PERFORMANCE CHARACTERISTICS OF A COMPRESSION IGNITION ENGINE OPERATED ON BRASSICA OIL METHYL ESTERS

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ABSTRACT

There is an increasing interest in many countries to search for suitable alternative fuels that are environment friendly. Although straight vegetable oils can be used in diesel engines, their high viscosities, low volatilities and poor cold flow properties have led to the investigation of various derivatives. Biodiesel is a fatty acid alkyl ester, which can be derived from any vegetable oil by transesterification. Biodiesel is a renewable, biodegradable and non-toxic fuel. In this study, Brassica oil (Brassica juncea seed oil) was transesterified with methanol using sodium hydroxide as catalyst to obtain brassica oil methyl ester (BOME). This biodiesel was tested in a single cylinder 4 stroke diesel engine (Kirloskar) to evaluate the performance characteristics.

Keywords: biodiesel, brassica oil, IC engine, transesterification, performance evaluation.

INTRODUCTION

Vegetable oils present a very promising alternative to diesel oil since they are renewable and have similar properties. Many researchers have studied the use of vegetable oils in diesel engines. Vegetable oils offer almost the same power output with slightly lower thermal efficiency when used in diesel engine [1-7]. Reduction of engine emissions is a major research aspect in engine development with the increasing concern on environmental protection and the stringent exhaust gas regulation. Vegetable oils are a mixture of organic compounds ranging from simple straight chain compared to complex structure of proteins and fat-soluble vitamins. They are usually triglycerides generally with a number of branched chains of different lengths. Research in the direction of vegetable oils as compression ignition (CI) engine fuel has yielded encouraging results [8-14].

The use of neat vegetable oils poses some problems when subjected to prolonged usage in CI engines. These problems are attributed to high viscosity, low volatility and polyunsaturated character of neat vegetable oils [1, 2]. Some of the common problems of vegetable oils in diesel engines in the long run are coking and trumpet formation on the injectors, carbon deposits, oil ring sticking, and thickening and gelling of lubricating oil as a result of contamination by the vegetable oils [2]. Different methods such as preheating, blending, ultrasonically assisted methanol transesterification and supercritical methanol transesterification [12, 13, 15, 16] are being used to reduce the viscosity and make them suitable for engine applications.

ART Saka and Kusdiana [2] prepared biodiesel using rapeseed oil and supercritical methanol to investigate the possibility of converting the triglycerides of the rapeseed oil to rapeseed oil methyl esters (ROME). Murayama *et al*., [3] evaluated waste vegetable oils as a feedstock for biodiesel production. This research was focused on the engine performance and emission characteristics of esterified vegetable oil, when used in a diesel engine. When blends of biodiesel and diesel are used in diesel engines, a significant reduction in hydrocarbons (HC) and particulate matter (PM) are observed but NOx emissions are found to have increased. In general, engine performance and power remains unchanged [17, 20-23, 24]. Akasaka *et al*., [20] found that under partial load conditions, soybean methyl ester (SME) addition increases PM emissions. Agarwal [17, 22, 23] observed significant improvement in engine performance and emission characteristics for the biodiesel-fuelled engine compared to diesel-fuelled engine. Thermal efficiency of the engine improved, brake specific energy consumption reduced and a considerable reduction in the exhaust smoke opacity was observed.

Blending

Undoubtedly, transesterification is well-accepted and best method of utilizing vegetable oils in CI engine without any long-term operational and durability problems. However, this adds to the cost of production because of the chemical process involved. In rural and remote areas of developing countries, where grid power is not available, vegetable oils can play a vital role in decentralized power generation for irrigation and electrification purposes. In these remote areas, different types of vegetable oils are available locally but it may not be possible to chemically process them due to logistics problems. Hence, using blended vegetable oils is an attractive alternative. Keeping these facts in mind, a set of engine experiments were conducted using different typical oils available in rural areas on a type of engine, which is very frequently used for agricultural, irrigation and electricity generation purposes. The engine performance is also compared with the transesterified fuel.

