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THE INFLUENCE OF BIO ADDITIVE ON THE COMPRESSION IGNITION ENGINE WITH DIESEL AND MAHUA METHYL ESTER BIODIESEL

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ABSTRACT

The experimental investigation analyses various characteristics of diesel engine like performance, combustion and emission with diesel and 20% concentration of mahua biodiesel blend in diesel with bio additives. Both the diesel and biodiesel fuel was injected at 23º BTDC. The testing was carried out with three different ratio of bio additive. Biodiesel was extracted from mahua oil, 20% (B20) concentration is found to be best blend ratio from the earlier experimental study. The bio additive was added to B20MEOM at the various concentrations of 1 mL, 2 mL and 3 mL, respectively. The main objective is to obtain minimum specific fuel consumption, better efficiency and lesser Emission using bio additive blends. The results concluded that full load show an increase in efficiency when compared with diesel, highest efficiency is obtained with B20MEOMBA 3 mL bio additive blend. It is noted that there is an increase in thermal efficiency as the blend ratio increases. This can be attributed to better combustion due to higher oxygen content in the bio additive blend. Biodiesel blend has performance closer to diesel, but emission is reduced in all blends of B20MEOMBA 3 mL compared to diesel. Thus the work marks for the suitability of biodiesel blends in diesel engine as an alternate fuel.

Key words: Methyl ester of mahua, Bio additive, Performance, Combustion, Emission.

INTRODUCTION

Due to global warming and depletion of petroleum product, a need of research for alternative fuel is most necessary in the world. Present CI engine necessitates clean combustion and increase in performance with varying operating condition. The demand of energy is raised mainly because of life style change, large amount of energy utilized in industrial, agricultural irrigation and raising in automobile. When looking for various sources of alternate fuel, it should safe guard the environment and ensure the long term

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availability of fuel[1]. In recent years, number of research is going on bio based energy. Bio based fuel has the more probability to aid the demand of fuel in proper method.

The large amount of renewable energy is obtained from biomass energy. The vegetable oil is derived from various sources of biomass energy. The non edible oil is less cost than edible oil. The non edible oil plant is grown in any climatic condition. Number of advantages results in using the vegetable oil such as increasing in agricultural economics, rural development and other main important advantage is reduced emission[2]. The chemical property of this fuel leads to reduce the emission. Presently many researchers investigated to reduce the emission in three methods. The first one for design parameter, second one for operating parameter and last one for fuel modification. The operating parameter includes various injection timing, various nozzle hole size and various compression ratio, and fuel modification for biodiesel, alcohol fuel, syngas gas and hydrogen fuel etc. Biodiesel reduces particulate matter considerably. The biodiesel is used in straight diesel engines results in considerable decrease of emission except NOx[3]. The properties are nearly equal to that of diesel.

Additives used in diesel engine

The cetane improver ethyl hexyl nitrate is used to find the performance and exhaust emissions of a single cylinder, air cooled, four stroke and direct injection diesel engine. The result depicted that there is an increase in brake thermal efficiency with the increase in the percentage of EGR which is accompanied by a reduction in brake specific fuel consumption and exhaust gas temperatures. The biodiesel with cetane improver under 20% EGR reduces NO_x emissions by 33% when compared to baseline fuel without EGR. However there is an increase in carbon monoxide (CO), hydro carbon (HC) and smoke emissions with an increase in percentage of EGR[4].

The testing of a fuel is experimented in DI diesel engine with cetane improver additive blends in diesel in range of 1 mL, 3 mL and 5 mL noted in all emission parameter and performance parameter such as BTE and SFC. The results show cetane value improved was used to reduce the NOx emission. The additive of 3 mL was selected as a best blend in both performance and emission parameter. They reported cetane improved additive produced higher NOx emission in low load and full load[5].

In the present work the bio mileage is used as an additive with 20% of methyl ester of Mahua. The additive is blended with B20MEOM in various proportions i.e. 1 mL, 2 mL and 3 mL, respectively in order to increase the cetane number in biodiesel. This additive will gives better performance with biodiesel and less emission at different loads.

