Performance and Emission Characteristics of Methyl Esters of Mahua Oil Blended with Diesel

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***Abstract*— The present work examines the use of non-edible oil viz Mahua. Basically Mahua oil is highly viscous viz 38.86 in this experiment. After trans-esterification it reduces to 4.5. Hence this oil has to be blended with diesel on volumetric basis so as to bring the viscosity in acceptable limits. A four stroke, single cylinder, water cooled compression engine with a bore of 80mm and stroke 110 mm is operated on neat diesel and a blend of up to 30%,with 10% of step addition of biodiesel. It was observed that increase in the biodiesel blend increases the brake thermal efficiency, power efficiency. Also emissions like UBHC, CO decrease.**

Keywords*— Mahua Oil, diesel engine, blending, performance, emissions

1. INTRODUCTION

There is an escalating concern over the price rise of crude petroleum. The exhaust emissions of diesel engines posed a basic threat to the global warming and acute health related problems. Thus the major foreign exchange of developing countries is diverting to import bill of crude petroleum products. Also there is a great pressure on international front to reduce the emission and subsequent global warming. Alternate fuel area is the one wherein the vegetable oils can be tested on diesel engines to conserve the petroleum products. Diesel engine has better fuel economy and lower strata of emissions of UBHC and CO due to better air utilization. However diesel engines are prone to higher levels of particulate matter and smoke density with NOx emissions. Hence vegetable oils with trans-esterification are an alternative to replace the diesel fuel use in partial.

Properties of crude vegetable oils suffers from higher range of viscosity and low volatility result in poor atomizing process and thus mixing with the air. Origin of the vegetable oil is also affects the oil content and other related properties. Trans-esterification of vegetable oil reduces the viscosity and other related properties and makes it suitable for the blending with neat diesel. However complete replacement is very difficult to provide. Biodiesel derived from nonedible feed stocks such as Mahua is reported as the feasible choice for developing countries. Growing Sharanappa G et.al[1] observed improved engine performance using Mahua as bio diesel. H Rehaman Gadge[4] used high speed Ricardo E6 engine and tested engine performance and emission. They found reductions in emission and brake specific fuel consumption together with increase in brake power,brake thermal efficiency. Mahua trees would also help in protecting the environment and benefit the farmers as well. It is the best substitute for kerosene [10]. Sukumar Puhan et.al [11] investigates the effect of injection pressures on performance, emissions, and combustion characteristics of DI engine using high linolenic oil methyl ester and observed reduction in CO,UBHC and smoke emissions with increase in oxides of nitrogen. Other researchers [1,2, 15, and 16] has also observed the same range viscosity. Transesterification and its utitlity in I C engines is an area of interest and any experimental validation provides the support for the same.

2.1 ENGINE SPECIFICATION

The photograph of diesel engine with thermocouple for sensing exhaust gas temperature is shown in figure 1. It is of single cylinder, four stroke, water cooled, and compression ignition engine with a bore of 80mm and stroke 110mm. Fuel is supplied to the fuel pump by gravity feed, through the fuel tank and paper element filter. The engine can be started by hand cranking using decomposition lever.
The tests were conducted at Reva Institute of Technology and Management, Banglore. The ester was mixed with the diesel in the proportion of 10, 20, 30 % on volume basis. For example, B0 indicates blend Mahua methyl ester (0% &diesel (100 %), B20 (Mahua methyl ester 20% and diesel 80%), etc on volume basis. The performance of the engine is evaluated in terms of brake thermal efficiency, brake specific energy consumption, exhaust gas temperature, and emission of the engine is analyzed (HC, CO, CO2).

Following parameters were measured from the experimental CI engine setup.
1. Brake power
2. Fuel consumption
3. Air consumption
4. Exhaust gas temperature
5. Cooling water temperature (inlet and outlet)
6. Speed of the engine
7. Exhaust gas analysis (CO2, UBHC, CO)

Table 5 The engine specifications

SL NO	PARAMETERS	SPECIFICATION
1	Type	TV 1 (kirloskar made)
2	Nozzle opening pressure	200 to 225 bar
3	Governor type	Mechanical centrifugal type
4	Number of cylinders	Single cylinder
5	Number of strokes	Four stroke
6	Fuel	Diesel
7	Compression ratio	16.5:1
8	Cylinder diameter (Bore)	80mm
9	Stroke length	110mm

