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EFFECT MODES METHANE FERMENTATION THE EFFICIENCY OF BIOGAS

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The analysis of conditions affecting the intensification of methane fermentation process. The degree of efficiency of biogas production and its heat value of temperature control digesters, raw materials, mixing, presence kosubstrativ

Biogas substrate bioshlam, digesters, gasholder, temperature, kosubstrat, mixing

Problem. Energy availability mankind become increasingly dependent on natural gas because of ease of use and environmental friendliness. However, its proven reserves will last only 60 years. And the largest natural gas reserves are concentrated only in certain regions of Russia, Iran, the Arabian Peninsula. Other countries have been forced to buy natural gas. Although Ukraine ranks third in Europe in the volumes of natural gas extraction (after the Netherlands and Norway), provides a local natural gas is only 20%. The rest is exported. But in Ukraine enough material for an analogue of natural gas - biogas, which is derived from biological material (manure, waste agricultural production and processing of agricultural products, biomass, etc.) in biogas plants. However, the effectiveness of biogas production is largely dependent on the mode of biogas plant [1].

Analysis of recent research. To intensify the process of methane fermentation is necessary to optimize the conditions under which the rate of enzyme reactions would be maximized. The creation

These conditions affect the following factors: the properties of the substrate temperature fermentation, pH, exposure (time) digestion, the presence of anaerobic conditions and the type of community methanogens used in digesters. The composition of manure biomass and its properties greatly influence the methane digestion process. In modern biogas plants are processed substrates with dry matter content of 12% and a maximum length of fibrous or steblevydnyh particles not exceeding 30 mm [2]. After loading the substrate in the digesters biogas yield per unit time increases sharply at first, and then achieving maximum gradually decreases. It should also be noted that the herb contains many proteins, and therefore has a high reaction rate and provides a large gas output, while the straw and dung of cattle because of the large proportion of lignin fermented much slower and produce less biogas [3]. Preparation of raw materials requires certain requirements. The condition for the application of organic material in the process of fermentation is the absence of the toxic compounds and appropriate grinding material that can afford to increase biogas production by 20%. Using homogeneous biomaterial significantly increases the efficiency of the flow of fermentation. Undesirable components of the process is the presence of inhibitors that are difficult to decompose biologically, such as disinfecting materials, detergents, antibiotics and pesticides used in agriculture [4]. Not urges life methanogens and some inorganic substances, they can not be used, for example, to dilute manure water remaining after laundry detergents [5]. Chicken manure is often inhibits methane fermentation excess NH3 [6]. The stability of the process largely depends on the pH stability. The process of anaerobic fermentation possible by changing the pH in the range of 6,0-8,5, but generally try to maintain pH 7,0-8,0 because at lower pH below 6.5 is deteriorating biogas yield by 30-40%, while pH 6.0 almost completely inhibited the development of methane microflora [2].°C) and thermophilic – 54°C. Although the process of decomposition of cellulose in thermophilic conditions is 14 times more intense than in mesophilic and the number of biogas obtained at 25-30% higher in thermophilic conditions thermophilic processes are less stable than the mesophilic, permissible temperature fluctuations are considerably reduced [8]. The process of fermentation of biomass (exposure digestion) is also one of the important parameters of methane fermentation. In most cases, the processing of manure biomass methanogenesis process occurs within 24-28 days or more. In practice, exposure methane fermentation to obtain biogas set depending on the temperature and degree of decomposition of organic matter in the following intervals: at 10-25°C to 30 days at 25-40°C– 10 to 20 days, at 45-55°C– 4 to 8 days [2]. The degree of decomposition of organic matter (bioconversion) bezpidstylkovoho manure depends on exposure. The maximum extent of bioconversion of organic matter 53% (technical digestion) is achieved only with long exposure and practice is not used. The best organic fertilizer at a mesophilic methane fermentation mode is obtained when the degree of bioconversion of organic matter 30-33%, while the observed maximum biogas yield. To achieve this level of bioconversion of organic matter in flow reactors exhibit complete mixing required 20-22 days. Exposure methane fermentation, along with a daily output bezpidstlkovoho manure defines the working volume bioreactor [2]. The average duration of the fermentation of raw materials at psychrophilic temperature-tour mode is between 30-40 days or more, the mesophilic mode – within 10-20 days, with thermophilic – within 5-10 days [9]. A very important factor for the efficient flow temperature fermentation process is mass that is fermented. Methane fermentation begins at 6°C. At a lower temperature methane stops. Along with increasing temperature increases rapidly gassing. Thus, at 30°With the selection of biogas is 12 times faster than at 10°C [10]. However, with increasing temperature decreases methane content in biogas. This is due to the fact that at high temperatures, dissolved carbon dioxide in the substrate becomes more intense in the gaseous phase (in biogas), thereby reducing the relative content of methane [11].

