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Effect of Compression Ratio on Diesel Engine Performance and Emission with Diesel- Ethanol Blends

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Abstract: - Present work was performed in a 3.7kW, 4 –stroke single cylinder, water cooled, variable compression ratio, diesel engine fueled with the different blends of ethanol and diesel fuel run on three different compression ratios of 17, 17.5 and 18. The experiments were conducted for engine emission and performance with blendes of ethanol of 5% with diesel termed as fuel E5, 10% as fuel E10, 15% as fuel E15 and 20% as fuel E20. The experiment was performed for 50% load condition Studies showed that HC decreases with the increase in compression ratio. When the percentage of ethanol increases in the blend HC also increases. Smoke reduces as compression ratio increase. When compared with diesel fuel the smoke increases for all blends for lower CR while for higher CR smoke reduces drastically. As compression ratio increases the NOx increases for neat diesel while NOx decreases for lower blends .CO was not changed with compression ratio for all the blend of fuel. Brake specific fuel consumption decreases with the compression ratio increases. Brake thermal efficiency increase with the compression ratio for all fuel. Exhaust gas temperature increases with compression ratio for all blends.

Index Terms— Variable compression ratio, Emission, Ethanol, Blends.

1 Introduction

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There are number of research work going on the alternative fuel applied in diesel engines. However, stable emulsion requires a small amount of additive. The ethanol is a low cost oxygenate having 35% of oxygen content has been used for blending with diesel to prepare a diesel –ethanol blended fuel"[2]", "[3]". By using ethanol in diesel engine the significant reduction may be obtain in PM emission for engines"[4]". Increase in thermal efficiency with increasing blend value has also been reported "[5]". Diesel fuel blended with ethanol up to 10% volume can be used to solve the fuel shortage problem, increase the energy conversion efficiency, improve fuel economy and reduce harmful emission and also reduce CO and NOx and PM."[6]". Nilesh M. et al "[2]". Examined in the CI engine at variable compression ratio for different blends of ethanol- diesel of 5%, 10%, 15% and 20% ethanol they observed only marginal variation of BMEP of different blends as compared to neat diesel fuel. As the compression ratio changes slight reduction in brake power at CR 18 was found. The fuel blend E5 has lower fuel flow among the all fuel but when the CR decreases, the fuel flow increases, as the proportion of ehanol increases.

Ali Turkcan et al "[7]". experimentally evaluated combustion characteristics of the IDI diesel engine fueled with E-diesel and M-diesel blend at different injection timing of 250, 200 and150 CA before top dead center, selected blend of (M5,M10, E5 and E10) under the common load and speed. It was found that the maximum cylinder gas pressure and maximum heat release rate increased with advancing fuel delivery timing for all test fuels. The ignition delay, total combustion duration and maximum pressure rise rate increased with advanced fuel delivery time. It has been also found the cyclic variability of the fuels was higher comparing with original and retarded injection timing for fifty cycle of each fuel.

Jincheng H.et al [8] investigated the performance of diesel engine with blend of diesel –ethanol fuel and compared with performance and emission of neat diesel. It is reported that due to lower heating value of ethanol there is an increase in fuel consumption. Thermal efficiency is comparable with neat diesel. The smoke emission lowered than that of neat diesel. Carbon monoxide (CO) reduced for half load condition while increased for low load and speed. NOx emissions were reported different for different speed, load and blend while. Hydrocarbon emissions were all higher for top loads at high speed.

K Murlidharan et al "[9]" investigated performance, emission and combustion characteristics of diesel engine operating at different compression ratios of 18:1, 19:1, 20:1 and 22:1 for blends of methyl esters of waste cooking oil of 20%, 40%, 60% and 80% by volume basis. It was observed that the brake thermal efficiency for B40 is slightly higher that of standard diesel at higher compression ratios. The mean effective pressure for B40 was higher at lower compression ratios and lower at higher compression ratios than for standard diesel. Also result indicated longer ignition delay, maximum rate of pressure rise, lower heat release rate and higher mass fraction burnt at higher compression ratio for waste cooking oil methyl ester as compared with standard diesel.

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Objective of this paper is to study the effect of compression ratio on the performance and emission of diesel engine with the diesel ethanol blends.

