EXPERIMENTAL INVESTIGATION ON DIESEL ENGINE FUELLED WITH CANOLA OIL METHYL ESTER AND DIESEL BLEND

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Abstract—*A biodiesel derived from non-edible oils can be used as a fuel for diesel engine. In today scenario, the biodiesel extracted from plant leaves and seeds etc., reduces the usage of diesel fuel. The non-edible oils such as Jatropha, Karanja, Mahua, Neem and Nerium etc., are easily obtainable and can be used in CI engines. So, it reduces the fuel demand. Therefore, introducing a new biodiesel also supports to reduce the fuel demand. So, this study is focussed on the performance and emission characteristics of COME – Diesel blendused in CI engine.*

Keywords—Performance, combustion, emission, methyl ester, diesel engine.

1. INTRODUCTION

The selection of non-edible oil for biodiesel production was studied [1]. The collection of oil seeds from plant trees is complicated task, when compared to the cultivable oil seeds. The biodiesel production process is completely analysed regarding the use of suitable catalysts, additives, various transesterification processes etc. Then the researchers are continued their work to improve the property of biodiesel over other fuels [2]. Further, it was proved that jojoba oil has suitable chemical and physical characteristics and can be used in diesel engines. The performance of varies concentration of jojoba oil showed that the small increase in BSFC, decrease in NO_x emission and soot formation when compared to diesel [3]. Many experiments were conducted using edible oils because of its availability. Apart from that the transesterification of edible oil is cheap, rapid and economical. The biodiesel is showed that it reduces the exhaust gas emission in the atmosphere [4]. In another study, the density, pour point and viscosity of the blended fuel is increased while increasing concentration of methyl ester. The results concluded that fuel properties of the blends similar to that of diesel up to the addition of 20% methyl esters [5]. The performance characteristics of the diesel engine such as BTE, BSFC and EGT of the fuel blends (B10 and B20) were compared with diesel. The researchers showed that the considerable reduction in CO, CO_2, smoke and HC emissions are 33.3%, 8.4%, 43.4% and 29.4% respectively. The results also showed that the NO_x emission was high due to the presence of oxygen in the biodiesel [6]. Generally, the biodiesel plants can be cultivated in waste land. Apart from this, the physical and chemical characteristics of biodiesel derived from non-edible sources such as Jatrophacurcas, Pongamiapinnata, Madhucaindica, etc., are bounded under the limits of ASTM specifications [7]. The specific fuel consumption of the Ceibapentandra-biodiesel blend (CPB10) is less when compared to diesel. Further, emissions of CO, HC and smoke are less for all the biodiesel mixes, but the emission of NO_x and CO_2 are increased compared to diesel [8]. The BTE and NO_x emission were reduced while using soyabeen oil-biodiesel blend [9]. The BSEC values are better while using rice bran oil. In particularly, 25% of the rice bran oil blended with diesel showed low viscosity, better combustion and reduced emissions than other blends with rice bran oil [10]. Although, the vegetable oil blends provide the reduced CO, HC and smoke emission and increased the NO_x emission when compared to diesel. Further, the engine performance with vegetable oil mix or biodiesel was almost identical with diesel fuel [11]. However, blending of jatropha, karanja, mahua, linseed, rubber seed, cotton seed and neem oil are showed significantly reduction of HC, CO and PM but increase in NO_x emission. The results exhibit that diesel engine fuelled with 20% vegetable oil and 80% diesel gives best engine performance [12]. Further, blending of biodiesel reduce the emission of PM, HC and CO and fuel consumption, NO_x emission increased when compared to diesel [13-14]. The Jatropha-diesel blend gives less BTE but more BSFC values when compared to diesel. Further, it provides the less emissions of HC, CO, smoke and more NO_x emission when compared to diesel [15]. The performance and emissions of using B10 and B20 blends of Jatropha methyl ester in diesel engine is evaluated. The reduced HC emission of B10 and B20 was 3.84%, 10.25% and CO emission was 16% and 25% when compared to diesel. The NO_x also reduced by 3%, 6% respectively while using B10 and B20 [16]. The CO, smoke and NO_x of karanja methyl ester (KME) mixed with B40 were decreased by 80%, 50% and 26%, respectively. Further, B40 also showed 6% increment in brake power output [17].

