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A Study on the Effect of Injection Pressures On the Performance and Emission Characteristics of C I Engine with Pongamia Pinnata Methyl Ester as Fuel

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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 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. Pongamia pinnata (Honge oil) is non edible vegetable oil. Experiments were conducted on 10 HP single cylinders, four stroke, water cooled CI engine using honge oil methyl esters to study the engine performance and emission at different injection pressures of 180, 200 and 220 bar. Non edible honge oil bio diesel was tested for their use as substitute fuels for diesel engines. The results showed a better performance and reduced emission at an injection pressure of 200 bar.
***Keywords*:** Honge Oil Methyl Ester; CI Engine; Injection Pressure, Performance and Emission Characteristics.

I. INTRODUCTION

Self efficiency in energy requirement is critical to the success of any developing economy. 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. 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:

- Base catalyzed transesterification of the oil.
- Direct acid catalyzed transesterification of the oil.
- 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.

2.1. 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].

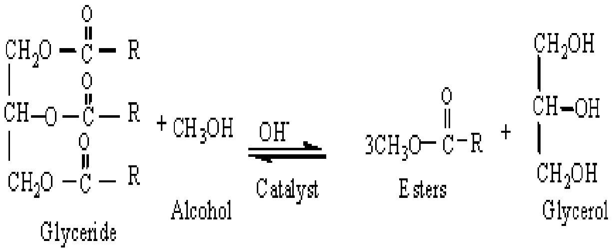

Figure 1: Transesterification Reaction

III. 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 Vegetable Oils and its Methyl Ester with Conventional Diesel Fuel.

Properties	Diesel	Raw Honge oil	HOME
Density (kg/m^3) at 40^0C	828	915	873
Specific Gravity at 40^0C	0.828	0.915	0.873
Kinematic Viscosity (centi stokes) at 40^0C	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 (^0C)	56	231	171
Fire Point (^0C)	63	243	184

IV. EXPERIMENTAL SETUP AND TEST PROCEDURE

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 = 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.

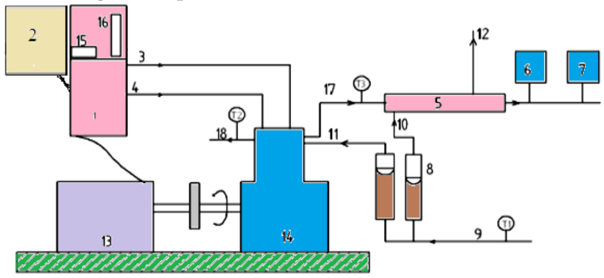

Figure 2: Schematic Diagram of the Experimental Set-up

V. RESULT AND DISCUSSION

5.1. Effect of Injection Pressure on Engine Performance

i) Brake thermal efficiency

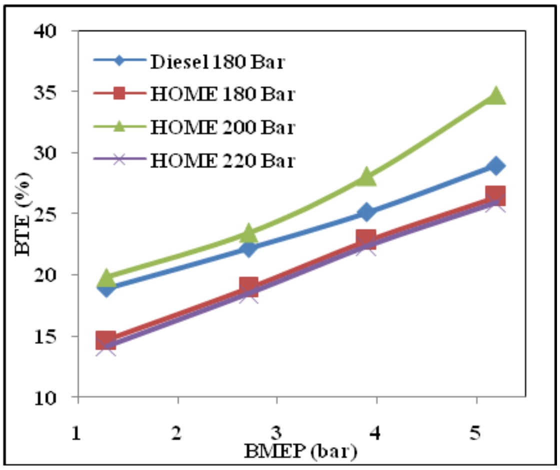

Figure 3: Variation of BTE v/s BMEP

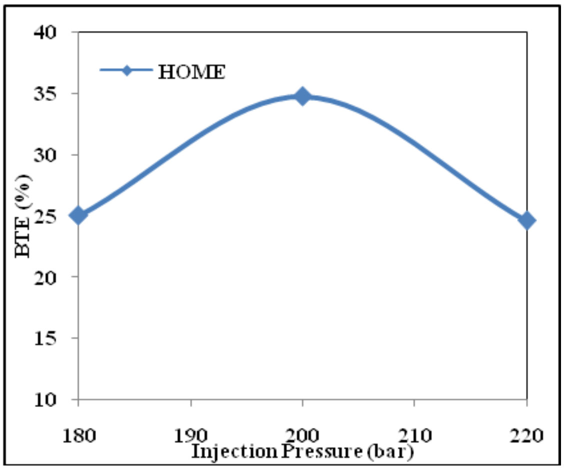

Figure 4: Variation of BTE v/s IP

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 three different injection pressure (IP) of 180, 200 and 220 bar for methyl esters of honge oil

