# Experimental Investigation of Performance, Emission and Combustion Characteristics of Mahua Biodiesel in a Multi Cylinder Engine at Varying Load and Varying Speeds

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*Abstract*— The automobiles play an important role in the transport system. With an increase in population and living standard, the transport vehicles as well as car population is increasing day by day. All these are increasing exhaust pollution and particularly in metros as density of these vehicles in metros are very high. This work deals with the experimental work carried out to evaluate the effects of Mahua biodiesel on the performance, emission and combustion characteristics of a multi cylinder (four), four stroke, vertical, water cooled, computerized TATA make IndicaV2 diesel engine. The investigations carried out in studying the fuel properties of Mahua biodiesel. Engine tests have been carried out with the aim of obtaining comparative measures of brake power, brake specific fuel consumption, Exhaust gas temperature and emissions such as CO, HC smoke and $NO_x$ to evaluate and compute the behavior of the diesel engine running on biodiesel at different speeds such as 1500 rpm, 2500 rpm and 3500 rpm. Engine performance values such as , brake thermal efficiency, brake specific fuel consumption, exhaust gas temperature have been investigated on varying engine speed with variation of loads and emissions such as CO, smoke $NO_x$ and HC also investigated, According to the results, the best performance and less emission obtain with Mahua biodiesel at 2500 rpm as compared to that of diesel.

***Key words:*** Mahua Biodiesel, Multi-Cylinder Engine, Emissions

## I. INTRODUCTION

Indiscriminate extraction and lavish consumption of fossil fuels has led to reduction in underground-based carbon resources [1]. The sky rocketing oil prices exert enormous pressure on our resources and seriously affect our economy. The fact that petroleum based fuels will neither be available in sufficient quantities nor at reasonable price in future has revived interest in exploring alternative fuels for diesel engines [2]. The search for an alternative fuel, which promises a harmonious correlation with sustainable development, energy conservation, management, efficiency and environmental preservation, has become highly pronounced in the present context. Renewable energy technologies fit well into a system that gives due recognition to decentralization, pluralism and local participation [3].

### A. Mahua

Mahua oil is obtained from dried seeds of the mahua plant. Mahua plant shown in Fig 1. is a large deciduous tree growing widely under dry tropical and sub tropical climatic conditions [4]. It is an important tree for the poor; it is greatly valued for its flowers and its seeds. The tree has religious and aesthetic value in the tribal culture. In some countries, Mahua oil is considered as edible as it is used only for preparing ghee, but in our country it has been considered as non-edible oil [5]. Its botanical name is Maduca Indica and common English name is Maduca or Butter tree


Fig 1: Mahua

In this project the following results has been obtained and studied using mahua biodiesel such as performance, emission, combustion characteristic on multi-cylinder diesel engine with varying loads and varying speeds as 1500 rpm, 2500 rpm, 3500 rpm.

## II. OBJECTIVE OF THE PROJECT

The major transportation of goods depends upon diesel engine. The cars, busses, trucks, rail engine etc are having multi-cylinder in nature. These passenger and goods transport vehicles generally operates on part load due to continuous variation of speed and load. On the other hand due to the rapid depletion of conventional of diesel oil an alternative fuels that to liquid in nature is to be evolved. It is also observed in literature review that a very few work has been done on use of biodiesel on multi cylinder diesel engines. For designing of practical engine running purely on biodiesel needs a huge amount of data for analysis and decision making and there is a need of such data on multi cylinder diesel engine. An attempt is made in this project to evaluate performance, emission and combustion of multi-cylinder diesel engine using Mahua biodiesel.

## III. EXPERIMENTATION

### A. Preparation of Biodiesel:

Biodiesel is the name of a clean burning alternative fuel, produced from domestic, renewable resources. Biodiesel contains no petroleum, but it can be blended at any level with petroleum diesel to create a biodiesel blend. It can be used in compression-ignition (diesel) engines with little or no modifications. Biodiesel is simple to use, biodegradable, nontoxic, and essentially free of sulphur and aromatics. Biodiesel is made through a chemical process called transeterification where by the glycerin is separated from the fat or vegetable oil. The process leaves behind two products-methyl esters (the chemical name for biodiesel) and glycerine (a valuable by-product usually sold to be used in soaps and other products) and biodiesel is better for the environment because it is made from renewable resources and has lower emission compared to petroleum diesel.

