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COMPARATIVE PERFORMANCE EVALUATION OF GASOLINE AND ITS BLENDS WITH ETHANOL IN GASOLINE ENGINE

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Abstract

The rapid depletion of petroleum fuels and ever increasing price of them has led to an intensive search for alternative fuels. Biofuels being renewable and ecofriendly are attracting growing interest around the world. Ethanol (C_2H_5OH), an alcohol found to be a promising alternative fuel for gasoline engine. Ethanol is an attractive alternative fuel and blends can be used as fuel in order to substitute some part of gasoline. In this research work, procedures of measuring fuels have been used to blend the ethanol produced from sugar cane with gasoline and base fuels used for the experiment. Properties of ethanol-gasoline blended and base fuel were first examined by the standard ASTM test methods D86, D130, ES626:2008 (ANNEXB), ES640:2001 (ANNEXA), D323, D1298 and fuel was blended in different volume rates E0, E5 and E10. Moreover, the experimental comparative performance evaluation are tested and evaluated at 8:1 compression ratios. The performance and exhaust emission were carried out on gasoline engines by using TD43F variable compression engine test rig and Exhaust gas analyzer 5000 and the following test results were summarized. Best performance with maximum reduction is 2.9% P_b is obtained for all samples for the compression ratio of 8:1 at speed of 2000 rpm. Blending increases η_b for compression ratio of 8:1. Compression ratio of 8:1 is recommended to use E10.

***Keywords*:** Ethanol, compression ratio, Performance, emissions

1. Introduction

The rapid depletion of petroleum fuels and an era of ever increasing price of them has led to an intensive search for alternative renewable fuels. Bio-fuels are attracting growing interest around the world, as a way to both reduce green house gases (GHG) and dependence on petroleum-based fuels. The most promising substitutes for petroleum fuels are alcohols mainly, ethanol and methanol for extending additive and replacing gasoline. Alcohol has been used as a fuel for auto-engines since 19th century. These alcohols can be readily made from a number of non-petroleum sources.

Ethanol (C_2H_5OH) or ethyl alcohol can be produced by fermentation of carbohydrates, which occur naturally and very abundantly in some plants like sugar cane and from starchy materials like maize, potatoes. Hence these fuels can be produced from highly reliable and long lasting, renewable raw material sources. Ethanol is an attractive alternative fuel and ethanol-gasoline blends can be used as fuel in order to substitute some part of gasoline in engine applications. Ethanol fuel is ethanol (ethyl alcohol), the same type of alcohol found in alcoholic beverages. It can be used as automobile engine fuel, mainly as a biofuel additive for gasoline. Bioethanol, unlike petroleum, is a form of renewable energy that can be produced from agricultural feed stocks.

Blending of ethanol with benzene in Ethiopia, which saves over 1.8 million dollars in foreign currency of the country so far, was interrupted for three months due to the major ethanol provider sugar factory was shut down for maintenance. Ethiopia's biggest sugar factory, Finchaa, one of the three state-owned factories, has been producing up to eight million liters of ethanol in this year (2010/2011).

Finchaa was ceased ethanol production on Thursday September 3rd, 2009, after supplying its product for exactly one year to Nile Petroleum Ethiopia, which is the sole oil blending company in the Ethiopia. As a result of interruption of ethanol production, the price of benzene in the country is expected to rise significantly when the blending stops.

Ethanol can be blended with gasoline in varying quantities up to pure ethanol (E100), and most spark-ignition gasoline engines will operate well with mixtures of 10% ethanol (E10).

This research deals with experimental comparative performance evaluation of gasoline engine using pure gasoline and ethanol-gasoline blended fuels at blended rate of E0, E5 and E10 ethanol on conventional internal combustion(IC) spark ignition (SI) gasoline engine of different compression ratios.

2. Materials and Methods

The methodology which was followed to meet the objectives of the research study. Bioethanol blending Characterization of samples used, Engine tests with ethanol blends as fuels and Data analysis.

