Performance and Emission Analysis of Compression Ignition Diesel Engine With Diesel Additives and Mahua Biodiesel

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Abstract*— The insufficiency of conservative fossil fuel, their increasing cost and the detrimental effects of combustion engendered pollutants seems to make alternative birthplaces more alluring. Mahua is non-comestible in nature and is available abundantly. The present experiment assesses the performance and emission distinctive of a diesel engine using dissimilar blends of mahua biodiesel, 2-EHN and ethanol with mineral diesel. Biodiesel and diesel additive was blended with diesel in proportions of 20%, 100% by mass and studied under various load conditions. The performance and emission parameters were found to be better than the mineral diesel. The brake thermal efficiency and brake specific fuel consumption were better than mineral diesel for various precise blends. The emission characteristics were also deliberated and volume of exhaust gas temperature and unborn hydrocarbon were found to be lesser than pure diesel.

Keywords*— Mahua Biodiesel; Transesterification; A1-2Ethylhexyle Nitrate, A2-Ethanol; B100-Bio diesel; D100-Pure diesel; BL 1-B10 A1(10) D80; BL 2-B10 A2(10) D80; BL 3-B10 A1(5) A2(5) D80; BL 4- B20 D80

I. INTRODUCTION

Environmental contamination and depletion in fossil fuel resources forced scientists and engineers to concentrate investigation on renewable alternative to conventional fossil fuel. An immense deal of explorations work mainly on diesel engines has taken place not only in the design are but also in penetrating an alternative fuel [1-4]. Many researchers have concluded that biodiesel holds pledge as an alternative fuel. At present biodiesel produced mainly from meadow crop oils like rape seed, sun flower etc. We can see the various properties shown in the table 1 with comparing pure diesel. Transestrification, also called alcholysis, is the displacement of one alcohol from an ester by another alcohol in a process similar to hydrolysis. ***RCOOR'+R''OH→ RCOOR'' +R''OH.*** Triglycerides are readily trans-esterified in the presence of alkaline catalyst at atmospheric pressure and at a temperature of approximately 60^0 to 70^0 [4-5]. Automobile sector contributes a significant amount of carbon dioxide, one of the principal greenhouse gasses. [6]

II. MATERIALS AND METHODS

1. Biodiesel properties

Table 1

Fuel properties of crude mahua oil, mahua biodiesel and pure diesel

Properties	*CMO*	*D100*	*B100*
Density at 15^0C (kg/m^3)	960	851	881
Viscosity at 40^0C (mm^2/s)	24.5	2.59	3.96
Calorific value (MJ/kg)	36	42.1	36.7
Acidic value (mg KOH/g)	38.1	-	0.41
Flash Point(^{0}C)	231	67	208
Pour Point(^{0}C)	15	-20	5
Water content (%)	1.43	0.02	0.05
Ash content (%)	0.89	0.01	0.01
Carbon residue (%)	3.72	0.18	0.20

2. Diesel additive properties

Table 2

Properties of 2-EHN, Ethanol

Properties	*2-EHN*	*Ethanol*
Molecular weight (g/mol)	175.23	46.06
Flash point (^{0}C)	36	9
Freezing point(^{0}C)	-45	-114
Boiling point(^{0}C)	79.48	78.37
Auto ignition temperature(^{0}C)	130	425
Density (kg/m3)	960	480

3. Experimental setup and procedure

The engine was used for experimental work consist of single cylinder, four stroke, diesel engine which connected to eddy current type dynamometer. The Rota-meter provided flow of water measurement purpose. The provision available to provide different load (3 kg, 6kg, 9Kg and 12 kg) on the engine, leading to load ranging like 0% 25% and ending up at 100% (Fig.1). A five gas analyzer was used for the measurement of carbon monoxide (CO), nitric oxide (NO), carbon dioxide (CO_2) which was measured as ppm, fitted at the exhaust, by this arrangement we can get the emission characteristics [6-9] (Fig.2). A burette which is made from glass is provided for fuel measurement biodiesel and diesel separately, a stop watch is also used and then we could calculate the bsfc[11-13]. The experiment was started at a rated speed of 1500 rpm. No adjustment was made at the fuel injection timing; 23° BTDC was used for diesel and mahua biodiesel, respectively. [9-11] The experiment was conducted by using D100, B20 A1(5) A2(5) D70, B20 A1(10) D70, B20 A2(10)D70, B20 B80 and B100, at different load conditions on the engine from 0% to 100% in appropriate steps at compression ratios (CR) of 17.5:1.