Table 3.1 shows the values of different properties such as density, kinematic viscosity, flash point, fire point and calorific value of diesel and neat Mahua biodiesel.

| **Fuel samples Properties** | **Diesel** | **Mahua biodiesel** | **Apparatus used** |
|---|---|---|---|
| Fuel density in $\frac{kg}{m^3}$ | 830 | 875 | Hydrometer |
| Kinematic viscosity at 40$^o$C in cst | 4.6 | 5.0 | Redwood viscometer |
| Flash point in $^o$C | 51 | 160 | Ables apparatus |
| Fire point in $^o$C | 57 | 170 | Ables apparatus |
| Calorific value in $\frac{kJ}{kg}$ | 43000 | 38963 | Bomb calorimeter |

Table 3.1 Properties of Diesel and Mahua biodiesel

## B. *Engine*

The engine chosen to carry out the experimentation is multi (four) cylinder, four stroke, vertical, water cooled, computerized TATA make IndicaV2 diesel engine. Fig 3.7 photograph taken from the IC engine laboratory, PDA College of Engineering shows engine connected with controlling unit. Fig 2 shows schematic diagram of engine, dynamometer, controlling unit smoke meter and exhaust gas analyzer. Table 3.3 shows the specification TATA IndicaV2 engine.


Fig 2: Engine connected with dash board

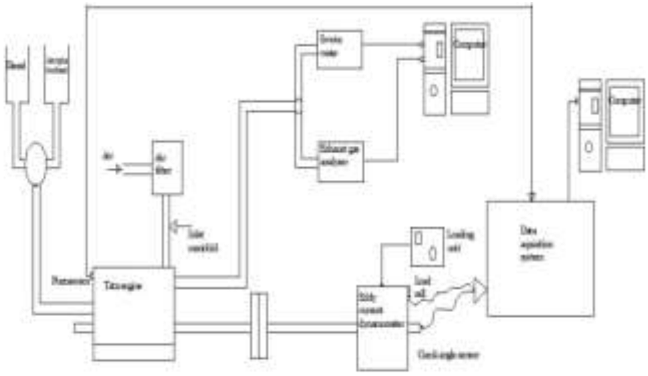

Fig 3: Schematic diagram of experimental set up

| | | |
|---|---|---|
| 01 | Manufacturer | TATA |
| 02 | Model | TATA IndicaV2 |
| 03 | Engine | CI Engine |
| 04 | Type | 4 stroke, 4 cylinder, water cooled |
| 05 | Bore | 75 mm |
| 06 | Stroke | 79.5 mm |
| 07 | Compression ratio | 22:1 |
| 08 | Rated Power | 39 kW @5000 rpm |
| 09 | Fuel | Diesel |

Table 3.3: Technical Specification of TATA IndicaV2 Engine

## C. *Experimental Procedure*

For getting the base line data of engine first the experimentation is performed with diesel and then with biodiesel.

- Fill the diesel in fuel tank
- Start the water supply. Set cooling water for engine at 650 LPH and calorimeter flow at 150 LPH.
- Also ensure adequate water flow rate for dynamometer cooling and piezo sensor cooling.
- Check for all electrical connections. Start electric supply to the computer through the UPS.
- Open the lab view based engine performance analysis software package “engine soft” for on screen performance evaluation.
- Supply the diesel to engine by opening the valve provided at the burette.
- Set the value of calorific value and specific gravity of the fuel through the configure option in the software.
- Select run option of the software. Start the engine and let it run for few minutes under no load condition.
- Choose log option of the software. Turn on fuel supply knob. After one minute the display changes to input mode then enter the value of water flows in cooling jacket and calorimeter and then the file name (applicable only for the first reading) for the software. The first reading for the engine gets logged for the no load condition. Turn the fuel knob back to regular position.
- Repeat the experiment for different load and speed.

- All the performance readings will be displayed on the monitor.
- Using AVL Dismoke 1000 and exhaust gas analyzer CO, $CO_2$, UBHC, smoke opacity will be recorded.
- Now clear the diesel present in the engine and use neat biodiesel as a fuel, repeat the same procedure.
- At the end of the experiment bring the engine to no load condition and turn off the engine and computer so as to stop the experiment.
- After few minutes turn off the water supply.

## IV. RESULTS AND DISCUSSIONS

This chapter consists of three types of experimental analysis, first one is performance characteristics like brake thermal efficiency, specific fuel consumption, and EGT against brake power, second one is emission characteristics like carbon monoxide (CO), unburned hydrocarbon(HC), smoke opacity and $NO_x$, finally third is the combustion characteristics like pressure, and cumulative and net heat release rate with varying loads and different speeds such as 1500 rpm, 2500 rpm and 3500 rpm respectively are drawn shown in fig 4 through 24.

