Performance Characterization of Single Cylinder DI Diesel Engine Fueled with Karanja Biodiesel

Ramchandra S. Jahagidar, Eknath R. Deore, Milind S. Patil, Purushottam S. Desale

Abstract—Continuous increase in fuel prices and fast depletion of the available petroleum reservoirs has renewed an interest in the field of biodiesel. In this contest an experimental investigation has been conducted on single cylinder diesel engine fuelled with the blends of Karanja and Diesel. Engine performance is also evaluated using pure Karanja fuel without any modification in a present engine. Experimental test have been carried out for performance characterization of water cooled DI diesel engine. 20% biodiesel fuel and 80% diesel fuel is called as a BK20 and 80% biodiesel and 20% diesel fuel is called as a BK80. The effect of these fuel blends is studied experimentally using 3.75 kW DI diesel engine. Experiments where conducted for different blends and its effect on break power, fuel consumption, break thermal efficiency, volumetric efficiency exhaust gas temperature etc with respect to the load on the engine are reported.

Keywords-component; Diesel engine, Biodiesel, Karanja, fuel consumption, Break thermal effieciency)

I. INTRODUCTION

Low fuel consumption and better efficiency are the facts that attracts towards the use of diesel engine. Increasing consumption rate of diesel fuel and environmental issues has renewed an interest of the researchers to explore the alternative fuels to diesel fuel. Presently petroleum fuel including diesel is depleting at a an increased consumption rate of 3%. [1] Easy availability, renewable and greener to the environment are the three major advantages of the biodiesels to attract major researchers. Because of similar properties with the diesel fuel bio diesel can be considred as a better alternative to the diesel fuel. Also the biodiesel has lower sulphur and aromatics contents and reduced CO2 emissions compared with diesel fuel. [2] By 2017, 20% blend of biofuels with diesel has been approved by the Gov. of India in 2009. About 38 million tones of petroleum products are consumed in India in the year 2007. It is expected that it may be doubled by the end of 2030. This implies a larger scope of production and use of biofuels in India. [3-6].

Biodiesel are produced by transesterification process. Transesterification is a process in which esters of saturated and unsaturated monocarboxylic acids of common vegetable oil and animal fats are react with alcohol in presence of catalyst.

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Other processes of biodiesel production are Biox co-solvent process and Supercritical alcohol process and In situ biodiesel process. [7] Biodiesel can use and mix with diesel fuel and engine does not required major changes in engines. The use of biodiesel reduces the emissions of soot by 60% and CO by 50%. [8] Hence in this experimental analysis biodiesel blends are used for characterization of the single cylinder DI diesel engine. The aim of the present study is to experimentally investigate the effect of different biodiesel blends on the performance of diesel engine.

II. MATERIALS AND EXPERIMENT

Commercial diesel fuel used in India which was obtained locally is used as a base line fuel for this study. Test fuel samples are prepared at B. S. Deore College of Engineering and properties are tested from the third party Horizon Services, Chemical Lab at Pune (MS). Density and Heating value of test fuels is as given in the table 1. 20% biodiesel fuel and 80% diesel fuel is called as a BK20 and 80% biodiesel and 20% diesel fuel is called as a BK80. D is referred as pure diesel and K is for Karanja fuel. Viscosity, Density, Moisture and Total acid number in the blended fuel have shown higher value than diesel while the Sulphur level decreased. This is due to higher Viscosity, Density, Moisture and Total acid number and less Sulphur content in Bio-diesel. The Engine oil used for the study purpose meets the API CH-4, ACEA A3/B4; SAE 15W-40 specification.

Table – 01 Property of Fuel Samples

FUEL	Density (Kg/m^3)	Calorific Value (KJ/Kg)
Diesel (D)	822	42200
Karanja (K)	861.25	36120
BK20	837.85	33400
BK40	843.7	32779
BK60	849.55	31199
BK80	855.4	30300

Experiments were performed with Kirloskar make single cylinder diesel engine. This is a single cylinder, water cooled open combustion chamber diesel engine. Technical details of the engine are given in Table 2. All experiments were performed after ensuring the full warm-up. A plan was designed for the experimental investigation. Different blends of fuels were tested. The tests were conducted for different blends and were repeated for four times for every kind of fuel, in order to increase the reliability of the test results. For each of the fuel blend, the engine was run on five different loads, i.e. idle (0kg), 2kg, 4kg, 6kg and 8kg of break load on dynamometer. The engine load was controlled by dynamometer.

