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Research Article

APPROBATION OF A NEW BIOGAS TECHNOLOGY: EXPERIMENTS AND RESULTS

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ABSTRACT

There is currently a problem in the crop-growing branch of the republic – deficiency in mineral and qualitative organic fertilizers. This problem can be smoothed by means of production of the fertilizer out of the volume of liquid manure. That's why development of technology for utilization of cattle liquid manure ensuring not only observance of environmental safety, but also contributing to creation of energy-saving closed production with generation of mineralized organic fertilizer which allows increasing crop capacity; feeding vitamin supplement; additional energy source in the form of biogas is a relevant objective of scientific and practical interest. There are various ways and methods for processing of cattle liquid manure. However, for natural climatic conditions of Yakutia anaerobic fermentation in biogas units (BU) is the most appropriate way. But the problem is what fermentation conditions and what equipment are able to ensure maximum efficiency of the process at minimum costs, and it requires special research. The researchers are conducted on the basis of general provisions of research and development performance. The authors used theories of similitude and experimental design, methods of mathematical programming and imitational modelinge.

INTRODUCTION

Evaluating the conditions of animal breeding and crop farming in Yakutia over the last years, one should state significant negative qualitative and quantitive changes taking place in the main processes of agrarian business. Farm and private subsidiary economies mostly basing on primitive technologies and hand labor have to a great extent depleted the resources of their development which has led to the acceleration of technological degradation, reduced production potential and economic viability of the branch (Druzyanova, 1998; Agricultural sector of the Republic, 2003; Tikhonov, 1988; Report of Animal Breeding, 2013; Russian Academy of Sciences, Agriculture in the RS, 2015). The animals are currently kept in primitive buildings, facilities for animals of Yakutian type – 'khotons', which initially exclude the possibility of installing technological equipment. All the processes at the farms are performed manually. There is only a small percent of the applied equipment – milking plants (Tarkhayev,1983).

Today there is also a significant problem in the crop farming branch of the Republic – the deficiency in mineral and qualitative organic fertilizers. This problem may be smoothed through production of

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the fertilizer out of the generated volume of liquid manure. The leading Soviet scientist in the sphere of mechanization of agriculture S.V. Melnikov noted that the problem of rational use of manure as organic fertilizer for creation of the feeding base at simultaneous observance of requirements of environmental protection from the pollution by the waste of animal breeding is of an exclusive national economic significance (Melnikov, 1985).

Definitely, to our mind, return of the fertilizer into the croplands is a great result of processing of the waste and recovery of natural resources. Processing of manure in biogas units will allow avoiding those negative moments when nutritional chemicals of manure are lost at other ways of processing. Besides, the main condition of efficient use of the fertilizer will be observed – consistent distribution of semi-free-flowing biologically fermented manure along the field. The obtained ecologically friendly fertilizers completely preserve nitrogen (compared to the classical ways of compost preparation, when about 40-50% of nitrogen are lost) in ammoniac form, the most appropriate for plants.

Objective of the research. Development of scientific and technical bases for creation of energy-saving technologies of cattle liquid manure processing in the conditions of Extreme North.

There are various ways and methods for processing of cattle liquid manure. However, for natural climatic conditions of Yakutia anaerobic fermentation in biogas units (BU) is the most appropriate way. But the problem is what fermentation conditions and what equipment are able to ensure maximum efficiency of the process at minimum costs, and it requires special research. There are the following raditional materials for anaerobic fermentation: manure of animals, slaughterhouse waste, agriculture and food-industry waste, some energy crop and products (rape plant, silage etc.), dumping ground waste (Kapitonov, *et al.*, 2016).

In comparison with other kinds of waste, liquid manure has a peculiarity – stale as its component specifies narrow correlation of C: N in it, which may vary from 5:1 to 8:1 (Koriat, 1978).

