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SEMI - CONTINUATIVE FERMENTATION TECHNOLOGY AND TECHNICAL MEANS

Summary. The article is devoted to increasing the efficiency of using agricultural waste, a method for creating compact containers for a biogas generator and examples of recipes for loading it to produce biogas in a cyclic process are proposed. A technological scheme and a recipe for loading a biogas generator are proposed. The graphical parameters of the complex-shaped reactor vessel are determined. The amount of materials for its implementation and the location of the elements are determined. It has been proven that for a stable supply of biogas to the system, it is necessary that the sections of the cycles corresponding to the completion of the reaction are blocked by the sections of the cycles of the biogas generator entering the operating mode. It has been proved that it is necessary to organize the process of processing, converting renewable resources, namely agricultural waste, according to scientifically based methods, which should ensure not only the appropriate quality of the energy product, but also a certain energy efficiency of the process.

Key words: compact biogas generator, biogas and fertilizer production efficiency, semi-continuous fermentation technology, fermentation concentration, carbon number, digester materials.

Formulation of the problem. Integration into the world community, the growth of agricultural production, the growth of competition contributes to the fact that Ukrainian producers are beginning to pay more attention to the efficient use of agricultural waste. At present, there has been a trend towards the rational use of agricultural waste and the utilization of biomass energy in the form of biogas [1]. The production of biogas in a farmstead requires little investment and quickly brings useful results and is exactly the tool that, based on the tracking of production technology, allows one to draw a conclusion about the efficiency of biogas and fertilizer production.

By-products in the form of agricultural waste, namely plant biomass and animal manure, are renewable resources, and therefore can be used for



energy needs.

In the context of saving energy resources and improving environmental safety, the use of plant biomass and animal manure for energy needs and the development of areas is currently a very urgent problem [2].

Analysis of recent research. Many studies have been devoted to the issues of obtaining biogas [1,2,3,4], however, design solutions are mainly aimed at the manufacture of large biogas plants with a daily load of more than 80 tons [1]. At the same time, to obtain biogas, it is sufficient to provide fermentation conditions by maintaining an anaerobic environment, temperature, acid (pH) regimes and pressure [2].

The most common methods of using by-products of plant biomass and animal manure are: obtaining fertilizers, obtaining biogas and biomethane, and using the energy product as a biofuel in furnaces. [1-5,7,9]. There is an opportunity to increase the efficiency of biomass use by chemical treatment [8,9]. Therefore, the search for ways to improve the efficiency of its use plays an important role, since it allows for a long time to reduce the loss of valuable energy raw materials.

Formulation of the purpose of the article. The purpose of the study is to establish the possibility of increasing energy efficiency and stability of biogas production, determining the optimal formulation and design when using biogas generators.

To achieve this goal, the following tasks have been set:

1. Suggest technology and paradigm of bioreactor operation.
2. Determine the design parameters of the biogas generator.

The research methodology is based on a modified method for studying the process of obtaining biogas.

Main part. The minimization of energy resources in agricultural production systems stimulates interest in renewable energy research. All over the world, research is underway on the use of crop and animal waste for biogas production. Biogas generators are widely used in China [2,4]. However, when using large individual plants in small farms, it is difficult to achieve stable biogas production. It is possible to significantly improve the process by creating special schemes of biogas generators.

Overview of the basic design data of the compact biogas generator

Technology data.

1. Working pressure in the digester ≤ 800 mm H₂O.
2. Maximum pressure in the digester ≤ 1200 mm H₂O.
3. Maximum charge volume 90 % of the total volume of digester.
4. Volume of outlet tank is 50% of the gas products volume per day.
5. Minimum soil cover on the cover of digester ≥ 250 mm.
6. Load on the soil base ≥ 5 tons / m².
7. Main technology data target.
8. Gas lost is lower 3% of total gas producing when the pressure is

- 800 mm H₂O in the digester during 24 hours.
9. The biogas producing efficiency is 0.15...0.3 biogas m³ / digester m³ per day.
 10. Volume of biogas storage is 50% of biogas producing volume per day.
 11. Strength secure coefficient $K \geq 2.65$.
 12. It can be used for 20 years.

