Investigation on Performance and Emission characteristics of Mahua Methyl Ester (MME), in Single Cylinder Diesel Engine using Different Blends

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Abstract— In this present work, Mahua oil a non-edible type is used for studying its suitability in diesel engine and to study the fuel properties such asspecific fuel consumption, brake thermal efficiency, emissions of CO, CO_2, NOx, and un-burnt hydrocarbonsof methyl ester of Mahua oil blends with diesel fuel from 20 to 100% by volume and running in a single cylinder four-stroke diesel engine. Tests were performed on the diesel engine; various above mentioned properties of these fuels are evaluated and compared to that of conventional diesel fuel.

Keywords: Mahua methyl ester (MME), conventional diesel, trans-esterification process

I. INTRODUCTION

The world is presently confronted with the twin crises of fossil fuel depletion and environmental degradation. Indiscriminate extraction and lavish consumption of fossil fuels have led to reduction in underground-based carbon resources. The search for alternative fuels, which promise a harmonious correlation with sustainable development, energy conservation, efficiency and environmental preservation, has become highly pronounced in the present context. The fuels of bio-origin can provide a feasible solution to this worldwide petroleum crisis. Gasoline and diesel-driven automobiles are the major sources of greenhouse gases (GHG) emission. Scientists around the world have explored several alternative energy resources, which have the potential to quench the ever-increasing energy thirst of today's population. Various biofuels, energy resources explored includes biomass, biogas, primary alcohols, vegetable oils, animal fats, biodiesel, etc.

The esterification-transesterificationstage evidently able to increase the quantity and quality of biodiesel from used frying oil. By esterification, theyield increased and the free fatty acid content reduced. Transesterification with 6:1 methanol molar ratio and 1.5% catalyst couldincrease the yield up to 9.9%[1].Use of multi functional additives for diesel will lead better fuel conservation and emissioncontrol takes place. Engine performance values did not change significantly with biodiesel fuels, but exhaust emissionprofile was improved [2].

Transesterification of cottonseed oil was carriedout using ethanol and potassium hydroxide (KOH). The maximum predicted % yield of98% was obtained at a catalyst concentration of 1.07% (wt/wt) and ethanol to cottonseed oil molar ratio of 20:1 atreaction temperature of 25 ^{0}C [3].

Two different biodiesels were prepared from animal fat-basedyellow grease with 9% free fatty acids and from soybean oil. The neat fuels and their 20%blends with No. 2 diesel fuel were studied at steady-state engine operating conditions in a fourcylinderturbocharged diesel engine. Both biodiesel fuels provided significantreductions in particulates, carbon monoxide, and unburned hydrocarbons, the oxides of nitrogen increased by 11% and 13% for the yellow grease methyl ester and soybean oil methyl esterrespectively [4].

This work is compare the performance and emissions of a diesel engine run on soybean oil methyl ester (SOME), Pongamia methyl ester (PME) and diesel fuel. A 4-stroke single cylinder direct injection water cooled constant speed diesel engine was first run with diesel fuel and then bio-diesel. The performance of the two biodiesels (SOME&PME) and diesel is compared on the basis of brake thermal efficiency and exhaust gas temperature and the emissions compared are carbon monoxide, hydrocarbons, smoke number and oxides of nitrogen. It is found from the results that biodiesels differ very little from diesel in performance and emission [5].

Tocomparethe engine performance and emission results ofbiodiesel produced from Jatropha oil when applied in differentproportions in multi cylinder diesel engine. Results revealed thatbiodiesel blends produce less CO (up to 52.6%) and lower HC(up to 48%) with an increase in emission of NO (up to 11.82%).Biodiesel also presented a slight increase in brake specific fuelconsumption (up to 8.33%) which may be acceptable consideringthe reduction in exhaust emissions [6].

II. EXPERIMENT WORK

A. Steps Involved in the Production of Mahua Methyl Esters:

- Refining of oils
- Analysis of vegetable oils
- Stage selection for the conversion of crude oil to esters
- Acid catalyzed transesterification, shown in fig. 1 & Fig. 2
- Base catalyzed transesterification, fig.3
- Water wash, fig.4

Fig. 2.1(a): Mahua Seed Oil Heating With Reactants in a Three Neck Flask

Fig. 2.1(b): FFA and other Impurities Separated from Oil After 1st Stage of Transesterification

