

STUDIES OF PERFORMANCE PARAMETERS IN MILKING ROBOTS AFTER SOFTWARE IMPROVEMENT

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Abstract. Robotic milking of cows began in Latvia in 2007, when it was introduced on two farms, including the training and research farm “Vecauce” of the Latvia University of Biological Sciences and Technology (then the Latvia University of Agriculture). These were the DeLaval VMS robots that are still in use on the farm “Vecauce”. A similar study was carried out already in 2009, but since then DeLaval milking robots have undergone technical and software updates and improvements. Therefore, a comparison of the operation indicators of these robots with the latest model of the same company, VMS V300, was made. Research shows that performing all technical maintenance intended for the VMS robot and replacing the original management system software can ensure successful operation of this robot even after 16 years of use. However, it has difficulties with accurately attaching the milking tubes to the respective cow’s teats. Because of this, the application of tubes is delayed and the average milking time of one cow reaches 8.25 minutes. When milking with the company’s latest generation VMS V300 robot, which uses a 3D camera to connect the milking tubes, the average milking time is only 6.6 minutes. Therefore, we can assume that the robots used on the farm “Vecauce” for milking cows are morally and physically obsolete.

Keywords: automatic, frequency, interval, milking, robots, systems.

Introduction

The first cow milking robot in the world was introduced in the Netherlands in 1992 [1], and the first cow milking robots in Latvia – in 2007. They were four DeLaval VMS robots, two of which were introduced on the farm “Dimanti” of the Smiltene region, and two more - in the newly built milking cow barn “Ligotnes” of the LBTU training and research farm “Vecauce” [2].

However, the new Vecauce cowshed was not originally intended for robotic milking of animals. Such an idea was born only during construction, considering that of the 530 cows planned in the barn, 90 could be milked with the help of two robots, and the rest of the cows - in the milking hall provided for in the project. Therefore, guided by the recommendations of DeLaval specialists, a separate annexe was built at one end of the farm, where not only the two robots could be placed, but also a milk room and a computer room for servicing the robots.

Considering that such cow milking solution was introduced in Latvia, LLU created a research group, which started a detailed study of robotic milking and its comparison with already traditional technologies [3; 4] and similar studies in other countries [5]. Therefore, information was obtained on the frequency of robot visits, the amount of milk milked, the duration of individual milking operations, the effect of power consumption during milking, etc., as well as a number of errors that interfered with the proper progress of the milking process was discovered and eliminated. Appropriate recommendations and proposals for the introduction of robotic cow milking on other farms were also developed.

Currently, less than 16 years have passed since introduction of these robots. According to the information provided in the specialized literature [6; 7], the normative service life of milking equipment is 10-12 years. Of course, during this period, all technical maintenance for robots [8] was carried out, as well as individual assemblies and worn parts were replaced, including in 2017 they were equipped with improved control software. However, every technique wears out morally and physically over time.

Therefore, the aim of this article was to find the current performance indicators and working capabilities of the two robots used in Vecauce, taking into account their relatively long service life, and to compare their performance indicators with the latest robot model VMS V300 of the same manufacturing company.

Materials and methods

The research was carried out on two farms, not only in the LBTU teaching and research farm “Vecauce”, but also on the Jelgava district farm “Putrinās”. This is due to the fact that at the beginning of 2022, the newest version of the “DeLaval” cow milking robot VMS V300 was put into operation on

the farm, and there were opportunities for comparison with the older VMS models that operate on the farm “Vecauce”. Two robots work on the farm “Vecauce” and 90 cows are milked, while 185 cows are milked on the farm Putrinās with four robots. In addition, both farms have about the same milk yield of cows.

The research used the information in the management systems, which shows the average milk yield of the cows, the number and duration of milkings, as well as other characteristic parameters, while the application of milking tubes was evaluated according to the timing results. The management system data include the period from 01.01.23-15.02.23, while the studies of the cow milking process took place from 16-28.02.23.

