Construction of a Biogas Digester Using Gas and Temperature Sensor

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Abstract: - The construction of a biogas digester is the main emphasis of this project. Biogas is a mixture of gases created during the anaerobic decomposition of organic material, including food waste, animal waste, sewage, and waste from farms and plants. One of the major causes is environmental degradation, which has emerged to be the greatest threat to the health of the environment and the economy of the underdeveloped areas. But with the discovery and application of biogas which is a gaseous fuel obtained from biomass by the process of anaerobic digestion, most problems are resolved. The project's aim is to create a biogas digester that leverages animal manure to generate biogas for usage at Covenant University. The digester selected for construction is a barrel drum digester for the production of biogas using cow dung. The cow dung was tested for a total of 14 days, during which the days of gas production and digestion were observed, and the biogas was then tested with the gas and temperature sensor and was confirmed to detect gas and temperature.

Keywords: - Municipal, anaerobic, biogas, renewable energy, fossil fuel, environmental degradation

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1. Introduction

Non-renewable energies are always used which harms the environment and are very inefficient such as diesel generators and others. This project takes an approach to producing biogas using animal waste. And this can be achieved by using animal waste to produce biogas as a reliable energy source. Today's energy challenging behaviour is critical to explore and harness new renewable and eco-friendly energy sources. In rural parts of developing nations, a variety of agricultural wastes are widely available and have a great potential to meet the energy demand, particularly in the household sector. There are thought to be over 250 million cattle in India alone, and more than 12 million biogas plants could be built if just a third of the excrement they produce each year could be used for this purpose [1].

Certain types of biomasses can be used via biogas technology to partially satisfy energy demands. A well running biogas system may provide consumers and the community with several advantages, culminating in resource conservation and environmental preservation. Additionally, electricity, which is the backbone of modern economies, is unavailable or worse yet, unreliable because less than 4,000 MW of the 7,876 MW installed electricity capacity have been generated. This has reduced the amount of potential energy that can be harnessed to fuel the economic growth of the nation [2].

The most promising options for future energy development and conservation often come from renewable sources of energy. As a result, the development of renewable energy sources is the current topic of interest. One type of renewable energy is biogas which helps an economy grow economically and technologically by lowering energy costs and improving the social structure.
In several nations around the world, it serves as an alternative energy source. Depending on the temperature and the method used, producing biogas requires a different amount of time. Additionally, biogas is unavoidable due to the lack of a biogas

industry, particularly in Nigeria, the rise in fuel prices, and the accessibility of waste. The by-products of organic waste, including human and animal waste, are extracted by the biogas digester, and can be used in place of conventional fuels and fertilizers because it involves turning waste into wealth and is easy to produce without necessarily needing highly skilled labour for its operation, biogas is a good, economical, and alternative energy source. The availability of trash, the rise in fuel prices, and the lack of a biogas industry, particularly in Nigeria, make biogas necessary. Utilization of biogas has gained importance in recent years, mainly due to the availability of cheap raw materials and environmental compatibility. Further, with an increase in the cost of petroleum products, biogas can be an effective alternative source of energy for cooking, lighting, food processing, irrigation, and several other requirements [3].

Biogas occurs when microorganisms break down in the absence of oxygen. This process is called anaerobic digestion. For this to occur, the waste material needs to be enclosed in an environment without oxygen. However, the following are among the raw materials used by the biogas plant to create biogas: Agricultural waste, garbage, manure (for example, cow dung), sewage [4]. Additionally, energy is a crucial factor in global development and plays a vital role in domestic, industrial, and transportation sectors. Its significance cannot be overstated, as it is the foundation of economic and social advancement. However, in Nigeria, the lack of access to a range of modern energy services has hindered progress in important human development metrics. The absence of reliable and high-quality electricity has led to a growing reliance on standby generators that operate using petroleum products like fuel and diesel. Unfortunately, the by-products generated from their combustion contribute significantly to environmental degradation, climate change, and global warming [2].

