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*Research Paper*

# EXPERIMENTAL INVESTIGATIONS ON FOUR STROKE SINGLE CYLINDER DIESEL ENGINE USING MIXTURE OF MAHUA-MILK SCUM METHYL ESTER AS ALTERNATIVE FUEL

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Biodiesel is a fatty acid alkyl ester which is renewable, biodegradable and non toxic fuel which can be derived from any vegetable oil and animal fats. Vegetable oils and animal fats in their raw form have high viscosity that makes them unsuitable as fuels for diesel engines. Transesterification is one of the well-known process by which fats and oils are converted into biodiesel. The reaction often makes use of acid/base catalyst. The present study consists of the production of biodiesel from Mahua oil and Milk Scum oil with the use of potassium hydroxide as a base catalyst. The basic fuel properties of produced methyl ester was tested as per the Indian Standards and was found to be within the standard limits of biodiesel. This paper also deals with the experimental investigation on four stroke single cylinder diesel engine using diesel, biodiesel and its blends.

***Keywords:*** Mahua oil, Milk scum oil, Methanol, Potassium hydroxide, Transesterfication, Biodiesel

## INTRODUCTION

Alternative fuel derived from vegetable oil and animal fat have increasingly important due to decreasing petroleum resources and increase in pollution problems. Bio-diesel is a cleaner fuel than petroleum diesel and an exact substitute for existing compression engines. Biodiesel has received much attention in the past decade due to its ability to replace fossil fuels, which are likely to run out within a century. Especially, the environmental issues Concerned with the exhaust gases emission by the usage of fossil fuels also encourage the usage of biodiesel, which has proved to be eco friendly far more than fossil fuels. Biodiesel is known as a carbon neutral fuel because the carbon present in the exhaust was originally fixed from the atmosphere. Biodiesel can be

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used in its pure form or can be blended with diesel to form different blends. It can be used in diesel engines with very little or no engine modifications. This is because it has properties similar to mineral diesel.

Biodiesel is a nonpetroleum-based fuel defined as fatty acid methyl or ethyl esters derived from vegetable oils or animal fats and it is used in diesel engines and heating systems.

## MATERIALS AND METHODS

In the present work Mixture of Mahua and Milk Scum Methyl Ester was chosen as a new fuel for investigation.

Biodiesel from Mahua seed is important it is found abundantly in tribal areas. Mahua is a nontraditional and non edible oil also known as Indian butter tree. Mahua seed contain 30-40% fatty oil called mahua oil. The free fatty acid value of mahua oil was found to be 10.5%.

The Milk scum was collected from the Karnataka Milk Federation, Karnataka. The malk scum was heated and filtered to remove waste particle like sand, packing materials, insects and other impurities present in the scum. The free fatty acid of the oil was found to be 7.6%.

Availability of these oils is region specific and it is not possible to have sufficient amount of oil at one place to produce bio-diesel to cope with the increasing demand for energy in terms of diesel consumption. It is therefore, needed to try different mixtures of oil for biodiesel production for fulfilling the requirement of the country without depending requirement of the country without depending on the availability of a specific oil.

Mixture of Mahua and Milk Scum Methyl Ester was made by mixing of produced Mahua biodiesel and Milk Scum biodiesel in equal proportion on weight basis.

### Experimental Procedures

#### *Acid Esterification*

The experiments were performed in a laboratory scale apparatus. The raw oil was added into the reaction flask equipped with reflux condenser, magnetic stirrer and thermometer, and it was heated. When the predetermined temperature is reached, the fixed amount of alcohol/catalyst mixture was added to oil and mixing rate was held constant at 1000 rpm for all runs. The progress of the reaction was monitored by measuring acid value of oil. On completion of this reaction, the product is poured into a separating funnel for separating the excess alcohol-water fraction and impurities moves to the top surface and is removed. The acid value of the product separated at the top was determined. The product having acid value less than 2 mg KOH/g in the pretreatment process was used for the main transesterification reaction to get high ester yield after the process.

#### *Transesterification*

After removing the impurities of the product of pretreatment process, it is transesterified to mono-esters of fatty acids; however the acid value of Mahua oil and Milk Scum oil was found to be 1.54 and 1.24 mg KOH/g and was transesterified directly. The transesterification process and laboratory apparatus were the same as those of pretreatment process except for catalyst. After the transesterification reaction, the glycerin layer was separated in a separating funnel and the ester layer was washed with warm water. After washing, the methyl ester was subjected to a heating at 110 °C to remove excess alcohol and water.

