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Advances in Applied Science Research, 2013, 4(1):319-329

ISSN: 0976-8610
CODEN (USA): AASRFC

Experimental investigation on D. I. diesel engine fuelled by ethanol diesel blend with varying inlet air temperature

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ABSTRACT

Ethanol is a bio-based renewable and oxygenated fuel, thereby providing potential to reduce the PM emission in diesel engine and to provide reduction in life cycle of carbon di-oxide. So that reduces ozone layer depletion. There are several studies which reports improvement in the engine performance and emission by using ethanol blend fuels. Many researches going on in the area of ethanol as alternate fuel, the commercialization of this fuel is not achieved in the Indian automobile scenario. It is mainly because of installation of refilling stations and the problems encountered in the engine while ethanol is used as a fuel. The problem such as starting trouble, cold starting problem, Aldehyde emission coming out from the engine and the stringent norms followed by the government for the use of ethanol. The main objective of this project is to study the performance, and to control the emissions of the diesel engine using blended fuel by preheating the inlet air. The present work has been carried out using single cylinder, four stroke, water cooled diesel engine. In this phase, experiment investigations are conducted using five sets of blended fuels i.e 10%, 15%, 20%, 25%, 30% Ethanol – Diesel blend have been prepared and preheating the inlet air to 40ºC, 50ºC and 60ºC. The performance and emission characteristics are studied and compared with the base fuel.

Keywords: Ethanol blend, Diesel engine, Performance.

INTRODUCTION

Over the past decade, researchers have sought ways to oxygenate diesel. However, it has been found that most conventional fuel oxygenates, such as MTBE, TAME, MEK, etc., were not suitable for diesel fuel use. Ethanol as a diesel oxygenate, while compatible, does not blend effectively with diesel. Ethanol-diesel blends phase separate when exposed to small amounts of water and/or low temperatures [4, 7, 9,]. However, it has been proven that ethanol in diesel reduces tailpipe emissions of PM, CO, and NOx. Ethanol is an alternative renewable fuel produced from different agricultural products [6,13]. The ethanol-Diesel emulsion technique is one of the techniques to be able to use ethanol without any modification in Diesel engines. Studies on the use of ethanol in diesel engines have been continuing since the 1970s.The initial investigation were focused on reduction of the smoke and particulate levels in the exhaust[2,9,18]. Ethanol addition to diesel fuel results in different physical-chemical changes in diesel fuel properties, particularly reductions in cetane number, viscosity and heating value. Therefore, different techniques involving alcohol-diesel dual fuel operation have been developed to make diesel engine technology compatible with the properties of ethanol based fuels [1, 8, 14,]. Ethanol is a promising oxygenated fuel. Pure ethanol with additives such as cetane improver can sharply reduce particulates [3,5]. At the early stages, poor fuel economy and low ignitability were the main barriers to apply ethanol fuel on diesel engines. Since late 1990s, ethanol blended diesel fuel has been used on heavy-duty and light-duty diesel engine in order to modify their emission characteristics [10, 16]. There are several techniques involving alcohol-diesel dual fuel operation. The high self ignition diesel fuel ensures the ignition of alcohol in dual fuel operation [12, 15]. The most common methods for achieving dual fuel operation are:

Alcohol fumigation the addition of alcohols to the intake air charge displacing up to 50% of diesel fuel demand [11]. Dual injection separate injection systems for each fuel, displacing up to 90% of diesel fuel demand. Alcohol-diesel fuel blend mixture of the fuels just prior to injection, displacing up to 75% of diesel fuel demand [11, 18]. Alcohol - diesel fuel emulsion using an emulsifier to mix the fuels to prevent separation, displacing up to 25% diesel fuel demands. The easiest method by which alcohols can be used in diesel engines is in the form of blends. For lower alcohols, this approach is limited to ethanol because methanol is not soluble or has very limited solubility in the diesel fuel [9]. Since low hp stationary diesel engines are commonly used in the agricultural and performances using ethanol-diesel blends. A study was, therefore undertaken with the objective of finding out the maximum possible replacement of diesel by ethanol as a sole fuel and to compare the performance of a variable speed C.I engine using diesel [7, 8]. The engine was tested for performance and emission for the above three methods of 100% ethanol operation in both the standard and LHR diesel engine and the results are compared [14]. The spark assisted ethanol operation in the LHR engine gave the highest brake thermal efficiency and the lowest emission.

