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Performance Evaluation of CI Engine using Karanja Biodiesel as an Alternative Fuel

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ABSTRACT

Biodiesel is an alternative diesel fuel that is produced from renewable resources. The use of biodiesel is rapidly increasing around the world, making it incumbent to fully understand its impacts on the diesel engine combustion process and pollutant formation. Biodiesel is known as the mono-alkyl-esters of long chain fatty acids derived from renewable feed stocks, such as, vegetable oils or animal fats, for use in compression ignition engines. In the present work, the performance of single cylinder water-cooled diesel engine using methyl-ester of Karanja oil as fuel was evaluated for its performance and exhaust emissions. Different blends of Karanja Oil (B5, B10, B15, B20) were compared for their performance characteristics with pure Diesel(B100).The performance was assessed for the parameters viz. Indicated Power, Fuel Consumption, Break Thermal Efficiency, Air fuel Ratio, BSFC(Break Specific Fuel Consumption), Exhaust gas Temperature against different loads.
Keywords : - Biodiesel, Diesel Engine, Performance, Emissions.

I. INTRODUCTION

Day by day on international level the concern about environmental pollution is growing due to extensive use of different conventional resources as fuels which are found in earth's crust. The nations are continuously working together to mitigate the effect of pollution on environment. Different alternatives are being proposed to replace the conventional diesel fuels. Biodiesel is considered to be most prominent alternative to replace conventional diesel fuel.

Worldwide Diesel is used as the major fuel in transportation. Diesel Engines (CI Engines) have higher compression ratio than Gasoline engine (SI Engines).Hence, it is more favoured for transportation than SI engine due to higher thermal efficiency. But the combustion of Diesel releases many pollutants like CO_2, CO, NOx in atmosphere which are solely responsible for pollution and environmental degradation. In recent years use of biodiesel has attracted attention as alternative fuel for diesel in CI engine. The effect of global warming can be mitigated using biodiesel due to low sulphur content and aromatic hydrocarbons.

Biodiesel is defined by ASTM International as a fuel composed of mono alkyl esters of long-chain fatty acids derived from renewable vegetable oils or animal fats meeting the requirements of ASTM D6751 (ASTM 2008a). The use of Biodiesel in CI engine gives similar performance characteristics as that of conventional diesel (karnwal et. al 2010). The biodiesel cannot be directly used because of its high viscosity causing ring sticking, injector coking, or injector deposition problems in long run, therefore practically the oil is mixed with conventional diesel to make blends.

Biodiesel is mainly produced from different types of vegetable oils (like karanja, rapeseed, soybean, canola, sunflower, palm oil etc.).Transesterification is most commonly used method of preparation of biodiesel from vegetable. Oil because of its low cost and simplicity. (Sharma et.al 2009 and Balat et. al 2010). Transesterification is esterification of fatty acids (vegetable. oils) in presence of alcohol and catalyst to produce Methyl ester (Biodiesel) and Glycerol (Patni et. al 2013).

N. Stalin et al (2007) conducted a study on performance evaluation of CI engine using Karanja Biodiesel. They conducted study using eight blends of Karnaja oil and

Diesel and compared the results with Pure Diesel. The study concluded by recommending B40 as an optimum blend to use in CI engine without much modification in engine with thermal efficiency increased up to 70% compared to other blends.

Avinash Kumar Agarwal et al (2015) analysed in-nozzle flow and spray characteristics for three fuels namely mineral diesel, karanja oil and jatropha biodiesel. Above characteristics were obtained for three blends (B5, B20, and B100) each of Karanja and Jatropha biodiesel and compared with the same of pure diesel. The study concluded that the Karanja biodiesel showed better atomization than jatropha. Pure Diesel had better atomization compared to that of other two blends.

P.K. Sahoo et al (2009) compared performance and emission characteristics of jatropha, Karanja and polanga biodiesel as fuel in tractor engine. Three blends (B20, B50, and B100) of each of above types were compared for performance and emission. It was concluded that Brake specific fuel consumptions for all the biodiesel blends with diesel increases with blends and decreases with speed. There is a reduction in smoke for all the biodiesel and their blends when compared with diesel. Smoke emission reduces with blends and speeds during full throttle performance test.

Atul Dhar et al (2014) analysed two blends of Karanja biodiesel (10% & 20% KOME) on the basis of performance, emission and combustion characteristics with respect to the pure diesel concluding that the blends were better than pure diesel. Comparative investigation of performance, emissions and combustion characteristics of Karanja biodiesel blends and mineral diesel showed that up to 20% Karanja biodiesel blend can be utilized in an unmodified DICI engine.

