A STUDY ON SMALL SCALE BIOGAS PRODUCER -ENGINE SYSTEM FOR PUMPING WATER

BY

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B.Sc. (Agric. Mechanization), Ain Shams University, 2002

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ABSTRACT

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A simple method and technique for handling, storing and utilizing of biogas have been done. Spark Ignition SI engine was modified to power a water pump for irrigation by using 100% biogas as fuel (gasoline starting). A gas mixing device was designed to meter biogas into air stream of amount dictated by the engine speed and the load to obtain a proper proportion of biogas and air that burn for SI engine operation. An inner tube of tractor tire was used for storing and handling biogas from the biogas digester to the engine-pump site. It was filled up with biogas by using a modified passenger car compressor.

Biogas was analyzed to determine CO_2 percentage by using alkaline $Ca(OH)_2$. The average percentage of CH_4 and CO_2 were found to be approximately 69.6% and 30.4%, respectively. The calorific value of biogas was calculated and found to be 2944.8 kJ/m^3. A comparison between biogas and the liquid fuel (kerosene and gasoline) was made. The results showed that at 2500 rpm engine speed, specific energy consumption under biogas mode was decreased by an average of 80.3% and 79% when compared to gasoline and kerosene mode of operation, respectively. The total pump efficiency of biogas operation was about 58%.

Key Words: Bio-fuels, biogas, calorific value, fuel consumption, methane, gasoline engine, engine performance, pump performance.

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INTRODUCTION

Energy plays a vital role for rural development. The price of oil, however, has crossed above 140 $ per barrel in the international market (2008) and is expected to increase further. Therefore, a major concern for most of scientists nowadays is the use and availability of energy especially renewable energy (solar energy- wind energy- biogas -etc). At the same time there are many problems in waste management. Egypt only produces a lot of tons of wastes especially organic wastes (plant residues- animal residues). **Helmy et al.** (**2003**) reported that there were 31.42 M ton/ year of plant residues and 55.37 M ton /year of animal residues and at the same time we have problem with energy like any other rural country. So biogas is a useful source for solving those problems.

Producing biogas from treating organic wastes can provide us with acceptable amount of energy and also a high quality fertilizer and work as odor controller (environmental friendly). Biogas is not just for agricultural wastes but also for industrial (**Lettinaga and Van Haandel, 1992)**. In Egypt the first biogas digester was in Elgabel El-Asfer farms in 1939 to treat sewage sludge (**Alaa El-din et al, 1983**). After that many digesters have been built in Egypt by the scientists to evaluate biogas production and the materials which can be used to feed the digester and their effects on biogas production and methane concentration in the gas.

Biogas can be upgraded for utilizing in internal combustion engines to increase its calorific value by removing H_2S and/or CO_2, also it can be compressed. The methods selected for the treatment of biogas will depend upon the intended use of the gas and the composition of the gas.

Internal combustion engines have been fueled by biogas from municipal digester systems for many years ago with varying degrees of success. In recent years, this application has been extended to agricultural and industrial systems for a variety of power requirements. Biogas can be used in both CI (compression ignition) engines and SI (spark ignition) engines **(Kofoed and Hansen, 1981)**.

The self-ignition temperature of biogas is high and hence it resists auto ignition, this is desirable feature in spark ignition SI engines, as it will reduce the chances of knock **(Propatham et al.-a, 2007)**.

In general, using biogas as a fuel has the following advantages (Robert et al., 1998- House, 1981):

1. The combustible constituent (methane) makes it a good fuel for internal combustion engines.

2. It's a by-product of waste treatment and thus it's free excepting low capital investment required for the handling system.

3. It has a very high octane rating.

4. It leaves little or no more carbon deposition in the cylinder or on the piston.

5. It greatly reduces the amount of sludge buildup in the oil, and thus means longer distances between oil changes.

6. It has no tetraethyl lead to foul spark plugs and pollute the air.

7. It mixes better with air than (liquid) gasoline, resulting in a better ignition in the cylinder.

8. It results in less valve burning.

9. It burns clean and without as many harmful pollutants as other fuels.

Therefore, the aim of this research is to:

1- Investigate the possibility of handling, storing and utilizing biogas;

2- Design a gas mixing device to meter biogas into air stream;

3- Modify and convert S.I engine to power a water pump for irrigation by using 100% biogas as a fuel;

4- Compare the output power of using biogas with the liquid fuel (kerosene and gasoline).

REVIEW OF LITERATURES

Literatures with relevance to the topic of this study come from different directions. One is historical background another direction is the literatures on biogas, delaying materials; and the various plant (digesters) for different biomaterials, plant size. The last direction is utilization of biogas.

