Experimental Investigation of Diesel Engine with Ethanol Diesel Blend in Different Injection Pressures & Compression Ratio

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Abstract:-Engines have been used in various fields and its field of application is still increasing with the passage of time. With the increased usage of the engines, fuel required is higher and so the demand of petroleum fuels is increased. Alternate fuels have been used to fulfill the demand of fuel. Moreover the very low emissions norms have led to the experimentation and analysis to attain preferred operating parameters of the engines run with these alternate fuels. Analysis of operating parameters to suit these alternate fuels have been in study to improve the performance and also emission reduction of engines. Ethanol, a renewable fuel which is widely available from the agricultural wastes has been in study to be used as a fuel in conventional engines in many countries. This experiment's objective is to analyse the working of a single cylinder diesel engine using Ethanol blend with different injection pressure and compression ratio. The engine is run with both Diesel and also Ethanol blend at various selected parameters. The engine operation involves different percentage of Ethanol as 10%, 20%, 30%, 40% and also 50% ethanol and observations carried out for the same. The injection pressure used is 205, 230, 255 & 270bar with compression ratio as 17.5, 18.5 & 19.5 CR. Ethanol with low density & higher heat of vaporization needs low injection pressure & higher compression ratio for efficient working. Also the emissions using Ethanol fuel are much lower as the ethanol fuel has no aromatic chain that causes soot formation and reduced NOx emission. 10% Ethanol adaption at 230bar IP & 19.5CR provides the highest efficiency and also optimized emission like NOx, HC and CO.

Keywords: Diesel, Ethanol, Injection Pressure, Compression Ratio, Diesel Engine, Performance and Exhaust Emission analysis

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I. INTRODUCTION

Demand for petroleum products is increasing day-by-day however the resources are fairly limited. Also there is increase in the environmental pollution specially pollution from the automotive/engine exhaust.Due to known hazardous effect of environment pollution and strict pollution norms reducing exhaust emissions and increasing the fuel economy of internal combustion engines have found global importance. Therefore to overcome these issues study on alternative fuel's use in the engines is being carried out by various organizations.

Engines are operated in the region of lower equivalence ratios to improve efficiency and reduce emissions. Due to increase in the vehicle population, the lean combustion technology is employed mainly in IC engines. The NO_x emission can be reduced only by reducing the flame temperature of combustion. Lean burn engines produce lower temperatures so that reduction in formation of thermal oxides of nitrogen happens. The excess air employed for lean burning results in a more complete combustion of the fuel which reduces both the hydrocarbon and carbon monoxide emissions [4].

Alcohols have been used as fuels for engines since 19^{th} century. Among the various alcohols, ethanol is known as the most suited renewable, bio based and eco-friendly fuel for internal combustion engine. The most attractive properties of ethanol as an internal combustion engine fuel is that it can be produced from renewable energy sources such as sugarcane, cassava, many types of waste bio mass materials, corn and barley.Ethanol is a widely available renewable fuel which can be produced by fermentation and distillation from biomass. As a fuel for CI engines, ethanol has some advantages over diesel fuel such as reduction of soot, CO, unburned HC emission. Although having these advantages, due to limitation in technology, economic and regional considerations, ethanol still can't be used extensively. However, ethanol blended with diesel can be used as fuel in CI engines.

Ethanol has higher miscibility in diesel than methanol. But using ethanol-diesel blend has disadvantages like lower miscibility at lower temperature, Phase separation and lower heating value, cetane number and viscosity [12][10]. In addition, they reported that ethanol-containing diesel fuel exhausted greater formaldehyde, formic acid, and acetaldehyde emissions than did normal diesel. Additives (propanol and various biofuels) are used to enhance phase stability, improve cetane number, and reduce ignition delay and cycle irregularities [10] [7]. Different additives perform their own unique action on its addition to the blend of fuel.

II. Experimental Work and Methodology

The engine used in the study was a vertical, single cylinder, water-cooled, four strokediesel engine. The engine was coupled to an eddy current dynamometer to measure the engine output power. Burette was used to measure fuelconsumption of diesel-Ethanol fuel and a digital tachometer is used to measure the speed of engine.Exhaust gas analyzer is used for measuring HC (ppm),NO(ppm), CO (% by vol.), CO_2 (%by vol.)and O_2 (% by vol.).

TEST ENGINE:

Fig.1. Actual photograph of experimental engine.

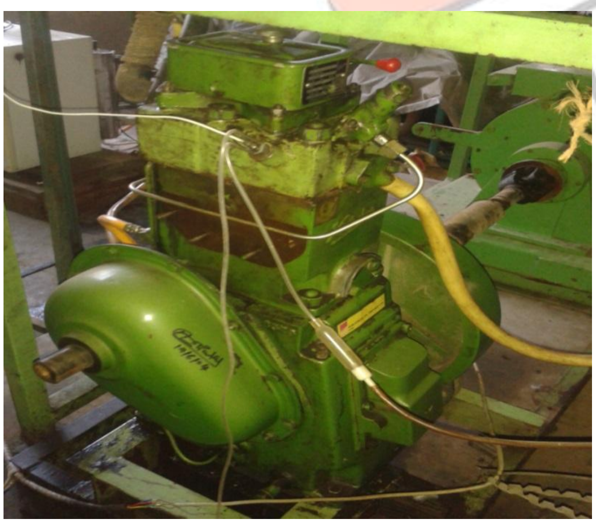
TABLE-1 TECHNICAL SPECIFICATION OF ENGINE.

