Performance & Emission Analysis of Mahua Biodiesel Blends with Diesel Oil using Single Cylinder Diesel Engine

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Abstract— Nowadays world is facing fuel problems due to increasing automobiles, power plant and industries, increasing of these results in production of more emission like CO, HC and NOX. This Situation leads to seek an alternative fuel for diesel engine. Biodiesel is found as an alternative fuel for diesel engine .The ester of vegetable oil and animal fat are known as bio diesel. This paper investigates the prospect of making bio diesel from Mahua oil. Madhuca Indica is renewable and non edible plant. Madhuca indica trees are seen more in tribal areas. It is a fast-growing tree that possesses evergreen or semi-evergreen foliage. Mahua bio diesel is an oxygenated fuel; it has more oxygen and can be used in diesel engine without any modification. In present work the emission characteristics of Mahua biodiesel the blends of Mahua methyl ester and diesel in the proportion B10, B25, B50, B75 and B100 are prepared analysed and their performance and emissions characteristics are compared with the performance and emission characteristics of diesel and the emissions like CO, HC, NOX and CO2 are obtained. The results are compared with pure diesel.

Key words: biodiesel, Mahua, Madhuca Indica, diesel, free fatty acids

I. INTRODUCTION

Biodiesel is a methyl ester of fatty acid derived by using a range of organic sources of oils. [1] Biodiesel is a renewable fuel, biodegradable and non toxic. Biodiesel can be produced from vegetable oil, used cooking oil or animal fat. Mahua or Hippe is a medium to large tree with round canopy; Madhuca indica (Madhuca longiofolia) trees are seen more in tribal areas. It is a fast-growing tree that possesses evergreen or semi-evergreen foliage, and belongs to the family Sapotaceae. Mahua tree gives 20-200 kg seeds per Annum. Mahua seed contain 30-40% fatty oil. The following figure shows the plant and seeds of Mahua.

Fig. 1.1: Mahua tree and seeds

The fully growing waste land and dry land, the Mahua tree reach a tallness of up to 20 m and is fit for all weather condition. The Mahua trees have scattering branches and rounded top head which have an attractive construction look. Mahua tree have a bulky scattering root structure. The Mahua fruits look like a berry, egg form. The grown seeds can be obtained in the period of June to July. The Mahua tree begins to gives seeds after planting seventh year.

II. MATERIALS AND METHODS

The Mahua bio-diesel be prepared by using three march transesterification processes because of their FFA level is more than 1%. In the first march, esterification result is carried out by adding up 15 ml CH3OH to 100 ml Mahua oil and 0.5ml H2SO4. This reaction is carried at temperature range between 50^0c to 60^0c with reaction period of 60 minutes. In the second march 8ml methanol is added to the sample obtained from first march with 0.5 ml sulfuric acid with reaction instance of 60 minutes and the temperature range 50^0c to 60^0c. In third march transesterification retort was completed by adding 15ml of CH3OH to the trial gets from earlier march and 0.5gms of sodium hydroxide with retort instant of 60 minutes and temperature is 560c to 650c. Mahua bio-diesel blends were arranged by mixing B10, B25, B50, B75 and B100 respective bio-diesel with diesel oil on volume basis.

III. EXPERIMENTAL SETUP

The engine performance and emission were conducted on single cylinder diesel engine. First the engine was run with diesel and readings were recorded and then the biodiesel blends with diesel in different parameters like B10, B25, B50, B75, B100 was used and readings were recorded.

