

PERFORMANCE EVALUATION OF C.I. ENGINE WITH COTTON SEED OIL

SHYAM KUMAR RANGANATHAN¹, ANIL GANDAMWAD² & MAYUR BAWANKURE³

^{1,2&3}Mechanical Engineering, Jawaharlal Darda Engineering College, Yavatmal, India
E-mail : shyam_kumar052@yahoo.in, anilg_94 @rediffmail.com, mayurbawankure@gmail.com

Abstract - The paper describe the comparative performance of single cylinder diesel engine with direct use of cotton seed oil methyl ester and preheated condition at variable temperature such as 50, 70 and 90°C. The properties such as viscosity, flash point, pour point were experimentally measured of COME, thus obtained are comparable with ASM biodiesel standards. The COME has been tested in single cylinder four stroke diesel engine coupled with rope brake dynamometer, such as BSFC, BTE, B.S.E.C. are calculated and exhaust gas temperature were measured. The experiment was carried out varying load at constant speed. The results revealed that preheating COME up to 90°C at higher load lead to increase in brake thermal efficiency is 2 % as compared to diesel fuel and brake specific fuel consumption increases at higher load as compared to diesel fuel. There is no significant change found in brake power where as exhaust gas temperature of all preheated biodiesel COME is high and break specific energy consumption required to preheat COME is high as compared to diesel. However, the optimum conditions for biodiesel production are suggested in this paper. A maximum of 76% biodiesel was produced with 20% methanol in presence of 0.5% potassium hydroxide.

Keywords - Alternative fuel; Cottonseed oil methyl ester, preheated biodiesel.

I. INTRODUCTION

Biofuels are renewable and reduce gases emissions. They are increasingly used as alternative to petroleum fuels. Cottonseed oil and its methyl esters are expected to become one of these biofuels in countries where cottonseed oil is plentiful such as India it may become an important alternative fuel. Many researchers have experimentally investigated the performance and emissions characteristics of both the cottonseed oil [2-4] and cottonseed oil methyl ester [5-8]. In general it has been reported by some researchers [2-4] that if raw cotton seed oil is used as diesel fuel, engine performance decreases, CO, and HC emissions increase and NO_x emissions also decrease accordingly. Geyer et al. [5] reported on cottonseed oil methyl ester as a fuel in a direct injected diesel engine and concluded that the thermal efficiency was increased, smoke opacity was reduced and NO_x emissions were increased. Lilkic and Yucesu [6] have studied the effects of cotton seed oil methyl esters on engine performance in a single cylinder diesel engine. Their experiments showed that there was little or no significant difference between the torque and power output of CSOME and diesel fuel usage especially at medium and higher speeds. Carraretto et al. [7] reported that the performance was slightly reduced with SFC was notably increased with the use of CSOME. CO emissions were reduced but NO_x were increased. Rakopoulos et al. [8] made a study to evaluate and compare the use of a high variety of vegetable oils or biodiesels of various origins including cottonseed as supplements to conventional diesel fuel at blend ratios of 10/90 and 20/80 in a direct injection [di] diesel engine. Results showed that the smoke density was significantly

reduced with the use of biodiesel blends of various origins with respect to that of the neat diesel fuel. On the contrary, it was increased with use of vegetable oil blends of various origins, with this increase being higher the percentage of vegetable oil the blend. On the contrary to [5,7], the emissions were slightly reduced with the use of biodiesel or vegetable oil blends [8]. The CO emissions were reduced with the use of biodiesel but increased with the use of raw vegetable oil. The engine performance with the biodiesel and vegetable oil blends of various origins was similar to that of neat diesel fuel with nearly the same brake thermal efficiency, showing higher specific fuel consumption.

II. PRODUCTION OF COME

COME was prepared as shown in figure No.1. The transesterification process of cottonseed oil was performed using 5 g potassium hydroxide as catalyst and 200 ml methyl alcohol per 1L, Pure cottonseed oil. First, the cottonseed oil was heated to about 70 °C in a reactor then; the catalyst was mixed with methyl alcohol to dissolve and added to the heated cottonseed oil in the reactor. After the mixture was stirred for 1 h at a fixed temperature of about 70 °C, it was transferred to another container and the separation of the glycerol layer was allowed. Once the glycerol layer was settled down, the methyl ester layer formed at the upper part of the container was transferred to another vessel. After that, a washing process was carried out to remove some unreacted remainder of methanol and catalyst using distilled water and blown air. Then, a distillation process at about 110 °C was applied for removing water contained in the esterified cottonseed oil. Finally, the

produced cottonseed oil methyl ester (COME) was left to cool down.

