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Comparative Analysis of Performance and Emission Parameters of A C.I. Engine Fuelled With Different Blends Of Biodiesel Derived From Mahua Oil And Waste Cooking Oil

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Abstract: Now a day the world is facing the duel crises of fossil fuel depletion and environmental degradation. From the point of view of global environment protection and the concern for long-term supplies of conventional diesel fuels, it becomes necessary to develop alternative fuels comparable with conventional fuels. Alternative fuels should be, not only sustainable but also environmentally friendly. Biodiesel is a safe alternative fuel to replace traditional petroleum diesel. The present study focuses on comparison of performance and emission of a 4-stroke CI engine run on three different biodiesels viz. MOME, MOEE and WCOME separately. A single cylinder four stroke diesel engine (Kirloskar) was tested at full load with the blended fuel at the rated speed of 1500 rpm. MOME, MOEE and WCME blended with diesel in proportions of 5%, 10%, 15% and 20%, by volume and pure diesel were used as fuel. Engine performance (specific fuel consumption, brake thermal efficiency, and Brake power) and exhaust emission (HC, CO, CO2 and Nox) were measured to evaluate and compute the behavior of the diesel engine running on biodiesel. The engine test result shows higher brake thermal efficiency and lower NOx Emission in case of methyl ester of Mahua oil compared to other two fuels i.e. MOEE and WCOME.

Keywords: Mahua oil Methyl Ester, Mahua oil Ethyl Ester, Waste cooking oil, Performance and Emission.

I. 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 a non-traditional, non- edible oil also known as Indian butter tree. Another best alternatives is biodiesels obtained from Waste cooking oil, mainly coming from frying residues, can be used as raw material to obtain a diesel fuel (biodiesel) The high cost of biodiesel is mainly due to the cost of virgin vegetable oil. The use of waste frying oil, instead of virgin oil, to produce biodiesel is an effective way to reduce the raw material cost because waste frying oil is estimated to be about half the price of virgin oil [3-4]. Each human being in this mother earth can feel the effect of economic crisis that is mainly caused by unstable price of petroleum. Waste cooking oils (WCO) can be used directly as diesel substitute waste cooking oil disposed from restaurants in large quantities. But higher viscosity restricts their direct use in diesel engines.

The present experimental work investigates about the production of biodiesel from Mahua oil and waste cooking oil by transesterification with methanol and ethanol preparation of test fuels for the engine experiments in the form of three blends of MOME, MOEE,WCME and Diesel as B5, B10, B15 and B20 and measurement of various engine performance and emissions parameters.

II. 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 methyl esters as well as ethyl ester .The methyl and ethyl 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 to70°C. 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 glycerine 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 [4]. Transesterification reactions for waste cooking oil were carried out in a 250ml glass reactor with a condenser. Used Waste Cooking Oil which was heated to 100°C was got from a sweet stall. First, a known quantity of the catalyst system loaded externally was dispersed in methanol under magnetic stirring. Then Waste Cooking Oil (WCO) in the molar ratio of 6:1, methanol to oil was added to the mixture and heated to about 60°C. The reaction was allowed to take place for two hours after which the two phase product formed as a result of transesterification was separated using a separating funnel. Upper layer consists of biodiesel, alcohol and some soap(formed as result of side reaction saponification free fatty acids get converted to soap) Lower layer consists of Glycerine, excess alcohol, Catalyst, impurities, and traces of unreacted oil. Purification of the upper layer was done by washing with warm water. As water is immiscible with Biodiesel it can easily be separated from biodiesel. Fuel properties of all test samples were determined as prescribed by BIS, India. The physical properties of, Mahua oil methyl ester Mahua oil Ethyl Ester and Waste cooking oil Methyl ester with Diesel are compared with diesel fuel and are given in Table 1.

