

# Performance and Emission Characteristics of Four Stroke C.I Engine with Mahua and Cotton Seed Bio-Diesel Blended with Diesel

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*Abstract*— Fuels derived from petroleum are becoming increasingly scarce and expensive. A shortage of petroleum products is likely if the current trend continues. Finding sustainable energy sources could help alleviate this issue to a large extent. Biodiesels, made from a wide variety of vegetable oils, are a viable alternative. The purpose of this research was to evaluate the efficiency and emissions of a four-stroke diesel engine using Mahua biodiesel and Cotton seed biodiesel blended with diesel as a replacement fuel. The performance of the engine with biodiesel blend B20 as fuel is compared with the diesel fuel on the basis of brake specific fuel consumption, brake thermal efficiency, exhaust gas temperature and emissions of hydrocarbons and oxides of nitrogen. Based on the results of this research, the engine's performance with these biodiesel blends is similar to that of diesel, but the emissions of hydrocarbons are lower. The performance and emission characteristics of biodiesel blends made from cotton seed are superior than those made from Mahua biodiesel, it has been discovered.

**Keywords-** Cotton seed biodiesel, , Mahua biodiesel. Performance and Emissions

## I. INTRODUCTION

The depletion of world petroleum reserves and the global environmental pollution problems stimulated the search for the alternative source for petroleum based fuels. A major solution to reduce this problem is to search for an alternative fuels. Bio diesel [1] produced from vegetable oils can be used as an important alternative to the diesel oil, since they are renewable and can be produced in rural areas. The inventor of diesel engine Rudolf Diesel predicted that the plant based oils are widely used to operate diesel engine. The vegetable oil [2] has great potentials as alternative diesel fuel. Several researchers found [3] that the use of pure vegetable oils as fuel in diesel engine can cause numerous engine related problem such as injector choking, piston deposit formation and piston ring sticking due to higher viscosity and low volatility of vegetable oils. An effective method of using vegetable oils [4] in diesel engine is by modifying the vegetable oils into its monoesters (Biodiesel) by transesterification. Transesterification [5] of vegetable oil provides a significant reduction in viscosity, thereby enhancing their physical and chemical properties and improve the engine performance. Though the biodiesel has several advantages [6] over pure vegetable oil, it has disadvantages like low calorific value, higher viscosity and poor cold flow properties as compared with diesel. This drawback may be managed with the employment of blended fuel of biodiesel and diesel fuel.

## II. LITERATURE REVIEW

Researchers from various parts of the world have carried out various experiments on a diesel engine with various biodiesels and its blends with diesel to evaluate the performance and emission characteristics.

Dilip kumar et al (7) has conducted experiments on a CI engine with the biodiesel blends of cotton seed and neem biodiesels separately and suggested that the blend B20 is the optimum blend which can produce better performance for diesel engines.

Agarwal. A.K et al (8) has investigated the effect of the Karanja biodiesel blends on the DI diesel engine and concluded that the Karnja biodiesel can be used as a partial substitute of diesel up to 20% (B20) without any major modifications in the existing engine.

Anbumani et al (9) and LoveKush Prasad et al (10) evaluated the performance of a single cylinder diesel engine with neem biodiesel blends and established that the neem biodiesel blend B20 can be used as fuel to run CI engine.

### III. MATERIALS & METHODS

In the present work engine tests were conducted with Mahua and Cotton seed Biodiesel blends separately to evaluate performance and emission characteristics. The performance of the engine with biodiesel blend B20 as fuel is compared with diesel fuel. Cotton [11] has long been known as nature's unique food and fiber plant. It produces both food for man and feed for animals in addition to a highly versatile fiber for clothing, home furnishings and industrial uses. Cottonseed oil [12] has a ratio of 2: 1 of poly un saturated to saturated fatty acids and generally consists of 65-70% unsaturated fatty acids including 18-24% monounsaturated (oleic) and 42- 52% polyunsaturated (linoleic) and 26-35% saturated (palmitic and stearic). Mahua seed [13] is additionally known as *Kochia Latifolia*, *Madhuca indica*. It's also referred as Indian Butter Tree. Mahua may be a medium to giant tree, which can attain a height of up to twenty meters. Its provender (oil cake) is employed as bio-fertilizer and organic manure. Biological science name is "*Madura long folia*." The foremost element fatty acids of mahua oil are Palmitic (16-28%), lipoid (20-25%), Arachidic (0-3.3%), Oleic (41-51%) and Linoleic (9-13%). Mahua may be non-traditional and non-edible oil. Mahua is a very important plant having vital socio-economic worth. This species will be planted on edges of roads and canal banks etc., on large scale and in social biological science programme, notably in social group (tribal) areas .