If there large biogas yield, but it is not flammable, it often means that the surface material in the reactor formed foam or peel. If low gas pressure at all, it might mean that formed a crust that locks the gas pipe. It is therefore necessary to remove crust from the surface material in the reactor.

Feature of peel is that it is not fragile, but viscous and can be very hard for a short period of time. For the destruction peel it must be maintained in a humidified condition. That crust can pour water from above or drop into the substrate [5]. However, a slight crust floating on the surface of the substrate in useful for colonization sulfur bacteria, which are included in the purification of biogas desulfurization [12].

Stable operation of biogas installation support by mixing the substrate. The purpose of mixing is formed by the release of biogas mixing of fresh substrate and bacteria (scion) prevent the formation of crust and sediment, preventing the appearance of areas with different temperatures within the digesters, ensuring even distribution of populations of bacteria, the impossibility of forming clusters and voids, which reduce the effective area of the reactor. When choosing a method of mixing remember that fermentation is a process of life symbiosis of different strains of bacteria and in the destruction of the community would be counterproductive fermentation until the time of formation of a new symbiotic bacteria. It is very frequent or prolonged stirring detrimental. Recommended slow stirring substrate digesters every 4-6 h [13].

A necessary condition for the efficient operation of the biogas plant is the presence of a thermal protection [13]. In psychrophilic mode at term resistance 1 (m2·°C) / W and negative ambient temperatures in teplozatraty envelope biogas plants are 25-30 W, mesophilic regime – 45-65 W, thermophilic mode at -20° C reach 75W. The smallest heat loss achieved with thermal resistance of more than 1 (m2·°C) / W [14]. Therefore, to reduce heat loss digesters should be provided with thermal insulation, have a minimum surface area or underground or semi location [13].

The purpose of research. Determine the degree of technological factors on the effectiveness of biogas suitable for use for energy purposes.

Results. The effectiveness of biogas was determined according to the type of raw materials, availability kosubstrativ, temperature biogas plant, with or without stirring substrate. Experimental studies were carried out in parallel on two biogas plants in educational and scientific laboratories in Bioconversion AIC National University of Life and Environmental Sciences of Ukraine. The composition of the biogas plant is digesters volume 30 LContaining stirrer and a heating device and gasholder.

