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Injection Characteristics of a CI Engine Fuelled with Pongamia Pinnata Methyl Ester

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ABSTRACT

Compression ignition engine is a popular prime mover in rural areas, particularly in the places where electrical power is not available. The rapid depletion of fossil fuel has stimulated worldwide efforts to produce alternative fuel to diesel fuel. Use of bio origin fuel as an alternative fuel can contribute significantly towards the twin problem of fuel crises. The fuel of bio origin may be the bio diesel obtained from edible or non-edible vegetable oil through transesterification process. Most of the properties of bio diesel compare favourably with the characteristics required for diesel fuel. This fuel in the form of blend with diesel performs almost as well as neat diesel fuel with no engine modification. Honge oil is non-edible vegetable oil. Experiments are conducted on 10 HP single cylinders, four stroke, water cooled CI engine using honge oil methyl esters to study the engine performance at different injection pressures and different injection timing. The effect of injection pressure on the performance at three different working pressures of 180, 200, and 220 bar and at three different timing of 23^0, 27^0 and 30^0 are studied. Non edible honge 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 and injection timing 30^0 bTDC.

Keywords: Honge Oil Methyl Ester; CI Engine; Injection Pressure; Injection Timing; Performance Characteristics.

I. INTRODUCTION

Self-efficiency in energy requirement is critical to the success of any developing economy. With the depletion of oil resources and negative impact associated with the fossil fuels, there is a renewed interest in alternate energy sources. In this focus a much concentration is directed towards the production of bio diesel. Bio diesel is briefly defined as the monoalkyl esters of vegetable oils or animal fats. Bio diesel is the best candidate for diesel fuels in diesel engines. Bio diesel also exhibits great potential for compression ignition engines. Diesel fuel can also be replaced by bio diesel made from vegetable oils. Bio diesel is now mainly being produced from honge oil, cotton seed oil, neem oil, etc [1,2 and 3].

II. METHODS AND MATERIAL

A. BIO DIESEL PRODUCTION

Bio diesel can be produced from straight vegetable oil, animal oil/fats, tallow and waste oils. There are three basic routes to bio diesel production from oils and fats:

1. Base catalyzed transesterification of the oil.
2. Direct acid catalyzed transesterification of the oil.
3. Conversion of the oil to its fatty acids and then to bio diesel.

Almost all bio diesels is produced using base catalyzed transesterification as it is the most economical process requiring only low temperatures and pressures and mostly producing a 90 to 95% conversion yield.

i. TRANSESTERIFICATION PROCESS

The Transesterification process is the reaction of a triglyceride with an alcohol to form esters and glycerol. A triglyceride has a glycerine molecule as its base with three long chain fatty acids attached. The characteristics of the fat are determined by the nature of the fatty acids attached to the glycerine. The nature of the fatty acids can in turn affect the characteristics of the bio diesel. During the transesterification process, the triglyceride is reacted with alcohol in the presence of a catalyst, usually a strong alkaline like Potassium hydroxide. The alcohol reacts with the fatty acids to form the monoalkyl ester or bio diesel and crude glycerol. In most production process, methanol or ethanol is the alcohol used and is base catalyzed by either potassium or sodium hydroxide. Potassium hydroxide has been found to be more suitable for the ethyl ester bio diesel production. The reaction between the fat or oil and the alcohol is a reversible reaction and so the alcohol is added in excess to drive the reaction towards the right and ensure complete conversion. The products of the reaction are the bio diesel itself and glycerol. A successful transesterification reaction is signified by the separation of the ester and glycerol layers after the reaction time. The heavier, co product, glycerol settles out [4, 5 and 6].

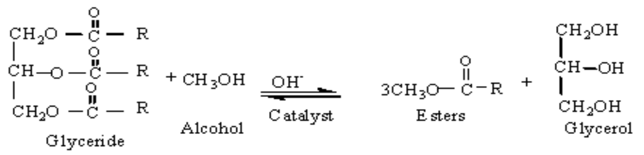

Figure 1: Transesterification Reaction

B. PROPERTIES OF HONGE OIL

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

Table 1: Comparison of Properties of Raw egetable Oils and its Methyl Ester with Conventional Diesel Fuel.