2.1 Blending of Fuels

Blending: -Blending is the process of obtaining a product of desired ratios by mixing certain product in some suitable proportion. Samples of blended fuels E5, E10 in table 2.1as below.

Table 2.1 Blending fuels for E5 and E10.

S/N	Type of fuel	Amount in liter/s	Total amount in liters	Designation of blended fuels
1	Gasoline Ethanol	9.5 0.5	10	E5
2	Gasoline Ethanol	9 1	10	E10

2.2 Characterization of Samples Used

The sample of E0 and E100 with the ratio of E5 and E10 were blended which was required for the experiment and the samples were taken to the Ethiopian petroleum Enterprise and EAEDPC for laboratory characterization of the properties of the blended fuels and Pure gasoline. So result only shows the samples tested and blended used for the experimental study.

2.3 Engine Test with Ethanol as Fuels

The experimental program was carried out using a TD43F Variable Compression engine Test Rig (TQ brand) figure1.2 below. The specifications of tested engine are given in table-2.2. Fuel consumption is measured by timing the flow through a graduated pipette; time was recorded until 8ml was consumed while the engine was operating at a pre set engine speed in rpm and respective torque. Then the given 8ml was divided by the time recorded to obtain the volumetric fuel flow rate at the specified rpm. This value was multiplied with the density of the tested fuel to get the fuel mass flow rate.

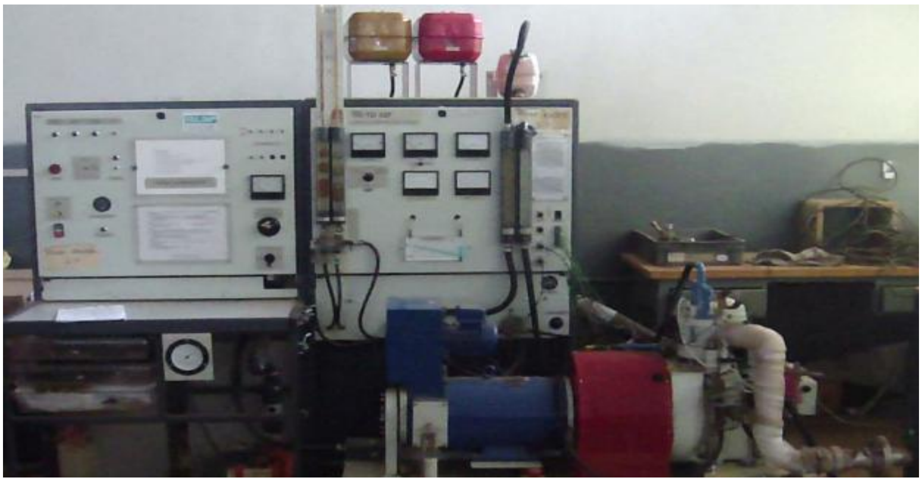


Figure2.1 TD43F variable compression ratio of engine test rig.

Table 2.2 Tested engine Specifications.

Parameter	Unit
Brake power @rated speed	9.5KW@ 2500 rpm
Maximum Torque	45Nm
Type of Engine	Single cylinder, Spark ignition and 4 Stroke
Compression Ratio	5:1 to 11:1 but adjusted @ 8:1
Bore& Stroke	95mmx82mm
Swept volume	$582X10^{-6}m^3$
Method of Starting	Electric motor cranking
Method of loading	Eddy current Dynamometer
Method of Cooling	Water cooling
Ignition timing	30°BTDC to 10°ATDC but adjusted @15°BTDC
Type of Ignition	Spark ignition
Recommended spark plugs	G-63
Lube Oil	SAE 40

