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Performance Characteristics of a Diesel Engine Using Mahua Biodiesel as Alternate Fuel

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Abstract: The aim of this study is to assess the performance, emission and combustion characteristics of diesel engine using mahua methyl esters. In the present work, mahua methyl esters and its blends with diesel were used as fuel. Various proportions of mahua methyl ester fuel blends (25% and 50%) were used for conducting the performance tests at varying load conditions. Various parameters such as thermal efficiency, specific fuel consumption, emission of carbon dioxide, carbon monoxide, hydrocarbons and oxides of nitrogen gases in exhaust were recorded. The important properties of mahua methyl esters are compared with diesel standards. The test results indicate that the fuel of B25 can be used in diesel engines without any engine modifications.

Key words: Biodiesel · Mahua methyl esters · Performance · Emission · Combustion

INTRODUCTION

The transport sector plays a major role in the economic development of the country. The motor vehicle population in India is about 80 million and has also increased tremendously over the last decade; which has further pushed demand for eco-friendly fuels. The various alternative fuel technologies discussed are that they provide reduced emissions.

It was in the focal point of 20th century that bio derivative diesel was regarded once more as a potential fuel alternative, as a biodiesel technology known as transesterification was introduced [1]. The methyl esters of oils of 26 varieties were found most appropriate for use as biodiesel [2]. Considering the special effects of methanol fraction, acid concentration and response time to decrease free fatty acid and the period of pretreatment biodiesel fuel with mahua oil is prepared [3]. Nuclear magnetic resonance test can be done to establish the biodiesel alteration [4].

Biodiesel is an esterified version of vegetable oil. This could be edible or non-edible oils. Oils having high free fatty acids (FFA) need a different treatment from that of low FFA oils. High viscosity and FFA and Gum cause clogging and injector nozzle plugging. High FFA results in corroding engine parts, increases viscosity and tends to increase deposit [5].

Blending of vegetable oils with diesel fuel would resolve such troubles of diesel engine [6] and results in low CO, HC and smoke emission and higher thermal efficiency [7]. Biodiesel is eco friendly and renewable in nature. Numerous researchers carried out with dissimilar types of non edible oils in their customized and clean forms [8-11].

In the present investigation, B25 and B50 blends were used as fuel and the performance was compared with diesel.

Transesterification: The mahua oil used for biodiesel production must be moisture free because each molecule of water destroys the active sites of catalyst; thus; decreasing its concentration. The FFA content of the oil is supposed to be less than 1% when methanol was used; Potassium hydroxide was used as the catalyst for transesterification. This procedure has been generally used to decrease the viscosity of triglycerides. The reaction is conducted at temperature close to the boiling point of methanol, 60-70°C, at atmospheric pressure. The mahua oil chemically reacted with alcohol in the presence of a catalyst to produce methyl esters. After completing the process, they were separated in the separating flask under gravity.

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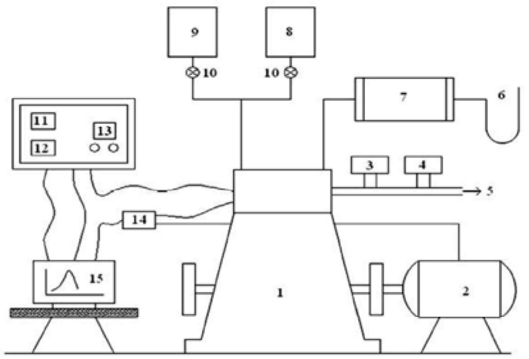
Table 1: Properties of mahua oil, mahua methyl esters and its blends

Fuel	Viscosity mm^2/s at 40°C	Calorific value MJ/kg	Density kg/m^3 at 40°C	Flash point °C
B50	3.88	40	855	94
B25	3.84	41.4	843	90
Diesel	3.8	42.8	830	58
Mahua oil	18.4	36.1	918	207

