The Application Of Portable Biogas Device For Laboratory Training

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Abstract: The mathematics has very important role in making portable biogas device which able to use for student in laboratory education It is needed to calculate the volume, the ratio of gas and liquid applied and etc. The design and application of portable biogas technology is done by mathematic calculation and trial and error using the materials used drum, oil, cow dung, plastic hoses, simple pressure control and using ballast pendulum. The basic design for the manufacture of portable biogas devices is based on research conducted by EPA USA . In the study the maximum solids content in slurry was 12.5 percent. However, based on experience of using local cattle, the content of solids in slurry is used 50%. This can be made by mixing 1 part of cow dung with 1 part water or one bucket of cow dung with 1 bucket of water. The slurry volume is 75% the volume of the main tank. The volume of the remaining main tank (25% volume) is used for gas reservoirs and to facilitate gas distribution. Slurry retained in the tank for 20 - 30 days according to HRT (Hydrostatic Retention time).

Keywords: mathematics. design, slurry, volume, biogas

1, INTRODUCTION

We take the viewpoint that definitions and theorems are tools for capturing, analyzing and understanding mathematical concepts and hence, like any tools, require diligent engineering [19]. The more expensive price of fuel oil and limited petroleum reserves today, efforts should be made to find alternative energy sources from new and renewable raw materials. One of the new and renewable energy is biogas. Biogas is a gas produced from the process of decomposition of organic materials by microorganisms in conditions in the absence of oxygen (anaerobes). Organic materials of biogas sources include cattle dung, horses, buffaloes, pigs, chickens, goats; Tofu industry waste, tempe, soy sauce, oil palm and tapioca; Organic trash households, restaurants and markets. Biogas from livestock waste is one of the feasible alternatives to be applied in rural communities as well as in farm centers. Biogas contains about 60% CH_4 (methane gas), 38% CO_2 (carbon dioxide) gas and about 2% of N_2 gas (nitrogen) and other gases. Biogas equivalence withther gas fuels is 1 m^3 biogas equivalent to 0.46 kg of LPG gas, or 0.62 liters of kerosene, or 0.52 liters of diesel oil, or 0.80 liters of gasoline, and or 3.5 kg of wood Burn [2]. The Use of biogas on a small scale or household that is as fuel cooking and lighting. The use of biogas at medium and large scale is as fuel for power generation, heating, transportation, and injection to city gas channel. The developed product is favorable for its long life, light in weight and it has ability to produce enough methane gas to suffice the domestic requirements [11].. The Ex situ biogas upgrading to 96% CH_4 is achieved in thermophilic up-flow reactors [10]. Special attention was paid to gas to liquid transfer of H_2. The final model was successfully validated considering a set of Case Studies. Biogas composition and H_2 utilization were correctly predicted, with overall deviation below 10% compared to experimental measurements.

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Parameter sensitivity analysis revealed that the model is highly sensitive to the H_2 injection rate and mass transfer coefficient. The model developed is an effective tool for predicting process performance in scenarios with biogas upgrading [5]. Zeolite was proven to be useful in stabilizing the growth of the microorganism and reducing the inhibitors in the leachate. The growth behavior of the microorganism before and after the zeolite addition was identified through the mathematical modelling and the statistical approach.([9]. Subsequently, methanol synthesis has been studied using the same mathematical approach, with the aim to identify the most adequate operating conditions for the direct conversion of the syngas obtained from reforming process into methanol. The simulations suggested that steam reforming of biogas, with high methane content, is the most appropriate route to produce a syngas quality suitable for the new proposed approach [1]. . The results offer a promising starting point for local entrepreneurs to implement similar business models, particularly at a small scale with a modest capital investment of about $1500, with revenue of about $100 per week, and a payback period of 18 months on the investment [4]. The established models, which included biogas production and consumption rates, were used to determine the optimal Biogas Storage volume and operation parameters for improving biogas plant performance. In contrast to the biogas usage level achieved with the established Biogas Storage tank (76.4%), that obtained with an optimal system could reach up to 85.7% and the feeding frequency for a 1-year operation could be decreased 6.5 times. [14]. Biogas upgrading technologies have received widespread attention recently and are researched extensively. Microbial biogas upgrading (biomethanation) relies on the microbial performance in enriched H_2 and CO_2 environments. In this review, recent developments and applications of CH_4 enrichment in microbial methanation processes are systematically reviewed. During biological methanation, either H_2 can be injected directly inside the anaerobic digester to enrich CH_4 by a consortium of mixed microbial species or H_2 can be injected into a separate bioreactor, where CO_2 contained in biogas is coupled with H_2 and converted to CH_4, or a combination here of [17]. Biogas production technology is not a new technology, because since the 1970, Denmark has done research, development, and application of this technology. Recorded in Denmark has 20 centralized plant processing plants and 35 farming plant installations [18]. China has also built 7 million units of biogas reactors in the 1980s, while India also launched no less than 400,000 biogas reactors at the same time [17]. Technology of small scale biogas, medium scale and large scale very potential to be applied by enthusiasts of energy made from new and renewable raw materials including biogas from cattle dung. Indonesia, which has the potential of livestock and the number of rural communities who have not received electricity supply, is very appropriate to apply biogas production technology. It is based on the technology of biogas production is not complicated or not high-tech data that is fully controlled by the general public and biogas enthusiasts. Some of the goals to be achieved on the design and application of portable biogas technology are:

1. Get a biogas reactor that is easily moved from one place to another elsewhere according to location of user needs.
2. Provision of fuel utilizing livestock waste
3. Helping rural communities in terms of daily energy needs.
4. Getting ready-made organic fertilizer as a by-product of the biogas reactor.

