BIOGAS OPERATED WATER HEATER SYSTEM

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ABSTRACT

This project utilized biogas as alternative source of fuel utilized for water heating purpose in gas geyser. The gas geyser mainly used in house hold application for water heating. The main fuel used in a gas geyser is Liquefied Petroleum Gas (LPG), is a byproduct of petrol refining and natural gas. As a LPG is mainly used for cooking application in all over the world therefore the consumption of LPG is very high compare to its availability. Therefore day by day tariff for LPG is increasing which is expensive and infeasible for rural people. In most of rural India availability of biogas is free and obedient which can be utilized for water heating application in gas geyser. Our main purposed is to use biogas as a fuel in gas geyser at the place of LPG for water heating purpose. For the production of biogas floating drum type biogas plant is selected which is one of the commonly used biogas plant for small application. The design has been done by considering the number of members in one family and with respective that the dimensions for float type drum is selected. Material (cow dunk + water) is directly feed through the inlet section attached at the bottom of digester tank, this material required time (approximately 15-20days) for digestion process after that the gas is stored in gas chamber, in digester tank waste digested material comes out from outlet pipe which situated at the top of digester tank. Then the generated gas is pass to gas geyser though gas pipe, it is controlled by flow control valve (On/Off) on gas tank. Gas geyser has main parts like control valves, sensors, copper tubes, solenoid valve, lighter, electronic kit and battery etc. In gas geyser biogas comes through inlet valve up to the burner and cold water enter in copper tube though inlet valve, after that burner is ignited through lighter and the heat is absorbed by copper tube in water. Then hot water comes out from outlet pipe.

Keyword: - *Introduction, Construction, Working, Methodology, Specifications, Results, Conclusion, References*

1. INTRODUCTION

Water heating is a heat transfer process that uses an energy source, to heat water above its initial temperature. Typical domestic uses of hot water include cooking, cleaning, bathing, and space heating appliances. This requirement can be fulfill by the use of gas geysers. Geysers are gaining in popularity due to its simplicity in design and high thermal efficiency which converts chemical energy fuel into heat energy. It mainly use for water heating application for domestic uses. Recently the geysers working on electricity and gas fuel (LPG).
Today every country draws its energy needs from a variety of sources. Sources are broadly categorized as commercial and non-commercial. The commercial sources include the fossil fuels (coal, oil and natural gas). In the

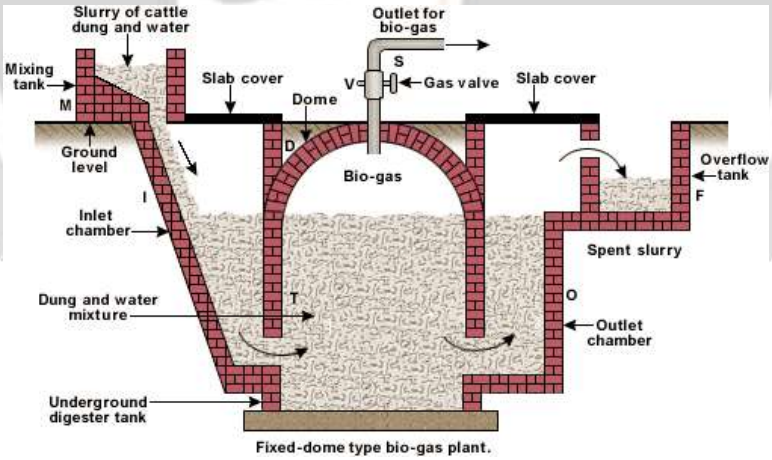
past few years, it has become obvious that fossil fuel resources are fast depleting and that the fossil fuel era is gradually coming to end. About 70% ofIndia's energy generation capacity is from fossil fuels, with coal accounting for 36% of India's total energy consumption followed by crude oil and natural gas at 28% and 6% respectively. As increasing the cost of LPG and more consumption of electricity, people living in rural area do not afford the high cost, they finds other alternative on it. So to fulfill their demands and reduce the consumption of fossil fuels, biogas is the best fuel source having colorific value of 32-36 MJ/kg.