Blend preparation and stability study

Ethanol is insoluble with diesel to make it soluble researcher indentified co solvent (Tetrahydrofuran and Emulsifier like bio diesel) can be used to preserve the blend. Mixing of bio diesel with the blend of ethanol- diesel improves the solubility of ethanol into diesel for wide range of temperature. An octyl nitrate (2 EHN) is used as cetane improver for diesel which can also be used for ethanol- diesel blend. The purity of the ethanol used is of 99.9%. The series of tests was performed to observe the solubility of ethanol and diesel with the help of additive and biodiesel. Diesel, ethanol and biodiesel were mixed into a homogenous blend in a container by stirring it. The blend was kept in cylindrical glass container to study the solubility and phase stability for 24 hours. The low volume percentage, i.e., 5 and 10 of ethanol is easily miscible and found to be stable as much as 7 to 17 days but higher concentration of ethanol with diesel is not stable for longer period of time. Phase separation was takes place soon after stirring. To overcome this problem biodiesel is added in equal proportion to the ethanol. The volume percentages tested were 5%, 10%, ethanol with diesel (0.7% and 1% additive respectively) and 15% and 20% of ethanol with equal amount of biodiesel and diesel (1% additive in each). They were named E5 E10, E15 and E20. The additive is supplied by Energenics Pte. Ltd. Singapore. The entire test was carried out as per ASTM standards. However it is worth noting that considerable loss of calorific value due to addition of ethanol in diesel is compensated by using biodiesel. The blend proportion is shown on table 1. The addition of ethanol to diesel fuel simultaneously decrease cetane number, high heating value, aromatic fractions and kinematic viscosity of ethanol blended diesel fuels and changes distillation temperature “[10]”.

Table 1:- Blend proportion

Fuel	Diesel	Biodiesel	Ethanol	Additive
Neat diesel	100	0	0	0
E5	94	0	5	1
E10	89	0	10	1
E15	69	15	15	1
E20	59	20	20	1

2 METHODOLOGY

2.1 Experimental set up

Present work was carried out on four stroke single cylinder, water cooled, 5 HP diesel engine. widely used for irrigation purposes manufactured by kirlosker (OEM). All the blends were examined on three different compression ratio, i,e 17, 17.5 and 18 The engine was run for half an hour at no load condition, before taking measurements to stabilize the engine, than after loaded 50% of the maximum load and measurement was taken for all compression ratio. The measurement was repeated two times and was averaged for good results. The specification of engine is listed in the table 2.

Parameters	Details
Engine power	3.7kW
No of cylinder and stroke	Single cylinder 4 stroke
Bore	80 mm
Stroke	110mm
Speed	1500 rpm
Compression Ratio	12:1 to 18:1
Cooling	Water

Table 2:- Specification of Engine

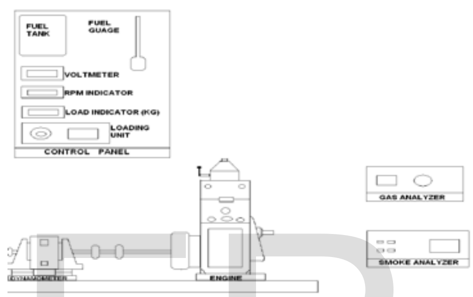

Figure1. Schematic diagram of engine setup

The experimental procedure includes study of the stability of blends, measurement of physico-chemical analysis as per ASTM/BIS and engine performance emission studies.

