Experimental study of performance of a single cylinder diesel Engine operated with diesel fuel blended with biodiesel of mustard oil

Babul Saikia, D.K. Mahanta

Abstract In this work, bio-diesel from mustard oil has been produced and tested in a compression ignition engine by blending with diesel. The objective of the work is to determine the performance parameters of the bio-fuel. The different properties like density, viscosity, heating value of the blending B10, B20, B30, B40 and B50 are determined. A single cylinder four stroke CI engine is tested with the all the blending fuels. The different parameters like brake horse power, brake specific fuel consumption, brake thermal efficiencies for the fuels are determined. It is found that bsfc for biodiesel increases for higher blending of biodiesel, because of the lower heating value of biodiesel as compared to diesel fuel. For using higher blending of biodiesel, the fuel must be preheated in order to reduce the density and viscosity of the fuel. Compared to diesel fuel, a little amount of power loss occurs for biodiesel blends.

Index Terms— Biodiesel, blending, brake thermal efficiency, mustard oil, trans-esterification, density, viscosity.

1 INTRODUCTION

The revolutionary change in the field of engineering was made first while the steam engine was invented. With the passage of time the working fluid of the engine became petroleum product like diesel, petrol, LPG, kerosene, natural gas aviation fuel etc. The huge amount of natural stock of petroleum did not let human being to think of the present scenario of energy in the world. From recent survey it becomes clear that the total petroleum stock whole over the world will last only for a few decades. So now it is high time to think for some replacement of the petroleum which is renewable andeasily available. Otherwise we will leave the world for our next generation with zero energy potential. This leads to a stage where it is necessary to find

1. Some energy sources which can be reproduced or renewable
2. Technologies by which the energy can be extracted from the source.
3. Affect of the fuel on environment i.e. the pollution characteristics.[3]

Keeping in mind these facts, one such source of energy is being analysed in this paper. A single cylinder internal combustion engine is run with the help of a modified fuel in which diesel is replaced by a blending fuel of biodiesel of mustard oil and conventional diesel in some specific ratio.

2 BIODIESEL DERIVED FROM MUSTARD OIL.

2.1 Transesterification reaction.

Transesterification is also called alcoholysis is the displacement of alcohols from an ester by another alcohol in a process similar to hydrolysis except that alcohol is used instead of water [5]. This has been widely used to reduce the viscosity of tri-glycereids. Following are the reaction steps.

1st step: 250 ml of methanol (CH_3OH) with 90% purity is allowed to react with 150 ml of sodium hydroxide (NAOH) with 1 normality. The mixture is swirled continuously until whole the NAOH get dissolved in methanol. The reaction is exothermic reaction.[4]

2nd step: Heat up 1 litre mustard oil upto 60^0 C and then add this hot mustard oil to the glass container having the methanol and sodium hydroxide mixture. Start swirling upto 10 minutes so that the mustard oil is completely dissolve in the mixture after completion of the reaction the product is kept for at least 24 hours for separation of the biodiesel and glycerol.

3rd step: After 24 hours two distinct layers will be seen in the container [1]. The upper layer is biodiesel whereas the lower layer is glycerol. Thus biodiesel is separated out from the mixture.

2.2 Fuel properties of biodiesel and their blends.

2.2.1 Heating value

Heating value indicates the energy density of the fuel. In this study ASTM 2382 method has been adopted to measure the heating value of biodiesel and it's blend. Table 1 shows the heating value of diesel, biodiesel and their blends.[2]

Table 1

Fuel	Heating value
Fossil diesel	44.00
Biodiesel B100	35.5
B50	39.97
B40	41.28
B30	41.78
B20	42.18
B10	43

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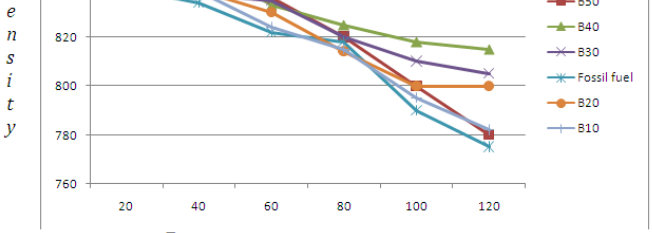

Fig 4: Temperature v/s density curve of different blending fuel.