According to the authors (Afanasyev, 1995; Varlamov, 1969; Gorbunov, 1988; Dokuchaev, *et al.*, 1976; Dolgov, 1984; Mineev, 2004) compared to litter manure nutritional chemicals of liquid one have greater solubility. So, nitrogen of liquid manure is soluble by more than 50%, while potassium is soluble nearly by 100%. It is important to consider the fact that phosphorus of liquid manure is better soaked into the plants, then phosphorus of mineral fertilizers. Except for three main nutrients for plants, liquid manure contains many microelements. Thus, liquid manure may be considered as complex fertilizer.

Biogas technologies are currently developed and successfully applied throughout the world. The main goal of biogas technology is waste reclamation, production of organic fertilizers, recovery of environment. Simultaneously it produces biogas – one of the kinds of alternative fuel (Mishunin, *et al.*, 1989; Movsesov, *et al.*, 1988; Muromtsev, *et al.*, 1986; Murugov, *et al.*, 1993; Yanko, *et al.*, 1978). However, with the purpose of replenishment of rapidly dwindling resources of energy carriers, the leading biogas countries regard as of paramount importance generation of the biggest volume of gas from organic wastes. That's why BUs have large methane digesters and occupy quite wide areas. Besides, in order to ensure their uninterrupted operation significant volumes of energy plant materials are procured. All of this leads to significant capital costs for construction of waste handling stations and subsequently such projects are of long-term recoupment and require state governmental subsidies.

MATERIALS AND METHODS

General methods of the experimental researches

The objective of the experimental researches is confirmation and elaboration of the developed theoretical provisions as well as compliance of the parameters and modes of functioning of the technical equipment for anaerobic reclamation of cattle liquid manure. The program of experimental researches includes collection of necessary statistical information for solution of the optimization problem, substantiation of optimal operation parameters of the BU technical means. At this, there were the following main tasks of the experimental researches:

- Verification of theoretical principles and statements defining the character and structure of the design processes;

- Estimate of adequacy of the developed models for optimization of parameters of the suggested technical solutions and experimental confirmation of their effectiveness.

Regardless of the way of presentation of the object, kind and character of its change, the main thing at optimization of systems is the choice of the most suitable solution. For solution of such complicated tasks it is necessary to apply the methods for systemic approach which is aimed at complex investigation of objects and processes. The peculiarity of the specified methods is application of system modeling and substitution for the time of analysis of real object by the model similar to it. At design of the models it is necessary to adhere to some principles, observance of which will allow obtaining adequate and precise reflection of the investigated process.

The investigations were conducted at the laboratory of alternative energy sources of the Road Transport Faculty at the Ammosov North-Eastern Federal University (Yakutia), and at the animal breeding farms of the Republic of Sakha (Yakutia).

The suggested methods on the intensification of the manure processing process in the biogas unit

Our world is the biggest methane digester. The surface layer of the earth and the ocean containing the diversity of microorganisms perform the processes of processing significantly extended in time. Thus, biogas technologies are based on complicated natural processes of organic substances biological decomposition in anaerobic (airtight) conditions under the influence of a special group of anaerobic bacteria (Unguryanu, 1988; Akhmedov, 1988; Bouls, 1987; Volevakha, *et al*., 1983). But in comparison with nature, anaerobic processes in egg-shaped methane digesters are significantly accelerated through creation of optimal conditions. The ideal conditions of anaerobic fermentation can be set in an egg-shaped methane digester, but practical implementation is slowed by high costs of manufacturing of such tanks (Baader, *et al*., 1982). In this regard still bowl-shaped methane digesters got widespread use.

We suggest applying methane digester of such form at private animal breeding farms of Yakutia. BU stable operation only requires constant temperature of the process, but not its timely uniform distribution in operating volume, that's why we suggest excluding heating equipment.

Anaerobic fermentation of cattle manure in the BU may be intensified by optimization of 4 parameters – constant temperature of the process, concentration of the fermented material, specific rate of formation of methane microorganisms, and the structure of the methane digester. Search of the ways of optimizing the BU operation is going on. One may separate two groups of the intensification methods: the group of microbiological methods and the group of constructive technological methods (Karayeva, 2013; Ivanov, *et al*., 1984).

