

## Performance Characteristics of a Gasohol Fueled S.I Engine.

Laminu S. Kuburi, David O. Obada, Ibraheem A. Samotu, Chike V. Chira  
Obinna A. Osuchukwu and M. Jeremiah.

*Department of Mechanical Engineering, Ahmadu Bello University, Zaria, Nigeria.*

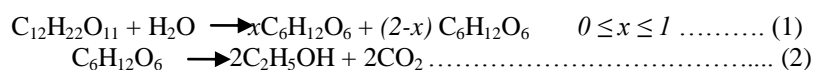
**Abstract:** - Ethanol is a renewable fuel which has the added advantage of improving performance in typically knock-limited operating regions due to the higher octane rating of the fuel. Ethanol was synthesized from groundnut seeds using fermentation method. An experiment was then designed to run a gasoline engine. In this work, the effect of ethanol addition to gasoline on the performance characteristics of a spark ignition engine at various speeds was established. Gasoline was blended with 20 – 80% of the extracted ethanol in an interval of 20%. Results of the engine test indicated that blending ethanol in a proportion of 40% with gasoline can be used as a supplementary fuel in modern spark ignition engines as it is expected to achieve optimum performance on the engine.

**Keywords:** - Ethanol, Gasoline, performance, Spark ignition engine.

### I. INTRODUCTION

While ethanol is an attractive option for offsetting dependence on petroleum based gasoline, the differences in fuel properties between gasoline and ethanol can significantly alter engine performance [1], [2], [3]. Due to the different molecular structure of ethanol, the stoichiometric air-fuel ratio of ethanol is substantially different than gasoline and the air and fuel controllers must target different values for ethanol blends. Ethanol also has a different laminar flame speed than gasoline; therefore, the rate at which flames propagate during combustion will differ depending on the fuel ethanol content and combustion phasing will be directly affected. In addition, as a result of its higher octane rating, ethanol has a higher resistance to knock than gasoline. Ethanol fuel is ethanol (ethyl alcohol), the same type of alcohol found in alcoholic beverages. It can be used mainly as a biofuel alternative to gasoline, and is widely used by flex-fuel light vehicles in Brazil, and as oxygenate to gasoline in the United States. Together, both countries were responsible for 89% of the world's ethanol production in 2008 [4]. As noted by Blume [5], the following are the key reasons for which ethanol is attractive as a substitute to gasoline: Ethanol is 98% pollution free; biodegradable; renewable; there is no carbon left when ethanol burns in cars; ethanol does not cause climate change; and all the by-products in the production of ethanol are edible and nontoxic, providing a very good source for animal feedstock.

Methanol has also been proposed as a fuel for internal combustion and other engines mainly in combination with gasoline. Historically, methanol was first produced from pyrolysis of wood. Presently, methanol is usually produced using methane as a raw material. Both methanol and ethanol burn at lower temperatures than gasoline, and both are less volatile, making engine starting in cold weather more difficult. Using methanol as a fuel in spark ignition engines can offer an increased thermal efficiency and increased power output due to its high octane rating (114) and high heat of vaporization. However, its low energy content of 19.7 MJ/kg and stoichiometric air fuel ratio of 6.42:1 mean that fuel consumption will be higher than hydrocarbon fuels [6]. Ethanol (CH<sub>3</sub>CH<sub>2</sub>OH) is more reactive than hydrocarbon fuels, such as gasoline. Since it is an alcohol, its molecular structure shows a polar fraction due to the hydroxyl radical and a non polar fraction in its carbon chain. That explains why ethanol can be dissolved in both gasoline (non polar) and in water (polar). Due to its short carbon chain, the properties of ethanol polar fraction overcome the non polar properties. The formation of hydrogen bridges in ethanol molecule results in higher boiling temperature in comparison to that of gasoline. Ethanol is less toxic than methanol – another alcohol used as fuel. The simple structure of ethanol molecule makes it suitable for spark ignition internal combustion engines operation. The high octane number of ethanol allows for higher compression ratios in comparison to gasoline fuelled engines [7]. In Brazil, ethanol is produced from sugar-cane, a renewable energy source. Sugar cane molasses contains about 40% sucrose, which hydrolysis by an enzyme called invertase produces glucose or fructose. The enzyme is elaborated by brewer's yeast. Ethanol is formed by glucose (C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>) fermentation in the presence of another enzyme called zymase. This is shown in the equations below;



Given the foregoing, the objective of this study was therefore to investigate the performance characteristics of a 2000rpm single cylinder gasoline generator engine using ethanol:gasoline fuel mixing ratios.

