Experimental Investigation on the performance and emission characteristics of Jatropha oil blended waste plastic oil in a CRDI Engine

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ABSRACT :

This paper describes an experimental study of using jatropha oil as a fuel in CRDI diesel engine. In this study the effect of using Jatropha oil – plastic oil blends (JP10 JP20) on the engine performance, exhaust emission have been experimentally investigated. This present work deals with 10% Jatropha oil and 90% waste plastic oil called JP10, 20% Jatropha oil and 80% waste plastic oil called JP20 were used in single cylinder four stroke, water cooled CRDI diesel engine. The experimental result showed that the carbon monoxide, hydrocarbons and exhaust gas temperature were significantly reduced. Oxides of nitrogen, Brake specific fuel consumption was increased and also brake thermal efficiency were found to have increased with Jatropha oil – waste plastic oil blends.

Keywords*: Diesel, jatropha, Plastic oil, Engine Performance, Emission.*

1.Introduction:

Due to gradual depletion of the world petroleum reserve, rising petroleum prices, increasing threat to the environment from exhaust emission and global warming have generated an intense international interest in developing alternative non petroleum fuels[1]. In observation of this, vegetable oil is a favorable alternative because it has a lot of advantages—it is renewable, environ-friendly and easily produced in rural areas, where there is an acute need for modern forms of energy[2-5]

Plastics are polymers, very long chain molecules that consist of monomers, linked together by chemical bonds. The monomers of petrochemical plastics are inorganic substances and are non-biodegradable. As per the survey conducted in India in the year 2000, nearly 6000 tonnes of plastic waste were produced on a daily basis and only 60% got recycled [6]. The remaining 40% could not be recycled. Many of the industries have developed several processes to convert waste plastics into fuels [7]. Almost all plastics are derived from petroleum. Plastics are polymers, very long chain molecules that consist of monomers, linked together by chemical bonds. Many researches involving thermal degradation of waste plastics into liquid fuel have been conducted. Thermal degradations are not only used for polymer but it is also used for aromatics and gas [8-9]. The production of liquid fuel from plastic waste would be a better alternative as the calorific value of the plastics is comparable to that of fuels, around 40 MJ/kg.[10]. The plastic oil is derived from the plastic waste. Plastic oil can be used directly or blended with diesel to operate compression ignition engine successfully.[11-12].

Many researchers have experimentally investigated the performance and emissions characteristics of jatropha oil blended with diesel [13-15]. The biodiesel is similar in fuel characteristics to conventional diesel in which it compares the fuel characteristics specified by standard specification of different countries. The objective of the present study is to investigate the performance, the emission characteristics of a diesel engine fuelled with Jatropha oil-plastic oil blends.

2.Plastic Waste to Waste Plastic Oil

Plastic waste material was converted into uniform size by the process of crushing, cutting and shredding in the feed system, for the purpose of handling and melting. This process of sizing and grading the waste was semi-automatic. The graded feed was stored in a hopper before feeding into the reactor by a conveyor feeder. The dust and the other fine wastes collected from the cyclone filter were disposed through a vent with particle size monitoring system. The plastic waste was treated in a reactor along with a catalyst and maintained at a temperature of 275◦C–375◦C at atmospheric pressure for about 3 to 4 hours. The outlet gas from the pyrolysis process was condensed in a series of condensers and the liquid obtained was taken as fuel. The uncondensed gases were let out into the atmosphere. Properties of diesel, plastic oil and jatropha oil are compared in Table 1.

3. Experimental Set Up

Tests were conducted on a single cylinder four stroke, direct injection, water cooling kirlosakar diesel engine at an engine speed of 1500 rpm. The engine has a 800cc cylinder volume. The test engine specifications are given in Table 2.The schematic arrangement of the experimental set up are shown in Figs. The test engine was directly coupled to an eddy current dynamometer for load measurement. Airflow meter was used to measure the airflow. The fuel measuring tube (burette) was used to measure the fuel flow rate. The pressure transducer was used to measure the cylinder pressure.