Semi - continuative fermentation technology.

The scheme of the technological process of semi-continuous fermentation for the production of biogas and fertilizers, presented in Fig. 1, is as follows: raw materials preparation, make up materials, materials mixed with fermentation bacteria, sewerage, digested sludge and water, supply new material in time or not in time, initial loading of the digester, primary fermentation in a digester, fermentation with biogas production, discharge in tanker, clean of digester, discharge fertilizations.

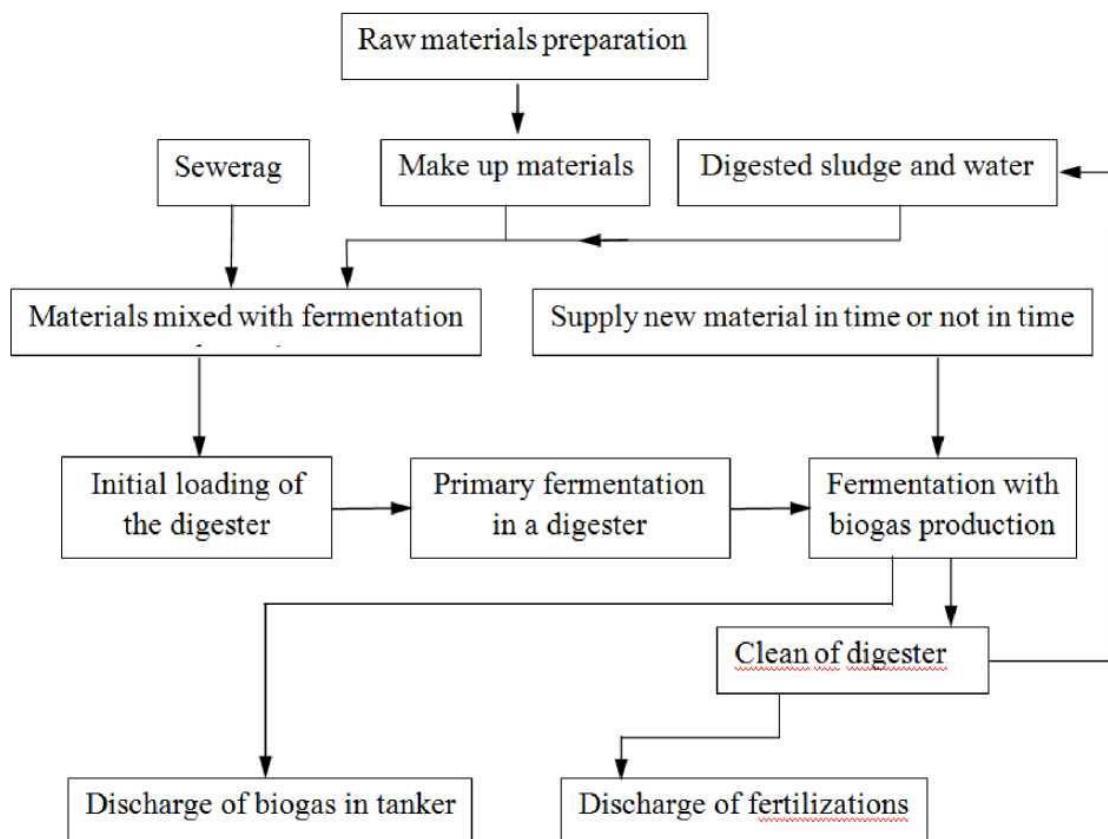


Figure 1. Scheme of the technological process for obtaining biogas and fertilizers

1 Technical features

1.1 A 8 m³ digester for one family must have more than 600 kg stalks and all excrements from animals and humans.

It is better use old stalks, the drye, the better. Summer harvesting for



using in winter and autumn harvesting for using in spring.

The discharge digester sludge can be used for fertilizers.

