UDC 637.134

# ANALYSIS AND JUSTIFICATION OF THE DESIGN IMPLEMENTATION OF THE WORKING UNIT OF A PULSATION HOMOGENIZER

Palianychka Nadiia, PhD., Assoc. Prof.,
Kovalyov Alexandr, PhD., Sen. Lect.,
Chervotkina Oleksandra, Assist.
*Dmytro Motornyi Tavria State Agrotechnological University, Zaporizhzhia, Ukraine*

***Problem statement.*** To obtain a homogeneous mixture of several components that are difficult to mix, special devices known as homogenizers are widely used. The homogenization process is applied in the agricultural, chemical, pharmaceutical, cosmetic, and processing industries. However, this technology has found its greatest application in the food industry, in particular in technological lines for milk processing and dairy production. The use of homogenization makes it possible to prevent the formation of a cream layer on the surface of milk and also contributes to improving the organoleptic properties of the finished product and increasing its digestibility.

Currently, valve-type homogenizers are predominantly used at milk processing enterprises. Although they ensure high quality of the final product, they have a significant drawback – high energy consumption of the process [1, 2]. In this regard, the issue of improving existing equipment and developing new types of homogenizers for milk emulsion, which would make it possible to achieve a high-quality product with significantly lower energy costs compared to valve-type units, is highly relevant today [3].

***Main materials.*** A review of scientific studies on this topic [4] made it possible to identify a promising type of homogenizer capable of providing a high degree of milk fat dispersion while requiring relatively low electrical energy consumption for the process. This type of equipment is a pulsation homogenizer [3].

In order to verify the validity of the proposed hypothesis, a laboratory prototype of a pulsation milk homogenizer was designed at the Dmytro Motornyi Tavria State Agrotechnological University, and a series of experimental studies of its operation was carried out (Fig. 1).

The installation includes containers for supplying milk to the homogenization unit and for collecting the processed product, a feed pump, a control valve, and a working cylindrical chamber of the pulsation homogenizer, inside which a piston with openings is located. The piston is set into reciprocating oscillatory motion by a drive consisting of an electric motor with an electronic shaft speed controller and a crank mechanism with an adjustable crank radius.

Operating principle of the device. Whole milk is supplied to tank 1, where it is preliminarily heated to the temperature required by the technological process. From this tank, the product is delivered by pump 2 to the homogenizer chamber 4 through valve 3, which serves to regulate the liquid flow rate. The electric motor, interacting with the crank mechanism, sets the rod in motion and provides reciprocating oscillations of the striker piston 5, as a result of which the milk fat phase is dispersed. After processing, the resulting milk emulsion is discharged and collected in tank 7 [3, 4].

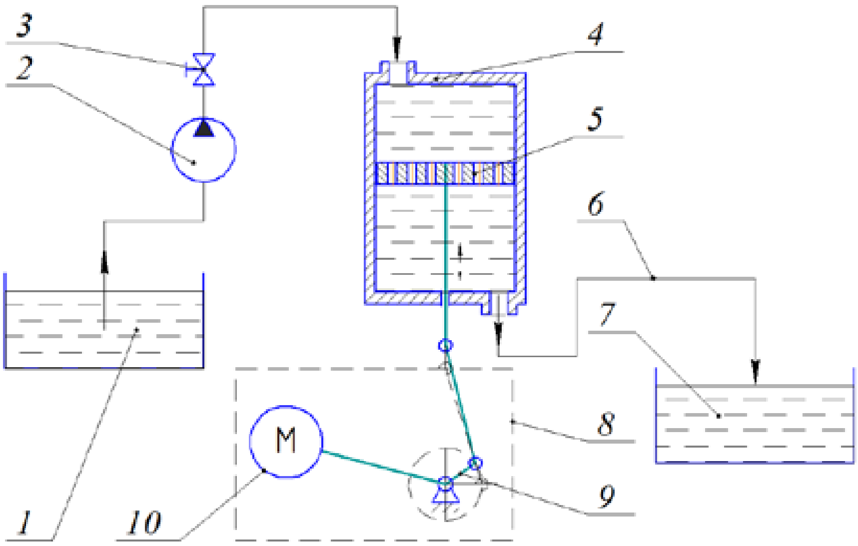


**Fig. 1. Structural diagram of the pulsation milk homogenizer:** 1, 7 – process tanks for milk supply and collection; 2 – pump; 3 – shut-off and control valve; 4 – homogenizer working chamber; 5 – piston; 6 – pipelines; 8 – working element drive; 9 – crank mechanism with adjustable oscillation amplitude; 10 – electric motor with a shaft speed controller.