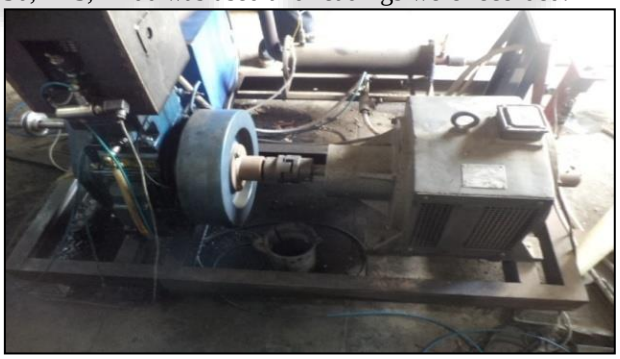

Fig. 3.1: Kirloskar single cylinder 4-stroke engine

Made	Kirloskar
Cycles used	Diesel
Number of strokes	4
Number of cylinder	1
Bore diameter	80 mm
Stroke	100 mm
Cooling system	Water cooled
Lubrication	Forced method
Output	3.675 kW at 1500 rpm
Dynamometer	D.C Generator
Armature	Shunt
Voltage	220 V
Rated BP	3.675 Kw
Air box orifice diameter	25 mm
Current	13 A

Table 3.1: Engine Specification

IV. RESULTS AND DISCUSSION

A. Properties of Mahua and their blends:

1) Result of viscocity

Viscosity is a flowing property of a fuel. Because it measure the flow behavior when a fuel flows in injector, and orifices. Figure 4.1 shows viscosity of Mahua oil, Diesel oil, B10, B25, B50, B75, and B100.

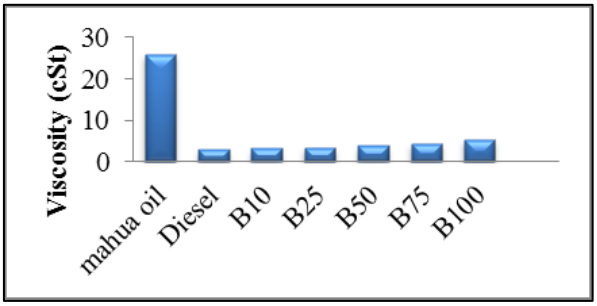

Fig. 4.1: viscosities of Mahua oil, biodiesel and its blends

Viscosity of B25 was observed 3.5 cSt which is 1.12 times higher than diesel oil; Mahua oil has highest viscosity 26 cSt at 40^0C which is 8.38 times more than diesel oil. Viscosity of Mahua oil is more than all other samples which is 4.72 times more than B100 (5.5 cSt). Figure 4.1 also shows that, biodiesel, diesel oil has lower viscosity than Mahua oil because of biodiesel and diesel oil thickness is small. The Figure shows the viscosity is increases with the percentage biodiesel blends.

2) Result of specific gravity

The specific gravity of Mahua oil, diesel oil and B10, B25, B50, B75 and B100 is shown in figure 4.2:

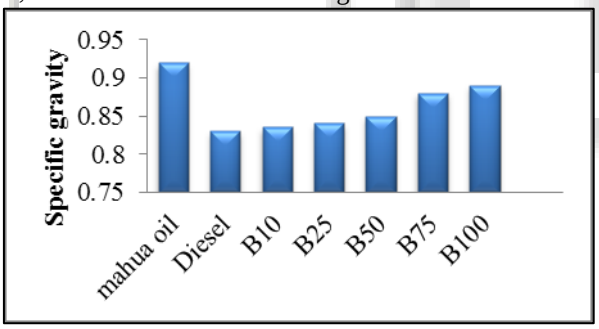

Fig. 4.2: Specific gravities of Mahua oil, diesel, mahua biodiesel and their blends.

Mahua oil has more specific gravity 0.920 which is reduced to 0.890 after transesterification. Specific gravity of B25 is very close to the diesel oil which is 1.012 times higher than diesel oil. B100 has s g of 0.890 which is 1.072 times more than that diesel oil. Specific gravity increases by increasing the percentage of biodiesel blends.

3) Result of Flash Point

Flash point of B10 is 70^0C. Flash point of B25 is 74^0C. Figure 4.3 shows the B100 flash point is more compare to all blends and diesel but lower than Mahua oil.