Electrical Dynamometer

10	Type	Foot mounted, continuous rating
11	Alternator rating	3KVA
12	Speed	2800-3000RPM
13	Voltage	220 V AC

4 RESULT AND DISCUSSIONS

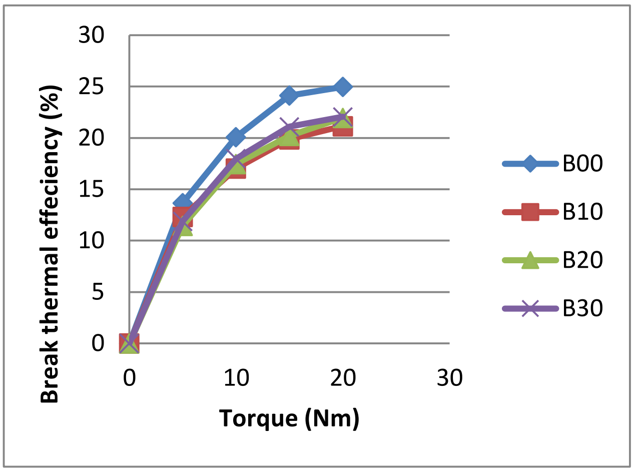
4.1 Engine performance

Biodiesel has a low calorific value due to the presence of dissolved oxygen i.e approximately 9 to 10 % lower than the neat diesel. Also the specific gravity is also high i.e.0.92 as compared to 0.85 of neat diesel. This reduces the energy content of biodiesel by 5 to 6 percent. The engine performance is carried out under following parameters.

4.2.1 Brake thermal efficiency:

The effect of load/bp on the brake thermal efficiency for ND and B10, B20, and B30 are shown in figure 3,4. As load/bp increases, there is a steady increase in brake thermal efficiency in all operational ranges. Mahua oil shows low decreased brake thermal efficiency as compared to ND over the entire load range. Though the oxygen present in biodiesel enhances the combustion characteristics, the higher range of viscosity, surface tension and poor spray characteristics due to high density reduces the atomization and poor spray pattern resulting in reduced brake thermal efficiency. Lower calorific values of biodiesel add to the reduced brake thermal efficiency. Maximum brake thermal efficiency is 23.38% for B30 at 20 N-m which is comparable with neat diesel. Range of B40 and B50 seems to be very near to the performance of neat diesel. It can be concluded that the performance of the engine with biodiesel blends is comparable to that of with HSD, in terms of brake thermal efficiency [1, 4, and 5]. This trend is also found in other methyl ester i.e.Jatropha observed by other researcher [12]

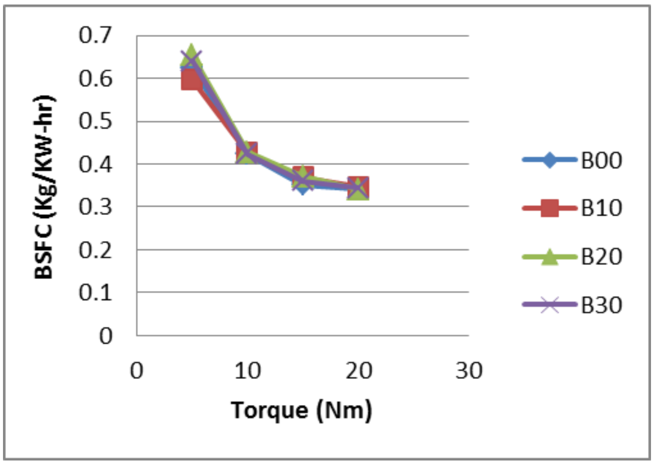
Fig 4 Brake Th Efficiency Vs Torque



4.2.2Brake specific fuel consumption (bsfc):

Bsfc of pure diesel is lower than that of other biodiesel. As the load increases the bsfc of all blends decreases[4]. This is due to the fact that ester has lower heating value compared to diesel; so more ester-based fuel is needed to maintain constant[4]. However at higher loads the neat diesel and other blends performance is comparable. This is due to the percent increase in fuel required to operate the engine is less than the percent increase in brake power due to relatively less portion of the heat losses at higher loads[1] For B20 at 5 N-m torque the bsfc is 0.65299 kg/kW-h, whereas it is 0.3404 kg/kW-hr for 20 N-m torque which is very near to diesel.

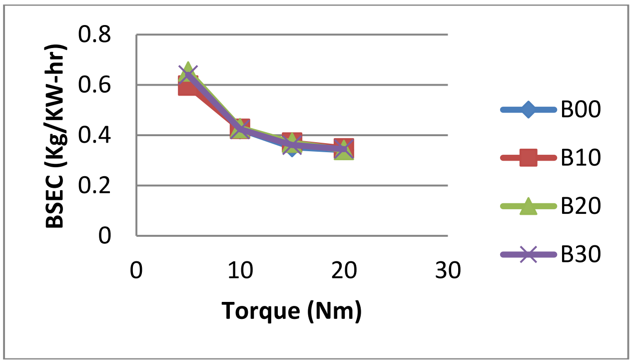
Fig 5 bsfc Vs Torque



4.2.3 Brake Specific Energy Consumption (BSEC):

As an ideal variable due to independent of the fuel, it is easy to compare energy consumption rather than fuel consumption. The variation in BSEC with bp/load for all fuels is presented in Figure 6 & 7. Brake specific energy consumption enables us to compare the fuel having different calorific values and densities. This specific energy consumption measures the amount of input energy required to develop one -kilowatt power. This is an important parameter to compare brake thermal efficiency of an engine because it is taking care of both mass flow rate and heating value of the fuel [4].In all cases, it decreased sharply with increase in percentage of bp/load for all fuels.At B30 bsec is near for higher values of bp. Hence B30 blend appears as the suggestible blend. The main reason for this could be percent increase in fuel required to operate the engine is less than the percent increase in BP due to relatively less portion of the heat losses at higher loads The lowest bsec is found fo B30 at higher loads. The bsec for all blends was higher than that of diesel. Different trends were obtained for different researchers[1],

