
# INVESTIGATION OF THE BIOGAS PRODUCTION PROCESS AT THE METANTENK INSTALLATION

**Umarova M.B.**
**Urazov F.B.**
**Abdurazzakova G.**
Tashkent Chemical Technological institute
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Biogas produced by these plants is a natural decomposition product arising during the fermentation of organic substances, it is a regenerative, as well as a source of energy harmless to nature and humans. At the same time, the production of biogas not only does not consume electricity, it provides raw materials for its production and saves the company from the need to lay a gas pipeline and conduct electricity from public networks. It also includes the processing of organic waste, sometimes toxic not only into biogas, but also into bio-fertilizer. Biogas production is an environmentally friendly way to recycle organic waste.

Biogas is formed in nature only if organic compounds decompose in anaerobic (without air access) conditions, for example, in swamps, on the banks of ponds and in the digestive tracts of certain animals. The technology of waste processing by anaerobic fermentation has been known since ancient times, but only now, using modern materials, design solutions, control devices and computer control, it has been possible to create new biogas plants with very attractive technical and economic indicators. Industrial production of biogas requires the development of an integrated technology that includes such components as a biomass accumulator, a digester (fermenter), in which fermentation takes place, and a biogas reservoir with a gas cleaning system.

**Methane-forming bacteria**. According to the three-domain system of Karl Wöse, the methane-forming bacteria belong to the Euryarchaeota type of the kingdom of Archaea. All methane-forming bacteria are strict anaerobes, do not form spores, are difficult to isolate in pure culture. To create the taxonomic structure of the methane-forming bacteria, a phylogenetic approach was used, based on a comparative analysis of the nucleotide sequences of 16S rRNA. In accordance with this approach, the Bergi group in the ninth edition of the Qualifier of Bacteria is divided into three orders (Methanobacteriales, Methanococles, Methanomicrobiales). Representatives of Methanobacterium are sticks, sometimes forming short chains; bacteria belonging to the genus Methanococcus have spherical cells located separately; Methanosarcina globular cells form cubic-shaped packets. Methane-forming bacteria inhabit the soil, silts of ponds, lakes, as well as in swamps (bubbles rising to the surface of the water - "swamp gas" - consist of methane).

In the depths of the oceans, these bacteria usually live in places of output of sulphates. Methane-forming bacteria multiply rapidly in the rumen of ruminants, where organic acids, $CO_2$, $H_2$, $CH_4$, are formed as a result of the decomposition of vegetable fodder microflora. A distinctive feature of the class Methanobacteria, which gave it its name is the ability to produce methane. This process takes place under the action of specific coenzymes: methanofuran, tetrahydromethanopterin ($H_4MP$), coenzymes F420 and F430, coenzyme M,

coenzyme B. Most often, the process of methanogenesis can be described by the general formula:
$CO_2 + 4 H_2 \rightarrow CH_4 + 2H_2O$
But neither hydrogen nor carbon dioxide is initially in the reactor. Synthesis of methane from the substrate (which can serve as solid and liquid waste from the agro-industrial complex, wastewater, municipal solid waste, waste from the timber industry) proceeds in four phases:
Hydrolysis phase. At the first stage, bacteria rearrange high-molecular organic substances (protein, carbohydrates, fats, cellulose) with the help of enzymes into low-molecular compounds, such as monosaccharides, amino acids, fatty acids and water. Enzymes secreted by hydrolytic bacteria split the organic components of the substrate into small water-soluble molecules. Polymers are converted to monomers.

**Acid forming phase.** Further, these compounds are decomposed into other organic substances (acids: acetic, propionic, butyric, alcohols, aldehydes) and compounds: $H_2$, $CO_2$, as well as $N_2$ and $H_2S$. This process proceeds until the development of bacteria slows down under the influence of the formed acids; anaerobic bacteria partially take part in it, consuming oxygen residues and thereby forming the anaerobic conditions necessary for methane bacteria.
Acetogenic phase. This phase is carried out by two groups of acetogenic bacteria. The first forms an acetate with the release of hydrogen:
$CH_3CH_2COOH + 2H_2O$ ⍰ $CH_3COOH + CO2 + 3H_2$
$CH_3CH_2CH_2COOH + 2H_2O$ ⍰ $2CH3COOH + 2H_2$

The second group of acetogenic bacteria leads to the formation of acetic acid by using hydrogen to reduce $CO_2$:
$4H_2 + 2CO_2$ ⍰ $CH_3COOH + 2H_2O$
Methanogenesis.

Acetic acid is decomposed into methane, carbon dioxide and water:
$CH_3COOH \rightarrow CH_4 + CO_2 + H_2O$

