Technical aspects dairy biogas production

Aspectos técnicos da produção de biogás em um laticínio

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Abstract

This paper presents initially some historical aspects of biogas production and shows the two most used biodigestors in Brazil: Batching or Discontinuous Biodigestors and Continuous Biodigestors, utilized for the biomass fermentation. Afterwards, the biogas production of a medium-size Dairy located in the Paraíba Valley is described and detailed. In this plant, the biogas average production is 80 Nm^3/h with inferior heat power of 22,475.80 kJ/Nm^3. This energetic good is produced from the organic material (wastes) decomposition deriving from the milk and milk Products production process, which are sent from the productive process to the Wastewater Treatment Plant (WTP). Its experimentally measured mol composition is: 62.7% CH_4, 3.4% CO_2, 2.4% H_2O and 14.1% H_2S. This work aims to verify the biogas production generated by milky product fermentation in the WTP. It can be concluded that through fermentation of milky products a large biogas production is obtained, which should be used as an energy source for the studied plant (VILLELA, 1998).

Keywords

Biogas. Biodigestors. Wastewater Treatment Plant (WTP).

Resumo

Este trabalho apresenta alguns aspectos históricos da produção de biogás e também a produção do biogás de um Laticínio, de médio porte, localizado no Vale do Paraíba. Nesse estabelecimento, a produção média desse biogás é de 80 Nm^3/h com poder calorífico inferior de 22.475,80 kJ/Nm^3. O biogás produzido neste Laticínio é proveniente da decomposição de material orgânico proveniente da Estação de Tratamento de Efluentes (ETE) e sua composição molar é a seguinte: 62.7% de CH_4, 3.4 % de N_2, 5% de CO, 2.4% H_2O e 14.1% de H_2S. Posteriormente, são apresentados os dois tipos de biodigestores existentes no Brasil: Biodigestores Descontínuos ou em Batelada, Biodigestores Contínuos utilizados para a fermentação da biomassa (VILLELA, 1998).

Palavras Chave

Biogás. Biodigestores. Estação de Tratamento de Efluentes (ETE).

Introduction

Formerly known as marsh gas, the biogas was discovered by Shirley in 1667. In the Nineteenth century, Ulysse Gayon, pupil of Louis Pasteur, performed the anaerobic fermentation of a water and manure mixture, at 35º C, obtaining 100 liters of gas per m3 of matter. In 1884, Louis Pasteur, when presenting his student's work to the Academy of Science, considered that this fermentation could be a heating and illumination source. In India, the idea of seizing the methane gas produced through anaerobic digestion was already verified in the twentieth century, more exactly in 1859, when in a leprous people colony, in Bombay, the first biogas direct utilization experiment was performed. About thirty years later, in 1895, the first European experiment was performed, with the use of biogas to light up some Exter, England, city streets. It was followed by other experiments, originated mainly from the initial enthusiasm that this process motivated. Besides that, this fuel could not be used as a substitute for the traditional ones, for its exploitation has been reduced, being limited to some random cases. It was only in 1940, due to remarkable energetic needs caused by the II World War, that the biogas was utilized again, in kitchens, house heating or internal combustion motors (PIRES, 1996).

During the years 50s and 60s the relative abundance of traditional energy sources discouraged the biogas recovering in the majority of the developed countries, and only in countries with little energy and capital resources, like India and China, the biogas played an important role, especially in small rural agglomerates. However, from the energetic crisis of the 1970s, the methane gas of the anaerobic biodigestors drew back the general attention leading to an increase of its production in the European countries. The situation was aggravated by the end of the last century due to the big urban centers population and industrial growth, jeopardizing principally the hydric resources. Attached to this uncontrolled growth, man faces the energetic problem, which involves the fossil energy availability and the difficulties and consequences of its use. Efforts have been made for the solution and the treatment of wastes, especially the ones that utilize biological methods, has been getting full attention (CAETANO, 1990).

Not long ago, biogas was seen as a subproduct, obtained from the urban waste anaerobic decomposition, animal residues and mud from domestic effluent treatment stations. However, the recent years accelerated economical development and the remarkable conventional fuels price increase has encouraged the investigations on the energy production from new alternative and economically attractive sources, trying, whenever possible, to create new energetic production approaches which make possible the exhausting natural resources savings or conservation.

This works aims to show that biogas, formerly seen as a sanitarian embankment anaerobic decomposition subproduct, can also be dairy-generated and later utilized as an energy alternative source.

Types of Biodigestors in Brazil

The option for a biodigestor depends essentially on the substratum characteristics, depuration needs, labor availability and economical conditions. There are two big types of biodigestors: “Discontinuous or Batching Biodigestors” and “Continuous Biodigestors”.

