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Effects of Diethyl Ether Fumigation in DI Diesel Engine Using Bio Ethanol Blended Diesel

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ABSTRACT: In this present paper the performance and emission characteristics of single cylinder DI diesel is subjected to addition of diethyl ether by fumigation into the inlet manifold with bio ethanol blended diesel as pilot fuel were discussed. The optimum percentage of bio ethanol blended diesel was chosen by the previous research work carried out by the author. The results are indicated that when fumigated diethyl ether percentages increases, the performances of the engine increases by 30%, 29% and 43% respectively for 10%, 20% and 30%. The smoke density is decreased by 17%, 31% and 32% compared with pure diesel. The emission of Nox and CO were increased at high level loads, the HC emissions were increased for lower loads but small deviations were recorded for higher level loads when the diethyl ether percentages increases.

KEYWORDS: Diethyl Ether (DEE), Fumigation, Performance, Emission and Bio Ethanol Blend.

1 INTRODUCTION

Most of the recent researches are focused in the field of alternative fuels to minimize the depletion of fossil fuel usage as well as to decrease atmospheric pollution due to the automobile emissions. Various research works were conducted on bio ethanol and found that it is a promising alternative fuel CI engines. These alcohols can be produced at large scale from the bio solid wastes, vegetable waste and other bio products like sugarcanes, maize, gaze etc..In this study bio Ethanol has taken for partial replacement to fossil fuel. The problem associated with bio ethanol is that the miscibility with diesel is possible in small percentages [2-4]. From the earlier studies the ethanol blend with diesel produces the decreased brake thermal efficiency while compare with neat diesel due to the lower calorific value of ethanol [1]. The ethanol fuel having low cetane number compare with diesel results in the property of ignition delay and lowers the heat release rate [3].

The potential of Diethyl ether have explained clearly by authors [5-7] that high cetane number fuel increases the process of vaporization of fuels in the combustion chamber results decrease in smoke opacity and increase in NOx emission. From the literature survey [8-10], the various types of duel fuel injection methods, the fumigation of secondary fuel into the intake manifold method has been adopted for this study due to eliminate the design modifications of test engine. The fumigation of secondary fuel and varying the injection timing are the best methods of introduction of alcohol fuel in large quantity in IC engines as per the literature survey [8]. The use of diethyl ether to reduce smoke and NOx emissions simultaneously with diesel and biodiesel fueled single cylinder DI diesel engines. Use of DEE addition to diesel fuel and biodiesel increases the BTE in a general trend. BTE rises 5.5% and 9.2% DEE-Diesel blends respectively [9]. The addition of 5% DEE with B25 revealed that reduction in smoke, CO emissions were slightly lower, NOx and HC increases slightly at full load conditions and BSFC was lower compare with bio diesel and ethanol bio diesel [10]. The fumigation of alcohols reveals the increased percentages of emissions. To avoid all these, the high cetane number and calorific value fuel diethyl ether (as a product from ethanol by dehydration) has been chosen as a secondary fuel for this study. In this present study the Diethyl ether has been injected through the inlet manifold of the engine at various percentages with respect to the mass flow rate of air.

2 TEST FUELS

In this present study Bio ethanol was blended with diesel at various percentages and subjected into stability test and the optimum percentage of bio ethanol has been chosen from previous experimental research work results. The E15 (15% of bio ethanol + 85% diesel) was chosen as pilot fuel for this present research work. The 99.9% anhydrous pure diethyl ether has been chosen as secondary fuel and injected into the inlet manifold at various percentages (10%, 20% and 30%) with respect to the calculated mass flow rate of air. The test fuels named as diesel, E15, E15D10, E15D20 and E15D30 respectively. The properties of test fuels were shown in table 1.

Table 1: Properties of Test Fuels.

