Experimental Studies on Single Cylinder CI Engine using Mahua Oil and Ethanol Blends

Narinder Singh, Narinder Kumar, SK Mahla

Abstract: ***Continuous rise in the conventional fuel prices and shortage of its supply have increased the interest in the field of the alternative sources for petroleum fuels. In this present work, experimentation was carried out to study the performance and emission characteristics of mahua oil and ethanol blends. For this experiment a single cylinder, four stroke, air cooled diesel engine was used. Initially the engine was run on diesel fuel and the readings were recorded. Then the engine was run on mahua oil and its different blends with ethanol. The blends containing 5, 10 and 15 percent ethanol fuel by volume were denoted as M5, M10 and M15 respectively. The tests were carried out over entire range of engine operation at varying conditions of load. The engine performance parameters studied were brake horse power, brake specific fuel consumption and brake thermal efficiency. The emission characteristics studied are CO, HC, CO_2 and smoke opacity. Brake thermal efficiency is high at low and medium loads. For M5 there is 5.1% increase in brake thermal efficiency compared to diesel at low loads. From emission of blends, it is found that HC reduces 11%, CO and smoke decreases by 19% and 33.7% when compared to those of diesel. The present experimental results show that mahua oil and ethanol blends can be used as an alternative fuel in diesel engine.***

Keywords- Biodiesel, Mahua Oil, Transesterification, Ethanol, Performance, Emissions.

I. Introduction

Now the day's fuel is most important part of human's life, in each and every field, fuel plays a crucial role. Fuel is used in transportation vehicles and in other machines as well. Conventionally fossil fuels, like Petrol, Coal, Diesel, Kerosene, and LPG are used as fuels in majority. But as population of world increasing continuously day by day, amount of fuel consumption also increased with it.

These conventional fuels are made from non-renewable resources and cannot be used or produce again. To avoid the extinction of conventional fuels, Non – conventional fuels are developed for use. These non – conventional fuels are made of renewable sources and produce less or no pollution on burning. Such fuels like bio – diesel, hydrogen, ammonia and compressed air etc. The use of vegetable oil as a fuel source in diesel engines is as old as the diesel engine itself. However, the demand to develop and utilize plant oils and animal fats as biodiesel fuels has been limited until recently. Biodiesel can be blended in any ratio with diesel oil i.e. it can be used alone or mixed in any ratio with petroleum diesel fuel. Biodiesel offers similar power to diesel fuel. One of the major advantages of biodiesel is the fact that it can be used in existing engines and fuel injection equipment with little impact to operating performance. Biodiesel has a higher cetane number than diesel fuel. Biodiesel is a cleaner-burning diesel fuel made from renewable sources such as vegetable oils. Just like petroleum diesel, biodiesel operates in combustion-ignition engines. The use of biodiesel in a conventional diesel engine results in substantial reduction of unburned hydrocarbons, carbon monoxide and particulate matter. Bio diesel from mahua seed is important because most of the states of India are tribal where it is found abundantly. The annual production of mahua is nearly 181 Kt. Mahua is a non-traditional, non edible oil also known as Indian butter tree. Mahua seed contain 30-40 percent fatty oil called mahua oil. Mahua is a medium to large tree. In India the mahua plant is found in most of the state e.g. Orissa, Chatishgada, Jharkhand, Bihar, Madhya Pradesh, and Tamilnadu. It can be successfully grown in waste land & dry land.

Fuel	Viscosity mm^2/s at 40°C	Calorific value MJ/kg	Density kg/m^3 at 40°C	Flash point °C
Diesel	3.8	42.8	830	58
Mahua Oil	18.4	36.1	918	207

Table 1 Comparison of properties of diesel and mahua oil

Ethanol (C_2H_5OH) is one of the possible renewable fuels for diesel substitution in CI (compression ignition) engines. It can be made from any starch bearing crops such as sugarcane, sorghum, corn, barley, cassava, and sugar beets. Besides being a biomass-based renewable fuel, ethanol has a cleaner burning characteristics and a high octane rating. The auto-ignition temperature of ethanol is higher than that of diesel fuel, which makes it safer for transportation and storage. The application of ethanol as a supplementary fuel will reduce environmental pollution.

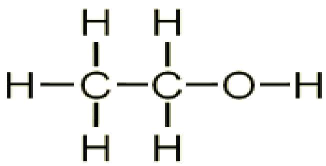

Figure 1 Chemical Structure of Ethanol

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II. EXPERIMENTAL SET-UP

The present research is aimed to investigate experimentally the performance and exhaust emission characteristics of a light medium diesel engine when running on mahua oil and blend of biodiesel with ethanol.

