Effect of Injection Pressure on the Performance and Emission Characteristics of CI Engine using Canola bio-diesel

[1] Anbarasu. A, [2] Muturaman. V, [3] Suthan. R, [4] Poyyamozhi. N
[1,2]Professor, Dept. of Mechanical Engineering, Panimalar engineering college, Chennai, India
[3,4]Asst.Professor,Dept.of Mechanical Engineering,Panimalar engineering college,Chennai, India

Abstract- **Due to the increasing demand for fossil fuels and environmental threat, a number of renewable sources of energy have been studied worldwide. An attempt is made to assess the suitability of vegetable oil for diesel engine operation, without any modifications in its existing construction. One of the important factors which influence the performance and emission of diesel engine is fuel injection pressure.The objective of this paper is to conduct the experiment to study the performance and emission characteristics of a single cylinder, 4 stroke, constant speed, and water cooled diesel engine running with diesel and blends of canola biodiesel at four fuel injection pressures of 180 bar, 200 bar, 220 bar and 240 bar. The injection pressure was changed by adjusting the fuel injector spring tension.The performance and emission characteristics were presented graphically and concluded that increase in injector opening pressure increases the brake thermal efficiency and reduces unburned hydrocarbon and Noxemissions significantly.**

Key words: Diesel engine, injection pressure, canola oil, performance, emission, combustion characteristics

I. INTRODUCTION

Developing countries are required to meet their petroleum demand on depend on other countries.Due to increase in population of vehicles the energy demand is increasing day by day. Diesel engines are chosen for transportation vehicles because of theirits intrinsic advantages of better fuel economy and high part load efficiency. With the rising cost of petroleum a major part of foreign exchange is utilized for importing petroleum. For this reason the countries are forced to search for substitute fuel for diesel engines. The straight vegetable oils can be used as a alternate fuel in diesel engines, but it have some disadvantages like gumming, sticking of piston and cylinder due to heavier hydrocarbon chain[1].The another important is viscosity of these oils also compared to that of diesel which leads to atomization and combustion problems. Preheating oil is the one method to reduce the viscosity [2] using straight vegetable oilsas a fuel. The results with preheating and without preheating show that with preheating of straight vegetable oil gives better performance compared to that of diesel. Splitting of the heavier compounds by a chemical process is the one more way of reducing the viscosity of oil. In this process the oil reacts with alcohol (methyl or ethyl) in presence of a catalyst (sodium hydroxide/ potassium hydroxide) and produces a product called as methyl or ethyl ester, which has properties comparable to that of diesel, and it is known as Biodiesel.This process is known ‘transesterification’. The biodiesel produced from canola with a yield of 95% using methanol and potassium hydroxide as a catalyst.The viscosity of the oilreduced to 5.38 Cst(at 40°C) by using transesterification and the flash point was 172°C. The use of vegetable oils and their methyl esters in a single cylinder diesel engine were studied [3].
They have used raw sunflower, cottonseed, soybean oils and their methyl esters. Their results specify a reduction in NOx emission and methyl esters are better than raw oils due to their intrinsic property of high density, higher viscosity, gumming and lower cetane number. The tests on a single cylinder C.I. engine was conducted with 3 different biodiesels viz methyl esters of honge, jatropha and sesame are reported[4]. All the fuels gave a considerably lower efficiency. HC and CO emissions were slightly higher and NOx emission decreased by about 10%. They have reported that these oils can be used without any major engine modifications.The nonedible vegetable oils such as putranjiva, karanja and jatrophaare used as fuel in a single cylinder diesel engine [5]. One of the chemical process called as degumming are used to remove the impurities by using concentrated phosphoric acid to get better its viscosity, cetane number and combustion characteristics.They have reported that jatropha gives better performance. Without any engine modification the test were conducted. The forecast of biodiesel production from vegetable oils in India were discussed [6], the yield and production cost of various methyl esters also given. Compare to petroleum fuels the methyl esters of nonedible oil are much cheaper. Depending on the engine size and type of combustion system employed the fuel injection pressure varies from the range of 200 to 1700 atmin a standard diesel engine [7]. The fuel diffusion distance turns into longer and the mixture formation of the fuel andalso combustion period became shorter when air was improved as the injection pressure becomes higher [8].
In this study, diesel oil and the blends of Canola Biodiesel at four fuel injection pressures of 180 bar, 200 bar, 220 bar and 240 bar were taken as fuels in a four-stroke single cylinder diesel engine. The engine speed was taken in a range of

1500 rpm. The engine performances and the emissions were considered.

II. MATERIALS AND METHODS

2.1 Preparation of biodiesel

Transesterification process is one of the method to convert canola oil into its methyl ester. In this process involves the triglycerides of Canola oil is allowed to react with methyl alcohol along with NaOH catalyst to produce glycerol and fatty acid ester. The ester has lower viscosity because the molecular weight of ester molecule is approximately one third that of oil molecule [9]. Due to low cost and physicochemical advantages with triglycerides and alkalies the methanol is used and also it is easily dissolved in it. When compare to acid catalyzed transesterification process the Alkali catalyzed transesterification process is faster one and it is most commonly and commercially used. a known value of (800 ml) canola oil mixed with 200 ml methanol along with 1.5g of sodium hydroxide and this solution was poured in a round bottom flask. This mixture were stirrer well until the ester formation began at the same time the mixture is heated to 70^{o}c.

