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Experimental Investigation of Performance, Combustion and Emission Characteristics of Multi Cylinder Diesel Engine Using Blend of Karanja and Jatropha Biodiesel

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Abstract:
Modernization and increase in the number of automobiles worldwide, the consumption of diesel and gasoline has enormously increased. As petroleum is non renewable source of energy and the petroleum reserves are scarce now days, there is a need to search for alternative fuels for automobiles. The intensive search for alternative fuels for compression ignition engines has been focused attention on fuels which can be derived from bio mass in this regard karanja and jatropha seed oil is found to be a potential fuel for C.I Engines. The properties of karanja oil and jatropha oil are determined by using standard methods. The experiment is to be conduct when the engine fuelled with mixing of karanja oil(50%) and jatropha oil(50%) blend by volume and then investigate the performance and emission characteristics of Multi Cylinder Four Stroke Compressed Ignition Engine at different brake power outputs, and then compared with that of diesel.

Key words:
Multi cylinder Engine, karanja, jatropha Combustion Characteristics, Performance Characteristics, Emission Characteristics.

I. INTRODUCTION:
Diesel engines are the most efficient prime movers. From the point of view of protecting global environment and concerns for long-term energy security, it becomes necessary to develop alternative fuels with properties comparable to petroleum based fuels.

Unlike rest of the world, India's demand for diesel fuels is roughly six times that of gasoline hence seeking alternative to mineral diesel is a natural choice. Biodiesel production is undergoing rapid technological reforms in industries and academia. This has become more obvious and relevant since the recent increase in the petroleum prices and the growing awareness relating to the environmental consequences of the fuel over dependency [1]. In recent years several researches have been made to use vegetable oil, animal fats as a source of renewable energy known as bio diesel that can be used as fuel in CI engines. Vegetable oils are the most promising alternative fuels for CI engines as they are renewable, biodegradable, non toxic, environmental friendly, a lower emission profile compared to diesel fuel and most of the situation where conventional petroleum diesel is used.

Even though "diesel" is part of its name there is no petroleum or other fossil fuels in bio diesel. It is 100% vegetable oil based, that can be blended at any level with petroleum diesel to create a bio diesel blend or can be used in its pure form. Non edible vegetable oils are the most significant to use as a fuel compared to edible vegetable oils as it has a tremendous demand for using as a food and also the high expense for production. Therefore many researchers are experimenting on non edible vegetable oils. In India the feasibility of producing bio diesel as diesel substitute can be significantly thought as there is a large junk of degraded forest land, unutilized public land, and fallow lands of farmers, even rural areas that will be beneficial for overall economic growth.

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There are many tree species that bear seeds rich in non edible vegetable oils. Some of the promising tree species are Pongamia pinnata (karanja), Jatropha curcas (Ratanjyot) etc. But most surprisingly as per their potential only a maximum of 6% is used. Biodiesel is a low-emissions diesel substitute fuel made from renewable resources and waste liqid. The most common way to produce biodiesel is through transesterification, especially alkali-catalyzed transesterification [3]. In this present investigation blend of karanja and jatropha oil is selected for the test and it's suitability as an alternate fuel is examined. This is accomplished by blending of karanja 50% and jatropha 50% by volume. Then the performance, combustion and emission characteristics of four cylinder diesel engine using v blend is studied and result are compared with diesel fuel.

II. THE PROPERTIES OF DIESEL FUEL AND KARANJA AND JATROPHA BLEND:

The different properties of diesel fuel and biodiesel blend are determined and given in below table. After transist verification process the fuel properties like kinematic viscosity, calorific value, and density, flash and fire point get improved in case of biodiesel. The calorific value of blend is lower than that of diesel because of oxygen content. The flash and fire point temperature of biodiesel is higher than the pure diesel fuel this is beneficial by safety considerations which can be stored and transported without any risk.

Properties	Diesel fuel	Biodiesel	Apparatus
Kinematic viscosity at 40° C (cst)	3.0	5.97	Redwood viscometer
Calorific value(KJ/Kg)	42,800	38,985	Bomb calorimeter
Density (Kg/m³)	830	893	Hydrometer
Flash point (°C)	51	162	Pensky martien's apparatus
Fire point(°C)	57	168	Pensky-martien's apparatus

Table 1: Fuel properties

III. EXPERIMENTATION

A. Engine components

The various components of experimental, photograph of the experimental set up is shown in Fig.1. Fig.2 shows line diagram. The important components of the system are

