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Performance, Combustion & Emission Analysis on Diesel Engine Utilizing Diethyl Ether as a Fuel Additives

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Abstract
As of late much research has been given to locate the reasonable elective fuel to oil based items. The present examination assesses the exhibition, burning and discharge parameters of the single chamber four-stroke diesel motor stacked up with the mixes of diesel and diethyl ether (DEE) as energized included substance. The radiations assessed were carbon monoxide (CO), hydrocarbon (HC), carbon dioxide (CO2), smoke, O2, NOx. It was represented that including oxygenated included substances improved the gleam point, thickness and consistency of the diesel fuel, dependent upon the course of action of included substances. Diesel is injected to start chamber with diethyl ether as an additional substance with various blend degree (5,10 and 15%). Engine execution regards didn't change out and out with diesel empowers, yet exhaust release profile was improved. The additional substance showed as an improvement in the capability of the engine. Antagonistic to oxygen included substances found very fruitful in controlling NOx game plan and HC release. In this paper the examination of mean gas temperature and fumes gas temperature of a pressure start (CI) motor utilizing diesel and diethyl ether mixes are finished. The outcomes are determined at various motor burdens at consistent pressure proportion of 18:1. It is seen that the most extreme ignition gas temperature, brake warm productivity increases with increase in load. The fumes gas temperature increments with increment in load for all mixes of fuel. The crucial objective of this assessment is to propel the key execution and release parameters. The examination result revealed that mf(mass of fuel) and B.P(brake control) had higher impact in giving the best outcomes to execution and emanation qualities. DEE15 was seen as the ideal mix for brake explicit fuel consumption(BSFC) and brake warm efficiency(BTE).

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1. Introduction

The thermal efficiency of diesel engine is more as compared to any other engine of either internal or external. The Internal combustion diesel engine is functioned by mechanical compression of cylinder owing to which the injected fuel inside the combustion chamber ignited at the elevated temperature of air present in cylinder. This diesel

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engine is the most popular among all other IC engines due to its design and user friendly operations for many applications such as thermal power, transportation, etc. There are many developments are technically achieved in order to improve the combustion process of this IC engine.

Some of the recent technical developments are the fuel infusion impeding, high pressure injection, exhaust gas recirculation (EGR), and air intake super charging.

There are three aspects for the diminishing of pollutant emission from the exhaust of diesel engine. These three aspects are development of combustion technique, exhaust after treatment technology and fuel melioration. Many researchers found from their experiments that various additives in diesel increase the performance of diesel engine considerably. The diesel engine produces many harmful air polluting materials directly or indirectly such as CO, NO_x, PM, HC, O_3 etc. In spite of its popularity due to use of low cost fuel, many investigations have been carried out by the researchers in worldwide to control the emission of polluting materials by changing engine design, modifying fuel etc. Out of many techniques, modification of fuel is the most efficient one. The exhaust of diesel engine emits different pollutants owing to the absence of complete ignition of diesel fuel.Keeping these above matters into consideration, many researchers are used oxygenated fuels such as DEE, alcohol, etc., along with diesel in various proportions. In this experiment DEE taken as additive. Diethyl ether blends with diesel at different proportions of (5%, 10% and 15% by volume) were used as a compression ignition engine fuel. DEE is an uncolored and highly volatile combustible fuel. It can be generated from ethanol, which is produced of biomass. So, DEE is considered to be renewable bio-fuel. It has several positive features like high oxygen content, high cetane number, wide flammability limits, low auto ignition temperature, high mixing ability with diesel.Diesel motor was chosen for the examination of performance, combustion & control of emission by taking compression ratio as 18 utilizing diethyl ether as added substance.

2. Literature Review

In an assessment Patil&Thipse examined the impact of oxygenated diethyl ether (DEE), cetane improver, as an added substance to ethanol-diesel mix on execution and outflow qualities utilizing an immediate infusion diesel motor. The exploratory aftereffects of DEE-ethanol-diesel mixes at full load condition show that the BTE of DE8E10D is improved by 15%; the smoke and NOx emanations of DE15E10D are diminished by 6.25% and 36% separately; while the CO and HC outflows are expanded by 43% and 42% individually when contrasted with flawless diesel [1]. Uslu researched the elective fuel utilizing diesel-diethyl ether (DEE) mixes on the presentation of the motor just as toxin discharges. Exploratory results demonstrated that expanding the measure of DEE in mixes, BTE and SFC expanded while, NOx, smoke, CO and HC diminished. Likewise EGT is diminished with the rising pace of DEE. Greatest increment in BTE was accomplished 8% with DEE7.5. Simultaneously, the greatest increment in SFC was accomplished with DEE10 at 10% [2]. The exhibition of diesel motor was explored utilizing DEE as an added substance with biodiesel mixes by PugazhVadivuEtetal. The warm productivity crumbled insignificantly by the expansion of DEE added substance. From the above trial it is reasoned that the discharge of both smoke and NOx is decreased by the expansion of 15%-20% of DEE in biodiesel mixes [3]. So as to assess the exhibition and ignition process investigation in a diesel motor, Ibrahim thought about four sorts of energizes. The various kinds of energizes were diesel, biodiesel-diesel blend, 5% DEE added substance by volume in biodiesel-diesel-DEE

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blend and blend of 10% DEE added substance by volume in biodiesel-diesel-DEE. Ibrahim finished up from this analysis that not just least brake explicit fuel utilization (BSFC) expanded by 8.1% yet in addition the most extreme warm proficiency decreased by 6.8% as for diesel fuel. It was additionally discovered that the presentation of motor was expanded significantly as for all powers by utilizing 5% DEE added substance in diesel biodiesel blend for most motor loads [4]. In another work, the effect of using immaculate perfect orange oil, perfect orange oil–diesel mix and the ideal stream pace of DEE with orange oil are evaluated for the presentation, outflows and ignition of a solitary chamber, diesel motor by K. Purushothamanet.al[5]. The trial results exhibit that smoke outflows, hydrocarbon (HC) and carbon monoxide (CO) decline while oxides of nitrogen (NOx) releases increase for orange oil and its blends differentiated to diesel fuel and DEE with orange oil.