For the conditions of Yakutia, we suggest using psychrophilous mode of cattle manure fermentation, simultaneously applying the following ways of the process intensification:

1. In the design engineering aspect – to use methane digester of small volume VM ≤1 m^3, which will allow reducing the costs, facilitating its manufacture, operation and maintenance.

2. When starting the methane digester, it is necessary to add the ferment into the fermented substrate contaminated with mesophilous methane microorganisms adapted to psychrophilous conditions (hereinafter, AMS – adapted mesophilous supplement).

AMS is suggested to be received in advance in a special stationary unit. At this, in the stationary unit at temperature 36°C comfortable conditions for generation, growth and production of mesophilous methane microorganisms are created. Hereinafter, by gradual decrease in temperature mesophylls undergone quenching and get turned to psychrophilous mode – in the end of the process the fermenting temperature reaches 10°C, and they get adapted to the psychrophilous mode. Next, the ferment with the adapted bacterial flora is put into the methane digester, while the AMS is loaded with the fresh-fermenting manure.

Fresh manure at loading into the methane digester gets into the environment containing the colony of methane microorganisms. Thus, the process of psychrophilous decomposition is intensified by supplementing of the AMS into the fermented manure, and the kinetics of anaerobic fermentation in the BU methane digester is improved.

The fresh manure loading mode is cycling. At the staring moment the operating volume of the methane digester is filled up by 2/3 by the homogenized mixture consisted of the AMS and the reclaimed fresh manure. Anaerobic conditions are created; the substrate is slowly mixed daily at the same time. After the processing is finished, the fermented manure (effluent) is loaded out of the methane digester not fully – a part of the effluent is left and serves the ferment for the further BU staring.

RESULTS AND DISCUSSION

Parameters of the manure reclamation process in mesophilous and psychrophilous modes

Methane digesters were installed directly in a cattle facility. Average temperature in the facility was equal to 12°C.

Preparation of the fermenting substrate with humidity equal to 93% – the mixture of fresh manure with water – was conducted as follows:

Using the standard technology, the humidity of the native manure was defined. In our case it is equal to 86 – 87 %.

We defined the necessary volume of water for dilution of fresh manure on the basis of Table 1 (Guzhilev, *et al*., 2006):

Thus, at humidity of fresh manure equal to 86% for obtaining of the substrate with humidity 93% it is necessary to homogenize 35.2 kg of manure with 52.8 l of 60°C water.

After homogenization the substrate temperature is in average equal to 40°C to 45°C (Gridnev, 1982; Kovalenko, 1984).

At temperature 60°C heat capacity of the substrate with humidity 93% will be as follows: c_{SUB} = 4080 J/(kg·K), while the consumed volume of heat Q_{SUB} =172.1 MJ, which is equal to consumption of electrical energy 47,8 kW·h.

Thus, at the initial stage of the starting in mesophilous mode it will not require additional heating, while in psychrophilous mode temperature 40°C to 45°C will allow intensifying the process of development of anaerobic methane microorganisms.

Fig. 1 represents the graph illustrating the results of the experiments – releases of biogas in mesophilous and psychrophilous modes of operation of a cycling BU.

In mesophilous mode general volume the produced gas is equal to 17.308 m^3, which is 1.7 times more than in psychrophilous mode (Table 2). If to take the cost of 1 m^3 of biogas as the same cost of 1 m^3 of natural gas, i.e. 6.13 RUR, then in mesophilous mode biogas with the cost of 106.09 RUR was obtained. However, for support of operating temperature 36°C the heating of the substrate required 1191.2 kW of electrical energy. At cost of 1 kW = 3, 12 RUR for the rural regions of Yakutia, the expenses were equal to 3716.54 RUR.

