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Ways To Improve The Process Of Anaerobic Fermentation The Bird Dung.

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ABSTRACT

An analysis of the anaerobic fermentation process, in particular, bird dung, is presented. It has been established that temperature effects in the fermented volume of the bioreactor have the greatest influence on the process of biogas formation. The presence of a temperature gradient causes a non-uniform temperature field in the volume of the fermented bioreactor. The main temperature change of the fermentation medium is formed in the layer near the surface of the coolant, which is called the thermal boundary layer. The intensity of the process of methanogenesis is determined by the laws governing the distribution of heat in the fermented medium. Therefore, the choice of the form of a bioreactor, for anaerobic fermentation of bird dung, is in conjunction with the choice of a heating and mixing device.

Keywords: bird dung, anaerobic fermentation process, fermentation modes, fermentation volume, thermal boundary layer.

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INTRODUCTION

The main attention in the design of biogas plants is paid to technological elements, which in one way or another influence the parameters of the biogas production process. Such technological elements include the processes of heating and mixing. Their effective use contributes to the creation of a homogeneous fermentation medium, both in temperature and in nutrient concentration, prevents the formation of a crust on the surface and a thick sediment at the bottom. As a result, the best living conditions of bacteria are provided. Identification of the most significant factor will allow to further clarify the mechanism of its action and find ways to intensify the process of methanogenesis.

Methane fermentation is a complex multistage process carried out by the natural microbial community under anaerobic conditions, the end result of which is the formation of a mixture of methane and carbon dioxide (biogas). Fermentation occurs in three stages [1, 2, 3, 4, 5]. At the first stage, in the process of biochemical cleavage (hydrolysis), the high molecular weight decomposition into low molecular weight compounds occurs first. At the second stage, with the participation of acid-forming bacteria, further decomposition of low molecular weight compounds occurs with the formation of organic acids, their salts, alcohols and other components. The final transformation of organic matter takes place at the third stage of the process with the participation of methane-forming bacteria. These reactions proceed simultaneously, and the methane-forming bacteria make much higher demands on the conditions of their existence than acid-forming [6]. The basis of these reactions, ultimately, are controlled biochemical processes of transformation of substances both inside the body and outside it. Complex biochemical transformations provide the required amount of waste products of bacteria, the output of which depends on the speed of the process.

MATERIALS AND METHODS

In general, the performance of the methane fermentation process is characterized by a change over time of an increasing amount of the final product - biogas. The mathematical description of the performance of the process (U) is [7]

$$U = \frac{dG}{d\tau}, \qquad (1)$$

G – current product quantities;

t – process duration.

Equation (1) characterizes the type of process but does not reflect the technological characteristics. Therefore, for calculations most often apply the general equation of the speed of the process, expressed through the degree of transformation of the basic substance

$$U = k \cdot \Delta C, \qquad (2)$$

k – process rate constant;

Δ*C* – process driving force.

Process driving force Δ*C* for homogeneous reactions is determined by the concentration of the substance consumed in the limiting reaction. The current concentration of this substance depends on the concentration of organic substances (OS) in the fermentation medium [2].

In industrial conditions of the process of methane fermentation, the concentration of organic matter in poultry manure is a constant value and depends on the technology of poultry. Therefore, the performance of the methanogenesis process is determined by the process constant *k*.

The process rate constant expresses the dependence of the process speed on its physical characteristics. For processes occurring in the kinetic region, namely, this is the process of methanogenesis, this dependence is expressed by the Arrhenius equation

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$$k = k_0 \cdot \exp\left(-\frac{E}{RT}\right), \quad (3)$$

k_0 – pre exponential factor;
E – activation energy, j / mol;
K – molar constant, J / (mol · hail);
T – temperature, K.

RESULTS AND DISCUSSION

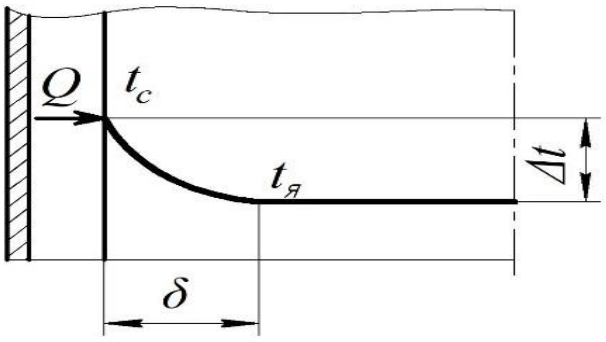
Analysis of equation (3) shows that the metabolic activity and reproductive ability of bacteria of the methanogenic association are in functional dependence on temperature.