1.1. Ethanol - diesel blend

The easiest method by which alcohols can be used in diesel engines is in the form of blends. Pure ethanol is completely miscible with diesel fuel at temperature in excess of about 30◦C. At lower temperatures, or when the ethanol contains water, miscibility is limited Co. Solvents, such as ethyl acetate, may be added to increase the range of miscibility [18]. The ignition properties of fuel mixtures containing more than about 25% of light alcohol are not generally found to be adequate.

For lower alcohols, this approach is limited to ethanol because methanol is not soluble or has very limited solubility in the diesel fuel. Since low hp stationary diesel engines are commonly used in the agricultural and performances using ethanol-diesel blends. A study was, therefore undertaken with the objective of finding out the maximum possible replacement of diesel by ethanol as a sole fuel and to compare the performance of a variable speed C.I engine using diesel.

1.2. Effect of additives with blend

Additives can be added with the diesel ethanol blend to, make up the cetane number which was reduced by the addition if ethanol, to ensure that the ignition properties are satisfactory. Additives can intensify the viscosity to ensure adequate lubrication of the injection pump, also it stabilize the mixture in the presence of a high water content, to ensure fuel homogeneity under all conditions[17]. Absolute ethanol is highly soluble in diesel fuel at contents of approximately 0-30% and 70-100%. But when the water content in the ethanol is increased by 1% there will be cloudiness in the mixture followed by separation, this occurrence can be prevented by additives like 1-octylamino-3-octyloxy-2-propanol, N-(2-nitrato-3-octyxpropyl) or N-octyl nitramine. All the experiments were performed without any modification on the engine. 1% isopropanol (on volume basis) was used an additive in the mixture to satisfy homogeneity and prevent phase separation.

1.3. Properties of iso ropanol

Chemical formula - C_3H_8O
Molecular weight - 60.1
Density at 15.5◦c - 786 g/m3
Boiling point - 82.5◦c
Heating value - $30.7*10^3$kJ/kg
Self – ignition temperature - 409◦c
Flash point - 11˚C

1.4. Air pre heater

In this project to preheat the inlet air, hot exhaust gas is used. For that an air pre heater is designed and fabricated.

1.5. Design calculation

The volume of pre heater is 50 times greater than the engine cc,
Volume of pre heater = 50 times of volume of engine cc
Volume of pre heater = 50 * 669cm^3
Volume of pre heater = 33459cm^3
Assume that the length of pre heater = 60cm

Volume of pre heater = $(\pi d^2/4)$ * length of pre heater
33450 = $(\pi d^2/4)$ * 60 d = 26.64cm

In air pre heater the size of the exhaust pipe is $1^{1/2}$ inch i.e., approximately 3.5cm, so the overall diameter in increased to d = 30cm

To increase the heat transfer rate, the fins to be introduced for good heat transfer properties, here cylindrical fins with rectangular cross section can be used, for the length of 600mm using 40mm is the pitch then 15 fins is used in the overall length.

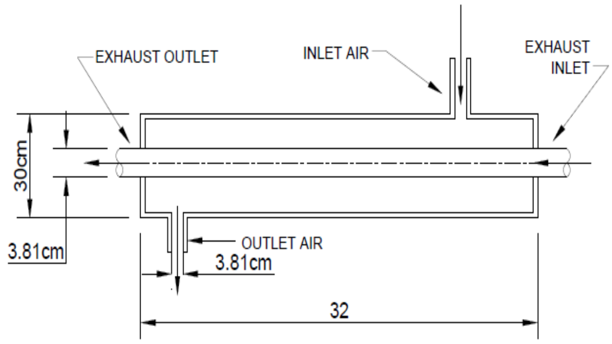

Figure1. Air pre heater set up

1.6. Air pre heating chamber

Air pre heater has an air inlet, and outlet, inlet is opened to atmosphere, or connected to manometer to calculate volumetric efficiency. A temperature sensor is connected to the air outlet to measure the air temperature which enters the combustion chamber. Temperature of air is controlled by closing and opening of the control valve in the exhaust line. The air pre heater is designed with respect to that of simple air box as a reference and the size is to bulkier so fins are incorporated to increase the heat transfer rate.