The influence of temperature. The degree of influence of temperature control digesters for biogas production efficiency was investigated by the example of methane fermentation of cattle manure moisture 93.4% at 55, 50, 45 and 40°C. The results of the study are presented in Fig. 1, which shows that an increase in temperature digesters biogas yield increases. Thus, the average biogas yield at 55°C is 7103 cm3 / day at 50°C– 5226 cm3 / day at 45°C– 4893 cm3 / day at 40°C– 2041 cm3 / day. Experiments duration of the lag phase was minimal and was less than a day (except for fermentation at 55°C, when due to changes in temperature and substrate length of the lag phase was 4 days). For all temperature conditions the amount of time the exponential phase and a phase of slow growth is within 14-15 days. During this time the biogas yield was: at 55° C – 11 254 cm3 / day, 50°C– 8980 cm3 / day, 45°C– 8059 cm3 / day, 40°C– 3611 cm3 / day. At the same time, during the stationary phase and phase of extinction, which for the duration of the experiments was 20-25 days, biogas yield was: at 55°C– 4797 cm3 / day, 50°C– 4179 cm3 / day, 45°C– 2632 cm3 / day, 40°C– 1108 cm3 / day. That is, the output value of biogas in the first 14-15 days and the next time the reactor are 2,1-3,3, which implies that if the main purpose is waste digestion biogas, a rational cattle manure fermentation is 14-15 days .

Effect of mixing the substrate. In the study of the influence of mixing the substrate to yield biogas substrate was used as cattle manure. One reactor mixing was carried out on the second mixer made 10 revolutions once a day. The research results are presented in Figure 2, which shows that in the absence of mixing biogas yield decreases. Thus, during the exponential phase and slower growth phase (11 days) with stirring substrate biogas yield was 7179 cm3 / day, without stirring – 5652 cm3 / day, which is almost 1.3 times less.

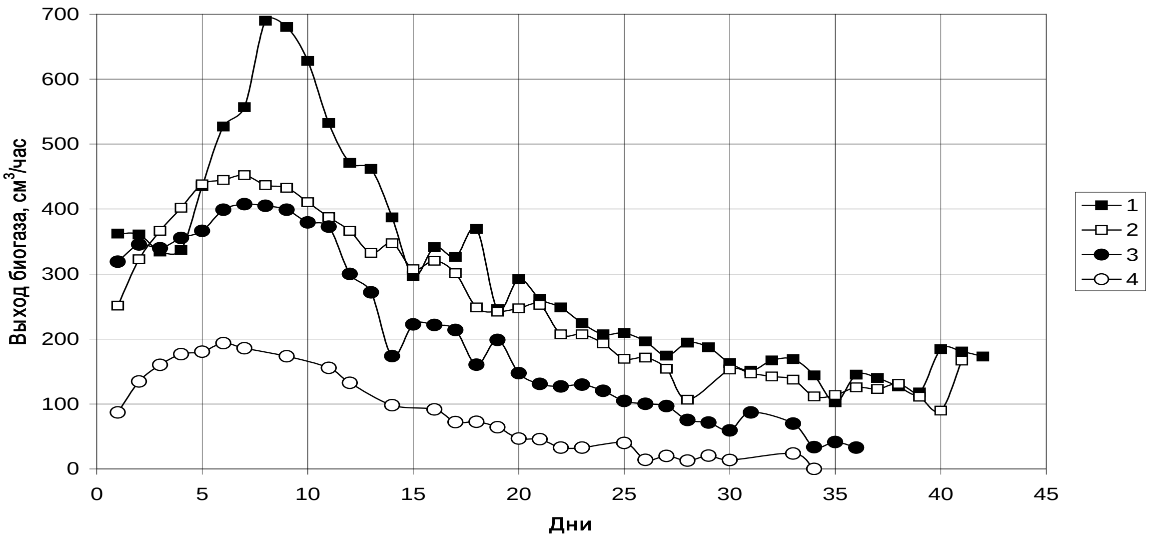

Fig. 1. Exit biogas methane fermentation in cattle hnoyivky 93% humidity at different temperature conditions: 1 – t = 55°C; 2 – t = 50°C; 3 – t = 45°C; 1 – t = 40°C

