Conditions for the effective use of milking machines

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Abstract. On dairy farms with a small number of livestock, it is not always profitable to use expensive high-performance machines and equipment. Here, it is more rational to use easy-to-maintain means of small mechanization, which significantly facilitate the work of the farmer, requiring low operating costs. milk production, in turn, is closely related to the method of keeping livestock. This method is a non-binding box method, in which, as domestic and foreign experience shows, labor costs are reduced several times. A significant increase in labor productivity in dairy cattle breeding provides, first of all, the development and implementation of advanced technologies in practice. Machine milking facilitates the work of operators and increases productivity, allows you to get clean, high-quality milk at a low cost. During milking cows, the service personnel must constantly monitor the process, do not miss its completion, turn off and remove the milking machine in time. Overexposure of it on the udder nipples after the end of milk excretion causes pain in the cow, a decrease in milk output, increases the duration of milking, leads to injury to the nipples, initiates mastitis disease. Technologies of industrial milk production the equipment used does not fully meet the zootechnical requirements for productivity, energy and metal consumption, reliability. Serial equipment is structurally difficult, the complexity of maintenance of automation tools for machine milking processes is great. The study of the technological process of machine milking shows that labor productivity at all milking plants depends primarily on the duration of manual operations and the time of milking cows. The article describes the automation of the milking process.

1 Introduction

The productivity of milking machines depends on many factors, but the decisive one is the milking cycle - the time of preparatory and final operations and machine milking itself. The second component of the cycle is about 2-4 times larger than the first, so it is important to

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know its expected value to calculate the parameters of the designed installations. There are three ways of milking cows: natural - sucking the udder with a calf, manual - squeezing milk from the udder with the hands of a milker, machine - sucking or squeezing milk with a milking machine In the process of machine milking, two tasks are realized: providing milk allowance (milk delivery) to animals and extracting milk from the udder (milking). According to time-lapse observations carried out in state farms and collective farms, the duration of manual operations on various milking machines ranges from 39 (on conveyors) to 140 seconds (when milking in buckets). Table 1 shows time-lapse observations carried out in state farms and collective farms on the territory of Yakutia.

Table 1. Time-lapse observations on the territory of Yakutia

Name of the operation	1	2	3
Approach to the machine (cow)	4	4	2
Transition with a milking machine	24	19	-
Intake and release of cows	-	-	13*
Distribution of concentrates	-	-	-
Washing and wiping the udder	30	26	15
Turning on the machine, putting on glasses	24	24	15
Turning off the vacuum, removing glasses	18	18	7
Draining milk	40	-	-
Total	140	91	39

Milking approximately 270 cows takes approximately 7-8 minutes (30%). This distribution of the milking time leads to downtime of equipment on conveyor and group installations and a decrease in their productivity. The total milking time can be reduced by selecting steel and using more advanced equipment.

2 Research methodology

Denoting the degree of loading of the milker c, the duration of the preparatory tp (cow intake, washing, wiping and udder massage, putting on glasses) and the final t3 operations (mechanical milking, removing glasses, cow release), cow milking time td and the number of devices serviced by one operator n, we express the relationship between these values for milking in stalls and for installations with sequential and parallel arrangement of machines:

$$c(t_p + t_d + t_z) = n(t_p + t_z) \tag{1}$$

From here, taking $t_p + t_{z3} = t_o$

$$n = c\left(\frac{t_d}{t_o} + 1\right) \tag{2}$$

The coefficient c, which depends on the operator's employment in manual operations, the values n and t_d, as observations have shown, can be taken equal to 0.85-0.95. This ensures the normal loading of the operator, taking into account the time for operations unforeseen by the process. When milking cows on a herringbone type installation, which has one milking machine for every two machines and is serviced by one operator:

$$c(t_d + t_o) = nt_o + t_1 + t_2 \tag{3}$$

where t_1 and t_2 are the duration of the intake of a group of cows into the machine and the release from the machine. Then:

$$n = \frac{ct_d - t_1 - t_2}{t_o} + c \tag{4}$$

The milking process on conveyor carousel installations can be divided into four zones (Figure 1).

The first zone of t_b - the intake of cows-is determined by the number of machines. Necessary to replace cows on the conveyor. In the latest designs, this number is reduced to a minimum (up to two).

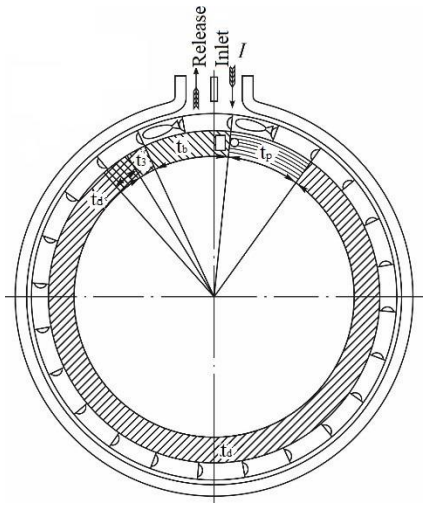

Fig. 1. Milking process zones on conveyor carousel installations t_p- preparation of the cow for milking; t_d- milking; t_b- intake and exhaust; t_3 and td- turning off the machine and machine milking