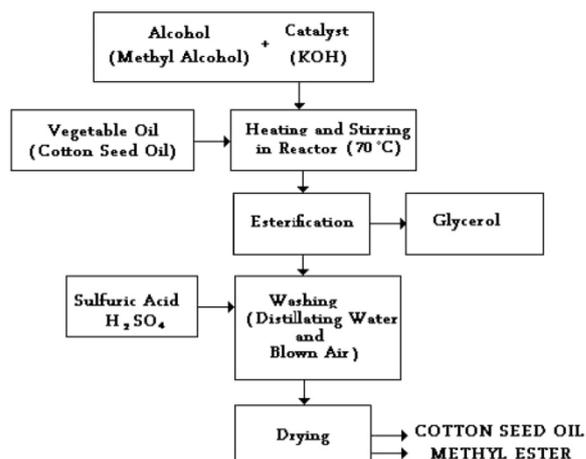


Fig 1: Flow chart COME

2.1 Optimization of different parameters for biodiesel production

The rate of conversion from CSO to COME depends upon the different parameters like oil temperature, reaction temperature, catalyst percentage, methanol percentage, purity of reactants, etc. In this work, reaction temperature, catalyst percentage and methanol percentage have been investigated.

2.1.1 Reaction temperature and biodiesel Production

Figure 2.1 shows the effect of methanol percentages on biodiesel production. The volumetric percentages of methanol were varied from 15% to 25%. The weight percentage of catalyst (KOH) was fixed at 0.5%. The reaction temperature was varied from 45 to 60°C. The maximum bio-diesel yield was noticed at 20% methanol. This was due to the fact that the 20% methanol has a favorable influence on maximum bio-diesel production. A maximum of 76% biodiesel production was observed at 20% methanol and at a temperature of 55°C

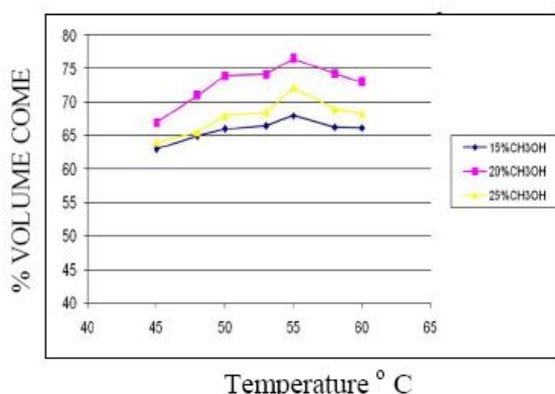


Fig. 2.1 : Effect of Temperature on Bio-Diesel Production (KOH=0.5%)

2.1.2 Influence of Catalyst Percentage on Biodiesel Production

Figure 2.2 depicts the influence of catalyst

percentages on bio-diesel production. The weight percentages of catalyst were varied from 0.5 to 0.75%. The optimum methanol percentage was kept constant to 20%. It can be seen from the figure that with the increase in lye catalyst, bio-diesel yield decreases. This may be associated with the increase in the formation of wax. The vegetable oil used in transesterification process contains many free fatty acids. The catalyst reacts with these free fatty acids and produces wax. A maximum of 76% bio-diesel yield was found at 0.5wt% Catalyst and at a reaction temperature of 55°C. If the weight percentage of catalyst is used below 0.5% the bio-diesel production was found minimum. Thus 20% methanol and 0.5% KOH were chosen as the optimum percentages for biodiesel

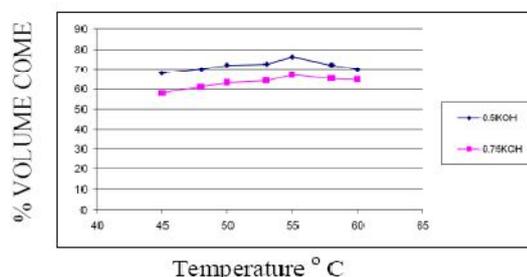


Fig. 2.2 : Effect of Catalyst (KOH) Percentages on Bio-Diesel (CH₃OH=20%).