Bhupendra Singh Chauhan et al (2013) conducted a study on performance and emission of CI engine using different blends of composition of 5%, 10%, 20%, 30% and 100% of KOME. They compared the results with pure diesel to conclude that UBHC, CO, CO2 and smoke were lower with Karanja biodiesel fuel. However, NOx emissions of Karanja biodiesel and its blend were higher than Diesel. The results from the experiments suggest that biodiesel from non-edible oil like Karanja and its blends with diesel could be a potential fuel for diesel engine and play a vital role in the near future especially for small and medium energy production.

In the present study, Karanja oil was considered as a potential alternative fuel for an unmodified diesel engine. Main aim of this study is to investigate the engine performance, emission and combustion characteristics of a diesel engine fuelled with karanja oil and its diesel blends (B5, B10, B15, and B20*)* compared to those of standard diesel. It is also hoped that the new data presented here will help in developing new predictive methods or procedures for these characteristics.

II. BLENDED FUELS

Commercial diesel fuel used in India which was obtained locally is used as a base line fuel for this study fuels by shaking. Density and heating value of fuels is as given in the tab. 1. B is referred as pure Karanja biodiesel fuel. Viscosity, Density, Moisture and Total acid number in the blended fuel have shown higher value than diesel. This is due to higher Viscosity, Density, and Moisture.

Table 1: Properties of Fuel Samples

Property / Fuel	% of biodiesel (v/v)	% of diesel (v/v)	Viscosity (NS/m^2)	Specific gravity	Calorific value (kJ/Kg)
Diesel	0	100	2.5	0.870	43500
B5	5	95	2.78	0.837	43119
B10	10	90	2.89	0.840	42738
B15	15	85	3.06	0.842	42357
B20	20	80	3.64	0.844	41956

Fig. 1 shows the graph which depicts the calorific values for different blends. The calorific value of the Pure Diesel was found to be highest compared to the four blends

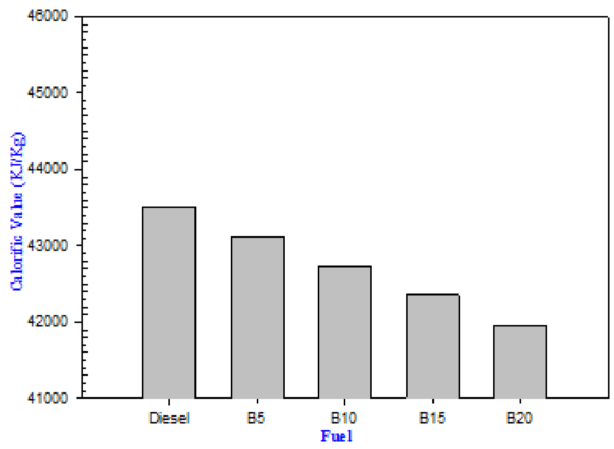

Figure 1: Calorific Values of Karanja Blend Fuels

Fig. 2 shows the column chart of viscosity of diesel with karanja blends. Chart shows that the viscosity of diesel is less than that of karanja blends and it increases with the increase of percentage of biodiesel in diesel.

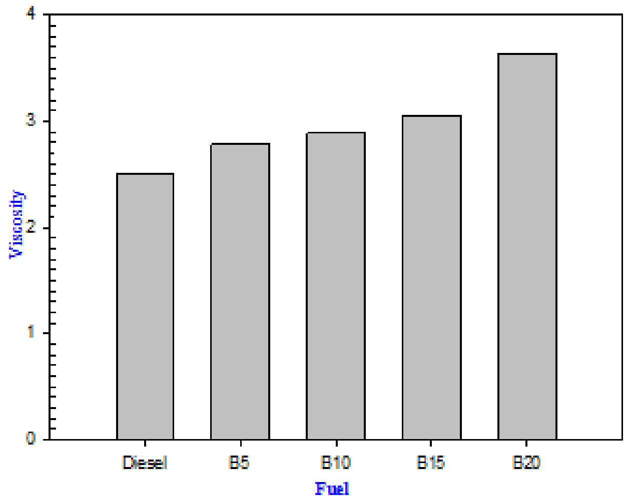

Figure 2: Viscosity of Diesel with Karanja Blends

III. TEST SET UP AND PROCEDURE

The experimentation was carried out in the research facility available with institute. The engine test rig (Fig.3) is a single cylinder, water cooled, four stroke diesel engines (10 kW), Kirloskar make connected to Rope brake dynamometer for loading. One Piezo sensor is mounted on engine head through a sleeve and other mounted on fuel line near injector for measurement of pressures. The test rig has transmitters for air and fuel flow measurements. Provision is also made for measurement of temperature of exhaust, cooling water and calorimeter water inlet and outlet and load on the engine. The Engine specifications are given in Table 2.

