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Effect of Injection Pressures on the Performance and Emission Characteristics of C I Engine with Cotton Seed Oil Methyl Ester

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Abstract: The world's rapidly dwindling petroleum supplies, their rising cost and the rapid growing of automobile have led to an intensive search for alternative fuels to replace diesel fuel. Agriculture and transport sectors consume maximum percentage of petroleum based fuels, where diesel engine happens to be the prime mover. There is a variety of alternative fuels available as renewable fuels to replace diesel. Vegetable oils and their properties being close to diesel so it may be considered as a promising alternative fuel for the diesel. The high viscosity and low volatility of these vegetable oils are the major problems when they use in diesel engines. Such type of problem can be addressed by the process of transesterification. In the present work, experiments were conducted on four stroke, single cylinder diesel engine using cotton seed oil methyl esters as fuel to study the engine performance and emission at different injection pressure. The effect of injection pressure on the performance and emission was studied at three different test pressures. Non edible cotton seed oil bio diesel was tested for their use as substitute fuels for diesel engines. The results showed a better performance at an injection pressure of 200 bar.

Keywords: Cotton Seed Oil Methyl Ester; CI Engine; Injection Pressure, Performance Characteristics and Emission.

I. INTRODUCTION

Energy from other than fossil fuel is an essential input for economic development of a country. The importance of an alternative fuel was recognized in the early 1900s by Dr. Rudolph diesel. Development and promotion of alternative fuel for compression ignition engine such as vegetable oil, is gaining sustained attention. Vegetable oils are becoming a promising alternative to diesel fuel because they are renewable in nature and can be produced locally are environmental friendly. They can be used in diesel engines as a straight replacement fuel for diesel after pre-treatment by transesterification process because of their much higher viscosity. In India only non edible oil can be used as a raw material for bio diesel production. These non edible oil seeds plants can be grown in non fertile land and waste lands. In our country these lands are much available. Non edible oil seed like jatropha curcus, cotton seed, pongamia pinnata, saemaruba etc., contains oil in seed. In our country there are more than 300 species of trees, which produce oil bearing trees [1, 2 and 3].

II. PREPARATION OF BIO DIESEL

Transesterification is a chemical process of transforming large, branched, tri-glyceride molecules of vegetable oils and fats into smaller, straight chain molecules, almost similar in size to the molecules of the species present in diesel fuel. The process takes place by the reaction of vegetable oil with alcohol in the presence of a catalyst. NaOH is used as a catalyst to improve the reaction rate and yield. Among the alcohols, methanol or ethanol are used commercially because of their low cost and their physical and chemical advantages. They quickly react with triglyceride and NaOH and are easily dissolved in them. A mixture of vegetable oil and NaOH are heated

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and maintained at 65^{0}C for 1 hour, while the solution is continuously stirred. Two distinct layers are formed, the lower layer is glycerine and the upper layer is ester. The upper layer is separated and moisture is removed from the ester by using calcium chloride [4, 5 and 6].

III. PROPERTIES COTTON SEED OIL

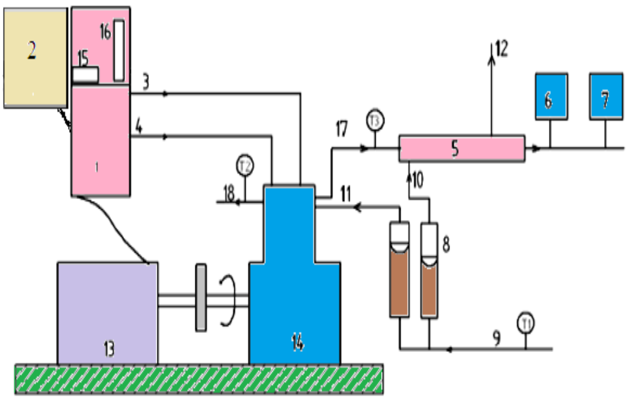
The fuel properties of diesel, raw cotton seed oil and cotton seed oil methyl ester (COME) were measured in the laboratories. The properties of these oils are shown in Table 1 [3 and 4].