2.1.3 Influence of Reaction Time on Biodiesel Production

Figure 2.3 shows the effect of reaction time on bio-diesel production. The catalyst percentage was set to 0.5. The reaction temperature was kept at 55°C. It was found that when reaction time increases, the bio-diesel production increases and reaches maximum at about 8hrs. Then bio-diesel production decreases with the increase in reaction time. When the mixture of CSO, methanol and catalyst was kept for 24hrs, the bio-diesel production was reduced to 70%. This was due to the fact that the tendency of soap formation increases with the increase in reaction time. It was found that for 8hrs the maximum bio-diesel production was 76.5%.

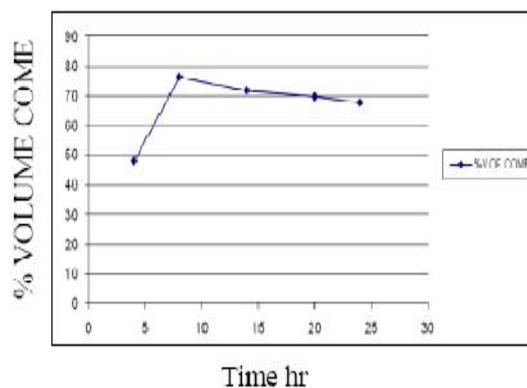


Fig. 2.3 : Effect of Reaction Time on Bio-Diesel Production (CH₃OH=20% KOH=0.5%, Reaction Temperature 60°C).

2.2 Kinematics Viscosity

As shown in Fig. 2.4 the kinematics viscosity of the COME gradually decrease with increase in temperatures. By increasing the temperature of the fluid, the intermolecular attraction between different layers of the fluid decreases, thus viscosity decreases. For proper functioning of the engine, it is necessary to reduce the viscosity of a fuel. Fuel with relatively higher viscosity will not break into fine particles when sprayed. Large particles will burn slowly resulting in poor engine performance. On the other hand, if the viscosity is too low, the fuel will not lubricate the moving parts of the injection pump and injection nozzle. It is seen that the kinematic viscosity is 6.54 cSt at 30^oC and decreases gradually to 2 cSt at 90^oC. At 70^oC the kinematic viscosity of COME was found to be 3.8 cSt which is much comparable to that of diesel fuel at 40^oC.

Fig. 2.4 : Temperature VS kinematics viscosity

III. EXPERIMENTAL SETUP

The experimental setup consists of a single - cylinder, four stroke, naturally aspirated diesel engine, data acquisition software [DAS] and COME heating tank fitted electric heater with proper temperature control as shown in fig 3. The specifications of the test engine are given in Table 1. Engine is coupled with rope brake dynamometer with cooling water arrangement.

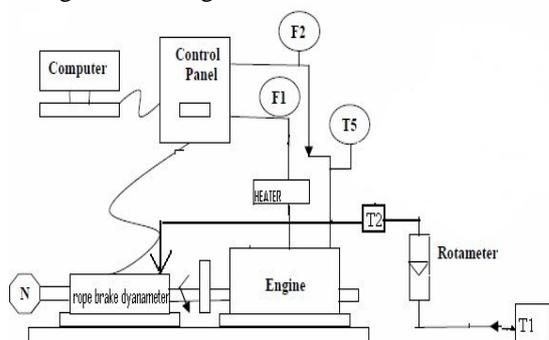


Fig. 3 : Experimental set up of engine Procedure

Experiments were performed with diesel fuel and neat biodiesel preheated up to four different temperatures, namely 30, 50, 70 and 90 ^oC. The properties of the fuels employed are shown in Table 2. The fuel consumption measurement was performed by gravimetric sensor. Exhaust gas temperature was measured by K type thermocouple submerged into exhaust pipe. Windows based Engine Performance Analysis Software Package; DAS was taken for performance evaluation. The tests were conducted at the rated speed of 1500 rpm at different loads. For this investigation the kinematic viscosity was measured with redwood viscometer, at above temperatures. Then fuel consumption, exhaust gas temperature were measured. Brake power, brake

specific fuel consumption, brake thermal efficiency are calculated.