1 – mesophilous mode (36°C): 2 – daily consumption of electrical energy in mesophilous mode, Q_{EL} (kW); 3 – psychrophilous mode (12°C); 4 – daily consumption of electrical energy in psychrophilous mode, Q_{EL} (kW)

In psychrophilous mode release of biogas is equal to 10.264 m^3, which corresponds to 62.91 RUR. As the expenses for heating the substrate one may take mixing of fresh manure with warm water which results in the fact that the fresh substrate prepared and loaded into the methane digester at the beginning of the process had temperature 40°C to 45°C. Thus, heat expenses in this mode are equal to the consumption of electrical energy 47.8 kW·h.

Increase in the time of soaking the fermenting

Table 1. Number of water per 10 kg of initial biomass, in liters

Necessary humidity, %	Initial humidity, %					
	65	70	75	80	85	90
86	15.0	11.4	7.8	4.3	0.71	-
90	25.0	20.0	15.0	10.0	5.0	-
92	33.8	27.5	21.3	15.0	8.75	2.5
94	48.3	40	31.7	23.3	15.0	6.7

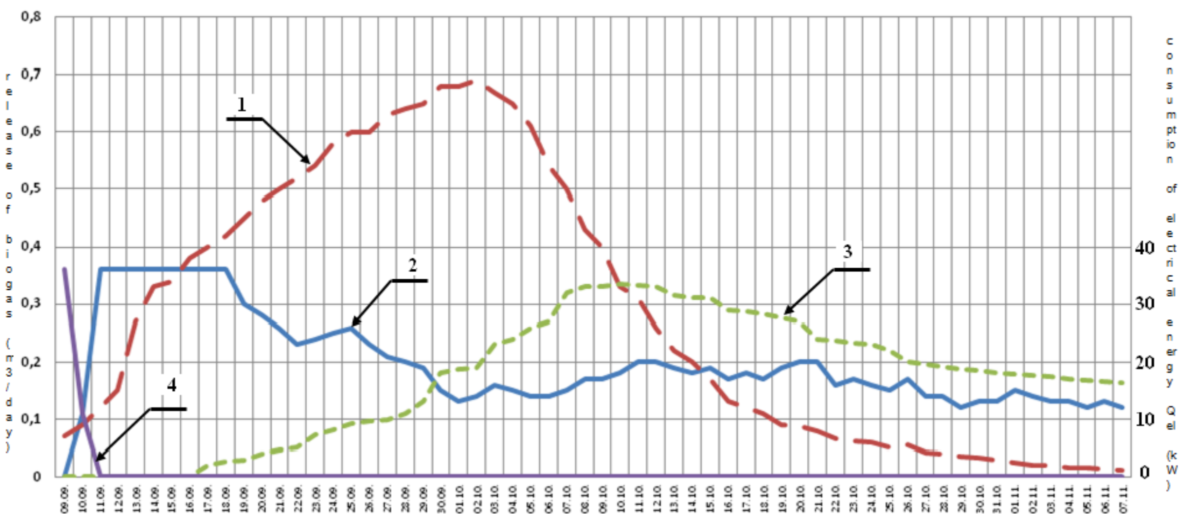

Fig. 1 Daily release of biogas at BU cycling operation.

substrate in the methane digester finally leads to obtaining the same volume of biogas of the same composition; at this, high temperatures contribute only to accelerating the decomposition process.

In our researches at 60 days of soaking of the substrate in mesophilous mode (36°C) the process of decomposition of the dry substance (DS) almost reached the maximum. It is evidenced by a rather high degree of decomposition of the DS – 42.4% and minimum release of the biogas at the end of fermentation – it was equal to 0.011 m^3/day.

In comparison with the completed mesophilous mode, the process in psychrophilous mode by the 60^{th} day only reached to the phase of destruction of the culture (Fig. 2). Release of biogas was equal to 0.164 m^3/day, which is by almost 15 times higher than in mesophilous mode.

The obtained results allowed making the following conclusions:

BU in mesophilous mode (36°C), set in the cattle facility with air temperature 12°C is energy-consuming and financially ineffective. For 60 days of operation the expenses were amounted for 3759.59 RUR.

