www.ijmer.com Vol.2, Issue.3, May-June 2012 pp-1375-1380 ISSN: 2249-6645

Experimental Investigation on the Performance & Emission Characteristics of non edible oil (Jatropha Curcus & Honge) as an alternate fuel in variable compression ignition engine

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ABSTRACT

Due to increase in the demand and scarcity in the availability of the fossil fuel, there is a need of alternate fuel in order to overcome the present crisis. The properties of the alternate fuel should be sustain the technology and have less detrimental effect on the environment in the light of the above properties, the researchers are attempting to develop the alternate fuel in the aspect of economic, environment and to continue the technology without the modification. Among all the available alternate fuel like hydrogen, methanol, etc., Biodiesel is considered as promising alternative fuel for the future. The present work aims to investigate the performance and emission characteristics of the Biodiesel like Honge and Jatropha for the CI engines. Engine test was performed at different loads and different compression ratio for constant engine speed. The emission characteristics are analyzed for different loads, compression ratio and for different blends. The experimental results showed J10 and H10 has less emission characteristic and have agreeable performance in compared with the diesel.

Keywords: **Biodiesel, Honge, Jatropha, Emission, Methyl Ester**

I. INTRODUCTION

Indeed, we are really experiencing the warmth of the global warming, where the climatic condition has changed, the level of sea has increased global temperature is increasing at an alarming rate as a result we had global meet and Kyoto protocol has drafted rules to minimize the global warming, where as automobile also have there contribution in global warming. It is a pure indication that to think of the Alternate fuels where the existing vehicles can use and reduce the pollution along with less dependable on the fossil fuel.

The economic situation of India which is mainly depending on the rural agriculture the use of Jatropha and Honge can increase the employment factor of rural India along with the increase in their income, which indirectly helps to increase the GDP growth of India. In the future scope the use of Biodiesel from blends to the 100% (cent percent) pure Biodiesel will remove the dependability on fossil fuel completely.

The processes of Biodiesel includes from the collection of dry seeds to the esterification of the oil, Esterification is the process where the methyl ester & glycerol are formed and glycerol are formed and glycerol being heavier settles down and methyl ester can be used as Biodiesel. Advantages of Biodiesel is

- It is renewable
- It is carbon neutral
- Blends up to 20% Biodiesel with 80% petroleum diesel can be used in unmodified diesel engines.

Banapurmath *et al.*, [1] have reported tests on a single cylinder C.I. engine with 3 different biodiesels viz methyl esters of honge, jatropha and sesam. All the fuels gave slightly lower efficiency. HC and CO emissions were slightly higher and NOx emission decreased by about 10%. Recep Altin *et al.*, [2] have studied the potential of using vegetable oils and their methyl esters in a single cylinder diesel engine. They have used raw sunflower, cottonseed, soyabean oils and their methyl esters. Their results indicate a reduction in NOx emission and methyl esters are better than raw oils due to their inherent property of high density, higher viscosity, gumming and lower cetane number.

B. Baiju *et al.*, [3] used methyl and ethyl ester from karanja oil to run C.I engine. They observed good engine performance with reduced emissions of HC and smoke. Deepak Agarwal *et al.*, [4] conducted experiments with esters of linseed, mahua, rice bran and Lome. They observed that the performance and the emission parameters were very close to diesel. They even observed that a diesel engine can perform satisfactorily by esterified biodiesel blends without any hardware modifications. Suresh Kumar *et al.*, [5] have investigated the performance and emission characteristics on a single cylinder diesel engine and reported decrease in NOx and HC emissions.

Nagarahalli. M.V *et al.*, [6] conducted experiments on Karanja biodiesel and its blends in a C.I. engine. Concluded that tests for emission and performance were conducted on 4 stroke, constant speed diesel engine said that the results are in line with that reported in literature by different literature and recommended 40% biodiesel 60% diesel (B40). Shivkumar et al., [7] conducted experiments on honge methyl ester using artificial neural network and concluded Break thermal efficiency of honge biodiesel with 20% diesel are very close for biodiesel operation for all compression ratios. Increase in NOx emission was observed for biodiesel blends compared to that of diesel for all compression ratios.

