An Experimental Investigation to Evaluate the Effect of Ethanol Blended Diesel Fuels on Performance and Emission of a C.I Engine

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Abstract

In order to investigate the effects ethanol-diesel blends on the performance and emissions of diesel engine, the comparative experiments were carried out on the single cylinder 4-stroke diesel engine having a capacity of 624 cc fueled with pure diesel and ethanol-diesel blends (E5, E10, E15 and E20) under different loads. Ethanol was added in proportion of 5, 10, 15, and 20% (by volume) with diesel for preparation of blends. The present work has resulted in giving a good insight into the performance & emission characteristics of the C.I. Engine using ethanol blends. Heat of combustion of all the blends is found to be lower than that of diesel fuel alone. However, the heating values of the blends containing ethanol lower than 10% are not much different from that of conventional diesel. Performance parameters like brake power, brake thermal efficiency, brake specific fuel consumption was measured at different loads. Emission parameters CO, CO_2, unburned hydrocarbon and nitrogen oxide was measured by exhaust gas analyzer. The performance parameters were marginally inferior but the emission is significantly reduced as the blend ratio is increased.

Index Terms **— Ethanol, Blending, Engine Performance, Emission Parameters, Brake Thermal Efficiency.**

1. Introduction

A diesel engine has received considerable attention because of its high thermal efficiency however; the diesel engine is the most significant contributor of pollutant which contributes to serious health problem Particulate matter emission from diesel contributes to urban and regional haze. HC and NOx emission leads to Ozone formation at ground level. With the stringent emission standard and limited petroleum reserve, alternative fuels for diesel engine have been used. Studies on the use of ethanol in diesel engines have been continuing since 1970s. Ethanol addition to diesel fuel results in different physical-chemical changes in diesel fuel properties, particularly reductions in cetane number, viscosity and heating value. Ethanol is a promising oxygenated fuel. Pure ethanol with additives such as cetane improver can sharply reduce particulates. 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.

1.1 Ethanol as Blending Component for Diesel

The use of alcohols in mixtures with diesel is limited to anhydrous ethanol, since methanol is practically insoluble in diesel [5]. The use of ethanol/diesel mixtures increases the ignition's lag time due to the low cetane number of ethanol. There are a number of fuel properties that are essential to the proper operation of diesel engine. The blended fuel is expected to comply with such properties as per standards of diesel. The addition of ethanol to diesel fuel affects certain important properties like blend stability, viscosity, viscosity, flash point, lubricity energy content and cetane number. The blended fuel therefore requires cetane improvers to be added. In fuel injection pump system the fuel has an important role for lubrication. In the present investigation performance and emission characteristics of engine were evaluated for diesel and its blend with ethanol varied from 5% to 20% is studied for at various loads.

2. Selection of Engine and Blends

A single cylinder, vertical, 4-stroke engine with bore of 85 mm and stroke of 110 mm manufactured by Topland was used in the experimental investigation. It has a provision of rope brake dynamometer to vary the load.

Table- 1 Specification of engine

No. of cylinders	1
R.P.M.	1500
Bore	85 mm
Stroke	110 mm
Capacity	624 cc
Output	3.5 H.P.
Dynamometer	Rope brake type
Fuel	Diesel and Blends of Ethanol
Sp.Gr of Diesel	0.82
Sp.Gr of Ethanol	0.78
CV of Diesel	42,188 kJ/kg
CV of Ethanol	29,700 kJ/kg
Fuel tank capacity	7.5 liters

The properties of various blends of ethanol with diesel were tested on engine described above are as follows:

Table- 2 Properties of Test Fuels [9]

Sr. No	Fuel	Density (kg/m^3)	CV kJ/kg	% Change in CV
1	Diesel	822	42188	-
2	5% Ethanol Blends	822	41398.6	-1.87
3	10% Ethanol Blends	821	40609.2	-3.74
4	15% Ethanol Blends	820	39819.8	-5.61
5	20% Ethanol Blends	819	39030.4	-7.49

Blends are prepared by adding appropriate amount of ethanol in pure diesel. Ex. Preparation of (5% E + Diesel) blends requires 5 ml of ethanol and 995 ml of diesel were mixed in flask on volume basis to prepare 1 liter of blend.

