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Local Application of Plug-Flow Biogas Digesters Using LDPE Material for Livestock Households in Vietnam

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Abstract

Nowadays, researches on large-scale biogas technology in the world focus to improving the performance of biogas production, the convenient operation and the reduced cost of biogas system. With these targets, the selecting of technology, design, fabrication materials and accessories are very necessary. Of all materials using to make the biogas device, the HDPE, PE, RED ... in PE technical fabrics are showing an economic and technical superiority over the others. LDPE is main product of plastic polyethylene - one of the popular plastics in the world based on its advantages (soft, tough and foldable). It can be soldered, pasted by simple techniques. Thurs, they are not only easy about installation, operation, but also are suitable to Vietnam's conditions cost. The biogas potential in Vietnam is quite huge now with 18,000 medium and large farms, but only a part of which used biogas recovery equipment from waste decomposition process and there is no biogas system which was designed to integrate on the national power grid. This paper aims to introduce a plug - flow digester using LDPE canvas being applied to a Vietnam local farm. This system has shown a good efficiency with limited investment.

1. Introduction

Nowaday, biogas technology is popular all over the world. Unlike some other biomass fuels (biodiesel, bioethanol...), biogas production is relatively simple and it does not touch the copyright issues[1]. The biogas derived from animal manure- a high potential source of organic is a sustainable and cost-effective energy source. This source does not affect the environment and the human health if it is handled properly[2]. However, complicated construction structures, difficult operating and maintemance, high investment are still major barriers to develop biogas systems. Thurs, all biogas digesters installed in rural area follow currently two main trends: low cost and simple struction[3]. According to some past statistics, there were more than 30 million digesters in China, about 3.8 million in India while Nepal and Banladesh were clearly lower with 0.2 million and 60 thousand respectively[4], [5]. Since then. Biogas systems have continuously increased both in quantity and installed surface. Biogas technology is particularly interested in developing countries like Vietnam. In particular, from 2003 to March 2017, a Netherlands Non Governmental Organization (SNV-Netherlands Development Organisation) has invested 158,500 domestic biogas digesters in 54 Vietnam provinces[6]. On 6 August 2019, SNV kicked off a fundation named by the Biogas Innovation Fund (BIF) to select 9 feasible projects out of 15 submitted proposals. This fundation is an initiative in the 3rd phase of Vietnam Biogas Programme (2016-2020) funded by GIZ/ Energizing Development (EnDev) and carbon finance, and implemented by SNV and the Vietnam Ministry of Agriculture and Rural Development[7]. BIF aims to develop new biogas digesters and to implement low cost ones in process of replacing two conventional types: Composite Digesters and KT digesters (built with bricks or concrete). With these reasons, this paper will introduce an effective biogas digester which was installed in a rural location in Vietnam. There is composed of 4 parts: Introduction, Description of Biogas System, Result and Discussion, and Conclusions.

2. Description of Biogas System

This biogas digester uses LDPE canvas to form the tubular shape. Main specifications of LDPE are shown in Table 1.

Table 1: Main specification of LDPE canvas

Number	***Parameters***	Value
1	Density (g/cm^3)	0.92-0.93
2	Melt temperature (^0C)	190
3	Tensile Strength (kg/cm^2)	114-150
4	Elongation at Break (%)	400-600
5	Brittleness Temperature (^0C)	-60

To take advantage of domestic wastes from farm activities, this system was equipped a pre-processing part before putting it into biogas digester, especially with domestic organic wastes such as vegetables, leaves. Animal manures were dumped directly into the tubular tank. In another way, it can be called by the hybrid biogas system. The operating principle is mapped in Fig.1. The operation is based on the principle of a plug-flow digester. The biological material flows through inlet pipe and moves along the biogas tank's length until the outlet pipe. The effluent of decomposing process spills out from the outlet pipe. The generated biogas is accumulated in the gas chamber above of the digestion tank. The more biogas generated, the higher gas pressure in the digester scored. The water level on which the effluent overflows through the outlet pipe is called by the operating water level.

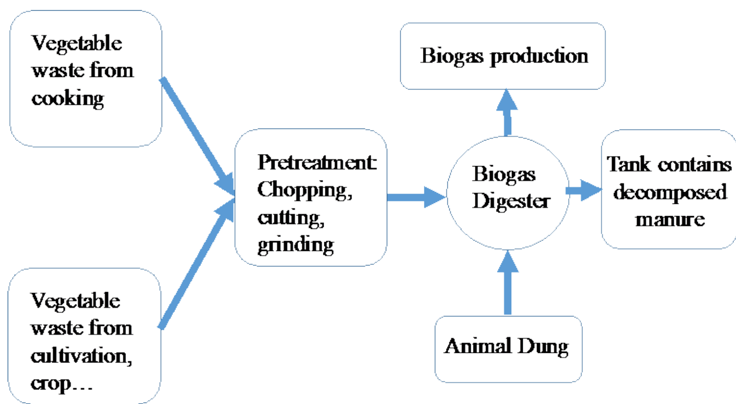

Fig. 1 Principe of a hybrid biogas system.

