UDC 638.21.4 BIOENERGY PLANT FOR CLEMATIC ZONES OF THE REPUBLIC OF UZBEKISTAN WITH A SOLAR HEATING SYSTEM FOR INDIVIDUAL USE

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Annotation: A bioenergetic installation with a solar heating system for individual use designed for the processing and disposal of agricultural waste of organic origin with the production of biogas and liquid high-quality organic fertilizers under conditions of anaerobic fermentation was developed and built.
Its structural scheme and the principle of operation of individual parts of this installation are presented. Particular attention has been paid to the use of solar and accumulated solar energy for heating the substrate in the reactor.
The article presents the results of studies on the release of biogas from cattle manure and manure at various temperatures of anaerobic digestion. The data presented are the basis for choosing the optimal fermentation temperature in a small-scale biogas plant, as applied to small individual farms.
The robot shows the main parameters of the proposed biogas plant. In view of the application of this technology in a small biogas plant, it is most rational in terms of the ratio of the cost of heat to energy and output biogas.

Keywords: biogas, bioenergy plant, hydrocarbon feedstock, biomass solar collectors (SC), heat sink, heat accumulator, fermentation, substrate, mesophilic regime, bioreactor, heat storage matrix (TAM)

1. Introduction

Economies in developed and developing countries are developing at an accelerated pace for the practical use of alternative energy sources as the most important factor for sustainable development and increasing the competitiveness of economies in the context of a decrease in world hydrocarbon reserves. Biomass is one of the most common alternative energy sources. Technologies for processing biological raw materials have been widely used to solve the problem of environmentally safe disposal of organic waste, reduce environmental pollution, as well as produce alternative biogas energy and valuable bio-fertilizers.

The leaders in this production are Denmark, Germany, USA, China, India and other countries. In the total energy balance of Denmark, biogas occupies 18%, Germany-8%, however, the latter leads in the number of medium and large biogas plants 10,000. By 2020, biogas production in the EU is projected to be equivalent to 29,43 million toe, which is equivalent to 36,29 billion m^3 of natural gas [1,2,3,4,5].

Uzbekistan has gained considerable experience in conducting scientific and experimental research in the field of using alternative energy sources, primarily solar and biogas energy, according to which development has been carried out for many decades. According to the innovation development strategy of the Republic of Uzbekistan, by 2025 an increase in the share of electricity production using renewable and alternative energy sources by more than 25% and one of the main directions in the implementation of yes value problem is the development of energy alternative and renewable resources. [2,5,6,7].

2. Research technique and analysis of the existing problem.

To date, there are various methodologies for evaluating the operation of pilot and industrial biogas plants, a set of their principles, methods and processes, as well as means for their implementation. Many authors noted that various factors influence the biogas production process, such as the potential of the feedstock, the design of the biogas plant, the physicomechanical properties of the loaded organic waste, the loading frequency, internal and external mechanisms to maintain temperature and humidity, etc. But besides this, it is necessary to note the importance of the human factor in the correct operation of the process of biogas and organic fertilizer production.

The proper operation of the biogas plant equipment, as well as the diagnosis of failures in its operation, depends on the knowledge of the microbiological sequence of the anaerobic process and the operator's experience. The basis of traditional methods of equipment assessment and analysis is the presence of an unambiguous functional relationship between the analyzed features and the technical condition of the evaluated biogas plant, which limits their use only for technically simple assemblies and mechanisms. Currently, a large number of installations for the production of biogas from organic waste in various countries have been developed and are functioning. However, most scientifically-based biogas plants are designed for the processing of waste from large livestock farms and require heating of fermentable biomass using electricity or heat from centralized networks, which hinders the efficient disposal of waste from individual and small farms dispersed in regions with a lack of centralized energy supply [8,9,10,11].

Ways of solving. The change in the structure of agricultural production in connection with the transition to market conditions led to an increase in the number of private dekhkans and farms. When solving energy supply issues, individual and farm households in remote areas of Uzbekistan that do not have centralized electricity and gas supply are in need of imported fuel materials [12,13,14,15].

Therefore, the development of small bioenergy plants (BECs) with heating of fermentable biomass due to local renewable energy sources is an urgent problem, the solution of which contributes to the direction of efficient waste management with environmental safety in the agricultural production of hard-to-reach regions.