P.Selva Havarasi et al. [8]. The main objective of this work is to optimize the transesterification process for methyl ester production and testing its performance in diesel engine. Used cooking oil is used as feedstock for the production of methyl esters in this work as they provide a viable alternative to diesel, due to its availability. The effect of excess methanol, catalyst amount, temperature, time of reaction was studied to optimize the transesterification process. All the reactions were carried out under the same experimental conditions. The performance and emission characteristics of used cooking oil methyl esters and its blend with diesel oil were analyzed in a diesel engine. The minor decrease in thermal efficiency with significant improvement in the reduction of particulates, carbon monoxide, and unburnt hydrocarbon was observed compared to diesel. **GVNSR Ratnakara Rao et al. [9]** Experimental investigations were carried out on a single cylinder variable compression ratio C.I engine using neat mahua oil as the fuel. Both the performance and exhaust analysis were carried out to find the best suited compression ratio. Tests have been carried out at 7 different compression ratios. All the experiments were carried out at standard test conditions like 70˚c cooling water temperature and at constant speed of 1500rpm. The result shows that 15.7 is the best compression ratio with mahua oil.

Sukumar Puhan, N et al. [10] in this study, mahua oil was transesterified with methanol using sodium hydroxide as catalyst to obtain mahua oil methyl ester. This biodiesel was tested in a single cylinder, four stroke, direct injection, constant speed, compression ignition diesel engine to evaluate the performance and emissions. **Hidekki Fukuda et. al. [11]** enzymatic transesterification using lipase has become more attractive for biodiesel fuel production, since the glycerol produced as a byproduct can easily be recovered and purification of fatty methyl ester is simple to accomplish. **Mustafa Canakci [12]** free fatty acids and moisture reduce the efficiency of transesterification in converting these feed stocks into biodiesel. Hence, this study was conducted to determine the level of these contaminants in feedstock samples from a rendering plant. Levels of free fatty acids varied from 0.7% to 41.8%, and moisture from 0.01% to 55.38%. These wide ranges indicate that an efficient process for converting waste grease and animal fats must tolerate a wide range of feedstock properties. **Purnananda Vishwanatha Rao Bhale** et al. [13] this paper is aimed to investigate the cold flow properties of 100% biodiesel fuel obtained from mahua oil, one of the important species in the Indian context. The performance and emissions with ethanol blended mahua biodiesel fuel and ethanol diesel blended mahua biodiesel fuel have also been studied.

II EXPERIMENTAL SETUP

2.1 Equipment Introduction:

First standard engine is fully instrumented and connected to the dynamometer. The experiments are conducted at constant speed and at four different loads levels viz., 20%, 40%, 60% and 80% of full load. The required engine load percentage is adjusted by using the eddy current dynamometer.

Fig.5.2 shows the schematic diagram of the complete experimental setup for determining the effects of TBC on the performance parameters of compression ignition engine. It consists of a single cylinder four stroke water cooled compression ignition engine connected to an eddy current dynamometer. It is provided with temperature sensors for the measurement of jacket water, calorimeter water, and calorimeter exhaust gas inlet and outlet temperature. It is also provided with pressure sensors for the measurement of combustion gas pressure and fuel injection pressure. An encoder is fixed for crank angle record. The signals from these sensors are interfaced with a computer to an engine indicator to display P-ϴ, P-V and fuel injection pressure versus crank angle plots. The provision is also made for the measurement of volumetric fuel flow. The built-in program in the system calculates indicated power, brake power, thermal efficiency, volumetric efficiency and heat balance. The software package is fully configurable and averaged P-ϴ diagram, P-V plot and liquid fuel injection pressure diagram can be obtained for various operating conditions.

