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Method for processing organic boat waste from "chorvaagroclaster" farm

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Abstract. The article describes the directions of development of the use of renewable energy sources in the modern world, which are producers of environmentally friendly energy with low costs and short-term processing of agricultural waste. The disadvantages of the known methods of manure processing and the installation for its implementation, such as processing organic waste in a thermophilic mode, have a non-Newtonian character with a liquid. It is an organic waste that does not exfoliate and this mixing requires a deep vacuum, which is impractical (not allowing) normal anaerobiosis of methane-producing bacteria. At the same time, the pre-prepared initial biomass is additionally maintained in the bioreactor and the level of biomass in the bioreactor is difficult to control during filling. In addition, it is shown that the proposed design, compared with the prototype, reduces the time of technological exposure of biomass in a bioreactor by 40–45%, increasing the productivity of commercial high-quality organic fertilizers and biogas by 35–40% and increasing the efficiency of processing organic waste 2–2.5 times.

1 Introduction

One of the main directions in the development of the use of renewable energy sources in the modern world is the production of environmentally friendly energy with low costs and rapid processing of agricultural waste [1, 2]. At the same time, it is economically feasible to use power-generating devices to ensure optimal performance, which is one of the most important tasks in optimizing the technology of stepwise processing of power equipment. Currently, efforts are being made in the world to increase the economic efficiency of renewable energy sources for anaerobic processing of organic waste [3–7].

2 Materials and Methods

Targeted research is being carried out in this area, including determining the optimal amount of biogas and organic fertilizers from a one-stage organic waste processing plant and the amount of biomass processed in each bioreactor. Determination of the duration and speed of mixing, as well as the number of daily mixtures; automatic control of the process and improvement of the quality of organic fertilizers include the introduction of modern types of devices. The definition of economic indicators is one of the important tasks.

In the republic, much attention is paid to scientific research aimed at the development of renewable energy sources and the creation of modern copies of renewable energy devices that preserve the original building materials, improve and accelerate the anaerobic process, improve the ergonomic and quality indicators of products. According to the Action Strategy for the Further Development of the Republic of Uzbekistan for 2017–2020, tasks were set to develop fundamentally new types of products and technologies, thereby ensuring the competitiveness of domestic goods in the domestic and foreign markets [8]. In this regard, in order to strengthen macroeconomic stability, it is important to focus on every aspect of the modernization and accelerated development of agriculture, as well as improve energy efficiency by optimizing the use of renewable energy sources. In world production, a manure processing method and an installation for its implementation are known [9–14]. As you know, organic waste such as manure, bird droppings, food residues, sewage and plant residues are fermented without access to air into energy and high-quality organic stress. At the same time, processing plants are called biogas and oxygen-free methods.

3 Results and Discussion

The disadvantage of the known methods of manure processing and the installation for its implementation is that when processing organic waste in a thermophilic mode, the non-Newtonian nature of the liquid is present. Since it is an organic waste, it will not delaminate and this mixing requires a deep vacuum, which is impractical (not allowing) normal anaerobiosis of methane-forming bacteria. At the same time, the pre-prepared initial biomass is additionally kept in the bioreactor, and the

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level of biomass in the bioreactor during filling is difficult to control.

In addition, the uneven distribution of the mixing force vertically when the cylindrical installation requires additional costs, which reduces the reliability of operation and increases the overall cost of processing organic waste.

We have developed a device, a method for processing organic waste related to devices for microbiological fermentation of organic substances, and it can be used in agricultural production to enrich organic waste, for wastewater treatment. According to the proposed method and installation for its implementation, in order to increase the efficiency of the processing process, as well as reduce the time of technological exposure of the substrate, mixing of the substrate during the fermentation process is carried out in layers without mixing the layers with each other and with simultaneous heating of the substrate.

In addition, the process of fermentation of organic waste is carried out under vacuum, and the mixing process is carried out by changing the magnitude of the vacuum. At the same time, a vertically installed bioreactor equipped with a holder is made in the form of a straight triangular prism. One of the ribs of the latter faces the heat exchanger; the device for unloading the fermented biomass is made in the form of vertical pipes installed in a cylindrical chamber. In this case, the heat exchanger is installed in the form of coaxially arranged cylinders with branch pipes installed tangentially in their walls for mixing and heating the substrate in the layer, while said pipes are located at different levels along the height of the heat exchanger.

The plant developed by us (Figure 1) of cattle waste from the “Chorva Agrocluster” farm enters the biomass pretreatment pit. At the same time, increasing the efficiency of the processing process, reducing the time of technological exposure of the substrate, mixing the substrate during the fermentation process is carried out by the bubbling method with simultaneous heating of the substrate, and the fermentation process in the bioreactor at three stages without mixing the substrate stages with each other.

