

Installation (Methane Tank) for the Production of Biogas from Organic Waste

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Abstract:

The article deals with the structure and principle of the biogas plant. Types of plants for producing biogas from organic waste are highlighted.

The author emphasizes the importance of choosing a mixing method, since optimal mixing of the raw material increases the biogas yield.

The author concludes that the choice of mixing method is based on the process of digestion, which is a process of life activity of symbiosis of different bacterial strains and the destruction of this community. Therefore, too frequent or prolonged mixing is harmful.

This article may be useful for specialists in various sectors of the national economy.

Keywords: biogas, bioassay, methane-producing bacteria, bioreactor, gas tank, mechanical agitators, fermentation, fermentation.

Current energy problems from all current fuel and energy sources it can only be solved by Factor use. More and more in the world and in Uzbekistan the issue of lack of energy resources remains acute. Currently, the sun, the wind technologies for obtaining fuels from energy, bioenergy biomass successfully develop started. Biomass means large-scale renewable energy resources and wood, industry, includes agricultural and household waste. Biomass as an energy source through biochemical processing to obtain activated, gasification, pyrolysis, alcohol or biogas can be used. Each of these processes has an area of application for its intended purpose.

Biogas is a renewable energy source, one of the cleanest fuels, and after appropriate purification and preparation to biomethane, it is a practical analogue of natural gas. Biogas is produced from any kind of organic raw materials, waste and residues of the agro-industrial complex (livestock, poultry, crop production), food and processing industry, sugar and alcohol factories, energy crops, waste

from supermarkets, hotel and restaurant businesses, households, etc. Biogas formation is a natural phenomenon observed as a result of anaerobic (i.e. oxygen-free) degradation of organic substances and waste in soil, swamps, ocean, etc. Biogas is also produced in landfills, where food waste decomposes in aerobic (i.e. with oxygen access) conditions. Biogas can and is produced by biogas plants, which, in fact, intensify the natural processes of splitting organic waste by converting them into sealed tanks and maintaining an appropriate microclimate, which is provided by technological equipment, including full process control.

Biogas can be obtained from almost all types of organic waste, and organic waste steadily arises and accumulates. In Asia, millions of small biogas plants have been built in private households in order to provide energy resources for cooking and lighting in rural areas. During World War II, German military trucks were refueled with biogas collected from farm animal manure. Over the past 50 years, the development of anaerobic reactors (biogas plants) has naturally been significantly improved, technically and technologically, providing a higher yield of methane (CH_4) and maximum use of the potential of organic raw materials. To date, thousands of projects have been implemented around the world, they have been carried out both on small dairy farms and at municipal wastewater treatment plants, demonstrating the environmental friendliness and economic attractiveness of biogas production systems. The construction of biogas plants (BGS) allows you to benefit from biogas, get away from odors and improve the quality of organic fertilizers. In the agro-industrial complex, BSU is also used for the purpose of pre-treatment of waste, where biogas is used to partially or completely compensate for energy costs and reduce the volume of waste that is sent for recycling. In addition to the main products, each enterprise generates waste. Waste disposal is an integral part of the production cycle and if this segment is not present in the enterprise, then, most likely, we are talking about creating and increasing environmental hazards. The organic waste of an enterprise and household is its own unused energy resource. BSU is an organic waste recycling facility. Biogas, as a product of the plant's operation, can replace part of its own energy needs, and biofertilizers can improve the condition of the land and increase crop yields. The amount of biogas that we can get from organic waste depends, in fact, on the waste and on the technological solution selected for the implementation of a biogas plant. There are different technologies that make it possible to obtain 20 m³ of biogas from a ton of organic waste, while others provide production of up to 800 m³ from a ton of organic waste. Everything depends on the quality of organic waste, the technical and technological solution and the corresponding quality of operation of the BSU.

