

Performance and Emission Characteristics of Diesel Engines Fueled With Jatropha Oil Methyl Esters

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ABSTRACT

Increase in crude oil price and impact of environmental pollution of increasing exhaust emission there is a need for suitable alternative fuels for diesel engine. The use of vegetable oils in CI engine results in low CO and HC emissions compared to conventional diesel fuel. The present study covers the various aspects of biodiesels fuel derived from crude jatropha oil and performance, emissions study on four stroke compression ignition engine using jatropha oil. Crude jatropha oil is converted to jatropha oil methyl esters by transesterification process. In the initial stage, the tests are conducted on the four stroke single cylinder water cooled direct injection diesel engine with constant speed by using diesel and base line data is generated by varying loads. In second stage, experimental investigation has been carried out on the same engine with same operating parameters by using the jatropha oil of methyl esters in different proportions as P10, P20 and P30 to find out the performance and emissions parameters. Finally the performance and emission parameter obtained by the above test is compared with the baseline data obtained earlier by using diesel. The blend P30 shows best performance and reduced emission in terms of brake thermal efficiency, BSFC and CO, HC, NOX, smoke density. Finally results show in engine performance and emission parameters justify the potentiality of the jatropha oil methyl esters as alternative fuel for compression ignition engine without any engine modification.

Keywords: Biodiesel, Emissions, Performance, Jatropha Oil Methyl Esters Blends

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1. INTRODUCTION

Bio-diesel is not your regular vegetable oil and is not safe to swallow. However, biodiesel is considered biodegradable, so it is considered to be much less harmful to the environment if spilled. Biodiesel also has been shown to produce lower tailpipe emissions than regular fuel. The best thing about biodiesel is that it is made from plants and animals, which are renewable resources. Biodiesel is defined as mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats which conform to ASTM D6751 specifications for use in diesel engines. Biodiesel refers to the pure fuel before blending with diesel fuel. Biodiesel is the name of a clean burning alternative fuel, produced from domestic, renewable resources. Biodiesel contains no petroleum, but it can be blended at any level with petroleum diesel to create a biodiesel blend. It can be used in compression-ignition engines with little or no modifications. Biodiesel is simple to use, biodegradable, nontoxic, and essentially free of sulfur and aromatics. Biodiesel fuel is reliable, renewable, biodegradable and nontoxic. It is less harmful to the environment for it contains practically no sulfur and substantially reduces emissions of unburnt hydrocarbons, carbon mono-oxide, sulfates, poly

cyclic aromatic and particulate matter. It has fuel properties comparable to mineral diesel and because of great similarity; It can be mixed with mineral oil and used in standard diesel engine with minor or no modifications at all. Bio-diesel works well with new technologies such as catalyst (which can reduce soluble fraction of diesel but not the solid carbon fraction), particulate traps an exhaust gas circulation. It can be produced from any kind of oil both vegetable and animal source. Used frying oil can also be used and, therefore, be very promising alternative for waste treatment. It can strengthen economy by creating more jobs and create independence from the imported depleting commodity, petroleum. It can also be used as a way of stimulating and supporting agriculture.

2. BIODIESEL PRODUCTION

Jatropha oil is heated to a temperature of 100–120 °C to remove water contents present in vegetable oil followed by filtration. The oil is processed under base-catalyzed transesterification method where it is mixed with 250 ml of methanol and 9 g of potassium hydroxide (KOH) pellets per liter of vegetable oil and placed on a hot plate magnetic with stirring arrangement for 1–2 h up to 60 °C and then it is allowed to settle down for about 4–6 h to obtain biodiesel and glycerol. The biodiesel obtained is further washed with distilled water three times for the removal of acids and heated above 100 °C to remove the moisture present in the biodiesel. Schematic diagram of biodiesel plant is shown in Fig2.1.