The performance test was carried out on a single cylinder DI diesel engine using high speed diesel, methyl ester of mahua oil, diesel additives (2-EHN, Ethanol) and their blends with diesel by ENGINE SOFT by Apex Innovations pvt ltd (Fig.1). The engine exhaust gas was analyzed and calculated by TESTO 350 gas analyzer (Fig.2). [8-12]

Figure 1

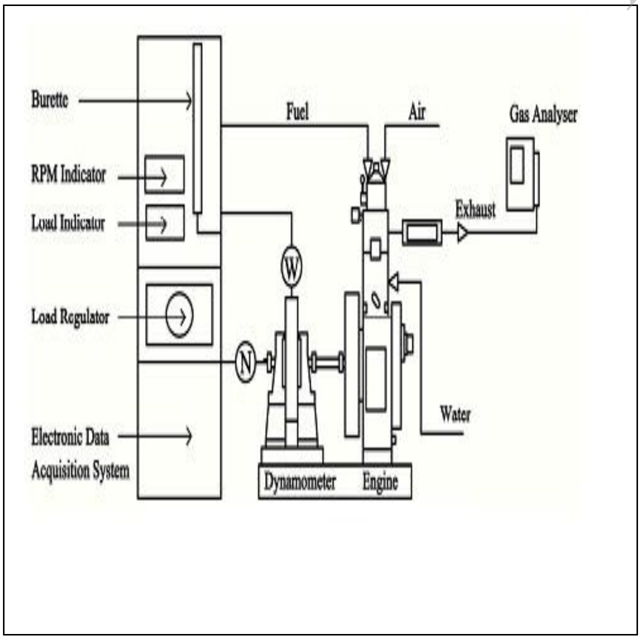

Fig.1 Experimental setup

Figure 2

Fig.2 Gas analyzer

III. RESULTS

1. Performance analysis

A. Brake thermal efficiency (BTE)

The BTE of direct injection diesel engine obtain for different blends shown in figure.3 as a function of load for compression ratio is 18.1. It can be seen from this figure that BTE in general, increasing with increasing in load.

The variations in BTE between various loads of blends at full load conditions were more than those at parts loads. The BTE of BL 1 was about 3% more than that of pure diesel (D100) for BL 2 it was like 1.6 %. For BL 4 and BL 100 it was like 2%, 5% more as compared to D100.

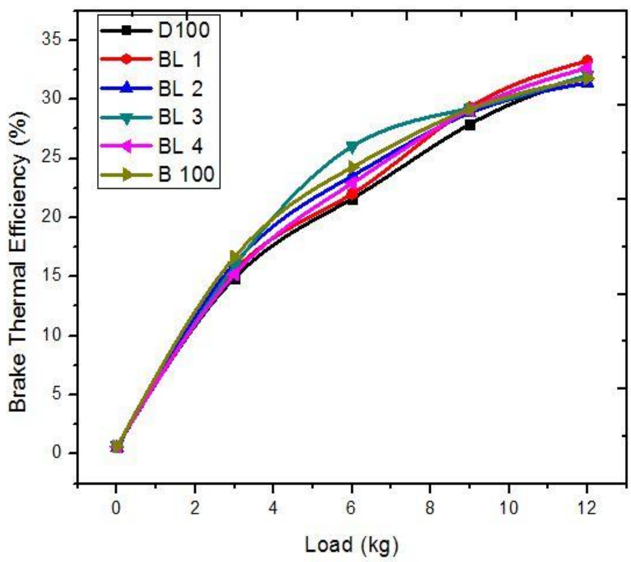

Fig.3 BTE vs Load

B. Brake specific fuel consumption (BSFC)

The variation of BSFC with load for different fuels is presented in fig.4. The BSFC, in general, was found that decreasing with addition of biodiesel and additives. The BSFC of BL 1 was about 28% less than that of pure diesel (D100) and for BL 2 it was like 10 %. For BL 4 and BL 100 it was like 32%, 35% less as compared to D100.

