Effect of DEE on the Performance and Emission Characteristics of a LHR - DI Diesel Engine operated by Coconut shell oil – Diesel Blend

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Abstract — **The current investigation is concentrated on the influence of DEE on the performance and emission characteristics of LHR DI diesel engine is fuelled with Coconut shell oil-Diesel blend. The certain parts (piston top, cylinder head and valves) of the diesel engine are coated by zirconia ceramic material to minimize the heat loss from the engine. Several experiments have been conducted using different combinations. Initially, diesel and CSO20D80 (Coconut shell oil 20%, Diesel 80%) blend are used in DI diesel engine for experimental investigation. Then diesel, CSO20D80 with and without DEE is used in LHR DI diesel engine. The optimized results are obtained while using CSO20D80 with 15% DEE in Low heat rejection DI diesel engine.**

Key words: Coconut shell oil; LHR; zirconia; Diethyl ether.

I. INTRODUCTION

The world consumes around 70% of fossil fuels and its energy. The scholars are well concentrated to reduce the usage of fossil fuels in the vehicle sector to maintain the clean environment. In recent years, the biodiesel production is considerably increased to meet the needs of the future energy demand. The direct injection diesel engine can be operated using biodiesel blend without altering the engine design parameters. Generally, the biodiesel is extracted from the seeds, shells and leaves of the plants. The production of biodiesel is mainly depends on obtainability of plants and cost need for preparation. In common, the biodiesel is extracted from the various plants like cashew, Jatropha, papaya, eucalyptus etc. The biodiesel is prepared using various methods like pyrolysis, micro-emulsification and transesterificaton etc. When DI diesel engine is operated using biodiesel, the obtained result shows that CO, HC, and soot formation are minimized but NOx is increased, small increase in BSFC when compared with diesel. The investigators are concluded that the presence of oxygen in biodiesel leads to complete combustion and best emission norms [1-2]. In low heat rejection engine, ceramic material is coated using plasma spray method on inner part of the cylinder head, piston crown and valves. So, the heat energy inside the engine is augmented by reducing the heat transfer through the coated parts. This increases the thermal efficiency of the DI diesel engine [3-7]. When biodiesel is used in LHR diesel engine, both availability of oxygen and high temperature increases the NOx emission. The scholars also tried to minimize the NOx emission by changing the injection timing in LHR diesel engine [8, 9]. The diesel engine performance is also improved by varying the fuel properties using chemical additives. Some researchers got small improvements in NOx [10,12]. The authors also concluded that the biodiesel-eucalyptus oil blend (B20E70DEE10) with DEE has similar properties like diesel [11]. The authors have been conducted experiments in diesel engine using canola oil methyl ester and diesel blend in various proportions and concluded that B20 provides better combustion and emission characteristics [12].

In this research work, the coconut shell oil is extracted using pyrolysis process and blended with diesel. Few experiments have been conducted to investigate the effect of 15% of DEE on the performance and emission characteristics of LHR DI diesel engine powered by CSO20D80. The test blends are CSO20D80 with and without DEE, diesel used as a reference fuel.

II. CSO20D80+15%DEE PREPARATION

The coconut shells are pulverized using pulverized machine then CSO oil is derived by using conventional mechanical screw type expellers and added with methanol in the ratio (4:1), 1% of sodium hydroxide is used as catalyst during transesterificaton process. The mixture is heated around 70^{o}C - 80^{o}C for 3 hours and oil is removed. Then it is blended with diesel in the ratio CSO20D80 to avoid poor starting characteristics. Finally, 15%DEE is added with CSO20D80 to improve the volatility and reduce the ignition delay.

III. COATING IN DI DIESEL ENGINE

During practical applications, nearly 30% of heat energy is used for useful work during combustion process and remaining heat energy carried away by exhaust gas, cooling medium, cylinder walls and etc. So, the piston top, inside of cylinder head and valves are coated with zirconia ceramic material using plasma spray method to enhance the engine performance by decreasing the heat loss. This modified engine is called low heat rejection engine. This also reduces the ignition delay and specific fuel consumption.