Number of Cylinder	1
Bore (m)	0.088
Stroke(m)	0.11
Compression ratio	17.5:1
Cooling type	Water cooling
Speed type	Constant speed
RPM	1500

The experimental setup consists of engine, fuel injection system, eddy current dynamometer, fuel and air flow measurement systems and also emission measurement system.The modificationsare done to attain required compression ratio and injection pressure.

TABLE-1 TECHNICAL SPECIFICATION OF ENGINE.

TEST ENGINE:



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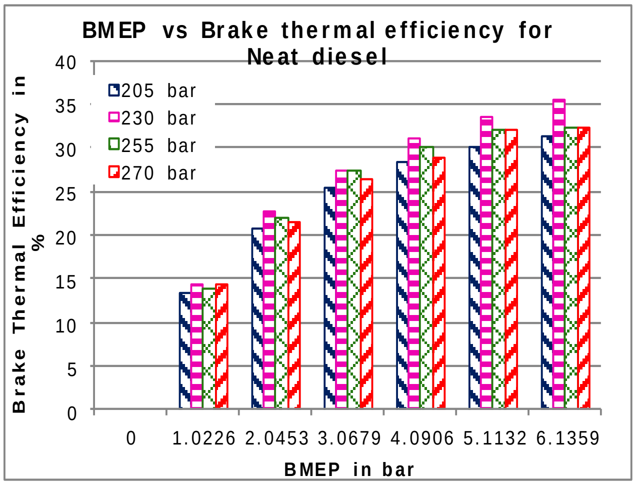
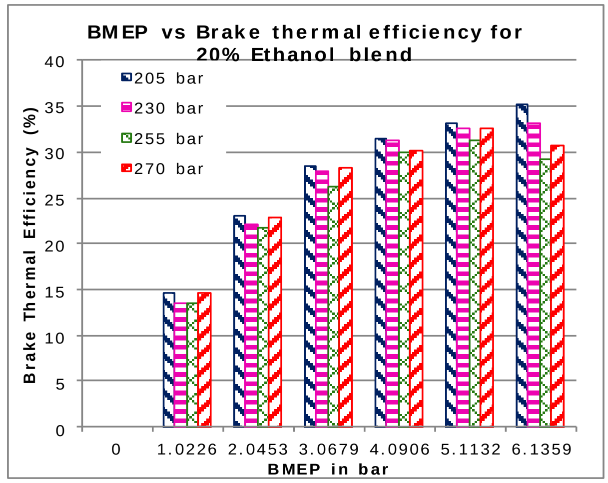
RPM	1500

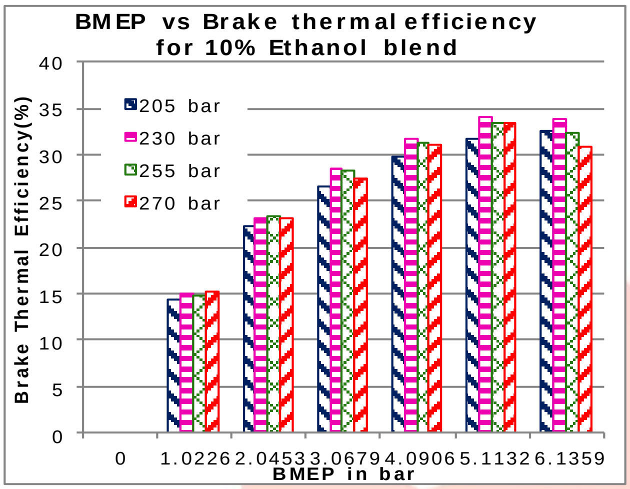
Fig.1. Actual photograph of experimental engine.

