EFFECT OF INJECTION PRESSURE ON PERFORMANCE AND EMISSION ANALYSIS OF CI ENGINE USING NON EDIBLE VEGETABLE OILS BIODIESEL AND THEIR BLENDS WITH DIESEL

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Abstract

Gradual depletion of world petroleum reserves and increase in the exhaust emissions day by day have led to an urgent need for alternative fuels to replace diesel. Vegetable oils biodiesel is considered as an alternative for diesel because of their properties which have been close to pure diesel. In the present study non edible vegetable oils like Honge and Jatropha oils biodiesel and their blends were used as fuel in a constant speed direct injection diesel engine. Further effect of injection pressure on the performance parameters such as brake thermal efficiency, brake specific fuel consumption, brake power and emission parameters such as HC, CO and NO_X were investigated in a constant speed direct injection diesel engine with varied injection pressures of 180, 200 and 220 bar.The test results showed that Honge and Jatropa oil biofuel blends are having good performance and emission results at 200 bar injection pressure when compared to 180 and 200 bar injection pressure. The test results also showed that performance and emission results of Honge and Jatropa biofuel blends are near to that of the results obtained for pure diesel and they can be used to replace pure diesel.

Keywords: - *Performance parameters, Emission parameters, Biodiesel, Jatropa oil, Honge oil*

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1. INTRODUCTION

Rising diesel prices, increasing threat to the environment from vehicle exhaust emissions and vastly depleting stock of fossil fuels have generated an intense international interest in developing alternative renewable fuels for IC engines. If we can harness non edible oils to make diesel, dependency on imported crude oil, if not totally eliminated, can be reduced. Most tree based oil seeds yield about 30% oil and 70% cake. The cake obtained has many uses, but if it becomes available in large quantities, it probably could be used in industrial fermenters to produce biogas [methane] and the sludge produced, therefore, can be used as quality fertilizer.

S. Jindal from his experiments concluded that combination increase of compression ratio and injection pressure and simultaneously retarding the injection timing results in lower emissions of NO_xas compared to pure diesel [1]. R. Selvan and Dr. K.Maniysunder from their experimentations concluded that brake power output, brake thermal efficiency, brake specific fuel consumption and volumetric efficiency of the engine with super charger are improved in comparison with naturally aspirated engine [2]. Sachindra Dhakad, Upendra Parashar, Devendra Singh D concluded from their experimental analysis that the blends of Jatropa oil with diesel could be successfully used with acceptable performance on B20 [3]. K. Kannan and M. Udaykumar from their experiments observed that brake thermal efficiency increasing in the order 250-200-180 bar injection pressure whereas for brake specific fuel consumption results were obtained in the reverse order [4]. N. Manikanda Prabhu, Dr.S. Nalluswamy and K. Thirumalai Rasureported from their tests that by using a heat exchanger, preheated Jatropa oil has the potential to be a substitute fuel for diesel engines [5].

1.1 By Products and Value Addition in Bio Fuel Industry

The cakes obtained after crushing of seeds contains concentrated organic manure containing nitrogen, phosphorous, potassium and micro-nutrients in appreciable quantity. They easily decompose in the soil and they are also having good insecticidal properties. The cakes can also be used for making compost and also for biogas production. The Sludge obtained after biogas production is good organic manure. The composition of organic manure of different non-edible seeds is as follows

Table 1: Table showing organic manure content of non-edible seeds

Cakes	**Nitrogen %**	**Phosphorus %**	**Potassium %**
Pongamia(HONGE)	3.9-4.0	0.9-1.0	1.0-1.4
Mahua	2.5-2.6	0.8-0.9	1.2-1.9
Jatropa	4.0-4.2	1.0-2.0	0.9-1.0
Simarouba	7.7-8.1	1.0-1.1	1.2-1.3
Neem	5.2-5.3	0.5-1.0	1.4-1.5

2. TRANS-ESTERIFICATION PROCESS

The first step of trans-esterification is to find out the free fatty acid content present in the pure vegetable oil. It is to be carried out because the method to be followed for trans-esterification is based on the amount of free fatty acid present in the oil. Following are steps of biofuel production

1. Two stage process
2. Single stage process
3. Methanol recovery
4. Washing of biodiesel
5. Drying of biodiesel

Fig 1: 3-Neck flask for trans-esterification

Fig 2: figure showing Jatropa and Honge oil

2.1 Two Stage Process

Two stage processis also called acid catalyzed process and is the reaction of fat withmethanol in the presence of acid catalyst for example sulphuric acid and is carried out when the free fatty acid content in the oil is more than 4 percent. The process is carried out in a 3 neck flask with magnetic stirrer shown in the figure 1. Reflux condenser was used for condensing of methanol back into the 3 neck flask during the process. The oil was heated at constant and uniform temperature of 60^{o} c. In the meantime acid methanol solution was prepared depending on FFA percentage and added to 3 neck flask and reaction mixture is allowed to settle for 90 minutes. After 90 minutes free fatty acid collected at the top was separated from the oil. Free fatty acid content of the oil was calculated again. The above procedure is repeated until free fatty acid content reduces to less than 4 percent.

