

# Characterization of Mahua Methyl Ester in DI Diesel Engine

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**Abstract**— In this work mahua seeds were used to produce vegetable oil because of ease availability and low cost. By using catalytic transesterification vegetable oil extracted from mahua was converted into methyl ester. After that, the chemical and thermal properties of methyl ester was analysed as per ASTM standards. The mahua methyl ester and blends with diesel were analysed to find the performance, emission and combustion characteristics at standard injection pressure of 220bar in stationary Kirloskar AV1 engine. The emission characters like HC, CO and NOx were analysed using AVL di gas analyser. The smoke was measured using AVL make Hatridge smoke meter. Combustion characteristics were analysed through AVL combustion analyser. From the results B25 methyl ester have the nearly similar performance, emission and combustion characteristics with diesel fuel.

**Keywords**— Biodiesel, DI diesel engine, Performance, Emission, Combustion.

## I. INTRODUCTION

One of the main factors to concern the world economy and politics is the sustainability of petroleum resources, which is the significant source of global energy resource [1]. Though, the world energy demand is increasing faster caused by too much use of fossil fuels. Because of diminution of conventional petro fuel and ever-increasing environmental concern, alternative source like biodiesel has been developed [2, 3]. The history of biodiesel starting with the use of vegetable oils and it was investigated as early as the period when the diesel engine was developed [4]. Rudolf Diesel, the inventor of diesel engine, attempted peanut oil for fuel for his engine. As of early 1900s, vegetable oils were analysed, including castor oil, palm oil and cottonseed oil. Early studies confirmed sufficient performance of vegetable oil as suitable fuel for diesel engines. In the face of biodiesel in diesel engines, it produces some troubles in engine when utilized [5-7]. The neat and blended biodiesel have impact on the engine performance as well as emissions, as it has dissimilar thermal and chemical properties from diesel. Further research is necessitated to expose further regarding the properties of biodiesel produced from catalytic transesterification and their consequences on the combustion and the fuel injection system. Many researchers found that the biodiesel may have used in the diesel engines without any modification [8-10]. Even if numerous advantages can be attained with the use of

biodiesel, a small number of its intrinsic properties like density and viscosity are designate to improve. Later studies have exposed that increasing the biodiesel blend ratios and as a result of density and viscosity, can lead to poor atomization of the injected fuel with air [11]. The results are ever-increasing in the average droplet size of the sprayed fuel and the fuel breakup time. In this work, biodiesel was produced using catalytic transesterification from mahua oil and tested its blend in DI diesel engine.

## II. MAHUA BIODIESEL PREPARATION AND PROPERTY ANALYSIS

The process of catalytic transesterification to synthesis biodiesel requires an alcohol and catalyst wherein, the triglycerides with larger molecules are broken into mono glyceride and esters. In the work, the extracted mahua seed oil was transesterified using potassium hydroxide and methanol to produce mahua methyl ester [12]. For synthesizing one litre of methyl ester 180ml of methanol and 8g of KOH was used for the conversion process. The formed glycerol has been drained out and the left out methyl ester was washed with distilled water to take away the impurities and the remaining glycerol. Afterwards, the mahua methyl ester is heated up to 90°C to remove the traces of water present in the final product. Finally, the fuel properties were analysed as per ASTM standard methods and tabulated in the Table 1. After the

catalytic transesterification the thermo physical properties of mahua methyl ester were analysed and compared with biodiesel standards. The mahua methyl ester properties reveal that the raw mahua seed oil has higher viscosity, which does not support its direct use in diesel engine.

Therefore, it is essential to transesterify the extracted mahua seed oil to reduce its viscosity, and get it to the tolerable biodiesel standard so as to create it possible for diesel engine operation. The schematic diagram of transesterification plant is shown in Figure 1.