The volume of decomposition part in the digester (including both acidification and methanogenesis) is calculated according to Equation 1:

$$V_d = M \times RT \qquad (1)$$

Of which:

V_d: Volume of decomposition part

M: Volume of daily feed (kg/day)

RT: Retention time (day)

The volume of biogas part is calculated by the formula:

$$V_g = G \times k \qquad (2)$$

Of which:

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V_g: Volume of biogas part

G: Gasification power of digester (m^3/day)

k: Biogas compressibility factor (approximate 1)

The total volume of digester:

$$V_{tot} = V_g \times V_d \qquad (3)$$

.

With experimental parameters in Table 2, the result shows that the total volume of digester is 4 m^3. This result was applied in local farm in Vietnam and the system (Figure 2) has been tested within 2 months.

Fig. 2 The plug-flow digester installed in a rural location in Vietnam

Table 2: Parameters for calculation of the total volume of digester

Parameters	***Unit***	Value
Volume of Decomposition part	kg/day	20-25
Dilution rate (water/dung volunm rate)		2
Retention time	day	40

3. Results and discussion

For feed material, animal dung is mixed with water at a ratio of 1:2 and then loaded into the digestion tank through the inlet pipe so that the mixture is 50-60% of the tank capacity. This means that the initial loading volume of the 4.8 m^3 tank will be 2.4 - 3.0 m^3 or the required volume of 1.2-1.5 m^3. It is possible to add the waste from the kitchen and vegetable by chopping, pre-tempering for about a week and then mix with water at a ratio of 1: 1 and into the tank. During the first 20-30 days, depending on the temperature of the environment, it will start to replenish daily for stable fermentation. When the decomposition tank starts to blister, the gas also begins to form, the larger the bulge, the more gas is produced, the higher the gas consumption, the greater the risk of cracking the welds. Disintegration tank and gas leakage.

Evaluating external conditions affect the biogas quality and productivity of digester. Temperature is an important parameter affecting gas production, methanogens can live at low or very low temperatures but the operating temperature is 25-35ºC. The variability of temperature is one of assessments of biogas productivity (for example in November in Hanoi (Figure 3)).

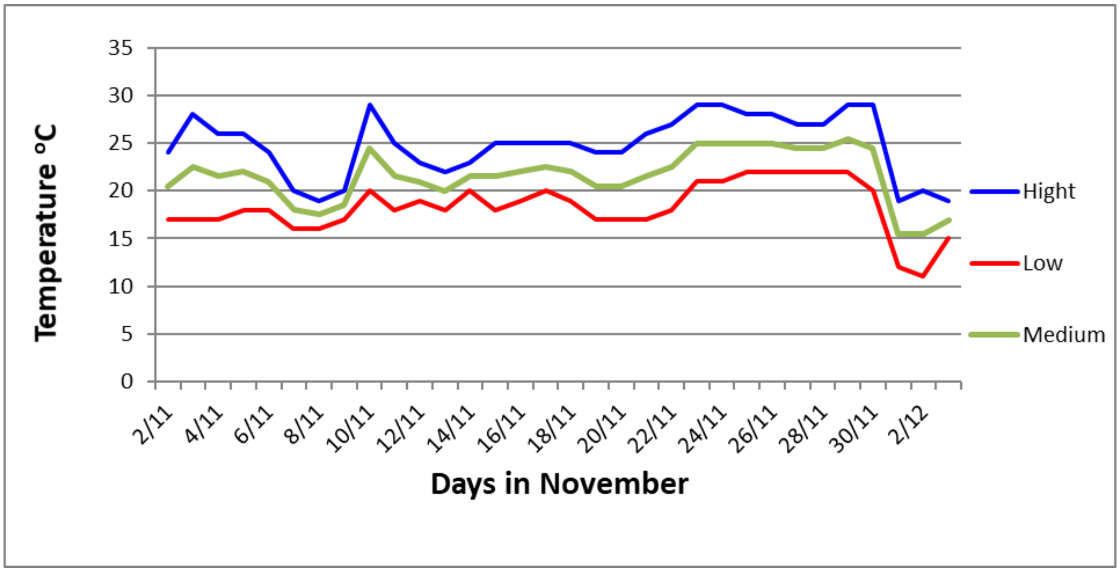

Fig. 3 Variability of temperature in November in Hanoi

In November, outside of Hanoi, it is cold, the average temperature is 21ºC, the highest is 29ºC and the lowest is 12ºC. The fluctuation of temperature between day and night is not too different. However, this weather is not too favorable for the fermentation process although the temperature is not too low compared to the methanogens's operating temperature. In one week, the fermentation process takes place normally. After 5 operating days, the biogas bag began to inflate and reached the sketch after one week of operation. By December, the temperature drops to an average of 15-17ºC. The temperature effect is presented by the comparaison between November and December in Table 3, Table 4 and Figure 4.