Properties	***Diesel***	***Bio Ethanol***	***E15***	***DEE***
Density- Kg/m^3	833	772	821.3	713.4
Specific gravity	0.831	0.769	0.813	0.712
Kinematic Viscosity cSt (mm^2/s) @ 40° C	3.0	1.2	2.8	0.23
Cetane number	49	6	41	127
Flash point °C	64	13	59	-40
Auto ignition temperature °C	315	235	306	160
Low calorific value(KJ/KG)	42500	24500	40125	33890
Oxygen content – wt%	0	34.8	--	21.6
Carbon content – wt%	87	52.18	--	64.9
Hydrogen content – wt%	13	13.04	--	13.5

3 EXPERIMENTAL WORK

The experiment is conducted on Kirlosker TV-1 engine. The specifications of the engine are tabulated in table 2.The engine ran at constant speed at 1500 rpm for different load conditions. For applying loads the engine was coupled to an eddy current dynamo meter and the smoke density was measured using an AVL smoke meter. Oxides of nitrogen emissions were measured using AVL Di-gas analyzer. The exhaust gas temperature was measured by the thermocouple connected with digital indicator and specifications of all measuring instruments are given in table 3.

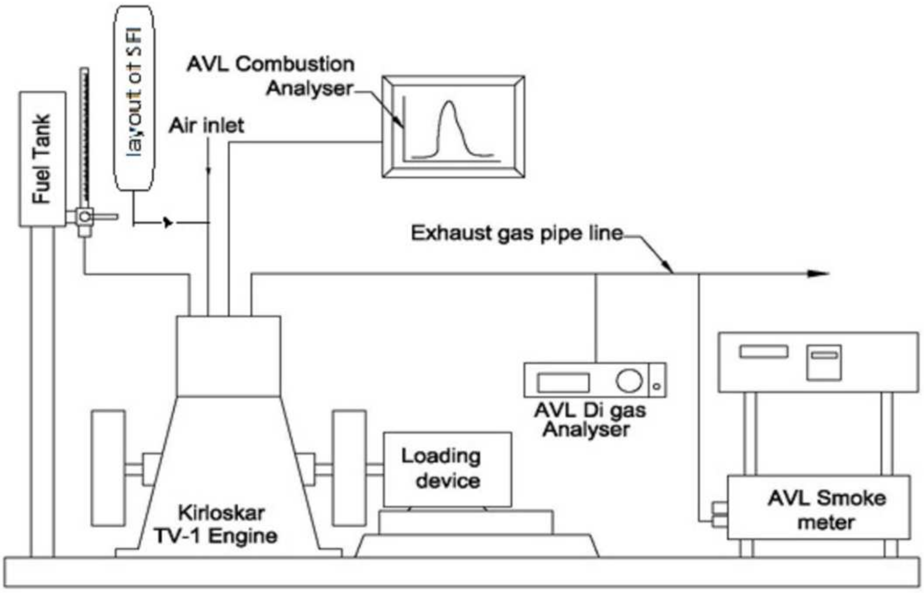

Figure 1: Layout of Experimental Setup with Secondary Fuel injection (SFC).

The separate secondary fuel injection system is developed for diethyl ether injections at 10%, 20% and 30% in inlet manifold with respect to mass flow rate of inlet air. The mass flow rate of air is calculated for each load conditions of test engine. The injection of diethyl ether into the inlet manifold is done by low pressure injector which is connected to pressure gauge to maintain the injection pressure. The other end of pressure gauge is connected with fuel pump placed in the diethyl ether fuel tank. The secondary fuel injection system consist a return value to adjust the injection pressure. The power supply to the injectors is connected through a digital counter which is getting continuous signals from the proximity sensor placed in fly wheel of the engine. The interval of injection timing is done by the counts which made from the rpm of test engine.

Table 2: Specifications of test engine.

Engine type	Single cylinder,4stroke,DI
Bore	87.5 mm
Stroke	110 mm
Comp. ratio	17.5 : 1
Rated power	5.2 KW
Rated speed	1500 rpm
Fuel type	Diesel
Cooling System	Water
Injection pressure	220 kgf/cm^2
Ignition Timing	23° C Before TDC (rated)

Table 3: Specifications of Instruments used.

TYPE	Measuring Range
AVL-Smoke meter	0 – 99.99 opacity in %
AVL-DIGAS Analyzer	HC / ppm 0 - 20000 CO / % 0 – 10, NOx/ ppm 0 – 4000, CO2 / % 0 – 20.

The experimental setup are shown in figure number 1.The experiment is conducted on sole diesel, E15, E15+10%dee, E15+20%dee and E15+30%dee to find out the optimum fumigative percentage of Diethyl ether into the inlet manifold. The engine was allowed to run with sole diesel fuel at a constant speed for nearly 30 minutes to attain the steady state condition at the lowest possible load. The engine was run twice and average values were taken.