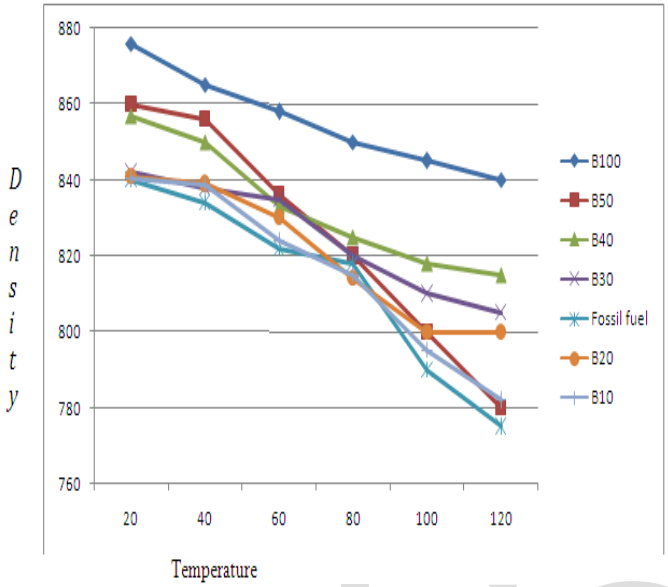

Fig. 1: Density v/s temperature curve for different fuels.

2.2.3 VISCOSITY

Viscosity of fuel exerts a strong influence on the shape of the fuel spray. High viscosity causes low atomization and high penetration of the fuel jet. Figure 2 indicates that B100 has about 5 times higher viscosity than conventional diesel at room temperature. On the other hand B50, B40, B30, B20 has almost 2.5 to 3 time's higher viscosity than conventional diesel at room temperature. But at higher temperature, the viscosities of B20, B30 B40 and B50 are comparable with conventional diesel fuel. B10 has comparable viscosity with diesel at all temperatures. So from viscosity point of view B20, B30, B40, B50 fuels can be used after slight preheating of the fuel. B10 can be used without any preheating and B100 fuel cannot be used as replacement of conventional diesel fuel.

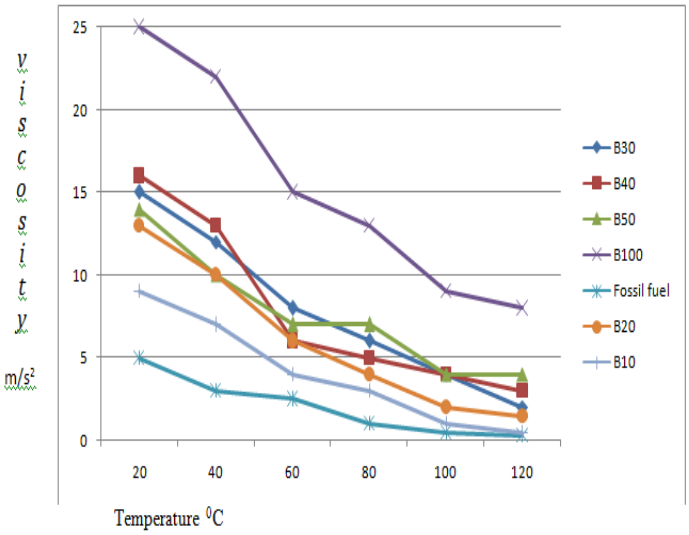

Fig. 2: Viscosity v/s temperature curve for different fuels.

3 ENGINE PERFORMANCE TESTING

The biodiesel and diesel blending fuel is used as alternative of diesel fuel to operate a diesel engine and performance data were recorded. The specification of the engine is given in the table2.

Table 2: Engine specifications.

Make and model	Kirloskar TV1
BP & speed	3.5 kw at 1500 rpm
Type of engine	1 cylinder DI type, 4 stroke
Compression ratio	12-18
Type of engine	Compression ignition
IV opening	4.5° before TDC
IV closing	35.5° after BDC
EV opening	35.5° before BDC
EV closing	4.5° after TDC
Bore and stroke	87.5 mm and 110 mm
Nozzle opening	200- 220 bar
Cooling medium	Water cooled

4 EXPERIMENTAL SET UP.

The experimental set up consists of engine test bed with fuel supply system and different metering and measuring devices with the engine. A water brake dynamometer was coupled with the engine. Load was varied by means of flow control of the dynamometer. Fuel is supplied from an external source. Preheating of the fuel is done manually by gas burner. Engine speed is measured by digital tachometer. Lube oil temperature and exhaust gas temperature was measured by K type thermocouple.