Fig. 2.2: Glycerol Settling After the Stage of Transesterification

Fig. 2.3: The Separated Glycerol and Water Washed Esters in Separating Flask

B. Properties of the Biodiesel Obtained after Transesterification:

Density(kg/m^3)	880
Specific gravity	0.88
Flash point(^{0}C)	217
Free fatty acids	6.25%
Acid number	17.5
Calorific value(KJ/kg)	39988.12

Table 2.1: Properties of Biodiesel

C. Experimental Setup:

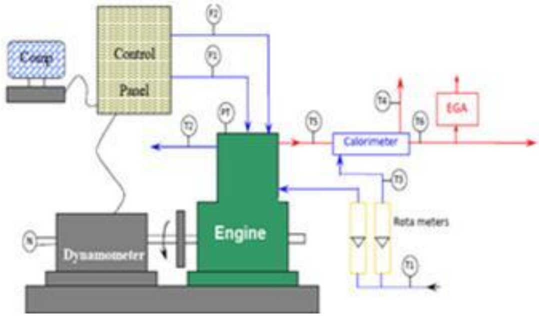

Fig.2.35: Experimental Setup

Where, T1, T3 = Inlet Water Temperature.

- T2 = Outlet Engine Jacket Water Temperature
- T4 = Outlet Calorimeter Water Temperature
- T5 = Exhaust Gas Temperature before Calorimeter
- T6 = Exhaust Gas Temperature after Calorimeter
- F1 = Fuel Flow DP (Differential Pressure) unit
- F2 = Air Intake DP unit
- PT = Pressure Transducer
- Wt = Load
- N = RPM Decoder
- EGA = Exhaust Gas Analyzer (5 gas).

D. Engine Test Procedure:

A four stroke, single cylinder water cooled diesel engine is employed in the present study. Experimental set up as shown in fig.5 QROTEK 401 fig.6 Five gas analyzers was used to measure the concentration of gaseous emissions such as Oxides of nitrogen, unburned hydrocarbon, carbon monoxide, carbon dioxide and oxygen level. The performance and emission tests are carried out on the C.I. The engineuses various blends of diesel-biodiesel-ethanol blends as fuels. The tests are conducted at the constant speed of 1500rpm at various torque.

In the present experiment, engine parameters related to the thermal performance of the engine such as brake thermal efficiency, brake specific fuel consumption, brake specific energy consumption, exhaust gas temperature is measured. In addition to that, the engine emission parameters such as Oxides of nitrogen, unburned hydrocarbon, carbon monoxide, carbon dioxide and oxygen level.

Fig. 2.4: Five Gas Exhaust Analyzer with Probe

III. RESULTS

A. Performance and Emission Characteristics of MME Fuel at Injection Pressure 200 Bar at 20%, 40%, 60%, 80% and 100% Biodiesel:

- Waterflow: 30cc/Sec

- Injection pressure: 200 bar
- Engine Speed: 1500 RPM
- Injection Timing: 27^0BTDC

1) Brake Thermal Efficiency:

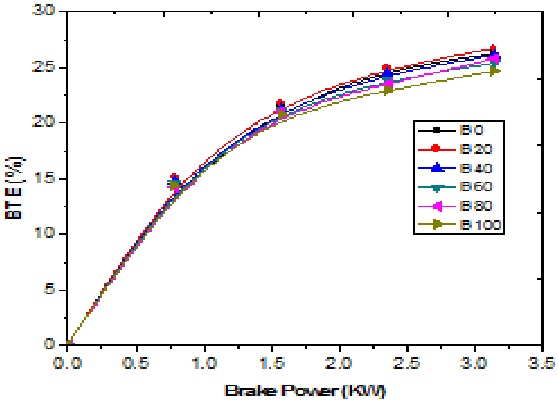

Fig. 3.1: Variations of Brake Thermal Efficiency with Brake Power

Fig.7 shows the brake thermal efficiency, increased with brake power for all fuel mods. The brake thermal efficiency of Mahua oil biodiesel (B100), blend of diesel and biodiesel (20%, 40%, 60%, 80% and 100%) is as shown in the graph. The brake thermal efficiency of blend B20 was higher than that of the conventional diesel fuel over the entire range of the load. The reason may be the extended ignition delay and the leaner combustion of biodiesel.