It was fit onto the cylinder head with a charge amplifier. AVL di-gas analyzer was used to measure NOx, HC and CO emissions in the exhaust gas. Exhaust gas temperature was measured with a thermo couple. AVL smoke meter was used to measure the smoke density in the exhaust. Combustion characteristic of the engine was measured by the AVL combustion analyzer.

Table 1: Specification of Test Fuels

Property	Diesel (16)	Plastic oil (16)	Jatropha oil
Gross calorific value (kJ/Kg)	46,500	45,216	39071
Density @ 30 ^{0}C in (gm/cc)	0.84	0.794	865
Kinematic viscosity, cst @ 40^{0}C	2.0	2.85	4.8
Cetane number	55	51	52
Flash point (^{0}C)	50	41	135
Fire point (^{0}C)	56	43	140

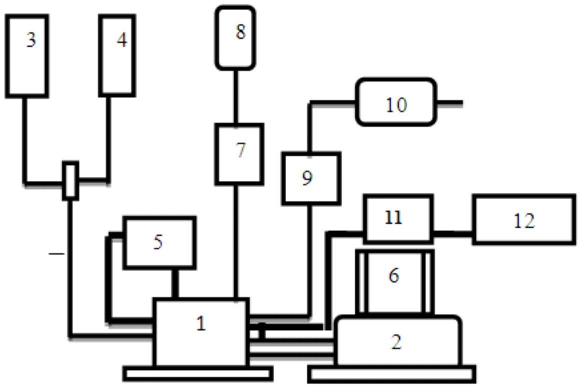

Fig. 1.Experimental setup.

The nomenclature of the numbers are mentioned below:

- Engine
- Dynamometer
- Fuel Tank
- Fuel Measuring Tube(burette)
- Cooling Water Inlet and Outlet
- Thermometer
- Control panel
- Air flow meter
- Air filter
- Smoke meter
- Exhaust gas analyzer
- Charge amplifier monitor

Table 2 : Specifications for kirlosakar diesel engine

Parameter	Specification	Unit
Power	3.7	Kw
Speed	1500	rpm
Cylinder bore	0.08	m
Stroke	0.11	m
Number of Cylinders	1	--
Number of Strokes	4	--
Type of cooling	Water	--

4. Results and Discussion

The experiment was conducted in a standard diesel engine at an engine speed of 1500rpm. A comparison of the engine performance and the emission for the following.
combinations was made and the results have been presented.

- Diesel (DF)
- Plastic oil (PO)
- Plastic oil- Jatropha oil (JP10, JP20)

4.1 Performance

4.1.1 Brake thermal efficiency

The brake thermal efficiency with the engine load of plastic oil-jatropha oil blends is compared with the diesel and the plastic oil as shown in Fig.2. It can be observed from the figure that the brake thermal efficiency of JP10 and JP20 are 26.2% and 25.5%, while those of diesel and plastic oil are 29% and 27.5%. The brake thermal efficiency has slightly decreased with the increase of Jatropha oil in the blends. It is noted that diesel fuel has the higher brake thermal efficiency compared to plastic oil and Jatropha oil blends. The reason may be the Lower calorific value and higher viscosity is the reasons for the lower brake thermal efficiency for waste plastic oil-jatropha oil blends.

