DETERMINATION OF OPERATING PARAMETERS IN MILKING ROBOTS WITH FREE COW TRAFFIC

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Abstract. In 2012 the first robot milking farm was introduced in Turkey. The basic idea is that cows are milked without human assistance with getting into the milking unit voluntarily at any time of the day. After milking they can move to the feeding area as well as resting area (cubicles). In this paper we studied the capacity of milking robots, daily robotic load, milking frequency per robot per hours, and the analyzed cow traffic has been chosen "free" in the farm. The research shows that every hour a robot milks in the average 6.1 cows. The robotic load at the present cow herd (123 cows) is 77.4 %. Both robots are loaded the same percentage (18.7-18.5 %). The number of herd is plenty enough for two robots.The aim of the research was to state how often the cows come to robots during all day and evaluate the cow traffic system on the farm. Milking average is 2.42 times a day. This is pretty close to the optimal and recommended interval (2.5-3.0 times per day). The robot idle time is approximately 18 %. In this case a large percentage of cows are fetched by workers.

Keywords: robotic milking system, robotic load, milking interval, milking frequency, robotic milking capacity.

Introduction

The main principle in robotic milking systems is that the milking process is started by the cow voluntarily coming to the robot at any time of the day. The will to be milked is an instinctive behaviour of the cow that it must fulfil everyday routine, such as feeding, resting and water [1]. The success of automatic milking is dependent on the cow and her willingness to visit the automatic milking stall voluntarily with sufficient frequency to support an economic level of milk production [2]. Using robots in the milking process is much more different than milking with traditional methods [3; 4]. The aim of robotic milking is to be able to milk the cow at correct frequency during the whole lactation [5].

In robotic systems, the milking frequency per cow is between 2 and 4 in the herd average. On the other hand, young heifers are more willing for milking than the cows in the mid-lactation or more[1]. Many factors such as the feeding method, cow flow, performance of the robot and herd size affect the frequency of milking [6; 7]. Feed is the primary motivation for the cow to visit the robotic milking stall. Highly motivated cows will visit voluntarily thereby decreasing the need to expend labour fetching cows, and they will visit more frequently and regularly leading to higher milk production [2] Cows are milked 2.4 to 2.8 times a day on average in free cow traffic, while these rates are between 2.5 and 2.9 in forced cow traffic[7]. Not only the cow traffic directly affects this result. The fetching and involuntary milking percentages of the cows can also be added to it [3; 8]. In another research the annual milk yields of 59-68 milked cows with a milking average of 2.4-2.6 per cow per day were reported [9].These kinds of researches were conducted many times in countries where the robots are widely used. However, differences arising from the unique features of the dairy farms in different countries may affect the results.

The fact that the purchasing cost of a robotic milking unit is high necessitates the use of the robot at the highest capacity possible. The milking frequency of the cow is one of the main factors affecting the loading of the robot at full capacity. The factors affecting the milking frequency can be listed as follows [10; 11]:

- ensuring ease of entry into the robot;
- the will of the cow to be milked, motivation of the concentrated feed offered in the robot, or the forcing the cow into the robot;
- the tendency of the cows with high milk yield to come to the robot more frequently to be milked;
- length of the milking period depending on the milk yield of the cow and the flow rate of the milk flowing from the teats;
- in case a buffer tank is unavailable, the length of the period required to empty the milk cooling tank and wash the system milk line are the main factors affecting the milking frequency.

In the research it was aimed to determine the robot performance on a farm where the free cow traffic is used with two milking robots established in Turkey. The basic criteria such as the number of daily milking of the robots, milking frequencies throughout the day, time ratios spent in milking-washing and on idle time, and the ratios of the number of daily milking were addressed. Although Turkey has not had any special experience in robotic milking yet, an experience is undertaken in terms of the application of the new technologies and rational use on the farm where the research is carried out.

Materials and methods

The research was carried out on a private farm operating in Tekirdag province. During the experiment approximately 123 Holstein Friesian dairy cows were in the barn and 90 and 34 of them were in the first and second lactation respectively. There are 4 DeLaval milking robots on the farm. There are two similar barn sections on the farm, and two milking robots were placed in each section. The experiments were carried out in two milking robots that were actively operating. The other two robots will started to be used when the farm achieves the necessary cow capacity. The "free cow traffic" was adopted on the farm for directing the cows to the milking robot for the sake of cow welfare [11]. The cows are given ration feed with TMR twice a day at 8:00 in the morning and evening. The feeding lines are 42 m at the both sides of the barn (about 70 cm per cow). Additionally, concentrated feed given in the robots depends on the individual cow requirements. The cows going out of the robots were set free whether to go to the feeding area or the cubicles. Four cow brushes and 6 troughs were located in the barn. The robots were washed 4 times a day with 3 alkaline acid automatically (at 00:00, 06:00, 12:00, and 18:00). Each takes 20-25 minutes. The washing at 18:00 takes almost 1.15 hours with milk discharging. Manure was removed once every hour with a scraper at each row. The layout plan of a barn section on the farm is shown in Fig. 1.