Biodiesel Production For the present work mahua oil is used as feedstock for biodiesel production. Alcohol and catalyst used are methanol and KOH. Following are the steps in biodiesel production:

- **Mixing of alcohol with catalyst:** In the present work, 250 ml of methanol and 7.5 gm of potassium hydroxide (KOH) was mixed in round bottom flask.
- **Reaction:** The alcohol/catalyst mixture is added to 1000 ml of mahua oil. The reaction is carried out at 60oC and atmospheric pressure for around 2 hours.
- **Separation of glycerine and biodiesel:** Once the reaction is complete, the two major products are glycerine and biodiesel. The glycerol phase is much denser than biodiesel phase and settles at the bottom of the reaction vessel and can be separated easily. The solution is left for 24 hours to settle down.
- **Purification of crude biodiesel:** Water washing is used to remove both glycerol and alcohol as they are soluble in water.

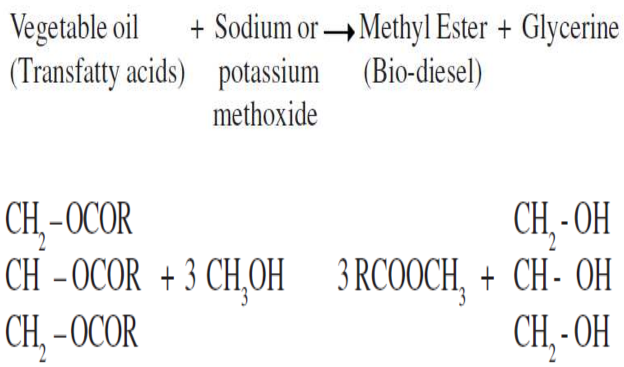


Fig 2 Chemical reaction during the process of transesterification

Diesel engine selected for the experimentation is the make of the Kirloskar Oil Engines Limited, India. It is a single-cylinder, 4-stroke, water-cooled diesel engine of 5 hp rated power. Direct injection CI engine that has been designed for petroleum diesel combustion. The fuel injector is located near the combustion chamber centre. The single cylinder diesel engine test rig consists of a generator machine coupled to a load cell and it is used to load the engine. The starting of the engine is done by manual cranking with the help of detachable pawl type handle. The fuel is supplied to the engine from the fuel tank through fuel filter after fuel measurement using burette. The pressure and temperature of the air supplied to the engine is also measured. The rotation is clock-wise facing the flywheel in the engine.

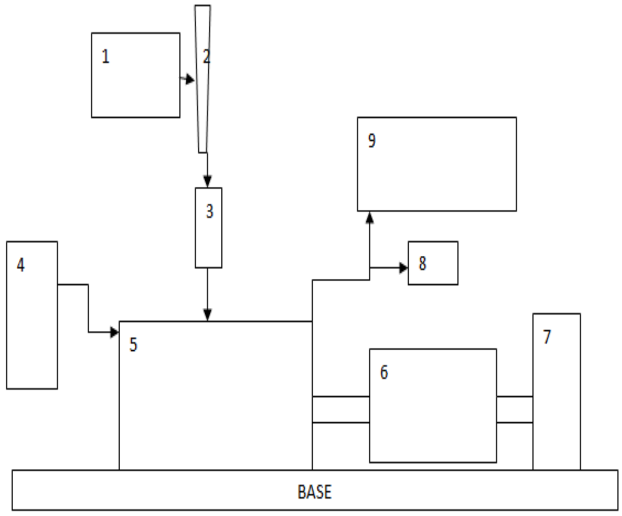


Figure 3 Schematic arrangement of the test rig

Parts of the Test Rig

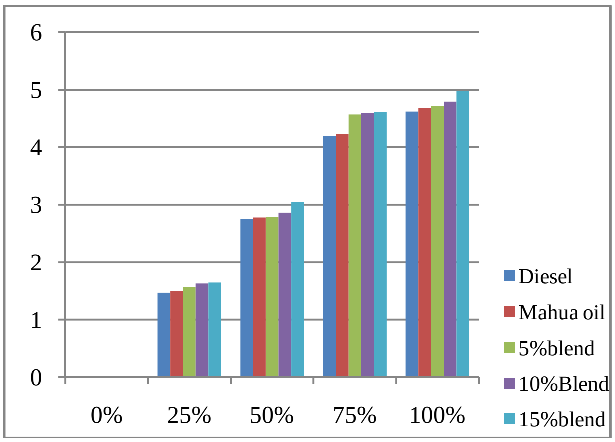
1. Fuel tank
2. Burette (for fuel measurement)
3. Fuel filter
4. Air filter
5. Diesel engine
6. Generator
7. Load cell
8. Thermocouple
9. Emission gas analyzer

