ANALYSIS OF OPTIMUM TEMPERATURE AND VALIDITY OF BIOGAS PLANT

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Abstract— Nowadays, the Global warming and climatic changes have enough deviation to be taken as Earth's atmosphere being at a high risk. The increasing temperature of Earth is an important symptom of this destruction. Combustion of Fuels and violation of conventional energies are highly responsible for this situation. Along with it, one more problem is arising rapidly that is waste management. India is a highly populated country; hence the waste generated per person is more. At this moment India is facing a huge problem of waste management along with energy crisis. Biomass is biological material derived from living, or recently living organisms. Biogas technology is based on anaerobic fermentation of organic waste that includes cowdung, human manure, agricultural wastes etc. The bacterium responsible for the fermentation process is dependent on the temperature. In this research paper, the optimum temperature is obtained at which the efficiency of Biogas plant can be reached to the maximum level.

Keywords— Biogas plant, Digester, Slurry, Temperature Controller, Methane.

I. INTRODUCTION

INDIA is an agricultural country. About 85% of total population lives in villages. Resource of commercial fuel is very limited in the country. Due to inefficient way of burning huge quantity of biomass fuels is wasted. In this context biogas technology can play a vital role in conservation of biomass resources. The potential of organic fertilizer and biogas with a number of raw materials available in India is 106.89*109 kg/year and 5,628.1mm3/year respectively. On the basis of raw materials around 4 million biogas plants can be constructed. Up to now approximately 23,500 biogas plants are installed in the country. The dissemination rate is very slow. Many biogas plants are not working due to different reasons. It is necessary to ascertain the reality and to give right direction for the future. This study was focused on status of existing biogas plants and identifying the different reasons of failure of biogas plants. So it is necessary to increase the efficiency of plant and make more reliable.

II. BIO GAS

Biogas is produced by animal and human manure, leaves, twigs, grass, anaerobic fermentation of organic materials such as industrial waste gas produced by the mixture of methane, carbon dioxide, hydrogen and many other gases i.e. sulphids. The presence of methane in biogas for cooking, lighting, and prime movers for power, which makes it suitable property, lends combustion. Working of Bio gas plant is such that Slurry (a mixture of equal amounts of biomass and water) is prepared in the mixing tank. Preparation of slurry inlet pipe through the digester is fed into the chamber. The plant is left unused for about two months and the introduction of slurry is stopped. During this period, anaerobic fermentation of biomass takes place in the presence of water and produces biogas digester.

Biogas is gas resulting from an anaerobic digestion process. A biogas plant can convert animal manure, green plants, waste from agro industry and slaughterhouses into combustible gas. Biogas can be used in similar ways to natural gas in gas stoves, lamps or as fuel for engines. It consists of 50-75% methane, 25-45% carbon dioxide, 2-8% water vapour and traces of O_2 N_2, NH_3 H_2 H_2S. Compare this with natural gas, which contains 80 to 90% methane. The energy content of the gas depends mainly on its methane content. High methane content is therefore desirable. A certain carbon dioxide and water vapour content is unavoidable, but sulphur content must be minimized - particularly for use in engines [2]. The average calorific value of biogas is about 21-23.5 MJ/m³, so that 1 m³ of biogas corresponds to 0.5-0.6 l diesel fuel or about 6 kWh. The biogas yield of a plant depends not only on the type of feedstock, but also on the plant design, fermentation temperature and retention time..

Biogas being lighter rises up and starts collecting in the gas holder. The gas holder is now starts moving. Gas holder cannot rise beyond a certain level. Starts collecting more and more gas, more pressure to be exerted on the slurry begins. Spent slurry is forced into the chamber now shop from the top of the chamber. The chamber is filled with slurry store expenses, additional overflow tank is forced out through the outlet pipe.

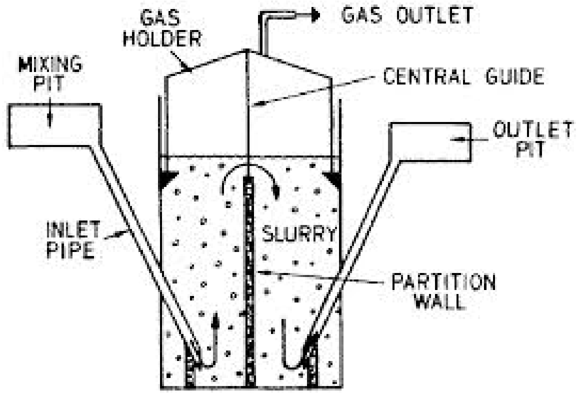

Fig.1 Construction diagram of Biogas Plant.