The Batching Biodigestors are loaded at a time and kept closed during an adequate period of time. The organic matter is discharged later. It is a quite simple system, with little professional requirements. It can be installed in an anaerobic tank or in a series of tanks, depending on the biogas demand and on the raw material availability and quality.

The most common Continuous Biodigestors in Brazil are the classic models from India and China, where they are used in small and medium size rural communities. They are very interesting for the use of different animal and vegetal organic wastes, requiring, however, periodic and most of the times daily loading, and waste handling. Each fermentation chamber cubic meter at 30 to 35º C can produce 0.15 to 0.20 m3 of biogas a day. This operation generally requires 30 to 50 days, according to the environment temperature (BENINCASA; ORTOLANI; LUCAS JUNIOR, 1990).

Indian model biodigestor

The Indian model biodigestor has a mobile iron-built or fiberglass dome, and as the gas is formed, it is stored under the dome. This type of biodigestor, due to the continuous formation of gas, keeps a constant pressure, which allows the gas ceaseless utilization. It presents a central wall that divides the fermentation tank, making feasible the separation of the already fermented biomass and its posterior discharge (BENINCASA; ORTOLANI; LUCAS JUNIOR, 1990).

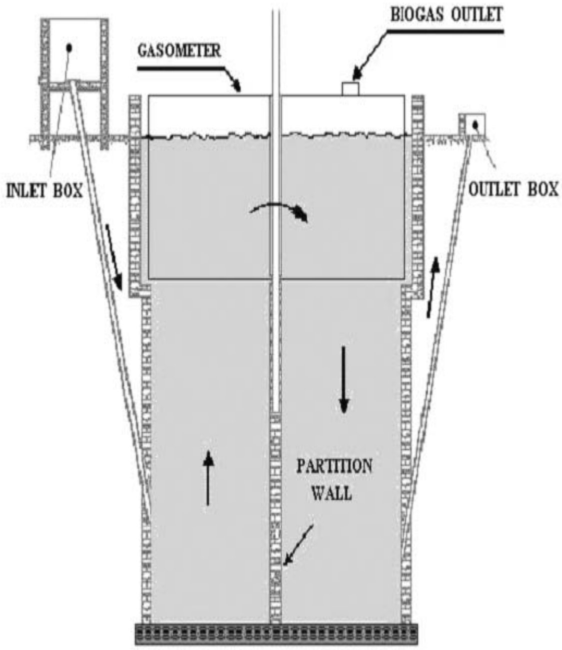

Figure 1 – Indian Model Biodigestor (BENINCASA; ORTOLANI; LUCAS JUNIOR, 1990)

Chinese model biodigestor

This biodigestor is formed by a masonry cylindrical camera, for the fermentation, and a vaulted dome, impermeable, destined to the gas storage. The reactor works based on the hydraulic press principle, so there is an increase of gas pressure inside the biodigestor, which corresponds to the dislocation of biomass from the fermentation chamber to the outlet box and in the opposite direction when the decompression occurs (BENINCASA; ORTOLANI; LUCAS JUNIOR, 1990).

Word Biogas Projects

A lot of projects have been developed nowadays in different regions.

- Portugal, Aire and Candeeiros Mountains Natural Park. - A pig breeding effluents treatment Collecting Plant was built. This organ is responsible for the gas treatment and production, whose valorization in electric energy allows not only the Station energetic needs satisfaction but also the surplus energy sale, providing a financial income that supports the Plant operational costs (PIRES, 1996).

- In Buenos Aires, Argentina, there is a grange whose main activity is based on a she-goat and sheep flock, with a small amount of birds. The biogas generated from the organic matter is utilized to supply a thermotank that helps the digestion chamber and other places heating (NOGUERA, et al, 1996).

- In France, for a lot of years, the CIRAD (Center of Agronomical Research International Cooperation for the Development) has been exploring the different possibilities of biomass utilization. In one of the research units, there is an institute that works with the biogas production "Transpaille" process. This process

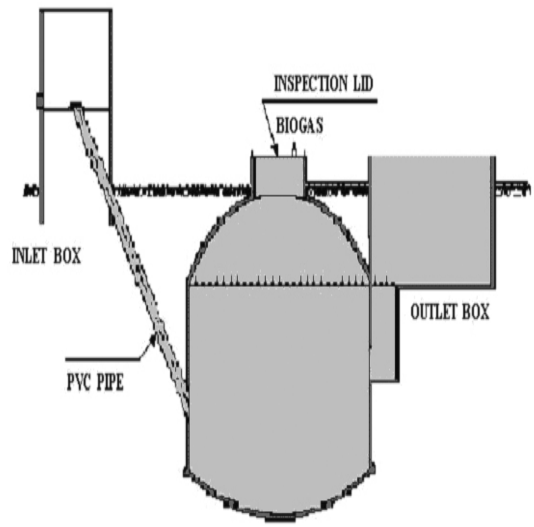

Figure 2 – Chinese Model Biodigestor (BENINCASA, 1990)

was elaborated in Senegal – Africa between 1985 and 1995 and nowadays has 18 installations to produce biogas from a number of organic matters (chiefly wastes in form of straw). The methane is obtained through anaerobic fermentation in metallic-plated cylindrical chambers mounted and soldered on the premises. The installations work in semi-continuous regimen. A subproduct of the fermentation is the composed fertilizer, valorized in the hortifruit urban greenbelt. A number of installations are already in operation or in project in Africa (Senegal, Nigeria, Togo, Sudan, Mali, Tchad), Mexico, Brazil and Colombia (THÉRY, 1997).