Table 1: Properties of Diesel, Raw Vegetable Oils and its Methyl Ester

Properties	Diesel	Raw Cotton Seed Oil	Cotton Seed Oil Methyl Ester
Density (kg/m^3) at 40^{0}C	828	941	890
Specific Gravity at 40^{0}C	0.828	0.912	0.872
Kinematic Viscosity (centi tokes) at 40^{0}C	3.0	50	4.2
Calorific Value (kJ/kg)	42960	39600	40600
Flash Point (^{0}C)	56	220	142
Fire Point (^{0}C)	63	253	176
Iodine Value (gm I_2/kg)	38.3	96.4	100
Saponification Value	Nil	193.2	100

IV. EXPERIMENTAL SET UP

The experimental set-up and schematic diagram of the present work with various components is shown in Figures 1. The experimental work carried out for the objectives, requires an engine test set up adequately instrumented for necessary performance and emission characteristics and optimization of injection pressure of cotton seed oil methyl ester and pure diesel fuel blend (20% Bio diesel and 80% Diesel) were used to test a TV1, Kirloskar, single cylinder, 4-Stroke, water cooled diesel engine having a rated output of 10 HP at 1500 rpm and a compression ratio of 17.5:1. The engine was coupled with an eddy current dynamometer to apply different engine loads.



1 = Control Panel, 2 = Computer system, 3 = Diesel flow line, 4 = Air flow line, 5= Calorimeter, 6 = Exhaust gas analyzer, 7 = Smoke meter, 8 = Rota meter, 9= Inlet water temperature, 10= Calorimeter inlet water temp., 11= Inlet water to engine jacket, 12 =Calorimeter outlet water temp., 13 = Dynamometer, 14 = CI Engine, 15 = Speed measurement, 16 = Burette for fuel measurement, 17 = Exhaust gas outlet, 18 = Outlet water from engine jacket, T1= Inlet water temperature, T2 = Outlet water temperature, T3 = Exhaust gas temperature.

Figure 1: Schematic Diagram of the Experimental Set-up.

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V. RESULTS AND DISCUSSION

A. Effect of Injection Pressure on Engine Performance

(i). Brake thermal efficiency (BTE)

Variation of BTE for compression ratio of 17.5:1 with Brake mean effective pressure (BMEP) at different injection pressure (IP) for COME is shown in Figure 2 and 3. The BTE of COME increases with increase in BMEP but the BTE for COME at 220 bar is less than other lower pressures, this is due to poor atomization and blending of vegetable oils with diesel.

The BTE is increased with increase in IP due to the reduction in the viscosity, improved atomization and better combustion. The BTE is maximum at 200 bar, this is due to fine spray formed during injection and improved atomization is shown in Figure 3. Further the BTE tends to decrease, this may be due to that at higher IP the size of fuel droplets decreases and very high fine fuel spray will be injected, because of this, penetration of fuel spray reduces and momentum of fuel droplets will be reduced. The maximum break thermal efficiency of COME at 200 bar pressure is 33.21% and it is very close to diesel fuel efficiency at full load condition [7 and 8].