1.1 BIOGAS

Biogas is a renewable, high-quality fuel, which can be produced from a lot of different organic raw materials and used for various energy services. Biogas technology has been developed and widely used over the world, because it has a lot of advantages, including reduce of the dependence on non-renewable resources, high energy-efficiency, environmental benefits, availability and cheap resources to feedstock, relatively easy and cheap technology for production, extra values of digested materials as a fertilizer, etc. Biogas is produced when microorganisms degrade organic materials in the absence of oxygen. The feedstock can derive from the agricultural, industrial or municipal sources. There are different types of biogas plants, floating drum and fixed dome biogas plants used in India.

1.1.1 FIXED DOME TYPE BIOGAS PLANT

A fixed-dome plant consists of a digester with a fixed, non-movable gas holder, which sits on top of the digester. When gas production starts, the slurry is displaced into the compensation tank. Gas pressure increases with the volume of gas stored and the height difference between the slurry level in the digester and the slurry level in the compensation tank. The costs of a fixed-dome biogas plant are relatively low. It is simple as no moving parts exist. There are also no rusting steel parts and hence a long life of the plant (20 years or more) can be expected. The plant is constructed underground, protecting it from physical damage and saving space. While the underground digester is protected from low temperatures at night and during cold seasons, sunshine and warm seasons take longer to heat up the digester. No day/night fluctuations of temperature in the digester positively influence the bacteriological processes.

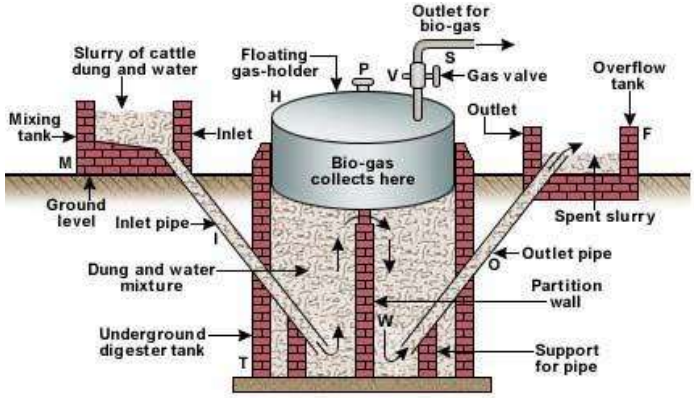


Fixed-dome type bio-gas plant.

1.1.2 FLOATING DOME TYPE BIOGAS PLANT

A floating-drum plant consists of a cylindrical or dome-shaped digester and a moving, floating gas-holder, or drum. The gas-holder floats either directly in the fermenting slurry or in a separate water jacket. The drum in which the biogas collects has an internal and/or external guide frame that provides stability and keeps the drum upright. If biogas is produced, the drum moves up, if gas is consumed, the gas-holder sinks back.The main digester pit is made as a brick lined cylindrical hole in the ground. The floating gas drum is made of steel and is designed to move

up and down as gas collects and is used. It also is designed to rotate about a vertical axis at the centre of the cylinder.



Floating gas-holder type bio-gas plant.

The floating dome biogas plant allows maintaining constant pressure of gas, easy for construction of gas holder using steel, plastics and composites.

1.2 GAS GEYSER

In the project, gas geyser operates on LPG fuel is replaced with the Biogas. In gas geyser cold water from tank flows when a hot water tap is opened, then water flow is detected by a sensor and biogas flow is starts through the gas burner. The ignition is needed to start manually by operating LPG lighter (Igniter). The water typically follows a serpentine pattern through the heat exchanger, absorbing as much heat as possible. The heat exchanger is a device which transfers heat from one medium to another.

2. CONSTRUCTION

The construction and fabrication of various parts of the Gas geyser are as follows: -

1. Casing

2. Heat exchanging tube
3. Gas Burner
4. Solenoid valve
5. Sensor
6. Valves
7. Flue outlet
8. Electronic kit
9. Battery
10. Butane lighter

2.1.1 CASING

Casing is provided an a water heater assembly for protecting against dust, atmospheric conditions as well as the flame generated by the burner will get burn without any atmospheric barriers like wind flow etc. is the main purpose to provide casing on a assembly. It also provided for protecting human against harm by overheating of burner and other electrical circuits. Casing is made up of stainless steel and nickel base alloys and plays a very crucial role for the better functioning of water heater.