The stalk should be cut into 3-5 cm long and the corn stem must be pressed-breaking first and then cut.

1.2 Materials make up:

The materials make up must be according the fermentation concentration and carbon ration (table 1).

1.3 Mixing with fermentation bacteria material. Fermentation bacteria material can be found i the sludge and the city sewer lake or pond sludge.

The sludge under the meat and food factory sewer is best material as that contains much organic matter. When sewage sludge is used, the quantity of sludge is 10 ... 15% of the fermentation material. The more fermentation bacterial material and more biogas is produced.

Table 1

Recipe for biogas generator loading

№	Raw materials	weight ratio	5...6 % consistency		8,,9% consistency		10...14% consistency	
			material weight, kg	water weigh, kg	material weight, kg	water weigh t, kg	material weight, kg	water weigh t, kg
1	fresh pig manure	-	333	667	445	555	555	445
2	fresh cattle manure	-	353	647	470	530	588	412
3	fresh pig manure: wheat straw	4,5/1	163/36	801	217/48	735	227/60	668
4	fresh pig manure: corn stem	2,95/1	133/45	822	177/60	761	221/75	704
5	fresh cattle manure: wheat straw	40/1	331/8	660	440/11	549	551/13	436
6	fresh cattle manure: corn stem	23/1	307/13	679	410/17	557	513/22	464
7	human dung: wheat straw	1,8/1	92/51	853	122/68	810	153/85	762
8	human dung: corn stem	4,3/4	68/60	872	90/80	830	112/100	789
9	pig manure: human dung: wheat straw	1/1/1	50/50/50	850	66/66/66	802	82/82/82	754
10	pig manure: human dung: corn stem	1/0,75/1	54/40/54	852	72/54/72	802	89/67/89	755
11	pig manure: cattle manure: wheat straw	3/1/0,5	159/53/26	762	211/71/35	863	267/88/74	604

Note: 1. This is, content material per cubic meter fermentation liquid in the digester.



1.4 First to put breaded dry stalks into the digester and stamp press that the layer is about 10...20 cm. Secondly to put excrement from animals and human, the third is fermentation bacteria material. And then put another layer stalks. After stamp press that put excrement and fermentation bacteria material. Layer by layer, until finish all the row material. The excrement and fermentation materials can be mixed with water. The volume of water is about one third of total water in the digester.

The row materials begin first fermentation. Digester do not cover. The first fermentation time is 1...2 days in spring and summer, 3...5 days in autumn and winter.

1.5 During the fermentation the temperature of fermentative material get up higher and higher. When the temperature will reach 40...60 °C, the water can be put into the digester from charge and discharging pipe. When water volume will reach total water volume, water mix with the row materials.

Acidity and alkalinity (pH value) should be checked with the pH paper.

If the pH is above 6 the digester can be sealed. If the pH volume is below 6, some lime stone or ammonia water can be put into digester to adjust the pH volume to 7 and the digester can be covered.

After filling the digester, the biogas pipe and the stone plug are inserted into the throat of the digester, which turns off.

1.6 After digester sealed for 2...3 days the biogas can be used. They must test in the burner (they must not test in the biogas pipe).

If the flame is light, then the next day you can use it as normally. If the flame does not light, check the all system and remove all gas from the digester. Repeat the test the next day until biogas is produced normally.

2 Management

2.1 It is better to connect the toilet and piggery with the biogas digester, so as the excrement can flow into the digester. Some stalk can be charge according to do gas productive. The volume of discharge should be equal the volume of charge.

If the digester is without connecting with the toilet and piggery stalks and manure should be charged each 8 days after digester beginning gas productizing and the volume of gas producing become lower. The charge volume that equal discharge volume is 20 % of total digester volume.

