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An Experimental Investigation on the Effect and Performance of Ethanol Diesel Blends

V. Bharathkumar[1] and S.Venkatesh[2]
[1]*M.Tech. Scholar, Department of Mechanical Engineering, GMRIT, Rajam, Andhra Pradesh, India*
[2]*Assistatnt Professor, Department of Mechanical Engineering, AITAM, Tekkali, Andhra Pradesh, India*

[1]*Corresponding Author: venketadabharath09@gmail.com*

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ABSTRACT
This experimental study's current goal is to investigate the use of various ethanol and diesel blends in order to analyze their performance parameters and emission characteristics on a high speed, single-cylinder, four-stroke Kirloskar AV1 Diesel engine while comparing them to neat diesel under a range of loads and at a constant speed of 1500 rpm. Three distinct blends—E10 (ethanol 10%, diesel 90%), E20 (ethanol 20%, diesel 80%), and E30 (ethanol 30%, diesel 70%)—were used in the experiment, along with an additive called n-butanol to avoid phase separation with the diesel. For all test samples, the performance parameters, including specific fuel consumption (SFC), brake thermal efficiency (BTE), and emission characteristics, including CO, HC, CO2, and NOX, were identified and compared to diesel. According to this study, while using mixes of ethanol instead of diesel at specific loads, efficiency was somewhat boosted and exhaust emissions were decreased. According to the experiment's findings, diesel and ethanol mixes are adequate and acceptable alternative fuels for diesel engines without requiring any adjustments.

Keywords: *blends, diesel engine, ethanol, emissions*

I. INTRODUCTION

Diesel engines are higher in thermal efficiency, output power, and economy of fuel than petrol engines. The severe pollutants from diesel engines are carbon monoxide (CO), carbon dioxide (CO_2), unburnt hydro carbons (HC) and oxides of nitrogen (NO_X). Now a day the researchers are facing the challenges like scarcity of fuel, demand of energy, hazards of environment and strict norms on emissions. So the interest of researchers is on the above mentioned challenges to overcome it with the help of alternate fuels like ethanol. R. Parthasarathi et al conducted experiment with diesel ethanol emulsions and found that the BTE was improved with decreasing in SFC for 40% ethanol blend when compared with diesel but the emissions like HC, CO_2, NO_X are slightly higher except smoke density. An experiment was conducted by D.C. Rakopoulos et al on a heavy duty diesel engine with 5 and 10% of ethanol by volume with diesel and compared with diesel. They observed that the brake thermal efficiency was improved and the emissions CO and NOX were slightly reduced and HC was increased when compared with diesel. Another researcher Jincheng Huang et al conducted an experiment with diesel ethanol blends of 10, 20 and 30% volume proportions to investigate its performance and emissions on a diesel engine. They observed the phase separation between diesel and ethanol. To avoid this and increase the stability of the samples an additive n-butanol was added. Their results showed that the smoke emissions were decreased with the blends of ethanol than diesel but the SFC was increased due to the lower heating value of diesel.

In recent days the researchers are concentrating on alternative fuels due to the decrease in the reserves of conventional fuels like diesel and petrol vastly day by day. The greenhouse gases like CO_2 cause global warming and hazardous impact on environment. So to decrease the harmful emissions it is necessary to go for an alternative fuel. For this ethanol is one of the best and suitable alternative fuel for diesel engines. Ethanol is a renewable fuel which is available from plants, sugar cane bagassae, rice bran, banana pseudo stem, barley, corn waste etc. Hence the researchers showing the interest to use it in diesel engines. Another advantage with the ethanol is it can be easily blend with the diesel with the help additives like n-butanol and emulsifiers like ethyl acetate and equipment like magnetic and mechanical stirrers. Guven Gonca investigated the performance and NO_X emissions with diesel and ethanol (15% by volume) blends. He found that the performance was increased and the NO_X emissions were reduced considerably. Another researcher Yanuandri Putrasari et al performed an experiment on an diesel engine with the ethanol diesel blends to know the feasibility and suitability to say whether it is an alternative fuel for diesel engine or not. From the experiment he found that the engine power and indicated mean effective pressure were increased with

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increasing the percentage of ethanol in the diesel. The SFC and exhaust gas temperature were also decrease and the emissions CO, HC and smoke were decreased with increase in ethanol quantity. S. Gomasta used an emulsifier ethyl acetate to improve the stability and phase separation between the ethanol and diesel blends and performed the experiment successfully. Similarly at different high altitude regions Jilin Lei et al performed the experiments with the blends of ethanol in a proportion of 10,15, 20 and 30% ethanol on volume basis with diesel and got the results like better equivalent SFC than diesel at different atmospheric pressures with slight increase in CO,HC emissions.