2.1.2 Heat exchanging tube

A heat exchanger is a piece of equipment built for efficient heat transfer from one medium to another. Copper tube is most often used for supply of hot and cold tap water in a system. Copper has many desirable properties for thermally efficient and durable heat exchangers. First and foremost, copper is an excellent conductor of heat. This means that copper's high thermal conductivity(385 W/mK) allows heat to pass though it quickly. Other desirable properties of copper include its corrosion resistant, maximum allowable stress and internal pressure, thermal expansion, high melting point, ease of fabrication etc. Copper tube inlet is connected to cold watersupplyand otheris to the hot water tap.

2.1.3 Gas burner

A gas burner is a device that produces a controlled flame by mixing a fuel gas such as acetylene, natural gas, or propane with an oxidizer such as the ambient air or supplied oxygen, and allowing for ignition and combustion. This being the main component where combustion takes please to release heat. There is gas delivery line which leads to it in addition to an adjustment to control the rate of atmospheric air mixing with the burning gas

The design of biogas burners is similar to the concepts of LPG burner design with the fundamental differences of stoichiometric air requirement, energy content and supply pressure. Biogas has a lower calorific value than LPG and thus requires less air per unit of fuel for complete combustion. Domestic biogas is supplied through small scale bio

digesters and rarely have supplementary compression mechanisms to reduce gas volume for long term storage. Therefore, gas pressure will vary throughout a cooking event. So, without the modification of the LPG injector orifices and flame ports, the higher pressure drop through conventionally smaller LPG orifices and ports will likely reduce overall efficiency and may prevent continuous stove operation. A study by Ko and Lin compliment this discussion by asserting that using the same gas stove design to burn gases with various heating values is inappropriate and hazardous.

2.1.4 Solenoid valve

A solenoid valve is an electromechanically operated valve. The valve is controlled by an electric current through a solenoid in the case of a two-port valve the flow is switched on or off; in the case of a three-port valve, the outflow is switched between the two outlet ports. Multiple solenoid valves can be placed together on a manifold.

Solenoid valves are the most frequently used control elements in fluidics. Their tasks are to shut off, release, dose, distribute or mix fluids. They are found in many application areas. Solenoids offer fast and safe switching, high reliability, long service life, good medium compatibility of the materials used, low control power and compact design.

In some solenoid valves the solenoid acts directly on the main valve. Others use a small, complete solenoid valve, known as a pilot, to actuate a larger valve. While the second type is actually a solenoid valve combined with a pneumatically actuated valve, they are sold and packaged as a single unit referred to as a solenoid valve. Piloted valves require much less power to control, but they are noticeably slower. Piloted solenoids usually need full power at all times to open and stay open, where a direct acting solenoid may only need full power for a short period of time to open it, and only low power to hold it.

Fig.No.3.1.1.4: Solenoid valve

A solenoid valve has two main parts the solenoid and the valve. The solenoid converts electrical energy into mechanical energy which, in turn, opens or closes the valve mechanically.

2.1.5 Sensors

A sensor is a device, module, or subsystem whose purpose is to detect events or changes in its environment and send the information to other electronics, frequently a computer processor. A sensor is always used with other electronics, whether as simple as a light or as complex as a computer.

Heat sensor- A heat detector is a fire alarm device designed to respond when the convictedthermal energy of a fire increases the temperature of a heat sensitive element. The thermal mass and conductivity of the element regulate the rate flow of heat into the element. All heat detectors have this thermal lag. Heat detectors have two main classifications of operation, "rate-of-rise" and "fixed temperature". The heat detector is used to help in the reduction of damaged property. It is triggered when temperature increases.

Flowsensor - Reed switches and sensors are highly effective solutions for flow sensing applications that can be used for detecting the presence of fluid flow in a system or even measure the rate of fluid flow.

