

# Experimental Investigation on Performance and Emissions of Mahua Biodiesel in CI Engine Employing EGR (Exhaust Gas Recirculation)

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**Abstract**— Trans-esterified Mahua oil, also known as Mahua bio-diesel is best replacement for diesel fuel in CI engine due to several reasons. Mahua Bio-diesel is a renewable, inexhaustible and a clean burning fuel. It can be used in diesel engine without modification. It has no aromatic, no-sulfur and contains 10-12% oxygen by weight. The purpose of this study is to summarise the effect of blend of Mahua oil methyl ester and cooled EGR in order to reduce pollutant from diesel engine emission of NO<sub>x</sub>, CO, HC. To study various performance parameters such as brake thermal efficiency (BTE), BSFC, Exhaust Gas Temperature (EGT).

**Key words:** Mahua oil, EGR, NO<sub>x</sub> emission

## I. INTRODUCTION

Biodiesel refers to a vegetable oil or animal fat-based diesel fuel consisting of long chain alkyl (methyl, ethyl, or propyl) esters. Biodiesel is typically made by chemically reacting lipids (e.g., vegetable oil, soybean oil, animal fats) with an alcohol producing fatty acid esters. The environmental pollution caused by diesel engines becomes a major concern throughout the world. Diesel engines produce smoke, particulate matter, oxides of nitrogen (NO<sub>x</sub>), oxides of carbon (CO & CO<sub>2</sub>) and unburnt hydrocarbon (HC). Several alternative fuels have been studied to either substitute diesel fuel partially or completely. Alternative fuels derived from biological sources provide a means for sustainable development, energy conservation, energy efficiency and environmental protection. Some of the alternative fuels explored are biogas, ethanol, and vegetable oils etc.

From various researches it's found that NO<sub>x</sub> emission is higher in Mahua based bio-diesel. An effective technique to reducing NO<sub>x</sub> emission in diesel engine is Exhaust Gas Recirculation (EGR). NO<sub>x</sub> are formed when the combustion temperature is high. Any technique that reduces the combustion temperature will thus lead to decreased NO<sub>x</sub> formation. EGR technique involves recirculation of exhaust gas in to the intake system of the engine. The recirculated exhaust gas displaces some of the normal intake charge of the engine, which slows and cools the combustion process, thereby reducing NO<sub>x</sub> formation. In this project the cooled EGR is used as it can reduce the NO<sub>x</sub> emission. In cooled EGR the recirculation is varied from 5 to 15%.

## II. MATERIALS AND METHOD

### A. Test Fuel

Mahua oil (*Madhuca Indica*) is one of the forest based tree-borne nonedible oils with large production potential of about 60 million tons per annum in India. The Mahua tree belongs to the genus *Madhuca*. The tree, its seed and flowers had been very useful in Indian economy for a long time. The flowering season extends from February to April. It is rich in sugar (73 %) and next to cane molasses; it constitutes the most

important raw material for alcohol fermentation. The yield of alcohol is 405 liters from one ton of dried flower. The kernel of the Mahua fruit contains about 50% oil. The expelled cake is relevant to recover the residual oil. Fresh oil is yellow in colour, while commercial oil is generally greenish. As this tree grows mainly in forest area and also in waste and fallow land, its cultivation would not produce any impact on food production but would in an attempt is made in this paper to study the feasibility of Mahua methyl ester and its blends with diesel fuel for a compression ignition engine.

Fuel properties	Mahua Biodiesel	Diesel
Specific gravity	880	850
Flash point (°C)	208	68
Calorific value (MJ/kg)	37	42
Viscosity cSt @ 40 °C	3.98	2.6
Auto ignition temperature(°C)	240	316
Boiling point(°C)	-	188-343
Carbon residue	0.20	0.70

Table 1:

### B. Test Engine

The experimental investigation carried out in a single cylinder 4-stroke water cooled diesel engine developing 6.0 HP at 1500 RPM was used. The engine details are given in table 1. The schematic of the experimental set up is shown in fig 1. A DC Electrical dynamometer was used for loading the engine.

The EGR setup consist of a water cooled heat exchanger for cooling exhaust gas, reaction chamber and valves fitted to control the quantity of exhaust gas being recycled.

