Experimental Investigation Of Performance And Combustion Characteristics In A Direct Injection Diesel Engine Using Diesel And Jatropha Biodiesel

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Abstract

Biodiesel has become a key source as a substitution fuel and is making its place as a key future renewable energy source. Biodiesel derived from vegetable oils are quite promising alternative fuels for diesel engines. Use of vegetable oils in diesel engines leads to slightly inferior performance and higher smoke emissions due to their high viscosity. The performance of vegetable oils can be improved by modifying them through the transesterification process. In the present work, the performance of single cylinder direct injection diesel engine using jatropha biodiesel as fuel was evaluated for its performance and combustion characteristics. The fuel properties of biodiesel such as kinematic viscosity, calorific value, flash point, fire point and density were found. A wide range of engine loads and jatropha biodiesel/diesel ratios of 25/75% (J25), 50/50% (J50), 75/25% (J75), and 100/00% (J100) by volume were considered. The following performance parameters were measured; brake thermal efficiency, mechanical efficiency and specific fuel consumption. Results indicated that J25 has closer performance to diesel and J100 has lower brake thermal efficiency, mainly due to its high viscosity compared to diesel. The brake thermal efficiency for biodiesel and its blends was found to be nearly equal to that of diesel fuel at rated load conditions and there was slight difference between the biodiesel and its blended fuels efficiencies. For jatropha biodiesel and its blended fuels, the exhaust gas temperature increased with increase in brake power and amount of biodiesel.

Key words: Jatropha biodiesel, diesel engine, transesterification, performance and combustion characteristics.

1. Introduction

The continuous rise in global prices of crude oil, increasing threat to environment due to exhaust emissions, the problem of global warming and the threat of supply fuel oil instabilities have adversely impacted the developing countries, more so to the petroleum importing countries like India. Major portion of today's energy demand in India is being met with fossil fuels. Hence it is high time that alternate fuels for engines should be derived from indigenous sources. As India is an agricultural country, there is a wide scope for the production of vegetable oils from different oil seeds. The present work focused only on non-edible oils as fuel for engines, as the edible oils are in great demand and far too expensive. Vegetable oils are one such alternative source. Diesel engines have the advantages of better fuel economy, lower emissions of HC and CO. However, diesel engines suffered from high emissions of PM/smoke density and NOx, and there is inherent tradeoff between them from the point of view of long term energy security, it is necessary to develop alternative fuels with properties comparable to petroleum based fuels. The main commodity source for Bio-diesel in India can be non-edible oils obtained from plant species such as Jatropha curcus (Ratanjyot), Pongamia pinnata (Karanja), Calophyllum inophyllum (Nagchampa), Hevcca brasiliensis (Rubber), etc. The use of biodiesel in conventional diesel engines results in substantial reduction of un-burnt hydrocarbons, carbon monoxide and particular matters. India is one of the fastest developing countries with a stable economic growth, which multiplies the demand for transportation in many folds. Fuel consumption is directly proportionate to this demand. India depends mainly on imported fuels due to lack of fossil fuel reserves and it has a great impact on economy. India has to look for an alternative to sustain the growth rate.. Recent studies and research have made it possible to extract bio-diesel at economical costs and quantities. The blend of Bio-diesel with fossil diesel has many benefits like reduction in emissions, increase in efficiency of engine, higher Cetane rating, lower engine wear, low fuel consumption, reduction in oil consumption etc. Biodiesel is defined as mono-alkyl esters of long chain fatty acids derived from vegetable oils or normal fats. The process of converting vegetable oils into Biodiesel is called Transesterification. Biodiesel can be made from a wide range of easily renewable plant oil sources and animal fats even waste oils thrown away by most restaurants. Combustion of vegetable oil produces negligible sulphurdioxide emissions and much less toxic emissions. Vegetable oil is biodegradeadable, safe to store and transport does not cause environmental or health problems [1].

2. Properties of diesel fuel and NOME

The different properties of diesel fuel and JOME are determined and given in below table. After transisterification process the fuel properties like kinematic viscosity, CV, density, flash and fire point get improved in case of biodiesel. The calorific value of methyl ester 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.

