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Local Production Technology of Ethanol from Maize and Product Performance as Fuel in a Spark Ignition Generator Set

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Abstract: *This research highlights local ethanol production technology, which has been in used to produce ethanol basically for consumption. The locally produced ethanol burns relatively clear as the amount of gasoline decreases. The performance test carried out showed that E100 have the least specific fuel consumption of 2.5ml/min. Also blending of ethanol with gasoline help to reduce -harmful emissions in to the atmosphere, if proper investigation is conducted to find ways of mixing ethanol and gasoline or the option of exploiting use of vegetable oil in place of mineral lubricating oil.*

Keywords: *Ethanol, Maize, Alcohol, Fermentation, Petroleum, Glucose, Aluminum, Laboratory.*

INTRODUCTION

GENERAL BACKGROUND

Ethanol fuel is ethyl alcohol, the same type of alcohol found in alcoholic beverages. It is most often used as a motor fuel, mainly as a bio-fuel additive for gasoline. World ethanol production for transportation fuel tripled between 2000 and 2007 from 17 billion to more than 52 billion liters.

Ethanol is widely used in Brazil and the United states and together both countries were responsible for 89% of the world's ethanol fuel production in 2009 (ethanol. Org. 2005). Most cars on the road today in the US run on blends of up to 10% ethanol, although the use of 10% ethanol with gasoline is mandated in some states and cities of America. Since 1976 the Brazilian government has made it mandatory to blend ethanol with gasoline and since 2007 the legal blend is around 25% ethanol and 75% gasoline (ethanol. Org, 2005).

Bio-ethanol unlike petroleum is a form of renewable energy that can be produced from agricultural feed stocks. It can be made from very common crops such sugarcane, maize, potato etc.

Agricultural feedstock are considered renewable because they get energy from the sun using photosynthesis, provided that all minerals required for growth such as nitrogen and phosphorous) are returned to the land. Renewable energy offers a better way unlike fossil fuels. Some energy source are renewable because they are naturally replenished, that is if managed can last forever. Their supply is so enormous that they can never be meaningfully depleted by human. However renewable energy sources have less damaging environmental effect than fossil fuel and nuclear energy source. Renewable energy is energy that comes from natural resources such as sunlight, wind, rain, biomass and geothermal heat.

1.2 STATEMENT OF THE PROBLEM

High cost of petroleum products is a big issue today in the world even in oil producing nations; this has prompted the need to find an alternative for fossil fuel so as to reduce dependence on petroleum. Among other issues raising fears is global warming caused by the emission of harmful greenhouse gases into the atmosphere, from burning of petroleum products. Greenhouse effect is the caused by the accumulation of carbon dioxide in the earth atmosphere. Also depletion is another issues calling for serious attention. Petroleum products are not naturally replenished so continual leads to decrease in deposit in the earth crust.

1.3 AIMS AND OBJECTIVE

The aim of this project is to produce ethanol from maize using local technique. Other objectives are;

` 1. To test and evaluate the performance of the produced ethanol as fuel, either as a whole or in proportions with gasoline.
2. To analyze the emissions produced.

1.4 SCOPE AND LIMITATION

This project work is centred on the local production technology of ethanol and the use of the ethanol produced as fuel in a gasoline engine.

The evaluation was carried out in an open space.

1. LITERATURE REVIEW

2. MAIZE AS AN INDUSTRIAL CROP

The history of maize and its domestication may be traced to some 8000 years. Maize spread across the length of America and subsequently to Europe, Africa and Asia. Teosinte (zea mexicana) has been linked with the earliest maize in Mesoamerica and was first harvested as early as 10000 years ago. The origins of the maize began on the pacific slop of the modern Mexican state of Oaxaca, Tehuacan and the valley of mexico. The earliest primitive corncobs discovered Mesoamerica were obtained from specimen recovered within a cave near Oaxaca From there maize diffused rapidly into Central America and then into South America by way of the eastern slopes of the Andes approximately 4000 years ago (U.S dept of agric, 2007).

