Exhaust Emissions of Ethanol-Unleaded Gasoline blends in Spark Ignition Engine

Deepak Kumar, Ajay Trehan

Abstract— in this study, the effect of unleaded gasoline and unleaded gasoline blended with 5%, 10 % and 15% of ethanol on the exhaust emission of a spark-ignition engine were experimentally investigated. Exhaust tests were conducted for carbon mono oxide (CO), carbon dioxide (CO_2), unburn hydrocarbon (HC) and nitrogen oxide (NO_x), using unleaded gasoline-ethanol blends with different percentage of fuel at wide open throttle (WOT) opening position and variable engine speed ranging from 900 to 3000 rpm. The results showed that blending unleaded gasoline with ethanol decrease the concentration of carbon mono oxide, nitrogen oxide and unburn hydrocarbon, while it increase the concentration of carbon di oxide. The 15 vol % ethanol in the fuel blend gave the best results for all measured parameters at all engine speed.

Index Terms— unleaded gasoline, ethanol, unleaded gasoline-ethanol blend, emission, carbon mono oxide, unburn hydrocarbon, blending.

1 INTRODUCTION

The increasing demand for energy and stringent pollution regulation, as a result of the population growth and technological development in the world, promote research an alternative fuels [1]. Ethanol was the first fuel among the alcohol to be used to power vehicle in the 1880s and 1890s. Henry ford presented it as the fuel of choice for his automobile during their earliest stages of development [2].
Among the various alcohols, ethanol is known as the most suited fuel for spark-ignition SI engines [3]. The most attractive properties of ethanol as an SI engine fuel are that it can be produced from renewable energy sources such as agriculture waste and it has high octane number and flame speed [3].

Presently, ethanol is used in SI engines with gasoline at low concentration without any modification. Pure ethanol can be used in SI engine but necessitates some modification to the engine. To avoid modification engine design, using ethanol-gasoline blended fuel was suggested and so, cold start and anti knock performance will be improved [4]. The addition of ethanol to gasoline has shown to reduce hydrocarbon emissions, with the reduction increasing as the blend ratio is increased. The reason given for this is the reduction of the higher boiling point gasoline fraction in the fuel blend [5].

Hamdan and jubran [6] using the ATD 34 engine conducted performance test using different ethanol-gasoline blends. The maximum percentage of ethanol (E %) used was 15 %. The best performance was achieved when 5 % ethanol-gasoline blend was used, with thermal efficiency increasing by 4 % under low speed conditions and 20 % at the high speed condition.

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The objective of the present paper is to investigate the effect of ethanol- unleaded gasoline blends on the spark ignition engine performance at wide open throttle opening position and variable engine speed operating conditions.

2. EXPERIMENTAL APPRATUS AND PROCEDURE

The experiments were conducted on a three cylinder, four stroke spark ignition (SI) engine. The engine has a swept volume of 796 cm^3, a compression ratio of 8.7:1 and a maximum power of 10.5 KW at 2400 rpm. The engine was coupled to an eddy current dynamometer (type-FTAC engine dynamometer). Fuel consumption was measured by using a calibrated burette and stopwatch with an accuracy of 0.3 sec. The accuracy of measurements of different parameters is given in table 1.

Table 1: The accuracy of measurements

Measurement	Accuracy
Load	±4 Nm
Speed	±30 rpm
Time	±0.3 sec
Temperature	$\pm2^0$C

The performance of ethanol and its blends with gasoline (E5, E10 and E15) were evaluated and compared with gasoline fuel. The properties of ethanol fuel are given in table 2. Above 20 % ethanol, engine could not run smoothly, therefore experimental results obtained up to this percentage of ethanol will be presented. The fuel blends were prepared just before starting the experiment to ensure that the fuel mixture is homogeneous and to avoid of the reaction ethanol with water.

Fuel properties were determined at the laboratories of sardar swaran singh national institute of bio- energy, kapurthala, jalandhar, Punjab. The properties of fuel are summarized in table 2.

