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Performance and Emission Analysis of CI Engine with Ethanol Blended Fuel

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Abstract— Considering energy crises and pollution problems today, investigations have been concentrated on decreasing fuel consumption by using alternative fuels and on lowering the concentration of toxic components in combustion products. In the present work, the variable compression ratio Compression ignition engine designed to run on Diesel has been tested with pure Diesel, and Diesel blended with ethanol 0%, 05%,7.5%,10%,12.5% and 15% by volume without any engine modifications has been tested and presented the result. Performance tests were conducted for, fuel consumption, volumetric efficiency, brake thermal efficiency, brake power, engine torque and brake specific fuel consumption, while exhaust emissions were analyzed for carbon monoxide (CO), carbon dioxide (CO2) and NOx at constant engine speed of 1500 rpm. The results showed that blending ethanol with Diesel increases the Indicated power, brake thermal efficiencies and fuel consumption, while it decreases the brake specific fuel consumption and volumetric efficiency. The CO and CO2 emissions concentrations in the engine exhaust does not vary substantially while NOx reduces upto 50%.The 15 volm% ethanol in fuel blend gives the best results for all measured parameter at all engine speeds.

Index Terms— CI Engine, pure diesel, blended diesel, ethanol, emissions, performance, fuel consumption.

1 INTRODUCTION

Ethanol (ethyl alcohol) and methanol (methyl alcohol) are two types of alcohol fuels. The use of pure alcohols in internal combustion engines is only possible if the engine is designed or modified for that purpose. However, in their anhydrous or pure forms, they can be mixed with diesel in various ratios upto certain limit for use in unmodified diesel (CI engine) engines, and with minor modifications can also be used with a higher content of ethanol. Typically, only ethanol is used widely in this manner, particularly since methanol is toxic. The world is presently confronted with the twin crises of fossil fuel depletion and environmental degradation. Indiscriminate extraction and lavish consumption of fossil fuels have led to reduction in underground-based carbon resources. Alcohol fuels particularly ethanol can be produced by fermentation of bio mass crops, mainly sugar cane, wheat and wood. The engine thermal efficiency can be improved with increasing of compression ratio. Alcohols burns with lower flame temperatures and luminosity owing to decreasing the peak temperature inside the cylinder and hence the heat losses and NOx emissions are lower. Fuel additives are very important, since many of these additives can be added to fuel in order to improve its efficiency and its performance. One of the most important additives to improve fuel performance is oxygenates (oxygen containing organic compounds). Several oxygenates have been used as fuel additives, such as methanol, ethanol, tertiary butyl alcohol and methyl tertiary butyl ether.

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Emission standards are requirement that set the limit amount of pollutants in environment. There are several types of emission from diesel engine, such as CO2, CO,HC, particulate matter & Oxides of nitrogen. There are several oxides of nitrogen like NO,NO2, N2O,N2O3 etc. Hence for Convenience Oxides of N2 are express as NOx. NOx is Produce when N2 and O2 combine at higher temperature ranging from 11000C upward. Automobile factories ,power generation and petrollium refineries are the main source of NOx

2 LITERATURE REVIEW

2.1 Review

A review on the properties and specifications of ethanol blended with diesel fuel. Special emphasis is placed on the factors critical to the potential commercial use of these blends. These factors include blend properties such as stability, viscosity and lubricity, safety and materials compatibility. The effect of the fuel on engine performance, durability and emissions are also considered. The formulation of additives to correct certain key properties and maintain blend stability is suggested as a critical factor in ensuring fuel compatibility with engines. However, maintaining vehicle safety with these blends may entail fuel tank modifications [1].

The experiments were conducted on a water-cooled single cylinder DI diesel engine using neat diesel fuel. E5 D, E10, D, Ethanol - diesel blended fuels. They are indicated that the brake thermal efficiency increased and brake specific fuel consumption increased with an increase of ethanol contents in the blended fuel at overall operating conditions, also found that NOx emissions reduced, HC increased for ethanol-diesel when compared to neat diese They reported that the exhaust gas temperature, exhaust emissions (CO and NOx) were lower

with operations on ethanol-diesel blend [2].

