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PERFORMANCE AND EMISSIONS CHARACTERISTICS OF A DIESEL ENGINE WITH VARIOUS INJECTION PARAMETERS USING BIO DIESEL

Kumar P L[1], Honnegowda[2], Dr Ramesha D K[3], Rajesh A[4]
[1]Assistant Professor, Dept of Mech Engg., BIT, Bangalore, Karnataka, India
[2]Associate Professor, Dept of Mech Engg., BIT, Bangalore, Karnataka, India
[3]Associate Professor, Dept of Mech Engg., UVCE, Bangalore, Karnataka, India
[4]Assistant Professor, Dept of Mech Engg., BIT, Bangalore, Karnataka, India

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 are conducted on four stroke, single cylinder diesel engine using cotton seed oil methyl esters as fuel to study the engine performance at different injection pressures. The effect of injection pressure on the performance was studied at three different test pressures. Non edible cotton seed bio diesel blended with diesel were tested for their use as substitute fuels for diesel engines. The results showed a better performance with 20% bio diesel and 80% diesel fuel at an injection pressure of 200 bar and injection timing 30^0 bTDC.
Keywords: Cotton Seed Oil Methyl Ester; CI Engine; Injection pressure; Injection Timing; Performance Characteristics

1. 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 environmentally friendly. They can be used in diesel engines as a straight replacement fuel for diesel fuels after

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pre-treatment because of their much higher viscosity by transesterification process. 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.

2. 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 tri-glyceride and NaOH and are easily dissolved in them. A mixture of vegetable oil and sodium hydroxide are heated and maintained at 65^0C 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. It is observed that 90% ester can be obtained from vegetable oils.

3. 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.

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 40^0C	828	941	890
Specific Gravity at 40^0C	0.828	0.912	0.872
Kinematic Viscosity (centi stokes) at 40^0C	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

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Iodine Value (gm I_2/kg)	38.3	96.4	100
Saponification Value	Nil	193.2	100

4. EXPERIMENTAL SET UP

The schematic diagram of the present work experimental set up with various components is shown in Figure 1. The experimental work carried out using Kirloskar, single cylinder, 4-stroke, water cooled diesel engine having a rated output of 5.2 kW 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.

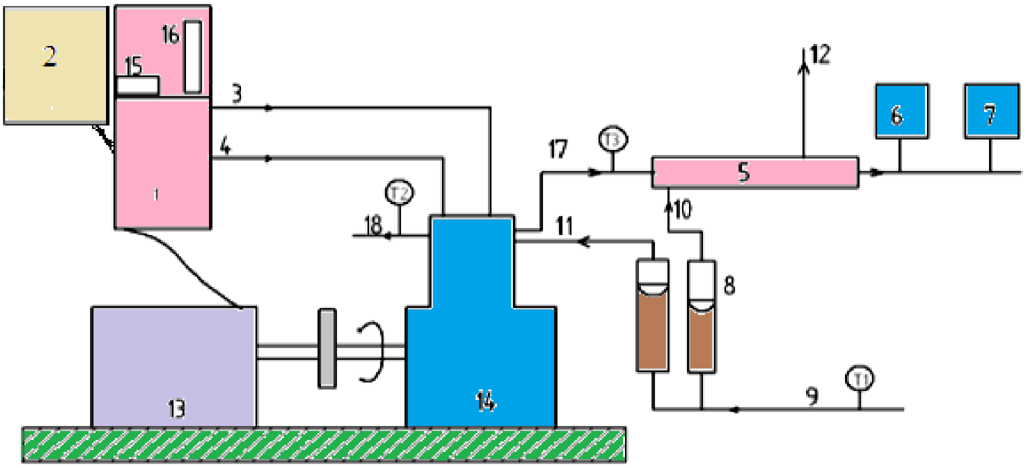

Fig 1: Schematic Diagram of the Experimental Set up

1 = Control Panel, 2 = Computer system, 3 = Diesel flow line, 4 = Air flow line, 5= Calorimeter, 6 = Exhaust gas analyser, 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.

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5. RESULTS AND DISCUSSION

5.1 EFFECT OF INJECTION PRESSURE ON ENGINE PERFORMANCE

i) Brake thermal efficiency (BTE)

Variation of BTE for compression ratio of 17.5:1 with BMEP (Brake mean effective pressure) at different injection pressure for methyl esters of cotton seed oil (COME) and at IT 27^0 bTDC is shown in Figure 2. 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.