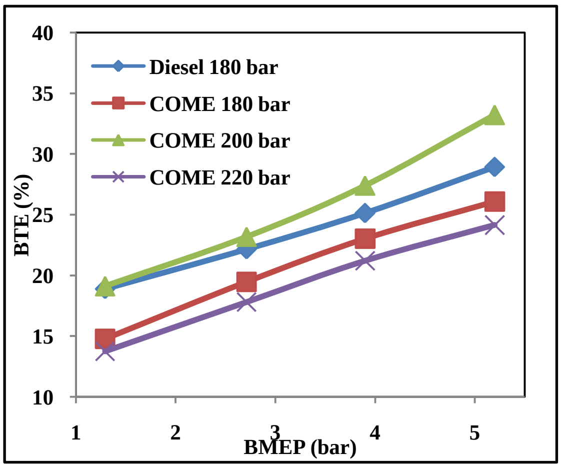

Figure 2: Variation of BTE Vs BMEP

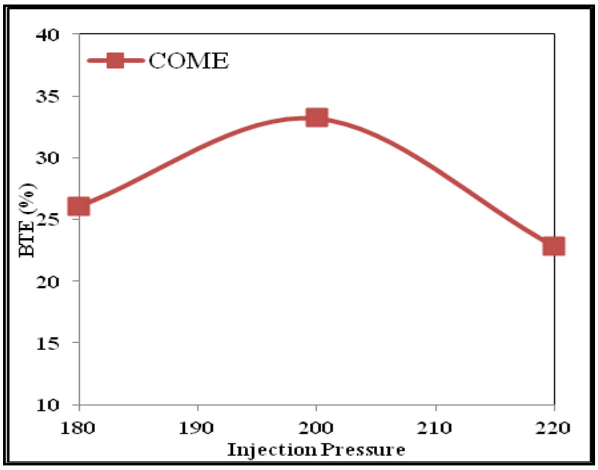

Figure 3: Variation of BTE Vs IP

(ii). Brake specific fuel consumption (BSFC)

Variation of BSFC with BMEP at different IP is shown in Figures 4 and 5. The BSFC decreases with increase in BMEP is shown in Figure 4. The BSFC of COME is higher than diesel; it may be due to lower calorific value of bio diesel. Figure 5 shows the variation of BSFC with varying IP for COME. It is found that the BSFC is decreased with increase in IP up to 200 bar. This may be due to that, as IP increases the penetration length and spray cone angle increases. From Figure 5, BSFC for COME is 0.268 kg/kW-hr at 200 bar and increase in IP from 180 to 220 bar, the BSFC is increased to 0.39 kg/kW-hr [8 and 9].

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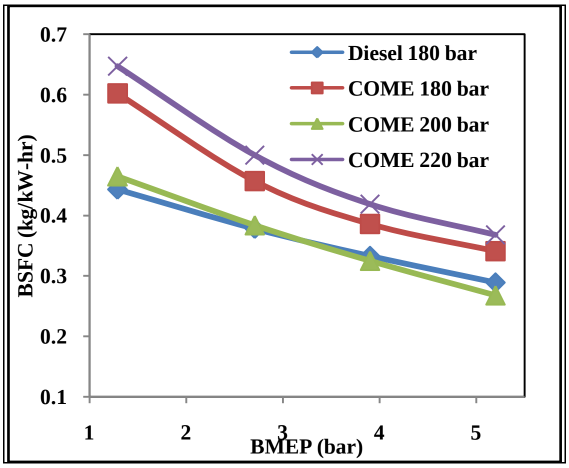

Figure 4: Varitation of BSFC Vs BMEP

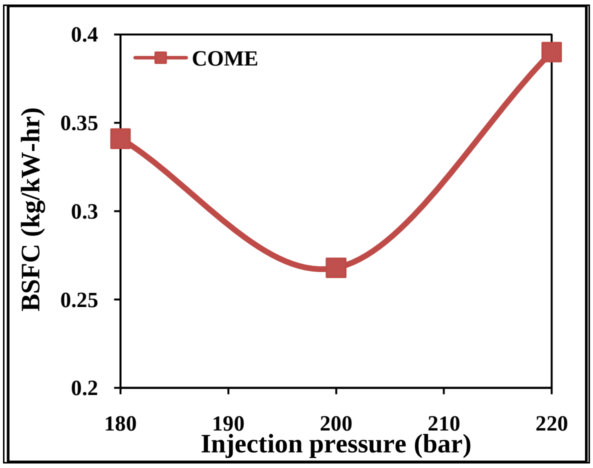

Figure 5:Varitation of BSFC Vs IP

B. Effect of Injection Pressure on Emission

(i) Unburnt hydrocarbons (UBHC)