EXPERIMENTAL

In this experimental investigation was analysis in three different compression ratio in various load at rated speed at 1500 rpm. It is a single cylinder, four stroke, vertical, water cooled DI diesel engine. The engine details were mention in Table 1. The both diesel and biodiesel fuel was injected at 23 ºBTDC. In this work, experimentation was carried at different compression ratio of 17.5, 16.5 and 15.5. Biodiesel was extracted from mahua oil used in 20% (B20) concentration with diesel in all compression ratios[6]. The physical properties in B20 MEOM are provided in Table 2. Smoke reading was identified by smoke meter and hydrocarbon, carbon monoxide and oxides of nitrogen emission were collected from engine tail pipe. The engine cooling was made by water at constant flow rate for entire experiments. Engine load was varied by adjusting knob, it connected to the eddy current dynamometer. The fuel utilization was measured by burette with periodic time. During this interval of time, the utilization of fuel was measured, with the help of the stopwatch. In each load the performance parameter and emission parameter were measured[7]. The experimental system line sketch is plotted in Fig. 1. The inlet and exhaust gas temperature were measured by Chromel-Alumel K-type thermocouples. The combustion parameter was measured by combustion analyzer.

Table 1: Details of experimental engine

Manufacturer	Kirlosker TV – I
Category	Vertical cylinder, DI diesel engine, VCR engine
Number of cylinder	1
Bore stroke	87.5 mm 110 mm
Compression ratio	17.5
Speed	1500 rpm
Rated brake power	5.2 kW
Cooling system	Water cooling
Injection timing	23°BDTC

Table 2 physical properties in B20 MEOM

Test property	B20 MEOM
Density at 15°C kg/m^3	879.6
Kinematic viscosity at 40°C	4.53
Flash point (PMCC) °C, (min)	126
Pour point °C	4
Gross colorific value k.cal/kg	9823

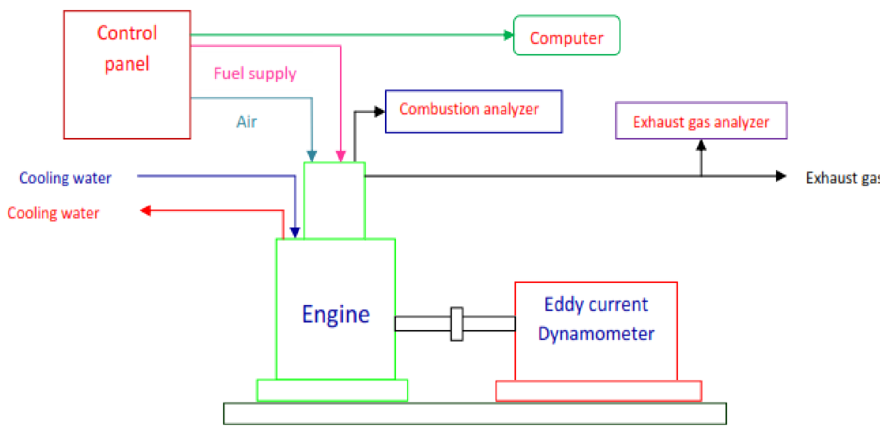

Fig. 1: Line sketch of experimental system

RESULTS AND DISCUSSION

Performance characteristics

The results for the variation in the specific fuel consumption with increasing brake power on the engine for the various blends of bio additive and diesel is presented in Fig. 2. From this graph, it is seen that the specific fuel consumption decreases with increase in bio additive blend. This is mainly due to the combined effects of the relative fuel density, viscosity, and heating value of the blends[8]. However, at higher load, specific fuel consumption in MEOMBA 3 mL blend of bio additive is lower in comparison to other blends. Throughout the entire load range, minimum specific fuel consumption is obtained with bio additive blends.