4 Result And Discussion

4.1 Performance Characteristics

The specific fuel consumptions for test fuels at each load in terms of brake power are shown in figure 2 and percentage variations of SFC for each test fuel at full load condition are shown in figure 3. The SFC for E15 is slightly high while compare with pure diesel. When injected percentage of DEE increases specific fuel consumption of the test engine increases. This is due to calorific value of ethanol is less compare with diesel, when DEE injected percentage increases the net calorific value increases result in decreased specific fuel consumption. The specific fuel consumption is 45% less while 30% injection of DEE into inlet manifold compare with pure diesel.

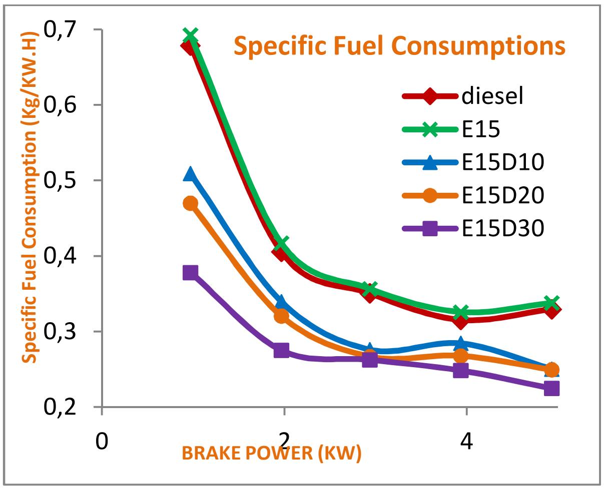

Fig 2: Brake power Vs SFC.

