PORTABLE BIO GAS DIGESTER

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Abstract— The main theme of our project is to produce biogas from kitchen waste and animal (cow and buffalo) waste. Biogas is a clean and renewable fuel. The main part is digester. In the digester, bacteria is convert organic waste into methane gas through the process of anaerobic digestion. Biogas plants significantly curb the greenhouse effect. Biogas is first created as a landfill gas. This is because the gas is produced by the breakdown of biodegradable waste which is found within a landfill. The gas has a chemical reaction as a result of the decomposing of waste. Most common problem biogas production is, the large hydraulic retention time of 30-50 days (due to temperature conditions) and low gas production in winter. To overcome that problem we using stirrer for better production of biogas during winter season. By using portable biogas digester to overcome the biogas production on 365 days.

Key words: Digester, Anaerobic digestion, stirrer

1. INTRODUCTION

Presently, India is facing severe problem in the sector of Energy production, which may be more serious in the coming decade or so. With the rapid decrease in our underground natural resources (such as Petroleum and Coal) quantity and level throughout the world and problem related to their effective combustion, the growing demand to get access to the new sources of energy, like renewable energy and their resources is measuring their margins. The demand for petroleum products and their necessary utilization in the modern world is increasing with every passing day. The modern scientist and researches are grapping and hovering so as to invent various ways to tackle such imminent problems.

India has been spending a large amount of capital to import these products from overseas like, the Arabic region, the Persian gulf , OPEC (oil & petroleum exporting countries) etc. The key issues faced by most developing and developed countries of the world today are mainly future energy security and better use of natural resources. There is a vast loop hole in terms of energy production and consumption in this country. This situation may get more aggravated as it is in the long term with unemployment and low gross domestic products (GDP). Limited availability and lack of energy remains one of the most important hindrances affecting industrial development in the country. On the other side India is also facing serious natural calamities like environmental pollution, disturbance in weather and global warming. Greenhouse effect is certainly a matter of serious concern for the survival the human species and nature. Deforestation and environmental clearance is a matter, where serious thinking is to be done. We need to rejuvenate the same to attain prosperity and up-hold the nature-human relationship. Most of the part of our country lives on charcoal and fire wood for fuel supply and living which requires cutting down of trees, which in turn decreases the fertility of soil and causes soil erosion. Though conventionally, a large population of rural India lives on wood, cow-dung cakes, charcoal, etc due to its ease of use, availability throughout the year, but there are problems associated with the by-product generated, causing diseases due to smoke and harmful gases evolving out of it.

Kitchen waste is organic material having the high calorific value and nutritive value to microbes, that's why efficiency of methane production can be increased by several orders of magnitude. It means size of reactor and cost of biogas production is reduced. Also in most of cities and places, kitchen waste is disposed in landfill or discarded which causes public health hazards and diseases like malaria, cholera, typhoid. Inadequate management of wastes like uncontrolled dumping bears several adverse consequences: It not only leads to polluting surface and groundwater and further promotes the breeding of flies, mosquitoes, rats and other disease bearing vectors. Also, it emits unpleasant odour & methane which is a major greenhouse gas contributing to global warming. So Instead of discarding it as waste, this so called waste could be utilized subsequently to substantiate the production of fuel. In most rural and urban areas, the disposal and overhanging of these waste causes environmental pollution and diseases. Allocating this waste into a biogas plant also means that higher efficiency, reduced cost of fuel is inherited.

1.1 Biogas

It's a mixture of gases produced by the microorganisms during the anaerobic fermentation of biodegradable materials. Anaerobic fermentation is a biochemical process in which a particular kind of bacteria digests biomass in an oxygen-free environment resulting in production of CH4, CO2, H2 and traces of other gases along with decomposed mass.

1.2 Properties of Biogas

Biogas is a mixture of different components and the composition varies depending upon the characteristics of feed materials, amount of degradation, etc. Biogas predominantly consists of 50 to 70 per cent methane, 30 to 40 per cent carbon dioxide and low amount of other gases. The composition and the properties of the biogas are given in the following table 1.1 and 1.2

Composition of biogas

Name of the gas	Composition in biogas (%)
Methane (CH_4)	50-70
Carbon dioxide (CO_2)	30-40
Hydrogen (H_2)	5-10
Nitrogen (N_2)	1-2
Water vapour (H_2O)	0.3
Hydrogen sulphide (H_2S)	Traces

Table 1.1: Composition of biogas

Properties of biogas

Properties	Range
Net calorific value (MJ/m^3)	20
Air required for combustion (m^3/m^3)	5.7
Ignition temperature (^0C)	700
Density (kg/m^3)	0.94

Table 1.2: Properties of gas

2. PROBLEM IDENTIFICATION

Most common problem in biogas production is, the large hydraulic retention time of 30-50 days (due to temperature conditions), low gas production in winter. To overcome that problem we using stirrer for better production of biogas during winter season. To reduce energy consumption we extract biogas from digester through anaerobic condition. Digester should be warm to produce biogas, so we coated outside the digester black color paint.