Table 1**:** Comparison of properties of Mahua oil Methyl Ester, Mahua oil Ethyl Ester and Waste cooking oil Methyl Ester with Diesel [5,6,13]

Properties	**Diesel**	**MOME**	**MOEE**	**WCOME**
Density Kg/m^3	850	916	920	876
Sp. gravity	0.85	0.916	.865	.893

Kinematic Viscosity at 40^0C	3.05	5.8	6.2	5.658
Calorific Value (KJ/kg)	42800	39400	39100	39767
Flash Point ^{0}C.	56	129	164	160
Fire Point ^{0}C.	63	141	173	164

III. EXPERIMENTATION

3.1 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 2.

Table2. Test engine specifications

Rated power	5.2 kW @ 1500 rpm
Speed	1500 RPM
No. of cylinders	ONE
Compression Ratio	17.5 : 1
Bore	87.5mm
Stroke	110mm
Orifice Diameter	20mm
Type of Ignition	Compression Ignition
Method of loading	Rope Brake
Method of Starting	Crank Start

3.2 Working Procedure

The Bio-diesel prepared by using Mahua and waste Cooking oil was tested in a Single cylinder Four stoke diesel engine running at full load and constant speed of 1500 rpm. Ambient temperature of the test laboratory was maintained at 30°C while carrying out the work. The MOME, MOEE and WCOME are blended with diesel in the different ratios.

3.3 Engine performance and Emission test

Engine performance test with pure diesel, biodiesel B5, biodiesel B10, biodiesel B15 and biodiesel B20 are given below.

Table3 BSFC (kg/kWh) at full load for different blends

Fuel type	**MOME**	**MOEE**	**WCOME**
DIESEL	0.33	0.33	0.33
B5	0.35	0.38	0.4
B10	0.36	0.38	0.45
B15	0.36	0.36	0.42
B20	0.38	0.4	0.47

Table 4 B.P (kW) at full load for different blends

Fuel type	**MOME**	**MOEE**	**WCOME**
DIESEL	4.91	4.91	4.91
B5	4.93	3.82	3.85
B10	5.02	3.12	4.2
B15	5.06	3.12	4.6
B20	5.06	4.02	4.5

Table 5 BTE (%) at full load for different blends

Fuel type	MOME	MOEE	WCOME
DIESEL	23.83	23.83	23.83
B5	21.05	18.19	21.5
B10	22.32	18.57	21.2
B15	23.17	20.06	20.13
B20	23.08	21.03	19.02

Table 6. HC emission (ppm) at full load for different blends

Fuel type	MOME	MOEE	WCOME
DIESEL	67	67	67
B5	70	80	110
B10	68	76	100
B15	30	50	123
B20	73	85	124

Table7. CO Emission (ppm) at full load for different blends

Fuel type	MOME	MOEE	WCOME
DIESEL	0.01	0.01	0.01
B5	1.4	2.03	0.03
B10	0.97	1.82	0.02
B15	0.03	0.32	0.03
B20	1.24	2.2	0.29

Table 8. CO_2 Emission (ppm) at full load for different blends

Fuel type	MOME	MOEE	WCOME
DIESEL	10.08	10.08	10.08
B5	11.6	11.5	11.7
B10	10.4	11	11.5
B15	5.3	5.3	6.3
B20	12.5	12.6	13.03

Table 9.NOx emission (ppm) at full load for different blends

Fuel type	MOME	MOEE	WCOME
DIESEL	1908	1908	1908
B5	1764	1604	1853
B10	1840	1830	1902
B15	645	500	1400
B20	1446	1208	2006

IV. **RESULTS & DISCUSSION**

4.1 Engine Performance

The Engine performance was measured using 100% Diesel, 5%, 10%, 15% and 20% blends of MOME, MOEE and WCOME 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.