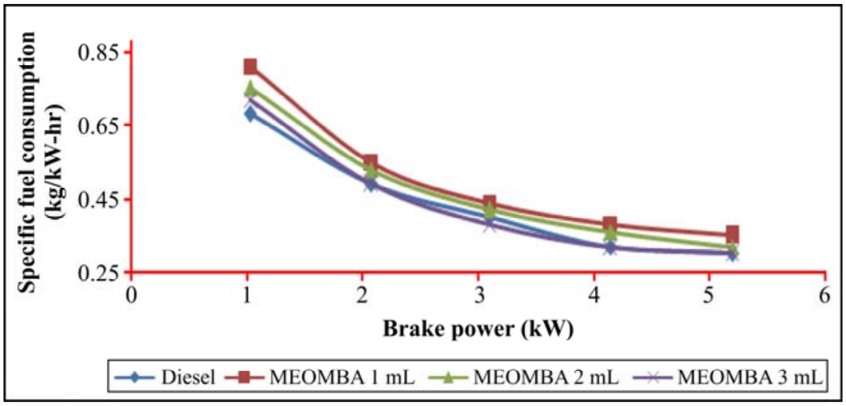

Fig. 2: Specific fuel consumption with brake power

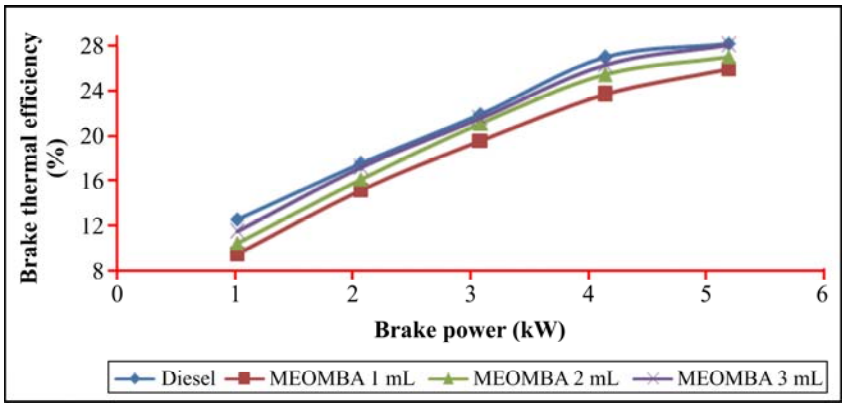

Fig. 3: Brake thermal efficiency with brake power

The brake thermal efficiency of the engine with various blends of bio additive is presented in Fig. 3. It is observed that the brake thermal efficiencies increase with brake power. The brake thermal efficiencies of the bio additive blends are higher than that of diesel fuel. It can be noticed that full load show an increase in efficiency when compared with diesel, highest efficiency is obtained with MEOMBA 3 mL bio additive blend[9]. It is noted that there is an increase in thermal efficiency as the blend ratio increases. This can be attributed to better combustion due to higher oxygen content in the bio additive blend.

Emission characteristics

Fig. 4 shows the variation of smoke density with brake power. It can be observed that smoke density increases with an increase in the brake power. Maximum emission occurs at maximum load. It can be seen that MEOMBA 3 mL bio additive blend effectively reduces the smoke density. The oxygen enrichment provided by the bio additive leads to smoke reduction[10].

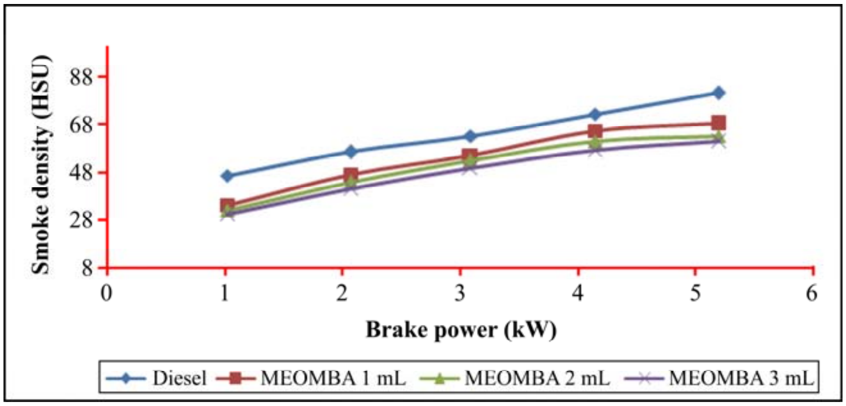

Fig. 4: Smoke density with brake power

Fig. 5 shows the comparison of the NO_x concentration being emitted from the engine exhaust using neat diesel and bio additives. The concentration of NO_x is increased when the load is increased[11]. It is due to conversion of elemental nitrogen to NO under the condition of high gas temperature which can be easily combined with oxygen to create nitrogen dioxide. In all Bio additive blended NOx is increased compare with diesel.

