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Performance Analysis And Emission Testing On Diesel Engine by using Biodiesel as MAHUA Oil

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Abstract- **Diesel engines are the major source of transportation, power generation marine applications etc. Hence diesel is being used extensively, but due to gradual depletion of world petroleum reserves and the impact of environmental pollution of increasing exhaust emissions, there is an urgent need for suitable alternative fuels for use in diesel engines. In view of the vegetable oils like mahua oil are considered as alternate fuels to diesel which are promising alternative because they have advantages like they are renewable, Eco-friendly and produced easily in rural areas, where there is an acute need for modern forms of energy. With this objective, the present work has focused on the performance and emission characteristics of mahua non-edible vegetable oil and its blend with diesel on a single cylinder diesel engine and its suitability as an alternative fuel. The oil blended with diesel in 25/75%, 50/50%, 75/25% and 100% on the volume basis, then analyzed and compared with diesel. The performance and emission characteristics of blends are evaluated at different loads (brake power) of 0,1,2,3,4,5 kW at constant rated speed of 1500 rpm and results are compared with diesel.**

Keywords: **Mahua oil, Alternative fuel, Diesel Engine Performance and Exhaust Emissions etc.**

1. INTRODUCTION

According to the present scenario, diesel engines are used to power automobiles, locomotives, ships and irrigation pumps. It is also used widely to generate electric power.

Diesel engines offer higher thermal efficiency and durability. Due to these advantages, the environmental pollution caused by diesel engines becomes a major concern throughout the world.

As per need analysis various researches are under process to control pollution, to protect ozone layer and to increase performance and emission characteristics by using alternative fuels. Bio fuels are being given serious consideration as potential sources of energy in the future, particularly in developing countries like India. The use of edible oil to produce biodiesel in India is not feasible in view of big gap in demand and supply of such oil. As India is deficient in edible oils, some developmental works have been carried out by government of India for producing bio diesel from non traditional oil like Jatropha, karanja, neem, undi, sal, etc. By considering the present scenario the alternative fuels are contributing to overcome the situation. Alternative fuels derived from biological sources provide a means for sustainable development, energy conservation, energy efficiency and environmental protection. Some of the alternative fuels explored are biogas, ethanol, vegetable oils etc. Hence in this research mahua oil used as bio fuel to conduct the performance and emission characteristics and properties of the oil such as calorific value, flash point, fire point and viscosity in C.I engine and also technical feasibility of the oil.

2. PRESENT WORK

Properties	Mahua oil	Diesel
Kinematic viscosity @ 40°C (N-s/M2)	38.4	4.1
Density @ 30°C (kg/m3)	912	840
Flash point (°C)	180°C	51°C
Pour point in (°C)	12°C	15°C
Net calorific value (kJ/kg)	37082	43600
Acidity (mg KOH/gm)	27.9	0.2
Ash (%)	0.1	0.01
Carbon residue (%)	0.43	0.3
Moisture (%)	0.09	0

In the present work, biodiesel was produced from the mahua oil through transesterification process and effect of various parameters like molar ratio and amount of catalyst to be used were investigated to achieve maximum yield. Mainly here focused on the performance and emission characteristics of mahua non-edible vegetable oil and its blend with diesel on a single cylinder diesel engine and its suitability as an alternative fuel. The oil blended with diesel in 25/75%, 50/50%, 75/25% and 100% on the volume basis, then analyzed and compared with diesel. The performance and emission characteristics of blends are evaluated at variable loads (brake power) of 0,1,2,3,4,5 kW at constant rated speed of 1500 rpm and results are compared with diesel.

3. EXPERIMENTAL SET UP

The experiment test bed consists of single cylinder, naturally aspirated, four strokes, constant speed and water cooled, direct injection diesel engine. An eddy current dynamometer; fuel tank with thermostat controlled heater is inbuilt in control panel with fuel measuring unit, and two filters are installed: one at exit of tank and other at fuel pump. Thermocouple is used to measure the lubricating oil temperature; Exhaust gas analyzer and smoke opacity meter is used to measure exhaust gas composition and smoke density and finally a high speed computer based design data acquisition system is used in which cylinder pressure and TDC signals were acquired and stored.

Table 1: Comparison of properties of mahua oil & diesel

Fig.1 Experimental setup of Diesel Engine

3.1 Technical features of smoke meter

Smoke sampling: Partial flow
Zeroing: Automatic
Measurement Range %: 0-100% with 0.01 Resolutions
Measurement Range k: 0-9.99 (0.00) with 0.01 Resolution
The cooling water temperature is maintained constant (65 to 70°c) throughout the research work by controlling the flow rate of the fuel.