4.1.1 Brake Power

Variation in B.P of different fuel with respect to biodiesel % in the blend at constant load is shown in the Fig. 1. The power developed by the engine is lower for MOEE and higher for MOME However with B20 blend the brake power of all fuel is very close to that with diesel

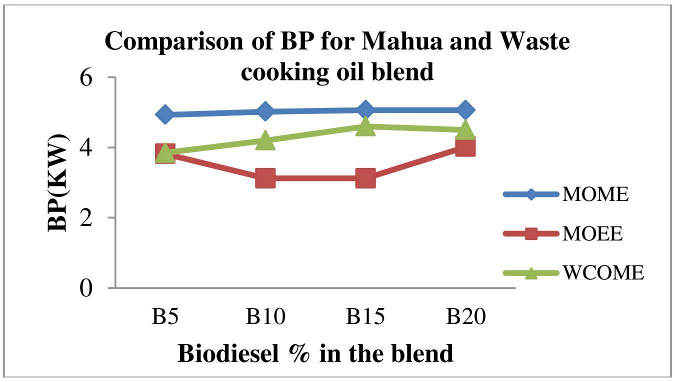

Fig.1 Comparison of Brake power for Mahua and Waste cooking oil biodiesel blends

Diesel is having the highest heating value amongst B5, B10, B15 and B20. So, maximum brake power is obtained in fuelling diesel in comparison toB5, B10, B15 and B20 respectively

4.1.2 Brake specific fuel consumption (BSFC)

Variation in BSFC of different fuel with respect to biodiesel % in the blend at constant load is shown in the Fig. 2

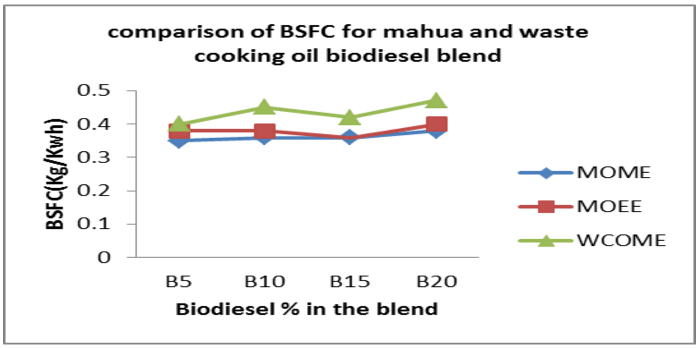

Fig. 2 Comparison of fuel consumption for Mahua and Waste cooking oil biodiesel blends.

From the graph It was observed that the brake specific fuel consumptions MOEE is lower among these three fuel and higher than diesel at constant load up to blends B20.The specific fuel consumption was found to be higher than diesel at full load because of the combined effects of lower heating value and the higher fuel flow rate due to high density of the blends. 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. The higher BSFCs for MOME, MOEE and WCOME can be related, reasonably, to the lower calorific value of the biodiesels. Due to lower calorific value of biodiesels, more biodiesel is consumed in order to meet the load demand

4.1.4. Brake Thermal Efficiency

Variation in BTE of different fuel with respect to biodiesel % in the blend at constant load is shown in the fig.3.

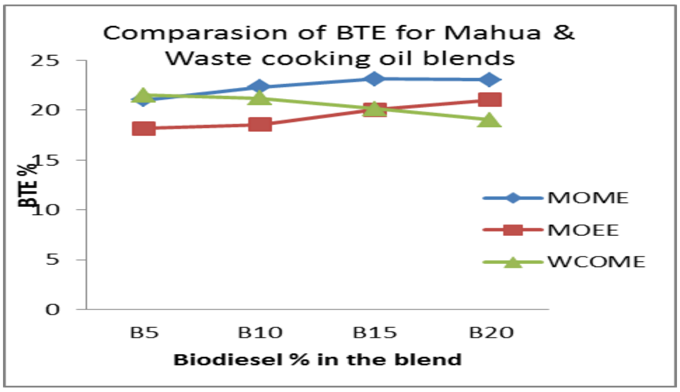

Fig. 3 Comparison of brake thermal efficiency for Mahua and Waste cooking oil biodiesel blends

From graph and Table 4 it was observed that at full load conditions, brake thermal efficiency of MOME is higher than other two fuels i.e MOEE and WCOME for different blend ratio up to B20 but is less than diesel. The lower calorific value and higher viscosity of biodiesels compared to that of diesel are responsible for low BTE of biodiesels. The higher viscosity of biodiesel is the cause for poorer mixture formation in the cylinder.