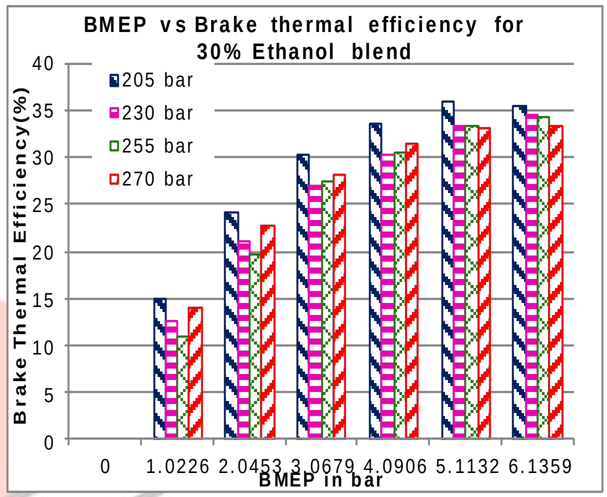
III. Results and Discussion

A. Engine Performance Parameter for Conventional Diesel with different IP & CR:

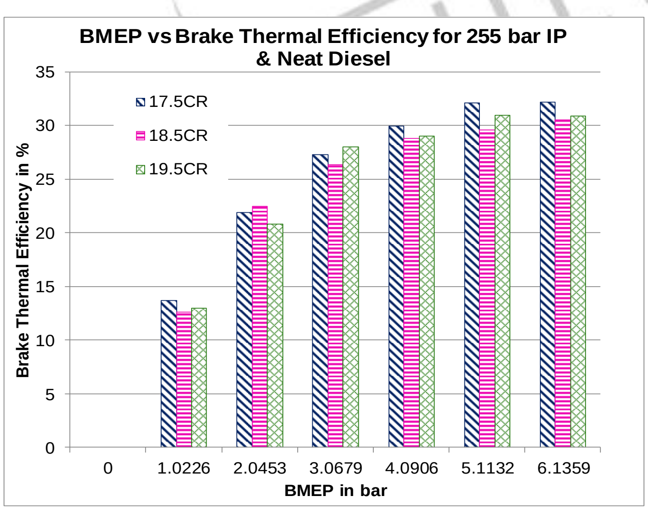


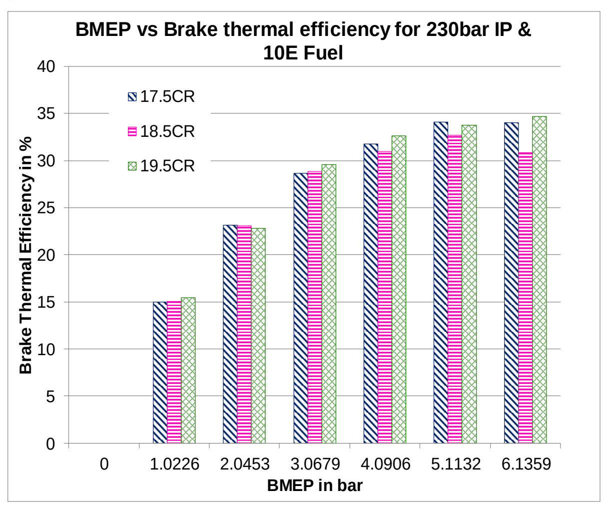


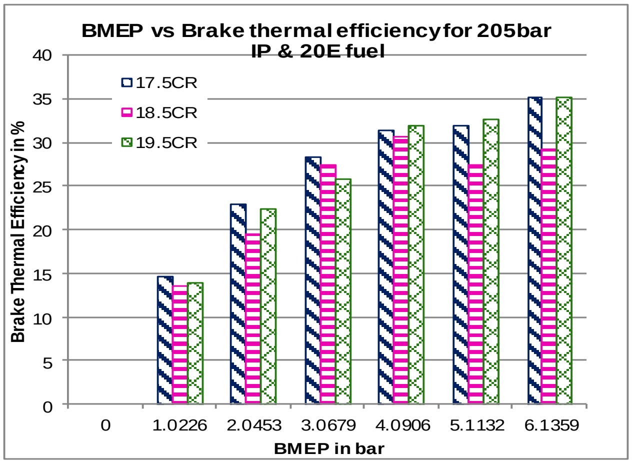


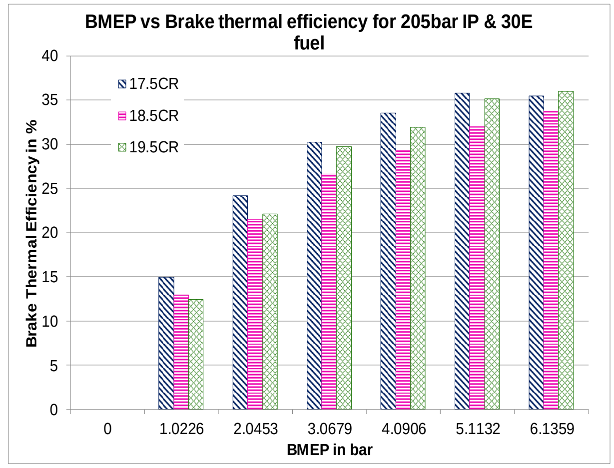


The performance is measured mainly in terms of brake thermal efficiency. From the above graphs it is observed that the brake thermal efficiency decreases is highest for 255bar for neat diesel, 230bar for 10% Ethanol, 205bar for 20% Ethanol and 205bar for even 30% Ethanol. Hence these injection pressures are considered as preferred pressures for each fuel and in these IP of each fuel, CR is varied and the following is observed:



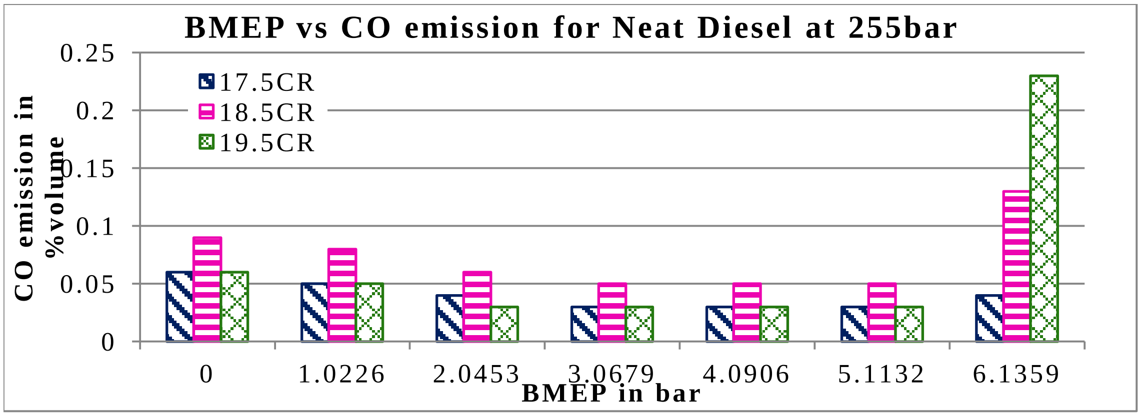


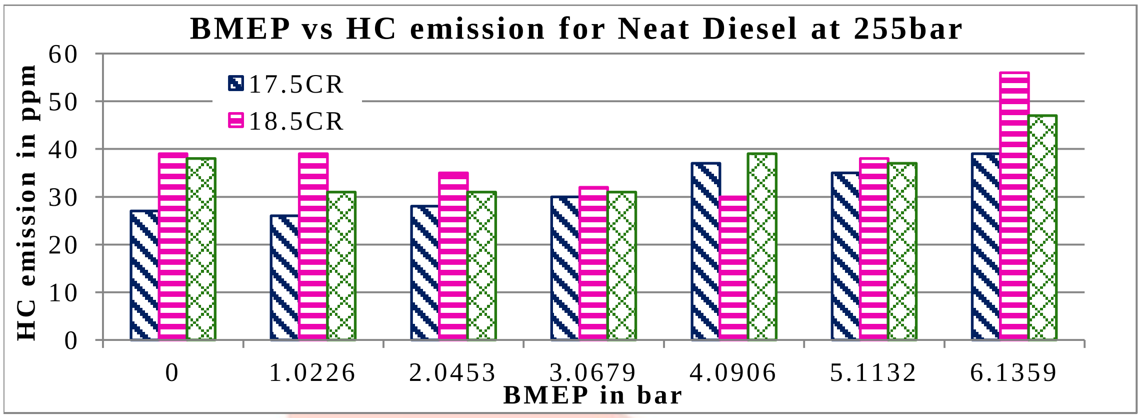


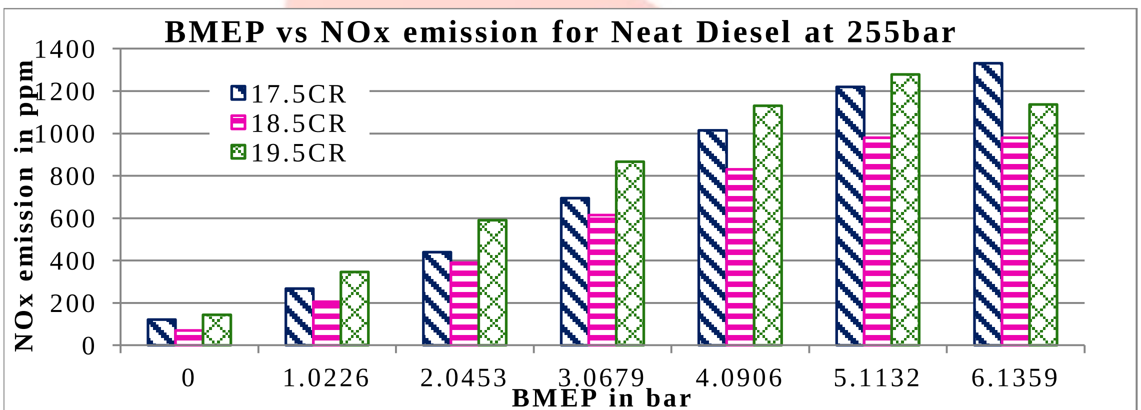


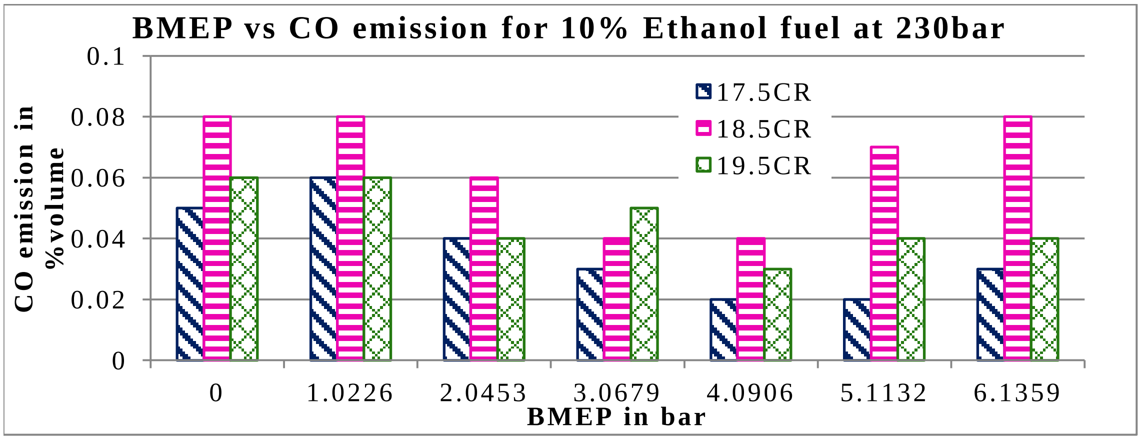
The graphs show that the efficiency varies with CR change in terms of 17.5CR, 18.5CR and 19.5CR. Here the brake thermal efficiency attained is higher for 255bar IP & 17.5CR for neat diesel, 230bar IP & 19.5CR for 10% ethanol, 205bar IP & 19.5CR for 20% ethanol and 205bar IP & 19.5CR for 30% Ethanol.