Transesterification

A 500 ml 3-necked round bottom flask equipped with mechanical stirrer, thermometer and condenser with guard tube to prevent moisture entering into the system, was heated to expel residual moisture. On cooling, 200 ml (180 g) of Brassica oil (crude grade) was added to the flask. The oil was stirred and heated in a silicon oil bath to 60°C at which recently prepared sodium methoxide (40 ml methanol and 1 g NaOH) was added rapidly under stirred condition and the reaction continued for two hours at the same temperature. Two layers were observed clearly on cooling. The top layer was biodiesel and the bottom denser layer was glycerin. The top layer was neutralized by diluted acetic acid and washed with distilled water.

MATERIALS AND METHODS

The experiments were carried out on a single cylinder 4 stroke diesel engine of a model manufactured by Kirloskar oil engines Ltd., the largest manufacturer of portable multi-fuel engines. Fuel consumption was measured by a U-tube manometer. The engine was started on neat diesel fuel and warmed up. The warm up period ended when the liquid cooling water temperature was stabilized. Similar procedures were repeated for the BOME fuel. The tests were repeated for four times and each test was done for 3 h. Finally, the average value of the four readings was taken for the calculation.

Figure-1. Overall view of experimental setup.

Table-1. Specifications of the engine.

S. No.	Parameters	Specification
1	Type	Four stroke, single cylinder, water cooled, engine
2	Made	Kirloskar oil engines Ltd, Pune, India
3	Loading device	Mechanical
4	Speed	1500 rpm
5	Power	5 Hp

Table-2. Properties of the brassica oil.

Properties	Brassica oil	Diesel
Specific gravity	0.672	0.83
Calorific value (MJ/kg)	42.1	43.22
Flash point (k)	518	47
Viscosity	33.8	5.8
Fire point(c)	90	64

Performance and evaluation of the engine

The engine performance tests were conducted with a single cylinder 4 stroke diesel engine set up. The parameters like fuel consumption were measured at different loads for diesel and with various combinations of dual fuel. Brake power, brake specific fuel consumption and brake thermal efficiency was calculated using the collected test data.

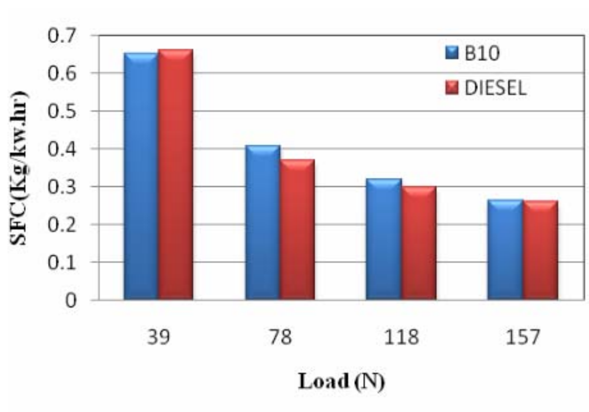

Figure-2. Effect of Load on specific fuel consumption for diesel and blends of Brassica oil (B10).

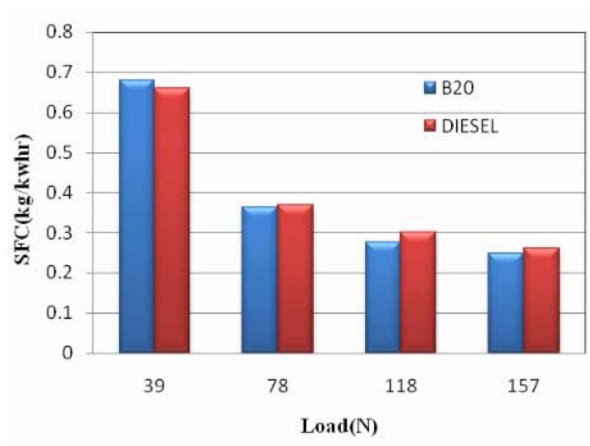

Figure-3. Effect of Load on specific fuel consumption for diesel and blends of Brassica oil (B20).