3. Experiment

3.1 Experimental setup

The present investigation assesses the performance of CI engine in terms of exhaust gas temperature, brake specific fuel consumption (BSFC) & the brake thermal efficiency (BTE), in the laboratory. The engine is fueled by diesel and diesel diethyl ether in different proportion in order to study the parameter under the effect of the fuel additive DEE (Diethyl ether). This parameter is compared in which it will throw light on the effect of the fuel additive ethanol to diesel on the engine performance, combustion and emission characteristics. The results obtained are investigated and described with the help of the work done and outlined by several analysts.

A Kirloskar made, 661cc capacity, naturally aspired, four stroke, single cylinder developing an utmost power of 5.20kW at 1500rpm is used to perform the investigation. The engine is connected to an eddy current dynamometer. The engine could be gradually loaded by activate a knob on the dynamometer. A load indicator indicates the engine load. Fuel is supplied from a 15lt capacity fuel tank mounted on the top of the panel box with appropriate connections for fuel flow. The cylinder pressure is used by the help of a piezo sensor operating in the range of 5000 psi. A rotameter provided the measured data pertaining to the amount of cooling water flow. Engine rpm is measured by a Kubler make digital rotary encoder with a range of 1 to 10000 rpm.

3.2 Experimental Procedure

The block diagram of the examination setup can be found in Figure 1. The experimental data are recorded after the engine attained a steady state. During the experiment the engine is started at no load condition to full load condition at a constant compression ratio of 18. The engine is run with neat diesel and diethyl ether-diesel blend to find its effect. The tests are carried out at constant speed of 1500 rpm. Fuel consumption is measured using a measuring burette in the data acquisition system. Brake thermal efficiency, brake specific fuel consumption, exhaust gas temperature, mean gas temperature, cylinder pressure and exhaust gas emission are all measured at different loads and a constant compression ratio of 18 separately with neat diesel and diesel-ethanol combination.

Table 1: Specification of the Engine

Make	Kirloskar
Detail of the engine	Laboratory testing type, 4-stroke, single cylinder water cooling system, compression ignition type(CI)
Power ratings	5.20Kw at a constant 1500 rpm speed of rotation

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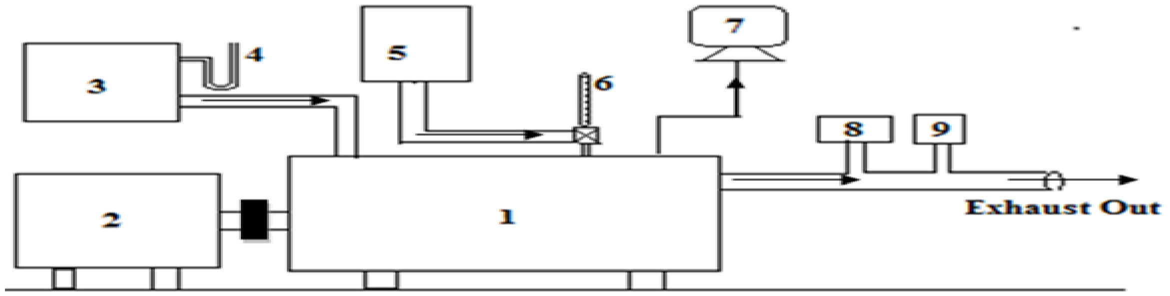
Speed particulars	1500 rpm
Compression ratio	18:1
Bore	87.5 mm
Stroke	110 mm

The fuel (diesel) flow rate is maintained by the help of a governor provided with the system for fuel injection. The details of engine layout and engine setup are shown in Figure 1 and 2.



1. Engine	6. Burette
2. Eddy current dynamometer	7. Data acquiring system
3. Air box	8. Gas analyzer
4. Manometer	9. Smoke meter
5. Fuel tank	10. Coupling

Figure 1: Layout of the Engine

Figure 2: Actual Engine setup

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3.3 Recording of Emission Characteristics

The extent of NO, CO_2, HC and CO emissions in the exhaust gas are measured using a multi-gas analyzer model AVL – 444 models. The range of measurement and the accuracy of the measured values obtained through an analysis of the exhaust gas by the multi gas analyzer are presented in the table 2 as detailed in the related manual. A smoke meter, AVL-437 model with a measuring range from 0 to 100% at a resolution 0.1% is used for measurement of the smoke capacity.

3.4 Properties of Fuel

Correlation between fuel properties of Diethyl ether utilized as a premixed fuel and diesel utilized as a legitimately injected fuel in this examination is given below.

TABLE 2: Comparison of fuel properties

Properties	Diesel	DEE5	DEE10	DEE15
Density (kg/m^3)	849	805	815	828
Cloud point (°C)	5	2	-2	-1
Pour point (°C)	-2	-10	-11	-2
Kinematic viscosity (cSt)	3.9	3.622	3.110	3.000
Calorific value (MJ kg^{-1})	42	35.26	34.72	33.9

3.5 Preparation of Diethyl ether blend

Finding an elective fuel like Diethyl ether is basic. It is relied upon to benefit automobile users, remote trade saves and to ensure issues like a dangerous atmospheric deviation. In our nation diethyl ether fuel is similarly more affordable than diesel. Along these lines it tends to be considered as a research interest. It was shown that diethyl ether-diesel blends were technically acceptable for the existing diesel engines. It is added to diesel at the proportion of 5%, 10% and 15% proportion. It is stirred for 3 hours. The blend exhibited excellent miscibility properties with no residue at the bottom of the container (Figure 3) even after 24 hours of blending. This blend is thus selected for use as a fuel for running the engine.

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Figure 3 Arrangement of Diethyl ether and diesel in the wake of blending demonstrates no precipitation

3.6 Error examination

The error and vulnerabilities in the examination are consequences of a faulty instrument, faulty calibration, working conditions, environment, faulty observation methods and modes of test. Uncertainties reflect measures of the accuracy of the experiment. Uncertainties associated with measuring different types of parameters were determined by using root mean square method. Table 3 houses the percentage of vulnerabilities associated with the measurement of various parameters.

