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The Influence of Ethanol–Gasoline Blends on Performance Characteristics of Engine Generator Set

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Abstract: *The aim of this research is to study the influence of using ethanol-gasoline fuel blends on spark ignition engine performance characteristics and compare the obtained results with those using base gasoline. An electric generator operated by a SI (spark ignition, four stroke, single cylinder, air cooled) engine was used for conducting this study. The tested fuels were gasoline (E0) and gasoline-ethanol blends (E5, E10, & E15). The test was conducted at a constant speed of 3000 revolutions per minute (rpm) under varying electric loading conditions. The experimental results revealed that with the use of ethanol-gasoline blends, the overall efficiency of the engine -generator set and exhaust gas temperature increased while total fuel consumption and specific fuel consumption showed a trend of decreasing. Finally, the E15 blend showed a comparatively good performance compared with that of base gasoline.*

Keywords: *Alternative fuels, Ethanol, Ethanol- gasoline blends, Performance.*

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I. INTRODUCTION

Fuel additives are very important, since many of these additives can be blended to fuel in order to enhance its performance and its efficiency. One of the most important additives to improve fuel performance is oxygenates (oxygen containing organic compounds) such as methanol, ethanol, tertiary butyl alcohol and methyl tertiary butyl ether [1].Ethanol is known as the most suited fuel for spark-ignition (SI) engines. It can be used in SI engines as pure or by blending with gasoline. Whereas it can be used in SI engines by blending with gasoline at low concentrations without any modification .The most attractive properties of ethanol as an SI engine fuel are that it can be produced from renewable energy sources such as agricultural feedstock and it has high octane number and flame speed [2].

Many researchers have been studied the possibility of using ethanol-gasoline blends as fuel for a spark ignition engine. **Yusaf et al** performed a series of engine tests by using four blends with a ratio of 5, 10, 15 and 20 % of ethanol– and gasoline by volume to evaluate the performance and emission in a spark ignition engine. They concluded that the addition of 5% to 15% ethanol to gasoline increased the torque, power output, brake thermal efficiency and the volumetric efficiency of the engine while decreased the brake specific fuel consumption [3]. **Yinn Lin et al** investigated the influence of using ethanol-gasoline blends (E0,E3,E6 & E9) on energy efficiency and emission of a small generator at different loads and at a constant speed. Test results showed that the E6 blend gave the best results of the exhaust emissions, and the E9 blend gave the best results of engine performance and the particle emissions [4].**Ravishankar and Kumar** examined the performance of two wheelers (4-stroke, BAJAJ, SI) using ethanol- gasoline blends (E0, E5, E8, E10, E12, E14, E16 and E18). They concluded that E8 and E16 blends showed a comparatively better engine performance than pure gasoline [5]. **Nallamothu et al** evaluated performance and exhaust emission of a SI engine by using two blends of ethanol – gasoline (E0,E5 and E10). Test results indicated that the best performance was obtained for all samples for the compression ratio of 8:1 at a speed of 2000 rpm. Finally, they recommended using E10 at a compression ratio of 8:1 [6].

Kumar et al tested different blends of ethanol –gasoline fuels (E0,E5,E10,E15& E20) to evaluate the performance and emission of a spark ignition engine at (no load-Constant rpm Test) .They concluded that 10% ethanol blended gasoline would be the best choice for use in the existing spark ignition engines without any modification to increase the engine efficiency and reduce exhaust gasses [7].**Bokhary et al** investigated the utilization of ethanol-unleaded gasoline blends (E0, E5, E10, E15) on a SI engine. The results showed that when ethanol added to gasoline, performance characteristics such as brake power, brake torque, brake thermal efficiency, volumetric efficiency, and brake mean effective pressure were found to be greater than pure gasoline.Also, it was found that a decrement in brake specific fuel consumption and Exhaust gas emissions were lower by using ethanol-gasoline blends. Finally, they concluded that the E15 blend was found to be the effectual substitution that achieved satisfactory engine performance and exhaust gas emissions [8]. **Tiwari and shrivastava** evaluated the performance of spark ignition engine with a ratio of 10% 20% and 30% of ethanol and gasoline by volume. The test results revealed that among the various blends, the blend E10 was the most suitable one from the engine Performance. However, it showed better engine performance and least brake specific fuel consumption [9] **Joshi et al** found out the effect of E0, E10, E20, E30 and E40 on performance parameters and emission characteristics of a SI engine. They concluded that the benefit of ethanol using resulted in an improvement in mechanical Efficiency and thermal efficiency and a decrease in fuel consumption [10].