3 MATERIAL AND METHODOLOGY

3.1 METHODOLOGY

In this section the detailed work regarding blend preparation and experimentation is described. For blending we use 99.99% pure ethanol which is produced by 'Analytical cs Reagent' and diesel.

3.1.1 PREPARATION OF BLEND

For the presented work the different blends of diesel and ethanol are used. They are E05, E7.5, E10, E12.5 & E15, the number following E indicates percentage of volumetric amount of ethanol in diesel. These blends are prepared for one liters of each category. The ethanol used for blend preparation is 99.9% pure and the properties are given by the supplier in the test report provided [12].

3.1.2 PROPERTIES OF BLENDS

The properties of blended fuels are determined at the beginning of the experiment. If the properties of the pure Diesel and ethanol are known, the properties of the blended fuels are calculated as follows.

$$P_{bl} = \frac{X_{gpg} + X_{epe}}{100}$$

$$(A/F)_{bl} = \frac{X_{gpg(A/F)g} + X_{epe(A/F)g}}{X_{gpg} + X_{epe}}$$

Where, g and e subscript used for gasoline and ethanol respectively. bl subscript used for blend

Xd and Xe = percentage of Diesel and ethanol in blend respectively

ρd and ρe = density of Diesel and ethanol respectively

3.2 PROPERTIES OF DIESEL AND ETHANOL:

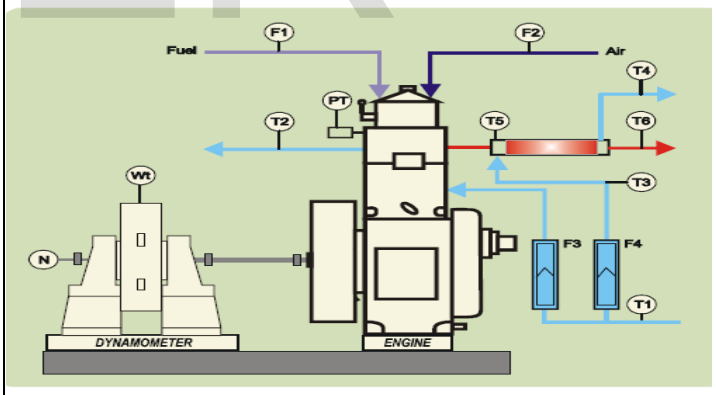
TABLE 1
PROPERTIES OF DIESEL AND ETHANOL

Sr. No.	Fuel property	Diesel.	Ethanol
1	Formula	C16H34	C2H5OH
2	Density (kg/m3)	815	785
3	Lower heating value (KJ/kg)	42000	26900
4	Stoichiometric air/fuel ratio	15.2	9
5	Research cetane number	48	8
6	MolecularWeight (kg/kmol)	114.18	46.07
8	Molar C/H ratio	305	840
9	Boiling point(0C)	180-300	78

3.2 RESEARCH ENGINE TEST SET UP

The setup consists of single cylinder, four stroke, Multi-fuel, research engine connected to eddy current type dynamometer for loading. The operation mode of the engine can be changed from diesel to Petrol or from Petrol to Diesel with some necessary changes. In both modes the compression ratio can be varied without stopping the engine and without altering the combustion chamber geometry by specially designed tilting cylinder block arrangement. Setup is provided with necessary instruments for combustion pressure, Diesel line pressure and crank-angle measurements. These signals are interfaced with computer for pressure crank-angle diagrams. Instruments are provided to interface airflow, fuel flow, temperatures and load measurements. The set up has stand-alone panel box consisting of air box, two fuel tanks for duel fuel test, manometer, fuel measuring unit, transmitters for air and fuel flow measurements, process indicator and hardware interface. Rotameters are provided for cooling water and calorimeter water flow measurement. A battery, starter and battery charger is provided for engine electric start arrangement.

The setup enables study of VCR engine performance for brake power, indicated power, frictional power, BMEP, IMEP, brake thermal efficiency, indicated thermal efficiency, Mechanical efficiency, volumetric efficiency, specific fuel consumption, A/F ratio, heat balance and combustion analysis. Labview based Engine Performance Analysis software package "Engine soft" is provided for on line performance evaluation [3].