Apart from this, the karanja biodiesel and its mixes showed 3-5% reduction in BTE than diesel. The emission of UBHC, CO, CO_2 and smoke are comparatively less in case of karanja biodiesel when compared to diesel. However, the NO_x emission of karanja biodiesel and its mixes has higher value than diesel. Further, the peak cylinder pressure and heat release rate value lower for karanja biodiesel and its mixes [18]. The experiments were conducted by using mahua oil methyl ester (MOME), mahua oil ethyl ester (MOEE) and mahua oil butyl ester (MOBE), performance and emission characteristics of diesel engine are studied. The CO and NO_x emissions are lower while using MOME, MOEE and MOBE and CO_2 emission was higher than the diesel. Further, the MOME can be effectively used as suitable alternate for diesel fuel compared with other esters based on the performance and emission characteristics [19]. Further, the use of MOME showed 20% increase in fuel consumption than diesel. Moreover, the emissions of CO and HC are reduced by 26% and 20% respectively than diesel. However, the MOME showed about 4% drop in NO_x emission than diesel [20].

The literature study is confirmed that biodiesel can be used as an alternative fuel for diesel engines. But, the availability of the biodiesel is an important consideration and limited depending upon the climate and the area. The various biodiesels such as jatropha, mahua, karanja, neem and their derivatives are used in diesel engines with little or no modifications. Many scholars are proved that the biodiesel is an alternate for diesel after the transesterification of raw vegetable oil. It is also showed that the biodiesel cannot be used as a sole fuel in CI engine. Most of the experiments are concluded that blending of 20% biodiesel with 80% diesel is the best combination for CI engines. So, recently many studies are being carried out to identify novel biodiesel composition and evaluate the effectiveness of these novel biodiesel for CI engines. The present experimental work shows the performance and emission characteristics of CI engine fuelled with canola oil methyl ester - diesel blend. The test blends are COME10D90, COME20D80, COME30D70, COME40D60 and diesel fuel used as a reference fuel.

2. COME PREPARATION.

Initially, canola oil extracted from the seeds by using mechanical screw type expellers. Then it is reacted with three moles of methanol in the presence of sodium hydroxide (NaOH) catalyst during transesterification process to obtain a mixture of methyl ester, fatty acids and glycerol. Esterification enables removal of fatty acids and glycerol. The methyl ester that is remains in the mixture is called as biodiesel. The characteristics of canola biodiesel are almost matching the diesel".

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3. EXPERIMENTAL DETAILS.

The experiments have been conducted in a single cylinder, four strokes, water cooled, CI diesel engine operated under uniform speed. The schematic diagram of the test engine is shown in Fig. 1. It is attached with eddy current dynamometer to apply the brake load. The test engine was started initially with diesel and allowed to run for ten minutes. The exhaust gas analyser helps to measure the emissions of CO, HC and NOx. Then, exhaust gas is passed through the smoke meter to measure the smoke density. Further, AVL indimeter software with suitable instruments and sensors are used to calculate the cylinder pressure and crank angle of the combustion as shown in Fig. 1. The specifications of the test engine are shown in Table. 1.

TABLE I. SPECIFICATIONS OF THE TEST ENGINE.