The objective of the present study is to investigate the impact of ethanol-gasoline blends on performance characteristics of engine generator set at different loads. The tests were carried out at the automotive laboratory, faculty of engineering, Minia University, Egypt.

II. MATERIAL AND METHODS

The YAMAHA engine-generator set was chosen for carrying out the experiments. It consisted of a-171cc, single cylinder, 4-stroke, air-cooled, SI engine directly coupled to an electrical generator of rated output capacity of 2 kW, 220V, 50Hz electricity. The technical specifications of the tested engine and the electrical generator are shown in Table 1 and Table 2. Several incandescent bulbs mounted parallel on a load board were used as variable electric loads. The electrical load was observed using a digital watt meter.

The rate of fuel consumption in each test was measured using a calibrated fuel burette with the valve. Thiswas done by noting the time taken to consume 50 ml of the fuel then dividing the mass by the time.

The exhaust gas temperature was measured using the K-type thermocouple placed in the exhaust manifold. The thermocouple was connected to PID temperature controller, then the PID converts the thermocouple signal into a temperature reading of degrees Celsius, which can be readon display .The schematic diagram of the experimental setup is shown in Figure 1.

Four different fuel samples were experimentally examined during this study. Base gasoline (92 octane) was obtained from local Fuel Station. Ethanol with the purity of 99.9% was obtained from local chemicals supplier. The fuel properties are shown in Table 3. For the testing purpose, the calorific value of gasoline is assumed to be 44.0 MJ/kg and the calorific value for ethanol is taken to be 26.9 MJ/kg. The densities for gasoline and ethanol are 0.765 g/cm^3 and 0.785 g/cm^3 respectively [1]. The base gasoline was mixed with ethanol to get three test mixtures E-5 (95% gasoline+ 5% ethanol), E-10 (90% gasoline+10% ethanol) and E-15 (85% gasoline+15% ethanol). The heating (lower) values and densities of different ethanol-gasoline blends have been calculated by the weighted average method. The calculated values of ethanol have been shown in Table 4. The fuel blends were prepared just before starting the experiment to ensure that the fuel mixture is homogeneous.

The engine was started by hand cranking with a recoil starter. Just after the engine has started, the choke valve was turned into full open position. The engine was allowed to run for a period of 10-15 minutes for warm-up and reaching steady conditions. The experiment was conducted at a constant speed of 3000 revolutions per minute (rpm) and at varying the electrical load from no load, 0.52 kW, 1.03 kW, 1.50 kW, and 1.93 kW. The tested fuels were gasoline (E0) and gasoline-ethanol blends E5, E10 and E15. Tests were carried out at first using pure gasoline fuel (base fuel) to create the baselinedata, then different ethanol-gasoline blends were examined under same operating conditions. The engine was not modified at using any fuel. After the engine had reached the stabilized working condition, performance parameters were recorded. Before running the engine to a new fuel blend, it was allowed to run for a sufficient time to eliminate the remaining fuel from the previous experiment. The parameters, such as fuel consumption rate, specific fuel consumption and overall efficiency, were estimated using the following equations:

a) Total fuel consumption:

$$\text{T.F.C (kg/hr)} = \frac{m*\rho*3600}{1000*T} \quad (1)$$

Where m = fuel burette reading in cc, ρ= density of fuel in gram/cc and T = time taken in seconds.

b) Specific fuel consumption:

$$\text{S.F.C (kg/kW.hr)} = \frac{T.F.C}{P} \quad (2)$$

Where T. F. C = Total fuel consumption in (kg/hr) and P = output power of generator in kW.

c) The overall efficiency of the engine generator set:

$$\eta\ (\%) = \frac{3600*P}{T.F.C*LHV} *100 \quad (3)$$

Where T. F. C= Total fuel consumption in (kg/hr), LHV = lower heating value of fuel in kJ/kg and P = output power of generator in kW.

Table 1: Specifications of the tested engine.