All this dictates that for the large-scale use of biogas plants in private and individual farms, first of all, taking into account their regional and local conditions, the need to develop small energy-saving, economical, environmentally friendly, and high-performance BECs [16,17,18,19].

In this regard, an experimental bioenergy plant of a commercial nature with a solar heating system designed for individual use (Fig. 1), consisting of a bioreactor (1), a solar collector (2), a heat accumulator (3), and a gas scrubber, was built in the Bukh.ITI heliopolygon. 4) and gas storage capacity (gas tank) (5).

In the manufacture of these parts, we proceeded from the requirements of energy saving and ecology of their expected effectiveness.

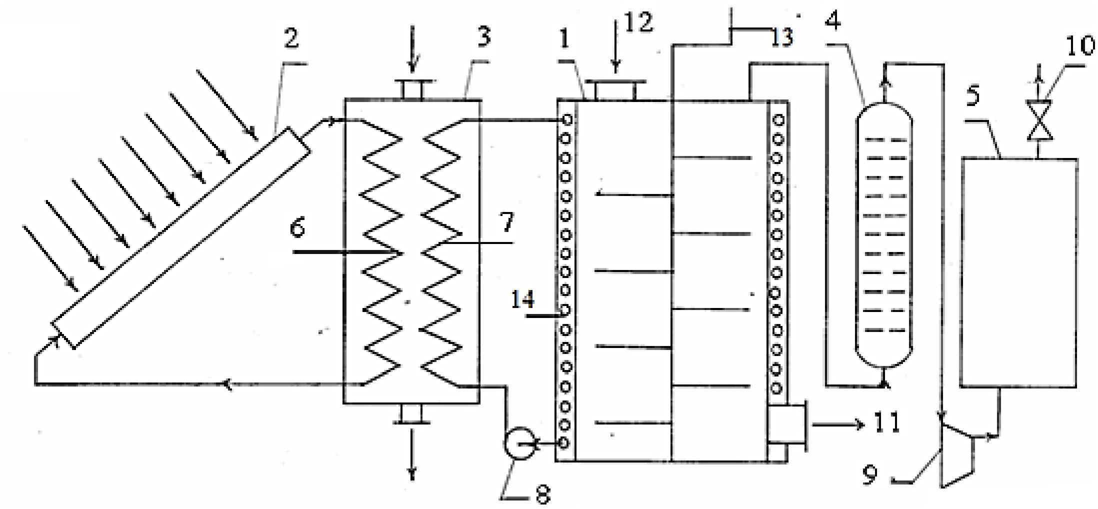

Figure 1. Schematic diagram of an experimental production biogas plant with a solar heating system.

Solar collectors (SC) of various designs are traditionally made of metal materials. The SK offered by us is made of alternative non-metallic materials. A solar collector made in the form of a “hot box”, inside of which there is a heat receiver-collector made of a black plastic pipe — a collector with inlet and outlet pipes.

The heat-accumulating part is a “SANDWICH” with a thickness of 100 mm cylindrical tank (3), inside which are placed two heat exchangers - one (6) for heating TAM, the other (7) provides heat to the bioreactor. Both heat exchangers are made of plastic pipes in the form of a coil. The tank is filled with TAM, for which we used six-hydrated calcium chloride ($CaCl_2.6\ H_2O$) with a melting point almost equal to the optimum temperature of the mesophilic regime of the fermented substrate (36–39 ^{0}C). The heat of fusion and the density of crystalline hydrate are respectively equal to: 174.4 kJ / kg and 1634 kg/m^3.

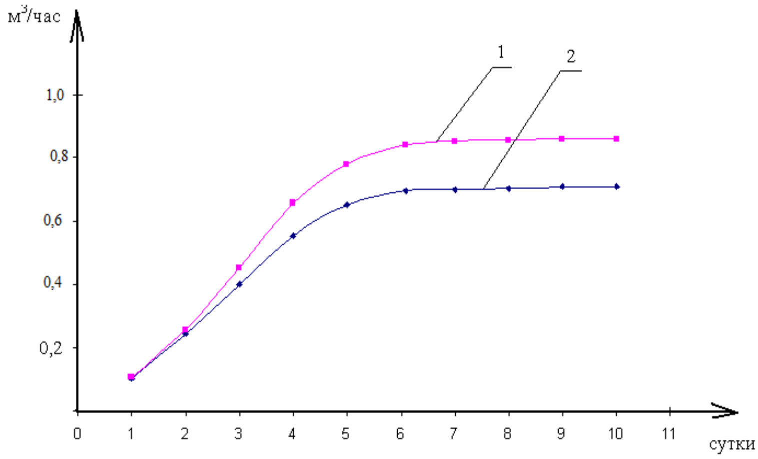

Figure 2. The results of experimental studies on the output of biogas with various substrates: 1 - chicken droppings, 2 - cattle manure (cattle) in the period May