3. Experimental Setup

A single cylinder, vertical, 4-stroke engine with bore of 85 mm and stroke of 110 mm is considered in this study. The diesel engine is an air-cooled developing about 3.5 HP at 3000 rpm. The engine is rope started. The engine is couple to a rope brake dynamometer to absorb the power produced. The consumption of fuel is measured by means of burette and a stopwatch. A three-way cock regulates the flow of diesel from the tank of the engine.

Fig.1: Single cylinder 4-stroke diesel engine setup

3.1. Fuel Flow and Speed Measurement

A fuel tank with a burette of a capacity of 624 cc is mounted on a stand at an approachable height with required piping joints. Fuel is fed to the injector pump under gravity and the volumetric flow rate is measured by burette. A digital tachometer as shown in Fig.2 is used to measure the speed of an engine.

Fig.2 : Tachometer

3.2. Dynamometer

Dynamometer having rope which is wrapped over the rim of a pulley keyed to the shaft of the engine. A rope is wound around the circumference of the brake drum. The one end of the rope is attached to a spring balance, whereas other end carries the dead weights. The engine is thus run at a ‘constant speed’ which is measured with the help of a tachometer. If the power produce is high, so will be the heat produced due to friction between the rope and wheel, and a cooling arrangement is necessary. For this, the channel of the flywheel usually has flanges turned inside in which water from a ripe is supplied. An outlet pipe with a flattened end takes the water out.

3.3. Experimental Procedure

The engine was started with neat diesel as fuel at no load by pressing the inlet with decompression lever and it was released suddenly when the engine was hand cranked at sufficient speed and it was allowed to run at no load conditions. The engine was then loaded gradually from no load to full load keeping the speed within the permissible range and the observations of different parameters were recorded. With the fuel measuring apparatus and stop watch the time elapsed for the fuel consumption for 10 cc of fuel was measured. The other observations recorded were brake load reading, engine speed and emissions were also measured. The various blends of ethanol with diesel were tested on same engine in the same manner as described above are as follows:

1) 95% diesel + 5% ethanol
2) 90% diesel + 10% ethanol
3) 85% diesel + 15% ethanol
4) 80% diesel + 20% ethanol

Performance tests were carried out on the diesel engine with different fuels i.e. with neat diesel and with various blends of ethanol with diesel respectively. The parameters to be recorded for all the fuels tested were fuel flow rate, engine speed, brake load, and the performance parameters were calculated from their fundamental relations.

4. Computations

4.1 Brake Power: Brake power is defined the power developed by the engine at the shaft .and here generator is attached with the engine so, it can be calculated by the following equation**:**

Engine output = 3.14×D×9.81×N×T / (60×1000) kW
Where D = Overall diameter = 0.261m
W_1 = Dead Weight kg-f
W_2 = spring balance reading kg-f
T = Net load (W_1 - W_2) kg-f
N = Engine speed rpm

4.2 Engine Input: Power input to the engine calculated as follows,
Time for 10cc of fuel consumption, t sec
Fuel consumption per minute, Q= (10/t) × 60 cc/minute
TFC = (Q × Sp.Gr. of diesel/ 1000) kg/min
Heat input = TFC × calorific value of diesel
Input power = Heat input / 14.34 kW

4.3 Brake Thermal efficiency: The Brake thermal efficiency of an engine is calculated by,
Engine efficiency = Engine output /Input power×$100^0/_0$

5. Result and Discussion

Experiment was conducted to find the effect of ethanol blended diesel fuel on the engine performance parameters such as brake thermal efficiency, brake specific fuel consumption, brake specific energy consumption and exhaust emission parameters such as unburned hydrocarbons, carbon mono-oxides, carbon dioxide nitrogen oxides and oxygen were recorded. The brake thermal efficiency with different load at 5, 8, and 10 kg-f is shown in Fig. (3), (4) and (5) respectively.