2.2 Single Stage Process

Single stage process is also called base catalyst process and is similar to two stage process but it is carried out when the free fatty acid content in the oil is less than 4 percent. Instead of acid here sodium hydroxide is used as catalyst which is a base.The process is carried out until free fatty acid content of oil reduces to less than 0.5 percent.

2.3 Methanol Recovery

After trans-esterification the next process is to recover methanol from the oil. It is also carried out in 3 neck flask. The oil was heated up to 70^{o}c. the constant speed of 200 rpm and 70^{o}c was maintained during the process. The process is continued until methanol condensation stops.

2.4 Washing of Bio-Diesel

After methanol recovery the next process is to carry out bio-diesel washing. It is carried out using washing funnel. Nearly 300 mile liter of warm water at 40^{0} c was sprayed into biodiesel and allowed to settle for 15 minutes. The bottom soap water was drained. The above procedure is repeated for 4-5 times.

2.5 Drying of Biodiesel

After bio-diesel washing the next process is to remove water content present in the oil by heating it up to 100^{0} c.

3. PREPARATION OF BLENDS & FUEL PROPERTIES

Fig 3: photographic view of tested engine

The blends are prepared on a volume basis at room temperature. Clean measuring glass jars are used to prepare different blends. The required quantity of both biodiesel [Honge and Jatropa] are calculated and taken based on the blend percentage and then mixed together to form blend. For example the blend J15+H15+D70 means 15% of Jatropa, 15% of Honge & 70% of diesel is mixed to form the blend. Similarly the different blends are prepared and named.

Table 2: properties of fuels

Fuels	Density (kg/m^3)	Flash point(°c)	Viscosity (Cst)	Calorific value
Diesel	825	52^0	2.38	43990 kJ/kg
Jatropa	875	198	5.34	38835 kJ/kg
Honge	890	206	5.65	36995 kJ/kg
J15+H15+ D70	841	62	3.65	41230 kJ/kg
J30+H00+ D70	832	59	3.55	43071 kJ/kg
J00+H30+ D70	855	63	3.88	39572 kJ/kg

4. EXPERIMENTAL PROCEDURE &TEST RIG

Table 3: Engine specification

Engine specification	
Engine type	Four stroke
Fuel type	Diesel
Aspiration type	Natural
Bore	0.08 m
Stroke	0.11 m
Connecting rod length	0.235 m
HP	5 HP
Starting	Crank shaft
Compression ratio	16.7 000
Area of piston head	0.005 m^2
Number of cylinder	1
Injection angle	23^{0}CA

Here in this study a constant engine speed of 1500 rpm and fixed compression ratio of 16.7:1 are maintained. The diesel engine is experimented for 3 differentinjection pressures of 180, 200 and 250 bars. The standard injection pressure and injection timing of the testing engine were 200 Bar and 23^0 CA respectively. The load on the engine is applied using eddy current dynamometer. Emissions are recorded by multi gas analyzer MN-05. The engine is put to idling for 15 minutes before every set of experimentation for the purpose of attaining steady state. The readings were taken for standard operating conditions of the engine and then the standard injection pressure of the engine is varied and the same procedure is repeated for other two injection pressures varied i.e. 180 and 220 bar injection pressures. The above procedure is repeated for different blends of biodiesel. Modified injection pressure results are compared for performance and emission characteristics with standard injection pressure using both diesel and biodiesel. In each set of experimental test readings, brake thermal efficiency, brake specific fuel consumption, brake power and concentrations of CO, HC & NO_X are taken.

5. RESULTS & DISCUSSION

5.1 Performance Analysis

5.1.1 BSFC

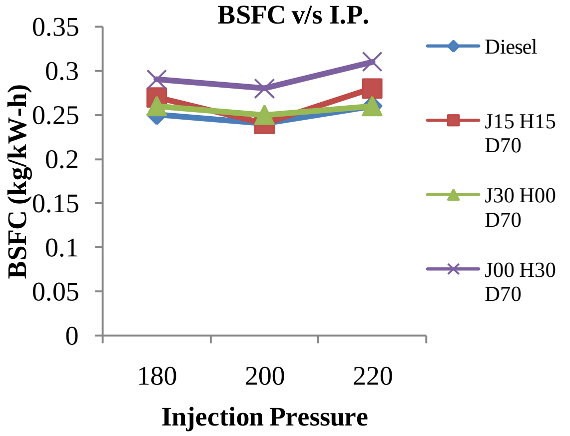

Fig 4: showing variation of BSFC v/s I.P.

