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Performance and Emission Characteristics of a Diesel Engine Fueled with Blend of Vegetable Oil Esters

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***Abstract*— Numerous investigations have been done with vegetable oil as a fuel in a compression ignition engines, even though still there are barriers to use vegetable oil as a fuel. This mainly due to their higher viscosity, poor volatility and heavy chemical structure. This paper investigates the scope of utilizing biodiesel developed through the various biodiesel developed through ethanol, methanol and butanol as a alcohols used for manufacturing it .This paper investigates the performance and emission characteristics of a 20% blend of ethyl, methyl and butyl esters of Pongamia (EEPO, MEPO,BEPO) and Mahua oil (EEMO,MEMO,BEMO) with diesel. The results clarified that the performance and emission characteristics of a 20% blend methyl esters of Pongamia oil were superior than all other fuels.The results observed were slight reduction of brake thermal efficiency and reduction of hydrocarbon emission, carbon monoxide emission, and smoke emission with increase in carbon dioxide emission.**

***Index Terms*—Alternate fuel, Butyl ester, Mahua, Pongamia.**

I. Introduction

The world today is in need of alternate fuel source because of fuel depletion and increase of fuel demand. The yearly reports in pollutants of atmosphere are also in increasing trend, the need is to develop the eco friendly fuel to meet the fossil fuel depletion. These reasons increase the attention towards vegetable oil as an alternate fuel source. Biodiesel is the name of clean burning fuel, produced from domestic renewable resources. It contains no petroleum but it can be blended at any level with petroleum diesel to greater biodiesel blend. It can be used in CI engine with no major modifications. It is simple to use, bio degradable, non toxic and essentially free of sulphur and aromatics.

A. Need of biodiesel

The world energy supplying has relied heavily on non-renewable crude oil derived (fossil) liquid fuels out of which 90% is estimated to be consumed for energy generation and transportation. It is also known that emissions from the combustion of these fuels are the principal causes of global warming and many countries have passed legislation top arrest their adverse environmental consequences with population increasing rapidly and many developing countries expanding their industrial base and output, worldwide energy demand is bound to increase on the other hand, known crude oil reserves cloud be depleted in less than 50 years at the present rate of consumption. This situation initiated and has sustained interest in identifying and channeling renewable raw materials into the manufacture of liquid fuel alternatives because development of such biomass based power would ensure that new technologies are available to keep pace with society need for new renewable power alternative for future. For these reasons use of vegetable oil as fuel is initiated worldwide.

The choice of vegetable oil as engine fuel naturally depends upon the local conditions prevalent availability of a particular vegetable oil in excess amount. There are various oils which are being considered worldwide for use in the engines, these include Pongamia oil, Mahua Indica oil Cotton seed oil, Rice bran oil, Sunflower oil, Soyabean oil, Rape seed oil, Jatropha oil and etc.

In this investigation Pongamia oil and Mahua oil are used due to their origin is in India and its easy availability.

From previous studies it is evident that there are various problems associated with vegetable oil, being used as fuel in C.I. Engines. There are mainly caused by the high viscosity value of the vegetable oil. This higher viscosity is due to free fatty acid present in the oil. This free fatty acid is due to large molecular mass and chemical structure of vegetable oil, which in turn leads to problem in pumping, combustion and atomization on C.I engines therefore it is necessary to reduce the free fatty acid and viscosity of vegetable oil to make it suitable as an alternative fuel for diesel engine. The various methods which have been envogue to use vegetable oil efficiently some of them are

1. Transesterification process
2. Preheating the oil
3. Blending with diesel
4. Use of additives
5. Pyrolysis

In this project work, transesterification process has been taken as a process for conversion of vegetable oil to biodiesel. Before transesterification process, the sum amount of free fatty acid present in the oil has been estimated in the presence of monoglycerides and triglycerides. In this process

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the triglycerides in the vegetable oil are converted to their mono esters by reacting it with alcohol in the presence of a potassium hydroxide (KOH) as a catalyst.In this investigation 20% blend of vegetable oil and 80% diesel fuel is used since it doesnot need any engine modification.