Biogas is a product made through the fermentation of biodegradable substances like sewage, manure, and wastewater from industrial operations and livestock farms [5]. Anaerobic bacteria consume organic materials to create "biogas" when no oxygen is present (anaerobic condition). Waste materials that can be used to make it include manure, sewage, wastewater from industrial facilities and livestock farms, as well as agricultural waste. 60% to 70% of biogas is methane (CH4), 28% to 30% is carbon dioxide (CO2), and 2% or less is hydrogen sulfide (H2S), nitrogen (N2), and steam [6]. The quantity of combustible methane has a significant impact on the property of biogas, whereas carbon dioxide has no effect because it is not combustible. Protein, carbohydrate, and lipid compounds—both in solid and liquid forms—are examples of organic materials that are frequently discovered in trash. According to recent research, biogas has a significant competitive advantage because of the country's large biomass potential, which is projected to be about 8 x 102 MJ, and offers a cost-effective, long-term alternative [2]. Improper disposals of waste, such as indiscriminate dumping in landfills and unauthorized areas, worsens environmental degradation and exacerbates global warming. To decrease our reliance on fossil fuels, increase energy accessibility, and protect Nigeria's vast biomass potential, biogas technology is a feasible solution because of its resource technology and adaptability to rural environments [7].

2. Methodology

The digester selected for construction is a barrel drum digester for the production of biogas using cow dung as shown in Figure 1. For the system to work effectively a few equipment are needed. This equipment's are needed in order to control the system and prevent leakage as shown in Table 1.

The first thing that was done was to get cow dung. After getting this cow dung. The one gotten was almost half dried, it was weighed and was found to be 8.56 kg; water of the same weight value was weighed and added to it. The plastic container that was used was thoroughly washed with soap. It was allowed to dry properly after this. The dung was allowed to go through thorough fermentation process after being mixed in water at a ratio of 50 to 50 with water.

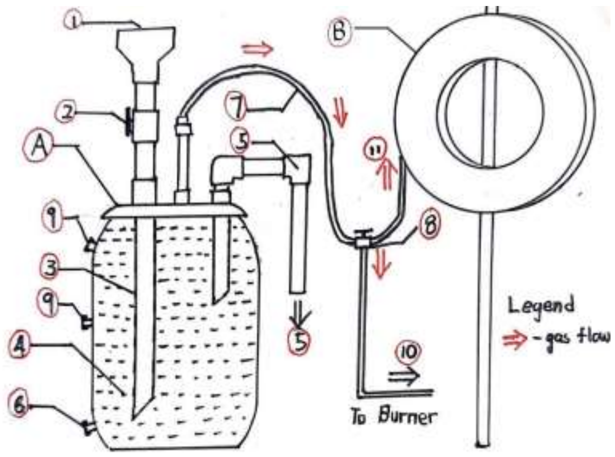

Figure 1. Biogas Digester Overall Setup

Table 1: Equipment Used for a Biogas Digester

S/N	**Names of part**	**Functions**
1	30-gallon barrel	Biogas digester-Anaerobic digestion occurs here
2	Food waste inlet	Grinded food waste is deposited via this funnel
3	Food waste inlet ball valve	Closes the food inlet pipe
4	Food waste pipe	Guides the food waste into the digester and is goes 80%-90% of the way into the digester
5	Water + manure + fruit waste	Substrate and medium for anaerobic bacteria
6	Slurry outlet pipe	Slurry is expelled from this pipe and can be used to fertilize vegetable gardens
7	Cleaning pipe + blind socket	Slurry is emptied via this valve if cleaning is to be done
8	Gas outlet	Biogas produced leaves the digester via this outlet and into the tube
9	Three-way gas valve	Used to direct the biogas from biogas digester to the tube. Gas flow is mediated by twisting the valve knob.
10	Extra slurry holes	Used to remove slurry in case the slurry outlet pipe is blocked
11	Tyre Tube	Used as the gas storage unit. Biogas produced is stored here.
12	Gas outlet (to tube)	Biogas that flows from the biogas digester into the tyre tube for storage. The flow is controlled by the three - way valve.
13	Gas outlet (to the burner)	Biogas is directed to the bunsen burner from the tube. The flow is controlled by the three-way valve.
14	Extra gas outlet	Extra gas outlet will be used in case main gas outlet gets clogged.

It was left in this condition for two weeks for it to go through proper fermentation. It should be noted that nothing else was added to it during this period, after the expiration of these two weeks fermentation process. Pawpaw, grape, tobacco, and ash were put together in a 5-liter container; after being cut into pieces. Water was added into the 5-liter container to fill it up to the brim, the whole content was thereafter poured into the fermented cow dung. The whole content was then stirred together properly.