Organic waste is concentrated in a sealed gas-tight insulated container, in which a stable temperature is maintained and periodic mixing is ensured. Under the influence of these conditions, those present in organic raw materials split it with the release of biogas – a mixture of gases mainly consisting of CH_4 (50-75%), CO_2 (25-45%) and a small amount of related gases. BGS are performed based on the volume of household or enterprise waste, respectively, capacities from 10 kWh and up to tens of MWh are possible. Biogas can be produced both in industrial conditions and in the conditions of a private household, where the main types of raw materials, as a rule, are household waste and livestock waste. Home-made BSU allows you to get biogas for a 4-6 hour cooking period, or for the purpose of lighting or heating the room. And in addition to its own renewable energy source in the form of gas, electric and thermal energy, the biogas plant also produces high-quality fertilizers. In the laboratory test, we carried out periodic mixing of the substrate, which ensured the efficient and stable operation of the BSU. Mixing is the release of the formed biogas, mixing of fresh substrate and bacteria (inoculation), preventing the formation of crust and sediment, preventing the formation of areas of different temperatures inside the methane tank, ensuring uniform distribution of the bacterial population, preventing the formation of voids and accumulations that reduce the effective area of the BSU. When choosing the mixing method, we took into account that the fermentation process is a process of vital activity of the symbiosis of

various bacterial strains and the destruction of this community. The fermentation process will be unproductive until a new community of bacteria is formed. Therefore, too frequent or prolonged stirring is harmful. Slow mixing of the substrate is recommended every 4-6 hours. Optimal mixing of raw materials increased the biogas yield to 50-70%. Methane is the main constituent gas of biogas. Methane is also a major component of natural gas, a fossil fuel. Biogas is suitable for replacing natural gas in many cases and is widely used for cooking, heating, steam production, electric and thermal energy production, as an automobile fuel and for supply to gas transmission networks. First of all, reducing carbon dioxide emissions and improving air quality. Biogas purified to biomethane has properties similar to natural gas, but additionally contributes to reducing carbon dioxide emissions by at least 90%, which is explained by the production of a renewable source from biomass.

Biomethane is a biogas purified from impurities of by-gases, it is an environmentally friendly analogue of natural gas. Natural gas is a fossil energy resource, whereas biomethane is a renewable energy source. An additional advantage of biomethane is its almost CO₂ neutrality. BSU ensures the disposal (processing) of organic waste of hazard class 3 and 4 according to Resolution No. 344 of July 12, 2003, in the following modes: - in the psychrophilic mode, the optimal temperature in the BSU is 15-20 ° C, but it may be lower. In this mode, the waste is recycled for 30 to 40 days. Psychrophilic mode is usually used in the summer when the heat and the amount of substrate (waste) is significantly less than usual, for example, due to grazing; - in the mesophilic mode at a temperature of 30-40 ° C, organic waste is processed for 7-15 days, depending on the type of waste; - in thermophilic mode at a temperature of 52-56 ° C, organic waste is processed in 5-10 days, while the quality of gas and fertilizers, according to a number of indicators, is usually lower than in mesophilic mode. In addition, thermophilic mode traditionally consumes more energy for heating. This mode is most suitable for those whose main task is to recycle a large amount of waste. By optimizing the operation of the plant and the composition of waste, it is possible to accelerate processing even up to 3-4 days. The benefit of working in thermophilic mode is that the cost of 1 kW of installed BSU power is sharply reduced. The requirements for the permissible limits of temperature fluctuations of the substrate, for optimal gas formation, the more stringent the higher the temperature of the fermentation process: at a psychrophilic temperature regime – $\pm 2^{\circ}\text{C}$ per hour; mesophilic – $\pm 1^{\circ}\text{C}$ per hour; thermophilic – $\pm 0.5^{\circ}\text{C}$ per hour. To determine the effectiveness of the implementation of this installation, its assessment was carried out using the energy method.



Each cubic meter (m³) of biogas contains the equivalent of 6 kWh of calorific value. But when we converted biogas into electrical energy by burning it in a biogas-powered cogeneration module, we

