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Design And Analysis of A Hydraulic Biogas Digester Using Agricultural Biomass

*Abubakar R. Ahmad
Department of Agricultural And Bio-Environmental Engineering Technology, Audu Bako College of Agric. Danbatta, PMB 3159 kano, Kano State, Nigeria
*Corresponding Author: *Abubakar R. Ahmad*

ABSTRACT: *Agricultural Biomass represents one of the most important sources of clean energy which can be used for domestic energy source, using different technologies. This can replace, partially or totally, the existing fossil fuels that are used today. Connected with the existing status of energy problem and the abandon biomass waste, this project is henceforth aimed at. In this paper different types of agricultural biomasses (dry leave, kitchen waste, sliced grass etc.) are used for obtaining biogas using the anaerobic fermentation process. The paper highlights the design for hydraulic digester of 300 liter capacity, made up of galvanized iron sheet, which consists digestion and hydraulic chambers for safety. A total of 120kg of biomass was charge and mixed with 360kg of water and made air tied. After twenty number of days, 0.7014kg of biogas was produced with maximum production on eleventh day.*

Keywords: *Agricultural Biomass, biogas, anaerobic fermentation, small-scale installation, pilot installation.*

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I. INTRODUCTION

The basis of life is energy. The most fascinating feature of any civilized society is the availability of energy for domestic, Agricultural, and industrial purposes. The available energy sources in Africa are wood, fossil fuels (coal, petroleum, and natural gas), hydro etc. A more serious problem is our increasing population culminating in high-energy demand and limited and fast depleting energy resources, which can result in severe energy crisis. This calls for serious measures and adequate policies in perfecting, utilization, exploration, and exploitation of our energy sources and pursuit of new alternative energy source and its conservation. This alternative energy should be adequate and within the reach of the rural people because about 70% of the total population in Africa live and depend almost 100% on fuel wood, which could lead to “world wood crisis”, as cutting of trees is not balanced by proper afforestation. The Food and Agricultural Organization (FAO) estimated in 1981, that nearly one billion people are living in regions with either acute shortage of or deficient wood supply situation. [1]

Research has shown the potential use of the wastes as substrate for microbial biogas production resulted in the investigation of alternative systems of using our wastes. Hence forth, efforts should be geared to reverse this trend by proper use of this alternative energy source -biomass. [2] Biogas, which is a biomass resource, is said to be ideal in deciding alternative source of energy in the sense that it is local in origin and production. It is also the energy that is useful for all-purpose; heating, lighting, small-scale electric power generation etc.[3] With above problem couple with the sorry state of our national electric power generation, the generation of biogas is found to be welcome idea for domestic Agricultural and industrial uses.

Biogas generation

Anaerobic digestion (AD) is natural biological process carried out by bacteria in the absent of air, in which organic material is broken down into stable fertilizer and useful biogas which comprises mainly methane and carbon dioxide. These anaerobic bacteria are an integral component of nature’s waste management and are commonly found in soils and waters, as well as in landfill sites. [5] Biogas is produced by anaerobic digestion of biological wastes such as cattle dung, vegetable wastes, sheep and poultry droppings, municipal solid waste, industrial wastewater, landfill, etc. [6] Biogas is a lean gas that can, in principle, be used like other fuel gases for households and industrial purposes: Gas cookers/stoves, Lamps, Radiant heaters, Incubator, Refrigerators, and Engines [7]

II. MATERIALS AND METHOD

The research work is divided into stages, through which the end result is expected.

(a) Design stage

Design for digester

- A 300 gallon digester chamber was designed using galvanized iron sheet and made sure it is leak-proof for water
- An inlet pipe is made of concrete, inserting slantly into the lower part of the digester.
- A movable plug is attached at the top center for accessing the digester chamber as well as outlet valve and pressure gauge.
- Slurry valve is placed at some distance away from the bottom so that some part of the slurry remains.
- Hydraulic chamber of 100 gallon capacity is placed above the digester chamber so that when biogas is produced, the gas pressure displaces some part of the liquid into the hydraulic chamber making the liquid at higher level. On the contrary, when the gas is used, liquid gets back into the digester chamber so that the liquid level drops. In this way, internal and external pressure is balanced.

(B) Experimental stage

This stage involves collection of the biomass from all angle such as kitchen waste, sliced grass, and dry leaves plus cow dung. The biomass is then charged into the digester and makes air tight. The gas generated is then compressed into cylinder.

The table below shows the biomass plus water charged into the digester

	Biomass	Mass (kg)
1.	Cow dung	40
2.	Kitchen waste	50
3.	Dry leave	5
4.	Grass	25
	Total	**120**

The mass of water charged into the digester = 300 kg

Hence the ratio = 360/120 = 3, i.e. for every 1 kg of biomass is mixed with 3 kg of water

III. RESULT AND DISCUSSION

The table below shows the operational parameters of the hydraulic digester for twenty numbers of days.