Schematic arrangement

Fig1. Rerearch engine test setup

In this fig following nomenclature is used,

T1=Temperature of jacket water IN
T2=Temperature of jacket water OUT
T3=Temperature of water calorimeter IN
T4=Temperature of water calorimeter OUT
T5=Temperature of Exhaust Gas, before calorimeter
T6=Temperature of Exhaust Gas, after calorimeter
F1=flow rate of fuel
F2=flow rate of air

F3=flow rate of engine cooling water
F4=flow rate of calorimeter cooling water
Wt=load cell reading
N=Engine speed tachometer reading

3.3 EXPERIMENTAL PROCEDURE

The tests were performed at full throttle opening and compression ratio 18:1. The speed range considered was 1500 rpm. The speed was varied by varying the load on dynamometer. All the necessary parameters were measured and recorded by the computer with the aid of "IC engine Software made by Appex Inovation". The exhaust emissions were measured for each case of speed using an exhaust gas analyzer. The above procedure was repeated for each of the blended fuels E05,E7.5,E10,E12.5,and E15

Fig. 2 Experimental procedure

4 RESULT AND DISCUSSIONS

4.1 ENGINE PERFORMANCE

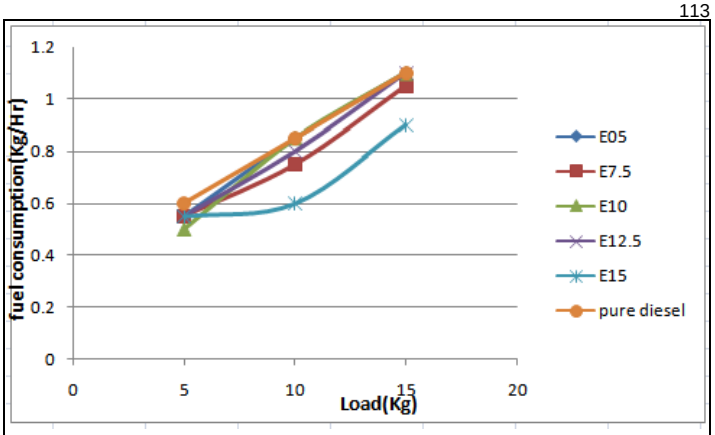


Fig 3. Engine load V/S Fuel Consumption Cr18

Fuel Consumption As shown in above graphs it can be seen that the fuel consumption gradually decreases significantly with the use of E12.5 & E15 over the pure diesel at all different load. This decreases in fuel consumption by the fact that as the engine speed increases, the air velocity increases and the pressure decreases at the carburetor venture. Consequently, the pressure drop between the pressure at carburetor venture and the pressure (atmospheric) inside the float chamber increases, which causes more fuel consumption.

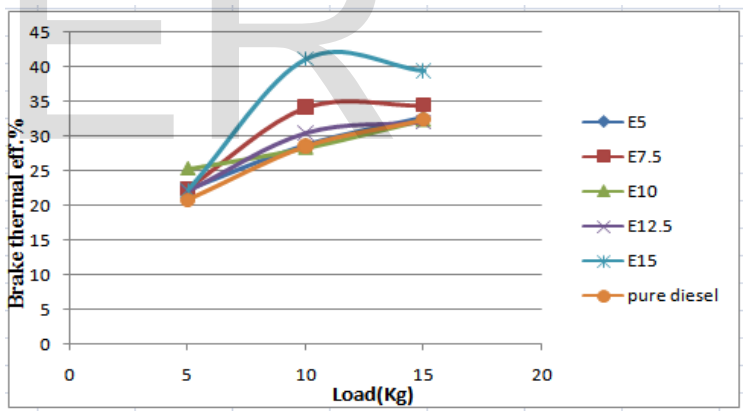


Fig 4. Engine Load V/S Brake Thermal Efficiency Cr18

Brake Thermal Efficiency: - The effect of various fuels on break thermal efficiency (BTHE) has shown in fig above. Ethanol addition to diesel raises engine volumetric efficiency and causes leaner operation. As a result, combustion become more complete or more stoichiometric therefore, flame temperature and cylinder pressure rise to their higher values. Thus mean indicated work and mean indicated pressure increases because of the increases in cylinder pressure. Therefore, engine power output and thermal efficiency increases with increasing ethanol content of the blended fuel are lower than that of diesel.The blend run consistently with 2-3% higher break thermal efficiency.