Table 2.1 Fuel properties

Properties	**Diesel fuel**	**JOME**
Kinematic viscosity at 40^0 C (cst)	3.0	5.97
Calorific value(KJ/Kg)	42680	39415
Density (Kg/m^3)	830	0.899
Flash point (^{0}C)	51	162
Fire point(^{0}C)	57	168

3. Experimentation

3.1 Engine components:

The various components of experimental set up are described below. Fig.3.1 shows line diagram of the experimental set up. The important components of the system are

(i) The engine

(ii) Dynamometer

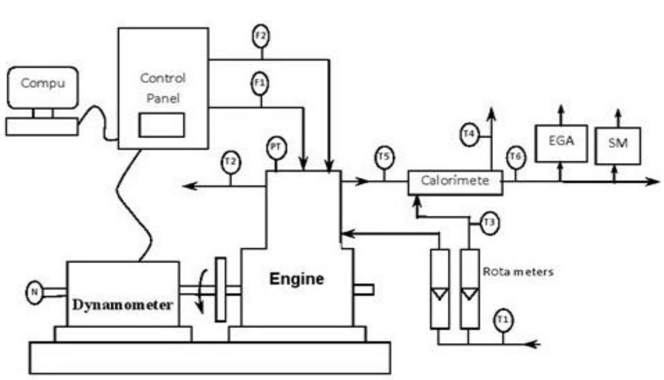

Fig-3.1 experimental set up

Table 3.1 Notation

PT	Pressure transducer
N	Rotary encoder
Wt	Weight
F1	Fuel flow
F2	Air flow
F3	Jacket water flow
F4	Calorimeter water flow
T1	Jacket water inlet temperature
T2	Jacket water outlet temperature
T3	Calorimeter water inlet temperature = T1
T4	Calorimeter water outlet temperature
T5	Exhaust gas to calorimeter temperature
T6	Exhaust gas from calorimeter temperature

Table 3.2 Engine specifications

Manufacturer	Kirloskar oil engines Ltd, India
Model	TV-SR, naturally aspirated
Engine	Single cylinder, DI
Bore/stroke	87.5mm/110mm
C.R.	16.5:1
speed	1500r/min, constant
Rated power	5.2kw
Working cycle	four stroke
Injection pressure	200bar/23 def TDC
Type of sensor	Piezo electric
Response time	4 micro seconds
Crank angle sensor	1-degree crank angle
Resolution of 1 deg	360 deg with a resolution of 1deg

4. Result and discussions

After detail study of performance and combustion characteristics of jatropha biodiesel and its blends in diesel engine. It can be seen that 25% jatropha biodiesel blend and diesel are having almost same characteristics.

4.1. Brake thermal efficiency:

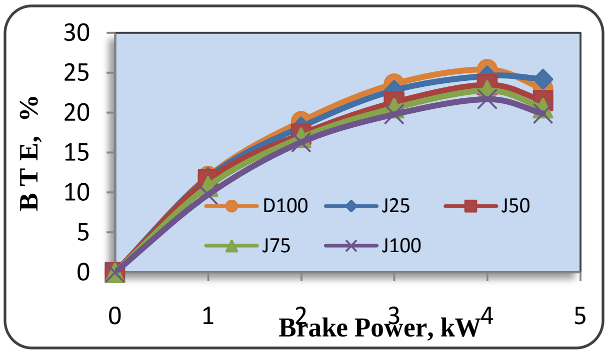

Figure 4.1 Variation of brake thermal efficiency with brake power

The variation of Brake thermal efficiency with Brake power for diesel, and jatrophabiodiesel and its blend are shown in figure 4.1. It shows that brake thermal efficiencies of all the blends are slightly lower at almost all load levels. Among the blends J25 is found to have the maximum thermal efficiency of 24.2% at a brake power of 4.7 kW while for diesel it is 23.25%.

4.2. Specific fuel consumption:

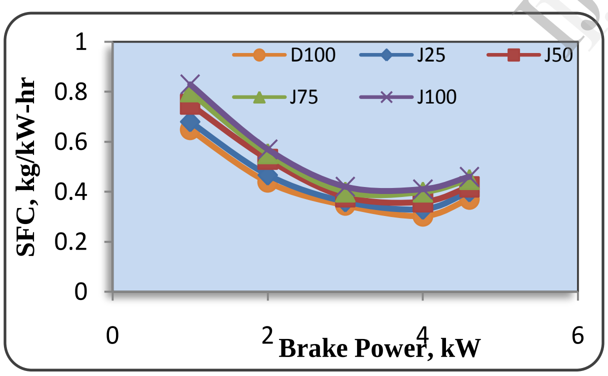

Figure 4.2 Variation of specific fuel consumption with brake power

The variation of specific fuel consumption with Brake power for diesel, and jatropha biodiesel oil and it's blends are shown in figure 4.2. Specific fuel consumption for jatropha biodiesel blends are higher than diesel for certain lower loads, but for higher loads, consumption rate remains almost constant as evident from the graph. The specific fuel consumption for biodiesel is 0.46Kg/kW-hr at full load and for diesel at full load is 0.37 Kg/kW-hr.

