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ESTABLISHMENT STRUCTURAL-TECHNOLOGICAL SCHEME OF COLLECTOR OF MILKING MACHINE

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Abstract. The design and technological scheme of the two-chamber milking machine collector with a portion air intake, which provides improved transportation of the milk mixture, has been develops. The influence of changes in the volume of the collector's milk chamber and the intensity of milk transfer on the pressure in the rate of sucking is studied. The conditions for improving the transportation of milk to the main milk pipeline with a milk hose from the milking machine collector are substantiate. The influence of the diameter of the throttle hole on the production of a given air flow in the section of the milk chamber of the collector to create the necessary pressure gradient is established.

Key words: collector of milking machine, milk/air mixture, intensity of milk output, throttle hole.

Introduction

The design parameters of milking machines and their operating modes should have a minimum effect on the change in the quality of milk. It is known that in modern milking machines the source of deterioration of milk quality is air that comes to the milk chamber of the collector through the throttle channel of the valve mechanism rod.

Formulation of problem

This is a forced conventional design solution because the intake of air into the collector is primarily needed to improve the transportation of milk to the milk pipeline due to the increase in the pressure gradient.

But when this occurs, fluctuations in the level of vacuum pressure in teat end spaces of the milking cups during the phase sucking.

A non-adapted to the modes of milking the amount of air that comes to the milk chamber, leads to the appearance of milk-air mixture in the milk hose, which worsens not only the quality of milk, but also the conditions of its transportation to the main milk pipeline.

Analysis of recent research results

Transportation of milk from the milking machine to the milk pipeline is accompany by a vacuum drop due to the intake of atmospheric air and overcoming resistance forces. The main characteristics of the suspended part of the milking machine is the diameter and length of the milk hose. The volume and design of the collector, the location and the diameter of the throttling. The works of scientists [1-8] are aimed at studying the laws of the influence of the diameter of short milk tubes, long milk hose, the volume of the collector and the air intake parameters on the mode of transportation, the health of the animal and, as a result, the quality of milk.

The flow of air into the milk collection chamber of the collector ensures its emptying during the compression phase. The spatial location of the intake air hole in the system "milking cup-collector-milk hose" is not regulate and depends on the structural features of the suspended part of the milking machine. The diameter of the hole is usually within 0.8-1 mm, which provides an air supply speed of 8-10 1 / min, which is enough for an effective mode of transportation of milk.

Insufficient air leakage reduces the speed of milk transportation by the milk hose, which leads to excessive pulsation of the vacuum in the collector, to avoid which it is necessary to increase the milking speed to 8.5 m/sec. Taking into account pulsations, in modern two–phase milking machines the average speed of movement of a mixture of milk and air in a flexible pipeline with a diameter of 0.014 m is 0.98-1.26 m/sec. The duration of one pulse (DA-2, ADU-1) is 0.8-0.9 s, and this indicates the presence of pulsation of the milk flow in the hose 2-2.2 m long during its transportation to the height of the milk pipeline 1,7–1,8 m.

Studies [9] found that the optimal mode of transportation would be provide under the condition of two–phase flow rate within 6,4-7,8 m/s, which exceeds the above boundary conditions. In addition, the increase in the speed of transportation of the milk mixture leads to an increase in the influence of air on the quality of milk, the mode of its transportation to the milk pipeline becomes dispersed [9, 10, 11]. Therefore, the decision to increase the efficiency of the process by increasing the speed of milk transportation is doubtful.

Purpose of research

The purpose of research is to improve the quality of milk by improving the design and technological scheme of the milking machine collector and the establishment of rational regime characteristics.

Results of research

Theoretical background and analytical studies make it possible to establish a rational design and technological scheme of the milking machine collector [12, 13] (Fig. 1).
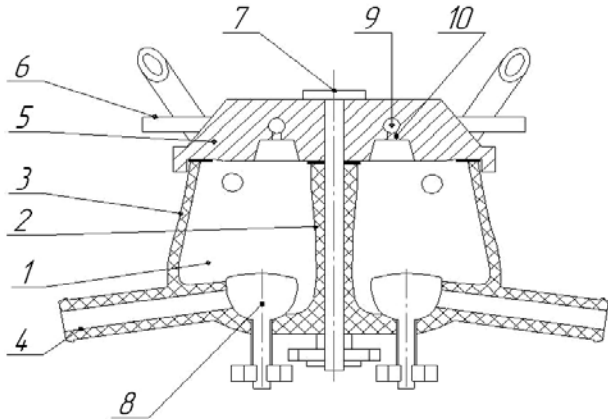

Fig. 1. Designed milk collector of a milking machine: 1 – milk chamber; 2 – dividing wall; 3 – body; 4 – milk branch pipe; 5 – cover with the air distribution chamber; 6 – air pipes to the teat cups; 7 – connecting mechanism; 8 – the valve; 9 – air inlet to pulsator; 10 – throttle opening.