2.2 If the gas productivity decrease rapidly, connecting of the pipeline switcher should be checked.

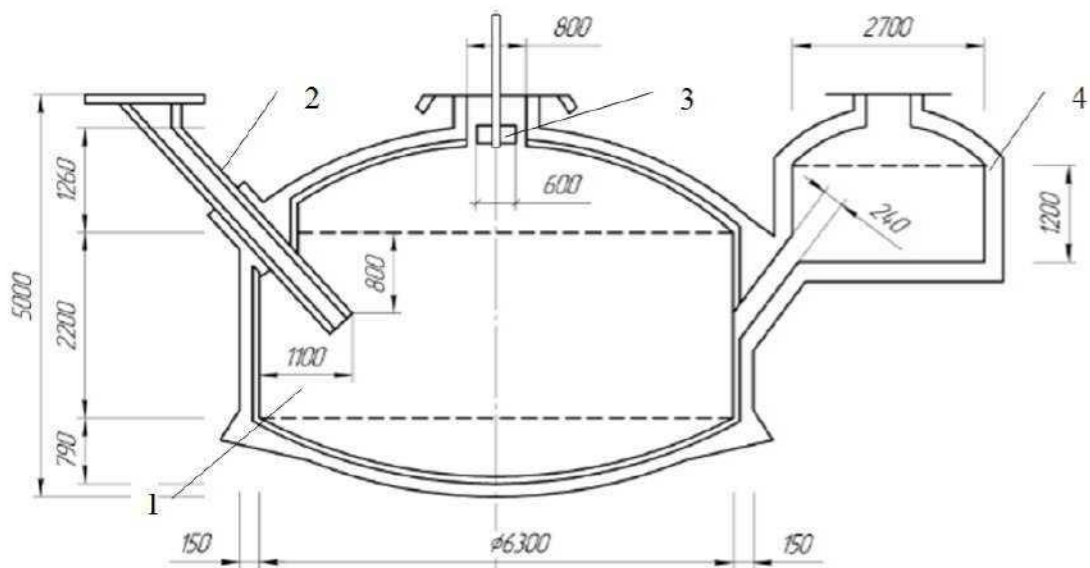
Discharge is according to time when the fertilizers, is needed. The pump can be used for discharge and also can be used for stirring fermenting materials in the digester usually.

2.3 Discharge is according to time when the fertilizers, is needed. The pump can be used for discharge and also can be used for stirring fermenting materials in the digester usually.

2.4 Farm chemical, pesticide, bactericide etc. is strictly prohibited to put into the digester.

Construction and materials

The production of biogas in a farmstead requires little capital investment and quickly brings useful results [10]. For the construction of a biogas generator for 8 m³ (see Fig. 2), cement grade 425, sand, crushed stone are required. These materials are used to make concrete used for the bottom, walls and roof. A biogas generator is usually built underground, and below the freezing level of the soil. After the manufacture of the biogas generator, it is necessary to plaster it from the inside with cement mortar once or twice. Then dissolve the wax or paraffin in machine oil and heat the mastic to 100 - 200 °C. Using a blowtorch, the walls of the biogas generator are heated from the inside to 60 - 70 °C and covered with prepared mastic. Then the wax plaster is again heated with a blowtorch so that it impregnates the cement. To supply biogas to the place of consumption, a gas pipeline must be hermetically connected to the nozzle in the cover of the biogas generator. Its length should not be more than 30 m. At the lowest point, it is necessary to provide a device for draining condensate, but it is better to ensure its free flow into the biogas generator.



1 – main tank, 2 – loading pipe, 3 – plug with a gas outlet pipe, 4 – reservoir for creating hydraulic pressure

Figure 2. Structural diagram of a biogas generator for a farmstead

Construction materials

1. Concrete grade 200# (No 200), (cement grade 425...525).

The composition of the components for the preparation of 1 m³ of concrete: water - 175 kg, cement (grade 425) - 301 kg, sand - 560 kg, cobble



(rock rubble 5...25 mm) - 1320 kg, or water - 185 kg, cement (grade 525) - 280 kg, sand - 655 kg, cobble (rock rubble 5...15 mm) - 1280 kg.