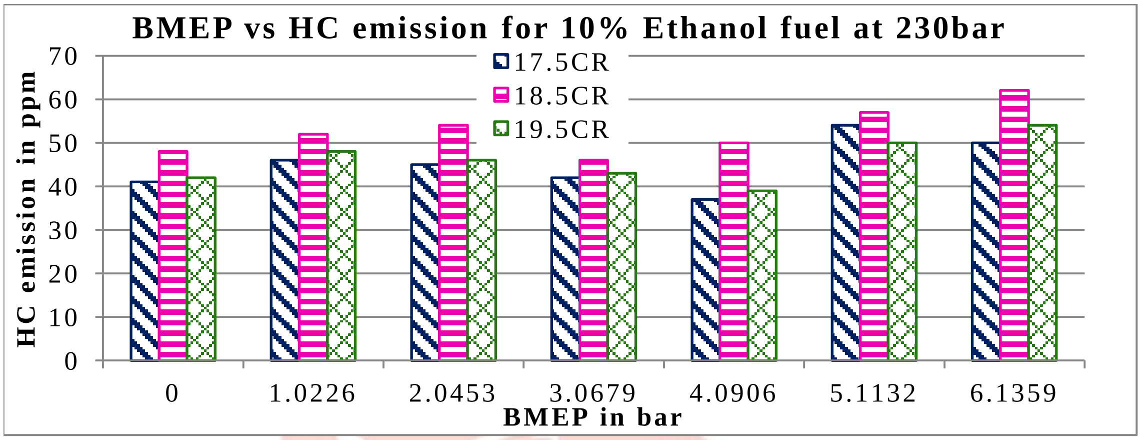
B. Engine Emissions Parameter for preferred Injection pressure and various Compression ratio for each fuel:

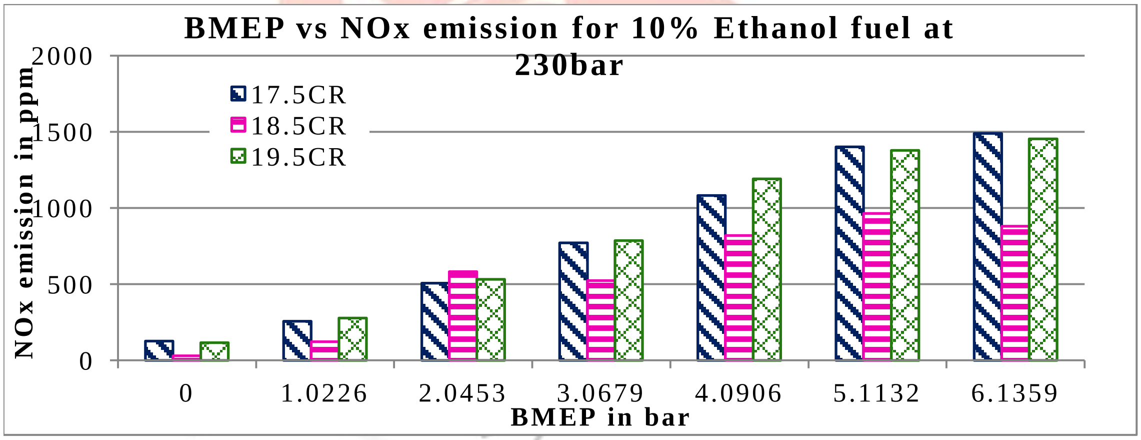

BMEP vs CO emission for Neat Diesel at 255bar
CO emission in %volume
BMEP in bar
17.5CR
18.5CR
19.5CR
0.25
0.2
0.15
0.1
0.05
0
0
1.0226
2.0453
3.0679
4.0906
5.1132
6.1359