## II. METHODOLOGY

### 2.2 Experimental Procedure

#### 2.2.1 Biodiesel Synthesis

Groundnut shells of samnut-38 specie was obtained from institute of agricultural research, Samaru Zaria and taken to the microbiology laboratory Ahmadu Bello University Zaria for synthesis. Groundnut shells are agricultural residues and a readily available source of lignocelluloses. This residue was washed with distilled water and then dried for three days at 60°C in a hot air memmert oven. This was done to reduce the moisture content and make them more susceptible to milling.

The substrate was milled with mortar and pistil, sieved to pass through a mesh sieve. 1500g of the sample was weighed and then soaked in 1% (w/v) sodium hydroxide solution (substrate + solution) for 2hours at room temperature after which it was washed with distilled water and dilute HCL until the wash water was neutral on PH scale. It was then set in memmert oven (Model UE-500 DINII2880) overnight at 60°C to dry. The fermentation medium used for the ethanol production consisted of glucose 8%(w/v) peptone 0.1%(w/v), malt extract 0.1%(w/v), yeast extract 0.2%(w/v), ammonium sulphate 0.2%(w/v) and ferrous sulphate, 0.001%(w/v). 200ml medium culture was prepared and 300ml dispense was added into each 500ml erlenmeyer flask. The flasks were sterilized in an autoclave (Model Astell ASB 300) at 121°C for 15minutes at 151bs pressure and inoculated with 15ml and 4ml containing growth innocula of *S. cerevesiae* and *A. niger* cells and 2 million spores respectively.

The flasks were incubated on orbital shaker (Model vineland NJ SH2-526) with an initial agitation rate of 300rpm at 30°C for seven days. The sample was withdrawn at interval of 24hours for distillation.

#### 2.2.2 Fuel Properties Determination

Fuel properties of tested blends were determined in accordance with American Standard for Testing Materials (ASTM) procedures for petroleum products.

Each fuel sample was evaluated to determine the density, API gravity, heat of combustion. The density of each tested sample was measured by hydrometer method (ASTM D287 Standard). The API gravity was calculated from density results. Heat of combustion was measured in record bomb calorimeter according to PARR 1266 standards, France (ASTM D240).

#### 2.2.3 Engine Performance Evaluation

A load test was done with gasoline and its blends with ethanol as fuel on the Peters PIAW carburetted single cylinder four stroke SI engine with maximum speed of 2000rpm.



Figure 1: A pictorial view of the Peters PIAW S.I engine used in this study.

This was done to obtain a set of performance parameters. The performance parameters were calculated using the following equations:

#### 1. Brake Power

$$BP = \frac{W \times N \times 0.736}{C} \text{ _____ (3)}$$

Where;

BP = Break Power (KW)  
 W = weight reading from scale in kg  
 N = speed of the engine in rpm  
 C = constant 1000

**2. Mass of fuel consumed**

$$mfc = \frac{XCC \times 0.72 \times 3600}{1000 \times T} \text{-----(4)}$$

Where;  
 mfc = mass of fuel consumed  
 XCC = Burette reading in mm  
 0.72 = density of gasoline in gram/mm  
 T = time taken in seconds

**3. Specific fuel consumption**

$$\text{Specific fuel consumption (sfc)} = \frac{mfc}{BP} \text{-----(5)}$$

**4. Actual volume of air sucked into the cylinder**

$$\text{actual air volume suck into cylinder (V}_a\text{)} = 3600 \times C_d \times A \times \sqrt{2gH} \text{-----(6)}$$