In psychrophilous mode one may achieve optimal decomposition of organic substance of the fermenting manure, i.e. obtaining qualitative fertilizer in the following cases:

- increasing time of soaking the substrate in the methane digester;

- intensifying the process in the way in order to have optimal concentration of methane microorganisms in the methane digester at the moment of the BU starting.

Kinetic curve of growth of the methane microorganisms (Fig. 2) is of a complicated nature (Barotfi, *et al.*, 1988; Korablev, 1988):

Assessment of the biogas unit operation at application of the adapted mesophilous supplement into the processing substrate in psychrophilous cycling mode

As a result of comparison of formation rate and final release of biogas the fourth experiment shows the best results.

In the first experiment biogas was produced in 8 days after loading. In 21 days it qualitatively kept the process of burning which evidences formation inside of the methane digester of stable mode of anaerobic fermentation. Since this moment during 10 days the volume of fuel gas was increasing. Within 31 days 3.81 m^3 of biogas was produced, an average outlet was equal to 0.12 m^3. Since the 32^{nd} day of stable operation the release of the biogas decreases, but not stops, and finally it is equal to 0.26 m^3/day. Within 45 days of the methane digester operation the biogas volume amounted to 8.47 m^3 and in average it was equal to 0.19 m^3/day.

Table 2. Scheme of the conducted experiments and the volumes of the obtained biogases

p/p	The volume of the adapted mesophilous supplement (AMS), kg	Volume of fresh manure loaded into the methane digester, kg	Calendar period	Release of biogas, m^3
1	13	127	From 25.11.2013 to 09.01.2014 (45 days)	8.471
2	26	114		10.643
3	39	101		10.904
4	52	88		11.889

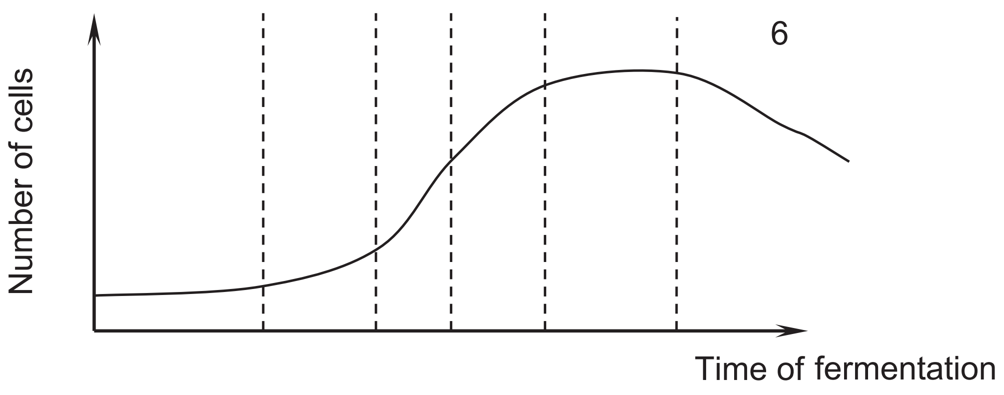

Fig 2 Kinetic curve of growth of the methane microorganisms' population: 1 – Induction period (lag-phase); 2 – Phase of exponential growth; 3 – Phase of linear growth; 4 – Phase of growth declining; 5 – Stationary phase; 6 – Phase of destruction of the culture.

The second experiment shows that biogas was produced in 7 days after loading the substrate. In 17 days, the biogas burns well. From this day, the volume of the fuel gas is increasing during 14 days and is equal to 0.19 m^3/day. Since the 32nd day the volume of biogas starts decreasing and it reaches 0.081 m^3/day in 45 days. Total release of the biogas is equal to 10.64 m^3. Average volume of biogas in this experiment is equal to 0.23 m^3/day.

In the third experiment biogas was produced in 6 days after loading of the substrate into the methane digester (Fig. 3). In 13 days the gas burns stably. From this moment volume of the biogas is increasing during 28 days and average release of biogas is equal to 0.23 m^3/day. Since the 29th day the volume of biogas starts decreasing, but does not stop releasing. In the end of the experiment daily release of biogas is equal to 0.062 m^3/day. Total release of biogas is equal to 10.904 m^3. Average release of biogas in this experiment amounts to 0.24 m^3/day.