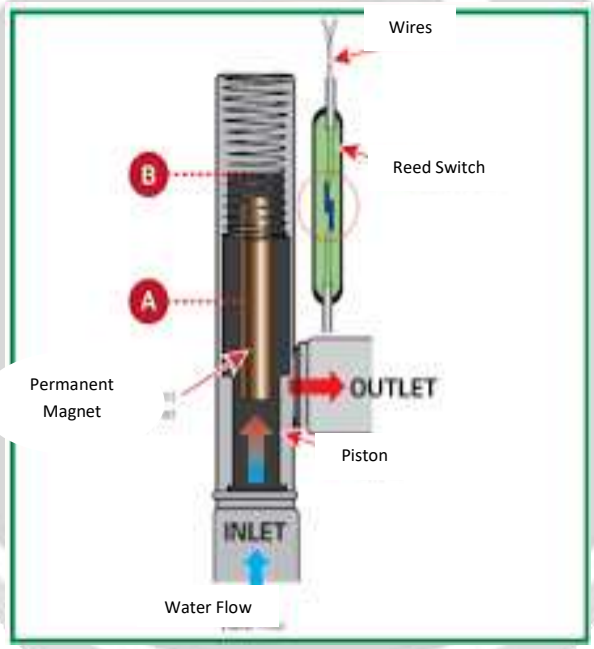


Fig.No.3.1.1.5: Flow sensing valve

2.1.6 Valves

A valve is a device that regulates, directs and controls the flow of a fluid (gases, liquids, fluidized solids, or slurries) by opening, closing, or partially obstructing various passageways. In an open valve, fluid flows in a direction from higher pressure to lower pressure. Modern control valves may regulate pressure or flow downstream and operate on sophisticated automation systems. Valves have many uses, including controlling water for industrial uses for controlling processes, residential uses such as on/off and pressure control to dish and clothes washers and taps in the home.

Valves used in project

- Gas flow control valve
- Water flow control valve
- Summer/winter position valve

Fig.No.3.1.1.6: Gas and Water flow control valve

Gas flow control valve

Gas flow control valve is used to give the required flow of biogas to the burner. It has three position Low, Medium and High. When the gas flow is less, after that the temperature gets lower down, whereas the gas flow gets increased then the temperature rises up.

Water flow control valve

Water flow control valve is used to control the flow of water though tap, it has three position low, medium and high. When the valve is set at low position the flow is less and rise in temperature of water is more.

Summer/winter position valve

This valve has two positions summer and winter. In summer position only two strips of burner produced flame and in winter position all three strips of produced flame.

2.1.7 Flue outlet

A flue is a duct, pipe, or opening in a chimney for conveying exhaust gases from a fireplace, furnace, water heater to the outdoors. Historically the term flue meant the chimney itself. Hot air inside the geyser is comes out through flue outlet because fresh oxidize supply of air into it support combustion. As combustion products contain carbon monoxide and other dangerous compounds, proper 'draft', and admission of replacement air is imperative.

Fig.No.3.1.1.7: Flue outlet

2.1.8 Electronic kit

An electronic kit is a package of electrical components used to build an electronic device. Generally, kits are composed of electronic components, a circuit diagram (schematic), assembly instructions and often a printed circuit board (PCB) or another type of prototyping board.

2.1.9 Battery

A primary cell is a battery that is designed to be used once and discarded, and not recharged with electricity and reused like a secondary cell (rechargeable battery). In general, the electro-chemical reaction occurring in the cell is not reversible, rendering the cell un-rechargeable. As a primary cell is used, chemical reactions in the battery use up the chemicals that generate the power; when they are gone, the battery stops producing electricity and are useless. Primary cells are made in a range of standard sizes (1.5volt, 3 volt, 6 volt, 12 volt, 24 volt) to power small household appliances such as flash-lights and portable radios; the project includes two batteries of 1.5 volts.

Fig.No.3.1.1.9: Battery

2.1.10 Butane lighter

A lighter is a portable device used to create a flame, and to ignite a variety of combustible materials, such as cigars, gas stoves, fireworks, candles or cigarettes. It consists of metal or plastic container filled with a flammable fluid or pressurized liquid gas, a means of ignition to produce the flame, and some provision for extinguishing the flame. Alternatively, a lighter can be powered by electricity, using an electric arc or heating element to ignite the target

One of the first lighters was invented by the German chemist named Johann Wolfgang Dobereiner in 1823 and was often called Dobereiner's lamp.[1] This lighter worked by passing flammable hydrogen gas, produced within the lighter by a chemical reaction, over a platinum metal catalyst which in turn caused it to ignite and give off a great amount of heat and light.[1]