3.2 Engine Specifications

Make	Kirloskar oil engines Ltd. India
Type	Single cylinder Direct Injection, CI engine
Model	TV-SR II, naturally aspirated
Stroke	110mm
Bore	87.5mm
Injection pressure	180bar
Rated output	5.2 KW
Compression ratio	16.5:1
Speed	1500 r/min, constant
Working cycle	Four stroke
Type of sensor	Piezo electric
Loading device	Eddy current dynamometer

3.3 Experimental Technique:
The important fuel properties of various blends of fuel where determined according to standard procedure. Before the actual tests are carried out the engine is checked for lubrication and fuel supply. Rotating the flywheel manually and operate the decompression lever to start the engine. If the engine starting is difficult for blends, the engine is run on diesel initially. The engine was tested at injection pressures 180 bar with different blends. The experiments were conducted at constant speed of 1500rpm as applicable for stationary engine. The engine was coupled with an eddy current dynamometer. The standard instrumentation was used to measure the fuel consumption, exhaust temperature, coolant temperature for the stabilization of measuring parameters at each load setting and at the start of each test, time period of 10 minutes and 30 minutes were allowed. Four blends of transesterified mahua oil with diesel, pure oil and pure diesel were tested with the engine. The fuel blends were prepared in the proportion of B25, B50, B75 and B100 volume by volume with diesel, respectively. Pure transesterified mahua oil (100%) is also used as another blend to run the engine. The base line test was conducted with diesel only. In the process of testing with transesterified mahua oil – diesel fuel blends, no change was made in the engine. The engine was directly started on the fuel blends without a change over from diesel fuel. The engine performance was compared on the basis of diesel parameters i.e. power output, specific fuel consumption, brake thermal efficiency, heat input and brake specific energy consumption.

The values of power output, specific fuel consumption (SFC) and brake thermal efficiency, and heat input and brake specific energy consumption etc. readings are automatically calculated and stored in high speed computer based design data acquisition system.

4. RESULTS AND DISCUSSION

Six sets of experiments were conducted on single cylinder direct injection diesel engine by using diesel, mahua oil and biodiesel as fuels. In each set of tests readings of engine power, fuel consumption, exhaust gas temperature, brake

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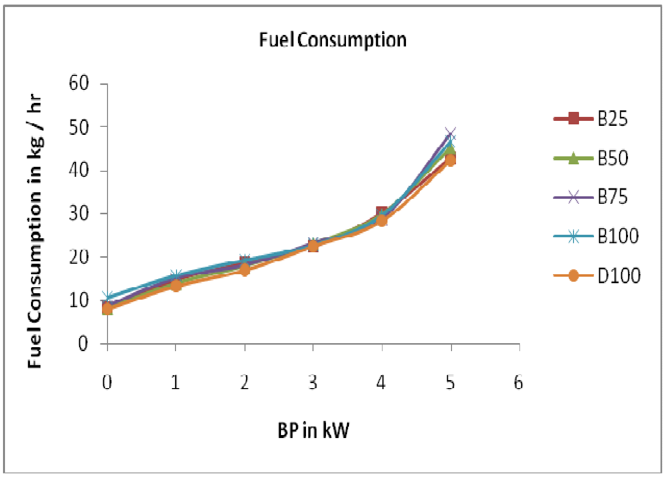
thermal efficiency, volumetric efficiency cylinder wall temperatures, and so on, were taken for zero to different loads at constant speed.

