STUDIES ON THE EFFECT OF BIODIESEL AS AN ALTERNATE FUEL ON DIESEL ENGINE

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Abstract

To meet the rising energy demand and replace reducing petroleum reserves, fuels such as biodiesel and bioethanol are in the forefront of alternative technologies. The viable alternative fuel for compression-ignition engines is biodiesel. Biodiesel is briefly defined as the esters of vegetable oils or animal fats. Biodiesel is the best candidate for diesel fuels in diesel engines. Biodiesel burns like petroleum diesel as it involves regulated pollutants. On the other hand biodiesel probably has better efficiency than gasoline. Biodiesel also exhibits great potential for compression-ignition engines. Diesel fuel can also be replaced by biodiesel made from vegetable oils. Experiments were initially carried out on the engine using diesel as a fuel to provide base line data. The different parameters like specific energy consumption, power, and efficiencies are determined at various load conditions. The results obtained are weighed with those under pure diesel mode of operation.

Keywords: Biodiesel, Alternate fuel, Diesel Engine, Fuel Consumption.

I. INTRODUCTION

The scarcity of conventional fossil fuels, growing emissions of combustion generated pollutants, and their increasing costs will make biomass sources more attractive (Sensoz *et al.*, 2000). On the other hand, biomass use, in which many people already have an interest, has the properties of being a biomass source and a carbon-neutral source (Dowaki *et al.*, 2007). Experts suggest that current oil and gas reserves would suffice to last only a few more decades. 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. Worldwide, petroleum is the largest single source of energy, surpassing coal, natural gas, nuclear, hydro, and renewables (EIA, 2006). 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 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. 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. A simple method to lower the molar mass is to transesterify the triglycerides. In the most commonly used process, the glycerol moiety is replaced by three molecules of methanol to yield methyl esters. The methyl esters perform as good as regular diesel fuel, and perhaps better. One of the attractive characteristics of biodiesel is that its use does not require any significant modifications to the diesel engine, so the engine does not have to be dedicated for biodiesel.

In this work the non-edible vegetable oil obtained from Pongamia Pinnata was transesterified to reduce its viscosity by removing glycerol from it. The Biodiesel obtained after transesterification process was used as a substitute for diesel fuel.

The properties of the biodiesel obtained are determined and compared with the diesel fuel properties and ASTM standards. The biodiesel obtained from transesterification of Pongamia extract is tested for various properties like viscosity, calorific value, flash point, cloud point etc., Similarly for various biodiesel blends (B5, B10, B15 and B20) the properties are determined. The properties of diesel fuel are considered as base values for comparison. The Biodiesel and its blends were used to run constant speed stationary diesel engine.

II. BIODIESEL CHARACTERIZATION

A. General Characteristics:

Pongamia Pinnata (Karanj) is a medium sized evergreen avenue tree planted in most parts of the country. It is a nitrogen fixing leguminous tree that grows wild in India up to 1200meters altitude. It tolerates salinity, drought resistant and grows in degraded lands even under water logged conditions. At commonly used spacing of 3m x 3m 1000 trees can be planted per hectare, these trees yield 10 to15 tonnes of seeds per hectare on maturing. Since 15 to 20 years old tree use soil to more than 10m depth (unlike agricultural crops which use only 150mm of topsoil) both the survivability during dry periods and annual output per hectare are better. There is also no possibility of total yield failure with trees in any year. The trees start flowering from 4th to 5th year but pod production is maximum from 9th year onwards and last for 25 to 30 years

Each tree yields on average 10-12 kgs of seeds normally under rain fed conditions with 25% of oil. Its collection period is usually from month of May to June.

B. Chemical Properties:

Table 1. Pongamia Seed Composition

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

III. 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.

Specification of diesel engine

Make	:	Kirloskar
Type	:	Four Stroke
Number of Cylinder	:	Single Cylinder
Type of Cooling	:	Water Cooled
Rated Power	:	10kW
Rated Speed	:	1500 rpm
Loading Device	:	Hydraulic Dynamometer
Bore	:	102mm
Stroke	:	116mm
Fuel Tank Capacity	:	5 litres
Capacity of Burette	:	100cc
Air Tank Size	:	400mm x 400 mm
Orifice Diameter	:	30mm

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 cooling water temperature at the outlet was maintained at 700C. The engine speed was held at 1500 rpm and the power output was varied. The engine was next run with various blends of biodiesel and the performance tests were carried out as before. The different parameters like specific energy consumption, power, and efficiencies are determined at various load conditions.

The results obtained are weighed with those under pure diesel mode of operation. The Hydraulic 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, biodiesel 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., were measured and recorded.

IV. RESULTS AND DISCUSSIONS

In this work the non-edible vegetable oil obtained from Pongamia Pinnata was transesterified to reduce its viscosity by removing glycerol from it. The Biodiesel obtained after transesterification process was used as a substitute for diesel fuel.

Table 2. Characteristics of Diesel, Biodiesel and its blends

Properties	*Diesel*	*B100*	*B5*	*B10*	*B15*	*B20*
Flash Point °C	60	127	62	63	63	65
Fire Point °C	65	132	65	67	68	70
Cloud Point °C	13	15	13	13	13	13.3
Pour Point °C	1	10	2	4.3	5	6.1
Specific Gravity at 25°C	0.836	0.889	0.841	0.849	0.853	0.861
Viscosity at 30°C (Centistokes)	3.155	10.40	3.573	3.986	4.387	4.782
Iodine Value	38.3	30.48	38.1	36.83	35.56	34.29
Cetane Number	49.69	-	50.07	50.74	51.02	51.39
Calorific Value (KJ/kg)	42000	36009	41362	40390	38930	37957
Density (kg/m^3)	837.5	891.47	842.52	851.36	854.4	862.78

Table 2 shows the characteristics of diesel, biodiesel and its blends

The relationship between Total Fuel Consumption and Brake power for different blends and diesel is shown in Fig 1. The figure shows that the Total Fuel Consumption for B20 is higher as compared to other blends and diesel. This is due to the fact that calorific value for B20 is low hence more fuel is consumed for the same power developed as compared to Diesel and other blends.