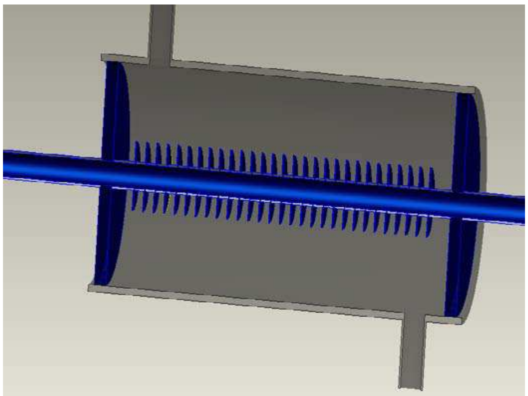

Figure 2.air pre heater model (sectional view)

Figure3. Fabricated air pre heater

MATERIALS AND METHODS

The engine used in this experiment was a single cylinder DI diesel engine with a bore 88mm, a stroke of 110mm and compression ratio of 18:1. The rated power was 5.9 kW. Tests were carried out at 1800 rpm. The rope brake dynamometer used to load the engine. Pre heater is fixed in the inlet manifold. Engine has been tested for five different loads for each blended fuel and the inlet air temperature 40ºC, 50ºC and 60ºC respectively. The performance and emission readings were tabulated and Calculation, graph to be plotted and it is compared with base fuel. The Crypton exhaust analyzer and AVL smoke meter were used to measure the CO, HC, Nox, CO2 and Smoke opacity in exhaust emissions and emission characteristics graphs to be drawn and it is compared with the neat diesel. The testing procedure is as follows. After completion of standard warm up procedure, to pre heat the inlet air, Air pre heater is warm up to the temperature required after it reaches required temperature. The general experimental procedure for the various ethanol diesel blends have been tested at different load conditions. The observation made during the test for determination of various engine parameters, as brake load, engine speed, time for diesel and ethanol diesel blends consumption. The Crypton exhaust analyzer and AVL smoke meter were used to measure the CO, HC, No_x, CO_2 and Smoke opacity in exhaust emissions.

Figure 4. Engine setup

RESULTS AND DISCUSSION

3.1 characteristics of diesel and ethanol diesel blend without pre heating

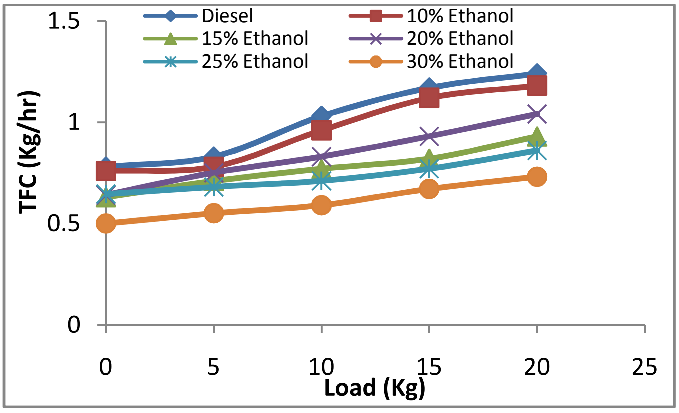

Figure5. Comparision of TFC with load for base and various ethanol blend

The TFC increases with increase in load, TFC for diesel lower than that of ethanol diesel blends as shown in graph. Because ethanol has lower calorific value than that of diesel . As the calorific value of diesel decreases with increase in the proportion of ethanol, total fuel consumed by the engine rises it is found that TFC is more for ethanol diesel blends as a matter of energy content. Brake specific fuel consumption is decreases with the increasing of loads. SFC for ethanol diesel blends lower than that of diesel.

Fuel consumption is an important criteria, it is obvious that the SFC decrease with the increasing of load. Here total fuel consumption and specific fuel consumption is increased with increasing ethanol content in blend fuel. This is due to the fact that the low heat value of ethanol is about 2/3 of that of diesel. When engine running with 30% ethanol SFC get increased to 0.7313 kg/kw-hr than the diesel 0.491 kg /kw-hr.