Table 2: Fuel properties

Properties	Gasoline	Ethanol
Chemical formula	C_8H_{16}	C_2H_5OH
Molecular weight	112.32	46.08
Density	764	786
Stoichiometric AFR	14.7	8.98
Research octane number	97.4	113
Motor octane number	88.4	93
Vapour pressure (kpa)	62.3	20.1

3. RESULTS AND DISCUSSION

CORBON MONO OXIDE (CO)

Fig1. Show the effect of the ethanol % in fuel blends on the carbon mono oxide. From figure it can be seen that when the ethanol percentage in fuel increases, the CO concentration decreases. It can be seen from figure that when etanol percentage increases, the CO concentration decreases which means the proper combustion of fuel. Compared to unleaded gasoline, using blended fuels containing ethanol resulted in a significant reduction in CO emission. This is because ethanol is oxygen containing fuel, and their oxygen content in the blended fuel can improve the combustion process. The CO concentration in the exhaust gas emission at 1740 rpm for gasoline fuel was 1.41 (%V) while the CO concentration of E5, E10 and E15 at 1740 rpm was 1.28 (%V), 1.21 (%V) and 1.05 (%V) respectively. The CO concentration at 1740 rpm using E5, E10 and E15 was decreased by 9.2 %, 14.1 % and 25.5 % respectively.

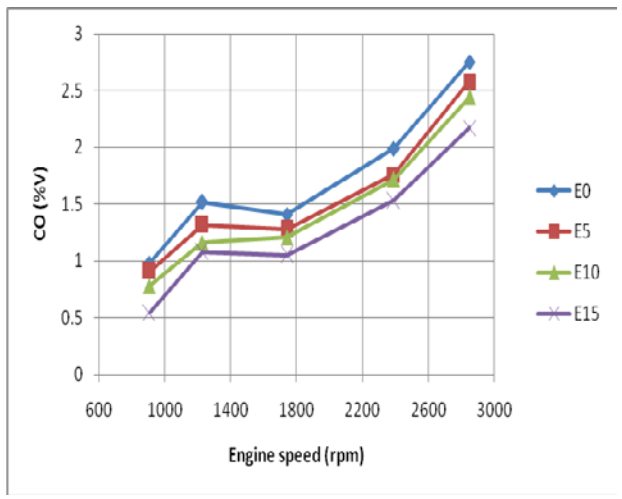

Fig1. Carbon mono oxide (% V) as a function of speed (rpm)

CARBON DI OXIDE (CO_2)

Fig2 show the effect of the ethanol % in fuel blend on the carbon di oxide. From figure it can be seen that CO_2 concentration increases as the ethanol percentage increased. CO_2 emission depends on CO emission concentration and relative air fuel ratio. The CO_2 concentration in the exhaust gas emission at 1740 rpm for gasoline fuel was 13.6 (%V) while the CO_2 concentration of E5, E10 and E15 at 1740 rpm was 13.8 (%V), 13.9(%V) and 14.3(%V) respectively.

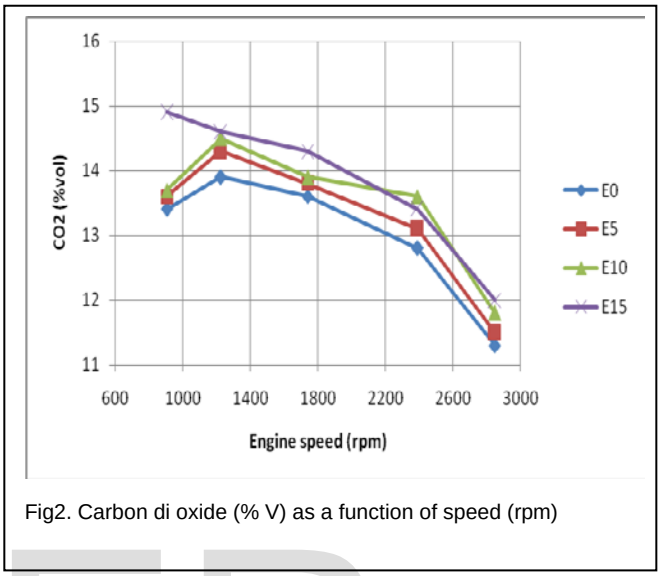

Fig2. Carbon di oxide (% V) as a function of speed (rpm)

UNBURN HYDROCARBON (HC)

Fig3. Show the effect of the ethanol % in fuel blend on the unburn hydrocarbon. From figure it can be seen that HC concentration decreases as the ethanol percentage in fuel increases. Ethanol fuels have higher oxygen content than unleaded gasoline, which improve the combustion process and lead to low HC emission. The HC concentration in the exhaust gas emission at 1740 rpm for gasoline fuel was 158 ppm, while the HC concentration of E5, E10 and E15 at 1740 rpm was 154 ppm, 153 ppm and 149 ppm respectively.

