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Features of the technology of anaerobic processing of biotails using humidity control devices

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Abstract. The article discusses the technical foundations and practical methods of processing organic waste in a biogas plant, as a result of which biogas is obtained, the effect of biomass moisture on the output of biogas is studied. The principles of quality management of natural and man-made energy resources are outlined, in order to increase the efficiency of the technology of anaerobic processing of biogas production, considering the concentration of methane, due to continuous and remote measurement of the effect of humidity of the base raw materials at the output from biogas. The article analyzes the method and recommends the use of devices for monitoring and regulating biomass moisture indicators.

1. Introduction

Biogas is one of the promising types of alternative energy sources around the world.

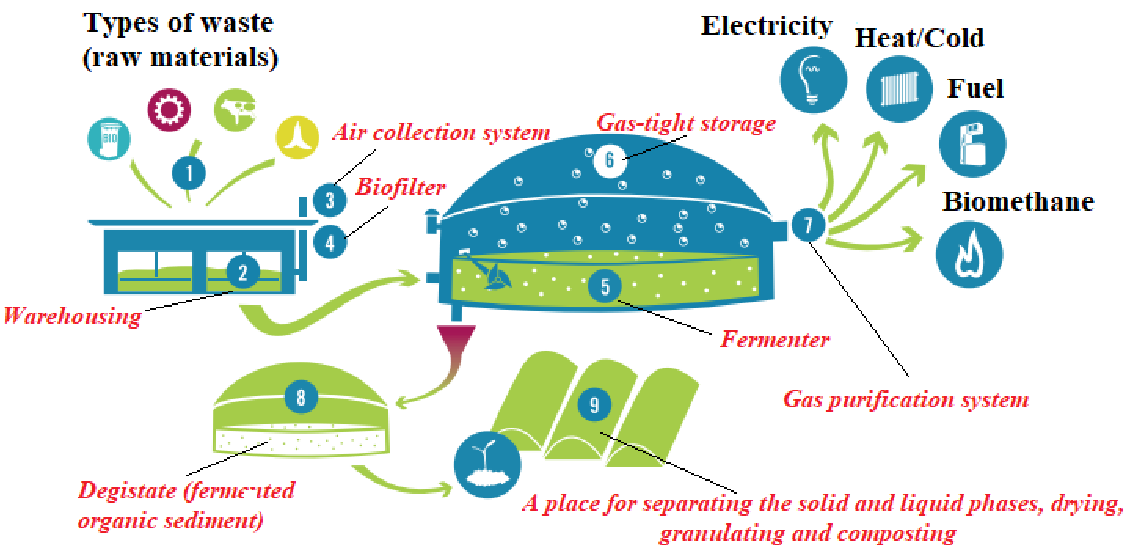

Figure 1. General view of the anaerobic fermentation system of organic waste and by-products of plant or animal origin to obtain biogas.

A biogas plant is a complex of plants for the processing of various agricultural and household waste, which produces biogas containing at least 60-95% of the methane concentration, as well as high-quality mineral fertilizer. After purification of biogas from various impurities, the result is biogas used as a natural gas. The biogas plant itself is economical, i.e. it consumes only up to 15% of the energy produced in winter and only up to 5% in summer.

A biogas plant is usually supplemented with a biogas enrichment system, resulting in biomethane, a gas that is similar to natural gas, it can be used for heating, refueling cars and various other purposes.

However, the technologies used and a number of equipment are not yet fully responsible for obtaining biogas from the raw materials used with the maximum methane yield. The technological solutions used for obtaining biogas from waste are only 30-60% of organic impurities, the methane content in biogas mainly reaches only 60-70%. However, many experts do not investigate and do not consider many factors, especially at the biogas outlet. More importantly, there is no accounting for the concentration of methane at the outlet, and here it should be noted that most users use the process of anaerobic digestion in thermophilic conditions at 45-55 °C to improve the output of biogas from the system.

Analysis of the literature [1-10] in the field of biogas production in most cases describes that one of the most porular bio-sources for the production of biogas and as the main raw material is attributed to cow manure. The results and analysis of the content of one head of cattle (cattle) provides up to 30 m3 of liquid manure.