To meet the energy demands of the growing needs and to protect the environment from pollution ethanol is one of the best alternative fuel. Tarkan SandalcJ et al made the blends E10, E15 and E30 with diesel to predict its suitability on a diesel engine and found positive results. With proportions of 5, 15 and 20% by volume basis in diesel the test was made by Santosh Kumar Kurre and found that the BTE was slightly decreased and SFC was increased with increase in concentration of ethanol. Due to complete combustion with ethanol and diesel blends the HC and CO emissions were reduced. Due to higher latent heat of vaporization it absorbs the heat during combustion such that the NO_X emissions were reduced with the blends of ethanol.

II. TEST SAMPLES AND ITS PREPARATION

The fuels used in the present experiment are diesel and ethanol of purity 99%. In this work study pure diesel was taken as a base fuel to make diesel and ethanol blends. The ethanol has been blended with diesel on the basis of volume. Totally three blends were prepared which are E10 (ethanol 10%, diesel 90%), E20 (ethanol 20%, diesel 80%) and E30 (ethanol 30%, diesel 70%). The blends were made with the help of magnetic stirrer. The stirring was done until the mixture was made homogeneous. To avoid the phase separation of mixture n-butanol was chosen as an additive and 6% of n-butanol was added in each blend.

Table I: Properties Of Tested Fuels

S.no	**Property**	**Diesel**	**Ethanol**
1	Density at 20ºc(kg/m^3)	836	787
2	Specific Gravity at 20ºc	0.80	0.795
3	Kinematic viscosity at 40ºc(mm^2/s)	2.7	1.2
4	Calorific value(Kj/Kg)	42,500	26,400
5	Cetane no	50	5-8

III. EXPERIMENTAL SETUP DESCRIPTION

Experiments were conducted out on a 4- stroke, single cylinder, water cooled high speed DI diesel engine as shown in the figure to determine the performance and emission characteristics. The specifications of the test engine setup are presented in Table.2. A rope brake dynamometer was used to load the engine to find out its performance at various loads. The rate of flow of the fuel was measured by observing the time taken for consumption of fuel of a volume of 10cc through a burette with stopwatch. The engine exhaust gas emission characteristics like carbon monoxide(CO), unburned hydro carbons(HC), carbon dioxide(CO_2), and oxides of nitrogen(NO_X) were measured by using a INDUS 5 gas analyzer.

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Figure 1: Experimental set up

Figure 2: INDUS 5 Gas Analyzer

Table II: Technical Specifications Of The Engine

1	Type of engine	4Stroke,single cylinder, high speed engine
2	Type of cooling system	Water cooled
3	Model	Kirloskar AV1
4	Cylinder Bore x Stroke (mm)	80 mm X 110mm
5	Compression ratio	16.5:1
6	Brake power	3.75 Kw
7	Speed	1500 rpm
8	Injection pressure	200 bar
9	Load type	Mechanical

IV. EXPERIMENTAL PROCEDURE

The experiment was carried out on the engine with diesel and blends of ethanol E10, E20 and E30. At first the load test was conducted with all the test samples at the loads of 0kg, 3kg, 6kg, 9kg and 12kg. The time taken for consumption of 10cc of fuel was noted down with the help of stop watch for each load for all the samples and simultaneously corresponding readings of exhaust emissions like CO, HC, CO_2, and NO_X were also noted down and set to zero before each cycle. All the

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readings were tabulated in detail to calculate the brake thermal efficiency, specific fuel consumption. Later the graphs were plotted between loads and emissions and performance parameters for comparative analysis.

V. RESULTS AND DISCUSSION

The results have been discussed according to the experimentation on diesel engine with different blends of ethanol and diesel.

Performance Analysis

The Performance analysis has been put down by experimentation on High speed diesel engine with the blends of ethanol and diesel. The following parameters have been calculated for its performance analysis.

- Specific fuel consumption
- Brake Thermal efficiency

A. Specific Fuel Consumption(SFC)

In the fig 3 it shows the variation of specific fuel consumption with respect to various loads for different blends of ethanol and diesel fuel. From the experiment it has been observed that SFC is decreasing with increasing the load for both diesel and ethanol blends. But with increase in percentage of ethanol in blends SFC is also slightly increasing when compared with diesel and blends at their corresponding loads. The SFC is slightly less for diesel than ethanol blends at maximum load and its values are 0.34, 0.35, 0.37 and 0.37 Kg/Kwhr for diesel E10, E20 and E30 respectively.