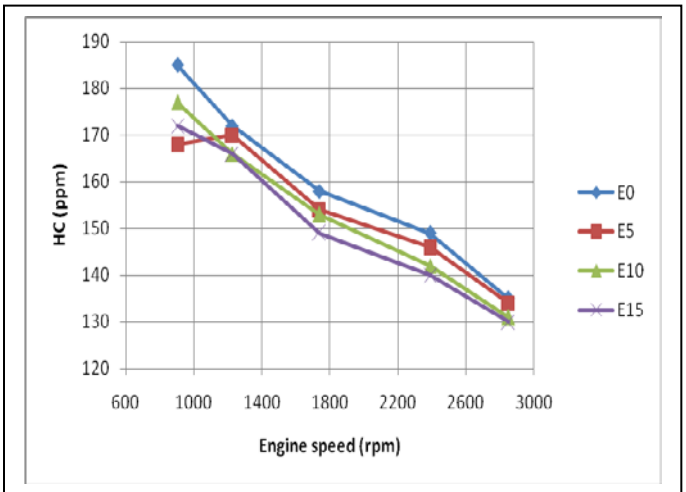

Fig3. Unburn hydrocarbon (ppm) as a function of speed (rpm)

NITROGEN OXIDE (NO_X)

Fig 4.show the effect of the ethanol % in fuel blends on the nitrogen oxide. From figure it can be seen that NO_X concentration decreases as the ethanol percentage in fuel increases. Nitric oxide level mainly depends upon the peak temperature achieved during combustion. Especillay nox emission is formed above 1500˚C. The high heat of vaporization of ethanol fuel lowers the flame temperature and this lower the nox emission.The NO_X concentration in the exhaust gas emission at 1740 rpm for gasoline fuel was 1320 ppm, while the NO_X concentration of E5, E10 and E15 at 1740 rpm was 1267 ppm, 1208 ppm and 1168 ppm respectively. The NO_x concentration at 1740 rpm using E5, E10 and E15 were decrease by 4.2%, 8.48% and 11.51% respectively in comparision to gasoline.

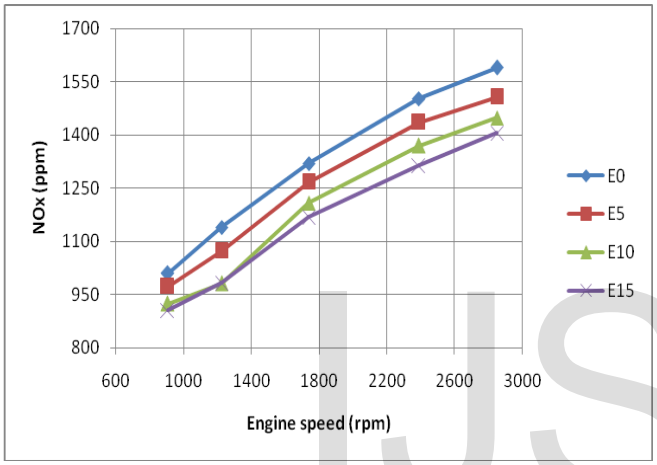

Fig 4 nitrogen oxide (ppm) as a function of speed (rpm)

4. CONCLUSIONS

General results concluded from this study can be summarized as follow:

1. Ethanol addition to gasoline will leads to leaner operation and improve combustion process.
2. Ethanol addition results in a decrease in carbon mono oxide concentration, unburn hydrocarbon concentration and nitrogen oxide concentration by about 16.31%, 3.7% and 7.9% mean average value, respectively. In addition carbon dioxide concentration increases by about 2.9%.
3. The 15% ethanol fuel blend gives the best results of the engine emission.
4. The 15% ethanol fuel blend by volume can be used in SI engine without any modification to the engine design and fuel system.

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