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Mechanical Engineering

Elixir Mech. Engg. 52 (2012) 11305-11308

ISSN: 2229-712X

# Performance,combustion and emission evaluation in DI diesel engine using diesel and biodiesel

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**ARTICLE INFO**

**Article history:**

Received: 11 September 2012;

Received in revised form:

23 October 2012;

Accepted: 3 November 2012;

**Keywords**

Biodiesel,

Combustion,

Emission,

Methyl ester.

**ABSTRACT**

The growing concern due to environmental pollution caused by the conventional fossil fuels and the realization that they are non-renewable have led to search for more environment friendly and renewable fuels. Among various options investigated for diesel fuel, biodiesel obtained from vegetable oils has been recognized world over as one of the strong contenders for reductions in exhaust emissions. In this present experimental work is carried out the performance and emission characteristics of diesel and biodiesel (Mahua) is analyzed. The results of depicts B20 Mahua blend of biodiesel is having the better characteristics in terms of performance and emission.



## Introduction

Several countries including India have already begun substituting the conventional diesel by a certain amount of biodiesel. Worldwide biodiesel production is mainly from edible oils such as soybean, sunflower and canola oils. Since, India is not self sufficient in edible oil production, hence, some non-edible oil seeds available in the country are required to be tapped for biodiesel production [1]. The most common blend is mix of 20% bio-diesel with 80%biesel. Bio-diesel is the only alter native fuel that runs in any conventional, unmodified diesel engine. It can be stored anywhere that diesel fuel is stored. The life cycle production and use of bio-diesel produce approximately 80%less carbon dioxide emission, and almost 100%less sulphur dioxide. Vegetable oil is a promising alternative to petro diesel fuel because it has several advantages. It is renewable, environmental friendly and can produce easily in rural areas, where there is an acute need for modern forms of energy. Crude vegetable oil in diesel engine gives several engine problems like valve sticking, injector coking, piston sticking and occurrence of carbon deposit [2]. High viscosity and low volatility of the oil is the main reason for the engine problem [3]. These problems can be resolved by transesterfying the crude vegetable oil with alcohol. In this paper, non-edible oil, Madhuca Indica, is used to run the engine and carry out performance combustion, and emission tests, Madhuca Indica (biological name) or Mahua in Hindi or Illupai in Tamil.

## Experimental Setup

The experiments diesel with bio-diesel mixture was carried out in DI diesel engine. The test engine is a single cylinder, direct injection, water cooled Compression Ignition engine. The experimental setup is shown in figure 1. Diesel engine was directly coupled to an eddy current dynamometer. The engine was always run at its rated speed. The governor of the engine was used to control the engine speed. The dynamometer was interfaced to a control panel. Experimental tests have been carried out to evaluate the performance, emission and combustion characteristics of a diesel engine when fuelled Mahua oil MEOM and its blends of 20%, 40%, 60%, 80% and 100% of biodiesel with ordinary diesel fuel separately at different load. The emission like HC, CO, and NOx, were measured in the exhaust gas analyzer and smoke density was measured in the smoke meter. AVL 444Di-gas analyzer was used to measure the oxides of nitrogen. AVL 437 smoke meter was used to measure the density of exhaust gases. AVL combustion analyzer was used to analyze the combustion characteristics.

**Table 1. Specifications of the Test Engine**

| | |
|---|---|
| Type | Vertical, Water cooled, Four stroke |
| Number of cylinder | One |
| Bore | 87.5 mm |
| Stroke | 110 mm |
| Compression ratio | 17.5:1 |
| Maximum power | 5.2 kW |
| Speed | 1500 rev/min |
| Dynamometer | Eddy current |
| Injection timing | 23° before TDC |
| Injection pressure | 220 kgf/cm$^2$ |

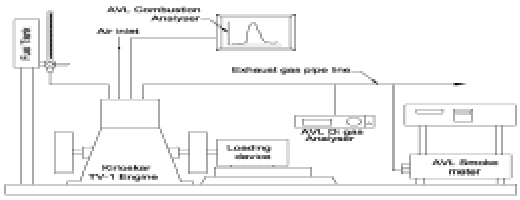


**Fig. 1. Test Engine**

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**Result and discussion**

**Performance characteristics:**

**Specific fuel consumption**

The variation of specific fuel consumption with increasing brake power is shown in Fig 2. The data shows the specific fuel consumption for diesel was less compared to various blends of bio diesel. Also it was evident from the graph that the difference in fuel consumption between diesel and B20 blend was very negligible.