A characteristic structural feature of the collector (Fig. 1) is the presence of two separated by a partition milk collection chambers, each of which is connected to the milk pipeline through a separate milk hose and collects milk from only two milking glasses. In this case, each milk-collecting chamber is connect by calibrated holes with the corresponding distribution chambers of the collector. Due to this solution, the mode of milk transportation will be improve, the pressure in the milk chamber during the sucking stroke is stabilize, and its effective "purge" during the compression phase is ensure.

The principle of operation is as follows. When connecting the milking apparatus to the system vacuum and milk tubing, vacuum pressure at raised shut-off valve 8 is, circulate through the nozzles 4 into the milk collection chambers 1 and to the teat end space milking cups. Simultaneously, through the distribution chamber 5 and the nozzles 9 and 6 of the vacuum pressure from the pulsator spreads to the milking cups, in which the sucking phase should occur. Milk enters one of the sections of the milk chamber 1 and is discharged through the 4 pipe and milk hose to the milk pipeline. In the next phase, the pulsator through the nozzle 9 directs up to a couple of milking cups of atmospheric air. There is a phase of compression, stops sucking milk from the nipples. At this moment, the atmospheric air through the calibrated hole 10 enters the to the milk chamber. An additional increase in pressure will be created, which will improve the mode of movement of the milk-air mixture to the milk pipeline. During the

compression phase of one pair of milking cup in the other pair, the sucking phase occurs.

The described mode of operation of the developed collector will eliminate the causes accompanying the pulsation of the milk flow, dispersion of fat particles and, accordingly, the deterioration of its quality.

To improve the transporting properties of the developed collector to the milk chamber during the compression phase must enter the air with atmospheric pressure. The duration of filling the air of the milk chamber of the collector depends on its volume, the diameter of the throttle hole and the pressure at the beginning of the phase on both sides of the opening.

Thus, for a certain period **dt** to the milk chamber of the collector through the air hole will enter the air volume of the **$V_{nк}$** with intensity **Q_n**, which will cause a change in pressure on the **dp**. Let's make a differential equation of material balance:

$$Q_n p dt = V_{nк} dp,$$

where p is the variable pressure value over dt, kPa;

$Q_п$ - intensity of air intake through the throttle, m³/s;

$V_{пк}$ is the volume occupying air and causes a change in pressure on dp, m³.

Divide variables and integrate the resulting equation:

$$\frac{dp}{p} = \frac{Q_n}{V_{nк}} dt,$$

Under initial conditions t = t0 = 0, become C2 = 0, we perform the potentiation:

$$p = e^{\frac{Q_n \cdot t}{V_{nк}}} \cdot e^{\ln C_1},$$

$$e^{\ln C_1} = C_1 = p_n,$$

For t = t₀ = 0, the equality $p = p_n$ is executed, then. Where p_n is the initial pressure in the collector milk chamber, respectively, is

$$p_n = \Delta p + p_к, \text{ kPa.}$$

The solution of equation (2) will look (Fig. 2):

$$p_{nк} = p_n \cdot e^{\frac{Q_n \cdot t_{ст}}{V_{nк}}},$$

where $p_{nк}$ is the pressure in the collector chamber after the compression tact, kPa; $t_{ст}$ is the duration of the compression tact, s.

The air entering to the milk chamber of the collector occupies the entire free volume ($V_{nк}$) and provided the presence or absence of milk in milk collections is carried out the equality $V_{nк}=V_к$ or $V_{nк}=V_n$. However, regardless of the volume $V_{nк}$, the pressure increases with the increase in the air supply (Fig. 2). Moreover, a lower level of pressure is observe in collectors with a large free volume, regardless of the air supply intensity (Q_n). The higher initial pressure (p_n)) is characterize by a higher pressure ($p_{nк}$)) at the end of the compression tact, in accordance with equation (5).

The amount of air entering the dairy chamber of the collector during the compression tact depends on the driving pressure difference between the distribution and dairy chambers of the collector. In accordance with the Bernoulli equation [14, 15] for a gas medium, we can write:

$$\frac{\upsilon_n^2}{2} \rho_p = p_p - p_n,$$

where ρ_p – air density at pressure pp, kg/m³;

p_p – air pressure in the collector chamber during the compression tact, kPa;

υ_n – air speed in the outlet section of the throttle, m/s.