2) Brake Specific Fuel Consumption:

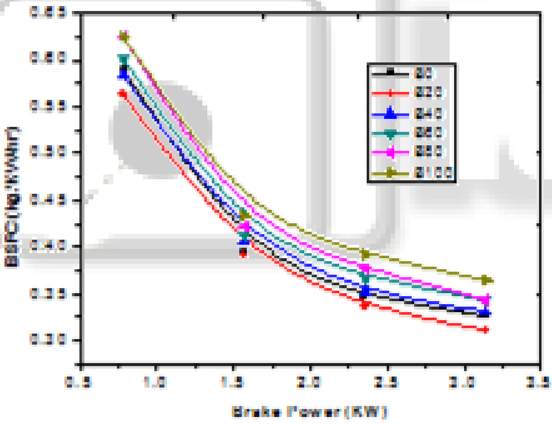

Fig. 3.2: Variation of Brake Specific Fuel Consumption with Brake Power

The variation of brake specific fuel consumption with brake power for diesel fuel and MME blends (20%, 40%, 60%, 80% and 100%) is as shown in the figure.

The BSFC reduced with load for all the fuel modes. The BSFC for the blend B20 is less as compared to diesel and all the other blends (B40, B60, B80 and B100) consumes more fuel than diesel. The BSFC increased by 8.08%, 10.71%, 12.58% and 13.78% respectively, with the blends B20, B40, B60 and B80 compared with diesel.

3) Carbon-Dioxide Emission:

The variation of carbon dioxide with brake power for diesel fuel and MME blends (20%, 40%, 60%, 80% and 100%) is as shown in the fig.9

The CO_2 emissions increased with load for all the fuel modes

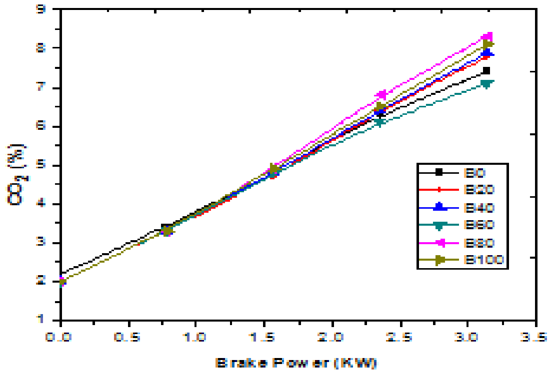

Fig. 3.3: Variation of CO_2 with Brake Power

CO_2 emission for the blends B100 and B80 are higher than the emission from diesel and blend B20. The CO_2 emission increases with the increase in percentage of the blend (bio-diesel). The CO_2 emissions increased by 3.7%, 2.30% and 3.03% respectively with 20%, 40% and 80% of biodiesel in diesel compared to diesel at maximum load condition. And also the carbon dioxide emission of B100 increases a value of 5.45% when compared to diesel at maximum load condition.

4) Hydro-Carbon emissions:

The variation of hydro carbon emission with brake power for diesel fuel and MME blends (20%, 40%, 60%, 80% and 100%) is as shown in the fig.10

The HC emissions were minimum at medium load and maximum at full load of the engine for all the fuel modes. The HC emission of the pure biodiesel and the biodiesel blends where less as compared to pure diesel.

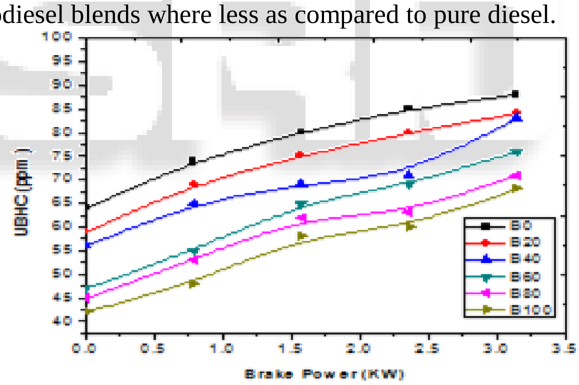

Fig. 3.4: Variation of Hydrocarbon with Brake Power

The pure biodiesel produced lowest HC emissions among all fuels. Biodiesel has a higher Cetane number than conventional diesel, resulting in more complete combustion in the cylinder.The HC emissions were 3.5%, 5.55%, 6.75%, 8.02% and 9.77% lower than those of diesel fuel at full load of the engine. Among these blends, the blend B100 had the lowest HC emissions at the full load of the engine

5) Oxides of nitrogen emission:

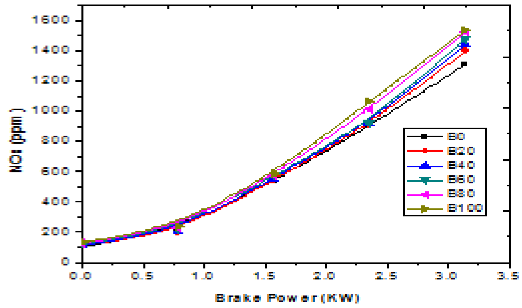

Fig. 3.5: Variation of Oxide of Nitrogen with Brake Power

The variation of Oxides of nitrogen emission with brake power for diesel fuel and MME blends (20%, 40%, 60%, 80% and 100%) is as shown in the fig.11

The NOx emissions of biodiesel, and diesel-biodiesel blends goes on increasing and it is more at medium and high loads than those of diesel fuel. It is due to the higher oxygen content and combustion temperature of the biodiesel.