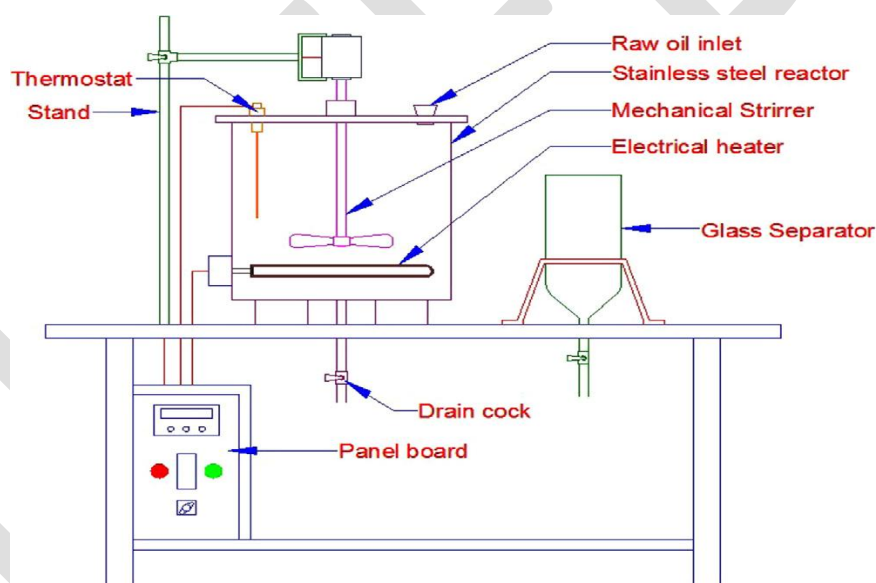


Fig2.1: Schematic diagram of biodiesel plant

3. PROPERTIES OF FUEL

Some of the important properties of Jatropha raw oil, JOME are compare with the diesel are shown in the Table 3.1.

Table 3.1 Properties of Raw Jatropha Oil in Comparison With Diesel.

Property	Jatropha Raw Oil	JOME	Diesel
Specific gravity	0.929	0.878	0.830
Kinematic Viscosity (mm ² /s at 40°C)	36.50	10.72	2.6
Calorific Value(kJ/kg)	34000	35500	42500

Table.3.2 Properties of JOME blend P10, P20, P30

Property	P10	P20	P30
Specific gravity	0.839	0.846	0.852
Kinematic Viscosity (mm ² /s at 40°C)	3.412	4.224	5.036
Calorific Value(kJ/kg)	41650	40800	39950

4. EXPERIMENTAL SETUP

Experimental setup consisting of four stroke single cylinder diesel engine with mechanical brake drum fixed to the engine fly wheel was selected for the study. A separate panel board is used to fix burette with stop cock performance analysis is, to fill up the identified diesel fuel blend into the fuel tank mounted on the panel frame. the engine is started the engine and allowed it to stabilize at rated speed(1500rpm).Now load the engine in steps of quarter, half, three fourth and full load and allow the engine to stabilize at each load. Record all the required parameters indicated on the digital indicators which are mounted on the panel board like, speed of the engine from digital rpm indicator, load from the spring balance, fuel consumption from burette, quantity of airflow from manometer. In addition to this, exhaust gas is sent into exhaust gas analyzer. For the analysis of emissions present particular diesel fuel blend. Sct-g-5 multi gas analyzer (5 gases) is based on infrared spectrometry technology with signal inputs from an electrochemical cell. Non-dispersive infrared measurement techniques are used for CO, CO₂, O₂, NO_x and HC gases. Load the engine step by step and note down corresponding parameters. Turn off the fuel knob provided on the panel after the test. The experimental setup is shown in Fig4.1, Gas Analyzer in Fig 4.2.



Fig4.1: Experimental Setup

Table 4.1: Specifications of the Experimental Engine:

ENGINE	FOUR STROKE SINGLE CYLINDER
Make	Kirloskar
BHP	5hp
Rpm	1500
Fuel	Diesel
Bore	80 mm
Stroke Length	110 mm
Starting	Cranking
Working Cycle	Four Stroke
Method Of Cooling	Water Cooled
Method Of Ignition	Compression Ignition



Fig4.2: Gas Analyzer

Table 4.2: Specifications of the gas analyzer:

1	CO	0 to 9.99% vol. Res. 0.01%
2	HC	0 to 20000 ppm. (Propane) Res. 1 ppm
3	CO ₂	0 to 20.00% vol. Res. 0.10%
4	O ₂	0 to 25% Res. 0.01%
5	Lambda	0.200 to 1.800% Res. 0.001%
6	Air / Fuel	0 to 30:1 Res.1

