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EMISSION ANALYSIS OF A MEDIUM CAPACITY DIESEL ENGINE USING MAHUA OIL BIODIESEL

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Abstract

The stringent emission norms cannot be met through engine design and exhaust after treatment alone. Use of oxygenated fuel like biodiesel as a alternative to diesel may be the best way to reduce emissions today. In this study, Diesel fuel and pure biodiesel (mahua oil) were tested on a single cylinder naturally-aspirated direct-injection diesel engine. The study aims to investigate the effects of the mahua oil biodiesel on existing diesel engine emissions. The effect of test fuels on engine emissions like CO, HC, CO2, NOx and smoke emissions was investigated with respect to the load on engine. Smoke opacity of Diesel engine was lower in case of biodiesel of mahua oil as compare to mineral diesel. NOx emissions was little higher during the whole range of loading, which is a typical characteristic of biodiesel. However the increments are within in the narrow range. CO2 emissions was bit higher which is the indication of better combustion due to presence of rich oxygen in the mixture, it results in the low values of CO and HC during the whole range of experiments. Thus considering environmental norms most of the engine emissions, it can be concluded and biodiesel derived from mahua oil could be used in a conventional diesel engine without any modification.

Key words : Diesel engine, Transesterification, Biodiesel (mahua oil), emissions, etc

1. INTRODUCTION

Though diesel engines have several advantages like high thermal efficiency, torque capacity, low CO and HC emissions, reliability, adaptability and economical in operation, they suffer from high concentration of NOx , smoke and particulate emissions. Reduction of exhaust emissions is extremely important for diesel engine development in view of increasing attention regarding environmental protection and emission norms. Bio-fuels made from agricultural products (oxygenated by nature), may not only offer benefits in terms of exhaust emissions, but also reduce the world's dependence on oil imports. Among these, vegetable oils or their derived bio-diesels(methyl or ethyl esters) are considered as very promising fuels[1]. Due to its reproducibility and non-toxicity, biodiesel has been considered as a potential substitution of diesel fuel. Furthermore, due to its similar properties with diesel fuel, there is no need to modify the engine when it is fueled with biodiesel or its blends [2].

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Renewable energy sources, and particularly biofuels, are being promoted as possible solutions to address global warming and the depletion of petroleum resources [3]. There are following advantages of the bio-diesel over petroleum based diesel fuel [4] -

First, Biodiesel is a good lubricant about 66% better than petro diesel;

Second, Biodiesel produce less smoke and particulate matters as it is free of sulfur and aromatics;

Third, Biodiesel has higher cetane number having well anti knocking property;

Forth, Produce lower carbon monoxide and hydrocarbon emissions;

And Bio-diesel is renewable, biodegradable and non-toxic.

In comparison with petroleum-based diesel fuel, biodiesel is characterized by:

- Lower heating value (by about 10-12%);
- Higher cetane value (typically 4560);
- About 11% oxygen content (petroleum-based diesel contains no oxygen);
- No aromatics contents
- No sulfur or extremely low sulfur content;
- Better lubricant;
- Higher viscosity;
- Higher freezing temperature (higher cloud point and pour point);
- Higher flash point;
- No toxicity or low toxicity;
- Different corrosive properties;

Godiganur et al. [5] observed significant improvement in engine emission characteristics for the biodiesel fuelled engine compared to diesel fuelled engine. Schumacher et al. [6] performed some tests on 6 V 92 TA DDC heavy-duty diesel engines fuelled with soy biodiesel and its blends with diesel fuel. It was observed that, fueling with biodiesel/ diesel fuel blends reduced PM, THC and CO, and increased NOx emissions. Chauhan et al. [7] compare performance, emission and combustion characteristics of biodiesel derived from non-edible Jatropha oil in a dual fuel diesel engine with base line results of diesel fuel. The results from the experiments suggest that biodiesel derived from non-edible oil like Jatropha could be a good substitute to diesel fuel in diesel engine in the near future as far as decentralized energy production is concerned. Chauhan et al. [8] studied a fumigation system for introduction of ethanol in a small capacity Diesel engine and to determine its effects on emission. Results show that fumigated Diesel engine exhibit better engine performance with lower NOx, CO, CO2 an d exhaust temperature. Ethanol fumigation has resulted in increase of unburned hydrocarbon (HC) emission in the entire loadrange.

