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Potential of biogas production in an anaerobic digester solar assisted

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Abstract.

This article discusses an installation of anaerobic biodigestion aided by a heating system using solar energy to maintain the temperature inside the digester above the ambient temperature and thus increase the production of methane which can be used as fuel. The facility is located in Mexico City. In experimental tests a temperature difference of 10.14 ° C between the temperature inside the digester and room temperature was obtained. These results imply a potential for improvement in the production of biogas and methane yield of 16.6%. This improvement was achieved due to the use of the solar collector.
The implementation of this technology involves stop issuing 13983.15 kg (CO2) per year for a 150 l digester volume operation.

Key words

Biogas, Digester, Energy, Fuel, Solar

1. Introduction

The use of fossil fuels such as coal, gasoline, natural gas and oil in the human activities along with deforestation and other factors have caused the increase in temperature of the atmosphere. This phenomenon has been observed since the late nineteenth century, the increase in global temperatures is caused by the sharp increase in greenhouse gases in the atmosphere resulting from the use of fossil fuels.

The greenhouse effect is a natural phenomenon in which the heat radiation from the sun incident on a surface, in this case earth, is absorbed by the gases in the atmosphere and is re-emitted in all directions, resulting in increased surface temperature. The most efficient heat absorbing gases are called greenhouse gases or greenhouse gases, including CO_2 is that it is the humanity in their consumption of resources has increased to historically unprecedented levels and is causing global warming.

A major source of emission of this gases is the organic matter decomposition in open dumps, most of these sites do not have control of the processing of waste.

Therefore, at present, it is increasing the use of alternative energies such as: solar wind, geothermal and biomass. At the same time it seeks to take advantage of organic waste becoming a source of pollution into a source of energy friendly to the environment. This can be achieved by using anaerobic digestion of organic matter such as food waste.

Anaerobic digestion is a biological process is conducted in absence of oxygen, in which organic matter is converted into biogas through metabolism of various microorganisms, which is composed mainly of methane (50-80 % v/v) and carbon dioxide gas formed can be used to produce electricity or to supply a heating system [1].
The use of these technologies for treating organic waste has the following advantages:

• Through the process of digestion waste becomes fuel [2].
• Emission of greenhouse gases is decreased.

• The resulting digestate from biogas production process can be used as mulch or integrated into a composting process [3].

• Reduces the volume of waste that must be landfilled.

One of the most important parameters in the process of producing biogas by anaerobic digestion is the temperature [4]. This process can be performed at temperatures below 20 °C call pshychrophilic [5], however, the best yields in biogas production have been reported in mesophilic and thermophilic conditions with optimal values of 35 °C and 55 °C respectively [6].

To maintain temperatures in the mesophilic or thermophilic ranges during anaerobic digestion, energy investment in a system that supplies heat to the digester is necessary. This involves an extra cost at the operation of anaerobic digesters.

An alternative to solve this problem is the use of solar energy by implementing a solar collection flat type with storage tank that would supply heat to the anaerobic digester by using an internal coil.

Using a solar collector allows heat supply to the anaerobic system at a low cost and with a very low environmental impact because digester is not necessary to use fuels [7].

This article discusses an installation of anaerobic biodigestion aided by a heating system using solar energy to maintain the temperature inside the digester above the ambient temperature and thus increase the production of methane which can be used as fuel. The facility is located in Mexico City.

2. Description of the installation.

The solar collector auxiliary system, serves heat water by a flat solar collector 2.08 m^2 of catchment area connected to a hot water tank of 200 liters capacity which is in charge of storing thermal energy and thus circulating the working fluid through coils which it is located within the digester with capacity of 150 liters and is responsible for getting the heat from the water heater to the substrate.
This heating system replaces a traditional system would use a fossil fuel helping to reduce the emission of greenhouse gases. The biogas obtained as biodigestion product can be used as an energy source for heating or to produce electricity through a generator that uses methane as fuel.

Development in experimental tests were carried out for 30 days nonconsecutive using water as the process fluid within the anaerobic digester.
The available solar radiation during the day was on average 655 W/m^2 reaching 874 W/m^2 or less. The available solar energy was quantified and integrated, and used for the overall thermal efficiency of the system which averaged 11.23 %.
During the night periods it is impossible to obtain direct radiation to provide heat to the digester. However, studies suggest that it is not necessary to maintain a constant temperature fully within the digester.

