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Full Length Research Paper

Physico-chemical properties of bio-ethanol/gasoline blends and the qualitative effect of different blends on gasoline quality and engine performance

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Physico-chemical and operational properties of various gasoline bio-ethanol blends were evaluated. Bio-ethanol was obtained through distillation from maize (*Zea mays*), sugar cane (*Saccharum* L), raffia (R*affia vinefera*) wine, and palm wine and then purified using a rotavapor. Engine trails involved combinations of various ratios of gasoline/bio-ethanol as fuel in a small unmodified gasoline engine connected to a dynamometer. The vapour pressure, octane number, flash point, specific gravity, and energy density of various compositions of the blends were evaluated. Sugar cane gave the highest yield of alcohol 97.99 g per kg of produce while the lowest amount of alcohol of 10.5 ml per kg of produce was obtained from palm wine. Engine power decreased from 0.400 kW with 100% gasoline as fuel to 0.108 kW with a gasoline ethanol ratio of 1: 10. The octane number increased from 93 at E10 to 106 at E90. The energy density decreased from 33.180 MJ/l at E10 to 23.600 MJ/l at E90. Other physical observations suggest that to successfully run a gasoline engine with bio ethanol/gasoline blends some modifications would have to be done on the engine, including advancing of ignition timing, provision of air tight fuel conduit network, and modification of piston heads to improve pre-combustion fuel homogenisation.

Key words: Ethanol gasoline blends, bio-ethanol, octane number, bio-fuels, renewable energy.

INTRODUCTION

The prices of petroleum products are generally on an increasing trend and consequently affecting the general cost of living. This continuous increase has resulted in the prices of some products tripling in the last decade. In some communities, in the developing nations these products are not only expensive but they are not readily available because of the poor road infrastructure necessary for their distribution. The consumption of petroleum products also has other inconveniencies such as environmental pollution and the emission of green house gasses generally believed to be responsible for global warming. The general trend all over the world now is to reduce the over dependence on petroleum products so as to help reduce the effects of global warming. Other possible advantages of abandoning petroleum products is the fact that alternative sources can be produced from renewable resources that are available almost everywhere that there is life. This avoids the employment of heavy infrastructure for long distance transportation and distribution.

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Abbreviations: $\mathbf{M_m}$, mass of the maize (kg); $\mathbf{V_b}$, Volume of beer (l); $\mathbf{R_1}$, specific yield (l kg^{-1});$\mathbf{V_{al}}$, Volume of alcohol (l); $\mathbf{R_2}$, Specific yield (%); **R,** juice yield, l kg^{-1}; $\mathbf{V_j}$, quantity of juice obtained(l); $\mathbf{M_s}$, mass of the sugar cane used (kg).

The need for alternative sources of energy especially those that can be produced and utilized in enclave areas cannot be over emphasised. Amongst the various alternatives that are attracting attention today, is the use of ethanol as fuel for the motor vehicle engine.

Various fractions of ethanol are already being used in many countries around the world to blend with gasoline and diesel. Proponents of this technology argue that an alcohol fuel provides high quality, low cost fuel for exceptional engine performance (RFA, 2001). Ethanol-blended fuels account for approximately 30% of all automotive fuels sold in the U.S. and ethanol acts as antifreeze in the engine during winter (RFA, 2001). This high quality and high-octane fuel is capable of reducing air pollution and improving automobile performance (Wei-Dong et al 2002; Al-Hassan 2003). One of the major advantages of using ethanol as fuel for the car is that it is a renewable source of energy with possibilities of sustainable production and exploitation.

The problem however is that of other aspects surrounding the use of ethanol blended gasoline. Ethanol has some lower physico-thermal characteristics when compared to gasoline. The effect of blending these two fuels at different ratios on engine performance serviceability and service life has not been published. What are the necessary modifications that have to be made on a modern compression ignition engine if this potential fuel is to successfully replace or complement petroleum fuels? There is a considerable dearth of knowledge on the physico-chemical properties of various compositions of gasoline ethanol blends. Many trails and development exercises have been carried out in many countries around the world but very little data is available for designers.

Earlier work, such as that of Johansen and Schramm (2009), investigated the low-temperature miscibility of ethanol gasoline-water blends in flex fuel applications at -25 and -2°C. It was found out that the blend can be successfully used without phase separations within the tested temperature range. A study of some fuel properties of ethanol blended with diesel was carried out by Ajav and Akingbehin (2002) and it was concluded that ethanol blend percentages of up to 20% had acceptable fuel properties for use fuel in farm machines. This has also been confirmed by RFA (2001) and Amulya et al. (1997). The performance and pollutant emissions of a four stroke SI engine operating on ethanol blends of 0, 5, 10 , 15 and 20% fuel using artificial neural network was investigated by Kiani et al. (2010), Najafi et al. (2009) and Mustafa et al. (2009). They found a decrease in CO and HC emission with the introduction of ethanol into gasoline.

