DOI: 10.32782/2220-8674-2024-24-2-4
UDC 637.143

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IMPROVEMENT OF THE HOMOGENIZER HEAD DESIGN

Summary. An analysis of the equipment used for the homogenization of milk raw materials was carried out. Technologies for obtaining homogenized milk are considered. Disadvantages of existing technological processes have been identified. The areas of improvement of homogenization processes are defined and the need for the development of equipment for their implementation is substantiated. The research methods of the homogenization process are substantiated, a description of the studied raw materials is given, and the design of the homogenizer head is proposed. The influence of the geometric parameters of the modernized homogenizer head on the efficiency of the homogenization process was determined, and the optimal parameters were determined experimentally. As a result of the conducted research, it can be concluded that the homogenization process is very important for the production of pharmaceutical emulsions. The calculation and modeling of the homogenizing head of the valve homogenizer was carried out. In order to carry out two-stage homogenization, it was proposed to modernize the homogenizing head. the previous design is inferior to the modernized one in terms of homogenization of food liquids

Key words: homogenization, milk raw materials, fat balls, nozzle diameter, homogenizer head, preparation of raw materials, piston stroke, viscosity of emulsions, density of emulsions.

Formulation of the problem. The yogurt production process is now almost fully automated, thanks to modern equipment. For this, you will need a technological line, which includes a pump, a two-layer tank made of food-grade stainless steel and equipped with a frame-type device, a normalizer, a homogenizer, and a separator for separating cream.

The technological process of yogurt production by the tank method consists of the following operations: reception and preparation of raw materials and materials, normalization of fat and dry substances, cleaning, homogenization of the mixture, pasteurization, cooling, fermentation, introduction of fillers and dyes, fermentation, mixing, cooling, bottling, packaging, labeling and storage [1].

Milk, selected for quality, is normalized according to the mass fraction of fat and dry matter. For fat, milk is normalized either in the flow, using a separator - normalizer, or by adding whole milk or cream to skimmed milk [2]. In terms of solids, milk is normalized by adding milk powder, which is reconstituted in accordance with current regulatory documentation [3]. In addition, normalization of dry matter is carried out by evaporating pasteurized and homogenized milk at a temperature of 55-60 °C.

In the production of sweet yogurt, normalized milk is heated to 43 ± 2 ° C, sugar, previously dissolved in part of normalized milk at the same temperature in a ratio of 1:4, is added [4]. The mixture is purified on separators - milk purifiers, homogenized at a pressure of 15 ± 2.5 MPa and temperature of 45-85 ° C.

The end of fermentation is determined by the formation of a strong clot. The curd is cooled for 10-30 minutes and mixed in order to obtain a uniform consistency of the milk curd and to avoid whey separation [5]. The curd, cooled to 16-20 ° C, is sent for bottling, packaging, labeling and re-cooling in refrigerating chambers to a temperature of 4 ± 2 ° C. After that, the technological process is considered complete, the product is ready for sale [6].

Valve-type homogenizers are the main devices for homogenization of liquid food products. In them, the product is homogenized at different temperatures and different pressures, depending on the production technology [7]. All valve homogenizers have a similar design. The main unit is the homogenizing head, in which homogenization takes place [8]. The quality of the process depends on the operation of such elements as the seat and the valve. If one of these elements is damaged, the quality of homogenization deteriorates significantly [9].

Homogenization of liquid products by pushing them through the valve gap of the homogenizing head of the machine received the greatest distribution in the processing industry [10].

Analysis of recent research and publications. Two-stage homogenization is used in industry. The working pressure in the injection chamber is equal to the sum of both differences. The use of two-stage homogenization is due to the fact that in many emulsions, after homogenization of the first stage, there is agglomeration of dispersed particles at the exit, which worsen the dispersion effect [11].

The task of the second stage consists in fragmentation and dispersal of such relatively unstable formations [12].

This requires not a very large mechanical action, therefore the pressure drop in the second stage of the homogenizer is much smaller than in the first stage, on the operation of which the degree of homogenization mainly depends [13].

The productivity of the homogenizer is regulated by the frequency of rotation of the electric motor and crankshaft with different eccentricity of the crank [14].