4.3.Mechanical efficiency:

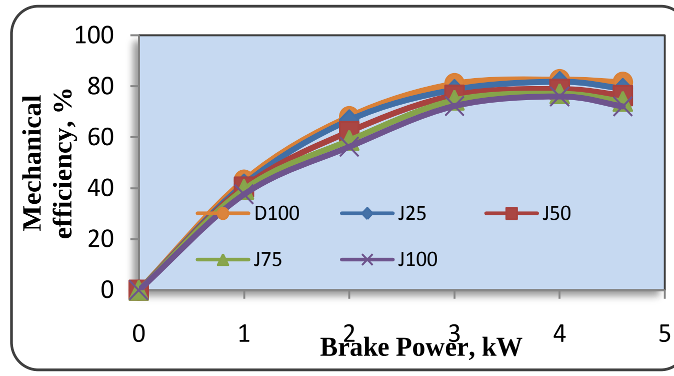

Figure 4.3 Variation of mechanical efficiency with brake power

The variation of mechanical efficiency with brake power, for diesel and jatropha biodiesel blends are as shown in figure 4.3. The mechanical efficiency of diesel is slightly higher than the jatropha biodiesel. From the graph it is evident that with increase in the concentration of Jatropha biodiesel in neat diesel decreases the mechanical efficiency. Mechanical efficiency of both diesel and biodiesel are equal at 25% of blend.

4.4. Air-Fuel ratio

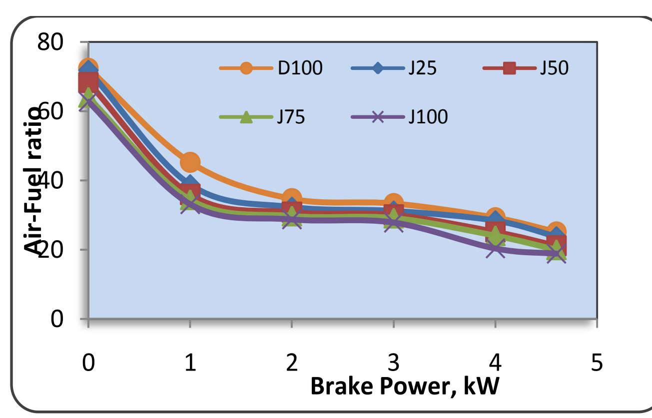

Figure 4.4 Variation of air-fuel ratio with brake power

The variation of air fuel ratio with brake power for diesel and jatropha biodiesel blends are shown in figure 4.4. It can be observed that air fuel ratio of pure diesel is slightly higher than other Jatropha biodiesel and its blends, and we can also see that the air fuel ratio decreases as the load increases. The air-fuel ratio for diesel and biodiesel are equal at 25% blend. The air-fuel ratio for diesel is 25.2 at full load and at 25% blend of biodiesel is 23.8 at full load.

4.5. Indicated mean effective pressure

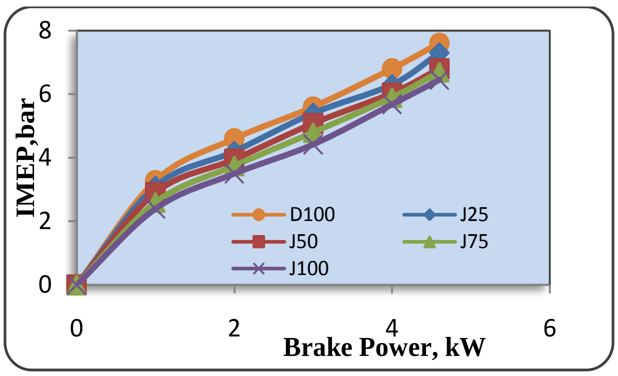

Figure 4.5 Variation of indicated mean effective pressure with brake power

The variations of indicated mean effective pressure with brake power for diesel and jatropha biodiesel blends are shown in figure 4.5.The indicated mean effective pressure increases with increase in concentration of jatropha in diesel fuel this is because of volatility and calorific value of JOME.

4..6. Exhaust gas temperature

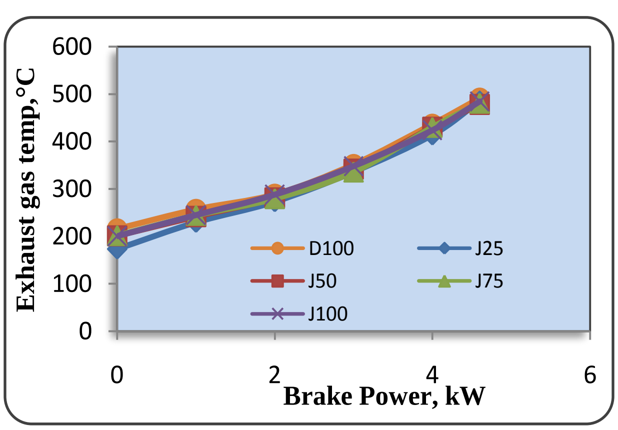

Figure 4.6 Variation of exhaust gas temperature with brake power

The variation of exhaust gas temperature with brake power for diesel, and other blends of jatropha biodiesel are shown in figure.4.6, the exhaust gas temperature of all the biodiesel are lower than the diesel as it is evident from the graph. The exhaust gas temperature of all the blends and 100 percent diesel increase as the load increases. It is observed that, at full load the exhaust gas temperature is maximum, this is because; at full load the chemically correct ratio of air and fuel is used, due to chemically correct ratio of air and fuel, high heat is generated inside the cylinder.