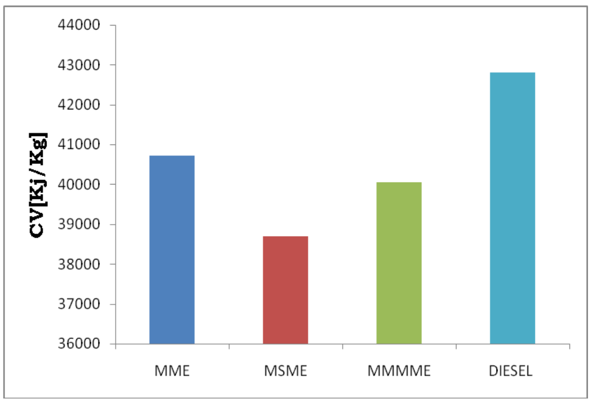
## RESULTS AND DISCUSSION

Figures 1 to 2 shows the important fuel properties like calorific value, flash point and kinematic viscosity of diesel, Mahua Methyl Ester (MME), Milk Scum Methyl Ester (MSME), and Mixture of Mahua and Milk Scum Methyl Ester (MMMME). The experiments were conducted on a direct injection compression ignition engine for various loads with an intention of studying the behavior of the engine in regard to performance and emission characteristics when it was run on several combinations of diesel, biodiesel and blends.

### Fuel Properties

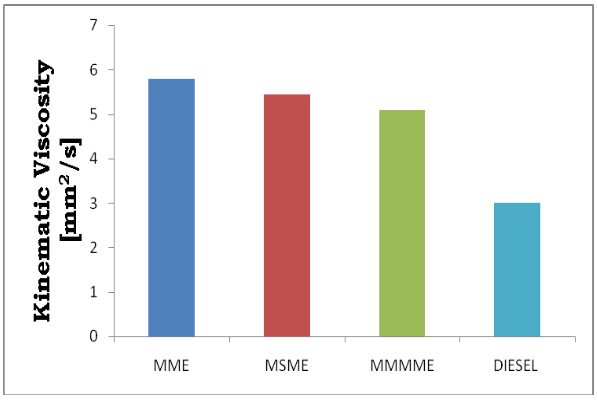
The CV is defined as the quantity of heat produced by the complete combustion of a unit mass of the fuel and it expressed in kJ/Kg. It can be seen from the Figure 1 that the calorific value of MMMME was high compared to that of MSME. This effects the brake thermal efficiency.

**Figure 1: CV of Methyl Esters and Diesel**




Kinematic viscosity is defined as the property of a fluid that resists the force tending to cause the fluid to flow. Figure 2 shows the kinematic viscosity of MME, MSME, MMMME and diesel. It can be observed that the viscosity of MMMME was less than MME and MSME.

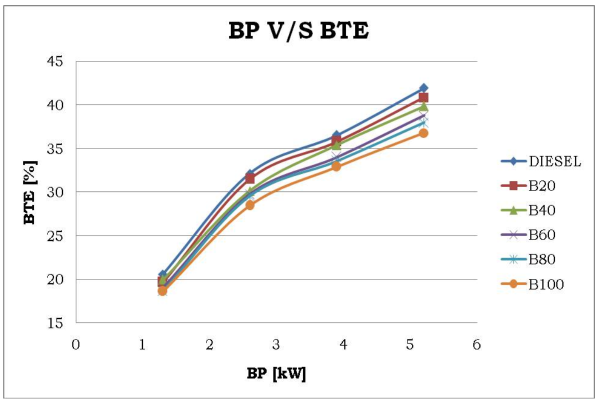
**Figure 2: KV of Methyl Esters and Diesel**




### Performance Test on Diesel Engine Using Diesel, Biodiesel and its Blends

Brake thermal efficiency is defined as the ratio of energy in the brake power, to the input fuel energy in appropriate units. The brake thermal efficiency with diesel and its blends with biodiesel at varying loads are compared in Figure 3 The thermal efficiency are observed

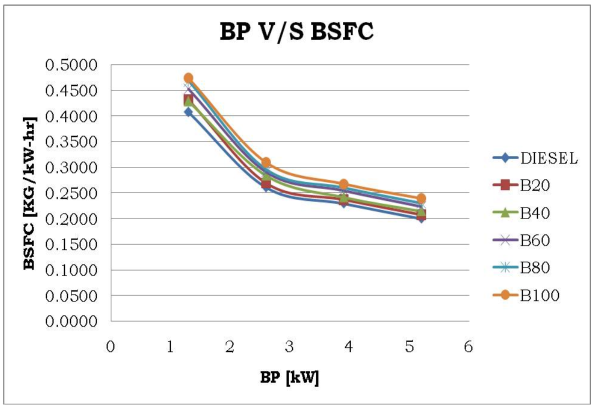
**Figure 3: Variation of BTE with BP**



to be identical at lower load conditions for all the blends but at higher load (above half load) the thermal efficiency for the blend is higher compared to neat biodiesel. It is observed that the thermal efficiency of diesel fuel is increased about 12% when compared to that of neat biodiesel at 100% load. This could be due to less specific fuel consumption and more heating value of diesel. The thermal efficiency is decreases with increasing the percentage of the blends.