The main working organs of the homogenizing head are the seat and the valve, the degree of dispersion of the particles during homogenization depends on their design. The valve gap can be smooth or wavy with a constant or variable cross-section. To overcome resistance when passing through a narrow gap, the product is supplied under high pressure (up to 20 MPa). The force applied when feeding the product raises the valve, and a narrow channel is formed between it and the seat through which the liquid flows. The valve remains above the seat in the floating bath, and due to the change in hydrodynamic conditions, the height of the channel is constantly changing [15].

The force with which the valve is pressed against the seat is often created by a spring, in some designs - by pressurized oil, and can be adjusted. It is determined by the pressure with which the product is supplied [16].

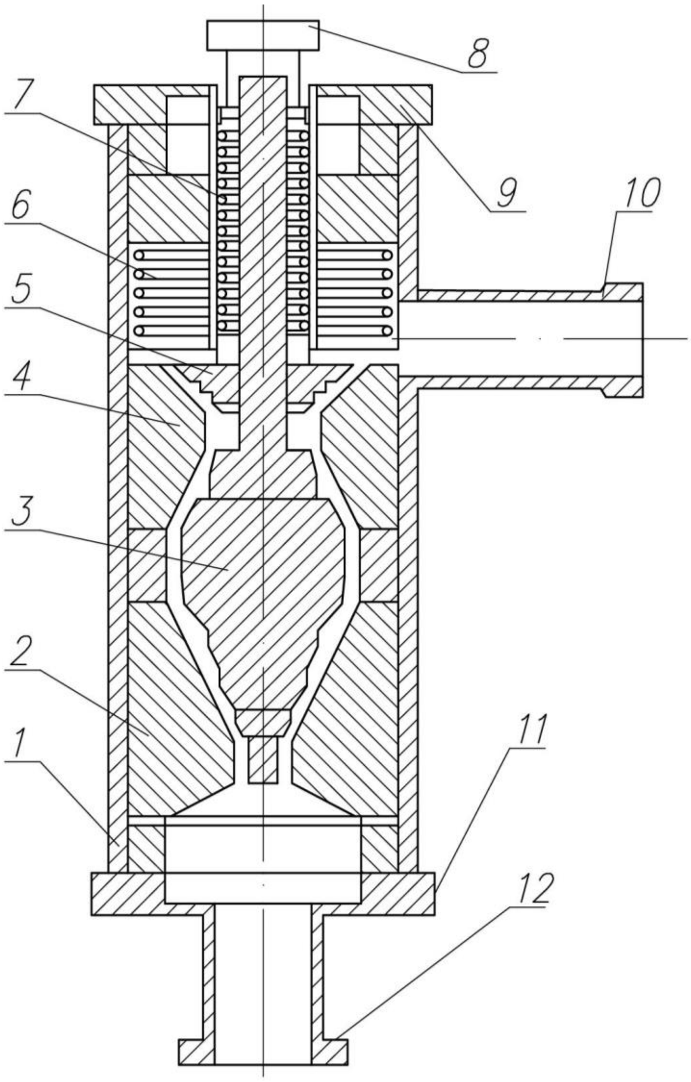
The fineness of grinding depends on the pressure, the design of the homogenizing head, the uniformity of the supply, the condition and pretreatment of the product. According to the type of homogenizing head, homogenizers can be divided into single-, two- and multi-stage. The homogenizing head is the node of the homogenizer, where the spraying of the treated medium takes place directly [17].

The two-stage head consists of a body and a valve device, the main parts of which are the valve seat and the valve. The valve is connected to the rod, the protrusion of which is pressed by a spring. The compression force of the spring is adjusted by moving the cap nut with the steering wheel, which, together with the spring, rod and cup, form a pressure device. The liquid pumped by the pump under the valve plate presses on the plate and pushes the valve away from the seat, overcoming the resistance of the spring. In the gap formed between the valve and the seat with a height of 0.05 to 2.50 mm, the liquid passes at high speed, homogenizing at the same time.

Formulation of the purpose of the article. Improving the design of the homogenizer head and determining the rational parameters of its operation.