### *A. Performance, Emission and Combustion Characterstics of Mahua Bio-Diesel and Diesel on Diesel Engine At Speed of 1500 Rpm*

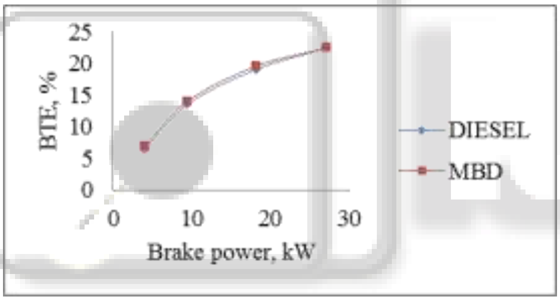


Fig. 4: Variation of brake thermal efficiency with brake power

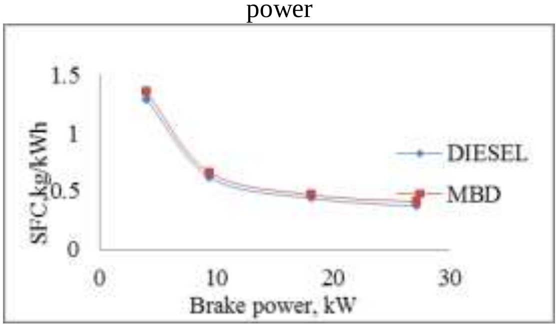


Fig. 5: Variation of specific fuel consumption with brake power

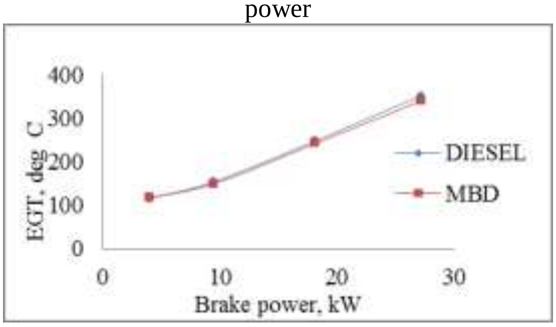


Fig. 6: Variation of EGT with brake power

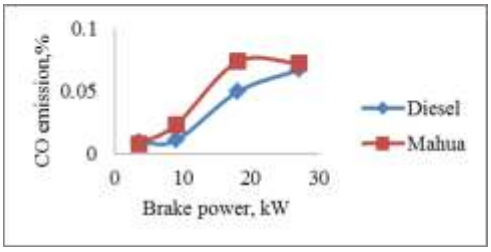


Fig. 7: Variation of carbon monoxide with brake power

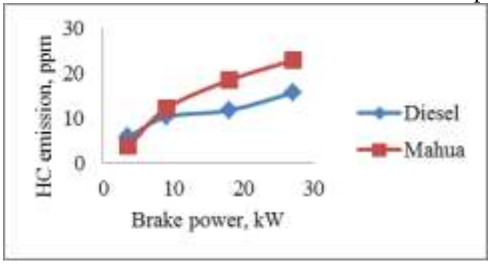


Fig. 8: Variation of unburnt hydrocarbon with brake power

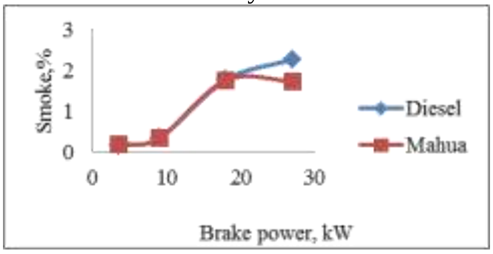


Fig. 9: Variation of smoke opacity with brake power

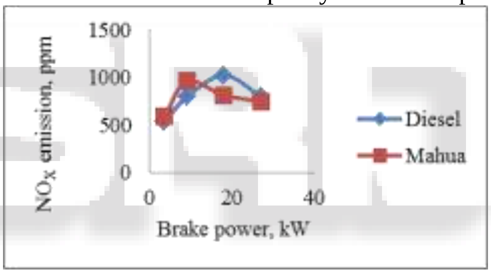


Fig. 10: Variation of $NO_x$ with brake power

### *B. Performance, emission and combustion characterstics of Mahua bio-diesel and diesel on diesel engine at speed of 2500 rpm*