#### 1) Experimental Setup

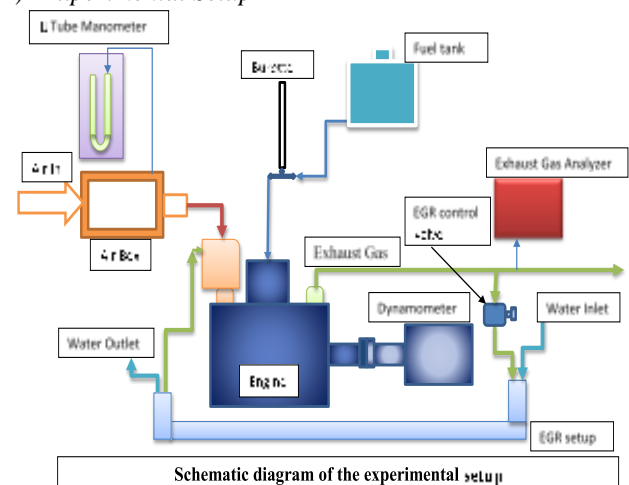


Fig. 1: Schematic Diagram of the Experimental Setup  
The technical specification of the engine is as under.

Engine	Capstone
Dynamometer	DC Electrical
Bore	87.5
Stroke	110
Displacement	661
Compression Ratio	17.5
R.P.M.	1500
H.P.	6.0

Table 2: Technical Specification of the Test Engine

### III. EXPERIMENTAL PROCEDURE

The engine was coupled to a DC Electrical dynamometer to measure the output, fuel flow rates were timed with calibrated burette. Exhaust gas analysis was performed using exhaust gas analyzer.

The blends of B0, B10, B15, B20, and B25 of Methyl Ester of Mahua Diesel was prepared by volume basis and used for experimental purpose.

The engine was tested no EGR and with EGR at the rate of 5, 10, and 15 % exhausts gas re-circulation. The amount of exhaust gas into intake pipe is controlled through the EGR-valve. The EGR is cooled by water the intake temperature can be controlled at the range of about 30-35 °C. The engine speed, fuel consumption, and exhaust gas re-circulation rate also recorded. Exhaust gases were analyzed by 5-gas analyzer in which CO, CO<sub>2</sub>, O<sub>2</sub>, HC, NOx, were recorded.

### IV. RESULT AND DISCUSSION

Based on the experimental results the graphs were drawn. These graphs show the variation in brake thermal efficiency, BSFC, and emissions.

#### A. Engine Performance

In fig.3 shows the variation of brake thermal efficiency on brake power with effect of EGR. The brake thermal efficiency is decreases with rise of EGR at the rate of 10 %.

##### 1) Effect of Load on Exhaust Gas Temperature

The exhaust gas temperature is measured by a thermocouple attached to the outlet manifold. The variation of temperature with the increase in load for all the cases is measured. Graph 5.1 shows the variation of exhaust gas temperature with an increase in percentage Of biodiesel and percentage of load.

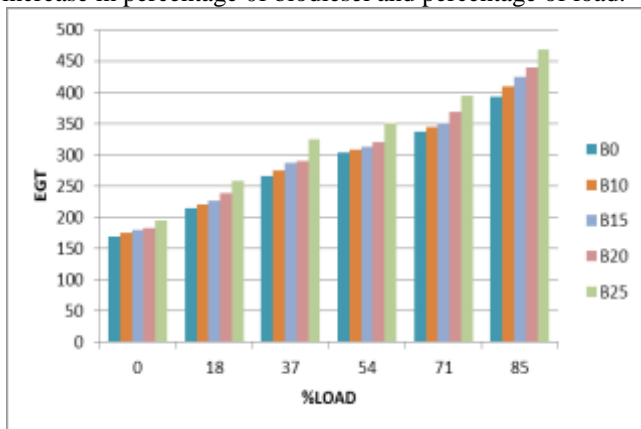


Fig. 2:

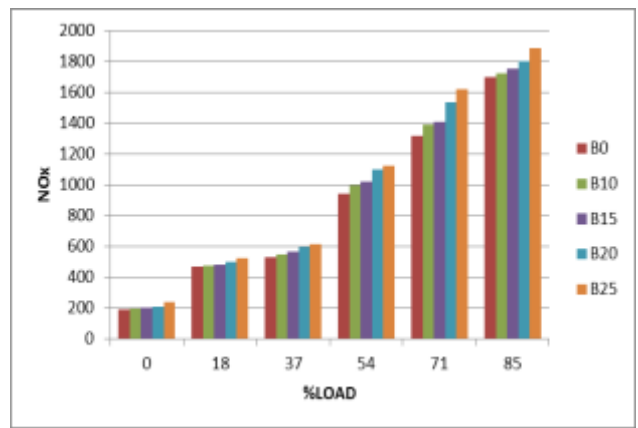


Fig. 3:

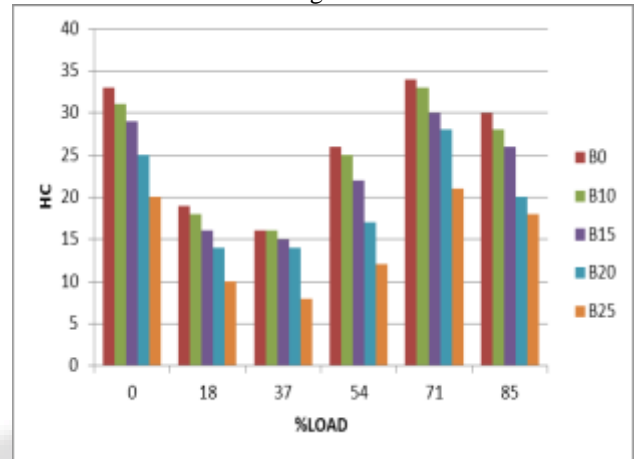


Fig. 4:

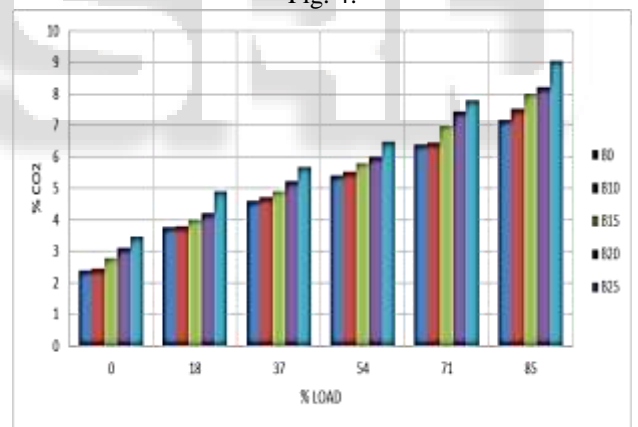


Fig. 5:

The exhaust gas temperature increased with the increase in the load. This is due to more amounts of fuel combustion inside the combustion chamber at a higher load as compared to a lower load and complete combustion of the fuel leading to higher combustion temperature.

##### 2) Effect of Load on Brake Thermal Efficiency

The brake thermal efficiency is measured at every 18% rise in load from 0% to 85% of rated load condition. The brake thermal efficiency increases with the increase in load up to 85%.

For Biodiesel, The brake thermal efficiency of conventional diesel engine is higher than the Biodiesel at lower loads.

##### 3) Effect of Load on Volumetric Efficiency

The volumetric efficiency decreases with increase in Load and this is due to the fact that the engine cylinder temperature during suction is higher for higher load conditions.

## B. Engine Emission

### 1) Effect of Load on NO<sub>x</sub> Emission

The NO<sub>x</sub> emission is observed with different load conditions. Graph 5.2 represents the variation of NO<sub>x</sub> emission with the increase of load from 0% to 85% at every 18% load rise. The NO<sub>x</sub> emission is observed to be increasing with load and this is due to the rise in combustion temperature favoring the NO formation.

### 2) Effect of Load on HC Emission

The hydrocarbon emission is observed with different load conditions. Graph 7.3 represents the variation of HC emission with the increase in load from 0% to 85% at every 18% load increase. HC emission decrease with increase in load denotes a much complete combustion taking place in the engine combustion chamber.

### 3) Effect of Load on CO<sub>2</sub> Emission

As seen from the graph CO<sub>2</sub> emission increases with increase in the load. CO<sub>2</sub> emission increases with increase percentage of Biodiesel.

## V. CONCLUSIONS

An experimental investigation was conducted to test the performance and emission characteristics of Mahua Biodiesel and its fuel blends with diesel in a single cylinder diesel engine with the effect of EGR, the results obtained suggest the following conclusion.

- With the effect of EGR, brake thermal efficiency decreases with B10, B20 and B30 when compared to naturally aspirated diesel engine.
- With no EGR B0, B10, B15, B20, and B25 blends, BSFC values are increased compared to EGR incorporated engine.
- With no EGR B0, B10, B15, B20, and B25 blends, TFC values are increased compared to EGR incorporated engine.
- NO<sub>x</sub> emission decreased with EGR, CO emissions increased and HC emissions decreased in all blends of Mahua Biodiesel.
- B20 is the best blend with diesel showed better results with brake thermal efficiency, Brake specific fuel consumption, Total fuel consumption and less NO<sub>x</sub> emission with 10 % of EGR.