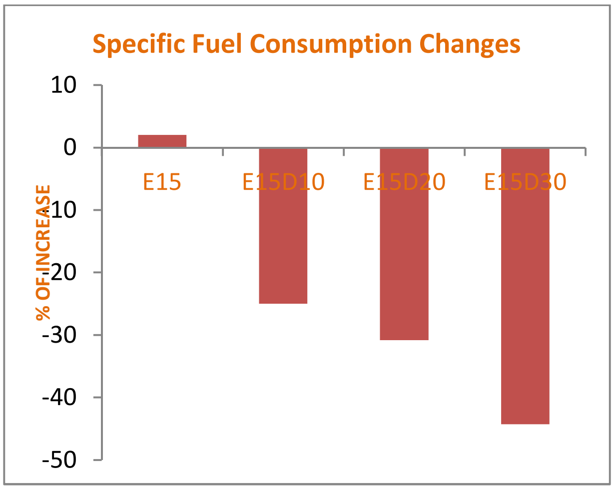

Fig 3: Percentage Variations of SFC

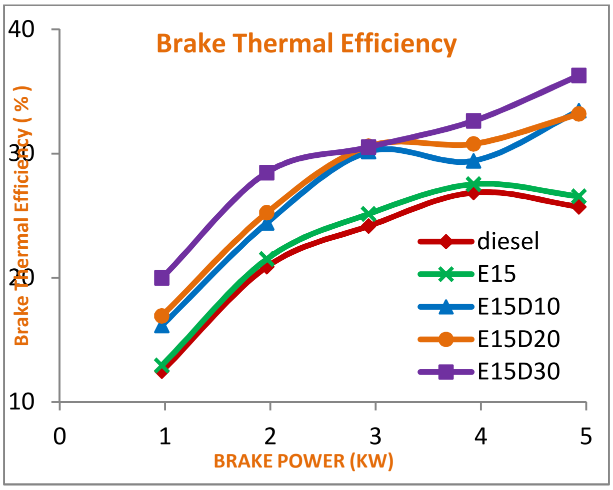

Fig 4: Brake power Vs BTE

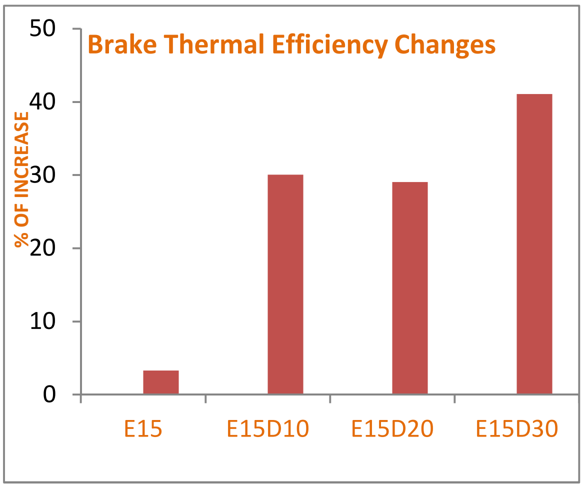

Fig 5: Percentage Variations of BTE.

The brake thermal efficiency for all test fuels at each brake power are shown in figure 4 and percentage variations of BTE for each fuel at full load condition are shown in figure 5. The brake thermal efficiency has improved for all test fuels while compare with pure diesel. The maximum brake thermal efficiency has achieved for 30% injection of DEE. For 10% and 20% injection shows 30 percentage increases in brake thermal efficiency at full load conditions while compare with pure diesel and E15. The specific fuel consumption inversely proportional to the brake thermal efficiency, hence the net calorific value and oxygen available in ethanol and DEE plays a major role in brake thermal efficiency increases.

4.2 EMISSION CHARACTERISTICS

The CO emissions for test fuels at each load in terms of brake power are shown in figure 6 and percentage variations of CO emission for each test fuel at full load condition are shown in figure 7. The CO emission for E15 is slightly high while compare with pure diesel. The increased injected percentage of DEE increases CO emissions of the test engine marginally. This is due to excess oxygen available in diethyl ether enhance the inlet air condition. The CO emissions were increased by 37%, 90% and 100% at full load conditions respectively for 10, 20 and 30 percent diethyl ether injections.

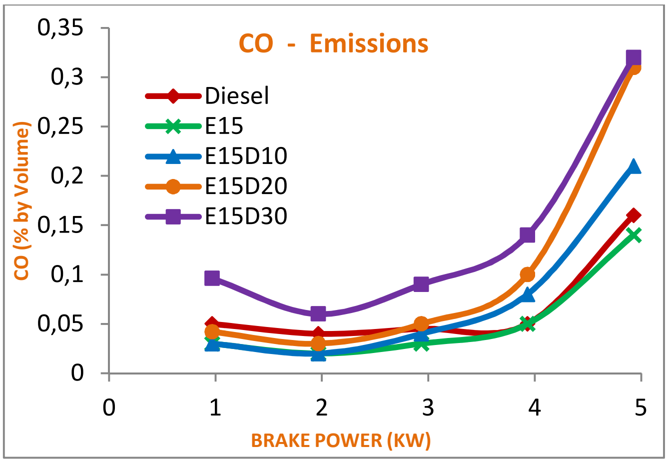

Fig 6: Brake power Vs CO Emissions.

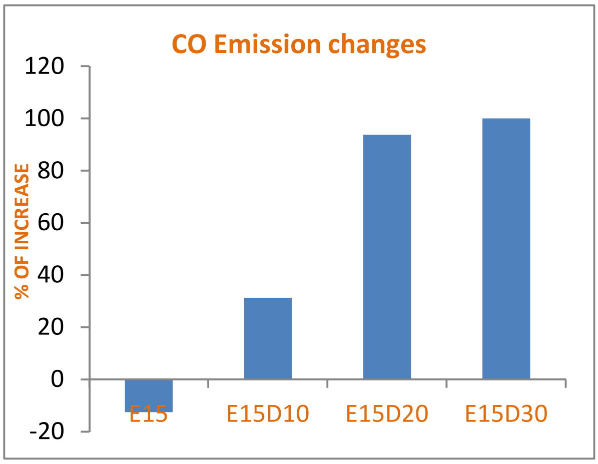

Fig 7: % Variations of CO Emissions.