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Table 3: Uncertainty associated with the experiments

Measured Quality	Uncertainty
CO	±0.03
CO_2	±0.06
HC	±0.42
O_2	±0.01
NO	±0.45

4 Results and discussion

4.1 Analysis of the parameters for evaluating engine performance

4.1.1 Influence of engine load on BSFC for diesel and diesel-DEE blend

It seems that the BSFC decreases with increase in load. It may be due to decrease in pumping losses with increasing load. As compared to diesel mode a DEE15 combination results in a 15.78% decrease in the BSFC. This decreased BSFC is recorded 0.32 kg kWh^{-1} at heavy engine load. Similar results were also found by Patil and Thipse [9]. The reduction in BSFC with DEE addition is related with the improved combustion processes due to a higher cetane number of DEE in additions to its low boiling point and additional oxygen content that suppresses the unfavorable combustion characteristics [10].

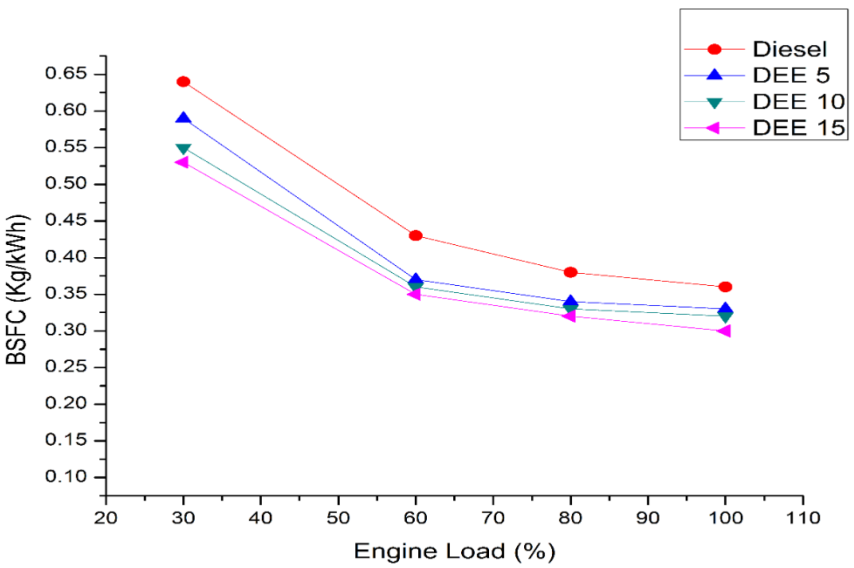

Figure 4:Variation of BSFC with engine load

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4.1.2 Influence of engine load on brake thermal efficiency (BTE) for diesel and diesel-DEE blend

Figure shows the brake warm effectiveness of the motor at various motor loads. Brake warm proficiency increments with an expansion in motor load because of a decrease in start delay, heat misfortune and addition in influence yield. With DEE15 the BTE increments to 27.12% at 80% motor load, the expanded being higher contrasted with the situation when the motor is run in the diesel mode. DEE augmentations increment in the BTE is because of nonstop vanishing of DEE that effectively blend in with air framing a reasonable blend for burning. Likewise the went with additional oxygen accessibility with DEE options additionally improves the BTE. The most extreme estimation of brake warm effectiveness is seen as 29.44% for DEE15 at full load.

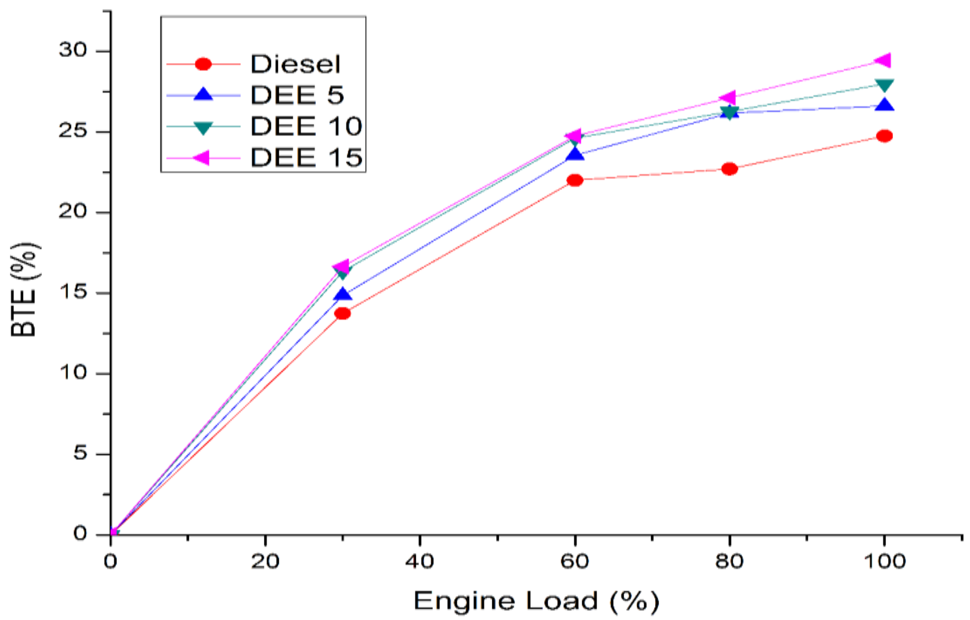

Figure 5: Variation of BTE with engine load

4.1.3 Influence of engine load on exhaust gas temperature (EGT) for diesel and diesel-DEE blend

A group of exhaust temperature with motor load is showed up in underneath chart. It is seen that the fumes temperature increments with increment in motor load. It is a result of the path that at higher loads there is augmentation in fuel luxury and to some degree inferior start. An EGT estimation of DEE15 is 304.95°C at 80% motor load when the motor is run in the DEE15 mode. This is about 5% lower than the EGT recorded when the motor is run in the diesel mode. This bringing down of the EGT is because of a low breaking point of DEE with a high cetane number. EGT is diminished when the motor is controlled by the DEE15 fuel-blend, the mix diminishing the start span. The high warmth of vaporization of DEE additionally decreases the in-chamber temperature along these lines bringing down the EGT.