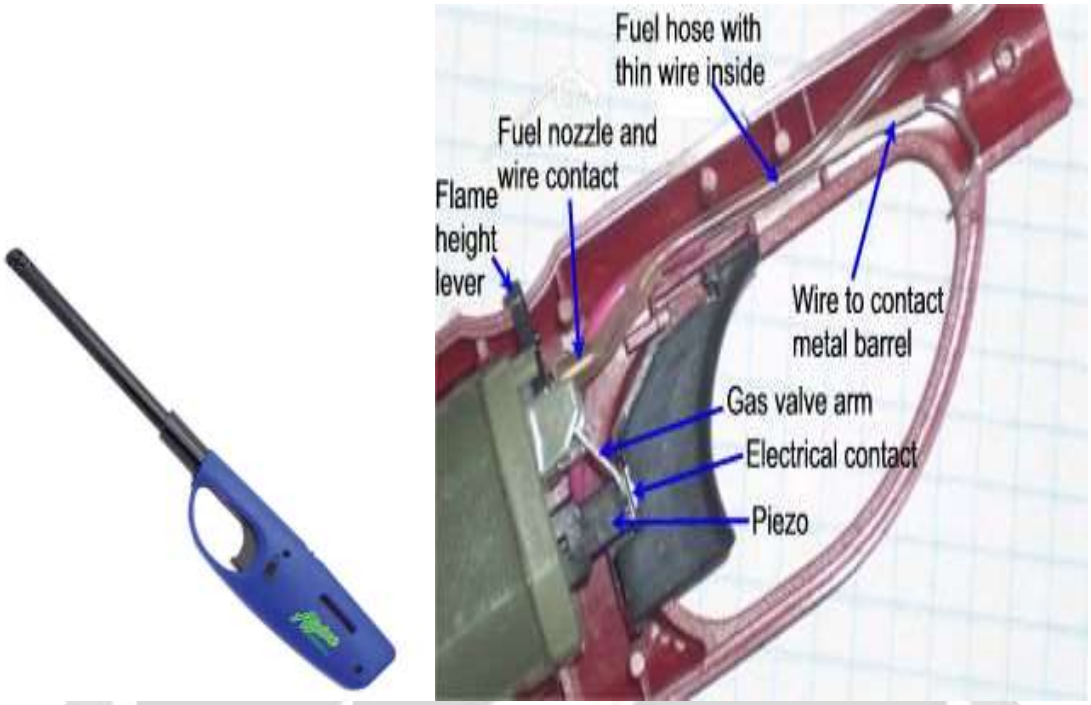


Fig.No.3.1.1.10: Butane Lighter

Butane lighters have a valve orifice that meters the butane gas as it escapes.[6] Butane lighters combine the striking action with the opening of the valve to release gas. The spark ignites the flammable gas causing a flame to come out of the lighter which continues until either the top is closed, or the valve is released.

The butane lighter is use to produce initial flame just for 1-3 seconds, that starts the burning of biogas through the burner. This lighter is well positioned in gas geyser so that flame coming out from it starts burning the biogas.

3. WORKING

- Cold water flows into the gas geyser when a hot water tap is opened inside your home.
- The water flow is detected by a flow sensor that operate solenoid valve, to allow flow of biogas.
- Then butane lighter operate to ignite biogas to heat the water in the heat exchanger.
- The water typically follows a serpentine pattern through the heat exchanger, absorbing as much heat as possible.
- An electronic control unit modulates the gas burner to maintain a set water temperature.
- Then the hot comes out from heat exchanging tube to hot water tap.

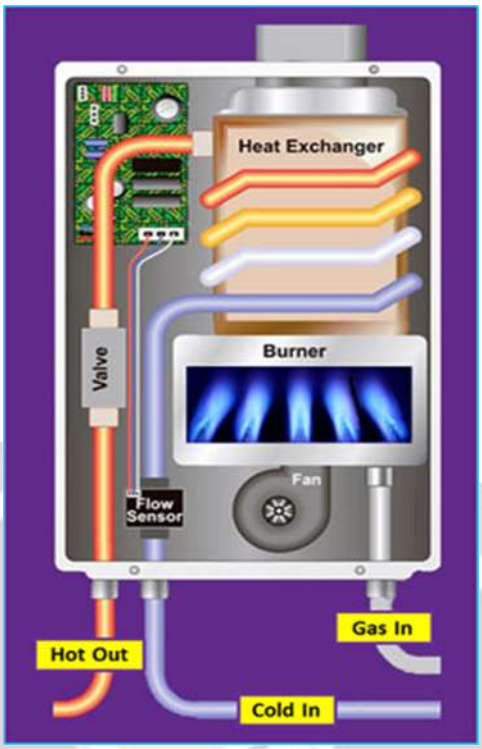


Fig No.3.1:Gas Geyser

3.1. Fabrication of biogas Plant

3.2.1. What is biogas?

It mainly comprises of hydro-carbon which is combustible and can produce heat and energy when burnt. Bio-gas is produced through a bio-chemical process in which certain types of bacteria convert the biological wastes into useful bio-gas. Since the useful gas originates from biological process, it has been termed as bio-gas. Methane gas is the main constituent of biogas.

