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AUTONOMOUS BIOGAS INSTALLATION WITH SOLAR HEATING SYSTEM

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An experimental production biogas plant based on solar heating has been designed and built. Its structural scheme and results of calculations of parameters of a biogas plant are given based on the statistical data of Uzbekistan on the availability of biogas and solar energy potential. So, results of experimental researches on biogas production at mesaphilic mode of plant operation are given. Possibilities of using biogas plants with heating fermented biomass at the expense of renewable energy sources in conditions of small consumer farms are considered.

***Keywords*: Biogas plant, energy saving, ecology, collector, solar heating, heat storage.**

Introduction

At present, economically developed and developing countries are accelerating the development of practical use of alternative energy sources as an important factor for sustainable development and to increasing the competitiveness of economies in the face of a reduction in the world's hydrocarbon reserves [1]. In Uzbekistan, considerable experience has been accumulated in carrying out scientific and experimental research in the field of the use of alternative energy sources, primarily solar and biogas energy, for which development has been carried out for many decades [2].

Currently, a large number of biogas plants have been developed and are functioning from organic waste in various countries. However, most scientifically-based biogas plants are designed for waste treatment of large livestock complexes and provide for heating the fermented biomass by using electricity or heat from centralized networks, which hinders the efficient utilization of waste from individual and small farms dispersed in regions without a centralized power supply [3, 4].

On the other hand, the change in the structure of agricultural production in connection with the transition to market conditions has led to an increase in the number of private dehkan and farmer households. In solving energy supply problems, individual and farming enterprises in remote areas of Uzbekistan that do not have centralized electricity and gas supply are in need of imported fuel materials [5].

Therefore, the development of autonomous bioenergy plants with heating of fermented biomass at the expense of local renewable energy sources is an urgent problem, the solution of which contributes to the direction of effective utilization of waste with ensuring environmental safety in the agricultural production of hard-to-reach regions. All this dictates that for large-scale use of biogas plants in farm and individual farming, above all, given their regional and local conditions, the need to develop small energy-efficient, economical, environmentally friendly and high-performance biogas plants (BGP) [6].

4. The experimental procedure and the experimental setup

In this connection, an experimental biogas plant of industrial character with a solar heating system (Figure 1), consisting of a bioreactor (1), a solar water heater (2), a heat accumulator (3), a gas scrubber (4) and a gas storage tank (gas holder) (5). In the manufacture of these parts, we proceeded from the requirements of resource conservation, the environment and their expected effectiveness.

Solar water heating collectors (SWC) of various designs are traditionally made of metal materials. The SWC offered by us is made of alternative non-metallic materials. Solar water heater made in the form of a "hot box", inside of which a heat collector is made of a plastic pipe of black color, a collector with inlet and outlet nozzles.

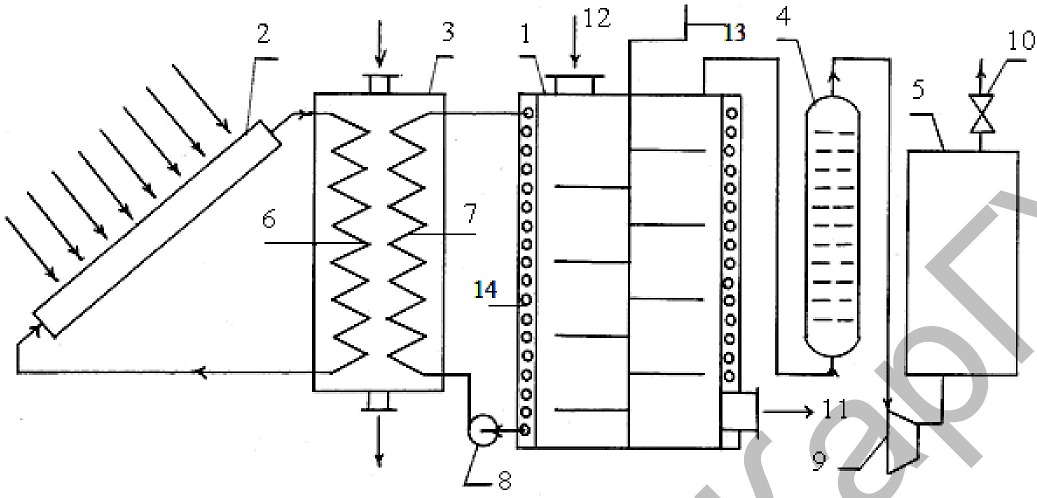

Fig.1. Schematic diagram of an experimental-production biogas plant with a solar heating system.

The heat-storage part is a well-insulated (from the outside) cylindrical container (3), inside which there are two heat exchangers - one (6) for heating the heat-storage material (HSM), and the other (7) provides heat to the bioreactor. Both heat exchangers are made of plastic pipes in the form of a coil. The capacity is filled with HSM, as which we used hexahydrate calcium chloride ($CaCl_26H_2O$) with a melting point almost equal to the optimum temperature of the mesophilic regime of the fermentable substrate (36-39)°C. The heat of fusion and the density of crystalline hydrate are, respectively, 174.4 kJ / kg and 1634 kg / m^3.

One of the main elements of the BGP is a bioreactor, which is a hermetically sealed cylindrical vessel 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, a mechanism (13) is placed in the middle for mixing the fermentable substrate. On the outside of the cylinder, the container is densely (in height) surrounded by plastic pipes serving as heating elements (14) and on which a metal wire is stretched. Further, the reactor is thermally insulated from the environment by mineral wool, the thickness of which is 10 cm.