2-1- Historical background

One of the earliest to mention biogas was **Van Helmot in 1630** in a communication about an inflammable gas emanating from decaying organic matter. **In 1776 Alessandro Volta** became the first to conduct experiments with biogas from the bottom sediments of ponds in northern Italy **Hohlofeld and Sasse (1986)**.

The first plant for obtaining methane from human wastes was built in 1990 at the Homeless Cepers Asylum, Matunga, now known as Acworth Zeprosy, Hospital Wadala, India **Sathianathan (1995)**.

Hohlofeld and Sasse (1986) reported that after the First World War, a form of setting tank involving the anaerobic digestion of municipal sewage began to appear in Germany. The methane gas produced in such systems was either used for fueling the town truck yard or fed into the public gas supply network.

In Egypt the first biogas digester was in Elgabel el-asfer farms in 1939 to treat sewage sludge the number of units of biogas reach 29 digester their volume vary from (6 – 140) m^3 **Alaa El-din et al. (1983**). After that many digester built in Egypt by the scientists to evaluate biogas production and the materials which can be used to feed the digester and its effect on biogas production and methane concentration in the gas.

Lettinaga G. and Van Haandel, A. (1992) mentioned that the use of the Anaerobic Digestion (AD) process for treating industrial waste water has grown tremendously during the past decade. Worldwide, more than 1,000 vendor supplied systems now operate or are under construction. It is estimated that European plants comprise 44% of the installed base. Only

14% of the systems are located in North America. A considerable number of the systems are located in South America, primarily Brazil, where they are used to treat the **vinasse co**. product from sugar cane-based ethanol production

EL-Shimi and Badawi (1993) reported that, the sludge obtained from biofermentation process contains high concentration of plant nutrients and organic matter. The application of this sludge at the rate equivalent to traditional chemical fertilizer increased the yield of maize 35.7%, wheat 12.5%, rice 5.9%, broad beans 6.6%, cotton 27.5%, carrots 14.4% and spinach 20.6%.

2-2- Biogas system

(Roos and Moser, 1997) reported that biogas technology is a manure management tool that promotes the recovery and use of biogas as energy by adapting manure management practices to collect biogas. The biogas can be used as a fuel source to generate electricity for on-farm use or for sale to the electrical grid, or for heating or cooling needs. The biologically stabilized byproducts of anaerobic digestion can be used in a number of ways, depending on local needs and resources. Successful byproduct applications include use as a crop fertilizer, animal feed, bedding, and as aquaculture supplements.

A typical biogas system consists of the following components:

1. Residues collection
2. Anaerobic digesters
3. Factors affecting on biogas production
4. Gas handling
5. Gas utilization

Residues Collection

2-2-1-1 Plant residues

Biogas generation from agricultural residues, by anaerobic digestion, digesters was monitored throughout 150 days of batch operation, the amounts and quality of gas yields (CH_4 an CO_2 contents), the destruction volatile solids (V.S), pH changes and energy balance were investigated **El-Ashry (2001)**. But some times these residues need pretreatment in air **Hegazy (1994)** stated that the biogas can be produced from rice straw and maize stalks as agricultural wastes, widely found in the Egyptian rural, after its aerobic pretreatment with Phenerochaete and Chrysosporiuin as a legnin degrading fungus.

After the aerobic digest (AD) the residues get into the anerobic digest. The aerobic pretreated rice straw after 10-30 days, were subjected to anaerobic fermentation for biogas generation of additional 90 days. The water was added to reach total solids of 8% **Aly (1985)**.

2-2-1-2 Animal and human residues

Zaghloul (1993) reported that the biogas production was higher for poultry manure and cattle dung than the water hyacinth and tomato shoots. He also found that the gas production reached its maximal levels after 17-28 days which differed according to the type of digesting materials.

EL-Hadidi (1999) used a stainless steel biogas horizontal digester (cylindrical in form), to produce a biogas from cattle dung through anaerobic treatment. The digester has gross dimensions of 80 cm long, 25 cm diameter and 1 mm thick with a net surface area of 6283 cm^2 to reduce the heat losses from the curved surface area, the digester was insulated using 1.0 mm thick glass wool insulation. The fermented slurry was heated by warm water (35 °C). The biogas production rate had specification, 307 $L.kg^{-1}$ 66.6% methane content and 21855.3 kJ/m^3 calorific value. This type of digester (horizontal) produces about 235L/kg digested material, and the digested