Although there has been a wide spread call for the production of bio-ethanol for engine fuel, the performance of the engine with this fuel seems not to have been mastered by the technological industry. The call for bio-ethanol seems to be politically motivated and is aimed at fuel autonomy, decreasing dependence on foreign oil, environmental sanitation and less on machine life and fuel performance. Bio-ethanol has unavoidable anti fuel characteristics like moisture, lower calorific value and a higher flash point. What are therefore the effects of the various blends on these characteristics and what is the best suitable mixture?

This study was carried out in order to:

(1) Publish the physico-chemical properties of a wide range of ethanol gasoline blends.
(2) Investigate the amount of bio-ethanol obtainable from some tropical bio products.
(3) Determine the performance of an unmodified gasoline engine using various blends.
(4) Propose necessary modifications that have to be carried out on the modern SI compression engine if this fuel is to partially or fully replace gasoline or diesel.

The study would help energy stake holders in mapping out the choice of strategies towards energy self sufficiency using bio-ethanol. Many developing countries that are not car manufacturers would like to be involved in bio-ethanol production for car use. However, they soon discover that for bio ethanol to be successfully used in blending engine fuels, the car manufacturing industry has to be aware ahead of time to make the necessary modifications on the engine. These modifications depend on the physico-chemical properties of the bio ethanol/ gasoline ratio that is chosen. While much work has been done on this area in countries like Brazil and the United States of America, very little data is published on the effects of a wide range of mixtures on the physico-chemical properties of the blends.

METHODOLOGY

Substrates and production of ethanol

Sugar cane

The stems of the cane were cut into pieces of length 25 cm each. This was to make sure that they would go into the hydraulic press used in the extraction of the juice. The pieces were weighed on a balance of sensitivity 0.01 g. Pressure applied on the cane was of the order of 70 MPa until all the mechanically extractible juice was expelled from the cane. The juice was collected and the volume measured in a graduated cylinder. The juice yield of the cane was expressed using Equation 1.

$$R = V_j / M \qquad (1)$$

where R is the juice yield in L kg^{-1}; V_j is the quantity of juice obtained in L ; and M is the mass of the sugar cane used kg.

The juice obtained was diluted which double the volume of water and one litre of the mixture put inside a 1.5 L plastic bottle, sealed air tight and left for fermentation. These bottles were left for 12 days under ambient temperatures between 18 to 22°C with distillation trials being carried out each day until it was clear that there would

Table. 1. Composition of bio-ethanol/gasoline blended samples used for analysis.

Sample code	% Ethanol	% Gasoline
E10	10	90
E20	20	80
E30	30	70
E40	40	60
E50	50	50
E60	60	40
E70	70	30
E80	80	20
E90	90	10

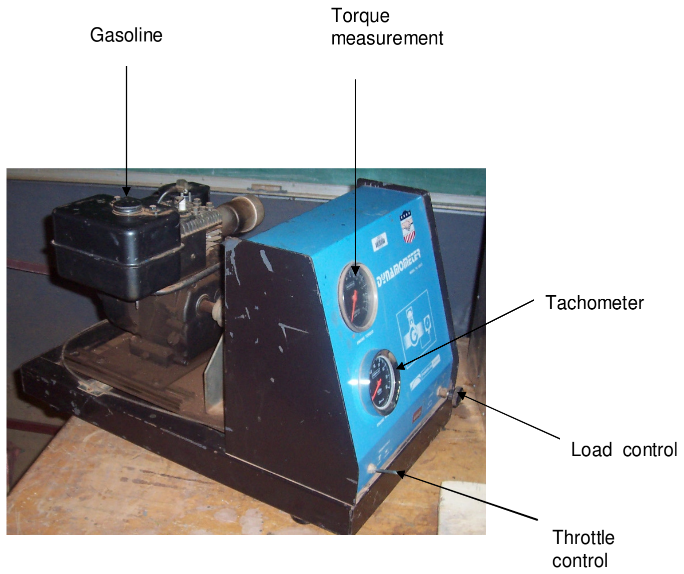

Figure 1. Dynamometer and engine assembly used to test the performance of bio-ethanol/gasoline blended fuel.

be no further increase in the yield of alcohol produced.

Palm wine

Wines obtained using the traditional method from *Elaeis guineensis* and from *Raphia vinifera*, were tested. The traditional method involves cutting the shoot of a central stem in a mature cluster of palms and attaching a container for the collection of the sap. The sap or wine that comes out is usually sweat and becomes very alcoholic as days go by. Different samples obtained from palm bushes in the western region of Cameroon were used. One litre of each wine was put in 1.5 L plastic bottle and sealed airtight. Fermentation was done at 18 to 22°C for 14 days with distillation trials on samples every day until alcohol production became maximum.

