

Performance Characteristics of Karanja Biodiesel and Its Blends in a C.I. Engine

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ABSTRACT

In the present investigation experimental work has been carried out to analyze the emission and performance characteristics of a single cylinder 3.67 kW, compression ignition engine fuelled with mineral diesel and diesel-biodiesel blends at an injection pressure of 200 bar. The performance parameters evaluated were break thermal efficiency, break specific energy consumption (BSEC) and the emissions measured were carbon monoxide (CO), carbon dioxide (CO₂), hydrocarbon (HC), and oxides of nitrogen (NO_x). The results of experimental investigation with biodiesel blends were compared with that of baseline diesel. The results indicate that the CO emissions were slightly higher, HC emissions decreased from 12.8 % for B20 and 2.85 % for B40, NO_x emissions decreased up to 39 % for B20 and 28 % for B40. The efficiency decreased slightly for blends in comparison with diesel. The BSEC was slightly more for B20 and B40. From the investigation it can be concluded that biodiesel can be used as an alternative to diesel in a compression ignition engine without any engine modifications. Keywords: diesel engine, karanja biodiesel, engine performance, exhaust emissions, cost comparison.

I INTRODUCTION

The ever increasing number of automobiles has lead to increase in demand of fossil fuels (petroleum). The increasing cost of petroleum is another concern for developing countries as it will increase their import bill. The world is also presently confronted with the twin crisis of fossil fuel depletion and environmental degradation. Fossil fuels have limited life and the ever increasing cost of these fuels has led to the search of alternative renewable fuels for ensuring energy security and environmental protection. For developing countries fuels of bio-origin can provide a feasible solution to this crisis. Certain edible oils such as cottonseed, palm, sunflower, rapeseed, safflower can be used in diesel engines. For longer life of the engines these oils cannot be used straightway. These oils are not cost effective to be used as an alternate fuel in diesel engines at present. Some of the non-edible oils such as mahua, castor, neem (*Azadiracta indica*), rice bran, linseed, Karanja (*Pongamia pinnata*), jatropha (*Jatropha curcas*) etc. can be used in diesel engines after some chemical treatment. The viscosity and volatility of these vegetable oils is higher, and these can be brought down by a process known as "transesterification". Biodiesel has a higher cetane number than petroleum diesel, no aromatics and contains upto 10% oxygen by weight. The characteristics of biodiesel reduce the emissions of carbon monoxide (CO), hydrocarbon (HC) and particulate matter (PM) in the exhaust gas as compared with petroleum diesel [1, 2].

Sanjib Kumar Karmee et al., [3] have prepared biodiesel of *Pongamia Pinnata* with a yield of 95% using methanol and potassium hydroxide as a catalyst. The viscosity of the oil decreased from 74.14 Cst (at 30°) to 4.8 Cst (at 40°C) on

transesterification and the flash point was 150°C. Both these properties meet the ASTM and German biodiesel standards. Suresh Kumar et al., [4] have investigated the performance and emission characteristics on a single cylinder diesel engine and reported decrease in NO_x and HC emissions. A 40% blend (B40) of biodiesel in diesel has been recommended by the authors. Recep Altin et al., [5] have studied the potential of using vegetable oils and their methyl esters in a single cylinder diesel engine. They have used raw sunflower, cottonseed, soybean oils and their methyl esters. Their results indicate a reduction in NO_x emission and methyl esters are better than raw oils due to their inherent property of high density, higher viscosity, gumming and lower cetane number. Banapurmath et al., [6] have reported tests on a single cylinder C.I. engine with 3 different biodiesels viz methyl esters of honge, jatropha and sesame. All the fuels gave a slightly lower efficiency. HC and CO emissions were slightly higher and NO_x emission decreased by about 10%. They have reported that these oils can be used without any major engine modifications.