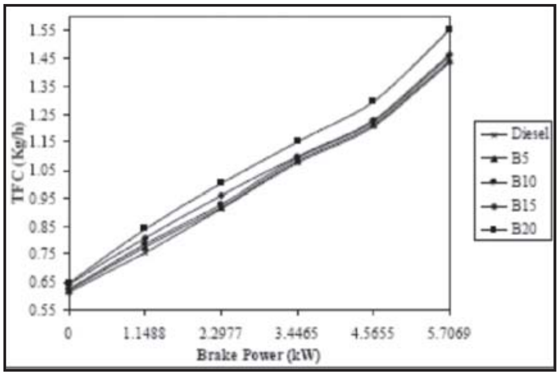

Fig.1. Total fuel consumption Vs Brake power

The relationship between Specific Fuel Consumption and Brake power for different blends and diesel is shown in Fig 2. The specific fuel consumption decreased with an increase in engine load. This is due to the fact that brake horsepower of the engine (constant speed type) increases with an increase in brake load. The differences in brake specific fuel consumption is a reflection of the differences in fuel densities and calorific values, it resulted in their higher fuel consumption and as such higher brake specific fuel consumption. The higher density of the blend containing a higher percentage of Pongamia esters might lead to more discharge of fuel, thereby increasing specific fuel consumption.

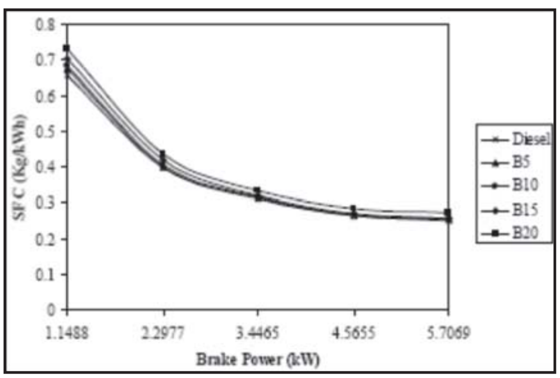

Fig. 2. Specific Fuel Consumption Vs Brake power

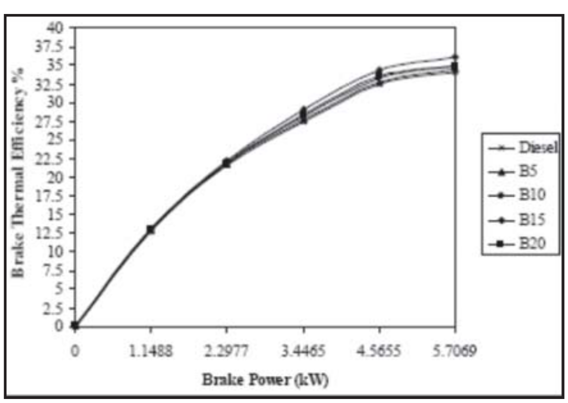

Fig. 3. Brake thermal efficiency Vs Brake power

The relationship between Brake thermal efficiency and Brake power for different blends and diesel is shown in Fig 3. 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 Biodiesel-air premixed mixture. The Biodiesel-air premixed mixture is less lean at higher loads which burn completely. It was found that brake thermal efficiency was lower at low loads. This is due to the very lean premixed 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.

The relationship between Mechanical efficiency and Brake power for different blends and diesel is shown in Fig 4.

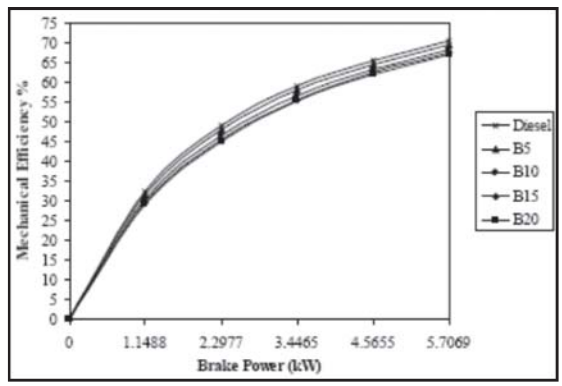

Fig. 4. Mechanical efficiency Vs Brake power

It can be seen from the figure that the mechanical efficiency increased with increase in the load. The figure shows that the mechanical efficiency for B20 and other blends is lower as compared to diesel. This is due to the fact that frictional losses are more for B20 and other blends as compared to Diesel.

The aim of the present investigation was to analyse the usability of biodiesel as a replacement to diesel in an unmodified CI engine. It was found that blends of biodiesel and diesel could be successfully used with acceptable performance and better emissions than pure diesel up to a certain extent.

V. CONCLUSION

From the experimental investigation, at full load the engine consumes about 8% higher fuel as compared to diesel when it is running on B20. The Specific fuel consumption is slightly increased when higher blends of biodiesel are used. At peak load SFC is increased by 7.5% for B20 when compared to diesel. Improves the brake thermal efficiency as compared to diesel at all outputs. At full load the engine running on diesel has 3% higher mechanical efficiency when compared to the engine running on B20.

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