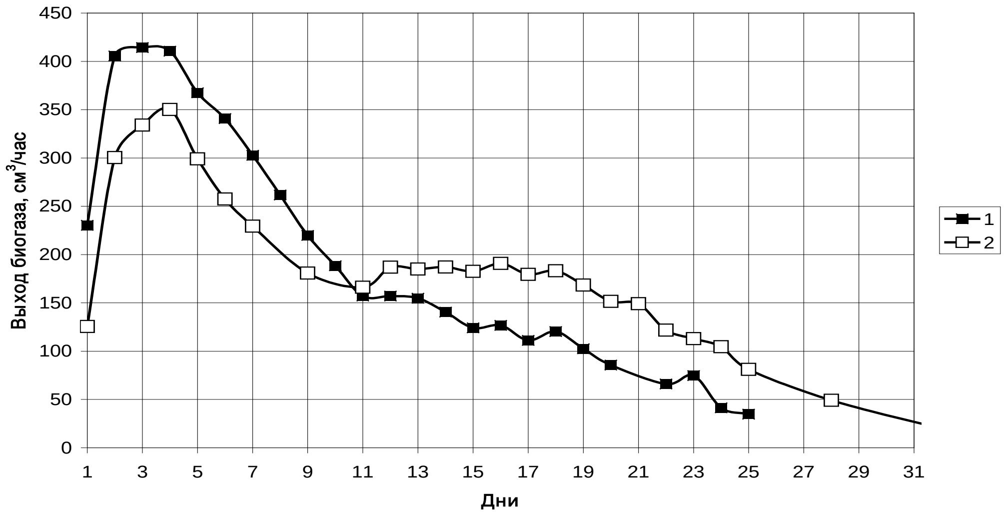

Fig. 2. Exit biogas methane fermentation in cattle hnoyivky humidity 93% at 40°C 1 - with stirring; 2 - without stirring.

Effect of substrate type. Studies were conducted on different substrates: hnoyivka cattle, chicken manure and mixtures thereof. If you study the influence of cattle manure to biogas output to be considered a diet food: in one case basis constituted kontskormy feed and hay, otherwise – straw.

The influence of feeding cattle on biogas yield is presented in Fig. 3. The research was carried out at a temperature of fermentation 40°C with stirring substrate. Biogas yield during the exponential phase and slow growth phase (11 days) at Fed kontskormamy and hay was 7179 cm3 / day. Where was the basis stern straw, biogas yield was 4125 cm3

/ day. From the above it follows that the presence of a large number of undigested manure cellulose and hemicellulose biogas yield decreases by 1.7 times.