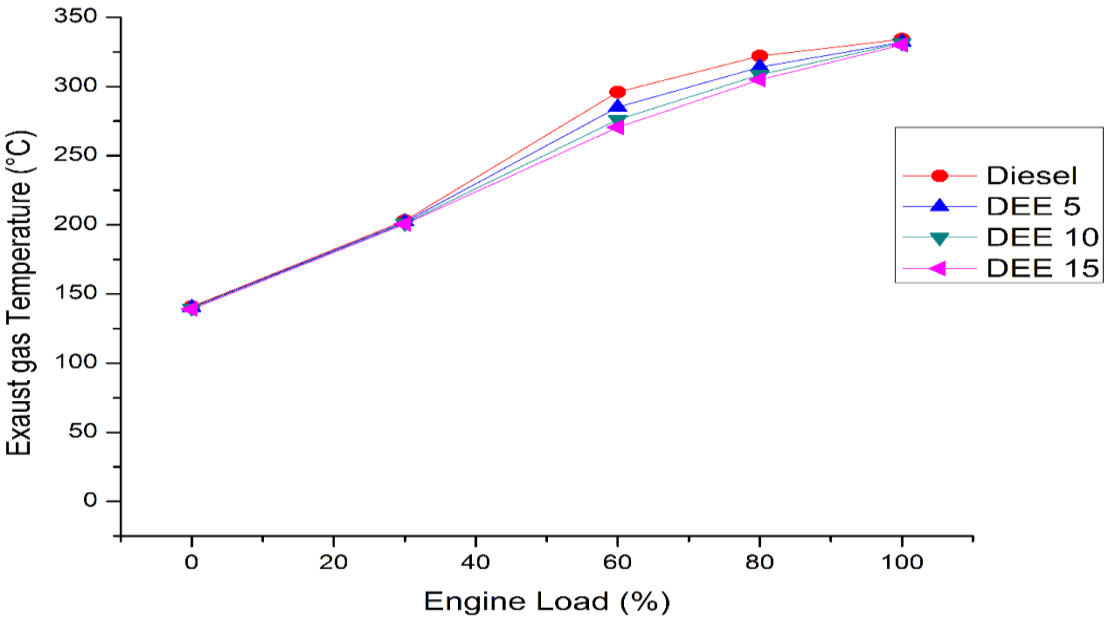

Figure 6:Variation of EGT with engine load

4.2Combustion analysis

4.2.1 Maximum combustion gas temperature at different crank angles as influenced by the engine load for diesel and diesel-DEE blend

Maximum combustion gas temperature increases with increase in load for diesel and the blends of diethyl ether. This is due to the fact that with increase in load the heat release rate increases. DEE15 blend decrease the maximum combustion gas temperature to 1230°C at 100% engine load. As compared to the diesel mode we can see that the value of the maximum combustion gas temperatures is 6.81% lower.

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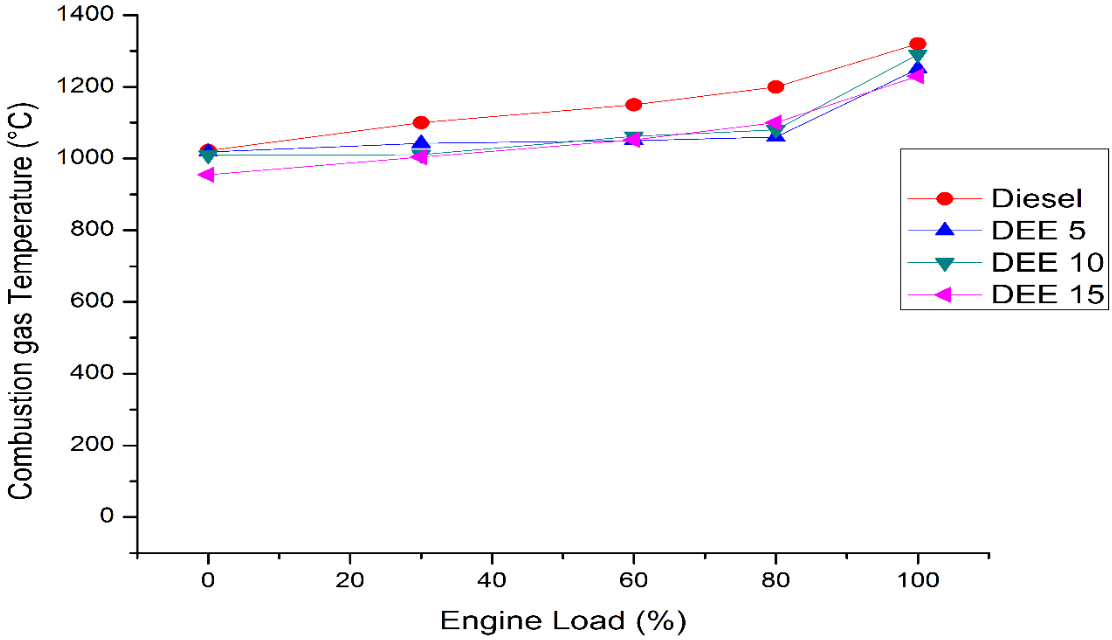

Figure 7: Variation of Maximum combustion gas temperature with Engine load

4.4.2 Pressure ofcylinder at various crank angles as influenced by the engine load for diesel and diesel-DEE blend

The variation in the in-cylinder pressure with a crank angle at different engine loads in the engine fuelled by diesel and DEE-diesel blend with different combination (5%, 10% and 15%) presented in the figure. The maximum cylinder pressure in this case is decreased by 25% respectively at full engine loads. This may be due to the low boiling point of DEE, which is responsible for its prior combustion and its higher latent heat of vaporization prompts to decreases in the combustion temperature, thus resulting in the lower value peak pressure.