Presentation of the main research material. The modernization of the homogenizing head consists in carrying out two-stage homogenization in one head, instead of in two, as it happened before. For this, the following construction is proposed.

This design provides for the use of a double valve. The first is a valve with an inclined and concentric groove in the horizontal plane, the second, the upper valve also has a groove. Each valve is lifted separately under fluid pressure. Valve springs have different stiffness, which allows these valves to rise separately from each other, thereby increasing the fluid pressure at the inlet. The surface of the valve has a groove that increases the degree of grinding of raw materials (Fig. 1).



1 – body; 2 – lower saddle; 3 – a valve with an inclined and concentric cut in the horizontal plane; 4 – upper saddle; 5 – upper inclined valve; 6 – upper valve spring; 7 – lower valve spring; 8 – ring; top nut; 9 – upper nut; 10 – outlet pipe; 11 – lower nut; 12 – inlet pipe

Fig. 1. Modernized homogenizing head with a double valve

The product is fed through the lower nozzle into the head, after which it creates pressure on the valve, which in turn creates pressure with the help of a spring and rises together with a large spring and a movable seat. When the product passes through the first valve gap, it enters the previous chamber. The anterior chamber fills and creates pressure on the movable saddle. The saddle rises and creates a second valve gap. After passing through two slits, the homogenized product is released for further processing.

During the research, the initial parameters remain the same as in the non-modernized head: υ = 10 m/s, emulsion density ρ = 1035 kg/m3, dynamic emulsion viscosity μ = 0.0026 Pa·s.

After the calculations, the velocity distribution and total pressure distribution were obtained.

The emulsion enters with a speed υ = 10 m/s, and gradually the speed increases because the cross-section of the working volume narrows. When the emulsion enters the valve gap, the speed becomes maximum. After that, the speed decreases in front of the second gap. In the second gap, the speed increases gradually, as the cross-section of the working volume narrows, and at the exit from the valve gap, it also reaches the maximum speed. It is established that the greatest pressure is created in front of the valve, after the valve rises under the action of pressure and the emulsion passes through the valve gap, the pressure gradually decreases.

The pressure along the movement of the emulsion changes from the largest value to the smallest. The velocity initially has a small velocity, and in the valve gap it reaches a maximum value, after which the velocity gradually decreases. The pressure changes from its highest value, after passing through the valve gap, it gradually decreases. It can be seen from the speed graph that the speed increases in the valve gap, then decreases before the second gap, increases again in the second valve gap and gradually decreases after that. To compare the speeds in both homogenizing heads, let's plot the speed lines in one graph.

From the graph, you can see how the speed of the emulsion differs before and after the modernization of the homogenizing head. Therefore, the speed of emulsion passage in the modernized head increases twice, as it passes through two valve slots. Therefore, it can be said that two-stage homogenization of the product takes place in the modernized homogenizing head. The use of two-stage homogenization is due to the fact that in many emulsions, after homogenization of the first stage, there is agglomeration of dispersed particles at the exit and the creation of "clusters", which worsen the effect of dispersion.

The task of the second stage consists in fragmentation and dispersal of such relatively unstable formations. Therefore, for better homogenization, such a homogenizing head is more convenient to use.

Determination of rational parameters of the homogenization process in order to establish the rational parameters of the homogenization process and determine the geometric dimensions of the main elements of the homogenization head, it was necessary to conduct a series of experimental studies.

At the first stage of research, it was necessary to determine the dependence of the average diameter of fat balls on the homogenization pressure and the diameter of the inlet valve. Graphic dependences of the values of the average diameter of fat globules are presented (Fig. 2). During the experimental studies, the diameter of the intake valve was changed using special nozzles. Also, the stroke of the plunger was changed with the help of a crank mechanism.