Maize

The grains were weighed on a sensitive balance and then soaked in water for 24 h and washed thoroughly. They were then aerated on a platform in a shade during which the seeds were watered every morning and evening. This was to provoke the germination of the seeds. The germinated seeds were then sun dried to moisture content of 7% and then milled to obtain corn flour. The milling process was made to provide finely ground grain so that the starch would easily absorb water. The flour was then soaked in water for 30 min, stirred and left for about 2 h for the starch to settle. After this excess water was drained from it and the paste was boiled slightly and the drained water was re-added to it and was left for 12 h. The substrate was sieved from the water and the remaining water boiled again for two hours. The liquid was then filtered and fermented to obtain malt. The specific yield R_1 of alcohol in litres per kg of maize was estimated using Equation 2 and the percentage specific yield was estimated using Equation 3.

$$R_1 = Q_b/M_m \tag{2}$$

where M_m is the mass of the maize kg; Q_b is the quantity of malt in L; and R_1 is the specific yield L kg^{-1}

$$R_2 = \frac{Q_{al.} \times 100}{Q_b} \tag{3}$$

where Q_{al} is the quantity of alcohol L; Q_b is the quantity of malt, and R_2 is the specific yield %.

Distillation step

The prepared substrates were distilled in a Liebig condenser while heating the liquid in a 3 L round bottom flask and the temperature of the water in the heating jacket was set at 90°C. The temperature was first adjusted until the boiling point of methanol, 53°C in order to separate possible methanol from the final product. The distillate made of water and ethanol was collected at a temperature of 90 to 91°C and this temperature was maintained until there was no more alcohol condensing in the system. The distillate, a mixture of water and ethanol also known as azeotrope was collected in a graduated cylinder and then purified in a rotavapor to obtain 95% pure ethanol.

Nine blends of ethanol gasoline mixtures were used. The blends are usually referred to as EX, where E represented bio-ethanol and X represented the percentage of the bio ethanol in the blend. For example, E10 means a blend composition in which bio ethanol is 10% and gasoline is 90%. The various compositions are shown in Table 1.

Dynamometer/engine calibration

During the engine trails, various ethanol gasoline blends were used as fuel to run a small gasoline engine attached to a dynamometer and the break power developed by the engine was computed using the torque output and the maximum engine speed developed. Before this was done it was necessary to calibrate the equipment using gasoline only as fuel.

The equipment used was a 4 hp engine attached to a dynamometer of the type Power Lab PL 100D. The engine dynamometer assembly is shown in Figure 1. This dynamometer consisted of a fined rotor mounted in cradle housing. The engine being tested was attached to drive the fine rotor section as described in the PL-D dynamometer laboratory and technical manual. During tests water was introduced into the dynamometer under pressure into the water absorption unit mounted in an

Table 2. Ethanol production from maize grain.

Trial	Quantity of malt (L)	Quantity of ethanol (cl)	Ethanol yield (cl/L)
1	4.55	12.50	2.75
2	5.10	15.00	2.97
3	5.00	16.50	3.30
Mean	4.87		3.01

adjustable bracket system. As the engine being tested had to pump the water, this placed a load on the engine and the load was varied by decreasing or increasing the water in the system. The outward movement of the water caused the housing to rotate in its cradle and a scale attached to the housing enabled the torque to be measured using a load cell and a bourdon tube gauge. The said system was designed to measure brake horsepower and torque at various data points throughout the speed range of the engine being tested. The mechanical energy of the engine was converted into heat energy in the form of hot water. As the hot water left the dynamometer, the system was cooled and therefore no auxiliary cooling was required.

The values obtained during calibration were taken, as standard values so that the readings obtained using different fuel combinations would be compared to these.

Fuel combustion rate

The fuel consumption characteristics of the engine were studied using various combinations of ethanol gasoline/ethanol blends as shown in Table 1. This was necessary in order to determine the effect of the various blends on mileage. The engine was maintained at constant acceleration. The rate of fuel consumption was determined using the following equation:

$$\mathrm{F_r} = \frac{V_f}{T} \tag{4}$$

where F_r is the average fuel consumption rate of the engine (litres / hour); V_f is the volume of fuel in litres; and T is the time used in consuming the fuel in hours.