Without taking into account the influence of friction on the change of airflow velocity in the initial section, we write:

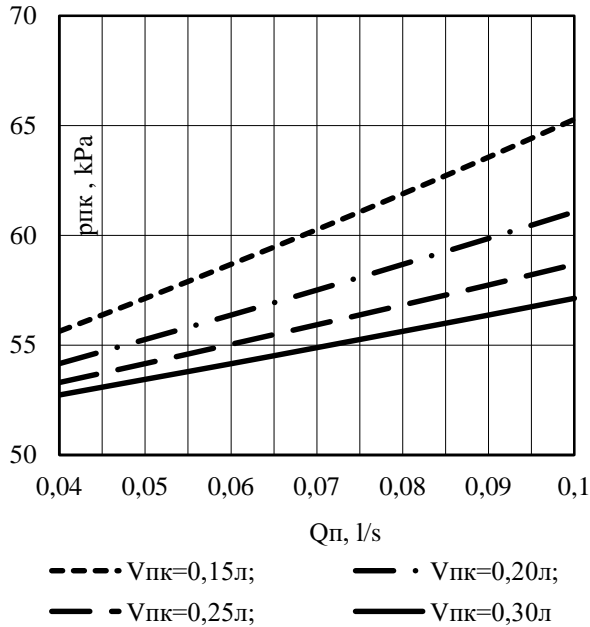$$\upsilon_n = \sqrt{\frac{2(p_p - p_n)}{\rho_p}}.$$

Fig. 2. The dependence of the pressure value ($p_{nк}$) at the end of the compression stroke on the air supply intensity (Q_n) and the volume of the air occupied ($V_{nк}$) in the collector chamber of the collector, under the initial pressure $p_n = 50$ kPa and the constant duration of the $t_{cт} = $ const.

It is known that during the compression tact in the collector chamber the pressure is equal to atmospheric, that is, $p_p = p_{atm}$. The pressure in the dairy chamber (p_n) can established using the Boyle-Mariotte law:

$$p_n = \frac{p_к V_к}{V_n} = \frac{p_к V_к}{V_к - V_{мc}} = \frac{p_к V_к}{V_к - \frac{1}{2}(Q_м - Q_м e^{-t_c})t_{cc}},$$

where $V_{мc}$ – the volume of milk in the milk chamber of the collector during the suction stroke, m³;

t_c – time coordinate of sucking tact (takes values from 0 s to t_{cc}), s.

The coefficient ½ in equation (8) is determined by the design of the developed two-section milk chamber of the collector (see Figure 1). To each part, only milk comes from two milking cups with a pairwise milking, and the minus value of the time coordinate of the sucking time indicates a constant continuous flow of milk through the outlet duct. Thus, the pressure p_n has a variable amount during the sucking tact (Fig. 3) and depends on the degree of filling of milk from the dairy chamber of the collector.

With the increase in the volume of the collection collector chamber (V_k), the pressure (p_n) at the end of the sucking cycle is reduced (Fig. 3), regardless of the intensity of milk yield (Q_m). However, regardless of the volume of the collector chamber of the collector (V_k), the pressure p_n increases with an increase in the intensity of milk yield (Q_m). This can be explained by the change in the volume of milk in the milk chamber of the collector. So, at the intensity of milk yield from 0.005 to 0.04 l / s, the volume free of milk increases by 50.4-53.6% with an increase in the volume of the milk chamber of the collector from 0.08 to 0.16 liters. In the second case, regardless of the volume of the collector chamber of the collector, the volume occupied by milk increases to 87.5% with an increase in the intensity of milk yield from 0.005 to 0.04 l/s.
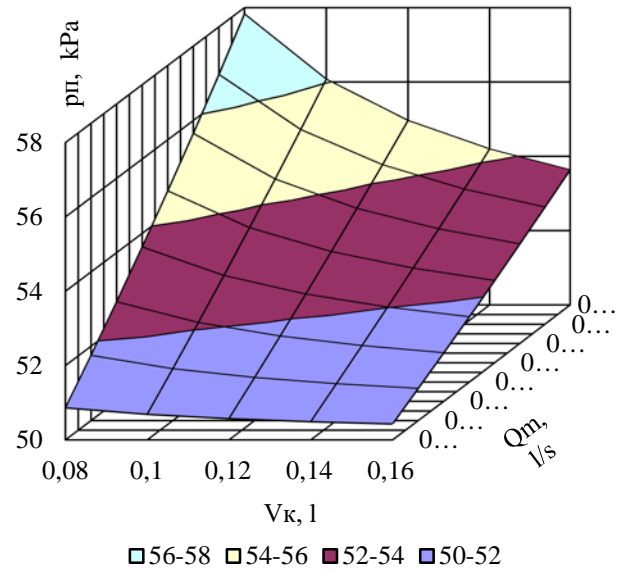
Fig. 3. The dependence of the pressure value (p_n) at the end of the sucking tact on the milk yield intensity (Q_m) and the volume of the milk collector chamber of the collector (V_k), under the initial pressure $p_k = 50$ kPa and the duration of sucking $t_{ss} = 0.6$ s.