Table 2: Engine specifications

Make and model	Kirloskar, TV-I
Bore	87.5 mm
Stroke	110 mm
Cylinder diameter	0.0875 m
Stroke length	0.11 m
Compression ratio	17.5:1
Orifice diameter	0.02 m
Power	5.2 kW
Rated speed	1500 rpm
Injection pressure	220 kgf/cm^2
Injection timing	23° before TDC



1. Engine
2. Eddy Current Dynamo Meter
3. AVL Smoke Meter
4. AVL Dia-Gas Analyses
5. Exhaust Gas
6. U Tube Mano Meter
7. Air box
8. Diesel Tank
9. Bio Diesel Tank
10. Control Valve
11. Load Indicator
12. Temperature Indicator
13. Speed Indicator
14. Charger Amplifier
15. Monitor

Fig. 1: Experimental setup

Experimental Setup: Figure 1 shows the experimental setup. A stationary diesel engine is used in this experiment. The engine specifications are shown in Table 2.

The engine was started with diesel fuel and when the engine reached the operating temperature, it was loaded using an electrical dynamometer. After equilibrium state is reached, the speed, fuel consumption and manometer head were noted. Then the blends of biodiesel and diesel were used in different proportions such as B25 (25% biodiesel) and B50 (50% biodiesel). The same procedure was repeated for blended biodiesel. The emission values were also recorded.

RESULTS AND DISCUSSION

Figure 2 shows the brake power having an increasing trend. There is an increase in brake thermal efficiency of the diesel with fuel blends of mahua biodiesel. The mahua B50 gives higher brake thermal efficiency than the diesel fuel at all load conditions. At full load condition the brake thermal efficiency of the biodiesel blend B25 is lower than that of standard diesel. The brake thermal efficiency depends upon the combustion quality of the fuel. The mahua methyl ester blends give better combustion quality than that of diesel.

The specific fuel consumption depends upon the mass flow rate of hydrogen. The mass flow rate of hydrogen is low for biodiesel where as for diesel, it is slightly high. So it leads to increase in specific fuel consumption. At low load condition the specific fuel consumption of fuel blends B25 is lower than that of diesel. At full load condition the specific fuel consumption of the fuel blends B25 and B50 is higher than the diesel fuel. It is also observed that specific fuel consumption decreases with the increase of injection pressure.

The exhaust gas temperatures of mahua B25 and B50 blends are lower than that of diesel fuel due to the lower heating value of the blend. The higher viscosities of