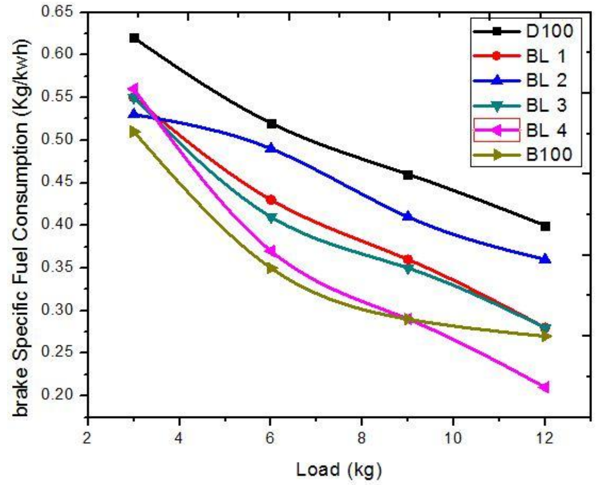

Fig.4 BSFC vs Load

2. Emission analysis

A. Exhaust gas temperature

The Exhaust gas temperature with respect to varying in loads (Fig.5) in general, was found that decreasing with addition of biodiesel and additives. The BSFC of BL 1 was about 4.3% less than that of pure diesel (D100) and for BL 2 it was like 2.3 %. For BL 4 and BL 100 it was like 3%, 2% more as compared to D100. In case of BL 3 it was 3.7 % more than diesel.

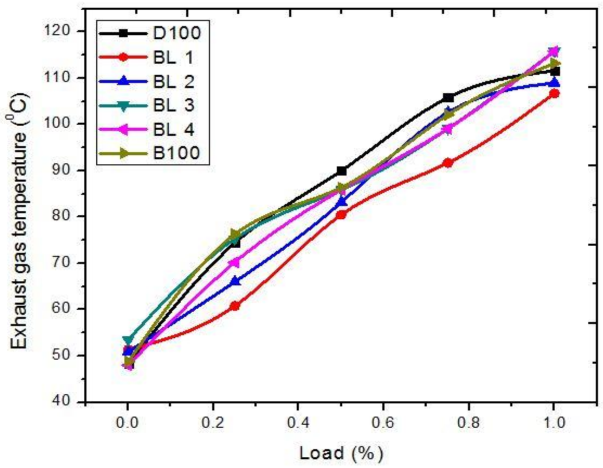

Fig.5 Exhaust gas temperature vs Load

B. Unborn hydrocarbon (CxHy)

The CxHy with respect to varying in loads (Fig.6) in general, was found that decreasing with addition of biodiesel and additives. The BSFC of BL 1 was about 16% less than that of pure diesel (D100) and for BL 2 it was like 10%. For BL 4 and BL 100 it was like 15%, 8% less as compared to D100. In case of BL 3 it was 5% less than diesel.

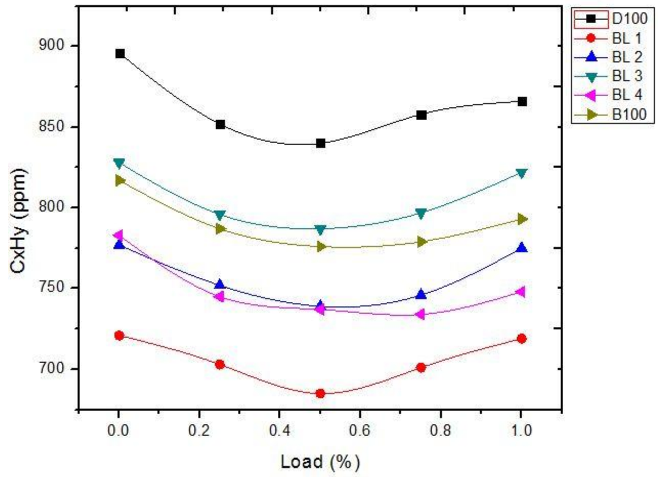

Fig.6 CxHy vs Load

IV. CONCLUSIONS

The aim of the present experimental investigation was to analyses the performances and emissions of Mahua biodiesel, 2-EHN and Ethanol blends with pure diesel. The following conclusions are drawn from the tentative results:

- Mahua biodiesel and diesel additives (2-EHN, Ethanol) seems to have a potential to be used as a substitute fuel in Direct Injection diesel engines without any alteration.
- The brake thermal efficiency (Fig.3) was 3% better than D100 and for the bland BL1 shows a better efficiency as compared to the pure diesel.
- Brake specific fuel consumption is lower for Mahua biodiesel blends and additives than D100 (Fig.4). The blend BL1 have 30% less BSFC then D100
- Most of the major exhaust pollutants such as CxHy and exhaust gas temperature (Fig.6) (Fig.7) are reduced with the use of biodiesel and the additive. By using BL4 we can reduce 16% CxHy and exhaust gas temperature like 4.3% for BL1.
- From the experimental analysis for both performances and emissions, it is concluded that BL1 could replace the diesel for diesel engine for better performance.