One of the main elements of the BEU is a bioreactor, which is a hermetic cylindrical container with a diameter of 1.5 m and a height of 2 m (V = 3,5 cubic meters).

In the upper and lower side parts, loading (12) and unloading (11) hatches are provided. Inside the reactor in the middle is placed (installed) a mechanism (13) for mixing the fermented substrate. The biomass is heated by hot water supplied to the heat exchanger 14 located on the inner surface of the reactor. Further, the reactor is thermally insulated from the environment with mineral wool, the thickness of which is 10 cm. In order to obtain the temperature necessary for the fermentation process and, if possible, to maintain it constant, it is necessary, first of all, to heat the substrate supplied to the reactor to the desired temperature; also constant by supplying heat to compensate for heat loss.

The fermented substrate is heated to the temperature of the mesophilic regime (t=35-380 ^{0}C) and this temperature is maintained in the bioenergy installation we developed using a solar collector. Heat generation is carried out as follows: in the afternoon, the sun's rays passing through a transparent fence heat the water collector. Heated water from the collector enters the heat storage tank and passes through the heat exchanger (6) and, giving up its significant potential to TAM, enters the collector again. It happens during the day in clear sunny weather. And in the heat storage part, since we chose $CaCl_2$ as the TAM. $6H_2O$, thermal processes occur differently. With the arrival of heat from the solar collector, the crystalline hydrate begins to heat up, its temperature rises until it reaches the melting value, i.e. 36-39 ^{0}C. Further, excess heat is accumulated due to the phase transformation of crystalline hydrate. Thus, in the heat accumulator we offer, the temperature is kept constant, i.e. equal to the optimal temperature of the mesophilic regime of the fermented substrate. At night, the installation works due to the heat accumulated during the day (heat of the phase transition of $CaCl_2$. $6H_2O$ crystallohydrate), which thus ensures round-the-clock operation and increases the efficiency of the bioenergy installation.

The bioreactor and, therefore, the fermentable substrate are heated through a sealed water heating system containing a heat exchanger (7), a water pump (8) and heat exchangers (14) in the form of spiral wound from the outside of the reactor through which the coolant (water) circulates.

Our experiments have shown that the proposed biogas plant, the volume of which is 3,5 m^3, is able to process 90 kg of manure per day in the mesophilic mode and produce about 20 m^3 of biogas and a little less than 90 kg of liquid organic biofertilizers. The latter contain a number of organic substances that contribute to an increase in soil permeability and hygroscopicity, while at the same time preventing erosion and improving general soil conditions. Organic matter is also the basis for the development of microorganisms that convert nutrients into a form that can easily be absorbed by plants.

The results of parallel practical studies on the cultivation of tomatoes in helioteplice showed that, tomato productivity with the use of biofertilizers increased by 40-50%.

To study the temperature and thermal conditions, as well as the performance of the unit relative to the biogas produced, we conducted a series of experiments with various substrates in various meteorological conditions. The results of such experiments are shown in Fig. 2.

The experiments showed that under the mesophilic mode of operation of the bioreactor, gas productivity practically did not decrease when the temperature deviated by 1 - 20 C from the optimum and the process of substrate fermentation lasted 25 ... 30 days.

In the course of the study, it was found that the intensity of the process largely depends on temperature and humidity in the bioreactor [20,21]. t was shown that under the mesophilic regime (36-38 ^{0}C), the process of methane fermentation proceeds more intensively, as evidenced by the greater biogas yield and increased methane content in it.

The conducted studies allow us to develop a technology for processing chicken manure (as well as other organic waste), which is the most promising from the point of view of environmental protection and ecology of non-renewable natural energy sources [22-35].

Figure-3. General view of a pilot production biogas plant

The application of this technology will allow the most complete use of energy and raw materials potentials contained in organic waste. In addition, these plants can process one structural organic waste such as cattle, chicken, pig and others separately.