- The engine
- Dynamometer
- Smoke meter
- Exhaust gas analyzer

Fig. 1: Photograph of experimental setup

Component	Specifications
Engine	Tata Indica V2, 4 Cylinder, 4 Stroke, water cooled, Power 39kW at 5000 rpm, Torque 85 NM at 2500 rpm, stroke 79.5mm, bore 75mm, 1405 cc, CR22
Dynamometer	eddy current, water cooled
Temperature	eddy current, water cooled
Piezo sensor	Range 5000 PSI
Air box	M S fabricated with orifice meter and manometer
Load indicator	Digital, Range 0-50 Kg, Supply 230VAC
Engine Indicator	Input Piezo sensor, crank angle sensor, Input Piezo sensor, Communication RS 232, Crank angle sensor, No. No. of channel 2,
Software	IC Enginesoft, Measurement and Automation
Temperature Sensor	Type RTD, PT100 and Thermocouple Type K
Fuel flow transmitter	DP transmitter, Range 0-500 mm
Air flow transmitter	Pressure transmitter,
Load sensor	Load cell, type strain gauge, Range 0-50 Kg

Table 2: Technical specifications of the Kirloskar diesel engine

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IV. RESULT AND DISCUSSIONS:

A. Introduction:

The experimental results obtained from the tests carried out on engine performance combustion and emission characteristics are presented in this section. Performance characteristics like, brake thermal efficiency, specific fuel consumption, Emission characteristics like CO,CO2 and finally combustion characteristics. The engine is connected to computer, all the data stored in computer with the help of engine software and exported in the below graphical form.

B. Performance characteristics:

The variation of torque with brake Power for selected diesel and biodiesel blend are shown in fig 4.1.For a given brake power the torque of the biodiesel blend is low compared to that of diesel.

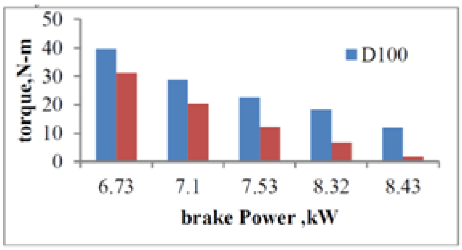

Fig. 4.1: Variation of torque with brake power.

It is also seen that the difference between torque of biodiesel and diesel increases as brake power increases. At about 25% of the load the torque of blend is 31.2 N-m lower than that of diesel. The maximum torque recorded for diesel is 39.65 N-m and for blend it is 31.14 N-m at 6.73 kW of brake power.

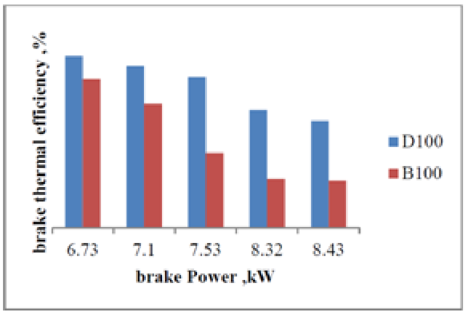

Fig. 4.2: Variation of brake thermal efficiency with brake power

The variation of brake thermal efficiency with brake power is shown in fig 4.2 . Brake thermal efficiency appraises how efficiently an engine can transform the supplied fuel energy into useful work. Most of the supplied fuel energy will be loss as heat with the engine cooling water, lubricating oil and exhaust gas. It is also seen that the brake thermal efficiency decreases when the engine runs with biodiesel as fuel. The brake thermal efficiency for biodiesel is 22.06 at a brake load of 6.73kW &the same for pure diesel is 25.79 %at a power Output of 6.73kW, and it goes on decreasing with increase in power output. It is also seen that the difference between brake thermal efficiency of biodiesel and diesel increases as brake power increases.

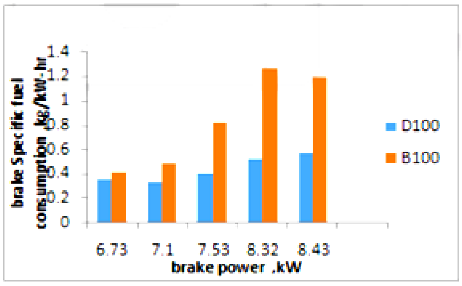

Fig. 4.3: Variation of Brake specific fuel consumption with brake power

The fig 4.3 shows the variation of the brake specific fuel consumption with brake power. The specific fuel consumption for biodiesel blend goes on increases with increase in power output as compared to pure diesel. This may be due to the lower calorific value of biodiesel compared to the diesel value. For diesel the specific fuel consumption is 1.2 kg/kW-hr at a power output of 8.32kW and for biodiesel blend it is 1.27 kg/kW-hr at a power output of 8.43kW. Fuel properties like density, viscosity and calorific value clearly influence BSFC. For example, lower calorific value means more fuel is need to be burned in the combustion chamber for the same power output. Again higher kinematic viscosity of biodiesels may cause poor atomization of the fuel, hence poor mixing with air and hence higher BSFC.

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It is also seen that the difference between brake specific fuel consumption of biodiesel and diesel increases as brake power increases.