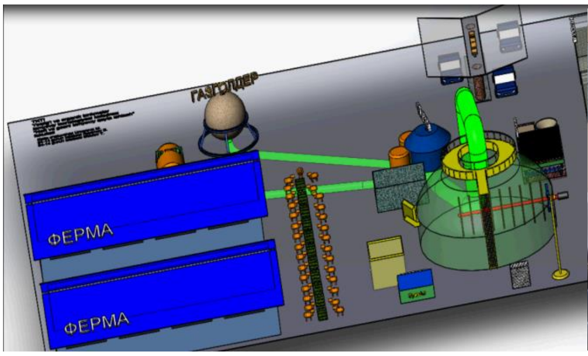
Hydrogen and carbon dioxide (CO2) are converted to methane and water:
$CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$
Optimal conditions for methnogenesis
Methane-forming bacteria - strict anaerobes. The first studies of pure cultures isolated from the rumen of ruminants showed that their growth is possible at the initial redox potential of the environment below -300 mV. The growth of some species is completely suppressed when the content in the gas phase is more than 0.004% molecular oxygen. However, species with relatively low O2 sensitivity are described. Superoxide dismutase is found in their cells. Perhaps in nature, such species can maintain viability during short-term contact with O2 and resume growth under anaerobic conditions. Most methane-producing bacteria have a temperature optimum for growth in the region of 30–40 degrees C, i.e. are mesophiles, but there are species that have an optimal zone shifted towards lower (25 degrees C) or high (55-65 degrees C) temperatures. Extremely thermophilic organism Methanothermus fervid us, growing at 55-97 degrees C (optimum 80 degrees C), has been isolated. All known representatives of this group are neutrophils with an optimum pH in the region of 6.5-7.5. At optimal, even activity of acid-forming and methane bacteria, maintaining the pH value in the desired range does not require additional efforts. However, sometimes acid-forming bacteria begin to multiply faster than methane bacteria, because of which the concentration of volatile

fatty acids in the fermentation chamber increases and so-called "acidification" occurs, resulting in a decrease in biogas output, and the acidity of biomass increases. Among the methanogens there are halophiles, which require as one of the optimal conditions for an increase in the content in the medium to 65-70 g / l NaCl. The fermented organic mass should not contain substances (antibiotics, solvents, etc.) that adversely affect the livelihoods of microorganisms. During the synthesis of methane under artificial conditions, due to the restriction of free space, a floating crust periodically forms on the surface of the organic mass, interfering with the output of biogas. Therefore, it must be eliminated by mixing the contents of the bioreactor 1-2 times a day. Mixing also contributes to the uniform distribution of temperature and acidity in the biomass in the digestion chamber.

Modern biogas plants are a complex set of engineering structures, including equipment for the preparation of raw materials and processing it into biogas, equipment for further purification of biogas, its storage and equipment for the production of electricity and heat. Biogas equipment is designed in such a way that the processing of organic waste is not accompanied by characteristic odors and does not emit toxic substances into the atmosphere. It does not consume electricity - but, on the contrary, it produces it (if we consider the entire complex of construction called "biogas station" as biogas equipment, which carries out all stages of the process that turns waste into heat and light). The technology of biogas production is associated with intensive decomposition of organic matter using special coenzymes and conditions. Liquid and solid wastes enter the bioreactor (metatank), where they are fermented and mixed so that bio-fertilizer and biogas are obtained at the output. Next, biogas enters gas holders, is cleaned and stored, and for further use, the gas enters the cogeneration unit based on a biogas generator, which produces electricity and heat. Structurally, biogas generators are a body divided into chambers by partitions, in which various gas mixtures are contained and interact. Thus, the organic waste of the enterprise is not discharged and does not pollute the environment, but is used in the future for the benefit of the enterprise in its new capacity.

**A bioreactor** is the basis of any biogas plant, and its requirements are quite stringent. Thus, the body of the bioreactor must be sufficiently durable with the absolute hermeticity of its walls. Mandatory good thermal insulation of the walls and their ability to reliably resist corrosion. It is necessary to provide for the possibility of loading and emptying the reactor, as well as access to its internal space for maintenance. Forms of reactors are very diverse. So, from the point of view of creating the most favorable conditions for mixing the liquid substrate, gas accumulation, removal of precipitation and destruction of the crust formed, it seems reasonable to use a reservoir that looks like an egg. Large reactors of this form are usually constructed from concrete. There are cylindrical tanks, with conical upper and lower parts, with a characteristic small space for gas accumulation and a limited volume for the floating crust, as well as with a good slag removal. However, in such reactors less favorable conditions are created for the displacement of the liquid substrate. Large-volume tanks of this form, used in municipal installations for cleaning and decomposition of wastewater, as well as reactors in the form of eggs, are made of concrete. However, "cylindrical" reactors are somewhat cheaper. In individual farms, usually use cylindrical reactors, small capacity, made of steel or fiberglass. It is also necessary to note the advantages of bio-adjustments: they satisfy the needs of the economy in energy carriers contribute to the protection of the environment, as in the process of anaerobic waste processing produces environmentally friendly organic fertilizer; cellulose is destroyed, a significant amount of protein nitrogen goes into ammonia, available to plants; the process of decomposition of litter is accelerated, as compared with the usual overheating in piles, while weed seeds, helminths die, the odor threshold is reduced. The use of fermented mass can 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), the ratio is 22% to 78%.



Laboratory testing we carried out periodic mixing of the substrate in the digester, which ensured the effective and stable operation of the BSU. Mixing - the release of biogas formed, mixing fresh substrate and bacteria (vaccination), preventing the formation of crusts and sediments, preventing the formation of different temperature areas inside the digester, ensuring uniform distribution of bacteria populations, preventing the formation of voids and clusters, reducing the effective size of the digester. When choosing the method of mixing, we took into account that the process of digestion is a process of vital activity of symbiosis of various strains of bacteria 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 mixing is harmful. Slow mixing of the substrate every 4–6 hours is recommended. Optimal mixing of raw materials increased biogas yield up to 50%. The proposed project is based on the efficient use of solar panels and wind turbines, as well as providing remote areas of Uzbekistan with electricity, mineral fertilizers, as well as an additional sustainable source of energy, alternative fuels from biogas. Patent Certificate No. DGU Nº. 12066 issued by the Intellectual Property Agency under the Ministry of Justice of the Republic of Uzbekistan to determine the parameters of biogas production technology from local raw materials