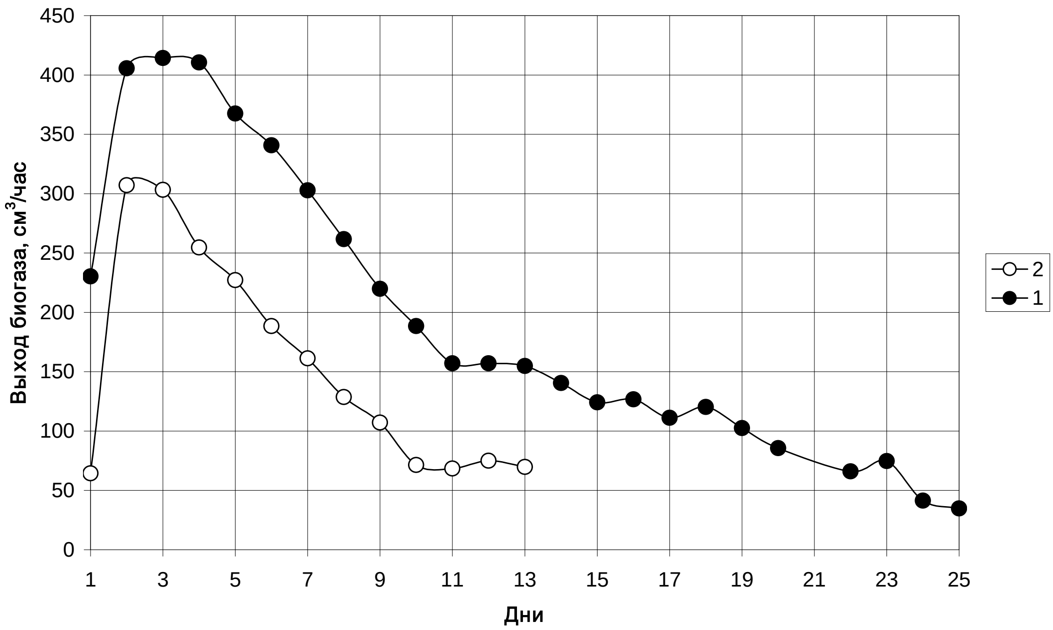

Fig. 3. Exit biogas methane fermentation in cattle hnoyivky humidity 93% at 40°C 1 - at Fed cattle hay and concentrates; 2 - Fed cattle in roughage (straw).

When used as a substrate chicken manure, compared with hnoyivkoyu cattle biogas yield increases dramatically (Fig. 4). Thus, the biogas yield of chicken manure fermentation for 13 days is 91 845 cm3 or 3827 cm3 / day, while the 32-day fermentation of manure– 117112 cm3 or 3660 cm3 / day. Peri-from the most productive two phases: phase and exponential slowdown is 9 days, during which time the biogas yield of chicken manure was 8356 cm3 / day with cattle hnoyivky – 4881 cm3 / day.

However, the fermentation of chicken manure, unlike hnoyivky cattle, an increased yield of hydrogen sulfide, as evidenced by the characteristic odor and methane yield significantly lower. Thus, the first 10 days biogas does not burn, burning the next few days there, but very bad, intermittently, often burning interrupted.

When used as a substrate mixture hnoyivky cattle and chicken manure biogas yield, compared with net hnoyivky fermentation of cattle increases, but the methane content in biogas that low. Thus, the temperature of fermentation 55°C and 50° With complete combustion of biogas is observed only on day 7 of digesters at 45°C and 35°C– on Day 4. Burning biogas formed by fermentation hnoyivky cattle in most experiments was observed for the first fermentation, in some cases recorded his lack of combustion in the first 1-2 days.