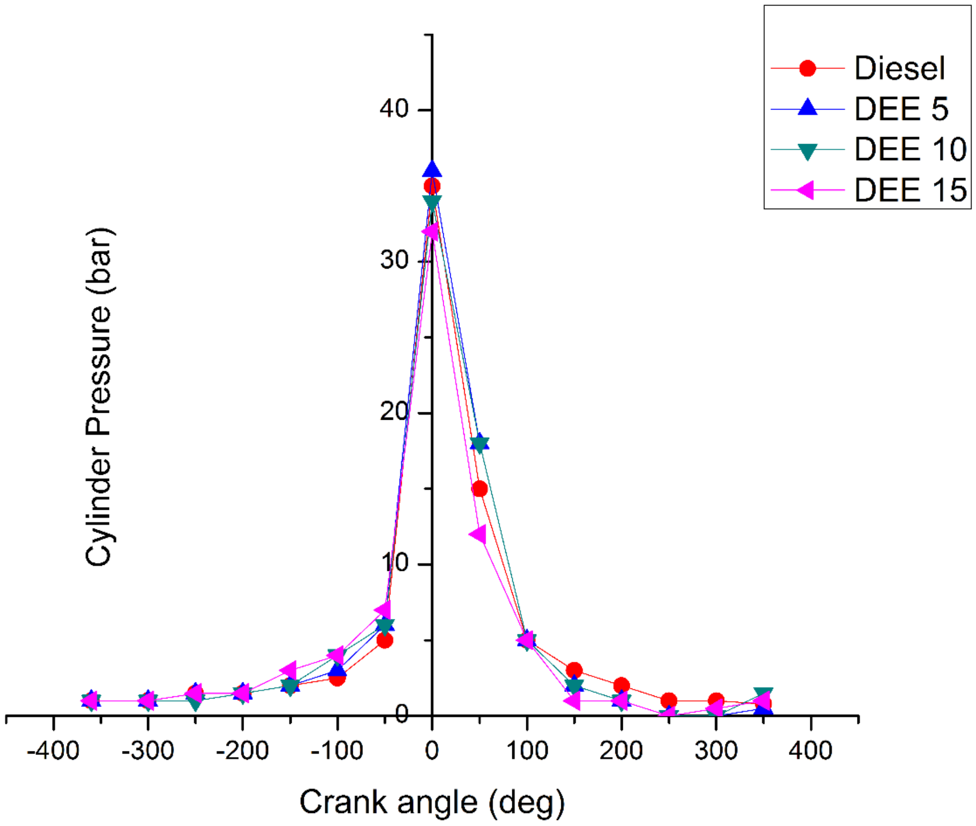

Figure 8:Variation of cylinder pressure with crank angle

4.3 Emission parameters analysis

4.3.1 Engine emission of carbon monoxide (CO) using diesel and diesel-DEE combination

The CO emissions are drastically lowered, by about 60% when compared to diesel at 80% engine as when fueling the engine with DEE15 blend. Attributed to addition of DEE, which results in a better combustion process because of its low viscosity & boiling point. The above helps in proper mixing of the fuel with air causes to prior burning process. In addition, the molecular oxygen in DEE causes complete oxidation of the fuel air mix improving the process of combustion[11].

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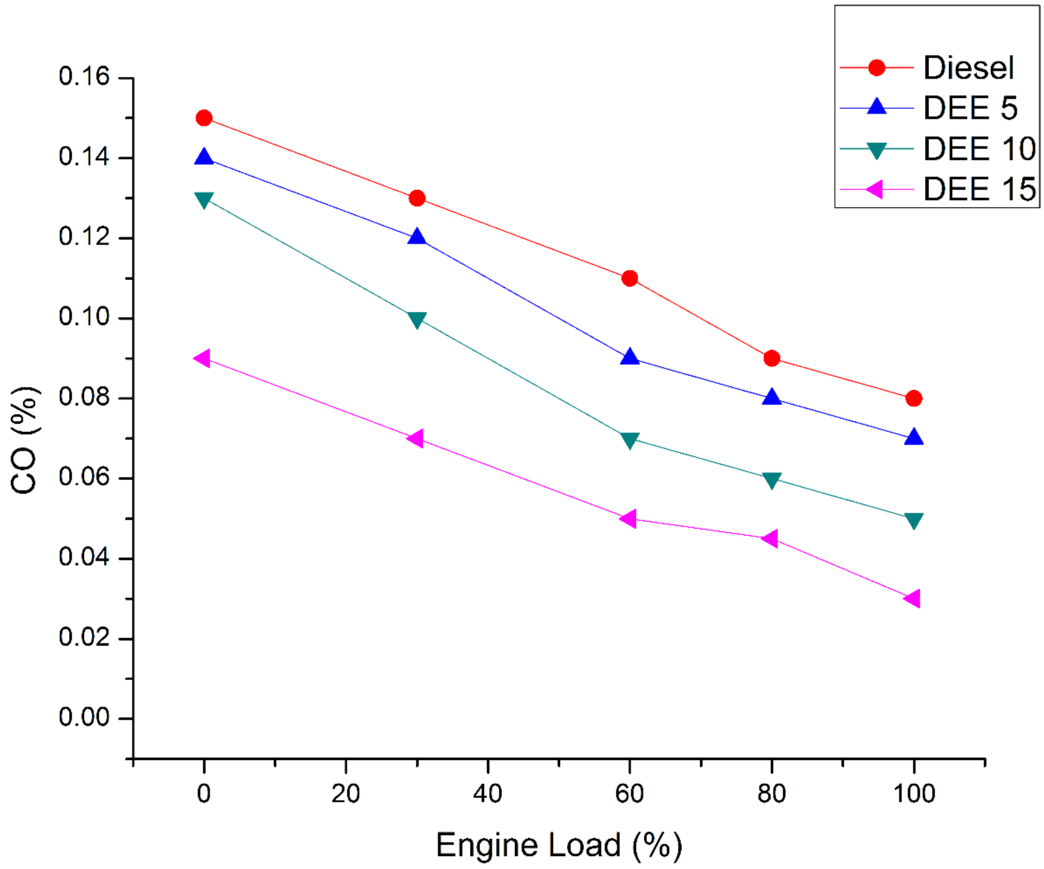

Figure 9: Engine load and carbon monoxide (CO) emission variations

4.3.2 Engine emission of carbon dioxide (CO_2) using combination of diesel and diesel-DEE

The CO_2 emissions are drastically lowered in comparison with the diesel while fueling the engine with DEE15 blend. This can be attributed to the addition of DEE, which results in a better combustion process due to the oxygen presence in DEE increases the oxygen percentage in the cylinder, So that it makes a positive effect on decreasing CO_2 emissions. Also high cetane number of additives of DEE reduces the time of combustion and improves combustion and gives lower CO_2 emissions.