Homogenization of milk fat globules in this type of homogenizer occurs due to the formation of a velocity gradient in the emulsion flow, which arises at the outlet of the striker piston openings under the action of their pulsating oscillations. As a result of this воздействие, intensive fragmentation of the milk fat phase takes place, while the process does not require significant energy input [5, 6].

One of the key factors determining the degree of dispersion is the geometric shape of the striker piston openings (Fig. 2).

Cylindrical openings. When the liquid enters the opening (Fig. 2a), the jet becomes constricted under the action of inertial forces of the fluid particles. As a result, at the outlet of the opening the flow acquires a diameter corresponding to its geometric dimensions.

With this opening geometry, an absolute pressure lower than atmospheric is formed in the region of jet contraction. As a result, the flow velocity at the outlet of the opening becomes lower than that in the constricted zone.

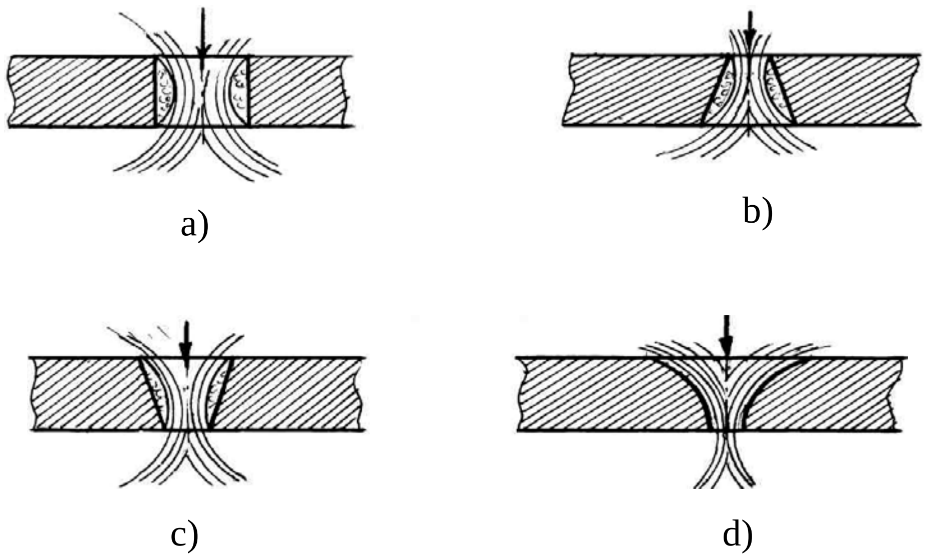

**Fig. 2. Configuration of the openings in the working piston of the pulsation milk homogenizer:**

a) cylindrical; b) inverted truncated cone; c) direct truncated cone; d) conoidal shape.

When the head exceeds a critical value, the absolute pressure in the jet constriction zone inside the opening reaches the vapor pressure level, which leads to the occurrence of cavitation phenomena.

In openings shaped as inverted and direct truncated cones (Fig. 2b, c), during jet contraction at the outlet, the vacuum formations are smaller in size compared to those in cylindrical openings. This results in lower head losses and a higher jet outflow velocity.

In openings with a conoidal configuration (Fig. 2d), i.e., shaped according to the form of a contracted jet, vacuum cavities are not formed. As a result, the discharge coefficient reaches its maximum value, while the jet velocity is slightly lower compared to the previous case.

Among the analyzed opening configurations:

– the highest milk discharge coefficient is characteristic of conoidal openings ($\mu = 0.947…0.979$, $\varepsilon = 1$, $\varphi = 0.947…0.979$) [6];

– the maximum milk flow velocity is achieved in conical openings converging at an angle of 45°, which are characterized by the following values: $\varphi = 0.983$, $\varepsilon = 0.875$, $\mu = 0.857$.

Since the milk flow velocity is the determining parameter for pulsation homogenization, it is advisable to select a conical shape of the openings with a cone angle of 45° in order to ensure its maximum value.

Experimental studies conducted to verify the proposed hypothesis showed that the laboratory prototype of the pulsation milk homogenizer provides a degree of dispersion Hm = 4…5, while the specific energy consumption is 0.82 J/kg. The obtained results confirm the high efficiency of the proposed technological equipment.

***Conclusions.*** At present, the development of energy-efficient equipment for the homogenization of milk emulsion in the production of milk and dairy products is of particular relevance. It has been established that one of the most promising solutions in this area is a pulsation milk homogenizer, the design features of which ensure a high degree of fat phase dispersion under conditions of low electrical energy consumption. According to the results of the experimental studies, it was determined that a laboratory prototype of such a homogenizer makes it possible to achieve a degree of dispersion of Hm = 4…5 at a specific energy consumption of 0.82 J/kg, which confirms the high efficiency of the proposed technological equipment.

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