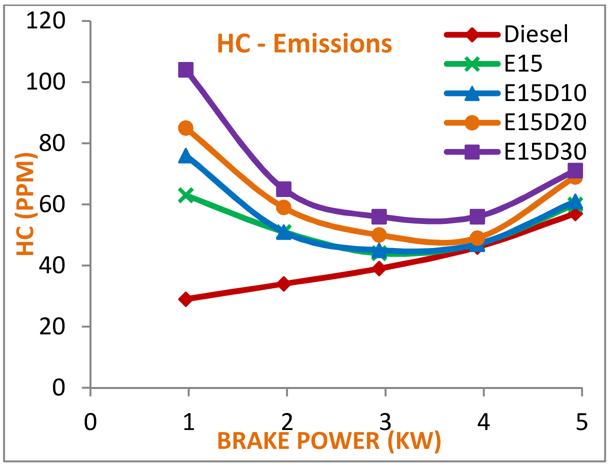

Fig 8: Brake power Vs HC Emissions

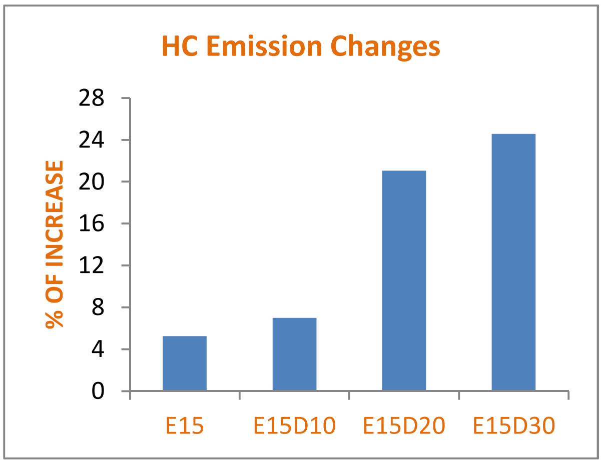

Fig 9: % Variations of HC Emissions.

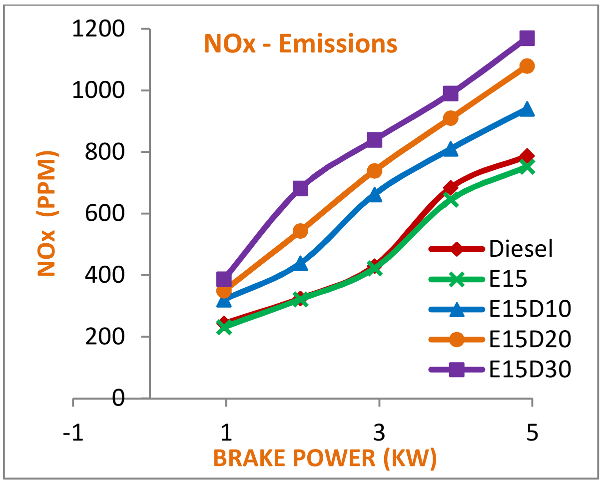

Fig 10: Brake power Vs NOx Emissions.

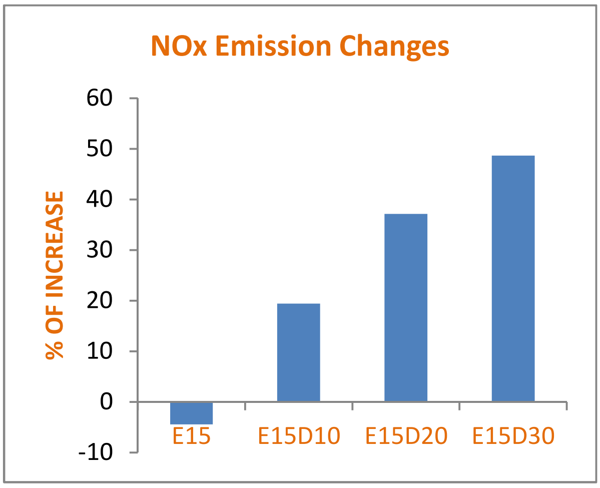

Fig 11: % variations of NOx Emissions.

The HC emissions for each test fuel with respect to load were shown in figure 8 and the percentage variations at full load condition for each fuel are shown in figure 9. The HC emissions are increased for E15 by 5%. The addition of DEE at 10 and 20 percent by injection at full load condition resulted in increase of HC emissions by 8% and 22% respectively. However HC emissions are increased marginally at initial and mid level loads due to higher heat of evaporation of ethanol into diesel cause slower the process of fuel evaporation leads the unburned hydrocarbon increases at initial loads. When the lower heat of evaporation fuel DEE injected induces the process earlier than diesel results in decreases of HC at high level loads.