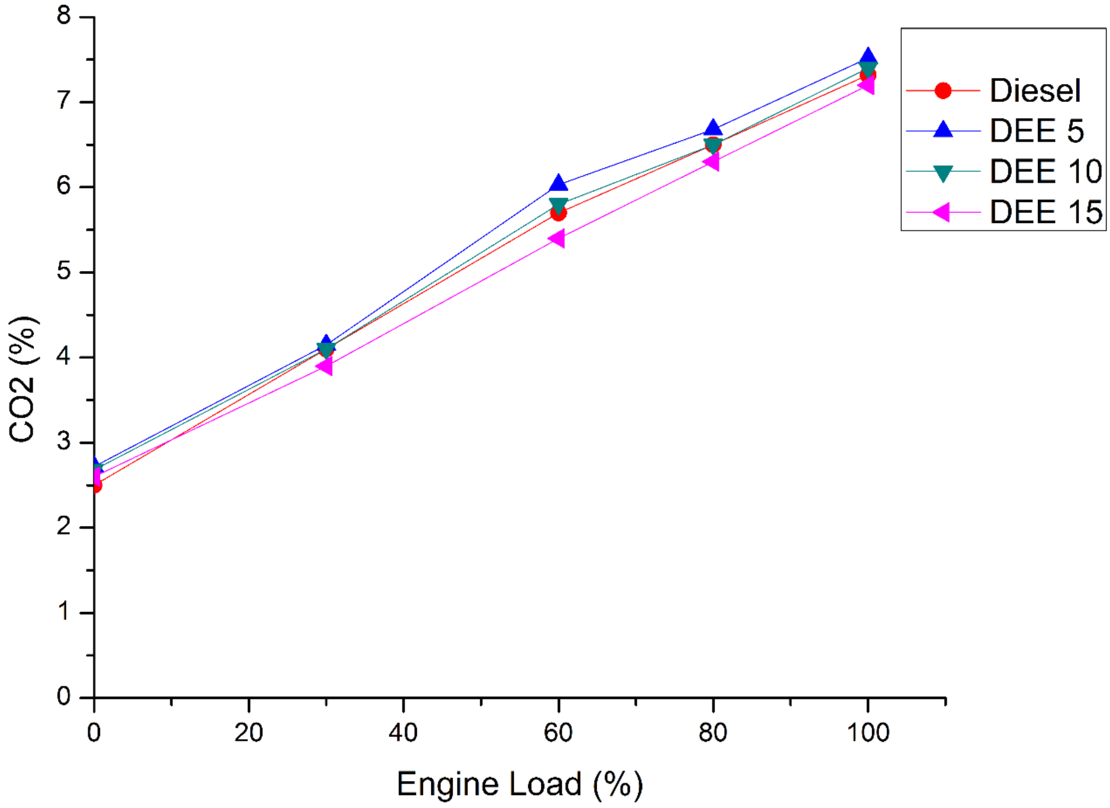

Figure 10: Engine load and carbon dioxide (CO_2) emission variations

4.3.3 Engine emission of hydrocarbon (HC) using diesel and diesel-DEE combination

DEE15 combination lowers the HC emission by about 36% and 80% engine load than that when the engine is run in the diesel mode. DEE additions result in thedecrease of HC emissions compared to all the tested combinations of fuel as observed from the recorded results. This is attributed to the “boiling point and high cetane number of DEE”, which improves a process of combustion process rapidly reaching an activation temperature ofa carbon combustion and improved hydrogen fuel’s oxidation leading to a complete combustion and consequent reduction in HC emissions [12].

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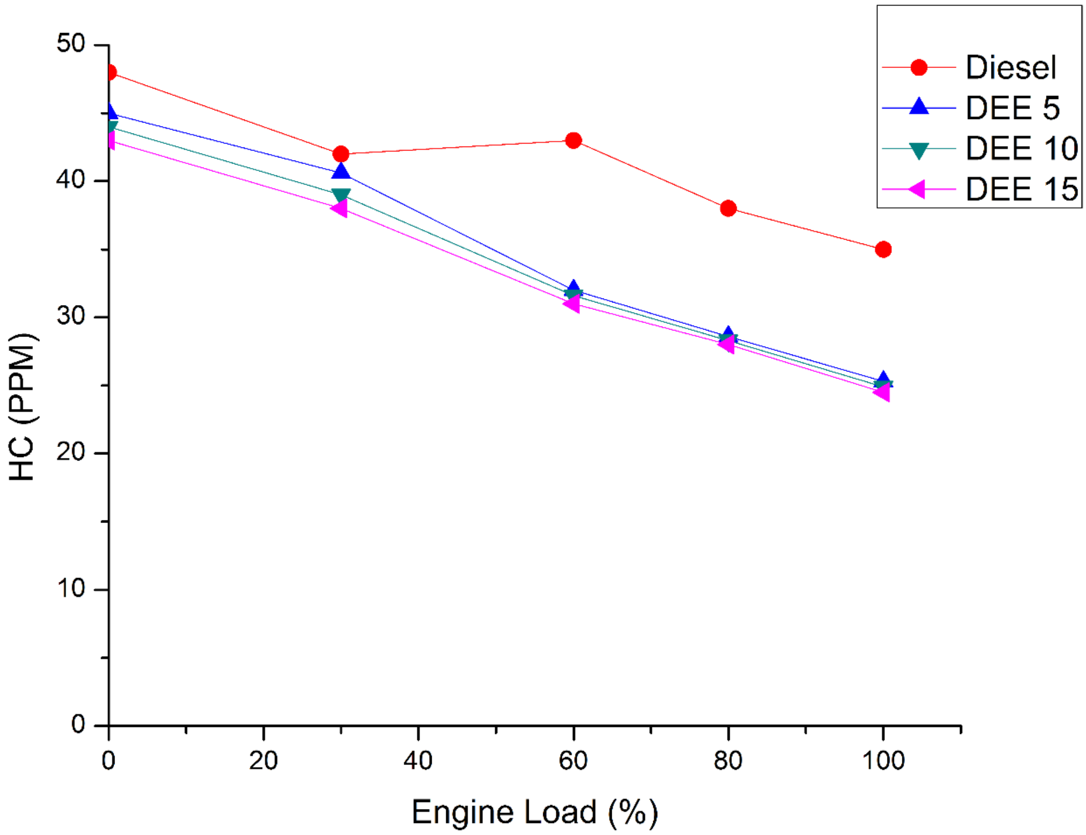