5. RESULTS AND DISCUSSION

The performance characteristics such as Specific Fuel Consumption (SFC), Brake thermal Efficiency (BTE) and the emission characteristics such as NO_x, HC, CO and Smoke Density are plotted against the brake power

5.1 Engine performance parameters

5.1.1 Brake Thermal Efficiency

The variation of brake thermal efficiency with brake power is shown in Fig. 5.1. From the plot it is observed as the BP increases there is considerable increase in the BTE. The BTE of diesel at full load is 32.82% while the blends of P30 are 34.79%, among three the maximum BTE is 34.79% which is obtained for P30. The BTE of JOME is increases up to 6.25% as compared with diesel at full load condition. Almost all blends show slightly better BTE than diesel at higher load conditions. The higher thermal efficiencies may be due to oxygenated fuel gives a better fuel combustion delivering improved thermal efficiency and the additional lubricity provided by the fuel Blends .

5.1.2 Brake Specific Fuel Consumption

Figure.5.2 shows the variation of the brake specific fuel consumption with brake power. When two different fuels of different heating values are blended together, the fuel consumption may not be reliable, since the heating value and density of the two fuels are different. In such cases, the brake specific fuel consumption (BSFC) will give more reliable value .the brake specific fuel consumption was determined for jatropha methyl ester-diesel fuel blends as the product of the specific fuel consumption and the calorific value. At full load condition the BSFC obtained are 0.26 kg/kW-hr, 0.260 kg/kW-hr, 0.255 kg/kW-hr and 0.259 kg/kW-hr for fuels of diesel, P10, P20 and P30 respectively It can be observed from the fig.6.4 that the BSFC for JOME is lower at all blends as compared to that of diesel fuel at full load. The availability of the oxygen in the jatropha methyl ester-diesel fuel blend may be the reason for the lower BSFC. In the case of lower load conditions, the incomplete mixture of high viscosity JOME may lead to incomplete combustion and require additional fuel air mixture to produce the same power output as that of diesel fuel.

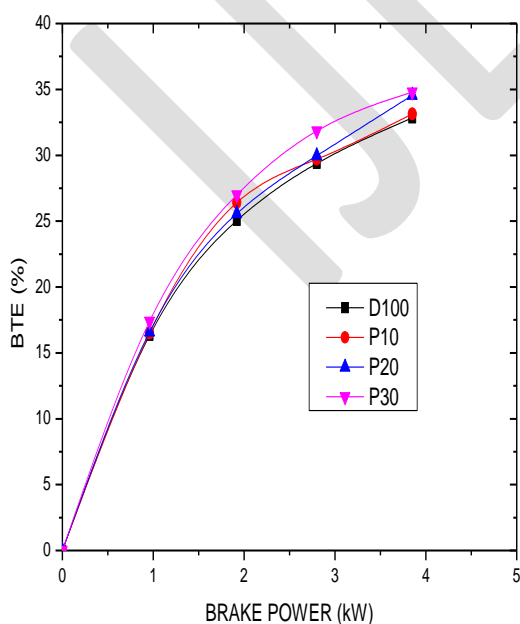


Fig 5.1: Variation of Brake Thermal Efficiency with Brake Power

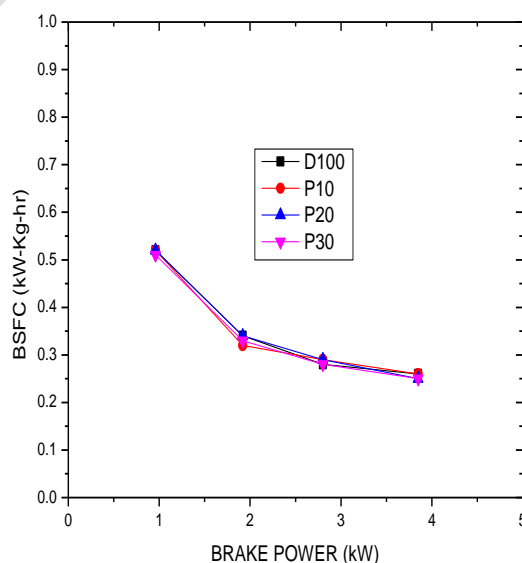


Fig 5.2: Variation of BSFC with Brake Power

5.2 Emission parameters

The experiments are conducted on the four stroke single cylinder water cooled diesel engine at constant speed (1500 rpm) with varying loads with diesel and different blends of jatropa oil like P10, P20, and P30. Various emission parameters in the sense of smoke density, unburned hydrocarbons, carbon monoxide and oxides of nitrogen are discussed below.