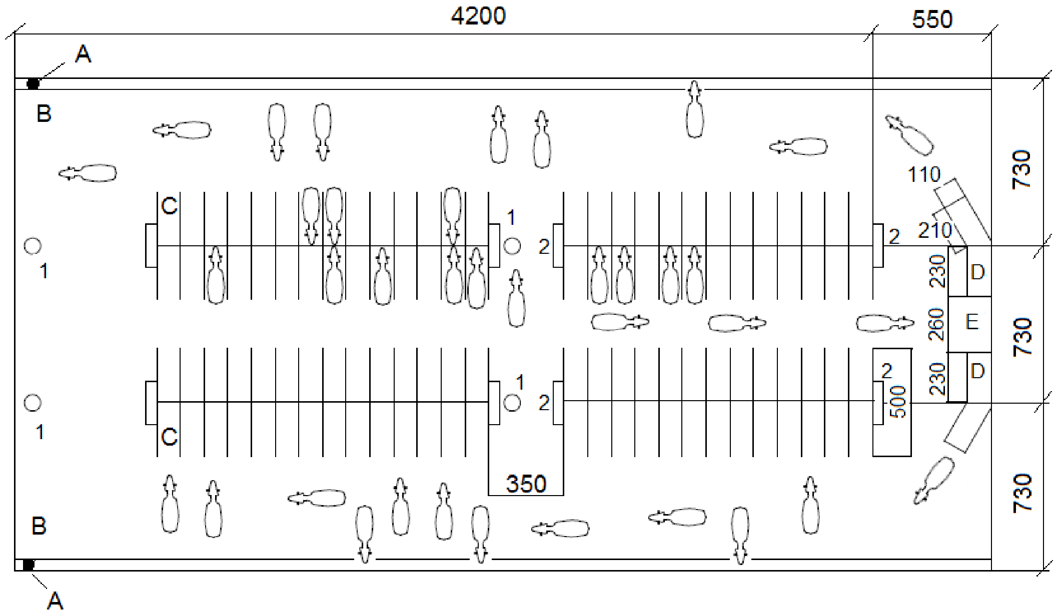

Fig. 1. **Layout plan of the free-type barn where the experiments are carried out (the sizes are in centimeters):** A – Forage line; B – Feeding area; C – Cubicles; D – Robots; E – Waiting area; 1 – Cow brushes; 2 – Troughs

The research was initialized approximately 2-2.5 months after the milking robots were installed in the farm, when the cows got used to the new order and milking conditions. The research was conducted in 3 consecutive periods, each consisting of 20 days. Approximately 123 cows were present in the barns in these periods. We can summarize the main investigation parameters in our study as follows:

- number of daily milking per robot;
- total milking frequencies of the two robots during the day;
- milking, washing and idle time of the robots in a total of three periods;

- milking, washing and idle time of the robots individually;
- number of daily average milking of the cows in three periods;
- rate of the cows milked to the number of milking in three periods;
- optimum herd size that a robot will serve;
- questioning the type of cow traffic.

The research data were extracted from the computers connected to the computer daily and analysed on MS Excel program.

Results and discussion

The daily average milking frequency of the cows is the most important and basic indicator showing the performance of the robot. The loading of two milking robots on the farm (daily number of milking) was shown in Fig. 2. As it is seen in the figure, both robots were visited at close frequencies (daily average is 121). Similar to the study of Laurs et al. (2009), the results were found close to our study as the maximum number of milking was found as 138 and the average number of milking as 128 on the farms where two robots are used [10]. However, in the comparison of minimum values, it was found as 119 milkings on average in Laurs et al. (2009) [10], while 44 on average in our study. The reason for this can be shown as the idle time spent for washing the robot and taking out milk at certain times of the day is long. The system stops completely in both activities.

