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PERFORMANCE EVALUATION OF BLENDS OF MAHUA OIL METHYL ESTER FOR COMPRESSION IGNITION ENGINE

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ABSTRACT

Decline in fossil fuel resources along with high crude oil prices generated attention towards the development of fuel from alternate sources. One of the best alternatives is biodiesels obtained from different vegetable oils. In the present study attention is being focused on comparison of performance and emissions results of biodiesel derived from Mahua oil when applied in different proportions in compression ignition (diesel) engine. A single cylinder four stroke diesel engine (Kirloskar) was tested at various loads with the blended fuel at the rated speed of 1500 rpm. Mahua oil methyl ester blended with diesel in proportions of 5%, 10%, 15%, and 20%, by volume and pure diesel were used as fuel. An AVL gas analyzer and a smoke meter were used for the measurements of exhaust gas emissions. Engine performance (specific fuel consumption, brake thermal efficiency, and exhaust gas temperature) and emissions (HC, CO, CO_2, NO_x and Smoke Opacity) were measured to evaluate and compute the behavior of the diesel engine running on biodiesel. The results show that the brake thermal efficiency of diesel is higher at all loads followed by blends of Mahua methyl ester and diesel. Experimentally the maximum brake thermal efficiency and minimum specific fuel consumption were found for blends up to 20% Mahua oil methyl ester at all loads among the blends. The specific fuel consumption was found to be even lower than the conventional diesel for blends up to B20. The brake thermal efficiency for B10 and B20 were also closer to diesel and the CO emissions were found to be lesser than diesel while there was a slight increase in the smoke opacity and NO_x. The reductions in brake specific fuel consumption and CO emissions made the blend of biodiesel B20 a suitable alternative fuel for diesel

KEYWORDS: Mahua oil Methyl Ester; Diesel Engine; Biodiesel; Performance; Emission.

INTRODUCTION

There has been an increase in effort to reduce the reliance on petroleum fuel for energy generation and transportation and attention is being focus on alternate fuel. Among the alternative fuel, biodiesel and diesohol have receive the much attention for diesel engine due to their advantages as the renewable, domestically produced energy resources and they are environmentally friendly because there is substantial reduction of unburned hydrocarbon, CO and particulate matter when it is used in conventional diesel engine. Straight vegetable oils (SVOs) have their fair share of problems in unmodified CI engines. These problems include: cold-weather starting, plugging and gumming of filters lines and injectors, engine knocking, carbon deposits on piston and head of engine, excessive engine wear and deterioration of engine lubricating oil. Vegetable oils decrease power output and thermal efficiency while leaving carbon deposits inside the cylinder. Most of these problems with vegetable oil are due to high viscosity, low cetane number, low flash point, and resulting incomplete combustion. To avoid some of these problems, vegetable oils have been converted via a chemical process, known as transesterification process. Resulting fuel is biodiesel, a biodegradable and nontoxic renewable fuel. Furthermore, biodiesels have reduced viscosity, and improved volatility when compared to ordinary vegetable oils. Most CI engines can run on biodiesels without modifications. The mono alkyl or methyl esters of the vegetable oil produced during transesterification are popularly known as biodiesel.

Biodiesel can be produced either from edible or from non- edible oils. Most of the edible oils are produced from the crop land. The use of edible vegetable oils for bio diesel production has recently been of great concern because they compete with food materials Bio diesel from mahua seed is important because it comes under non-edible category of oil and most of the states of India are tribal where it is abundantly found. The annual production of non-edible seed was greater than 2 MT of which mahua is nearly 181 KT [1]. Mahua is an non-traditional, non- edible oil also known as Indian butter tree.

The present experimental work investigates about the production of biodiesel from mahua oil by transesterification with methanol, preparation of test fuels for the engine experiments in the form of four blends of mahua oil biodiesel (MOME) and Diesel as B5, B10, B15 and B20 and measurement of various engine performance parameters and exhaust emissions.