Figure 4 shows that the for all fuels best values of BSFC are obtained at 200 bar due to better utilization of fuel at this injection pressure. For biodiesel blends values of BSFC are slightly higher than pure diesel because of lower calorific value. For Jatropa blend the value of BSFC is lesser than value obtained for Honge blend by 10%because calorific value of Jatropa is higher than Honge.

5.1.2 B.P

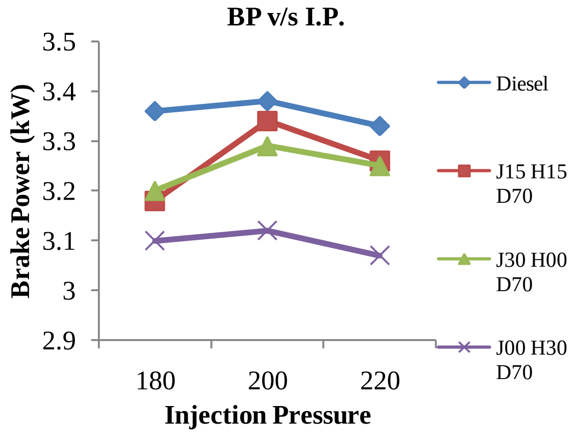

Fig 5: showing variation of BP v/s I.P.

Figure 5 shows that the values of B.P. increases from 180-200 bar I.P. and then decreases from 200-220 bar this is caused because of better atomization of fuel with increase in injection pressure from 180-200 bar and then at 220 bar with further increase in atomization momentum of very fine fuel droplets drops. For bio fuel blends B.P. value slightly less than diesel because of less energy content and high viscosity of biofuels.

5.1.3 BTE

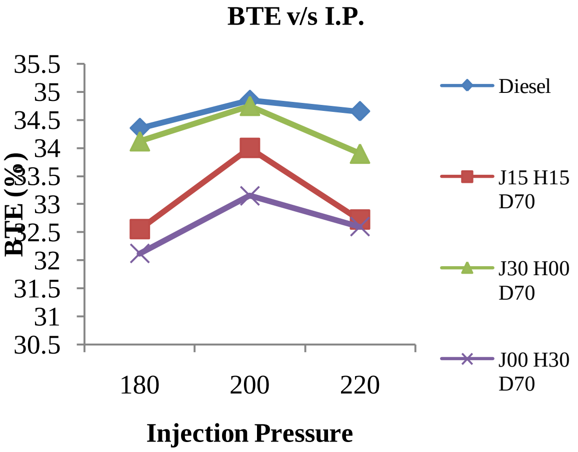

Fig 6: showing variation of BTE v/s I.P.

Figure 6 shows that the value of BTE obtained for diesel remains same at all injection pressures with slightly increase in the value of BTE at 200 bar injection pressure. The BTE obtained for Honge blend is 10% less than the BTE obtained for Jatropa. This is because of lower energy content of Honge as compared to Jatropa which gives lower values of brake power. The decrease in BTE value is observed with increase in injection pressure from 200-220 bar.

5.2 Emission Analysis

5.2.1 HC

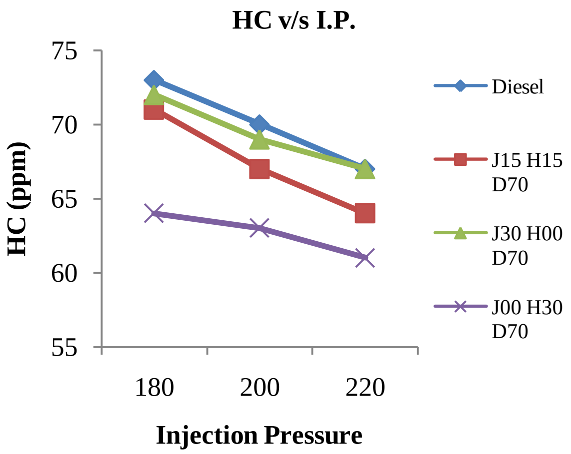

Fig 7: showing variation of HC v/s I.P.

From the figure 7 it is observed HC emissions were found decreasing for biodiesel blends as compared to diesel blends this is because the sufficient availability of oxygen at higher temperatures results in complete combustion. HC emissions decreasing with increase in injection pressure.This is because of better atomization and higher temperature of gases at higher injection pressures results in increase in combustion efficiency. For Honge blends HC emissions found less than Jatropa blends this is because high oxygen content of Honge results in combustion of unburnt HC at high temperature.