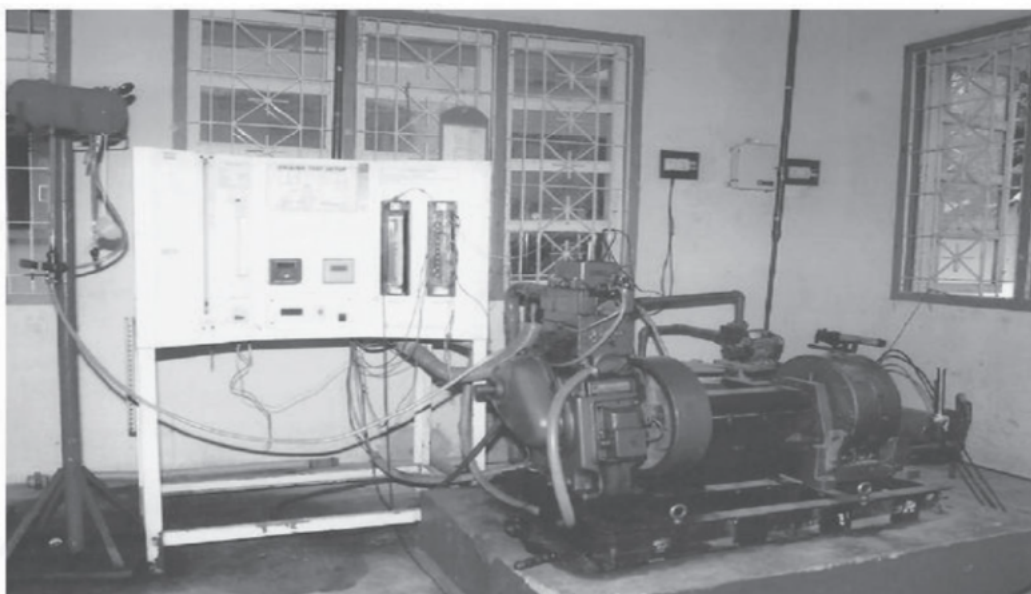
Many researches have used Methyl esters of *Pongamia pinnata* [7,8], mahua oil [9], rapeseed oil [10], linseed oil [11], soybean [12,13], jatropha [14], cottonseed [15,16,17], and palm oil [18] reported the performance and emission characteristics in diesel engines. Barnwal et al., [19] have discussed about prospects of biodiesel production from vegetable oils in India. They have also given the yield and production cost of various methyl esters, in general non-edible oils. The methyl esters of non-edible oil are much cheaper than petroleum diesel. The objective of this paper is to investigate the performance and emission characteristics of a single cylinder, 4 stroke, constant speed, water cooled diesel engine with

diesel and blends of bio-diesel and diesel (B20, B40) at a fuel injection pressure of 200 bar.

II EXPERIMENTAL SET-UP

A typical 3.75 kW single cylinder, 4-stroke, constant speed (1500 rpm) diesel engine used for agricultural applications in rural India was selected for investigation to study the performance and emissions. The engine was coupled to an eddy current dynamometer (Make-BENZ SYSTEMS, PUNE, INDIA), Figure-1. The specifications of the engine are given in Table-1. Tests were conducted

using diesel and biodiesel-diesel blends at no load, 33.3%, 66.6% and 100% of rated load of the engine at the rated speed of 1500 rpm. A blend of 20% biodiesel and 80% diesel (by volume) is denoted by B20. The performance parameters, efficiency and brake specific energy consumption (BSEC) are compared. Exhaust gas composition was measured using NDIR based exhaust gas analyzer [Make: AVL Austria; Model: Digas 444]. The analyzer measures CO, CO₂, HC, O₂ and NO_x in the exhaust. The range and accuracy of the 5- gas analyzer is given in Table-2.