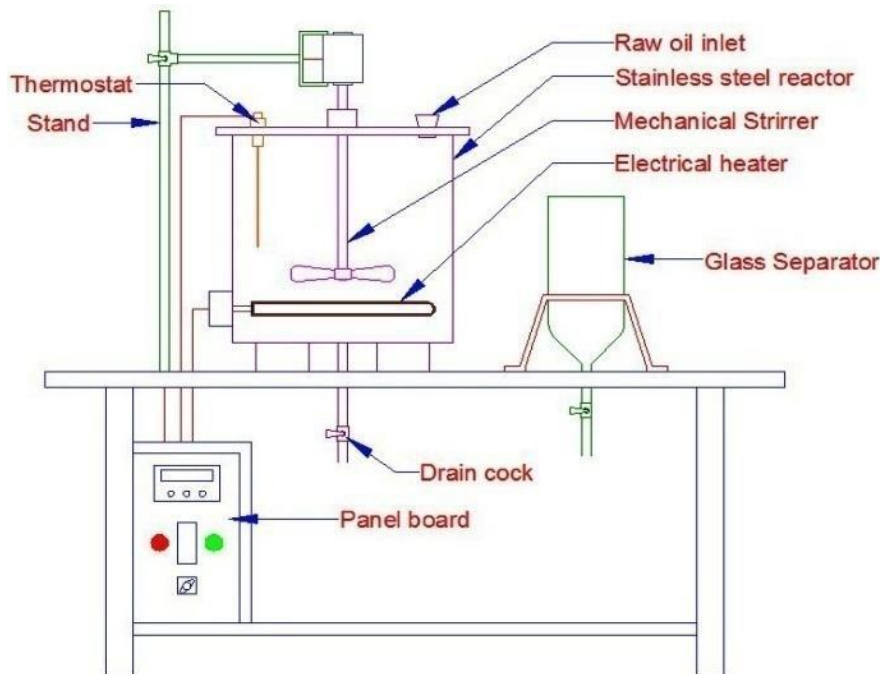


Fig.1: schematic diagram of transesterification plant

Properties	B100	B25	Diesel
Specific gravity	0.8614	0.8403	0.83
Kinematic viscosity in cst	4.23	3.71	3.6
Flash point	143°C	83°C	74°C
Fire point	153°C	89°C	84°C
Gross calorific value in KJ/kg	42220	42510	42700
Pour point	< -9°C	< -12°C	< -23°C
Density in kg/m3	871	831	822

### III. EXPERIMENTAL SETUP

The experimental investigations were carried out in Kirloskar AV-I diesel engine. A stationary four stroke single cylinder water cooled engine with brake power of 3.7 kW at constant of 1500 rpm was employed in this work. The test engine was connected to an eddy current dynamometer with control systems. The test engine is also

furnished with crank angle encoder sensor and piezo electric type in-cylinder pressure sensor. AVL made Di-gas analyzer was employed to analysis the emissions like CO, HC and NOx from the exhaust gas. AVL Hatridge type smoke meter was employed to the measure the smoke density from the engine exhaust gas. The schematic view of the test engine was shown in the Figure 2.

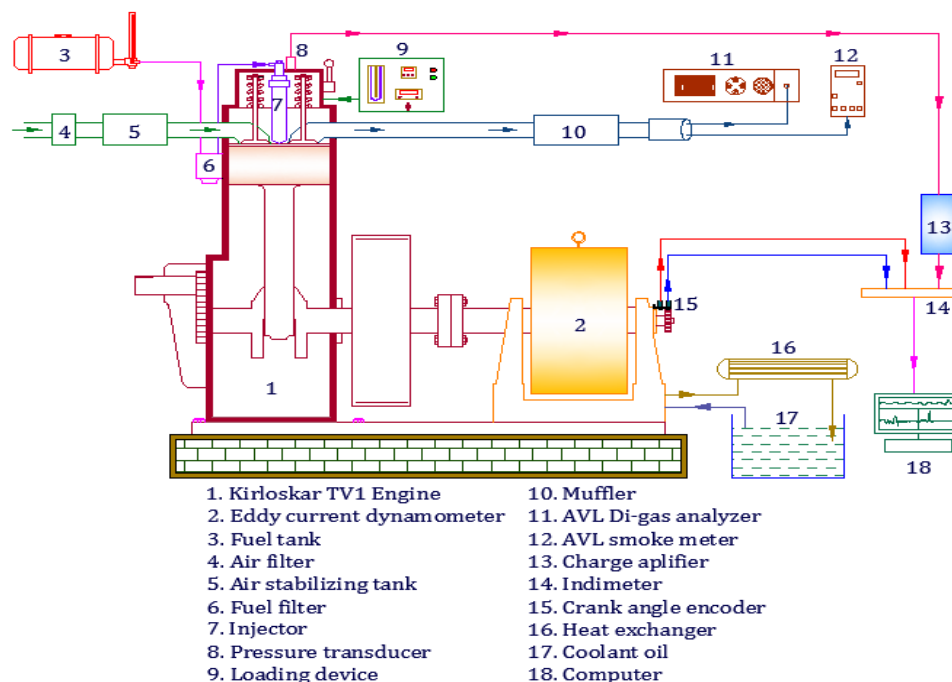


Fig.2: Schematic view of the test engine

#### IV. RESULTS AND DISCUSSION

The experiment is carried out in the single cylinder, four stroke, water cooled diesel engine. The experiments were conducted with neat diesel fuel and with mahua biodiesel and its biodiesel blends. Test engine was found smooth throughout the experiments with mahua biodiesel and its blends.