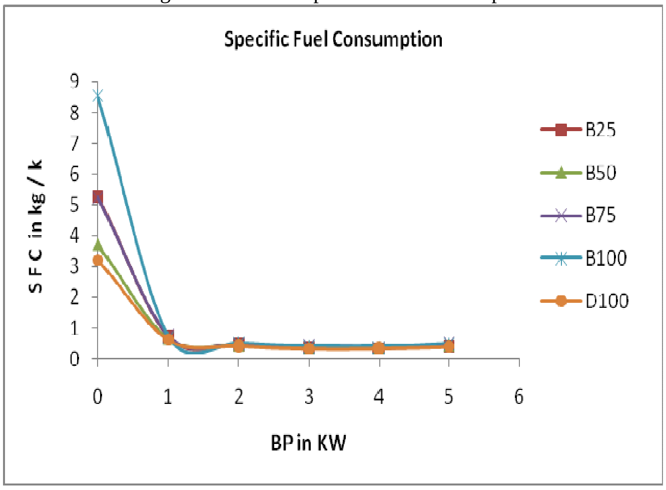
Performance Characteristics

Fig.4.1 Variation of Fuel Consumption



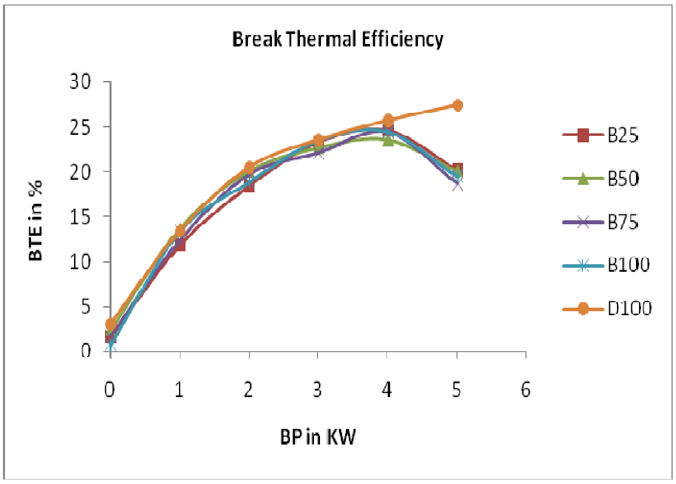
Comparison of the Fuel consumption for the diesel engine run with diesel and biodiesel blends is shown in Fig.4.1. The Fuel consumption values of the diesel engine run with diesel were lower than biodiesel blends and at maximum load it is slightly higher than those of the diesel engine. Fuel consumption is decrease up to 4% in the case of diesel engine run with biodiesel (mahua oil) at maximum load.

Fig.2 Variation of Specific Fuel Consumption



Comparison of the specific Fuel consumption for the diesel engine run with diesel and the biodiesel blends is shown in Fig.4.2. Because of the higher surface temperatures of its combustion chamber, the BSFC values of the biodiesel blends were lower than those of the diesel engine. The relative reduction in the SFC is seen to be within the range of 3–7%. Lower heating value of the biodiesel blends caused an increase in specific fuel consumption of the biodiesel.

Fig.4.3 Variation of Break Thermal Efficiency



Brake thermal efficiencies of diesel engine run with diesel and biodiesel blends at injection pressure 180 bars is shown in the fig.4.3. Here, thermal efficiency diesel is lower than to biodiesel because of the reduction in heat loss to the coolant water and conversion of heat into useful work due to better atomization of fuel which leads to the complete combustion of fuel. The brake thermal efficiency of the biodiesel improved due to the engine power and torque did not deteriorate too much according to diesel fuel.

Fig.4.4 Variation of Volumetric Efficiency

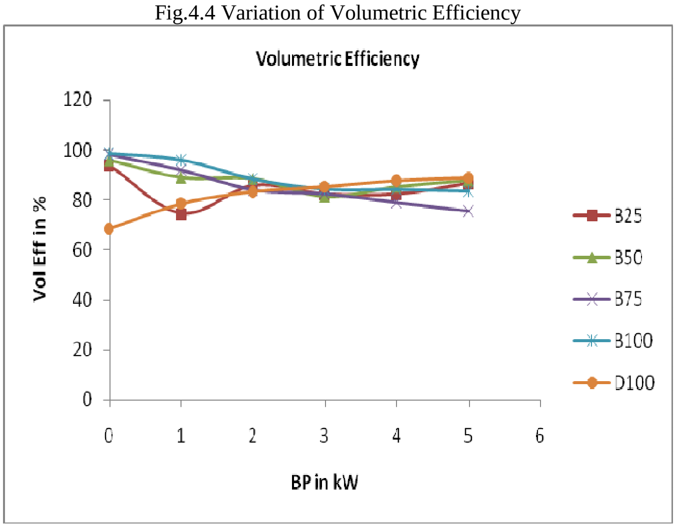


Fig.4.4.shows the comparison of volumetric efficiency of biodiesel with diesel. The volumetric efficiency of the biodiesel blends was observed to be higher than diesel at part loads (2kW and 3kW) and was decreasing with the increase in the load. This can be attributed to the presence of oxygen in the biodiesel which helps in complete combustion of fuel even at maximum loads thereby releasing more heat which intern causes in the heating up of intake manifold and thereby, in the reduction of volumetric efficiency.