IV. EXPERIMENTAL SETUP

The Kirloskar single cylinder, four stroke, water cooled, DI vertical diesel engine is developing 5.2 kW power at 1500 rpm is used for the investigation. The piston crown, cylinder head and valves of the direct injection diesel engine is coated with zirconia ceramic material using plasma spray method. The low heat rejection direct injection diesel engine is connected with AG10 model water cooled eddy-current dynamometer and control unit. An orifice meter is used to control the air flow rate. The exhaust gas temperature is measured with help of K type thermocouple. The fuel flow rate is measured with help of burette and stop watch. The xorri gas analyser used to measure the exhaust gas emission HC, CO, CO_2 and NO_X. The AVL437C smoke meter used to measure the smoke level. The engine specifications are listed in the Table.1.

Table.1. Engine specifications

Type of engine	Kirloskar Single cylinder, DI diesel engine, four stroke and vertical
Bore	80 mm
stroke	110 mm
cooling	water cooling
speed	1500 rpm
Compression ratio	17.5 : 1
IVO	4.5 ^{o} A TDC
IVC	35.5 ^{o} A BDC
EVO	35.5 B BDC
EVC	4.5 ^{o} A TDC
SOI	23 ^{o} A B TDC
Power	5.2 kW (7.2 PS)

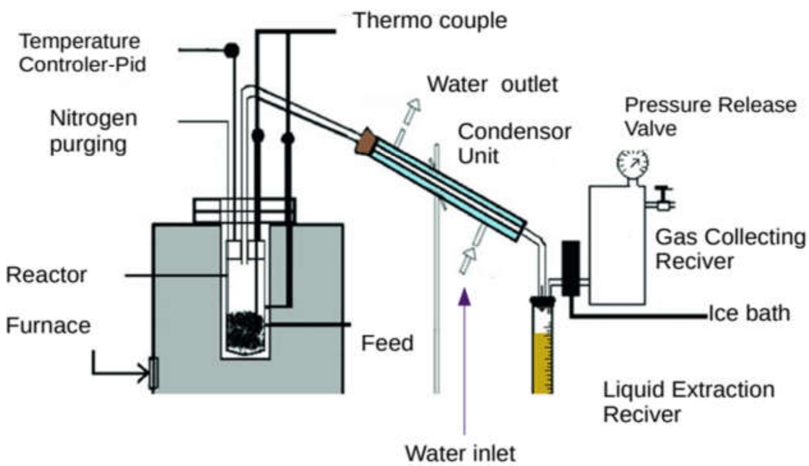

Fig. 1 Pyrolysis experimental set up

The pyrolysis setup is shown in Figure.1. It consists of a reactor made up of stainless steel (L-145 mm, I.D -37 mm and O.D - 41 mm) sealed at one end and open at the other end. The electric furnace is used for heating the reactor and temperature is measured by K type thermocouple attached with inside the reactor, temperature is controlled by an external PID controller. The particular quantity of coconut shell is loaded in pyrolysis reaction. The condensable liquid product is collected through the condenser and weighed. After pyrolysis, the solid residue left inside the reactor is weighed.

Table.2. Fuel Properties

Properties	**Diesel**	**Coconut shell oil**
Density @ 15^{0}C (kg/m^3)	840	1053
Kinematic viscosity @ 40^{0}C (Cst)	2.9	*1.47*
Flash Point (^{o}C)	54	44
Fire point (^{o}C)	64	52
Gross heating value (kJ/kg)	42700	29750
Cetane number	49	60