Manufacturer	Kirloskar oil engines limited
Model	SV1
Type of engine	Vertical, 4-stroke,single cylinder, compression ignition diesel engine
Displacement	661 cc
Max brake power	5.2 kW
Speed	1500 rpm
CR	17.5:1
Lubrication system	Forced feed system
Bore and stroke	87.5 x 110 mm
Method of cooling	Water cooled
Fly wheel diameter	1262 mm
Injection pressure	200 bar

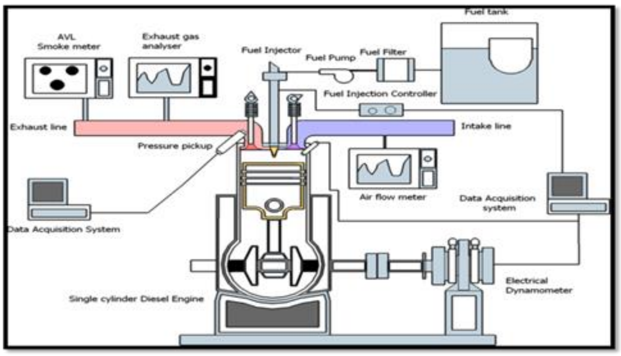

Fig.1. Schematic diagram of engine setup

Several tests were conducted under constant speed of 1500rpm by varying the loads. The loads are varied from no load to full load by 25%. Several blends of biodiesel such as A20, A40, A60, A80 and A100 are used as test fuel. The engine tests have been conducted thrice and the average value is taken. Uncertainty analysis also carried out to prove the accuracy of the experiments. The uncertainty analysis of various parameters was calculated using the percentage of uncertainties of various instruments as shown in Table 2.

Table.2. Experimental uncertainties.

Parameters	Systematic Errors (±)
Speed	±1 rpm
Load	± 0.1 N
Time	± 0.1 s
Brake power	± 0.9434 kW
Temperature	± 1°C
Pressure	± 0.616144bar
NOx	± 10 PPM
CO	± 0.03%
CO2	± 0.03%
HC	± 1.5 PPM
Smoke	± 1 HSU
Airflow	± 0.6481kg/hr
Viscosity	± 0.7 centistokes
Fuel Flow	± 0.731kg/hr

4. RESULTS AND DISCUSSION.

A. *Brake Thermal Efficiency (BTE).*

In general, the BTE is the ratio between the brake power obtained from the engine and the fuel energy supplied to the engine. The BTE shows the effective conversion of heat energy into mechanical energy. Apart from this, BTE mainly depends on the engine design, fuel type and engine application. Fig.2 shows the variation of BTE with brake power for varies proportions of blends and diesel. The remarkable reduction of BTE occurs due to low heating value, lean air fuel mixture, higher viscosity and higher density of biodiesel when compared to diesel. The low BTE directly relates to higher BSFC. The oxygen content increases with increasing the percentage of the COME, which reduces the heating value and in turn reduces the BTE.

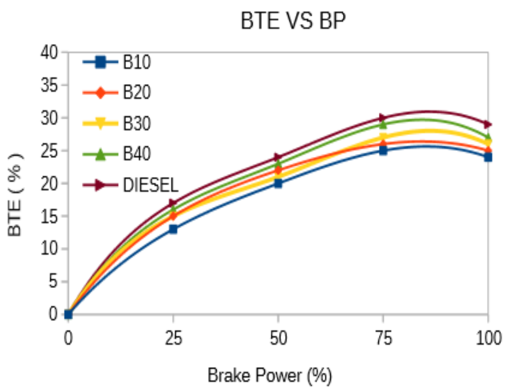

Fig. 2 . Brake thermal efficiency Vs Load.

B. *Emission Characteristics of Carbon Dioxide.*

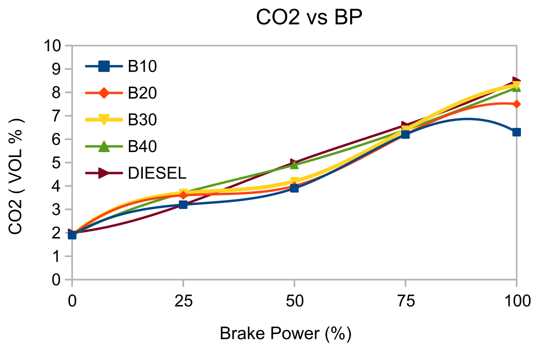

Fig. 3 Carbon dioxide emissions.

Fig. 3 shows the variations of CO_2 with brake power. It exhibits the percentage of CO_2 increases while blending of COME with diesel. The B40 results are almost similar to that of neat diesel compared with other blends.