In order to obtain the temperature necessary for the fermentation process and, if possible, to keep it constant, it is necessary first of all to heat the substrate supplied to the reactor to the desired temperature; also constant, supplying heat to compensate for heat losses.

The heating of the fermentable substrate to the temperature of the mesophilic regime (t = 35-38^0C) and the maintenance of this temperature in the bioenergetic system developed by us is carried out with the help of a helium heater. Heat production is carried out as follows: during the day, the sun's rays passing through the transparent enclosure heat the water collector. The heated water from the collector enters the heat storage reservoir and passes through the heat exchanger (6) and also gives its significant HSM potential, again it enters the collector. This happens in the daytime in clear sunny weather. And in the heat-storage part, since we chose as the HSM the $CaCl_2$ $6H_2O$, 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 point, i.e. 36-39^{o}C. Further, excess heat is accumulated due to the phase transformation of crystalline hydrate. Thus, in the heat accumulator proposed by us, the temperature is kept constant, i.e. equal to the optimum temperature of the mesophilic regime of the fermentable substrate. At night, the installation operates due to the heat accumulated during the day (the heat of the crystal hydrate transition of $CaCl_2 \cdot 6H_2O$), thus ensuring 24-hour operation and increasing the efficiency of the bioenergy plant.

Heating of the bioreactor and, consequently, of the fermentable substrate is carried out through a sealed water heating system containing a heat exchanger (7), a water pump (8) and heat exchangers (14) in the form of spirally wound on the outside of the reactor, through which the coolant (water) circulates.

5. Experimental results

Our experiments showed that the proposed biogas plant, whose volume is 3.5 m^3, is able to process 90 kg of manure per day in the mesophilic regime and produce about 20 m^3 of biogas and slightly less than 90 kg of liquid ecologically clean biofertilizers. The latter contain a number of organic substances that contribute to increasing the permeability and hygroscopicity of the soil, while at the same time preventing erosion and improving general soil conditions. Organic substances are also the basis for the development of microorganisms that transfer nutrients into a form that can easily be assimilated by plants. The results of parallel practical studies on growing a tomato in a helio-greenhouse showed that the yield of tomato when using biofertilizers increased by 40-50%.

To study the temperature and thermal regimes, as well as the capacity of the plant with respect 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.

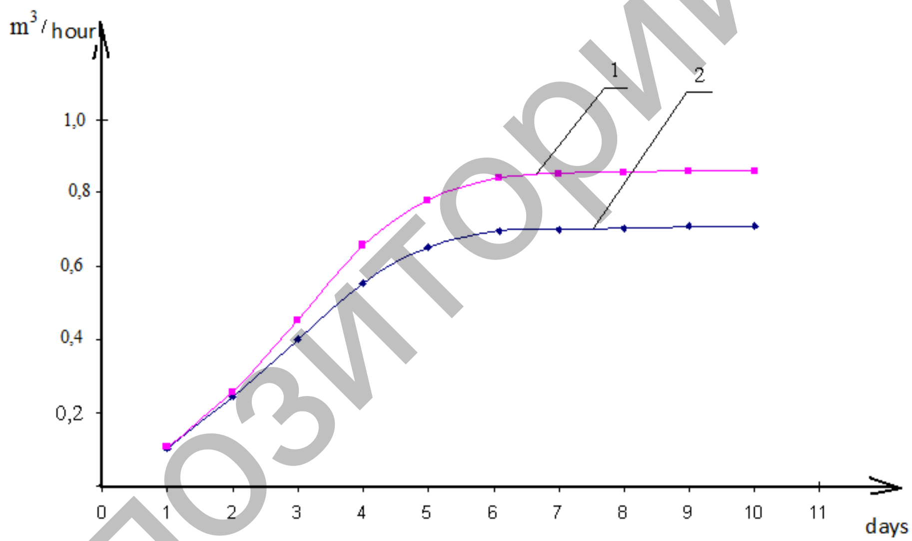

Fig.2. The results of the experimental studies on the release of biogas with various substrates: 1 - chicken litter; 2 - manure of cattle.

The experiments showed that under the mesophilic mode of operation of the bioreactor, the gas productivity practically did not decrease with a temperature deviation of 1-2 ^{0}C from the optimum and the substrate fermentation process lasted -25-30 days.

In the course of the study, it was found that the intensity of the process depends largely on the temperature and humidity in the bioreactor. It is shown that during the mesophilic regime (36-38^{0}C), the process of methane fermentation proceeds more intensively, as evidenced by a greater yield of biogas and a higher content of methane in it.

Conclusion

The conducted researches allow to develop the technology of processing chicken manure (and also other organic wastes), which is the most promising in terms of protecting the environment and the environment of non-renewable natural energy sources. The use of this technology will make it possible to make full use of the energy and raw materials potentials contained in organic waste.

The obtained results allow calculating the parameters of a biogas plant taking into account local biomass resources and using this energy to save fuel and electricity fuel, to obtain high-quality fertilizer and, thus, to exclude dependence on imported energy carriers and improve the environmental performance of the republic.

Also, long-term field trials of the proposed design of the biogas plant were conducted, as a result of which its autonomous working capacity was revealed in the climatic conditions of the Bukhara region.

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