2. MATERILAS AND METHOD

The design and application of portable biogas technology is done by mathematics calculation and trial and error using the materials used poliethylene drum, used oil, cow dung, plastic hoses, and simple pressure control.

2.1. Basic Design

The basic design for the manufacture of portable biogas devices is based on research conducted by EPA USA [22]. In the study the maximum solids content in slurry was 12.5 percent. However, based on experience of using local cattle, the content of solids in slurry is used 50%. This can be made by mixing 1 part of cow dung with 1 part water or one bucket of cow dung with 1 bucket of water. The slurry volume is 75% the volume of the main tank. The volume of the remaining main tank (25% volume) is used for gas reservoirs and to facilitate gas distribution. Slurry retained in the tank for 20 - 30 days according to HRT (Hydrostatic Retention Time).

2.2. Portable Biogas Devices

The main part of portable biogas devices consist of:

- Main tank (tank digester)
- Cover vessel (gas container)
- Inlet and outlet channels
- Gas pressure regulator
- tank digester (wheeled)

Portable biogas portable device diagram is shown in Figure 1. Figure 1 shows a portable biogas maker that consists of: 1) The gas pressure regulator in the digester may be a T or a pressure controller. 2). tube cap (gas reservoir), 3) slurry inlet, 4) Tank Digester 5) Slurry outlet, 6) Wheel to move.

Figure 1. *Biogas Portable device*

Remarks: 1) The gas pressure regulator in the digester may be a T or a pressure controller. 2). tube cap (gas reservoir), 3) slurry inlet, 4) Tank Digester 5) Slurry outlet, 6) Wheel to move.

2.3. Tank digester

Ways of making:

1. Take one drum used oil and cut as high as 60 cm so that the top opens according to the image.
2. The top piece is used for the gas storage tube according to the drawing.
3. In 30 cm from above the ring is made for the oil reservoir to prevent biogas leakage.

2.4. Gas Cover (Gas container)

How to manufacture is as following.

1. The lid of this digester is made from the top of the drum (while making the digester) and is also used as a gas container ;
2. This gas container equipp with a gas valve and pressure manometer.

2.5. Inlet and outlet pipe

The inlet and outlet pipe are made using a 3 inch diameter iron pipe. Each pipe has a slope angle of about 45 degrees to the digester as shown in Figure 2
The end of the pipe is covered with screw so it can be easily disassembled by rotating the cap.

2.6. Gas pressure regulator

The gas pressure pendulum is made of stone weighing 5 kg and given a handle of iron to be hung with straps as a pressure control. At the time of high gas pressure then the stone pendulum is placed on top of the gas cylinder. This pressure control can also use the T model tube.

2.7. Wheeler Digester Tank Holder

Stroller made of thick wood 4 cm and installed 4 wheels so that digester easy to move place as needed.

3. RESULT AND DISCUSSION

3.1. Preliminary

In the operation of portable biogas need detailed introduction of each tool component. This is to avoid wrong operation or wrong procedure in the implementation of raw material preparation, anaerob fermentation process until the occurrence of biogas as the final product. Biogas is a flammable gas, colorless and odorless so it needs to be careful in its packaging, its distribution, its pressure regulation up to its use. Excessive gas pressure, ie, several times atmospheric pressure is very dangerous when it occurs in biogas, because of the biogas nature of combustible. Whenever it is necessary to pack the biogas under high pressure it is necessary to use a particular tube as it does on LPG or LNG gas.

3.2 Operation Phase and Student training in laboratory

Some stages in the operation of portable biogas for student in training as follows:

A. Tank cleaner of gas container and fermentation tank.
The biogas device should clean as well as possible. It will influence the anaerobic fermentation along 20 until 30 days. The student should clean it inside part of digester mainly.

B. Installation of gas container tanks perpendicular to the digester so that biogas that will occur collected on the cover of this digester. The stuident should be carefully in setting the cover of digester as the gas collector. The sealer is lubrication oil of SAE 90 in the wall of digester and the wall of gas collector.

C. Manufacture and insertion of slurry or media for anaerobic fermentation into the main 1111111111tank (digester) and stirred evenly.

The preparation of slurry should be prepare one part of water and and one part of cow ung and mixed gently as well before anaerobic fermentation process.

