Contemporary Technical Solutions for Milking Stalls and Dairy Barns with AMS

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Abstract: - In recent years, there has been an increase in dairy consumption in many countries. For this reason, the number of dairy farms and herds' sizes is also increasing. To reduce the work of operators, many innovative solutions are developed in animal husbandry. The present paper describes and analyzes different technologies applied in cow farms, focusing on robotic and automated milking systems (AMS). The cost of purchasing an AMS is high, and the robot should be used at its highest possible capacity. This paper provides guidelines for increasing the capacity of AMS by reviewing and analyzing information from various articles on this topic. Also, here are presented different types of parlor configurations, dairy farm management, and the most frequently used elements of barns and milking stalls.

Key-Words: - AMS, AMS capacity, milking parlor, milking stall, dairy barn design, management of dairy farms

Received: September 25, 2021. Revised: June 27, 2022. Accepted: July 8, 2022. Published: July 29, 2022.

1 Introduction

Nowadays, automatic milking of cows is applied on an increasing number of dairy farms. The main reason for this is the indisputable economic efficiency of the application of automated milking systems (AMS), which can be expressed in the following aspects:

- Significant reduction in the number of operators working in the cow farms;
- Increasing the number of milked animals for a given time;
- They give a possibility to increase the milking frequency, which leads to an increase in milk yield in one day [1].

The cost of purchasing an AMS is high, and for this reason, the robot should be used at its highest possible capacity. The capacity of an AMS is the amount of collected milk in one day. One of the main ways is increasing the cows' milking frequency which is usually from two to four times a day [2]. The AMS capacity depends on many different factors like the number of cows in the herd, feeding method, AMS performance, and cow flow [3, 4]. According to the international requirements, the milking should be initiated by the cow, which goes to AMS voluntarily at any time of the day. For that purpose, the cows are encouraged to enter the milking stall by providing water, preferred or concentrated food, or a possibility to take a rest [5]. Usually, cows with high yields are milked more frequently. Another aspect affecting the used AMS capacity is the time for discharging the milk tank, which depends on the time for washing the milk line and the availability of the second tank in the system [6, 7].

In addition to the milking frequency, an essential factor for animals' lactation is the observance of an appropriate daily routine. It includes the following activities feeding, milking, drinking water, lying down for a rest, and sleeping. For each of these activities, a specially adapted space should be used. The cow traffic between the rooms can be managed as free or selectively guided with fetching cows if necessary [8].

Machine milking has been known and applied for several decades in countries with livestock breeding traditions like Bulgaria. The author of [9] describes in detail the elements and gives directions for the operation of the machine, which made it possible to milk the cows even on the pasture.

The present paper aims to point out the contemporary technical solutions applied on dairy farms. Next section analyses the most commonly used management solutions in dairy barns applying AMS concerning the milking frequency, feeding, and cleaning. It also explains the types of animals' traffic between the different areas in a barn. The last subsection describes the milking parlors located on

a rotating platform. The third section presents the elements of dairy barns that apply an AMS. Section 4 presents the different elements of a milking stall. The paper ends with a concluding part and a summary of the presented technological solutions.

2 Design and Managing Dairy Barns

Nowadays, cow farms organize their activities in different ways, using a variety of technical innovations and methods of their application. This section analyses the main types of dairy barns with AMS according to their design and management regarding cow traffic, milking frequency, and feeding.

The dairy farms may have one or more AMS boxes (stalls), depending on the herd size. In big dairy farms, many cows can be milked simultaneously. They apply various configurations of the milking parlors: parallel (Fig. 1), auto-tandem milking parlors (side-opening, see Fig. 2), herringbone (cows stand at 45° angle to the edge, see Fig. 3), and rotatable platform (carousel, see Fig. 4) [10]. The last configuration is explained in details in subsection 2.4.

Another significant activity in dairy barns is stall cleaning. It usually lasts about 20 min and is performed twice a day. The other areas like resting, waiting, exit areas, and cross-over gates are also cleaned with the same frequency. Automatic manure scrapers clean the barns' floors hourly to take out the animals' dung [12].