- *Babul Saikia is currently persuing master of engineering in department of mechanical engineering in Assam engineering college, India, PH-+918822737687. Email: 93.babul@gmail.com*
- *D.K. Mahanta is currently working as a proffessor in department of mechanical engineering in Assam engineering college India PH-+919864289072. E-mail: dimbendra@yahoo.co.in*

5 PERFORMANCE ANALYSIS

5.1 VARIATION OF BSFC WITH RESPECT TO BHP

Figure 3 shows variation of bsfc with bhp for different fuels. The curve indicates bsfc for biodiesel blends are higher at low percentage of load and it decreases with the increase in % load. It is also observed from the curve that specific fuel consumption increases with increase in biodiesel blend [8]. This is mainly due to the relationship among volumetric fuel injection system, fuel specific gravity, viscosity and heating value.

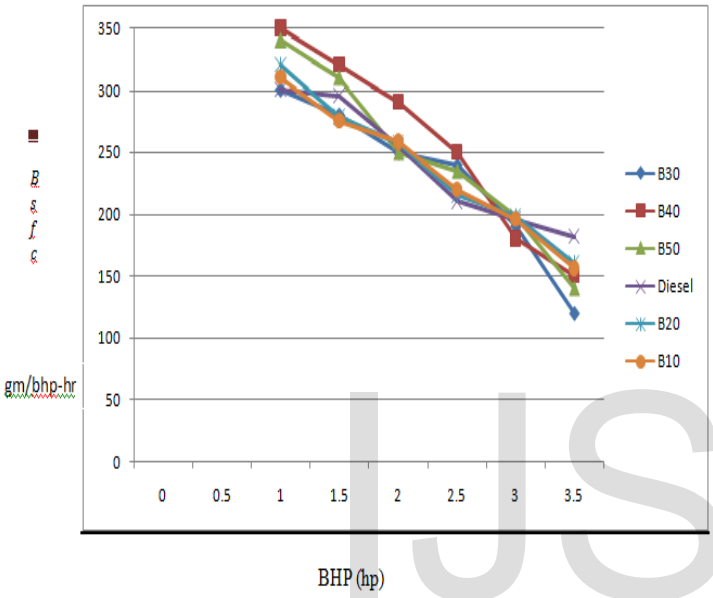

Fig. 3: Variation of bsfc with bhp for different fuels.

5.2 RELATION BETWEEN BHP AND BTE

Figure 4 shows relation between brake horse power and brake thermal efficiency for different fuels. Bsfc is a measure of overall efficiency of the engine. Bsfc is inversely related with efficiency. Lower the value of bsfc higher is the overall efficiency of the engine. However for different fuels with different heating values, bsfc is misleading and hence the brake thermal efficiency is employed when engines are fueled with different types of fuels. From the figure it is evident that bfsc for biodiesel blend is always higher and the bte is always lower than that of diesel fuel. This is because biodiesel blends have lower heating value than the diesel.

5.3 VARIATION OF EXHAUST GAS TEMPERATURE WITH BHP

Figure 5 depicts about variation of exhaust gas temperature with bhp for different fuels. From the curve it is observed that except B30 all other biodiesel blends have higher exhaust gas temperature than diesel fuel. At starting condition higher exhaust gas temperature but but lower power output for biodiesel blends indicate late burning to high proportion of biodiesel. This would increase the heat loss , making the combustion less efficient.