MATERIALS AND METHODS

Biodiesel is typically produced through the reaction of a vegetable oil or animal fat with methanol in the presence of a catalyst to yield glycerine and methyl esters .The methyl esters produced in this process are called biodiesels. This process of production of biodiesels is called transesterification [2-8]. In the last several years, many researchers have conducted studies on various compression ignition engines using biodiesels.[9-12],Transesterification process involves heating the mahua oil, from which the biodiesel fuel is extracted. When the temperature of approximate 65 to70ºC. The oil is held in that temperature for certain period of time exactly 25 minutes. In this preparation, for 1000 ml of mahua oil, 300 ml of methanol and 30g of potassium hydroxide are added. The mahua oil chemically reacts with alcohol in the presence of a catalyst to produce methyl esters. After this the whole mixture is stirred for 1 hour. After completing the mixing stage, a separating flask allows the mixture to settle down. Separating and settling can be done on a single flask. When allowing the mixture to be in the flask for 24 hours the settling takes place where the glycerin gets settled down and esters get separated up. After separation of the methyl esters, it is washed in order to get clear solution of methyl esters, obtained by the spraying of distilled water over the solution which has already been separated and heating for removal of water was done using the 10 liters biodiesel reactor [13] Fuel properties of all test samples were determined as prescribed by BIS, India.

EXPERIMENTAL SETUP

A single cylinder, four-stroke, direct injection (DI), water-cooled, diesel engine with mechanical rope brake loading was used for this study which is developing a power output of 5.2 KW @ 1500 rpm. The engine specifications are given in Table 3. The engine was tested with Diesel, and blend ratios at 20%, 40%, 60%, 80% and 100% load at a constant speed of 1500 rpm. A burette and a stop watch were used to measure the fuel flow rate on volume basis. The engine has run smoothly through the whole study and no major problem was reported. Performance parameters such as brake power, brake thermal efficiency, brake specific fuel consumption, brake specific energy consumption were evaluated. An AVL 5 gas analyzer and an AVL smoke meter were used for the measurement of Emissions such as UBHC, CO, CO_2, NO_x, wave length and smoke opacity respectively.

RESULTS AND DISCUSSION

The results and discussion may be combined into a common section or obtainable separately. They may also be broken into subsets with short, revealing captions.

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Tables:

Acid	Formula	Percentage
Palmitic acid $C_{16:0}$	$C_{16}H_{32}O_2$	16-28.2
Stearic acid $C_{18:0}$	$C_{18}H_{36}O_2$	20-25.1
Arachidic acid $C_{20:0}$	$C_{20}H_{40}O_2$	0-3.3
Oleic acid $C_{18:1}$	$C_{18}H_{34}O_2$	41- 51
Linoleic acid $C_{18:2}$	$C_{18}H_{32}O_2$	8.9-13.7

Properties	Diesel	Raw mahua	MME
Density Kg/m^3	850	924	916
Specific gravity	0.85	0.924	0.916
Kinematic viscosity at 40^{0}C.(Cst)	3.05	39.45	5.8
Calorific Value (KJ/kg)	42800	37614	39400
Flash Point ^{0}C.	56	230	129
Fire Point ^{0}C.	63	246	141

Eingne Performance Parameters:

The engine performance with mahua biodiesel was evaluated in terms of brake power, brake specific fuel consumption, brake specific energy consumption, and thermal efficiency at different loading conditions of the engine. Engine performance was measured using 100% Diesel, 5% MOME, 10% MOME, 15% MOME and 20% MOME only. This blend ratio was selected because it is practically viable to have this ratio because of low availability of biodiesel and also it is in line with the intention of the Government of India to blend up to 10% biodiesel with mineral diesel for the automobile sector.

Brake Power:

Variation in B.P. of blends B5, B10, B15, B20 and diesel with respect to change in load is shown in the fig 4.1. The power developed by the engine at varying load is higher for Diesel and slightly less for the blends of MOME. However with B20 blend the brake power developed is very close to that with diesel.

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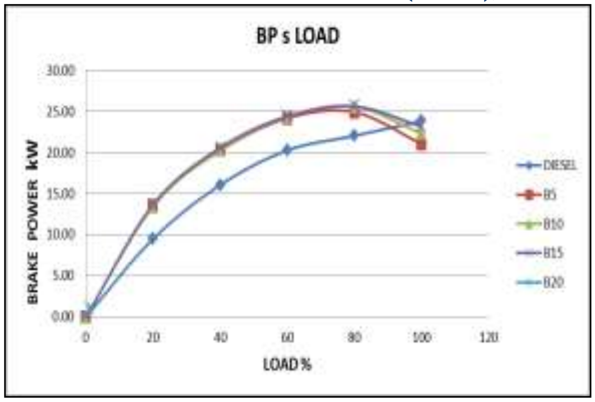

Figure4: Variation in brake power with change in load

Brake power of the engine increases with increase in the load on the engine. At no load conditions, the brake power of diesel, B5, B10, B15 and B20 is almost same. As the load increases, B.P. of the engine starts to be less for biodiesel blends as compared to diesel. The decrease in B.P. is due to the higher viscosity and density and lower heating value of biodiesel than diesel. As the quantity of the biodiesel increases in the blend, B.P. of the engine decreases due to the higher viscosity and lower heating value of the blends as compared to petro diesel [16]

Diesel is having the highest heating value amongst D, B5, B10, B15 and B20. So, maximum br

Brake specific fuel consumption (BSFC):

Variation in BSFC of blends B5, B10, B15, B20 and diesel with respect to change in load is shown in the fig 5.

