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Performance and Emission Characteristics of a Diesel Engine Fuelled with Biodiesel extracted from Karanja Oil

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Abstract

The depleting reserves of petroleum and environmental issues have led to the search for more environmental-friendly and renewable fuels. Biodiesel obtained from various renewable sources has been recognized as one of the alternative fuel due to its biodegradability, high cetane no, no sulphur emissions and low volatility. Biodiesel derived from non edible feed stocks such as karanja oil are reported to be feasible choices for developing countries including India where consumption and cost of edible oil is very high .The aim of present work is to optimize the biodiesel production from karanja oil through transesterification process. The optimum conditions for maximum yield were obtained at molar ratio of 8:1 for acid esterification and 9:1 molar ratio for alkaline esterification, 0.5wt% catalyst KOH using mechanical stirrer. The various performance and emission parameters like brake power (BP), specific fuel consumption(SFC), brake thermal efficiency (BTE), CO emissions, CO_2 emissions, HC emissions, NOx emissions were evaluated at different loads in a 4 stroke, single cylinder, water cooled, diesel engine. These performance and emission parameters of diesel fuel were compared with that of B10, B20, B30, B40 and B50. The performance parameters of B30 blend were similar to those of diesel. It was found that CO_2, HC and CO emissions decreases as the blend content increases whereas the NOx emissions increases as the blend content increases.

Keywords: *Emission Characteristics, Diesel Engine, Biodiesel, Karanja Oil*

Introduction

Due to scarcity and increasing costs of conventional fossil fuels, biodiesel as a fuel has become more attractive fuel. Experts suggested that current oil and gas reserves would tend to last only for few decades. To fulfil the rising energy demand and replace reducing oil reserves renewable fuel like biodiesel is within the forefront of other technologies. Biodiesel has proved to be a possible alternative for diesel in compression ignition engine. Biodiesel burns like petroleum diesel as it involves regulated pollutants. Diesel fuel can be replaced by biodiesel made from vegetable oils (Bobade *et al*., 2012). Biodiesel is now mainly being produced from soybean, rapeseed, and palm oils. In developed countries, there is a growing trend toward using modern technologies and efficient bioenergy conversion using a range of biofuels, which are becoming cost wise competitive with fossil fuels oils (Sahoo and Das, 2009). India enjoys some special advantages in taking up plantation of tree-borne oil seeds for production of bio diesel due to vast unutilized land. The use of biodiesel results in substantial reduction of un-burnt carbon monoxide and particulate matters.

It has almost no sulphur, no aromatics and more oxygen content, which helps it to burn fully. Its higher cetane number improves the combustion (Sharma *et al*., 2010). Sunflower and rapeseed are the raw materials used in Europe whereas soybean is used in USA. Thailand uses palm oil, Ireland uses frying oil and animal fats (Bobade *et al*., 2012). In India vast research has been done on biodiesel from jatropha oil. It is proposed to use non-edible oil for making biodiesel, as consumption from edible oil is very high in India (Mamilla *et al*., 2011).

Technical Specifications of the Engine

In this work experiments were conducted on 4 stroke, single cylinder, C.I engine (Kirloskar Oil Engineers Ltd., India) of maximum power-3.68 KW with AVL smoke meter. The experimental setup is show in figure 1

Figure 1 The experimental setup

Materials and Method

In the present work engine tests were conducted with karanja bio Diesel blends (B10, B20, B30, B40 and B50) in comparison to diesel separately to evaluate performance and emission characteristics. Karanja oil is extracted from the seeds of karanja tree (Sahoo and Das, 2009). Karanja tree is a medium sized tree and is found almost throughout India. The tree is wonderful tree almost like neem tree and drought resistant (Kesari *et al.*, 2010).It is found mainly in the Western Ghats in India, Australia and some regions of Eastern Asia. Its cake is used as pesticide and fertilizer. The seeds contain 30-40% oil that can be processed to produce a high quality biodiesel fuel, usable in a standard diesel engine (Thiruvengadaravi *et al.*, 2012). The various properties of the karanja bio diesels are presented in table 1.

