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The effects of ethanol-unleaded gasoline blends on engine performance and pollutant emission in a Spark-Ignition engine

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Abstract— The purpose of this study is to experimentally investigate the effect of ethanol and unleaded gasoline blended with0%, 5%, 10 % and 15% on the performance and pollution emission of a spark-ignition engine.In Performance tests we calculated fuel consumption, engine torque, brake power, brake thermal efficiency and brake specific fuel consumption.In pollution emission we calculated concentration of CO,CO_2 and unburned hydrocarbon. In all test we use unleaded gasoline-ethanol blends with different percentage of fuel at wide open throttle opening position and variable engine speed ranging from 850 to 3200 rpm. The results showed that blending unleaded gasoline with ethanol increase the torque, brake power, fuel consumption and brake thermal efficiency, while it decreases the BSFC. In case of emission, the concentration of carbon mono oxide and unburn hydrocarbon decreases, while it increase the concentration of carbon di oxide with increase in concentration of ethanol in gasoline. 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, pollutant emission, engine performance, engine torque, brake power.BSFC

1 INTRODUCTION

Alcohol has been used as a fuel almost since automobile invented [1]. Ethanol was the first fuel among the alcohol to be used to power vehicle in the 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.
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.

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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 8.8:1 and a maximum power of 10.8 KW at 2450 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 0.4 sec. The accuracy of measurements of different parameters is given in table 1.

Table 1: The accuracy of measurements

Measurement	Accuracy
Load	±5 Nm
Speed	±35 rpm
Time	±0.4 sec
Temperature	±3^{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,

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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	46.18
Density	765	788
Stoichiometric AFR	14.8	8.90
Research octane number	97.6	114
Motor octane number	88.6	95
Vapour pressure (kpa)	62.5	20.3

3. RESULTS AND DISCUSSION

Fuel consumption

The effect of the ethanol-unleaded gasoline blends on the fuel consumption is shown in fig1. From fig1, the m_f increases as the percentage of ethanol increases for all engine speed. The behavior is due to the low heating value (LHV) per unit mass of the ethanol fuel, which is lower than that of the unleaded gasoline fuel. Therefore the amount of fuel introduced into the engine cylinder for a given desired fuel energy input has to be greater with the ethanol fuel. At the engine speed of 905 and 2850 rpm, the relative increase of m_f is approximately 10% and 8% respectively. In addition, m_f increases about 4.3 times as the engine speed increases from 905 to 2850 rpm.

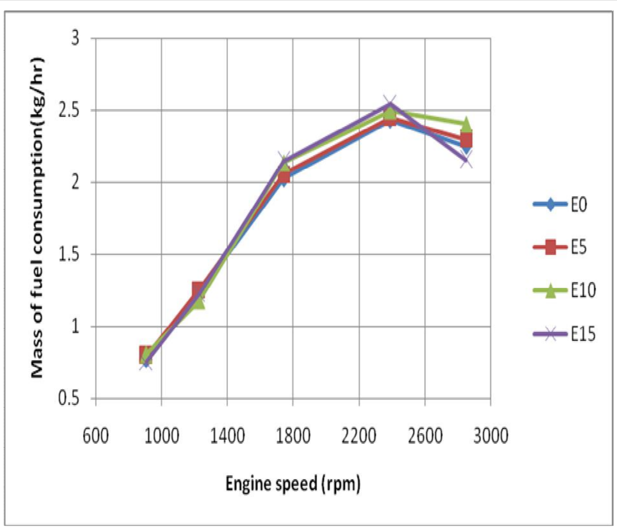

Fig 1 mass of fuel consumption (kg/hr) as a function of speed (rpm)

BRAKE TORQUE

The effect of ethanol –unleaded gasoline blends on brake torque is shown in fig2. It is clear from fig2 that T increases as the Percentage of ethanol increases up to 1740 rpm engine speed. This increase continue of ethanol addition to gasoline decreases its heating value; the increases in torque and power were obtained. This is explained with several reasons. With increase of ethanol will produce lean mixture that increase the relative air fuel ratio to a higher value and makes the burning more efficient. The improved anti-knock behavior allowed a more advanced timing that results a higher combustion pressure and thus higher torque. Beneficial effect of ethanol as an oxygenated fuel is a possible reason for more complete combustion, thereby increasing the torque.