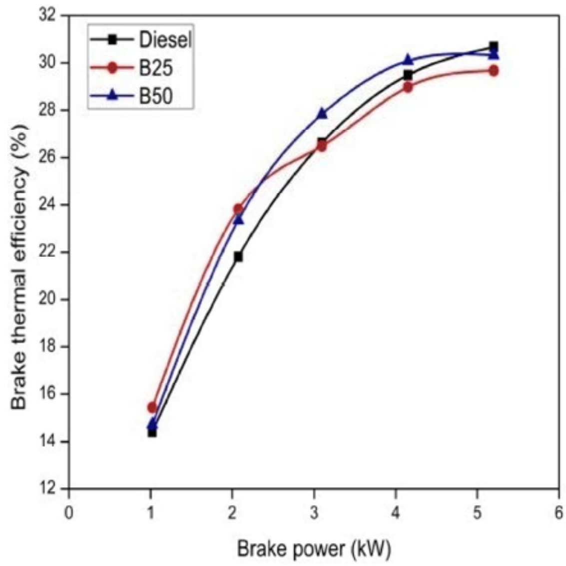


Fig. 2: Brake thermal efficiency Vs brake power

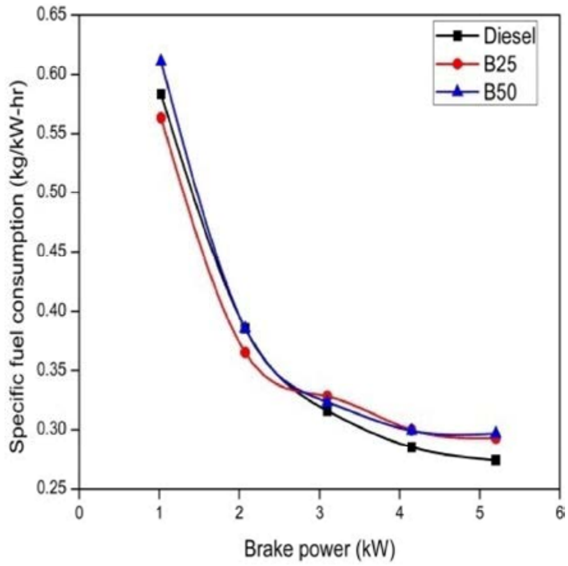


Fig. 3: Specific fuel consumption Vs brake power

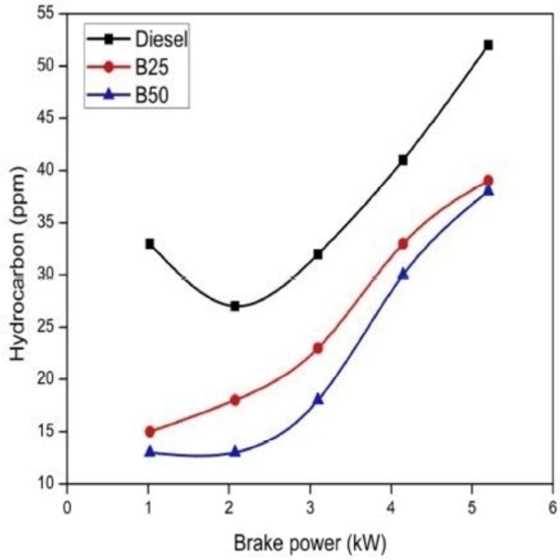


Fig. 5: Hydro carbon Vs brake power

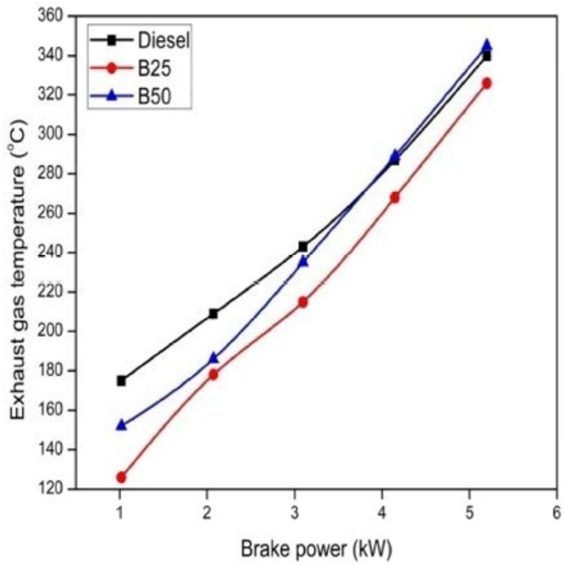


Fig. 4: Exhaust gas temperature Vs brake power

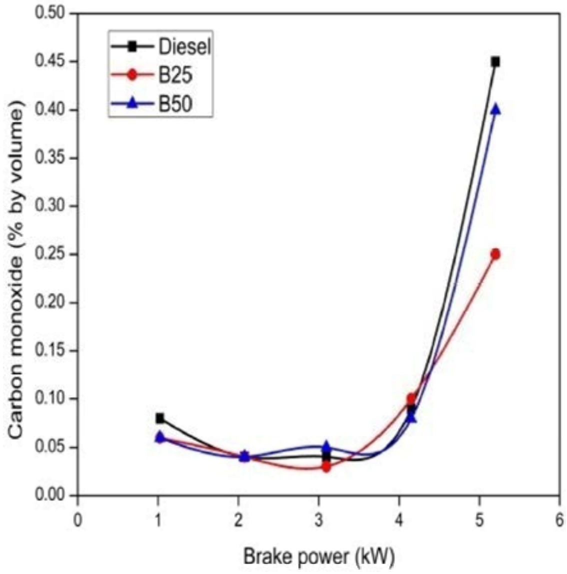


Fig. 6: Carbon monoxide Vs brake power

mahua oil compared with standard diesel fuel have adverse effects on combustion. These factors also cause to produce low exhaust temperature. At high load condition the biodiesel blend B50, exhaust gas temperature is similar to the diesel fuel.

