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EFFECTS OF PREHEATED CRUDE JATROPHA OIL ON PERFORMANCE AND EMISSIONS OF DI DIESEL ENGINE

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Abstract- **Nowadays alternative fuel research has gained prominence in the context of depletion of conventional fossil fuels. Diesel is being consumed in agricultural and transport sectors. Hence efforts are going on to search for suitable substitutes for diesel fuel (DF). Vegetable oils are important substitutes for diesel fuel as their properties are comparable to diesel. Only non-edible vegetable oils can be considered as fuels in diesel engine, as edible oils are in great demand due to socio economic restrictions. In the present work, the crude jatropha oil (CJO) is used as the alternative fuel for diesel. Experiments were conducted on the Conventional Diesel Engine (CE) to evaluate the performance and emissions at different operating conditions (normal and pre-heated temperature) of CJO with varied injection pressures. The results were compared with that of the diesel operation at the manufacturer's recommended injection pressure of 190 bar. The performance of the engine improved with preheated condition of the vegetable oil when compared with normal condition. The preheated vegetable oil at higher injection pressure gave comparable performance to that of diesel operation at recommended injection pressure**
Keywords – Crude jatropha oil, Performance, Exhaust Emissions, Injection pressure, Normal temperature, Preheated temperature

1. INTRODUCTION

Diesel fuel (DF) is consumed heavily in many sectors like transport, agricultural etc. But due to depletion of fossil fuels, there is a strong necessity for substitutes for diesel fuel. Vegetable oils are important substitutes for diesel fuel as their properties are comparable to diesel and are renewable in nature. Only non-edible vegetable oils can be considered as fuels in diesel engine, as edible oils are in great demand due to socio economic restrictions. They have comparable cetane number (in the range of 40–45) and energy content as of diesel and therefore they can be effectively used in diesel engines. However, the viscosity of vegetable oils is high. So an attempt is made to examine the performance of preheated crude jatropha oil in diesel engine. Preheated temperature is the temperature at which viscosity of the vegetable oil is matched to that of DF at room temperature. Crude Jatropha Oil (CJO) has been preheated to 125^0C to get the desired effect.

Different oil crops can be cultivated in different areas depending on climatic conditions. Several researchers conducted the experiments with the vegetable oils with diesel engines and could successfully replace 100 % diesel fuel with the vegetable oils.

The researchers [1-3] concluded that the performance of crude vegetable oil deteriorated and emissions improved when compared to pure diesel operation on the conventional engine. The researchers [4-8] have studied the influence of injection pressure on the performance of DI diesel engine with vegetable oil operation. An increase in injector pressure resulted in improved performance and reduced smoke emissions. The researchers [9-11] investigated experimentally the performance of a compression ignition engine fuelled with preheated vegetable oils and found that the performance of preheated vegetable oils were comparable with that of the diesel operation; the pollution levels are slightly inferior to that of a diesel operation.

The present work consists of experimental investigations on the performance and emissions of diesel engine at normal (NT) and preheated (PT) temperatures of CJO with varied injection pressures. The results thus obtained were compared with that of the diesel operation at manufacturer's recommended injection pressure of 190 bar.

2. MATERIALS AND METHODS

Fig.1 shows the schematic diagram of the experimental set up for the diesel operation. The engine is a single cylinder, four stroke and direct injection type diesel engine with a rated output of 3.68 kW at a rated speed of 1500 rpm. The compression ratio is 16:1. The manufacturer's recommended injection timing and injection pressures are 27 bTDC and 190 bar respectively. The brake power was measured by an electrical dynamometer. The consumption of air and fuel by the engine were measured by air-box method and burette method respectively. The specifications of the engine are given in Table-1.

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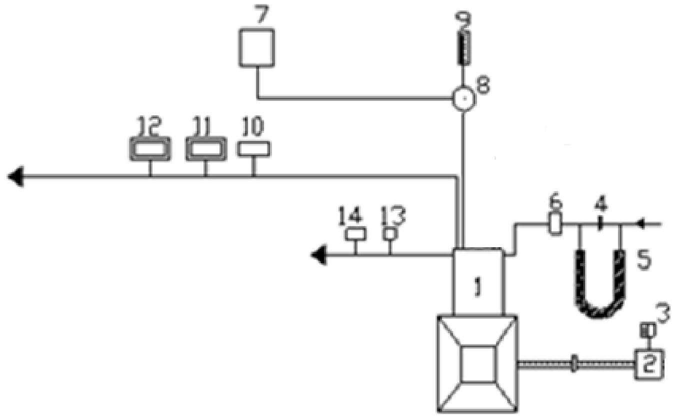