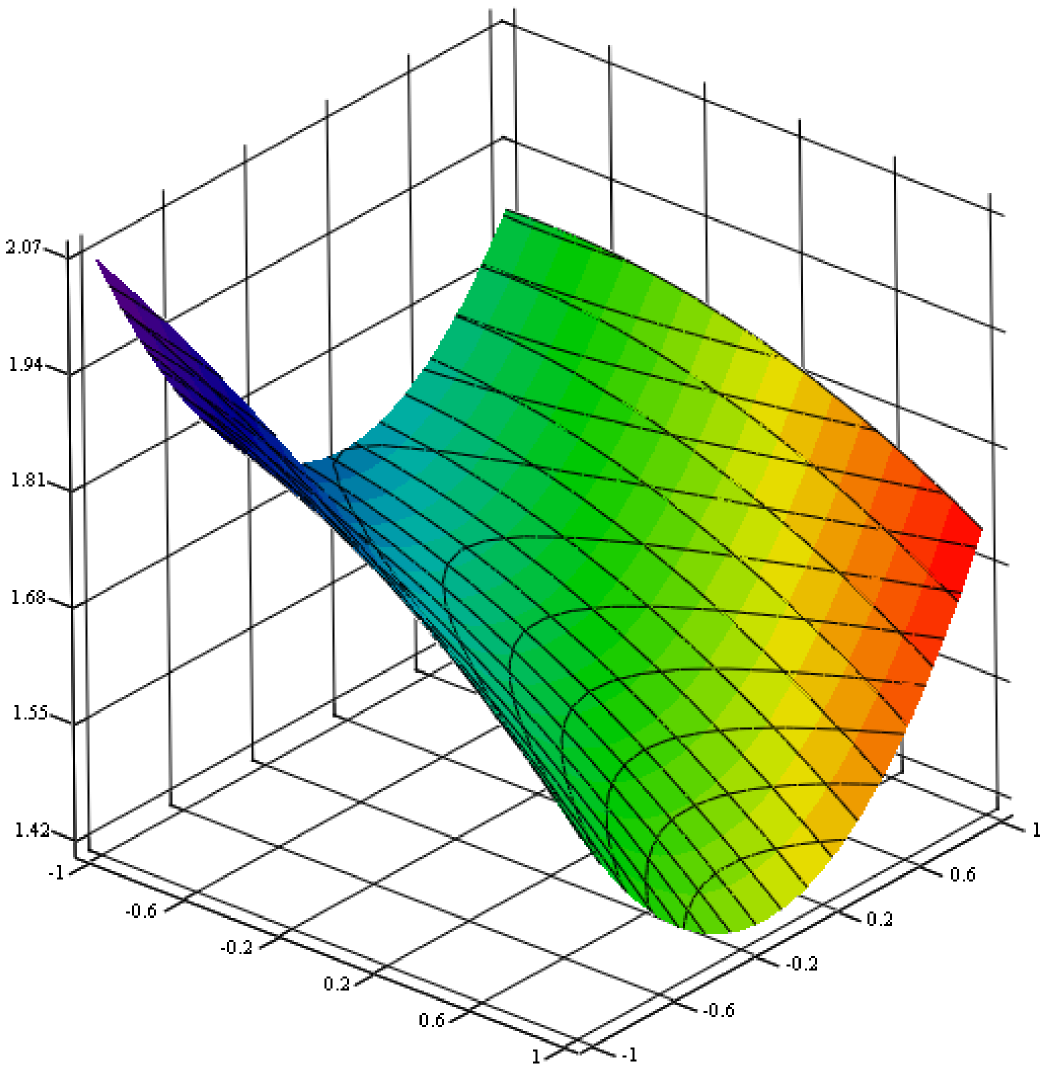


Fig. 2. Dependence of the average size of fat globules on the homogenization pressure and the diameter of the inlet valve. The stroke of the piston is 0.06 m

The conducted studies show that with increasing homogenization pressure, the average diameter of fat globules decreases. Process studies were carried out for homogenization pressure values of 8 MPa, 10 MPa, 12 MPa, and 16 MPa. Also, with the help of special nozzles, the diameter of the inlet valve of the homogenizer was changed. The values of the diameter of the inlet valve hole were: 5 mm, 10 mm, 15 mm and 20 mm.

During the experimental studies, the stroke of the plunger was changed by changing the crank mechanism. The stroke of the piston has values of 0.06 m, 0.07 m and 0.08 m.