Figure 11: HC emission at different engine load

4.3.4 Engine emission of nitrogen oxide (NO_X) using diesel and diesel-DEE blend

In comparison to diesel mode, DEE15 combination results in a 35% rise in the NO emissions at 80% engine load. The increase the NO emissions with the DEE addition are because of higher content of oxygen which improves the process of combustion and give higher NO. The low boiling point and largercetane number of DEE reduces combustion duration resulting prior state of combustion during the pre-mixed stage in which NO is mostly produced [13, 14].

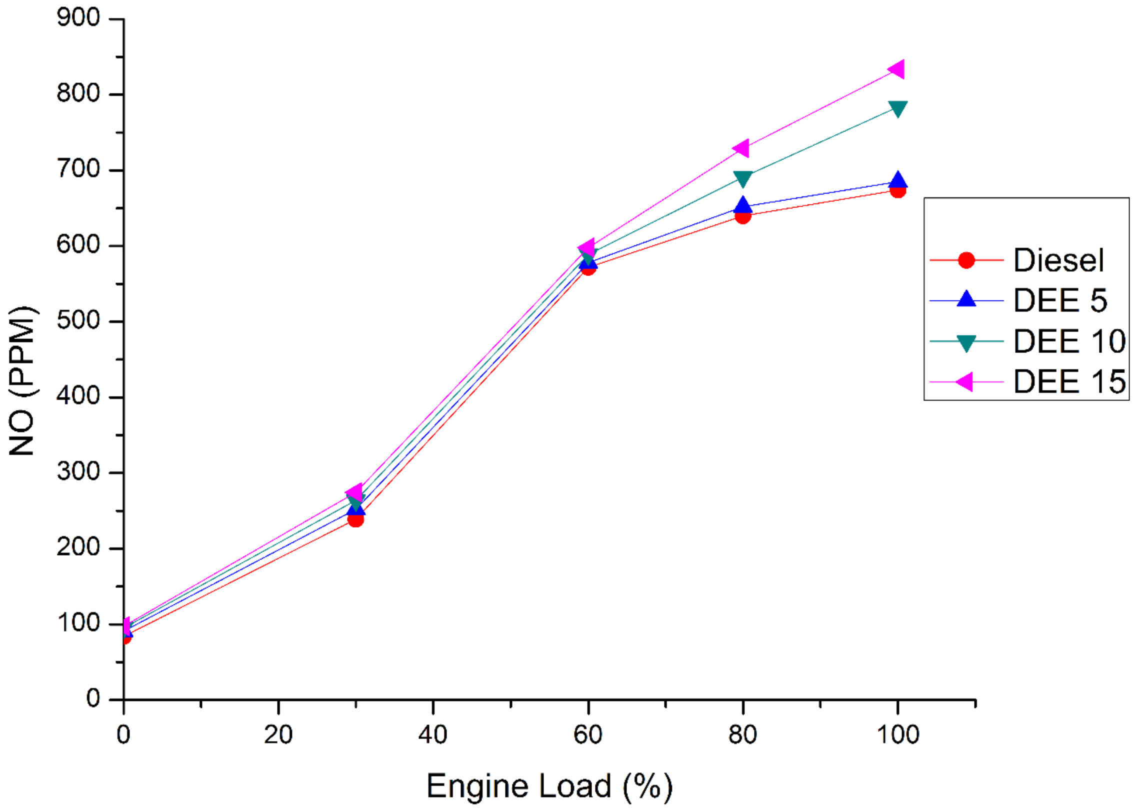

Figure 12: NO_X emission at different engineload

4.3.5 Engine emission of smoke opacity using diesel and diesel-DEE blend

DEE15 combination reduces the smoke capacity by about 72% at 80% engine load as compared to the case when the engine is fueled by diesel mode. The DEE mix improves the combustion processes and molecular oxygen content of DEE does not promote any arrangement of smoke during the dispersion period of burning[14].

