)

S. No	Type of Fuel	Diesel, Biodiesel, Blend Fuel, Test Fuel (Ethanol + BF)
1	Ethanol	100% Ethanol
2	Diesel	100% Diesel
3	B100	100% Biodiesel
	B50 (BF)	50% Biodiesel + 50% Diesel
4	E0BF100 (TF)	0% Ethanol+100% BF
5	E4BF96 (TF)	4% Ethanol+96% BF
6	E8BF92 (TF)	8% Ethanol+92% BF
7	E12BF88 (TF)	12% Ethanol+88% BF
8	E16BF84 (TF)	16% Ethanol+84% BF
9	E20BF80 (TF)	20% Ethanol+80% BF

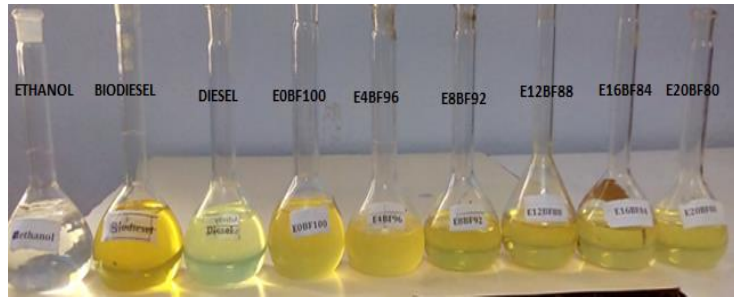

Fig. 8 Samples of all Tested Fuels

Experimentation: Experiments were conducted to study the fuel properties of a three component fuel system comprising Ethanol with Biodiesel and Diesel blend (B50) at different proportions. The palm oil is used to produce biodiesel by transesterification process. The calorific value of the test fuel samples was measured using a bomb calorimeter, the flash point was determined by the ASTMD93 method using a Pensky–Martens closed cup tester and the cetane number was determined using a portable cetane/octane meter. Biodiesel has a higher CN than petro-diesel because of its higher oxygen content. Density was measured by using a pycnometer at room temperature. The Redwood viscosity value is the number of seconds required for 50 ml of oil to flow out of a standard viscometer at a definite temperature. It was established that most of the fuel samples have heating values very close to that of petro-diesel. The measured properties of test fuel are compared on bar diagrams with diesel fuel.

III. Results and Tables

RESULTS AND DISCUSSION

***Density*:** Figure **9** shows variation of density for different test fuels along with ethanol, diesel and biodiesel. It can be observed that density of biodiesel is higher when compared to density of diesel and ethanol. The density of test fuel decreases with increase in percentage of ethanol due to the fact that ethanol has lower density and will lower the density of blend fuel (**B50**). Fuel with higher density is not suitable as it leads resistance to flow. However the results of test fuels at different proportions of ethanol decrease to lower density values which is within acceptable limits and improves the performance of engine. The density of test fuel decreases by 0.54%, 1%, 1.64%, 2.1%, 2.73% as the ethanol percentage increases by 4%, 8%, 12%, 16% and 20% respectively. The lower value of density is desirable for easy flow of fuel through the injection pump and

ISSN : 2277-1581
1 Jan. 2018

nozzle injector for maximum engine power output. Improper mixing of fuel with air contributes to incomplete combustion that leads to low power output.