5.2.2 CO

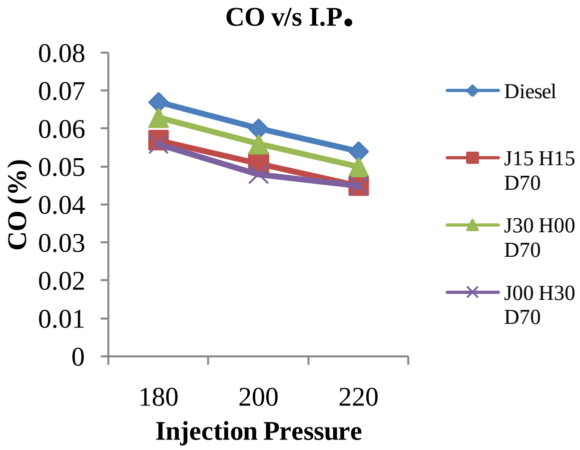

Fig 8: showing variation of CO v/s I.P.

From the figure 8 it is observed that CO emissions found decreasing with increase in injection pressure. The biodiesel blends shows lower values of CO as compared to pure diesel this is due to extra amount of oxygen content present in the biodiesel. This extra oxygen results in oxidation of CO into CO_2 which reduces CO emission.

5.2.3 NO_X

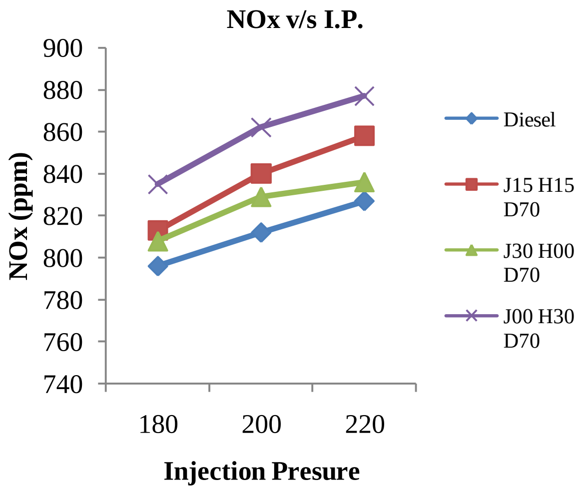

Fig 9: showing variation of NO_x v/s I.P.

From the figure 9 it is observed that for both blends and with increase in injection pressure NO_x emission increases. This is because of higher temperature at high injection pressure and high oxygen content of biodiesel. The oxygen content present in the biodiesel reacts with nitrogen present in the intake atmospheric air at high temperatures and results in higher values of NO_X emissions.

6. CONCLUSION

From the results obtained it is concluded that

1. From the experiments it has been concluded that both Honge and Jatropa oils can be easily blend with pure diesel.

2. The values of brake power for Jatropa and Honge blends were found near to values obtained for pure diesel with slight decrease.
3. BTE of Jatropa blend is found almost near to BTE of diesel. BTE obtained for Honge blend is less than Jatropa blend by 10%.
4. The values HC & CO obtained for all biodiesel blends are less than the values obtained for pure diesel.
5. The NO_x values obtained for all biofuel blends are higher than values obtained for diesel by 5-10%.

FUTURE WORK

The following aspects are recommended for future work

1. Experimented can be conducted using preheated biofuel.
2. Effect of compression ratio on performance and emissions of engine using biofuels can be found.
3. Effect of EGR on NO_X emissions can be conducted.

NOMENCLATURE

B.P- Brake Power,
BSFC- Brake Specific fuel consumption,
BTE- Brake Thermal Efficiency,
HC- Hydro Carbons,
CO- carbon monoxide,
NO_X- oxides of nitrogen,
EGR- Exhaust Gas Recirculation,
ppm- parts per million.

REFERENCES

[1] S. Jindal, "Effect of engine parameters on NO_X emissions with Jatropa bio diesel as fuel'', international journal of energy and environment, 2010, Vol 1, issue 2.

[2] R.Selvan, Dr. K. Maniysundar, "Performance and Emission Analysis of Diesel Engine using Jatropa oil with Super charger and EGR" IJETAE, January 2014, vol4, issue1.

[3] S. Dhakad, U. Parashar, D.S. Dandotiya, V. Dhakad, J.S. Gurjar " Practical Performance of Internal Combustion Engine Using Jatropha Oil as A Bio-Fuel" International Journal of Emerging Technology and Advanced Engineering, October 2013 Vol 3, Issue 10.

[4] K. Kannan& M. Udayakumar 'Experimental study of the effect of fuel injection pressure on diesel engine performance and emission' ARPN Journal of Engineering and Applied Sciences,May 2010 Vol 5, issue 5.

[5] N. M.Prabhu, Dr.S.Nallusamy , and K. ThirumalaiRasu "experimental analysis of Jatropa and Curcas bio-diesel for optimum blend characteristics" Bonfring International Journal ofIndustrial and Management Science, June 2012 Vol 3, issue 2.