Figure 3: Photographic view of Test Facility

Table 2: Engine Specifications

Description	Type
Make of the Engine	Kirlosker oil Engine
Type of Engine	Vertical, 4S, High speed, CI Engine
No. of cylinders	1
Max. Rated speed	1500 rpm
Injection Pump & Type	Single Cylinder Flange Mounted
Specific Fuel Consumption (SFC)	25 gm/kwh
Governor Type	Mechanical Centrifugal Type
Brake Horse Power (BHP)	10KW (7.4 BHP)
Type Of Dynamometer	Rope Brake Dynamometer
Method of cooling	Water cooling
Thermocouples	K-Type
Sensors	Piezo electric sensor

Test Procedure

Initially when the engine was started using diesel it was allowed to run on idle for warming up the engine. When the engine got properly warm up the different readings of manometer, engine speed, rotameter reading, and load on engine in kg, fuel consumption for a fixed time limit, calorimeter temperature readings was noted. After that load was given to the engine by the rope bake dynamometer which increased the torque on the engine and allowed running for stipulated amount of time minutes. Increase in torque result in change of speed which was maintained constant at 770 rpm by adjusting acceleration throttle. Then different data were recorded. Likewise six tests were conducted for a particular fuel on increasing load conditions keeping speed constant. Engine was allowed to cool for about an hour before testing of next blend fuel. Same procedure was followed using different blends of karanja biodiesel and diesel and data were recorded.

Experiments were performed on Kirloskar make single cylinder diesel engine. This is a single cylinder, water cooled engine. Technical details of the engine are given in Table 2. The tests were conducted for different blends at constant speed. For each of the fuel blend, the engine was run on six different loads, i.e. 0kg, 3kg, 5kg, 7kg, 10kg and 12kg of break load on dynamometer. Load beyond 12 kg results in heavy vibrations and abnormal noises, hence test run was not conducted.

The engine performance tests were conducted with a rope brake-diesel engine set up. The parameters like fuel consumption and torque were measured at different loads at constant speed 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. The engine was sufficiently warmed up at every stage and the cooling water temperature was maintained at 30 °C.

IV. RESULTS AND DISCUSSIONS

After the experimentation was carried out for each fuel at each load the performance characteristics were determined. Different graphs of Indicated Power, Fuel Consumption, Break Thermal Efficiency, Air fuel Ratio, Break Specific Fuel Consumption, Exhaust Gas Temperature were plotted against different Loads.

4.1. Effect of Indicated Power on Engine Load

Fig.4 shows the variation of Indicated power with load for different fuel blends. In all the cases indicated power is increased with increased load as the heat lost to surrounding was reduced. Experimental results shows that the indicated power developed by the engine at all the loads for different blends of the fuel is more or less is same (1% change). Indicated power of B20 blend fuel is observed almost equal to the diesel fuel. B10 and B5 fuels indicated power is low at starting but increases on higher loads. At 10 kg of loading the indicated power Karanja fuel is higher than that of diesel except for B15.

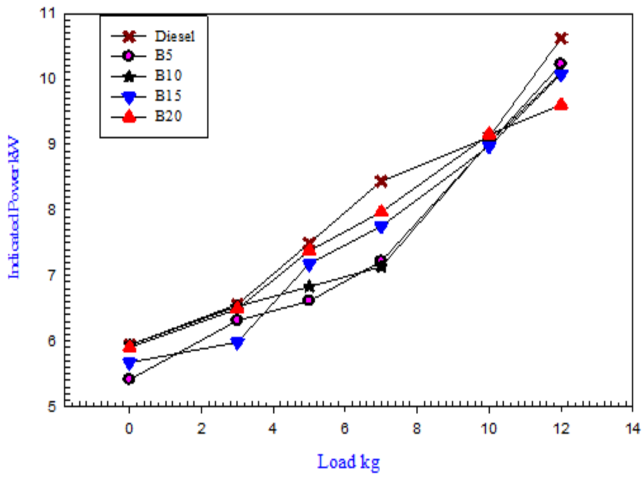

Figure 4: Graph showing Indicated Power (KW) against different Load (Kg) for pure diesel and combination of KOME blend

4.2. Effect of Fuel Consumption on the Engine

Fig. 5 shows the effect of fuel consumption of the engine for various blends. Results shows that fuel consumption for Karanja fuel for all the blends is smaller compare with higher load on the engine. With increase in load on the engine, fuel consumption for Karanja is more. Fuel consumption of fuel blend B20 is observed to be higher than that of pure diesel. At maximum loading of 10 kg the fuel consumption for pure diesel is lower than any other blend. Experimental results shows that fuel blends of karanja biodiesel consume less fuel than that of diesel.