3.2.2. Biogas production process

The process of bio-gas production is anaerobic in nature and takes place in two stages. The two stages have been termed as acid formation stage and methane formation stage. In the acid formation stage, the bio-degradable complex organic compounds present in the waste materials are acted upon by a group of acid forming bacteria present in the dung. Since the organic acids are the main products in this stage, it is known as acid forming stage. In the second stage, groups of methanogenic bacteria act upon the organic acids to produce methane gas.

3.2.3. Material and Method

Biogas composite digester (0.240 m^3 total volume per digester, 64 cm diameter) was used for the experiment. The gas holder (at a depth of about 75 cm,) before the experiment, the digester was tested for leak by pumping water into them and monitoring the water level for one week. The gas holder was inserted into the digester. Initial feedstock of cow dung 117 kg and 117 lit water with 1:1 ratio, accounting for about 75% of the digester volume, was fed into each digester on day 1 of the experimental period (march), and then left for around 15 days to allow the microbial fertilization community to develop. Thereafter, approximately 1kg of slurry was added from inlet every day, resulting in a retention time of 15 days.

The cow dung as a slurry used as feedstock in the digester was collected daily from the village farm, where the cow dung are kept in an open space area by the people. In addition, the work was also being done according to people live in village. Experience about the biogas formation, the slurry of cow dung was collected for biogas formation.

For the digester, the volume of biogas produced was measured daily from March to April. Reason for check lower sample of slurry is, whether the biogas which forms in the digester occupied the volume .pressure tube manometer was used to measure the gas pressure by releasing the produced gas through a valve which connected to the gas holder. This gas valve connected to the manometer at one end until the pressure in it headspace was measured to the ambient atmospheric pressure. Biogas samples were stored in gas digester, and the concentration of methane (CH_4) and carbon dioxide (CO_2) was measured weekly by a gas analyzer.

3.2.1 Components of biogas plant

3.2.4.1. Mixing tank –
The feed material (dung) is collected in the mixing tank. Sufficient water is added and the material is thoroughly mixed till homogeneous slurry is formed.

3.2.4.2. Inlet pipe –
The substrate is discharged into the digester through the inlet pipe/tank.

3.2.4.3. Digester –
The slurry is fermented inside the digester and biogas is produced through bacterial action. A **biogas digester** is a tank where inside Biogas is produced through the decomposition/breakdown of organic matter through a process called anaerobic digestion. It's called a digester because organic material is eaten and digested by bacteria to produce biogas. A biogas digester forms the most critical part of biogas production because without it, no biogas would be produced without the breakdown of organic waste.

Fig.No.3.2.4.3: Digester

3.2.4.4. Gas holder or gas storage dome –
The biogas gets collected in the gas holder, which holds the gas until the time of consumption. The floating gas holder type bio gas plant consists of a dome shaped gas holder made of steel for collecting bio gas. The dome shaped gas holder is not fixed but is moveable and floats over the slurry present in the digester tank. Due to this reason, this biogas plant is called floating gas holder type biogas plant.

Fig.No.3.2.4.4: Gas Holder

3.2.4.5. Outlet pipe –
The digested slurry is discharged into the outlet tank either through the outlet pipe or the opening provided in the digester.

3.2.4.6. Gas pipe –
The gas pipe carries the gas to the point of gas inlet of gas geyser.

Fig.No.3.2.4.6: Gas Pipe

3.2.4. Technical guidelines for establishment of biogas plants

3.2.5.1 Digester Design

A floating drum plant, a continuous ledge is built into the digester at a depth 10 cm. shorter than the height of the gas drum to prevent the gas holder from going down when no gas is left in it. It helps in preventing the gas inlet being choked. It also guides the gas bubbles rising from the side of the plants into the gas bolder.

In some plants slurry is fed at the bottom and removed at the top. When the digester diameter exceeds 1.6m, a partition wall is provided in the digester to prevent short circuiting of slurry flow and increasing its retention period. In case of fixed dome plants, the volume of digester comes to between 1.5 times to 2.75 times the gas produced per day. Here, the higher the plant capacity, the lesser becomes the ratio of digester volume to gas produced per day.