II. TRANSESTERIFICATION OF VEGETABLE OIL

To reduce the viscosity of the vegetable oil, transesterification method is adopted for the preparation of biodiesel. The procedure involved in this method is as follows: 1000 ml of vegetable oil is taken in a three way flask. 12-15 grams of Potassium hydroxide (KOH) and 200 ml of corresponding alcohol (Ethanol, Methanol, Butanol) are taken in a beaker. The Potassium hydroxide and the alcohol are thoroughly mixed until it is properly dissolved. The solution obtained is mixed with vegetable oil in three way flask and it is stirred properly. The corresponding alcohols oxide solution with vegetable oil is heated to 78ºC, 65ºC, 117ºC respectively for ethanol, methanol and butanol and it is continuously stirred at constant rate for 90 minutes, 60 minutes,80 minutes by stirrer correspondingly for ethanol, methanol and butanol . The solution is poured down to the separating beaker and is allowed to settle for 4-6 hours. The glycerine settles at the bottom and the ester floats at the top. Corresponding alcohol ester is separated from the glycerine. Then it is heated above 1000ºC and maintained for 10-15 minutes to remove the untreated alcohol. Certain impurities like sodium hydroxide (KOH) etc are still dissolved in the obtained biodiesel. These impurities are cleaned up by washing with 350 ml of water for 1000 ml of coarse biodiesel. This cleaned biodiesel is the corresponding ester of Vegetable oil. This bio-diesel of Pongamia pinnata oil and Mahua oil is being used for the performance and emission analysis in a diesel engine.

Note: For the present work 20% of MEPO, 20% of EEPO, 20% of BEPO, 20% of MEMO, 20% of EEMO, 20% of BEMO with 80% of neat diesel blends are being used.

III. EXPERIMENTAL SETUP OVERVIEW

The engine coupled with eddy current dynamometer is shown in figure 1, and the schematic view of engine setup is shown on figure 2.

Fig - 1 - Engine coupled with eddy current dynamometer

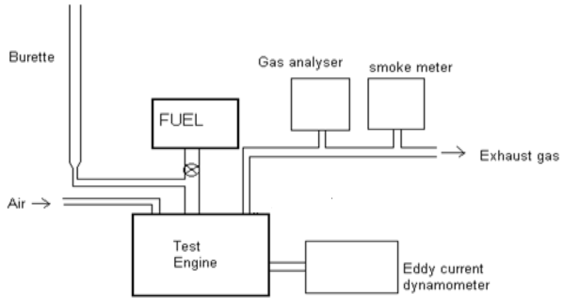

Fig.2 - Experimental Setup

The engine is fully equipped with measurements of all operating parameters. The arrangement requires the following systems and apparatus for carrying out the desired experiment.The engine used in test rig is a Kirloskar Model SV1, single cylinder, four stroke, water-cooled, direct injection type, diesel engine. To reduce the temperature of the cylinders and the lubricant, the cooling system of the engine is connected to a cooling-water tower by means of a cooling-water pipe line.

IV. PERFORMANCE ANALYSIS

A. *Brake Thermal Efficiency*

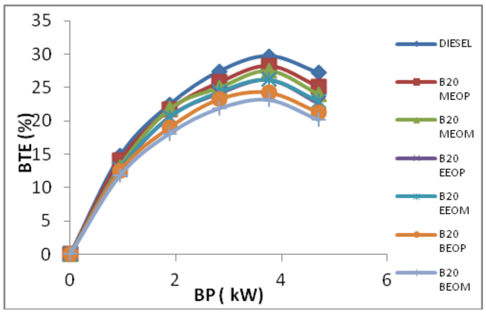

Fig.3. Brake thermal efficiency vs brake power for B20

The variation of brake thermal efficiency with brake power is shown in Fig.3. Brake thermal efficiency is defined as the ratio of energy in brake power to the input fuel energy in appropriate units. Thermal efficiency of the engine depends on fuel properties, engine specification and area of application. Thermal efficiency of the esters are inferior to diesel, this is due to the lower heating value of the vegetable oil. However brake thermal efficiency of MEPO is higher than other esters, this is due to the promotion of combustion process due to its lowered specific gravity and viscosity.