Table 3: Results of first mesurement in November

Date	Loading (kg)	Pressure (cm H_2O)	Pressure (atm)	Gas Productions (m^3)
20/11	10	20	0.019	0.26
21/11	12	15	0.014	0.37
22/11	15	17	0.016	0.42
23/11	15	15	0.014	0.42
24/11	12	15	0.014	0.40
25/11	12	15.5	0.015	0.39
26/11	15	16	0.015	0.42
27/11	15	15	0.014	0.40
28/11	12	17	0.016	0.40
29/11	12	15	0.014	0.39
Total	130			3.87

Table 3: Results of second mesurement in December

Date	Loading (kg)	Pressure (cm H_2O)	Pressure (atm)	Gas Productions (m^3)
1/12	15	14.5	0.014	0.30
2/12	15	14	0.013	0.32
3/12	15	16	0.015	0.35
4/12	15	15	0.014	0.32
5/12	12	15	0.014	0.35
6/12	15	15	0.014	0.39
7/12	12	13	0.013	0.32
8/12	12	14	0.013	0.30
9/12	10	10	0.01	0.29
10/12	10	12	0.012	0.29
Total	**131**			**3.23**

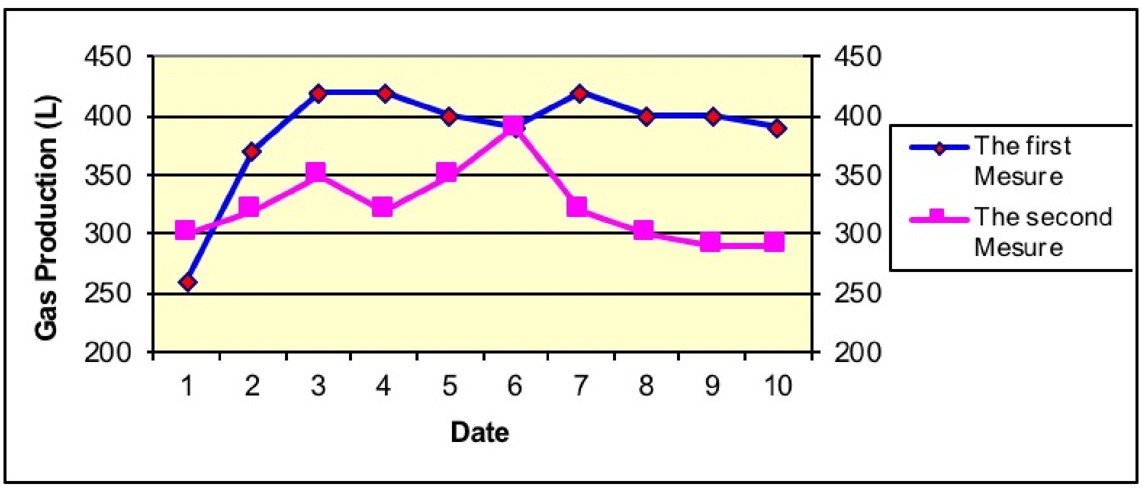

Fig. 4 Comparaison between two mesurements

Note that, all measurements were implemented with the stability of biogas's quality and presure.

The biogas pressure is not high because the maximum pressure tank reaches only 17cm of water column. The pressure is average of 12-15 cm water column is good for cooking but the flame will turn off if the water column drops down less than 2 cm. However, the cooking pressure may be even more limited due to the pressure loss over the length of gas tube. Therefore, it is often recommended that the stove be located near gas tank in condition of proof explosion.

Total gas volume of the first measurement was 3,870 liters (November), which was higher than that of the total gas volume in the second measurement - 3,230 liters (December), corresponding to the average temperature of phase 1 is 22-25ºC and phase 2 is 15-17ºC. When the feedstock is stabilized at 12-15kg per day and the temperature average is 20ºC, the output of gas is quite good.

4. Conclusion

Technical or LDPE tarpaulins are perfectly suited to make biogas from small to industrial scale in Vietnam's technical and natural conditions. Using flexible technical canvas to manufacture biogas tanks in the factory with the desired design, easy folding easy to pack when transported to the installation site. Installation of the tank is simple and does not require much time or labor, does not require the level of the installer. Gases affected by temperature and feedstock, in weeks with average temperatures higher than 20°C, produce better gas than those with temperatures below 18°C. The pressure of the tanks from the technical canvas as well as the tanks made of PE and low-pressure HDPE tarpaulin, on average from 15-20 cm head. The investment capital for the medium-scale model is acceptable and most likely to be expanded to include unstable livestock areas, crop residues and other plant species. Treatment efficiency: these tanks are effective 80-90% depending on the type of efficiency equivalent to other brick construction.

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