Asian Review of Mechanical Engineering
ISSN: 2249-6289 (P) Vol.1 No.2, 2012, pp.30-33

DOI: https://doi.org/10.51983/arme-2012.1.2.2299

Performance Characteristics of Diesel Engine Fueled by Biodiesel of Jatropha Oil and Soybean Oil

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Abstract - **Biodiesel is considered as an important renewable and alternative fuel of future. This paper focuses on the performance of biodiesel made from jatropha oil and soybean oil. The biodiesel was produced through transesterification process and it was blended with the fossil diesel. The blended mixtures were tested in an IC diesel engine attached with a dynamometer. On the basis of performance tests it was found that brake thermal efficiency of mixed jatropha and soybean biodiesel blends is nearer to pure diesel oil at different rpm. The brake specific fuel consumption obtained with biodiesel blend of mixture of jatropha and soybean oil is comparable with fossil diesel.**

Keywords: **Biodiesel, Alternative fuel, Jatropha oil, Soybean oil, Brake thermal efficiency**

1. Introduction

Diesel engines are used in a number of applications like heavy automobile engines, cars, small irrigation water pumping systems and small electricity generators etc. Therefore, diesel fuel is used much more than any other gasoline fuels. Diesel is produced from non-renewable fossil fuels which are limited in quantity and one day they would be exhausted. Biodiesel is an alternative and renewable fuel that can be produced from various vegetable oils, animal fats and waste cooking oil. Biodiesel can be blended with fossil diesel to create a biodiesel blend. This blend can be used in compression-ignition engines or oil-fired boilers and furnaces with little or no modifications.

Since biodiesel is produced from plants, it is considered as carbon neutral because after combustion it produces the carbon which has been absorbed during photosynthesis process. The use of biodiesel can reduce the use of petroleum based fuels and possibly lower the overall greenhouse gas emissions. Biodiesel, due to its biodegradable nature, and absence of sulfur and aromatic contents, produces less toxic emissions. Therefore it is considered as an environment friendly fuel. Many researchers have produced biodiesel by using different edible and non-edible vegetable oils and these biodiesels have been tested in diesel engines for their performance.

Hammerlein *et al*. conducted experiments using filtered rapeseed oil in diesel engine and found that the brake power and torque using rapeseed oil were 2% lower than that of diesel oil. But, NO_x and particulate emissions were lower as compared to diesel fuel combustion. However, noise and emission of CO and HC were higher [1]. Chio blended the diesel and biodiesel in the ratio of 80:20 and 60:40 by volume. The prepared blend was tested on a single cylinder caterpillar engine, using both single and multiple injection system. During high loads and single injection, the particulate matter and CO emissions were decreased. However, a small increase in NO_x was noticed when the bio-diesel concentration is increased. But in the case of multiple injection a decrease in particulate emission was observed with little or no effect on NO_x [2]. Agarwal used ethanol blended with diesel to study its performance and emissions in an Engine. The tests demonstrated that almost all the important properties of biodiesel are in very close to the fossil diesel [3]. Rao et al. found that the brake thermal efficiency for biodiesel and its blends was slightly higher than that of diesel fuel at tested load conditions. It was found that for jatropha biodiesel and its blended fuels, the exhaust gas temperature increases with increase in power and amount of biodiesel [4]. Godiganur et al. found that the blend of Karanja oil methyl ester and diesel can be used successfully as an alternative fuel without any affect on engine power and performance. Moreover, the amounts of exhaust emissions are lower than those of diesel fuel [5]. Mohanty *et al*. used Polanga oil to run an IC engine to evaluate the combustion performance and emission characteristics of diesel engine. It is found that Polanga oil can be used as an alternative fuel in diesel engine without affecting the performance of the engine [6].

Almost all of the vegetable oils can be used as raw material to produce biodiesel. But it is suggested that only non-edible oils should be used for this purpose due to obvious reasons. In the present study different blends of biodiesel from jatropha oil and soybean oil has been used in a diesel engine to check its performance and emission temperature. The jatropha oil is a non-edible oil and it can be produced from the carcass of jatropha plant. This plant can be grown on non-irrigated land without any special care.

II. Preparation Of Biodiesel

Vegetable Oils (Triglycerides) are ester of glycerol and fatty acids. A chemical reaction of these triglycerides with the alcohol in the presence of a catalyst produces methyl esters (biodiesel) and glycerol. This reaction process is known as transesterification. Currently, most commercial biodiesel is produced with the transesterification processes using a homogeneous alkaline catalyst, generally NaOH or KOH. The alkaline catalyst provides a faster reaction as compared to an acidic catalyst. The alcohol which is generally used is methanol due to its relatively low cost and a high cetane number of the produced biodiesel [7]. Methanol has an ability to react with triglycerides quickly and the alkali catalyst is easily dissolved. The rate of transesterification process depends upon the amount of methanol, catalyst, reaction temperature and reaction time. The chemical reaction is given below:

CH_2COOR

| Catalyst

$CHCOOR + 3CH_3OH \rightarrow CH_2OH)_2CHOH+3CH_3COOR$

$|CH_2COOR$

Catalyst

(Triglyceride + Methanol $\rightarrow$ Glycerol+Methyl Esters)

Theoretically, three moles of alcohol are required for each mole of triglyceride to produce three moles of fatty acid alkyl ester and one mole of glycerol. But since transesterification is a reversible reaction, excess amounts of alcohol are used to ensure that the oils or fats will be completely converted to esters, and a higher alcohol triglyceride ratio can result in a greater ester conversion in a shorter time. Therefore maintaining a high alcohol to oil ratio is essential. The commonly employed molar ratio for two-step acid transesterification is 6:1 and 9:1 for alkali catalyzed transesterification [8]. If molar ratio is further increased it makes it difficult to separate the glycerol from the oil [9]. The process temperature is constrained to be below the boiling point of the alcohol used. Reported reaction times for typical biodiesel production ranges from 30 minutes to over 2 hours, with catalyst concentrations that vary between 0.1 and 2% [10, 11]. In this study jatropha oil and soybean oil have been used as raw materials for producing two different types of biodiesels. KOH was used as catalyst. Table-1 shows properties of diesel and the oils which have been used for the production of biodiesel.

Table I Properties Of Jatropha Oil, Soybean Oil And Diesel

Fuel	Dynamic Viscosity at 20°C (cP)	Density (g/cc) at 30°C	Calorific Value (KJ/Kg)	Flash point °C	Cetane Number
Diesel	4.83	0.845	45,870	35	49.6
Jatropha Oil	50.73	0.93292	45,456	240	51
Soybean Oil	60	0.9239	38,000	254	34.8

For producing the biodiesel the vegetable oil was mixed with methanol and KOH. The mixture was heated at 60°C for 3 hours while stirring with magnetic stirrer. Mixing is very important in the transesterification reaction as triglycerides are immiscible in the alcohol solution. Transesterification was carried out at 60°C, which is just below the boiling temperature of methanol. The reaction mixture was allowed to settle to get biodiesel at the top and glycerin at the bottom. After separation the biodiesel was filtered to remove any solid particles then it was heated at 100°C for 10 minutes in stainless steel tank to remove any water contents.

After the preparation of two different types of biodiesel by using two different raw materials, three different types of blends of the biodiesel and conventional fossil diesel were prepared as shown in the Table II.

Table II Different Bends Of Biodiesel And Diesel

Blend	Ratio (By volume)	Given Name
Blend-1	Biodiesel from Jatropha 20% + Diesel 80%	Jatropha blend
Blend-2	Biodiesel from Soybean 20% + Diesel 80%	Soybean blend
Blend-3	Biodiesel from Soybean 10% +Biodiesel from Jatropha 10% + Diesel 80%	Soya+Jatropha blend

In the first blend 20% of jatropha biodiesel is mixed with 80% of conventional diesel. In the second blend 20% of Soybean biodiesel is mixed with 80% of conventional diesel. In the third blend 10% of jatropha biodiesel and 10% of soybean biodiesel is mixed with 80% of conventional diesel. After the preparation of blends, tests were conducted to determine the performance characteristics of the engine.

III. EXPERIMENTAL SET UP AND PROCEDURE

Experimental investigations were carried out on a double cylinder DI diesel engine to examine the suitability of jatropha and soybean biodiesel blends as alternate fuels. Two cylinder four stroke Kirloskar engine test rig with attached hydraulic dynamometer was used to conduct performance tests on engine. Specifications of test rig are given in Table III.

After warming up and stabilizing the engine, tests were conducted. For all the tests the speed of the engine varied from 1000 to 1500 rpm at a constant load. The jatropha and soybean oil blends were supplied as fuel to the enginr. Each experiment was repeated three to five times to calculate the mean value of the experimental data. The performance characteristics of the engine were evaluated in terms of brake thermal efficiency (BTE), brake specific fuel consumption (BSFC) and exhaust gas temperature (EGT). These characteristics were compared with the results of pure diesel.

TABLE III DIESEL ENGINE TEST RIG SPECIFICATIONS

Manufacture	Kirloskar Oil Engines Ltd.
Engine Type	4 stroke, double cylinder
Power	16 HP
R.P.M	1500
Cylinder bore	87 mm
Cylinder stroke	110 mm
Injection opening Pressure	200 bar
Cooling medium	Water cooled
Dynamometer type	Hydraulic

IV. RESULTS AND DISCUSSION

A. Engine Performance

Different blends of diesel and biodiesel are tested and compared with pure diesel for calculating BTE at different speeds as shown in Fig. 1. The graph reveals that, maximum value of BTE of different blends as well as pure diesel is exhibited at 1000 rpm of the test engine. It is also observed that at 1100 rpm the BTE of the jatropha blend approaches to that of pure diesel, however on increasing the speed it goes on decreasing. Soybean blend shows lower values of BTE at all selected rpm. It may be due to its lower calorific value. The soy+jatropha blend provide more BTE as compared to blends of only soybean or only jatropha. But the BTE of this blend is also less than the pure diesel.