The Mashad (2004) [8] conducted studies evaluating the effect of temperature will increase or decrease in the range of 10 °C, 10 °C decreasing by 10 hours a day and increasing it to 10 °C for 5 hours daily anaerobic digesters operated at 50 and 60 °C. The results showed greater methanogenic activity (SMA) in the digesters where the temperature decrease was performed daily. The results of this study suggest the feasibility of using solar energy to supply heat to the anaerobic digester during the degradation of organic matter.

3. Efficiency of heat transfer and potential production of biogas

Dates obtained during the study period showed a maximum temperature of 37.71 °C and a low of 26.31 °C, while the ambient temperature presented a maximum of 35.83 a minimum of 16.17 °C.
The difference between the minimum temperatures of the digester and the environment is of 10.14 °C, this implies a significant increase in the potential for biogas production using food waste as substrate biodigestion system proposed in this work. This coincides with what was reported by Kim et al (2006) [9], in which he analyzes the effect of temperature on the production of biogas and methane concentration. A temperature rise of 40 to 45 °C causes increased 19.17 % in the production of biogas, while raising the temperature from 40 to 50 °C causes an increase of 42.46 % in the production of biogas. In both cases the concentration of methane is higher than 60 % in the biogas.

Likewise Bouallagui et al (2004) [10] found that with increasing temperature from 20 to 35 °C in the process of anaerobic digestion of food waste with 8% total solids, performance biogas production increased 12.8 % while increasing the temperature from 20 to 50 °C, an increase of 59.59% is obtained in the production of biogas. Both in relation to the production of biogas obtained at 20 °C.

Moreover, the concentration of methane in the biogas is also affected by temperature, as shown in the work by Chae et al (2008) [11] in the anaerobic digestion of swine manure, which evaluated the methane yield at temperatures of 25, 30 and 35 °C (which are similar to those achieved by the anaerobic digester presented in this paper).

Chae, found that the concentration of methane in the biogas increases along with the temperature increase having a concentration of 43.8 % methane in biogas produced at 25 °C, 54.8 % at 30 °C and 60.4 % at 35 °C. These results clearly show that it is possible to increase the concentration of methane in the biogas in the 16.6 % increase in 10 °C temperature digester.

In this work, an increase of 10.4 °C in the digester relative to room temperature is obtained, this means an increase in the production of biogas and methane concentration therein, and a significant decrease in fuel consumption used to supply heat to the digester in order to raise the temperature.

One way to compare the amount of energy used to achieve the temperature rise is the use dioxide concept of equivalent carbon dioxide $(CO_2)_e$ and which is a ratio of potential CO_2 given fuel can issue a complete combustion per said unit fuel mass [12]. Making this comparison, the temperature increase mentioned, LPG 12.52 kg per day would be used to maintain the temperature anaerobic digester 10.14 °C above the ambient temperature, representing 38.31 kg $(CO_2)_e$ and; this equates stop issuing 13983.15 kg $(CO_2)_e$ and annual. Whereas an average low-polluting car emits between 100 and 120 g/km CO_2, they would be leaving to issue what this car produced by between 139831.5 and 116526.25 km. This distance represents the average car travel on a 10-year period.

In Mexico 86 343 tons of wastes per day are generated. The potential production of methane using this waste at temperature 25° C in anaerobic digestion is 24 957.53 tons of CH_4 that would be emitted to the environment if not used as fuel [13]. Using technology developed in this work could be produce 28 950 ton of CH_4 that can be used to generate electricity. If methane is not used as fuel, 607 965 ton of $(CO_2)_e$ would be obtained, however, by using it as fuel 79 614 ton $(CO_2)_e$ would be taken, which implies a 86.9% reduction of (CO_2) emissions to the atmosphere, therefore, this technology helps to reduce the emission of greenhouse gases and to mitigate climate change.

4. Results and Conclusion

The results show the feasibility of implementing this type of anaerobic digestion systems assisted by solar energy at different scales for use of debit form, parks, gardens and businesses and reducing the volume of contamination by organic waste and reducing costs generated disposal. At the same time biogas is obtained as a product of anaerobic digestion resulting in the generation of a product with high added value from the use of a residue considered polluting and thus contributing to the reduction of emissions of greenhouse gases.

Increased biogas production estimated temperature increase of 10.14° C using solar energy is approximately 16.6 %. This result suggests the possibility of scaling the system.

In recent years there has been implementing and developing technology research focused on ensuring sustainable development, part of this is the development of biogas, which represents an environmentally friendly alternative to be used as fuel. The raw material for their biogas production, are waste organic. This help to solve disposal of organic waste and other pollution problems.
Biogas is an excellent alternative to the use of technologies focused on environmental sustainability, as this represents a viable business in the regions where organic solid waste is a problem.

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