received about 2 kWh of useful electrical energy, the other part was converted into thermal energy, which can be used for heating needs. 2 kWh of energy is enough to power a 100 Watt lamp for 20 hours or a 2000 Watt hair dryer for an hour. The biogas production process can be divided into two main stages. 1. In fact, the formation of biogas from organic waste. 2. The process of converting biogas by burning it in a cogeneration module into electrical and thermal energy. The produced volumes of electric energy, as a rule, are sold to the grid at a special, "green" tariff, whereas thermal energy from the cogeneration module is directed to the own needs of the biogas plant, to the heating network for heating remote homes and institutions, and to maintain related production processes in the case of BSU inclusion in a closed production cycle. The amount of organic waste entering the biogas plant for fermentation practically corresponds to the volume at the outlet, but the quality of waste has changed for the better (less odor, improved fertilizer quality, reduced organic load, practically no pollution). At the exit from the BSU, it is no longer organic waste, but organic fertilizers, which we have divided into a solid fraction (compost) and a liquid fraction (liquid organic fertilizers). Such fertilizers are made for direct application to the soil, in accordance with certain deadlines and application standards. Biogas technologies make it possible to create a waste-free production cycle. The products of operation of the biogas plant are biogas and biofertilizers – fermented organic raw materials with improved properties, fertilizer, odorless, without pathogenic microflora and without weed seeds, etc. BSU have different shapes and designs, in accordance with the needs of the raw material base. A simple agricultural-type BSU can cost \$3,700 per installed kWh. A municipal BSU for processing food waste can cost up to \$19,000 per kWh. Each project is individual. The typical payback period of BSU, depending on the raw material base, is 4-6 years. The implementation period of the BSU depends on the projected and planned capacity of the facility. Low-power BGS are fast in construction due to the lack of need for capital construction, whereas the implementation of industrial-type BGS takes 18-24 months. Biogas production plants from organic waste are usually divided into four main types: 1.without heat supply and without mixing of fermented biomass; 2.without heat supply, but with mixing of fermented biomass; 3.with heat supply and mixing of biomass; 4.with heat supply, with mixing of biomass and with means of control and management of the fermentation process.

A bioreactor (methane tank) is the basis of any biogas plant, and its design is subject to fairly stringent requirements. Thus, the body of the bioreactor must be sufficiently strong with absolute tightness of its walls. Good thermal insulation of the walls and their ability to reliably resist corrosion are required. At the same time, it is necessary to provide for the possibility of loading and emptying the reactor, as well as access to its internal space for maintenance. Reactor shapes are very diverse. Thus, from the point of view of creating the most favorable conditions for mixing the liquid substrate, gas accumulation, precipitation removal and destruction of the resulting crust, it seems advisable to use an egg-shaped reservoir. Large reactors of this shape are usually constructed of concrete. Large-volume tanks of this shape, used in municipal installations for wastewater treatment and decomposition, as well as egg-shaped reactors, are made of concrete. However, "cylindrical" reactors are somewhat cheaper. In individual farms, cylindrical reactors are usually used, of small capacity, made of steel or fiberglass. The bioreactor consists of a sealed thermally insulated housing 1 with a lid 2, biomass supply pipes 3 and outlet 4, a biogas outlet pipe 5, an agitator heat exchanger 6. The agitator heat exchanger 6 is made in the form of a vertical tubular shaft with four blades made of chromium-molybdenum steel pipes, while the blades having a bracket shape are arranged symmetrically and rigidly they are attached to a vertical tubular shaft with the possibility of rotation in a horizontal plane. The heat exchanger-agitator 6 is installed coaxially with the fermentation chamber, the upper and lower parts of which are rigidly mounted in rolling bearings 7 with oil seals 8 attached to the lid 2 and the body 1 of the bioreactor and connected to the heat source by means of fixed cylindrical pipes 9, one end of which is connected to the heat source 10 by means of pipes 11 and 12, and in others, the ends of a vertical tubular shaft