C. *Brake Specific Fuel Consumption (BSFC).*

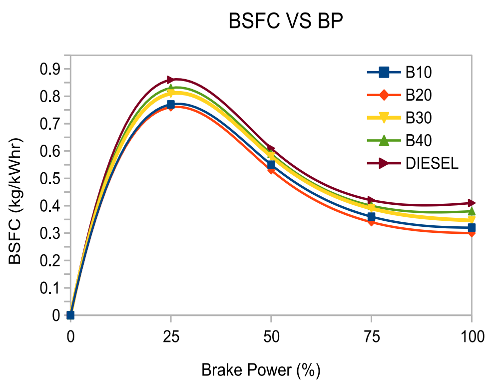

Fig. 4. BSFC Vs LOAD.

This parameter is also used for evaluating engine efficiency. The BSFC is the ratio of rate of fuel consumption to the effective power produced by the engine. Fig. 4 shows the variation of BSFC with brake power for various blending of COME with diesel. It is observed that the BSFC considerably decreases with rise of BP for all mixes at all loads, especially B20 shows minimal BSFC than other mixes. The BSFC for biodiesel is more compared to diesel fuel because of high density, high viscosity and low heating value. Thereby fuel consumption is increased.

D. Exhaust Gas Temperature (EGT).

The burning capacity of the engine is estimated from the exhaust gases temperature. Fig. 5 shows the variation of EGT with brake power for varies proportions of biodiesel and diesel. The results showed that the EGT increases with BP for all mixes at all loads. Further, B20 showed lowest EGT than all other mixes. Further, increasing the concentration of biodiesel in the mixes directly increases the oxygen content which improves the combustion and rises the inside temperature of the combustion chamber, subsequently EGT is also increased.

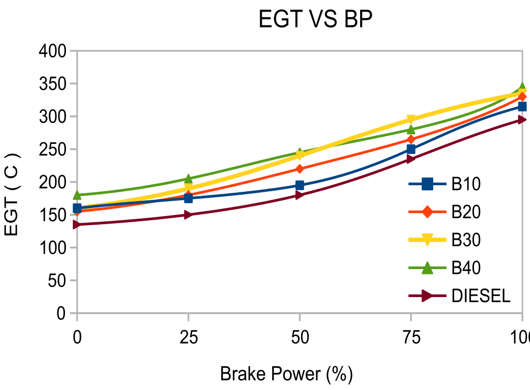

Fig. 5.Exhaust Gas Temperature (EGT).

E. Hydrocarbon Emission.

HC emission is mainly due to the incomplete combustion. Fig. 6 shows the variation of HC emission with brake power for different proportions of biodiesel blend and diesel. It is observed that the HC increases with brake power for all mixes at all loads. The results show that the B20 mix exhibited low HC than all other mixes. The emission of HC is slightly high in diesel fuel due to depleted oxygen supply and partial combustion causing enhanced HC emission. The B20 mix exhibits low HC emission when compared to diesel since biodiesel has high oxygen concentration and so enables effective combustion thereby HC emission is reduced.

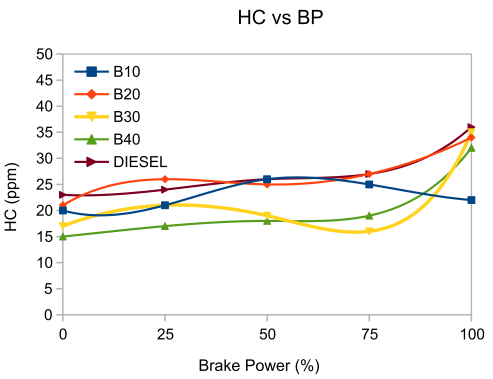

Fig. 6. Hydrocarbon emissions.

F. Carbon Monoxide(CO)Emission.

Fig. 7 depicts the variation of CO with brake power for different quantities of biodiesel mixes and diesel. The results showed that CO emission is decreased up to 75% of full load. In addition to that the B20 mix showed considerable reduction in CO than other mixes. The CO emission is increases with increase of biodiesel concentration due to the high viscosity directly causing poor atomisation, less homogenous mixture and irregular supply of fuel in the combustion chamber.