The biodiesel blends have more oxygen content than that of standard diesel. So it involves in complete combustion process. The hydrocarbon emissions of the biodiesel blends are lower than the standard diesel due to complete combustion process. When percentage of blends of biodiesel increases, hydrocarbon decreases. It can be due to improved combustion because of increased injection pressure and advanced injection timing. The figure clearly shows that the biodiesel B50 gives lower hydrocarbon emissions than that of the other designed fuels.

The carbon monoxide emission depends upon the oxygen content and cetane number of the fuel. The biodiesel has more oxygen content than the diesel fuel. So the biodiesel blends are involved in complete combustion process. The maximum carbon monoxide emission was observed at full brake power of the engine.

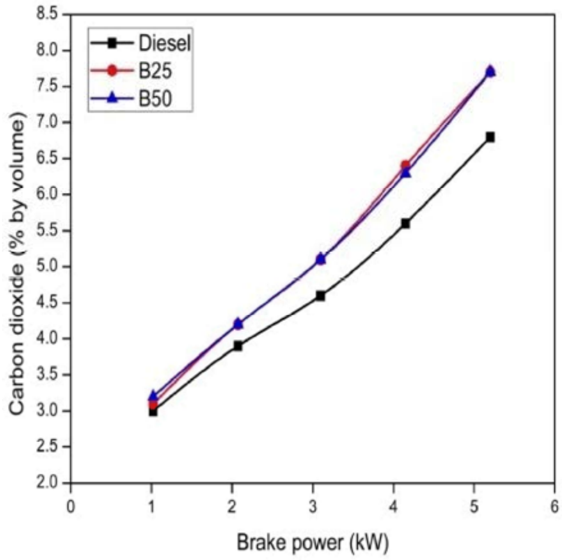


Fig. 7: Carbon dioxide Vs brake power

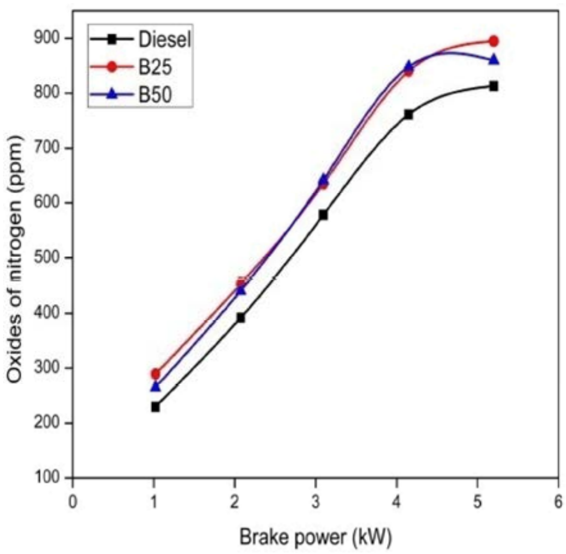


Fig. 8: Oxides of nitrogen Vs brake power

So as to conclude that the fuel blends of B50 give low carbon monoxide emission than other fuels at all load conditions.

The carbon dioxide emission depends upon the complete combustion of the fuel. The biodiesel blends have the 11.5% oxygen content, resulting in complete combustion. Due to the complete combustion of the biodiesel blends, carbon dioxide emission also increases. The carbon dioxide emission using diesel fuel is lower because of the incomplete combustion. The combustion of biodiesel also produced more carbon dioxide but crops are focused to readily absorb carbon dioxide and hence these levels are kept in balance.

