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Studying the Effect of Compression Ratio on DI-CI Engine Performance and Emission Characteristics Fueled with Ethanol Blended Diesel

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Abstract

The diesel engine performance and emission characteristics are influenced by various parameters. The effect of compression ratio and blending ratio of ethanol in diesel fuel on diesel engine performance and emission characteristics have been investigated. The engine characteristics were studied at different compression ratios varying from 15 to 19 and using different blends of ethanol, butanol and diesel (E10B5D85, E15B5D80 and E20B5D75). The experimental results reveal that the engine brake thermal efficiency increases as compression ratio increases for all blends. The brake specific fuel consumption decreases with increase of compression ratio for all fuel blends. The results also shows that brake specific fuel consumption remains higher for blends and increases with increase of ethanol blend percent compared to pure diesel. When compression ratio was increased from 15 to 19, the HC and CO emission decreased drastically and NO_X emission increased considerably.

Keywords: Performance, emission, compression ratio, ethanol blend and diesel engine

INTRODUCTION

Our sources of traditional fuels including petroleum diesel are limited and would be depleted in coming few decades. Owing to the fact that these fuels are typically not renewable, a lot of people are worried that a day would come when the demand for these fuels would be more than the supply, triggering a crisis of the fuels. Non-environmentalists also concur with the opinion that the majority of oil fields (situated in the Middle East) in the world are associated with problems – both political and economic. Many countries in the world are also facing lot of issues regarding environmental impact and availability of fossil fuels. Non renewability, rapid depletion and limited in reserves are the main challenges of existing fossil fuels. The use of these conventional fuels mainly in transportation sector has led adverse effect on environmental pollution [1]. So researchers are directed to search for clean alternative fuels such as alcohols, vegetable oils and biodiesel [2-4]. It is an inevitable for the development and utilization of alternative energy. Alcohol is considered as one of the suitable fuel substitution for diesel engines because it allows the diesel fuel to burn completely due to presence of more oxygen which improves engine characteristics [5]. Methanol, ethanol and butanol [6-8] are the alcohols which attract the attention of most of the researchers recently because of their ease of availability. More works were carried out with methanol from the past few years and less attention was paid towards ethanol and butanol. Ethanol and butanol can be produced from various renewable resources such as corn, sugarcane and wheat etc. [9-10]. Because of their high octane number, they are considered primarily good fuels for spark ignition engines. They have also been considered suitable fuels for compression ignition engines, mainly in the form of blends with diesel fuels [11].

H. Raheman and S.V. Ghadge [12] investigated the effect of compression ratio on performance of Recardo E6 diesel engine. They reported that the BSFC of engine is decreased when the compression ratio was increased. Mohammed EL Kassaby and Medhat A Nemit [13] studied the effect of compression ratio and blending ratio on engine with biodiesel and diesel. They used blending ratio 10,20,30,50 and compression ratio 14, 16, 18 for investigation. The BSFC for all blends decreases compression ratio increases and at all compression ratios BSFC remain higher for the higher blends as the biodiesel percent increase. The increase of compression ratio from 14 to 18 resulted in increase of BTE by 18.39%, 27.48%, 18.5% and 19.82% for the blends B10, B20, B30 and B50 respectively. The CO and HC emissions reduced and NO_X emission increased with compression ratio for all the blends. N. Ravi Kumar et.al [14] studied the effect of compression ratio and EGR on diesel engine characteristics and observed that the brake thermal efficiency increases and specific fuel consumption decreases with increase of compression ratio.

MATERIALS AND METHODS

A. *Engine*

4-Stroke 1-Cylinder water cooled Variable Compression Ratio Diesel engine was used to conduct tests which is shown in figure 1. An Eddy Current Dynamometer is attached to it to vary the loads. Manometer and rotameter are provided to measure the air flow and water flow. The detailed technical specifications of the test engine are given below.