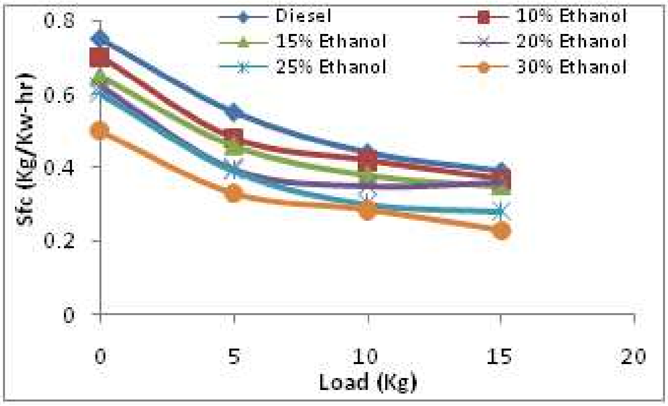

Figure 6. Comparision of SFC with load for base and various ethanol blend

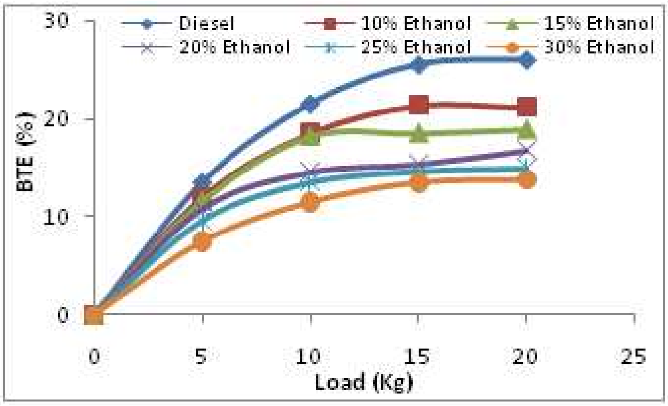

Figure7. Comparision of BTE with load for base and various ethanol blend

Brake thermal efficiency shows the performance of the engine for the particular fuel. From the experimental results, the engine brake thermal efficiency can be calculated from the BSFC and low heat value of the blend fuel. The calculated results are plotted in the graph from that the BTE of 30% ethanol-diesel blended fuel is lower at higher loads compared to diesel fuel due to the lower heating value of fuel.

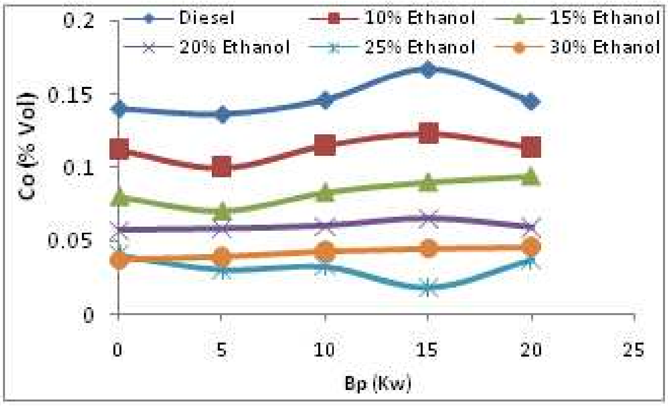

Figure8.Comparision of CO emission with load for base and various ethanol blend

CO emission is potentially dangerous, it should be reduced for the fuels having oxygen content in it but here CO emission increased at low and medium loads for blends, at higher loads emissions decreased with the increase of load for the ethanol diesel blended fuels.

HC emission increased with load increase. Addition of ethanol will lead to complete combustion so that HC emission should reduce, but here the introduction of ethanol in diesel fuel, HC emission increased at various load condition for 10% ethanol diesel blend HC emission is lower compare to the diesel fuel. HC emission for other blends i.e 20%, 25%, 30% is getting increased.