Then it was allowed to cool overnight without stirring. Two layers are formed. The bottom layer consists of glycerol and top layer was the ester.

2.2. Experimental Setup and Procedure

The performance tests for the stable Diesel-biodiesel are carried out on a computerized single cylinder four stroke direct injection variable compression ratio engine. The Table shows the specification of the engine. No modification or alteration has been made in the engine. The experimental setup consists of a variable compression ratio engine is coupled to an eddy current dynamometer.The specification of the engine is shown in Table1. During the engine test in order to collect, store and analyze the data a computerized data acquisition system is used. To measure cylinder gas pressure and the corresponding crank angleKistler piezoelectric pressure transducer and a crank angle encoder are used. A load cell is connected to eddy current dynamometer to measure the apply load on the engine. To measure the fuel flow two infra red optical sensors fixed to a burette used and an air flow sensor measure the inlet air flow rate, to measure inlet air and exhaust gas temperatures thermocouples are used. the exhaust gas constituents such as CO, HC, NO are measure by a AVL DIGAS analyzer and the smoke is measured using the AVL smoke meter.The experiments are conducted at the compression ratio of 17.5 and the results are recorded under steady state conditions.

Table 1.Specification of the engine.

Brake Power	3.7 kW
Speed	1500 rpm
npression ratio	17.5 (Variable)
Bore	80 mm
Stroke	110 mm
Ignition	Compression ignition
Cooling	Water cooled
oading System	ly current dynamometer

The fuels which have been used in this study are: Commercial diesel (D) and a blend of 20% biodiesel (B20), 40% biodiesel (B40), 60% biodiesel (B60) and 100% biodiesel (B100). The main properties of the test fuels are given in Table2.

Table 2. Properties of Canola biodiesel

Acidity as mg of KOH/gm	0.01
Density (kg/m^3)	886.5
Viscosity at 40 ^{o}C in cst	5.38
Gross calorific value (KJ/kg)	38758
Cetane number	48
Sulfur content (mg/L)	< 50ppm
Flash point	172^{o}c
Fire point	186^{o}c

The investigation was conducted at constant speed of 1500 rpm. The load applied to engine is through eddy current dynamometer and strain gauge was used to measure the load. The fuel injection pressure was set to 180 bar, 200 bar,220 bar and 240 bar. By adjusting the injector spring tension the Injection pressure was changed. The air flow was measured with an air manometer surge tank set which has orifice diameter of 20 mm.A blend of 20% biodiesel and 80% diesel (by volume) is denoted by B20. The performance parameters, efficiency and brake specific fuel consumption (BSFC) are compared.

III. RESULTS AND DISCUSSIONS

3. 1. Performance characteristics

3.1.1. Brake Thermal Efficiency (BTE)

At full load it was found that the highest brake thermal efficiency was obtained at 240 bar but this was decreases for lower pressure due to its lower calorific value.at higher injection pressure more quantity of fuel was injected so that the brake thermal efficiency is increased. The value of BTE is maximum at 240bar because during injectionfine spray formed and improvedatomization is shown in Figure 1.The brake thermal efficiency at all loads in injection pressure of 180, 200, 220 and 240 bar are shown in Figure-1.The reason for increasing BTE when increasing the injection pressure due to the reduction in the viscosity, improvedatomization and bettercombustion. the highest value of brake thermal efficiency for canola oil at240 bar pressure is 31.3% and it is close to diesel fuel efficiency (31.26%) at full load condition [13][14]

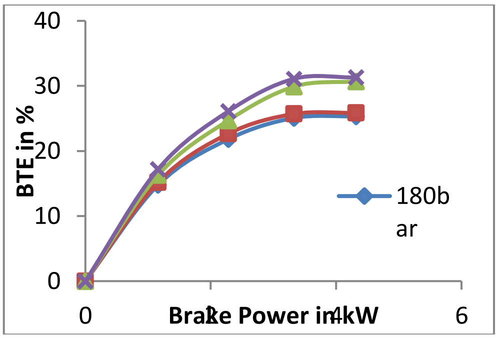

Figure 1. Load VsBrake Thermal Efficiency for differentinjection pressures of biodiesel

3.1.2. Brake Specific Fuel Consumption

The The deviation of brake specific fuel consumption at different loads at different injection pressure 180, 200, 220 and 240 bar are given in Figure-2. The effect of injection pressure on brake specific fuel consumption was found decreasing at the full loadin the order 180-200-220-240 bar. When fuel injection pressure is increased the BSFC decreases and BTE increases .It is found that specific fuel consumption deteriorating with increasing injection pressure for a heavy duty direct injection diesel engine [10].Also that the brake specific fuel consumption found increasing with injection pressure both in fixed load-variable engine speed and fixed engine speed-variable load tests [11]