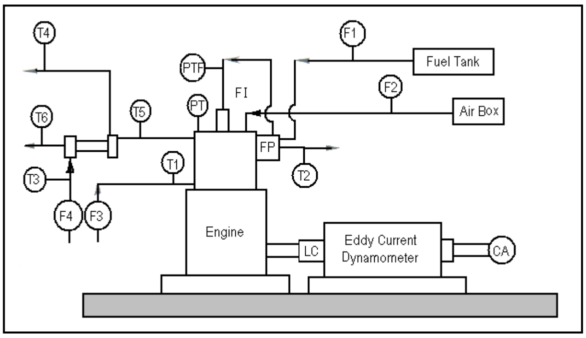

Fig. 5.2: Schematic Diagram of the Experimental Set-up.

PT	Combustion Chamber Pressure Sensor
F1	Liquid fuel flow rate
PTF	Fuel Injection Pressure Sensor
F2	Air Flow Rate
FI	Fuel Injector
F3	Jacket water flow rate
FP	Fuel Pump
F4	Calorimeter water flow rate
T1	Jacket Water Inlet Temperature
LC	Load Cell
T2	Jacket Water Outlet Temperature
CA	Crank Angle Encoder
T3	Inlet Water Temperature at Calorimeter
EGC	Exhaust Gas Calorimeter

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T4	Outlet Water Temperature at Calorimeter
T5	Exhaust Gas Temperature before Calorimeter
T6	Exhaust Gas Temperature after Calorimeter

2.2 Measurement System:
The test bed is fully instrumented to measure the various parameters such as flow measurement, load measurement, pressure measurement, etc during the experiments on the engine.

2.2.1 Flow Measurement:
Air flow measurement is done by the flow sensors, a conventional U- tube manometer as well as air intake differential pressure transducers unit present in the control panel. There are two parallel air suction arrangements, one for U- tube manometer having arranged of 100-0- 100 mm and another for pressure differential unit, which senses the difference in pressure between suction and atmospheric pressure. This difference in pressure will be sent to transducer which will give the DC volt analog signal as output which in turn will be converted into digital signal by analog to digital converter and fed to the engine software.

For liquid fuel flow rate measurement, the fuel tank in the control panel is connected to the burette for manual measurement and to a fuel flow differential pressure unit for measurement through computer.

Cooling water flow to the engine and calorimeter is measured by means of a calibrated Rota-meter with stainless steel float.

2.2.2 Load Measurement:
The eddy current dynamometer is provided to test the engine at different loading conditions. A strain gauge type load cell mounted beneath the dynamometer measures the load. The signals from the load cell are interfaced with analog to digital converter to give torque in N-m. The dynamometer is loaded by the loading unit situated in the control panel.

2.2.3 Pressure Measurement:
A water cooled piezo sensor mounted on the cylinder head measures the cylinder dynamic pressure and a piezo sensor mounted on the fuel line near the injector measures the fuel injection pressure.

2.2.4 Engine Speed Measurement:
Engine speed is sensed and is indicated by an inductive pickup sensor in conjunction with a digital RPM indicator, which is a part of the eddy current dynamometer control unit. The dynamometer shaft rotating close to inductive pickup rotary encoder sends voltage pulses whose frequency is converted to RPM and displayed by digital indicator in the control panel, which is calibrated to indicate the speed directly in number of revolutions per minute.

2.2.5 Temperature Measurement:
Chromium-aluminum thermocouples connected to digital panel meter are positioned at different locations to measure the following temperatures:

- Jacket water inlet temperatures (T1)
- Jacket water outlet temperatures (T2)
- Calorimeter inlet water temperature (T3)
- Calorimeter inlet water temperature (T4)
- Exhaust gas temperature before calorimeter (T5)
- Exhaust gas temperature after calorimeter (T6)

All the sensors which sense the temperature of respective locations are connected to the control panel, which gives the digital reading of the respective temperatures.

