Impact of Diethyl Ether on the Performance of LHR Diesel Engine Operated using Canola Oil Methyl Ester - Diesel blend

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ABSTRACT

The biodiesel prepared using non-edible oils can be directly used as a fuel in CI diesel engine without changing the engine design. But matching the property of diesel and overcome its drawbacks is necessary one. In this experimental study, the effort has been taken to improve the property of biodiesel blend by adding diethyl ether as additive. This work also deals about the impact of DEE on the performance and combustion characteristics of low heat rejection diesel engine powered by canola oil methyl ester and eucalyptus oil blend. Initially, the experiments are carried out in diesel engine using pure diesel and COME20% + EU80% combination. Then the experimental works are continued with diesel, COME20% + EU80%, COME20% + EU80% with 10%DEE combination in LHR diesel engine. The obtained results are compared in both cases with diesel and favourable outcomes are achieved while using COME20% + EU80% with 10%DEE in LHR engine. This blend almost matches the properties of diesel and provides less emission of CO, HC and smoke, it gives best results at full load operation.

Keywords: Performance, Emission, Methyl ester, Diethyl ether, Low heat rejection engine.

INTRODUCTION

In today's situation, the increasing biodiesel production from plant leaves and seeds etc., reduces the consumption of diesel fuel and reduces the emission level too. The non-edible oils prepared from Jatropha, Karanja, Mahua, Neem and Nerium etc., are easily available. Hence, presenting a new biodiesel supports to reduce the fuel demand for future too. The gathering of oil seeds from natural plants are complex one, while comparing with cultivable plant seeds. The generation of biodiesel is analysed using various catalysts, additives and different transesterification processes etc. Then the investigators are carried out their research to augment the biodiesel properties over other fuels [1]. Then, it was verified that jojoba oil has appropriate chemical and physical properties and suitable for diesel engines. The different concentration of jojoba oil performance is analysed and best combination results illustrates that the small rise in BSFC, NOx reduction and soot formation when compared to diesel [2]. Several works are conducted using edible oils. The transesterification of edible oil is economical and concluded that the biodiesel decreases the emission norms in the environment [3]. In another study, the density, pour point and viscosity of the biodiesel blend is improved while increasing the percentage of methyl ester. The outcomes showed that the fuel properties of the combination are similar to that of diesel up to the addition of 20% methyl ester [4]. The combustion characteristics of the diesel engine such as BTE, BSFC and EGT of the biodiesel mixture (B10 and B20) are compared with diesel. The scholars concluded that the moderate reduction in CO, CO2, smoke and HC emissions are 33.3%, 8.4%, 43.4% and 29.4% respectively. The outcomes also explained that the NOx emission was increased due to the presence of oxygen in the biodiesel [5]. Generally, the physical and chemical properties of biodiesel extracted from non-edible sources such as Jatropha curcas, Pongamia pinnata, Madhuca indica, etc., are limited under the limits of ASTM specifications [6]. The SFC of the Ceiba pentandra-biodiesel blend (CPB10) is less. Further, the emission norms of CO, HC and smoke are less for all the biodiesel blends, but the emission of NOx and CO2 are increased compared to diesel [7]. The BSEC values are good while using rice bran oil. In particularly, 25% of the rice bran oil and 75% of diesel combination showed low viscosity, better combustion and less emission than other blends [8]. The vegetable oil blend gives the reduced CO, HC and smoke emission and increased the NOx emission when compared to diesel. Further, the engine performance of biodiesel was almost equal to that of diesel fuel [9]. However, blends of jatropha, karanja, mahua, linseed, rubber seed, cotton seed and neem oil are showed reduction of HC, CO and PM but increase in NOx emission. The results display that the diesel engine fuelled with 20% vegetable oil and 80% diesel gives best engine performance [10]. The Jatropha-diesel blend provides less BTE but more BSFC values, it gives less emissions of HC, CO, smoke and more NOx emission when compared to diesel [11]. The CO, smoke and NOx of karanja methyl ester (KME) blended with B40 were decreased by 80%, 50% and 26%, respectively. Further, B40 also showed 6% increment in brake power output [12]. Apart from this, the karanja biodiesel mixes showed 3-5% reduction in BTE than diesel. The emission of UBHC, CO, CO2 and smoke are comparatively less for karanja biodiesel when compared to diesel. The NOx emission of karanja biodiesel and its blends has higher value than diesel [13]. The literature survey is confirming that the biodiesel can be used as an alternative fuel for diesel. But, the biodiesel availability is important factor and limited based on the climate and location. Many researchers are proved that the biodiesel acts as substitute for diesel after the transesterification of raw vegetable oil. It is also clear 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. The present investigation shows the performance and emission characteristics of CI engine fuelled with canola oil methyl ester–eucalyptus oil blend. The test blends are COME20EU80, COME20EU80+10%DEE and diesel fuel used as a reference fuel. The blends are tested in both low heat rejection engine and CI engine.