Results and discussion

Studies have shown that the average milk yield of cows has increased significantly after using robots on the teaching and research farm “Vecauce” of LBTU. If in 2007 they were approximately 6000 kg of milk from one cow, then in recent years the milk yield has reached 12000-13000 kg per year. At the same time, the average milking duration of cows has increased from 7.9 to 8.3 minutes. In addition, the part of the barn where robotic milking is introduced no longer tends to hold more than 90 milking cows.

According to the zootechnical requirements of machine milking of cows [9; 10], the milking cup may be applied only 50-60 seconds after various specific irritants start acting on it: sounds of milking machines, external washing of the udder teats, teat massage and drying, foremilk. As a result, the milking hormone - oxytocin is released in the pituitary gland of the cow’s brain, which begins to circulate through the cow’s body, together with the blood. Oxytocin also helps provide a stimulus for milk letdown. However, oxytocin is released for a limited period of time - approximately 4-6 minutes. If the cow is not milked during this time, the udder relaxes and some of the milk in it remains unmilked.

Each milking robot manufacturing company has developed and uses a different way of preparing and milking the cow’s udder. The cycle diagram of cow milking used by the company DeLaval, which was compiled based on the results of our timing and the data of the management system, can be seen in Figure 1.

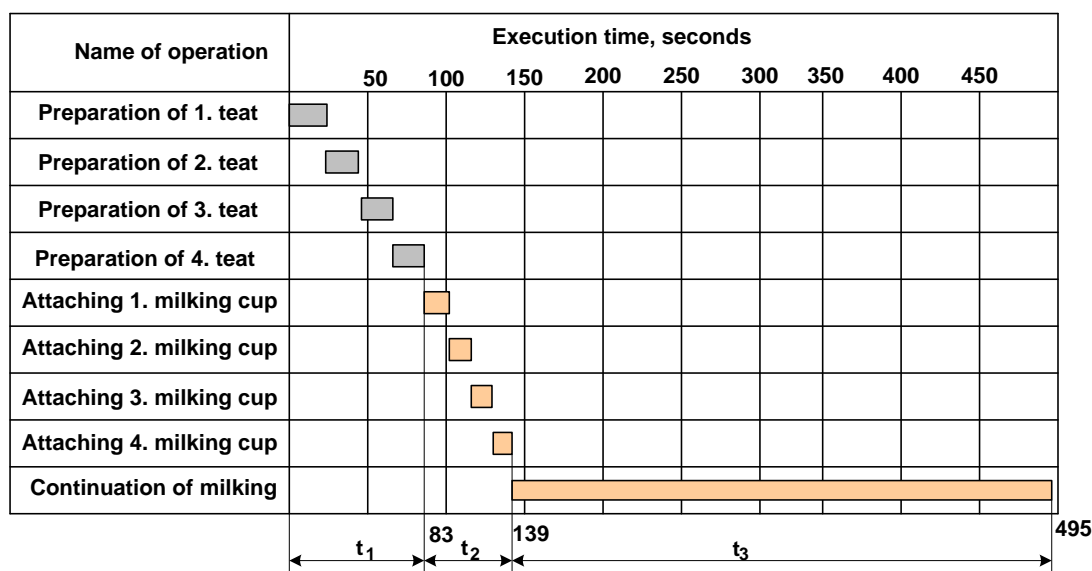


Fig. 1 Cyclogram of cow milking progress on LBTU teaching and research farm “Vecauce” (according to the average data obtained on 16.02.2023): t_1 – preparation of cow udders for milking; t_2 – connection of milking pipes; t_3 – progress of the milking process, including independent disconnection of the tubes from the milked cow’s teats

It can be seen from the figure that there are three stages in the milking process. In the first stage – t_1 , all four teats of the cow are prepared for milking. For this purpose, a specially designed tube is used, which is attached to each cow’s teat for 14 seconds, during which the outside of the respective teat is washed, dried and the first milk jets are wiped off. In the second stage - t_2 , the next round of cups intended for milking is attached to the cow’s teats, and in the stage t_3 - milking of cows with all the cups

connected to the teats, as well as their independent disconnection, as the amount of milk in the respective udder quarter decreases.