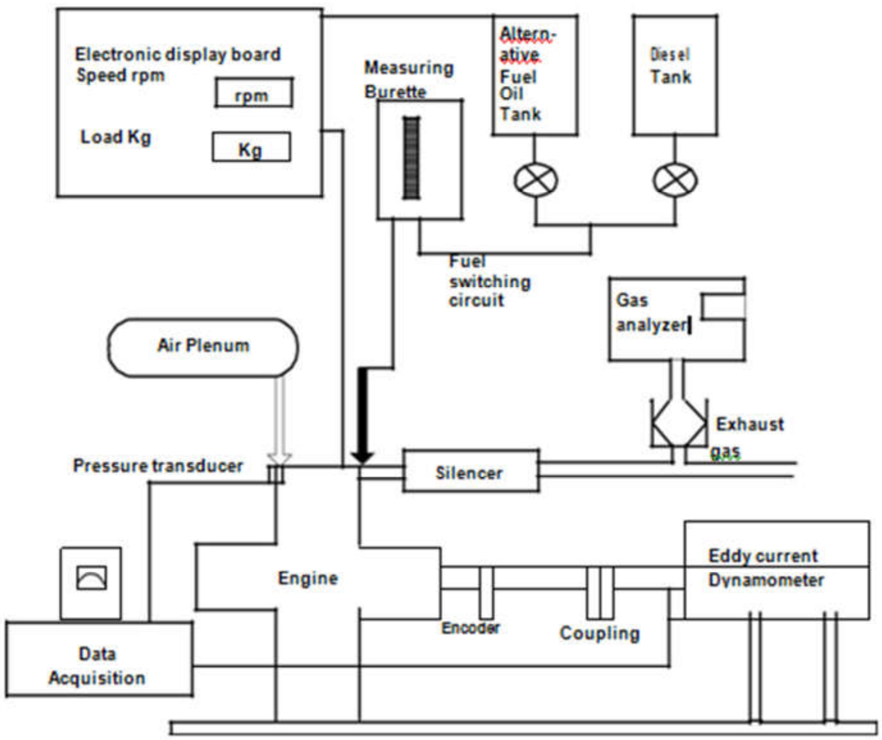

FIG.2 EXPERIMENTAL SET UP

V. EXPERIMENTAL PROCEDURE

The pyrolysis setup is shown in Figure.1. It consists of a reactor made up of stainless steel (L-145 mm, I.D -37 mm and O.D - 41 mm) sealed at one end and open at the other end. The electric furnace is used for heating the reactor and temperature is measured by K type thermocouple attached with inside the reactor, temperature is controlled by an external PID controller. The particular quantity of coconut shell is loaded in pyrolysis reaction. The condensable liquid product is collected through the condenser and weighed. After pyrolysis, the solid residue left inside the reactor is weighed.

VI. RESULT AND DISCUSSION

A Brake Specific Energy Consumption

The figure.3 describes the variation of BSEC with brake power for CSO20D80 with and without DEE, diesel in LHR-DI diesel engine. Brake specific energy consumption is defined as the amount of energy needed to produce 1kW power. While using CSO20D80+15%DEE in LHR DI engine, BSEC is reduced because of shortening the ignition delay caused by high in-cylinder temperature. This is caused by better combustion process.