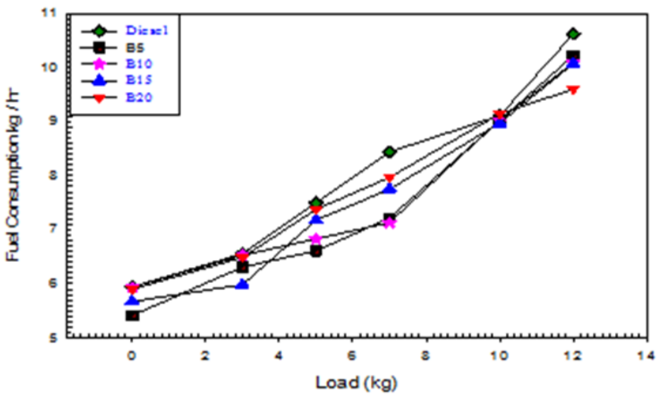

Figure 5: Graph showing Fuel Consumption (Kg/hr) against different Loads (Kg) for pure diesel and combination of KOME blend

4.3. Effect of Break Thermal Efficiency on the Engine

The variation of Brake Thermal efficiency with load for different fuel blends are shown in Fig. 6. In all the cases brake thermal efficiency is increased with increasing load. The maximum efficiency obtained in this experiment was 38.54% (B10). By considering the lower viscosity and higher Break Thermal Efficiency, B10 is the considered to be better option as the combustion takes place in presence of extra oxygen and higher lubricity due to higher viscosity than diesel. The value for diesel is (28.29%). B20 biodiesel blend has lower BTE than B10 and B5 this may be due to higher viscosity, inappropriate spray and inappropriate combustion which surpass the lubricity benefits, it is found that brake thermal efficiency for biodiesel in comparison to diesel engine is a better option for part load on which most engine runs.

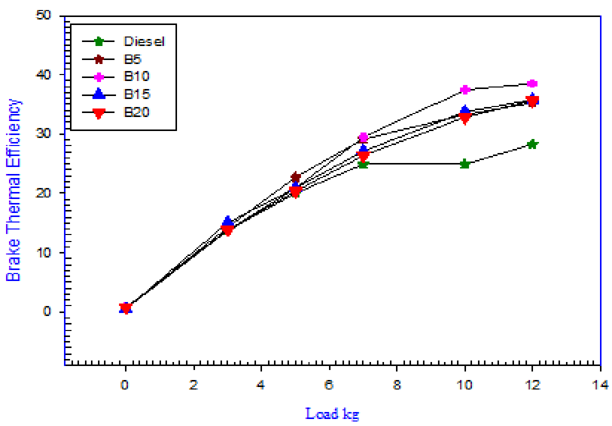

Figure 6 : Graph showing Brake Thermal Efficiency against different Loads (Kg) for pure diesel and combination of KOME blend

4.4 Effect of Air fuel Ratio on Engine

Air fuel ratio is defined as the ratio of air mass flow to rate of fuel flow rate. It is observed that the air fuel ratio decreases with increase in loads. The graph showing A/F ratio to different loads is shown in Fig.7.The decreasing behavior of A/F ratio with increasing loads is due to higher fuel requirement for higher loads.

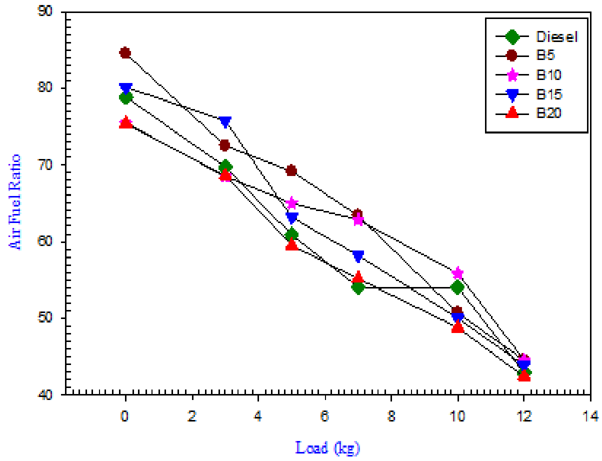

Figure 7: Graph showing Air Fuel Ratio against different Loads (Kg) for pure diesel and combination of KOME blend

4.5 Effect of BSFC on Engine

The variation of BSFC at different load is shown in Fig. 8. For all cases BSFC increases rapidly up to load 3 kg and abruptly reduce with increase in load up to 5 kg load and then observed a small slope of graph up to maximum load condition. BSFC for B20 was found to be higher than diesel because of higher density and lower calorific value, density, viscosity are the main parameters to determine BSFC. Higher density leads to more the fuel consumption thus more BSFC.