COME preparation

Initially, canola oil derived 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 remains in the mixture is called as biodiesel

EXPERIMENTAL DETAILS

The experimental works are carried out in a single cylinder, four stroke, water cooled diesel engine under constant speed. The schematic diagram of the engine is shown in Fig. 1. It is connected to eddy current dynamometer. The engine is started initially with diesel and allowed to run for fifteen minutes. The exhaust gas analyser is measured the emissions of CO, HC and NOx. Then, exhaust gas is delivered to the smoke meter for smoke measurement. Further, AVL in dimeter software with suitable instruments and sensors are used to estimate 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.1. Specifications of the test engine

Manufacturer	Kirloskar oil engines limited
Model	SV1
Type of engine	Vertical, single cylinder, 4-stroke, compression ignition diesel engine, direct injection
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

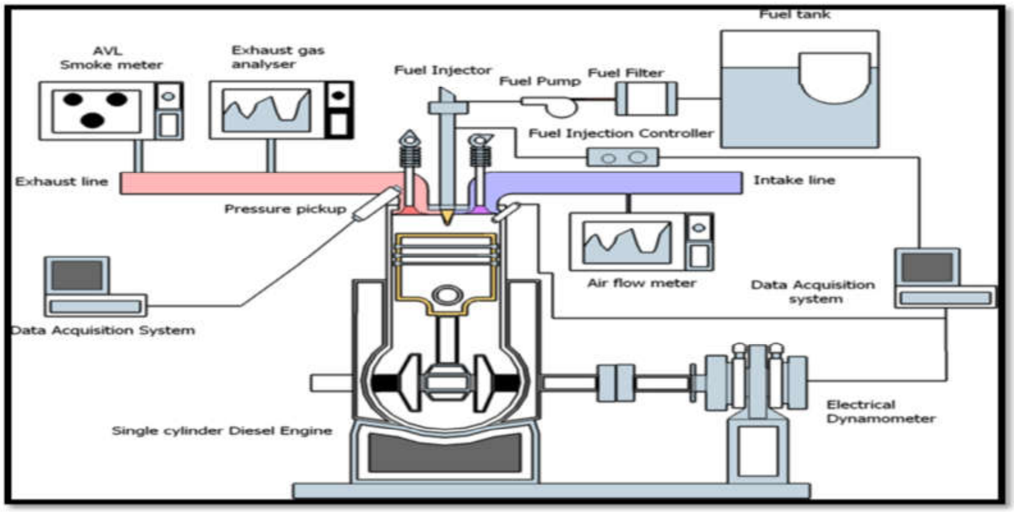

Fig.1. Schematic diagram of engine setup

Several experiments have been conducted under constant speed of 1500rpm by changing the applied loads. The loads are varied from no load to full load by 25%. The test blends are COME20EU80, COME20EU80+10%DEE and diesel fuel used as a reference fuel. The blends are tested in both low heat rejection engine and CI engine. The engine tests are carried out thrice and the average value is taken. Uncertainty analysis also performed to prove the accuracy of the experiments. The uncertainty analysis of several parameters was estimated using the percentage of uncertainties of different 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
NO_x	± 10 PPM
CO	± 0.03%
CO_2	± 0.03%
HC	± 1.5 PPM
Smoke	± 1 HSU
Airflow	± 0.6481kg/hr.
Viscosity	± 0.7 centistokes
Fuel Flow	± 0.731kg/hr.