5.2.1 Smoke Density

The variation of Smoke density with brake power is shown in Fig. 5.3 the Smoke is nothing but solid soot particles suspended in exhaust gas. The plot shows the variation of smoke level with brake power at various loads for different blends like P10, P20 and P30 tested fuels. At full load condition the smoke density obtained are 79.6 HSU, 71.63 HSU, 62.96 HSU and 53.28 HSU for the fuels of diesel, P10, P20 and P30. It is observed that smoke is gradually increases with increasing loads for P10 blends at full load conditions as compared to diesel, but in case of P20 and P30 blends slightly decreases at full load conditions as compared to diesel. The reason for the reduced smoke is the availability of premixed and homogeneous charge inside the engine well before the commencement of combustion. Higher combustion temperature, extended duration of combustion and rapid flame propagation are the other reasons for reduced smoke.

5.2.2 Carbon Monoxide Emission

The emission of carbon monoxide for various blends at different loads can be seen in Fig.5.4. The emissions are slightly higher for almost all blends of JOME. At full load condition the CO emission obtained are 0.07%, 0.09%, 0.12% and 0.10% for the fuels of diesel, P10, P20 and P30 respectively this can be attributed to higher viscosity of the fuel which results in poor atomization & incomplete combustion of the fuel. At higher load, more fuel is consumed which results in relative lowering of the availability of oxygen for the combustion of the fuel, which results in slightly higher carbon monoxide

5.2.3 Hydrocarbon Emission

The variation of HC emission with brake power is shown in Fig.5.5. The plot it is observed that the HC emission variation for different blends is indicated. That the HC emission decreases with increase in load for diesel and it is almost slightly decreases for all biodiesel blends except for P30. At full load condition the unburned hydrocarbons are obtained 58ppm, 24ppm, 19ppm and 53ppm for the fuels of diesel, P10, P20 and P30 respectively. At P30 HC emission increases gradually up to full load. it exhibits a shorter delay period and results in better combustion leading to low HC emission. Also the intrinsic oxygen contained by the biodiesel was responsible for the reduction in HC emission.

5.2.4 Oxides of Nitrogen

The variation of NO_x emission with brake power is shown in Fig.5.6. The plot it is observed that for different blends is indicated. At full load condition the NO_x emission obtained are 1236ppm, 1097ppm, 1039ppm and 1135ppm for the fuels of diesel, P10, P20 and P30 respectively. The NO_x emission for all the fuels tested followed an increasing trend with respect to load. The reason could be the higher average gas temperature, residence time at higher load conditions. A reduction in the NO_x emission for all the blends as compared to diesel was noted. With increase in the JOME content of the fuel, corresponding Increases NO_x emission.