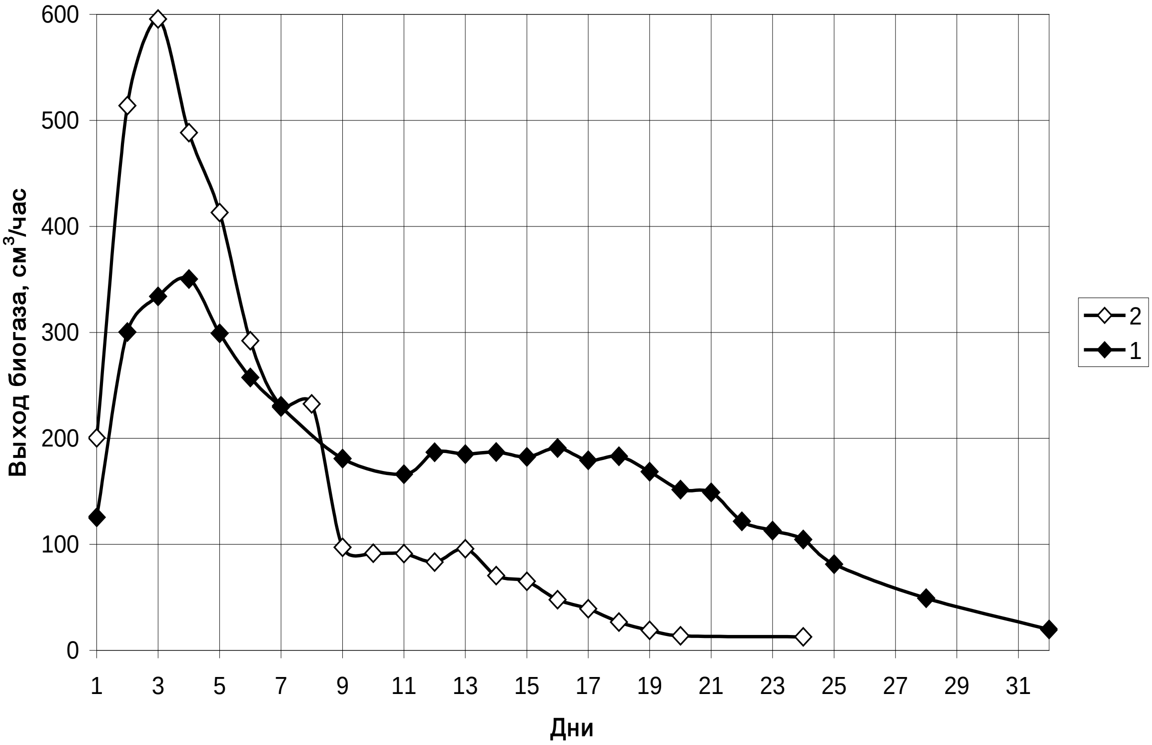

Fig. 4. Exit at biogas methane fermentation of various substrates without stirring 1 - hnoyivky cattle humidity 93% at 40°C; 2 - chicken manure humidity 73% at 40°S.

Effect kosubstrativ. As kosubstrativ used in the study of starch and glycerol.

The results showed that the use kosubstrativ leads to a sharp increase in the intensity of methane fermentation (Fig. 5). With the addition hnoyivky cattle starch digestion at 40°With a total logarithmic phase and phase of slow growth is about 7 days (from 4 to 11 days, curve 2, Fig. 5), during which stands 65 469 cm3 of biogas (or an average of 9353 cm3 / day). The stationary phase and phase dying very short, are only a few days, fermentation stops quickly. When fermentation hnoyivky cattle at 40°With no starch total time logarithmic phase and slow growth phase is approximately 9 days (1 to 9 days, 9 curve, Fig. 5), during which stands 35168 cm3 biogas (or an average of 2512 cm3 / day). Unproductive stationary and death phases are very long and are 23 days or more.

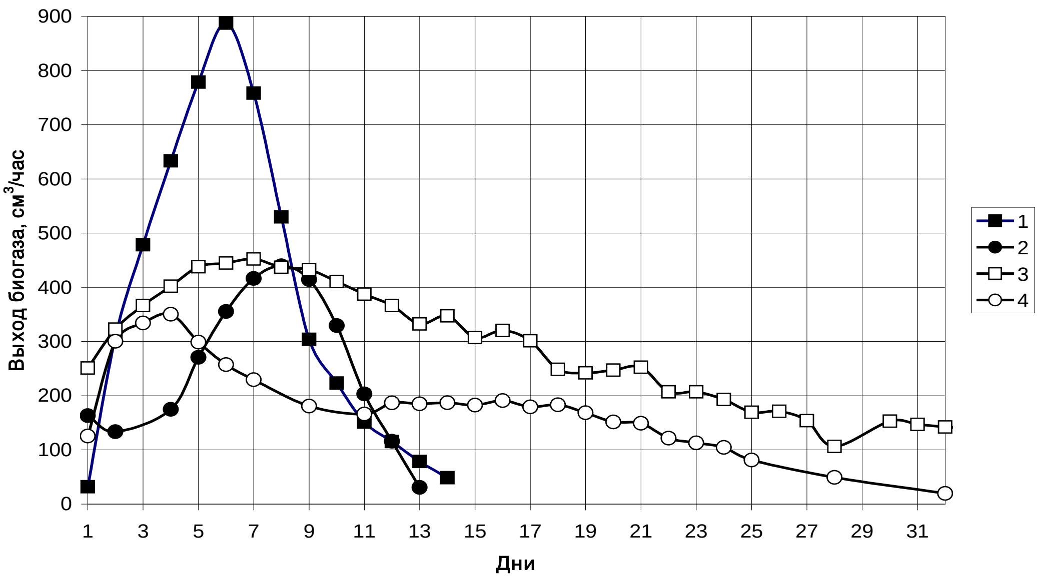

Fig. 5. Exit biogas methane fermentation in cattle using hnoyivky kosubstrativ without them: 1 - with the addition of 0.1 l crude glycerol fermentation at 50°C; 2 - with the addition of starch fermentation at 40°C; 3 - without kosubstrativ fermentation at 50°C; 4 - without kosubstrativ fermentation at 40°S.