Manufacturer	Kirloskar Oil Engines Limited, Pune, India
Model	AVL
Engine type	Vertical, single cylinder, water cooled, 4-stroke, constant speed (1500 rpm), Direct injection, compression ignition engine
Power (rated)	3.67 kW at 1500 rpm
Bore/Stroke	80mm/110mm
Displacement volume	553 cc

Fig.1 Experimental setup showing eddy current dynamometer, controller and gas analyzer

Table-1
Specifications of the engine

Exhaust gas	Measurement range	Resolution	Accuracy
CO	0-10% vol.	0.01% vol.	<0.6% vol.: ± 0.03%, ≥0.6%vol.:± 5% of ind. val
HC	0-20000 ppm	0.01% vol.	<2000 ppm vol.:± 10 ppm ≥2000 ppm vol.:± 5% of ind. val
CO ₂	0-20%vol.	0.1 % vol.	<10%vol.:± 0.5 %vol. ≥10% vol.:± 0.5% of ind. val
O ₂	0-22%vol.	0.01% vol	<2%vol.: ± 0.1%vol. ≥2% vol.:± 5%of ind. val

III ENVIRONMENTAL BENEFITS

Environmental benefits in comparison to petroleum based fuels include:

- "At the tailpipe, biodiesel emits more CO₂ than petroleum diesel". However, if "biomass carbon (is) accounted for separately from fossil-derived carbon", one can conclude that biodiesel reduces emissions of carbon monoxide (CO) by approximately 50% and carbon dioxide by 78% on a net lifecycle basis because the carbon in biodiesel emissions is recycled from carbon that was in the atmosphere, rather than the carbon introduced from petroleum that was sequestered in the earth's crust.
- Biodiesel can reduce by as much as 35 % the direct (tailpipe) emission of particulates, small particles of solid combustion products on vehicles with particulate filters, compared with low-sulfur (< 50 ppm) diesel.
- Particulate emissions as a result of production are reduced by around 50%, compared with fossil-sourced diesel. Biodiesel has a higher cetane rating than petrodiesel, which can improve performance and clean up emissions compared to crude petro-diesel (with cetane number lower than 40)

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IV RESULTS AND DISCUSSIONS

To determine performance and emission characteristics of the engine, tests were conducted at no load, 33.3%, 66.6% and 100% of rated load. The results of the engine emissions, carbon monoxide (CO), hydrocarbon (HC), carbon dioxide (CO₂), and oxides of nitrogen (NO_x), at 200 bar injection pressure and performance parameters efficiency and BSEC are shown in Figure 2 and 3. The emissions are compared with that of diesel. The CO emissions were slightly higher for B20 and B40 blends. HC emissions decreased by upto 12.8 % for B20 and 2.85% B40 compared to diesel at full load. The decrease however was insignificant. The decrease in these emissions can be attributed to the presence of oxygen in biodiesel leading to better utilization of fuel. Depending on load, the NO_x emissions decreased by 39% for B20 and 28 % for B40. This reduction may be due to better combustion of fuel. Similar results have been reported by Sureshkumar et al., [4], Banapurmath et al., [7]. The efficiency decreased by 2.8% for B20 and 2.7% for B40. The BSEC value increased by 7% for B20 and 1.9% for B40. The increase in these two values is due to the decrease in heat input at different blends as the heating value of the blend is less than that of diesel (by 3.28 % for B20 and 6.5% for B40). The above results indicate that both B20 and B40 blends can be used in diesel engines without any engine modifications. Better emissions and performance characteristics are obtained at a blend of B40.