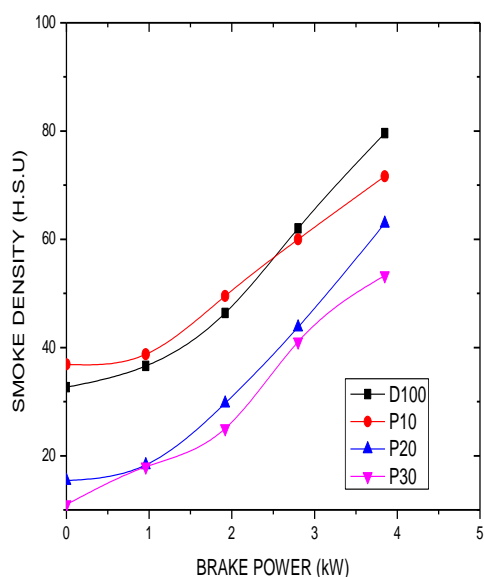


Fig 5.3: Variation of smoke density with Brake Power

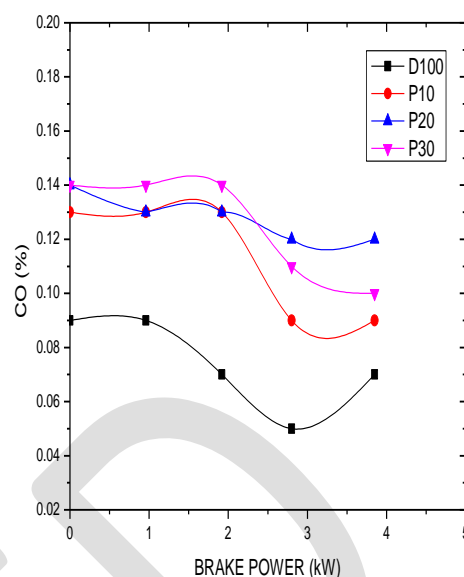


Fig 5.4: Variation of carbon monoxide with Brake Power

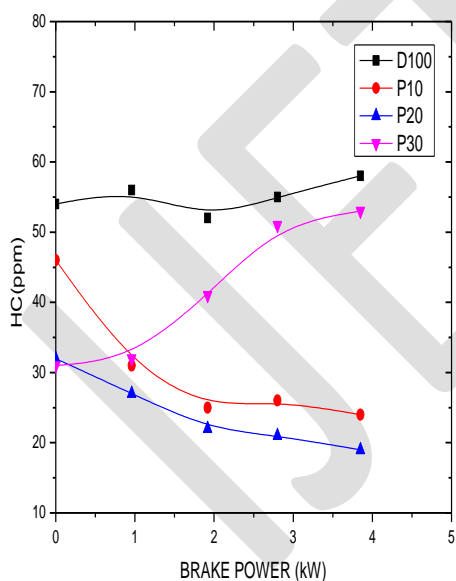


Fig 5.5: Variation of unburned hydro Carbons with Brake Power

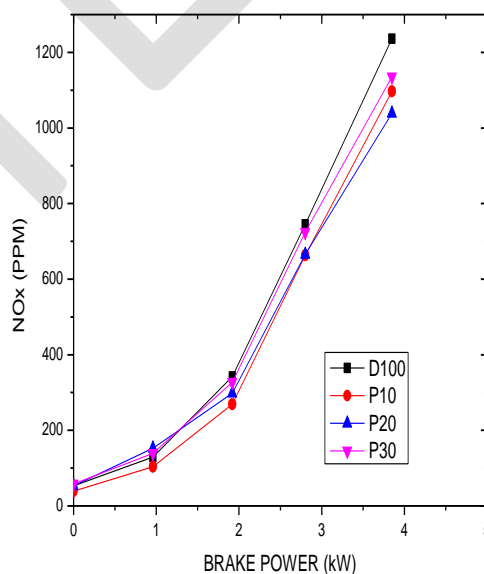


Fig 5.6: Variation of NO_x with Brake Power

6. CONCLUSION

In this experimental study, the effect of jatropha oil methyl ester blends and diesel fuel on engine performance and exhaust emissions were investigated on single cylinder, water cooled and direct injection at constant speed of 1500 rpm. Out of all blends of jatropha oil methyl esters P30 shows best results in performance and emissions parameters. The

conclusions of this investigation are compared with diesel base line data at full load as follows:

- The maximum brake thermal efficiency for P30 (34.79%) was higher than that of diesel (32.82%). The brake thermal efficiency increased in 6.02% compared with diesel.
- Brake specific fuel consumption is decreases in blended fuels. In P30 (0.259 kg/kW-hr) fuel the BSFC is lower than the diesel (0.268 kg/kW-hr) in 3.35%.
- Significant reductions were obtained in smoke level, CO emissions with P30 blend. Smoke level was decreased by 33.09% with P30 compared to diesel at maximum load of the engine. The highest decrease in CO emissions was obtained with P30 as 14.2% compared to diesel fuel.
- On the other hand, NO_x emissions were decreased with P30 compared to diesel. NO_x emissions were decreased by 18.28% with P30 compared diesel.

NOMENCLATURE

D100: Diesel

P10: Jatropha Oil Methyl Ester 10%+Diesel 90%

P20: Jatropha Oil Methyl Ester 20%+Diesel 80%

P30: Jatropha Oil Methyl Ester 30%+Diesel 70%

HSU: Hatridge smoke unit.

PPM: Parts Per Million.

NO_x: Oxides of Nitrogen.

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