Experimental Investigation of SI Engine Performance using Ethanol-Gasoline Blended Fuels

Deepak Kumar, Ajay Trehan

Abstract— These In this study, the effect of unleaded gasoline and unleaded gasoline blended with 5%, 10 % and 15% of ethanol on the performance of a spark-ignition engine were experimentally investigated. Performance tests were conducted for fuel consumption, engine torque, brake power, brake thermal efficiency and brake specific fuel consumption, using unleaded gasoline-ethanol blends with different percentage of fuel at wide open throttle opening position and variable engine speed ranging from 900 to 3000 rpm. The results showed that blending unleaded gasoline with ethanol increase the brake power, torque, brake thermal efficiency and fuel consumption, while it decreases the brake specific fuel consumption. 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, engine performance, brake specific fuel consumption, engine torque, brake power.

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.

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	$\pm 2^0$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 sar-

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dar 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

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.

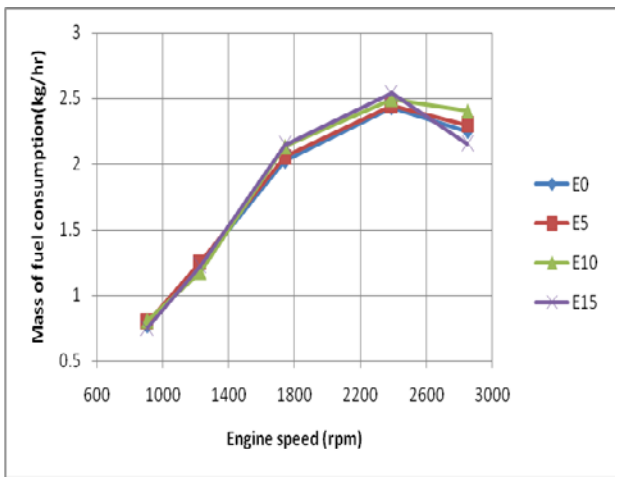

Fig 1 mass of fuel consumption (kg/hr) as a function of speed (rpm)

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.

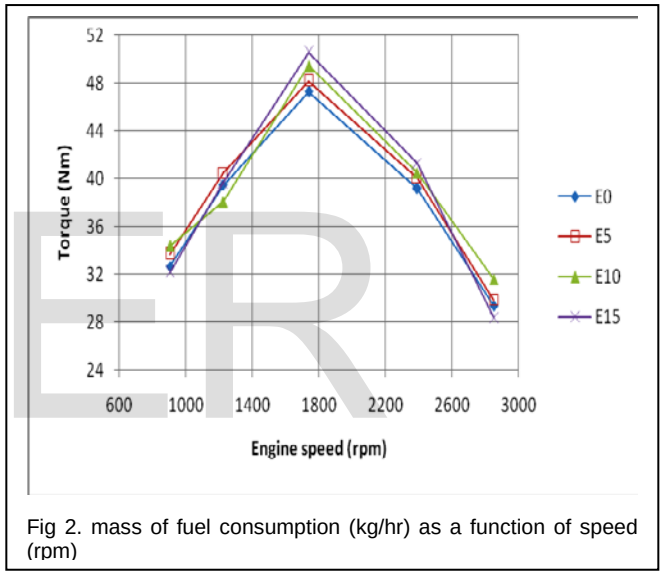

Fig 2. mass of fuel consumption (kg/hr) as a function of speed (rpm)

BRAKE POWER

The effect of ethanol-gasoline blends on brake power is shown in fig3. It is clear from fig3 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.

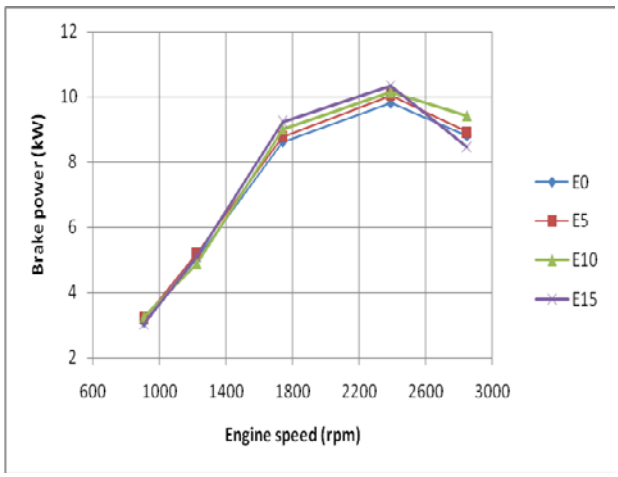

Fig 3 brake power (kW) as a function of speed (rpm)

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.

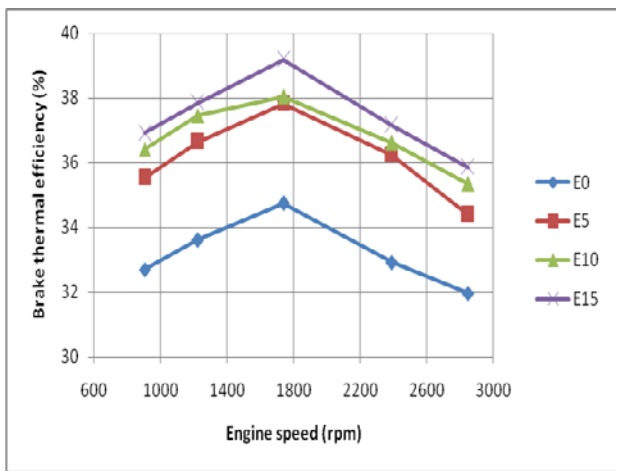

Fig 4 brake thermal efficiency (%) as a function of speed (rpm)

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.

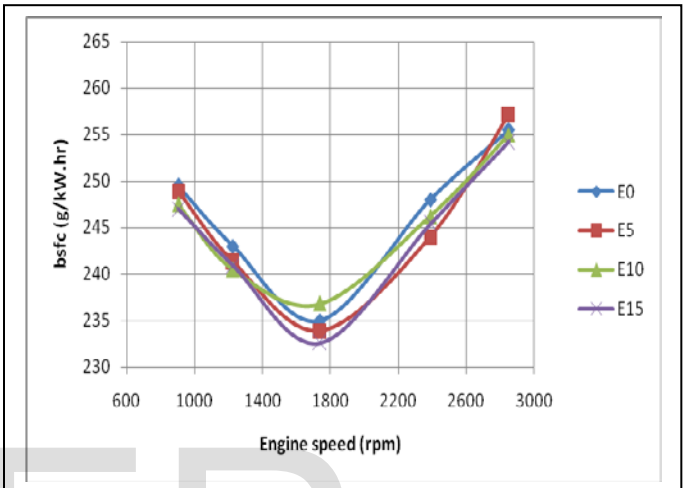

Fig 5 brake specific fuel consumption (g/kw.hr) as a function of speed (rpm)

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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