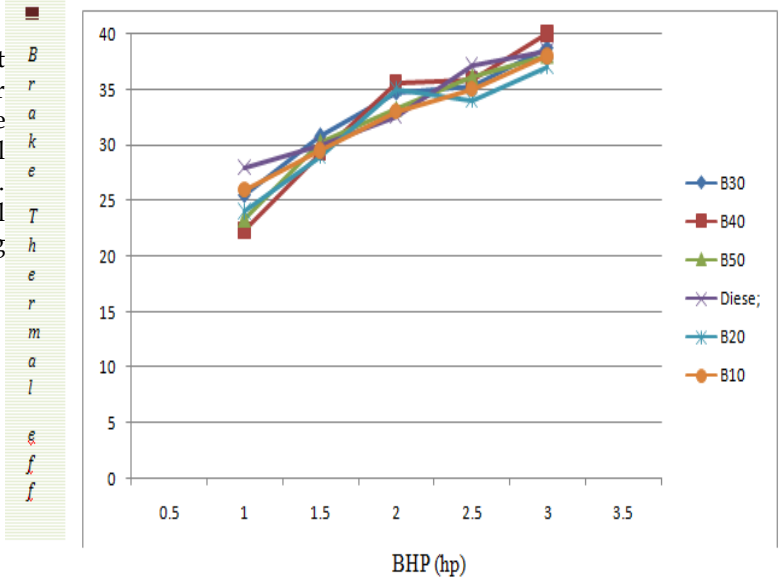

Fig. 4: bhp vs bte

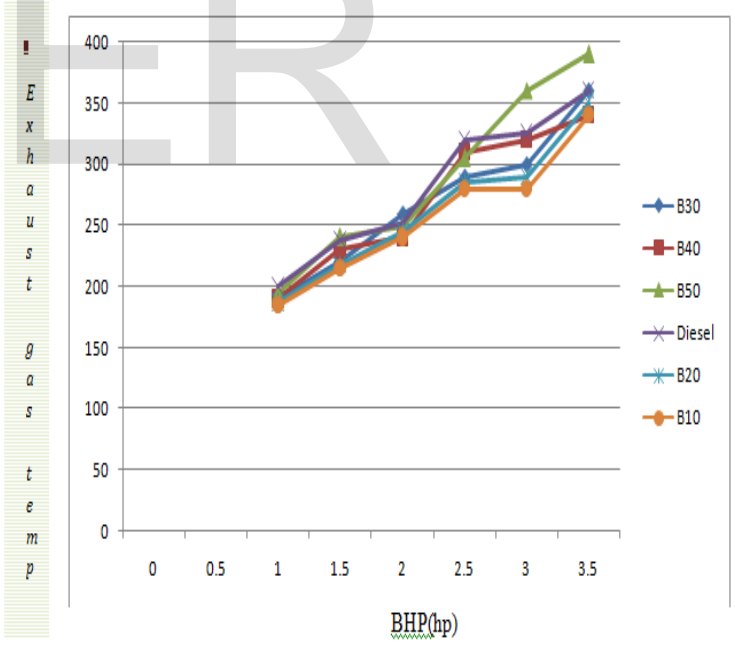

Fig. 5: bhp vs exhaust gas temperature

5.4 RELATION BETWEEN LUBE OIL TEMPERATURE AND BHP

Figure 6 shows the relation between lube oil temperature and bhp for different fuels. At lower bhp, diesel fuel and biodiesel blends have similar lube oil temperature. At higher % load condition, B50 shows higher lube oil temperature.

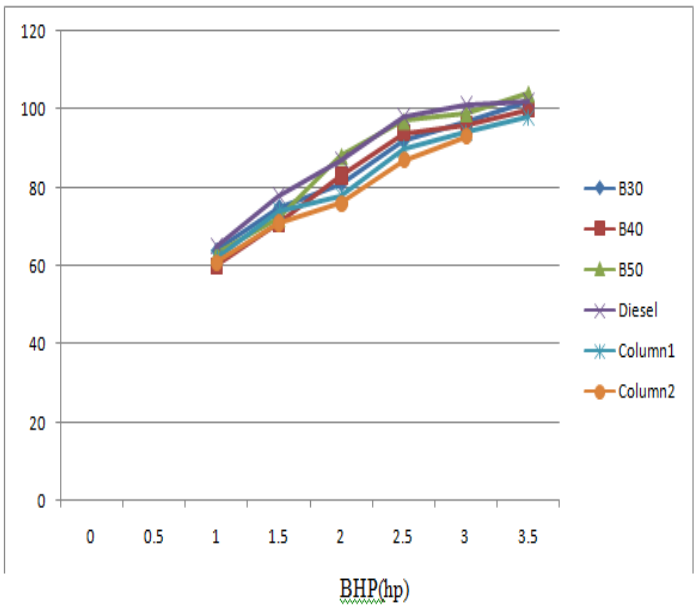

Fig. 6: Variation of lube oil temperature with bhp for different fuel.

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6. Conclusion

The following conclusions may be drawn from the experiment

- Biodiesel can be produced from mustard oil using transesterification reaction
- It is possible to run diesel engine with the biodiesel blend
- For using higher blends of biodiesel, the fuel must be preheated
- Bsfc for biodiesel increases for higher blending of biodiesel because of the lower heating value of biodiesel as compared to diesel fuel.
- Since the calorific value of the biodiesel blends is less than that of diesel fuel, the power produced with blending fuel is less as compared to that of with diesel fuel.

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