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Performance Analysis of Four Stroke Single Cylinder CI Engine Using Karanja Biodiesel-Diesel Blends

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Abstract: *In different researches many different types of alternative fuels are used. Based on literature review, it is concluded that for C I engine, Bio-diesel is the most promising alternative fuel. In this project works prospects and opportunities of utilizing 100% pure Karanja biodiesel and increasing Karanja biodiesel-diesel blend ratio as a working fuel in diesel engine is going to be studied by changing engine loads. Also based on experimentation most favorable blend and engine parameters are to be recommended for obtaining better performance. Karanja biodiesel presents a very promising scenario of working as alternative fuels to fossil diesel fuel. The properties of Karanja biodiesel can be compared satisfactorily with the characteristics required for I C Engine fuels specially C I engine. Experiments will be performed for five engine loads, i.e. 1,3,5,7 and 9 kg using pure diesel fuel and blends o Karanja biodiesel-diesel i.e. K10, K20, K40, K60, K80, pure Karanja biodiesel with constant speed of diesel engine. The parameters which will study in performance are brake thermal efficiency, indicated thermal efficiency, specific fuel consumption, mechanical efficiency and fuel consumption. The results of experiments observed with biodiesel blends were compared with that of baseline pure diesel. In the results its being found that the K20 Biodiesel blend has more promising results having lesser fuel consumption.*

Keywords : *C I Engine, Karanja Biodiesel, Blends, Performance analysis, dynamometer*

I. Introduction

In India one of the largest energy sources is coal, followed by petroleum and conventional biomass and waste. Since, the starting of the new Economic Policy in 1991, increased Indian population has moved towards the cities and urban people have altered away from conventional biomass and waste to other energy sources such as hydrocarbons, nuclear, biofuels, and other renewable. India's transportation sector, earlier fueled by petroleum products, is set to increase as the country focuses on developing road and railway transportation. The government plans to authorize some alternative fuel use, particularly with biofuel blends, and grow greater use of mass transit systems to limit oil demand growth. India was the fourth-largest consumer of crude oil and petroleum products in the world in 2013, after the US, China, and Japan. The variation between India's oil requirement and supply is widening, as demand increases. The fuel usage of the crude oil increase day by day in India. This also increases in diesel fuel usage because diesel is a main resource of transportation and passenger vehicle. In this research, it is trying to decrease diesel fuel consumption. One of the solutions of this problem is using an alternate fuel, which can be mixed with diesel in certain proportion. By using alternate fuel, not only reduce the need of diesel but also helpful to nation by decreasing fuel usage and find and use the reproducible sources of fuel production and also tarnish the effect of greenhouse gases.

II. Literature Review

The effect of Blending of dissimilar alternative fuel on Engine emission was carried out. A number of researchers had been done experiments with different unconventional fuels for the IC engine. It resulted that biodiesel of special vegetable oils like Karanja oil, Palm oil, Jatropha oil and Gases like CNG, LPG, hydrogen, etc. can be used as an substitute fuels for IC engines. (Nileshkumar, Patel, & Rathod, 2015)