In the fourth experiment biogas was produced in 5 days. In 9 days it keeps stably burning. The volume of gas increases in 16 days from 0.141 m^3/day to 0.6 m^3/day. And average release of biogas is equal to 0.27 m^3/day. Since the 25th day of operation daily release starts gradually decreasing and in 45 days it is equal to 0.015 m^3/day. Total release of biogas is equal to 11.889 m^3. Average daily release in this experiment amounts to 0.26 m^3/day.

Volume of the added AMS accelerates anaerobic processing of the fermented manure in direct ratio, which is shown by production of biogas in BU. In comparison with the first experiment in the subsequent experiments the following results in accelerating the gas production rate are obtained: in the second experiment – by 1.6 times; in the third experiment – by 1.8 times; in the fourth experiment – by 2.2 times.

The better the process is running, the more biogas is being produced. In the volume of the obtained biogas there are the following correlations in comparison with the first experiment: in the second experiment volume of biogas increases by 25.6 %; in the third experiment – by 28.7%; in the fourth experiment – by 40.3 %.

In comparison with the other experiments in the end of the 45the day in the first experiment daily release of biogas was equal to 0.269 m^3/day against 0.081; 0.062 and 0.015 m^3/day respectively. It shows that in the first experiment there is an amount of unprocessed substrate and the activities of anaerobic microorganisms are still in process. Such volume of biogas release in the second, third and fourth experiments is obtained in 19, 17 and 14 days.

The parameter, defining quality and completeness of the manure anaerobic reclamation is the degree of decomposition of the dry organic substance. In the fourth experiment the degree of decomposition of the dry substance (DS) is equal to 40.3%, which is a rather good result.

In our researches the biggest release of biogas was obtained in the 4th experiment and is equal to 11.889 m^3 or 0.26 m^3/day within 45 day of soaking. It is accepted that if the daily release of biogas decreases

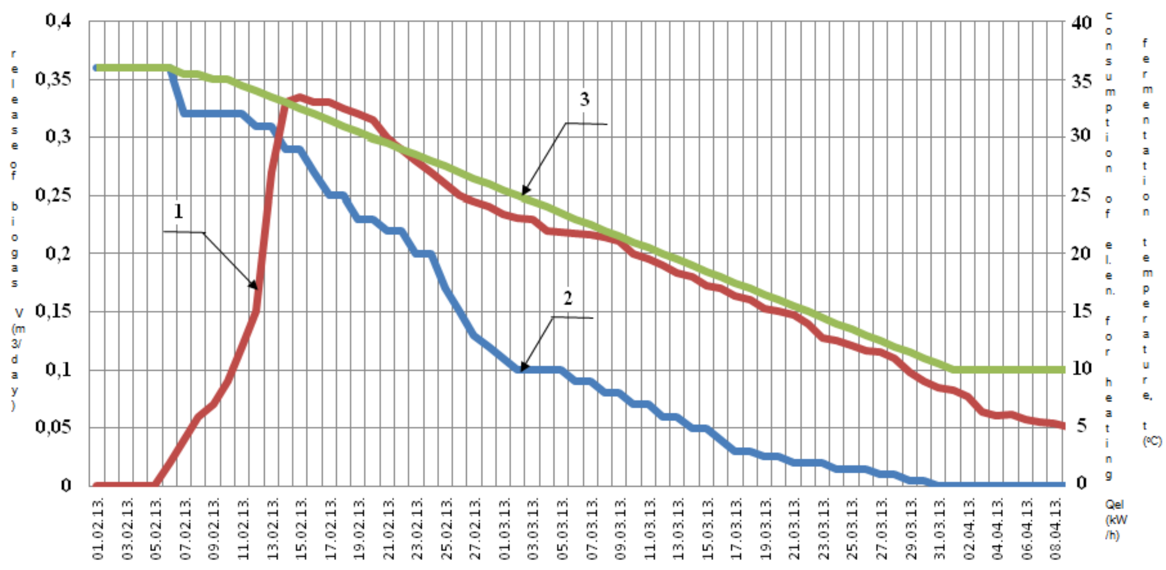

Fig. 3 The results of the experiment on adaptation of mesophilous methanogenic bacteria to the psychrophilous conditions in the BU methane digester: 1 – Release of biogas, V_B, m^3/day; 2 – Consumption of electrical energy for heating the fermenting substrate, Q_{el}, kW/day; 3 – Temperature of fermentation in methane digester, t_{ferm}, °C.