(HOME) is shown in Figures 2 and 3 respectively. The BTE 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 is close with diesel fuel efficiency and also observed that, the efficiency is again decreased at 220 bar IP as shown in Figure 3, 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 [7 and 8].

ii) Brake specific fuel consumption

Brake specific fuel consumption (BSFC) with BMEP at IP of 180, 200 and 220 bar is shown in Figures 4 and 5, the BSFC for HOME is higher than diesel fuel, which was observed due to lower calorific value of bio diesel.

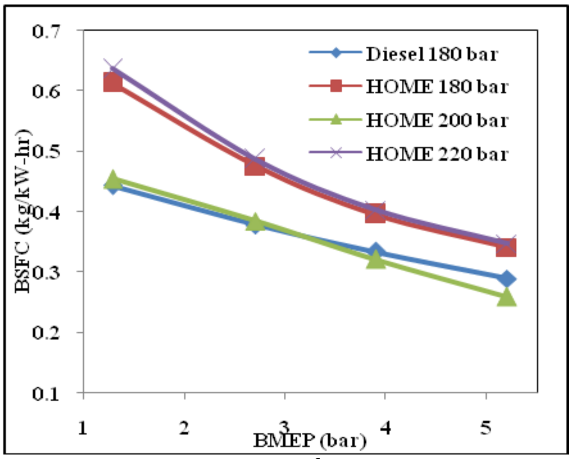

Figure 4: Varitation of BSFC v/s BMEP

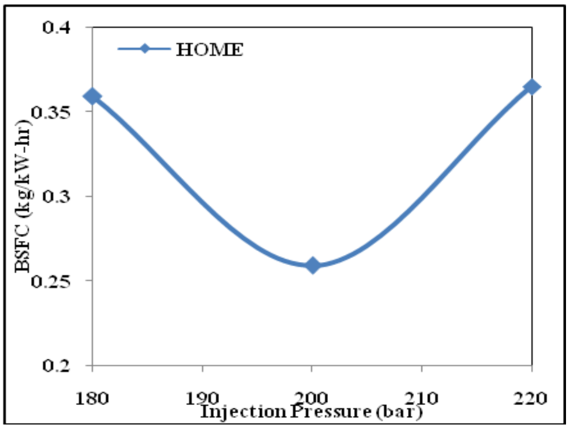

Figure 5: Varitation of BSFC v/s IP

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 200 to 220 bar the BSFC for HOME is increased to 0.365 kg/kW-hr, where as for diesel fuel 0.301 kg/kW-hr [8 and 9].

5.2. Effect of Injection Pressure on Emission

i) Unburnt hydrocarbons (UBHC)

igures 6 and7 shows the variation of UBHC with BMEP. The UBHC is increased with increase in BMEP for HOME. . It is observed from Figures 6, that the UBHC emissions for HOME 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 HOME at full load is approximately 25 to 30% lower than the diesel value (70%).