Table 1 Properties of the karanja bio diesels

Properties	Karanja Biodiesel	Diesel
Viscosity(at 40 ^{0}C)	6.2	3.8
Density kg/m^2	.860	.830
Sulphated ash content	-	.001
Specific gravity	.87	.85
Calorific value (KJ/kg)	40840	42800
Flash point	235	56

Results and Discussion

Variation of brake power with load

Figure 1 shows the variation of brake power with load for diesel and blends of biodiesel. It can be observed from the figure than brake power of all biodiesel blends remains same to diesel. Variations of load for different blends and diesel at all values of brake powers are within a very narrow range. Diesel shows better brake power than all biodiesel blends.

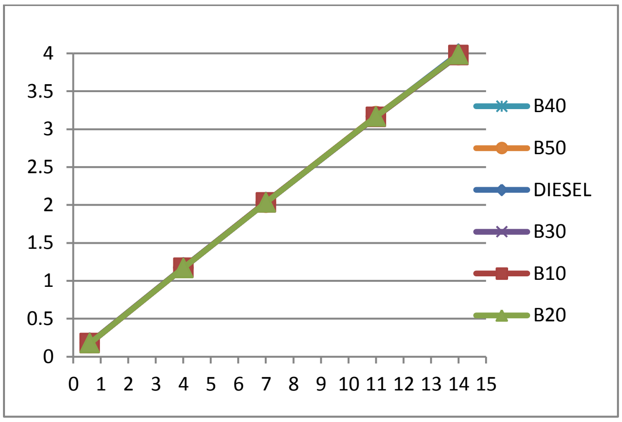

Figure 1 Brake power (kW) with load Load (kg)

Specific Fuel Consumption (SFC)

Figure 2 show the variation of specific fuel consumption of diesel and biodiesel blends at different loads. When two different fuels of different heating values are blended together, the fuel consumption may not be reliable, since the heating value and density of the two fuels are different. The specific fuel consumption (SFC) will give more reliable value (Sharma *et al.*,2014).It can be observed from the figure that at higher load the SFC for B30 blend is lower to diesel. The fuel consumption is found to be higher than diesel at all loads when the concentration of the karanja oil in the blend is more than 30% because of the lower heating value and high density of the blends. Higher concentration of the karanja oil in the blends increases viscosity which further increases the specific fuel consumption.

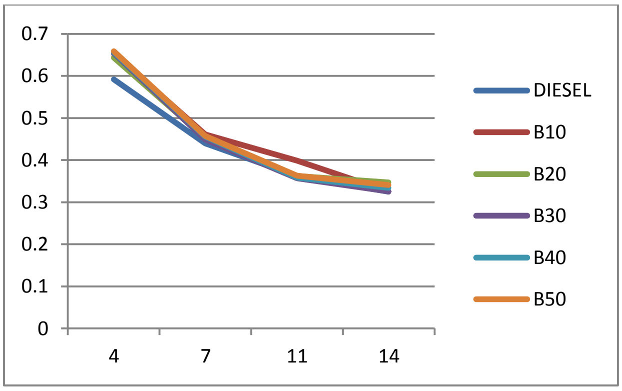

Figure 2 Specific fuel consumption (kg/kwh) v/s Load Load (kg)

Brake Thermal Energy

Figure 3 show the variation of brake thermal efficiency of diesel and biodiesel blends at different loads. It can be observed from the figure that, KME30 shows higher brake thermal efficiencies at all load conditions compared to that of diesel fuel. Almost all blends show slightly better BTE than diesel at higher load conditions. The higher thermal efficiencies may be due to the additional lubricity provided by the fuel blends and also report higher BTE for the 20% & 40% blends while the higher blends reported lower values of BTE due to low calorific value and higher fuel consumption (Lohith *et al*., 2012).