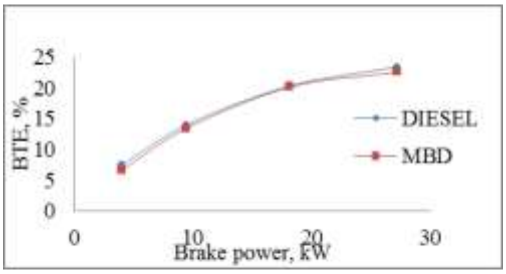


Fig. 11: Variation of brake thermal efficiency with brake power

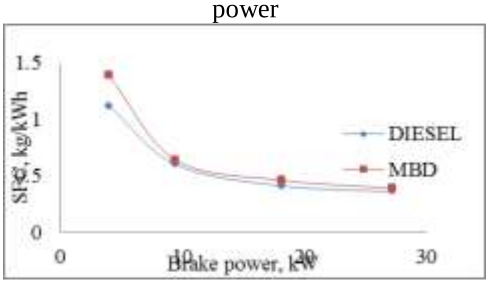


Fig. 12: Variation of specific fuel consumption with brake power

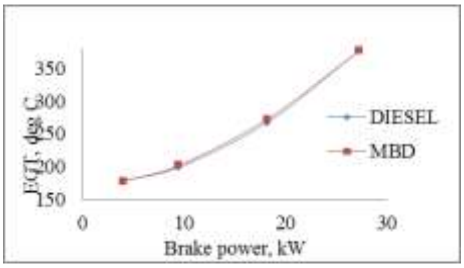

Fig. 13: Variation of EGT with brake power

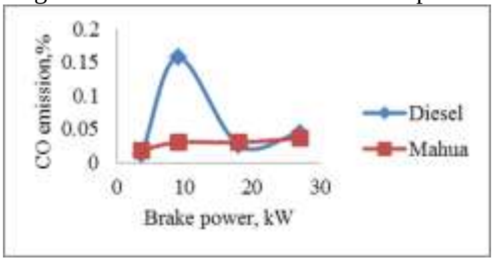

Fig. 14: Variation of carbon monoxide with brake power

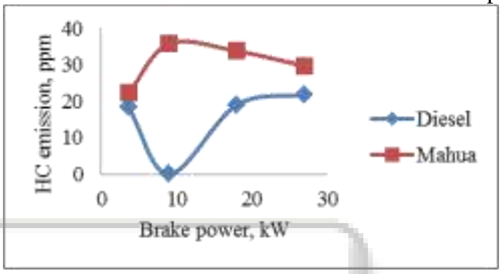

Fig. 15: Variation of unburnt hydrocarbon with brake power

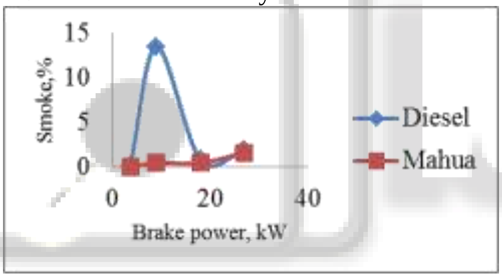

Fig. 16: Variation of smoke opacity with brake power

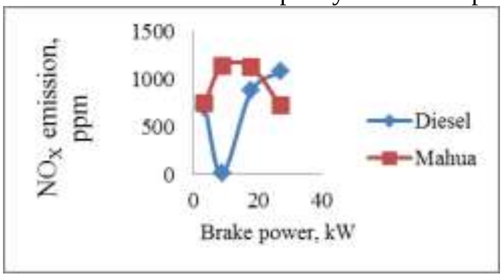

Fig. 17: Variation of $NO_x$ with brake power

*C. Performance, emission and combustion characterstics of Mahua bio-diesel and diesel on diesel engine at speed of 3500 rpm*