The work of GD is devoted to the study of the influence of temperature on the process of gas formation and the identification of the most effective temperature limits of fermentation. Ananiashvili, V. Baader, N.A. Barker, S. Bushfield, N.D. Jerusalem, D.R. Chen, A.G. Hashimoto [1, 8, 9, 10, 11] and others. Usually, there are three temperature intervals in the life of bacteria: psychrophilic, mesophilic, and thermophilic. The optimal value of temperature ranges depends on the qualitative composition of the fermented raw materials and the type of animals. For psychrophilic bacteria, the optimal temperature level is up to 20 ° C; Mesophilic bacteria function normally at a temperature of 30 ... 35 ° C [1, 12]. The optimum temperature level for thermophilic strains is, according to [3, 4] 43 ... 55 ° C, but not higher than 60 ° C.

The most unstable temperature regime is thermophilic. Temperature fluctuations, especially its sharp drops, have a negative impact on the rate of biogas production in this mode. The work of M. Brynt, S. Bushfield, V.Kh. Varela, A.V. Fisher, I.B. Krepisa [3, 5, 13]. All of them note that even minor temperature fluctuations (3 ... 4 degrees) dramatically affect the intensity of the methanogenesis process. Many researchers believe that the permissible fluctuation (unevenness) of the temperature at 53 ... 55 ° C is ± 1 degree [9, 14].

Consequently, the temperature range of the existence of protein structures of bacteria cells of the methanogenic association is very small and with increasing or decreasing temperature even by 2 degrees, time is needed to adapt them to new temperature conditions, which ultimately results in a decrease in the productivity of the process.

In practice, as is well known, it is not possible to create a uniform temperature field in the fermentation medium not only because of the inconsistency between the methods and systems of heating, but also the features of heat transfer in it. The fermentation of the raw material in the bioreactor is heated through the wall of the heating device, which is similar to the phenomenon of heat exchange between the liquid (in this case, the fermentation medium) and the solid surface (heat carrier wall) (Figure 1) [7, 15].



Q - heat flow; t_s is the temperature of the fermentation medium at the wall; t_r is the core temperature of the fermentation medium; Δt is the temperature difference; δ - thermal boundary layer

Figure 1: Diagram the process of heat exchange between the fermentation medium and the surface of the coolant in the bioreactor

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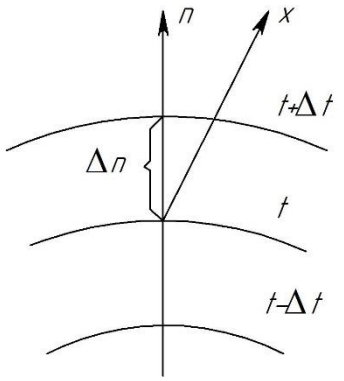
The peculiarity of this process is that the transfer of heat in the fermentation medium is carried out not only by the simultaneous action of heat conduction and convection but also due to its movement resulting from the release of biogas. Their cumulative action is called convective heat transfer or heat transfer.

The internal mechanism of the heat transfer phenomenon is explained on the basis of molecular-kinetic concepts: energy transfer occurs due to thermal movement and energy interaction between the microparticles that make up the fermentation medium. The thermal state of individual particles in it is different and in this case, the temperature t is a function of the x and y coordinates for the steady-state process:

$$t = f(x, y). \qquad (4)$$

The same temperature points in the fermentation medium form isothermal surfaces that do not intersect with each other (Figure 2).



***t + Δt; t;t; t – Δt* – isotherms; *n* – normal**

Figure 2: Isothermal surfaces of the fermented medium in the bioreactor

In this case, the temperature change in the fermented medium is observed in the directions crossing the isothermal surfaces. Moreover, a sharp change occurs in the direction of the normal n to the surfaces.

The limit of the ratio of temperature change Δt to the distance between isotherms Δn is the temperature gradient:

$$\lim_{n\to\infty}\left(\frac{\Delta t}{\Delta n}\right) = \frac{dt}{dn} = gradt\,. \qquad (5)$$

The presence of a temperature gradient causes a non-uniform temperature in the fermentation medium. The formation of temperature inhomogeneity in it occurs near the surface of the coolant. A layer (δ) is formed within which the main change in the temperature of the fermented medium occurs from a value equal to the temperature of the coolant surface t_s to the core temperature of the fermented medium t_r. This layer is called the thermal boundary layer.

For the area inside the thermal boundary layer, the condition:

$$\frac{dt}{dn} \neq 0, \qquad t_s \neq t_r,$$

on the outer border and outside

$$\frac{dt}{dn} = 0, \qquad t_s = t_r.$$

With a non-uniform temperature field in the fermented volume, the rate of methanogenesis will consist of the speeds of the process at points of the fermented medium with different temperatures. The difference in temperature at these points from the optimal value significantly reduces the microbiological activity of methane bacteria, and hence the overall rate of methanogenesis.

CONCLUSION

Consequently, the intensity of the process of methanogenesis is determined by the laws governing the distribution of heat in the fermented medium.

Based on the above, we can conclude that the choice of the bioreactor form, in which the process of anaerobic fermentation of bird dung will be implemented, is in conjunction with the choice of heating and mixing devices. Optimization of them will allow to create the optimal temperature regime of anaerobic fermentation in order to intensify the process of methanogenesis.

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