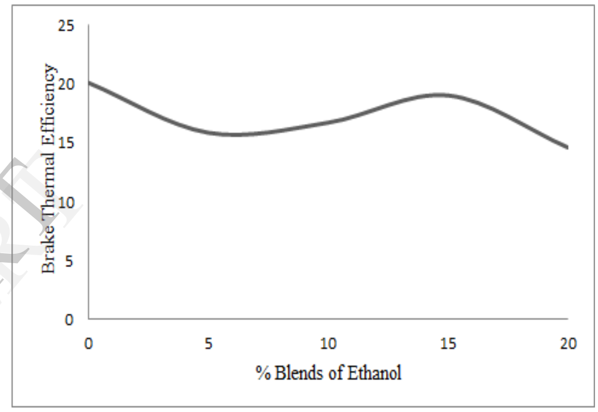

Fig. 3: Brake Thermal Efficiencies (%) Vs. Blends of Ethanol (%) at 5 kg-f load

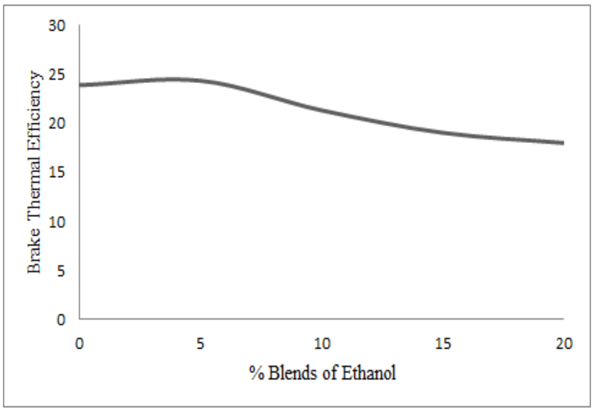

Fig. 4: Brake Thermal Efficiencies (%) Vs. Blends of Ethanol (%) at 8 kg-f load

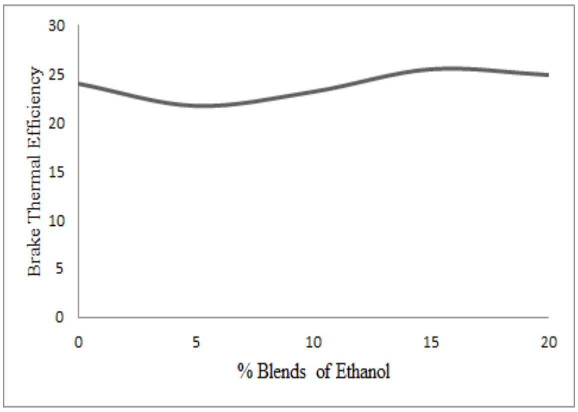

Fig.5: Brake Thermal Efficiencies (%) Vs. Blends of Ethanol (%) at 10 kg-f load

The efficiency of all four proportions of blends was found to be less than pure diesel. The reason being the calorific value and specific gravity of the ethanol blended diesel fuel is less than the pure diesel. As the blend percentage increases the specific gravity and the Lower Heating Value keeps on reducing. Hence it is concluded that as ethanol blend percentage increases the brake thermal efficiency is decreased.

Emission characteristics of the ethanol blended fuel also evaluated to findout amount of carbon-monoxide, unburned hydrocarbon, carbon-dieoxide, nitrogen oxides and oxygen in the flue gas by using the exhaust gas analyzer at no load condition. Fig. 6 represents the variation of CO emission with increasing ethanol in diesel.

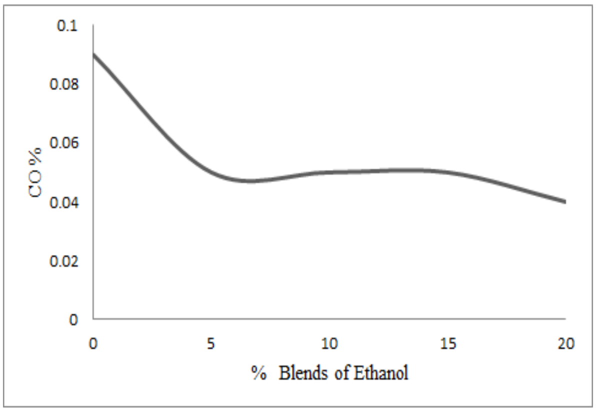

Fig.6: CO % Vs Blends of Ethanol (%)