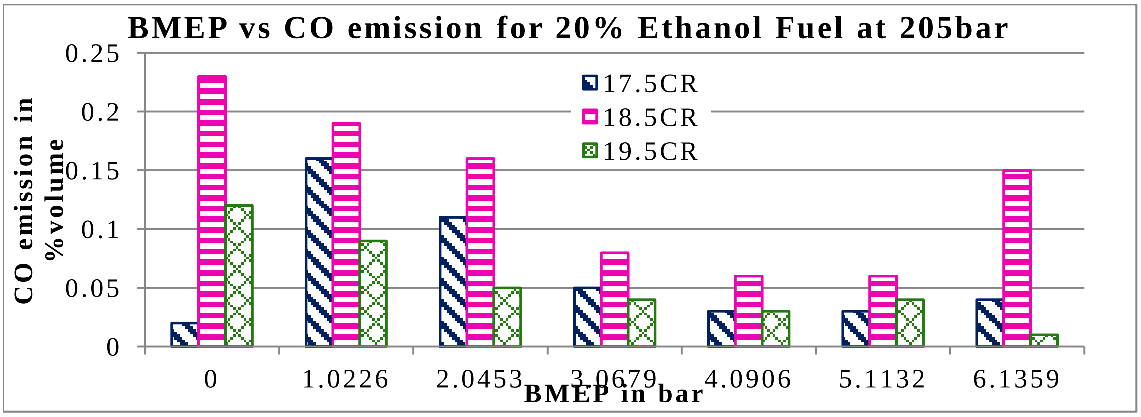

BMEP vs HC emission for Neat Diesel at 255bar
HC emission in ppm
BMEP in bar
17.5CR
18.5CR
60
50
40
30
20
10
0
0
1.0226
2.0453
3.0679
4.0906
5.1132
6.1359

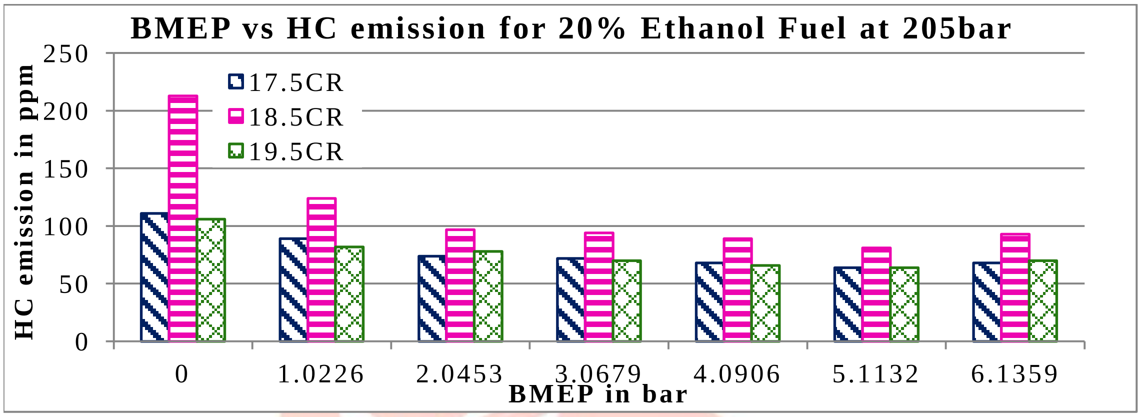

BMEP vs NOx emission for Neat Diesel at 255bar
NOx emission in ppm
BMEP in bar
17.5CR
18.5CR
19.5CR
1400
1200
1000
800
600
400
200
0
0
1.0226
2.0453
3.0679
4.0906
5.1132
6.1359

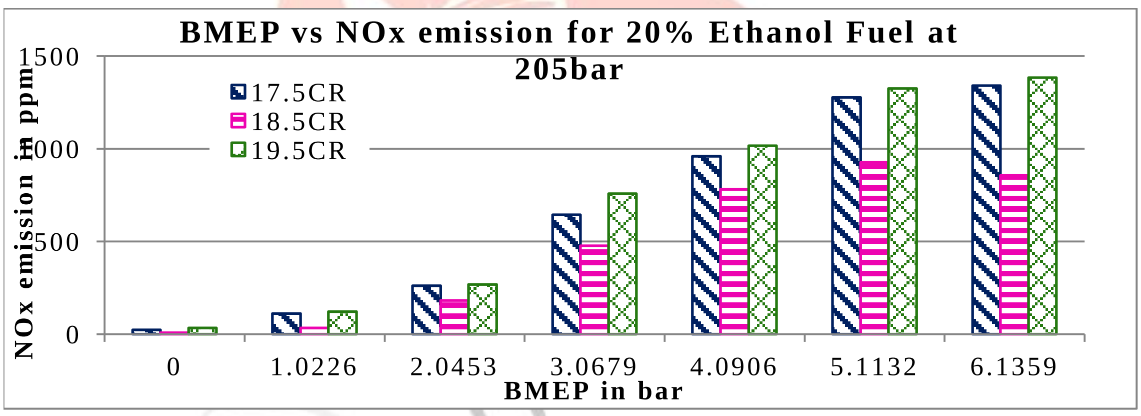

BMEP vs CO emission for 10% Ethanol fuel at 230bar
CO emission in %volume
0.1
0.08
0.06
0.04
0.02
0
17.5CR
18.5CR
19.5CR
0
1.0226
2.0453
3.0679
4.0906
5.1132
6.1359
BMEP in bar