Where;

$$H = \frac{h}{1000 \times (\rho_w / \rho_a)} \text{-----(7)}$$

d = 20mm

A = Area of orifice =  $\pi d^2 / 4 = 3.14 \times 10^{-4}$

h = manometer reading in mm

$\rho_w$  = density of water = 1000kg/m<sup>3</sup>

$\rho_a$  = density of air = 1.193kg/m<sup>3</sup>

C<sub>d</sub> = coefficient of discharge = 0.62

g = acceleration due to gravity = 9.81m<sup>2</sup>/s

**5. Swept volume**

$$V_s = \pi d_m^2 / 4 \times L \times N / 2 \times 3 \times 60 \text{-----(8)}$$

Where, V<sub>s</sub> = Swept Volume  
 d<sub>m</sub> = diameter of the bore = 0.0685m  
 L = length of the stroke = 0.072m  
 N = speed of the engine in rpm

**6. Volumetric efficiency**

$$\text{Volumetric efficiency } (\eta_v) = V_a / V_s \times 100 \text{-----(9)}$$

**III. RESULTS AND DISCUSSION**

The Calorific value, density and Specific gravity of Blends of gasoline and ethanol produced from Groundnut shell is presented in the table 1 below.

Table 1: Some Properties of Blends of gasoline and ethanol produced.

S/No	SAMPLE ID (%)	GROSS HEAT (MJ/KG)	INITIAL TEMPT., (°C)	FINAL TEMPERATURE (°C)	SAMPLE WEIGHT (g)	DENSITY (Kg/m <sup>3</sup> )	SPECIFIC GRAVITY
1	E <sub>0</sub>	480.2900	23.7654	26.6705	0.0001	703.5	0.7035
2	E <sub>20</sub>	459.0304	24.1345	25.4115	0.0001	712.3	0.7144
3	E <sub>40</sub>	437.6332	23.9650	24.1783	0.0001	724.2	0.7343
4	E <sub>60</sub>	364.1156	24.9673	25.3214	0.0001	737.9	0.7453
5	E <sub>80</sub>	230.6436	25.3219	26.5336	0.0001	746.7	0.7467

From the results obtained, it was observed that the gross heat of the blend was decreasing with increase in the percentage of ethanol added. On the other hand the density and specific gravity of the blend are increasing with increase in the percentage of ethanol added. This implies that the mass of the synthesized ethanol is higher that of pure gasoline which resulted in the increase of the blends' densities.

3.1 Engine Performance Analysis

For the experiment, the electrical load from the dynamometer was varied and the resultant mechanical load was noted for each sample at various speeds. Tables 2, 3, and 4, given below are for the samples test conducted. Data were obtained based on the engine operating parameters and instrument readings.

Table 2: Specific Fuel Consumption (SFC) at different Engine Speed

Samples Speed rpm	E <sub>0</sub> (kg/Whr)	E <sub>20</sub> (kg/Whr.)	E <sub>40</sub> (kg/Whr.)	E <sub>60</sub> (kg/Whr)	E <sub>80</sub> (kg/Whr.)
1000	0.27	0.31	0.32	0.32	0.34
1200	0.31	0.33	0.36	0.32	0.34
1400	0.32	0.40	0.37	0.36	0.33
1600	0.41	0.39	0.36	0.37	0.33
1800	0.42	0.36	0.35	0.34	0.32

Table 3: Engine Power at different Engine Speed

Samples Speed rpm	E <sub>0</sub> (KW)	E <sub>20</sub> (KW)	E <sub>40</sub> (KW)	E <sub>60</sub> (KW)	E <sub>80</sub> (KW)
1000	1.05	1.45	1.55	1.50	1.35
1200	1.25	1.75	1.70	1.72	1.71
1400	1.85	1.95	2.30	2.15	2.10
1600	1.70	2.25	2.70	2.30	2.35
1800	2.05	2.55	2.70	2.60	2.60