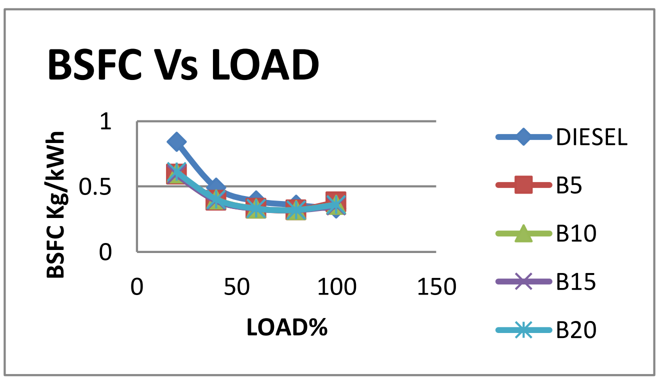

Figure5: Variation in brake specific fuel consumption with change in load.

From the graph It was observed that the brake specific fuel consumptions of diesel as well as the blends were decreasing with increasing load. It is interesting to note that for the blends B10 and B20, the specific fuel consumption is less than that of diesel. This is due to the presence of oxygen in the biofuel which enables complete combustion. However if the concentration of mahua oil in the blend is more than 30 percent by Volume the specific fuel consumption was found to be higher than diesel at all loads. This is because of the combined effects of lower heating value and the higher fuel flow rate due to high density of the blends. The variations in the specific fuel consumption with load follows a similar trend with the test results reported in the literature [17]. Higher proportions of mahua oil in the blends increases the viscosity which in turn increased the specific fuel consumption due to poor atomization of the fuel.

Brake Specific Energy Consumption (BSEC):

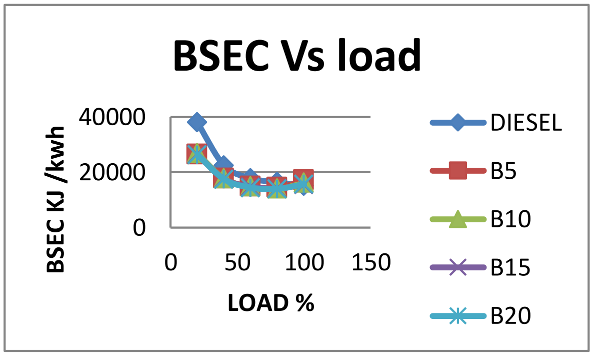

Figure6:.Variation of brake specific energy consumption with change in load

The variation in BSEC with load for all fuels is presented in Fig.6. In all cases, it decreased ake power is obtained in fuelling diesel in comparison to B5, B10, B15 and B20 respectively sharply with increase in percentage of load for all fuels. The main reason for this could be that the percent increase in fuel required to operate the engine is less than the percent increase in brake power, because relatively less portion of the heat is lost at higher loads. This trend was observed due to lower calorific value, with increase in biodiesel percentage in blends. This trend of BSEC with increasing load in different biodiesel blends were also reported by some researchers [18,19] while testing biodiesel obtained from mahua oils.

Brake Thermal Efficiency:

Change in BTE of blends B5, B10, B15, B20 and diesel with respect to change in load is shown in fig.7.