Engine Type	Air cooled ,4-stroke gasoline, OHV
Displacement Volume	171 cc
Bore x Stroke	66 mm x 50 mm
Fuel delivery system	Conventional carburetor
Compression Ratio	8.5:1
Rated Output Power	2.7 KW at 3000 rpm
Engine Oil capacity	0.6 liter

Table.2. Single phase AC generator specifications.

Type	Single Phase AC
Rated Frequency	50 Hz
Rated Current	9.1 A
Rated Voltage	220 V
Rated output power	2 KW at 3000 rpm
Maximum Power	2.3kW

Table 3. Gasoline and ethanol properties [1]

Property	Gasoline	Ethanol
Formula (liquid)	C8H18	C2H5OH
Molecular weight (kg/ kmol)	114.15	46.07
Density (kg/m^3)	765	785
LHV (kJ/ kg)	44,000	26,900

Table 4. Characteristics of ethanol- gasoline blends.

Fuel % composition by volume	Lower heating value (kJ/kg)	Density (g/cm3)
100% gasoline + 0% ethanol	44000	0.765
95% gasoline+ 5% ethanol	43120	0.766
90% gasoline + 10% ethanol	42250	0.767
85% gasoline + 15% ethanol	41380	0.768

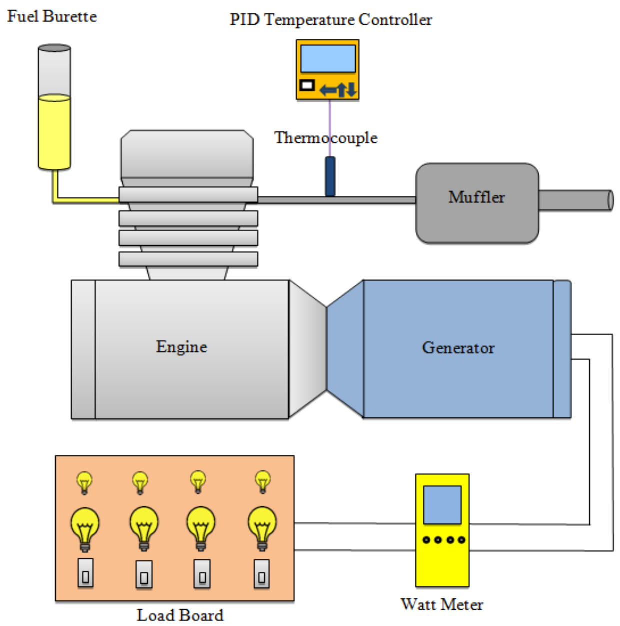

Fig1. Schematic diagram of experimental setup.

III. RESULT ANDDISCUSSION

3.1. Total fuel consumption (T.F.C).

The variation of fuel consumption with respect to change in load using gasoline and ethanol- gasoline blends is presented in Fig.2. For all fuels, the fuel consumption of the engine is increased linearly with increase in electrical load. This is expected because more fuel is burnt at higher loads to achieve the power requirement.

It is observed that there is no significant difference in the fuel consumption of gasoline and its blends. In general, the E 15 fuel produces the lowest fuel consumption at all load condition. This is due the increase of octane number and the presence of oxygen in the fuel blend which enhance the combustion efficiency.