V. ACKNOWLEDGEMENTS

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VI. REFERENCES

1. Dr.G.R.Ksastry, *Bio-diesel Bio-degradable Alternative Fuel for Diesel Engines* .Readworthy Publications Pvt. Ltd. ISBN 13: 978-81-89973-50-6, ISBN 10: 81-89973-50-9
2. A. Murugesan, C. Umarani, R. Subramanian, N.Nedunchezhian. *Bio-diesel as an alternative fuel for diesel engines—a review*. Renewable and Sustainable Energy Reviews 13 (2009) 653–662
3. Avinash Kumar Agarwal, AtulDhar. *Experimental investigations of performance, emission and combustion characteristics of Karanja oil blends fuelled DICI engine*. Renewable Energy 52 (2013) 283e291
4. Rosli Abu Bakar. Semin and Abdul Rahim Ismail. *Fuel Injection Pressure Effect on Performance of Direct Injection Diesel Engines.* American Journal of Applied Sciences, 2008 5 (3): 197-202.
5. Ismet Celýkten. *An experimental investigation of the effect of the injection pressure on engine performance and exhaust emission in indirect injection diesel engines*.Applied Thermal Engineering, 2003, 23, 2051–2060.
6. Venkateswarlu K., Murthy B, and Subbarao V. *An Experimental Investigation on Performance, Combustion and Emission Characteristics of Diesel- Biodiesel Blends with Isobutanol as an Additive.* SAE Technical Paper 2012-28-0011.
7. Manish Nandi, K. *The Performance of Ditertiary- Butyl Peroxide as Cetane Improver in Diesel Fuels.ARCO Chemical Company,* Newtown Square, PA 19073.
8. Sathiyagnanam,A.P. Saravanan,C.G. and Dhandapani,S. *Effect of Thermal-Barrier Coating plus Fuel Additive for Reducing Emission from DI Diesel Engine.* Proceedings of the World Congress on Engineering, 2010, Vol II WCE 2010, June 30 - July 2, 2010, London, U.K.
9. SundarRaj, C. Sendilvelan,S. and Arul,S. *Performance of a Thermally Insulated Constant Speed Diesel Engine with Dioxane Blended Fuels.* Global Journal of Researches in Engineering, 2010, Vol. 10 Issue 2 (Ver 1.0).
10. Murat, Karabektas. And Murat, Hosoz. *Performance and emission characteristics of a diesel engine using isobutanol–diesel fuel blends.* Renewable Energy, 2009(Elsevier), Volume 34, Issue 6, Pages 1554-1559.
11. VenkataSubbaiah,G. Raja Gopal,K. Syed AltafHussain. DurgaPrasad,B. and TirupathiReddy,K. *RiceBran Oil Biodiesel As andditive In Diesel-Ethanol Blends For Diesel Engines.* Ijrras, 2010, 3(3).
12. AnandaSrinivasan, C. and Saravanan, *C.G. Study of Combustion Characteristics of an SI Engine Fuelled with Ethanol and Oxygenated Fuel Additives.* Journal of Sustainable Energy & Environment, 2010, 85-91.
13. Venkanna, B.K. Swati B.Wadawadagi, VenkataramanaReddy,C. *Effect of Injection Pressure on Performance, Emission and Combustion Characteristics of Direct Injection Diesel Engine Running on Blends of PongamiaPinnata Linn Oil (Honge oil) and Diesel Fuel*. The CIGR Ejournal, 2009, Manuscript number 1316. Vol. XI.
14. Wang,X.G. Zheng,B. Huang,Z.H. Zhang,N. Zhang,Y.J. and Hu, E.J. *Performance and emissions of a turbocharged, high-pressure common rail diesel engine operating on biodiesel/diesel blends.* Proc. IMechE Part D: J. Automobile Engineering, 2010, Vol. 225.
15. Mustafa Canakci. CenkSayin.AhmetNecatiOzsezen and Ali Turkcan.*Effect of Injection Pressure on the Combustion, Performance, and Emission Characteristics of a Diesel Engine Fueled with Methanol-blended Diesel Fuel.Energy Fuels*, 2009, *23* (6), pp 2908–2920.