The transferring of the biogas into a cylinder is done at 4:00 pm every day

Day	Pressure (Mmhg)	Mean Daily Temperature (^{O}c)	Initial Mass Of Cylinder M_i (Kg)	Final Mass Of Cylinder M_f (Kg)	Mass Of Gas Generated (Kg) $M_g = M_f - M_i$
1	25.00	30.334	3.650	3.650	0.000
2	40.00	34.67	3.731	3.700	0.031
3	40.00	35.86	3.783	3.750	0.033
4	38.00	33.77	3.725	3.750	0.025
5	42.50	36.45	3.750	3.775	0.038
6	30.00	37.45	3.775	3.800	0.015
7	38.00	37.00	3.800	3.825	0.025
8	34.00	36.00	3.750	3.770	0.020
9	36.00	33.80	3.274	3.240	0.034
10	35.45	43.00	3.697	3.652	0.045
11	34.43	40.20-	3.597	3.542	0.055
12	34.43	36.70	3.652	3.612	0.040
13	37.34	34.00	3.485	3.451	0.034
14	36.34	35.23	3.585	3.42	0.043
15	35.54	35.65	3.740	3.701	0.039
16	34.45	35.43	3.603	3.550	0.053
17	32.43	34.43	3.700	3.660	0.040
18	36.56	35.32	4.035	4.001	0.034
19	32.34	35.8	3.703	3.66	0.043
20	35.54	36.00	3.565	3.520	0.045
	Total				**0.7014**

IV. DISCUSSION

From the table above at first day there is zero production of biogas, then the following ay production stated with maximum value of 0.3100. the production increases further untill the highest production which is on eleventh day with value of 0.055. the it started decreasing and fluctuate till on 20th day with value of 0.045. the total production on 0st day is 0.7014kg

V. CONCLUSION

In the present scenario of energy crisis in world, biogas generation is a strong viable alternative. After construction, it is concluded that the design can be a welcome idea to developing countries because of its low production cost. The digester produced 0.7014kg biogas within twenty numbers of day. this can replace some part of energy needed at domestic level. To better utilize the natural energy source that is provided by agricultural biomass, this designed system is recommendable as it is safer. The system costs $78.08 to create, which is affordable.

VI. RECOMMENDATION

A research should be conducted to the scrubbing of the biogas of other gases, specifically hydrogen sulfide and carbon dioxide.

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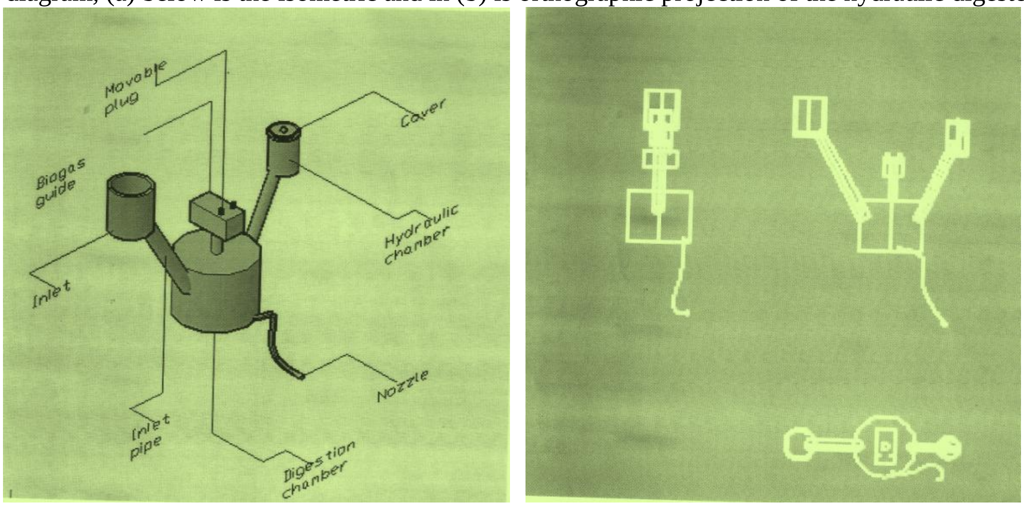
In diagram, (a) below is the isometric and in (b) is orthographic projection of the hydraulic digester:



(a) Isometric projection (b) Orthographic projection

Fig 01 Hydraulic biogas digester

1Raphael Mivanyi "The Toxicity of Mahogany Seed Oil Against Callosobruchus Maculates In Storage of Cowpea (Vigna Unguiculata) in Hong District Adamawa State. Nigeria." American Journal of Engineering Research (AJER), vol. 7, no. 01, 2018, pp. 01-03.