The NOx emissions of B20, B40, B60, B80 and B100 were 1.49%, 2.95%, 3.56%, 4.65% and 5.16% higher than diesel at full load of the engine. The oxide of nitrogen emission of B100 goes on increasing and it is 8% higher than the diesel.

6) Carbon-Monoxide Emission:

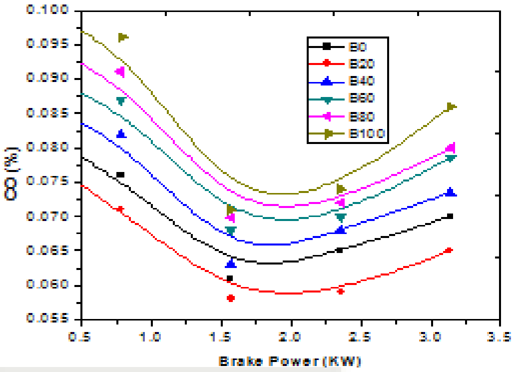

Fig. 3.6: Variation of Carbon Monoxide with Brake Power

The variation of carbon monoxide emission with brake power for diesel fuel and MME blends (20%, 40%, 60%, 80% and 100%) is as shown in the fig.12

The CO emissions slightly increased at low and medium loads and increased significantly at higher loads with all the fuel modes. The CO emissions of the diesel-biodiesel blends were not much different from that of conventional diesel at low and medium loads as shown in the figure. However, the CO emissions of these blends decreased significantly, when compared with those of conventional diesel at full load of the engine. This is due to the higher amount of oxygen with the biodiesel addition, which will promote the further oxidation of CO during the engine exhaust process.The CO emissions reduced by 22.2%, 33.3%, 44.4% and 54.4% for the blends B40, B60, B80 and B100 than the conventional diesel.

7) Unused Oxygen Emission:

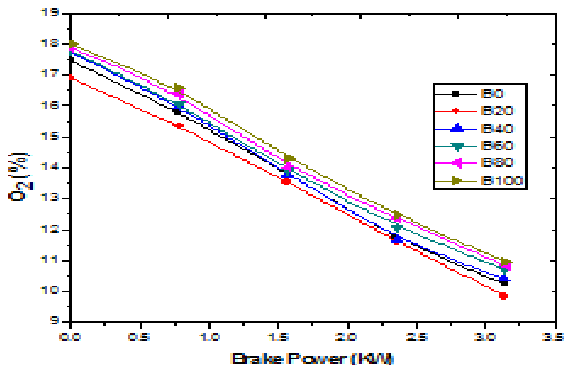

Fig. 3.7: Variation of Unused Oxygen with Brake Power

The variation of unused oxygen emission with brake power for diesel fuel and MME blends (20%, 40%, 60%, 80% and 100%) is as shown in the fig.13

The unused oxygen emissions reduced with load for all the fuel modes. The unused O_2 emission of biodiesel (B100) is 1.87% lower than those of diesel fuel. From figure B20 has the less unused O_2 when compared to the other blends (B40, B60, B80 and B100) and diesel. The unused O_2 emissions of blend B20 is 1.87% lower than of diesel fuel. The O_2 emissions reduced with increase in biodiesel percentage in the blend.

IV. CONCLUSIONS

1) The recovery of Mahua methyl ester of lowest kinematic viscosity (5.0 Cst) with 98 % recovery is possible at the following standardized parametric conditions.

First stage (Acid catalyzed)	**Second stage (Base catalyzed)**
Methanol concentration: 30%	Methanol concentration: 15%
Reaction temperature: 55-60^{0}C	Reaction temperature: 55-60^{0}C
Catalyst concentration (con. H_2SO_4): 0.2%	Catalyst concentration (KOH): 1.2%
Reaction time: 2 hours	Reaction time: 2 hours
Settling time: 6 hours	Settling time: 6 hours

2) The injection pressure 200 bar was found to be the optimum IP and better results were obtained for biodiesel blends at 200 bar IP
3) The emission such as CO and UBHC were lower for biodiesel and increase of NOx emission in the case of biodiesel.5.

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