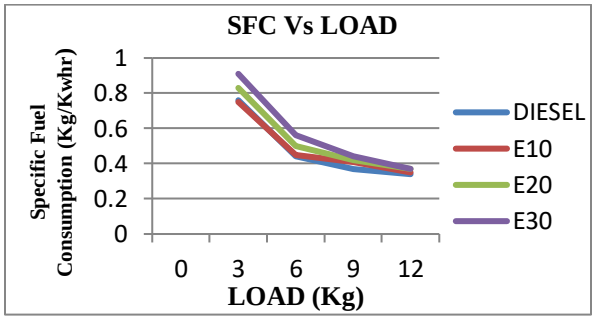

Figure 3: Specific Fuel Consumption Vs Load

B. Brake Thermal Efficiency(BTE)

In the fig 4 it shows the variation between brake thermal efficiency and load of the engine for diesel and ethanol blends. It has been observed that the BTE was increasing with increase in loads for both diesel and ethanol blends. The BTE was slightly increased with all the blends of ethanol than diesel. The BTE for diesel, E10, E20 and E30 are 23.89, 24.90, 24.74 and 24.23% respectively at maximum load. From the experiment it has been found that the maximum BTE is observed for E10 blend than other.

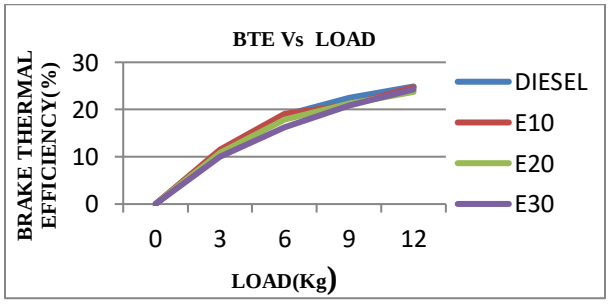

Figure 4: Brake Thermal Efficiency Vs Load

Emission Characteristics

The emission characteristics were found with the help of INDUS-5 gas analyzer. The finding emission characteristics were discussed below.

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C. Carbon Monoxide (CO)

In the fig 5 it shows the comparison of carbon monoxide with respect to loads for diesel and different blends of ethanol. From the experiment it has been found that the CO was increasing with increasing the load for diesel. But with the blends of ethanol the CO was decreased along with rise in the load. The CO emissions for diesel, E10, E20 and E30 at maximum load are 0.046, 0.038, 0.032 and 0.028% respectively. Lesser CO was occurred with E30 at full load when compared with diesel and other blends.

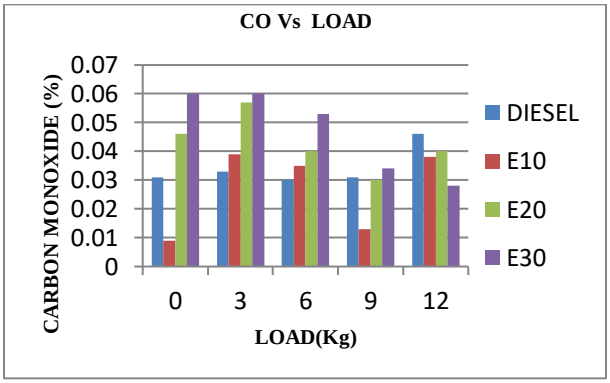

Figure 5: Carbon Monoxide Vs Load

D. Hydro Carbon (HC)

In the fig 6 it shows the variation of HC along with different loads for diesel and various blends of ethanol. From the experiment results it has been found that the HC was decreased first and then increased for diesel and blends of ethanol. The minimum HC was obtained at half load condition with all the test fuel samples. At half load condition the HC was maximum with E30 when compared with diesel and other blends the respected readings are 4, 6, 8 and 10 ppm for diesel, E10, E20 and E30. From the reading it was observed that the HC emission is higher with the blends of ethanol than diesel.