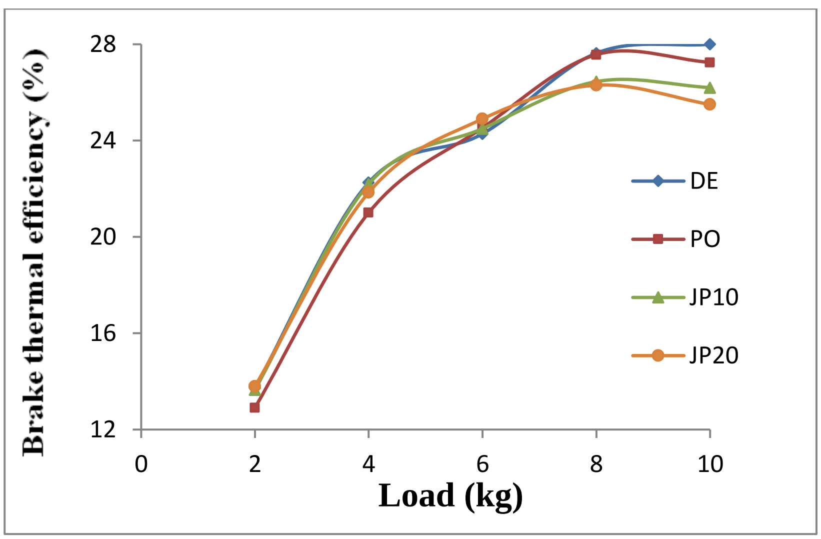

Fig 2:Variation of BTE with load

4.1.2 Brake specific fuel consumption

Fig.3 shows that the variation of the brake specific fuel consumption with load for the tested fuels. It can be observed from the figure, that the brake specific fuel consumption has increased with the increase percentage of Jatropha oil-Plastic oil in the blends. Brake specific fuel consumption of diesel and plastic oil are 0.28kg/kWhr and 0.29kg/kWhr at full load. In the case of plastic oil- Jatropha oil blends, it varies from 0.65kg/kWhr and 0.66kg/kWhr at 20% of load to 0.31kg/kWhr and 0.32kg/kWhr at full load. The result noted that increasing jatropha oil ratio in the fuel blend causes an increase in the brake specific fuel consumption. The main reason for the increase of specific fuel consumption is due to the lower heating value of than that of diesel and waste plastic oil. The increases the viscosity which in turn increased the specific fuel consumption due to poor atomization of the fuel.

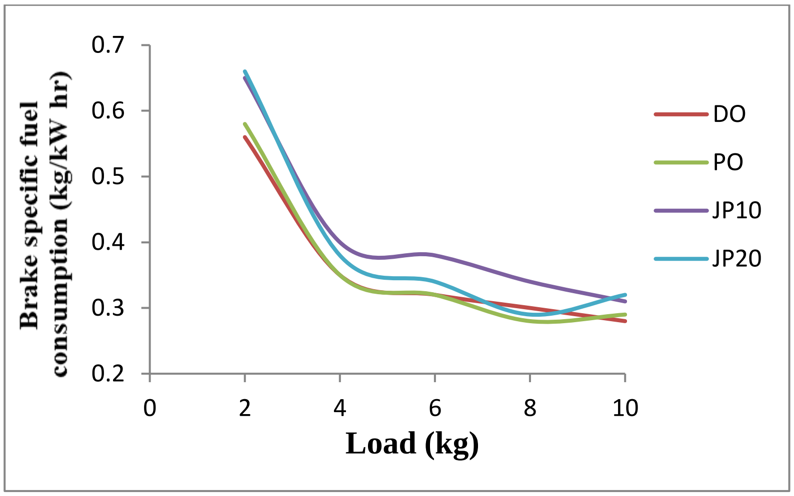

Fig 3:Variation of Bsfc with load

4.2 Emission

4.2.1 Carbon Monoxide

The variation of carbon monoxide with load is shown in Fig. 4. The concentration of CO emission varies from 0.09% at 20% of load to 0.18% at full load for diesel. It varies from 0.10% at 20% of load to 0.20% at full load for plastic oil, whereas it varies from 0.08% and 0.16% at 20% of load to 0.07% and 0.14% at full load for plastic oil-jatropha oil blends (JP10, JP20). The results showed that when the Jatropha oil ratio in the mixture increased, the CO concentration in the exhaust decreased. The reason may be jatropha oil has the oxygen molecule An enrichment of oxygen owing to jatropha oil addition can be noticed and the increase in the proportion of oxygen will promote the further oxidation of CO during engine exhaust process.

