

Performance and emission analysis of Multi-cylinder SI Engine using Ethanol blended with gasoline

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Abstract - Petrol engines are widely used in transportation and Agricultural sectors. The exhaust of petrol engine contains hazardous pollutants such as Hydrocarbons (HC), Carbon Monoxide (CO), Nitrogen Oxides (NO_x), Sulphur Oxides (SO_x) and particulates. This emission from engines causes a lot of health problems such as lung cancer, tuberculosis and other respiratory diseases to human beings. Further, burning of the fossil fuels creates a higher level of pollutant gases in the atmosphere, which increases the global warming. Therefore the emission from petrol engines has become a serious subject for research. In the phase of work the emission of pollutants were studied by modifying the fuel by mixing ethanol in various proportions. By increasing the ethanol proportions, unburned Hydrocarbons (UHC), CO and NO_x have been observed to be decreased due to the high latent heat of vaporization of ethanol. In fuel modification experiments, when 30% of ethanol mixed with 70% of gasoline, large percentage of reduction of all pollutant emissions were observed. In addition, the brake thermal efficiency also has been increased due to the fuel modification.

Key Words: Multi-cylinder, SI Engine, Ethanol and Gasoline.

1. INTRODUCTION

Increasingly, the strong and stringent air pollution regulations on emission standards provide serious challenges for automobile manufacturers. During the past decades, extensive research has been carried out to decrease the emission of toxic components of combustion gases. Considerable development has been made in fulfilling the standards in the recent years.

The new combustion systems and new technologies contribute to these achievements. Fuel modifications are commonly utilized as a solution in meeting legislated emission requirements. In this work an attempt has been made to control the engine exhaust emissions by blending ethanol with gasoline to reduce the harmful S.I Engine pollutants.[3],[7]

2. EXPERIMENTAL SETUP

Five gas analyzers were used for the measurement of HC, CO, NO_x and CO₂. Experiments were initially carried out on the engine in order to provide base line data. The engine was stabilized before taking all measurements subsequently. The experiments were repeated by keeping different catalyst coated filter in the exhaust. A multi cylinder Four Stroke Petrol Engine was used. Engine details are given in Table-1.

Table -1: Engine Specification

Parameter	Details
Engine	Four-Stroke Multi cylinder SI Engine
Make	Premier Automobile Limited, India
Rated power	7.5 kW
Maximum speed	4500rpm
Bore diameter	68mm
Stroke	75mm
Displacement volume	1089cc
Compression ratio	7.3:1
Number of cylinders	Four
Cycle	Four
Cooling	Water
Lubrication	Forced Lubrication
Starting system	Battery Ignition System

The experimental layout is shown in Fig 1.

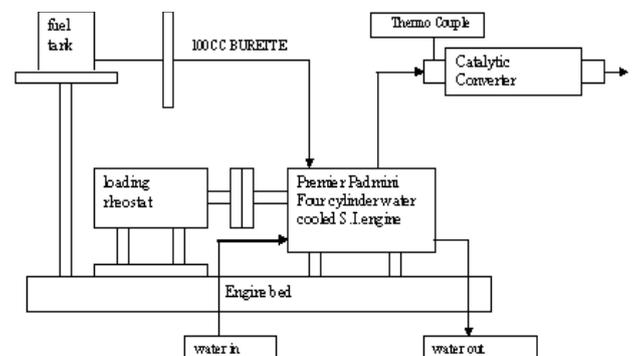


Fig 1: Layout of Test Engine

An electrical Dynamometer is used for loading the engine, the specification which is shown in table-2.

Table -2: Alternator Specification

Parameter	Details
Loading device	Electrical
Rated power	7kW
Rater speed	1500rpm



Fig. 3 Automatic Exhaust Emission Analyzer

Schematic diagram of the Test Engine are shown in Fig 2.



Fig 2: Test Engine

The present experimental setup for testing the performance of emission of engine shown schematically in figure 2, which consist of multi-cylinder water cooled petrol engine coupled to alternator with water rheostat. The fuel level in the fuel tank, flow of cooling water and level of lubricating oil sump is checked before starting the engine. The engine is started by turning the ignition key and the clutch lever is disengaged to couple the engine and adjusted to the speed of 1440 rpm. The engine is allowed to run for 10 minutes to attain steady state condition. At no load condition, CO, CO₂, HC & NO_x are measured by using exhaust gas analyzer. The load on the engine is increased by dipping the electrode in the water of the rheostat after reaching the steady state conditions all the above readings are taken for each increment of the load. The load is completely removed and the speed is reduced before stopping the engine. Then the metal oxide coated piston has been fitted and the emission analysis has been carried out.