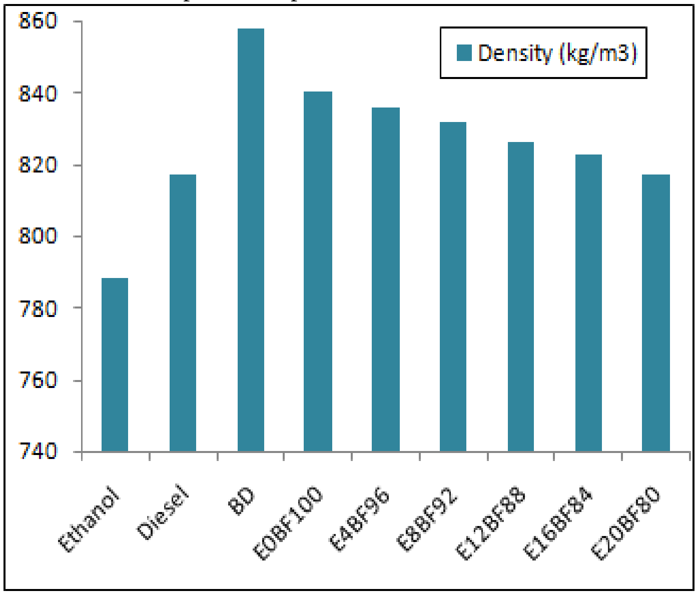

Fig.9. Density values of Ethanol, Diesel, Biodiesel and Test fuel

Kinematic Viscosity**:** The measured viscosity of test fuels is shown in figure **10**. With the percentage of ethanol increase in test fuels the viscosity decreases. This is mainly due to very low viscosity of the ethanol when compared to viscosities of biodiesel and diesel fuel. For the test fuel the maximum of 41% viscosity is decreased with 20% of ethanol in B50 blend fuel. The reduction in viscosity improves fluid flow, atomization of fuel which leads to better combustion for higher output and lower engine emissions.

Calorific Value**:** The calorific values of test fuels are shown in figure **11**. This is one of the important properties as it influence on power output of an engine. The result shows that calorific value of test fuels decreases with increase in ethanol percentage. This is because of lower heating value of ethanol and biodiesel in the test fuel as compared to diesel. The calorific value of blend fuel (B50) decreases to the average of diesel and biodiesel values. With the addition of ethanol in B50 blend fuel the calorific value of test fuels decreases marginally. For the test fuel with 20% of ethanol in blend fuel the maximum of 18.3% decreases as compared to B50. At higher percentage of ethanol the test fuel have better combustion characteristics due lower viscosity and releases total heat energy as work output of the engine.