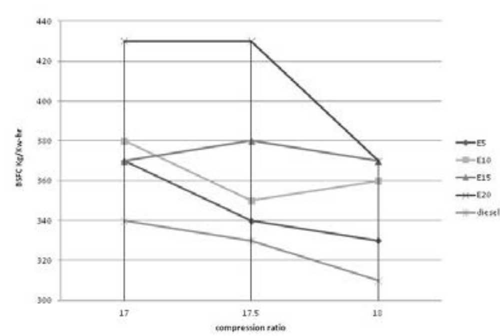

Figure 2. Plot between compression ratio and BSFC

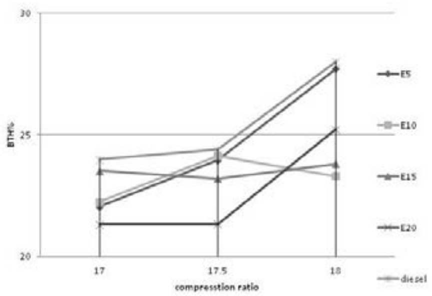

Figure 3. Plot between compression ratio and BTH

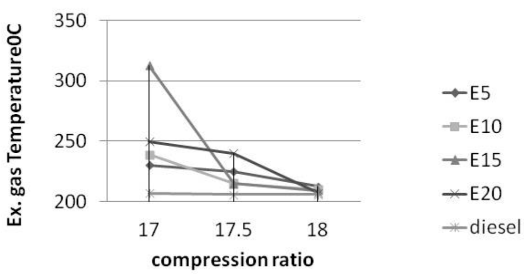

Figure 4. Plot between compression ratio and exhaust gas temperature

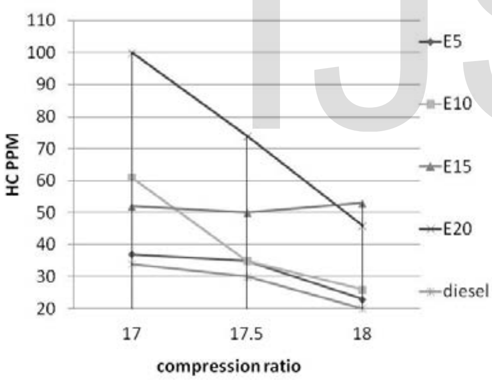

Figure 5. Plot between compression ratio and hydrocarbon

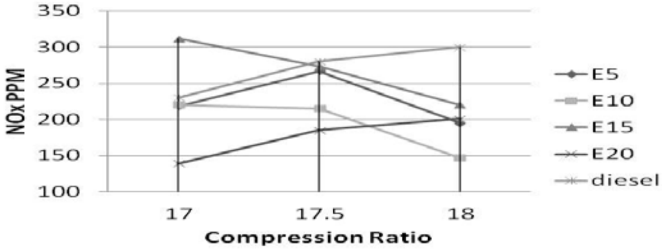

Figure 6. Plot between compressrion ratio and NOx

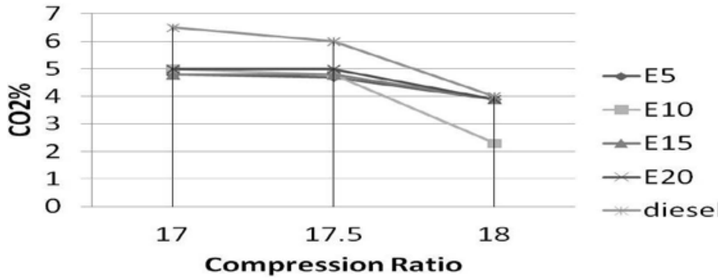

Figure 7:- Plot between compression ratio and CO2

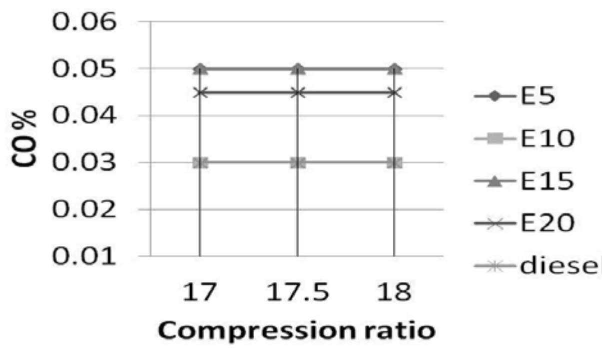

Figure 8:- Plot between compression ratio and CO

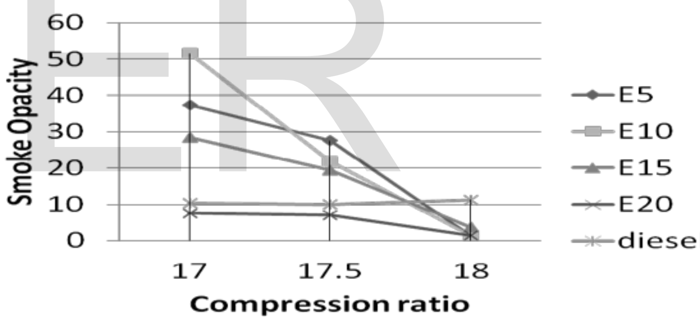

Figure 9:- Plot ebetween compression ratio and smoke opacity

Results and Discussion: - After experimentation the various graphs were plotted taking compression ratio on X-axis and different parameter on Y-axis. The results have been analyzed firstly, corresponding to performance parameter (BSFC, BTH and exhaust gas temperature) and subsequently emissions (HC, CO2, NOx, CO and smoke opacity) come out from the tail pipe.