4. Engine Emissions

4.1 Hydrocarbons (HC)

Fig.4 shows the variation in the quantity of unburnt hydrocarbons of different fuel with respect to biodiesel % in the blend at full load condition.

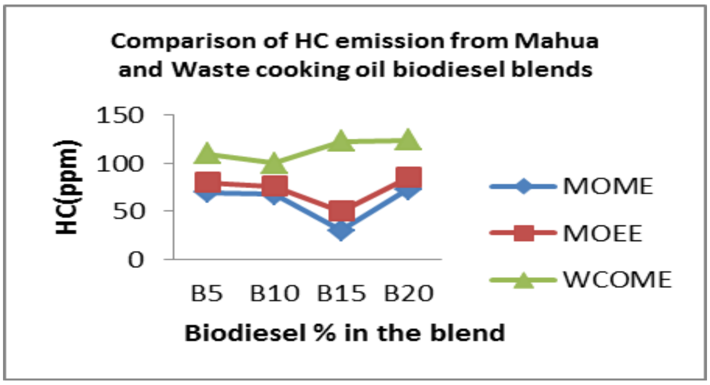

Fig. 4 Comparison of HC emission from Mahua and Waste cooking oil biodiesel blends

At full load WCOME produce maximum unburnt hydrocarbons in comparison to other test fuel along with diesel also. This is due to the presence of methanol in crude biodiesel which result in low cetane number value of the waste cooking oil biodiesel. Because unburned hydrocarbons are the products of incomplete combustion, the lower cetane number of blend fuels results in lower tendency to form ignitable mixture, and thus, higher unburned hydrocarbons. Higher viscosity of the waste cooking oil biodiesel also plays a key role in increasing the unburnt hydrocarbons in the exhaust emissions. Due to the higher viscosity, all of the hydrocarbons present in the waste cooking oil biodiesel do not get completely burnt, so come out in the engine exhaust in the form of carbon particles.

4.2.2. CO Emissions

Fig.5 shows the variation in the quantity of carbon mono-oxide of different fuel with respect to biodiesel % in the blend.

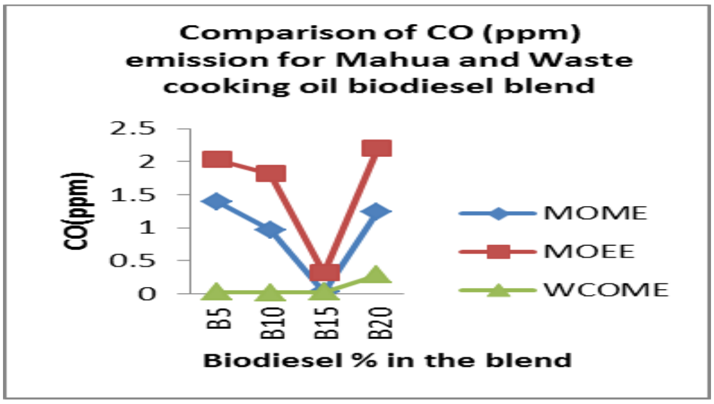

Fig. 5 Comparison of CO emission from Mahua and Waste cooking oil biodiesel blends.

At full load conditions, amount of CO emitted by B5, B10, B15, B20 and diesel is almost same whereas amount of CO emissions produced MOEE is more than other two fuels. CO is mainly produced due to incomplete combustion. In case of B10 and B15, there is less amount of methyl esters present as compared to B20. So, B10 and B15 gets required amount of oxygen to get converted into CO_2, thus resulting in less CO as compared to diesel and B20. B20 does not get required amount of oxygen to get converted into CO_2, so results in more quantity of CO in the engine exhaust.

