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Fabrication of Biogas Pilot Plant for Power Generation

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ABSTRACT

Biogas is a renewable energy source which can be generated by decomposition of organic waste. The biogas pilot plant refers to the design of the biogas plant being used for minimal purposes & requirements. The reference of the design for the plant is the existing floating dome type structure. Some modifications in the existing referred design are being made to make the plant portable. The apparatus will be used to generate power by the means of a generator and an electrical circuit connected to it. The generator will be powered by the biogas being generated in the tank. The research is carried out to increase the productivity of the gas & and to check for the increment in the efficiency of gas produced by mixing additives, varying the constituents of slurry & pre-treatment of waste.

Keywords: Biogas, Pilot Plant, Efficiency, Additives, Slurry, Pre-treatment

I. INTRODUCTION

Biogas refers to a mixture of different gases produced by the breakdown of organic matter in the absence of oxygen. It can be produced from raw materials such as agricultural waste, manure, municipal waste, plant material, sewage, green waste or food waste. Biogas is a renewable energy source. It can be produced by anaerobic digestion with anaerobic organisms, which digest material inside a closed system, or fermentation of biodegradable materials.

Biogas is primarily methane (CH4) and carbon dioxide (CO2) and may have small amounts of hydrogen sulfide (H2S), moisture and siloxanes. The gases methane, hydrogen, and carbon monoxide (CO) can be combusted or oxidized with oxygen.

Organic material grows, is converted and used and then grows in a continuously repeating cycle.

In today's fast growing world of new innovations & technology, we are utilizing the non-renewable energy sources in a huge amount, which not only affects their prolonged production, but is also contributing towards the global environmental hazards & climate change.

The world population is currently relying on the existing available energy sources (carbonized fuels), not focusing on the alternative sources of energy. The carbonized fuels cause greenhouse effect and they will perish with time. On the contrary, biogas, being the renewable energy source, can be used as an alternative for these exhaustible energy sources.

We are concentrating on making the biogas a more viable source for power generation so that the dependency on fossil fuels is reduced.

Applications: Biogas can be used for electricity production on sewage works. In a CHP (Combined Heat & Power) gas engine, where the waste heat from the engine is conveniently used for heating the digester, cooking, space heating, water heating and process heating. If compressed, it can replace compressed natural gas for use in vehicles, where it can fuel an internal combustion engine or fuel cells and is a much more effective displacer of carbon dioxide than the normal use in on-site CHP plants.

II. LITERATURE REVIEW

This research paper includes information & statistics about biogas generation from plant biomass and agricultural waste, addition of waste paper in co-digestion, achievements of biogas from anaerobic digestion i.e. in the absence of oxygen and generation of biogas from different biomass product with waste's hydrothermal pre-treatment.

Some of the important points from the research papers are highlighted below:

i. For per gram VS (Volatile Solids) of raw biomass waste, the order of biogas production potential are as follows: food waste > fruit/vegetable waste > manure > municipal sewage sludge > cow manure
ii. With hydrothermal heating, the biodegradation of biomass waste is improved.
iii. The amount of methane productions of treated manure, fruit/vegetable waste and municipal sewage sludge increased by 14.6, 16.1, and 65.5% respectively.
iv. On the contrary, after heated treatment, the methane production of food waste and cow manure decreased.
v. The effect of waste paper on fixed amount of cow dung and water hyacinth was found to increase biogas production in a parabolic manner.
vi. It was observed that a waste paper concentration of 17.5g is the maximum amount of waste paper needed to combine with 5g of cow dung and 5g of water for maximum production of biogas.
vii. Pre-treatment of manure by separation produces a solid fraction with significantly higher methane potential per unit of volume (55 L/kg FPMF – filter pressed manure fibre) as compared to raw cow slurry (10 L/kg).
viii. Effecting higher dry solids content of feedstock either through agricultural practice or separation techniques may lead to lower transportation costs, smaller facilities and lower thermal parasitic demand.

By adding accelerants in the anaerobic digestion process, the digestion performance is greatly enhanced due to the adsorption of the substrate onto the surface of the additives.

III. MATERIALS & METHODS

3.1. Materials Used

The material being used to produce the biogas is purely cow dung. A part of organic waste is added to boost up the productivity of the gas being generated. The cow-dung and water are mixed in equal quantities of 500kg each. The slurry is prepared by mixing the two components.

The digester tank for the plant is a plastic water tank made up of food grade plastic with a threaded lid. The tank is UV stabilized that imparts high strength to the material. The capacity of the tank is 1000 L.