3. Exhaust emission analyser

Measurement was done with the help of Automatic Emission Analyser QRO – 402. (Fig. 3)

A cooling water pipe line is coiled on the outer wall of the chamber to prevent overheating, and to reduce the out gassing by circulating the water. Alternatively a glass bell jar is supplied along with the unit. The analyzer is configured to perform a measurement by applying non-dispersive infrared (NDIR) method for analyzing CO, HC and CO₂ and electro-chemical method for analyzing NO₂ and O₂. In NDIR analyzing method, an infrared flashing lamp is attached at one end of the sample cell and a detecting sensor at the other end, so that it can detect the component of gas and in turn its density. The electrochemical method measures the gas density by using the quantity of electron which produced in the time of oxidation and reducing reaction of the gas.

4. Results and Discussion

4.1 Performance analysis on Fuel Modification:

The brake thermal efficiency is one of the important factors for the engine performance. The variation of the brake thermal efficiency with respect to fuel modification, in-cylinder modification, after treatments were investigated as a function of load and the results are presented below.

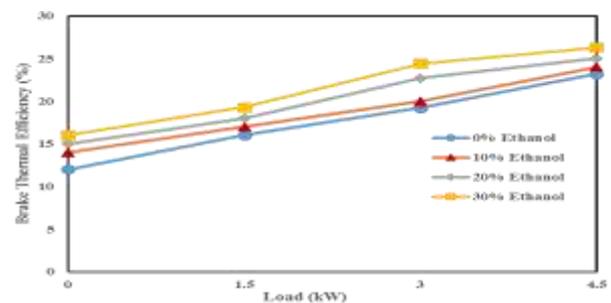


Figure 4

As can be seen from Figure 4, the brake thermal efficiency increases with load of the engine. Moreover, it is noticed that the addition of ethanol to petrol relatively increases the brake thermal efficiency. The enhancement in the brake thermal efficiency is due to the increase in the

oxygen content which leads to better combustion and efficiency.

4.2. Effect of Emission Control on Fuel Modification

The fuel has been modified by adding ethanol with gasoline in various proportions and the emission analysis has been carried out to find the emission level of CO, CO₂, HC and NO_x. Ethanol content has been increased from 0 to 40% in the interval of 5% with gasoline and the emission has been analyzed. However, for this the emission of various pollutants with respect to load at a constant speed of 1500 rpm for the modified fuel having 0%, 10%, 20%, 30% and 40% of ethanol blended with gasoline. The emission plots for various pollutants are shown in Figure 5-8.

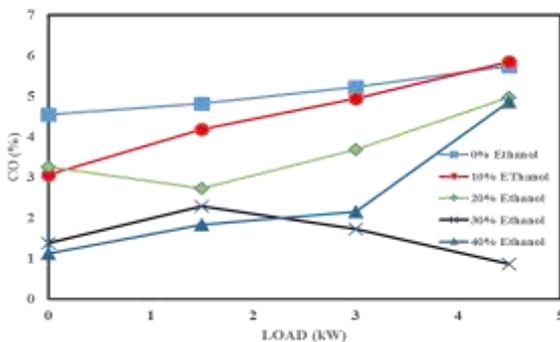


Figure 5

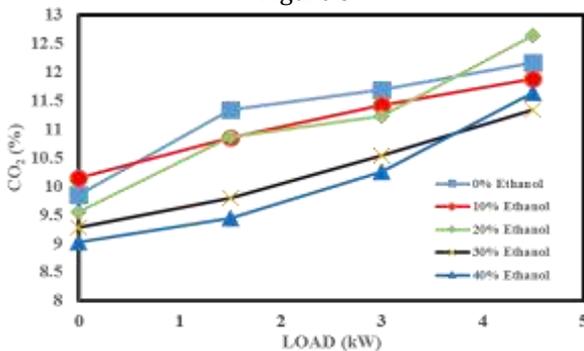


Figure 6

Figure 5 shows the variation of CO emission with respect to various load conditions for different proportions of ethanol blended with gasoline. It has been observed from the fig. 5 that the percentage of CO emission has decreased as the ethanol content increased in the fuel. Moreover, the fuel with 30% ethanol has been observed as most efficient modified fuel for the control of CO emission. Since the ethanol has oxygen in its molecule, the oxygen content in the 30% ethanol blended gasoline has been increased which promote the complete combustion. Due to this reason, the formation of CO has been reduced and hence the CO emission has been reduced. On the other hand, it has been observed that the CO emission has been increased when the load is increased due to the incomplete combustion caused by the

increase of load. However, in the case of 30% ethanol blend with gasoline, it is observed that the CO emission has decreased as well as the temperature might have increased and rich oxygen content enabled efficient clean combustion. At the same time, it has been observed that the CO emission has studied to increase when the ethanol content increase beyond 30%. This is due to increased vapour pressure of ethanol and more latent heat of vapourization which reduces the combustion efficiency and hence the effectiveness is reduced.