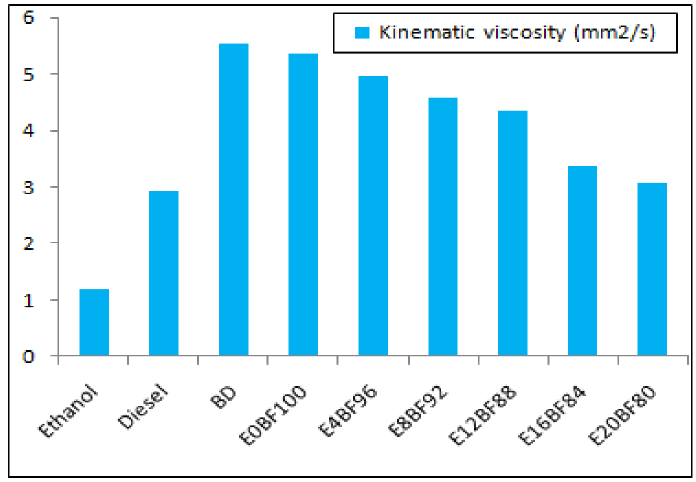

Fig.10. Viscosity values of Ethanol, Diesel, Biodiesel and Test fuel

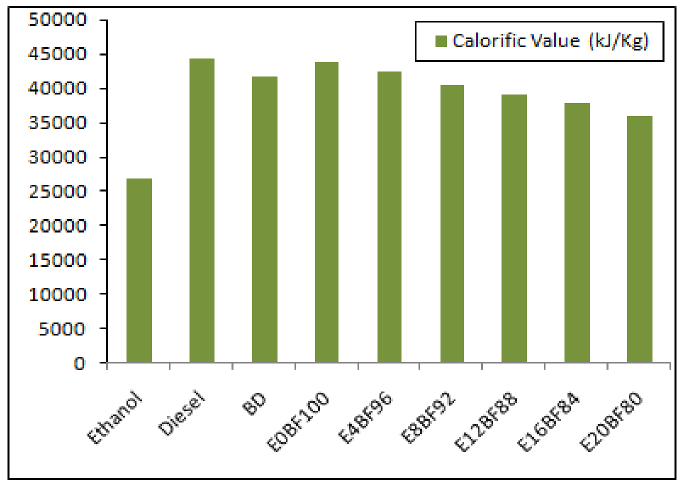

Fig.11. Calorific values of Ethanol, Diesel, Biodiesel and Test fuel

Flash and Fire point**:** Flash and fire points of ethanol, diesel, biodiesel and test fuels are shown in figure **12**. Biodiesels are non volatile due to higher molecular weight. Biodiesels produce sufficient vapours at higher temperatures to form a combustible mixture with air hence flash and fire points of biodiesel are much higher than diesel and ethanol. As the flash and fire points of ethanol are very less when compared to diesel and biodiesel, the flash and fire points of the test fuels decreases with increase in percentage of ethanol in blend fuel. For the test fuel E20BF80 the flash and fire points are 51ºC and 54ºC slightly lower than the flash and fire points of the conventional diesel 57ºC and 63ºC which makes it as a convenient fuel as that of diesel.

Cloud and Pour point**:** The cloud and pour points of ethanol, diesel, biodiesel and test fuels are presented in figure **13**. The cloud and pour points are gradually decreases with increase in percentage of ethanol in test fuel as compared to diesel. The minimum value of cloud point is -5ºC for 20% of ethanol in test fuel E20BF80. The pour point of biodiesel is higher than diesel due to increase in viscosity at reduced temperatures that ceases the oil to flow. However, the presence of ethanol in test fuel affects the pour point. The test fuels with less percentage of ethanol were found to have minimum variations in pour points where as at higher percentages the pour point decreases drastically to -13ºC because of more quantity of ethanol at very low pour points.