Figures 6 and 7 shows the variation of UBHC with BMEP. The UBHC is increased with increase in BMEP for COME. It is observed from Figures 6, that the UBHC emissions for COME is lower than the diesel fuel, indicating that the heavier hydrocarbon particles that are present in diesel fuel increase UBHC emissions. The UBHC emission of COME at full load is approximately 25 to 30% lower than the diesel value (70%). Hydrocarbon chains of original vegetable oil that have been chemically split off from the naturally occurring triglycerides and its one end of the hydrocarbon chains are oxygenated. The presence of oxygen in the fuel was thought to promote complete combustion that leads to lowering the UBHC emissions. This reduction indicates more complete combustion of the fuel.

As the IP increases the UBHC emission will decrease as seen in the Figure 7 for COME and at 200 bar IP there is minimum UBHC emissions. At 220 bar it seems to be an increase in UBHC which may be due to finer spray, which reduces momentum of the droplets resulting in less complete combustion. The UBHC level at full load falls down from 62 ppm to 44 ppm for COME [22 and 23].

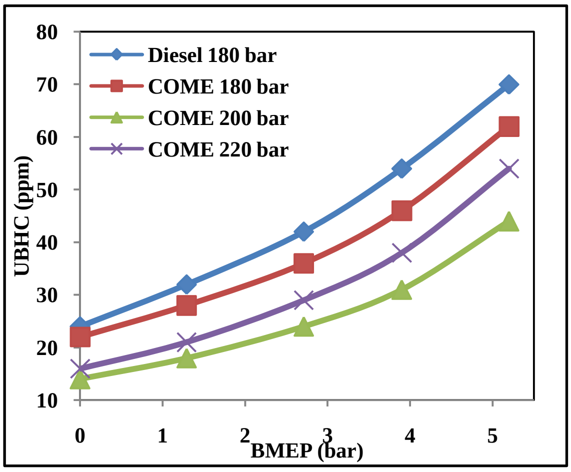

Figure 6: Variation of UBHC v/s BMEP

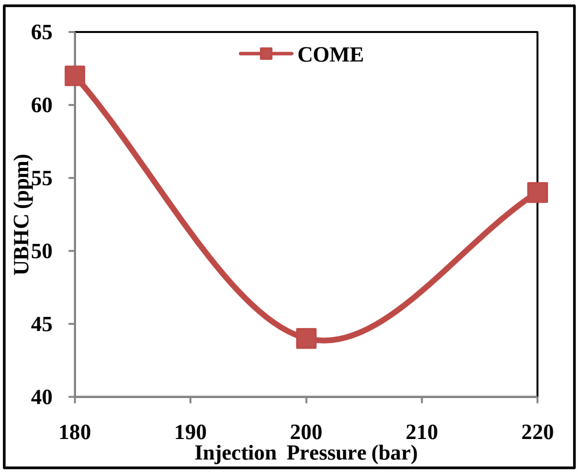

Figure 7: Variation of UBHC v/s IP

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(ii) Carbon monoxide (CO)

Variation of carbon monoxide with BMEP is shown in Figures 8 and 9. Carbon monoxide emissions from a diesel engine mainly depend upon the physical and chemical properties of the fuel. The bio diesel itself contains 11% of oxygen which helps for complete combustion. From Figures 8 it is found that the amount of CO increase at part loads and again greater increase at full load condition for COME. This is common in all internal combustion engines, since air-fuel ratio decreases with increase in load. The carbon monoxide emission increases when fuel air-ratio becomes grater. The CO emission for fuels used at full BMEP is approximately 32% lower than the diesel. The lowest CO emission is observed at 200 bar is 0.30% for COME is shown in Figure 9 [24 and 25].