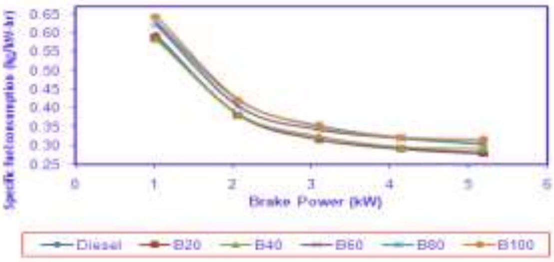


**Fig. 2. Specific fuel consumption Vs brake power**

**Brake thermal efficiency**

The variation of brake thermal efficiency with respect to brake power is shown in Fig 3. It is seen that brake thermal efficiency increases with increase in break power for diesel and biodiesel blends. The brake thermal efficiency of diesel is superior for diesel compared to biodiesel blends. Also from the data, it is noted that the brake thermal efficiency of B20 blend is nearer to that of diesel compared to other biodiesel blends. This variation in brake thermal efficiency for biodiesel blends is due to higher viscosity and lower volatility, which leads to poor mixture formation. This results in decrease of brake thermal efficiency for biodiesel blends.

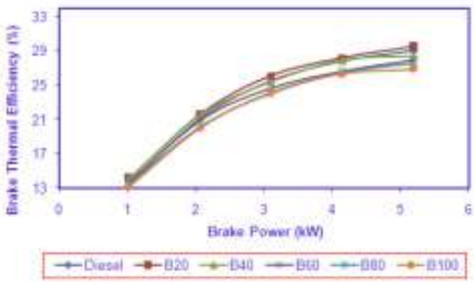


**Fig. 3. Brake thermal efficiency Vs brake power**

**Emission characteristics:**

**Smoke density**

From the test data shown in the Fig 4, it is observed that smoke density of diesel is higher compared to biodiesel blends. It is evident from the graph that, among the biodiesel bunds the smoke density of B20 blend is lower. Higher thermal efficiency means, better and complete combustion and lesser amount of unburnt hydrocarbon in the engine exhaust thus improving smoke density values.

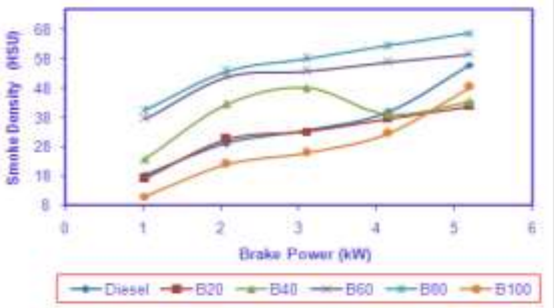


**Fig. 4. Smoke density Vs brake power**

**Oxides of nitrogen**

Fig 5 shows the variation in the NOx emission of diesel and biodiesel with respect to brake power. The formation of NOx in the cylinder depends on the engine in-cylinder temperature and the rate of combustion. The two most important factors in determining the NOx formation by the combustion process are stoichiometric air fuel ratio and the flame temperature. It can be observed that the formation of NOx for biodiesel operation is lower when compared to that of diesel operation. This is due to the decrease in in-cylinder temperature, which is reflected in lesser exhaust gas temperature. The figure clearly illustrates the NOx emission is higher for biodiesel blends compared to diesel at full load condition.

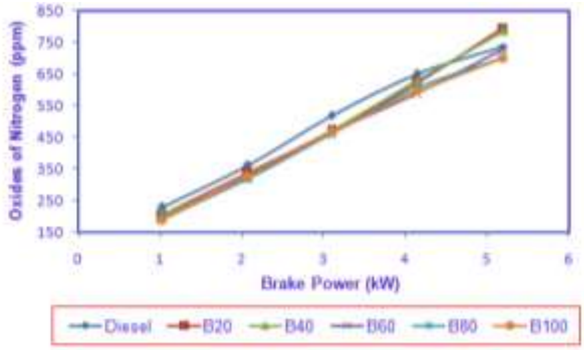


**Fig. 5. Oxides of nitrogen Vs brake power**

**Hydrocarbon**

Fig 6 shows the rate of hydrocarbon emission for diesel and various blends of biodiesel. The data clearly depicts, the emission rate of hydrocarbon is higher for diesel compared to blends of biodiesel. During full load condition, an exception arises, where emission rate is higher for B20, B40 blends of biodiesel. The reduction of emission in biodiesel is because of presence of oxygen in the fuel. The oxygen presence promotes complete combustion, thus the reduction in HC emission.

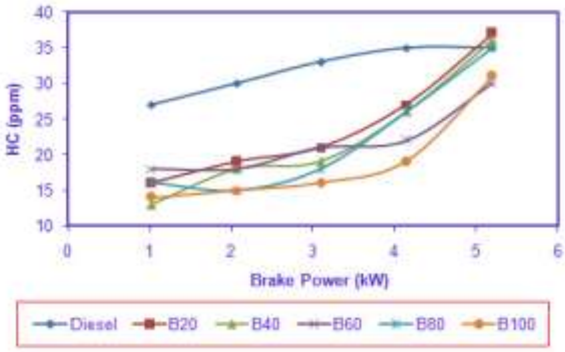


**Fig. 6. Hydrocarbon Vs Brake Power**

**Exhaust gas Temperature**

The variation in exhaust gas temperature with brake power for biodiesel operation and diesel is depicted in Fig 7. It can be observed that the exhaust gas temperature for biodiesel operation is lower compared to that of diesel. This may be due to the decrease in in-cylinder temperature.