RESULTS AND DISCUSSION

(i) Brake Thermal Efficiency (BTE)

The BTE of the engine shows the actual conversion of heat energy into mechanical energy. Fig.2 illustrates the variation of BTE with brake power for different cases. The low BTE directly relates to higher BSFC

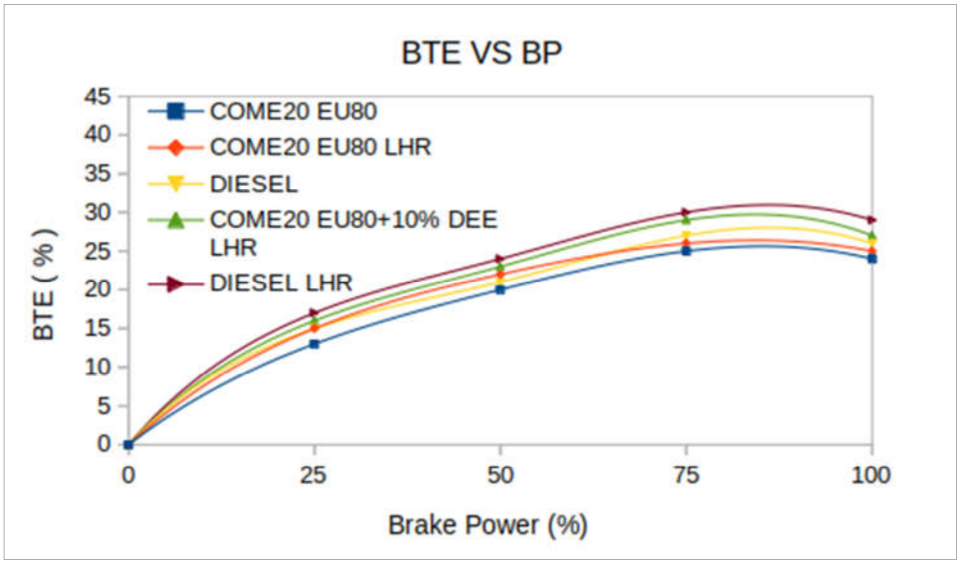

Fig. 2. Brake Thermal Efficiency vs Load

(ii) Emission Characteristics of Carbon Dioxide

Fig. 3 shows the variations of CO_2 with brake power. It exhibits the percentage of CO_2 increases while blending of COME with EU. The COME 20EU80+10%DEE results are almost similar to that of neat diesel compared with other cases.