in its volume by less than 50% of the methane digester capacity, than the process of anaerobic fermentation is stopped (Table 3).

In this case methane digester has the capacity of 0.7 m^3, so, at achieving 0.35 m^3/day the BU operation should be stopped. At this, in the methane digester 50 kg should remain as the AMS for the next starting.

In 31 days, i.e. on December, 29 2013 in the fourth experience the release of biogas amounted to 0.354 m^3/day. Thus, in 30-31 days the process of anaerobic manure reclamation should be stopped. Total release of biogas over the period of 31 is equal to 10.220 m^3, which corresponds to 0.329 m^3/day (Table 4):

Thus, effective period of the reclaimed manure soaking in the methane digester of 0.7 m^3 capacity at adding 52 kg of adapted AMS is within 30…32 days.

Adaptation of mesophilous methanogenic bacteria to psychrophilous conditions in the BU methane digester

The process of adaptation of mesophilous methanogenic bacteria in the BU methane digester obtained at 36°C to psychrophilous temperature mode of 10°C required 60 days, i.e. 2 months.

In 6 days after starting the methane digester in mesophilous mode (36°C) biogas is produced in the BU. In 8 days the gas burns stably. From this day we begin to decrease the temperature by 0.5°C daily. At decreasing the temperature from 36°C to 32.5°C release of the gas increases, which shows formation for the mesophilous microorganisms of comfortable conditions of production in methane digester. In his work Baader writes that at 33°C favorable environment for the highest metabolic activity of mesophilous microorganisms is created (Baader, *et al.*, 1982).

Sensitive to the decrease appears to be temperature range from 30°C to 25°C – the transfer phase from mesophilous to psychrophilous mode. Next, with the decrease of the temperature the methane generation process became stable.

The process is not finished here, it requires to be run to the moment when the biogas release becomes minimum and amounts to 0.015 m^3/day.

Table 3. The results of the experiments at addition into the fresh fermenting substrate of AMS in the cycling psychrophilous mode of BU operation

p/p of experiment	Weight of adapted ferment, kg	Humidity of adapted ferment, %	Weight of loaded fresh manure, kg	Humidity of fresh manure, %	Ash-content of fresh manure, %	Temperature of fermentation, °C	Period of fermentation, days	The period of days after biogas is produced	The period of days after fuel biogas is produced	Total release of biogas, m^3	Daily release of biogas, m^3/day	Daily volume of biogas in the end of the experiment, m^3/day	Decomposition degree of dry organic substance, %
1	13	92…93	127	92…93	18,2	9…11	45	8	21	8.471	0.19	0.26	22.3
2	26		114		18,2			7	17	10.643	0.23	0.081	31.1
3	39		101		18,2			6	13	10.904	0.24	0.062	36.7
4	52		88		18,2			5	9	11.889	0.26	0.015	40.3

Table 4. Analysis according to the results of the 4th experiment

	Criterion	Value
1	Capacity of methane digester, m^3	0.7
2	Volume of the loaded fresh manure, kg	88
3	Volume of the loaded adapted AMS, kg	52
4	Period of the substrate soaking in the methane digester, day	45
5	Total release of biogas, m^3	11.889
6	Daily release of biogas, m^3/day	0.260
7	Period of achieving the daily volume of biogas (V_{g-50m}), equal to 50% of the methane digester capacity, day	31
8	Release of biogas (V_{g-30}), m^3	10.220
9	Daily release of biogas (V_{g-30}), m^3/day	0.329

At such daily volume of gas the degree of the DS decomposition achieves necessary 40%.