China and South East Asia, maize is cultivated in rotation with other crops. More traditional crops like rice and millet and sequential cropping (relay cropping) strategies permit a form of multiple cropping that overlaps the life cycles of two or more crops. These methods made possible the generation of crop surplus in Asia beyond those originally identified with the exclusive or traditional reliance on rice as primary cultigens. hi fact maize is used throughout Asia to supplement more traditional crops by extending the growing season and expanding production potentials throughout the year, in addition, the production of maize fodder and feed for livestock has fueled the adoption of maize agriculture throughout the developing countries of Africa. Maize provides the world's most cost-effective and highest-yield plant resource, currently available for the production of livestock forage, fodder and feed (Doenswell *et al,* 1996).

Maize is seldom described outside of the so-called Mesoamerica triumvirate of maize, beans and squash. Early Mesoamerica people planted these food crops together, often planting beans and squash adjacent to maize so as to provides farmers plant stalks on which to extend their vines.

2.2 HISTORY OF ETHANOL

Ethanol is a very important compound because it has more uses than almost any other organic compound. It is the essential ingredient in alcoholic drinks and it is well known for its intoxicating effect on consumers. Ethanol has been produced successfully for use as fuel in Brazil since 1975. Maize is the starting material; it is crushed by rollers after harvest to extract the juice. Sucrose is extracted from the juice as a commercial product, but this leaves a syrup called molasses which contains glucose and fructose. Ethanol is distilled to separate it from other fermentation products.

Ethanol was used as lamp fuel in the United States as early as 1840, but a tax levied on industrial alcohol during the Civil War made it uneconomical. The tax was repeated in 1906 from 1908 run ethanol with the advent of prohibition in 1920, ethanol fuel sellers were accused of being allied moonshiners, and ethanol fuel fell in disuse until later in the 20th century.

2.3 INDUSTRIAL ETHANOL

Industrial ethanol is ethanol standardized for its specification’s chemical purity or technical properties. To contrast, alcoholic drinks are standardized and evaluated like food products; there are various grades of industrial ethanol for solvent, disinfectants, chemical precursor and cleaning uses.

Chemically pure ethanol may also be used to produce alcoholic drinks, e.g Koskenkorva lower quality or waste stream ethanol finds uses and may be deliberately contaminated poisonous or bad testing additives.

2.4 FERMENTATION

Fermentation can be simply defined as the chemical breakdown of carbohydrates by micro-organisms, this leading to alcohol production. When substance like pineapple containing sugar are left for some time, they will produce alcoholic drinks as a result of fermentation (Stan chemistry 2000). Fermentation is made possible by the action of biological catalysts called enzymes; these enzymes can be gotten from the yeast fungi. Chemically fermentation can be represented by the equation

$$C_6H_{12}0_6 \quad 2C_2H_5OH + 2C0_2.$$

There are basically two types of fermentation usually determined by the presence or absence of oxygen during fermentation, these are; aerobic and anaerobic fermentation. Industrial alcohol is produced under anaerobic situations, that is, in the absence of air. Commonly used yeast such as baker's yeast *(saccharomyces cerevisae* or *schizosaccharomyces pombe)* is used in anaerobic fermentation. All alcoholic beverages with the exception of a few are produced by carbonic maceration are produced by fermentation process.

CHEMISTRY OF FERMENTATION

STARCH $2(C_6H_{10}O_5)_n$

Analyze

MALTOSE $C_{12}H_{22}O_{11} + H_2O$

Maltase

GLUCOSE $2C_6H_{12}O_6$

Zymase

$2C_2H_5OH_5 + 2CO_2$

2.5 PROPERTIES OF ETHANOL

2. 5.1 PHYSICAL

is a colorless, inflammable liquid with a spirituous smell and burning. Ethanol boils at 351IK, it freezes at 155k, mixes with water in all portions and it is readily oxidized by the system when consumed internally is a source of energy. It can dry over anhydrous calcium to $CaCL_2.4C_2H_5OH$.