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Table 02 Engine Specifications

	Description	Type
1.	Name of the Engine	Kirloskar oil engine AV1
2.	Type of engine	Vertical, 4S, High speed, CI engine
3.	No. of cylinders	1
4.	IS rating at 1500 rpm	3.7 kW
5.	Cubic capacity	0.533
6.	Compression ratio	16.5 : 1
7.	Injection pump & type	Single cylinder, Flange mounted
8.	Governor type	Mechanical centrifugal type
9.	Maximum permissible Back Pressure	2.5 kPa
10.	Method of cooling	Cooling water

The engine performance tests were conducted with a rope brake-diesel engine set up. The parameters like speed of engine, fuel consumption and torque 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. The engine was sufficiently warmed up at every stage and the cold water temperature was maintained at 52 °C. The fuel injection pressure was maintained at 200 bar throughout the experiment. A Honey Well Chromel-Alumel thermocouple with a digital display meter was used to measure the exhaust gas temperature. Fig 01 shows the photograph of the DI Diesel engine.

Fig 01 Photograph of Single Cylinder DI Diesel Engine

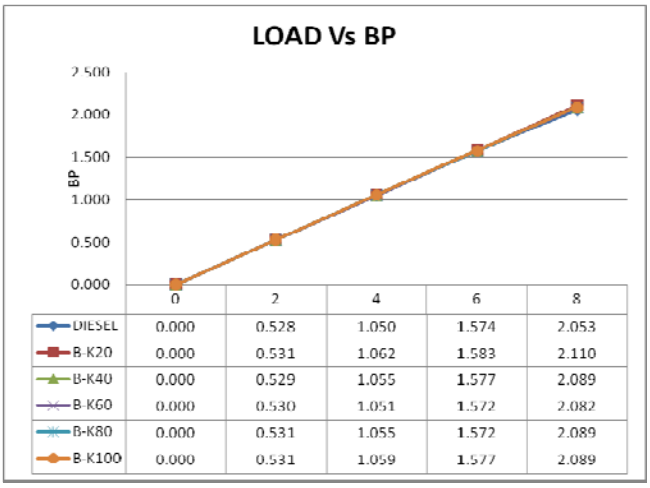

Fig 02 Break Power Vs Load on Engine

III. Engine Test Results and Discussion

A. Effect on Break Power of the Engine

Experimental results shows that the break power developed by the engine at all the loads for different blends of the fuel is more or less is same. Fig 02 represents the effect of break power vs the load on the engine. Brake power for Karanja fuel is observe to be slightly higher compare with diesel. At 70% loading the brake power Karanja fuel is 1.75% higher than that of diesel. For other blends the brake power for Karanja is also observed to be at higher side

B. Effect on Fuel Consumption of the Engine

Fig 03 shows the effect of fuel consumption of the engine for various blends. Results shows that about 20 % loading of the engine 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. For a blend of BK 40 it is observed that the fuel consumption is less than that of pure diesel. At maximum loading @ 70% the fuel consumption for pure diesel is lower than any other blend. Fig 04 represents Break Specific Fuel Consumption BSFC with respect to the loading of the engine.

C. Effect on Fuel Consumption of the Engine

Fig 05 shows the effect on Mechanical Efficiency with respect to the load on the engine. No any significant changes are observed over the entire range of the loading of he engine and different blend %.