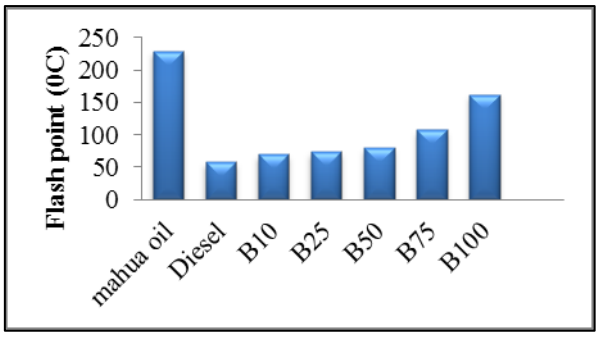

Fig. 4.3: Flash points of Mahua oil, diesel and biodiesel blends.

4) Result of Fire Point

Fire point of B10 is 77^0C. Fire point of B25 is 80^0C. Figure 4.4 shows the fire point increases when increase in proportion of methyl ester in the blends.

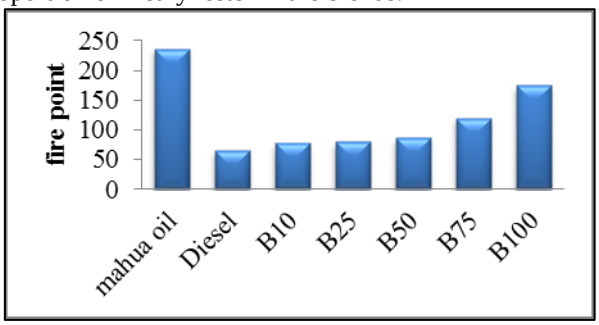

Fig. 4.4: Fire points of Mahua oil, diesel and biodiesel blends.

5) Result of heating value

Figure 4.5 indicates Mahua oil has heating value of 37.2 MJ/kg it is 1.16% lesser than the diesel oil. B100 has the heating value of 39.8 MJ/kg it is 1.09% lesser than diesel oil. B25 has the heating value of 42.1 MJ/kg it is 1.03% lesser than the diesel oil. B10 has the heating value 42.6 MJ/kg very close to diesel.

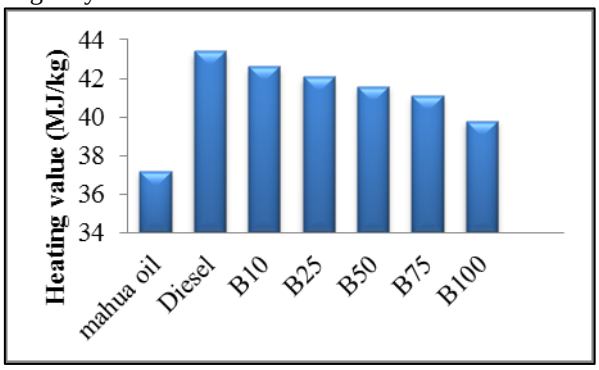

Fig. 4.5: Heating values of Mahua oil, biodiesel blends and pure diesel.

The lower heating value could attribute to the presence of few hydrogen atoms and large quantity of oxygen atoms in the molecules. The lower heating value of biodiesel and its blends gives result in loss of thermal efficiency as compared to diesel oil.

B. Engine Performance

The results on Engine performance gives the result of Brake power on the mainly SFC, BTE, Mechanical Efficiency, and on various emissions.

1) Result of BP on SFC

Above figure indicates that with increases in the Brake power on the engine SFC has decreased. It is observed that Mahua biodiesel blends B10, B25 have specific fuel consumption close to diesel. SFC increased by increases proportion of biodiesel blends. SFC for B100 is more than all blends because when load is increases with increasing fuel consumption, diesel is less fuel consumption than the all blends.