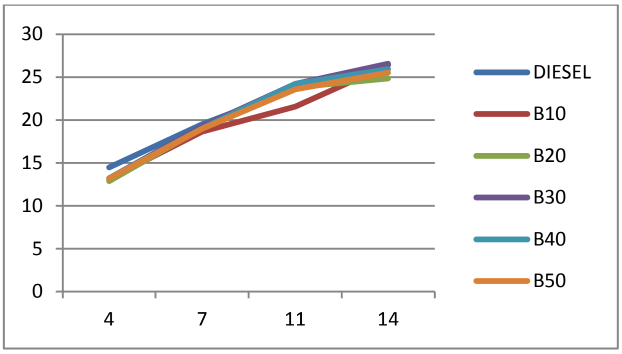

Figure 3 Brake thermal efficiency (%) v/s Load Load (kg)

Hydrocarbon emission (HC)

Figure 4 show the variation of HC emission with different blends at different loads. Biodiesel blends give lower HC emission as compared to diesel. Due to better combustion of the biodiesel inside the combustion chamber and the availability of the excess oxygen content in the biodiesel blends as compared to diesel. HC emission of biodiesel is lower than diesel due to better combustion of biodiesel (Singh *et al*., 2013).

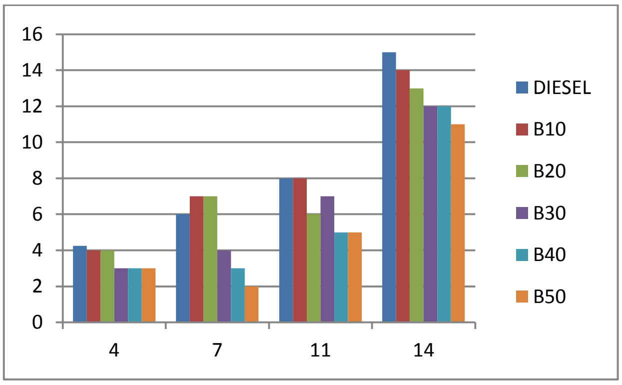

Figure 4 HC emission (ppm) v/s Load Load (kg)

Nitrous oxides emission (NOx)

Figure 5 show the variation of NOx emission with different blends at different loads. About 90% nitrogen in the exhaust is in the form of nitric oxide. The three important factor which support the formation of nitric oxide such as oxygen concentration, combustion temperature and retention time (Nabi *et al*., 2009). These three conditions are attained in biodiesel combustion very rapidly as compared to diesel. NOx formations for biodiesel blends are always greater than diesel. At higher loads, more fuel is burnt and higher temperature of the exhaust gases which result in higher production of nitric oxide. Anything which causes combustion temperatures to rise will also cause NOx emissions to rise. Misfire can also cause NOx to rise because of the increase in oxygen that it causes in the catalytic converter feed gas. NOx is more likely to cause respiratory problems such as asthma and coughing (Lohith *et al*., 2012).

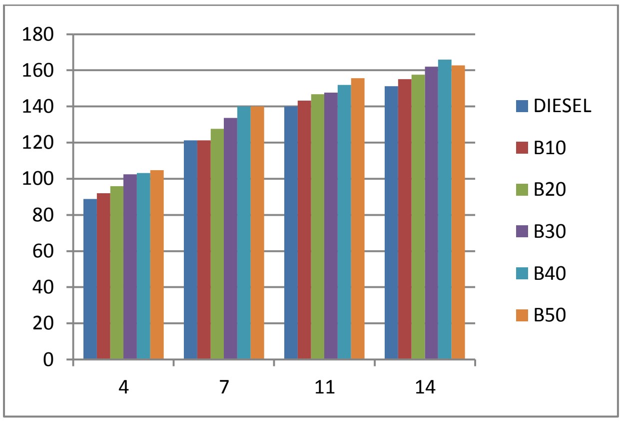

Figure 5 Nitrous oxide (ppm) v/s Load Load (kg)

Carbon Dioxide emission (CO_2)

Figure 6 show the variation of Carbon Dioxide emission with different blends at different loads. Carbon dioxide is a by-product of efficient and complete combustion. Carbon dioxide levels are affected by air/fuel ratio, spark timing and any other factor which affect the combustion efficiency. At all loads biodiesel blends give less CO_2 as compared to diesel. The CO_2 emission increases with increase in load due to higher fuel entry as the load increases. Biofuels contain low carbon content as compared to diesel due to this CO_2 emission are also low. At full load of 10 kg, CO_2 emission was increased by about 31.88% as compression ratio increases from 14 to 18 (Deore *et al*., 2013).