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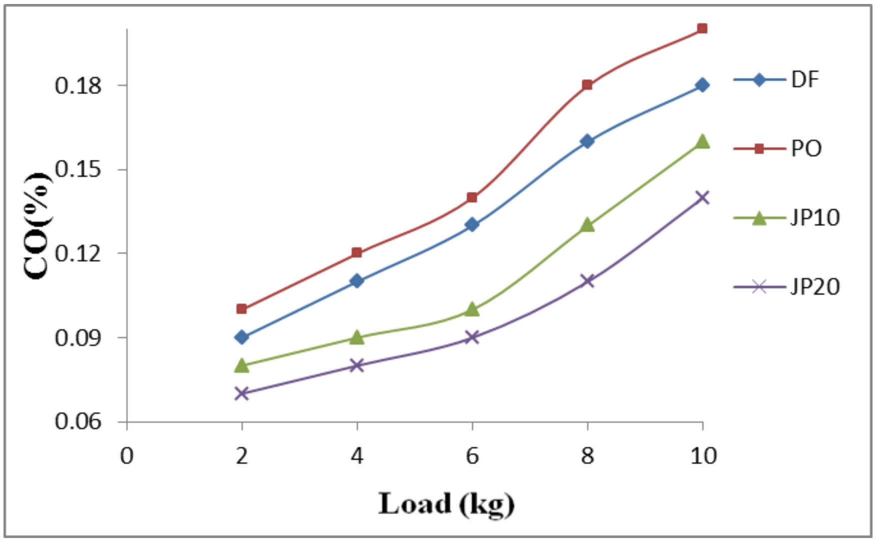

Fig 4:Variation of CO with load

4.2.2 Unburned Hydrocarbon

It is shown that increasing jatropha oil in the blends reduces significantly HC emissions comparatively to ordinary diesel and plastic oil. The variation of unburned hydrocarbon with load for tested fuels is shown in Fig. 5. Unburned hydrocarbons are formed when the fuels are burned partly. Unburned hydrocarbon varies from 32ppm at 20% of load to 57ppm at full load for diesel. It varies from 34ppm at 20% of load to 60ppm at full load for plastic oil. In the case of plastic oil-jatropha oil blends (JP10, JP20), it varies from 29ppm and 27ppm at 20% of load to 51ppm and 49ppm at full load. From the results, it can be noticed that the concentration of the. HC emission decrease is higher with a higher percentage of jatropha oil in the blend. This is due to the increase in oxygen content in the blend which improves the combustion quality in the combustion chamber.

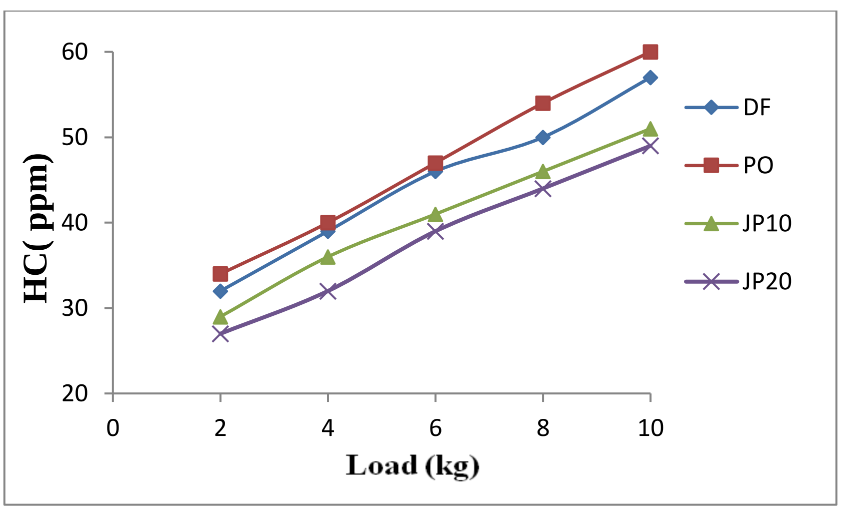

Fig 5 : Variation of HC with load

4.2.3 Oxides of Nitrogen

In the figure: 6 NOx emissions with engine load of DF, PO, JP10, and JP20 are compared with each other. At load 2 kg NOx emission for DF is 129 ppm, PO is 150 ppm, JP10 is 180ppm, and JP20 is 200ppm at maximum load DF have 1005ppm, PO have 1020 ppm, JP10 have 1150ppm, JP20 have 1250ppm NOx emissions. Here the value of JP10 and JP20 are comparatively higher than DF and plastic oil in medium and maximum load. This result was reasonable, since higher values of combustion temperature and presence of oxygen with biodiesel result in an increase in NOx generation. [16].