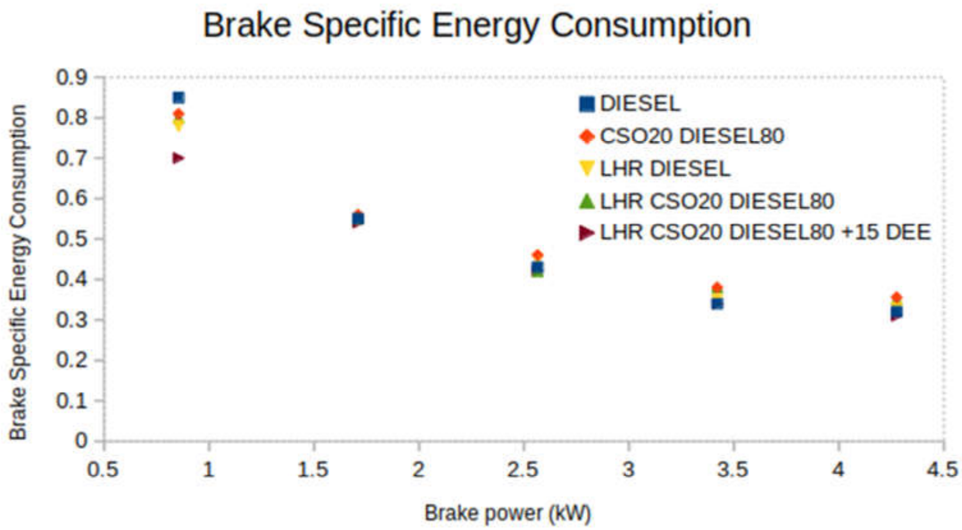

Fig.3 BSEC Vs Brake power

B. Brake Specific Fuel Consumption

The figure.4 shows the variation of BSFC with brake power. The BSFC is the quantity of fuel consumed for generating 1kW of power per unit hour. The graph indicates that BSFC decreases with increase in load. It can be seen that fuel consumption is less for diesel in LHR when compared with others. This is because of higher calorific value of diesel when compared with blends. Out of five tests, CSO20D80+15%DEE in LHR and LHR diesel have the best BSFC rates. At full load, LHR CSO20D80+15%DEE exhibits low BSFC which is 4%, 9% and 11% less than that of LHR diesel, diesel in DI engine and CSO20D80 in in DI engine. Therefore CSO20D80+15%DEE decreases the BSFC because of its higher volatility which speeds up the mixing fuel air mixture and leads to good combustion process.

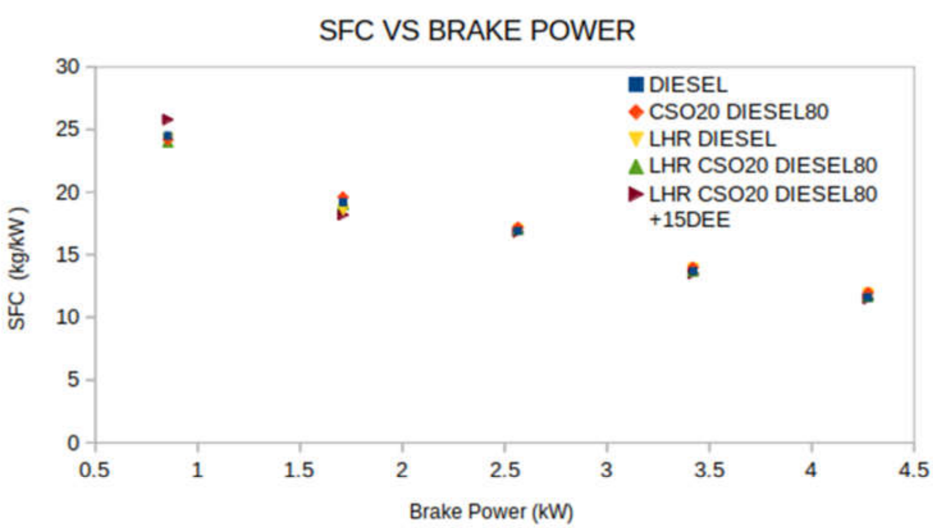

Fig.4 BSFC Vs Brake power

C. Brake Thermal Efficiency

The figure.5 illustrates the variation of BTE with brake power. The BTE can be improved by engine design modification. So, That LHR engine used effectively to increase the BTE by avoiding the heat losses. At full load, the LHR CSO20D80+15%DEE has good thermal efficiency of 32.5% which is 0.7%, 1.8%, and 7% greater than LHR CSO20D80, LHR diesel and CSO20D80 in DI engine respectively. So, DEE helps for better atomization and mixing the fuels perfectly.