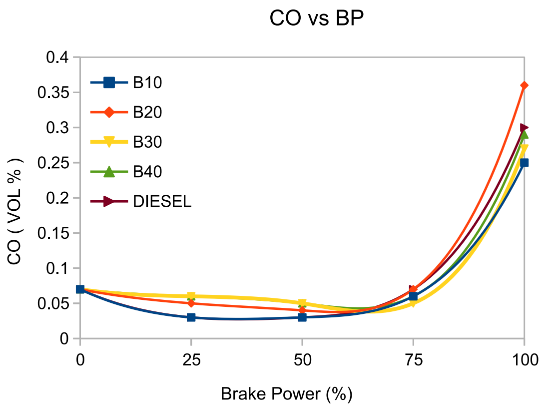

Fig. 7. Exhaust Gas Temperature (EGT).

G. Oxides of Nitrogen Emission.

Emission of NO_x depends on in-cylinder temperature. Fig.8 shows the rate of oxides of nitrogen emission with brake power for varying concentration of biodiesel mixes and diesel. The results showed that emission of NO_x increases with increase in brake power for all biodiesel mixes at all loads. Additionally, the mix B20 showed considerable reduction in NO_x emission than other mixes. The diesel fuel also showed less NO_x emission mainly due to negligible oxygen content. When the biodiesel is present in the combustion chamber the temperature raises to a maximum due to the presence of high oxygen content that leads to NO_x emission.

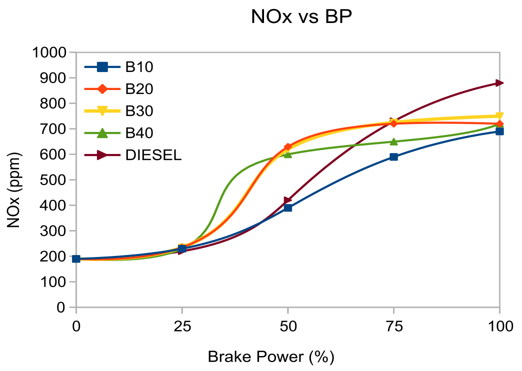

Fig. 8. Exhaust Gas Temperature (EGT).

H. Smoke Emission.

In general, the smoke density depends on the fuel and its usages. Fig. 9 shows the variation of smoke emission with brake power for different proportions of biodiesel mixes and diesel. The results showed that the smoke decreases considerably with respect to increase in brake power for all mixes at all loads. Further the presence of higher oxygen content in biodiesel showed improved combustion and also considerable reduction in smoke emission. It is also concluded that smoke emission is increased significantly due to the partial combustion mainly because of the low calorific value biodiesel.

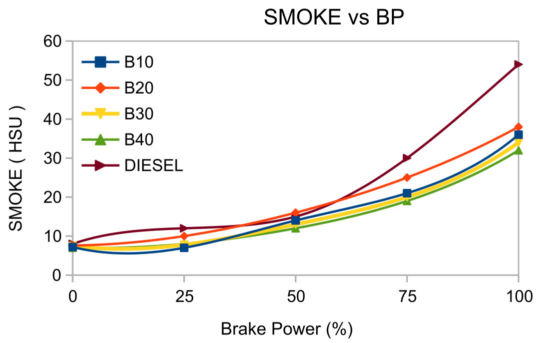

Fig. 9 smoke density.

5. CONCLUSION

This work concluded that B20 exhibits superior performance and showed remarkable reduction in exhaust emissions except NO_x emission. The B100 exhibits lowest performance, highest emissions among all exhausts. The B20 exhibits least NO_x emission than other combinations. Apart from the above result, B20 also exhibits outstanding cylinder pressure and heat release rate when compared with different proportions. The results resolve that the B20 exhibiting higher performance, combustion and emission characteristics without any modifications in diesel.

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