C. Emission characteristics.

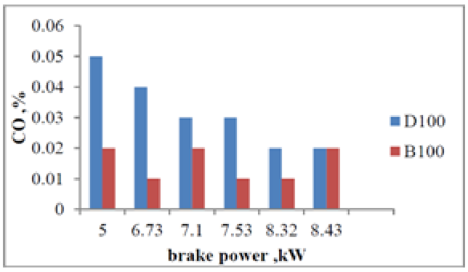
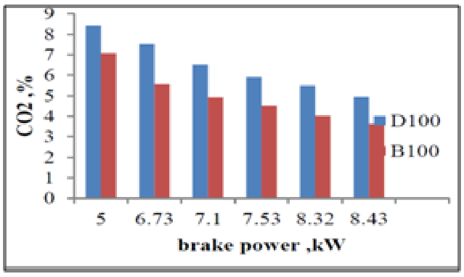


Fig. 4.4: Variation of % of CO with brake power.

From Fig.4.4, the variation of emission of carbon monoxide with Brake Power can be observed for biodiesel blend and Diesel fuel. The results show that CO emission of biodiesel blends is lower than Diesel fuel at low load condition. The percentage of CO emission is as shown in fig 4.4. CO emission for biodiesel is 0.02% at higher power outputs compared to pure diesel which is 0.05%. The oxygen rich biodiesels results in more complete combustion of the blends which helps to convert CO into CO2. At higher outputs, the cylinder combustion temperature is high which results in more complete combustion. So, the trend is more dominant at higher power outputs. At lower power outputs, the kinematic viscosity of biodiesel predominates the combustion process which results in comparatively higher CO emission.



b

Fig. 4.5: Variation of % of CO2 with brake power.

The fig 4.5 gives the variation of carbon dioxide emission with brake power when biodiesel and diesel is used as fuel.

The carbon dioxide emission is found to lower for biodiesel compared to diesel at all power outputs. The results show the increases in CO2 emission as the power output increases as compared with the diesel. At 8.43 kW brake power, carbon dioxide value recorded for diesel is 5.2% volume and for biodiesel blend is 3.82% volume.

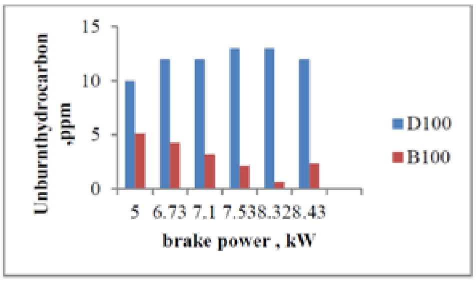


Fig. 4.6: Variation of unburnt hydrocarbon with brake Power.

Fig4.6 shows variation of hydrocarbon (HC) emission with brake power for diesel and biodiesel. The nature of HC emission is similar with CO emission. Here also the higher oxygen content of biodiesel is attributed for lower HC emission. At lower power output the emission of hydrocarbon is high, but at higher power outputs, the trend is very much clear. Higher power outputs ensure better mixing of fuel and air hence better combustion. At 8.43 kW brake power diesel recorded 11.8ppm and the biodiesel blend is 3ppm of unburnrt hydrocarbon.

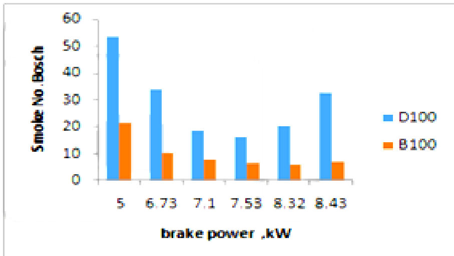


Fig. 4.7: Variation of smoke with brake power

Smoke formation occurs at the extreme air deficiency. Air or oxygen deficiency is locally present inside the diesel engines. It increases as the air to fuel ratio decreases.

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Fig 4.7 shows variation of smoke emissions with biodiesel and diesel with the brake power. Since at higher compression ratios better combustion may take place inside the engine cylinder trying to reduce the smoke emissions. it is also observed that formation of smoke for biodiesel is minimum at higher power outputs compared to diesel, because of the atomic bounded oxygen which helps in better combustion, thus reducing the smoke. At 8.43 kW of brake power the value of smoke recorded for diesel 32.95 Bosch unit and for biodiesel blend is 9.85 Bosch units.