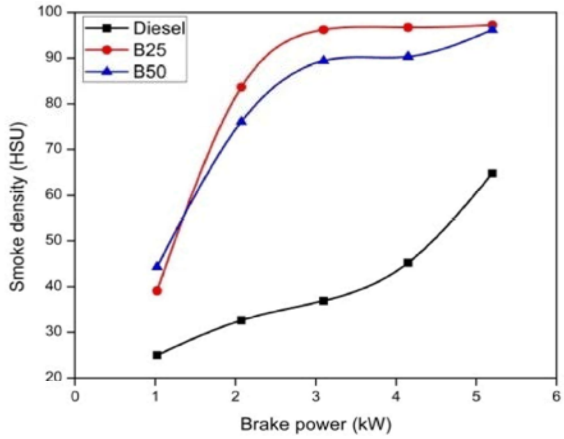


Fig. 9: Smoke density Vs brake power

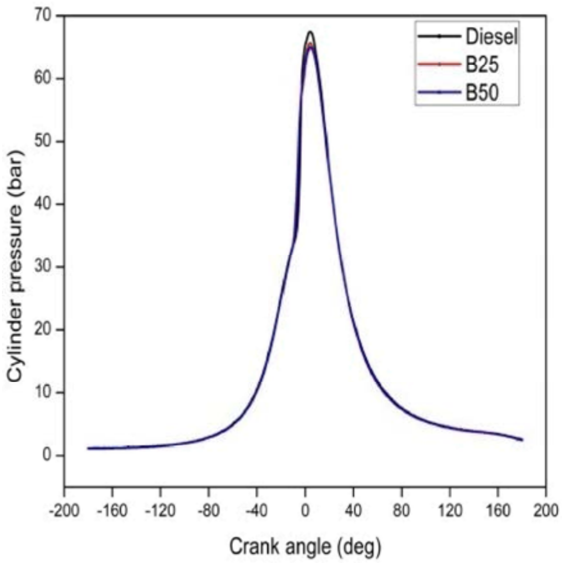


Fig. 10: Cylinder pressure Vs crank angle

No_x emissions depend up on the oxygen concentration and the combustion time. At all loads conditions NO_x emission of biodiesel blends is always higher than that of standard diesel due to the oxygen concentration and combustion timing. The cetane numbers of the biodiesel blends are lower than that of standard diesel. This causes increase in the NO_x emission of the biodiesel blends. The shorter ignition delay could be a reason of increased NO_x emission. Reduction of NO_x emission is possible with the proper adjustment of injection timing.

At all load conditions the smoke density of the biodiesel blends were always higher than that of diesel fuel. The smoke density increases due to insufficient combustion and higher ignition delay. The biodiesel blend has high viscosity, larger fuel droplet sizes and decrease

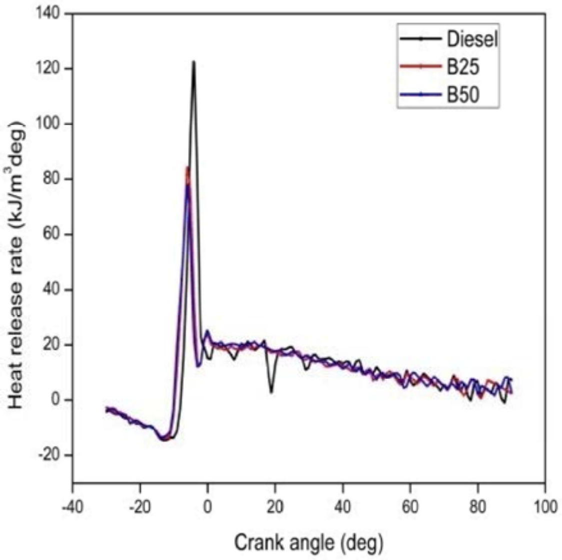


Fig. 11: Heat release rate Vs crank angle

in fuel air mixing rate. These are the factors involved to increase the smoke density of biodiesel blends. The fuel blend B25 gives high smoke emission than all the other used fuels.

Peak pressure for diesel was 67.5 bar. The peak pressure of fuel blends B25 and B50 is lower than that of standard diesel. At the time of injection, biodiesel has less air fuel mixture for combustion. The peak pressure depends upon the premixed combustion phase. Due to the premixed combustion phase of burning, lower pressure was obtained for mahua biodiesel blends. The cylinder pressure decreases as the proportion of methyl ester blends increases. So for the biodiesel blends, cylinder pressure is lower than the standard diesel.