Maulik A Modi et. al. (2014) was studied the effect of Palm Seed Oil and Diesel Blend fueled in Single Cylinder C I Engine for Brake Thermal Efficiency Parametrically Optimized Using Taguchi Method. In this research, the effects of three parameters load, compression ratio and injection pressure are used as variable for optimization. The results of experiment identify that injection pressure 180 bar, 16 compression ratio and engine load 10 kg are optimum parameter set for highest BTHE (Modi, Patel, & Rathod, 2014). Krunal B Patel et. al. (2013) was studied on Taguchi Method for the Parametric Optimization of Single Cylinder C I engine fueled with Pyrolysis Oil and Diesel Blend finding out Specific Fuel Consumption. In this experimental work the four parameters are injection timing, injection pressure, compression ratio and engine load are in use as variable parameters for optimization. The analysis of the Taguchi experiment identifies that compression ratio 16, 22° injection timing and engine load 3 kg are most favorable parameter setting for lowest BSFC. Engine performance least influenced by Compression ratio and is mostly affected by engine load (K. B. Patel, Patel, & Patel, 2013). P Mahanta et. al. (2006) was studied in this Present work to deals with testing a performance of a C I engine with different blends of non-edible oil as well as their methylesters with petrodiesel. Further, the blend can be used in nay existing CI engine without modification and preheating. Results obtained with B15 and B20 show improvement in BTHE and reduction in BSFC, especially at higher load. Emission results show significant reduction in percentage of CO and HC for B15 and B20 at medium and high power output.(Mahanta, Mishra, & Kushwah, 2006) S. Ghosh et.al. (2012) was researched on investigation of Direct Injection Diesel Engine Using Pongamia Oil for most favorable Performance and Exhaust Emission. Various blends in the order of B25, B50, B75, B100 for Pongamia and Diesel are made by transesterification process on volume basis and used as fuels in a single cylinder four stroke direct injection C I engine and compared with pure diesel fuel. The engine tests have been done with the aim of obtaining, BSFC, BTHE, Emission levels of diesel engine running on Pongamia oil and its blend. This blend B25 considerably decreases the emission of NOX and CO emission in exhaust gases (Ghosh & Dutta, 2012). Nagarhalli M. V. et.al. (2010) was investigated performance and emission characteristics of Karanja biodiesel and its blends in a C I engine and its economics. In the present investigation, experimental work has been carried out by using mineral diesel and biodiesel-diesel blends at an injection pressure of 200 bar. HC emissions decreased by 3 % for B40 and 12.8 % for B20 at full load. NOX decreased by 28 % for B40 and 39 % for B20 at full load, BSEC increased by 1.9 % for B40 and 7 % for B20 at full load; Hence a blend of 40% biodiesel and 60% diesel (B40) is suggested (Nagarhalli & Nandedkar, 2011).

From the above referred research paper it is concluded that, Blend is useful as an alternative fuel without any modification into existing engine but for better result for performance & exhaust emission optimization is required for engine parameter. Rather than directly use the biodiesel of any content used by blending with diesel provides more promising results. Both edible and non edible oils of different contents blended with diesel can be used as a working fluid in IC Engine effectively. Karanja biodiesel which is a non-edible oil has a wide potential to be used as biofuels in CI Engine. It can be blended with diesel and worked in the CI Engine effectively. Since it is a non-edible it also reduce the dependency on other edible oils used as a biofuel. Extraction of oil from Karanja seeds is much more than the other oil seeds, and conversion of biodiesel from Karanja oil is pretty simple with the help of the transterification process. Possibility of using karanja biodiesel with diesel in some proportion, thus reduce dependency on fossil fuel. Reduce emissions than the diesel engines, hence saved atmosphere.

III. Karanja Biodiesel

Pongamia pinnata (Karanja) belongs to the sub family Fabeacae (Papilionaceae), also called Derris indica and Pongamia glabra. It is a small to medium sized evergreen tree with a short bole. The tree is planted for shade and is grown as decorative tree. Pongamia pinnata is one of the few nitrogen fixing trees producing seeds consist of 30-40% oil. The natural distribution is along coasts and river banks in lands and constitutional to the Asian subcontinent, also cultivated along canal banks, road sides and open farm lands. The Karanja biodiesel is extracted from Karanja oil by using base catalyzed transesterification process. Different fuel properties like density at 15°C (kg/m3), kinematic viscosity 40°C (cSt), flash point (°C), fire point (°C), cetane no. and calorific value (kJ/kg) of Karanja biodiesel is compared with pure diesel properties. And it seems that some properties are far better than pure diesel. Kinematic viscosity and density were superior to diesel this may result in inappropriate spray characteristics. Flash point and fire point were more than diesel and this established the safety of biodiesel storage. Calorific value is less as compared to pure diesel. (Alam, n.d.)