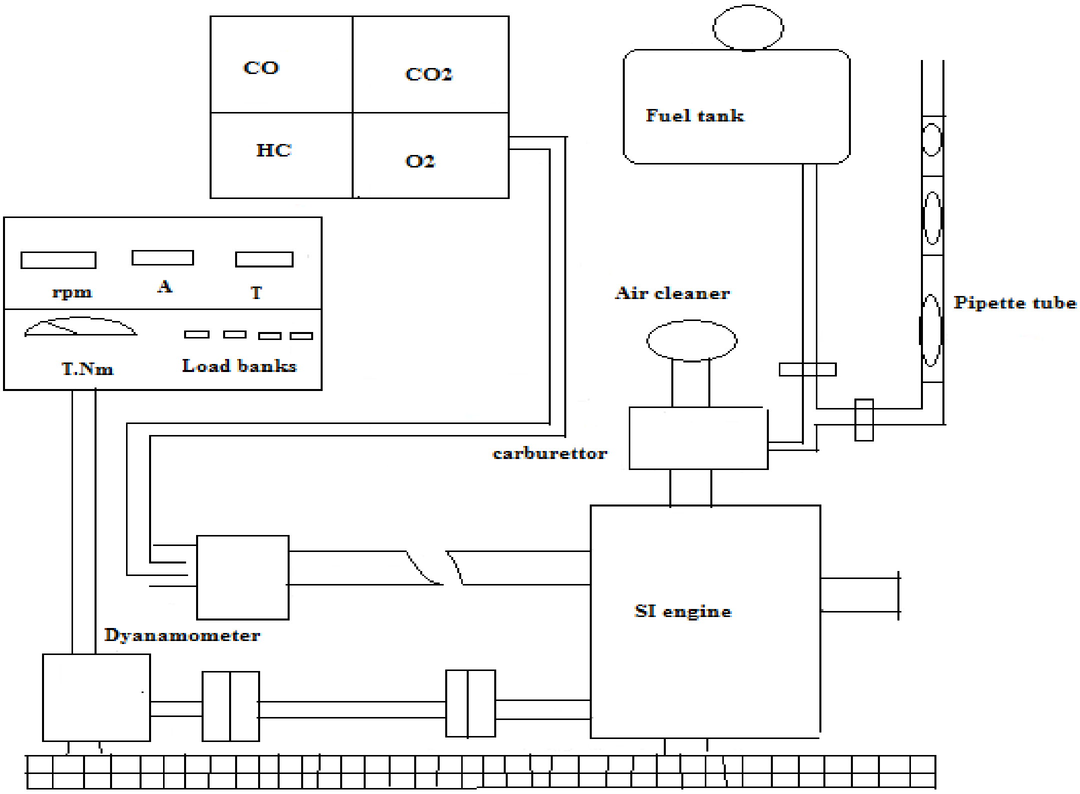


Figure2.2 Engine test Experimental set up illustration

3. Test Results and Discussions

3.1 Important Properties of Tested Base Fuel and Blend

Table 3.1 Important properties of tested E0, E5 and E10

S/N	PROPERTY	TEST METHOD ASTM	LIMITS	TEST RESULT FOR REGULAR GASOLINE	TEST RESULT FOR E5	TEST RESULT FOR E10
1	Density @15℃,g/ml	D1298	Report	0.7401	0.7436	0.747
2	Density @20℃,g/ml	D1298		0.736	0.7395	0.7429
3	Distillation	D86				
	IBP			38.5	39.5	38.5
	10% volume, recovered, ℃		Max.70	54	53	53
	50% volume, recovered, ℃		77-121	103	103	90
	90% volume, recovered, ℃		Max.190	175.5	174.5	175.5
	FBP		Max.225	219	220.5	214
	Residue % vol.		Max.2.0	1.4	1.4	1.4
4	Ethanol content, % by volume) max.	ES625:2008 (ANNEXB)	Max.10	-	5	10
5	Water tolerance	ES640:2001 (ANNEXA)	No phase separation shall be observed	-	Pass	Pass
6	Reid vapor pressure at 37.8℃KPa	D323	Max.69	53.78	51.02	34.47
7	Copper strip corrosion 3hrs @50℃	D130	Max No.1	1a	1a	1a
8	HHV of the sample cal/g			10175.99	9760.75	8857.33

3.2 Performance Characteristics

3.2.1 Brake Power (P_b)

$$P_b = \frac{2\pi NT}{60000} \text{ (Kilowatt)}$$

The data from the engine using E0, E5 and E10 was put in the table and graphically as below for 8:1 compression ratios. A close resemblance of brake power (P_b) output was observed at engine speeds of 2000 rpm for the fuels E0 and E5. With E5 more brake power (P_b) output was obtained at engine speeds of 1250 rpm and 2500 rpm than the others.