Properties	Diesel	Raw Honge oil	HOME
Density (kg/m^3) at 40^{0}C	828	915	873
Specific Gravity at 40^{0}C	0.828	0.915	0.873
Kinematic Viscosity (centi stokes) at 40^{0}C	3.0	42.78	5.46
Calorific Value (kJ/kg)	42960	35800	38874
Iodine Value (gm I_2/kg)	38.3	82.78	90
Saponification Value	Nil	179.55	90
Flash Point (^{0}C)	56	231	171
Fire Point (^{0}C)	63	243	184

C. EXPERIMENTAL SETUP AND TEST PROCEDURE

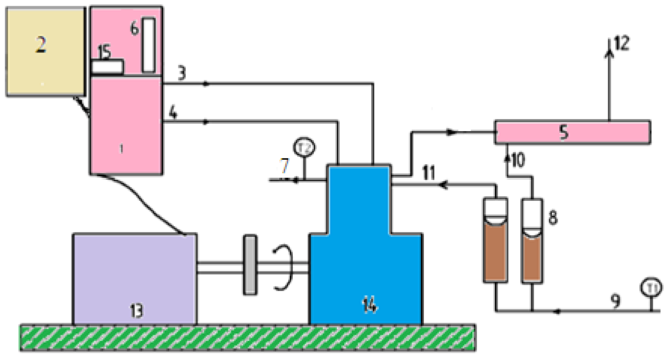

Figure 2: Schematic Diagram of the Experimental Set-up

Experiments were conducted on a Kirloskar TV1 type, four strokes, single cylinder, water cooled diesel engine test rig having a rated output of 10 HP at 1500 rpm and a compression ratio of 17.5:1. Figure 2 shows the schematic experimental set up. Eddy current dynamometer was used for loading the engine.

1 = Control Panel, 2 = Computer system, 3 = Diesel flow line, 4 = Air flow line, 5= Calorimeter, 6 = Burette for fuel measurement, 7 = Outlet water from engine jacket, 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, T1= Inlet water temperature, T2 = Outlet water temperature, T3 = Exhaust gas temperature.

III. RESULTS AND DISCUSSION

A. Effect of injection pressure on engine performance

i) Brake thermal efficiency

Brake thermal efficiency (BTE) is increased with increase in brake mean effective pressure (BMEP) due to reduced heat loss with increase in power and increase in load. Variation of BTE with BMEP at different injection pressure (IP) of 180, 200 and 220 bar and at injection timing (IT) 27^0 bTDC for methyl esters of honge oil (HOME) is shown in Figures 3 and 4 respectively. From Figures 3 and 4 efficiency of HOME is low at lower IP; this is due to poor atomization and mixture formation of vegetable oils during injection. With increase in IP, the BTE is increased due to the decrease in the viscosity, improved atomization and better combustion.

The maximum efficiency for HOME tested is obtained at 200 bar IP is 34.72%, which are very close to diesel fuel efficiency and also observed that, the efficiency is again decreased at 220 bar IP, 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.