Long-term field tests of the proposed design of the biogas plant were also carried out, as a result of which its autonomous performance in the climatic conditions of the Bukhara region was revealed.

3. LITERATURE

1. Vondra, M., Touš, M., Teng, S.Y.Digestate evaporation treatment in biogas plants: A techno-economic assessment by Monte Carlo, neural networks and decision trees (2019) Journal of Cleaner Production, 238, statya № 117870
2. Tikhonravov V.S. Resource-saving biotechnologies for the production of alternative fuels in animal husbandry // Scientific and Analytical Review - FGBNU Rosinformagrotekh - Moscow, 2011. - 52 r.
3. Komilov O.S.Sharipov M.Z.Tilloev L.I. Issledovanie biogazovoy ustanovki s sistemoy solnechnogo obogreva.Razvitie nauki i teknologiy.2015.№1.s.76-79.
4. Birkin S.M. Improvement of technologies and technical means of utilization of large carcasses. Autoref. dis. … K-ta. science. Volgograd, 2009. S 20.
5. Komilov, O.S., Astanov, S.Kh., Safarov, O.F., Sharipov, M.Z., Faizullaev, A.R., Tillaev, L. Combined solar drying unit. Applied Solar Energy, 2009, 45 (4), pp. 262-265. doi:
6. Nesse, AS, Sogn, T., Børresen, T., Foereid, B. Peat replacement in horticultural growth media: the adequacy of coir, paper sludge and biogas digestate as growth medium constituents for tomato (Solanumlycopersicum L.) and lettuce (Lactuca sativa L.) (2019) ActaAgricultureuraScandinavica Section B: Soil and Plant Science, 69 (4), pp. 287-294.
7. Imomov Sh. Engineering Design Calculation of a Biogas Unit Recuperator.Applied Solar Energy, September 2007. Volume 43. Issue 3. pp. 196-197.
8. Birkin S.M. Improvement of technologies and technical means of utilization of large carcasses. Autoref. dis. … K-ta. science. Volgograd, 2009. S 20.
9. Williams A., et al., Pollutants from the combustion of solid biomass fuels, Progress in Energy and Combustion Science 38, 2012, pp. 113-137.
10. Karlstrom O., Brink A., Hupa M., Time dependent production of NO from combustion of large biomass char particles, Fuel 103, 2013, pp. 524-532.
11. Serafimov LA, Timoshenko A.V. Current state and prospects for the development of gas fractionation processes // Science and technology of hydrocarbons. -2000. -№4.62-72rr.