Table 1: Fuel Properties of Karanja biodiesel and Diesel

Property	Method Of Testing	Karanja Biodiesel	Diesel
Density at 15°C (kg/m^3)	Gravimetry	860	833
Kinematic viscosity at 40°C (cSt)	U-Tube	5.2	3.0
Flash point (°C)	Open cup	174	74
Fire point (°C)	Open cup	230	120
Cetane no.	ISO 5165	41.7	49.0
Calorific value (kJ/kg)	Bomb calorimeter	37000	42850

IV. Experimental Setup

The experimentation was done to check out the performance characteristics of Karanja biodiesel. In this experimental setup it consists of single cylinder four stroke C I engine of direct injection type. And it is attached to eddy current type dynamometer for variable loading. Among different engine parameters we choose varying engine load in proportion of 1,3,5,7,9 kg and Diesel-Karanja biodiesel blends in the proportion of 10,20,40,60,80%. Diesel, Karanja biodiesel K100 and its blends K10, K20, K40, K60, K80 were used to test on the engine of the specifications mentioned in Table.2. There is no modifications in C I engine were done. The load was given to the engine by using the Eddy current dynamometer. The engine speed in rpm was sensed using a sensor installed in the dynamometer. And on the control panel of the dynamometer recorded speed was displayed.(T. M. Patel & Trivedi, 2015)

Fig. 1: Test engine setup

Table 2: Technical specification of Engine

Sr No.	No. of Cylinders	1
1	No. of strokes	4
2	Cylinder Diameter	87.5 mm
3	Stroke Length	110 mm
4	Connecting rod Length	234 mm
5	Orifice Diameter	20 mm
6	Dynamometer arm Length	185 mm
7	Fuel	Diesel
8	Power	3.5 kW
9	Speed	1500 rpm
10	CR Range	12:1 to 18:1

V. Methodology

To meet the objective, the subsequent steps must be performed:-

- Find out suitable Karanja biodiesel and check out its properties and compared it with pure diesel.
- Look after all the parameters to be affected in diesel engine.
- Select the parameter on which experiment should be done.
- Experimental set up is being done.
- It contains various equipments like single cylinder four stroke diesel engine of direct injection type, eddy current dynamometer etc.
- In this experiment used the single cylinder water cooled constant speed diesel engine. The experiment is to be done by using the various fuels like Karanja biodiesel - diesel and its blend at different proportion.
- The experimental analysis engine performance characteristics like Fuel consumption, SFC, indicated thermal efficiency, Break thermal efficiency and mechanical efficiency find out for different blends and analyzed.

VI. Result And Discussion

According to the observed data collected from the experiment and the calculations are made following analysis are being done. Graphical comparison of different performance characteristics like Fuel consumption, Specific fuel consumption, ITHE, BTHE and mechanical efficiency for different blends of Karanja biodiesel - diesel with varying load is being done.

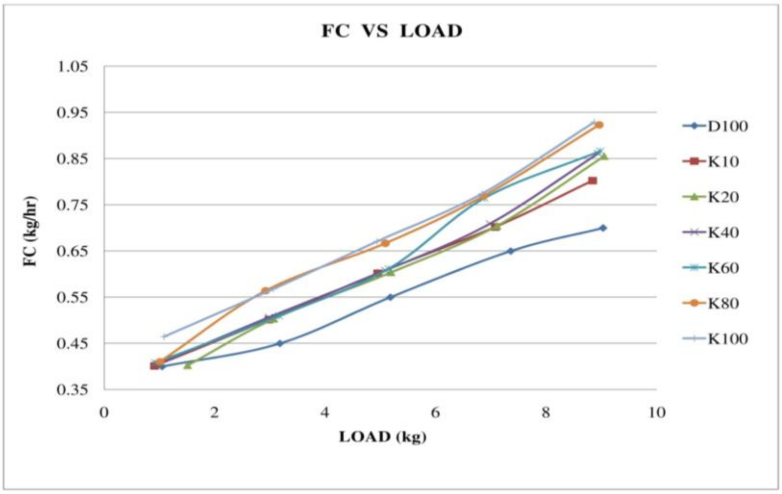

Fig. 2: Variations of Fuel consumption with Load

The variations of Fuel consumption with varying Load under various blends of Karanja biodiesel are shown in fig.2. From above figure it is being concluded that the FC of all blends are slightly more than the diesel fuel at all varying loads. But K20 D80 Karanja biodiesel blend has considerable lesser fuel consumption than all among blends and diesel at lower loading conditions.