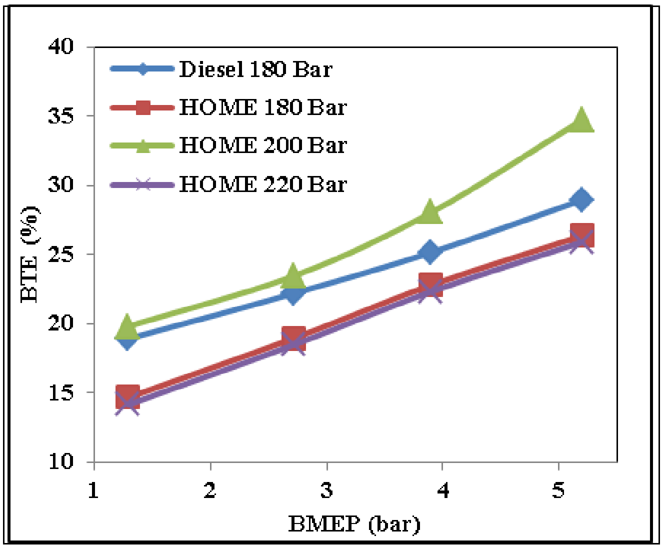

Figure 3: Variation of BTE v/s BMEP

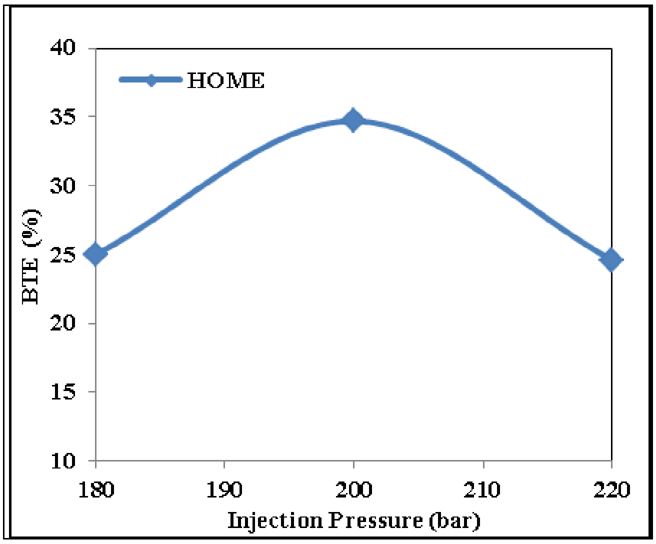

Figure 4: Variation of BTE v/s IP

ii) Brake specific fuel consumption

Brake specific fuel consumption (BSFC) with BMEP at IP of 180, 200 and 220 bar and at IT of 27^0 bTDC for HOME is shown in Figures 4 and 5. Figure 4 shows that the BSFC for HOME is higher than diesel fuel, which was observed due to lower calorific value of bio diesel. Figure 5 shows the variation of BSFC with varying IP at maximum BMEP condition for HOME, It is found that the BSFC is decreased with increase in IP to 200 bar. This may be due to that, as IP increases, the penetration length and spray cone angle increases, so that at optimum pressure, fuel air mixing and spray atomization will be improved.

However lowest BSFC for HOME tested was found to be at 200 bar IP is 0.259 kg/kW-hr and increase in IP from 180 to 220 bar the BSFC for HOME is increased to 0.365 kg/kW-hr, whereas for diesel fuel 0.301 kg/kW-hr.