##### 4.1 PERFORMANCE CHARACTERISTICS

Figure 3 shows the effect of mahua methyl ester on Brake thermal efficiency with respect to brake power. From the data obtained, it is found radical changes in brake thermal efficiency at different Brake powers among

mahua methyl ester and its blends. These radical changes happened because of difference in thermal and physical properties of mahua methyl ester and its blends with respect to diesel. Higher density and viscosity as compared to diesel fuels leads to the lower BTE in the case of neat mahua methyl ester (B100). It is clear from the figure, brake thermal efficiency increases with respect to increase of brake power. The brake thermal efficiency in the case of B100 is much higher than the neat diesel. In the case of B20, it shows the nearer value to the diesel fuel. The BTE was found to 23% and 25.3% in the cases of B20 and B100 mahua biodiesel blends.

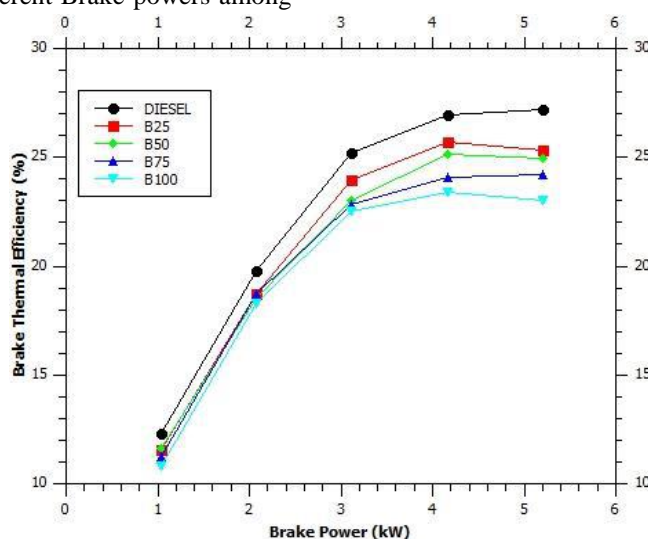


Fig.3: Brake thermal efficiency against brake power

#### 4.2 EMISSION CHARACTERISTICS

Figure 4 shows the effect of mahua methyl ester on NOx emission with brake power for various blends. NOx emission is happened through chain reactions concerning nitrogen and oxygen present in the ambient air. These retorts depend particularly on temperature take place during combustion. So the diesel engines drive with the excess air. The oxides of nitrogen are a function of residence time and combustion temperature. In several

studies, it was seen that the NOx emission varied with respect to the engine load and the comparable results were attained in this study also [13,14]. For the mahua biodiesel (B100) the NOx was significantly lower than that of diesel. The NOx showed lower when the mahua biodiesel blends were increased. The NOx emission of mahua biodiesel blend (B25) biodiesel blend shows the nearer value with the diesel fuel.

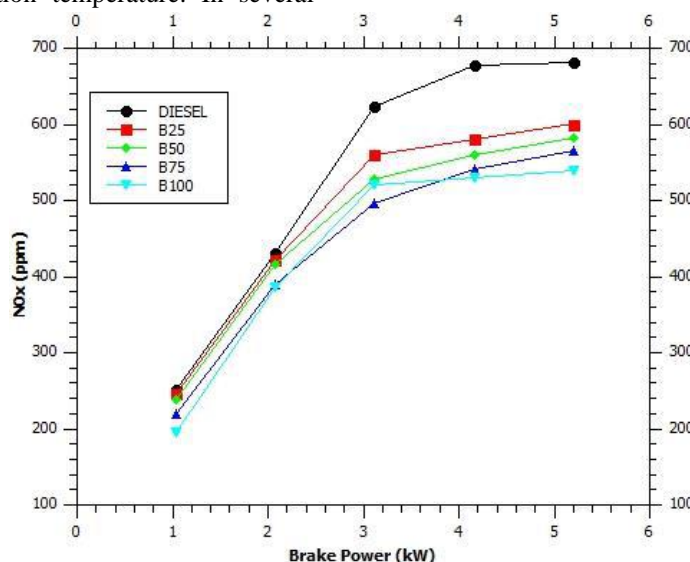


Fig.4: NOx emission against brake power

Figure 5 revealed that there is a significant hike in the HC emission with blends of mahua biodiesel compared to diesel. The higher density and lower flash & fire point may be the reasons for this hike in HC emission in the cases of mahua biodiesel blend. The lower temperature in combustion chamber due to poor atomization prevents the condensation of the heaviest hydrocarbons in the sampling