2. The total consumption of materials for the manufacture of a digester:

- cement - 733 kg,
 - sand - 1.371 m³,
 - cobble (rock rubble) - 1.54 m³,
 - wax - 6 kg.
3. Concrete is used for cover, wall and bottom.
4. Red brick can be used for wall.

Digester sealing layer.

1. Plaster the inner surface of the digester by cement liquid 1...2 times.
2. Plaster the inner surface of the digester by cement - sand thick liquid 1:3 (cement: sand <2.5mm).
3. Plaster the inner surface of the digester by cement liquid.
4. Plaster the inner surface of the digester by cement-sand thick liquid 1:2.5 (cement: sand <2.5mm).
5. Mix wax with 3...5% engine oil and heat to 100...200 °C.
6. Using a flamethrower heat the inside of digester to 60...70 °C and then daub mixed heat wax, and then use flamethrower to heat wax again to make wax permeate into cement.
7. Using a knife, scrape off excess wax. Wax layer is controlled in 1 mm.

Biogas pipe laying.

1. Do best to lay pipe in the short distance, straight to avoid the pressure losing.
2. Connector should be sealed.
3. The turning should not be small, it is better larger 120°.
4. The distance biogas pipe should not be over 30 m.
5. The biogas pipe cannot pass where easy- exploding or easyburning please.
6. The outside pipe should be laid underground; the laying depth is under the frozen soil. The pipe can use plastic pipe or steel pipe. The slope of the pipe not smaller than 1 % and put the drainpipe in the lowest point or pipe slop to the digester.

Conclusions

1. A scheme of the technological process for obtaining biogas and fertilizers is proposed.
2. The recipe for biogas generator loading has been determined.
3. A design scheme for a biogas generator for a farmstead is proposed, which should provide not only the appropriate quality of the energy product, but also a certain energy efficiency of the process, as well as high-quality fertilizers.



The proposed design and scheme of the technological process for obtaining biogas and fertilizers, taking into account the use on a farmstead, can be used in the design of biogas generators and the selection of equipment.

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ТЕХНОЛОГІЯ НАПІВБЕЗПЕРЕРВНОЇ ФЕРМЕНТАЦІЇ ТА ТЕХНІЧНІ ЗАСОБИ

Анотація

Стаття присвячена підвищенню ефективності використання відходів сільського господарства, шляхом створення компактної біогазогенераторної установки, удосконалення технології виробництва біогазу, запропоновано методику створення компактних ємностей для біогазогенератора та приклади, рецептура його оптимального завантаження для вироблення біогазу, що знаходиться у циклічному процесі. Визначено, що найпоширенішими методами використання побічної продукції сільського господарства, а саме рослинної біомаси та гною тварин є: отримання добрив, отримання біогазу та біометану та використання енергопродукту як біопалива у котельних топках. Запропоновано оптимальну технологічну схему та рецептуру завантаження біогазогенераторної установки сумішшю відходів сільського господарства. Визначено графічні параметри та розміри ємності реактора біогазогенератора складної форми. Визначено кількість матеріалів для його реалізації та розташування елементів. Доведено, що для стабільного виробництва біогазу в систему, необхідно щоб ділянки циклів відповідні завершення реакції були перекриті ділянками циклів виходу біогазогенератора на робочий режим. Доведено, що необхідно організувати



процес переробки, перетворення відновлюваних ресурсів, а саме відходів сільського господарства за науково-обґрунтованими методиками, які мають забезпечити не лише відповідну якість енергопродукту, а й певну енергетичну ефективність процесу. Запропонована нами технологічна схема та конструкція біогазгенератора, який складається з основного резервуару для анаеробної ферментації, завантажувальної труби, резервуару для створення гідравлічного тиску, збірника газу та газової трубки. Запропонована методика оптимізації роботи біогазгенератора може бути використана під час проектування біогазгенераторних установок для відходів сільського господарства для потреб як в великих так і малих фермерських господарств.

Ключові слова: компактний біогазовий генератор, ефективність виробництва біогазу та добрив, технологія напівбезперервної ферментації, концентрація ферментації, вуглецеве число, матеріали для виготовлення метантенка