Measurement of physico-chemical properties

The flash points of the blends were measured using the Pensky-Martens closed cup method as detailed in ASTM D93 as described by Ajav and Akingbehin (2002). The octane number of the various blends was measured using a portable cetane/octane meter adapted to ASTM D 2699-86 and D 2700-86 methods while the energy densities of the different gasoline ethanol blends were determined by burning a known amount of blend in a Gallenkemp ballistic bomb calorimeter. The specific gravity of the various bio-ethanol/gasoline blends was determined using the specific gravity bottle as described by Ajav and Akingbehin (2004). The vapor pressure of the blends was determined using the ASTM test method D4953-99a standard test method for vapor pressure of gasoline and gasoline oxygenated blends (dry method). The experimental set up was similar to the one described by Kar et al. (2009). The auto ignition point was measured according to the procedure described in ASTM E659.

RESULTS AND DISCUSSION

Results of specific bio ethanol yield from each crop are shown in Tables 2, 3, 4 and 5. Analysis of the ethanol production from maize (Table 2) grain shows that a kilogram of this maize variety would produce about 10.58 cl of the ethanol 95°or about 1.06 L from 1 per kg of maize. Grain ethanol yield from maize literature shows a lot of variation. Grain ethanol yields of 64 L of ethanol from 100 kg of maize of grain or about 0.64 L per kg (Zeinlin'ska et al., 2009). Research at the University of Arkansas reports more than 3.90 L of ethanol from per kg of maize. Therefore the ethanol yield obtained in this investigation was lower. This could be due to the variation in species and agronomic practice. This is confirmed by Persson et al. (2009, 2010) who stated that the production potential of ethanol from maize varies with weather and climatic conditions as well as crop management practices The maize used for the experiments was locally grown by the villagers with probably very little scientific input. No literature was available for comparison of alcohol yield from palm wines and raffia wine shown on Tables 4 and 5. From Figures 2 and 3, it can be seen that the yield of ethanol is the maximum after three days of fermentation. The maximum for palm wine is about 3.2 cl/L, while the maximum yield for raffia wine is 1.2 cl/L. The maximum yield of alcohol for sugar cane juice is about 100 cl/L and for corn it was about 3.33 cl/L of malt. After three days of fermentation, the alcohol yield drops considerably for all the four substrates. This can be explained by the fact that after three days of fermentation, oxidation reactions proceed in the formation of acetic acid and ethanoic acid, thereby decreasing the alcohol yield. Alcoholic fermentation is catalysed by yeasts. The drop in alcohol production is due to the action of vinegar production bacteria. They are as abundant as yeast in nature and they feed themselves on the alcohol and produce acetic acid. Table 6 shows the results of the calibration experiment. As the loading increased, the speed of the engine decreased and the break power developed increased. The maximum power developed was about 405.0 W corresponding to an engine speed of 1900 rpm. The engine developed the lowest power of 136.3 W at a maximum engine speed of 2400 rpm. These values were used to standardise the engine/dynamometer assembly since the unmodified engine was designed to run with E0 or 100% gasoline.

Table 3. Production of ethanol from sugar cane juice.

Trial	Mass of sugar cane (kg)	Quantity of juice (L)	Quantity of water added (L)	Quantity of ethanol (cl)	Ethanol yield (cl /kg) of sugar cane	Ethanol yield cl/L of sugar cane juice
1	4.234	1.90	4.0	190	44.87	100.00
2	4.574	2.19	4.0	208	45.47	94.98
3	4.312	1.94	4.0	192	44.52	98.99
Mean	4.473	2.01	4.0	192	44.08	97.99
SD					0.48	2.66

Table 4. Ethanol production from fresh palm wine.

Trial	Quantity of palm wine (L)	Quantity of ethanol (cl)	Ethanol yield (cl/L)
1	3.00	13.50	3.50
2	4.00	13.80	3.45
3	5.00	17.50	3.50
Mean	4.87		3.48
SD			0.03

Table 5. Ethanol production from fresh raffia wine.

Trial	Quantity of raffia wine (L)	Quantity of ethanol (cl)	Ethanol yield (cl/L)
1	3.00	3.6	1.20
2	4.00	4.9	1.23
3	5.00	5.8	1.16
Mean	4.87		1.20
SD			0.04

Table 6. System calibration using gasoline as fuel.

Load (turns)	Torque (Nm)	Speed of rotation (rpm)	Break power (Watt)
0	0.0553	2400	136.30
1	0.0553	2300	130.57
2	0.0691	2200	155.85
3	0.1659	2100	357.79
4	0.1936	2000	397.46
5	0.2074	1900	404.62