with oil seals 8 are installed. In the middle of the upper part of the vertical tubular shaft, a driven pulley 13 is rigidly attached, connected to the electric motor 14 by means of a V-belt transmission 15. The electric motor 14 is controlled by a microprocessor relay 22. From the heat source 10, the heated coolant flows through the supply pipe 11 through a cylindrical pipe 9 into the vertical tubular shaft of the heat exchanger-agitator 6 and is distributed under pressure over all its blades, heating the biomass. Through the lower part of the heat exchanger-agitator 6, the heated coolant enters the lower cylindrical pipe 9 and returns to the heat source 10 through the pipe 12. There is a constant heating of the biomass and circulation of the coolant. When the electric motor 14 is switched on, the torque is transmitted through the V-belt transmission 15 to the driven pulley 13, which rotates the vertical tubular shaft of the heat exchanger-agitator 6 with a rotation speed of 7.8 min⁻¹, carrying out uniform heat exchange and mixing of biomass. The biomass is mixed after 2.3 hours, lasting 10.15 minutes, the whole process is controlled by relay 22. Heating of biomass for the thermophilic process should not exceed 50.60 °C to reduce the energy intensity of the process and increase the volume of biogas output (the operating mode is chosen structurally depending on the type of waste), calculations of energy parameters allow us to conclude that the total heat costs for heating and maintaining a set temperature when using a combined heat exchanger and agitator are reduced, compared with by existing methods by 25-30%. The body of the bioreactor is insulated with polyurethane foam PU-ET. The lower part of the methane tank is a beveled cylinder, in the lower part of which there is an unloading device for removing waste mass in the form of sludge and solid sediment. This design variant of the methane tank frees the working part from stagnant zones, which allows you to use the entire volume of the methane tank. The volume of the beveled part, that is, the geometric parameters, are determined based on the volume of the spent substrate to be removed from the methane tank during the day. The initial mass is bird droppings, through a loading device it enters the fermentation chamber of the methane tank, where anaerobic fermentation takes place according to the thermophilic regime (50-55 °C), the humidity of the mass is 80% (20% is bird droppings, 80% is water). At the same time, the carbon and nitrogen of bird droppings are converted into methane with minor nitrogen losses. The formation of gas goes into a stable mode for 10-12 days after loading the mass. After the first loading and the beginning of gas release, the initial mass is loaded daily into the methane tank, and the fermented mass floats up and flows by gravity through the loading device into the container for the fermented mass.

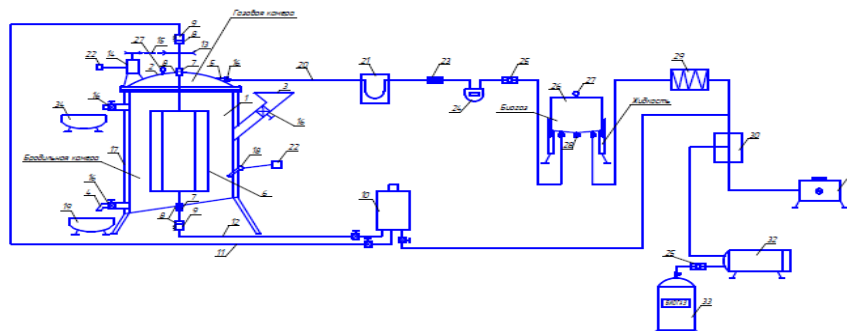


Figure 1 – Technological scheme of operation of the upgraded biogas plant:

1 - bioreactor housing (methane tank), 2 - removable housing cover, 3 - loading neck, 4 - discharge neck, 5 - biogas outlet, 6 - heat exchanger-agitator, 7 - bearing, 8 - oil seal, 9 - fixed cylindrical pipe, 10 - gas boiler for heating the methane tank, 11, 12 - supply and return pipeline, 13 - pulley, 14 - electric motor, 15 - drive belt, 16 - valve, 17 - thermal insulation, 18 - thermal sensor DTS-105-50M, 19 - waste mass tank (biofertilizers), 20 - gas pipeline, 21 - hydraulic seal, 22 - microprocessor regulator meter - TRM 202, 23 - filter, 24 - gas meter, 25 - check valve, 26 - gas tank, 27 - pressure gauge, 28 - drain fitting, 29 - spark extinguisher, 30 - automatic switch, 31 - gas consumer, 32 - compressor unit, 33 - biogas accumulator, 34 - reservoir for fermented mass. It is

also necessary to note the advantages of bio-installations: they satisfy the need of the economy for energy carriers; contribute to environmental protection, since in the process of anaerobic waste processing, an environmentally friendly organic fertilizer is obtained; fiber is destroyed, a significant amount of protein nitrogen passes into ammonia, available to plants; the decomposition process of manure is accelerated, compared with conventional overheating in burts, while weed seeds and helminths are dying, and the odor threshold is decreasing. The use of fermented mass makes it possible to increase the yield of field crops. If the efficiency of the process is divided into energy (from the use of biogas) and environmental (environmental protection), then the ratio is 22% to 78%.

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