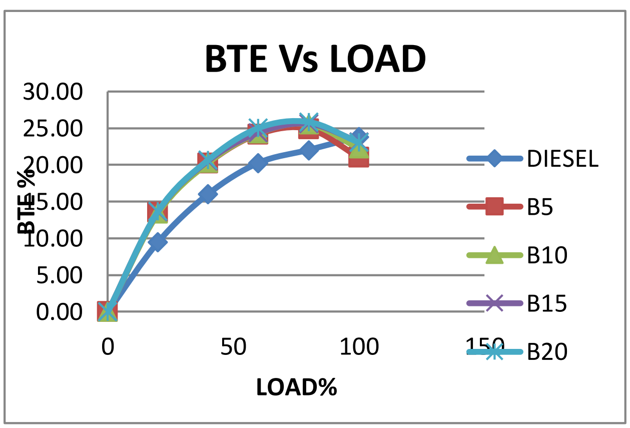

Figure7: variation in brake thermal efficiency with respect to change in load

At no load condition, brake thermal efficiency of B5, B10, B15, B20 and diesel is same. As the load on the engine increases, brake thermal efficiency increases because brake thermal efficiency is the function of brake power and brake power increases as the load on the engine increases. At no load condition, brake thermal efficiency of B5, B10, B15, B20 and diesel is same. At part load conditions, the brake thermal efficiency of B10 is more than diesel because mass of B10 supplied is 19.35% less than that of diesel and calorific value of B10 is also less than that of diesel. Brake thermal efficiency of B15 and B20 is almost same at part loads and is 16.67% less than diesel because of lower brake power and higher amount of fuel supplied. At full load conditions, brake thermal efficiency of B5, B10, B15 and B20 is almost same but is less than diesel.

Engine exhaust emissions

The emissions of HC, CO, CO_2 and NO_2 against load are shown in Figures. 8 to 11, with exception to the increases in carbon dioxide and oxides of nitrogen emissions with, increase in load, all other pollution parameters were found to decrease in general. Results were similar to those reported by Sharanappa Godiganur et al [20] The emissions of carbon monoxideunburned hydrocarbons and nitrogen oxide were examined and the results are shown below. Carbon monoxide and unburned hydrocarbons are the products of incomplete combustion whereas oxides of nitrogen are produced at very high temperatures.

Hydrocarbon:

Figure 8.shows the variation of hydro carbon with brake power. It is observed that the hydro carbon emission of various fuels is lower in low and medium loads but increased at higher loads. This is because, at higher loads, when more fuel is injected into the engine cylinder, the availability of free oxygen is relatively less for the reaction.

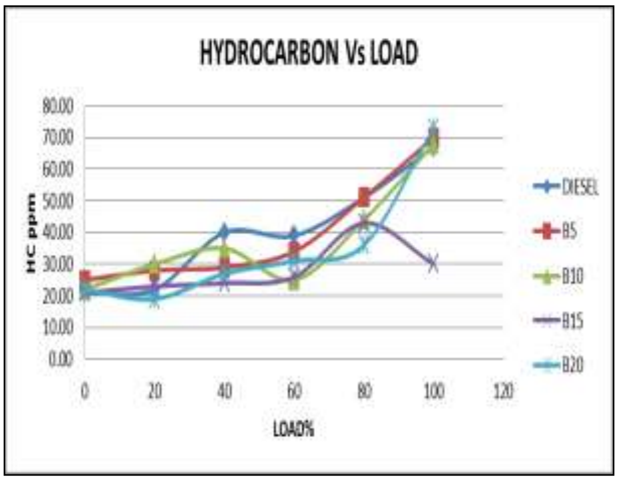

Figure 8: Variation in quantity of unburnt hydrocarbons with change in load.

Carbon monoxide:

Fig 9 shows the variation of carbon monoxide (CO) emission with Brake power for MOME and diesel. The carbon monoxide emissions are found to be increasing with increase in load from graph. It was noted that at low and medium loads, the carbon monoxide emission for B5, B10, B15 and B20 fuels were not much different from those of diesel. At full load, the carbon monoxide emissions of the fuels increase significantly when compared with diesel except B15.

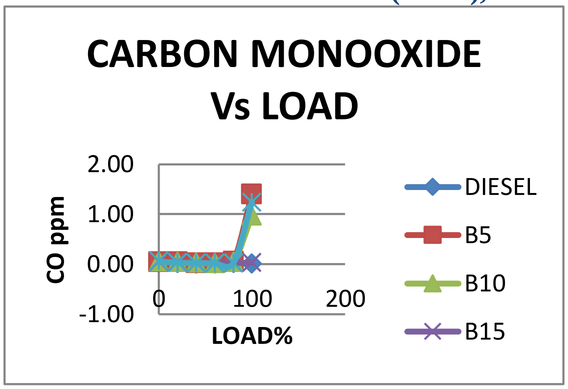

Figure9: variation in quantity of CO with change

Carbon dioxide:

Fig. 10 shows the variation of carbon dioxide ($CO2$) emissions with load. In a single cylinder 4-stroke diesel engine. it can be observed that the carbon dioxide emission increases with increase in load. The carbon dioxide emission is found to increase with increase in the concentration of biodiesel blends as the fuel. B100 emits more carbon dioxide which indicates the complete combustion of the fuel. The carbon dioxide emission from biodiesel engines can be absorbed by the plants for photosynthesis. The carbon dioxide level in the atmosphere may be kept in balanced condition due to the increased greenery and plants cultivated to yield bio fuels.