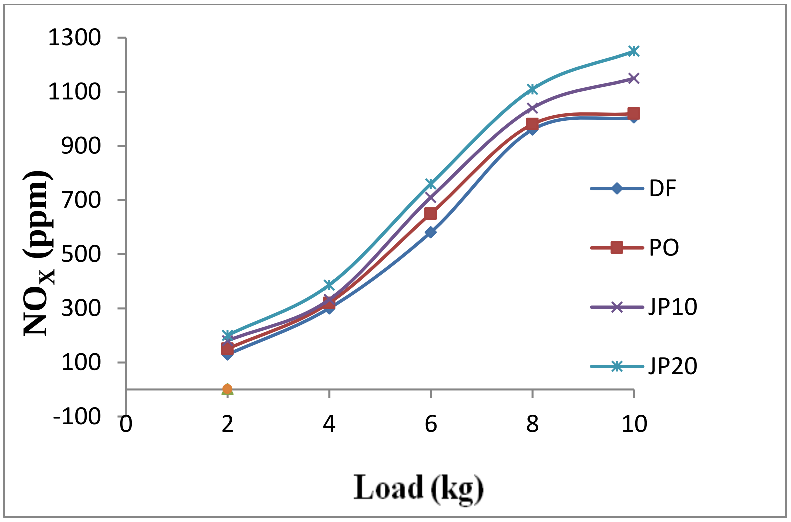

Fig 6:Variation of NO_X with load

4.2.4 Smoke

The variation of smoke emission with load for neat diesel fuel and blend was shown in fig. 7 Smoke opacity is indicative of dry soot emissions which are one of the main components of particulate matter. Smoke level value for diesel and plastic oil is 53.5% and 55.1. % at full load. 43.2% and 38.3% for JP10 and JP20. For biodiesel mixtures, smoke emission was less compared to neat diesel fuel. This is due to higher oxygen content of jatropha oil fuels reduces probability of rich zones formation and aromatics fractions contribute to the reduction of smoke

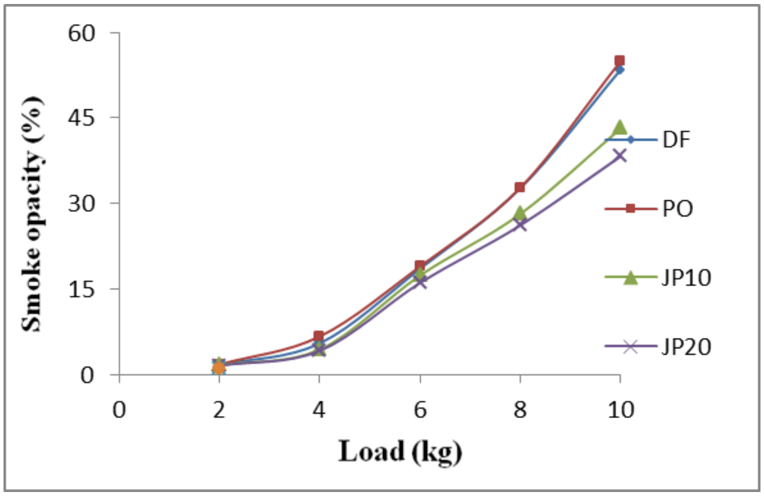

Fig 7:Variation of Smoke opacity with load

5. Conclusion

- Lower brake thermal efficiency is achieved by increasing the percentage of Jatropha oil in the blends. With the different percentage of jatropha oil blends (JP10, JP20), the brake specific fuel consumption is found to have increased for JP10 and JP20 blend fuel compared to the diesel and the Plastic oil. This increase is higher because of the higher percentage of jatropha oil in the blend.
- JP10 and JP20 blend fuel tends to produce lower exhaust CO values than the diesel and plastic oil.
- The use of Jatropha oil-plastic oil blends (JP10, JP20) caused an increase in the emission of NOx compared to the diesel and the plastic oil. HC emission of JP10 and JP20 blend fuels are marginally lower than that of the diesel and plastic oil.
- The soot emitted by the jatropha oil-plastic oil blends (JP10, JP20) is significantly lower than the corresponding neat diesel and plastic oil, with this reduction being the result of the higher percentage of jatropha oil in the blend.

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