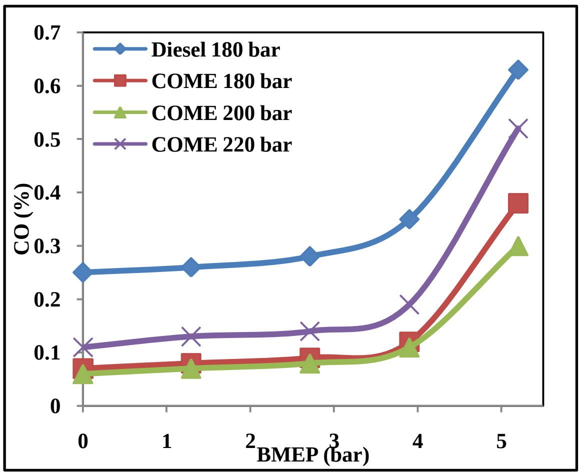

Figure 8: Variation of CO v/s BMEP

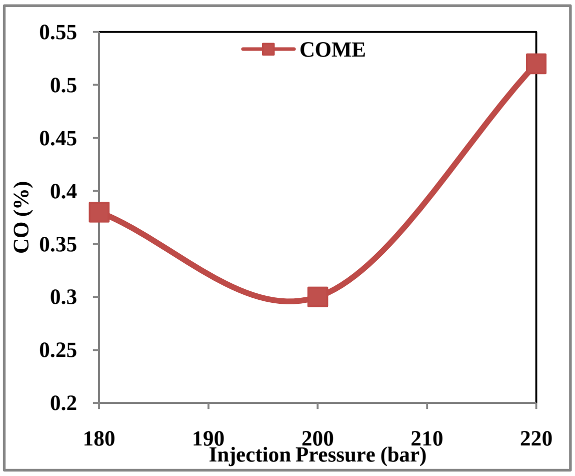

Figure 9: Variation of CO v/s IP

(iii). Oxides of nitrogen (NO_x)