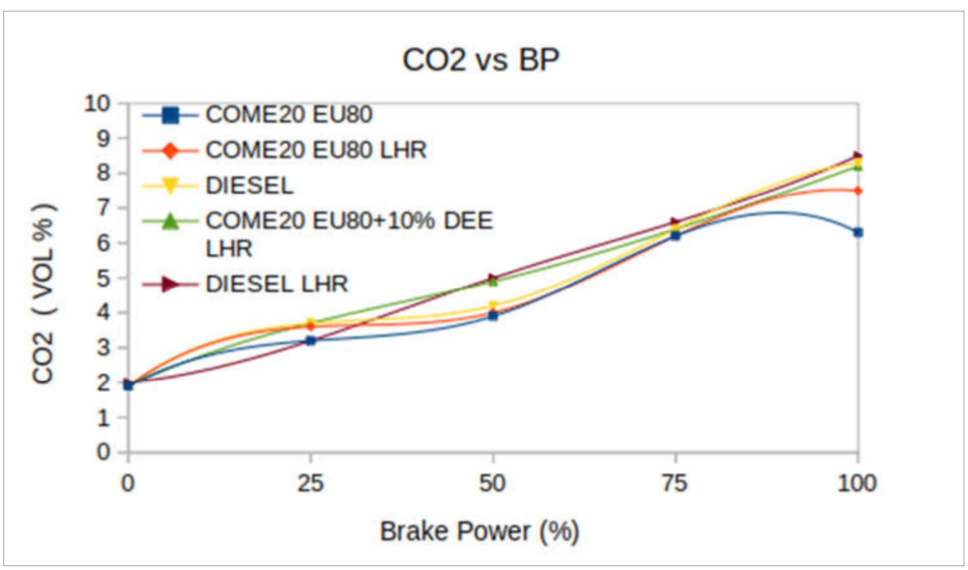

Fig. 3 Carbon Dioxide Emissions

(iii) Brake Specific Fuel Consumption (BSFC)

Fig. 4 shows the variation of BSFC with brake power. It is observed that the BSFC considerably decreases with rise of BP for all cases at all loads, especially COME20EU80+10%DEE shows better compared with other cases and nearly close diesel. The BSFC for biodiesel blend is more compared to diesel fuel because of high density, high viscosity and low heating value. Thereby fuel consumption is increased.