Total release of biogas is equal to 11,038 m^3. If to assess it by the cost of natural gas (1 m^3 = 6.13 RUR), then the cost of the obtained gas is equal to 67.66 RUR. The support of the temperature of fermentation required 909.50 kW of electrical energy (1 kW = 3. 12 RUR), which amounts to 2837.64 RUR. Thus, the costs were equal to 2769.98 RUR.

CONCLUSIONS

1. We developed the method for adaptation of mesophilous methanogenic bacteria (36°C) to psychrophilous conditions (10°C). In the created stationary unit mesophilous methanogens gradually transfer into psychrophilous fermentation environment with temperature 10°C, become resistant to temperature drop. The obtained substrate with the adapted mesophilous bacteria (AMS) is applied for starting of the BU in psychrophilous cycling mode. Thus, fresh manure is loaded into the methane digester containing active methanogenic bacteria which begin at once processing the organic substrate turning the biomass into the mineralized organic fertilizer.

Application of AMS accelerates biochemical methanogenic processes in psychrophilous mode and allows faster processing fresh manure – effective period of fermentation τ decreases from 40 days to 24 days. Acceleration contributes to the quality of the produced fertilizer, which is confirmed by increase in the following parameters:

- Volume of produced biogas by 1.6 times;

- Degree of decomposition of dry organic substance of the proclaimed manure equal to 40.3%.

2. Application of AMS not only reduces lag-phase and activates rapid growth of methanogens in a methane digester, but also reduces stationary phase of their development. Specific rate of growth of methanogenic microorganisms μ at pouring into the substrate of 52 l AMS is equal to 1/4 day-1, which is faster than usual process by 2.5 times. Specific rate of the biomass metabolism increases by 3.4 times and is equal to 1/5 day-1 in comparison with the experiment without AMS application. Application of the adapted mesophilous supplement in the methanogenic technology is a promising and effective way for improvement of kinetics and dynamics of psychrophilous cycling BU operation mode. The process of qualitative organic fertilizer production becomes more effective.

3. Based on theoretical and experimental researches the values of the following optimal factors are substantiated, which influence:

- Production of fertilizer: manure humidity W within 89% to 93%; period of the substrate soaking τ = 24…26 days; volume of methane digester VM = 0, 2…1.4 m^3;

- Production of biogas: quantity of dry substance S = 1…11%; fermentation temperature t with p=8…40°C; mixer capacity Nmix=1,4…3,8 kW.

4. We developed energy-saving technology of production of cattle manure fertilizer for application in individual farms located in remote settlements of Republic of Sakha (Yakutia). In comparison with the wide-spread mesophilous fermentation mode the new technology has the following advantages:

- Effectively operates at the animal facility temperature from 10°C, which is caused by stability of the applied adapted mesophilous bacteria to the temperature drops;

- Methane digester capacity VM = 0.2…1.4 m^3 allows reducing the costs and simplifying the technology of manufacturing, starting, operation, maintenance and repair of BU;

- Small methane digester provides the opportunity to significantly expand the BU capacities on the basis of module integration of methane digesters.

5. We substantiated the affluent quality. It is applied not only as fertilizer for crop, but also as a feeding vitamin supplement. The cattle affluent contains great diversity of nutrients necessary for balancing the diets not only by the content of protein, but also in mineral substances and B vitamins. A special interest is provoked by the content of such elements as selenium and E vitamin which belong to the category of antioxidants. Apart from the main nutrients there are 7 necessary microelements, 6 vitamins. In this regard we suggest the following: the line of the dietary supplement production from the BU affluent; addition of the affluent dose into the diet of laying hens and breeding-pigs.

Integration of biogas units into the peasant farm enterprise of Yakutia provide an opportunity to obtain in average 4659 t of mineralized organic fertilizer and 652 000 m^3 of biogas per day. The volume of the monetary funds resulted from realization of organic fertilizers is equal to 3.2 mln RUR.

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