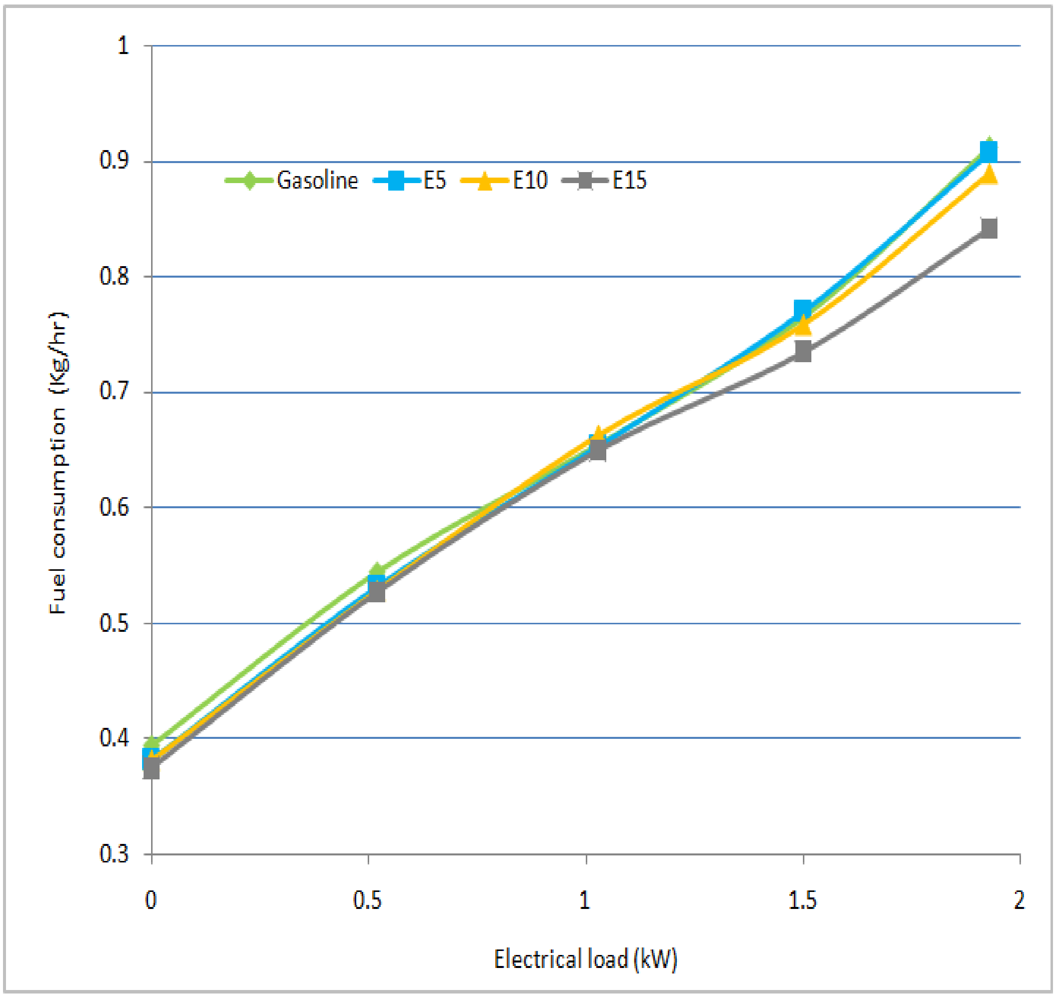

Fig 2.The effect of ethanol addition on total fuel consumption.

3.2. Specific fuel consumption (SFC).

The variation of specific fuel consumption with respect to load using gasoline and ethanol-gasoline blends is shown in Fig.3. All the tested fuels show a decreasing trend of SFC with respect to load. It is evident from the figure that the curve starts to drop with increase in electrical load and achieves a minimum value at maximum load case, representing a minimum fuel consumption per unit of power generated. However, it is observed that the SFC for E15 blend was considerably lower than the gasoline fuel at maximum load condition. This is due to the favorable properties of ethanol that present in the blend which help in a better combustion and thus lower SFC.