3.2.5.2 Gas Holder Design

The design of a gas holder is influenced by the digester diameter and distribution of gas use during the day. For domestic plants, the gas holder capacity is kept at 60 per cent of a day's gas production and in case of laboratories, it is kept at 70 per cent of the day's gas production.

In a floating drum plant, the gas holder diameter is 15 cm. less than the diameter of the digester and accordingly the other dimensions are decided. The gas holder can be given a rotary movement around its guide to break the scum formation at the top.

In a fixed dome plant the dome angle is kept between 17° and 21° and it gives a pressure upto 100 cm. of water. Due to higher pressure, the diameter of gas pipelines can be reduced and the gas can be taken to greater distance. In this plant, care should be taken to provide an earth pressure equivalent to 100 cm of water column from the top of the dome. Always use *'A'* class bricks in the domes for better stability.

3.2.5.Points to be considered for construction of a biogas plant

- While selecting a site for a biogas plant, following aspects should be considered
- The land should be leveled and at a higher elevation than the surroundings to avoid water stagnation
- It should be nearer to the intended place of gas use (e.g. home or farm).
- It should also be nearer to the cattle shed/ stable for easy handling of raw materials.
- Adequate supply of water should be there at the plant site. The plant should get clear sunshine during most part of the day.
- The plant site should be well ventilated.
- A minimum distance of 1.5m should be kept between the plant and any wall or foundation.
- It should be at least 15m away from any well used for drinking water purpose.

3.2.5. Availability of raw materials

The size of the biogas plant is to be decided based on amount of methane gas to be produce. For e.g. the average gas production from dung may be taken as lit/kg of fresh dung. The total dung required for production of 0.240 m^3 biogas is 117 kg. Hence, a minimum of one cattle is required to generate the required quantity of cow dung.

Table No.: 3.2.7.1: Availability of raw materials

Sr. No.	Feed Stock	Liter /kg of dry matter	% Methane content
1	Dung	350	50
2	Water	350	50

Useful Resources

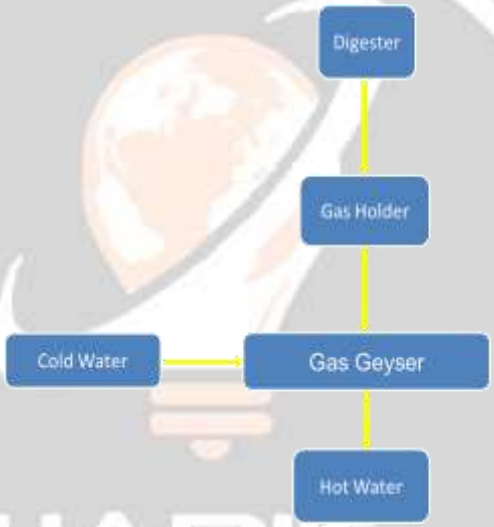
Average maximum biogas production from different feed stock

Average gas production from dung may be taken as 20 lit/kg of fresh dung when no temperature control is provided in the plant. One Cu. m gas is equivalent to 1000 liters.

Table No.: 3.2.7.2 : Average yield dung

Sl. No.	Living Beings	Quantity of Dung / Night Soil produced (kg/day)
1.	Cow	10.0
2.	Buffalo	15.0

4. METHODOLOGY



5. SPECIFICATION

- Digester Size = 250 lt = 0.25 M3
- Gas Holder = 150 lt = 0.15 M3
- Water / Cow Dung Ratio = 1:1
- Cow Dung Use = 120 kg
- Heater capacity of water = 6 Lt/min

6. RESULT

Temperature of water in LPG gas geyser

Inlet temp.in ^{o}c	22^{o}c
Oulet temp.in ^{o}c	45^{o}c

Temperature of water in biogas gas geyser

Inlet temp.in ^{o}c	22^{o}c
Oulet temp.in ^{o}c	47^{o}c

7.CONCLUSION

- Flame can be easily created in Gas-geyser with the help of biogas by replacing valve And increasing the nozzle diameter.
- As a biogas having lower calorific value it cannot easily ignite by spark ignition system which is already in the gas geyser so it can be replaced with a flame lighter.
- Biogas can be easily generated in all house in rural area with the help of small scale floating drum type biogas plant.
- The designed biogas floating drum (0.25m3) is convenient or sufficient for a small family for daily water heating purpose.

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