3.DESCRIPTION OF COMPONENTS

3.1 BIOGAS DIGESTER

A digester is also called "fermentation tank" and is mostly embedded partly or fully in the ground. It is generally cylindrical in shape and it is made of bricks in biogas plants.

It holds the slurry for a sufficiently long time to complete the digestion.

GAS HOLDER

Its function is to keep the gas for subsequent use. The gas connection for use is taken from the top of the gas holder. In some designs of biogas plants it may be separable from the digester whereas in other designs it may be an integral part of the digester.

3.2 GAS INLET PIPE

An inlet is provided to add the mixture of dung and water to the digester, ans is sloped accordingly. We use PVC pipe for inlet and outlet purpose.

OUTLET

The provision of an outlet is made to take out the digested portion of slurry. Ofter the mixture of dung and water inlet and outlet closed. The final wastes comes out of the outlt and used as fertilizer.

3.3 SLURRY MIXING TANK

This tank carries out mixing of the dung with water for induction in the digester, through the inlet.

Fig 3.3.1: Slurry mixing tank

Classification of biogas plants

Based on the nature of feeding, biogas plants would be broadly divided into 3 types and they are as follows:

i.Batch Type: The organic waste materials to be digested under anaerobic condition are charged only once into a reactor-digester. The feeding is between intervals. The plant is emptied once the process of digestion is complete. Retention time usually varies from 30 to 50 days. The gas production in it is intermittent. These plants are well suited for fibrous materials. This type of plant needs addition of fermented slurry to start the digestion process and it is not economical to maintain which are considered to be the major draw backs.

ii.Semicontinuous: A predetermined quantity of feed material mixed with water is charged into the digester from one side at specified interval of time; (say once a day) and the digested material (effluent) equivalent to the volume of the feed, flows out of the digester from the other side (outlet).

iii.Continuous type: The feed material is continuously charged to the digester with simultaneous discharge of the digested material (effluent). The main features of this type of plants are continuous gas production, requires small digestion area, lesser period for digestion, less maintenance, etc.

The biogas plants used in the villages are of semi continuous type employing animal dung and other biomass as the feed stock for biogas production. So the classification of semi-continuous type biogas plant is explained below:-

i.Fixed dome type model– A fixed dome type consists of an enclosed disaster

with a fixed non movable gas space. The gas is stored in the upper part of the digester.

ii. Floating drum type- It consists of a digester and moving gas holder. The gas holder floats either direct on fermentation of slurry on in water jacket of its own. When gas accumulates in the gas drum, it rises above and when gas is drawn out, it falls down.

iii. Balloon type: A balloon type consist of a plastic or rubber digester bag, in the upper part of which the gas is stored. The inlet and outlet is attached direct to the skin of the balloon. When the gas space is full, the plant works like fixed dome type.

Factors involved in biogas production

Biogas production involves different physical, chemical and biological process for conversion of biodegradable organic materials to energy rich gas.

i. C/N ratio

The ratio of carbon to nitrogen present in the feed material is called C:N ratio. It is a crucial factor in maintaining perfect environment for digestion. Carbon is used for energy and nitrogen for building the cell structure. Optimum condition for anaerobic digestion to take place ranges from 20 to 30. This means the bacteria use up carbon about 20 to 30 times faster than they use up nitrogen.

When there is too much carbon in the raw wastes, nitrogen will be used up first and carbon left over. This will make the digestion slow down and eventually stops. On the other hand if there is too much nitrogen, the carbon soon becomes exhausted and fermentation stops. The nitrogen left over will combine with hydrogen to form ammonia. This can kill or inhibit the growth of bacteria specially the methane producers.

ii. Temperature

Temperature affects the rate of reaction happening inside the digester. Increase in the ambient temperature increases the rate of reaction thus increasing the biogas production as well. Methane bacteria work best at a temperature of 350 – 380 C. The fall in gas production starts at 200C and stops at a temperature of 100C. Studies hoed that 2.25 m3 of gas was produced from 4.25m3 of cattle dung every day when the digester temperature was 250C. When the temperature raised to 28.30C the gas production was increased by 50 per cent to 3.75 m3 per day.