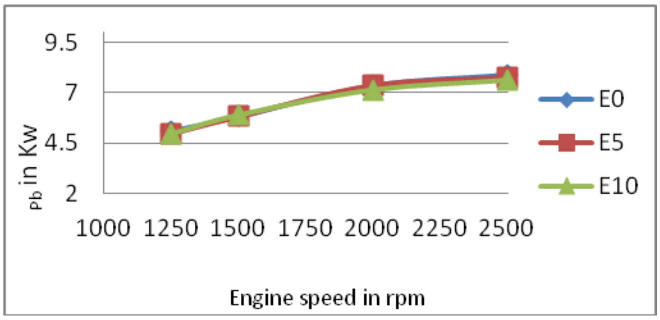


Figure 3.1 P_b output against engine speed at compression ratio of 8:1

3.2.2 Brake Torque (T_b)

In general E0 had maximum T_b at 1250 rpm and minimum at 2500 rpm, where E5 had maximum brake torque at 1250 rpm and minimum at 2500 rpm, E10 had minimum brake torque at 1250 rpm but maximum at 2000 rpm.

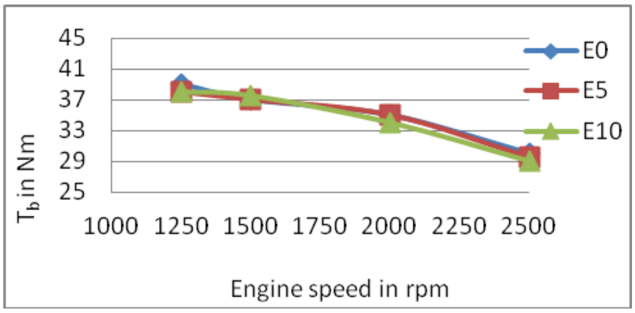


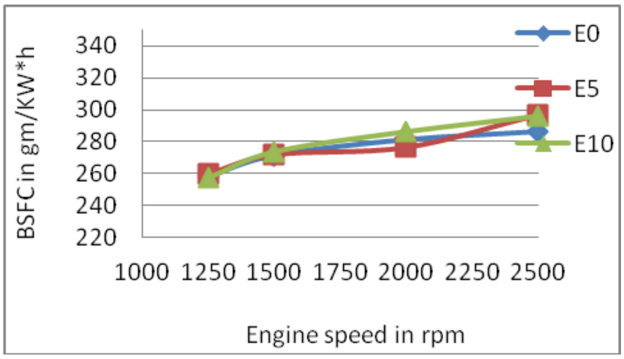
Figure3.25 T_b output at compression ratio of 8:1

3.2.3 Brake Specific Fuel Consumption (Bsfc)

The rate of fuel consumption is determined by allowing the engine to draw fuel from the pipette, using a stopwatch to time the consumption of 8ml of fuel.

$$\text{BSFC} = \frac{\text{consumption of fuel}\left(\frac{\text{mass}}{\text{unit time}}\right)}{\text{brake power}} \text{ or } \frac{m_f}{\text{brake power}} \text{ g/KWh)}$$

The fuel consumption had increased as blends percentage increased in the test with engine speed. The increased in BSFC for bioethanol blends was understandable as the bioethanol has less energy than pure gasoline. The higher the bioethanol content in the blended fuel, the lower heating value, results in higher BSFC.