Performance Analysis: -

A. Brake Specific Fuel consumption (BSFC)

Figure2. Shows the variation of BFSC with CR. for all the blends. They were compared with neat diesel. Brake specific fuel consumption decreases with the compression ratio increases. E20 shows decrease of 20% for lower compression ratio and 16% for higher compression ratio. This is due to fact that at higher compression ratio the pressure and temperature increases because of that the rate of combustion increases which gives better thermal efficiency thereby decreasing the BSFC.

B. Brake thermal efficiency (BTH)

Brake thermal efficiency increase with the compression ratio, this is because at higher compressrion ratio the rate of combustion of ethanol increase which result better thermal efficiency, and if compared to the neat diesel it is decrease for all blends. The major decrease in brake thermal efficiency was found 20% with higher compression ratio for E10. This is due to lower heating value of the test fuel. Figure3.

C. Exhaust gas temperature

Exhaust gas temperature decreases with compression ratio for all blends. When it is compared to the diesel fuel, this is due to fact that at higher compression ratio the pressure and temperature increases because of that the rate of combustion increases, more complete combustion results in lower losses during exhaust. At higher compression ratio it is nearer to neat diesel for all the blends. Fig 4

Emission Analysis: - Emission tests were performed using exhaust gas analyzer AVL Di-gas 444, for the HC, NOx, CO, and CO_2. For smoke measurement the AVL model 437C was used.

A. Hydrocarbon (HC)

From the figure 5. It is seen HC decreases with the compression ratio increases. When the percentage of ethanol increases in the blend HC also increases. E10 shows 44.2%, increase of HC for CR's 17, 62.2% higher HC than the pure diesel for CR 18. E20 showed increase in HC on ranges 56-66% than the diesel fuel for increasing CR. High latent heat of vaporization of ethanol tends to produce slow vaporization and mixing of fuel and air. In homogeneity of mixture may be other reason of increasing HC [13]

B. Nitrogen Oxides NOx

It is seen from the figure 6. As the compression ratio increases the NOx increases for neat diesel. E10 shows 33% reduction in the NOx emission compared between low compression ratio and higher compression ratio E15 shows 35.8% increase in NOx than diesel fuel for lower compression ratio. The NOx emission is decrease with the addition of ethanol. As the ethanol is an oxygenated fuel and it has higher heat of evaporation because of that it reduces the combustion temperature, causes NOx reduction [15].

C. Carbon Dioxide CO_2

Carbon dioxide decreases as the compression ratio increase it may also be seen from the graph there are 35.4% reduction for E5 and E15while 30% reduction of E20 if compared with neat diesel for CR 17.ethanol has higher oxygen contain and provide more oxygen for combustion may led to reduction of CO_2. Figure7.

D. Carbon Monoxide (CO)

There is no effect of CR on the emission of CO. while compared to neat diesel it is slightly higher for *E5* and E15. When ethanol is added with diesel it causes reduction in gas temperature which restrains the oxidation of CO, so CO emission slightly increased [16]. Figure 8.

E. Smoke Opacity

Smoke reduces as compression ratio increase. When compare with diesel fuel smoke increases for all blends for lower CR while for higher CR smoke reduces drastically. The oxygenated fuel has the oxygen atom strongly connected to carbon atom since it is difficult to break the bond between them. This restrains the formation of aromatic hydrocarbon and black carbon. So ethanol may provide oxygen atom in the fuel rich region and inhibit the formation of smoke [15.] figure 9.

Conclusion

Based on the studies the following conclusions may be made;

- HC decreases with the increase in compression ratio. When the percentage of ethanol increases in the blend the HC increases.
- As the compression ratio increases the NOx increases for neat diesel. The NOx reduces as the ethanol increases in the blend. The draustic NOx reduction of 65% was observed with E20 blend at compression ratio 17, as compared with the neat diesel.
- Carbon dioxide decreases as the compression ratio increases. At higher compression ratio (18) the reduction in CO_2 is less, (2.5%) for all the blends.
- Practically there is no effect of CR on the emission of CO as compared to neat diesel. It is slightly higher for E5 and E15 blends.
- Smoke reduces as compression ratio increase. When compared with neat diesel the smoke increases for all blends at lower CR whereas at higher CR the smoke reduces drastically.
- Brake specific fuel consumption decreases with the increase in compression ratio.
- Brake thermal efficiency increase with the compression ratio, and if compared to the pure diesel it decreases for all blends at compression ration 18. Fuel E20 has nearer value of efficiency of diesel fuel.
- Exhaust gas temperature increases with compression ratio for all blends.

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