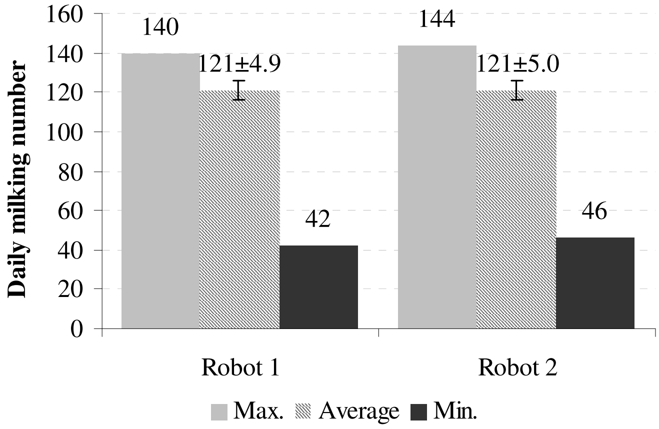

Fig. 2. **Number of daily milking per robot**

In our study, the milking frequencies of the robots during the day were detected and shown in Fig. 3. During the experiments, the total milking capacity of the two robots is 4.4 to 13.7 times per day on average. When these milking numbers are divided into 3 time periods in the daily 24-hour time period, the average in the period between 00:00 and 08:00 is 11.8, between 09:00 and 16:00 is 12.7, and between 17:00 and 24:00, it is 11.9. The daily milking frequency values of the robots in our research were found higher than the findings in the studies of Laurs et al. (2009) [10]. The comprehensive washing activity of the robots is done three times a day at 06:00, 12:00 and 18:00 when milk is delivered. Furthermore, the robots are unable to milk from18:00 when milk is discharged from the cooling tank up to the end of the operation as there is no buffer tank on the farm. Thus, both robots can milk 2.2 times on average between 18:00 and 19:00. The enterprise may be advised to purchase a buffer tank in order for the robots to be used more effectively during these hours. Other solutions are to make the milk delivery at the hours when milking is less intense or doing it with a pump that has bigger capacity to take the discharging time less than the current score.

When Fig. 4 is examined, a linear increase is seen in the loading rates of the robots in the consecutive three periods. However, the free times of the robots exhibited a linear decrease. These results show that during three periods following the period when the robots are first installed (after the adaptation period of 2-2.5 months; 60 days in total) the cows got used to the robots and increased their milking frequency. As the robots are washed three times a day periodically, the rates were found as 4.7 %.

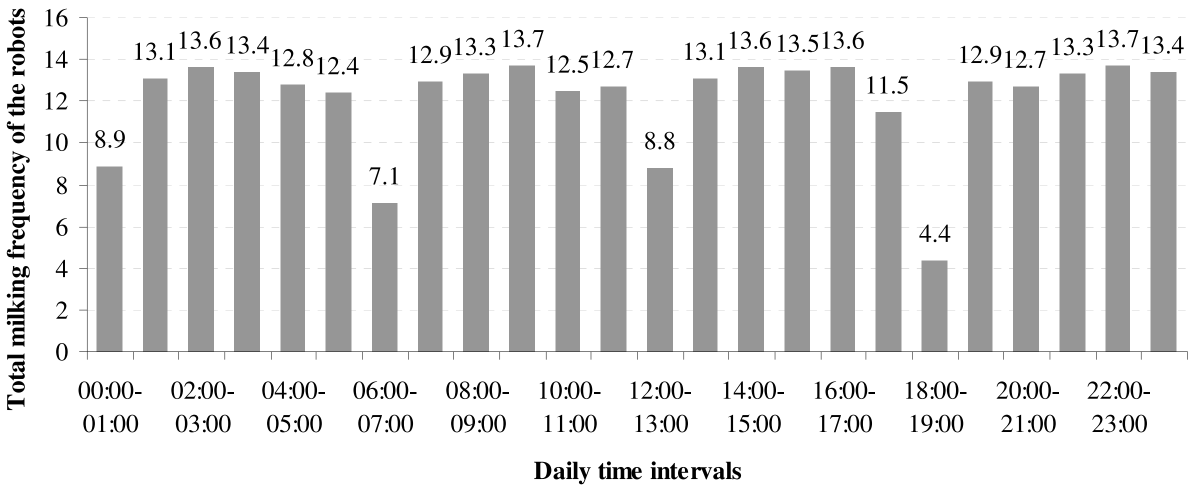

Fig. 3. **Total daily milking frequencies of the two robots**

The total loading rates of the robots in different periods given in Figure 4 were examined separately for each robot. As it is seen in Fig. 5, in the comparison of the two robots, the milking rates were found very close to each other (77.8 % and 76.9 %). Here, it is understood that the cows do not tend to choose any of the robots and do not have a problem in accessing the robot. The idle times of the robots were also found close to each other (17.5 % and 18.4 %). It is possible to decrease the idle time of the robot by increasing the number of the cows in the barn a bit. On the other hand, it can be thought that increasing the number of the cows cannot be individually sufficient in increasing the loading rate of the robot and it is also related to the management of the cow traffic [12]. In other words, it must be considered that the cow to be fetched is an important factor in decreasing the idle time of the robot.