3.2.4 Brake Thermal Efficiency (η_b)

Brake thermal efficiency is a measure of the efficiency of conversion of the fuel calorific value in to power. A measure of the overall efficiency of the engine is given by the brake thermal efficiency, defined as:

$$\eta_b = \frac{\text{brake power}}{\text{energy supplied}}$$

$$= \frac{\text{brake power}}{m_f \text{ (lower calorific value of the fuel)}} = \frac{1}{sfc \text{ (lower calorific value of the fuel)}}$$

$\frac{LHV}{HHV}$ = 0.91 for gasoline fuels. So lower calorific valve of fuels is as follows:

E0 = 39162.0229 KJ/Kg, E5 = 37566.711 KJ/Kg., E10 = 34087.1804 KJ/Kg

The brake thermal efficiency, is therefore, inversely proportional to the specific fuel consumption. Brake thermal efficiency in % for compression ratios of 8:1 is as given below.

E0 had maximum η_b at around 1250 rpm up to medium speed. E10 was with the highest thermal efficiency at around 1250 rpm and shown decreasing tendency with increase in speed. E10 had higher η_b than any other fuel used through the entire speed range. The efficiency with E5 fell in between E10 and E0.

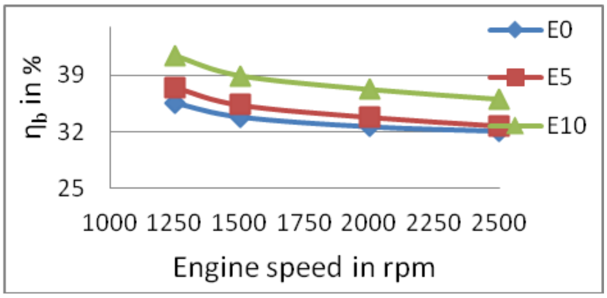


Figure3.5 η_b compression ratio of 8:1

3.2.5 Air/Fuel Ratio

The air/fuel ratio is defined as the mass flow of air divided by the mass flow of fuel. At around of 1500 rpm- 2000 rpm reference and the blended fuels had approximately same air/fuel ratios.

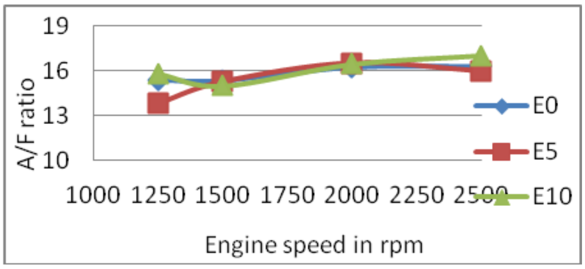


Figure 3.6A/F ratio at compression ratio of 8:1

3.3 Exhaust Emission Characteristics

Exhaust emissions at compression ratios 8:1 also considered as performance parameters for comparison of the fuels used in the experimental study.

3.3.1 Carbonmonoxide (Co) Emissions

At low speed of 1250 rpm all the fuel had the same CO emissions but up to medium engine speeds CO emissions of the blends for E5 and E0 are approximately the same.

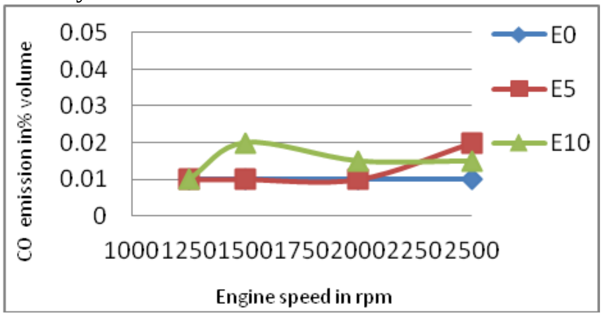


Figure 3.8 CO emission at compression ratio of 8:1

3.3.2unburned Hydrocarbon (Uhc) Emissions

UHC for E5 is the same at low speed of 1250 rpm and even low emission in the medium speed of 2000 rpm, which almost similar to E10 at maximum speed. But UHC for E10 was low at speed of 1250 rpm and high at speed of 1500 rpm but it was the same UHC at around 2500 rpm with E5.