## REFERENCES

- [1] H. Raheman, S.V. Ghadge "Performance of compression ignition engine with mahua (Madhuca indica) biodiesel" Fuel 86 (2007) 2568–2573 15 March 2007.
- [2] N. Saravanan, G. Nagarajan, Sukumar Puhan "Experimental investigation on a DI diesel engine fuelled with Madhuca Indica ester and diesel blend" biomass and bioenergy 34(2010 ) 838-843 18 February 2010
- [3] M. Pugazhvidivu, G.Sankaranarayanan "Experimental studies on a diesel engine using mahua oil as fuel" Indian Journal of Science and Technology Vol. 3 No. 7 (July 2010) ISSN: 0974- 6846
- [4] A.Haiter Lenin, R. Ravi, K. Thyagarajan "Performance Characteristics of a Diesel Engine Using Mahua Biodiesel as Alternate Fuel" Iranica Journal of Energy & Environment 4 (2): 136-141, 2013 ISSN 2079-2115 IJEE an Official Peer Reviewed Journal of Babol Noshirvani University of Technology DOI: 10.5829/idosi.ijee.2013.04.02.10
- [5] Avinasha P. S, Krishnamurthy K. N, Akash Deep B. N "Performance and Emission Analysis of Mahua Biodiesel Blends with Diesel Oil using Single Cylinder Diesel Engine"
- [6] M.Harinathareddy, P.Nageswara Reddy and K.Vijayakumar Reddy "Performance and Emission Characteristics of a Diesel Engine Operated on Mahua Oil Methyl Ester" M.Harinathareddy et al./ Elixir Mech. Engg. 55 (2013) 12978-12982 Accepted: 8 February 2013;
- [7] Santhosh.B, Dr. R.Suresh, Yathish.K.V "Experimental Investigations on the Use of Mahua Oil Methyl Ester Produced Using Magnesium Phosphate Catalyst as Fuel in a Compression Ignition Engine" International Journal of Innovative Research in Science, Engineering and Technology, ISSN: 2319-8753 (ISO 3297:2007 Certified Organization) Vol. 2, Issue 8, August 2013
- [8] C Solaimuthu,D Senthikumar ,K K Ramasamy "An experimental investigation of performance, combustion and emission characteristics of Mahua (Madhuca Indica) oil methyl ester on four-stroke direct injection diesel engine" Indian Journal of Engineering & Materials Sciences Vol. 20, Feb 2013 pp. 42-50
- [9] A. Paykani, A. Akbarzadeh and M. T. Shervani Tabar "Experimental Investigation of the Effect of Exhaust Gas Recirculation on Performance and Emissions Characteristics of a Diesel Engine Fueled with Biodiesel" IACSIT International Journal of Engineering and Technology, Vol.3, No.3, June 2011
- [10] Ghosh S, Dutta D. The Effects of EGR on the Performance and Exhaust Emissions of a Diesel Engine Operated on Diesel Oil and Pongamia Pinata Methyl Ester (PPME). International Journal of Engineering Inventions, 2012, 1(12): 39-44.
- [11] Ghosh S, Dutta D. The Effects of EGR on the Performance and Exhaust Emissions of a Diesel Engine Operated on Diesel Oil and Soybean Oil Methyl Ester (SOME). IOSR Journal of Engineering, 2012, 2(12): 47-52.
- [12] Kavati Venkateswarlu, Bhagavathula Sree Rama Chandra Murthy and Vissakodeti Venkata Subbarao. "The Effect of Exhaust Gas Recirculation and Di-Tertiary Butyl Peroxide on Diesel-Biodiesel Blends for Performance and Emission Studies". International Journal of Advanced Science and Technology Vol. 54, May, 2013
- [13] K Srinivasa Rao, K Bhaskara Mutyalu and A Ramakrishna "Effect of exhaust gas recirculation on performance and emission characteristics of diesel engine fueled with waste cooking oil methyl ester". ARPN Journal of Engineering and Applied Sciences ©2006-2015 Asian Research Publishing Network (ARPN). ISSN 1819-6608, VOL. 10, NO. 11, JUNE 2015
- [14] Paykani A, Akbarzadeh A, Shervani Tabar M T. "Experimental Investigation of the Effect of Exhaust Gas Recirculation on Performance and Emissions Characteristics of a Diesel Engine Fueled with Biodiesel. IACSIT International Journal of Engineering and Technology, 2011, 3(3): 239-243.

- [15] H.E.Saleh, Effect of exhaust gas recirculation on diesel engine nitrogen oxide reduction operating with jojoba methyl ester, *Renewable Energy* 34 (2009) 2178-2186.
- [16] Giorgio Zamboni, Massimo Capobianco Experimental study on the effects of HP and LP EGR in an automotive turbocharged diesel engine *Applied Energy* 94 (2012)117-128.
- [17] Deepak Agarwal, Shrawan Kumar Singh, Avinash Kumar Agarwal, Effect of Exhaust Gas Recirculation (EGR) on performance, emissions, deposits and durability of a constant speed compression ignition engine *Applied Energy* 88 (2011) 2900-2907
- [18] Avinash kumar agrawal, Shrawan kumar singh, Shailendra sinha and Mritunjay kumar shukla, Effect of EGR on the exhaust gas temperature and exhaust opacity in compression ignition engines *Sadhana* Vol. 29, Part 3, June 2004, pp. 275284.
- [19] Ming Zheng, Diesel engine exhaust gas recirculation a review on advanced and novel concepts, *Energy Conversion and Management*, Vol. 45, 2004, pp. 883900.