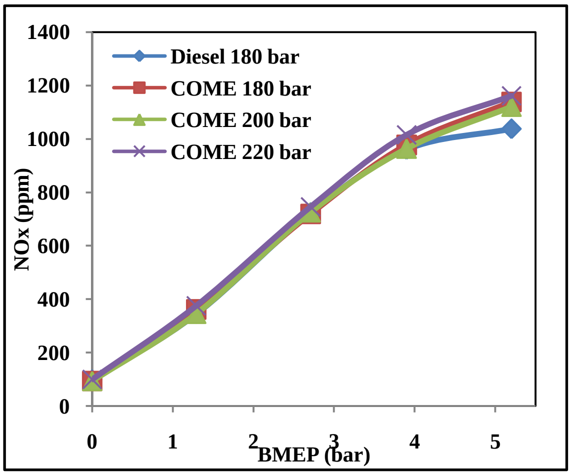

Figure 10: Variation of NOx v/s BMEP

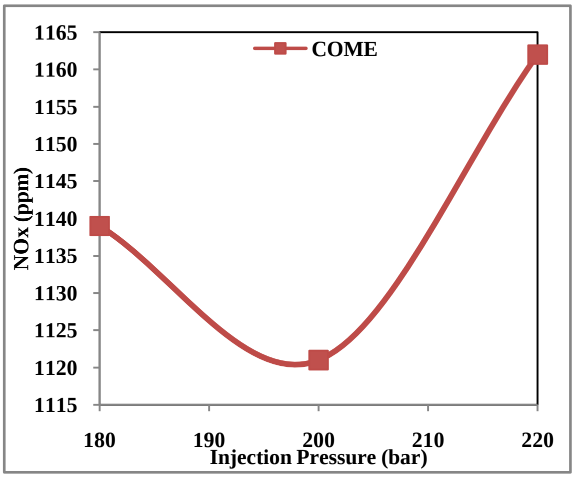

Figure 11: Variation of NOx v/s BMEP

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Variation of NO_x with BMEP is shown in Figures 10 and 11. The NOx results from the oxidation of atmospheric nitrogen at high temperature inside the combustion chamber of an engine rather than resulting from a contaminant present in the fuel. Figures 10 shows that the amount of NO_x is increased with increase in BMEP for COME, this is due to increase in temperature in combustion chamber, as NO_x formation is a strong temperature dependent phenomenon. From Figure 11, the average NOx emission in case of conditioned bio diesel is 1121 ppm at 200 bar for COME which is slightly higher than the diesel fuel (1038ppm). NO_x emissions were lower at 200 bar injection pressure indicating that effective combustion is taking place during the early part of expansion stroke [22 and 23].

(iv).Smoke opacity (SO)

Figures 12 and 13 indicate the variation of smoke opacity with BMEP. It is found that the opacity is increased with increase in load. Figures 12 shows that the opacity variation is lower for conditioned bio diesel compared to diesel fuel. The average opacity at full load for COME is 60.8%.

Figure 13 indicates the variation of opacity with IP at full load, it is observed that the higher opacity is occurred at lower IP (180 bar). Increase in IP from 180 to 200 bar for all fuels at full load, the opacity is reduced to 2 to 3%. It indicates that the variation of IP does not have much effect on opacity measurement [24 and 25].

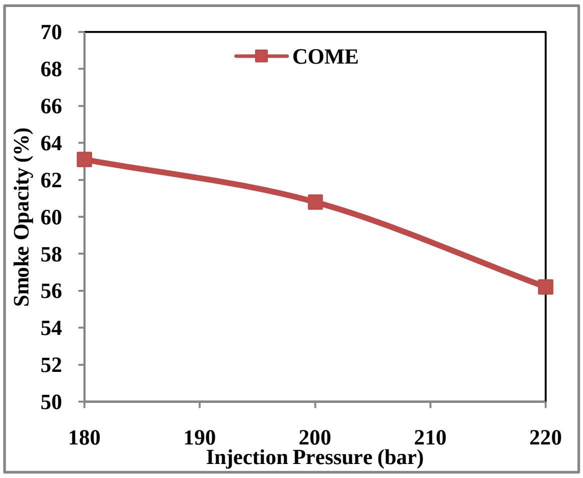

Figure 12: Variation of SO with IP

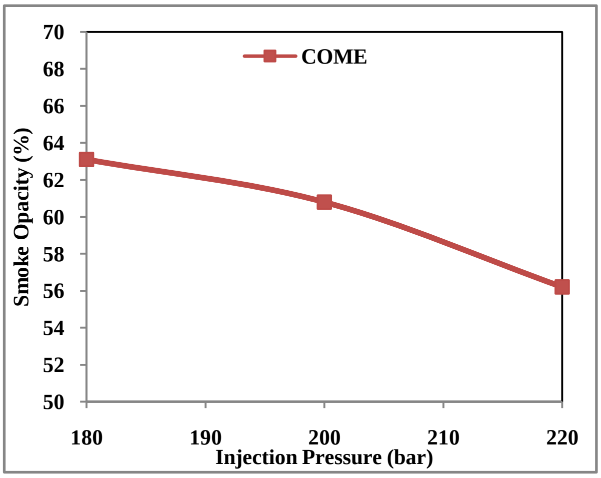

Figure 13: Variation of SO with IP

VI. CONCLUSION

1. Injector opening pressure increases from the rated value from 180 bar to 200 bar shows significant improvement in performance and emission characteristics with COME. At injector opening pressure 220 bar performance inferior than injector opening pressure 200 bar.
2. Usage of bio diesel there is a significant improvement in the performance and emission characteristics when the injector opening pressure properly optimized (say 200 bar), when a diesel engine is operated with conditioned oils of COME.

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