The premixed heat release of mahua methyl ester blend is lower than that of diesel, because of the lower calorific value of the methyl ester blends. The heat release rate curve shows the potential availability of heat energy, which can be converted into useful work. The maximum heat release rate is obtained of mahua methyl ester blend due to the shorter delay period (-5.2° for ester and-1.5° for diesel). The heat release rate of B25 blend is higher than the B50 blend due to reduced viscosity and better spray formation. The high viscosity of fuel leads to reduction in air fuel mixing rate. So the biodiesel blends produced less heat release rate compared to diesel.

CONCLUSION

The combustion and emission characteristics of single cylinder compression ignition engine fuelled with mahua biodiesel and its blends have been analyzed and compared to the standard diesel fuel. Based on the experimental results, the following conclusions are obtained.

- The brake thermal efficiency of mahua biodiesel blends is higher than that of diesel at all load conditions. At low load condition, the specific fuel consumption of mahua B25 was low when compared to diesel unlike all other blends.
- CO_2 emissions were almost similar to the diesel.
- The smoke density and NO_x of biodiesel blends were always higher than the standard diesel. The HC and CO emissions at different loads were found to be higher for diesel compared to mahua B25 and B50 blends.
- The waste-lands may be utilized for cultivation of the trees to give green cover. This is a renewable source of energy. The pollution from engines using the biodiesel blend is a less, reducing the carbon output.
- The trees absorb CO_2 from the atmosphere. Being agricultural labour concentrated, the scheme provides additional opportunities for employment hence employment generation mainly in developing countries.

REFERENCES

1. Fukuda, H., A Kondo and H. Noda, 2001. Journal of Bioscience and Bioengineering, 91: 405-416
2. Mohibbe Azam, Amtul and N.M. Nahar, 2005. Prospects and potential of fatty acid methyl esters of some non-traditional seed oils for used as biodiesel in India, Journal of Biomass and Bioenergy, 29: 293-302.
3. Shashikant, V.G. and Hifjur Raheman, 2005. Biodiesel production from mahua oil having high free fatty acids, Journal of Biomass Bioenergy, 28: 601-605.
4. Kapilan, N. and R.P. Reddy, 2008. Evaluation of methyl esters of mahua oil (Madhuca Indica) as Diesel Fuel, Journal of American Oil Chemists' Society, 85(2): 185-188.
5. Kratzeisen, M. and J. Muller, 2010. Influence of free fatty acid content of coconut oil on deposit and performance of plant oil pressure stoves, Fuel, 89: 1583-1589.
6. Ramadhas, A.S., S. Jayaraj and C. Muraleedharan, 2004. Use of vegetable oils as I.C. engine fuels-a review, Renewable energy, 29(5): 721-742.

7. Kapilan, N., T.P. Ashok Babu and R.P. Reddy, 2009. Characterization and Effect of Using Mahua Oil Biodiesel as Fuel in Compression Ignition Engine. Journal of Thermal Science, 18(4): 382-384.
8. Ghosh, M. and D.K. Bhattacharyya, 1998. Enzymatic Preparation of Polyethylene Glycol Esters of Castor Oil Fatty Acids and Their Surface-Active Properties, Journal of Surfactants and Detergents, 1(4): 503-505.
9. Eugeniusz Milchert and Anna Smagowicz, 2009. The Influence of Reaction Parameters on the Epoxidation of Rapeseed Oil with Peracetic Acid, Journal of American Oil Chemists' Society, 86: 1227-1233.
10. Umesha Shankar Shetty, Yella Reddy Sunki Reddy and Sakina Khatoon, 2011. Plastic fats from sal, mango and palm oil by lipase catalyzed interesterification, Journal of Food Science and Technology, online 24 August 2011.
11. Haiter Lenin, A., C.R. Berlin Selva Rex, K. Thyagarajan and M.S. Senthil Saravanan, 2012. Experimental Investigations on a Diesel Engine using Blends of Methyl Esters of Pongamia Oil as the Fuels, European Journal of Scientific Research, 72(2): 273-284.