D. The fermentation process
Along the fermentation process in 10 days the gas start been produced. The gas tank will rise up and it should keep so as the gas not running out the tank by controll the gas valve in up part of gas tank.

E. The biogas storage and its distribution

3.3. Tank Cleaning

Cleaning of the main tank (digester), gas barrier tank, inlet and outlet channel is done by spraying water until the impurities attached can be removed.

3.4 Installation of Gas Container Tank

Once clean and dry, the container tank is installed bada top (closed) tank digester. The room that occurs between the main tank and the gas container tank is filled with oil (SAE 90). It is intended to detect so that no biogas leak is produced. Oil filling should not burst into the tank digester that will be filled with slurry (media), because the oil will interfere with the fermentation process

3.5. Slurry Making and Input (Media)

The composition of the medical was made based on the results of the EPA USA [22], where the maximum solids content in the media was 12.5%. However, based on experience in biogas production using local cow dung raw materials, it is used solids content on media by 50% [4]. Media composition with a solid content of 50% can be prepared by mixing 1 part of local cow dung with 1 part water. Practically media is made by mixing 1 bucket of local cow dung with 1 bucket of water. The mixture is stirred until evenly distributed, The media is fed into the digester tank through the feeding line. The volume of the media in the digester tank is up to 75% of the volume of the digester tank. The residual volume of 25% is used to accommodate and the distribution of biogas produced. The media is arranged in a digester tank with residence time or HRT (Hydraulic Retention Time) for 20 - 30 days. By knowing the volume of media in the digester tank and the selected HRT time, it can be calculated the amount of media to be added to the digester tank every day. For the newly operating catalyst, it is advisable to allow fermentation for several days before routine media addition is added daily. The amount of media added daily is calculated based on the following equation:

$$m_{media} = \frac{0.25 \times 3.14 \times D^2 \times h}{HRT}$$

Where:
Mmedia: The amount of media added per day (liters / day)
D: Diameter of tank digester (dm)
H: High tank digester (dm)
HRT: Hydraulic Retention Time (20-30 days)

3.6. Fermentation Process.

Once the media is inside the tank digester, there will be a process of overhauling organic materials by bacteria contained in cow dung. In conditions without oxygen these organic materials can be converted into methane gas (CH4) which is the main component of biogas. The mechanism of the process of overhauling organic materials into methane gas is grouped into several stages:

A. Hydrolysis organic ingredients by facultative bacteria into water-soluble organic matter
B. The formation of volatile fatty acids from water-soluble organic material by acidogenous bacteria.
C. The formation of methane gas from volatile fatty acids by the methanogenesis bacteria group.

In the early stages of fermentation only form of volatile acids. It is worth noting, that the beginning of fermentation has not formed methane gas. Methane gas is formed after the formation of acids. The gases formed from these acids are removed After 20 days to 30 days of fermentation, methane gas starts. Gas starts to be accommodated in a gas container equipped with pendulum. Because there is pressure from the methane gas produced, the container tank starts to move up, Estimated methane gas produced is 28-35 liters / day for every 1 kg of cow dung. The production of methane gas indicates the organic materials present in the fermentation medium (cow dung solution) have been converted into methane gas. Therefore, it is necessary to suply the new cow dung media solution. After 20 days of fermentation, 1/20 the volume of media present in the digester is removed through the output channel. As the volume is released, a new cow dung media solution should be introduced into the digester. Entry and expenditure is done daily after the 20th day of fermentation. This biogas reactor output residue is an added value of the reactor because it can be used as a high nutrient fertilizer [13]. Estimates per day of gas production for 1 kg of cow manure produce 28-35 liters of biogas

3.7. Collector and Distribution of Biogas Produced

The produced biogas is accommodated in a gas container equipped with a pendulum, a pressure gauge (manometer) and an outlet gas valve (see figure). The pressure in the gas container will increase with the increase of biogas produced. The gas pressure in the container tank can be read on the manometer. When the pressure is large enough, biogas can be used as energy for everyday purposes. Biogas is removed through a tap connected to a plastic slang to the user. Biogas is a corrosive gas the gas line is recommended to be made from polymer material in the form of PVC pipe or PVC hose with a tight enough joint. Strongly transparent material is used for gas line (especially on horizontal channel) because Condensing gases that could potentially cause waterlogging that could lead to gas line obstruction. For the purpose of burning biogas there is a furnace, then at the end of the pipeline can be connected with nozzles of stainless steel.

4. CONCLUSSION

1. The role mathematics calculation is very important device . Biogas reactor is one of the energy technology solutions to overcome the society's difficulties due to the spike in fuel prices in the country. This technology can be applied immediately; Especially for rural people who raise livestock (cattle, buffalo, or goat).
2. Technology of this reactor has been developed long enough in various countries, either developed or developing country, with good result. For the user community, this biogas reactor will produce two advantages simultaneously, namely in the form of gas fuel (for cooking) and high quality fertilizer.
3. The size of portable biogas that is small enough can be used as a means for training or practicum equipment in formal and informal education laboratories.

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