Use as crude glycerol kosubstratu who is leaving biodiesel causes big problems with its disposal, even more intensifies methane fermentation hnoyivky cattle. At a temperature of fermentation 50°With a total logarithmic phase and slow growth phase is about 9-11 days (curve 1, Fig. 4), during which stands 114453-123560 cm3 of biogas (or an average of 11266-12717 cm 3 / day). Stationary phases, slowing growth and death is also very short, are a few days, and fermentation stops quickly.

The heat of combustion. The heat of combustion of biogas received periodic calculated as follows [15] after measuring its elemental composition analyzer GEM-500 (serial number E1328 / 04) and by the method described in [16].

When measuring the elemental composition of biogas analyzer output methane fermentation of cattle hnoyivky fermentation temperature 50°C is 50.4%, with the addition of glycerol hnoyivky – 56% (after preliminary relief hydrogen sulfide gas cap). This lower combustion of biogas, obtained by fermentation of cattle hnoyivky is 17.1 MJ / kg (22.8 MJ / m3), with the addition of bovine hnoyivky crude glycerol – 19 MJ / kg (24 MJ / m3).

In anaerobic digestion chicken manure and chicken manure mixture of hnoyivkoyu cattle in the first 5-10 days of fermentation an increased output of carbon dioxide and hydrogen sulfide and methane yield is low, resulting biogas is off. In the next 3-4 days the fate of carbon dioxide gradually decreases and methane - increases. Burning biogas becomes more stable, although the presence of hydrogen sulfide still quite high, as evidenced by the strong smell of rotten eggs. This net calorific value determined by the method of [16], gradually increased to 17-20 MJ / kg.

Conclusions

1. Increase temperature control methane fermentation leads to increased yield biogas, but it also increases the cost of heating the substrate.

2. When using a mixing substrate during methane fermentation biogas yield increases of at least 1.3 times.

3. When feeding of cattle feed containing a large amount of cellulose and hemicellulose, biogas yield decreases by 1.7 times.

4. Use as a supplement to the substrate or substrate chicken manure causes a significant increase in the yield of biogas, which is, however, poorly lit because of low methane and high carbon dioxide and hydrogen sulfide.

5. Use kosubstrativ increases biogas yield. One of the best kosubstrativ glycerin is derived as a byproduct of biodiesel production.

6. The content of methane in biogas produced from hnoyivky cattle is 50% of the cattle hnoyivky adding glycerol – 56%. The heat of combustion of the biogas is 17 and 19 MJ / kg (22.8 and 24 MJ / m3) responsibly.

References

1. Viktor Polishchuk. Design features digesters / Viktor Polishchuk, Svetlana Tarasenko Olga Sergeeva // MOTROL. Motoryzacja i energetyka rolnictwa. – Lublin, 2011. – Tom. 13 B. – S. 56-61.
2. The use of biomass for energy purposes in agriculture. Biogas technology. – Research: UkrNDIPVT them. L. Pogorelogo, 2008. – 72 c.
3. Baader V. biogas: Theory and Practice / V. Baader, E. untilit, M. Brennderfer. - M .: Kolos, 1982. - 148 c.
4. Bioenergy in Ukraine - the development of rural areas and for specific communities: Research guidelines for the implementation of best practice farms Poland, Lithuania and Ukraine on the creation of new bioenergy facilities, efficient production and use of biofuels: [Scientific and method. recommendations.] / [VA Dubrovin, MD Melnychuk, YF Miller, VG Myronenko et al.]. – K .: National University of Life and Environmental Sciences of Ukraine; Institute of Building, Mechanization and Electrification of Agriculture, Poland, Institute of Agricultural Engineering, Lithuania, 2009. – 122 c.
5. Vedeneev AG Byohazovыe technology in the Kyrgyz republic: Reference MANUAL / AG Vedeneev, TA Vedeneeva. - Bishkek: Euro, 2006 - 90 c.
6. Malofeev VM Biotechnology and Protection okruzhayuschey environment:

Uchebnoe posobye. - M .: Publishing Arktos, 1998. - 188 c.
7. Technology and equipment for renewable energy in agriculture / edited. VI Kravchuk, VA Dubrovin - Research .: UkrNDIPVT them. Pogorelogo L., 2010. - 184 c.
8. Alternative Energy: [teach. guide for students. HI. teach. bookmark.] / MD Melnychuk, VA Dubrovin, V. Mironenko, I. Hryhoryuk, VM Polishchuk, GA Golub, VS Targon, SV Dragnev, IV Svistunova, SM Kuharets. - K: "Agrar Media Group», 2011. - 244 c.
9. Vedeneev AG Construction of biogas plants: kratkoe guidance / AG Vedeneev, AN Maslov. - Bishkek: Euro, 2006 - 28 c.
10. Biological resources and technologies biofuels: Monograph / YB Blum, G. Geletukha, IP Hryhoryuk ,, KV Dmitruk, VA Dubrovin, AI Yemets, GM Slow, GM Kaletnik, MD Melnychuk, V. Myronenko, DB Rakhmetov, AA Sabirnyy, SP Tsygankov - K: "Agrar Media Group", 2010. - 408 c.
11. Вyohazovыe installation. Praktycheskoe posobye / Эder Barbara and Heinz Schulz. - M .: Kolos, 2008. - 240 c.
12. biogas based on vozobnovlyaemoho raw materials. Comparative analysis sixty One installation for the production of biogas in Germany. - Hyultsov. Germany: Spetsyalnoe agency vozobnovlyaeмыh resources (FNR), 2010. - 116 c.
13. GOST R 53790-2010: Netradytsyonnыe technology. Energetika byoothodov. General specifications requirements for byohazovыm settings. – [2010-05-31 Deystvytelen here]. – M .: Standartynform, 2011. – 10 c. – (Naczional`ny'j standard of the Russian Federation).
14. Ratushniak GS Heat losses in biogas plants under different temperature conditions of anaerobic fermentation / GS Limestone, KV Anokhina // Bulletin of Vinnitsa Polytechnic Institute, 2008. - № 5. – S. 20-24.
15. Enerhobiotehnolohiya. Guidelines for laboratory work in "Enerhobiotehnolohiya" for students of agricultural higher education institutions 3-4 levels of accreditation in the specialty 6.092900 "Ecobiotechnology" / MD Melnychuk, V. Myronenko, VM Polishchuk et al. – K .: Publishing Center NAU, 2008. – 28 pp.
16. V. Polishchuk Rapid method for determining the calorific value of biogas / VM Polishchuk, VE Vasylenkov, MN Lobodko, VS Voloshin // Scientific Bulletin of National University of Life and Environmental Sciences: Coll. Science. works. – Kyiv, 2012. – № 174. Part 2 – S. 258-263.

Conducted analysis uslovyy, vlyyayuschyh on yntensyfykatsyyu process metanonoho sbrazhyvanyya. The degree of influence on Opredelena Efficiency biogas production and ego Values teplovuyu temperature regime digesters, sыrevoy bazы, peremeshyvanyya, availability kofermentatorov

Biogas substrate, byoshlam, digesters, gasholder, temperaturnыy mode kofermentator.

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