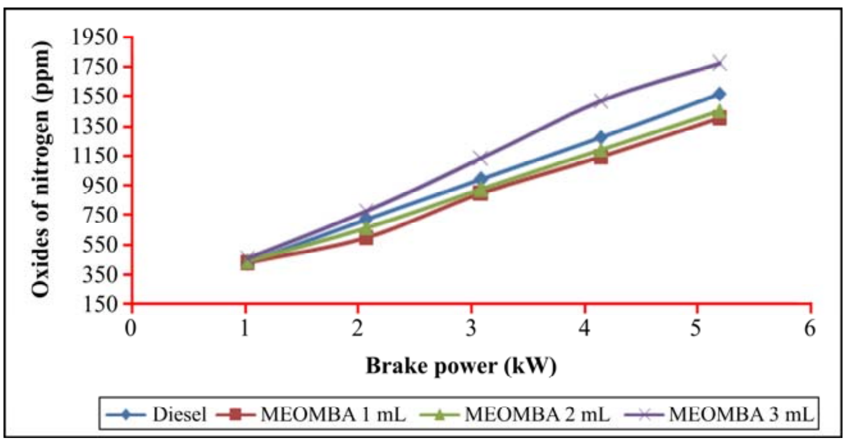

Fig. 5: Oxides of nitrogen with brake power

The comparison of the HC concentration being emitted from the engine exhaust using diesel and bio additive blends is shown in the Fig. 6. A MEOMBA 3 mL blend reduces the HC emission when compared with diesel. The reason can be attributed to the property of the bio additive blend to reduce the surface tension and make the cohesive bonding between the molecules stronger. This leads to better combustion when compared to diesel. Blending 3 mL of bio additive with diesel reduces the HC by 3 ppm at full load condition.

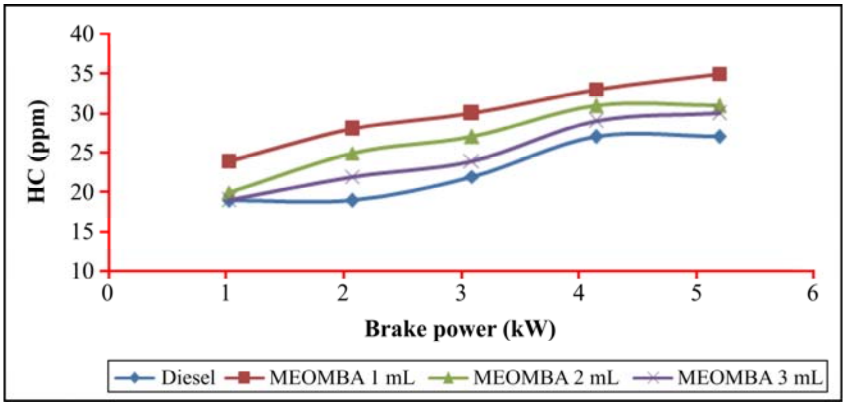

Fig. 6: Hydro carbon with brake power

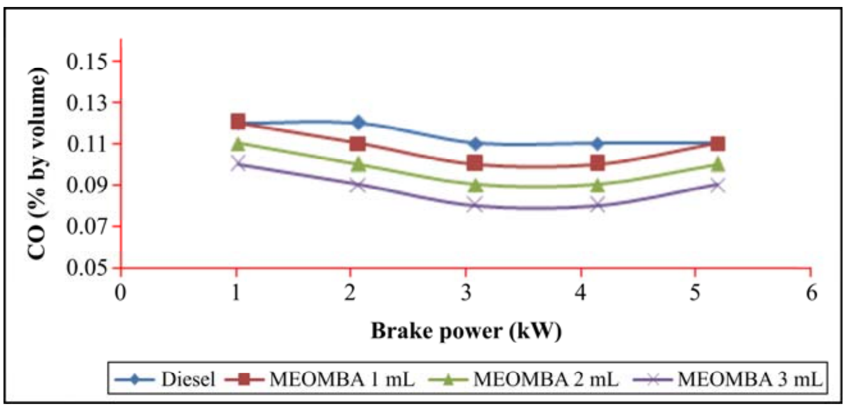

Fig. 7: Carbon monoxide with brake power

Emission of CO with brake power is shown in Fig. 7. It can be noticed that for diesel and bio additive blends CO emission first decreases and after reaching 40% load, it starts to increase. This behavior can be explained by the fact that at lower output, engine gets the lean mixture, and at a higher output, richer mixture is supplied to the engine that results in incomplete combustion and higher percent of CO. At a full load, CO emission reduces drastically with increasing amount of bio additive blends[12]. This phenomenon can be explained by the fact that at higher temperature, part of bio additive blends plays significant role in better combustion of fuel due to presence of oxygen in bio additive blends.

Combustion analysis

Fig. 8 shows the variation of cylinder pressure with crank angle. The peak pressure is increased by shortening the diffusion combustion phase. The diffusion phase can be shortened by an increased oxidation process with the help of bio additive. A high oxidation process occurs during the expansion stroke since there is high oxygen concentration in the bio additive blend that gives sufficient time during the diffusion combustion[13]. At operating load condition the peak pressure of diesel is 72.55 bar and for 3 mL bio additive blend it is 71.64 bar. This is due to faster burning of fuel which can take place in the initial stage of combustion[14]. Faster burning of fuel is due to better atomization because of low viscosity of the bio additive blends.