2.52 CHEMICAL PROPERTIES

Ethanol being a monohydric alcohol exhibits the properties of that particular series. Monohydric alcohols can be considered as derivatives of alkanes obtained by replacing one hydrogen atom by a hydroxyl group. Similarly, they can be considered as derivatives of water obtained by replacing hydrogen atom by an alkyl group. For this reason, ethanol exhibits the properties of both ethane and water.

MATERIALS AND METHODS

3.1 MATERIALS USED

1. Maize 2. Clay pots 3. Firewood 4. Funnel
5. Basin 6.Tray 7. Bottle 8. Bucket
9. Spatula 10. Gallons 11.Calabash 12.Water
13. Aluminum pipe 14.Aluminium pot

List of Symbols

EO
E10
E22
E85
E100
220/240 V
$2(C_6H_{10}O$
$C_{12}H_{22}O_{11} + H_2$
$2C_6H_{12}O_6$
$2C_2H_5OH_5 + 2CO_2$

3.2 PROCEDURES

3.2.1 PROPAGATION OF YEAST

Grain is malted by soaking it in water, allowing it to begin germination and then drying the partially germinated grain in a kiln. Malting grain produces enzymes that convert starches in the grain into fermentable sugars. (Wikisource 1911 Encyclopaedia Britannica).

Two measures of maize were poured into a bucket containing water. It was then left for 72hours to ensure that the grains germinated properly. As seen in picture below.

Figure: 1 Germinated maize grain

The germinated grains were taken out of the water and sun-dried to remove moisture content. This germination process introduces the organism or enzyme necessary for ethanol production. The sun-dried grains are ground into powder form and kept separately.

3.2.2 HYDROLYSIS AND FERMENTATION -

Another five measures of maize were also ground into similar sizes as the germinated grains. The grounded five measures of millet were put in a clay pot containing water, this was left 48 hours for fermentation to take place and this is characterized by stagnant bubbles on the surface of the moisture *(water + grounded grains)*. The mixture was then transferred into an aluminium pot. Heat is then applied to the aluminum pot from a firewood heat source. The mixture was heated for hours until it began to boil, as seen in figure below.

Figure: 2 Boiling maize/water mixture

During this, the mixture was continually stirred to ensure that the mixture remains homogenous. Further heating until evaporation of the moisture content begins, after evaporation of a large content of moisture a solid solution is formed as seen in picture below.

Figure: 3 Solid solution formed

The hot solid solution is transferred into a flat tray for it to cool over the night figure below.

Figure: 4 Cooled solid maize

After cooling down the solid solution is then transferred into the distillation clay pot, the germinated grain powder is also added into the same pot. To increase miscibility between the solid solution and the germinated grain powder, water was added to the mixture and then heat was applied to the setup.

3.3 SETUP DESIGN FOR LOCAL DISTILLATION PROCESS

Condensing tank

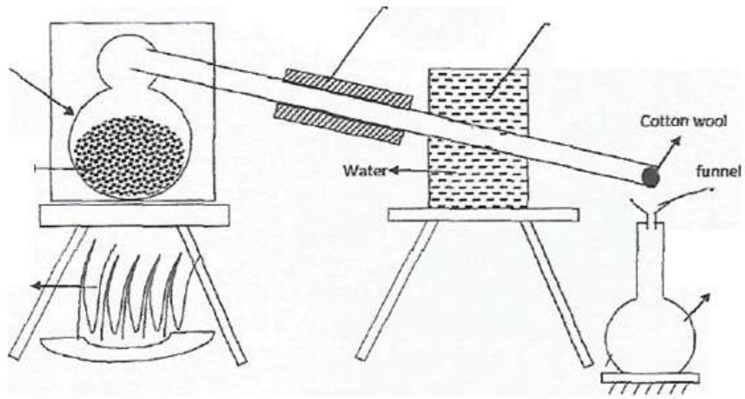

Figure: 5 Schematic diagram of local distillation process

The schematic diagram of the local distillation setup is as shown in fig.5. The setup contains three clay pots, an aluminum pipe, a funnel and a collecting bottle. The three clay pot of sizes large, medium, and small are referred to as pot A , pot B and pot C respectively.