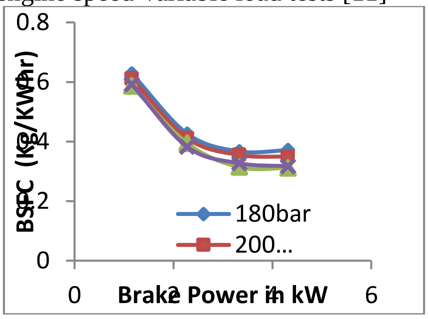

Figure 2. Load VsBrake specific fuel consumptionfor differentinjection pressures of biodiesel

3.2. Emissions characteristics

3.2.1 CO_2 emissions

The percentage of CO_2 in the exhaust gas was lower in the injection pressure 240 bar shown in figure3. From the graph it was observed that the percentage of CO_2 is in decreasing trend at all the loads in the order of 220-180- 200-240 bar fuel injection pressure.

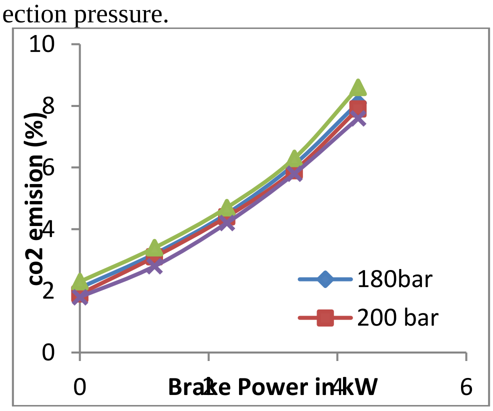

Figure 3. Load VsCO2 emission for differentinjection pressures of biodiesel

3.2.2 NO emissions

The main reason for NOX development isdependent upon the availability of oxygen during combustion and cylinder gas temperature. In The NOX emission for the light duty direct injection diesel engine was found lowest at 200 bar injection pressure from this study and it was found that decreasing in the order 240-220-180-200 bar injection pressure[12] at all loads as shown in Figure-4.

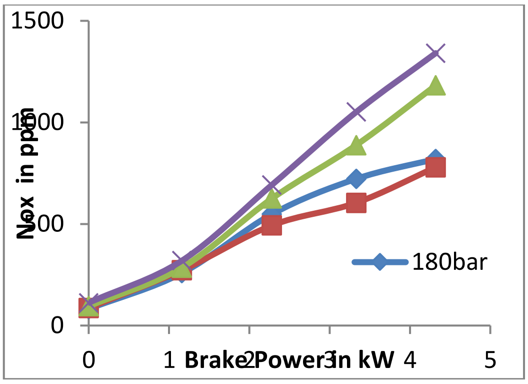

Figure 4. Load VsNOx emission for differentinjection pressures of biodiesel

3.2.3 HC emissions

The HC emission for canola biodiesel is found lower than the diesel fuelfrom Fig.5,this is because due the heavier hydrocarbon particles that are present in diesel fuel increase HC emissions. The HC emission deviation in the exhaust gases at various injection pressure of 180,200,220 and 240 bar at all the loads are shown in fig.5 and it was found that increasing trend in the order 200-180-240-220 bar injection pressure.

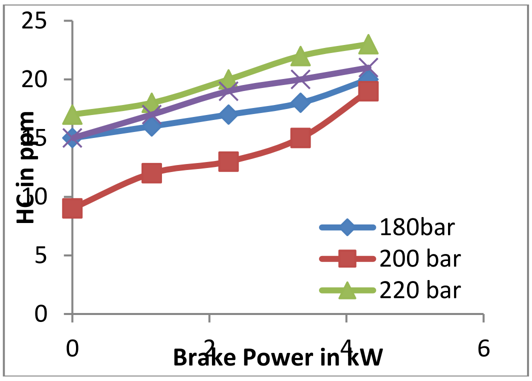

Figure 5. Load VsHydro carbon emission for differentinjection pressures of biodiesel

IV. CONCLUSIONS

For electrical power generation and agricultural water pumping the light duty diesel engines ar normally used. From this experimental study, the effect of injection pressure on the engine performance parameter such as brake thermal efficiency found increasing trend and brake specific fuel consumption found decreasing trend in the order of 180-200-220-240 bar injection pressure at full load. On the other hand at 240 bar injection pressure has higher brake thermal efficiency and lower brake specific fuel consumption was obtained and the percentage of improvement was very less.

The increasing injection pressure gave insignificant effect on engine performance.

At full load CO_2 and NOx emissions were found the lowest at 240 bar and 200bar and HC emission were found lowest at 200 bar.

Fuel economy is essential for engine andthe environmental protection is more important than fuel economy. Due to this reason the decreasing emission is the primary concern which demands moderate injection pressure for a light duty diesel engine.

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