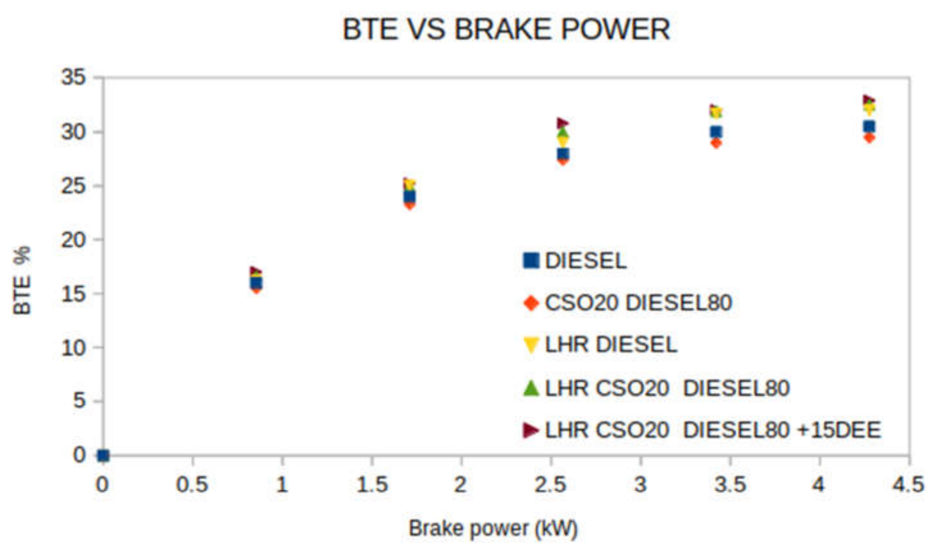

Fig.5 BTE Vs Brake power

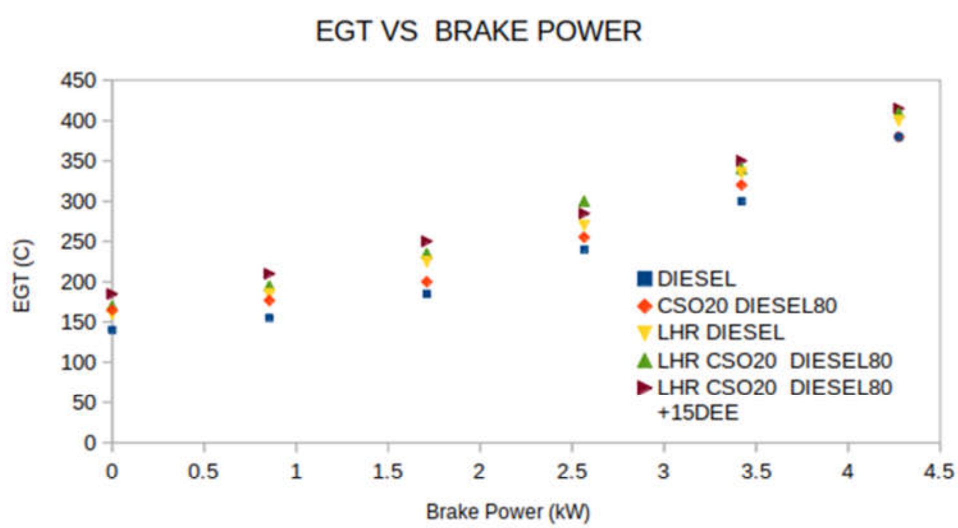

Fig.6 EGT Vs Brake power

D. Exhaust Gas Temperature

The figure.6 illustrates the variation of BTE with brake power. The BTE can be enhanced by engine design modification. So, The LHR engine is used effectively to increase the BTE by avoiding the heat losses. At full load, the LHR CSO20D80+15%DEE has good thermal efficiency of 29% which is 0.7%, 1.6%, and 8% greater than LHR CSO20D80, LHR diesel and CSO20D80 in DI engine respectively. So, DEE helps for better atomization and mixing the fuels perfectly.

E. CO emission

The figure.7 shows the variation of CO emission rate with brake power. The CO emission is formed due to incomplete combustion. The rich oxygen content leads to the better combustion process. It can be seen that diesel has relatively low oxygen content. So, high CO emission rate is observed on both standard and LHR engine. At full load, CO emission rate for CSO20D80+15%DEE is 23% and 32% less than diesel in LHR and DI engine respectively. CSO20D80+15%DEE with LHR engine shows the optimum results because DEE creates the lean mixture, low viscosity which helps to improve the atomization and combustion of the fuel.