The various properties [14] of the above bio diesels are presented in table 1.

TABLE I  
PROPERTIES OF FUELS USED

Properties	Cotton seed biodiesel	Mahua biodiesel	Diesel
Density (kg/m <sup>3</sup> )	874	880	830
Calorific Value (kJ/Kg)	40600	39500	43000
Viscosity @400C(cSt)	4.34	5.8	2.75
Cetan Number	55	50	51
Flash Point (oC)	70-110	145	74

### IV. TECHNICAL SPECIFICATIONS OF THE ENGINE

In this work experiments were conducted on 4 stroke, single cylinder, C.I engine (Kirloskar Oil Engineers Ltd., India) of maximum power-3.68 KW with AVL smoke meter and Delta 1600 S gas analyser.

### V. RESULTS AND DISCUSSIONS

#### A. Brake thermal Efficiency

The Figure 1 shows the variation of brake thermal efficiency of the engine with break power output. It is observed that the brake thermal efficiency of the engine represents very similar trends for all the fuel samples. In general the thermal efficiency depends on the combustion process which is a complex phenomenon that is influenced by several factors such as design of combustion chamber, type of injection nozzle, injection pressure, spray characteristics and fuel characteristics such as cetane number, volatility, viscosity, homogeneous mixture formation, latent heat of vaporization, calorific value etc.

It is evident that diesel fuel has the higher brake thermal efficiency compared to biodiesel blends. It is also found that the cotton seed biodiesel blends has the highest thermal efficiency because of its calorific value and viscosity as compared with Mahua biodiesel blends. With the higher calorific value the amount of heat produced in the combustion chamber is more, further the combustion is complete and produced higher temperatures. The efficiency of the engine with diesel is 29.18%, Mahua biodiesel blend B20 is 27.58% and for the cotton seed biodiesel blend B20 it is 28.45% at 3/4<sup>th</sup> of rated load. It is observed that the brake thermal potency of the engine with Mahua biodiesel blends is lower than the cottonseed biodiesel blends.

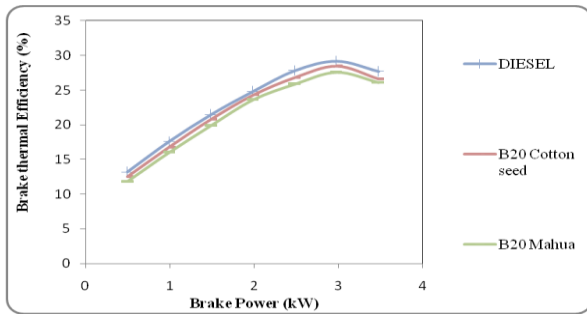


Figure 1: The variation of Brake thermal efficiency

### B. Brake specific Fuel Consumption

The variation of brake specific fuel consumption (BSFC) with break power is shown in Figure 2.

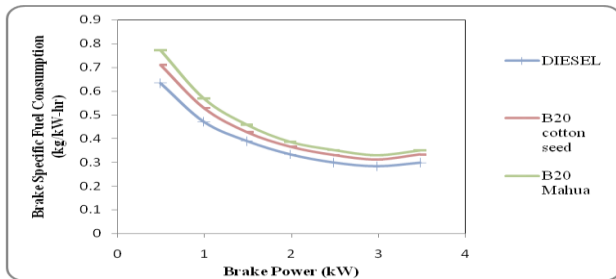


Figure 2: The variation of BSFC with brake power

The BSFC reduced with the load for all the fuels. The BSFC for all the biodiesel blends are higher than diesel fuel. The BSFC of cottonseed biodiesel blends are lower than the Mahua biodiesel blends. The specific fuel consumption is increased by 16% and 9.31% respectively with Mahua and cotton seed biodiesel blends compared with the diesel fuel. The BSFC is increased with increasing quantity of biodiesel in the blend because of the injection of less quantity of fuel due to the higher viscosity and lower heating value. The oxygenated biodiesels may lead to the leaner combustion resulting in higher BSFC. It is also observed that the BSFC of the engine with Mahua biodiesel blends is higher than the cottonseed biodiesel blends.

