Investigation Analysis on Design and Modification of a Conventional Floating Dome Digester

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ABSTRACT:

A 2 m^3 floating dome anaerobic digester has been developed and its performance is compared with that of conventional mild steel dome biogas digester The overall objective of carrying the work is to construct the transparent dome type biogas plant for better performance of the digester tank and to optimize the biogas generation under normal operating conditions. The experimental setup consists of a conventional biogas plant in which analysis is carried out to check the performance of the plant. Apart from that the biogas plant is modified from conventional mild steel dome type digester to transparent fibre type dome plant to capture the green house effect and the results are compared with the conventional biogas plant in order to check the performance of the modified biogas plant.The experimental setup consists of two plants which are located at Vyara region 60 km away from Surat. The two plants are studied under normal operating conditions in which one of the plant acts as reference to the modified plant. The reference plant is a conventional biogas plant with floating drum type digester having mild steel as a digester dome whereas the modified biogas plant is also a floating drum type digester plant with transparent fibre material as the dome.

KEYWORDS: *ANAEROBIC DIGESTER, TRANSPARENT FIBRE DOME, MILD STEEL DOME.*

I. INTRODUCTION:

There are a number of different types of biogas plants that can be used to treat different types of biomass, and each has its advantages and shortcomings In industry, so-called filter plants are sometimes used such as those using UASB (Upflow Anaerobic Sludge Blanket), which can treat biomasses with a low dry matter content. The advantage of this type is that the (hydraulic) retention time (the time a given biomass stays in the reactor before it is pumped out again) is very short, often only a few hours or a couple of days, and that the reactor tank therefore does not need to be quite so large. This type can also take relatively high COD load of 5-30 kg COD/m3/day In the following, only the floating dome digester type will be discussed, as this is the type most commonly for the decomposition of both agricultural residues and sewage sludge. Anaerobic digestion (AD) is the conversion of organic material directly to gas, termed biogas, a mixture of mainly methane (CH_4) and carbon dioxide (CO_2) with small quantities of other gases such as hydrogen sulphide (H_2S) (1), ammonia (NH_4), water vapour, hydrogen (H_2), nitrogen (N_2) etc. AD is the process of decomposition of organic matter by a microbial consortium in an oxygen-free environment. It is a process found in many naturally occurring anoxic environments including watercourses, sediments, waterlogged soils.

II. DESIGN AND CONSTRUCTIONAL DETAILS OF BIO-GAS PLANT

There are 3 main connecting parts:

1. Mixing chamber
2. Digester chamber
3. Expansion chamber

2.1 Mixing chamber:

The mixing chamber is one where animal excrement is mixed with water before it is poured into digester chamber. In the mixing pit, the substrate is diluted with water and agitated to yield homogeneous slurry. The fibrous material is raked off the surface, and any stones or sand settling to the bottom are cleaned out after the slurry is admitted to the digester. The useful volume of the mixing pit should amount to 1.5-2 times the daily input quantity.

Figure 2.1 Mixing chamber

The figure 2.1 shows the mixing chamber in which the Cow dung and water are mixed in equal proportions before passed into the digester tank. A rock or wooden plug can be used to close off the inlet pipe during the mixing process. A sunny location can help warm the contents before they are fed into the digester in order to preclude thermal shock due to the cold mixing water. In the case of a biogas plant that is directly connected to animal housing, it is advisable to install the mixing pit deep enough to allow installation of a floating gutter leading directly into the pit. Care must also be taken to ensure that the low position of the mixing pit does not result in premature digestion and resultant slurry formation.

2.2 Digester chamber

Digester chamber is one where excrement and water are fermented. Methane and other gases will be produced in the chamber and these gases will push manure and slurry at bottom of the floor into expansion chamber.