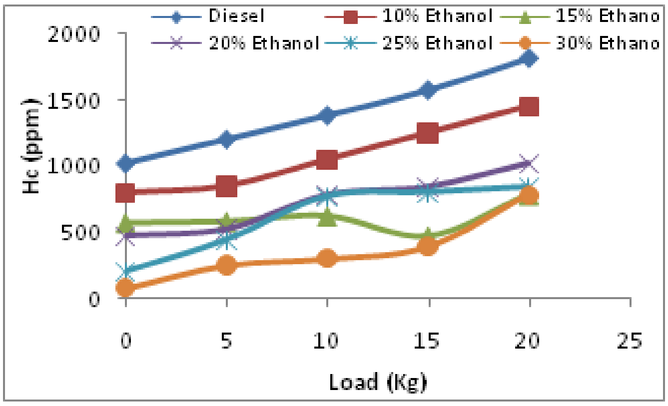

Figure9.comparision of HC emission with load for base and various ethanol blend

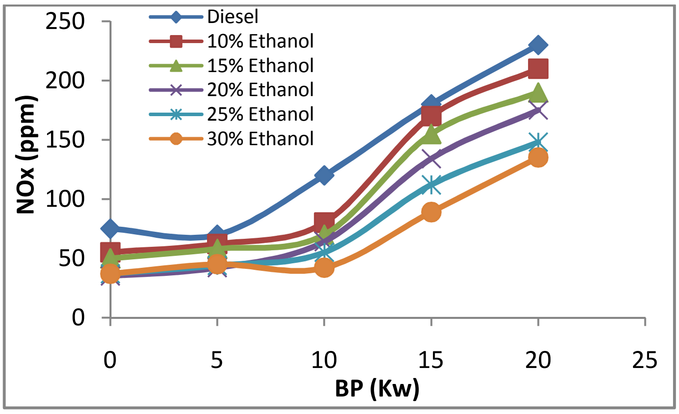

Figure10.Comparision of NO_x emission with load for base and various ethanol blend

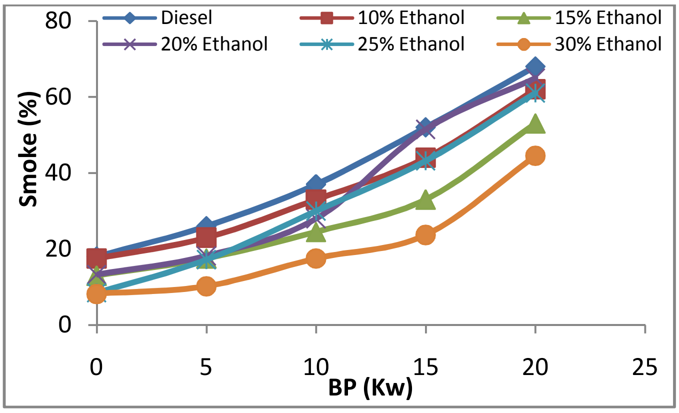

Figure11. Comparison of smoke opacity with load for base and various ethanol blend

From the above graph, generally for diesel fuel NOX emission is increased as the raise in the load. When percentage of ethanol in blend is increased the NOX emission is getting reduced, at higher load 30% ethanol blend produces 130PPM compare to the diesel fuel 209PPM. The smoke emission decreased as load increases as shown in graph. It is because of ethanol is an oxygenated fuel. Here 20% ethanol blend produces less smoke compare to the diesel fuel.

3.2. Characteristics of diesel and ethanol diesel blend at inlet air 40^{0}c

The TFC increases with increase in load, TFC for diesel lower than that of ethanol diesel blends as shown in graph. Because ethanol has lower calorific value than that of diesel . As the calorific value of diesel decreases with increase in the proportion of ethanol, total fuel consumed by the engine rises it is found that TFC is more for ethanol diesel blends as a matter of energy content. It shows that SFC is decreases with the increasing loads. SFC for ethanol diesel blend lower than that of diesel . But here due to pre heating air SFC of 10% ethanol diesel blend merely same as diesel fuel and the BTE of ethanol diesel blend is lower than the diesel fuel at 10% ethanol diesel blend produces higher BTE compare to diesel fuel i.e 4% is getting increased due to preheating of inlet air.