iii. Retention time

It is the theoretical time that particular volume of feedstock remains in the digester. In other words, retention time describes the length of time the material is subjected to the anaerobic reaction. It is calculated as the volume of digester filled with slurry divided by the feedstock added per day and it is expressed in days. Under anaerobic condition, the decomposition of the organic substances is slow and hence need to keep for long time to complete the digestion. In case of Indian digesters, where the feed stock is diluted with equal composition, so demarcation prevails between solid and liquid. In this case, biomass in the form of bacteria is washed out; hence the solid retention time (SRT) is equal to hydraulic retention time (HRT).

iv. Loading rate

Loading rate is defined as the amount of raw material fed to the digester per day per unit volume. If the reactor is overloaded, acid accumulation will be more obviously affecting daily gas production. On the other hand, under loading of digester have negative impact in designed gas production.

v. Toxicity

Though small quantities of mineral ions like sodium, potassium stimulates the growth of bacteria, the high concentration of heavy metals and detergents have negative impact in gas production rate. Detergents like soap, antibiotics, and organic solvents are toxic to the growth of microbes inside the digester. Addition of these substances along with the feed stock should be avoided.

vi. pH or hydrogen ion concentration

To maintain a constant supply of gas, it is necessary to maintain a suitable pH range in the digester. pH of the slurry changes at various stages of the digestion. In the initial acid formation stage in the fermentation process, the pH is around 6 or less and much of CO2 is given off. In the latter 2-3 weeks times, the pH increase as the volatile acid and N2 compounds are digested and CH4 is produced. The digester is usually buffered and the pH is maintained between 6.5 and 7.5. In this pH range, the micro-organisms will be very active and digestion will be very efficient. If the pH range is between 4 and 6 it is called acidic. If it is between 9 and 10 it is called alkaline. Both these are detrimental to the methanogenic (Methane production) organisms.

vii. Total solid content

The raw cow dung contains 80-82% of moisture. The balance 18-20% is termed as total solids. The cow dung is mixed usually in the proportion of 1:1 in order to bring the total solid content to 8-10%. This adjustment of total solid content helps in digesting the materials at the faster rate and also in deciding the mixing of the various crop residues as feed stocks in biogas digester.

viii. Feed rate

One of the prerequisites of good digestion is the uniform feeding of the digester so that the micro organisms are kept in a relatively constant organic solid concentration at all times. Therefore the digester must be fed at the same time every day with a balanced feed on the same quality and quantity.

ix. Diameter to depth ratio

Studies reveal that gas production per unit volume of digester capacity was maximum, when the diameter to depth ratio was in the range of 0.66 to 1.00. One reason may be that because in a simple unstirred single stage digester the temperature varies at different depths. The most activity digesting sludge is in the lower half of the digester and this is less affected by changes in night and day temperature.

x. Nutrients

The major nutrients required by the bacteria in the digester are, C, H_2, O_2, N_2, P and S, of these nutrients N_2 and P are always in short supply and therefore to maintain proper balance of nutrients an extra raw material rich in phosphorus (night soil, chopped leguminous plants) should be added along with the cow dung to obtain maximum production of gas.

xi. Degree of mixing

Bacteria in the digester have very limited reach to their food, it is necessary that the slurry is properly mixed and bacteria get their food supply. It is found that slight mixing improves the fermentation; however a violent slurry agitation retards the digestion.

xii. Type of feed stocks

All plant and animal wastes may be used as the feed materials for a digester. When feed stock is woody or contains more of lignin, then digestion becomes difficult. To obtain as efficient digestion, these feed stocks are combined in proportions. Pre-digestion and finely chopping will be helpful in the case of some materials. Animal wastes are predigested. Plant wastes do not need pre-digestion. Excessive plant material may choke the digester.

RAW MATERIALS USED IN BIOGAS PLANT

The most commonly used biodegradable wastes as follows

Animal wastes: Cattle dung, urine, fish wastes, piggery wastes etc.

Human wastes: Waste matter, urine etc.

Agriculture wastes: Sugarcane trash, tabacco waste, oil cake, vegetable wastes etc`

Industrial wastes: Sugar factory, paper factory etc.

3.4 STIRRER

The stirrers are provided in biogas plants of large size for stirring the slurry and the inside fermentation chamber to ensure the normal production of gas. The small size biogas plants can function without a stirring device.

Some biogas plants also have the arrangement of external heating by solar / electrical energy under colder climates.

Fig 3.4.1 Stirrer

3.5 BIOGAS HOLDING TUBE

The tube made of rubber inside the tube the biogas can be stored. The gas coming out of the digester through the gas flow hose. It stores the biogas and when never the need of gas it delivers through the gas outlet valve.