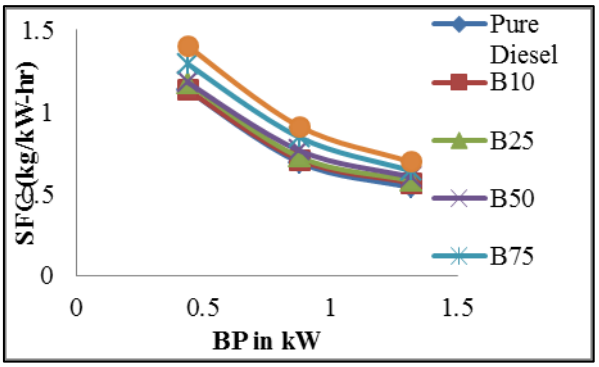

Fig. 4.6: Variation of BP with SFC

2) Result of BP on BTE

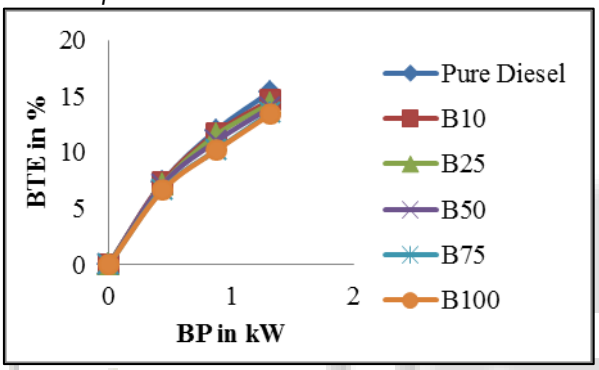

Fig. 4.7: Variation of BP with BTE

From figure 4.7 it is clear that the B10 has near to thermal efficiency as diesel. B10 curve almost nearer to the diesel line. The obtained result shows that BTE increases with increases BP for all blends of methyl ester and diesel.

3) Result of BP on Mechanical Efficiency

The obtained results show that mechanical efficiency increases by increasing BP for all blends of biodiesel and diesel.

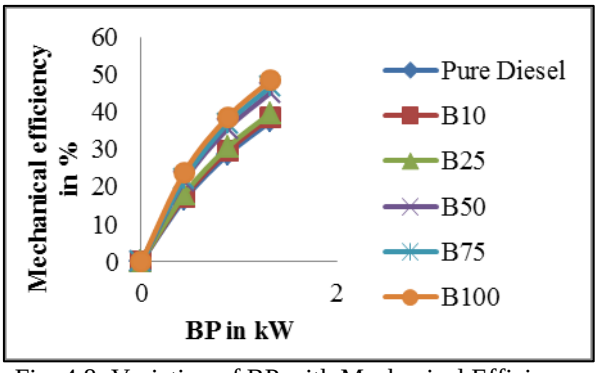

Fig. 4.8: Variation of BP with Mechanical Efficiency

From analyzing graph it shows that Mechanical efficiency of B100 is more than the all blends and diesel. B10 and B25 mechanical efficiency is very close with the diesel are shown in figure.

4) Effect of BP on CO emissions

The amount of air sucked for each cycle is nearly constant and irrespective of load so initially at no load, amount of fuel is less and sufficient excess air results in whole burning of fuel therefore reduction in CO is seen.

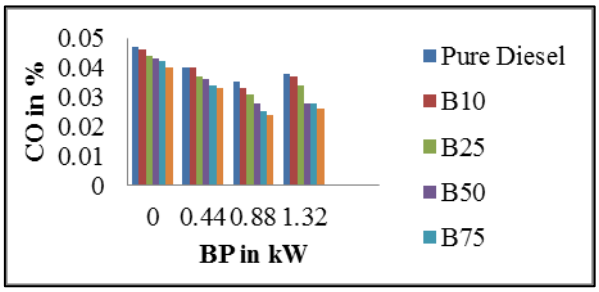

Fig. 4.9: Variation of BP with CO emission

By increase in load the excess air available and in turn air fuel ratio inside cylinder decreases. This will result in higher CO emission. Diesel oil is maximum CO emission than all other blends.

5) Effect of BP on CO_2 emission

Figure 4.10 shows the variation of CO2 emission with BP when engine runs on B10, B25, B50, B75, B100 and diesel.