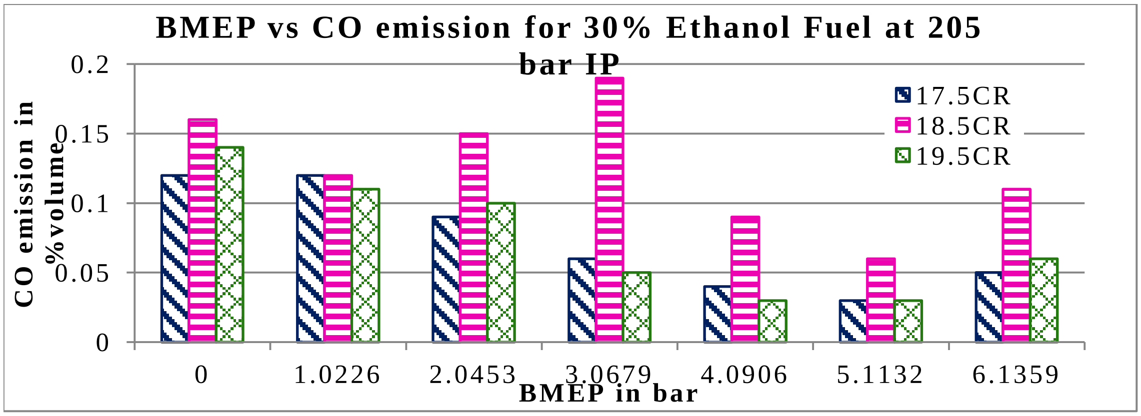

BMEP vs HC emission for 10% Ethanol fuel at 230bar
HC emission in ppm
70
60
50
40
30
20
10
0
17.5CR
18.5CR
19.5CR
0
1.0226
2.0453
3.0679
4.0906
5.1132
6.1359
BMEP in bar

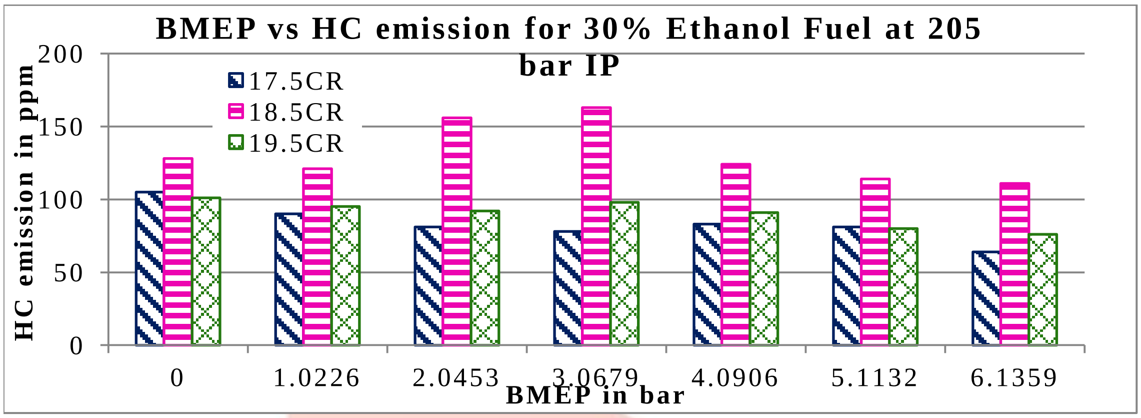

BMEP vs NOx emission for 10% Ethanol fuel at 230bar
NOx emission in ppm
2000
1500
1000
500
0
17.5CR
18.5CR
19.5CR
0
1.0226
2.0453
3.0679
4.0906
5.1132
6.1359
BMEP in bar

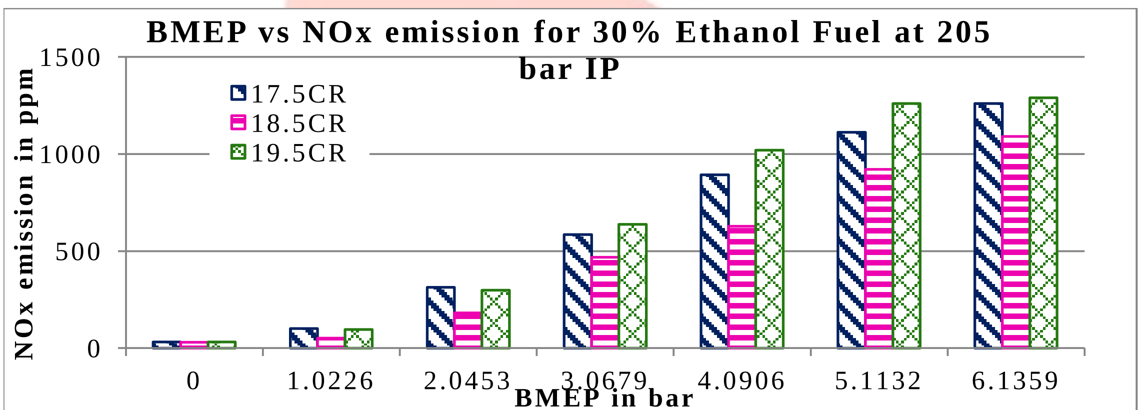

BMEP vs CO emission for 20% Ethanol Fuel at 205bar
CO emission in %volume
0.25
0.2
0.15
0.1
0.05
0
17.5CR
18.5CR
19.5CR
0
1.0226
2.0453
3.0679
4.0906
5.1132
6.1359
BMEP in bar