4.7. Cylinder pressure v/s crank angle

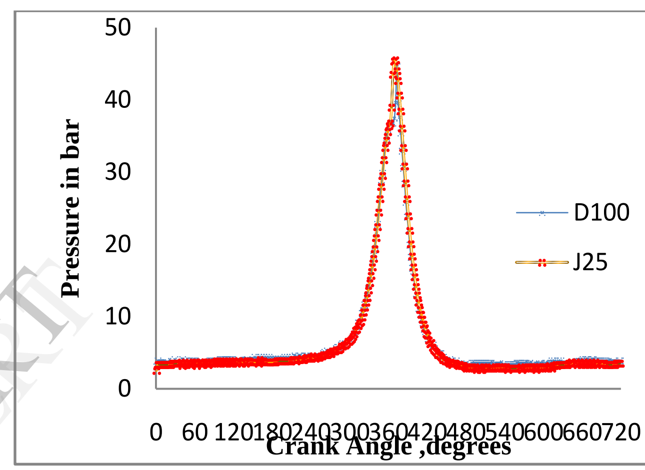

Figure 4.7 Variation of crank angle v/s cylinder pressure

In a CI engine the cylinder pressure is depends on the fuel-burning rate during the premixed burning phase, which in turn leads better combustion and heat release. The variation of cylinder pressure with respect to crank angle for diesel and 25% blend of Jatropha biodiesel are presented in Figure-4.7. Peak pressures of 44.6 bar and 45.38 bar are found for pure diesel and J25 respectively. From the test results it is observed that the peak pressure variations are less Since the properties such as calorific value, viscosity and density are brought closer to diesel after transesterification of the vegetable oil, no major variation in the pressures are found.

4.8. Heat release rate v/s crank angle

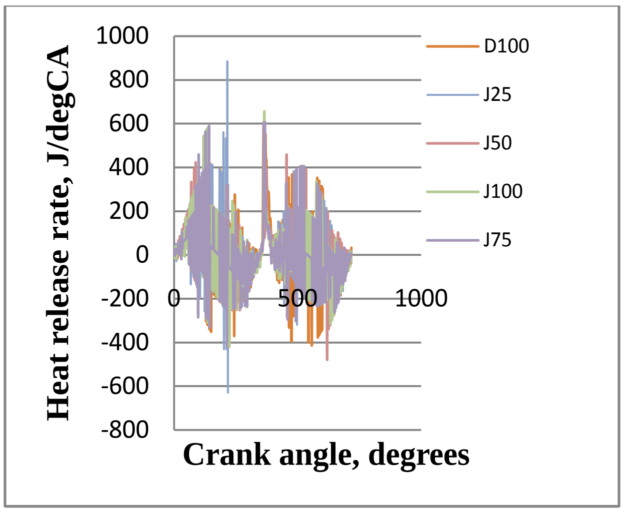

Fig 4.8 Variation of heat release rate v/s crank angle

Figure 4.8 shows the effect of crank angel on net heat release rate at maximum load for both neat diesel and J100. It is observed that the premixed burning is more dominant with diesel as expected. This could be the reason for the higher thermal efficiency of diesel. Jatropha biodiesel shows lower heat release rate during premixed burning phase compared to diesel. The high viscosity and poor volatility of J100 result in poor atomization and fuel air mixing rates. Hence, more burning occurs in the diffusion phase.

Conclusion

A single cylinder compression ignition engine was operated successfully using methyl ester of Jatropha oil as the soul fuel. The following conclusions are made based on the experimental results.

- Engine works smoothly on methyl ester of Jatropha oil with performance comparable to diesel operation.
- Methyl ester of Jatropha oil (J25) results in a nearly equal in thermal efficiency as compared to that of diesel.
- The exhaust gas temperature is decreased with the methyl ester of Jatropha oil as compared to diesel.
- Specific fuel consumption for jatropha biodiesel blends are higher than diesel for certain lower loads, but for higher loads, consumption rate almost equal to the diesel fuel.
- After the detail study of performance and combustion characteristics of jatropha biodiesel and its blends on normal engine we can observe that 25% blend of jatropha biodiesel in diesel fuel has almost same mechanical efficiency, same specific fuel consumption and same brake thermal efficiency.
- So we can conclude that without any modification in engine we can save diesel fuel for certain extent without any compromise with standard performance and combustion characteristics and in future jatropha biodiesel can be a best alternative fuel which can replace the diesel.

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