4.2. CO_2 Emissions

Fig. 6 shows the variation in the quantity of carbon dioxide of different fuel with respect to biodiesel % in the blend.

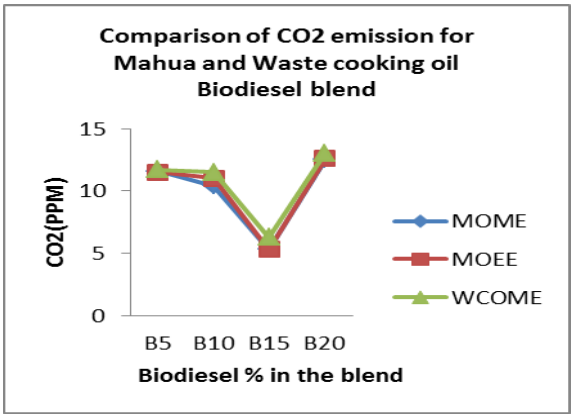

Fig. 6 Comparison of CO_2 emission from Mahua and Waste cooking oil biodiesel blends

From graph it was observed that WCOME emits more CO_2 as compared to other two fuels i.e. MOME and MOEE at full load condition and for all fuels it is less for blends B15.

4.2.3. NO_X Emissions

Fig.7 shows the variation in the quantity NOx emission of different fuel with respect to biodiesel % in the blend at full load condition.

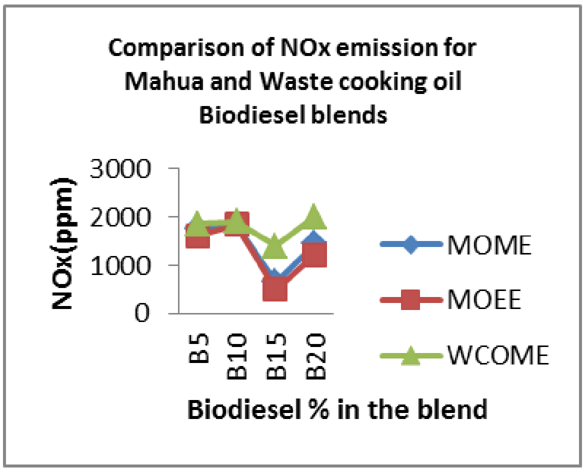

Fig. 7 Comparison of NOx emission from Mahua and Waste cooking oil biodiesel blends.

The amount of NOx produced by B5, B10, B20 and diesel is almost same at full load conditions and the amount of NOx produced by MOEE is less as compared to the other fuels. At full load conditions, there is increase in the amount of NOx emitted by biodiesel blends and diesel.

V. CONCLUSIONS

Firstly the methyl esters of Mahua oil and waste cooking oil were prepared by transesterification. In the second part experiments were carried out at full load condition. A B5, B10, B15, B20 blends of Mahua oil and Waste cooking oil methyl ester ware used as fuel for conducting the experiments. After that comparative analysis based on engine performance and emission results of B5, B10, B15 and B20 blends of Mahua oil and Waste cooking oil methyl ester with diesel The fuel properties and the combustion characteristics of WCOME are found to be similar to those of diesel. A minor decrease in thermal efficiency with significant improvement in reduction of particulates, carbon monoxide and unburnt hydrocarbons is observed compared to diesel The specific fuel consumption increases with increase in percentage of biodiesel in the blends due to the lower calorific value of biodiesel and The brake thermal efficiency decreases with increase in percentage of biodiesel in the blend. Among all these tested fuel BSFC is higher and BTE is lower for WCOME. The emissions of HC, CO, CO_2 and NO_x against load are shown in Figures 4 to 7, all emissions are higher for WCOME in comparison with other two fuels and all emissions by MOME is lower except NOx emission.

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