12. Murina VI, Kislenko NN, SurkovaYu.V. , etc. The technology of processing natural gas and condensate // Reference publication. Bosom. - Moscow, 2002. 518 r.
13. E.E. Marinenko. Bases of reception and use of biofuel for the decision of questions of power savings and protection of an environment in housing-and-municipal and an agriculture // the Manual. - Volgograd. - 2003. - 99 r.
14. Osmonov O.M. Nauchno-tehnicheskie osnovy sozdaniya avtonomnyx bioenergeticheskix ustanovok dlya krestyanskix khozyaystv v gornyx rayonax Kirgizii. Autoref. Diss… dok.tex.nauk. Moscow.2012.p.36.
15. Imomov, S., Kholikova, N., Alimova, Z., Nuritov, I., &Temirkulova, N. (2019). Oil purification devices used in internal combustion engines. International Journal of Innovative Technology and Exploring Engineering, 9(1), 3103–3107. https://doi.org/10.35940/ijitee. A9141.119119
16. Imomov, S. Z. (2007). Engineering design calculation of a biogas unit recuperator. Applied Solar Energy (English Translation of Geliotekhnika), 43(3), 196–197. https://doi.org/10.3103/ S0003701X07030188
17. Using renewable energy sources. Agricultural energy resources - collective work edited by B. Wheeler and M. Matyka. A. 2011 16.02.2011.
18. 18. Biomass feed for thermochemical reactors - Dai Jianjun, TsuiHeping, John R. Grace - "Progress in the field of energy and combustion of science" 38 (2012). 716-736 rr.
19. Chen Y., Hashimoto A. 2014. Kinetics of Methane Fermentation Biotechnology and Bioengineering Symposium. No.8, 269 - 282.
20. Nachwachsende - rohst off.de. Biogas on the basis of vozobnovlyaemogo syrya. Sravnitelnyy analiz shestidesyati odnoy ustanovki po proizvodstvu biogaz in v. -2010. 115 s.
21. Karlstrom O., Brink A., Hupa M., Time dependent production of NO from combustion of large biomass char particles, Fuel 103, 2013, pp. 524-532.
22. Serafimov LA, Timoshenko A.V. Current state and prospects for the development of gas fractionation processes // Science and technology of hydrocarbons. -2000. -№4. - P.62-72.
23. Murina VI, Kislenko NN, Surkova Yu.V. , etc. The technology of processing natural gas and condensate // Reference publication. Bosom. - Moscow, 2002. - P.518.
24. E.E. Marinenko. Bases of reception and use of biofuel for the decision of questions of power savings and protection of an environment in housing-and-municipal and an agriculture // the Manual. - Volgograd. - 2003. - S.99.
25. Imomov SH. J. Technological foundations of the process of obtaining biogas and sentences from agricultural wastes. Abstract of doctoral dissertation (dsc) on technical sciences. Tashkent - 2017.r.59.
26. Imomov Sh., Qayumov T., Mamadaliyva Z. Substantiation tne parameters of the primary processing in installation based on renewable energy Scientific papers. Series "Management, economic engineering in agriculture and rural development". Volume 18, pp / 157-162 / Lssue 4/2018. PRINT ISSN 2284-7995. E-ISSN 2285-3952.
27. Akhatov Zh.S., Samiev K.A., Mirzaev M.S., and Ibragimov A.E. Study of the Thermal Technical Characteristics of a Combined Solar Desalination and Drying Plant. Appl. Sol. Energy, 2018, vol. 54, no. 2, pp. 119-125.
28. Mirzaev M. S., Samiev K. A., and Mirzaev Sh. M. Experimental Study of Distance between Evaporator and Condensate of Inclined Multistage Desalination Plan. Applied Solar Energy January, 2019, vol. 55, no. 1, pp. 36-40.
29. K.S.Rakhmonov. Influence of leavens of spontaneous fermentation and phytoadditives on the provision of microbiological safety of bread // T. I. Atamuratova, N. R. Djuraeva,

I. B. Isabaev, L. N. Haydar-Zade//Journal of Critical Reviews //2020, Vol.7, Issue 5, pp. 850-860.

30. S.K. Jabborova.Application of products of processing mulberries and roots of sugar beet in the production of cupcakes // I.B.Isabaev., N.R. Djuraeva., M.T. Kurbanov.,l.N. Khaydar-Zade., K.S. Rakhmonov //Journal of Critical Reviews //2020, Vol.5, Issue 5, pp. 277-286.
31. K.S.Rakhmonov. Application of phito supplements from medicinal vegetable raw materials in the production of drugs // T. I. Atamuratova., M.E. Mukhamedova., N.K.Madjidova., I.Sh. Sadikov //Journal of Critical Reviews //2020, Vol.7, Issue 12, pp. 934-941.
32. N.R.Barakayev. Improvement of the design of mobile equipment for post-harvest processing of agricultural crops // A. N. Rajabov., M.T. Kurbanov., S.K.Kuzibayev //Journal of Critical Reviews //2020, Vol.7, Issue 14, pp. 306-309.
33. Djurayeva N, Mixtures of Vegetable Fat as a Potential Raw Material for Bakery// Barakayev N, Rakhmonov K,Atamuratova T, Mukhamedova M, Muzaffarova Kh. // International Journal of Current Research and Review// october 2020, Vol.12, Issue 19, pp. 140-148. DOI: http://dx.doi.org/10.31782/IJCRR.2020.12192
34. Djurayeva N, Plant-fat mixtures as a potential raw material for bakery production// Barakayev N, Rakhmonov K,Atamuratova T, Mukhamedova M, Muzaffarova Kh. // Plant Cell Biotechnology and Molecular Biology 2020 21(45-46), pp. 29-42
35. Ravshanov S.S, The impact of ultrasonic activated water on hydrothermal processing of wheat grains grown in dry climate conditions // Rakhmonov K.S., Amanov B.N. // Plant Cell Biotechnology and Molecular Biology 2020 21(45-46), pp. 1-8