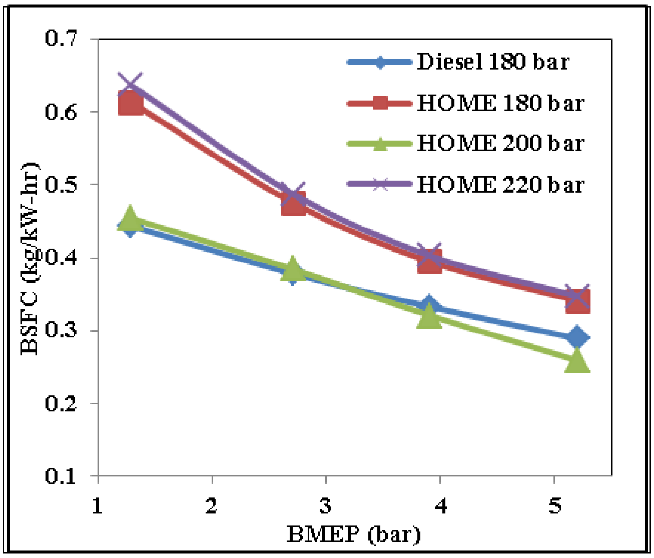

Figure 4: Varitation of BSFC v/s BMEP

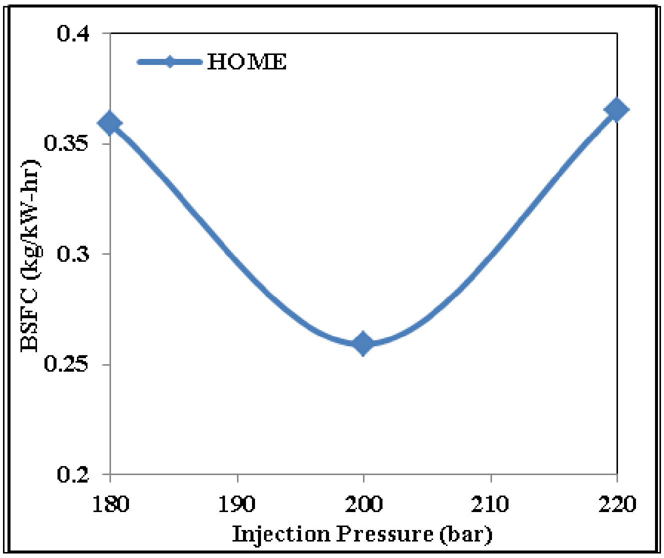

Figure 5: Varitation of BSFC v/s IP

B. Effect of injection timing on engine performance at optimized IP of 200 bar

i) Brake thermal efficiency

BTE with BMEP at various IT and at IP 200 bar for HOME is shown in Figures 6 and 7, the BTE is improved with increase in BMEP can be observed in Figures 6. The maximum BTE occurred at the static IT of 30^0bTDC is 36%. BTE as shown in Figure 7 increases when the IT is advanced (3^0). This is because starting the combustion earlier compensates the effect of slow burning.