Fig.1 shows the construction Diagram of Biogas Plant. The Basic Construction of Biogas Plant is divided in four parts namely Feed Inlet, Digester and Gas dome and slurry outlet. The Feed inlet consists of the mixing pit and inlet pipe in which the cow dung or the slurry feed is mixed with water. In some traditional Biogas plants hot water is mixed with slurry to increase the temperature but it may destroy the bacteria.

The Digester, is the vessel in which the reaction takes place. The gas produced by the fermentation is stored in the dome. and the remaining slurry is led out through the outlet pit.

The latter is used as fertilizer for plants.

Biogas supply store to get gas from the gas valve is opened. Begins to produce biogas, gas cost a steady supply of fresh slurry and the introduction of slurry can be ensured by regular removal. Methane production: Airtightnees: The breakdown of organic material in the presence of oxygen to produce CO^2 and methane in the absence of it creates. Temperature: Temperature for fermentation will be 35^oC-40^oC.

This stage may be represented by the following overall reaction:

Thought reaction of methane bacteria

$$nCH_{4+} (C_6H_{10}O_5)_n + H_2O \longrightarrow 3nCO_2$$

Individual reaction include:

1. Acid breakdown into methane

$$2C_3H_7COOH + H_2O \longrightarrow 5CH_4 + 3CO_2$$

2. Oxidation of ethanol by CO_2 to produce methane and acetic acid.

$$2C_3CH_2OH + CO_2 \longrightarrow 2CH_3COOH + CH_4$$

3. Reduction with hydrogen of carbon dioxide to produce methane

$$CO_2 + 4H_2 \longrightarrow CH_4 + 2H_2O$$

Fig.2Chemical reactions in the digester

III. PRICE AND ECONOMICS

Table 1.Comparison of LPG and Biogas with their prices.

Sr. No	Volume	Feed	Plant cost	Installation Cost	LPG saved	Cylinders saved	Savings	Pay back	Return on investment
	m^3	Kg	Rs	Rs	Kg /day	Cylinder/month	Rs/month	Years	Rs
1	0.25	1	10,000	1,900	0.1	0.2	246	3.4	40,500
2	0.5	2	12,000	1,900	0.2	0.4	492	2.0	93,500
3	1	5	19,000	1,900	0.4	0.8	984	1.6	1,95,000
4	2	10	34,000	1,900	0.8	1.7	1968	1.4	3,97,500
5	3	15	48,000	3,300	1.2	2.5	2952	1.4	6,07,000
6	4	20	64,000	3,300	1.6	3.4	3936	1.4	8,04,000
7	6	30	90,000	3,300	2.4	5.1	5904	1.3	12,11,500
8	2	25	34,000	3,300	0.8	1.7	1968	1.4	3,97,500

Table1 gives the numerical analysis of the Prices and Economics of the LPG and Biogas, and has the overview of biogas potential for LPG cylinders saved and profit margin for the Biogas. As stated above, by use of the 0.25cu.m. Biogas plant total profit amount estimated can be of about 40,500 INR.

IV. PROPOSED SCHEME

Bacteria are sensitive to temperature, which plays an important role in the digestion process of the slurry. For commissioning of bacterial activity, minimum temperature of at least 20° C are required. Generally, increase in temperature shorten processing time and reduce the required volume of the digester tank by 25 % to 40 %. The bacterium of anaerobic digestion can be divided into psychrophile (upto 20 °C), mesophile (20 – 40 °C) and termophile (above 40 °C) bacteria, based on the temperature,. The choice of the process temperature depends on the feedstock and of the utilized digester type. Thus, digesters have to be heated in colder climates in order to encourage the bacteria to carry out their function The main objective of this project is to determine and try to increase the efficiency of a Biogas plant. Nowadays, we find out amount of closure of the biogas Plants is increased a lot. The reasons behind this mainly are low availability of feeds, quality of feed, deposition of scum over the digester and temperature variations due to which the bacteria are unable to give larger methane output. The biogas output of the plant comprises of mainly 3 elements namely Methane, H_2S and CO_2.At normal temperature, Biogas generally comprise of 55-65 % methane, 35-45 % carbon dioxide,0.5-1.0 % hydrogen sulfide and traces of water vapour.

In this project, we are going to According to the objective and research carried out by using the optimum temperature of the digester we can get large amount of methane i.e. upto 90% methane out of total gas. This is done by varying the temperature of the digester between 15^o C to 55^o C. It also includes the determination of validity of the Biogas Plant of0.25 cu.m. of digester through which we get maximum amount of methane content than that of other gases.