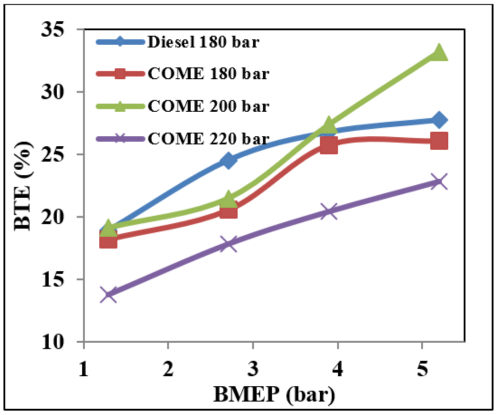

Fig 2: Variation of BTE Vs BMEP

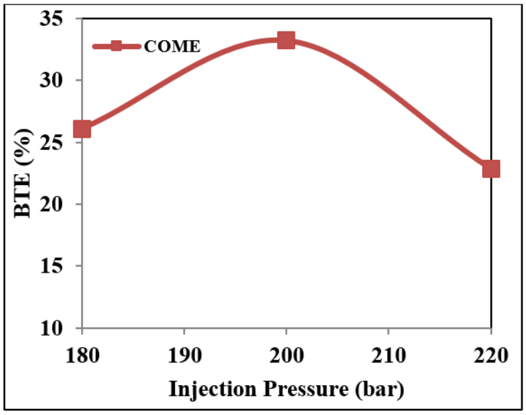

Fig 3: Variation of BTE Vs Injection Pressure

The BTE is increased with increase in injection pressure 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. Further the BTE tends to decrease, this may be due to that at higher injection pressure 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.

ii) Brake specific fuel consumption (BSFC)

Variation of BSFC with BMEP at different injection pressure is shown in Figures 4 and 5. The Figure 4 shows that the BSFC decreases with increase in BMEP. 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

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BSFC with varying injection pressures for COME. It is found that the BSFC is decreased with increase in injection pressure up to 200 bar. This may be due to that, as injection pressure increases the penetration length and spray cone angle increases. From the Figure BSFC for COME is 0.268 kg/kW-hr at 200 bar and increase in injection pressure from 180 to 220 bar, the BSFC is increased to 0.39 kg/kW-hr.

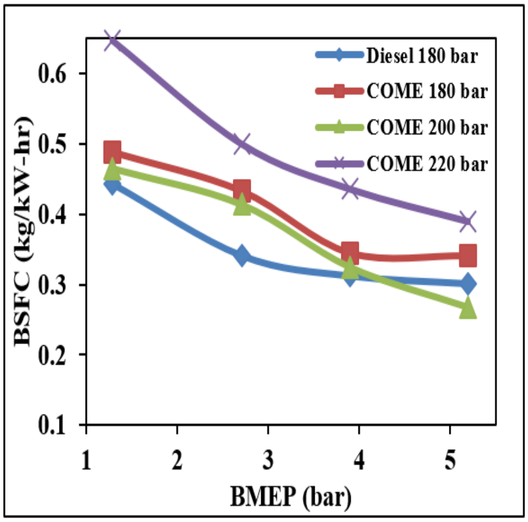

Fig 4: Varitation of BSFC Vs BMEP

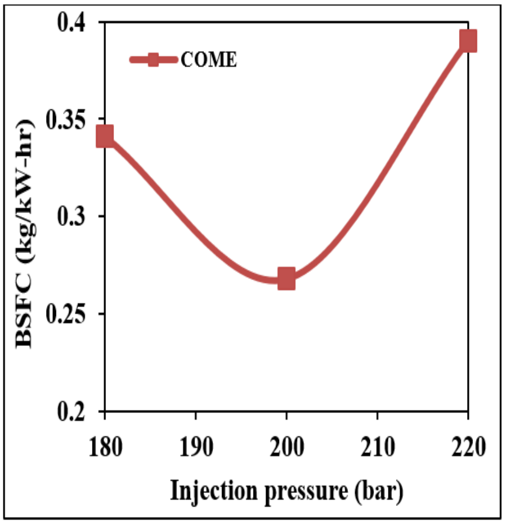

Fig 5:Varitation of BSFC Vs Injection Pressure

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5.2 EFFECT OF INJECTION TIMING ON ENGINE PERFORMANCE AT OPTIMIZED INJECTION PRESSURE OF 200 BAR.