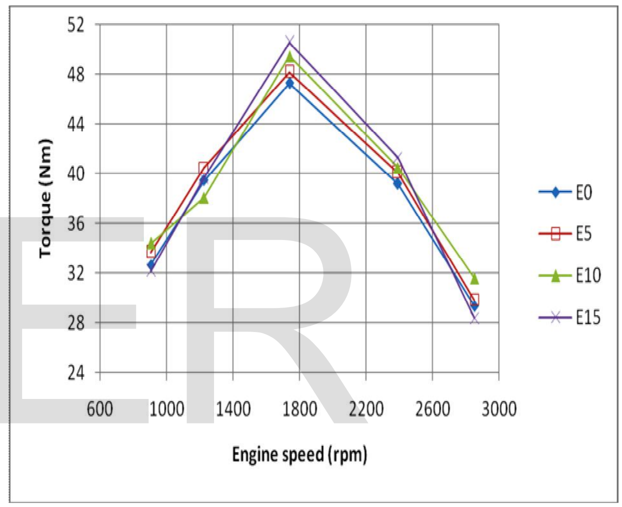

Fig 2. mass of fuel consumption (kg/hr) as a function of speed (rpm)

BRAKE POWER

The effect of ethanol-gasoline blends on brake power is shown in fig3. It is clear from fig that brake power (B_P) increases for all engine speed. The brake power is proportional to the product of the engine torque and speed, which show that brake power increases as the engine speed and torque increases. When the ethanol content in the blend fuel is slightly increased for all engine speed, the gain of the engine power was due to the increases of the indicated mean effective pressure.

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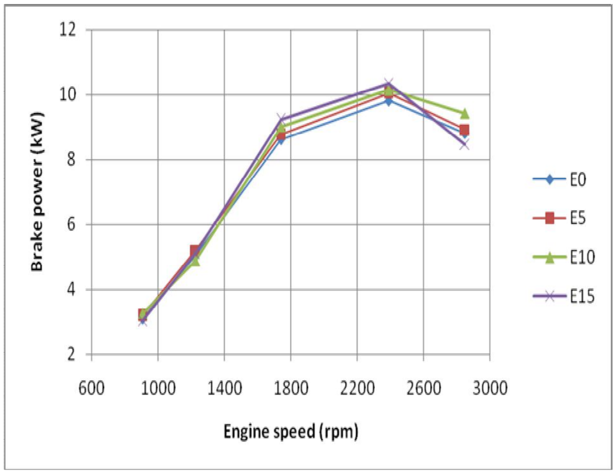

Fig 3 brake power (kW) as a function of speed (rpm)

BRAKE THERMAL EFFICIENCY

The effect of ethanol-unleaded gasoline blends on brake thermal efficiency is shown in fig4. The max brake thermal efficiency is recorded with 15% ethanol in the fuel blend for all engine speeds. As the ethanol percentage increases in the blend, the pressure and temperature decreases at the beginning of combustion. As the E% increases in the fuel blend, the indicated work increases since the mechanical efficiency is a function of engine speed only, the effect of increasing E% on brake thermal efficiency is the same as that as indicated efficiency.

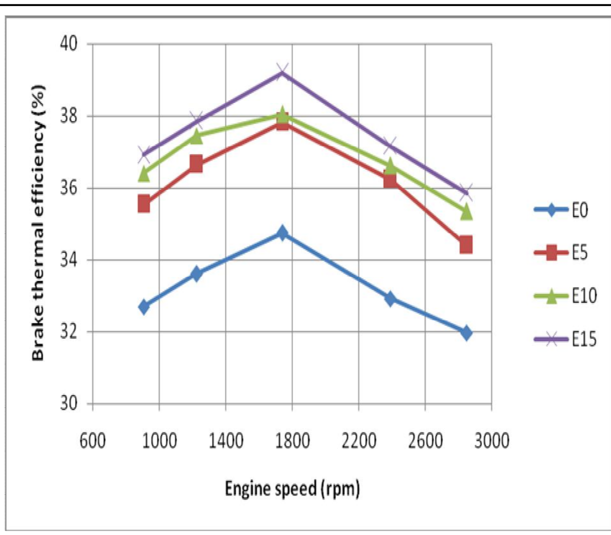

Fig 4 brake thermal efficiency (%) as a function of speed (rpm)

BRAKE SPECIFIC FUEL CONSUMPTION

Fig 5 shows the effect of using ethanol-unleaded gasoline blends on brake specific fuel consumption. Fig 5 shows that, the BSFC decreases as the E% increases upto 15%. This is a normal consequence of the behavior of the engine brake thermal efficiency shown in fig. on the other hand, as the engine speed increases to 1740 rpm, the BSFC decreases. This is due to the increase in brake thermal efficiency and decrease in equivalence air fuel ratio. A further increase in engine speed results in increasing brake specific fuel consumptions.