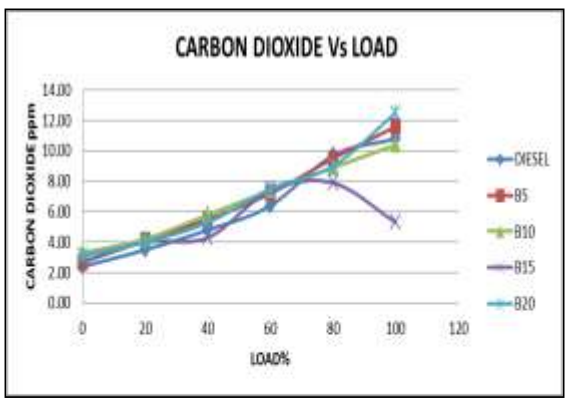

Figure10: variation in quantity of CO_2 with change in load.

Oxides of nitrogen:

Figure11 shows the variation of oxides of nitrogen (NOx) emission for diesel and MOME. In a single cylinder,4-stroke diesel engine with load Increase in the NOx emission is due to lower cetane number. It is observed that the NOx emission is increased with increase in the load. This reduction in NOx emission is due to the reduced rate of heat release. It is observed that oxygenated fuel blends can result in increase in NOx emission. It is also observed that complete combustion causes higher combustion temperature which results in higher NOx formation.

Figure11: variation in quantity of NOx

Smoke Opacity:

The smoke is formed due to incomplete combustion of fuel in the combustion chamber It is seen from the above set of results that the smoke opacity are less with blends of MOME in comparison to that of diesel fuel. This is because of better combustion of blends due to the availability of more oxygen in bio diesel. Overall, it is seen that neat biodiesel MOBD100 has given the least value of smoke opacity.

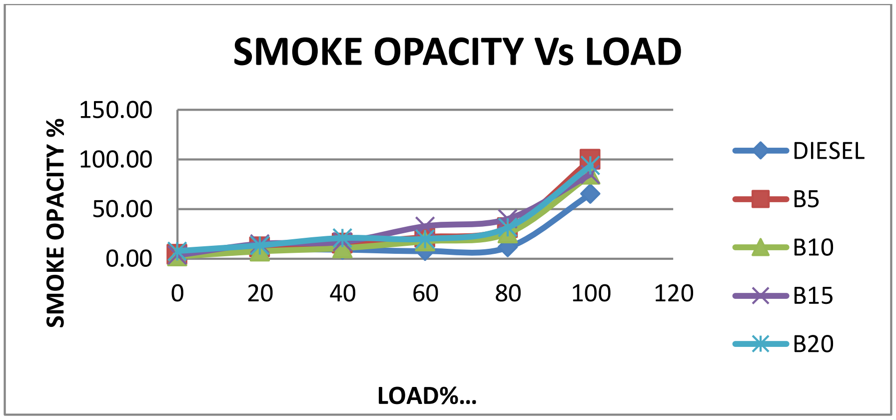

Figure12: variation in smoke opacity with change i

CONCLUSION

The experiments are carried out on a single cylinder diesel engine using biodiesel derived from mahua oil as an alternate fuel. The performance and emission of blends are evaluated and compared with diesel. From the above results, the following conclusions are drawn:

i) The brake power obtained with blended bio diesel fuel is less than that for mineral diesel fuel. This is mainly because of a lower calorific value of bio diesel in comparison to diesel. ii) Brake specific Fuel consumption using mahua biodiesel is less at low and medium loads. iii) Brake specific energy consumption is lower for mahua oil methyl ester-diesel blends than diesel at all loading. iv) The brake thermal efficiency of the engine with mahua methyl ester-diesel blend is high at low and medium load. v) Blended Bio Diesel fuel gives less emission than mineral diesel, except for carbon dioxide and NOx. Higher CO2 is released due to higher oxygen and carbon contents of biodiesel, Higher NOx releases are due to higher temperatures of combustion than mineral diesel fuel.vi) Form the above conclusions drawn, it is found that the performance of the test engine when operating with MOME blends were very satisfactory and close to that of Diesel oil and significant improvement was noticed in the exhaust emissions of CO, HC and Smoke when the engine was operating with the blends .Therefore it can be concluded that methyl esters of mahua oil can be successfully used as alternative fuel in diesel engines without any engine modifications. Biodiesel is a popular and promising environment friendly alternative fuel due to its renewable nature, clean burning characteristics less greenhouse effect and more greenery. Biodiesel is a promoter of the rural economy

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