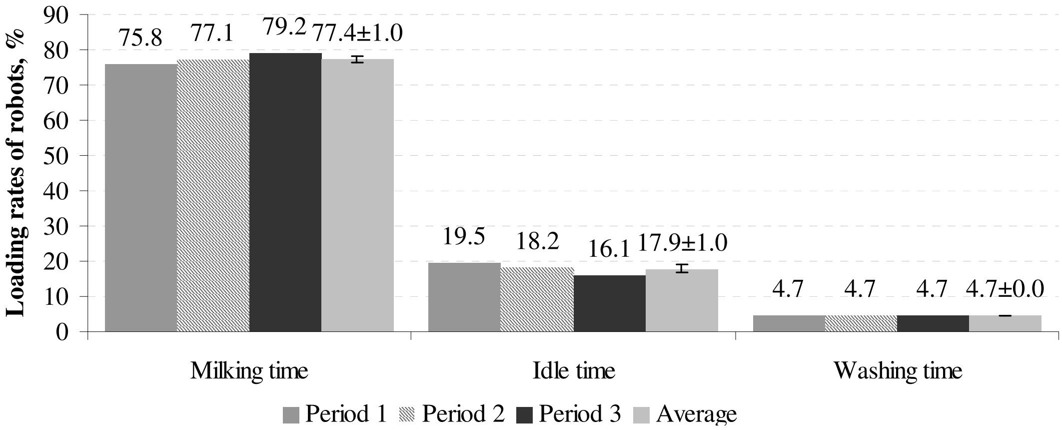

Fig. 4. **Ratios of milking, washing and idle times of the robots in three periods**

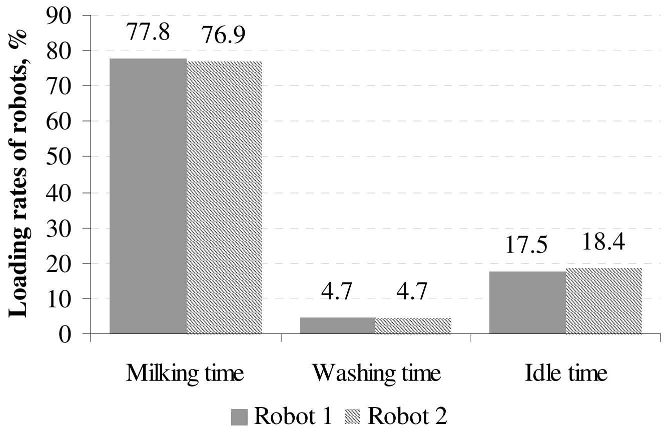

Fig. 5. **Ratios of milking, washing and idletimes of the robots**

The daily average number of milking of the cows milked by the robots in three periods was shown in Fig. 6. As it is seen in the figure, the cows come to the robot milking unit 2.42 ± 0.05 times a day on average. The result was found a bit lower (2.9 times) than the result obtained in the researches of Laurs et al. (2008) [13]. However, this rate is between 2.4 and 2.8 by different lactation periods of the herd in the barns with freecow traffic. Thus, the result obtained fulfils this condition. It may be necessary to adapt the cows to the free cow traffic in order to rise the result obtained in our study to the acceptable lower limit (2.8). Fetching the cow will increase the amount of milk obtained. However, it is necessary to carry out the fetching operation at first, and the cow should be adapted to this. Apart from this, the more effective use of the washing and milk discharge times at certain times of the day when the loading of the robots are found low (between 00-01; 06-07; 12-13 and 18-19) may increase the loading of the robots and the upper limit of the average milking frequency of 2.4 to 2.8 found in other researches can be achieved.

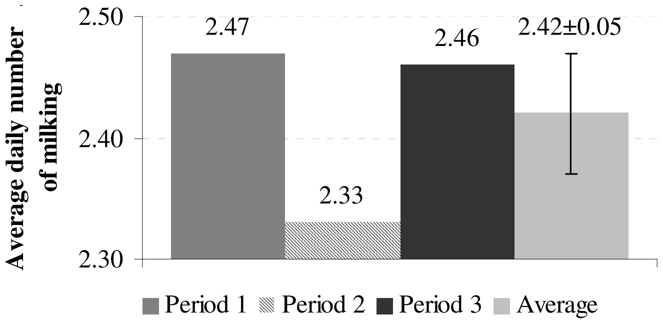

Fig. 6. **Daily average number of milking per cow in three periods**

The daily milking number values given in Figure 6 were examined in a more detailed way in three application periods. The distribution rates of the cows milked by the number of daily milking of the cows during the trials are given in Fig. 7.