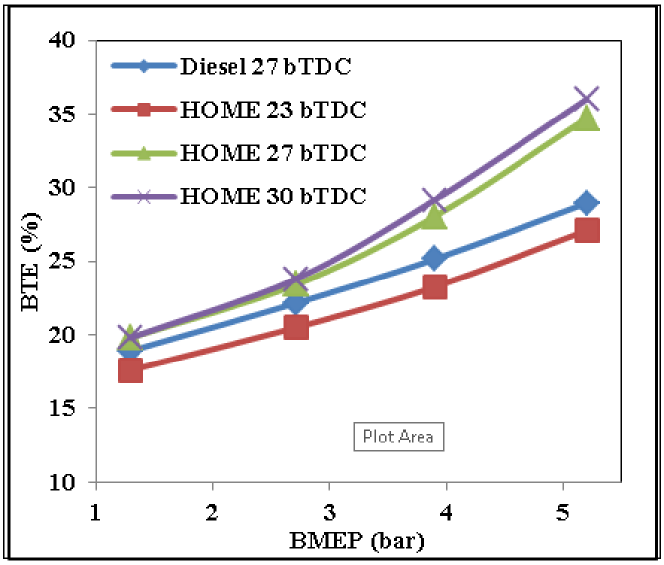

Figure 6: Varitation of BTE v/s BMEP

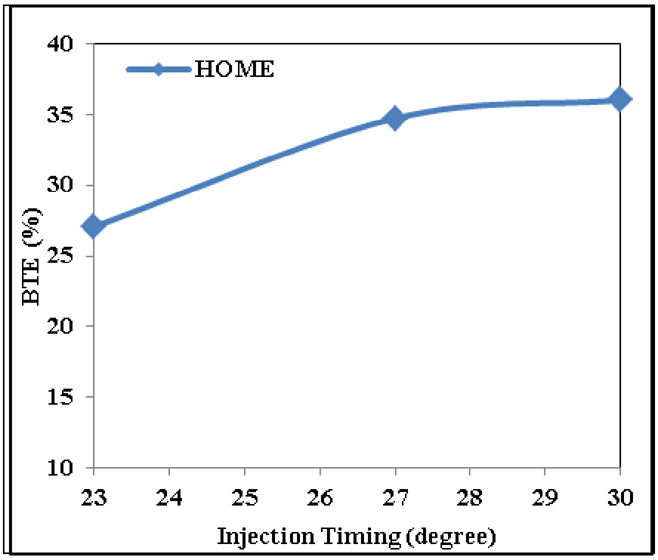

Figure 7: Varitation of BTE v/s IT

ii) Brake specific fuel consumption

BSFC with BMEP at various IT and at IP of 200 bar for HOME as shown in Figures 8 and 9. Figures 8 and 9 shows larger amount of conditioned bio diesel is supplied to the engine compared that of standard diesel. The higher brake specific fuel consumption values in the case of vegetable oil esters due to the higher density and lower calorific values. It can also seen from Figure 8 that advance of injection timing leads with lower BSFC this is due to optimum delay period and smaller amount of fuel during after burning.

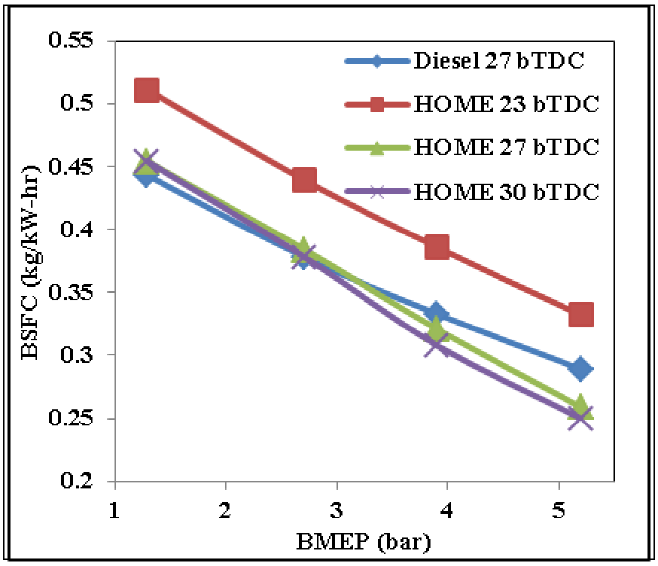

Figure 8: Variation of BSFC v/s BMEP

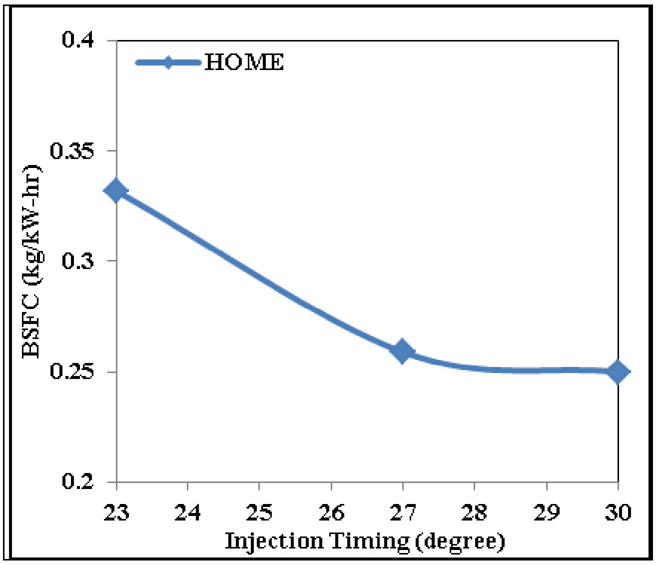

Figure 9: Variation of BSFC v/s IT

IV. CONCLUSION

Fuel injector opening pressure increases from the rated value for diesel 180 bar to 200 bar shows significant increase in performance with HOME due to better spray formation. At fuel injector opening pressure 220 bar performance inferior than fuel injector opening pressure 200 bar.

Advancing the injection timing by 30 crank angles (to 300bTDC) performance characteristics have been improved significantly.

From the experimental results and discussions it can be concluded that a significant improvement in the performance, if the fuel injector opening pressure and injection timing properly optimized (say 200 bar and 300bTDC), when a diesel engine is to be operated with conditioned oils of honge oil methyl ester. The comparison of methanol transesterified oils with diesel fuel in terms of performance shows acceptable results.

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