Fig 3.5.1 Biogas holding tube

HOSE AND T - JOINT, GAS VALVE

Hose used to carrying the biogas through the entire system. We use the hose size of 8mm and length of 2 metre.

T – Joint used to connect the three sides having same dimensions. One side the coming biogas hose is connected and another side storage of tye tube hose passage is connected.

Gas valve used to regulate the biogas from tyre tube to outlet. Through the gas valve biogas carried out and used for heating purposes.

3.6 PRESSURE GAUGE

Pressure measurement is the analysis of an applied force by a fluid (liquid or gas) on a surface. Pressure is typically measured in units of surface area. Many techniques have been developed for the measurement of pressure and vacuum.

Instruments used to display the pressure in an integral unit are called pressure gauges or vacuum gauges.

Fig 3.6.1 Pressure gauge

4. WORKING PRINCIPLE

4.1 ANAEROBIC DIGESTION:

Anaerobic digestion is a collection of processes by which microorganisms break down biodegradable material in the absence of oxygen. The process is used for industrial or domestic purposes to manage waste or to produce fuels. Much of the fermentation used industrially to produce food and drink products, as well as home fermentation, uses anaerobic digestion.

Anaerobic digestion occurs naturally in some soils and in lake and oceanic basin sediments, where it is usually referred to as "anaerobic activity". This is the source of marsh gas methane as discovered by Alessandro Volta

The digestion process begins with bacterial hydrolysis of the input materials. Insoluble organic polymers, such as carbohydrates, are broken down to soluble derivatives that become available for other bacteria. Acidogenic bacteria then convert the sugars and amino acids into carbon dioxide, hydrogen, ammonia, and organic acids. These bacteria convert these resulting organic acids into acetic acid, along with additional ammonia, hydrogen, and carbon dioxide. Finally, methanogens convert these products to methane and carbon dioxide. The methanogenic archaea populations play an indispensable role in anaerobic wastewater treatments.

Anaerobic digestion is used as part of the process to treat biodegradable waste and sewage sludge. As part of an integrated waste management system, anaerobic digestion reduces the emission of landfill gas into the atmosphere. Anaerobic digesters can also be fed with purpose-grown energy crops, such as maize.

Anaerobic digestion is widely used as a source of renewable energy. The process produces a biogas, consisting of methane, carbon dioxide and traces of other 'contaminant' gases. This biogas can be used directly as fuel, in combined heat and power gas engines or upgraded to natural gas- quality bio methane. The nutrient-rich digestate also produced can be used as fertilizer.

Many microorganisms affect anaerobic digestion, including acetic acid-forming bacteria (acetogens) and methane- forming archaea (methanogens). These organisms promote a number of chemical processes in converting the biomass to biogas.

4.2 PROCESS

Anaerobes utilize electron acceptors from sources other than oxygen gas. These acceptors can be the organic material itself or may be supplied by inorganic oxides from within the input material. When the oxygen source in an anaerobic system is derived from the organic material itself, the 'intermediate' end products are primarily alcohols, aldehydes, and organic acids, plus carbon dioxide. In the presence of specialised methanogens, the intermediates are converted to the 'final' end products of methane, carbon dioxide, and trace levels of hydrogen sulfide. In an anaerobic system, the majority of the chemical energy contained within the starting material is released by methanogenic bacteria as methane.

Populations of anaerobic microorganisms typically take a significant period of time to establish themselves to be fully effective. Therefore, common practice is to introduce anaerobic microorganisms from materials with existing populations, a process known as "seeding" the digesters, typically accomplished with the addition of sewage sludge or cattle slurry.

4.3 PROCESS STAGES

The four key stages of anaerobic digestion involve hydrolysis, acidogenesis, acetogenesis and methanogenesis. The overall process can be described by the chemical reaction, where organic material such as glucose is biochemically digested into carbon dioxide (CO2) and methane (CH4) by the anaerobic microorganisms.

Hydrolysis

In most cases, biomass is made up of large organic polymers. For the bacteria in anaerobic digesters to access the energy potential of the material, these chains must first be broken down into their smaller constituent parts. These constituent parts, or monomers, such as sugars, are readily available to other bacteria.

The process of breaking these chains and dissolving the smaller moleculesinto solution is called hydrolysis. Therefore, hydrolysis of these high-molecular-weight polymeric components is the necessary first step in anaerobic digestion.Through hydrolysis the complex organic molecules are broken down into simple sugars, amino acids, and fatty acids. Acetate and hydrogen produced in the first stages can be used directly by methanogens. Other molecules, such as volatile fatty acids (VFAs) with a chain length greater than that of acetate must first be catabolised into compounds that can be directly used by methanogens.