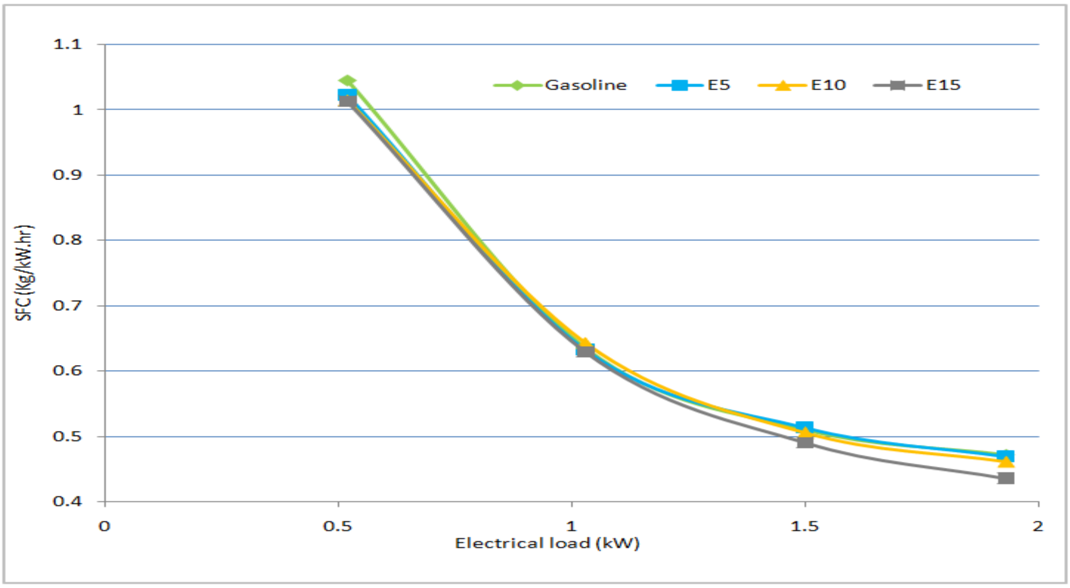

Fig 3.The effect of ethanol addition on SFC.

3.3. The overall efficiency of engine generator set (η).

The overall efficiency expresses the conversion from the chemical energy of fuel to the electrical energy in the generator [11]. Figure 4 represents the variation of overall efficiency with load for gasoline and its blends. As the electrical load increased, the overall efficiency of engine generator set increased for all types of fuel. It is observed that the E 15 fuel gave the higher efficiency than the gasoline fuel for all load conditions. This is attributed to the fact that ethanol is oxygenated fuel which aids in the complete combustion process. At maximum load, the overall efficiency of engine generator set using E15 blend was increased by 14.88% in comparison to pure gasoline.

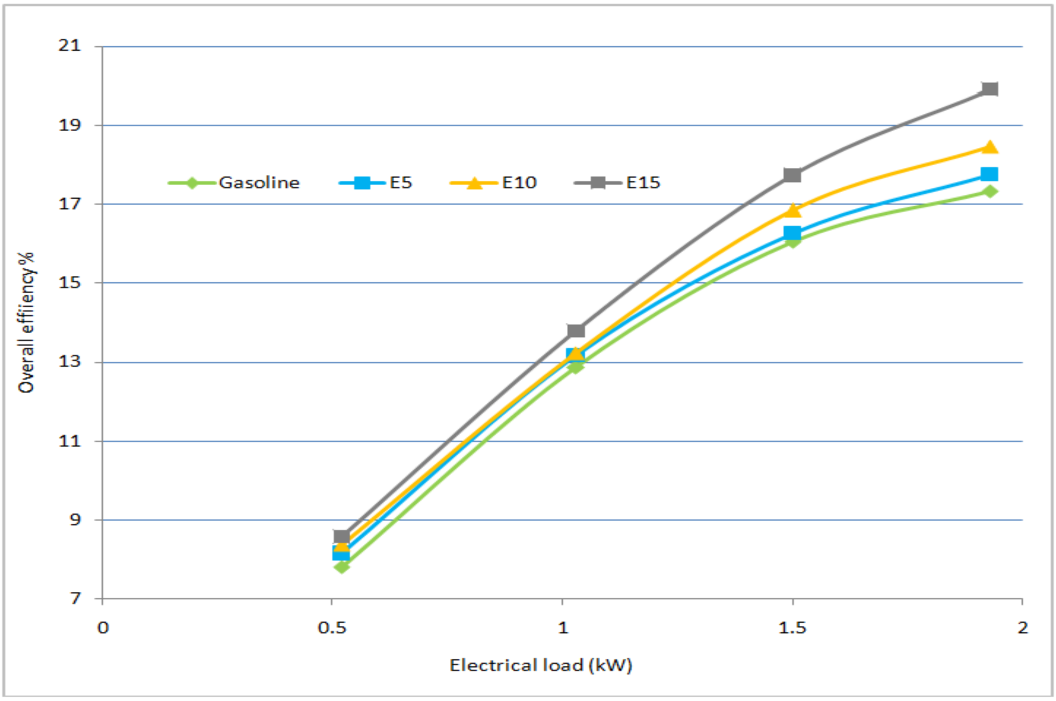

Fig 4. The effect of ethanol addition on overall efficiency.

3.4. Exhaust gas temperature (EGT).

The exhaust gas temperature (EGT) of an engine is an indication of the conversion of heat energy into useful work [12].The variation of exhaust gas temperature with respect to change in load percentage for tested fuels is plotted in Fig.5. It is observed that the EGT increases with rising in load for all fuels because more fuel is consumed at higher loads to achieve the power demand. It is also observed that the addition of ethanol to pure gasoline increases the exhaust gas temperature. This is due to improved combustion of fuel [8]. At maximum load, the exhaust gas temperature using E5, E10, and E15 was increased by 0.89%, 2.37% and 3.85%, respectively in comparison to pure gasoline.