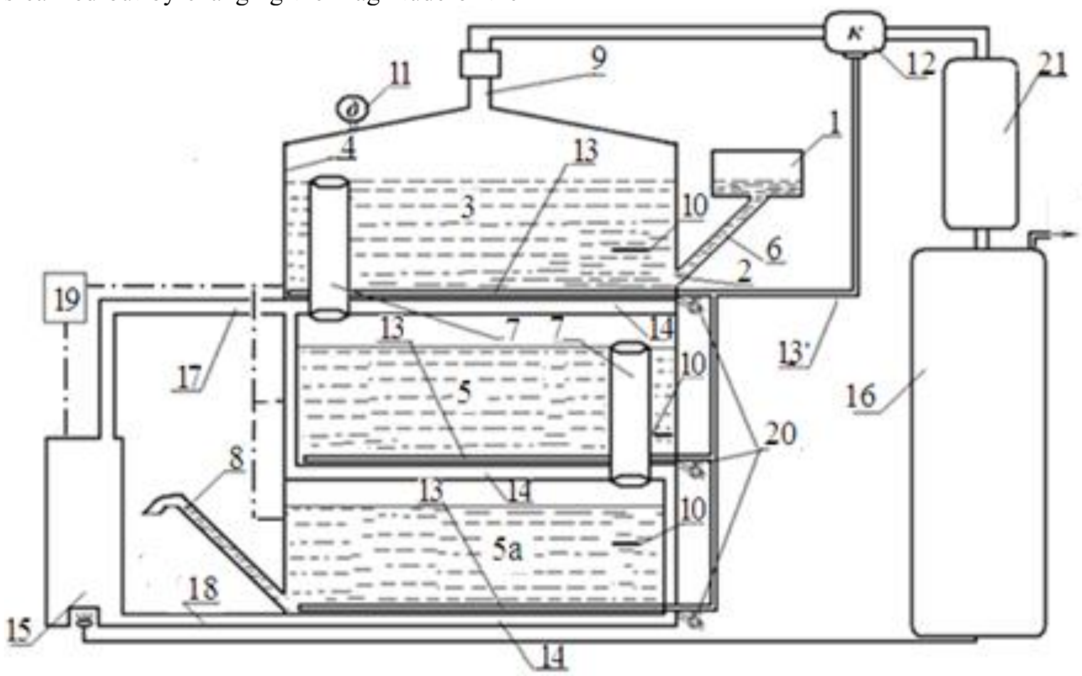

Fig. 1. Schematic diagram of staged anaerobic processing unit organic waste**:** 1 – capacity for the primary acceptance of organic waste; 2 – inlet; 3, 5 and 5a – processing tanks 1, 2 and 3 stages; 4 – bioreactor; 6 – pipe mixing, loading; 7, 8, 9, 17, 18 – pipes; 10, 11 – temperature and pressure sensors; 12 – compressor; 13 – bubble pipe; 14 – heater; 15 – boiler; 16 – gas holder; 19 – computer control line [25A]; 20 – faucet; 21 – gas filter; 22 – blade mixers

The pre-prepared organic waste, getting into the first stage, begins to intensively master in a certain order (sequence) the consumption of amino acids, i.e., diauxia occurs, that is, regulation of the mechanism of enzyme synthesis and adaptation of methane-forming microorganisms to the high “sensitivity” of the process of methane formation in chemical and biological composition of the fermented medium. With this method, the substrate is processed in one reactor at several stages, being activated at each stage by its specific methane-forming bacteria. The proposed installation, in order to increase the productivity of the production of methane-containing gas and the reliability of the installation, reduce energy costs for own needs, is equipped with stage separators and overflow pipelines connecting the stages, pipelines installed in the lower part for supplying gas to bubbling and a heat exchanger type of underfloor heating. The latter is made solid in the flat form. At the same time, the substrate-unloading pipe at the third stage of processing is set at such a level that would ensure the maximum volume of the substrate in this stage and the connecting pipe of the steps is made in the form of a rounded pipe, which has the ability to simultaneously pass biogas and substrate. In addition, the pipe connecting the steps is installed so that each of the steps has a maximum filling that does not interfere with bubbling mixing.

The method of anaerobic treatment was carried out as follows. When processing organic waste in one bioreactor, anaerobic processing is intensified at several stages. At the same time, each stage is provided with its own specific methane-forming bacteria that allow the intensity of methane formation [15–18]. This allows pre-prepared organic waste to get into the first stage; intensive development begins some sequence (sequence) of consumption of amino acids, i.e., diauxia occurs, that is, regulatory mechanisms for the synthesis of enzymes and adaptation of methane-forming microorganisms to a high "sensitivity" of the process of methane formation to the chemical-biological composition of the fermented medium [19–21].

The installation (Fig.1) consists of the following parts and assemblies. To increase the intensity and increase the continuity time of cultivation of methane-forming bacteria and to prevent uneven flow of fermented biomass into the bioreactor, the biogas plant is equipped with a loading neck 1, where stones and sands are sieved. Biomass brought to a moisture content of 92–94% is fed through the neck 2 into the tank 3 of the first stage of the bioreactor 4. There the fermentation process is intensified by aerobic microorganisms that oxidize hydrogen in the presence of air, to the next doses of bioreactor 4 loading.