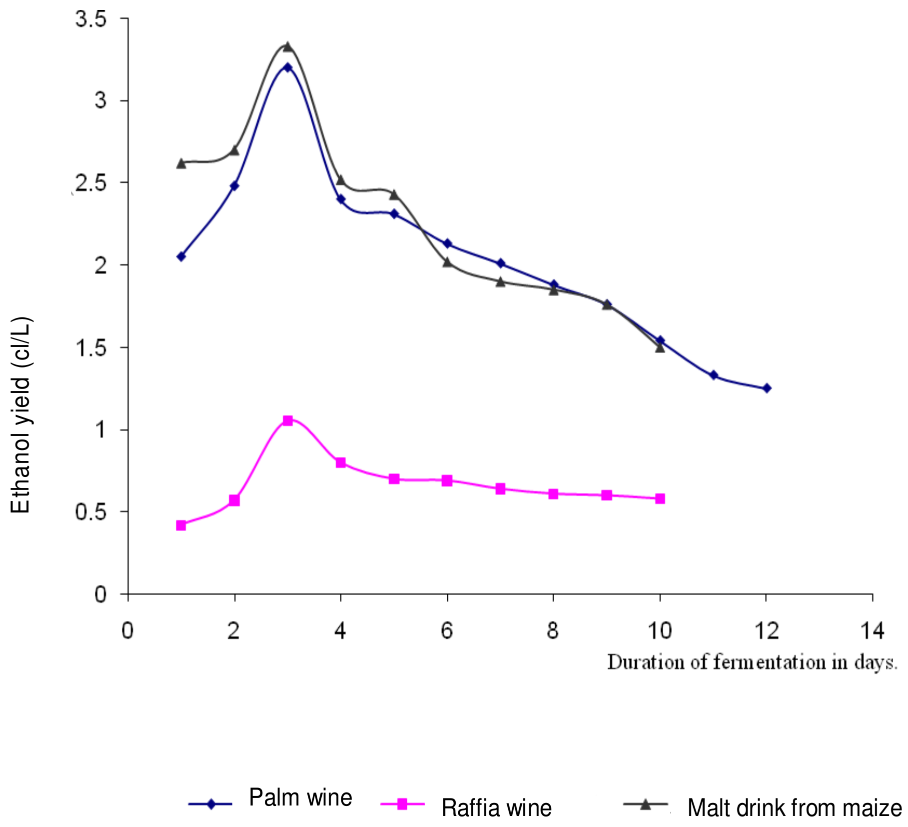

Figure 2. Variation of ethanol yield with duration of fermentation of three bio-materials.

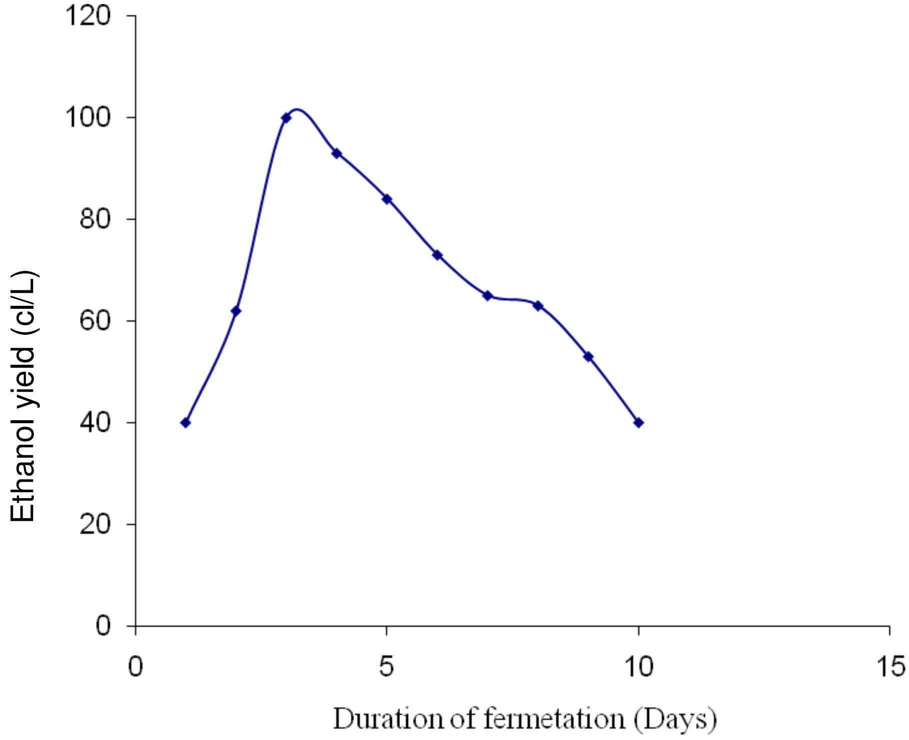

Figure 3. Variation of ethanol yield with duration of fermentation of sugar cane juice.

Table 7. Properties of gasoline fuel blended with various percentages of ethanol (Average values).