1. Engine, 2.Electical Dynamometer, 3.Load Box, 4.Orifice meter, 5.U-tube water manometer, 6.Air box, 7. Diesel tank, 8.Three-way valve, 9.Burette, 10.Exhaust gas temperature indicator, 11.AVL Smoke meter, 12.Netel Chromatograph NOx Analyzer, 13.Outlet jacket water temperature indicator, 14.Outlet-jacket water flow meter

Fig.1 Experimental set-up

Table-1: Specifications of test engine

Description	Specification
Engine make and model	Kirloskar (India) AV1
Maximum power output at a speed of 1500 rpm	3.68 kW
Number of cylinders ×cylinder position× stroke	One × Vertical position × four-stroke
Bore × stroke	80 mm × 110 mm
Method of cooling	Water cooled
Rated speed (constant)	1500 rpm
Fuel injection system	In-line and direct injection
Compression ratio	16:1
Aspiration	Natural
BMEP @ 1500 rpm	5.31 bar
Manufacturer's recommended injection timing and pressure	27^0 bTDC × 190 bar
Dynamometer	Electrical dynamometer
Number of holes of injector and size	Three × 0.25 mm
Type of combustion chamber	Direct injection type
Fuel injection nozzle	Make: MICO-BOSCH No- 0431-202-120/HB
Fuel injection pump	Make: BOSCH: NO-8085587/1

CJO was injected into the engine in the conventional manner, similar to that of diesel. The experimental set-up for jatropha oil operation will be same as that for diesel operation. Jatropha oil is non-edible. It can be obtained from Jatropha curcus plant, which can be grown in waste, arid lands and is not grazed by cattle. The seeds of the plant can be crushed to yield about 25% oil. The CJO has been found to be an attractive alternative fuel for diesel in C.I. engines. The properties of diesel and jatropha oil are given in Table-2.

A nozzle testing device was used to vary the injection pressure from 190 bar to 270 bar (in steps of 40 bar). Due to the practical difficulties involved, the maximum injection pressure was restricted to 270 bar. The effect of preheating of vegetable oil, at varied injector pressures, on the performance of the engine was studied. The results were compared with that of the diesel operation. A temperature indicator was used to measure the exhaust gas temperatures (EGT).

The smoke and NO_X are the main emissions from a diesel engine and they were measured by smoke meter and NO_X Analyzer respectively, at full load operation of the engine. The specifications of analyzers are given in Table-3.

Table-2: Properties of test fuels

Test Fuel	Kinematic Viscosity at 40^0C (mm^2/s)	Specific gravity at 15^0C	Cetane number	Lower Calorific value (kJ/kg)
Diesel	3.07	0.84	55	42000
CJO	31.05	0.92	48	36000

Table-3: Specifications of analyzers

Name of the analyzer	Principle of operation	Measuring Range	Precision	Resolution	Accuracy
AVL Smoke meter	Opacity	0-100 HSU	1 HSU	1 HSU	±1 HSU
Netel Chromatograph NO_X Analyser	Chemilucency	0-2000 ppm	2 ppm	1 ppm	±5 ppm

3. RESULTS AND DISCUSSION

The experiments were carried out with CJO operation at normal and preheated temperatures, with varied injection pressures of 190 bar, 230 bar and 270 bar. The results were compared with diesel operation at manufacture's recommended injection pressure of 190 bar. The investigations for evaluating the performance of the engine was categorized into two parts – (i) evaluation of performance parameters and (ii) measurement of exhaust emissions.

3.1 Performance Parameters

The part load variations of the parameters with respect to BMEP were small; hence bar charts were drawn for the performance parameters at full load operation of the engine with CJO operation.
The Fig.2 shows the bar chart, giving the variation of peak BTE at normal and preheated condition of vegetable oil with varied injection pressures. CJO operation gave lower BTE when compared with diesel operation because of low volatility, high viscosity and low calorific value of CJO. The peak BTE is lower by 11% for CJO operation compared with diesel operation at injector pressure of 190 bar. Increase of ignition delay with CJO operation might have contributed for the inferior performance.
From the same Figure, it is evident that the peak BTE of CJO operation increased with the increase of injection pressure. This was due to improved spray characteristics of the fuel with increased injection pressure. It is also evident from the figure that the peak BTE increased with the preheated condition of vegetable oil when compared with that of the normal condition. This was due to the decrease of viscosity of CJO at higher temperatures. The performance of CJO at injection pressure of 270 bar with preheated condition gave comparable performance to that of diesel operation.