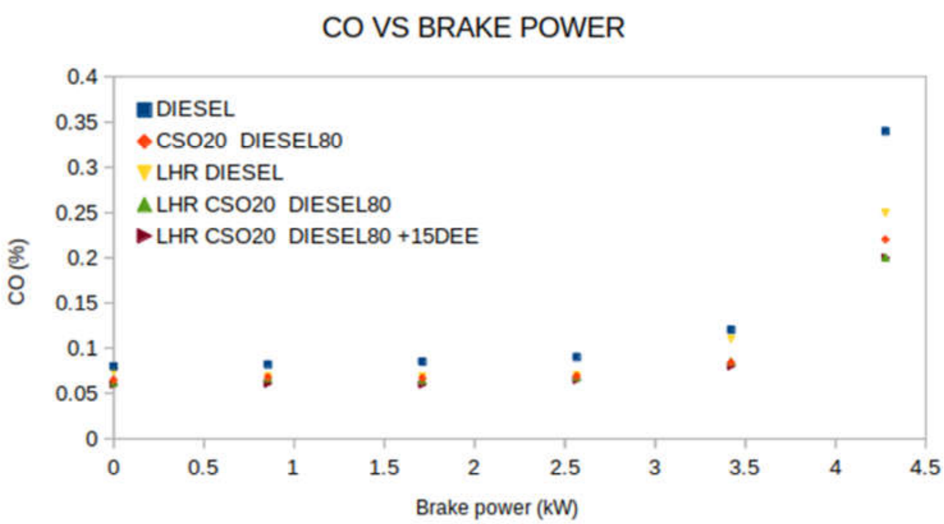

Fig.7. CO emission Vs Brake power

F. HC emission

The figure.8 exhibits the variation of CO emission rate with brake power. The CO emission is formed because of incomplete combustion. The rich oxygen content leads to the better combustion process. It can be seen that diesel has relatively low oxygen content. So, high CO emission rate is observed on both standard and LHR engine. At full load, CO emission rate for CSO20D80+15%DEE is 22% and 31% less than diesel in LHR and DI engine respectively. CSO20D80+15%DEE with LHR engine shows the optimum results because DEE creates the lean mixture, low viscosity which helps to improve the atomization and combustion of the fuel.

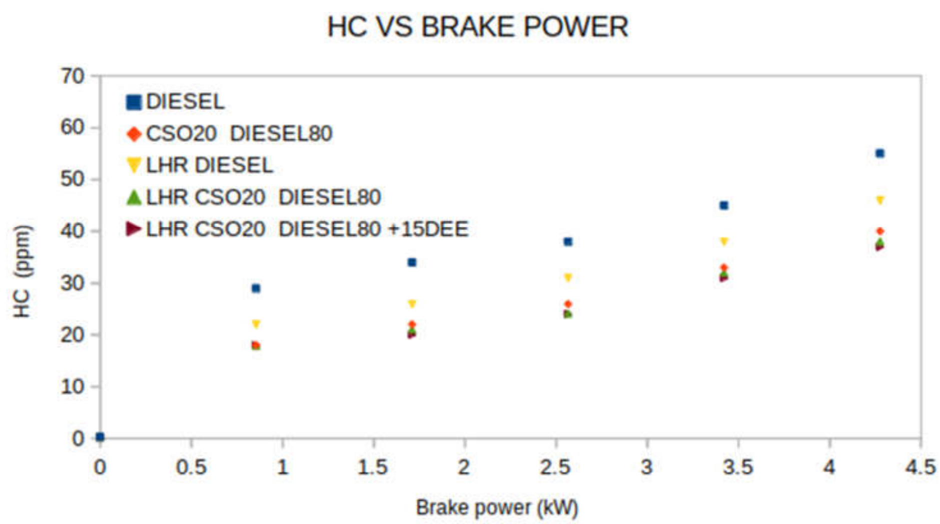

Fig.8 HC emission Vs Brake power

G. NO_x emission

The figure.9 shows the variation of NOx emission rate with respect to load. The combustion of fuel is an endothermic reaction and NOx is formed during high temperature. The graph shows that the NOx emission rate increases with increasing load. DEE decreases the NOx emission when it is added with CSO20D80. This is caused because DEE acted as a cooling medium. At full load operations, diesel exhibits 800 ppm NOx emission on DI diesel engine is less when compared with others.