Engine	:	4 Stroke 1 Cylinder
Make	:	Kirloskar
Compression Ratio:		17.5:1
Rated speed	:	1500
Bore	:	87.5 mm
Stroke Length	:	110 mm
Method of Ignition:		Compression Ignition

Figure 1: Experimental engine set up

B. Fuel

In this work the performance and emission characteristics of DI-CI engine was evaluated by using ethanol blended diesel. Different blends were prepared with ethanol-butanol-diesel percentage volume ratios of 10:5:85(E10B5D85), 15:5:80(E15B5D80) and 20:5:75(E20B5D75), for test the engine. To form a stable mixture of ethanol and diesel a 5% butanol was used for all the blends. The blend of E10B5D85 was identified as the best stable blend with very little and almost unseen stratification. The table1 describes important properties of these fuel blends.

Table 1: Properties of Fuels

Properties	Diesel	Ethanol	n-Butanol	E10B5D85	E15B5D80	E20B5D75
Density (kg/m^3)	820	785	800	812	810	807
Viscosity (cSt)	3.20	1.2	2.86	3.07	2.78	2.55
Heat Content (MJ/kg)	42.5	26.4	33.2	40.42	39.62	38.56

C. Exhaust Gas Analyser

Exhaust gas analyser shown in figure 2 is used to analyse the emissions. Carbon Monoxide, Carbon Dioxide, Hydro Carbons, Oxygen, Oxides of Nitrogen can be measured with this analyser. Non – Dispersive Infra – Red (NDIR) technique for Carbon Monoxide, Carbon Dioxide, Hydro Carbons and Electro Chemical sensors for Oxygen and Oxides of Nitrogen measurement were used. The specifications of exhaust gas analyser are given in table 2.

Figure 2: Exhaust gas analyser

Table 2: Exhaust gas analyzer specifications

Exhaust Gas Analyzer make and model: INDUS make and PEA 205		
Type of Emission	**Range**	**Resolution**
NO_X (ppm)	0-5000	1
HC (ppm)	0-15000	1
CO (%)	0-15.0	0.01

RESULTS AND DISCUSSIONS

DI-CI engine performance characteristics BSFC, BTE and emission characteristics CO, HC, NO_X were evaluated at different compression ratios from 15 to 19 with diesel and ethanol blend with butanol additive (E10B5D85, E15B5D80 and E20B5D75). The obtained results are discussed as follows.

A. Brake Specific Fuel Consumption(BSFC)

As shown in the fig.3 the BSFC for all blends decreases as compression ratio increases. The BSFC remains higher for the higher blends at all compression ratios of the engine. This may be due to improvement in combustion process at higher compression ratios. The BSFC of pure diesel (B0) and other blends decreased moderately when compression ratio was increase from 15 to 17. Further increase in compression ration from 17 to 19, the decrease in BSFC is comparatively higher. It is also clear that blends gives better decrease is BSFC than diesel as the compression ratio increase. This behavior may be due to higher volatility of ethanol compared to diesel fuel which result in improved combustion at higher compression ratios.