Sample code	% Ethanol	% Gasoline	Flash point (℃)	Auto ignition temperature (℃)	Vapour pressure (Kpa at 37.8℃)	Energy density (MJ/L)	Octane number	Specific gravity
E0	00	100	-65	246	36	34.2	91	0.7474
E10	10	90	-40	260	38.9	33.182	93	0.7508
E20	20	80	-20	279	39	32	94	0.7605
E30	30	70	-15	281	38	31.5	95	0.7782
E40	40	60	-13.5	294	35.6	30	97	0.7792
E50	50	50	-5	320	34	29	99	0.7805
E60	60	40	-1	345	31	28	100	0.7812
E70	70	30	0.00	350	28	27	103	0.7823
E80	80	20	5	362	24	26.5	104	0.7834
E90	90	10	8.5	360	18	23.6	106	0.7840
E100	100	00	12.5	365	9	23.5	129	0.7890

The measured properties of the various blends are shown in Table 7. Energy density decreases as ethanol concentration increases therefore more fuel should be consumed per mile as the ethanol fraction in the blend increases. The specific gravity of blends increased from 0.7508 for E10 to 0.7890 with E100. This was expected especially as bio ethanol is heavier than gasoline. This explains why when a mixture of bio ethanol gasoline is viewed inside a transparent container; ethanol is seen to settle at the middle sandwiching gasoline on top and water at the bottom. The immiscibility of the two liquids especially and higher ethanol fractions should be responsible for the unsteady engine production noticed during the tests. Amongst other modifications to be done in an SI engine should include the reduction of the carburettor jet sizes and modification of the piston head configuration to improve on the atomisation and homogenisation of the compound fuel.

The flash point increases from -65 at E0 to 12.5℃ with E100. The flash point indicates the temperature at which the fuel can vaporise to produce an ignitable mixture with air. At the flash point an applied flame gives momentary flash instead of some steady combustion. Therefore the flash point gives some indication on the flammability of the liquid. This shows that with the addition of ethanol fractions to gasoline the burning characteristics of the mixture reduces. It is important to note that the higher the flash point of a fuel the more difficult it is to start the car. For example, the flash point of E100 was found to be 12.5℃ meaning that starting will be very difficult at temperatures of about 9℃. Therefore a gasoline engine converted to an E 100 engine would need to use pre heater plugs in winter.

The specific gravity increases from 0.7474 at E0 to 0.7890 at E100. This shows that addition of ethanol to gasoline produces a fuel blend denser than gasoline. The specific gravity of a fuel is the weight of the fuel compared to the weight of the same volume of distilled water at a given temperature. It gives an indication of the purity of a fuel. When fuel is contaminated with another liquid, the specific gravity will either increase or decrease depending on the specific gravity of the contaminant. There is only one air/fuel ratio that gives the best performance of each combustion engine.

The ratio is determined by the weight of the air/fuel mixture. The fuel supply system of all engines such as carburetors and injection systems measure fuel by volume and because of this the injection jets will have to be modified every time the fuel specific gravity changes. The volume will have to be adjusted to maintain the weight of the fuel going into the engine for combustion.

Figure 4 shows the variation of research octane number with percentage of bio-ethanol. The Octane number increases from 91 at E0 (100% gasoline) to 106 with E90. Octane number of a fuel indicates its ability to resist pre- ignition and burn evenly. The Octane number of pure bio-ethanol is 129. This shows that the addition of bio-ethanol to gasoline improves considerably, the Octane number consequently increasing the activation energy of the fuel or the energy necessary to start a reaction. The research octane number RON or the measure of a blends' resistance to auto-ignition in the engine is defined