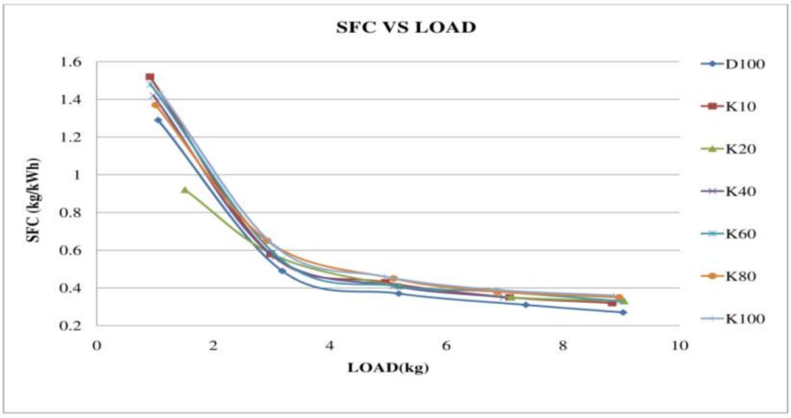

Fig. 3: Variations of Specific fuel consumption with Load

The variations of SFC with varying Load under various blends of Karanja biodiesel are shown in fig.3. When blending of two dissimilar fuels of different calorific values are blended together; the specific fuel consumption may not be reliable, since the calorific value and density of the two fuels are different. From above figure it's concluded that the SFC of K20 D80 is considerably less than diesel as well as all among Karanja biodiesel blends at lower loads. And at all loading condition it is nearer to the diesel.

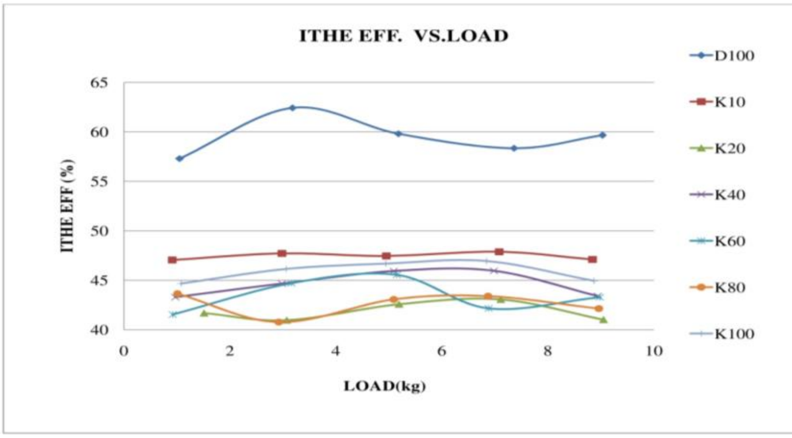

Fig. 4: Variations of Indicated thermal efficiency with Load

The changes in Indicated thermal efficiency with varying Load under various blends are shown in fig 4. It can be completely shown that the ITHE of diesel is much better than that of the other blends of Karanja biodiesel. K10 D90 has considerable more Indicated thermal efficiency than all among blends, but lesser compared to diesel.

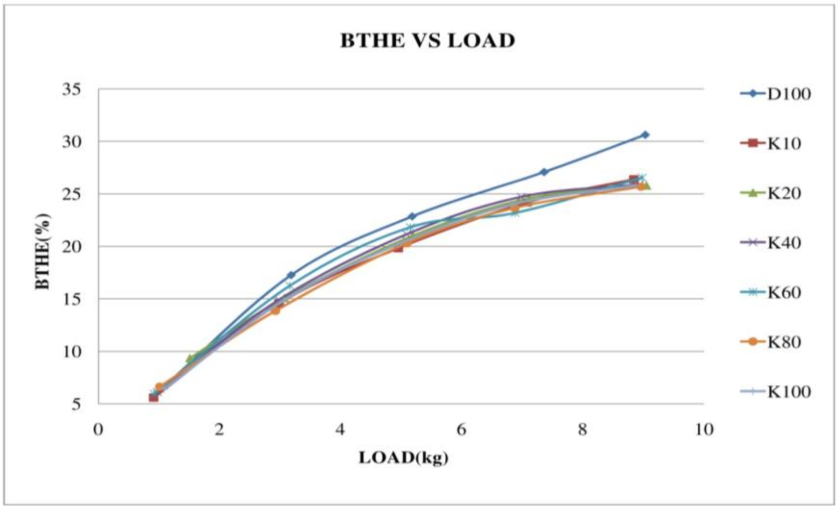

Fig. 5: Variations of Brake thermal efficiency with Load

With varying Load the variations of Brake thermal efficiency under various blends of Karanja biodiesel are shown in fig 4. From figure concluded that the BTHE of diesel is more than all other Karanja biodiesel blends on higher loads. And the Brake thermal efficiency of K60 D40 Karanja biodiesel blend is more among all other blends at all loads.