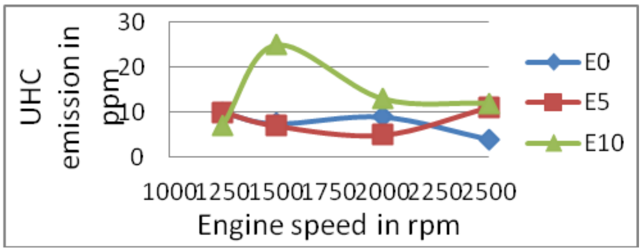


Figure3.9 UHC emission at compression ratio of 8:1

3.3.3 Carbodioxde (Co_2) Emissions

The amount of CO_2 emission for E10 is higher than all the fuels used in the experiment other than at low speed of 1250rpm. But for E0, CO_2 emissions decrease as engine speed increases. In the case of E5, CO_2 emissions are lower from lower to the medium speed and higher of all at maximum speed of 2500 rpm.

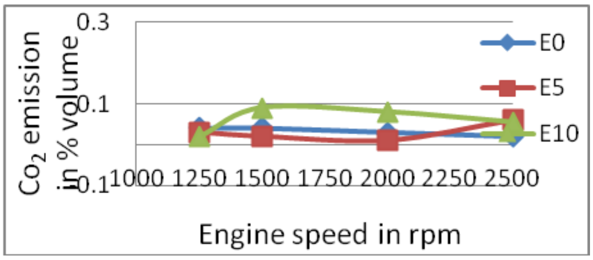


Figure 3.10 CO_2emission at compression ratio of 8:1

3.3.4 Oxygen (O_2) Emissions

A big variation with non uniform distribution was observed between the pure gasoline and blends. This implies combustion for gasoline was showing homogeneous and very complete combustion.

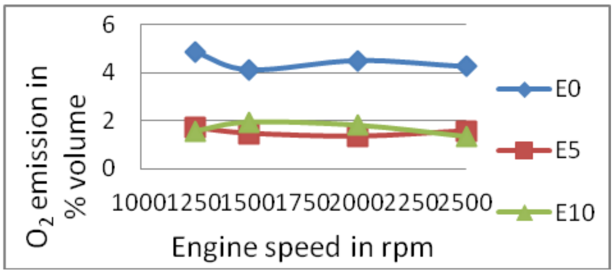


Figure 3.11 O_2 emissions at compression ratio of 8:1

4. Conclusions and Recommendations

The main aim of the study was to compare and evaluate the performance and emission of ethanol-gasoline blends and gasoline in single cylinder four stroke gasoline engine at three different compression ratios.

4.1 Based on The Some Properties Characteristics

Bioethanol handling and storage is the same as E0 as density of blends slightly higher than E0 and Initial boiling point is nearly the same no starting problem was seen. Blending was done manually the expected alcoholic content was good and proofed to the rated. Due to samples used was water free no engine installing during operation. Even Reid vapor pressure for E10 was lower for E10 no starting problem was phased due to lower volatility. Copper corrosion test is the same for all samples, so degree of corrosivity increases from 1 to 4, for hydrocarbon used for application of automobile is (1a to 3a). E10 had lower HHV than E0 with 12.96%, so fuel consumption increased. In general the blends were within the limit in their properties when compared to E0, so the blends can be used.

4.2 Based on the Performance Characteristics

P_b output at compression ratio of 8:1 and max. reduction in P_b output is 3.3% for E10. All samples have performed well at compression ratio of 8:1. BSFC was better for blends at compression ratio of 8:1. BSFC was similar for blends and E0 at compression ratio of 8:1. η_b is max. For blends, as % of blending increases than E0 at compression ratio of 8:1.

4.3 Based on the Emission Characteristics

CO emission for E0 and E5 approx. the same at compression ratio of 8:1. E10 had more UHC emission at 8:1 than E0. CO_2 emission is more for E10 at 8:1. O_2 emission is higher at 8:1 for E0 than blends.

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