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Fig.4.5 Variation of Exhaust Gas Temperature

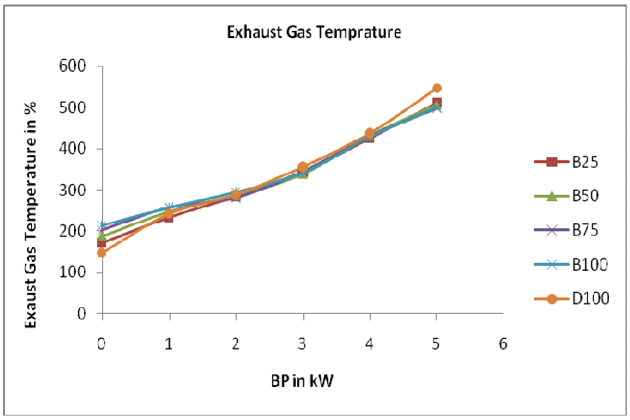

Fig.4.5.shows the comparison of Exhaust gas temperature of biodiesel with diesel. EGT indicates the burning efficiency. In diesel engine, there are four stages in combustion process, if the after burning stage is more or engine misfires or injection time is not proper then there is every possibility that EGT may be high. On the other hand, if the combustion process is perfect, then also EGT is likely to be high. It may be observed that thermal efficiency is more in case of biodiesel and this leads to a probable conclusion that the combustion process is better.

Emission Charecristics

Fig.4.6 Variation of Smoke in K

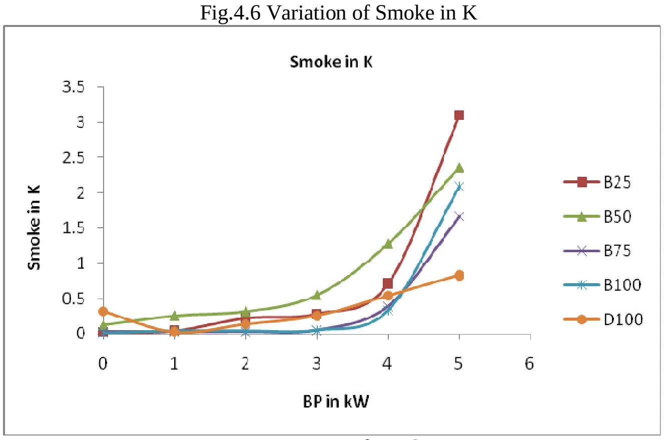

Fig.4.7 Variation of Smoke in %

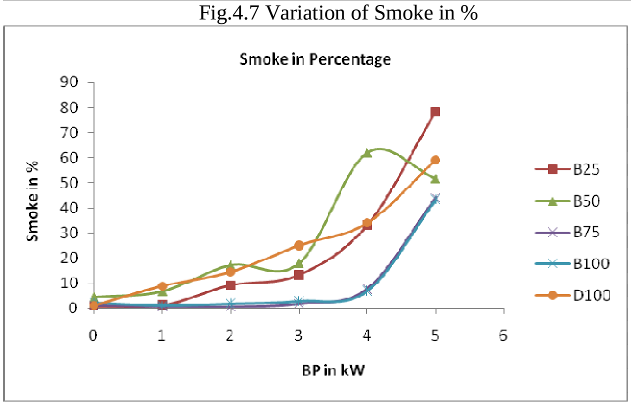

Fig 4.6 and Fig 4.7 shows variation of smoke emission with brake power for diesel, mahua oil and its blends in the test engine. Emission of smoke at low load and part load for mahua oil is lower than diesel this is due to the higher efficiency of mahua oil. It is found that the smoke density of the engine with mahua oil operation was higher than diesel.This negative effect is mainly due to the high viscocity and poor voltality of mahua oil caused poor injection and mixing charactiristics and incomplete combustion, these can be overcome by preheating the mahua oil.better performance. This is due to shorter delay period of fuel blends. The shorter delay period is mainly due to higher cetane number and better vaporization of fuel additives hence this duel effect helps to improve combustion temperature.