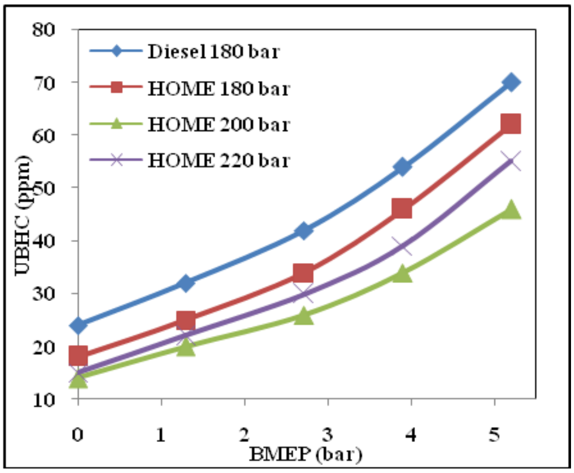

Figure 6: Variation of UBHC v/s BMEP

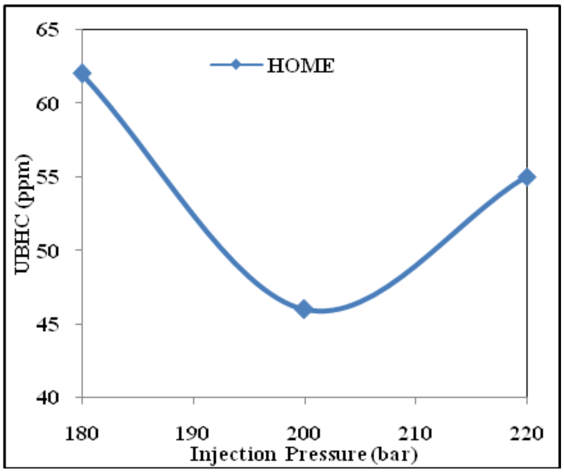

Figure 7: Variation of UBHC v/s IP

The presence of oxygen in the fuel was thought to promote complete combustion that leads to lowering the UBHC emissions. As the IP increases the UBHC emission will decrease as seen in the Figure 7 for HOME 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 HOME [10 and 11].

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 and 9 it is found that the amount of CO is increase at part loads and again greater increase at full load condition for HOME. 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 was observed at 200 bar is 0.32% for HOME is shown in Figure 9 [11 and 12].

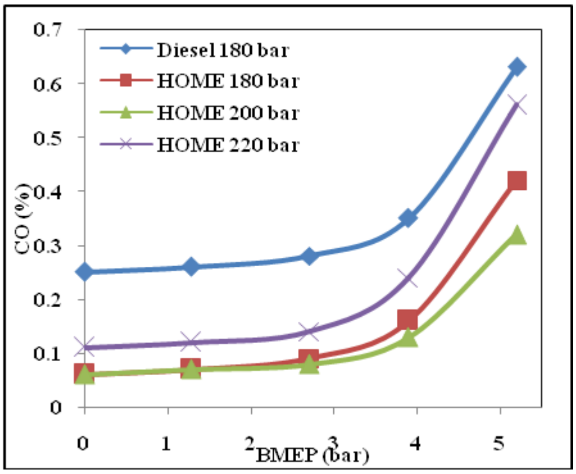

Figure 8: Variation of CO v/s BMEP

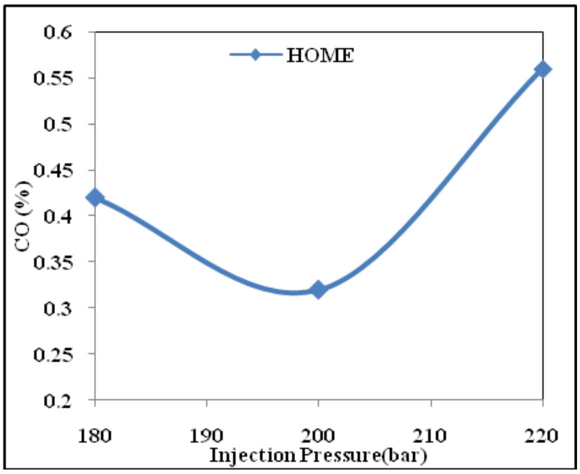

Figure 9: Variation of CO v/s IP

iii) Oxides of nitrogen (NO_x)

Variation of NO_x with BMEP is shown in Figures 10 and 11. The nitrogen oxides 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 and 11 shows that the amount of NO_x is increased with increase in BMEP for HOME, 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 1118 ppm for HOME which is slightly higher than the diesel fuel (1038ppm). NO_x emissions were lower at 200 bar injection pressure indicating that effective combustion was taking place during the early part of expansion stroke [10, 11 and 12].