Two major species of the genus Madhucaindica and Madhucalongifolia are found in India. These are so closly related that no distinction can be made in the trade of their seed or oil. The drying and decertification yield 70% kernel on the weight of seed. The kernel seed contain about 50% of oil. The oil yield in an expeller is nearly 34%-37%. The fresh oil from properly stored seed is yellow in colour. In the present paper the emissions of mahua biodiesel was studied in the diesel engine and the variation was measured with respect to the mineral diesel.

2. TEST ENGINE AND FUEL PROPERTIES

Experiments were carried out on a naturally-aspirated, water cooled, 6KVA single-cylinder, and direct-injection at a steady speed of

Table 1. Engine Specification

Make	Prakash diesels pvt.Ltd
No.of cylinders	Single
Type of cooling	Air
RPM	1500
Sfc g/kw-h	252
Rated power(KW)	6
CR	17
Bore,mm	87.5
Stroke,mm	110
Lubrication oil	SAE 40

1500 rpm diesel engine. The main specifications of the engine are shown in Table 1. An eddy-current dynamometer was coupled with the engine for measuring and adjusting the speed and torque of the diesel engine. The fuels used in this experiment include diesel fuel and mahua biodiesel. The mahua oil than transesterified to mahua biodiesel and then the estimation of important properties was done as per ASTM norms. The major properties of diesel fuel, mahua biodiesel were determined and are listed in Table 2. The schematic diagram of the experimental is as shown in the Fig.1, the units which are marked as 1-Engine Cylinder; 2-Flyweel; 3-Water Pump; 4-Air Intake Port; 5-Exhust Port; 6-Buerret; 7-External Fuel Tank; 8-Dynamometer; 9-Thermocouple; 10-Oil Tank; 11- Gas Analyser; 12-Inlet Cooling Water; 13-Outlet Cooling Water; 14-Smoke Meter; 15-Control Panel

3. RESULTS AND DISCUSSIONS

3.1 SMOKE EMISSION

The smoke variations are shown in Fig.2. Due to higer viscosity of mahua biodiesel as compared to diesel fuel,there is poor mixing of air/fuel,so as a result engine exhuast is more smoky at lower loads while using biodiesel as a substitue for diesel. But,at higher loads or full load engine exhaust is more smoky for diesel fuel. This is possible because of the higher cetane index and inbuilt oxygen of biodiesel fuel which results in better combustion resulting in reduction in smoke opacity.

3.2 NITROGEN OXIDES

The NOx values as parts per million(ppm) for diesel and biodiesel in exhaust emissions of engine are plotted as a function of load in Fig.3. From this Fig.3, it can be seen that NOx emissions are slightly incresed at all loads for biodiesel when compared with that of pure diesel. The NOx emissions increased with the increasing engine load, due to a higher combustion temperature. The most important factor for the emissions of NOx is the combustion temperature in the engine cylinder and the local stoichiometric of the mixture. It can be seen that within the entire range of loading, the

Table 2. Fuel Characteristics

Characteristics	Diesel	Mahua oil	Mahua Biodiesel
Density Kg/m3	815-860	921	860
CV(MJ/Kg)	43	36.54	38.12
Viscosity @40 in cst	2.4-4.1	38.3	5.2
CN	45-55	40-45	48
Flash point	58	234	184
Fire point	62	243	237
Oxygen content%	0	NA	11-14
B.P	180-360	NA	232

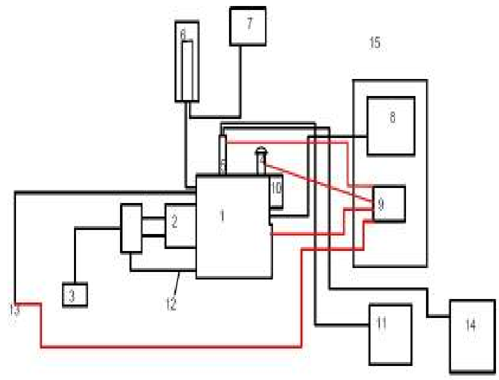

Fig. 1. Experiments setup diagram.