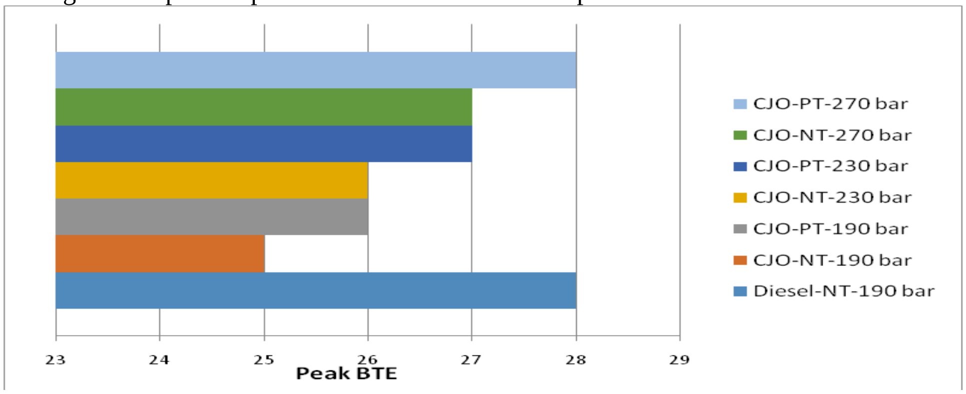

Fig.2 Bar chart showing the variation of BTE at full load operation

As fuels with different calorific values were used in the investigations, brake specific energy consumption (BSEC) defined as energy supplied through the fuel per unit power output of the engine was used instead of brake specific fuel consumption (BSFC), defined as fuel consumed per unit brake power. Fig.3 shows the bar chart, giving the variation of BSEC at full load with test fuels at normal and preheated condition of vegetable oil with varying injection pressures.

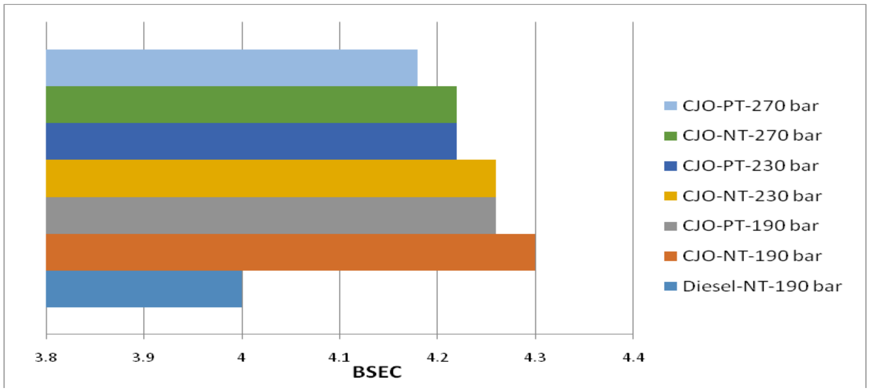

Fig.3 Bar chart showing the variation of BSEC at full load operation

It is evident from the Fig.3, that BSEC with CJO operation is higher than that of diesel operation. At an injection pressure of 190 bar, the BSEC for CJO operation was higher by 7.5% in comparison with diesel operation. Poor volatility, high viscosity and low calorific value of the CJO lead to deterioration in performance. BSEC at full load operation decreased with an increase of injection pressure. This was due to decrease of mean diameter of the droplet with increased injection pressure.

BSEC decreased with the preheated vegetable oil when compared with normal vegetable oil operation. Preheating of the vegetable oil reduced the viscosity, which improved the spray characteristics of the oil. BSEC was lower with diesel operation followed by crude vegetable oil at recommended injection timing. This was due to high calorific value and improved spray characteristics of the diesel fuel with high cetane value of the fuel in addition to its low viscosity.

The Fig.4 gives the bar chart, showing the variation of EGT at normal and preheated conditions of vegetable oil with varying injection pressures. CJO operation gave higher value of EGT compared with Diesel operation. Though the calorific value of CJO was less than that of diesel, the density of the vegetable oil was higher and therefore, greater amount of heat was released in the combustion chamber leading to higher EGT with CE, which confirmed that performance deteriorated in CE with CJO operation in comparison with diesel operation. This might also be because of high duration of combustion of vegetable oil causing retarded heat release rate. From the figure, it is noticed that, with CJO operation, the EGT at full load increased by 23% at injector pressure of 190 bar when compared with diesel operation.