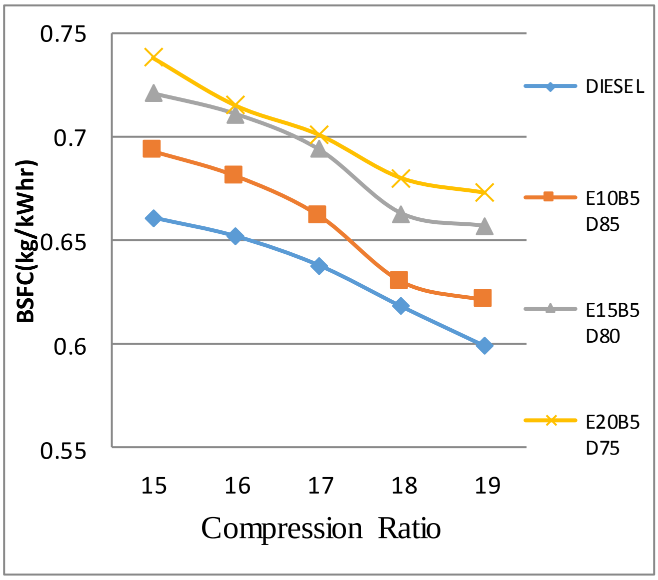

Figure 3: Variation of Brake Specific Fuel Consumption with Load

B. Brake Thermal Efficiency(BTE)

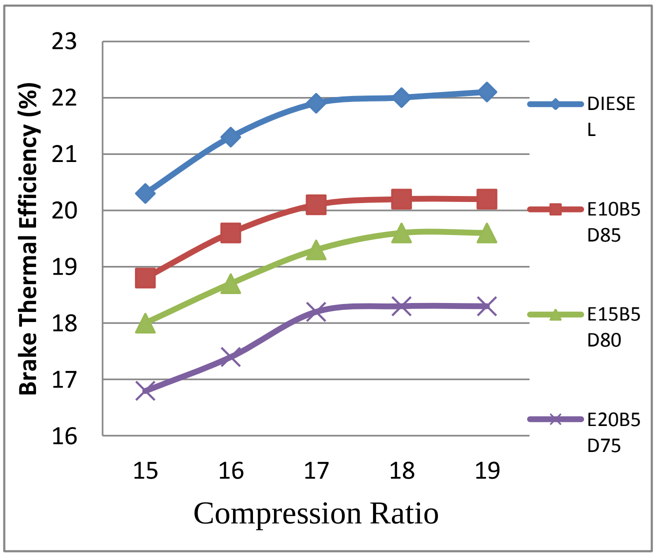

Figure 4: Variation of Brake Thermal Efficiency with Load

In general increasing the compression ratio improved the brake thermal efficiency of the engine. For all the blends brake thermal efficiency of the engine increases with increase in compression ratio from 15 to 19 as shown in fig.4. This improved performance of the engine at higher compression ratio may be due to the reduced ignition delay. The compression ration 19 was found to be best for all the blends tested.

C. Carbon Monoxide(CO) Emission

On an average the CO emission reduced by 24.7% when compression ratio was increased from 15 to 19 for the blend E20B5D75 as it can be seen from fig.5, similar values were obtained from the other blends. This inverse relationship of CO emission with compression ratio was observed for all blends. The possible reason for this trend could be that the increased compression ratio actually increases the air temperature inside the cylinder consequently reducing the delay period causing better and more complete combustion of the fuel and hence lower CO emission.