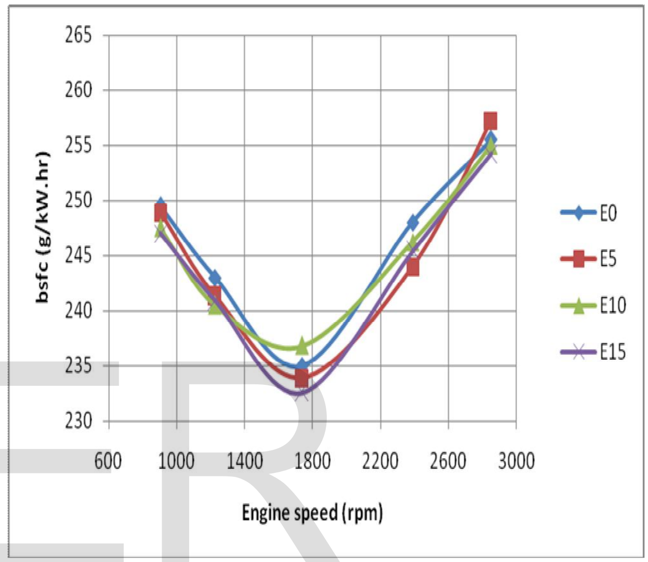

Fig 5 brake specific fuel consumption (g/kw.hr) as a function of speed (rpm)

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

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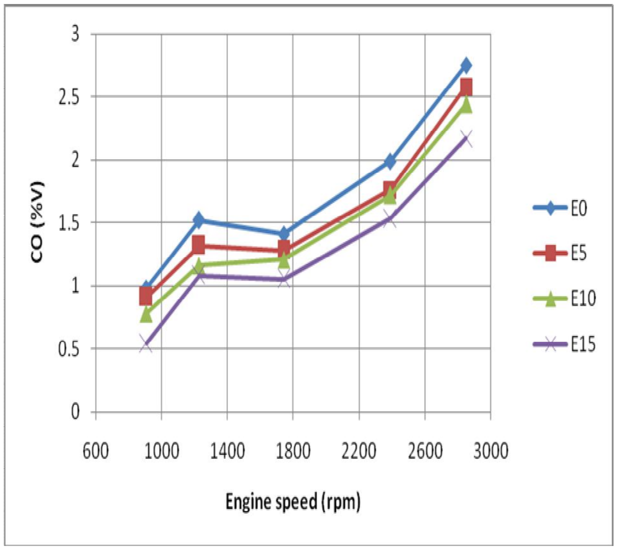

Fig1. Carbon mono oxide (% V) as a function of speed (rpm)

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.

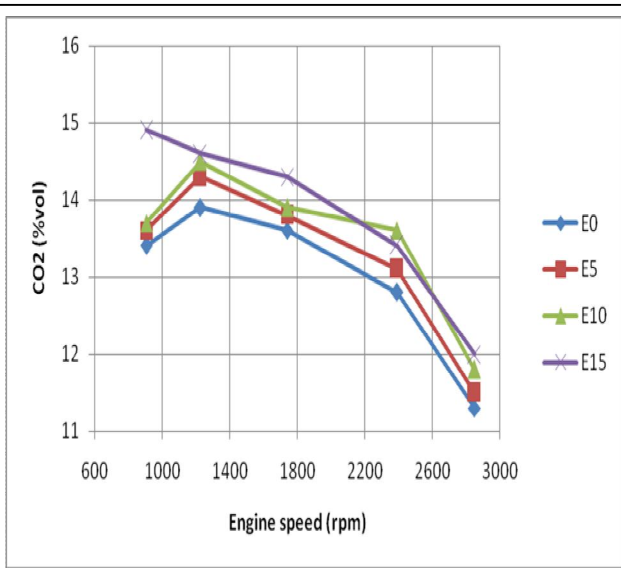

Fig2. Carbon di oxide (% V) as a function of speed (rpm)

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.

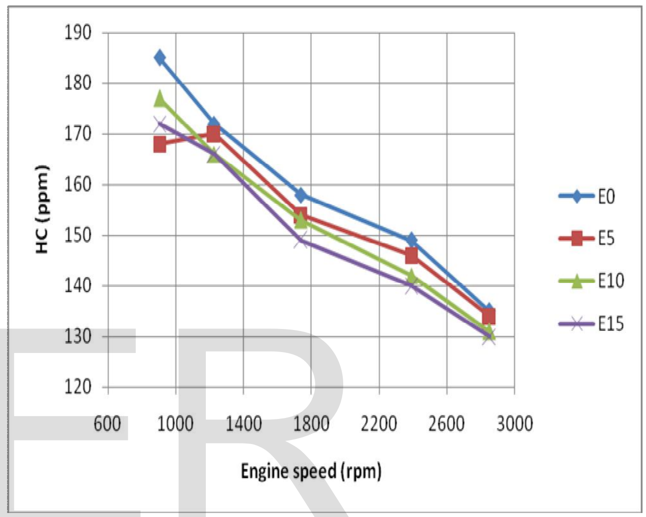

Fig3. Unburn hydrocarbon (ppm) as a function of speed (rpm)

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 an increase in fuel consumption, brake torque, brake power and brake thermal efficiency by about 5.9%, 7.8%, 8.2% and 8.7% mean average value, respectively. In addition brake specific fuel consumption decreases by about 2.2%.
3. The 15% ethanol fuel blend gives the best results of the engine performance.
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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