Figure2.2: Digester tank

The figure 2.2 shows the digester tank in which the manure is passed through the inlet chamber into the tank where fermentation of anaerobic digestion takes place. The inlet chamber opens from below into the digester which is a huge tank with a dome like ceiling. The ceiling of the digester has an outlet with a valve for the supply of biogas

2.3 Expansion chamber

Expansion chamber is one which collects excess manure and slurry. When gas is being used, manure and slurry will flow back into digester chamber to push gas up for usage. When the excess manure exceeds the volume of the chamber, the manure will be drained out. This system is called dynamic system, when gas is produced inside the pit, the gas pressure will push manure and slurry at the bottom of the pit to flow up into expansion chamber. When this gas is used the slurry in the expansion chamber will flow back into the digester chamber to push the gas up for usage. This happens consistently.

III. DESIGN/CONSTRUCTION

3.1 Construction Materials (For 2-Cubic-Meter Digester)

- Bricks approximately 700
- Cement, 6 bags.
- Sand, 74 cft.

- Crush 9 cft.Steel sheets for gas cap 20'x4' of 16 gauge.
- RCC pipe of 6 inch diameter, 12 feet.
- Angle iron 2 inch, 10 feet.
- Mild steel rods, approximately 18. feet (for bracing)
- GI pipe ½ inch dia, and fitting as per requirement.
- Plastic pipe ½ inch dia, as per requirement.
- Stove 1 No.
- Waterproof coating (paint, tar, asphalt, etc.), 4 liters (for gas cap).

3.2. Preparation of Foundation and Walls

- Dig a pit 1.5 meters in diameter to a depth of 2.4 meters.
- Line the floor and walls of the pit with baked bricks and bound it with lime mortar or clay. Any porousness in the construction is soon blocked with the manure/water mixture. (If a water table is encountered, cover the bricks with cement.)
- Make a ledge or cornice at two-thirds the height (226cm) of the pit from the bottom. The ledge should be about 15cm wide for the gas cap to rest on when it is empty
- Extend the brickwork 30-40cm above ground level to bring the total depth of the pit to approximately 3 meters.
- Make the input and output piping for the slurry from ordinary 20cm clay drainpipe. Use straight input piping. If the pipe is curved, sticks and stones dropped in by playful children may jam at the bend and cannot be removed without emptying the whole pit. With straight piping, such objects can fall right through or can be pushed out with a piece of bamboo.
- Have one end of the input piping 90cm above ground level and the other end 70cm above the bottom of the pit.
- Have one end of the output piping 40cm above the bottom of the pit opposite the input pipe and the other end at ground level.
- Put an iron or wire strainer (copper screening) with 0.5cm holes at the upper end of the input and the output pipes to keep out large particles of foreign matter from the pit.
- Construct a center wall that divides the pit into two equal compartments. Build the wall to a height two-thirds from the bottom of the digester (226cm). Build the gas cap guide in the center top of the wall by placing vertically a 7cm X 2.5 meters long piece of metal piping.
- Provide additional support for the pipe by fabricating a cross brace made from mild steel.

3.3 Prepare the gas cap drum

- Form the gas cap drum from mild steel sheeting of any thickness from .327mm (30 gauge) to 1.63mm (16 gauge).
- Make the height of the drum approximately one-third the depth of the pit (0.75 meters).
- Make the diameter of the drum 10cm less than that of the pit Using a flange, attach a 7.5cm pipe to the inside top center.
- Fix the lower end of the pipe firmly in place with thin, iron tie rods or angle iron. The cap now looks like a hollow drum with a pipe, firmly fixed, running through the center.
- Cut a 3cm diameter hole, in the top of the gas cap.
- Weld a 3cm diameter pipe over the hole.
- Fix a rubber or plastic hose--long enough to allow the drum to rise and fall--to the welded gas outlet pipe. A valve may be fixed at the joint.
- Paint the outside and inside of the drum with a coat of paint or tar.
- Make sure the drum is airtight. One way to check this is to fill it with water and watch for leaks.
- Turn the gas cap drum so that the outlet pipe is on top and slip the 7.5cm pipe fixed in the gas cap over the 7cm pipe fixed in the center wall of the pit. When empty, the drum will rest on the 15cm ledges built on either side. As gas is produced and the drum empties and fills, it will move up and down the center pole.
- Attach handles to either side of the drum.
- Weld a 10cm wide metal strip to each of the tie rod supports in a vertical position. These "teeth" will act as stirrers. By grasping the handles and rotating the drum it is possible to break up troublesome scum that forms on the slurry and tends to harden and prevent the passage of gas.