D. Combustion characteristics:

Variation of cylinder pressure with crank angle is as shown in the fig 4.8. From the figure it is evident that maximum pressure rise occurs for the diesel and it is recorded as 85.68 bar at an crankangle of 440 deg. and the same for biodiesel is 60.35 bar at an crank angle of 358 deg which is less than diesel. CI cylinder pressure depends on fuel burning rate during the premixed burning phase, which in turn leads

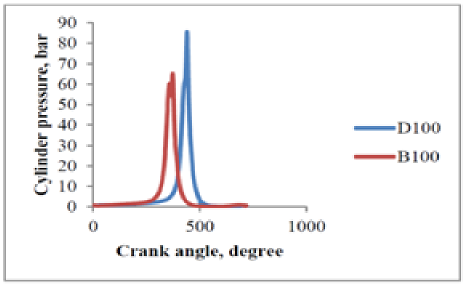

Fig. 4.8: Vaiation of cylinder pressure with crankangle.

maximum cylinder gas pressure. Due to higher brake specific fuel consumption and oxygen content, cylinder pressure is high for diesel. The maximum pressure generated is less for biodiesel since the combustion is slightly delayed as compared to diesel.

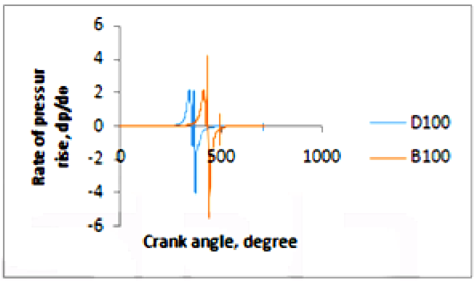

Fig. 4.9: Variation of Rate of pressure rice with crank angle.

Variation of rate of pressure rise with crank angle shown in fig 4.9. The combustion starts in the pre-ignition region where the rate of pressure rise increases slightly and then again decreases to a small extent. Near TDC the rate of pressure rise is high for both biodiesel blend and diesel. The rate of pressure rice for biodiesel is 42 bar at an crank angle of 434 deg, for diesel it is 2.2. bar at 334 deg crank angle.

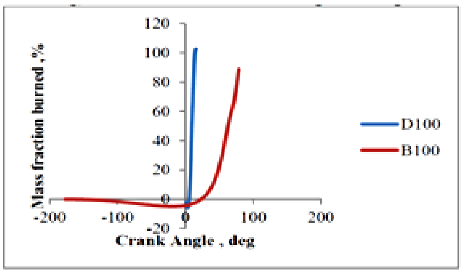

Fig. 4.10: Variation of Mass fraction burned with crank angle.

Variation of mass fraction burnt with crank angle is shown in fig 4.10. Diesel starts burning at 0 degree before TDC and continues up to 5 degree after TDC. From the graph it is observed that diesel burns before biodiesel, and generates higher pressure compared to biodiesel due to improper atomization, non uniform combustion. Since the chemical dissociation of biodiesel is improper at lower temperature gives abnormal combustion which leads to poor mass fraction burning.

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V. CONCLUSIONS:

From the performance and combustion testing of the engine it can be concluded that performance and combustion characteristics of diesel fuel are better. Emission testing gives emission characteristics of the engine, from the result it can be concluded that biodiesel blend is better. In this work performance of neat biodiesel blend (karanja and jatropha) and diesel is compared by the parameters like brake power, torque, brake thermal efficiency and specific fuel consumption. Combustion results of biodiesel blend and diesel is compared by the parameters like crank angle, cylinder pressure, mass fraction burned, rate of pressure rise.

(1) Some advantages obtained for biodiesel blend are, Transesterification process is the best process for the conversion of crude oil into biodiesel, since it gives the optimum result.

(2) The properties like viscosity, density, flash point and fire point of biodiesel blend are comparable with diesel.

(3) The maximum torque recorded for diesel is 39.65 N-m and for blend it is 31.14 N-m at 6.73 kW of brake power which shows biodiesel blend values are comparable with diesel.

(4) Diesel yields higher brake thermal efficiency compare to biodiesel blend. For diesel maximum brake thermal efficiency of 25.79 % for biodiesel blend 22.06 % at 6.73kW brake power.

(5) For diesel the specific fuel consumption is 1.2 kg/kW-hr at a power output of 8.32kW and for biodiesel blend it is 1.27 kg/kW-hr at a power output of 8.43kW

(6) At maximum power of 8.43 kW ,carbon monoxide recorded for blend is 0.02 % volume and for diesel it is 0.05 % volume.

(7) At 8.43 kW brake power, carbon dioxide value recorded for diesel is 5.2% volume and for biodiesel blend is 3.82% volume.

(8) At 8.43 kW brake power diesel recorded 11.8ppm and the biodiesel blend is 3ppm of unburnrt hydrocarbon.

(9) At 8.43 kW of brake power the value of smoke recorded for diesel 32.95 Bosch unit and for biodiesel blend is 9.85 Bosch units.

(10) Maximum cylinder pressure occurs for the diesel and it is recorded as 85.68 bar at an crankangle of 440 deg. and the same for biodiesel is 60.35 bar at an crank angle of 358 deg.

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