line, advising suitable conditions for HC analysis. From the figure, it is clear that the HC emission for the case of mahua biodiesel (B100) higher than the all fuel blends. The HC emission was significantly increased with the increase the percentage of mahua biodiesel in diesel. The least HC emission was found in the case of B25 at full load condition.

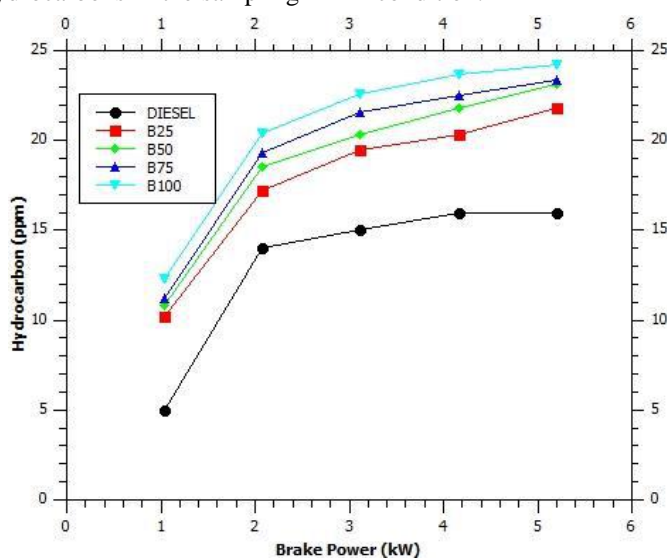


Fig.5: Hydrocarbon emission against brake power

Figure 6 revealed of the variation smoke density with brake power. The smoke density for mahua biodiesel and their blends are found higher than that of the diesel. Higher density and viscosity of the mahua biodiesel leads to poor and incomplete combustion of fuel, i.e. significant quantity of hydrocarbons present in the exhaust gases, which may results in higher smoke opacity. The smoke

emission was found 55HSU for B100 mahua biodiesel and it was 43HSU for diesel. Whereas smoke was found 48HSU for B25 mahua fuel blend which is nearer to diesel fuel when compared with other mahua biodiesel blends. As the higher density and lower calorific value of mahua diesel, larger fractions of the fuel carbon are not converted to CO, which results in soot formation.

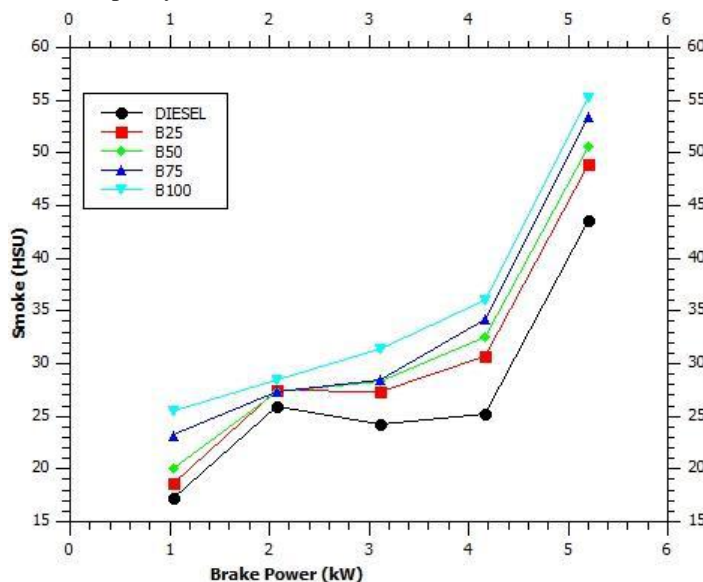


Fig.6: Smoke against brake power

### 4.3 COMBUSTION CHARACTERISTICS

Figure 7 shows the variant of in-cylinder pressure with engine crank angle. From the figure, it is reveal that peak in-cylinder pressure is significantly decreased with the increase of mahua biodiesel with diesel fuel. The in-cylinder pressure of a diesel engine probably depends on the quantity of fuel accrued in the fuel combustion delay

period and the rate of combustion in the premixed combustion phase [15]. The reason for the significantly decrease of in-cylinder pressure for mahua biodiesel and its blends may be due to poor evaporation and mixing. The peak in-cylinder pressure was 61bar in the neat diesel and whereas 58.3bar in the case of B100.