Table 1 : Test engine specifications

Parameter	Value
Type of Engine	4 Stroke
No. of Cylinders	1
Cylinder diameter (D)	0.08Mtrs
Cylinder Stroke (L)	0.11Mtrs
Rated output	3.5kw at 1500 rpm
Rated Speed	1500 rpm

Table 2:- The properties of diesel fuel and COME

Fuel	Diesel Fuel	COME
Specific gravity at 15 ^o C	0.84	0.885
Kinematic viscosity at 40 ^o C (Cst)	3.25	5.94
Lower heating value (kj/kg)	42,550	36,896
Flash Point (^o C)	55	200

IV. RESULTS AND DISCUSSION

4.1 Brake thermal efficiency of preheated COME and diesel

It can be observed from Fig. 4.1 that the thermal efficiency of COME50 and COME90 were 1.4% and 2% at higher load was higher than mineral diesel respectively. Preheating the fuel samples, which have higher viscosity than mineral diesel at room temperature, reduces the viscosity and increases the volatility. This enhances the fuel atomization leading to improved fuel air mixing. Oxygenated fuel gives a better fuel combustion delivering improved thermal efficiency. The unheated fuel samples show comparatively lower thermal efficiency possibly due to larger droplet size in the fuel spray.

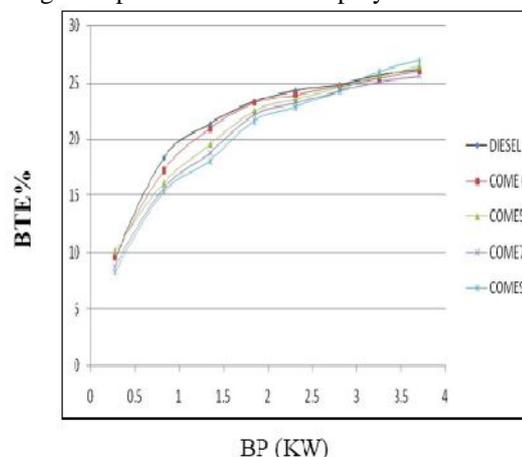


Fig. 4.1: BP VS BTE

4.2 Brake Specific Fuel Consumption diesel and preheated COME

Brake specific fuel consumption (BSFC) is a measure of volumetric fuel consumption for any particular fuel. Fig. 4.2 shows the BSFC for preheated COME and diesel. BSFC for COME90 preheated up to 7.8% is higher than diesel at higher load. This is mainly due to the combined effects of the fuel density, viscosity and lower heating value of COME. Higher density of COME leads to more fuel flow rate for the same displacement of the plunger in the fuel injection pump, thereby increasing BSFC. However on preheating, it is observed that all COME show higher BSFC compared to diesel.

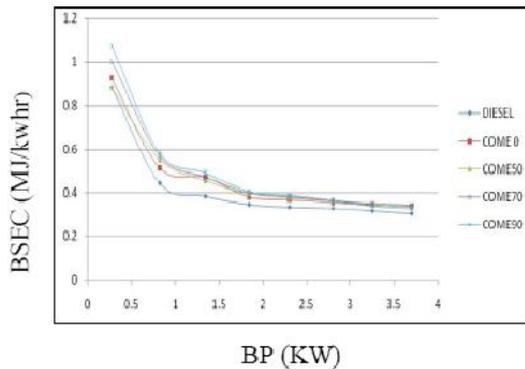


Fig. 4.2 : BP VS BSFC

4.3 Brake specific energy consumption diesel and preheated COME

Fig. 4.3 shows the variation of brake specific energy consumption (BSEC) for the engine using diesel, COME 0, COME50, COME70 and COME90 with respect to brake power output. Brake specific energy consumption (BSEC) is an ideal parameter for comparing engine performance. These figures show that the BSEC is lower for COME90 compared to diesel at higher load is 2.8%. The reduction in viscosity leads to improved atomization, fuel vaporization and combustion. It may also be due to better utilization of heat energy, and better air entrainment. It can also be seen that the minimum BSEC attained using COME90 at higher load was closer to that of diesel. This result indicates that the engine performance is approaching that of conventional diesel by preheating COME90.

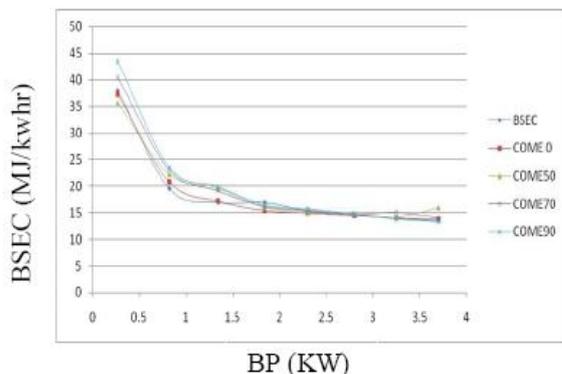


Fig. 4.3 : BP VS BSEC

4.4 Exhaust gas temperature (EXGT) of preheated COME and diesel

Fig.4.4 shows the variation of exhaust gas temperature with respect to brake power for the engine using diesel, COME 0, COME50, COME70 and COME90. The exhaust gas temperatures were higher for COME 0 (without preheating) than diesel as COME 0 contains constituents of poor volatility, which burn only during the late combustion phase. Figure also indicates the effect of increasing the inlet temperature of COME on exhaust gas temperature. It can be seen that the exhaust gas temperature was increased with preheating COME. This may be due to the increase in the combustion gas temperature.