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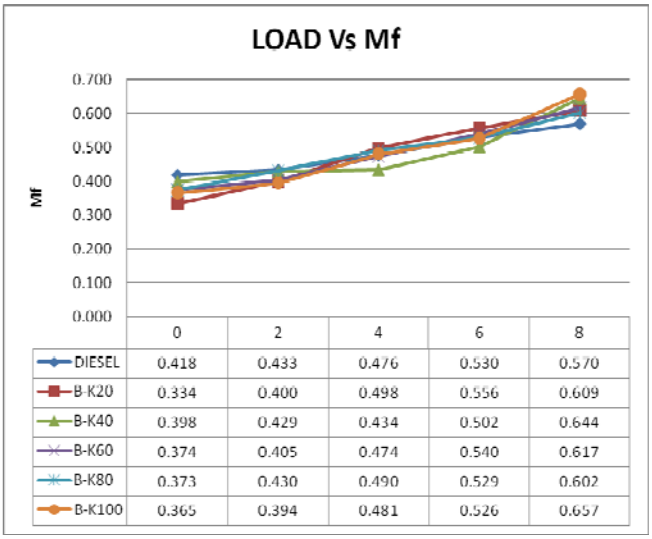
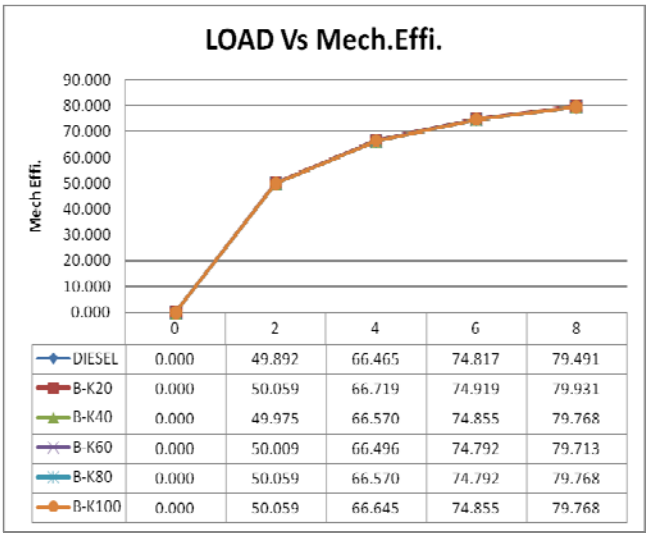


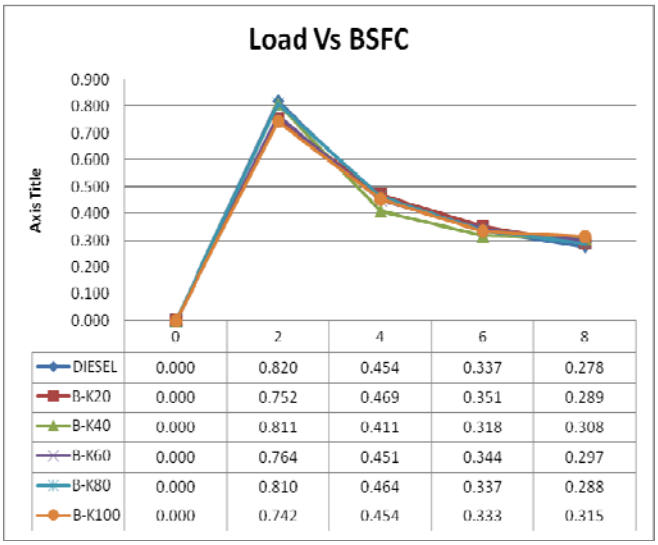
	0	2	4	6	8
DIESEL	0.418	0.433	0.476	0.530	0.570
B-K20	0.334	0.400	0.498	0.556	0.609
B-K40	0.398	0.429	0.434	0.502	0.644
B-K60	0.374	0.405	0.474	0.540	0.617
B-K80	0.373	0.430	0.490	0.529	0.602
B-K100	0.365	0.394	0.481	0.526	0.657