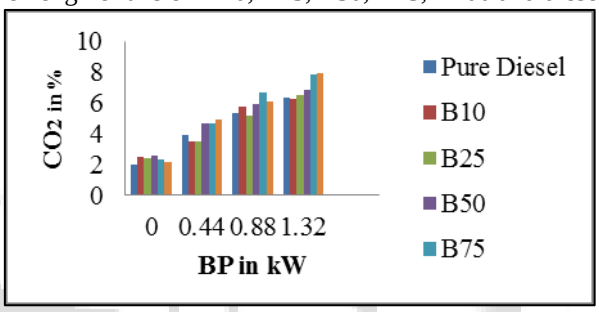

Fig. 4.10: variation of BP with CO_2 emissions

The carbon dioxide is gradually increases with increasing the load for all blends. The lower percentage of Mahua methyl ester blends emits less quantity of CO2 than diesel.

6) Effect of BP on HC emission (Unburned)

The Variation of BP with HC emission while CI engine runs on B10, B25, B50, B75, B100 and diesel is shown in figure 4.11

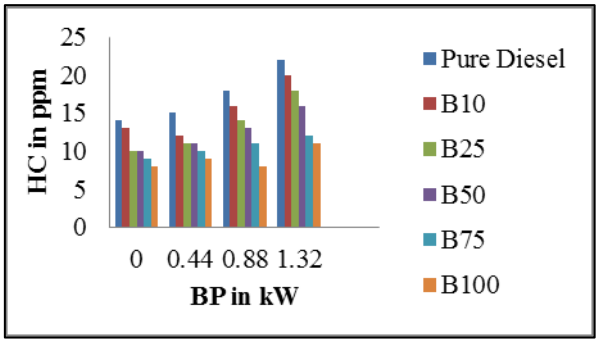

Fig. 4.11: Variation of BP with HC emission

It shows that HC emission increases by increasing of BP and decreases by increasing proportion of biodiesel.

7) Effect of BP on NO_x emissions

The variation of BP with NOx emission when diesel engine runs on B10, B25, B50, B75, B100 and diesel is shown in figure 4.12. And also show that NOx emission increases by increasing proportion of methyl ester.

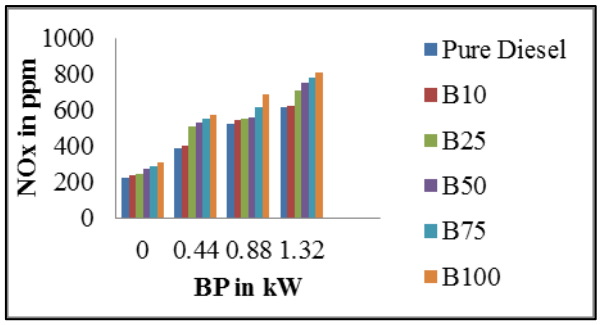

Fig. 4.12: Variation of BP with NO_x emissions

The primary reason of higher NOx emission of Mahua oil biodiesel fuel is contributed towards inbuilt oxygen. B10, B25 fuel shows lower NOx emission compared to B100.

V. Conclusion

The main aim of this experimental work was to study the effect of using various blends of bio-fuel and pure diesel on performance of normal single cylinder diesel engine. The blends tested where 10%, 25%, 50%, 75%and 100%. Bio-Diesel in pure diesel is a successful use as an alternative fuel.

- Mahua oil can be successfully transformed into biodiesel by the transesterification method.
- Transesterification process reduces viscosity of the Mahua oil and it improves the properties such as viscosity, flash point, fire point of the Mahua methyl ester.
- Smooth running of engine is observed with esterified Mahua oil compared with that of diesel.
- Brake thermal efficiency of B25 is closer to diesel.
- Specific fuel consumption of B10, B25 is close with the diesel.
- Minimum emission of CO compare with diesel.
- Highest HC emissions for diesel, B10 at no load, B100 has minimum HC emission at all loads.
- From this study it is conclude that the B10, B25 gives optimum performance where B100 gives the lower emission of HC and CO.
- Present experimental work shows the Mahua methyl ester give the good engine performance and less emission.
- Finally concluding B25 can be used as workable alternative fuel to operate single cylinder diesel engine with injection pressure of 180 bars.

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