International Journal of Engineering Research
Volume No.5, Issue No.8, pp : 709-711
ISSN:2319-6890)(online),2347-5013(print)
1 August 2016

Studies on Balloon Storage of Biogas for Anywhere Use

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Abstract: A Study on balloon storage of Biogas for anywhere use. Biogas was produced from an existing 3 m^3 floating drum continuous-flow biogas plant and stored in a tube balloon. Piping was done on the plant to allow for collection of the gas in the balloon. The pressure of the gas in the balloon was determined from the mass of gas collected and size of the balloon. The plant was started-up with 3000 L of water after which it was loaded with 520 kg of cattle dung mixed with 1370 L of water giving a ratio of cattle: waste of 1:8. The loading of the waste into the plant was done twice in 7days. The quantity of gas collected in the balloon was measured by weighing the balloon. A shed was built to accommodate the piping and the tube balloon. 0.45 L of biogas was collected in the tube balloon from 520 kg of the cattle dung in 50days. The movement of gas from the plant to the balloon was influenced by pressure. The study showed the difficulty in collecting biogas in containers because of the very low pressure of biogas plants that equilibrates with that of the balloon on delivering of very small amount of biogas to the balloon. Therefore, a compressor and non-return valve maybe required to move sufficient quality of gas from the plant to the balloon for use elsewhere out of outside the plant.

Keywords: Biogas, Balloon, Correlation, Cattle dung, and Pressure.

1. Introduction

Ultimately, the future of mankind rests with the development of renewable or inexhaustible sources of energy. The sun is the source of virtually all forms of renewable energy (Raven and Gregersen, 2007). Energy is naturally the prime mover of economic growth and development but the linkages between energy and development are complex and still imperfectly understood (Lindrofer, *et al.,* 2008).

All organic materials can be fermented or digested in a structure called a digester to produce biogas (Chawla, 1986). The production of biogas is a clever way of exploiting nature without destroying it **(**Persson *et al*,.2006). The amount of biogas that can be generated during anaerobic digestion is a function of the fraction of the organic material that is available to the anaerobic bacteria, that is, the biodegradable fraction and the operating environmental conditions of the process. **(**Mata-Alvarez, 2003) The more biodegradable the material, the greater the quantity of the biogas generated per quantity of material added to the digester. The biodegradable fraction of agricultural wastes, which is commonly used in biogas production, will vary being a factor of how the wastes were generated and handled prior to digestion. For example, only 40-50% of the volatile solids of dairy cattle manure may be biodegradable and thus available to produce biogas (Loehr *et al.*, 1977).

Biogas is produced by putrefactive bacteria, which break down organic material under airless conditions (Lindrofer,*et al.*, 2008). This process is called "anaerobic digestion". The gas is composed of about 70% methane and 30% other compounds. A typical composition of biogas would be 54 - 70 % methane, 27-45 % carbon dioxide, 0.5-30% nitrogen, 1-10 % hydrogen, 0.1% carbon monoxide, 0.1% oxygen and trace hydrogen sulphide (Hjorth *et al.,* 2009). Methane gas is a colourless, flammable and non-toxic gas. It possesses a slight but not unpleasant smell, however, if the conditions of digestion produce a significant quantity of hydrogen sulphide the gas will have a distinctly unpleasant odour (Ranade *et al.,* 1980).

Hydrogen sulphide can be removed by transferring the gas through iron-impregnated wood chips or iron fillings (Stout, 1990). Biogas is somewhat lighter than air. Air has a density of 1.2Kg/m3 while biogas has a density of 0.94Kg/m3. biogas with a composition of 60% methane and 40% carbon dioxide has a gas/air density of 0.83 and an ignition temperature in the range of 850-7000C (diesel oil 3500C, petrol and propane about 5000C). The temperature of the flame is 8700C (Sasse *et al.*, 1988). In a digester operating at maximum capacity, the biogas produced can generally be expected to have a heat value of about 22 MJ/m^3 at atmospheric pressure. In comparison, natural gas has a heat value of 37MJ/m^3, and a litre of gasoline contains about 33MJ/m^3 if the carbon dioxide component is eliminated by passing the gas through a solution of sodium or potassium hydroxide.