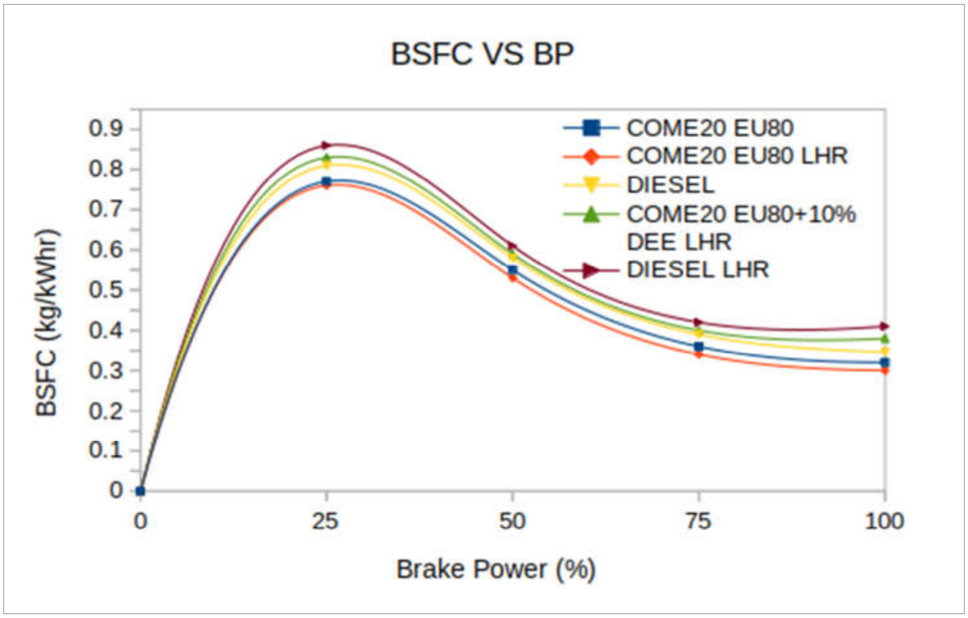

Fig. 4 BSFC Vs BP for all Loads

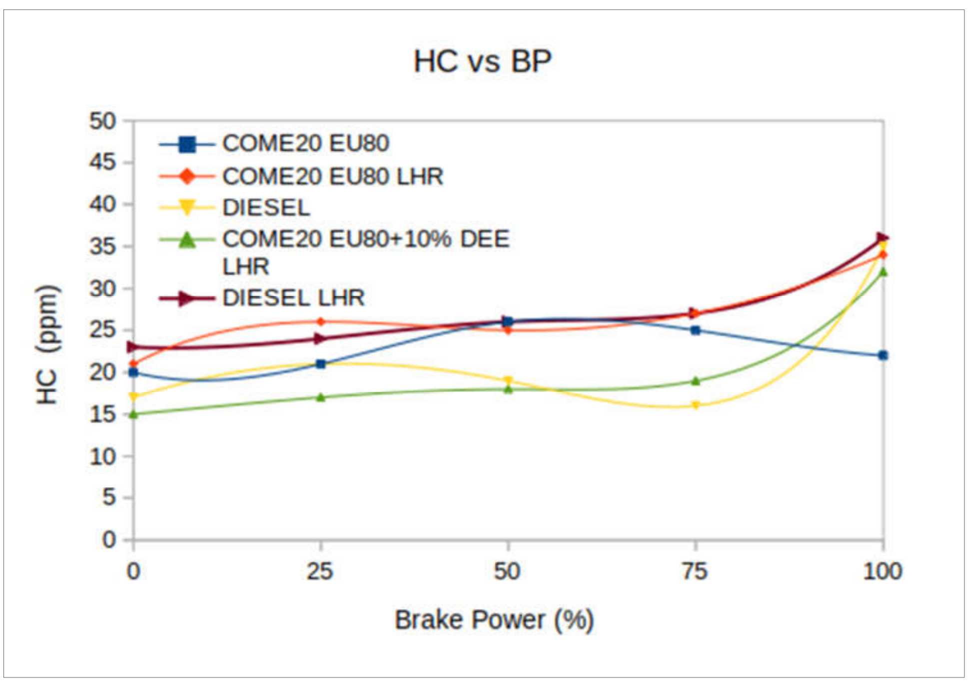

Fig. 5 Hydrocarbon Emissions

(iv) Hydrocarbon Emission

HC emission occurs due to the incomplete combustion. Fig. 5 shows the variation of HC emission with brake power. 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 COME20EU80 in LHR exhibits low HC emission when compared to diesel.

(v) Carbon Monoxide(CO)Emission

Fig. 6 depicts the variation of CO with brake power for various combinations. The results exhibited that CO emission is decreased up to 75% of full load. The CO emission is increases because of poor atomisation, less homogenous mixture and irregular supply of fuel in the engine combustion chamber.