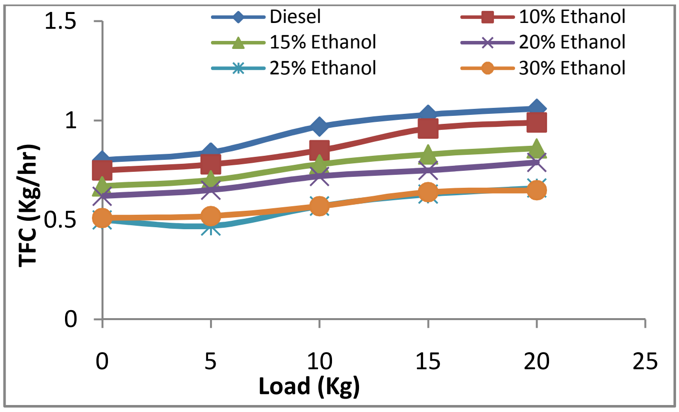

Figure11.Comparision of TFC with load for base and various ethanol blend

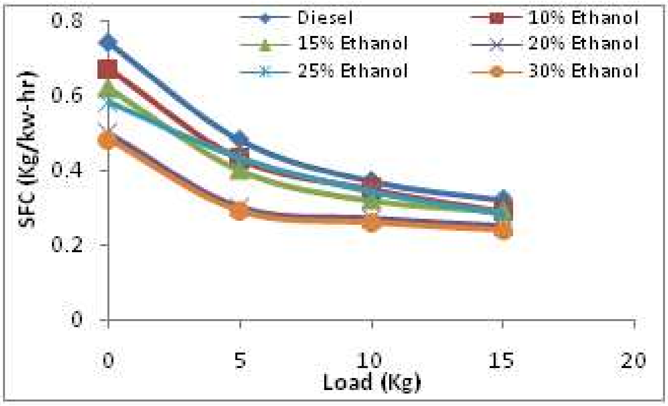

Figure12. Comparison of SFC with load for base and various ethanol blend

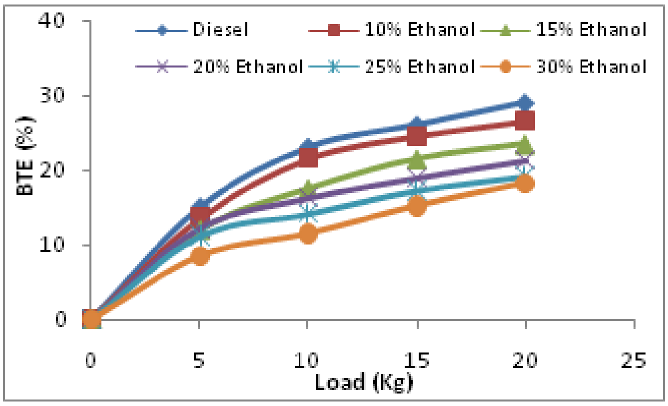

Figure13.Comparision of BTE with load for base and various ethanol blend

It shows that CO increased with load increases. CO of 30% ethanol diesel blend is higher compare to the diesel at higher load ethanol diesel blend produces 0.16%vol compare to diesel fuel 0.03 %vol. It shows that HC emission increased with load increases. HC of ethanol diesel blends higher than of diesel at all loads.

From the above graphs, generally for diesel fuel NO $_X$ emission is increasing as the raise in the load. When the percentage of ethanol in diesel blend is increased the NO_X emission is getting reduced, at higher loads 30% ethanol blend produces lower emission at higher load compare to the base fuel. the smoke emission decreased as load increases for without pre heating but here smoke emission is getting increased for various blends at different load condition.