Fig.4.8 Variation of Smoke in K

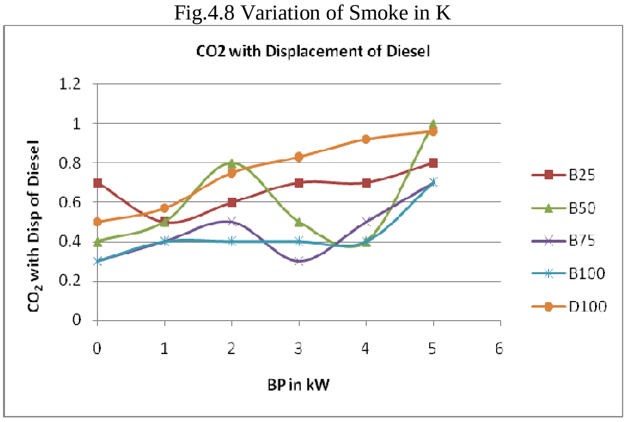

Fig.4.8 Shows the variation of CO2 concentration with diesel, mahua oil and biodiesel. It is observed that CO2 emission is more in case of ester based fuel due to the presence of oxygen and generally emission carbon dioxide increses with increasing load for both biodiesel and diesel . Increasing percentage of biodiesel in the blend, decrease the emission of CO2. For B25 biodiesel the CO2 emission is comparable with diesel.For B50 and B75 biodiesel the emission is less than diesel. This may be because of the fact that biodiesel is a low carbon fuel and also biodiesel has low elemental ratio of carbon to hydrogen as compare to diesel. Thus all CO2 released by the burning of biodiesel has no adverse effect on greenhouse gas formation.

Fig.4.9 Variation of Carbon Monoxide

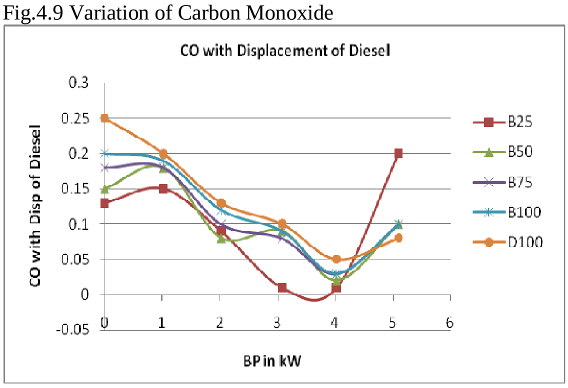

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Fig 4.9 Shows the variation of CO concentration with diesel, mahua oil and biodiesel. Here observed that at light load carbon monoxide of biodiesel is less than the diesel but while increasing the load carbon monoxide of biodiesel increases than the diesel this is due to incomplete combustion beacause of improper mixing of mahua oil with air. This can be reduced by preheating the mahua oil.

Fig.4.10 Variation of Unburnt Hydro Carbon

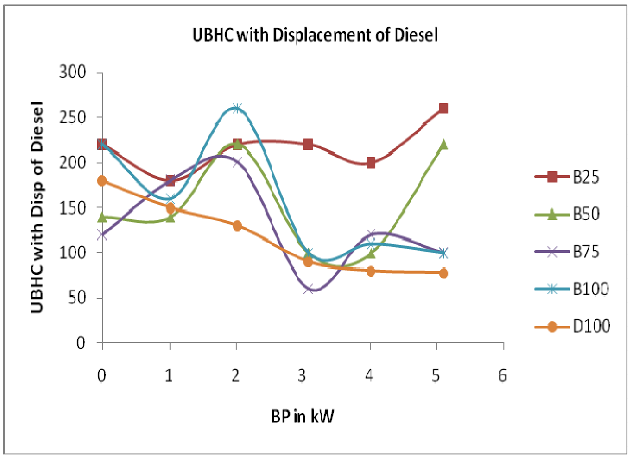

Fig 4.10 Shows the variation of UBHC concentration with diesel, mahua oil and biodiesel. In this test we have observed that HC concentration of biodiesel was higher than the diesel at all loads, this is due to poor injection of mahua oil and improper mixing with air in preparation phase, so resulted in incomplete combustion. To decerese the HC concentration better to preheat the mahua oil.

5. CONCLUSION

By transesterification process the fuel (biodiesel) properties are closer to diesel fuel.The better yield obtained for transesterification process at 25 ml of methanol, 2 gm of KOH for 100 ml of mahua oil. When biodiesel was used as fuel, increments in the engine efficiency were mainly caused by the higher mixture heating value of the biodiesel. The deterioration of the engine efficiency for biodiesel fuel was caused by the higher viscosity of the biodiesel The brake thermal efficiency of B25 was maximum at the injection pressure of 180 bars than any other blends. If the % of biodiesel is increased more than 25% then viscosity slightly increases. Therefore efficiency gets decreases. If the % of biodiesel is less than or equal to 25% then viscosity is optimum. So that, B25 has maximum efficiency.

The brake specific fuel consumption of B25 was minimum because of less fuel consumption. This is due to the density of the biodiesel is little much higher than diesel.

Brake specific energy consumption is also similar to that of brake specific fuel consumption and also at B25 has minimum value.

From the emissions test, we can say that B100 is more effective which has very less emissions than compared to any blends

The emissions of carbon monoxide and hydro carbons are minimum when the percentage of bio diesel is increasing in the blend. This is because generally the vegetable oils have fewer emissions.

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