The collector tank for the plant is of the same material, triple layered with a capacity of 750 L. This collector tank will work as the floating dome of the apparatus. The gas produced starts accumulating at the above wall of the collector tank & lifts it up, indicating that the gas is being generated & getting collected. A maximum gap of 5 cms on either sides of the tank is to be maintained so that the dome can float easily, without any disruption to the digester tank.

3.2. Generation of Biogas

The biogas is produced by following the steps as given below:

i. Slurry is prepared by mixing water in cattle dung in equal proportion in mixing tank.
ii. The slurry is then injected into a digester tank with the help of inlet pipe. The digester tank is a closed underground tank made up of bricks.
iii. Inside the digester tank, the complex carbon compounds present in the cattle dung breaks into simpler substances by the action of anaerobic microorganisms in the presence of water.
iv. This anaerobic decomposition of complex carbon compounds present in cattle dung produces bio gas and gets completed in about 60 days.
v. The biogas so produced starts to collect in floating gas holder and is supplied to homes through pipes.
vi. The spent slurry is replaced from time to time with fresh slurry to continue the production of bio gas.

3.3. Design Modification

Figure 1 shows the existing design of the floating dome type biogas plant. The digester tank described in the figure is below the ground level which creates a black-out environment for the gas to be produced. The inlet & outlet for the slurry & sludge respectively are at the ground level.

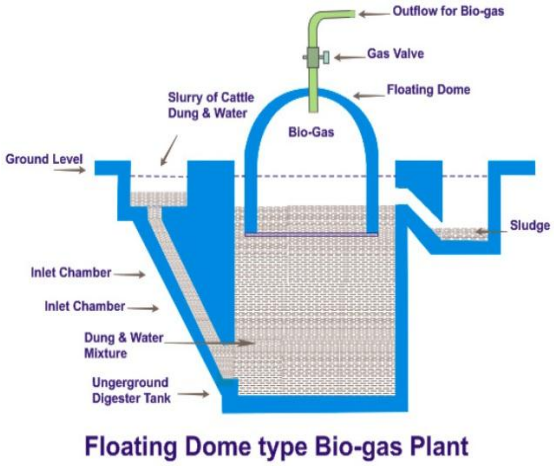

Figure 1. Floating Dome type Biogas Plant

The proposed modification in the design is that the complete setup is above the ground with the digester tank painted black, so as to create the adequate ambience for the generation of gas, as it was for the digester tank below the ground level.

Also, the complete setup will rest on a frame with wheels attached to it that will help to make it portable.

The outlet for produced biogas is connected to an inlet manifold of cylinder block in a generator. The gas from the manifold runs the generator, thereby, generating power.

3.4. Composition & Calorific Value

The composition of biogas produced consists of mainly of methane, carbon dioxide, and nitrogen and hydrogen sulphide. The setup requires only methane gas for power generation as it has quite similar composition and calorific value as that of petrol.

Calorific Value is the energy contained in a fuel or food, determined by measuring the heat produced by the complete combustion of a specified quantity of it, and is usually expressed in joules per kilogram (J/Kg).

The calorific values of various organic materials/fuels such as cow dung, coal, methane etc. gives a very high energy output. A table of the approximate calorific value of various fuels is as given below:

Table 1. Calorific Value of various fuels

Sr. No.	Fuel	Calorific Value (KJ/Kg) (Approx.)
1.	Cow Dung	8000
2.	Wood	22000
3.	Coal	33000
4.	Biogas	40000
5.	Diesel	45000
6.	Kerosene	45000
7.	Petrol	45000
8.	Methane	50000
9.	LPG	55000

The unwanted gases are removed from the composition by the means of extractors, so that a good quantity of pure methane gas is achieved.

IV. CONCLUSION

The biogas can be used as a replacement for fossil fuels or as a hybrid energy source that can reduce the dependency on carbonized fuels. The design modification is made portable so that it is easy to shift the setup to the desired location. Also, the pilot plant is economical as compared to the existing design of floating dome type. The setup of pilot plant can be used in the rural areas where there is shortage of power. As the cattle waste is present in abundance in the rural areas, the biogas can be a substitute for electricity being produced by thermal energy that is supplied to such areas. This can be of advantage to the small farmers who have less energy consumption requirements for their household purposes. Also, the biogas produced can be used as a cooking gas as it has good calorific value and the colour of the flame produced is completely blue, that indicates the absence of harmful and unwanted gases in its composition. Thus, the economical design of pilot plant can be used in housing societies to power the corridors and parking areas. The municipal loads can be divided by using biogas as an equivalent source of power generation.

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