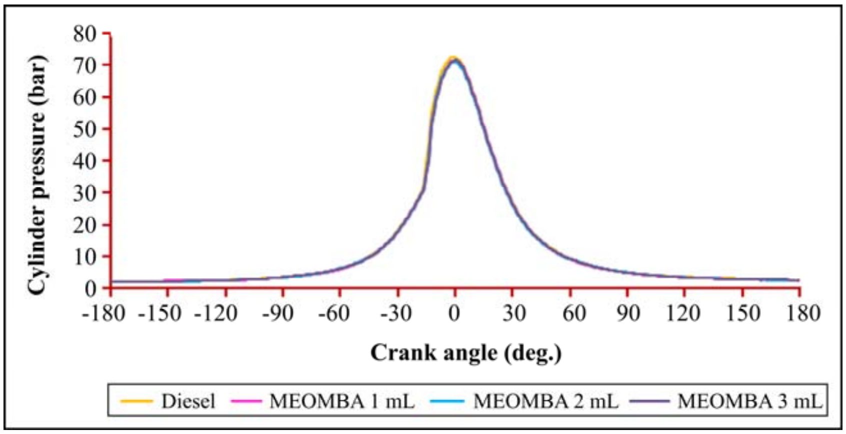

Fig. 8: Cylinder pressure with crank angle

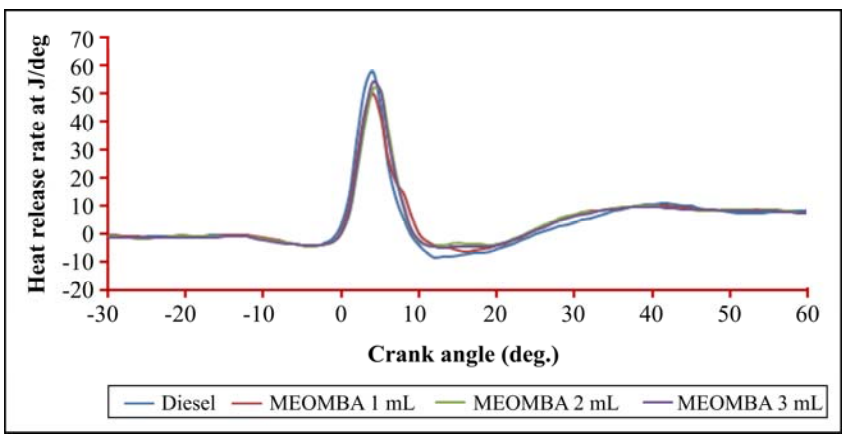

Fig. 9: Heat release rate with crank angle

Fig. 9 shows the variation of heat release rate for bio additive blends and diesel. The most significant observation is that the peak heat release rate is lower in the case of 2 mL and 3 mL bio additive blend as compared to diesel. It was observed that the maximum heat release rate was recorded for 2 mL and 3 mL bio additive blends. The heat release rate for 2 mL and 3 mL bio additive blends are 51.49 J/deg and 54.19 J/deg. The rate of heat release for the blended fuel shows short delay period. However the periods of premixed combustion of the entire bio additive blends shows no difference. But the rate of diffusion and combustion of the bio additive blends is much faster than that of diesel.

CONCLUSION

At higher load, specific fuel consumption in MEOMBA 3 mL blend of bio additive is lower in comparison to other blends. Throughout the entire load range, minimum specific fuel consumption is obtained with bio additive blends. It can be noticed that full load show an increase in efficiency when compared with diesel, highest efficiency is obtained with MEOMBA 3 mL bio additive blend. It is noted that there is an increase in thermal efficiency as the blend ratio increases. This can be attributed to better combustion due to higher oxygen content in the bio additive blend. It can be seen that MEOMBA 3 mL bio additive blend effectively reduces the smoke density. In all Bio additive blended NOx is increased compare with diesel. A MEOMBA 3ml blend reduces the HC emission when compared with other blends. It can be noticed that for bio additive blends CO emission decreases with diesel. At operating load condition the peak pressure of diesel is 72.55 bar and for 3 mL bio additive blend it is 71.64 bar. The most significant observation is that the peak heat release rate is lower in the case of 2 mL and 3 mL bio additive blend as compared to diesel. The heat release rate for 2 mL and 3 mL bio additive blends are 51.49 J/deg and 54.19 J/deg.

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