2.3 Working Procedure:

1) Switch on the mains of the control panel and set the supply voltage from servo stabilizer to 220volts.

2) The main gate valve is opened and the pump is switched ON and the water flow to the engine cylinder jacket (300 liters/hour), calorimeter (50 liters/hour), dynamometer and sensors are set.

3) Engine is started by hand cranking and allowed to run for a 20 minutes to reach steady state condition.

4) The engine soft version 3.0 is run to go on ONLINE mode.

The engine has a compression ratio of 17.5 and a normal speed of 1500 rpm controlled by the governor. An injection pressure of 190 bar is used for the best performance as specified by the manufacturer. The engine is first run with neat diesel at loading conditions such as no load, 20%, 40%, 60% and 80%. Between two load trials the engine is allowed to become stable by running it for 3 minutes before taking the readings. At each loading conditions, performance parameters namely speed, exhaust gas temperature, brake power, peak pressure are measured under steady state conditions along with the emission parameters of CO, CO_2, HC and NOx. The experiments are repeated for various combinations of diesel and honge biodiesel blends and also diesel with jatropha oil blends. With the above experimental results, the parameters such as total fuel consumption, brake specific fuel consumption, brake mean effective pressure; brake specific energy consumption, brake thermal efficiencies are calculated. And finally break power wih respect to percentages of CO, CO_2 and PPM's of HC, NOx are plotted with respect to loading conditions for diesel and each diesel oxygenate blend. From these plots, emission characteristics of the engine are determined.

www.ijmer.com Vol.2, Issue.3, May-June 2012 pp-1375-1380 ISSN: 2249-6645

III. Results and Discussions

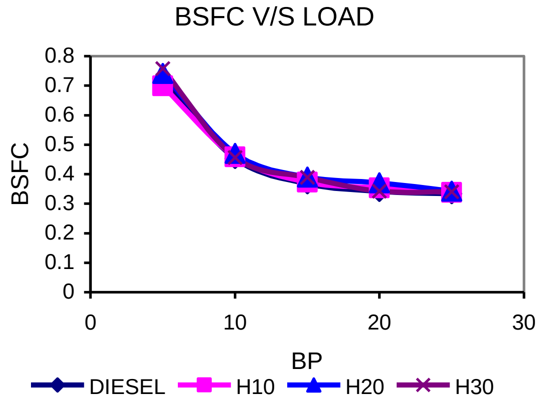

FIG.1

In the above fig.1 one cannot find much difference between the biodiesel of honge H10, H20, H30 along with the pure diesel the graph won't show much variation between the diesel and biodiesel

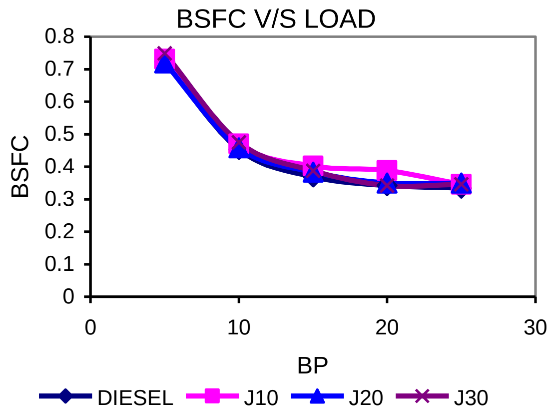

FIG.2

Similarly in the fig.2 graph of BSFC Vs BP we don't find much difference only slight variation in J10 otherwise it is equivalent to the pure diesel so the total conclusion from the above two graphs that we can use the biodiesel either jatropha or honge without the modification of the engine which gives similar result as of diesel.