B. *Specific fuel consumption*

Fig.4. shows the comparison of the specific fuel consumption between the diesel, MEPO, EEPO, BEPO, MEMO, EEMO and BEMO. Fuel flow rate per unit power output is termed as specific fuel consumption. Specific fuel consumption decreases sharply with increase in load for all fuels. The main reason for this could be that percent increase in fuel required to operate the engine is less than the percent

increase in brake power due to relatively less portion of the heat losses at higher loads As the SFC was calculated on weight basis; obviously higher densities resulted in higher values for BSFC. As the density of MEPO is lower than other esters and close to diesel, the trend is very close to diesel.

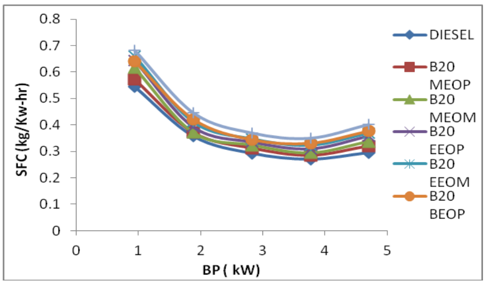

Fig.4. Specific fuel consumption vs brake power for B20

C. Total fuel consumption

Fig.5. shows the variation of total fuel consumption for various fuels. The total fuel consumption of engine was increased with B20 blend of vegetable oil ester. This may be due to higher specific gravity and oxygen content of the biodiesel fuel as compared with diesel fuel. Total fuel consumption of MEPO, EEPO, BEPO, MEMO, EEMO and BEMO are higher than diesel due to their higher specific gravity. As the specific gravity of MEPO is lesser than other esters, the total fuel consumption is less and close to diesel.

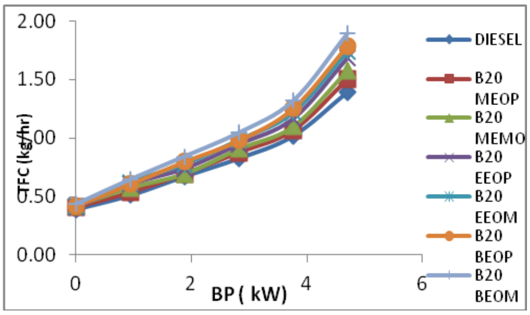

Fig.5.Total fuel consumption vs brake power for B20

V. EMISSION ANALYSIS

A. Unburnt Hydrocarbon emissions

From fig.6, it was observed HC emission is reduced in case of esters compared to diesel. This is due to the presence of oxygen in the fuel. Oxygen promotes combustion processes, in turn reduces the UBHC emissions compared to diesel.

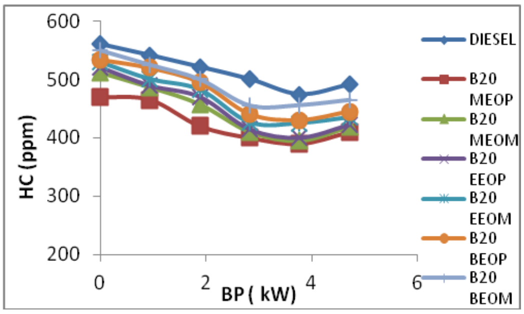

Fig.6. Hydrocarbon emission vs brake power for B20

B. Carbon monoxide (co)

Fig.7. shows the variation carbon monoxide with brake power. The lower CO emissions of esters may be due to their more complete oxidation as compared to diesel. CO produced during combustion of esters might have converted into CO_2 by taking up the extra oxygen molecule present in the molecular chain and thus reduced CO formation. It can be observed from figure that CO is increased at full load condition; this is due to excess fuel injected inside the cylinder leads to smoke and prevents oxidation of CO to CO_2.