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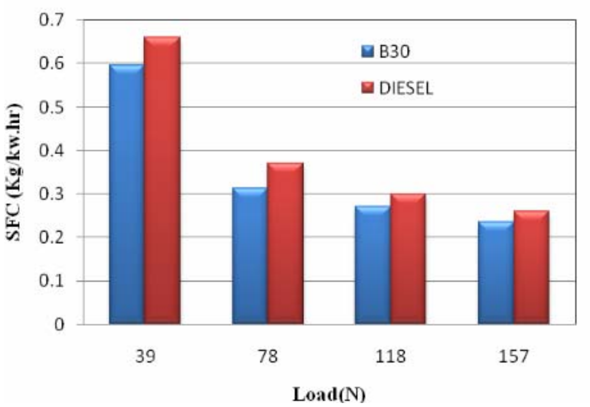

Figure-4. Effect of Load on specific fuel consumption for diesel and blends of Brassica oil (B30).

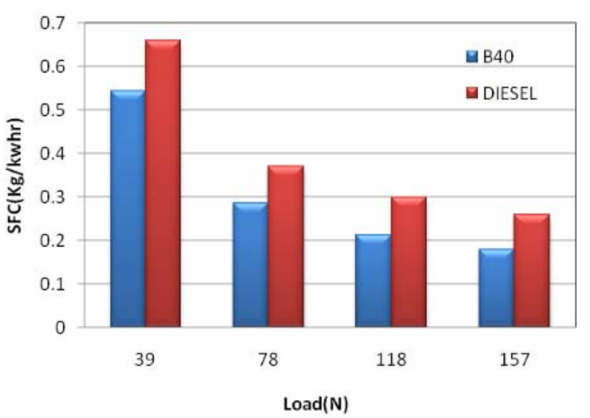

Figure-5. Effect of Load on specific fuel consumption for diesel and blends of Brassica oil (B40)

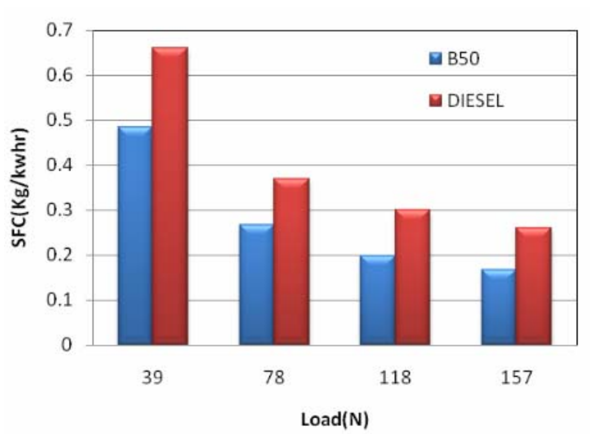

Figure-6. Effect of load on specific fuel consumption for diesel and blends of Brassica oil (B50).

Brake-specific fuel consumption

Figures 2, 3, 4, 5, 6 shows the effect of load on specific fuel consumption, for diesel and blends of Brassica oil. As the load increases, brake specific fuel consumption decreases and then increases for all the fuel samples tested. This can be correlated to the test results obtained for the brake power. The specific fuel consumption (SFC) for B10 and B20 are more or less equal to that of diesel. The SFC for B30, B40, B50 are less than the SFC for diesel. This may be due to the lower calorific value of biodiesel than diesel.