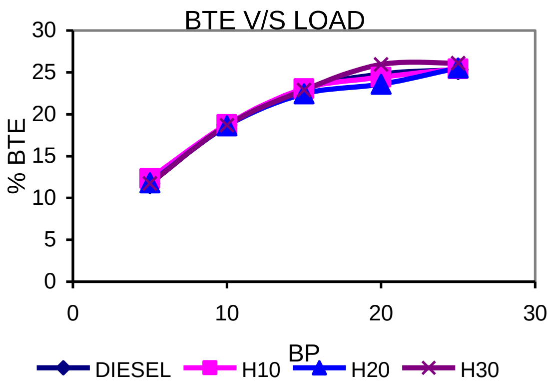

FIG.3

The Brake thermal efficiency for the pure diesel along with the blends of honge biodiesel is plotted in fig.3 and we find similar path followed by the diesel and biodiesel but little variation in load 20 for which H20 shows little less efficiency where as H30 is little bit more.

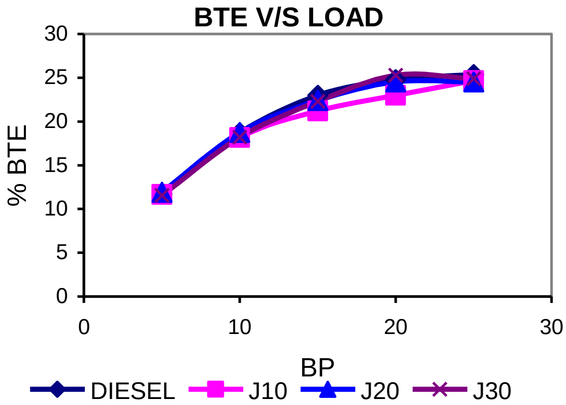

FIG.4

In case Jatropha biodiesel similar graph is obtained as in case of honge biodiesel but here J10is showing bit less efficiency and remaining is almost equivalent to that of pure diesel as shown in fig.4. Hence we get similar efficiency as in case of pure diesel.

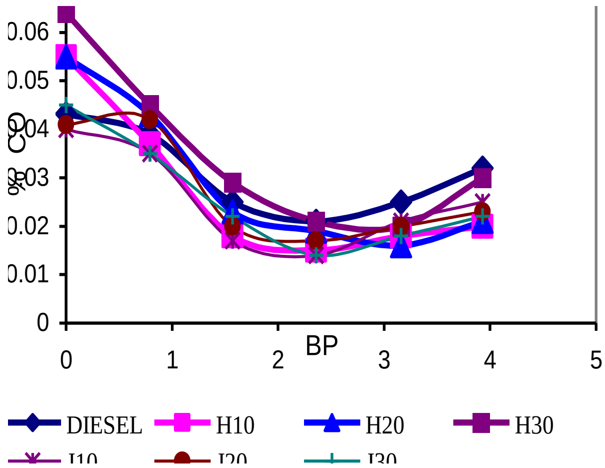

FIG.5

For the compression ratio 17.5 from figure5 it can be concluded that the percentage of carbon monoxide is higher at the beginning and keeps on decreasing as the load rate increases for BP 2.36 kw Honge10 gives the lower result compare to diesel H20 & H30 blends later there will be slight increase in the percentage of CO. emission of CO is higher at low load and again increases at high load due to the fact that incomplete combustion occurs at this loads (rich mixture).

Similarly for the same compression ratio the percentage of carbon monoxide is higher at the beginning and the blend of J10 has given the optimal result lower in the percentage of carbon monoxide for the similar BP 2.36 kw as shown in figure 5 comparatively the emission percentage of carbon monoxide for the pure diesel is more with respect to the Biodiesel of different blends but it can be concluded that the H10 and J10 is emitting lower percentage of carbon monoxide. Emission of CO is higher at low load and again increases at high load due to the fact that incomplete combustion occurs at these loads (rich mixture).