The production of the gas is accomplished in three phases, namely the hydrolysis, the fermentative (acid – forming) and the methane-forming phases (Seadi, 2000). The different groups of bacteria responsible for fermentation live in an interacting eco-system. Each type of bacteria depends on others. The fermentation time is shortest when populations of different bacteria are adequately balanced **(**Einola,*et al*,.2001).

1.1 Objective

The objective of the study is to determine Storage of Biogas for use outside the point of production (Anywhere uses).

1.2 Justification of the Study

Presently, biogas can only be used at the place of production, there is therefore a need to collect and used the gas outside its point of production.

2. Materials and Methods

A 3 m^3 floating drum biogas plant at the Teaching and Research Farm, University of Agriculture, Makurdi. Nigeria was used to produce biogas for storage in a tube balloon. (Hermansson, 2009). Piping work was done on the plant to allow for collection of the gas into the tube balloon.

The pressure of gas in the balloon was determined from the mass of gas collected in the balloon and the size of the balloon (equation 1).

The plant was to started – up with 3000 L of water after which it was loaded with 520 kg of cattle dung mixed with 1370 L of waters giving a ratio of waste: water 1:8 (Mayer, and Gruber, 2007).

The loading of waste into the plant was done twice in 7days. The quality gas collected and pressure of gas in the balloon were measured and determined every 5 days for 50 days.

The quantity of gas collected in the balloon was measured by weighing the balloon the gas. A correlation analysis was undertaken to determine the correlation between the daily gas collected in the balloon and balloon pressure, and cumulative gas in the balloon and the pressure of gas in the balloon using Excel, Microsoft Office 2010. A shed was built to accommodate the piping work and the tube balloon.

$$P = \frac{Mg}{A} \quad (1)$$

Where:

P = Pressure of gas in balloon, Kg/m2

M = Mass of biogas in balloon, Kg.

$$A = \frac{\pi d^2}{4}$$

d = Diameter of tube balloon, m.

g = Acceleration due to gravity

2.1 Description of the 3 m^3 Biogas Plant

Figure 1 is a diagram of the $3m^3$ floating drum biogas plant. The digester consist of a fermentation well of 1m in diameter and a depth of 1.9 m. The digester wall was plastered with cement and the base was concrete to avoid seepage into the digester. Inlet or influent pipe chambers are 60 cm x 87 cm, a pipe of 23 cm opens into the well and at the 30^oC from the vertical. A concrete ring will be placed at the mouth of the inlet pipe to ensure that no stone or other unwanted materials get into the well.

An effluent chamber of 93 cm x 98 cm and pipe of 20 cm diameter opens into the ground at about 90 cm from the base of the wall and the pipe was inclined into well at about 45^0C from the vertical. A water jacket directly above the well comprises of two concentric concrete rings. The steel cylinder gas holder tank of 96 cm diameter and 60 cm high seated completely in the water jacket, the outer ring being 147 cm diameter, 45 cm high and 14 cm thick (147 x 45 x 14) cm.

The inner ring has 79 cm diameter and 45 cm high with 10 cm thickness, (79 x 45 x 10) cm. the wall and the base between the two rings were plastered and concreted to avoid any form of leakage. A gas tank of 96 cm diameter and 60 cm height. The gas tank of floats and releases enriched methane gas for burning any time is required. The flexible hose will be connected to the valve on the gas holding tank to convey the enriched biogas to the storage point.