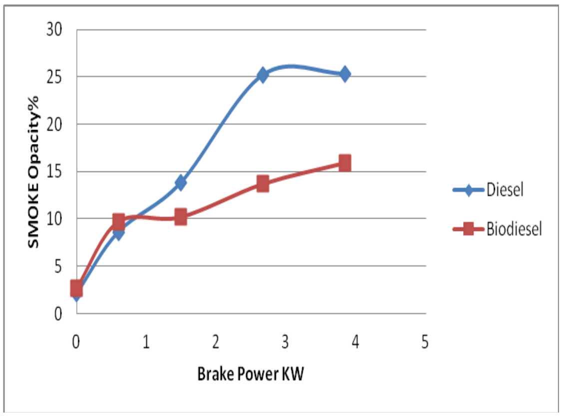

Fig. 2. Variation of smoke with Brake Power for diesel and biodiesel

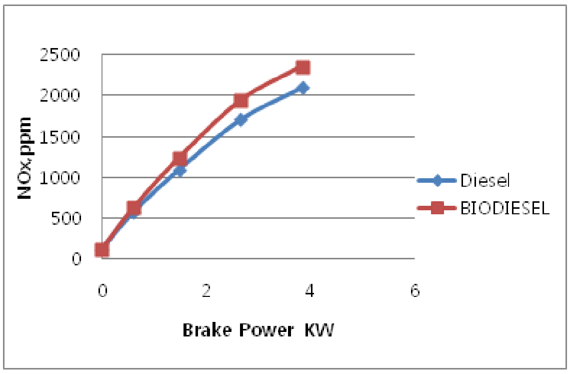

Fig. 3. Variation of NO_x with Brake Power for diesel and biodiesel

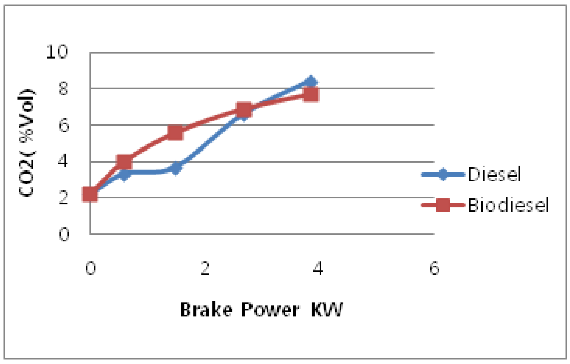

Fig. 4. Variation of CO_2 with Brake Power for diesel and biodiesel

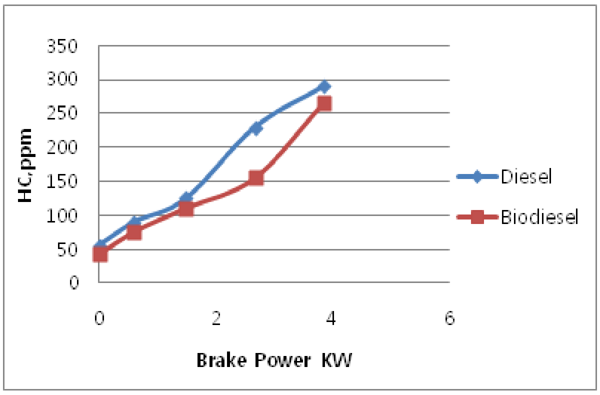

Fig. 5. Variation of HC with Brake Power for diesel and biodiesel

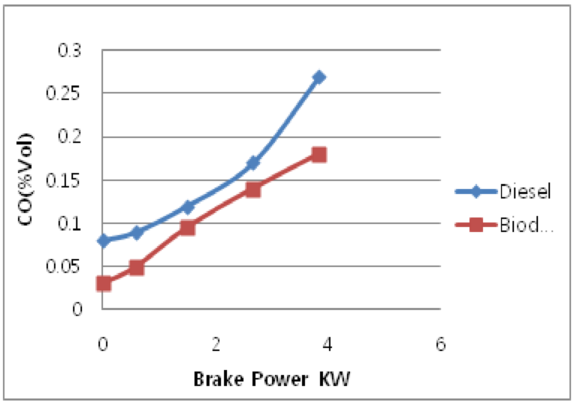

Fig. 6. Variation of CO with Brake Power for diesel and biodiesel

NOx emissions from the mahua biodiesel are higher than that of diesel fuel. The rate of formation of NOx emissions in diesel engines is primarily a function of flame temperature, which is closely related to the peak cylinder pressure and hence temperature the higher density of biodiesel compared to diesel fuel.

3.3 CO2EMISSIONS

As shown in Fig.4, CO_2 increases with respect to the load on engine. This variation is more for biodiesel as compared to diesel fuel. This may be due to more complete oxidation of biodiesel fuel due to availability of oxygen within the fuel itself. As biodiesel contains oxygen element, the carbon content is relatively lower in the same volume of fuel consumed at the same engine load.

3.4 HYDROCARBON

It is seen in Fig.5. that there is a significant decrease in the HC emission with mahua oil biodiesel as compared with diesel at higher load. Iniatially,at no load or part load conditions, combustion chamber temperature is lower and the result is poor complete oxidation of hydrocarbons. HC emissions increased slightly at part load conditions. This is due to lack of oxygen resulting from engine operation at higher equivalence ratio. Thus, high percentage of oxygen leads to low HC.

3.5 CO EMISSIONS

Variation of CO emissions with engine loading for both fuel is compared in Fig.6.It can be seen that CO emissions reduces when the engine is operated on biodiesel.Also,it is observed that at higer load CO emissions decreased significantly due to better burning of the fuel, as biodiesel is oxygenated fuel and contains oxygen which helps for complete combustion.