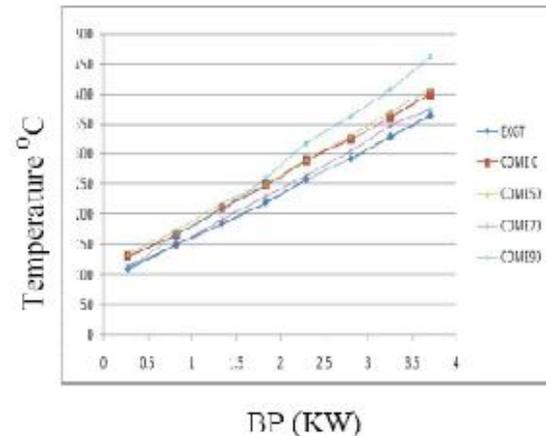


Fig. 4.4 : BP VS EXGT

V. CONCLUSIONS

Cottonseed oil methyl ester COME was produced by means of trans-esterification process using cottonseed oil, which can be described as a biomass based and renewable energy source. The viscosity of COME was reduced by preheating it before supplied to the test engine.

- Kinematics viscosity of COME is higher than those of diesel fuel. The heating value of COME lower while its flash point is higher than diesel fuel.
- Preheating of the COME caused a considerable decrease in its kinematics Viscosity thus causing them to approach the values of diesel fuel.
- A higher BTE was found with the preheated COME due to improved combustion compared to diesel fuel. Particularly COME 90 gives improvement in the BTE of the order of 2 % as compared to diesel.
- Compared to diesel fuel Exhaust gas temperature of COME 0, COME 50, COME 70 and COME 90 is high compared to diesel fuel.
- Compared to diesel fuel, brake specific fuel consumption for preheated COME90 7.8% is found higher.
- Break specific energy consumption required for COME 0 is 4.4% high and preheated COME90 is 2.8% low as compared to diesel fuel respectively.

- A maximum of 76% Bio-diesel production was found at 20% of methanol and 0.5% KOH and 55⁰ c reaction temperature.

REFERENCES

- [1] A.S.Ramadhas, S.Jayaraj, C.Muraleedharan [2004]. Use of vegetable oils as I.C. engine fuels-A review. *Renewable Energy* 29,727-742.
- [2] Ulusoy YA. Comparative study on the utilization of sunflower oil ,rapeseed oil cottonseed oil and soybean oil as fuel for diesel engine.PhD thesis, uludag university ,institute of natural and applied sciences ,bursa;1999[in Turkish]
- [3] He Y.Bao YD.Study on cottonseed oil as a partial substitute for diesel oil in fuel for single cylinder diesel engine .renewable energy 2005;30(5);805-13
- [4] Yucel HL.Resarch on the effect of cottonseed oil diesel fuel blends on the performance and emissions characteristics .PhD thesis ,Firat university ,institute of natural and applied sciences,Elazig;1998[in turkish]
- [5] Geyer SM ,Jacobus MJ,Lestz.Comparison of diesel engine performance and emission from Neal and transesterfied vegetable oils ASAE 1984;27(2):375-84..
- [6] Ilkilic C Yucesu HS. The effect of cottonseed oil methyl ester diesel fuel blends on performance of diesel engine. *Journal of Firat university natural and engineering sciences* 2002;14(1):199-205[in turkish]
- [7] Carraretto C Macor A, Mirandola A, Stoppota A, Tonon S , Biodiesel as alternative fuel: Experimental analysis and energetic evaluation. *Energy* 2004;29:2195-211
- [8] Rakopoulos CD,Antonopoulos KA, Hountalas DT, Giakoumis EG, comparative performance and emission study of direct injection diesel engine using blends of diesel fuel with vegetable oils or biodiesel of various origins. *Energy conservation and management* 2006 ;47:3271-87.