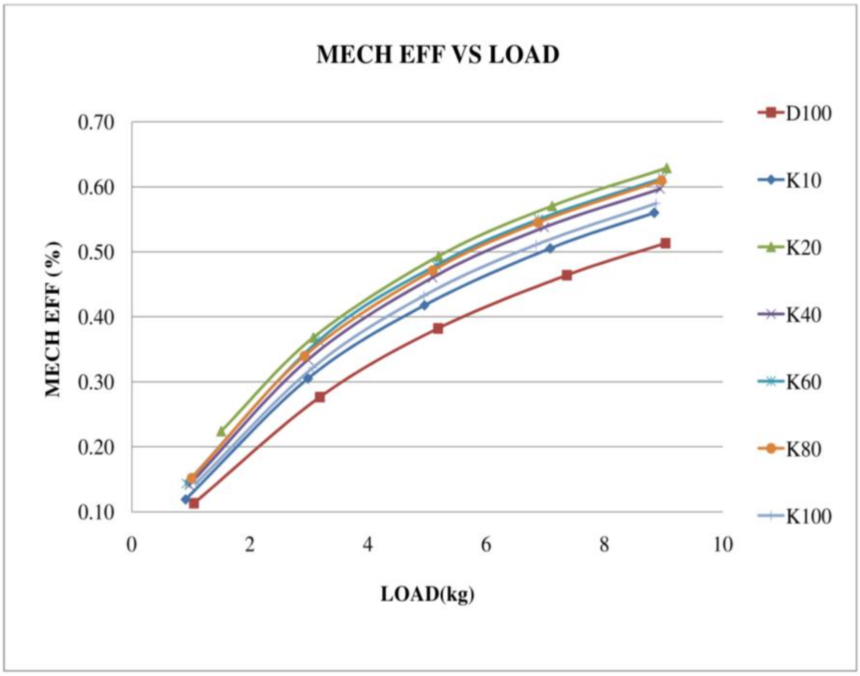

Fig. 6: Variations of Mechanical efficiency with Load

The variations of Mechanical efficiency with varying Load under various blends are shown in fig 6. It shows the comparison of mechanical efficiencies of different Karanja biodiesel blends with diesel. Mechanical efficiency is defined as the ratio of power available on the shaft to the power developed in the engine. From fig it is concluded that the mechanical efficiencies of all blends are far better than the diesel. From the graph it is concluded that the K20 D80 blend has a highest mechanical efficiency than all among blends as well as diesel. And mechanical efficiency increases with increase in load.

VII. Conclusion

Karanja Biodiesel fuel seems to have a potential to use as alternative fuel in diesel engines. Blending with diesel reduces the viscosity considerably. The following results are made from the experimental study-

- The fuel consumption of all blends is slightly more than the diesel at all varying loads. But K20 D80 Karanja biodiesel blend has considerable lesser fuel consumption than all among blends and diesel at lower loading conditions.
- At lower loads, it is being concluded that the specific fuel consumption of K20 D80 is considerably less than diesel as well as all among Karanja biodiesel blends. And it is nearer to the diesel at all varying loads.
- The indicated thermal efficiency of diesel is much better than that of the other blends of Karanja biodiesel. K10 D90 has considerable more ITHE than all other blends, but lesser compared to diesel.
- The Brake thermal efficiency of K60 D40 Karanja biodiesel blend is more among all other blends at all loads but considerably less than the diesel.
- The mechanical efficiency of all blends is more than diesel. It is concluded that the K20 D80 blend has a highest mechanical efficiency than all among blends as well as diesel.

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