Fig 03 Fuel Consumption (kg/hr) Vs Load on the Engine



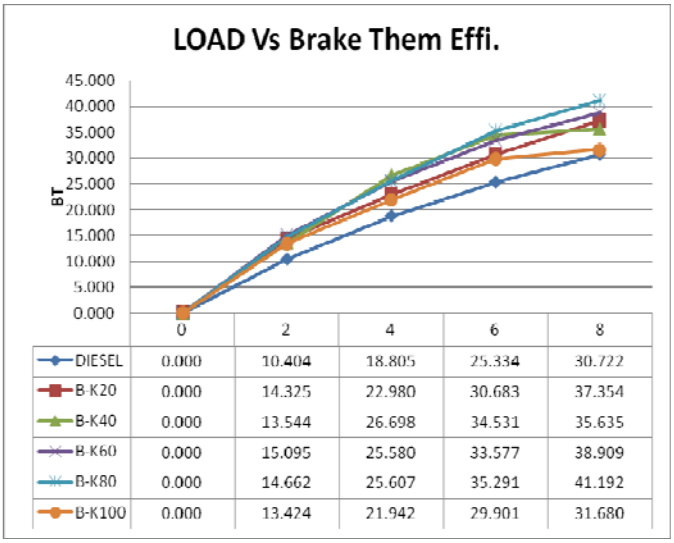
	0	2	4	6	8
DIESEL	0.000	49.892	66.465	74.817	79.491
B-K20	0.000	50.059	66.719	74.919	79.931
B-K40	0.000	49.975	66.570	74.855	79.768
B-K60	0.000	50.009	66.496	74.792	79.713
B-K80	0.000	50.059	66.570	74.792	79.768
B-K100	0.000	50.059	66.645	74.855	79.768

Fig 05 Mechanical Efficiency (%) Vs Load on the Engine



	0	2	4	6	8
DIESEL	0.000	0.820	0.454	0.337	0.278
B-K20	0.000	0.752	0.469	0.351	0.289
B-K40	0.000	0.811	0.411	0.318	0.308
B-K60	0.000	0.764	0.451	0.344	0.297
B-K80	0.000	0.810	0.464	0.337	0.288
B-K100	0.000	0.742	0.454	0.333	0.315

Fig 04 BSFC (kg/kW.hr) Vs Load on Engine



	0	2	4	6	8
DIESEL	0.000	10.404	18.805	25.334	30.722
B-K20	0.000	14.325	22.980	30.683	37.354
B-K40	0.000	13.544	26.698	34.531	35.635
B-K60	0.000	15.095	25.580	33.577	38.909
B-K80	0.000	14.662	25.607	35.291	41.192
B-K100	0.000	13.424	21.942	29.901	31.680

Fig 06 Thermal Efficiency (%) Vs Load on Engine

D. Effect on Break Thermal Efficiency of the Engine

Fig 06 shows the effect on break thermal efficiency of the engine. It is observed that the efficiency of the pure Karanja Biofuel (K) is more than that of the diesel engine. Pure Karanja fuel is having a more fuel consumption as compare with the diesel fuel how ever the heating value is less than that of the diesel fuel. It is also observed that the break power developed by the engine is almost same at all the loads. Theses observations may be the cause that the thermal efficiency of he Karanja fuel is more than that of the diesel fuel. It is also observed that the break thermal efficiency is quite better for biodiesel blends (BK 20 to BK60) compare with the Karanja fuel only. The break thermal efficiency at above 60 % loading is observed as quite high this may be due to the lower exhaust gas temperature as compare with diesel.

E. Effect on Volumetric Efficiency of the Engine

Fig 07 shows the effect on Volumetric Efficiency of the engine. Efficiency of the engine with pure karanja biodiesel is observed to be greater than that of the diesel fuel. This may be de to low exhaust gas temperature. Ir-respective of the load on the engine volumetric efficiency is observed to be maximum for the blends of BK 40 and BK 60. Maximum volumetric efficiency at about 70% loading of the engine with BK 60 blend the efficiency is observed as 81% where as for the diesel it was 70.13% only. The volumetric efficinecy of Karanja fuel is improved to 5% to 6% compare with diesel fuel at all the loads, however for the blends of B60 K the efficiency is improved at about 10% to 40%