V. NATURE OF BACTERIA

The anaerobic fermentation is basically possible between 3°C and approximately 70°C. The rate of methanation increases with temperature. Since, however, the amount of free ammonia also increases with temperature; the bio-digestive performance could be inhibited or even reduced as a result. In general, normal biogas plants perform satisfactory only where mean annual temperatures are around 20°C or above or where the average daily temperature is at least 18°C. Within the range of 20-28°C mean temperature, gas production increases over-proportionally. If the temperature of the bio-mass is below 15°C, gas production will be so low that the biogas plant is no longer be economically feasible.

VI. CHANGES IN TEMPERATURE

The process of methanogenesis is very sensitive to changes in temperature. Brief fluctuations not exceeding the limits may be regarded as still un-inhibitory with respect to the process of fermentation. The temperature fluctuations between day and night are no great problem for plants built underground, since the temperature of the earth below a depth of one meter is practically constant. The use of water jacket or insulation wall is nowadays emerging in the Biogas Technology.

VII. TEMPERATURE CONTROLLER

In this project we are using PT100 temperature sensor. This is a precision integrated circuit, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The controller is further connected to the Heater to heat the digester when temperature goes below set value. It is also interfaced with LCD display where we can get temperature indication.PT-100 is named as such because platinum is used as the sensing material, for increment or decrement of temperature, the resistance value of platinum changes linearly. A relationship between temperature and resistance. It is this relationship that is used to measure temperature.

This relationship is given by

$$R(T) = R(T0)(1 + \Delta T)$$

Temperature sensor

PT100-

A platinum resistance thermometer (PRTs) has temperature range (from –200 to +850 °C).

The principle of operation is to measure the resistance of a platinum element. The most common type (PT100) has a resistance of 100 ohms at 0 °C and 138.4 ohms at 100 °C. There are also PT1000 sensors that have a resistance of 1000 ohms at 0 °C. The relationship between temperature and resistance is approximately linear over a small temperature range: for example, if you assume that it is linear over the 0 to 100 °C range,. For precision measurement, it is necessary to linearise the resistance to give an accurate temperature. The most recent definition of the relationship between resistance and temperature is International Temperature Standard 90 (ITS-90).

The linearization equation is:

$$R_t = R0 * (1 + A* t + B*t2 + C*(t-100)* t3)$$

Where:

R_t is the resistance at temperature t, R0 is the resistance at 0 °C, and

A= 3.9083 E–3

B = –5.775 E–7

C = –4.183 E–12 (below 0 °C), or

C = 0 (above 0 °C)

For a PT100 sensor, a 1 °C temperature change will cause a 0.384 ohm change in resistance

VIII. TEMPERATURE RANGES OF BACTERIA

Table 2.Temperature stages of Bacteria

Type of bacteria	Working temperatures ^oC	Best temperatur e ^oC
Psychrophyle	00-20	10
Mesophyle	20-40	37
Thermophile	40-65	52

IX. CONTROL CIRCUIT

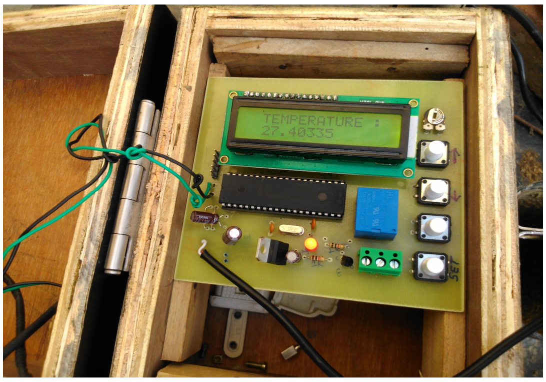

Fig.3 Pic controller kit for temperature sensing.

Figure 3. shows the kit of temperature controller in which we can sense the temperature and get it displayed on the LCD display.

Fig.4 Temperature Sensor PT100

Fig .4 shows the temperature sensor used in the project. PT100, it is a positive temperature coefficient sensor that has linear characteristics of temperature and resistance. The temperature sensor is inserted within the stomach of digester within the fluids. The sensor gives the temperature output in form of change in resistance. This deviation is given to the controller in form of electrical signal. The PIC controller has an inbuilt ADC which converts the analog signal in to digital signal. The Sensor is given an insulation wire at the connecting point. Being smaller in size the sensor is easily inserted in to the digester.

X. INSTALLED PROTOTYPE OF BIOGAS PLANT

We have installed a 0.25 cu.cm Biogas Plant. The Plant is of Floating Dome Type. The material for the Plant used is FRP. The plant is given thermal insulation by a water jacket around the digester.

Fig.5 The Installed Biogas Plant

XI. OBSERVATIONS FOR POULTRY

Table 3.Observed data for poultry waste feeding.