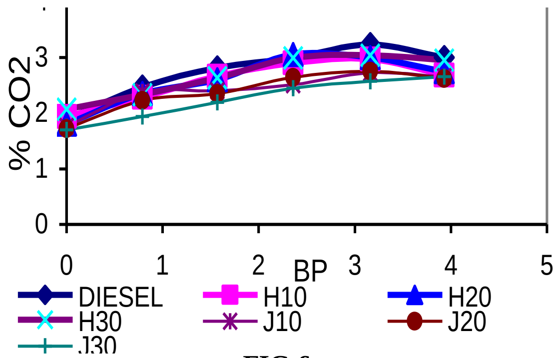

FIG.6

Where as in figure 6 the percentage of carbon di oxide keeps increasing as the Brake power increases and at the end there is a little decrease in the percentage of carbon di oxide even with the different blends of Honge along with pure diesel gives almost similar percentage of carbon di oxide emission of carbon di oxide is lower at less loads and increases at the higher loads, due to incomplete combustion.

For the blends of Jatropha along with the pure diesel the percentage of carbon di oxide is drawn for the emission result from figure 6 it can be concluded that the percentage of carbon di oxide for the blend J30 is much lower than the other blends of Jatropha and with pure diesel which is much higher than biodiesels.

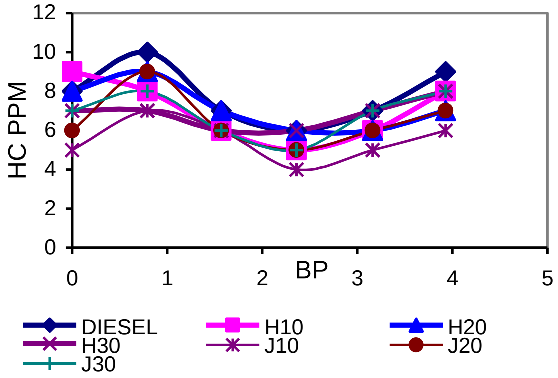

FIG.7

Graph is drawn for the hydrocarbon emission with respect to Brake power as shown in figure 7 for pure diesel and H20 blend the hydrocarbon emission increases slightly at the beginning and there is steep decrease in the hydrocarbon emission but for the blend H10 which varies moderately with the increase in Brake power and finally there is increase in the emission ppm for all the Honge blends with respect to pure diesel. In hydrocarbon emission can be observed at 50% loading.

In case of Jatropha Biodiesel blends with respect to the pure diesel as shown in figure 7 the emission of hydrocarbon varies with the increase in Brake power but we can conclude that the optimum results between 10 & 20 blends.

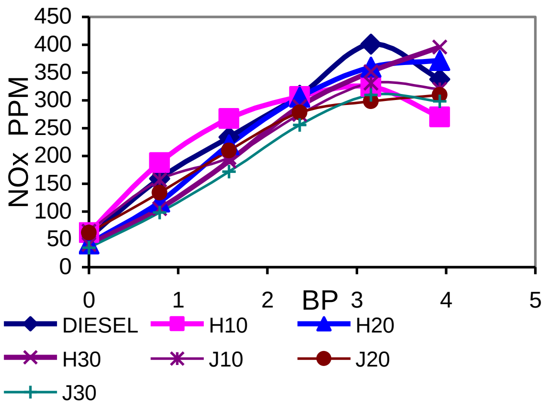

FIG.8

For NOx it increases as the load increases as at higher loads, higher combustion temperature causing more NOx formation refer figure 8.

IV CONCLUSION

Tests for emission and performance characteristics were conducted on a single cylinder, 4 stroke, constant speed diesel engine. From the above we can conclude that

- The engine can run without the manufacturer's modification for 20% blends with pure diesel either for jatropha or honge biodiesels.
- Emission for honge and jatropha with respect to pure diesel is lesser but for jatropha it is still lesser.
- Brake thermal efficiency for both honge and jatropha is similar and it walks along the path of pure diesel.
- The results are in line with that reported in literature by different researchers using various biodiesel fuels and their blends.

V. ACKNOWLEDGEMENT

The authors would like to thank the management of Sri Siddhartha Institute of Technology, Tumkur for their kind co-operation, principal for providing the lab facility to conduct the experiments and valuable support from the staff members of the mechanical department for their support during the course of this work.

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