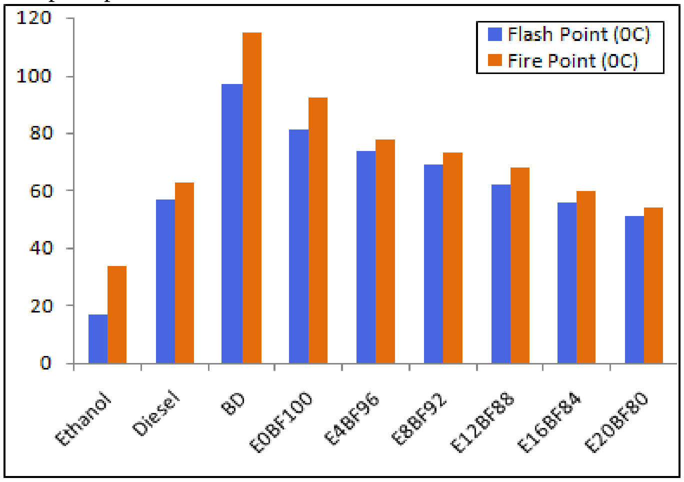

Fig.12. Flash and Fire point values of all Tested fuels

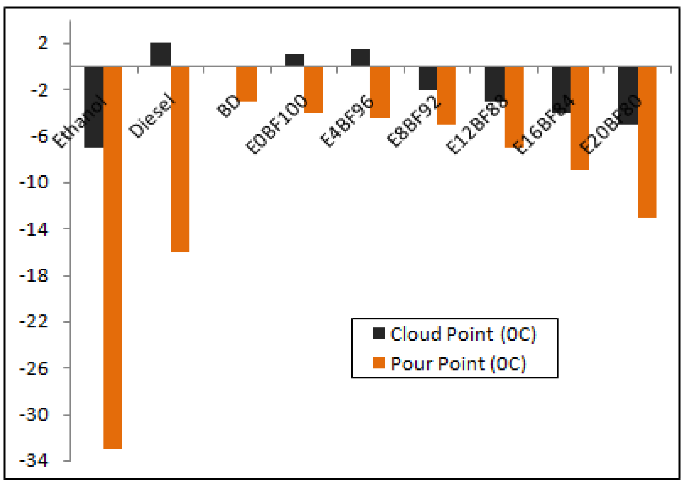

Fig.13. Cloud and pour point values of all Tested fuels

***Cetane Number*:** Biodiesel cetane value is higher when compared to diesel cetane value, but the cetane value of ethanol is very less as shown in figure **14**. Hence the cetane value of test fuel decreases with increase in percentage of ethanol. But the blend fuel B50 cetane value is the average of biodiesel-diesel cetane values. The test fuels containing 0% and 4% of ethanol are having higher cetane values than that of diesel and with 8%, 12%, 16% and 20% of ethanol are having lower cetane values, but within the acceptable limits of standard specifications as 51.4, 49.3, 47.6 and 44.9 respectively. So with higher cetane values better engine performance can be obtained.

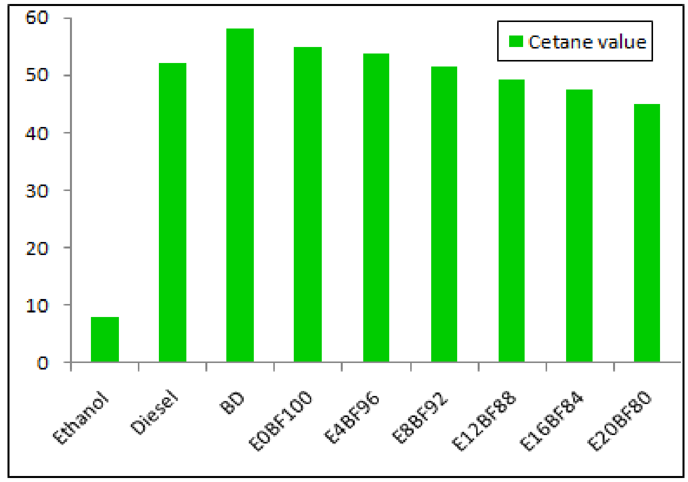

Fig.14. Cetane values of Ethanol, Diesel, Biodiesel and Test fuel

CONCLUSIONS

The following conclusions are drawn from the experiments conducted for the test fuel (B50 and ethanol) stability and properties as compared to diesel fuel.

- The flash and fire points of test fuels are gradually decreasing as the percentage of ethanol increases. At higher percentage of ethanol these values approaches to diesel.
- Viscosity and density of all test fuels were found to be within the standard limits as of diesel.
- Lower cloud points were recorded for all test fuels compared to diesel. The pour point decreases with increase in ethanol percentage and higher than diesel fuel up to 20% of ethanol in test fuel.
- Calorific value of test fuels was lower than diesel, but no significant difference for the test fuel containing less than 4% of ethanol.
- In general as the percentage of ethanol increases in test fuels the values of characteristic parameters are decreasing. At higher percentage of ethanol test fuels are very close to diesel fuel but the calorific value is less than diesel due to a major component of 50% biodiesel contribution in the test fuel.

REFERENCES

i. *Imdat Taymaz, Mehmet C., 2013. Performance and emissions of an engine fuelled with a biodiesel fuel produced from animal fats, Thermal Science, 17, pp. 233-240.*

ii. *Nitin Shrivastava, S. N. Varma, Mukesh Pandey., 2012. An experimental investigation of performance and exhaust emission of a diesel engine fuelled with Jatropha biodiesel and its blends, International Journal of Energy and Environment, 3(6), pp. 915-926.*

iii. *Robert J. Last, Micheal Kruger, Manfred Durnholz., 1995. Emissions and Performance Characteristics of A 4-Stroke, Direct Injected Diesel Engine Fueled With Blends of Biodiesel and Low Sulfer Diesel Fuel, SAE Trans.,950054, pp. 1-13.*

iv. *Michael J. Haas., Karen M. Scott., Teresa L. Alleman., and Robert L. McCormick., 2001. Engine Performance of Biodiesel Fuel Prepared from Soybean Soapstock: A High Quality Renewable Fuel*