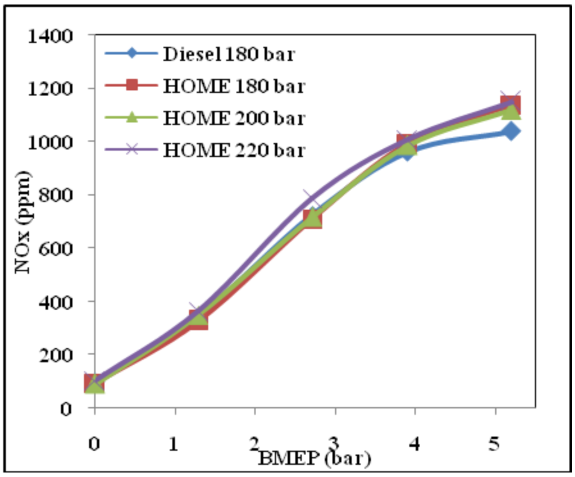

Figure 10: Variation of NOx v/s BMEP

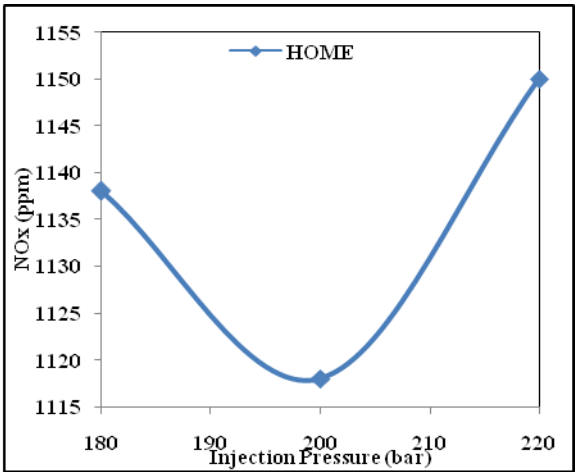

Figure 11: Variation of NOx v/s IP

iv) Smoke opacity (SO)

Figures 12 and 13 indicate the variation of SO with BMEP. It is found that the opacity is increased with increase in load. Figures 12 shows that the opacity variation is lower for HOME compared to diesel fuel. The average opacity at full load for HOME 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 HOME 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 [11 and 12].

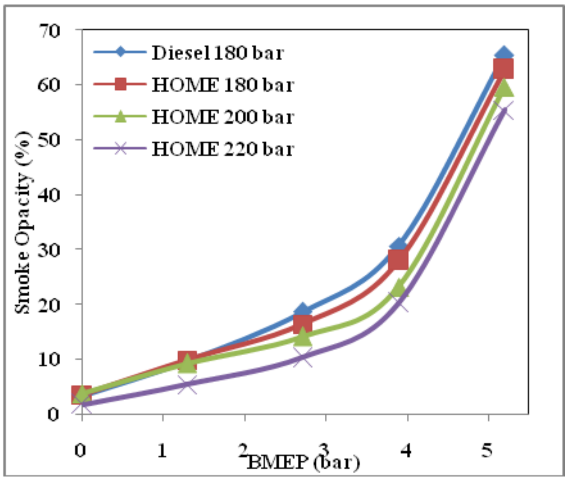

Figure 12: Variation of SO v/s BMEP

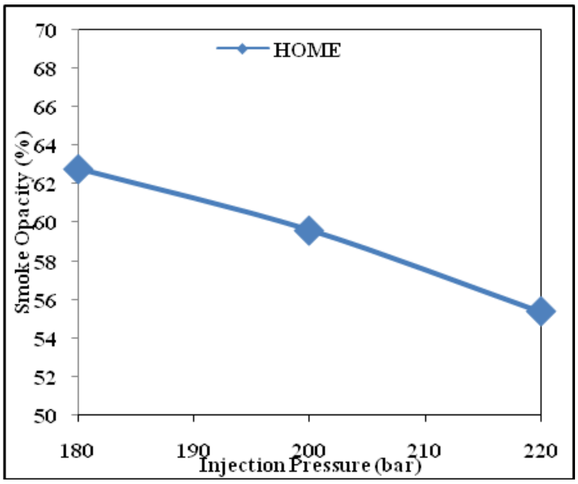

Figure 13: Variation of SO v/s IP

VI. CONCLUSION

Fuel injector opening pressure increases from 180 bar to 200 bar shows significant increase in performance and emission with HOME due to better spray formation. At fuel injector opening pressure 220 bar performance and emission inferior than fuel injector opening pressure 200 bar. From the experimental results it can be concluded that a significant improvement in the performance and emission, if the fuel injector opening pressure properly optimized (say 200 bar), when a diesel engine is to be operated with conditioned oils of honge oil methyl ester.

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