### C. Exhaust Gas Temperature

The Figure 3 shows the variation of exhaust gas temperature of the engine with break power output. The exhaust gas temperature in the combustion chamber depends on the calorific value, latent heat and viscosity of the fuel injected. The exhaust gas temperature was found to extend with increase in both the concentration of biodiesel within the blend and engine load. The rise in EGT with engine load is due to the actual fact that a more quantity of fuel is needed within the engine to get additional power required to take up conditional loading. For the diesel the exhaust gas temperature is low as compared with the biodiesel blends. The exhaust gas temperature for the diesel is 320°C, where as for Cotton seed biodiesel blend B20 and 332°C, for Mahua biodiesel blend B20 it is 336°C respectively at 3/4<sup>th</sup> of rated load. The exhaust gas temperature of Mahua biodiesel blends is slightly higher than the cottonseed biodiesel blends.

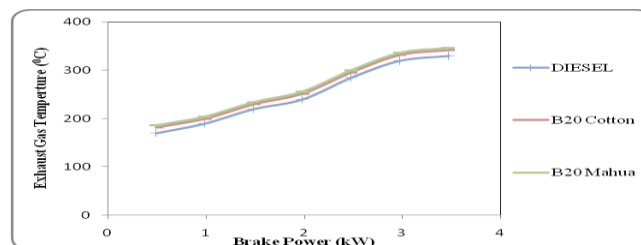


Figure 3: The variation of EGT with brake power

#### D. Smoke Density

The variation of the smoke densities with power output is shown in Figure 4.

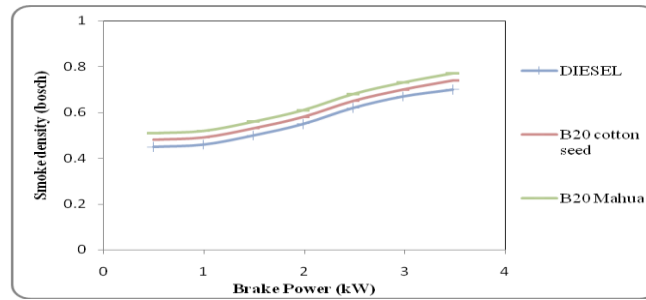


Figure 4: The variation of Smoke density with power output

The smoke opacity emissions increased with the increase of engine load. This is compensated up to certain extent due to the absence of aromatics and presence of inherent oxygen molecules in the biodiesel. These oxygen particles helps to promote stable and complete combustion by delivering oxygen to the combustion zone of burning fuel by reducing locally rich region and limit primary smoke formation and lower smoke emissions. Higher smoke emissions at higher loads may be due to poor atomization of biodiesel. When compared to diesel the increase in smoke emissions of biodiesel blends is higher due its high viscous nature. Due to higher viscosity of biodiesel the bigger size fuel molecules occurs and results in poor atomization of fuel.

#### E. Hydrocarbon emissions (HC Emissions)

The variation of hydrocarbon emissions with break power is shown in Figure 5. The HC emissions depend upon mixture strength i.e. oxygen quantity and fuel viscosity in turn atomization. The HC emissions increase with increasing load as well as increasing the amount of biodiesel in the blend. There will be similar trends for all the fuels. Lower heating value of biodiesel leads to the injection of higher quantities of fuel for the same load condition. More the amount biodiesel leads to more oxygen availability, either inherent in fuel or present in the charge. When compared to diesel, the oxygen availability in the biodiesels is more. So the HC emissions of the engine with biodiesel blends are less than diesel. The HC emissions of Mahua biodiesel blends are slightly higher than the cottonseed biodiesel blends.