The second zone-washing, wiping, udder massage and putting on glasses-determines the throughput capacity of the conveyor. During the preparation of the animal for milking (including putting on glasses), a milk allowance should be provided. In order for the milking process to be continuous, the operator must return to a certain point of the conveyor to prepare the next cow, having passed the path:

$$S = \frac{\pi d n_к}{60} t_п, \text{ m} \tag{5}$$

where d -is the diameter of the conveyor along the inner generatrix, m; $n_к$ -is the number of revolutions of the conveyor per minute. Denoting the speed of the operator's movement to the starting position v_0 (m/sec) and the number of machines on the conveyor N, we find the number of operators working in the second zone

$$K_2 = \frac{N n_к t_п}{60 v_o} \tag{6}$$

The third zone is milking cows. Actual milking time

$$t_d = \frac{1}{nк}\left(1 - \frac{N_o + N_п + N_c}{N}\right) \tag{7}$$

Here N_0=2 and N_c=1 are the number of stations in the first and fourth zones.

The number of machines required for the preparation of cows

$$N_п = \frac{N n_к}{60} t_п \tag{8}$$

The fourth zone is the disconnection of the vacuum and the removal of the milking cups, which require 5-7 seconds. At the same time, 10-15 seconds are spent on machine finishing. Conveyor plant performance:

$$W = \frac{60N}{t_{ob}}\left(1 - \frac{t_{ob}}{T}\right), \text{ cows/hour} \quad (9)$$

where T– is the duration of milking of the entire herd, min. If two operators are engaged in preparing cows and putting on glasses with a degree of loading c = 0'9', then with an installation capacity of 240 cows / hour and a turnover duration of t_{ob} = 8 minutes, the conveyor should have 34 machines, and the cows will be milked in 6.8 minutes. When choosing the type of milking machine, its productivity W and the duration of the shift of workers should be taken into account. Number of cash cows per unit:

$$o = W\left(\frac{T_c}{\eta} - t_u\right) \quad (10)$$

where η- is the multiplicity of milking cows per day; t_u - is the time of preparation of the milking unit for operation and care for it, hour.

When T_c = 7 hours, t_y = 1 hour. η = 2 installations with a capacity of 80, 100, 150 and 250 cows/hour can be used on farms with 200, 250, 370 and 620 dairy cows, respectively. On group installations with tethered animals, the productivity of one worker decreases due to the time spent on untying and when using milking machines, it is necessary to comprehensively mechanize the remaining processes on the farm, as well as constantly monitor the herd in order to prevent specific diseases and timely separate cows that have deviations from the requirements of machine milking. First of all, you need to know the number of samples (observations) of p_v necessary to obtain reliable statistical values:

$$n_v = \frac{\sigma^2 a_{t_0}^2}{\Delta t^2} \quad (11)$$

where σ- is the mean square deviation. (The preliminary value of σ was calculated by the formula:

$$\sigma = \frac{t_{max} - t_{min}}{\sigma}$$

Here t_{max}, t_{min}– maximum and minimum milking time. The range of variability is equal to 3σ); a to– the criterion of reliability of the average value of the machine milking time. With a confidence probability equal to 0.95, accepted a to= 2[1]; by 0.99 –a to=2.6; by 0.999–a to=3.3 and so on; Δt –Δt is the allowable discrepancy between the sample and the general average (statistical error).If taken on the basis of experimental data $\sigma = \frac{12.5-1.5}{6} \approx$ 1,8; a to = 2.6; Δt = 0.22 min (with a probability of reliability equal to 0.99), then according to the formula (11) we get $n_в = \frac{1.8^2 * 2.6^2}{0.22^2} \approx 450$.That is, in order to have a probability of reliability of statistical values equal to 0.99 (by Δt= 0.22min), it is necessary to conduct pv≥450 observations. [7-11]

To calculate the empirical and theoretical frequencies, as well as the average milking time to and the correction standard deviation σ_k, variation series were compiled. The values of to and σ_k were determined by the formulas:

$$t_0 = A_0 + K\frac{\sum ma}{n_в} \quad (12)$$

$$\sigma_к = K\sqrt{\frac{\sum ma^2}{n_в} - \left[\left(\frac{\sum ma}{n_в}\right)^2 + 0.0833\right]} \quad (13)$$

where A_o -is a conditional average approaching the arithmetic mean in its value; A - is the value of the class; m is the frequency of the variation series; a is the conditional deviation

of the class; n_v is the sample size in this variation series; 0.0833 is the Sheppard correction, which takes into account inaccuracies in grouping observations by classes.