As the diameter of the plunger stroke increased, the average diameter of fat balls decreased, which had a positive effect on the quality of dairy products. The next stage of the research was the determination of the average diameter of fat balls from the homogenization pressure, the diameter of the nozzle at the exit from the homogenizer. Figure 3 show graphic dependences of the values of the average diameter of fat globules. During the experimental studies, the homogenization pressure was changed, as well as the diameter of the outlet nozzle with the help of special nozzles. Also, as in the previous case, the stroke of the plunger was changed with the help of a crank-rod mechanism.

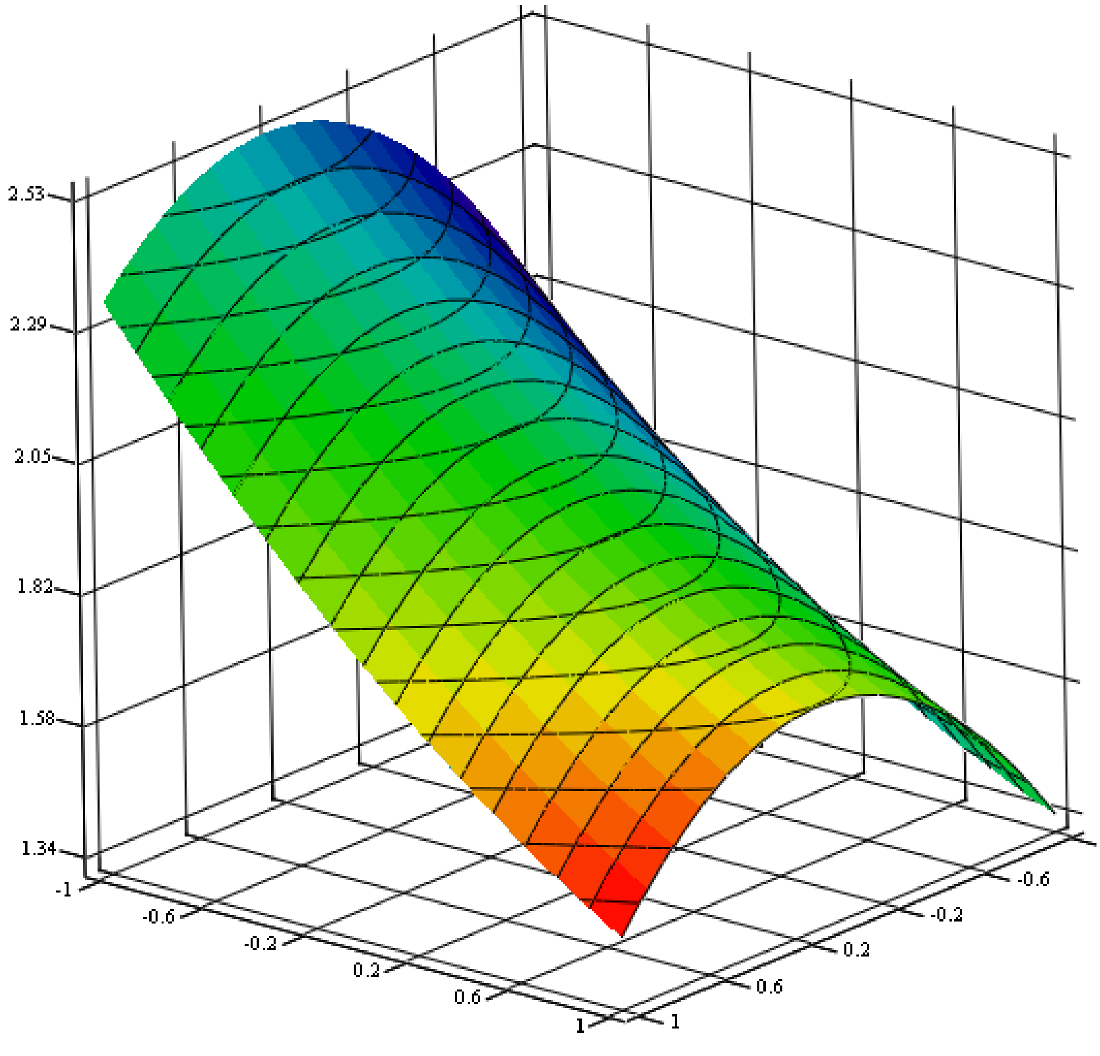


Fig. 2. Dependence of the average size of fat balls on the homogenization pressure and the diameter of the nozzle at the outlet. The stroke of the piston is 0.06 m

During the research, the diameter of the outlet nozzle was changed. Special nozzle nozzles with a diameter of 0.002 m, 0.003 m and 0.004 m were used.