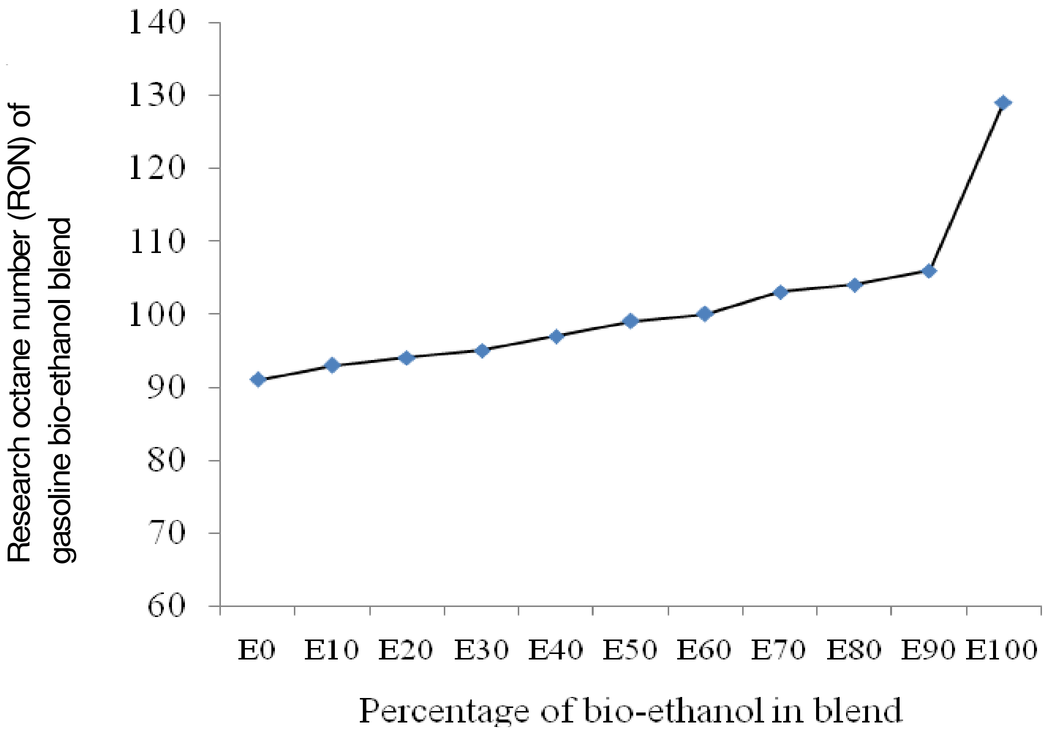

Figure 4. Variation of octane number with bio-ethanol percentage on blended gasoline.

by comparison with the mixture of iso-octane and heptane which would have the same anti-knocking capacity as the fuel under test. It is a measure of the fuel's tendency to burn in a controlled manner or a measure of its tendency to knock in an SI engine. As far as ignition only is concerned, the best blend would be E60 that gives exactly the same performance like iso-octane, that is, with an octane number of 100. Investigations on the auto ignition characteristics of ethanol in the 667 to 743K temperature range at one atmosphere were made by Bolentin and Wilk (1996), and conclusions were drawn that the ethanol concentrations proved to have a greater effect on the ignition delay times than did oxygen concentrations.

The vapor pressure of the blends decreases from E10 to E100. The vapor pressure of a liquid is very important because it affects the starting and warm up of spark ignition engines (Davis et al., 2002). At high altitudes and during high operational temperatures the cause of vapor lock in fuel pumps depends on the vapor pressure of the fuels. Therefore blending ethanol with gasoline negatively affects the ease of starting the engine.

Engine performance using various gasoline ethanol mixtures

The observations made using all compound fuels (various ratios of gasoline/bio ethanol mixture) were similar. We noted a very difficult starting of the engine and at times vibrations due probably to the water factions in the fuel and the fact that the improved octane rating produced uncontrolled ignition. Uncontrolled ignition in an internal combustion engine is very undesirable because it leads to reduced power no matter the energy density of the fuel. Therefore for an increase in the octane number to produce an advantage, the engine has to be modified to advance the timing and also increase the compression ratio. Other possible modifications could be; increasing the carburettor jet size, modifying the intake manifold for better fuel atomisation, modifying the piston head configuration. The rattling of the engine especially experienced with higher percentages of bio-ethanol was due to the moisture content of ethanol. In spite of the fact that the bio-ethanol obtained from distillation was purified in a rotavapor only 95% purity could be obtained and this is what is practically possible because of the hygroscopic nature of bio-ethanol. The remaining 5% is water residue from the distillation process and this contributes to some anti-fuel properties. The vibrations rattling and knock are due to the passage of fractions of ethanol containing water into carburettor. Bio-ethanol should be corrosive due to this moisture content and if higher percentages are used in compound fuels, degradation of some materials in the engine and the fuel system should be expected. Fuel tanks for blended fuels might therefore need to have a water trap that can be drained as soon as the fuel is put into the engine. However since the fuel