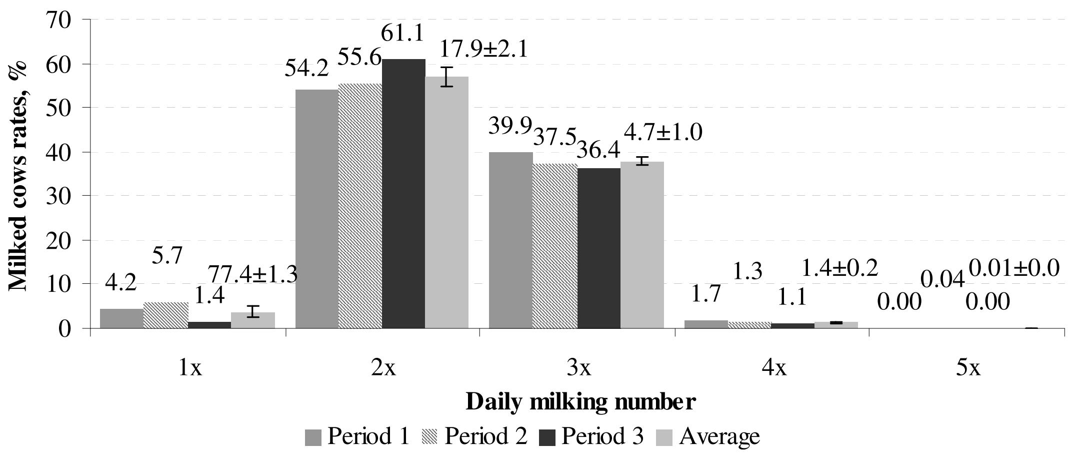

Fig. 7. **Ratios of the cows milked by the number of daily milking in three periods**

As it is seen in Fig. 7, 37.9 ± 1.0 % of the cows were milked three times, 57.0 ± 2.1 % were milked twice and 3.8 % were milked only once by the research average of all periods. While the highly productive cows on the farm should be milked three or four times a day, the number of milking remained at twice a day. The frequency of the high productive cows to come to the robot should be increased by instruction. According to the data extracted from the computer, 3.8 ± 1.3 % of the herd did not come to the robot for being milked. It will be necessary to check the lazy cows twice a day by stimulating them in order to increase the number of milking above 2. In case this is not done, the cow will come to the robot less frequently. Upon examining the periods in the figure, it is observed that there is an increase in the rate of milking of the cows that are milked twice a day, whereas there is a decrease in the rate of the cows being milked three times a day. 1.4 ± 0.2 % of the cows came to the robot four tims a day for milking. When the time on the computer is set at the limit (6 hours between two milkings), this is what it should be. Thus, it may be necessary to adapt especially the highly productive cows for milking four times a day.

In order to increase the effectiveness of the robots on the farm, two rows of cubicles close to the robots can be cancelled and a waiting space (e.g., 4x4 m in size) can be created; it can be enclosed and a one-waygate can be added. The worker fetches the belated cow, and it is thus prevented that the cow entering the waiting space goes back to the herd without being milked.

Conclusions

1. It was determined that both of the robots on the first robotic milking farm established in Turkey were loaded at equal rates (maximum average is 142).
2. The robotic loading was at equal numbers during day hours; however the loading between 13:00 and 17:00 was determined as higher than other hours.
3. The loading values of the robots are appropriate. Furthermore, the cows reached the average with the milking frequency of 2.4.
4. The freecow traffic applied in a commercial robot farm may require the fetching of the cows of which milking is delayed.The problem of "fetching cows" might be solved in some way by rewarding them with much more palatable concentrate. Routing for fetching cows should be simple and logical, so that this task can be combined with cleaning freestalls.
5. The compartments on the farm containing the troughs and brushes obstruct cow transits. It may be necessary to enlarge these transition sections. For this purpose, one or two cubicles close to this can be cancelled.
6. The cows visit the milking robot 2.4 times a day on average. And this is within the required values.
7. 37.9 % of the cows are milked three times a day, 57.0 % are milked twice a day, and 3.8 % are milked only once a day.

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