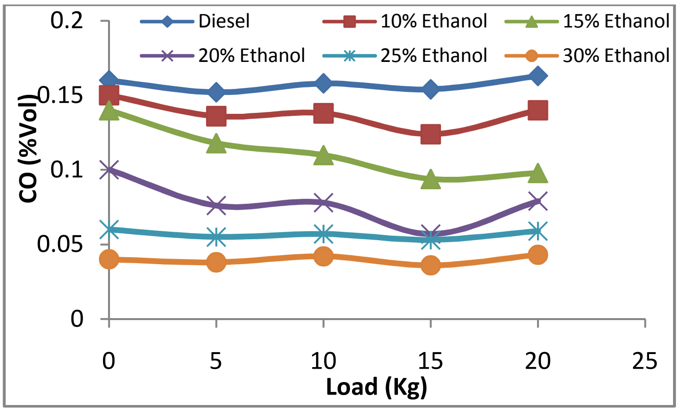

Figure14. Comparison of CO emission with load for base and various ethanol blend

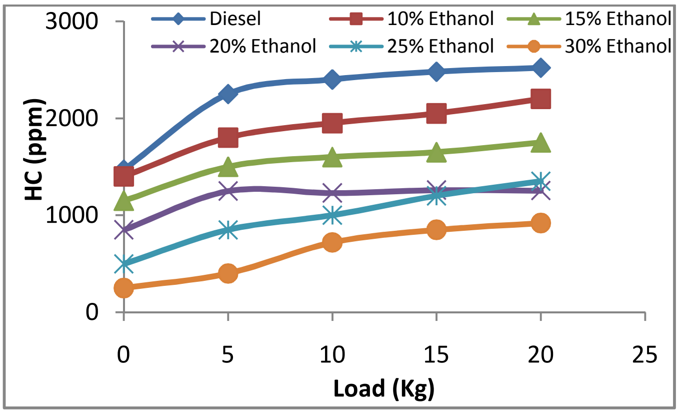

Figure15.Comparision of HC emission with load for base and various ethanol blend

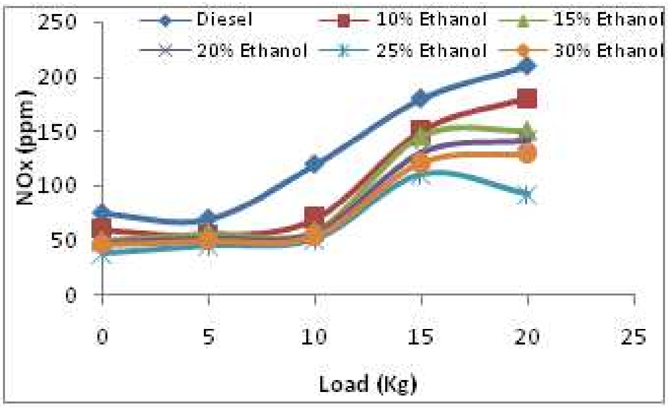

Figure16. Comparison of NO_x emission with load for base and various ethanol blend

3.3. Characteristics of diesel and ethanol diesel blend at inlet air 50°c

The total fuel consumption increases with load increases for diesel and ethanol diesel blend. TFC for diesel lower than that of ethanol and its blends, due to preheating 10% ethanol shows the measure value to of base fuel. For other blends TFC is higher compared to the diesel fuel.

Above graph shows that SFC decreases as load increases, SFC for ethanol blends is higher than the diesel fuel. This is due to ethanol has the lower calorific value compare to the diesel fuel. The BTE of ethanol diesel blend is lower than the diesel fuel but at 10% ethanol diesel blend produces higher BTE compare to diesel fuel, this is due to the pre heating of the inlet air.

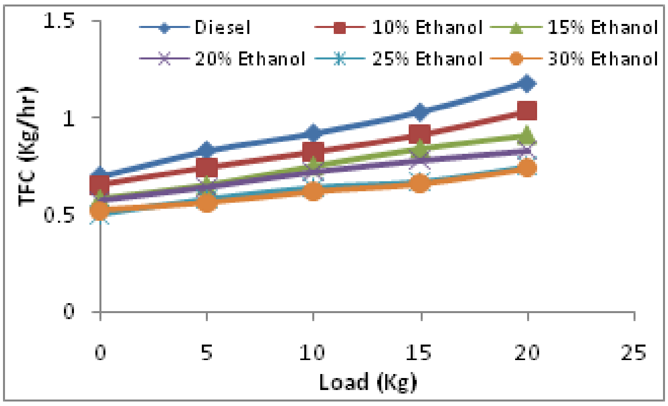

Figure17. Comparison of TFC with load for base and various ethanol blend

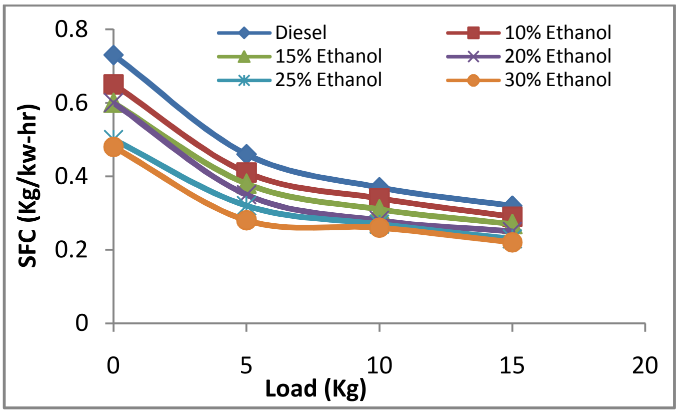

Figure18. Comparison of SFC with load for base and various ethanol blend

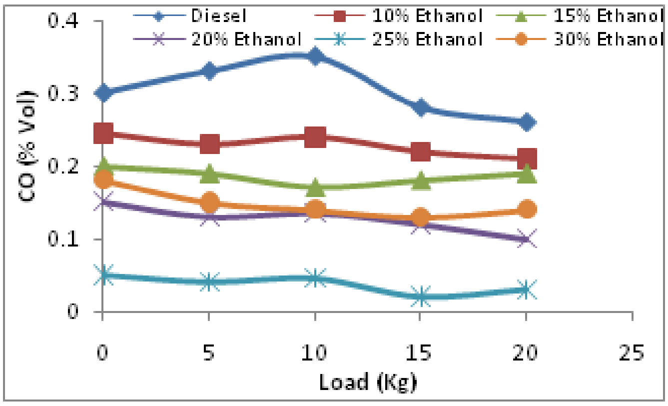

Figure19. Comparison of CO emission with load for base and various ethanol blend

It shows that CO increased with load increases. CO of 30% ethanol diesel blend is higher compare to the diesel at higher load ethanol diesel blend produces 0.29%vol compare to diesel fuel 0.03 % vol .It shows that HC emission increased with load increases . HC of ethanol diesel blends higher than that of diesel at all loads.