Brake thermal efficiency

The variation of brake thermal efficiency with load for different fuels is presented in Figure-6. In all cases, brake thermal efficiency is increased with an increase in percent load. This was due to a reduction in heat loss and increase in power with increase in percent load. The maximum brake thermal efficiencies were obtained for B30, B40 and B50 respectively, which were higher than that of diesel. The brake thermal efficiencies obtained for B20 are closer to that of diesel. The lower brake thermal efficiency obtained for B10 could be due to a reduction in the calorific value of bio diesel than diesel.

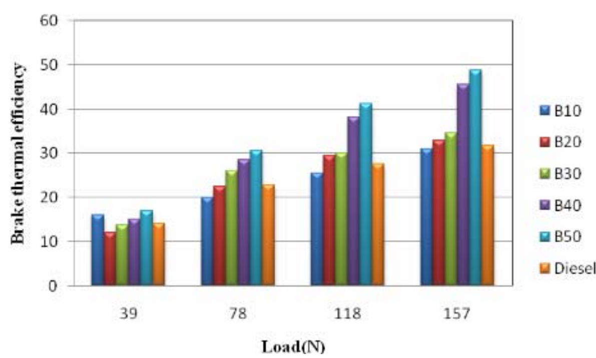

Figure-7. Effect of Load on brake thermal efficiency for diesel and various blends of Brassica oil.

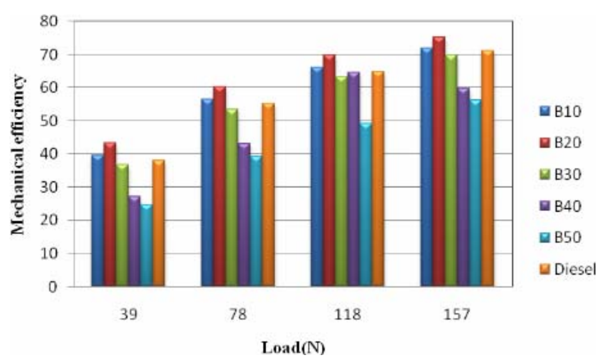

Figure-8. Effect of load on brake thermal efficiency for diesel and various blends of Brassica oil.

Mechanical efficiency

The variation of mechanical efficiency with load for different fuels is presented in Figure-7. In all cases, mechanical efficiency is increased with an increase in percent load. This was due to a reduction in heat loss and increase in power with increase in percent load. The maximum mechanical efficiencies were obtained for B20 respectively, which were higher than that of diesel. The Mechanical efficiencies obtained for B10 and B30 are closer to that of diesel. This lower mechanical efficiency obtained for B40 could be due to a reduction in the calorific value of bio diesel than diesel.

RESULTS AND DISCUSSIONS

In this study Brassica oil was transesterified with methanol to obtain methyl ester of low viscosity and good conversion of brassica oil ester. BOME posses lower calorific value compared to diesel. The specific gravity does not vary much compared to diesel. The kinematic viscosity is slightly higher than that of diesel however within the biodiesel standard limits Cetane no is slightly high by (10%) which is favorable for combustion. Flash and fire points are high which is advantages for fuel transportation.

Brake specific fuel consumption for diesel and blends of Brassica oil decreases and then increases as the load increases for all the fuel samples tested. This can be correlated to the test results obtained for the brake power. The specific fuel consumption (SFC) for B10 and B20 are more or less equal to that of diesel. The SFC for B30, B40, B50 are less than the SFC for diesel. This may be due to the lower calorific value of biodiesel than diesel.

The maximum brake thermal efficiencies were obtained for B30, B40 and B50, respectively which were higher than that of diesel. The brake thermal efficiencies obtained for B20 are closer to that of diesel. The lower brake thermal efficiency obtained for B10 could be due to a reduction in the calorific value of bio diesel than diesel.

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From the above discussions, following conclusions can be drawn.

- For all the fuel samples tested, brake power and brake thermal efficiency reach maximum values at 70% load;
- The dual fuel combination of B20 can be recommended for use in the diesel engines without making any engine modifications; and
- The cost of dual fuel can be considerably reduced than pure diesel.

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