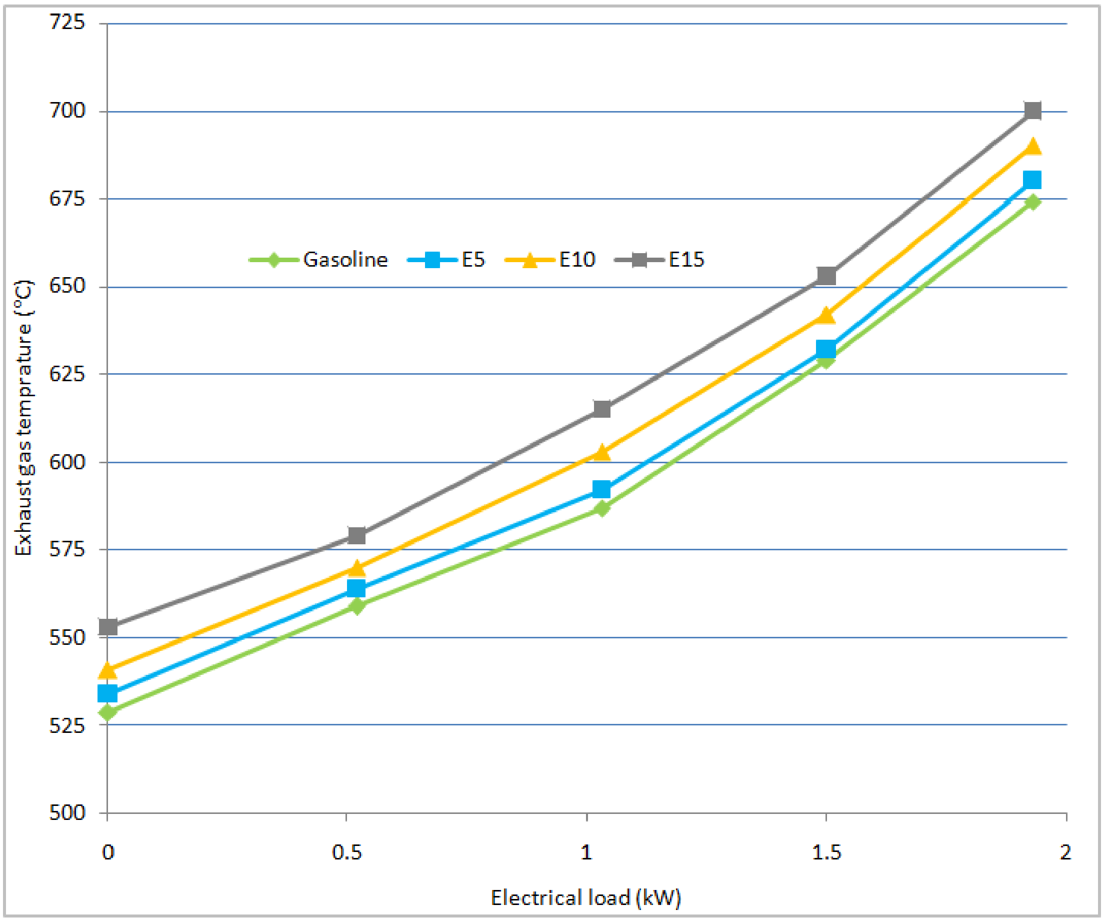

Fig 5.The effect of ethanol addition on EGT.

IV. CONCLUSION

This study led to some conclusions, which could be deduced as follows:

1. Burning ethanol-gasoline blend in SI engine improves the engine-generator set performance characteristics.
2. Ethanol - gasoline blend with percentage volume of ethanol up to 15% can be used in SI engine without any modifications.
3. The presence of oxygen and high octane number were significant features of using ethanol-gasoline blends.
4. The fuel consumption and specific fuel consumption showed a marginal decreasing with the use of ethanol – gasoline blends.
5. Ethanol addition to gasoline resulted in an increase in overall efficiency of the engine -generator set and exhaust gas temperature. For E15 blend, the overall efficiency and exhaust gas temperature at maximum load were increased by 14.88% and 3.85% respectively as compared to base gasoline.

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