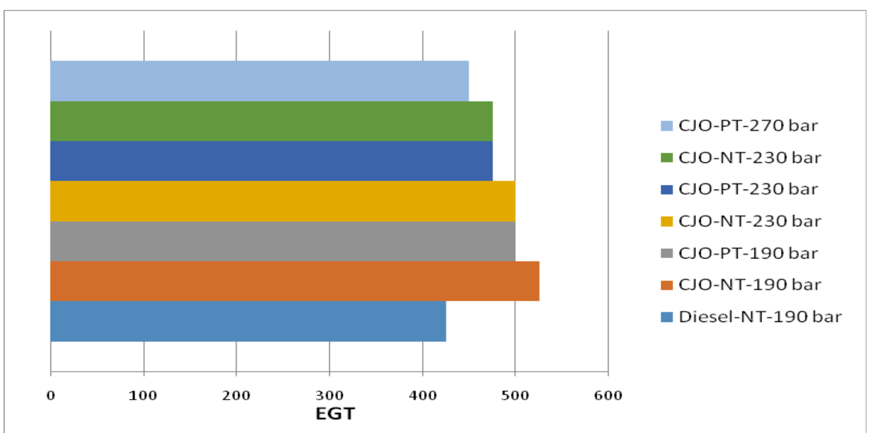

Fig.4 Bar Chart Showing The Variation Of EGT

With the increase of injection pressure, the EGT of CJO operation decreased. This might be due to the increased penetration of fuel particles into the air zone at higher injection pressures. It is also evident from the figure that the EGT decreased with the preheated condition of vegetable oil when compared with that of the normal condition. This was due to the decrease of viscosity of CJO at higher temperatures.

The Fig.5 gives the bar chart, showing the variation of volumetric efficiency with test fuels at normal and preheated condition of vegetable oil with varying injection pressures. From the figure, it is observed that, volumetric efficiency was lower with CJO operation than with diesel operation. This might be because of higher cylinder temperatures with CJO operation.

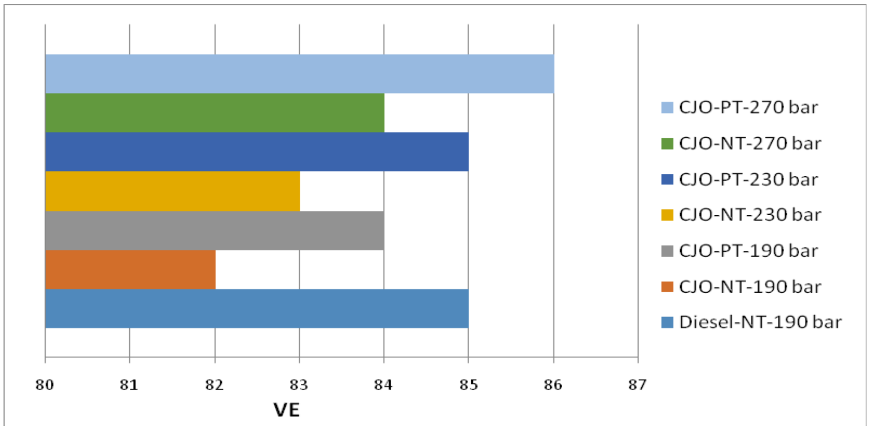

Fig.5 Bar Chart Showing The Variation Of Volumetric Efficiency

With the increase of injection pressure, the VE of CJO operation increased. This was due to improved fuel spray characteristics and evaporation at higher injector opening pressures leading to marginal increase of volumetric efficiency. Also the VE increased with the preheated CJO compared to normal CJO operation.

3.2 Exhaust Emissions

The Fig.6 gives the bar chart showing the variation of smoke in Hartridge Smoke Unit (HSU) with test fuels at normal and preheated condition of vegetable oil with varying injection pressures. From the figure, it is observed that CJO operation gave higher values of smoke emissions when compared with diesel operation. Smoke levels increases linearly with density of the fuel and increase of carbon to hydrogen atoms (C/H) ratio provided the equivalence ratio is not altered. The density of diesel and CJO are 0.84 and 0.92 respectively. High value of C/H ratio would lead to more concentration of carbon dioxide, which would be further reduced to carbon. The C/H values of diesel and CJO are 0.44 and 0.53 respectively. So the CJO operation gave higher smoke values compared to diesel operation.