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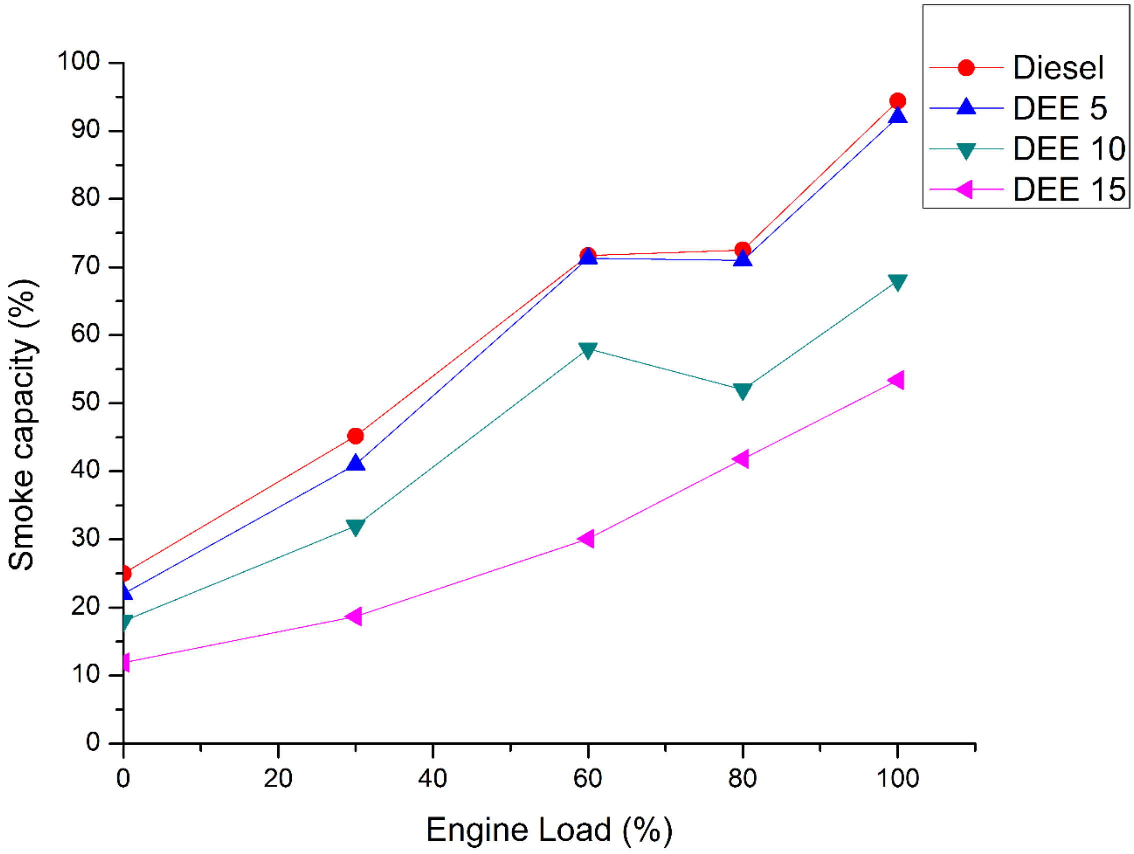

Figure 13:Smoke opacity emission at different engine load

4.3.6 Engine emission of oxygen using diesel and diesel-DEE blend

DEE15 combination exhibit an oxygen concentration lowered by almost 7% at 80% engine load as compared to the same observed when the engine is fueled by diesel alone. This because of DEE mix with diesel results in a greater utilization of oxygen that improves the combustion processes.

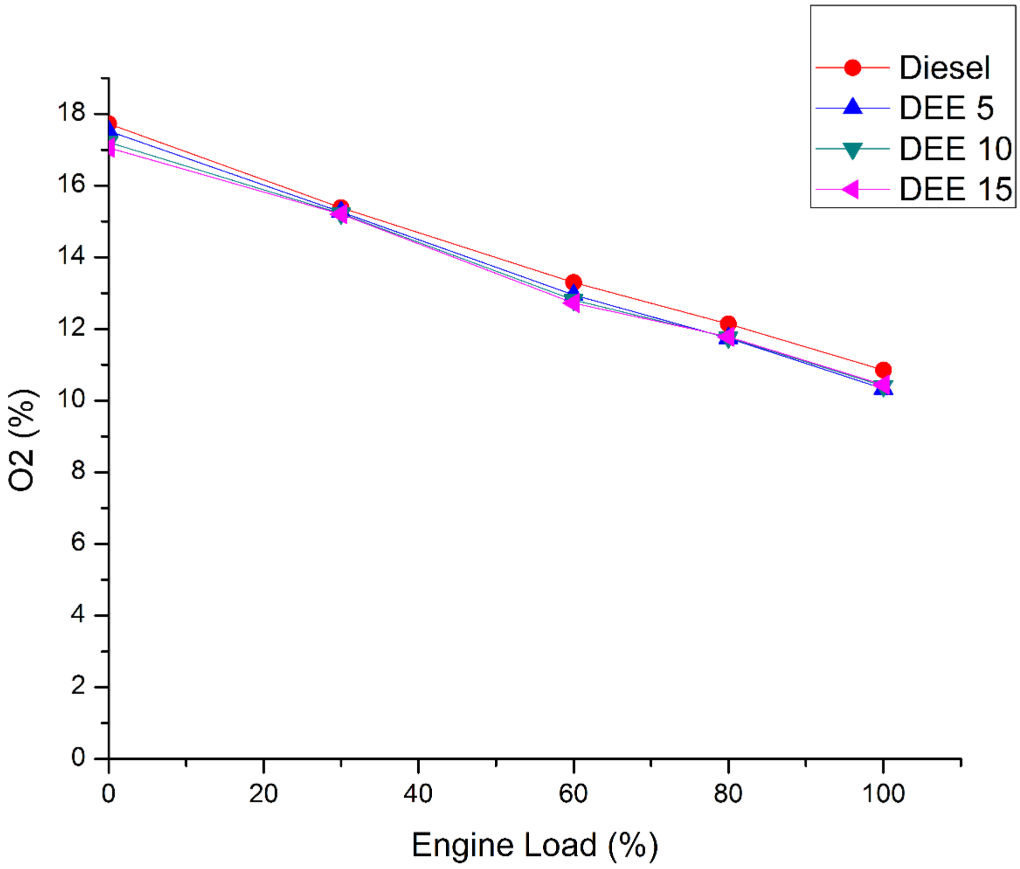

Figure 14:Oxygen emission at different engine load

5 Conclusions

The following is concluded after performing experiment and their vivid analysis pertaining to performance of a diesel engine and characteristics of the emission. When an engine is fuelled with diesel and DEE-diesel blend with different proportions separately.

- In DEE15 combination, the BTE of the engine is improved 27.12%. The maximum cylinder pressure and temperature are also higher in comparison with the operating engine's diesel mode.
- The BSFC is reduced by about 15.78% in DEE15 combination.
- The emission pertaining to CO, HC, O_2 in exhaust gas decreased and the emission pertaining to NO, CO_2 increased with DEE addition to diesel.
- DEE15 combination has shown the lowest HC and CO emissions compared to all other combinations.
- It is apparent that DEE15 blend gives empowering results concerning the exhibition of the motor, burning qualities and different risky emanations through the exhaust gas.

Thus, from the experimental findings it has been foundthat DEE15 fuel mix is one of the substitute fuel for CI diesel engine with an expected performance.

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