Fig 7 Comparison of bsec with Torque for diesel, methyl ester of MOME and its blends

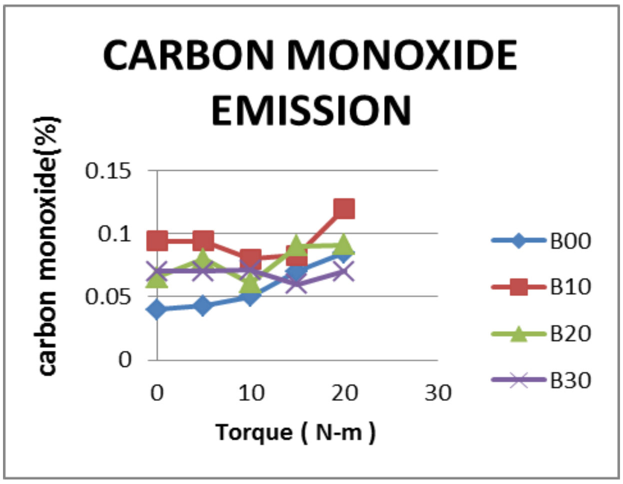


5. EMISSION CHARACTERISTICS:

Emissions are the concern of the present century. .Biodiesel is an alternative to meet the stringent emission norms of the country. Due to dissolved oxygen, the thermal efficiency is relatively better compared to neat diesel. However concern continues with the higher NO_x emissions. NO_x emission arises from the conditions of high temperature and oxygen availability.

5.1 CO Emissions:

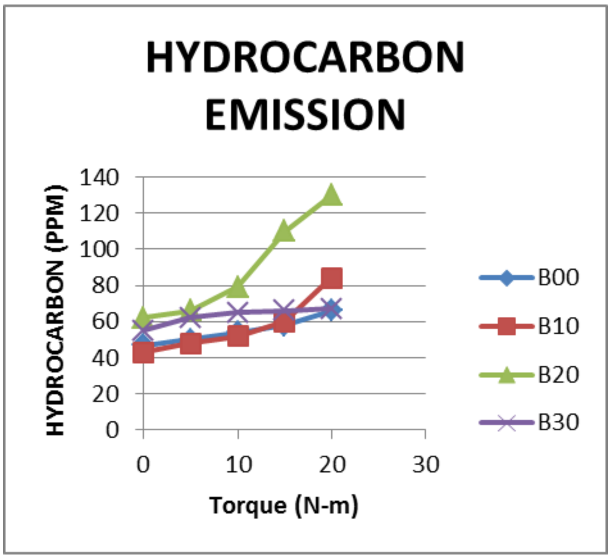
Fig 6 comparison of CO emission with Torque for diesel, methyl ester of Mahua and its blends



CO emissions are higher in biodiesel blends in comparison to neat diesel at low loads. This is agreeable with the other researcher [8]. This is due to cold engine, higher viscosity and poor atomization resulting in poor heat release. However at higher load the CO emissions of B60 reduce due to higher dissolved oxygen. B50 shows the lower emissions at higher loads. The other researcher also witnesses the same results [6].

5.2 HC Emissions:

Fig 7 Comparison of HC with Torque for diesel, Mahua methyl ester of and its blends



6. CONCLUSIONS:

From above investigation the following conclusion are drawn

1. The use of Mahua biodiesel and its blend result in better performance within the limits of B30 due to the higher values of viscosity as compared to then neat diesel.

2. The brake thermal efficiencies are significantly improved and become higher than diesel. Maximum brake thermal efficiency obtained is for the blend B20, which is by 3.65% as that of diesel at higher loads.

4. The fuel properties Mahua of seed methyl ester were within limits; all other fuel properties of Mahua methyl esters were found to be higher as compared to diesel.

5. The brake specific fuel consumption increased and brake thermal efficiency increased with increase in the proportion of biodiesel in blends.

6. The fuel properties of Mahua seed methyl ester were within limits; all other fuel properties except calorific

value of Mahua seed methyl esters were found to be higher as compared to diesel.

7. The brake specific fuel consumption decreased and brake thermal efficiency increased with increase in the proportion of biodiesel in the blends. A reverse trend was observed with increase in load.

Hence, Mahua seed methyl esters are may be considered as diesel fuel substitute.

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