Pot A contained the mixture, pot B which has a hole on one side was in inverted and inserted into pot A, the hole diameter is at least the diameter of the aluminum pipe. This was done for the purpose of preventing evaporation into the atmosphere during the heating.

The meeting point of both pots A and B was sealed with the cooked solid solution of millet to ensure it is airtight.

The smallest pot, pot C works as the condenser, this has a through hole at the middle. The hole diameter is similar to that of pot B.

One end of the pipe goes into the pot B and then passes through pot C, the points where the pipe passes through pot C is also sealed to prevent leakage of water.

Figure: 6 <u>Pot A</u>

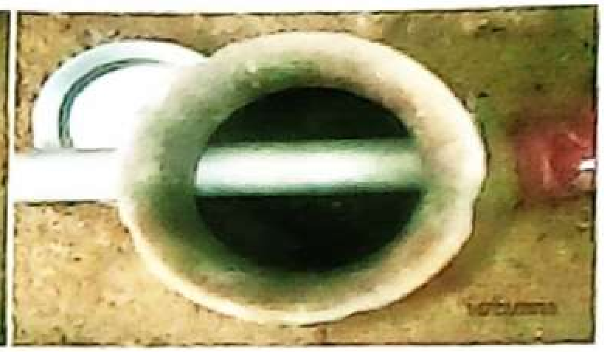

Figure: 7 Pot B   Figure: 8 Pot C

At the end of the aluminum pipe was a funnel inserted in a collecting bottle. In order to increase the rate of condensation, an auxiliary source of condensing was provided. This was done by wrapping a thick woollen material around the pipe just before the main the condenser that is, pot C.

The complete setup is as shown below

Figure: 9 Local distillation setup

3.4 LABORATORY DISTILLATION OF THE LOCALLY PRODUCED ETHANOL

Since the locally produced ethanol contained water, further distillation was required to remove water content. The setup contains an electric heater, round bottom flask, water tank, a retort stand, a condensing unit, fractionating column, water collector and a heat exchanging water tube as shown diagrammatically below.