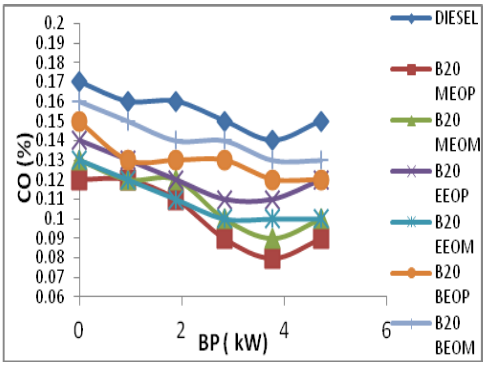

Fig.7. Carbon monoxi de emission vs brake power for B20

C. Carbon dioxide (co_2)

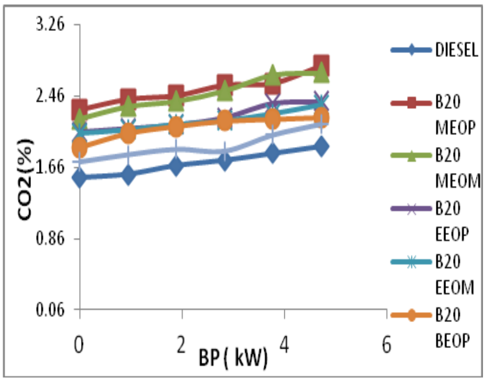

Fig.8.Carbon dioxide emission vs brake power for B20

Figure 8. shows the carbon dioxide (CO_2) emissions with brake power. The CO_2 emissions from a diesel engine indicate how efficiently the fuel is burnt inside the combustion chamber. Since the ester-based fuel burns more efficiently than diesel, MEOP shows maximum CO_2 emission.

D. Smoke

Figure 9. shows the variation of smoke with brake power. In case of B20 of vegetable oil esters the smoke emissions are reduced, this is because of complete combustion due to the oxygen content of the vegetable oil.

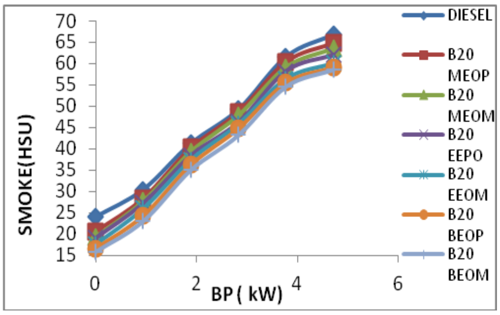

Fig.9.Smoke opacity vs brake power for B20

VI. Conclusion

The Kirloskar Engine was used to test B20 of methyl ester of Pongamia oil (MEPO),1 ethyl ester of Pongamia oil (EEPO), butyl ester of Pongamia oil (BEPO), methyl ester of Mahua oil (MEMO), ethyl ester of Mahua oil (EEPO) and butyl ester of Mahua oil (BEPO) and compared with conventional commercial diesel fuel. The brake thermal efficiency for biodiesel blend was found to be slightly less than that of diesel fuel at tested load conditions. The carbon monoxide (CO) emission of engine was decreased with biodiesel blend. The smoke and HC emission decreased with biodiesel blended fuels. The values of brake thermal efficiency for the blend B20 MEPO and B20 of MEMO is nearing with the sole fuel when compared with all other blends. From the above experimentation it is concluded that B20 methyl ester of Pongamia oil and B20 methyl ester of Mahua oil can be used in existing diesel engines without modification in the engine.

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