III. RESULT AND DISCUSSION

The objective of the research was to demonstrate that a diesel engine could be operated with blends of bio diesel and ethanol in diesel engine with minimal engine changes. In this study Pure diesel fuel was used as a base fuel for ethanol- bio diesel blends. The blends containing 5, 10 and 15 percent ethanol fuel by volume were denoted as M5, M10 and M15 respectively. The performance of engine is evaluated on the basis of parameters:-

- Brake Horse Power
- Brake Thermal Efficiency
- Brake Specific Fuel Consumption

Effect on Brake Horse Power (BHP)

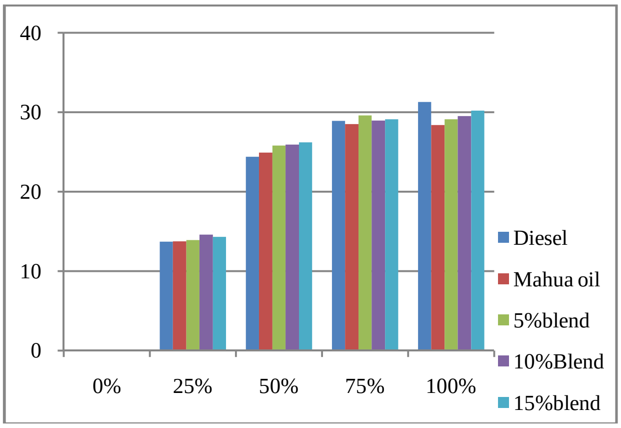


Graph 1 Variation of Brake Horse Power (kW) with Load

Graph shows that the BHP increase marginally with increase in % of ethanol and at M15 it is maximum, this is due to the fact that the addition of ethanol into the bio diesel helps in complete burning of the fuel and provides sufficient amount of oxygen for the proper combustion of the fuel.

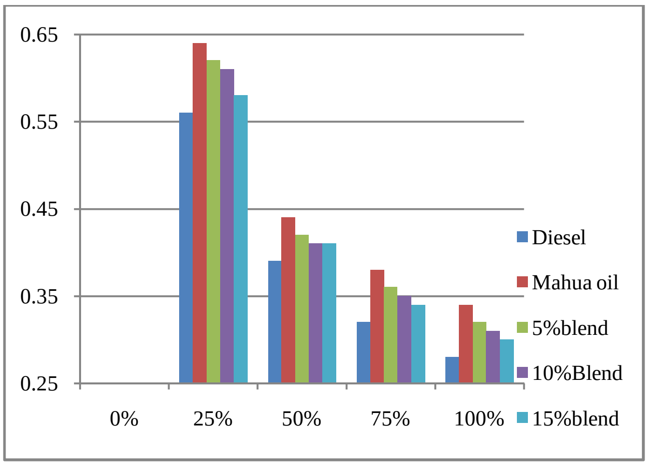
Effect on Brake Thermal Efficiency (η)

The variation of brake thermal efficiency with brake power is shown in graph. Brake thermal efficiency for M5 fuel is very close to that of diesel. At full load, the maximum brake thermal efficiency for diesel is 31.3 % for M5 the value is 29.1%, M10 is 29.5%, M15 is 30.2% and Mahua Oil is 28.4%. This decrease in values is due to poor combustion, low volatility, high viscosity and density.



Graph 2 Effect on Brake Thermal Efficiency (η)

Effect on Brake Specific Fuel Consumption (BSFC)



Graph 3 Variation of Brake Specific Fuel Consumption

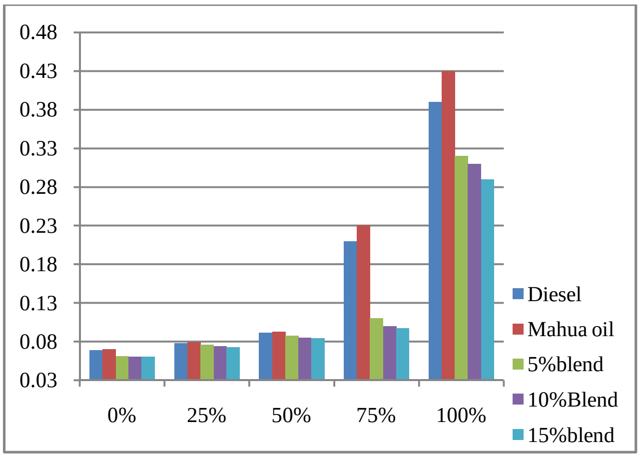
The variation of BSFC with load for different blends and loads are presented in chart 4.3. It is observed from the chart that the BSFC for all the fuel blends tested decrease with increase in load. This is due to higher percentage increase in Break power with load as compared to increase in the fuel consumption. The value of M15 fuel approximates that of the diesel. The minimum specific fuel consumption for M5 fuel and M10 are 0.32 kg/kW-hr and 0.31 kg/kW-hr against 0.28 kg/kW-hr of diesel. Specific fuel consumption of M15 is 0.30 kg/kW-hr and for mahua oil are 0.34 kg/kW-hr against 0.28 kg/kW-hr of diesel.