Dairy Generalities

The Dairy studied in this work comprises several buildings where the following sectors are allocated:

? Administration
? Frigorific Chambers
? Refrigeration Central
? Raw Material Stock
? Production Line
? Dining Hall
? Kettle Rooms
? Wastewater Treatment (Wastewater Treatment Plant)

Local and regional producers perform the milk

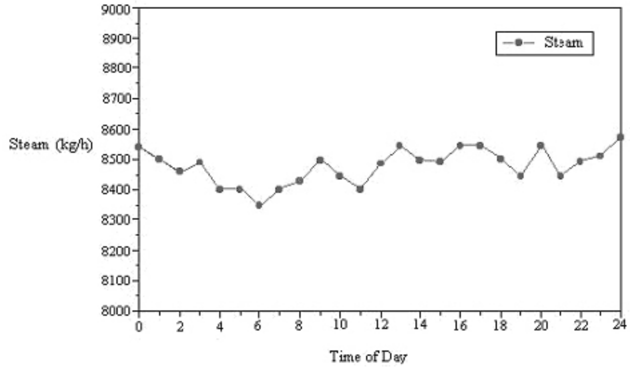

Figure 3 – Process Steam Consumption (1.08 MPa)

supplying for the Dairy. The milk is pasteurized and later utilized to manufacture several items produced by the Dairy, such as fruit pulp yogurts, flans, puddings and long life products (products with three month validity).

Process General Data

Figures 3 and 4 show the steam process consumption and the typical demands of electricity and frigorific power concerning the time of the day, respectively, through the Dairy information (VILLELA, 1998).

Figure 4 – Demand of electricity and frigorific power

Table 1 presents data concerning the dairy in question. Frigorific power refers to the cold water at 1° C for the unit frigorific chamber.

ITEM	DATA
Period of work	24 hours in 4 shifts
Kettle 1	ATA - MP - 812 (1.08 MPa) 8,500 kg/h of steam production 654 kg/h of fuel comsumption
Kettle 2	ATA - MP - 813 (1.08 MPa) 10,500 kg/h of steam production 769 kg/h of fuel comsumption
Steam pressure in the process	11 kgf/cm² (1.08 MPa)
Electricity peak demand	2,100 (kW)
Frigorific power	1,520.000 kcal/h (2,725 kW)

Table 1 – Dairy General Data

It must be noticed that Table 1 presents some complementary data, seeing that kettles 1 and 2 are utilized alternately, in order to always keep a kettle in "stand-by".

Dairy Biogas

The biogas generated in the Dairy Wastewater Treatment Plant is obtained through the waste material decomposition, which is usually mixed with water and submitted to treatment. The Dairy uses a Chinese model Biodigestor for the fermentation of the biomass from biogas.

Table 2 presents the biogas outflow generated in the Wastewater Treatment Plant, according to the days of the week.

DAYS OF THE WEEK	OUTFLOW [Nm^3/h]
Sunday	19.0
Monday	34.8
Tuesday - Friday	73.8
Saturday	53.6
AVERAGE	56.8

Table 2 - Dairy biogas outflow data

It can be noticed that the average outflow is approximately 57 Nm^3, but according to recent information from the Dairy, the average outflow and the biogas maximum production changed to 58 and 80 Nm^3, respectively, due to the Wastewater Treatment Plant maintenance executed.

From the data provided by the Dairy, it is noticed that the biogas inferior calorific power is 22,475.80 kJ/Nm^3; in a first analysis its molar composition presented the following values:

62.7 % of CH_4;
13.4 % of N_2;
5 % of CO;
2.4 % of CO_2;
2.4 % of H_2O;
14.1 % of H_2S.

Conclusion

From the mentioned data, it is noticed that since the 19th century biogas was already an alternative energy source, but only from the energetic crisis of the 1970s deeper studies experienced a new direction in the European countries. With the crisis and the remarkable increase in the tariffs, studies have been made in such a way to create alternative forms of energy production, efficiently and economically more feasible.

Thus, it can be verified that by means of the fermentation of the milk products in the Wastewater Treatment Plant, a great biogas production is obtained, which can be further used as an energy source, supplying the own Dairy needs.

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