Table 4: Volumetric Efficiency at different Engine Speed

Samples Speed rpm	E <sub>0</sub> (%)	E <sub>20</sub> (%)	E <sub>40</sub> (%)	E <sub>60</sub> (%)	E <sub>80</sub> (%)
1000	0.44	0.47	0.51	0.50	0.49
1200	0.46	0.52	0.53	0.52	0.51
1400	0.52	0.58	0.62	0.59	0.57
1600	0.53	0.65	0.76	0.71	0.68
1800	0.62	0.65	0.89	0.81	0.76

Figure 2 shows the effect of the ethanol fuel blending on the specific fuel consumption (SFC). The specific fuel consumption is slightly increased as the volume percentage of ethanol fuel increases in the mixture. This is due to the lower heating value of ethanol compared with gasoline (Table 2). From the graph, it was observed that the specific fuel consumption increases as the engine speed increases for control, but rises to a peak and fall at higher engine speed for the blends. Maximum specific fuel consumption of 0.4kg/Whr, 0.37kg/Whr and 0.37kg/Whr was obtained for E<sub>20</sub>, E<sub>40</sub> and E<sub>60</sub> at an engine speed of about 1400rpm for E<sub>20</sub> and 1600rpm for samples E<sub>40</sub> and E<sub>60</sub> respectively. For sample E<sub>80</sub>, the specific fuel consumption with respect to speed is almost linear; therefore, approximately constant with only a slight variation for increasing speed.

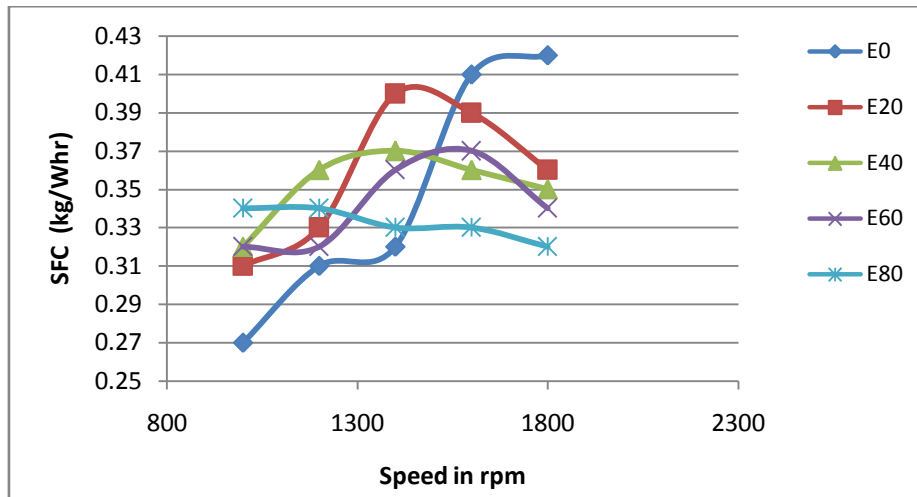


Figure 2: Effect of ethanol blends on the specific fuel consumption

Figure 3 shows the effect of the ethanol fuel blending on the brake power. As the ethanol content in the blend fuel increases, power also dramatically increases. This can be associated with higher heat of evaporation of ethanol compare to that of gasoline. High heat of evaporation can provide cooling for fuel–air charge, hence its density increases. Thus higher power output is obtained from the blends. However, power increase starts to decrease when ethanol content is more than 40%. This is due to the lower heating value of ethanol compared with gasoline (Table 3).