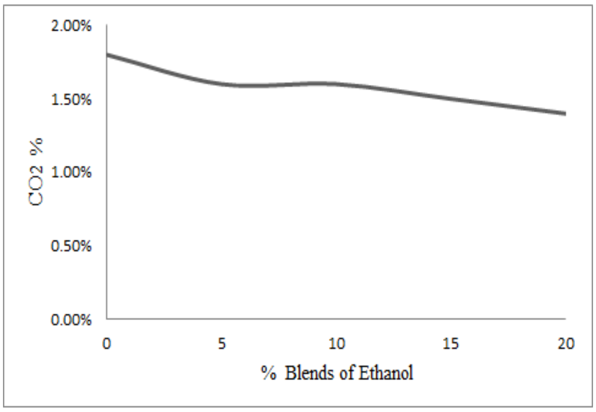

Fig.7: CO_2 % vs. Blends of Ethanol (%)

Since ethanol has lower carbon and higher oxygen content more ethanol in the blend results in less CO in exhaust emission. Fig. 6 shows that falling the trend of CO as the ethanol ratio in the blends increase, the CO concentration in the exhaust were decreased from 0.09% to 0.04%, hence in turns CO_2 concentration also decreased from 1.80% to 1.40%.

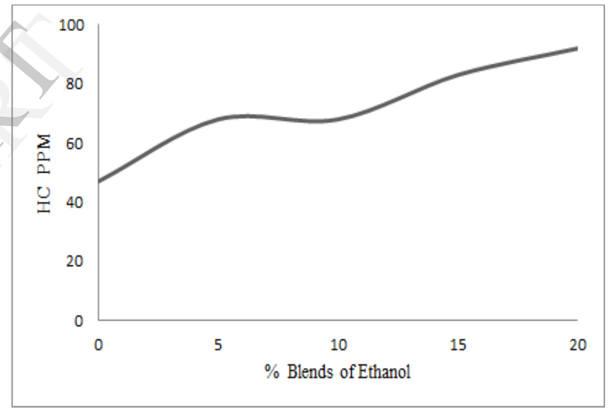

Fig.8: HC (PPM) vs. Blends of Ethanol (%)

Fig.8 represents the variation of HC emission with increasing ethanol percentage in the blends of diesel. Unburdened hydrocarbons are increase with increase in the percentage of ethanol in the blends from 47 PPM to 92 PPM due to atoms of diesel and ethanol in the blends is not mixed at molecular level during combustion.

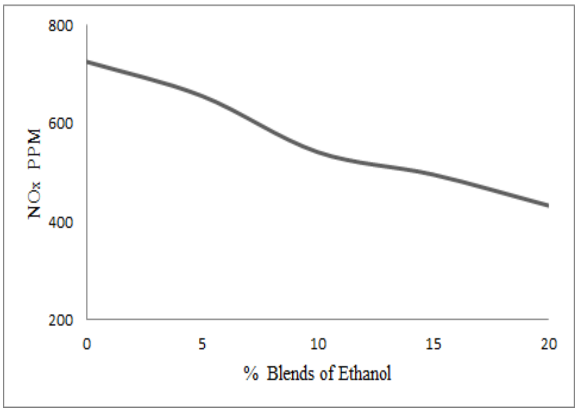

Fig.9: NO_x (PPM) vs. Blends of Ethanol (%)

Generally for diesel fuel NO_X emission is increased as the raise in the load [3]. When percentage of ethanol in blend is increased the NO_X emission is getting reduced. Fig.9 shows that nitrogen oxide considerably reduces with increasing ethanol in the blends from 726 PPM to 433 PPM at no load condition.

6. Conclusion

The objective of this study is to investigate the engine performance and emissions characteristics of a diesel engine operating on ethanol–diesel blends. On an energy basis, ethanol has lower calorific value than diesel hence it will consume more amount of fuel. These blends can also reduce greenhouse gas emissions. Based on the experimental results, the conclusions can be summarized as follows.

1 Without any modification ethanol-diesel blend up to 20% can be easily use in Diesel engine.
2 The brake thermal efficiency slightly decreases with ethanol blend no major difference has been found.
3 The emissions of CO were decreased and it found minimum at around 20% blend.
4 The emission of unburned hydrocarbon is increased with increase in ethanol blend.
5 Emission of nitrogen oxide considerably reduces with increasing ethanol in the blends.

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