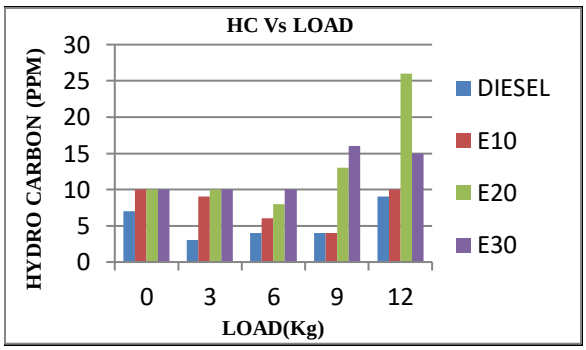

Figure 6: Hydro carbon Vs Load

E. Carbon Dioxide (CO_2)

In the fig 7 it shows the variation of Carbon dioxide emissions along with different loads for diesel and blends of ethanol. From the experimental results it has been found that the CO_2 was increasing with load for all the test samples. But up to half load condition there is a slight variation in CO_2 but after that there is a sudden increase was observed for both diesel and ethanol blends. The CO_2 emission was maximum for E30 by 3.06% at maximum load due to the availability of large quantity of oxygen in the sample.

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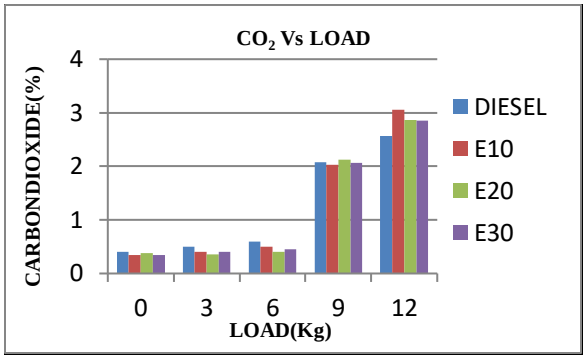

Figure 7: Carbon dioxide Vs Load

F. Oxides of Nitrogen (NO_X)

In the fig 8 it shows the comparison of oxides of nitrogen with respect to various loads for diesel and ethanol blends. From the results obtained by the experiment it indicates that the NO_X is zero at no load and then it was increased with increase in load for both diesel and blends of ethanol. When compared with blends of ethanol, for diesel the NO_X emissions are less. But among the blends for E30 the emissions of NO_X is less at a load of 6kg. At peak load condition the diesel has 119 ppm of NO_X where as for E10, E20 and E30 has 190,186 and 179 ppm respectively.

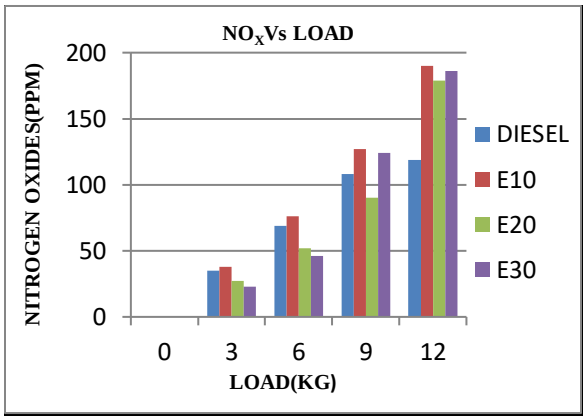

Figure 8: Oxides of Nitrogen Vs Load

VI. CONCLUSION

An experiment was conducted on a four stroke single cylinder high speed diesel engine with diesel and blends of ethanol to study its performance parameters and emission characteristics and to compare the results with diesel and ethanol blends. When compared with other alternative fuels like LPG and CNG the ethanol diesel blends were present in the initial step for development. Since the ethanol has less calorific value than diesel it consumes large quantity of fuel when compared with diesel. An additive n-butanol was chosen to avoid the phase separation in diesel ethanol blends. From the experiment the following results were obtained.

- With increasing the load on the engine the specific fuel consumption is decreasing for both diesel and ethanol blends. And it is also noticed that the fuel consumption was slightly increased with blends of ethanol than diesel and it also increasing with increase in percentage of ethanol with diesel among its blends due to its lower calorific value.
- The brake thermal efficiency was improved with increase in load for both blends of ethanol and diesel. The BTE was slightly increased and decreased up to some extent with respect to loads for the blends of ethanol. Among the blends with E10 the maximum BTE was obtained.
- The carbon monoxide was significantly decreased with blends of ethanol when compared with diesel. It is observed that with increase in blends ratio of ethanol CO is decreasing.
- The unburnt hydro carbons were decreased and increased with respect to load for both diesel and ethanol. At half load condition with diesel the HC emissions are less.

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- The carbon dioxide emissions are quite similar for diesel and blends of ethanol up to half load conditions but which is suddenly increased with higher loads.
- The oxide of nitrogen was less with ethanol blends than diesel at lesser loads but later it was increase slightly than diesel. Minimum NO_X emissions were obtained with E30 among the blends at particular loads.

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