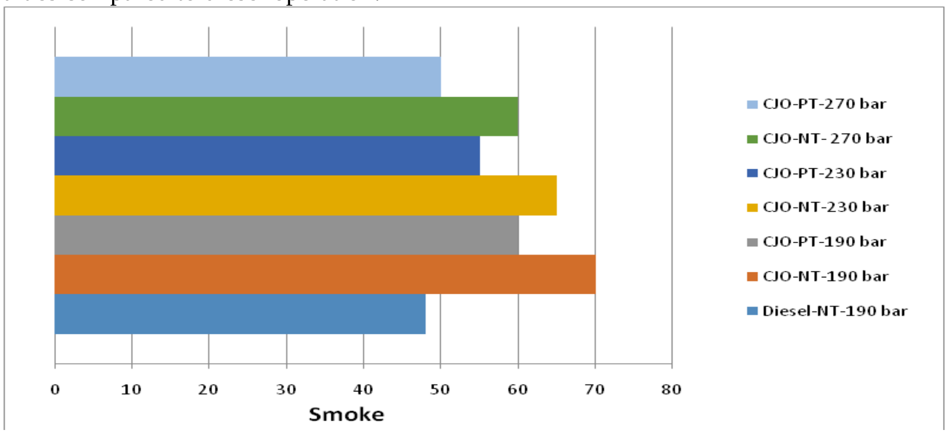

Fig.6 Bar Chart Showing The Variation Of Smoke Levels

Smoke levels decreased at preheated condition compared to normal condition of CJO. This is due to decrease of viscosity and density of vegetable oils at preheated condition. Smoke levels further decreased with an increase of injection pressure, due to efficient combustion at higher injection pressures, which improved the atomization with the reduction of mean diameter of the fuel particle.

The Fig.7 gives the bar chart showing the variation of nitrogen oxide (NO_X) with test fuels at normal and preheated condition of vegetable oil with varying injection pressures. The presence of higher temperatures and the availability of oxygen are factors for the NO_X formation. From same Table, it was observed that NOx emissions decreased with CJO when compared with diesel operation at recommended injection timing of 190 bar.

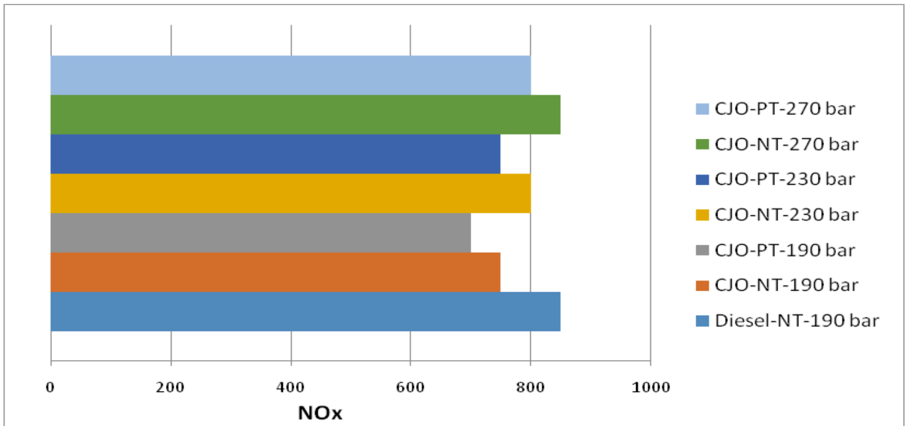

Fig.7 Bar Chart Showing The Variation Of NO_X Levels

NO_x emissions increased with the increase of injector opening pressure due to increase of fuel-air mixing rate, heat release rate during the premixed-combustion and mixing-controlled combustion phases. NO_X emissions decreased with the preheated condition of the CJO compared to normal condition of CJO.

4. CONCLUSION

[1]. The CJO operation showed the deterioration in the performance when compared with diesel operation. It gave lower BTE, higher BSEC, higher EGT, lower volumetric efficiency at recommended injection timing.

[2]. The performance of the engine improved with preheated condition of the CJO when compared with normal condition.

[3]. The preheated vegetable oil at higher injection pressure gave comparable performance to that of diesel operation at recommended injection pressure.

[4]. The performance increased with increase of injection pressure with CJO operation.

[5]. CJO operation gave higher values of smoke emissions and lower values of NOx emissions when compared with diesel operation

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