As the diameter of the outlet nozzle decreased, the average diameter of fat globules decreased. Also, as in the previous case, with an increase in the stroke of the plunger, the average diameter of the fat globules also decreased.

Thus, it was established that the stroke of the piston, the diameter of the inlet nozzle, and the diameter of the outlet nozzle affect the average size of fat balls.

Conclusions. The main advantages of introducing membrane technologies into the processing process are presented. The modernization of the homogenizing head consists in carrying out two-stage homogenization in one head, instead of in two, as it happened before. For this, the following construction is proposed. This design provides for the use of a double valve. The first is a valve with an inclined and concentric groove in the horizontal plane, the second, the upper valve also has a groove. Each valve is lifted separately under fluid pressure. Valve springs have different stiffness, which allows these valves to rise separately from each other, thereby increasing the fluid pressure at the inlet. The surface of the valve has a groove that increases the degree of grinding of raw materials. As a result of the research, it can be concluded that the process of homogenization is very important during the production of dairy products. The calculation and modeling of the homogenizing head of the valve homogenizer was carried out. In order to carry out two-stage homogenization, it was proposed to modernize the homogenizing head. the previous design is inferior to the modernized one in terms of homogenization of food liquids.

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Стаття надійшла до редакції 30.09.2024 р.

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УДОСКОНАЛЕННЯ КОНСТРУКЦІЇ ГОЛОВКИ ГОМОГЕНІЗАТОРА

Анотація

Проведено аналіз обладнання, що застосовуються для гомогенізації молочної сировини. Розглянуто технології отримання гомогенізованого молока. Виявлені характерні недоліки існуючих технологічних процесів. Визначено напрями удосконалення процесів гомогенізації та обґрунтовано необхідність розробки обладнання для їх реалізації. Обґрунтовано методи дослідження процесу гомогенізації, приведено опис досліджуваної сировини та запропонована конструкції головки гомогенізатора. Визначено вплив геометричних параметрів модернізованої головки гомогенізатора на ефективність процесу гомогенізації, експериментально визначені оптимальні параметри. Встановлено, що зі зростанням тиску гомогенізації відбувається зменшення середнього діаметру жирових кульок у молоці. В якості об'єкта дослідження обрано процес

гомогенізації молочної сировини. Наведено основні переваги впровадження мембранних технологій у процес обробки.

Модернізація гомогенізуючої головки полягає в тому, щоб проводити двухступінчасту гомогенізацію в одній головці, а не в двох, як це відбувалось раніше. Для цього запропонована наступна конструкція.

В даній конструкції передбачено застосування подвійного клапан. Перший являє собою клапан з похилим і концентричним нарізом в горизонтальній площині другий, верхній клапан також має наріз. Кожен клапан підіймається окремо під тиском рідини. Пружини клапанів мають різну жорсткість, що дозволяє цим клапанам підніматися окремо один від одного, тим самим збільшуючи тиск рідини на вході. Поверхня клапану має наріз, який збільшує ступінь подрібнення сировини.

У результаті виконаних досліджень можна зробити висновок, що процес гомогенізації являється дуже важливим під час виробництва молочних продуктів. Було проведено розрахунок та моделювання гомогенізуючої головки клапанного гомогенізатора. Для того щоб проводити двоступінчату гомогенізацію було запропоновано модернізувати гомогенізуючу головку. попередня конструкція поступається модернізованій у якості гомогенізації харчових рідин.

Ключові слова: гомогенізація, молочна сировина, жирові кульки, діаметр сопла, головка гомогенізатора, підготовка сировини, хід поршня, в’язкість емульсій, густина емульсій.