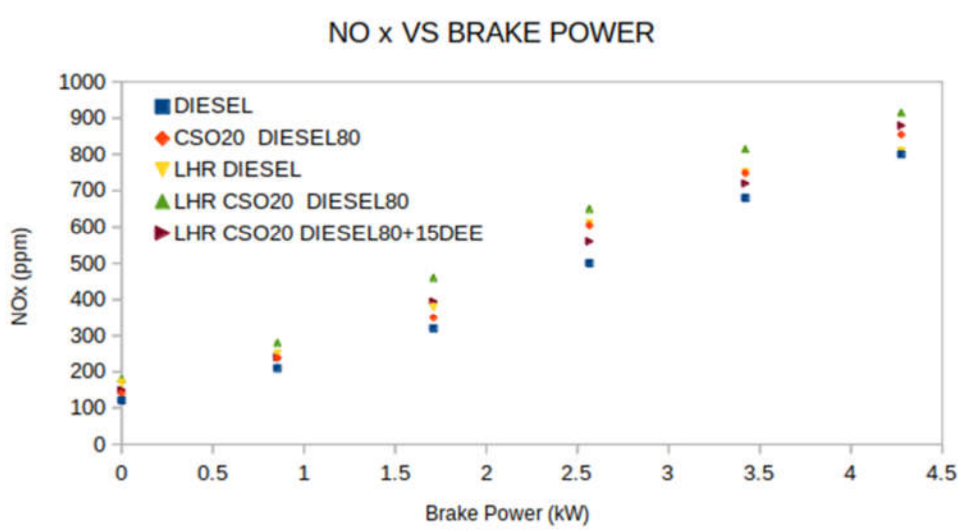

Fig.9 NO_x emission Vs Brake power

H. Smoke emission

The figure.10 shows the variation of smoke density with brake power. The Smoke emission indicates the incomplete combustion and increases with load. The CSO20D80+15%DEE blend decrease the smoke emission during high in-cylinder temperature in LHR engine.

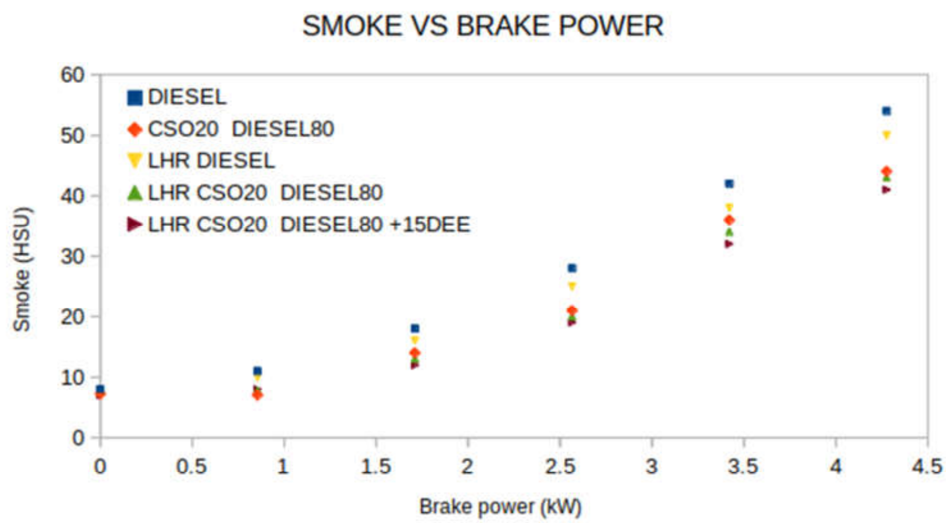

Fig.10 Smoke Vs Brake power

VII. Conclusion

This work is concluded that DEE acted as a fuel property modifier effectively. Five different experiments are conducted in DI diesel engine and LHR-DI diesel engine (Diesel, CSO20D80 with and without DEE) for investigation. The BSFC, BSEC and BTE values are best in LHR-DI engine while using CSO20D80+15%DEE when compared to other four. So, LHR and DEE helps to improve the atomization and the cold flow properties of biodiesel blend. The NOx emission rate is also reduced considerably. The CO emission is 19% less and HC emission is 29% less compared to diesel fuel.

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