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Research Article

Thermal Studies on a Diesel Engine using Vegetable Oil Blends

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Abstract

Vegetable oils can be used as an alternative fuel for diesel operations, but the higher viscosity of vegetable oil causes improper atomization of fuel during injection, resulting in incomplete combustion. The carbon residue of vegetable oil is also higher than that of diesel. This leads to more smoke density and particulate matter in the diesel engine exhaust. Vegetable oils have been gaining worldwide attention as an alternate energy source because they are environment friendly and renewable in nature. In this work, an attempt is made to reduce the viscosity by transesterification process and the resulting Biodiesel and its blends have been tested in an IC engines for thermal studies, while trying to assess its suitability as an alternate fuel.

Key words*: Vegetable oil, IC engines, Thermal studies etc.*

Introduction

The world consumption of petroleum fuels has hence increased enormously in the past few decades. Petroleum fuels, for all their advantages, also present serious problems. They are fossil fuels which are bound to be ultimately depleted. Petroleum deposits are very unevenly distributed in the world. For India, the only viable long-term solution to this problem is to develop alternative sources of energy, preferably renewable, which are located in our territory. In this regard, non-edible vegetable oils can be a partial replacement for diesel oil, which forms such an important input for our transportation and agriculture operations. Vegetable oils have the following advantages as a substitute for diesel oil: They are easily handled liquid fuel with properties close to those of diesel oil in many respects.

1. They are a renewable source of energy.
2. They mix easily with diesel oil. Hence they can be used in the blended form also.
3. They can be produced in rural areas by well-known agriculture practices. The extraction of the oil from the plants seeds is a relatively simple process which can also be carried out in rural areas.

Vegetable oils have always had their advocates ever since the advent of the diesel engine. In fact, Dr. Rudolf Diesel, the inventor of the diesel engine, used ground nut oil as fuel in his tests. He confidently predicted that one day his engine will be fuelled by vegetable oils, with their great advantage of being renewable. Obviously only non-edible vegetable oils can be used as fuels since edible oils are in great demand and far too expensive for this application.

In India Jatropha Curcas and Pongamia Pinnata are considered as the potential candidate for substituting diesel fuel. Although vegetable oils themselves have been tested in diesel engines the relatively high viscosities of the oils cause problems such as choking of the injectors, oil ring sticking and thickening of the lubricating oil. This high viscosity results from the high molar masses of the oils. In this work, transesterification is done to reduce the viscosity of raw vegetable oil (Pongamia Pinnata).

2. Properties

Table1 Pongamia Seed Composition

Name	**Composition**
Oil	27 to 39%
Protein	30 to 40%
Starch	6 to 7%
Crude fibre	~7%

3. Experimental set up and test procedure

The experimental set up consists of a single cylinder four-stroke, water-cooled and constant-speed (1500 rpm) compression ignition engine. The detailed specification of the engine is given below;

Make : Kirloskar
Type : Four Stroke
Number of Cylinder : Four Cylinder

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Type of Cooling	:	Water Cooled
Rated Power	:	5.4 kW
Rated Speed	:	1500 rpm
Loading Device	:	Eddy Current Dynamometer
Bore x Stroke	:	87.5 mm x 110 mm
Injection Pressure	:	220 kgf/cm^2
Ignition timing	:	23° before TDC(rated)
Ignition system	:	Compression Ignition

Experiments were initially carried out on the engine using diesel as a fuel to provide base line data. Under steady state conditions, the fuel consumption rate, air consumption rate, speed, exhaust gas temperature were recorded at various loads. The engine speed was held at 1500 rpm and the power output was varied. The engine was next run with various blends and the performance tests were carried out as before. Emissions like HC, NO_X, etc., and cylinder pressure, heat release rate, and smoke density were measured. The different parameters like specific energy consumption, power, efficiencies, Heat release rate, Nox concentration, HC concentration are determined at various load conditions. The results obtained are weighed with those under pure diesel mode of operation. The Eddy current dynamometer was used for loading the engine. Fuel consumption was measured on a volumetric basis using a burette and a stopwatch. Air flow was measured using an orifice flow meter. A series of experiments were carried out using diesel and the various blends. All the blends were tested under varying load conditions at the rated speed. During each trial, the engine was started and after it attains stable condition, important parameters related to thermal performance of the engine such as the time taken for 10 cc of fuel consumption, applied load, etc., the emission data were measured and recorded.

4. Results and discussions

In this work, the non-edible vegetable oil obtained from Pongamia Pinnata was transesterified to reduce its viscosity, and blended with sole fuel, diesel, in various ratios such as B20, B40, B60, B80 and B100. The blend obtained after this process was used as a substitute for diesel fuel.The relationship between Brake thermal efficiency and Brake power for different blends and diesel

Fig 1 Experimental setup

is shown below in Fig 2. It can be seen from the figure that the brake thermal efficiency increased with an increase in load. This can be due to more complete and timely combustion of the Biodiesel. The Biodiesel-air mixture is less lean at higher loads which burn completely.