A hole of 8mm in diameter was made at the side of the plastic container. A plastic tap base was fixed through this opening; followed by another hole on the cover of the plastic container which was 2mm in diameter as shown in Figure 2. A pierced-through tyre fab was fixed through this created 2mm hole on the cover of the plastic container, hot gum was then used to firmly secure the connection. This is shown in Figure 3. A hose was properly fixed on this fab using an iron clip as indicated by Figure 4. The fixed hose whose other end had earlier been terminated on a gas tap as illustrated in Figure 5. The other end of the tap was connected to a T joint copper hose via a rubber hose extension. The image of the T, joint is shown in Figure 6. Figure 7 shows the image of the used gas tap. The other end of the straight path of the T joint was connected to another gas tap via another rubber hose extension as shown in Figures 8 and 9.

The other end of this tap was thereafter terminated on the tyre tube through its fab. The T joint standalone hole was extended out via a long rubber hose. The other end of this rubber hose was terminated on another gas tap. This is shown in Figure 10. It should be noted that iron connectors were used at each rubber hose connection point to secure the connection firmly.

The biogas harvesting process typically involves the anaerobic digestion of organic material, such as animal waste or plant matter, to produce a mixture of gases that can be used as fuel. The primary components of biogas are methane (CH_4) and carbon dioxide (CO_2), along with smaller amounts of other gases such as hydrogen sulfide (H_2S) and nitrogen (N_2). The chemical equation for the production of biogas from organic material can be represented as:

$$C_6H_{12}O_6 \rightarrow 3CH_4 + 3CO_2$$

This equation shows the breakdown of a simple sugar (glucose, $C_6H_{12}O_6$) into three molecules each of methane (CH_4) and carbon dioxide (CO_2). This represents the basic chemical reaction that occurs during the anaerobic digestion process that produces biogas.

Figure 2. The Cover of the Plastic Container's Cover after a Hole was Punched through it

Figure 3. The Fab Connection on the Cover of the Container

Figure 4. The Biogas Digester Terminated Rubber Hose with Clip

Figure 5. The Gas Tap Termination from the Fab Connected to the Cover of the Biogas Plastic

Figure 6. The T joint is used in the Construction of the Biogas Digester

Figure 7. The Gas Tap was used in the Construction after the First Sets of Connection

Figure 8. The Gas Tap

Figure 9. The Gas Clip

Figure 10. Barrel Drum Biogas Digester

3. Results and Discussion

The analyses were done to ascertain that the constructed device was working in accordance with the set aim and objectives. The analyses are done based on the performance of the barrel drum digester. The performance of a biogas digester was analyzed through various parameters such as gas production rate, biogas composition, substrate degradation rate, pH, and temperature.

The gas production rate is a measure of the amount of biogas produced per unit of time. The cow dung was tested for a total of 14 days, during which the days of gas production and digestion were observed. To check for combustibility, the obtained gas was also burned. A burning test was conducted numerous times after the 14th day to determine the combustibility of the gas that had been produced. It was discovered that the digester-produced gas kept in the tyre tube was flammable as displayed in Figure 11. The amount of biogas created from cow dung over the course of 14 days is depicted in Figure 11 and Table 2. Since it takes longer for cow dung to disintegrate subsequently, when gas is being created, biogas from cow dung was not produced for the first eight days.

The process for producing gas from cow dung began on the ninth day, yielding an average amount of biogas of 997 g since this amount reduced to 993 g on the tenth day; and finally, to 990 g on the twelfth day. Reduces to 932 g on day 13, and 835 g of biogas is produced on the final day.

Figure 11. Bunsen burner test

Table 2. Result from Test Run

Result from Test Run		
S/N	**Number of Days**	**Mass of Biogas Produced**
1	Day 9	997
2	Day 10	993
3	Day 11	995
4	Day 12	990
5	Day 13	932
6	Day 14	835

4 Conclusion

In conclusion, a barrel drum biodigester was constructed and cow manure was used as the feed material during the testing of the constructed biodigester. The slurry's digestion took place anaerobically for three days and biogas was produced in the barrel drum digester with a volume of 10 kg and was tested to be combustible. Finally, the biogas was then tested with the gas and temperature sensor and was confirmed to detect gas and temperature of 36°C. The work recommends from the observations made during this whole project work that different types of digesters, such as floating drums and fixed drums, etc., may also provide excellent platforms for biogas work.

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Conflict of Interest

The authors have no conflict of interest to declare.