If this indicator is processed in biogas plants, then you can get about 1700-1800^{m3} of biogas. If these results are translated into combustion parameters, they can correspond to the following data: 200-1300 m3 of natural gas, or 150-1000 kg of gasoline, as well as 180-1200 kg of liquid fuel oil or 350-2600 kg of dry firewood.

To realize and obtain a sufficient maximum volume of biogas from fermentable masses, it is necessary to achieve high activity of microorganisms. To solve this problem, it is necessary to ensure the established viscosity of the substrate. One occurs when there are influencing factors in the raw material, such as dry, often large, as well as solids. These elements lead to the formation of a crust, they in turn lead to the stratification of the substrate and slow down or even stop the release of biogas. To solve this problem, before loading the raw material into the methanetheque, the raw material is crushed and mixed with a lower turnover of the mixing device.

All considered by-products of vital activity of all animals, including birds, have one common feature: they contain energy potential and are recommended as the optimal raw material for the production of biogas.

Therefore, in practice, many biogas producers use multicomponent fermentation, for these purposes they ferment several types of substrates, i.e. vegetable and animal origin.

When assessing the yield of biogas and the potential of biogas production, the calculation per ton of substrate is taken and on average, liquid cattle manure contains 25 Nm^3 of biogas, methane concentration at 60%, i.e. the yield of biogas from a ton of cattle manure is 25-45 Nm^3 [11].

In general, a biogas plant consists of the following elements: homogenization tanks (in these cases, raw materials are mixed, resulting in a homogeneous mass), a loader for waste and raw materials, a bioreactor, agitators necessary for mixing biomass, a gas tank (for storing finished biogas), a gas hot water boiler, pumping equipment, a separator, as well as tanks at the output of fertilizer waste.

The installation allows to obtain biogas and fertilizers from biomass waste. However, in order to obtain combined electricity and heat production, an additional cogeneration plant will be required. It is known that the power generation capacity of a biogas plant in most cases depends on the raw material base supplied to the bioreactor [12].

2. Material and methods

The purpose of our research is to study the efficiency of the technology of anaerobic processing of biogas production, considering the concentration of methane, due to continuous and remote measurement of the effect of humidity of the base raw material on the output from biogas.

To this end, it is necessary to perform a number of tasks, in particular, to analyze the existing ways of influence of humidity on the yield of biogas and to justify the control of humidity by an indirect method; to develop a model of the primary transducer and measuring device for monitoring the moisture content of biomass in a discrete mode.

Most biogas producers adhere to maintaining humidity at up to 95%, in the summer, and 85% respectively in the winter.

Researchers [13,] believe that the methane yield largely depends on the type of manure, as well as the moisture content of the manure, characterized by physical properties, where the main component of the RCS of manure is its humidity, depending on the system of its removal from livestock buildings, with mechanical removal of manure and littering of animals, the humidity is 75-90%, with litterless - 90-95%, and with hydraulic washing - 97-99%, i.e. as the water is diluted, the physical properties of the manure change, as well as the nutrient content [14].

Fig.2, the scheme of the experimental installation performed at the Department of Automation and Control of technological process and production of the "Tashkent Institute of Engineers of Irrigation and Agricultural Mechanization" of the National Research University is presented.

The moisture content of the feedstock is measured in three positions during the anaerobic fermentation process: the first measurement before the mixers are placed in the hopper, the second after the displacement of the feedstock and the third at the output after the completion of the anaerobic process in the collector of the output feedstock.

In hopper 1, cattle waste is loaded, water is also recharged, and mixed with a stirrer 2 in a mixer. The moisture content of the finished feedstock is measured via W_I and distributed to bioreactors 3-7 depending on the degree of humidity. The gas released from each reactor is measured using a gas analyzer $F_{I.}$ The measured gas is collected in gas reservoirs 8-12, to maintain the appropriate temperature bioreactors placed in one methanetheque using a thermal heater 14, the water temperature is controlled using a thermoconverter T_I, the output of waste from bioreactors 3-7 is collected in collector 15. Waste is used as mineral fertilizers; their humidity is also measured in a discrete mode and is considered when regulating humidity in general.