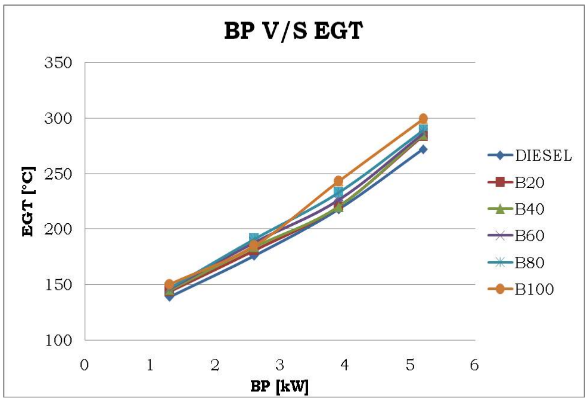
Brake specific fuel consumption is defined as the amount of fuel consumed for each unit of brake power developed per hour. Figure 4 shows the variation of BSFC with brake power for diesel, biodiesel and blends. It can be observed that the specific fuel consumption of biodiesel at all loads is higher than diesel fuel. This may be attributed to the lower heating value and higher density of biodiesel fuels. Higher proportions of biodiesel in the blends increase the viscosity which in turn increased the specific fuel consumption due to poor atomization of the fuel.

**Figure 4: Variation of BSFC with BP**



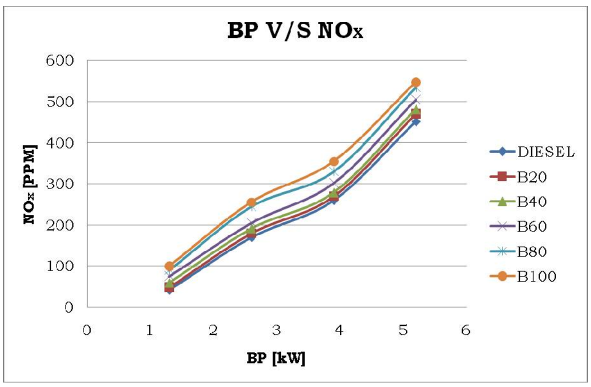

The exhaust gas temperature provides qualitative information about the progress of combustion in engine. Figure.5 shows the comparison exhaust gas temperature of diesel, neat biodiesel and its blends at varying load conditions. The biodiesel contains oxygen which enables the combustion process and hence the exhaust gas temperatures are higher.

**Figure 5: Variation of EGT with BP**




Nitrogen oxides are measured by an exhaust analyzer in parts per million (ppm). Nitrogen oxides are by products of combustion. NOx emissions are extremely undesirable. Three conditions which favor NOx formation are higher combustion temperature, more oxygen content and faster reaction rate. Figure 6 shows the variation of NOx with brake power. It is observed that the NOx emission

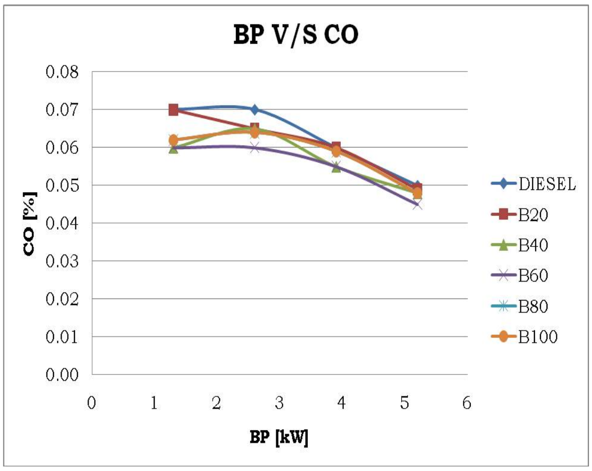
**Figure 6: Variation of NOx Emission with BP**



was more for the biodiesel compared to that of diesel at all the loads. This could be due to increase in the exhaust gas temperature.

Carbon Monoxide is measured by an exhaust analyzer in percentage. Carbon monoxide is one of the compounds formed during the intermediate combustion stages of hydrocarbon fuels. As combustion proceeds to completion, oxidation of CO to $CO_2$ occurs through recombination reaction between CO and the different oxidants. If these recombination reactions are incomplete due to lack of oxidants or due low gas temperature, CO will exist. Figure 7 shows the carbon monoxide emission of diesel, biodiesel and blends at various loads. B60 shows the lower CO emission compared to neat diesel at all loads.

**Figure 7: Variation of CO Emission with BP**




## CONCLUSION

The following conclusions are drawn from this investigation

- Important fuel properties like kinematic viscosity, flash point, density, pour point and calorific value are found to be within the limits of biodiesel standards.
- The thermal efficiency of diesel fuel is higher about 12% when compared to that of neat biodiesel at 100% load.
- It was observed that the specific fuel consumption of biodiesel and its blends at all loads was higher than diesel fuel.
- The exhaust gas temperature of biodiesel is the highest among all biodiesel blends and neat diesel fuel was observed. This increases the formation of NOx.
- The CO emissions low for biodiesel and its blends compared to diesel fuel were observed.

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