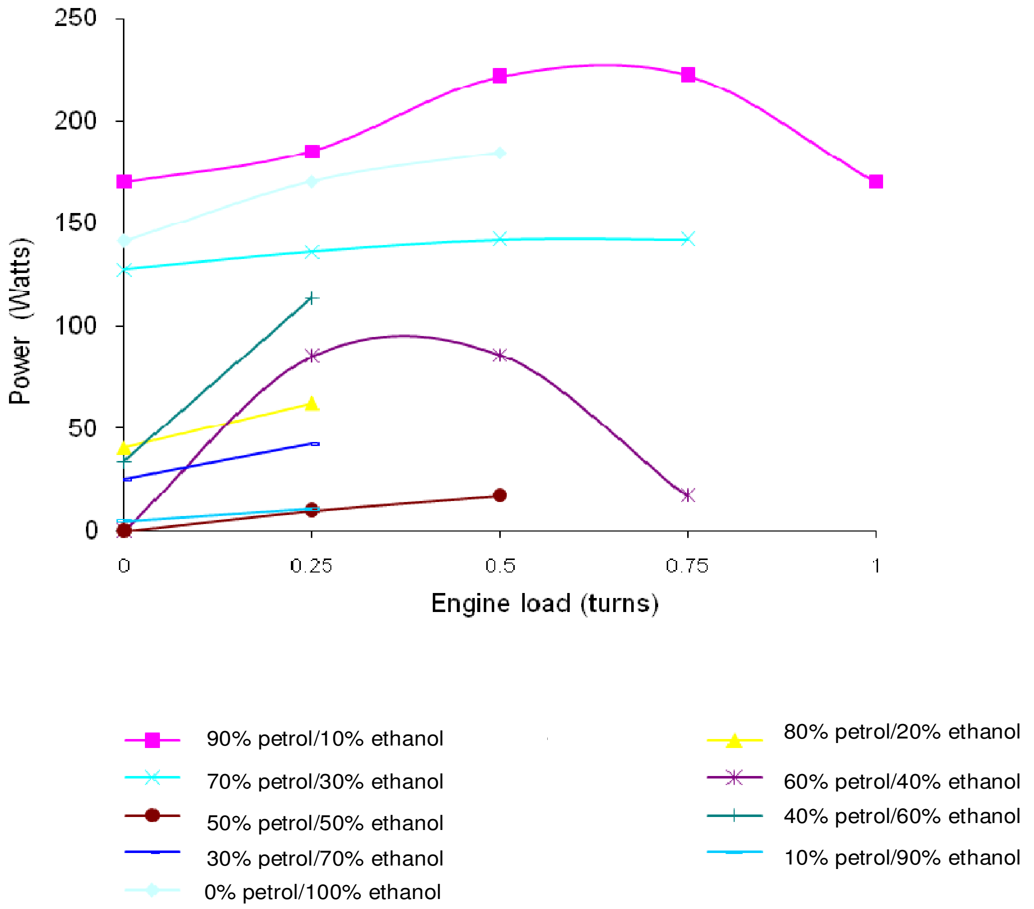

Figure 5. Variation of engine power with various loads for different qualities of ethanol gasoline blended fuel.

system is not airtight, more moisture should be expected in the system due to the activities of hygroscopic ethanol. Earlier researchers Gibson (1949) and Fubing et al. (2007), proposed the use of reformed ethanol in the engine to avoid some of these problems.

The maximum speed of the engine was about 2400 rpm for all mixtures including E0. Any attempt to load the engine using the load control valve resulted in turbulent combustion. This turbulence was due to the immiscibility of the two fractions of the fuels. Figure 5 shows the behaviour of the engine with different ethanol/gasoline ratios as fuel. We note that the engine develops the fastest speed with a fuel composition of 100% gasoline and 0% ethanol. The maximum engine power using the compound fuel was obtained with E10. E20 also gives some good results but the maximum is E30 after which the engine performance is no longer satisfactory. With E10, the engine does not tolerate any loading. However E10 gave the best engine increasing power without vibrations. As seen on Figure 3 the curve for E10 is smooth tolerating a wide range of load variations. E10 has also been recommended by Ceviz and Yüksel (2005). The maximum loading obtainable is ¼ turns. The engine develops the slowest speed when using fuel of composition, 30% gasoline and 70% ethanol.

Necessary engine modifications

From the results obtained in this investigation some recommendations can be made for modification of the standard SI gasoline engine to run successfully on gasoline/bio ethanol blends. These include advancing the engine timing, and increasing the compression ratio. Bio ethanol is lower energy fuel than gasoline. Gasoline has a negligible solubility in water while the blended fraction is very soluble. Phase separation occurs in the tank leading to lower octane component in the petroleum phase. It is therefore necessary to improve on pre and post induction mixing to neutralise the phenomenon of phase separation. This can be achieved amongst other possibilities by roughening the piston head to improve on atomisation.

Because bio ethanol is a very good solvent extra filtration is necessary between the tank and the engine to remove rust, and other dirt. A 10 micron filter can be good for such filtration. Higher percentages of ethanol may damage seals diaphragm, aluminium, and zinc plated components.

Conclusions

Bio-ethanol production from the chosen crops was feasible. Bio-ethanol production is highest after three days of fermentation using natural methods. The highest bio-ethanol production came from maize although the values got were lower than those obtained in the United States. Addition of ethanol to gasoline reduces the energy density of the volume. Engine speed increases and engine torque decreases. However overall break power increases. There is loss of fuel economy and consequently mileage with blended rations of bio-ethanol gasoline because the alcohol has a lower energy value than gasoline. Blended fuel is not yet a good option for less developed countries that are not manufacturing resistant parts. Anti-fuel properties of bio-ethanol blended fuels calls for serious engine modifications to avoid knock and unwanted emissions. These modifications include the advancing of engine timing, provision of airtight conduit lines, increasing the compression ratio and roughening of the piston head.

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