Figure 3.1 Different components of the digester tank

The figure 3.1 shows the different components of digester tank. The tank is built with a central pipe fitted to the dome and is rounded. The digester tank is a completely closed (oxygen free) system that receives and biologically treats manure with naturally occurring organisms. After the construction of entire anaerobic digester, the digester is replaced by fibre dome digester and the percentage composition of methane content of both the digesters has been evaluated.

Figure 3.2: Mild steel dome and Fibre dome

The figure 3.2 shows the mild steel dome and transparent fibre dome .The mild steel dome gets rust easily and gets corroded because of rust formation where as the transparent fibre dome is having grater design flexibility and high tensile strength and is durable to use. The heat restoring capacity is more in transparent fibre dome compared to that of mild steel dome.

- The major advantages of transparent fibre dome digesters are:

1. Lighter, enabling convenient transportation and requires less construction time.
2. Well sealed and air proof assures 100% gas tightness.
3. Retains heat rather than conducts it, absorbs heat better than metal.
4. Less expensive.
5. High strength to weight ratio
6. Greater design flexibility
7. It does not rust, rot, corrode or swell and is maintenance free.

IV. PERFORMANCE PREDICTION OF TRANSPARENT FIBRE DOME DIGESTER:

After the design setup has been made, the biogas sample is collected from the transparent fibre dome digester and is sent for gas chromatography analysis to determine the percentage composition of methane content. From this analysis it shows that the dome having the transparent fibre has rich methane content when compared with the conventional mild steel dome. The results reviewed that the transparent type of digester has more methane yield than that of mild steel dome type of digester because of that the transparent fibre type of dome digester has maintained good digestion temperatures inside the digester tank as of methanogens inside the digester are actively formed by the anaerobic digestion process. The results reviewed that methane composition is increased from 63.40% to 64.22% which holds good as of performance is considered .The greater methane yields results in better performance of the plant and proves to be more effective when compared to that of mild steel dome digester.

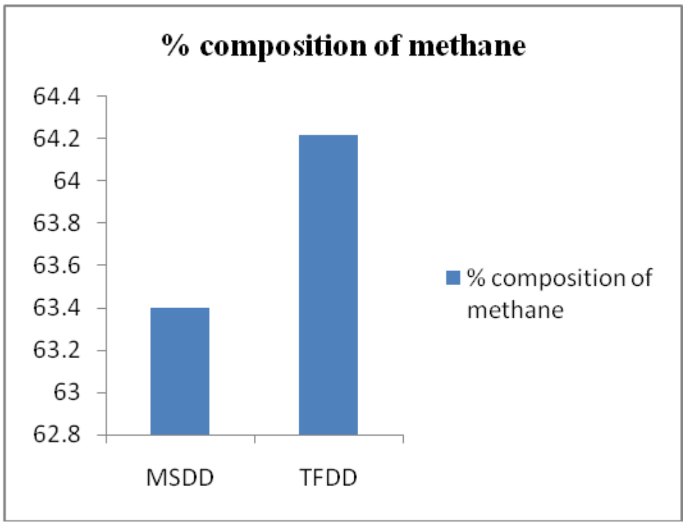

Figure 4.1: Methane yield composition from the two digesters

V. CONCLUSION

As from the studies the biogas plant operates better at higher temperatures which should be in the range of 30°c to 40°c (mesopholic).so the introduction of a fibre dome digester can make the plant to restore the heat during sunlight because of its transparent properties and the temperature regimes can be increased compared to that of mild steel in cold climatic conditions. The major disadvantage of conventional biogas plant is that labor intensive, high transportation cost and is 40% more expensive than transparent fibre dome digesters. The main drawback of mild steel dome digester is of its rust formation and gets corroded easily. So keeping these points in view and studying the fibre dome digester properties the plant is modified from conventional mild steel to transparent dome type digester.

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