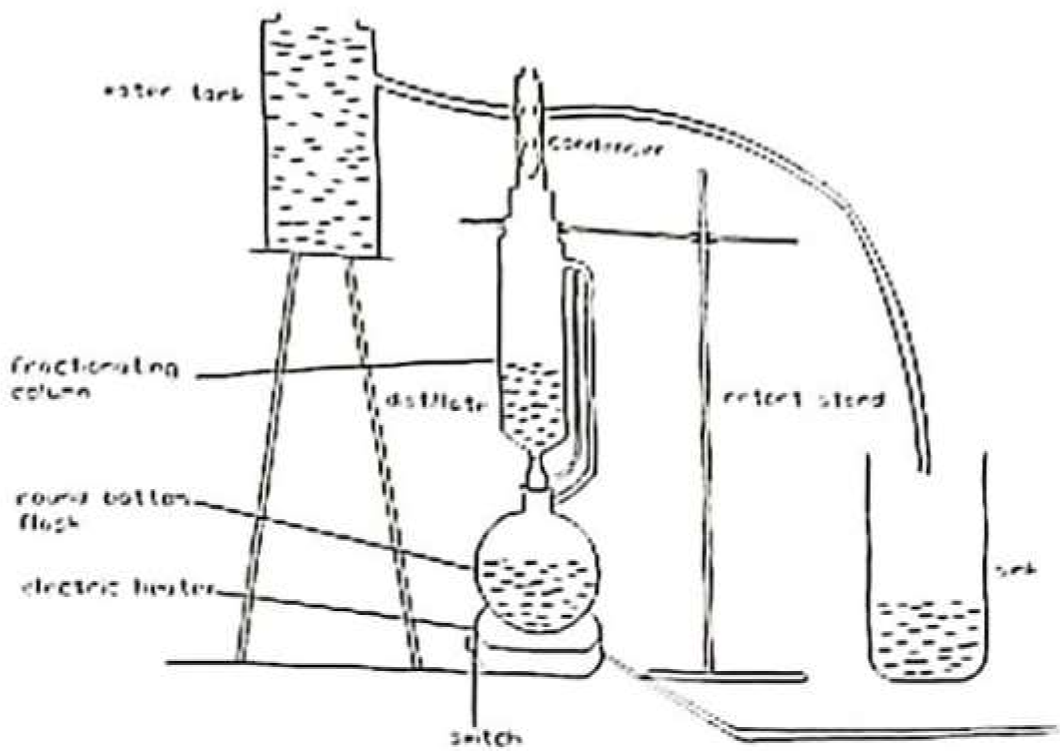

Figure: 10 Local distillation setup

The mixture of ethanol and water was poured into the round bottom flask and placed on the electric heater. The collecting/ fractionating column is inserted into the round bottom flask; the water tube passes through the fractionating column to the sink or tank collecting hot water.

Heat was then supplied to the setup and maintained at 80°c. The water from the water jar was turned on so that water passes through the condenser to provide the necessary cooling.

Hearing continued until the mixture began to boil and evaporation followed. The evaporated mixture escaped through the side walls of the condensing chamber and it was then collected as distillate just over the round bottom flask.

3.4 PERFORMANCE EVALUATION OF THE PRODUCED FUEL

BLENDING

The following materials were used in the blending of the produced fuel; a burette, funnel and a beaker. The produced fuel was mixed in the following proportion; E O (100% gasoline mixed with lubricating oil) E 10 (10% ethanol and 90% gasoline mixed with lubricating oil) E 22 (22% ethanol and 78% gasoline mixed with lubricating oil) E 85 (85% ethanol and 15% gasoline mixed with lubricating oil) E 100 (100% ethanol mixed with lubricating oil)

The pictures below show some of the blends after thorough shaking.

Figure: 11 Blends

Figure: 12 Various blends

TESTING

The produced ethanol was used as fuel in the internal combustion engine of a gasoline generator set (Model, Tiger 950) with a carburetor fuel system, a rated power of *65QKw*, a rated voltage of 220/240 V, a frequency of 50Hz and has only a single phase.