Figure 5 shows the variation of CO₂ emission with respect to load at constant speed of 1500 rpm for the modified fuel ethanol blended with gasoline. From the figure, it is observed that the percentage of CO₂ emission has been decreased from 9.85% to 9.03% for the lowest load. The similar observation has been made at higher load too. However the variation of CO₂ emission is not symmetric in nature with respect to ethanol content. Moreover, in contrast to the expectation that the emission of CO₂ should have been increased. In this study, it is observed that it has been decreased when 40% ethanol blended with gasoline, beyond which there is no systematic decrease and the combustion was also difficult due to moisture or vapour pressure as mentioned in the previous case. The reduction of CO₂ emission inferred that a clean combustion has been taken place.

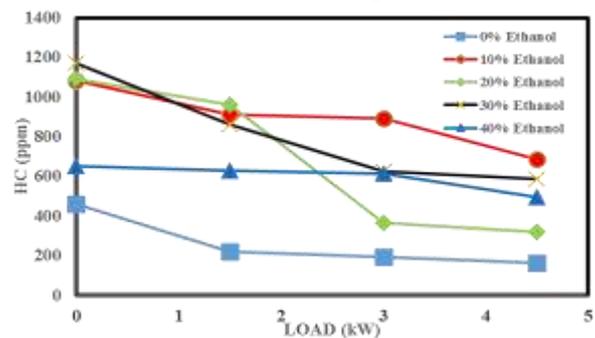


Figure 7

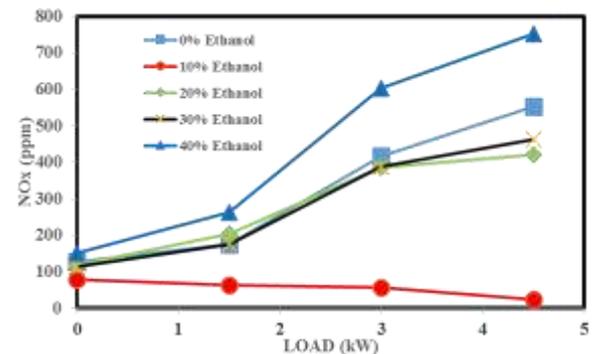


Figure 8

Figure 7 shows the variation of HC emission with respect to load at constant speed of 1500 rpm for the modified fuel of ethanol blended with gasoline. From the figure, it is observed that the HC emission has increased gradually as the ethanol content increased. This is due to the increased content of oxygen which enhanced the

combustion which reduces the oxygen exhaust and hence the formation of CO and CO₂ has been much reduced as observed in the previous cases. Due to this the heavier and unburned atoms have reacted with the hydrogen atoms present in the air fuel mixture and hence formed HC in excess. In addition it is also observed that the emission of HC is gradually decreased at higher load in all the cases which could be possible by the more clean combustion due to increased temperature at higher load for all modified fuel.

Figure 8 shows the variation of NO_x emission with respect to load at constant speed of 1500 rpm. It has been clearly understood from the Figure 7, the NO_x emission at higher load has increased due to higher peak cycle temperature which enhanced the formation of oxides of nitrogen except in the case of 10% ethanol blended with gasoline fuel. This may be due to the improper mixture of ethanol at lower concentration in the gasoline. Since the temperature at lower load is relatively low there is no much variation in the NO_x emission.

From this study, it has been clearly observed that addition of ethanol with gasoline is capable of reducing the harmful emissions like CO and CO₂. Moreover, it has been observed that 25-30% ethanol blended with gasoline has maximum capability for the emission control. Beyond 30% ethanol it started to take more time for the ignition and combustion has also been observed as poor due to which asymmetric emission of pollutant occurred.

5. Conclusions

Following are the conclusions based on experimental results. The brake thermal efficiency is upto 27% at 30% ethanol blended with gasoline.

- The use of ethanol blended with gasoline reduces the emission of
 - NO_x by 22 percent.
 - CO₂ by 20 percent.
 - CO by 20 percent.
 - HC by 54 percent.

From the conclusions it is found that the 30% of ethanol is the best to control the emission from the engines.

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