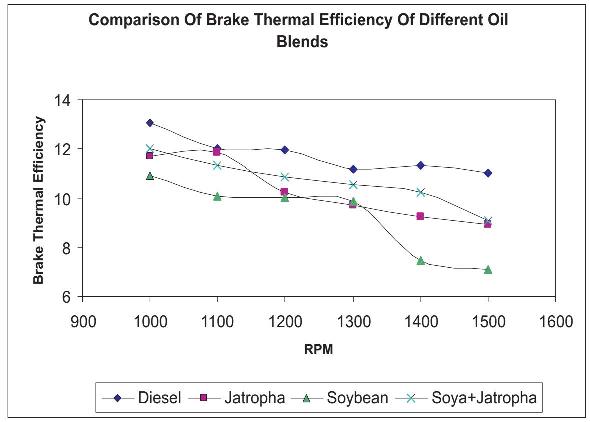

Fig. 1 Comparison Curves For Brake Thermal Efficiencies of Different Oil blends

B. Brake Specific Fuel Consumption

Brake specific fuel consumption (BSFC) has been evaluated for different blends and at different rpm as shown in Fig. 2.

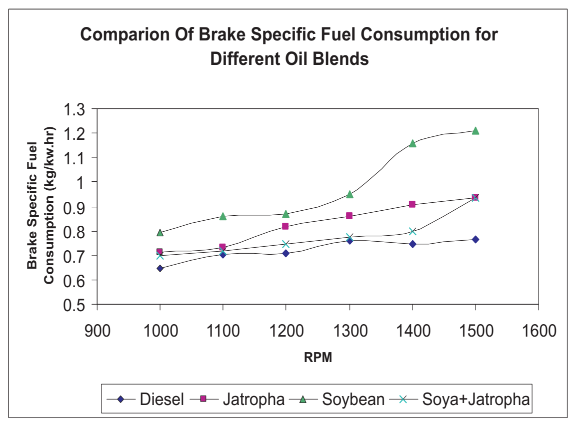

Fig. 2 Comparison Curves For Brake Specific Fuel Consumption of Different Oils

It is found that pure diesel has the lowest BSFC value. This is primarily due to the fact that diesel has the highest calorific value among three fuels, and needs the lowest fuel consumption rate for achieving the same engine brake horse power output as by the other three blends. The values of BSFC for soy+jatropha blend are slightly higher than pure diesel at all values of rpm. It has been found that for all types of tested fuels, as the rpm of engine increases BSFC also increases under constant load conditions. BSFC is higher in case of soybean blend with its lower BTE at all engine speeds.

C. Exhaust Gas Temperature

Exhaust gas temperature (EGT) increased with increase in engine speed for all the cases as shown in Fig. 3.

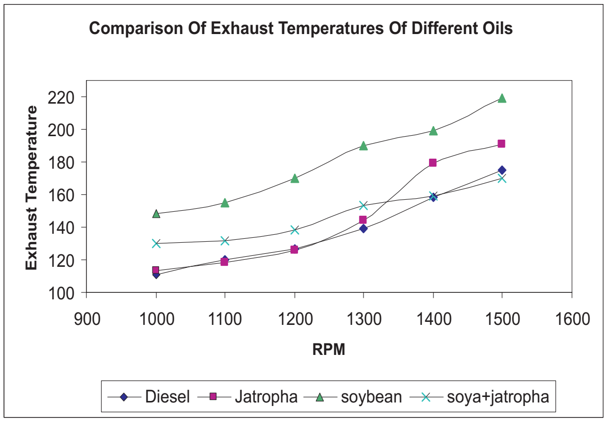

Fig. 3 Comparison Between Exhaust Temperatures of Different Oils

EGT values for jatropha blend are less than the pure diesel at 1100 rpm and it remains nearer to the EGT values of pure diesel upto 1300 rpm. After 1300 rpm EGT of jatropha blend increases and reaches to maximum value of 190°C at 1500 rpm. The EGT of soya+jatropha blend is near to pure diesel at 1400 rpm and slightly less than the pure diesel at 1500 rpm. EGT of soybean is higher as compared to tested blends at various speeds of the engine. EGTs of biodiesel blends are different from pure diesel oil, it may be due to their different calorific values and different trends in specific fuel consumption during the tests.

V. Conclusions

On the basis of performance tests it is found that BTE of mixed jatropha and soybean biodiesel blends is nearer to pure diesel oil at different rpm. The brake specific fuel consumption obtained with biodiesel blend of mixture of jatropha and soybean oil is comparable with pure diesel. Exhaust gas temperature of soybean oil is maximum at all recorded engine speeds as compared to other oil blends and pure diesel oil. The performance test carried out showed that blend of diesel and biodiesel (soya+jatropha blend) can be successfully used as an alternative fuel for diesel engines without any modifications.

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