Produced from a Waste Feedstock, Energy Fuels, *15 (5), pp. 1207-1212.*

v. *Seung Hyun Yoon., Su Han Park., Chang Sik Lee. 2008. Experimental Investigation on the Fuel Properties of Biodiesel and Its Blends at Various Temperatures, Energy & Fuels, 22(1), pp. 652–656.*

vi. *Venkateswara Rao, P., Prabhakara Chary, D., 2016. Investigation of biodiesel (POME and COME) and acetone blend fuels properties, International Journal of Recent Trends in Engineering and Technology, 2(9), pp. 61-66.*

vii. *Venkateswara Rao, P., 2017. Performance and emission analysis of diesel–biodiesel (kme) blends as fuel in d i diesel engine, International Journal of Current Research, 9(9), pp.57006-57009.*

viii. *Obed M. Ali, Rizalman Mamat, Nik R. Abdullah, and Abdul Adam Abdullah., 2015. Analysis of Blended Fuel Properties and Engine Cyclic Variations with Ethanol Additive, Journal of Biobased Materials and Bioenergy, 9(2), pp. 1– 7.*

ix. *Obed M. Ali, Talal Yusaf, Rizalman Mamat, Nik R. Abdullah,Abdul Adam Abdullah., 2014. Influence of Chemical Blends on Palm Oil Methyl Esters' Cold Flow Properties and Fuel Characteristics, Energies, 7(7), pp. 4364-4380.*

x. *Sarin A., Arora, R., Singh, N. P., Sarin, R., Malhotra, R. K., Kundu, K., 2009. Effect of Blends of Palm, Jatropha, Pongamia Biodiesels on Cloud Point and Pour Point, Energy, 34, pp. 2016-2021.*

xi. *Demirbas, A., 2000. A direct route to the calculation of heating values of liquid fuelsby using their density and viscosity measurements, Energy Convers Manage. 41(15), pp. 1609-1614.*

xii. *Kegl, B., Kegl, M., Pehan, S., 2088. Optimization of a fuel injection system for diesel and biodiesel usage. Energy Fuels, 22, pp. 1046–5417.*

xiii. *Klopfenstein, W. E., 1985. Effect of Molecular Weights of Fatty Acid Esters on Cetane Numbers as Diesel Fuels, Journal of the American Oil Chemists' Society, 62(6), pp. 1029-1031.*

xiv. *Helwani, Z., Othman, M. R., Aziz, N., Kim, J.; Fernando, W. J. N., 2009. Solid heterogeneous catalysts for transesterification of triglycerides with methanol: A review, Applied Catalasis A: General, 363, pp.1–10.*

xv. *Leung, Y. C., Wu X., Leung M K H., 2010. A review on biodiesel production using catalyzed transesterification, Appl Energy, 87, pp. 1083–1095.*

xvi. *Venkateswara Rao, P., and Appa Rao, B. V., 2011., Effect of adding Triacetin additive with Coconut oil methyl ester (COME) in performance and emission characteristics of DI diesel engine, International Journal of Thermal Technologies, 1(1), pp. 100-106.*

xvii. *Venkateswara Rao, P., and Appa Rao, B. V., 2011. Performance, Emission and Cylinder Vibration studies of DI diesel Engine with COME-Triacetin Additive Blends, International Journal of Engineering, Science and Metallurgy, 1(2), pp. 300-309.*

xviii. *Kapilan, N., Mohanan, P., and Reddy, R., 2008. Performance and Emission Studies of Diesel Engine Using Diethyl Ether as Oxygenated Fuel Additive, SAE Technical Paper: 2008-01-2466.*

xix. *Venkateswara Rao, P., and Ramesh, S., 2015. Optimization of Biodiesel production parameters (Pongamia pinnata oil) by transesterification process, Journal of Advanced & Applied Sciences, 3(3), pp. 84-88.*

xx. *Venkateswara Rao, P., and Prabhakara Chary, D., 2017. Experimental study of different biodiesels (COME, MOME, POME) and their blends properties with 2-propanone as an additive, Asian Journal of Science and Technology, 08(10), pp. 6005-6008.*