i) Brake thermal efficiency

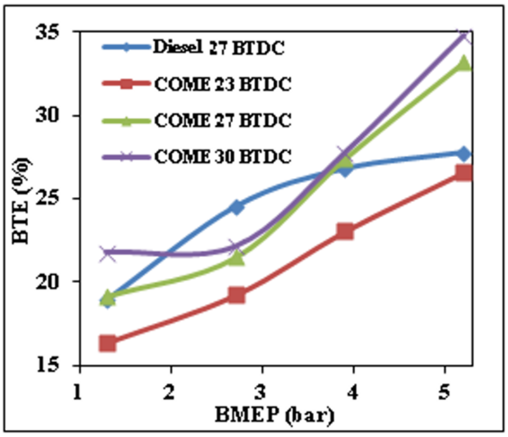

Fig 6: Varitation of BTE Vs BMEP

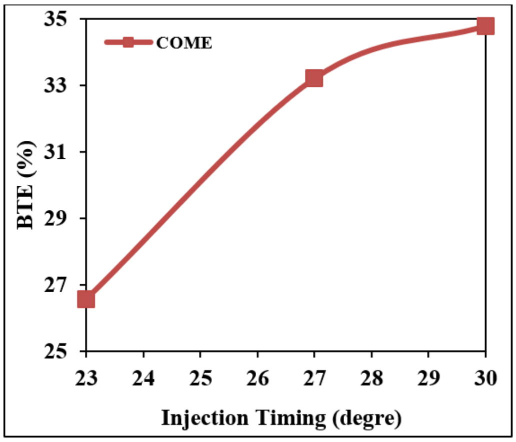

Fig 7: Varitation of BTE Vs Injection Timing

Variation of BTE with BMEP at various injection timing for COME is shown in Figures 6 and 7. From Figure 6 it is observed that the BTE is increases continuously with increase in BMEP. From Figure 7 BTE increases as the injection timing advanced. This is because early starting of combustion, which compensates the effect of slow burning. The maximum BTE occurred at the static injection timing of 30^0bTDC which is selected as optimal. The maximum BTE is found to be at 30^0bTDC is 34.79%.

ii) Brake specific fuel consumption

Variation of BSFC with BMEP for different injection timings is shown in Figures 8 and 9. Figure 8 shows the larger amount of conditioned bio diesel is supplied to the engine compared that of standard diesel. The higher BSFC values in the case of COME due to the higher density and lower calorific values. It can also observed from Figure 9 that advance of injection timing leads with lower BSFC this is due to optimum delay period and smaller amount of fuel during after burning.

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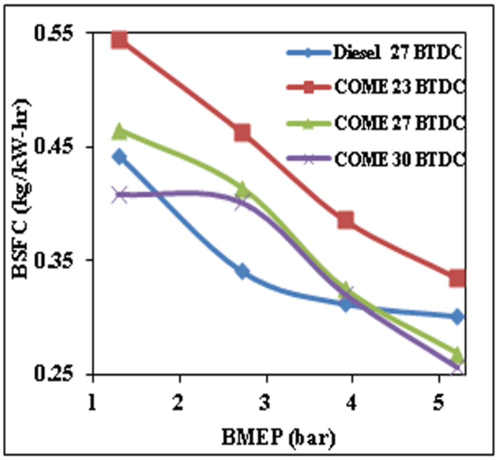

Fig 8: Variation of BSFC Vs BMEP

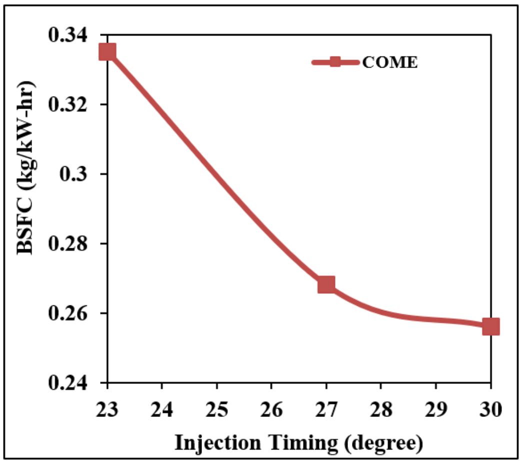

Fig 9: Variation of BSFC Vs Injection Timing

6. CONCLUSION

1. Injector opening pressure increases from the rated value for diesel from 180 bar to 200 bar shows significant improvement in performance with COME. At injector opening pressure 220 bar performance inferior than injector opening pressure 200 bar.
2. Usage of bio diesel the performance characteristics has improved significantly when injection timing advanced by 3^0.
3. There is a significant improvement in the performance, when the injector opening pressure and injection timing properly optimized (say 200 bar and 30^0bTDC), when a diesel engine is operated with conditioned oils of cotton seed methyl ester.

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