The exhaust emissions from the engine are evaluated on the basis of parameters:-

- Carbon Monoxide (CO)
- Hydro Carbons (HC)
- Smoke

Effect on CO

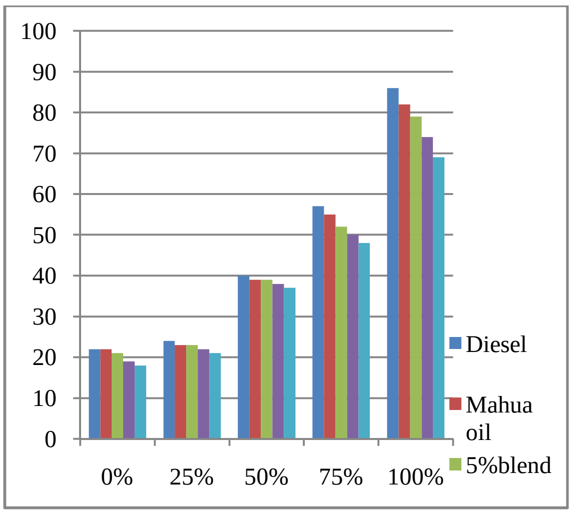
The carbon monoxide emissions are found to be increasing with increase in load from graph. It was noted that at low and medium loads, the carbon monoxide emission for M5, M10, M15 and mahua oil fuels were not much different from those of diesel. At full load, the carbon monoxide emissions of the mahua oil fuels increase significantly when compared with diesel. It is also observed that the carbon monoxide emission increase as the fuel air ratio becomes greater than the stoichiometric value.



Graph 4 Variations in CO % under Various Load Conditions

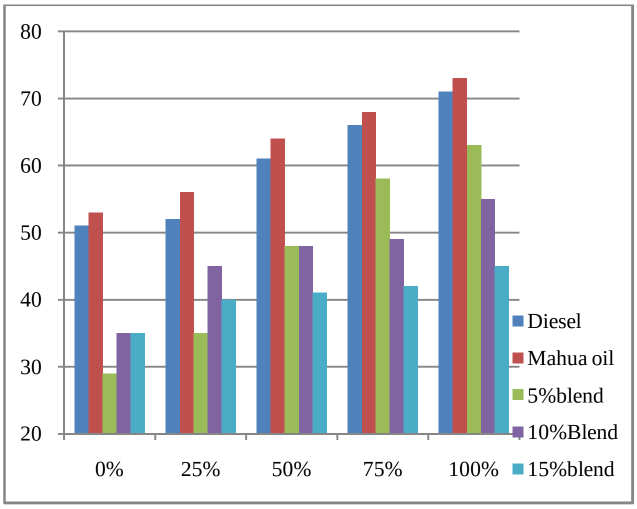
Effect on HC

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.



Graph 5 Variation of HC % under Load Conditions

Effect on Smoke Opacity



Graph 6 Variation of Smoke under Various Load Conditions

The decrease in smoke density is due to the presence of residual gases which affects the efficiency of the combustion process. The smoke density increases with increase in viscosity which results in decrease of fuel air mixing rate. With the addition of ethanol helps in maintaining the viscosity of the bio diesel and reduces the smoke opacity.

IV. CONCLUSION

The following conclusions are made based on the experimental results.

1. As the proportion of Mahua biodiesel increases in the blend, the brake thermal efficiency decreases. For M15, the brake thermal efficiency was 13.49% less than diesel but the addition of ethanol helps to compensate the losses.
2. More the proportion of Mahua biodiesel in the blend more is the increase in brake specific fuel consumption for any given load.
3. The carbon monoxide emissions are more with Mahua biodiesel but addition of ethanol reduces the CO emission.
4. At 100 % load, HC emissions for Mahua biodiesel and blends are quite high. At higher loads, as the quantity of Mahua biodiesel in the blend increases HC emissions decreases.

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