Sr. No.	Date	Feed Quantity ($x 10^{-2}$) cu.cm.	Water Quantity ($x 10^{-2}$) cu.cm.	Dome Height(cm)	Gas Volume ($x 10^{-2}$) cu.cm.
1.	08/09/15	2.35	2.35	55	1345.5
2.	12/09/15	2.35	2.35	52	1324.5
3.	16/09/15	2.35	2.35	53	1336.5
4.	20/09/15	2.35	2.35	55	1345.5
5.	24/09/15	2.35	2.35	55	1355.5
6.	30/09/15	2.35	2.35	53	1335.5
7.	06/10/15	2.35	2.35	53	1335.5
8	12/10/15	2.35	2.35	53	1335.5

Table3. Shows the observations for the biogas output when fed by the Poultry waste. In this phase, the poultry waste or chicken (hen) manure was collected and fed for around a month. We observed that for the feed and water proportion of 2.35 cu.cm each is sufficient enough for the full dome biogas generation i.e.1345.5cu.cm. of volume of gas.

XII. OBSERVATIONS FOR CATTLE WASTE

Table 4.Observed data for cattle waste feeding.

Sr. No.	Date	Feed Quantity (x10^{-})cu.cm.	Water Quantity (x 10^{-2}) cu.cm.	Dome Height (cm)	Gas Volume (x 10^{-2}) cu.cm.
1.	10/08/15	21.8	21.8	0	0
2.	14/08/15	21.8	21.8	0	0
3.	18/08/15	21.8	21.8	29	715.5
4.	22/08/15	21.8	21.8	0	0
5.	26/08/15	21.8	21.8	0	0
6.	30/08/15	21.8	21.8	55	1345.5
7.	04/09/15	21.8	21.8	55	1350.5

Table4. Shows the observations for the biogas output when fed by the Cowdung. In this phase, Cowdung, Buffalo, ox manure, cattle waste etc was collected and fed for around a month. We observed that for the feed and water proportion of 21.8 x 10-2 cu.cm each is sufficient enough for the full dome biogas generation i.e.1345.5 x 10-2 cu.cm. of volume of gas.

XIII. OBSERVATIONS FOR VARIABLE TEMPERATURE

Table 5. Observed data for cattle waste with different temperature conditions.

Sr.No.	Date	Feed Quantity (x10^{-2}) cu.cm.	Water Quantity (x 10^{-2}) cu.cm.	Dome Height (cm)	Temperature (^{o}C)	Heater	Heater Set value=36 ^{o}C	Gas Volume (x 10-2)cu.cm
1.	08/02/2016	21.8	21.8	55.1	28.0885	ON	32	1355.5
2.	09/02/2016	21.8	21.8	55.3	27.1735	ON	33	1355.5
3	10/2/2016	21.8	21.8	55.6	27.7845	ON	34	1360.6
4	11/2/2016	21.8	21.8	56	28.7823	ON	35	1363.4
5	12/2/2016	21.8	21.8	56.7	27.4545	ON	36	1365.5
6	10/2/2016	21.8	21.8	55.3	27.7845	ON	38	1355.5

Table 5.shows the observations for optimum temperature. According to the analysis, the optimum temperature for the maximum biogas generation is found out to be 36 oC. In the above readings the normal temperature of the Biogas digester was in the range of 27-28 oC so the heater has to remain in ON condition.

RESULTS

As compared to the observations for cowdung as the feed, the poultry feed required is less in quantity i.e. for 21.8 x 10-2cu.cm of cowdung waste produces equivalent biogas output to 2.358 x 10-2cu.cm of poultry waste.

CONCLUSION

According to the project observations, we observed following parameters:

1. The 21.8 x 10-2 cu.cm of cowdung gives 1355.5 x10-2 cu.cm of biogas.
2. The 2.35 x 10-2 cu.cm of poultry waste gives 1355.5 x10-2 cu.cm of biogas.
3. The poultry waste gives more biogas in less quantity than that of cowdung.
4. The bacteria depends on the temperature, so when the temperature is 36°C,we got maximum gas output.

FUTURE SCOPE

1. India has second largest biogas program in the world at rural and as well as urban levels.
2. Through this project we can get more efficiency of biogas plant.
3. And thus we can develop a sustainable

renewable energy program on biogas for replacing petroleum products by utilization of biogas in the country.

4. Biogas Technology has reached millions of users. It is used majorly for cooking, but electricity generation through the biogas is still under research.
5. Further biogas technology can be developed for rigid materials by using a crusher along with the plant.
6. It can be developed in urban area by use of kitchen waste and human manure.
7. Slurry of biogas can be used globally as organic fertilizer for farming.
8. It has enough potential totally replace the LPG.

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