Coefficient of variation (variability) of series:

$$C_{t_0} = \frac{\sigma_к}{t_0} 100\% \tag{14}$$

Error of the coefficient of variation:

$$\Delta C_{t_0} = \frac{C_{t_0}}{\sqrt{2n_в}} = \frac{\sigma_к}{t_0\sqrt{2n_в}} 100\% \tag{15}$$

Reliability criterion coefficient of variation:

$$a_{C_{t_0}} = \frac{C_{t_0}}{\Delta C_{t_0}} \tag{16}$$

The values of C_{t_0},$\Delta C_{t_0}$and $a_{C_{t_0}}$ were obtained equal to an average of 25.7%, 1.02 and 29.8, which indicates a small scattering of random variables, sufficient accuracy and reliability of the coefficient of variation. To determine how accurately the value t0of a random variable t_i is determined and to what extent it corresponds to the general mean tot, the statistical error Δto and the reliability criterion a to were calculated:

$$\Delta t_0 = \frac{\sigma_к}{\sqrt{n_в}} \tag{17}$$

$$a_{t_0} = \frac{t_0}{\Delta t_0} \tag{18}$$

Recall that if the error Δto fits into its average three times, then the probability of finding the general average to, in the interval to ± 3Δto is 0.997 [1]' and for a to = 4 and the interval to ± 4Δto is 0.9999. According to formulas (17) and (18), the values of Δto and a to are on average equal to 0.094 and 82.50, respectively, i.e. the error of Δto fits in its average 82.5 times. At the same time, the probability of finding the general average in the interval t_0 ±82.5Δt_0 (t_0g=6.6±0.004 min) is 0.9999. The statistical error σk and the reliability criterion for the mean square deviation of σ_k were determined by the formulas:

$$\Delta\sigma_к = \frac{\sigma_к}{\sqrt{2n_в}} \tag{19}$$

$$a_{\sigma_к} = \frac{\sigma_к}{\Delta\sigma_к} \tag{20}$$

When calculating, on average $\Delta\sigma_k$ = 0.066 and $a_{\sigma_к}$= 29.8 were obtained. The degree of accuracy of these data is quite sufficient, since at $a_{\sigma_к}$= 3 the probability of reliability is already 0.999. Statistical location of time t_0 is valid according to the normal law. The statistical distribution of time t_0 really obeys the normal law. This is also evidenced by the values of the coefficients of asymmetry and kurtosis, determined from the expressions:

$$K_s = \frac{\mu_3}{\sigma_к^3} \tag{21}$$

$$K_э = \frac{\mu_4}{\sigma_к^4 - 3} \tag{22}$$

(where μ_3 and μ_4 are the third and fourth central moments) and equal to 0.2 and 0, respectively. [12-15]

The statistical errors of the coefficients of asymmetry K_s and kurtosis K_e were calculated using the formulas:

$$\Delta K_s = \sqrt{\frac{6}{n_в}} \tag{23}$$

$$\Delta K_э = 2\sqrt{\frac{6}{n_в}} \quad (24)$$

And their criteria of reliability:

$$a_{K_s} = \frac{K_s}{\Delta K_s} \quad (25)$$

$$a_{K_e} = \frac{K_e}{\Delta K_e} \quad (26)$$

If the animals are milked out in less than 9.5 minutes, it is necessary to turn off the devices in time to prevent their overexposure. But at the same time, the productivity of the installation as a whole will significantly decrease due to the downtime of individual machines. To avoid a performance discrepancy, it is necessary to select cows with the same milking time. However, as practice has shown, it is very difficult to do this in one farm, since the milking time varies within large limits – from 1.5 to 13 minutes. From what has been said, it follows that the use of conveyor-ring milking units is ineffective in the case when cows differ significantly in milking time. The same conclusion suggests itself for the installation of the "herringbone", on which the milking is carried out in a group way. Figure 1 shows a generalized graph of the density of the distribution of milking time at the plants [2-6].

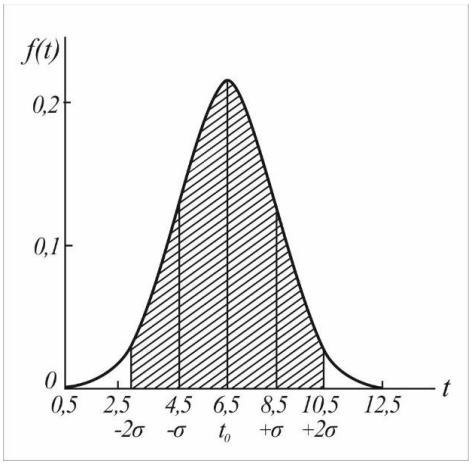

Fig. 2. Generalized graph of the density of the milking time distribution on the installations

The right combination of feed factors and individual properties of animals ensures their optimal development and high productive indicators. In the conditions of modern livestock complexes, characterized by a high concentration of livestock, this task is complicated by the need to collect and process huge amounts of information about individual productive indicators of animals in a limited time.[16-20]

3 Conclusion

Automated milking makes the work much easier. It is necessary to create a milking machine with passing machines located to its axis at an angle of approximately 30 °. It should have automatic devices that allow you to regulate the milking process. With such a design of the installation, the milker will be able to work simultaneously on six or more machines and, consequently, serve a larger number of cows per unit of time. When using milking machines, it is necessary to comprehensively mechanize the remaining processes

on the farm, as well as constantly monitor the herd in order to prevent specific diseases and timely separate cows that have deviations from the requirements of machine milking.

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