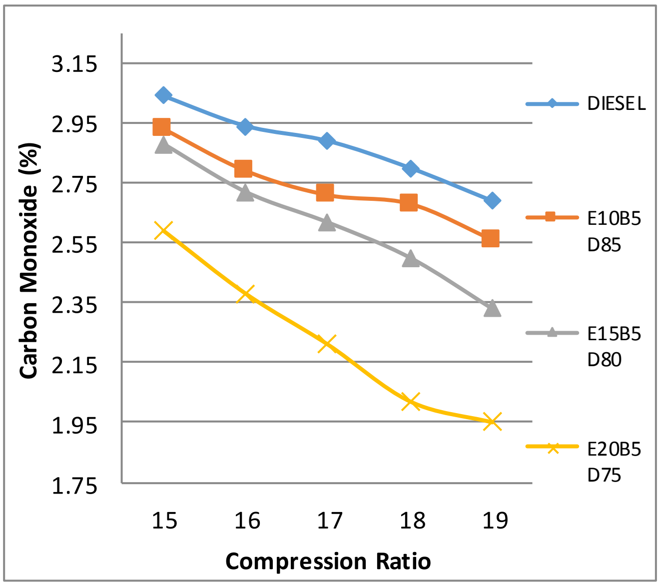

Figure 5: Variation of Carbon Monoxide Emission with Load

D. Hydro Carbons(HC) Emission

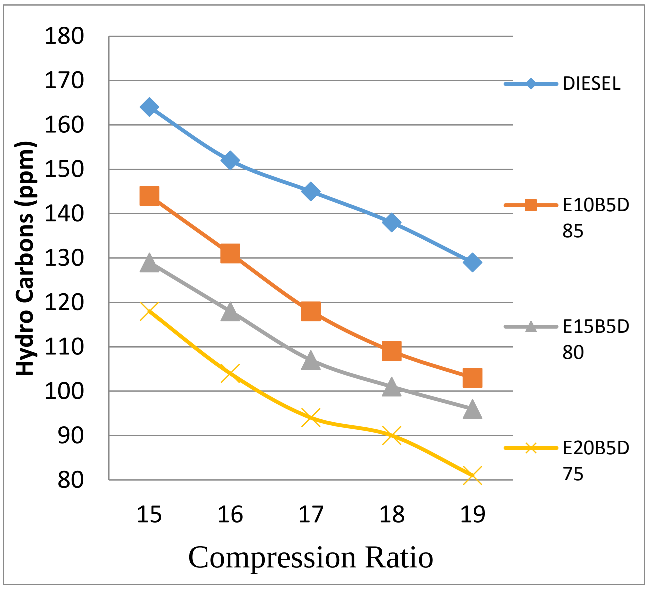

Figure 6: Variation of Hydro Carbons Emission with Load

It can be seen from the fig.6 that the HC emission decreased drastically when compression ratio was increased from 15 to 19 for all blends. The lower CO emission was observed at compression ratio 19. This may be due to decreased delay period and complete combustion of fuel at higher compression ratio.

E. Nitrogen Oxides(NO_X) Emission

Fig.7 shows the effect of compression ratio on NO_X emission. NO_X emission increases with increase of compression ratio. The increased amount of NO_X emission with compression ratio was observed for blends. The most significant factor that causes NO_X formation is high combustion temperature. The combustion temperature increases as compression ratio increase, the amount of NO_X increases. It was also observed that all blends produced higher NO_X than pure diesel for all compression ratios from 15 to 19.

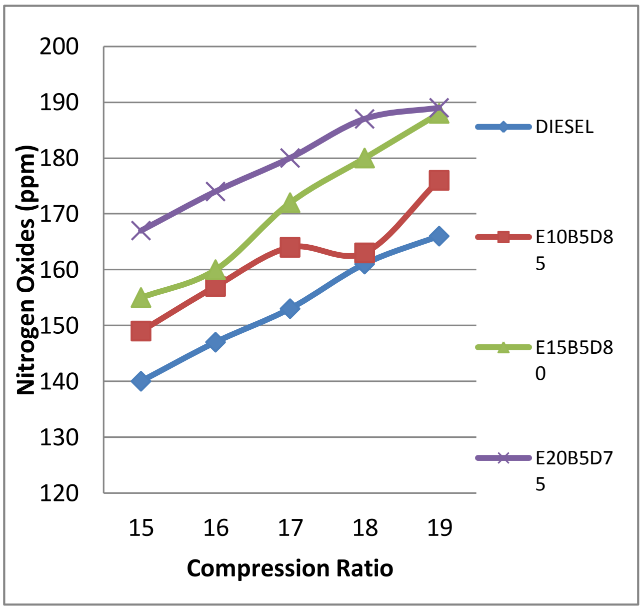

Figure 7: Variation of Nitrogen Oxides Emission with Load

CONCLUSION

The conclusions drawn from the present study are as follows

- ❖ The BSFC for all blends decreases as compression ratio increases and the BSFC remins higher for blends at all compression ratios
- ❖ The brake thermal efficiency of the diesel engine was decreased when ethanol blends were used compared to pure diesel. The change of compression ratio from 15 to19 resulted in increase in brake thermal efficiency for all blends and pure diesel
- ❖ On average for the blend E20B5D75 the CO emission decreased by 24.7%, HC emission decreased by 31.3% and NO_X emission increased by 13.13% when compression ratio was increased from 15 to 19
- ❖ In general increasing the compression ratio improved the performance and reduced the emissions of HC and CO with slightly increased NO_X emission

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