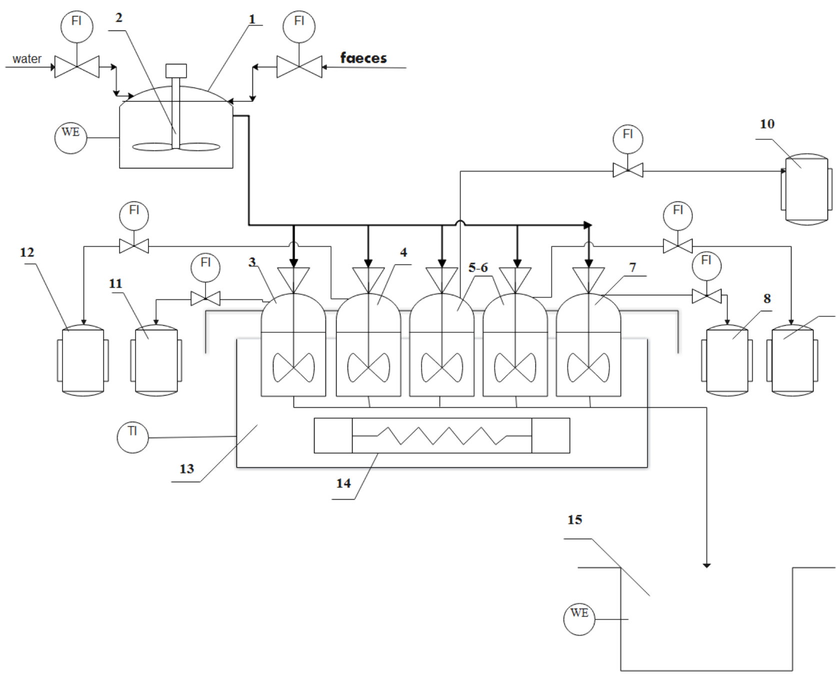

Figure 2. Scheme of the experimental plant for the production of biogas, considering the concentration of methane and humidity control.

In Fig.3. the calibration characteristics of the high-frequency biomass moisture control device are presented, in Fig. 4 dependence of the dielectric constant on the moisture content of the material

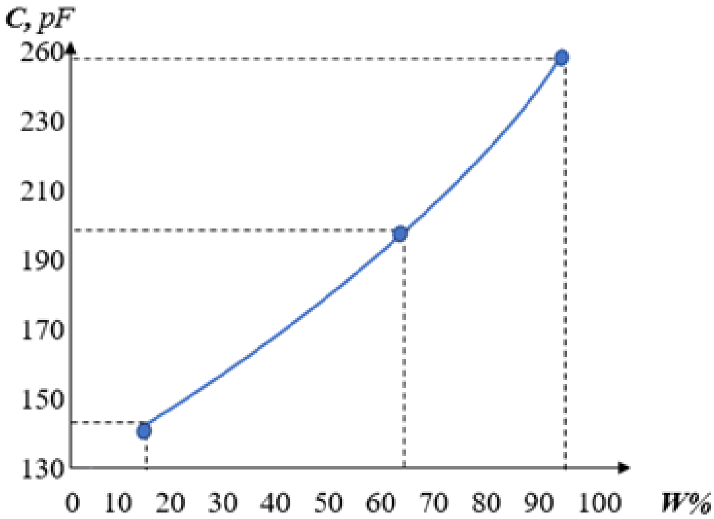

Figure 3. Calibration characteristics of the RF moisture meter for biomass

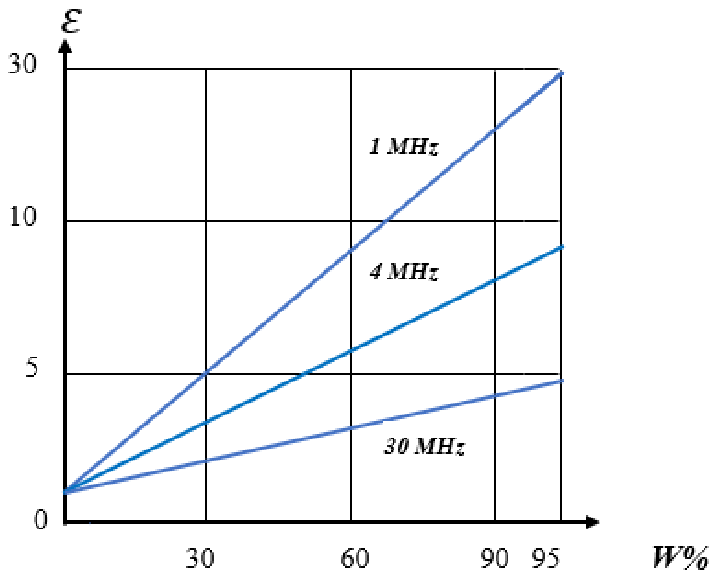

Figure 4. Dependence of the dielectric constant on biomass moisture

The method of humidity control in the production of biogas and the yield of a large concentration of methane is aimed at analyzing modern technologies for processing organic waste and scientific substantiation of the most effective technological solutions with high economic and environmental effects [15].