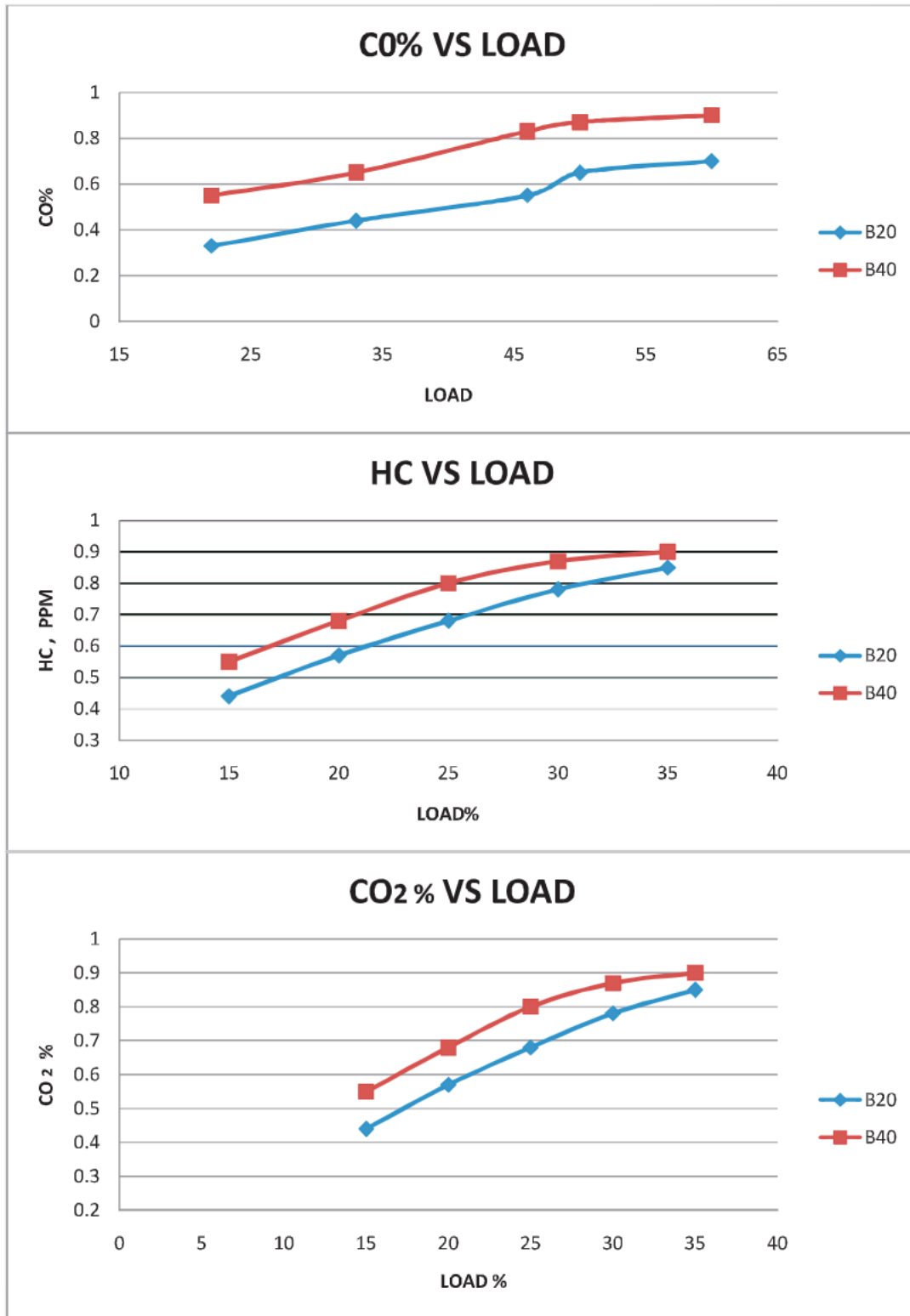


Fig. 2 Performance Analysis – CO, HC & PPM

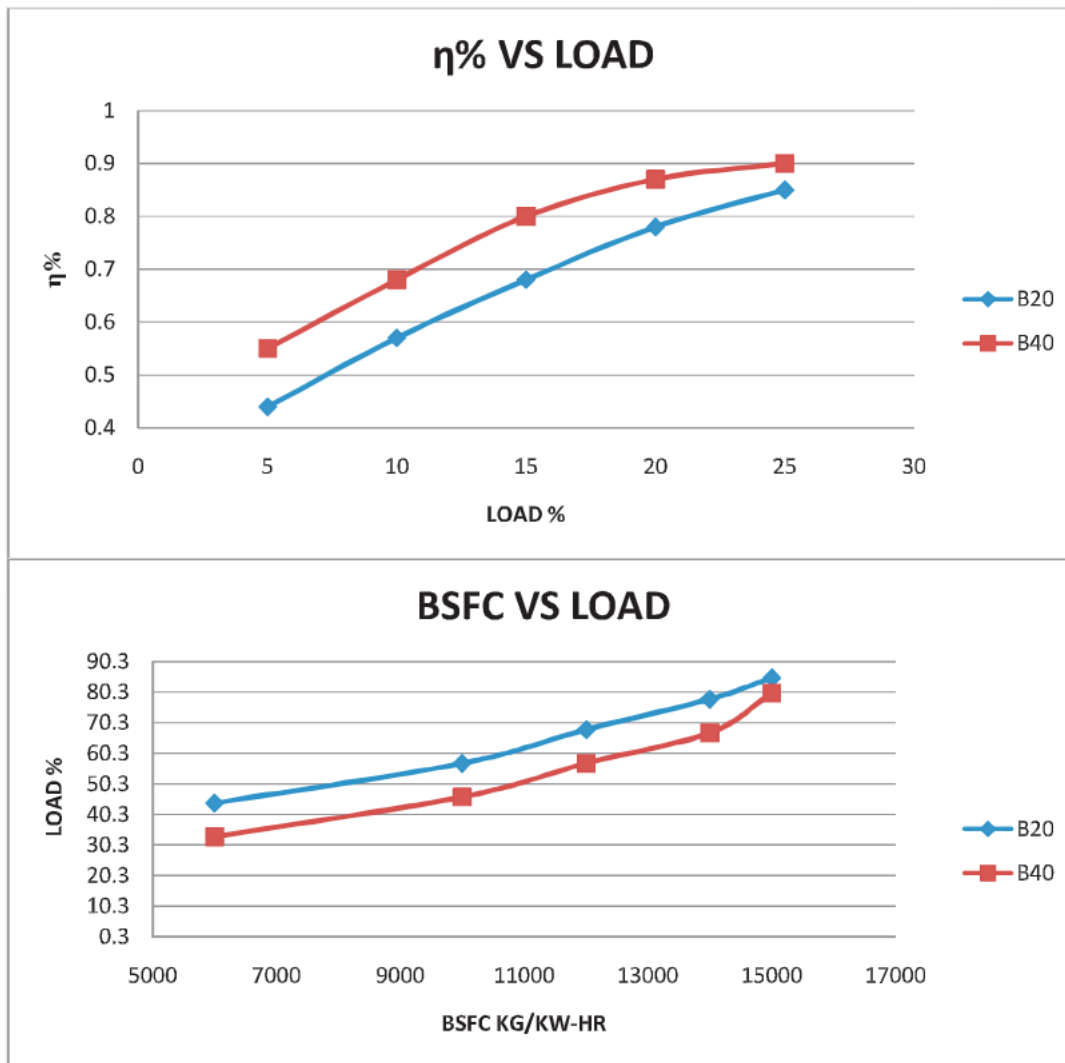


Fig. 3 Performance Analysis – Efficiency & BSFC

V CONCLUSIONS

Tests for emission and performance characteristics were conducted on a single cylinder, 4- stroke, constant speed diesel engine at an injection pressure 200 bar. Based on the tests the following conclusions can be drawn:

- (a) At an injection pressure of 200 bar, HC emissions decreased by 12.8 % for B20 and 3 % for B40 at full load. NOx decreased by 39 % for B20 and 28 % for B40 at full load, BSEC increased by 7 % for B20 and 1.9 % for B40 at full load;
- (b) Hence a blend of 40% biodiesel and 60% diesel (B40) is recommended. There was no significant change in efficiency;
- (c) The results are in line with that reported in literature by different researchers using various biodiesel fuels and their blends; and

- (d) Economic analysis shows that Karanja oil biodiesel can be used in an existing diesel engine without any engine modifications which will lead to employment generation and saving in vital foreign exchange. 55 VOL. 5, NO. 2, FEBRUARY 2010 ISSN 1819-6608 ARPJN Journal of Engineering and Applied Sciences

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