Assume that the airflow (G_n) to the volume of the collector's milk chamber, through the throttle, is constant. Then, taking into account the state of the gas equation for Clapeyron, we determine the mass of the partial volume of air:

$$m_{nn} = \frac{p_{nк} V_{nn}}{RT},$$

where m_{nn} – the mass of air in volume V_{nn}, kg;

V_{nn} – partial volume of air with pressure p_{nk}, m3;

R – specific gas has become, for air R = 287,1 j/ kg × K;

T – absolute temperature of air, K.

In turn, the partial mass of air (m_{nn}) entering the dairy chamber of the collector during the compression tact (t_{cm}) can be established using the equation:

$$m_{nn} = G_n t_{cт} = Q_n \rho_p t_{cт},$$

where G_n – mass flow of air, kg/s.

Equate (9) and (10) and separate the volume of air (V_{nn}) in milk free from the volume of the collector's milk chamber:

$$V_{nn} = \frac{RT \rho_p Q_n t_{cт}}{p_{nк}}.$$

Taking into account the equation of continuity of the flow of a continuous medium, we write:

$$\upsilon_n S_d = \frac{V_{nn}}{t_{\text{ст}}} \Rightarrow V_{nn} = \upsilon_n \frac{\pi d^2}{4} t_{\text{ст}},$$

where S_d – section area of the throttle, m²;

d – diameter of the throttle, m.

Equate (11) and (12) and select the diameter of the throttle (d):

$$\upsilon_n \frac{\pi d^2}{4} t_{\text{ст}} = \frac{RTQ_n \rho_p t_{\text{ст}}}{p_{n\text{к}}}, \quad d^2 = \frac{4Q_n RT \rho_p t_{\text{ст}}}{\pi \upsilon_n t_{\text{ст}} p_{n\text{к}}},$$

Since $RT\rho_\text{P} = p_\text{p}$, then equation (14) will take the form:

$$d = 2\sqrt{\frac{Q_n p_p}{\pi \upsilon_n p_{n\text{к}}}}.$$

Thus, the diameter of the throttle (Fig. 4, 5) depends on the initial and final levels of pressure of the corresponding cycles and the intensity of milk yield and airflow velocity.
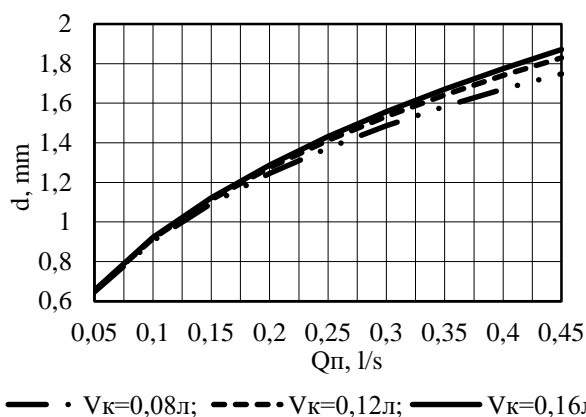

Fig. 4. Dependence of the diameter of the throttle (d) on the air supply intensity (Q_n) and the volume of the section of the collector chamber (V_k). Under the condition of the intensity of milk yield $Q_\text{м} = 0,03$ l / s and the values of the initial pressure $p_\text{к} = 50$ kPa and the duration of cycles sucking $t_c = 0.6$ s and compression $t_{\text{ст}} = 0.4$ s.
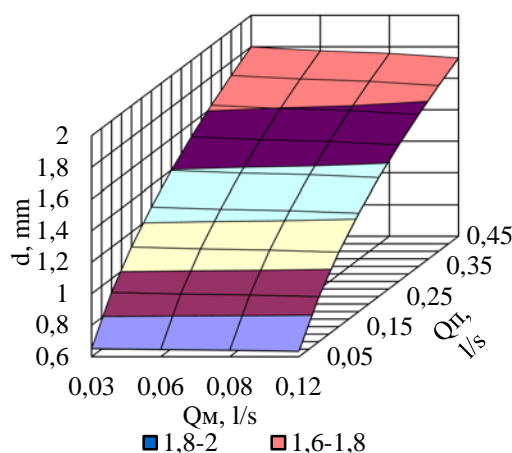