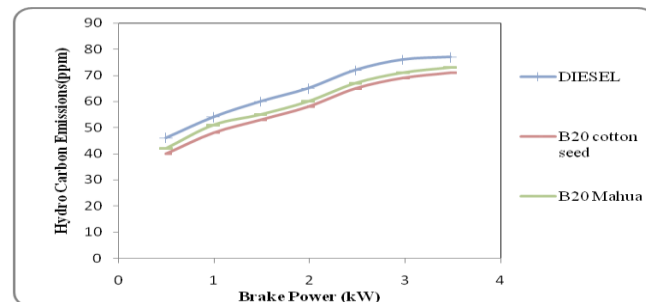


Figure 5: The variation of HC emissions with brake power

#### F. Carbon Monoxide Emissions (co emissions)

The variation of carbon monoxide emissions for is illustrated in Figure 6. It has been observed that the CO emissions are inflated with increase in engine load for all fuel samples. The CO emission of the engine with diesel oil is higher than the Cotton seed and Mahua biodiesel blends. The lower CO emission of biodiesel compared to diesel oil is due to the presence of oxygen in biodiesel that helps in complete oxidization of fuel. The surplus oxygen offered within the biodiesel converts the some of the CO into carbon dioxide and thus the CO emission is reduced. The CO emission for diesel oil is 0.67% volume, for Cotton seed biodiesel blend B20 is 0.615% volume and for Mahua biodiesel blend B20 is 0.623% volume at  $\frac{3}{4}$ th of rated load. The CO emissions of Mahua biodiesel blends are slightly higher than the cottonseed biodiesel blends

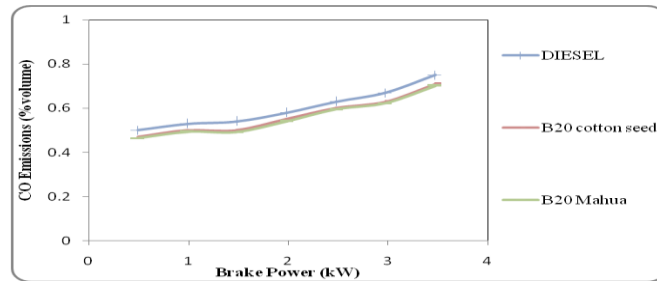


Figure 6: The variation of CO emissions with brake power

### G. . Nitrogen oxide Emissions

The variation of Nitrogen oxide emissions of the engine with diesel and biodiesels are illustrated in Figure 7. The NO<sub>x</sub> emission will increase with increase in load on the engine for each diesel and biodiesel blends. These higher NO<sub>x</sub> emissions could be due to the higher exhaust gas temperature at higher loads. The NO<sub>x</sub> emissions are slightly higher for Cottonseed biodiesel blends as compared with pure diesel. The rise of NO<sub>x</sub> emissions could also be related to the oxygen content of the biodiesel, since the biodiesel fuel provided extra oxygen for NO<sub>x</sub> formation. This one amongst the most reasons for the formation of higher NO<sub>x</sub> with the biodiesel blends as compared with pure diesel. The NO<sub>x</sub> emissions of Mahua biodiesel blends are slightly higher than the cottonseed biodiesel blends.

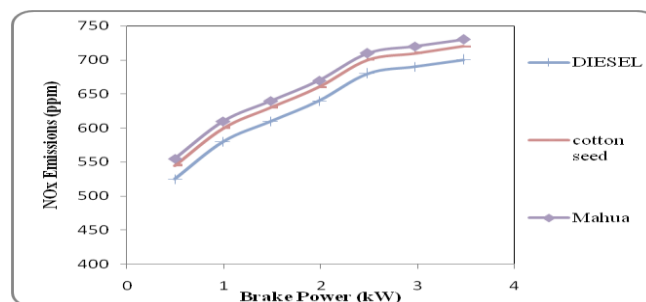


Figure 7: The variation of Nitrogen oxide emissions

## VI. CONCLUSIONS

The following conclusions are drawn based on the experimental results of the above work:

- The heating value and viscosity play a significant role in the braking thermal efficiency of the engine. Blends of biodiesel and diesel have inferior brake thermal efficiency. Brake thermal efficiency is greater in cotton seed biodiesel blends than in Mahua biodiesel blends. Cotton seed biodiesel blends have a lower BSFC than Mahua biodiesel blends, yet both are better than running the engine on diesel fuel alone.
- The BSFC of the engine with diesel fuel is lower than the biodiesel blends and the BSFC of cotton seed biodiesel blends is lower than the Mahua biodiesel blends.
- The exhaust gas temperature of the engine with diesel fuel is higher than the biodiesel blends.
- The CO and HC emissions from a diesel-fueled engine are lower than those from a biodiesel blend, and the CO and HC emissions from a blend made from cotton seed are lower than those made from Mahua.

Diesel fuel produces more smoke and nitrogen oxides (NO<sub>x</sub>) from an engine than do biodiesel mixtures.

The results show that when comparing the two biodiesels, cotton seed biodiesel performs better and produces fewer emissions than Mahua biodiesel. This means that cotton seed oil can be used instead of diesel in vehicles.

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