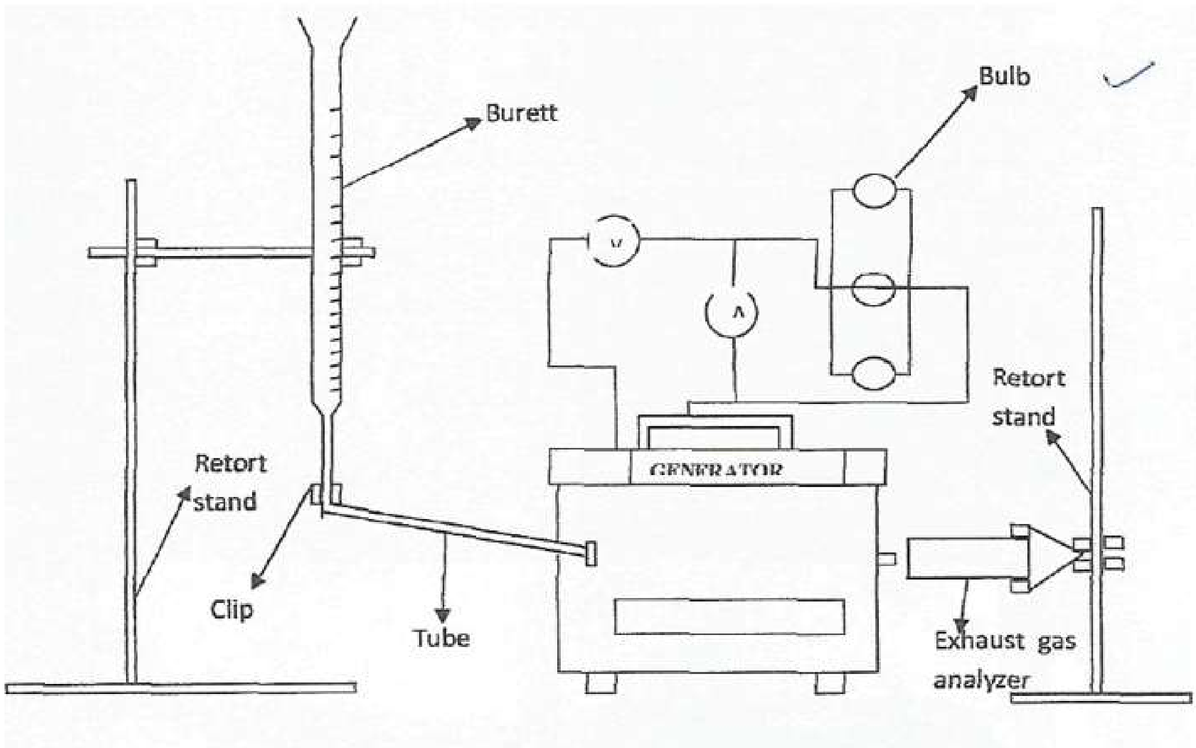

Fig: 13. Setup for performance evaluation

The fuel supply system was modified using a burette, clamp, tube and clip. This was done to facilitate proper fuel measurement.

The sample containing pure gasoline (E 0) was first tested to avoid problems of cold start. The other sample followed in order of increasing ethanol content or decreasing gasoline content by volume, which are E10, E22, E85 and E100 respectively.

Electric bulbs were used to put load on the generator set during operation, in order to evaluate the engine performance the generator set was kept under a constant load of 500W

50ml of each fuel sample was used to run the generator set, the volume consumed was recorded against their corresponding consumption time using a stopwatch. The exhaust gas analyzer was stationed at the exit of the generator

RESULTS AND DISCUSSION
LOCAL PRODUCTION PROCESS

It was observed that dried maize grains take three days (72hours) to germinate and also the fermentation of millet takes two days, which is characterized by stagnant bubbles seen on the surface of the mixture.

It was also observed that the distillate collected during the local process contained appreciable amount of water due to poor temperature control.

Table 2: cost of feedstock production and other products

S/No	Material	Quantity	Cost (#:k)
1	Millet	5.4kg	1610
2	Water	601itres	30
3	Firewood		200
4	Ethanol	2.3litres	

4.2 LABORATORY DISTILLATION

The laboratory distillation was characterized by rapid evaporation and condensation for the first three to four hours and as the ethanol content reduced the condensation also became slow.

Laboratory process yielded about 96 to 97% pure ethanol, as the residue in the round bottom flask lost the ethanol spirit smell.

Table 2: Results analyzed during performance evaluation

Runs	Fuel	Volume (ml)	Time (min)	Carbon monoxide (ppm)	Average volume (ml)	Average time (min)	SFC (ml/min)	rage
1	EO	40	4.27	408	32.5	3,89	8.35	979
2	EO	25	3.51	1550				
1	E10	40	5.15	304	42	5.64	7.5	408
2	E10	44	6.12	513				
1	E22	26	3.36	2436	32	3.84	8.3	1442
2	E22	38	4.32	448				
1	E85	15	1.25	376	30	2.67	9.0	1238
2	E85	45	4.09	2100				
I	E100	25	2.51	1538	23.75	2.03	2.5	939
2	E100	22.5	1.54	339				

CONCLUSION

This project work shows that local ethanol production technology is quite simple and economical, considering labor and energy, if harnessed properly may give yield to high grade ethanol. This local technology can serve as a starting point of meeting the ethanol demands of the country.

Ethanol produced by this process may not be used directly in internal combustion engine due to water content but can still serve the purpose of producing alcoholic drinks and if distillation process is controlled it can equally serve as fuel and octane enhancer in internal combustion engine of a gasoline generator. This work also shows that the E10 blend is the most advisable blend to be used in such generating set.

The tests carried out suggest that ethanol may not be completely miscible with gasoline in all proportion either due to the presence of lubricating oil or improper blending method.

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