Fig. 5. Dependence of the diameter of the throttle (d) on the air supply intensity (Q_n) and the intensity of milk yield ($Q_\text{м}$). Provided the volume of the section of the milk collector chamber of the collector $V\text{к} = 0,10$ l, the values of the initial pressure $p_k = 50$ kPa and the duration of sucking times $t_{cc} = 0.6$ s and compression $t_{\text{ст}} = 0.4$ s.

When increasing the supply of air (Q_n) to the section of the collector ($V_\text{к}$), it is necessary to increase the diameter of the throttle (Fig. 4). This is explained by the fact that at constant air velocity, which is regulated by a constant pressure difference (p_p-p_n) within the given volume of the dairy chamber, it is necessary to increase the volume of air (V_{nn}) in the milk-free volume to ensure the installation the given pressure value at the end of the compression tact ($p_{n\text{к}}$).

If the volume of the collector's milk chamber ($V_\text{к}$) is increased, the diameter of the throttle must be increased within the given air supply (Fig. 4). This can be explained by an increase in milk-free volume ($V_{n\text{к}}$) with a constant intensity of milk yield ($Q_\text{м}$).

With the increase in the air supply intensity (Q_n), the diameter of the throttle (Fig. 5) increases for a minimum (1.15 mm) and a maximum (1.09 mm) milk yield intensity ($Q_\text{м}$). This is due to the need to increase the pressure at the end of the compression tact ($p_{n\text{к}}$) with its unchanged duration ($t_{\text{ст}} = 0.4$ s).

A slight decrease (by 2.7-3.9%) of the diameter of the throttle when the intensity of the milk yield is increased from 0.03 to 0.12 l/s within the fixed air supply intensity (Q_n). It is can be explained by the decrease of the free space of milk ($V_{n\text{к}}$) the milk chamber of the collector (Fig. 5) and, accordingly, the higher level of pressure (p_n) at the end of the sucking tact.

Conclusion

Consequently, the diameter of the throttling hole significantly influences the flow of air to the section of the dairy chamber of the collector to create the necessary pressure gradient to improve the conditions for milk transport to the main milk pipe with a milk hose.

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СТВОРЕННЯ СТРУКТУРНО-ТЕХНОЛОГІЧНА СХЕМА КОЛЕКТОРА ДОЇЛЬНОГО АПАРАТА
О. В. Медведський, О. М. Ачкевич, В. І. Ачкевич

Анотація. В статті розглянута конструкція і технологічна схема двокамерного доїльного апарату колектора з частиною повітрозабірника, який забезпечує поліпшене транспортування молочної суміші. Також представлений вплив зміни обсягу молочної камери колектора та інтенсивність передачі молока на тиск у такті смоктання. Обґрунтовано умови для поліпшення транспортування молока до магістрального трубопроводу з молокошлангу від доїльного колектора машина. Також розглянуто вплив діаметра отвору дросельної заслінки на виробництво

заданої витрати повітря в розділі молококамери колектора, щоб створити необхідний градієнт тиску.

Ключові слова: колектор доїльного апарата, молоко-повітряна суміш, інтенсивність виробництва молока, отвір дроселя.

СОЗДАНИЕ СТРУКТУРНО-ТЕХНОЛОГИЧЕСКАЯ СХЕМА КОЛЛЕКТОРА ДОИЛЬНОГО АППАРАТА

А. В. Медведский, О. Н. Ачкевич, В. И. Ачкевич

Аннотация. В статье рассмотрена конструкция и технологическая схема двухкамерного доильного аппарата коллектора с частью воздухозаборника, который обеспечивает улучшенное транспортировки молочной смеси. Также представлено влияние изменения объема молочной камеры коллектора и интенсивность передачи молока на давление в такте сосания. Обоснованы условия для улучшения транспортировки молока до магистрального трубопровода с молокошлангу от доильного коллектора машина. Также рассмотрено влияние диаметра отверстия дроссельной заслонки на производство заданного расхода воздуха в разделе молококамеры коллектора, чтобы создать необходимый градиент давления.

Ключевые слова: коллектор доильного аппарата, молоко-воздушная смесь, интенсивность производства молока, отверстие дросселя.