4. CONCLUSION

Based on the results of this study, the following conclusions were observed:

- The fuel properties of mahua biodiesel used in th is study were within acceptable range for using as alternative for diesel except calorific value an d viscosity.
- The emission levels of CO and HC reduces with mahua biodiesel at higher loads.
- The emission level of NOx and CO_2 in the engin e exhaust increases at all loads.
- The exhaust is smokier at partial load when engi ne is operated on Mahua biodiesel.

REFERENCES

1. Rakopoulos,C.D., Hountalas, D.T., Zannis, T.C., 2004. Theoretical Study Concerning the Effect of Oxygenated Fuels on DI Diesel Engine Performance and Emissions. SAEpaper,01:1838.
2. Li D, Zhen H, Xingcai L, Wu-gao Z, Jian-guang Y, 2005. Physico-chemical Properties of ethanol-diesel blend fuel and its effect on performance and emissions of diesel engines. RenewEnergy,30:967–76.
3. Haseeb A., Fazal M.A., Jahirul M.I., Masjuki H.H. Department of Mechanical Engineering, University of Malya. Malaysia.
4. Agarwal AK 2007. Biofuels (alcohols and biodiesel) applications as fuels for internal Combustion engines. Prog Energy Combus tSci, 33:233–71.
5. Godiganur S, Murthy SC.H, Reddy RP 2009.6BTA 5.9 G2-1 Cummins engine performance and emission tests using methyl ester mahua(Madhuca indica) oil/diesel blends. .Renewable Energy, 34:2172-2177.
6. Schumacher LG, Borgelt SC, Fosseen D, GoetzW, HiresWG,1996. Heavy-Duty Engine Exhaust Emission Test Using Methyl Ester Soybean Oil/Diesel Fuel Blends. Bio resource Technology, 57:31–6.
7. Chauhan BS, Kumar N, Cho HM 2012. A study on the performance and emission of a diesel engine fueled with Jatropha biodiesel oil and its blends. Energy,37: 616-622.
8. Chauhan BS, Kumar N, Pal SS, Jun YD 2011. Experimental studies on fumigation of ethanol in a small capacity diesel engine. Energy,36:1030-8.