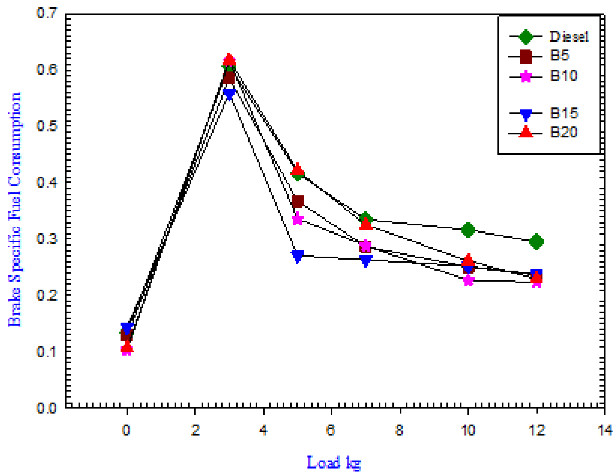

Figure 8: Graph showing Brake Specific Fuel Consumption against different Loads (Kg) for pure diesel and combination of KOME blend.

4.6 Effect of Exhaust Gas Temperature on the Engine

Fig. 9 shows the effect on the exhaust gas temperature of the engine. With increase in load on the engine the exhaust gas temperature increases. There is increase in flame temperature with biodiesel than that of diesel in spite of lower calorific value of blends compared to pure diesel. The increase in flame temperature increases the exhaust gas temperature. In the current investigation it was found that B10 blend had slightly lower exhaust gas temperature due to higher Break Thermal Efficiency which indicates an effective utilization of heat energy.

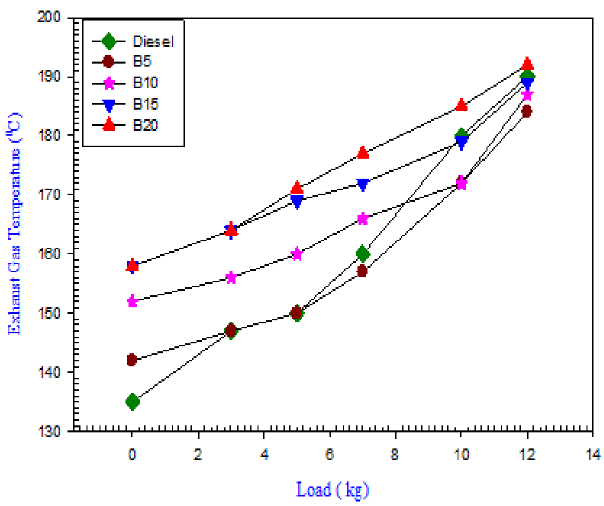

Figure 9 : Graph showing Exhaust Gas Temperature against different Loads (Kg) for pure diesel and combination of KOME blend

V. CONCLUSION

In the current investigation, it has been confirmed that karanja oil may be used as resource to obtain the bio diesel. The methyl esters of karanja seed along with diesel may reduce the environmental impacts of transportation and also reduce the dependency on crude oil imports, and also provide employments in agricultural field. The conclusions are summarized as follows.

1. The Indicated Power was observed to be almost same for all the blends with about ±1% change.
2. The fuel consumption for Karanja blends was smaller with increase in loads compared to that of Diesel. So the fuel required by the engine is less for the same load than that for pure Diesel.
3. There was increase in Brake Thermal Efficiency of B10 as compared to Pure Diesel because of complete combustion. Hence the Biodiesel blends can be efficient enough to use with CI engines.
4. As the Fuel Consumption is less for Karanja blends the A/F ratio was observed to be more for the same.
5. Higher density of Karanja Blends increased the Break Specific Fuel Consumption. The higher BSFC Karanja blends increases to maintain same break power output in view for the compensation of lower heating value as compared to Diesel.
6. The exhaust gas temperature was found to be higher in case of Karanja Blends which in turn will affect effective utilization of heat energy.
7. It was observed that the smoke and emissions for the blends of Karanja is less as compared to Pure Diesel.

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