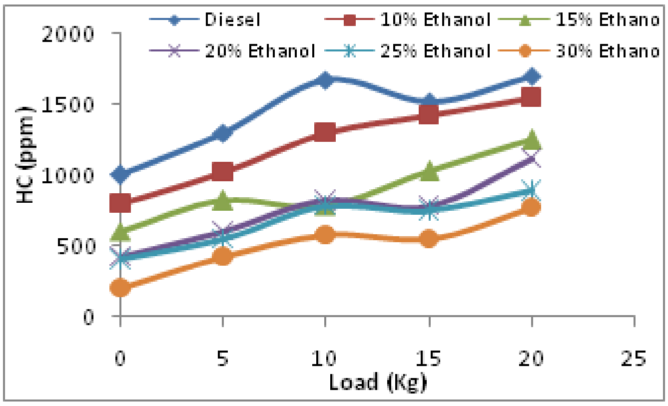

Figure20. Comparison of HC emission with load for base and various ethanol blend

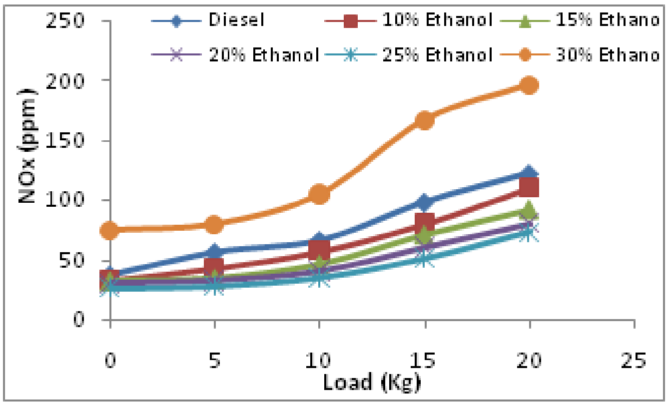

Figure 21. Comparison of NO_x emission with load for base and various ethanol blend

From the above graphs, generally for diesel fuel NO_X emission is increasing as the raise in the load. When the percentage of ethanol in diesel blend is increased the NO_X emission is getting reduced, at higher loads 30% ethanol blend produces lower emission compared to the base fuel. This is due to ethanol has the higher latent heat of vaporizations compare to the diesel fuel. The smoke emission decreased as load increases for without pre heating but here smoke emission is getting increased for various blends at different load condition. Performance and emission characteristics of diesel and ethanol diesel blend for 60ºC where also taken under consideration.

CONCLUSION

Performance and emission characteristics of various concentration of ethanol diesel blended fuel at different inlet air temperature is tested and compared with neat diesel fuel and following results were obtained. 1% of iso propanol addition to the ethanol diesel mixture satisfies homogeneity and prevents phase separation. The Total fuel consumption and SFC of ethanol diesel blended fuels increased for the reason that the low heating value of ethanol is about 2/3 of that of diesel, and it is increasing with increasing concentration of ethanol in blend. The Brake thermal efficiency of ethanol diesel blend is lower without pre heating condition, but at 40°Cand 50°C inlet air condition, for 10% ethanol diesel blends gives the much better BTE compare to the neat diesel fuel On emission characteristics CO and HC emission is increasing. Addition of ethanol will lead to complete combustion so that HC and CO emission should reduce, but here the introduction of ethanol in diesel fuel, HC emission increased at various load condition. CO and HC emission is higher for the pre heated condition compare to without pre heating condition. The NO_X emissions were reduces because it absorbs heat during combustion due to its higher latent heat of vaporizations. So it reduces the peak combustion temperature. When using ethanol diesel blends. Generally, smoke opacity is increased as load increases. Without pre heating condition produces less smoke compare with the preheating conditions for ethanol diesel blends.

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