The biomass brought to the requirements of anaerobic treatment is fed through the inlet neck 1 further along the loading pipe 6 of the vertically located cylindrical stationary bioreactor 4 in the tank 3 of the first stage. The bioreactor 4 is equipped with overflow pipelines 7 for loading the next tank 5 and 5a of the second and third stages, respectively, as well as an unloading pipeline 8. In the upper and from the tank part of the bioreactor 4 is installed to remove the released biogas, as well as thermometers 10 for temperature control and pressure sensor 11 fermentation. To ensure the uniformity of the distribution of the daily feedstock loaded into the bioreactor 4 and its constant contact with microorganisms, fresh nutrients, we keep the concentration of decomposition products at a low level and ensure the uniformity of the medium both in temperature. And in the concentration of nutrients throughout the volume the bioreactor 4 is autonomously installed mixing bubbling compressor 12. The compressor 12 is fed with biogas from the gas outlet pipeline 9 to remove the released biogas from the upper part of the bioreactor 4 and supplies under pressure to the lower part of the bioreactor 4 through the gas distributor 13 located above the heat exchanger 14 of the "warm floor" type. The biogas plant is also equipped with a heater boiler 15 and a gas holder 16.

To ensure the thermal regime of fermentation, an autonomously installed boiler heater 15 operating in a natural way forcing due to the temperature difference in the supply of hot water is equipped with a pipe for draining hot water 17 and supplying cold water 18. The thermal regime of the biogas plant is controlled by an automatic temperature control sensor 19. During maintenance for removal sedimented sand and non-decomposable inorganic impurities, a valve 20 is provided, installed in the lower part of each stage of biomass processing separately in the bioreactor 4. For preliminary cleaning of biogas before being fed to the gas tank 16, a water filter 21 is installed for cleaning biogas.

The proposed biogas plant operates as follows. The biomass brought to the requirements of anaerobic treatment is fed through the inlet neck 1 further along the loading pipe 6 of the vertically located cylindrical stationary bioreactor 4 in the tank 3 of the first stage. When pre-prepared biomass is loaded into the bioreactor 4, hot water is supplied to the heat exchanger 14, which works on the principle of a warm floor. After filling the first stage of the tank 3 of the bioreactor 4 with the help of a mixing compressor with three-way valves 12, air is supplied to the bioreactor 4 located in the upper part of the tank 3. In this case, intensive aerobic microorganisms oxidize hydrogen in the presence of air.

After filling the tank 3 of the first stage, the transfusion of biomass begins through the biomass overflow pipeline 7 to the next tanks 5 and 5a of the second and third stages, respectively. The loading of biomass into the bioreactor continues until the transfusion of biomass occurs through the unloading pipeline 8. At this time, mixing in the bubbling method and supplying hot water to heat up to the required processing temperature continues.

The brought temperature of the thermal mode of fermentation is controlled by an automatic temperature control sensor 19 54 (± 2) ˚C. At the same time, hot water from the boiler 15 is heated by burning biogas obtained from the gas tank 16 through the hot water outlet pipes 17 to the heat exchanger 14 of the bioreactor. The water from the heat exchanger 14, which works in a natural way, is pumped due to the difference in temperature controlled by the automatic temperature control sensor 19, enters the boiler 15.

During the technical maintenance of the bioreactor, the precipitated sand and non-decomposable inorganic impurities are removed through the hatch 20 installed at the bottom of each processing stage.

We proposed a method for processing organic waste and installations for the implementation of activating methane formation at each stage, having its own specific methane-forming bacteria. At the same time, the pre-prepared organic waste, getting into the first stage, begins an intensive assimilation of a certain sequence of consumption of amino acids, i.e. diauxia occurs, this allows the development of free oxygen entering the anaerobic process by newly loaded organic waste [22–26].

Regulatory mechanisms of enzyme synthesis and adaptation of methane-forming microorganisms to the high "sensitivity" is the methane formation process, to the chemical-biological composition of the fermented medium [27–29].

4 Conclusion

The proposed method is provided with an installation for its implementation additionally equipped with pipelines for supplying biogas from the bottom of the bioreactor. The loading and unloading pipeline of waste and wastewater is respectively installed, the lower and upper parts. In each stage of the lower part of the bioreactor, there is a heat exchanger to ensure the thermal regime of fermentation in the bioreactor. Connecting the biomass stages in a vertical bioreactor pipeline, the biomass is overflowed by displacement, providing a reliable way to process the biomass. At the same time, the proposed design, in comparison with the prototype, makes it possible to reduce the time of technological exposure of biomass in the bioreactor by 40–45%, to increase the productivity of commercial high-quality organic fertilizers and biogas by 35–40%, and to increase the efficiency of organic waste processing 2–2.5 times.

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