The NOx emission are shown in figure 10 and the variations in percentages with respect to full load for all test fuels are shown in figure 11. The ethanol blended diesel E15 shows slightly decrease in oxides of nitrogen, when the injection percentages of DEE increases the NOx emissions are increasing drastically. This is mainly due to oxygen available in DEE increases the cylinder temperature while combustion takes place that leads to the formation of oxides of nitrogen and that is evidently proved in heat release rate and exhaust temperature of test engine. The highest 48% increase in NOx emission were recorded at 30% of DEE injection while compare with sole diesel.

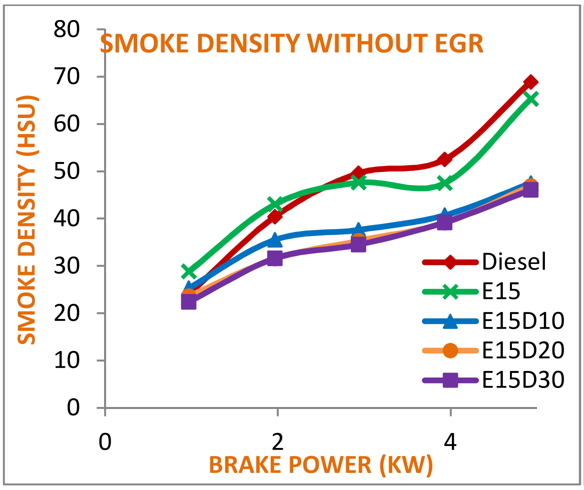

Fig 12: Brake power Vs Smoke Density.

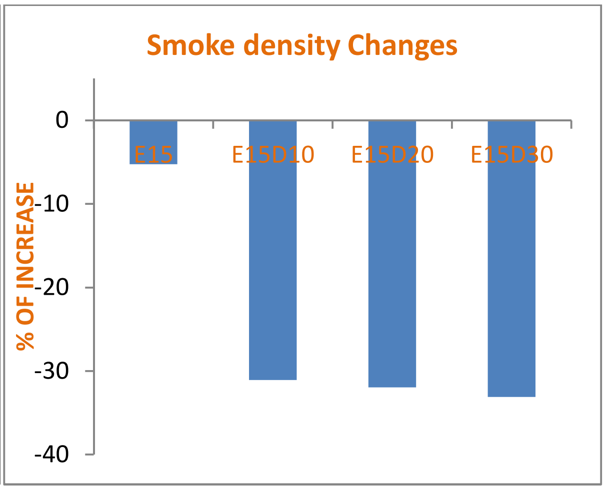

Fig 13: % Variations of Smoke Density.

The smoke density for all test fuels at each load are shown in figure 12 and the variations in percentages at full load condition for all test fuels are shown in figure 13. The smoke density decreased for all test fuels while compare with diesel. The maximum decreased percentage 32 is achieved for 30% injection of DEE. This is due to the oxygen enrichment of ethanol and DEE improves reactions in diffusion phase of combustion reflects in reduction in smoke density.

5 Conclusion

From the above experimental investigation,

- It has been concluded that the injection of diethyl ether into inlet manifold is limited up to 30%, beyond that heavy knocks were observed at full load conditions. The 30 percentage addition of DEE improves the performance and 10 percentage addition of DEE maintains and decreases the emissions than diesel (except NOx emission).
- From the above test fuel results, the higher brake thermal efficiency is recorded for 30% injection of DEE. The improved brake thermal efficiency is 43% compared with diesel.
- The smoke emissions are decreased for all percentages of injected DEE. The maximum reduction percentage is 32 for 30% of injection while compare with diesel and E15.
- The HC emissions are marginally increased for initial and mid level loads. However it increases slightly for higher level loads. The maximum increase of HC emission in full load condition is 28% with respect to diesel for 30% injection.
- The CO emissions are increased marginally. The highest CO emission variation by 90% with respect to diesel is recorded for 30% injection of DEE. The NOx emission is increased by 48% while compare with diesel for 30 percentage addition of diethyl ether.

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