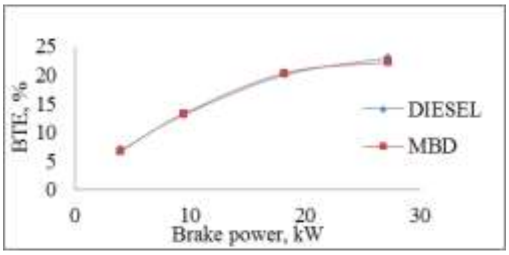

Fig. 18: Variation of brake thermal efficiency with brake power

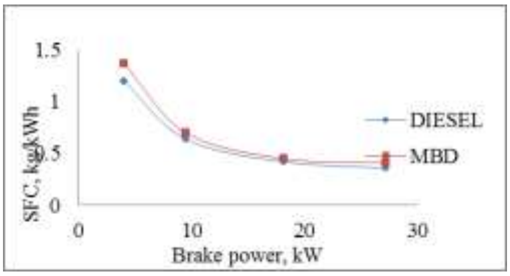

Fig. 19: Variation of specific fuel consumption with brake power

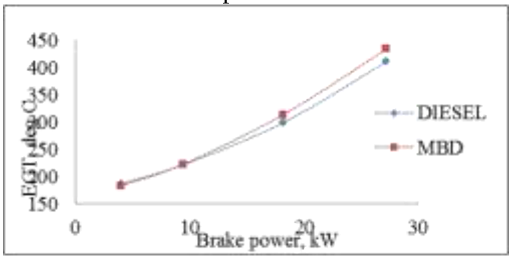

Fig. 20: Variation of EGT with brake power

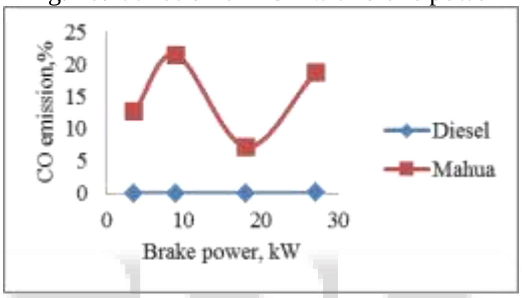

Fig. 21: Variation of carbon monoxide with brake power

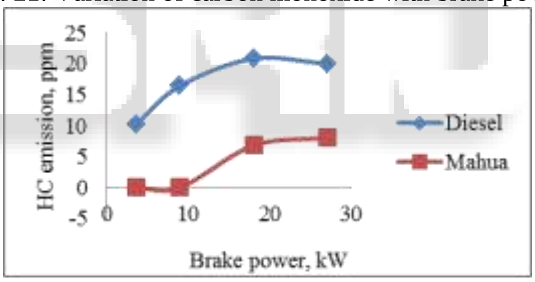

Fig. 22: Variation of unburnt hydrocarbon with brake power

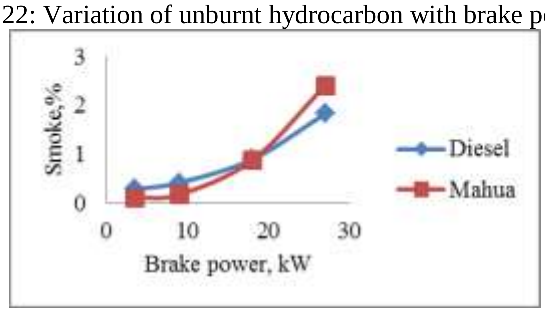

Fig. 23: Variation of smoke opacity with brake power

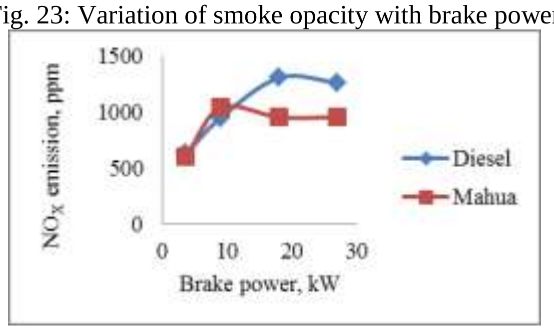

Fig. 24: Variation of $NO_x$ with brake power

 

## V. Conclusions

Experiment conducted on a four cylinder four stroke TATA INDICAV2 DIESEL ENGINE to compare the suitability of Mahua biodiesel as an alternate fuel. Then the performance and emission characteristics of biodiesel are evaluated and compared with diesel and optimum results are obtained. For conformation its available results are compared with the results of normal engine, mahua biodiesel available in literature for similar work.

From the above discussion, the following conclusions of the project are as follows.

- Neat mahua oil is converted into biodiesel using transesterification process. Characterization of mahua biodiesel is carried out, the specific gravity and calorific value of biodiesel is less than that of diesel,
- Viscosity of the neat mahua oil is at higher values. However viscosity of biodiesel is well comparable with diesel. Engine is producing the desired brake power at different speed compared with that of diesel.
- At the speed of 1500 rpm, BTE increased with increase in brake power for mahua biodiesel, CO and HC emissions increased for mahua biodiesel compared to diesel but smoke and $NO_x$ emissions decreased for mahua biodiesel compared to diesel.
- At the speed of 2500 rpm, BTE decreased with increase in brake power for mahua biodiesel, CO, smoke and $NO_x$ emissions were reduced for mahua biodiesel compared to diesel but HC emissions increased for mahua biodiesel compared to the diesel.
- At the speed of 3500 rpm, BTE decreased with increase in brake power for mahua biodiesel, CO and HC emissions increased for mahua biodiesel compared to diesel but HC and $NO_x$ emissions reduced for mahua biodiesel compared to diesel.
- From results we can see that the engine speed at 2500 rpm for mahua biodiesel gives the optimum results when compared to the speeds 1500 rpm, 2500 rpm, and 3500 rpm than diesel.

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