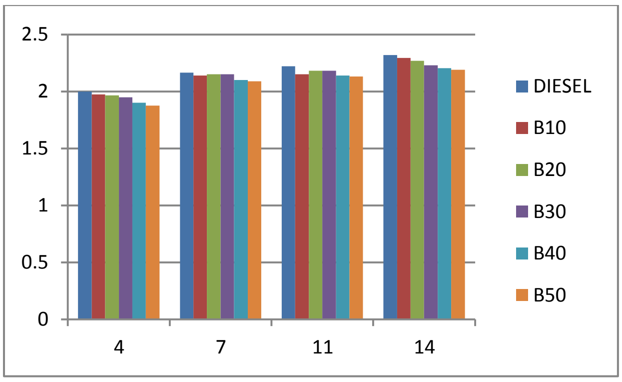

Figure 6 Carbon dioxide (ppm) v/s Load Load (kg)

Carbon monoxide emission (CO)

Figure 7 show the variation of carbon monoxide emission with different blends at different loads. Biodiesel blends give less carbon monoxide as compared to diesel due to complete combustion. With increases the percentage of biodiesel blend, carbon monoxide decreases. The more amount of oxygen content of biodiesels result in complete combustion of the fuel and supplies the necessary oxygen to convert CO to CO_2. All blends and diesel shows sudden increase in CO emissions at 14 nm load. Samantary *et al.*, reported that minimum and maximum CO produced were 0.005%, 0.016% resulting in a reduction of approximately 92% and 75% as compared to diesel.

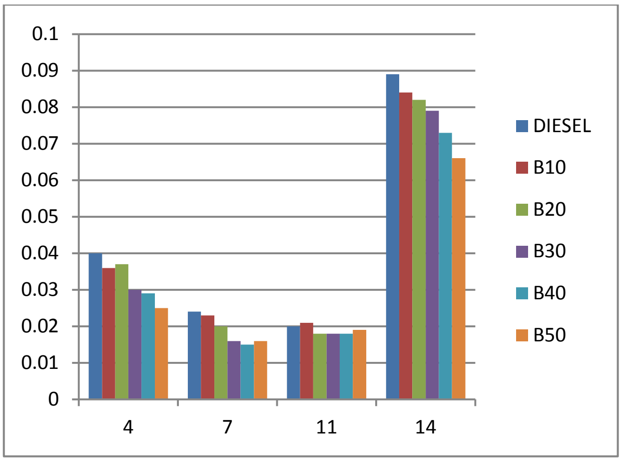

Figure 7 Carbonmonoxide (ppm) v/s Load Load (kg)

Conclusions

In the current investigation it is observed that the karanja biodiesel can be used as a partial substitute for diesel without any engine modification to reduce the impact on transportation and also reduce the dependency on crude oil imports, and also provide employments in agricultural field. The following conclusions are drawn from this investigation.

- The fuel properties like viscosity , density ,flash point, calorific value and ash content of the biodiesel compare well with accepted biodiesel standards i.e. ASTM
- The brake thermal efficiency of the engine depends majorly on the heating value and viscosity.
- The Specific Fuel Consumption of biodiesel blends is higher than the diesel.
- The Hydrocarbon emissions are less than diesel fuel as compared with biodiesel
- The NOx emissions increase with the higher temperatures in the chamber. NOx emission is low for diesel.
- The CO_2 emissions are lower for biodiesel blends as compared with diesel.
- The CO emissions are lower for biodiesel blends as compared with diesel.

The above investigations suggest that blend of karanja bio diesel blend– B30 is the optimum blend which can produce better values with Pure Diesel for Diesel engines as far as performance and emissions were considered. So that it can be used as alternative to diesel. Further studies can be done with certain additives to improve the emission characteristics

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