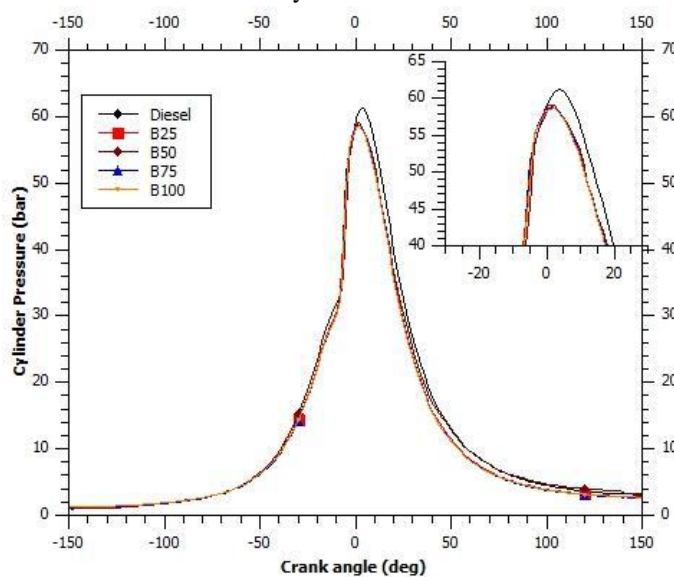


Fig.7: Cylinder pressure against crank angle



Figure 8 shows the variant of heat release rate (HRR) with engine crank angle. The peak HRR in the premixed combustion depends on the both physical and chemical delay periods, formation of air-fuel mixture and the rate of combustion [15]. From these results, it is understandable that the HRR of mahua biodiesel and its blends is lesser than that of diesel. This because of a longer

ignition delay exhibited by mahua biodiesel and its blends and tends the air-fuel blend to accrue in the combustion chamber. The poor atomization and lower calorific value of mahua biodiesel and its blends makes the heat release rate to decrease rapidly. The heat release rate of mahua biodiesel was found 117.3J/deg and it was 123.4 J/deg.

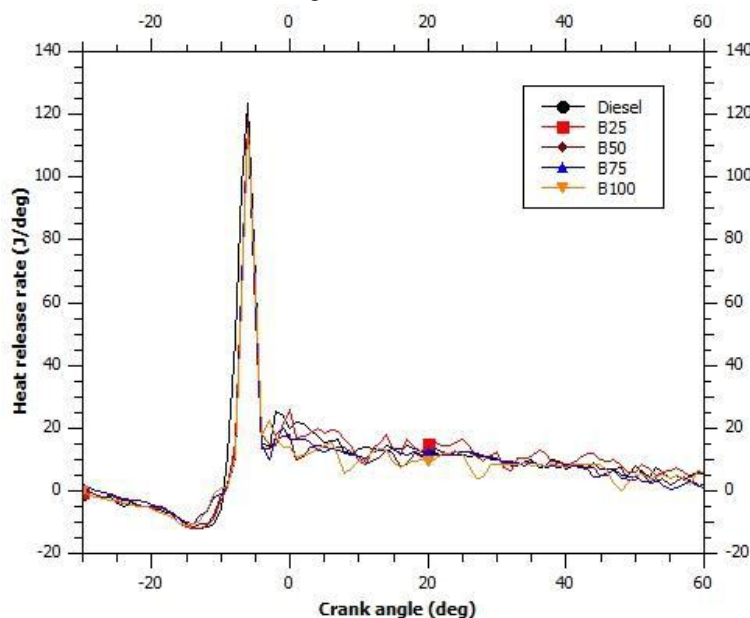


Fig.8: Heat release rate against crank angle

## V. CONCLUSION

The mahua biodiesel and its blends are analysed in diesel engine and the performance, emission and combustion characteristics are assessed and compared with diesel fuel. From the above discussion, the following conclusions are been drawn.

- Brake thermal efficiency is found low for mahua biodiesel and its blends compared with diesel. For B25 mahua biodiesel blend had nearer BTE when compared with. Standard fuel.
- From emission results, it is found that mahua biodiesel blend increases HC, CO and smoke emissions.
- NO<sub>x</sub> reduces considerably when compared to diesel.
- The present investigational results show that mahua methyl ester and its blends can be used as an alternative fuel in diesel engine.

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