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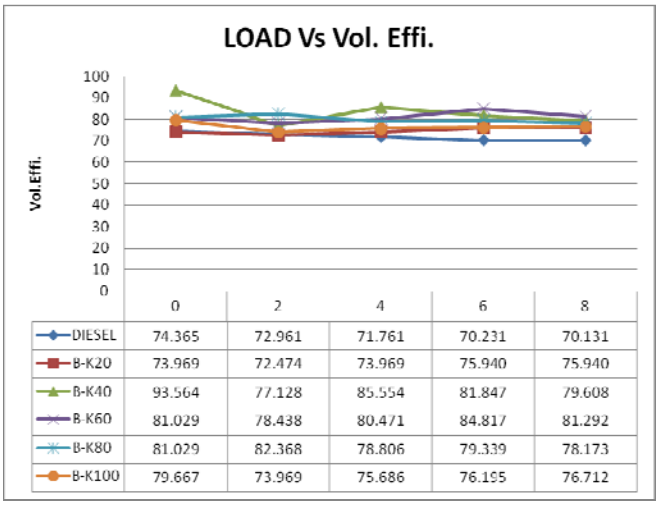
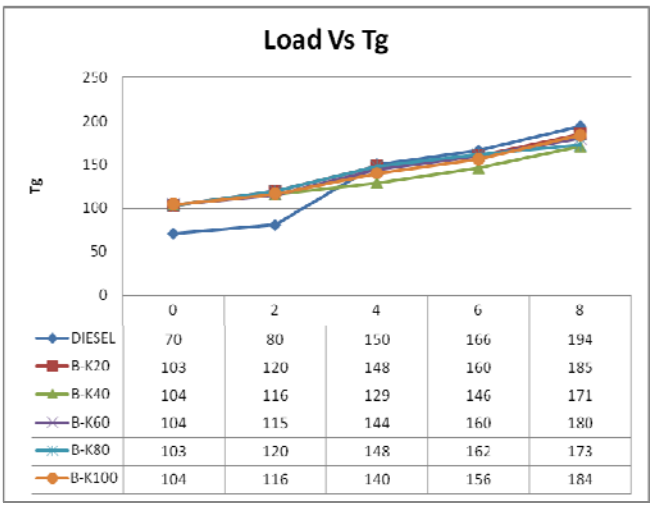


	0	2	4	6	8
DIESEL	74.365	72.961	71.761	70.231	70.131
B-K20	73.969	72.474	73.969	75.940	75.940
B-K40	93.564	77.128	85.554	81.847	79.608
B-K60	81.029	78.438	80.471	84.817	81.292
B-K80	81.029	82.368	78.806	79.339	78.173
B-K100	79.667	73.969	75.686	76.155	76.712

Fig 07 Volumetric Efficiency (%) Vs Load on the Engine



	0	2	4	6	8
DIESEL	70	80	150	166	194
B-K20	103	120	148	160	185
B-K40	104	116	129	146	171
B-K60	104	115	144	160	180
B-K80	103	120	148	162	173
B-K100	104	116	140	156	184

Fig 08 Exhaust Gas Temperature Vs Load on the Engine

F. Effect on Exahust Gas Temperature of the Engine

Fig 08 shows the effect on the exhaust gas temperature of the engine. With increase in load on the engine the exhaust gas temperature increases how ever for Karanja biodiesel the gas temperature is lower than that of the diesel fuel at higher load, where as at low and part load operation it is observed to be greater than that of the diesel fuel. For other blends not much more variation is observed for the gas temperature except for the higher loading. The exhaust gas temperature for the diesel fuel is higher than that of Karanja fuel. However for the blends of BK40 and BK60 are observed to be lower than that of diesel. This may be the results of high A/F. The lower exhaust gas temperature indicates that the effects of dissociation are signifcantly reduced that may reduces the pollutant CO

IV. Conclusion

Experimental investigations were performed on single cylinder DI diesel engine. Test where conducted on water cooled 3.75 kW diesel engine. Different fuel blends of Karanja biodiesel, diesel and Karanja biodiesel only where tested. Result shows that the break power of the engine was almost same for all the loads. However break thermal efficiency of the Karanja biodiesel where improved by 3 to 8%, Volumetric efficiency is also improved with reduction in exhaust gas temperature. Results obtained here shows that the Karanja biodiesel can itself directly used in the engine without any major modification. It is also observed that the blends of BK40 and BK 60 will have the optimum performance for the given conditions as explained earlier.

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