It is found that brake thermal efficiency was lower at low loads. This is due to the very lean Biodiesel-air mixture which leads to incomplete combustion. The differences in brake thermal efficiency is a reflection of the differences in combustion of fuels, it resulted in higher brake thermal efficiency for fuels with higher blend percentage.

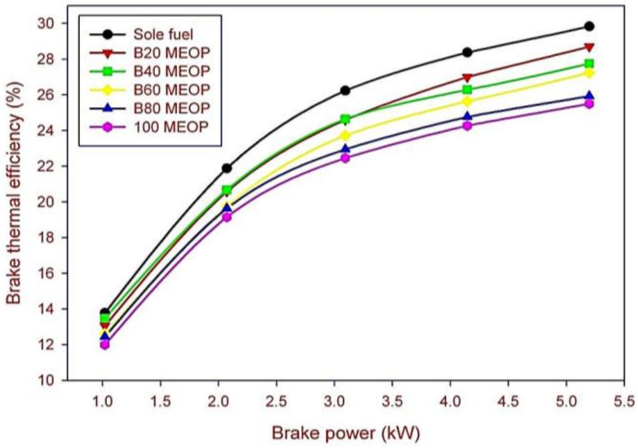

Fig. 2 Relationship between Brake thermal efficiency and Brake power for different blends and diesel

The relationship between Exhaust gas temperature and Brake power for different blends and diesel is shown below in Fig 3. It is clear from the figure that as load increases, the exhaust gas temperature increases. The maximum exhaust gas temperature was observed at maximum load. The analysis of variance for exhaust gas indicates that the fuel type and engine brake load have a significant effect on exhaust gas temperature. The exhaust gas temperature decreased for blends. Since Biodiesel is oxidized fuel, while burning has a lower burning temperature. Another reason could be the lower calorific value of blended fuel as compared to diesel alone.

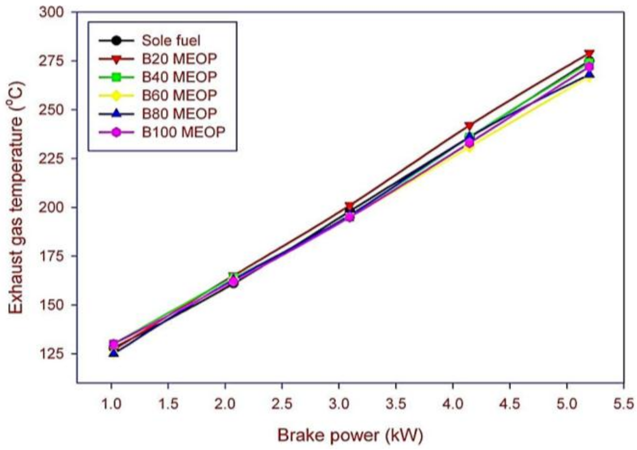

Fig. 3 Relationship between Exhaust gas temperature and Brake power for different blends and diesel

The effect of brake power on smoke densiity is shown below in Fig 4. Higher blends of Biodiesel (MEOP), due to its heavier molecular structure and higher viscosity, atomization becomes poor and this leads to higher smoke emission. It was observed that smoke emission increased with the increase in load.

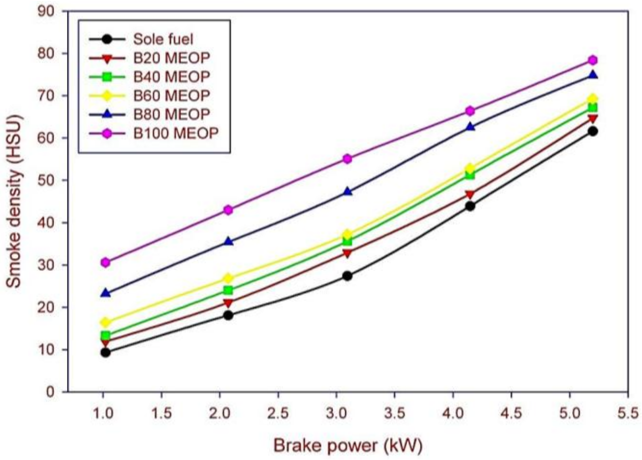

Fig. 4 Effect of brake power on smoke densiity

The effect of brake power on NOx levels for various blends of Biodiesel is shown below in Fig. 5. The Biodiesel blends show higher NOx emissions upto 60% load compared to standard diesel operation. However all blends show lesser emissions at peak load. This reduction in NOx emission is mainly associated with reduced premixed burning rate.