The advantage of this cow milking solution is that the dirty water from washing the teats, as well as the first milk streams, which tend to contain a lot of unwanted bacteria, are always separated and collected separately. In addition, after connecting all the milking cups, the robot arm rotates around its axis and grabs the milk hoses attached to the milking cups, with the help of which the milking cups are tilted by 10-15 degree towards the cow's head, thus facilitating the output of milk from the udder. However, such a system also has a drawback, as milking of each teat requires a double connection of cups (both the teat preparation cup and its milking cup). But it is associated with additional time consumption.

The results of cow milking obtained in the studies are summarized in Table 1.

Table 1

Research results

Indicators	LBTU teaching and research farm "Vecauce"		Jelgava region farm "Putrinās"
	2008	February 2023	February 2023
Average milk yield of cows, kg per cow per day	23.3	41.9	43.9
Average duration of cow preparation, t_1 , s	87.0	83.0	78.0
Average time of adding milking cups, t_2 , s	75.0	56.0	42.0
Average milking time of one cow, including udder preparation, t_3 , s	475.0	495.0	397.0
Milking with tube fall, %	no data	33.9	9.5

The timing results showed that on the "Vecauce" training and research farm, attaching cups to the cow's teat often happens with great difficulty, because the laser system of the robot, which guides the robot's arm, is unable to find the locations of the teats accurately and attach the relevant cups to them. Therefore, according to the results of the 2008 time trial, the average duration of preparing a cow's udder is 87 seconds, i.e. it exceeds one minute. Also in 2023, the time check-in Vecauce shows that, despite the software change for the control system in 2017, this indicator is 83 seconds, so it has decreased by only 4 seconds. The average time to add milking cups has decreased by 19 seconds. But the average milking time of one cow reaches 8.25 minutes.

However, significantly better indicators were obtained on the farm "Putrinās", where the company's latest generation cow milking robot VMS V300 "DeLaval" is used. In this robot, a 3D camera is used to find the cow's teats, which provides a spatial overview of the current situation. Therefore, tube connection is smooth and error-free, ensuring that the cow is prepared and all milking cups are connected within 120 seconds or 2 minutes. In addition, the milking duration of a cow has decreased by 98 s (about one and a half minutes), although the average daily milk yield of one cow is even slightly higher than in "Vecauce".

As it can be seen from Table 1, the number of cases where individual cups fall off during milking and need to be reattached has also significantly decreased. However, additional research is still needed for a more detailed explanation of this issue.

Conclusions

1. DeLaval cow milking robots used on the "Vecauce" teaching and research farm of LBTU were introduced in 2007, but they are still successfully used.
2. After replacing the software in the management system in 2017 and other modernization works for these robots, the duration of preparing the cow's udder before milking has decreased by 4 seconds, and the average duration of connecting the milking tubes by 19 seconds. However, it has been found that these robots have difficulties in accurately placing the milking cups on the corresponding cow's teats, as a result of which the average milking time of one cow reaches 8.25 minutes.

3. During the research of the DeLaval company's newest generation cow milking robot VMS V300 on the farm "Putrinās", it was found that the robot assembled on this farm works significantly better than the robots currently used in "Vecauce" in terms of all working parameters. Also, taking into account that the service life of milking equipment specified in the relevant regulations for cows does not exceed 12 years, while robots in "Vecauce" last almost for 16 years, it can be concluded that these robots are morally and physically outdated and need to be replaced with new ones.

Author contributions

Conceptualization, M.M. and J.P.; methodology, J.P.; software, J.P.; validation, M.M. and J.P.; formal analysis, M.M. and M.M.; investigation, M.M. and M.M.; data curation, M.M., J.P. and J.P.; writing – original draft preparation, M.M.; writing – review and editing, M.M.; visualization, J.P.; project administration, M.M. All authors have read and agreed to the published version of the manuscript.

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