BMEP vs HC emission for 20% Ethanol Fuel at 205bar
HC emission in ppm
250
200
150
100
50
0
17.5CR
18.5CR
19.5CR
0
1.0226
2.0453
3.0679
4.0906
5.1132
6.1359
BMEP in bar


BMEP vs NOx emission for 20% Ethanol Fuel at 205bar
NOx emission in ppm
1500
1000
500
0
17.5CR
18.5CR
19.5CR
0
1.0226
2.0453
3.0679
4.0906
5.1132
6.1359
BMEP in bar







The emission is considered for each fuel at preferred injection pressure and different CR. The emissions observed are CO, HC and NO_x. Emissions like CO & HC denotes incomplete combustion. The emissions considered are lowest for neat diesel at 255bar & 17.5CR, for 10% Ethanol at 230bar & 19.5bar and for both 20% &30% Ethanol at 205bar & 19.5 CR.

IV. CONCLUSION

The effect of fuel injection pressure on the performance and exhaust emission characteristics of a diesel engine fuelled with ethanol–diesel blends leads to the following conclusion:

- For Neat diesel, injection pressure of 230bar provides increase in performance but emissions is higher and so pressure of 255bar is optimum as it provides reduced emission and also enhanced performance of the engine due to perfect atomization and penetration of the fuel.
- Considering E10, 205 bar injection pressure provides least emissions when compared to other pressures and the performance is improved at 230 bar. But for an optimized output of power and emission, injection pressure of 230 bar is chosen as the other 2 pressures have a very high level of emissions with the least efficiency.

- For E20 the optimum injection pressure is 205bar as the emissions are the least comparing to other pressures and the performance is enhanced with less specific fuel consumption and high brake thermal efficiency which indicates higher energy utilization from the fuel at that pressure.
- For E30, the suitable injection pressure is 205 bar as the emissions are lower compared to other pressures considered and also the performance in terms of brake thermal efficiency is high with lower specific fuel consumption.
  This shows that a reduced injection pressure is needed for enhanced performance with reduced emissions on ethanol addition as the density of the fuel is reduced. Preferred injection pressure for neat diesel is 255bar, 230bar for E10 and 205bar for E20 & E30.

Result & Discussion for Compression Ratio Change:

Considering Compression ratio change for the preferred injection pressure as discussed in the above paragraph, the following aspects can be observed from 5.3.3:

- For neat diesel at 255 bar IP and different CR, it can be observed that the brake thermal efficiency is low for 18.5CR. 17.5CR and 19.5CR maintains nearly same BTE. But the emissions like NOx, HC, CO are lower for 17.5CR than 19.5 CR. Hence the preferred compression ratio for Neat diesel is 17.5CR.
- For 10% Ethanol fuel at 230bar IP and various CR, it is observed from the graphs 5.28 & 5.29 that BTE of 19.5 CR is higher than that of 17.5 CR especially at peak loads. Hence for peak load operations 19.5CR is preferred and is the operating condition involves lower load then 17.5 bar is preferred for 10% Ethanol at 230 bar IP.
- For 20% Ethanol fuel at 205 bar IP and 17.5, 18.5 & 19.5 CR, it can be noted in the graphs 5.30 & 5.31 that BTE is slightly higher for 19.5 CR than the other compression ratios and emissions like CO, HC are minimum for 19.5CR used. Here NO_x emission is a little higher for 19.5 CR but this can be due to high temperature reached due to much complete combustion that takes place inside combustion due to preferred conditions for complete combustion.
- For 30% Ethanol fuel, the efficiency of fuel with 18.5CR is the lowest. When 19.5 CR and 17.5 CR are compared, it is seen that the difference in brake thermal efficiency is very minute in terms of 0.5% at peak loads. But the emissions are much lower for 19.5CR. Also CO & HC is lower for 19.5CR than 17.5CR.Hence when low emission is in concern, the preferred CR is 19.5CR for 30% Ethanol fuel.

This above points show that higher compression ratio is needed than compared to neat diesel for enhanced performance with reduced emissions on ethanol addition as the heat of vaporization is higher for ethanol. Hence the preferred Compression ratio for neat diesel at 255bar IP is 17.5 CR & 19.5CR for 10E, 20E & 30E at 230bar, 205bar & 205bar respectively.

ACKNOWLEDGMENT

The authors would like to thank guide, H.O.D andteaching staff of mechanical and automobile engineeringdepartment for providing their valuable guidance andoverwhelming support to carry out this work.

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