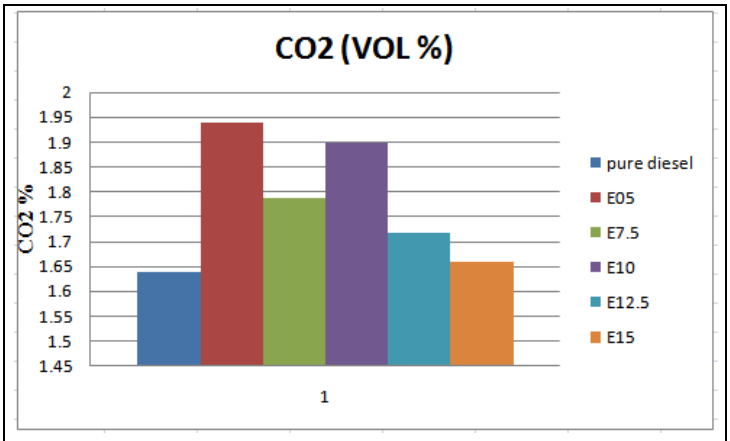


Fig 5. Co2 Emission Cr18

CO2 Emissions:- Co2 show slight decreases from E10 to E15 but heavy increase from E0 to E07.5 , at all different loads. This is due to combustion process as a result of the oxygen content in the ethanol fuel. In addition a decrease in CO2 emission of 4%, 10.2% and 12.4% is observed for the E10 to E15 respectively at the compression ratio 18:1. This can be seen in the fig, which shows the effect of various blends on emission at full throttle opening.

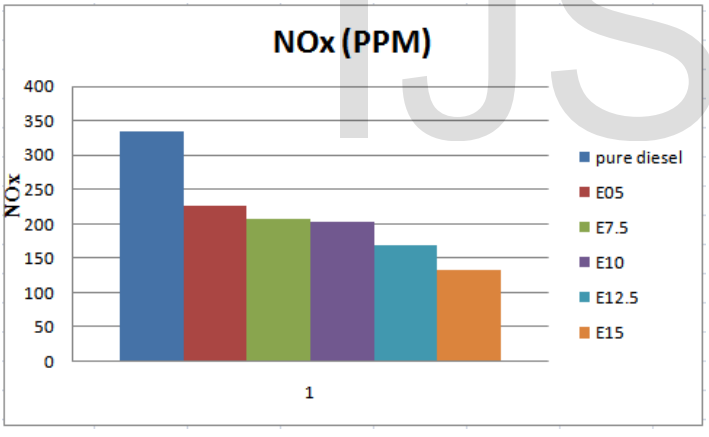


Fig 6. NOx (Ppm Vol) Cr 18

Blending of ethanol in diesel limits the maximum temperature during combustion, which reduces the tendency of nitrogen fixation at high temperature. Hence as shown in graph, reduction in NOx was found nearly 40-45% in E12.5 to E15 than pure diesel.

5. CONCLUSION

In this study, at different Load ethanol was used as fuel to improve performance and to reduce emission in an CI engine. Engine compression ratio was kept 18:1 and with suitable ethanol-Diesel blends E0,E05,E7.5,E10,E12.5 and E15 without any knock at full throttle opening.

The tests were performed at 1500 rpm and full throttle opening with E0 to E15 fuels. According to result of these tests it was found that the most suitable fuel in terms of engine performance and exhaust emissions is E12.5 and E15.Following experimental results it was determined as

1) Efficiency with the blended fuels is found to be 1.3% to 4.7% higher than that of pure Diesel in all speed range due to higher latent heat of evaporation of ethanol.
2) The lower energy content of blended fuels caused decrease upto 10% in brake specific fuel consumption of the engine depending on percentage of ethanol in the blend.
3) A no significant reduction in CO emission is observed due to oxygen enrichment resulting from ethanol and due to reduce volumetric efficiency.
4) E12.5 and E15 is to be found best suitable blend as after which a increase in the Oxygen contain of fuel causes Decrease in brake specific fuel consumption.
5) As the compression ratio increases upto 18:1, a decrease in brake specific fuel consumption upto 10% is achieved for E15 as compared with E0 beside lower heating value of E15.

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