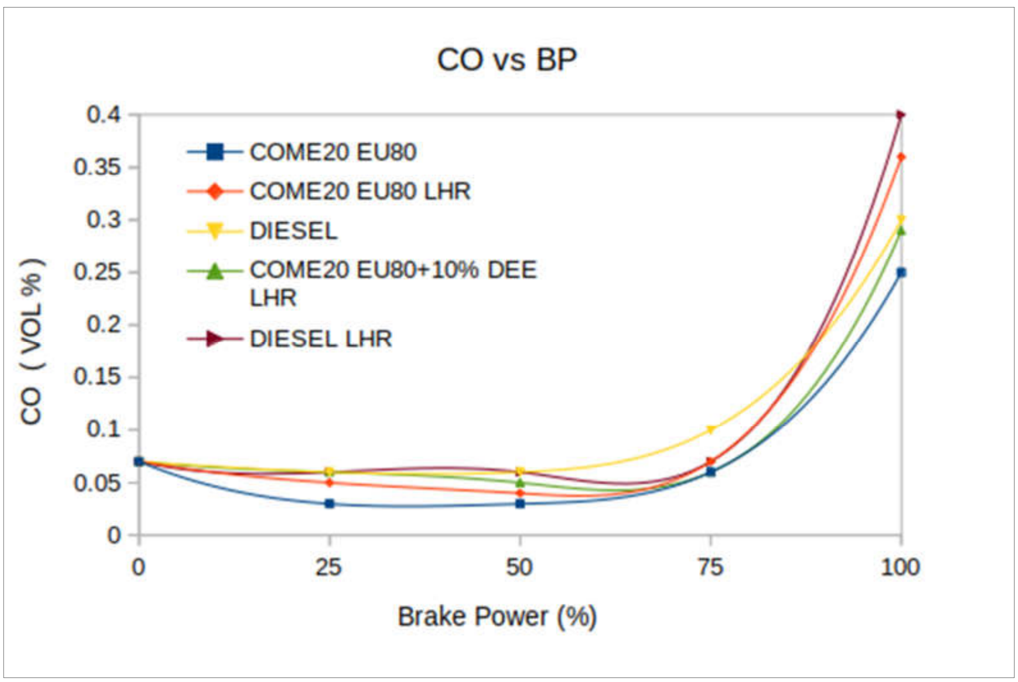

Fig. 6 Carbon Monoxide Emissions

(vi) Oxides of Nitrogen Emission

Emission of NOx depends on cylinder inner temperature. Fig.7 displays the oxides of nitrogen emission with brake power for various cases and diesel. The results showed that emission of NOx increases with increase in brake power for all types at all loads. The presence of oxygen in biodiesel blend leads to high NOx emission.

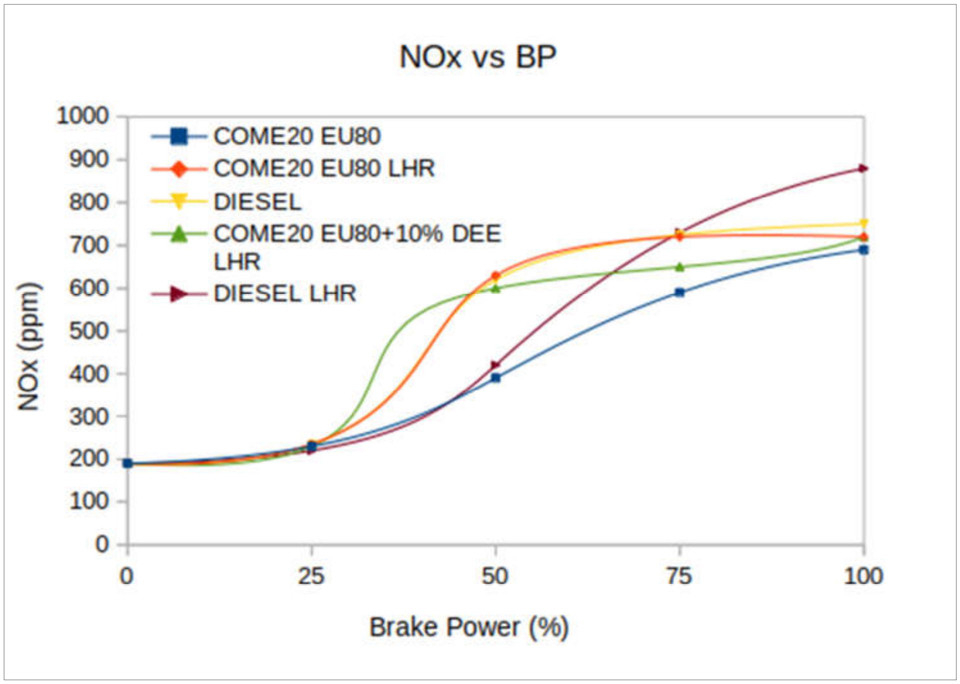

Fig. 7 Nitrogen Oxides Emissions

Conclusion

The experimental investigation is carried out using COME20EU80 in both CI and LHR engine, DEE added to this biodiesel blend and tested in LHR engine and diesel used as reference fuel. The work is concluded that COME20EU80+10%DEE exhibits almost superior performance in most of the cases and showed remarkable reduction in exhaust emissions except NOx emission. The obtained results are almost closer to the diesel fuel. Apart from the above result, COME20EU80+10%DEE displays outstanding cylinder pressure and heat release rate when compared with other cases.

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