Acidogenesis

The biological process of acidogenesis results in further breakdown of the remaining components by acidogenic (fermentative) bacteria. Here, VFAs are created, along with ammonia, carbon dioxide, and hydrogen sulfide, as well as other byproducts. The process of acidogenesis is similar to the way milk sours.

Acetogenesis

The third stage of anaerobic digestion is acetogenesis. Here, simple molecules created through the acidogenesis phase are further digested by acetogens to produce largely acetic acid, as well as carbon dioxide and hydrogen.

Methanogenesis

The terminal stage of anaerobic digestion is the biological process of methanogenesis. Here, methanogens use the intermediate products of the preceding stages and convert them into methane, carbon dioxide, and water.

These components make up the majority of the biogas emitted from the system. Methanogenesis is sensitive to both high and low pHs and occurs between pH 6.5 and pH 8. The remaining, indigestible material the microbes cannot use and any dead bacterial remains constitute the digestate.

Configuration

Anaerobic digesters can be designed and engineered to operate using a number of different configurations and can be categorized into batch vs. continuous process mode, mesophilic vs. thermophilic temperature conditions, high vs. low portion of solids, and single stage vs. multistage processes.

More initial build money and a larger volume of the batch digester is needed to handle the same amount of waste as a continuous process digester. Higher heat energy is demanded in a thermophilic system compared to a mesophilic system and has a larger gas output capacity and higher methane gas content.

For solids content, low will handle up to 15% solid content. Above this level is considered high solids content and can also be known as dry digestion. In a single stage process, one reactor houses the four anaerobic digestion steps.

5.APPLICATIONS & ADVANTAGES

1. Utilization of kitchen waste for biogas generation – By using kitchen waste as a source of biogas, there will be a reduction in the volume of household garbage.
2. Reduced dependence on imported fossil fuel like LPG.
3. Utilization of slurry for gardening.
4. Energy consumption at low cost.
5. Easy to dispose the waste, compact and simple construction of digester.
6. Reducing water and air pollution.
7. Saving time for collecting firewood.

6. CONCLUSION

The effective implementation of portable biogas digester for production of biogas by decomposing kitchen waste offers a relevant resource development solution and a rigid waste management system. Its low cost and its independent working conditions under suitable considered parameters prove that it is economic. It is a technology that can be surely assured for processing organic kitchen waste using a plastic biogas digester. It has suddenly experienced a significant positive vibe in the recent go and is a strong contender in becoming the next renewable energy source. Through the generation of biogas we can generate energy and satisfies the human energy needs.

7.REFERENCES

[1] Jantsch, T.G., Matttiason, B. (2004), “An automated spectropphoyometric system for monitoring buffer capacity in anaerobic digestion processes” Water Research. 38: 3645- 3650.

[2] Karve of Pune A.D (2006), “Compact biogas plant compact low-cost digester from waste starch”. www.bioenergylists.org.

[3] Karve .A.D. (2007), “Compact biogas plant, a low cost digester for biogas from waste starch” http://www.arti-india.org.

[4] Q. Zhao, E. Leonhardt, C. MacConnell, C. Frear and S. Chen, “Purification Technologies for Biogas Generated by Anaerobic Digestion”, CSANR Research Report 2010 – 001

[5] Dellena Gloria Alagcan,Sant K.Pratap, Manuel M.Alagcan Ginasha, D.R , Nacanieli S.Tuivavalagi, S.K. Garg, “Use of Compact Biogas Plant for Biogas Production Utilizing Waste Food Materials, Fruits, and Vegetable Peelings of High Calorific Contents”,

International Journal of Engineering, ijesm Science and Metallurgy, Vol.2, No.1 (2012)

[6] Subbarao Chamarthi, Subbarao Chamarthi, Purnanand V Bhale, N.Srinivasa Reddy, Ch Chandra Mouli, "Laboratory ScaleExperiments for Biogas Production using Gas Chromatography Analysis", IOSR Journal of Engineering, Vol. 3, Issue 7 (July. 2013)

[7] Ann C. Wilkie, "Biomethane from Biomass, Biowaste, and Biofuel", 2008 edition, ASM Press

[8] Gauri P. Minde, Sandip S. Magdum and V. Kalyanraman, "Biogas as a Sustainable Alternative for Current Energy Need of India", Journal of Sustainable Energy & Environment, Vol 4 (2013) 121-132

[9] Vincent Okudoh, Cristina Trois, Tilahun Workneh, Stefan Schmidt, "The potential of cassava biomass and applicable technologies for sustainable biogas production in South Africa: A review", Renewable and Sustainable Energy Reviews 39 (2014) 1035–1052.