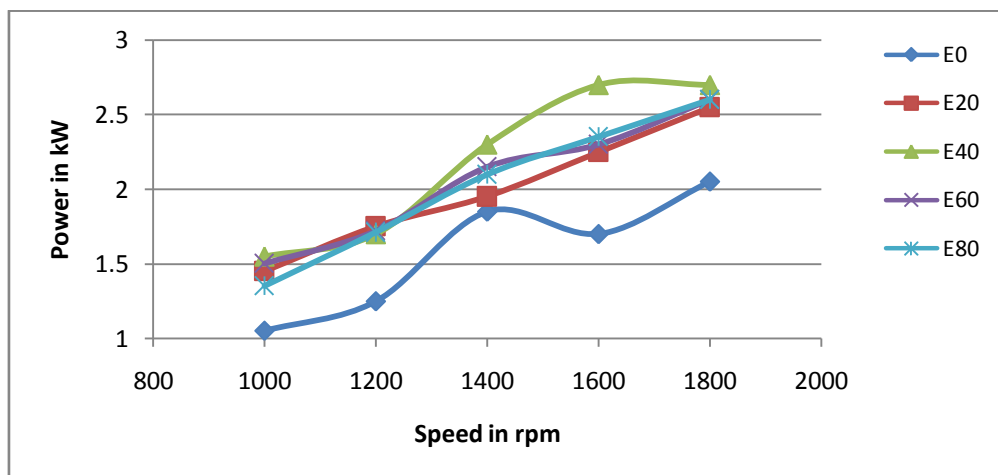


Figure 3: Effect of ethanol-gasoline blends on the engine power

Figure 4 shows the effect of the ethanol fuel blending on the volumetric efficiency. The volumetric efficiency increases as the volume percentage of ethanol fuel increases in the mixture. The heat of evaporation of ethanol is about 2.75 times higher than that of gasoline (Table 4), and this reduces the temperature of the intake manifold, and increases the volumetric efficiency. However, the volumetric efficiency starts to decrease when ethanol content is more than 40%.

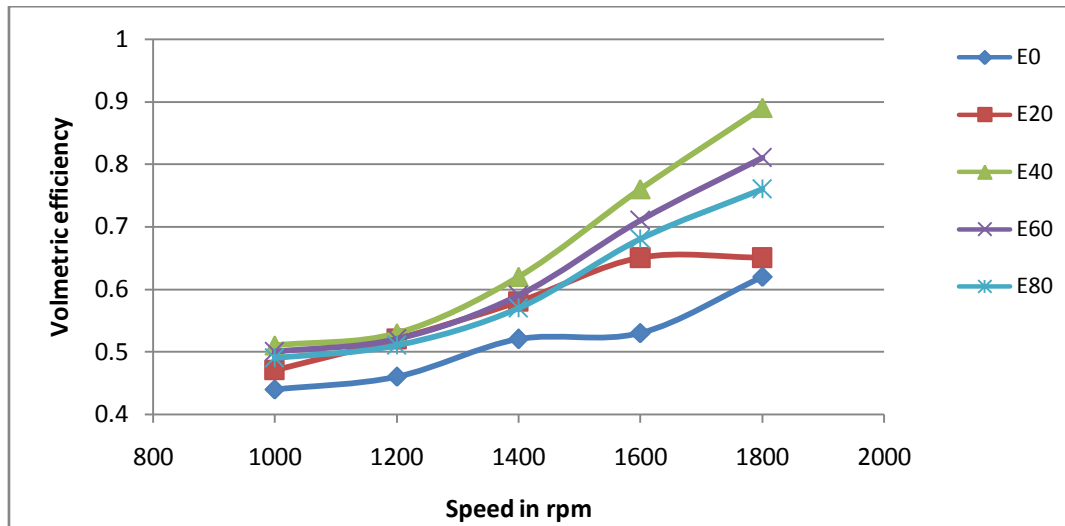


Figure 4: Effect of ethanol-gasoline blend on the volumetric efficiency

#### IV. CONCLUSION

Experiments have been conducted on a single cylinder petrol engine with different percentage of ethanol as additive to gasoline in respect to their performance indicating parameters. It is concluded that, increase in the engine speed causes increase in the rate of fuel consumption for control sample, while it decreases at higher speed for the blends. Furthermore, increase in percentage composition of ethanol increases the engine power and volumetric efficiency while the highest engine power of 2.70KW and volumetric efficiency of 0.76 were obtained from blend E<sub>40</sub>. Thus ethanol may be used as an additive for gasoline engines.

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