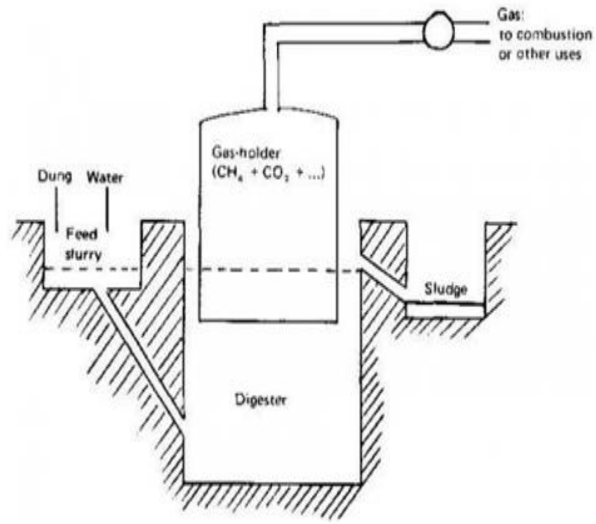

Figure 1: Diagram of the Biogas plant

2.2 Description of the Tube Balloon

Figure 2 is the picture and cross – sectional diagram of the tube balloon. An elastic and collapsible tube that is 0.97 m in diameter with a circumference of 1.95 m was adapted for use as a storage device in this study. An inlet pipe, which takes in the gas from the plant and an outlet pipe, which takes out gas from the tube each of 10 mm diameter and 100 mm long were incorporated into the tube. A valve connects each of the pipe to a hose that connects the biogas plant and exist valve from the tube. The tube expends when gas is collected and collapses when the gas is release from it. The exist valve from the tube remains closed until the tube is filled after which inlet valve is close and the tube is disconnected and taken to the point of use, where one of the valve is connected to the burner and other remain closed.

Figure 2: The tube balloon

2.3 Experimental Analysis

A correlation analysis between daily gas delivered to the balloon and pressure of gas in the balloon and the cumulative gas in the balloon was undertaken using Microsoft Excel 2010. The analysis was undertaken to determine if the pressure in the balloon has a linear relationship with the volume of gas in the balloon.

3. Result and Discussions

Table 1: Is the Summary of Measured Parameters

Day	Daily gas delivered to balloon (L)	Qty of gas that flowed back the plant (L)	Cumulative gas in the balloon (L)	Pressure of gas in balloon (Kg/m3)
0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0
15	0.07	0.0	0.07	1.1
20	0.16	0.0	0.23	2.6
25	0.0	0.16	0.07	1.1
30	0.0	0.0	0.07	1.1
35	0.0	0.5	0.02	0.4
40	0.07	0.0	0.07	1.1
45	0.15	0.0	0.15	2.4
50	0.0	0.09	0.06	1.3

3.1 Discussion

Table 1 is the summary of measured parameters the gas contained in the tube balloon was 0.45L from 520kg of cattle dung in 50 days. The movement of gas from the plant to the balloon is influenced by the pressure of gas in the system. Gas moved from the plant to the balloon when the plant pressure was higher than the balloon pressure. The minimum and maximum plant pressure is 0.41 kg/m^3 and 1.6 kg/m^3 respectively (Yusuf, 2011). Table 1 showed that gas was delivered from the plant (0.07 L) to the tube balloon on the 15th day of digestion when the balloon pressure was 1.1 $kg/m^{3,}$ which is lower than the maximum plant pressure of 1.6 kg/m^3. Gas flowed back into the plant from the balloon when a balloon pressure of 2.6kg/m^3 which is considerably higher than the maximum plant pressure reducing the quantity of gas in the balloon to 0.0L when a balloon pressure 1.1 kg/m^3 was attained. On attainment of the pressure, gas again, moved from the plant to the balloon, delivering 0.15 L of gas into the balloon. This resulted in a volume of 0.45 L of bio gas in the tube resulting in a tube pressure of 2.4 kg/m^3. Consequently, no further gas was delivered into the tube because of the resulting higher balloon pressure. The study showed the difficulty of collecting biogas in a container for use elsewhere because of the very low pressure of biogas plant. The pressure of the biogas plant equilibrates that of the balloon on delivery of a very small amount of biogas to the balloon. Therefore, a compressor and a non-return valve may be required to move sufficient quantity of the gas from the plant to the balloon for use elsewhere outside the plant.

3.2 Conclusion and Recommendation

It is concluded that:

i. 0.45L of biogas was collected in the tube balloon from the 520kg of cattle dung in 50 days

ii. The movement of gas from the biogas plant to the balloon was influenced by pressure.

iii. Gas flow was the unit of higher pressure gas flowed into and out of the tube balloon depending on the unit with the higher pressure.

iv. The study showed the difficulty in collecting biogas in container because of the very low pressure of biogas plants that equilibrated with that of the tube balloon on delivery of very small amount of biogas to the balloon.

It is recommended that; A compressor and a non-return valve may be required to move sufficient quantity of gas from the plant to the balloon for use elsewhere outside the plant.

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