3. Research results

The experimental plant for the production of biogas and the determination of methane concentration is one biomass mixer, 4 bioreactors, four gas holders for each bioreactor separately. Humidity measurement is carried out in two ways: the first by the standard method of drying in a laboratory furnace by thermogravimetric method, as well as measurement in an experimental device based on the dielcometric method.

In the studies, the manure consisted of 4 variants:

- the first and second variants, manure from RKS waste without various impurities, with a natural component without dispersion (without mixing) with a humidity of 62% 68%.

- The third and fourth version of manure from RKS waste with dispersion without various impurities of straw and various feeds was a humidity of 70% and 76%.

The humidity of biomass when loaded into the bioreactor was 80%, at a temperature of 50 ^{0}C.

Biomass digestion options in the first two variants were 14 days, and in the third and fourth variants 12 days.

The obtained results are reduced to the following indicators: - the volumetric yield of biogas during anaerobic digestion in the first two variants, the specific yield of biogas was - 1.9 m^3/ day, in thethird and fourth variants with dispersion (15-20 min.) was 2.7 $m^{3.}$

Measurements of methane concentrations in both cases were within the following limits: - 75% and 79%.

Thus, the use of dispersion of a mixture of biomass and a thermophilic fermentation regime at a humidity of over 80% will increase the productivity of biogas several times with a structure lasting 3-7 days of the entire fermentation cycle [16, 17]

Based on the results of the studies, it can be stated that the humidity value will allow to obtain and intensify the process of biogas yield with an increase in the ratio of methane concentration. At the same time, it will be possible to observe, as well as predict the entire process of biogas output. However, the humidity index of the fermented medium significantly affects the specific volume of biogas yield. Humidity can be used to control and control the biological process occurring in the bioreactor itself [18, 19, 20]

4. Discussion

Methane is the main component of biogas, which is used to produce thermal and electrical energy.

The study of the features of the process of anaerobic digestion and the effect of humidity on the process of biogas yield and methane concentration in the analysis of literary sources and the analysis of many researchers has not been carried out [21, 22]. This is the case when considering the pH control (acidity/alkalinity of the fermentation medium) [23, 24].

However, existing plants do not provide processing of manure effluents, for this purpose biogas plants are used using an anaerobic biofilter [25, 26].

There is also a processing of municipal organic waste, while huge costs are spent on the construction of methane tanks, they in turn are one of the main factors restraining the widespread use of anaerobic digestion technology, but neither in both systems is the influence of various factors on the output of methane concentration studied [27, 28].

5. Findings

Obtaining a heavy process that requires a technical approach using engineering calculations in the design of the system as a whole. In turn, the use of a biosystem makes it possible to independenceand receive energy from third-party sources, with a competent approach, it serves as a means of obtaining additional profits.

Based on the foregoing, we can draw a number of conclusions:

1. The analysis of literary sources confirms that the problems of energy supply are increasing all over the world, in connection with this, there is a growing interest in the processing of organic waste, in order to obtain biogas and mineral fertilizers. It, in turn, requires scientific research and the development of new technologies for processing organic waste, which allows increasing the concentration of methane, and the output of biogas.

2. It is determined that the production must be carried out in a thermophilic mode, or over 50 ºC, at low temperatures, biogas production usually decreases. However, using the temperature to the optimum (above 45 ºC) requires additional energy costs.

3. To increase the concentration of methane, and the yield of biogas must be regulated in the light, for these purposes it is more optimal to use indirect methods, using the humidity control deviceby the electrical method in a discrete mode [29].

4. Operational control of humidity must be carried out at all stages of anaerobic digestion, using moisture meters to measure the humidityof the fermented medium in real time.

5. Biomass moisture control devices should be paired as part of the automated process control system in the control of technological processes [30].

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