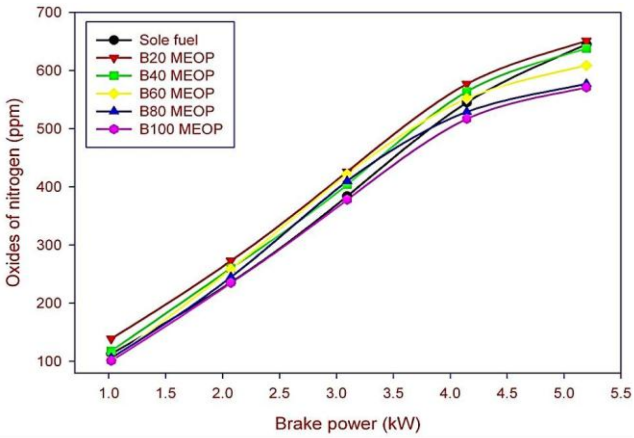

Fig. 5 Effect of brake power on NOx levels for various blends of Biodiesel

The effect of brake power on hydrocarbon emissions is shown in Fig. 6. At peak loads HC emissions is lower for blends compared to standard diesel operation. The lower thermal efficiency of the engine with these blends is also responsible for this trend. When thermal efficiency is lower there is a need to inject higher quantities of fuel for the same load condition.

Fig. 6 & 7, below shows the comparison of heat release rates for Diesel, and various blends of Biodiesel during normal engine operation. The premixed burning phase associated with a high heat release rate is significant with diesel operation which is responsible for higher peak pressure and higher rates of pressure rise. This is the reason for the higher thermal efficiency with diesel.

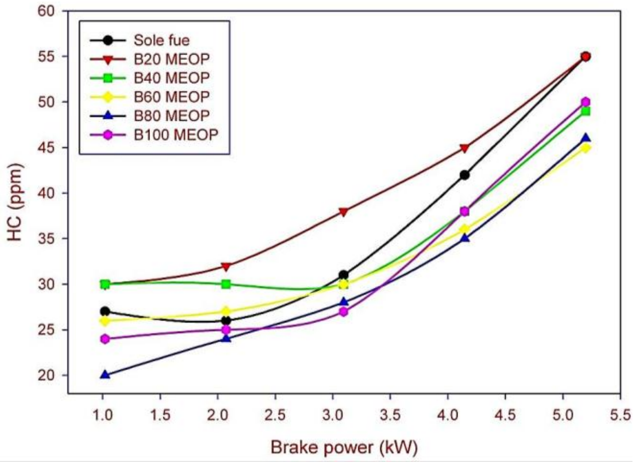

Fig 6 Effect of brake power on hydrocarbon emission

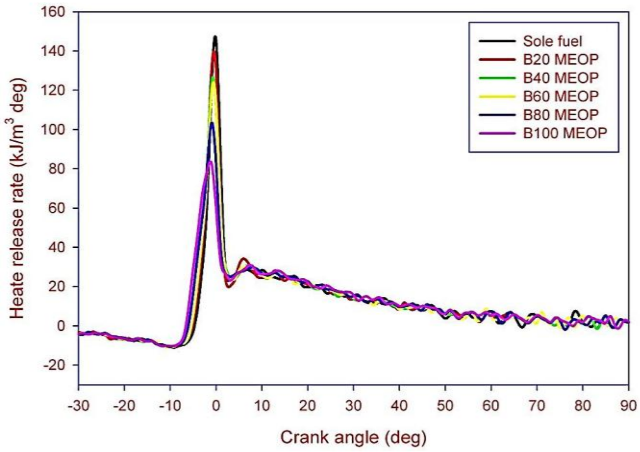

Fig 7 Comparison of heat release rates for Diesel, and various blends of Biodiesel

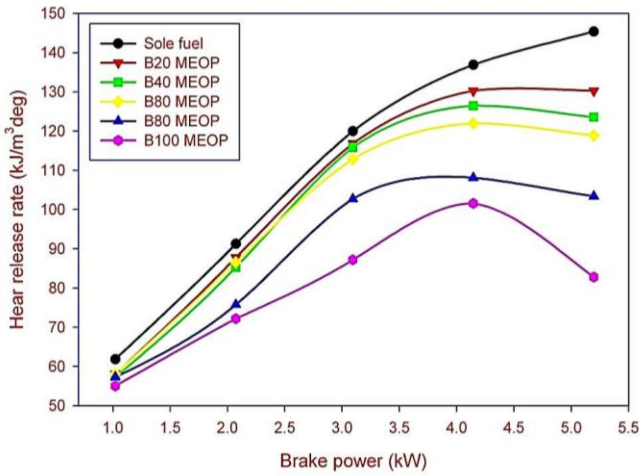

Fig 8 Heat release rate v/s Brake power

5. Conclusion

- There is no significant difference in the power produced and the efficiency of the engine.

- At full load the engine consumes up to 10% higher fuel as compared to diesel when it is running on Biodiesel blends.
- The Specific fuel consumption (SFC) is slightly increased when higher blends of biodiesel are used. At peak load SFC is increased up to 7.5% for Biodiesel blends when compared to diesel.
- At full load the engine running on diesel has higher mechanical efficiency when compared to the engine running on Biodiesel.
- Exhaust gas temperatures were lower for Blends when compared to diesel fuel.
- The properties found for the B100 were almost meeting the ASTM standards recommended for use in the diesel engines.
- The NO_X and HC emissions decreased for Biodiesel blends at maximum load when compared to diesel fuel.

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