**Combustion characteristics:**

**Heat release rate**

Fig 8 shows the heat release rate for diesel and biodiesel at different engine loads. Because of the vaporization of the fuel accumulated during ignition delay, at the beginning a negative heat release is observed and, after combustion is initiated, this becomes positive. Biodiesel experiences identical combustion stages with diesel. After the ignition delay, premixed fuel–air mixture burns rapidly, followed by diffusion combustion, where the burn rate is controlled by fuel–air mixing. It can be observed that combustion starts earlier for biodiesel at different engine loads. At lower engine loads, the heat release rate for diesel is slightly lower than that for biodiesel, but at higher engine loads, the heat release rate for diesel is higher.

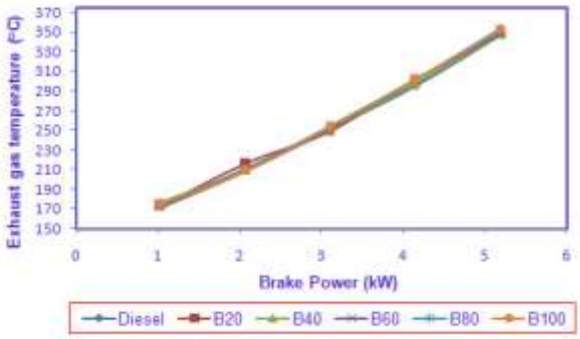


**Fig. 7. Exhaust gas temperature Vs Brake Power**

The crank angle at which the maximum heat release rate occurs is in advance for biodiesel. This is due to the start of combustion after TDC for both fuels at lower engine loads and the combustion starts later for diesel than for biodiesel. As the engine load is increased, the heat release rate for diesel is higher because of the longer ignition delay, during which more fuel is accumulated in the combustion chamber to release higher heat during the premixed combustion phase, as suggested earlier.

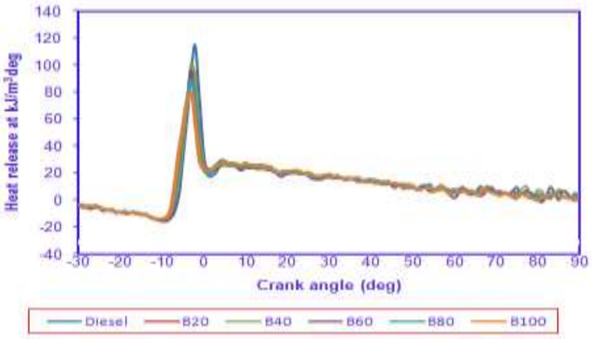


**Fig. 8. Heat release rate Vs crank angle**

**Cylinder pressure**

The variations in the rate of pressure rise with crank angle for diesel and biodiesel at different engine loads are shown in Fig 9. It can be seen that at lower engine loads the rate of pressure rise for diesel is slightly lower than for biodiesel. The reason is that, at this operating condition, a very small quantity of fuel is injected into the combustion chamber and combustion starts after the TDC. However, the rate of pressure rise is higher for diesel at higher engine loads. This is due to the higher rate of heat release during premixed combustion phase.

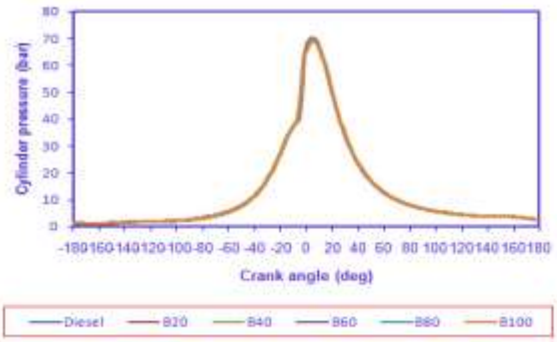


**Fig. 9. cylinder pressure Vs crank angle**

**Conclusion**

The objective of this study was to characterize the effect of biodiesel produced from Mahua oil on the combustion Characteristics, performance and exhaust emissions of a diesel engine. The properties, performance, emissions and combustion characteristics of the engine fuelled with biodiesel and diesel were compared. Based on the experimental results, the following conclusions can be drawn:

The brake specific fuel consumption increased and brake thermal efficiency decreased with increase in the proportion of biodiesel in the blends. Exhaust pollutant emission are reduced compared to diesel. Due to the different properties of biodiesel and diesel, both fuels exhibit different combustion characteristics with the variation of engine loads. At lower engine loads, the peak cylinder pressure, the peak rate of pressure rise and the peak heat release rate are slightly higher for biodiesel. At higher engine loads, the peak cylinder pressures for both fuels are almost same, but the peak rate of pressure rise and peak heat release rate are lower for biodiesel. The crank angles at which the peak values occur are in advance for biodiesel. Combustion for biodiesel starts earlier owing to a shorter ignition delay and advanced injection time at all engine loads. These would attract biodiesel as a suitable substitute for diesel fuel. As Mahua is a renewable fuel with it is performance similar to that of diesel and lower emissions it can be promoted as an alternative fuel for diesel either as a sole fuel or as a blended fuel with diesel which will be environmentally friendly in nature.

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