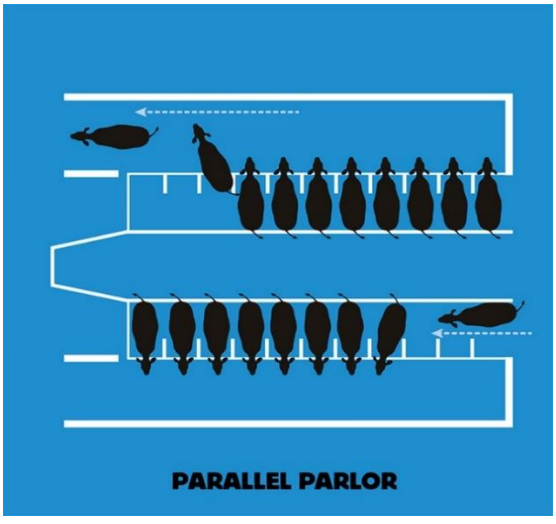

Fig. 1: Layout of parallel milking parlor [11]

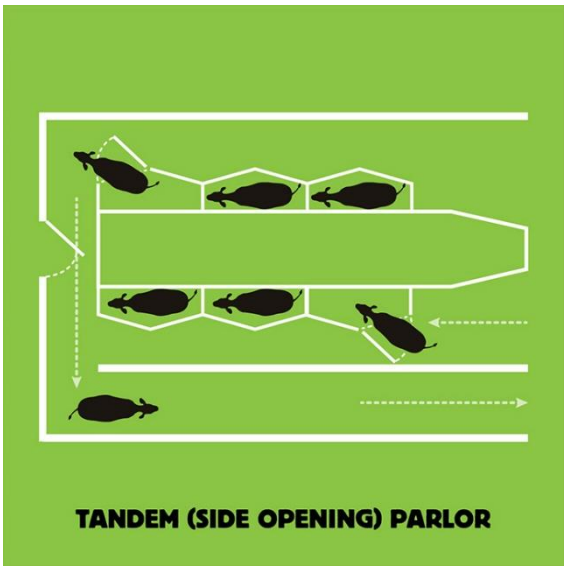

Fig. 2: Tandem milking parlor [11]

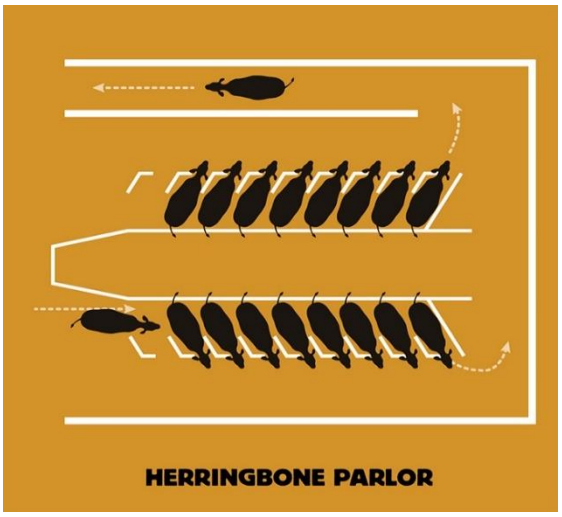

Fig. 3: Herringbone (fishbone) milking parlor [11]

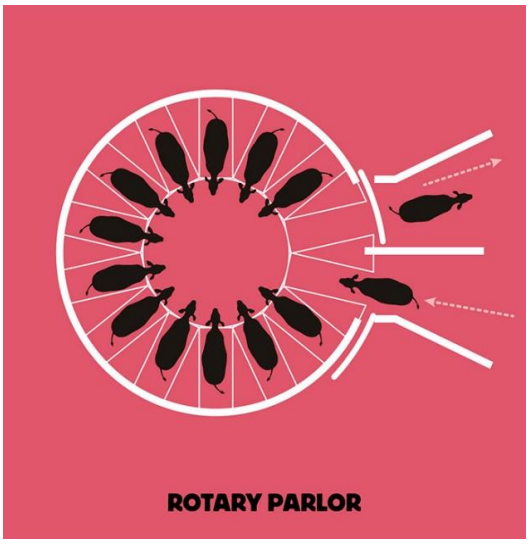

Fig. 4: Rotary milking parlor [11]

2.1 AMS with Free or Directed Cow Traffic

One of the crucial decisions in farm management is the way the animals move. The cows' passage between the rooms and open spaces in a barn can be free or directed traffic.

Free cow traffic: In some farms, cows walk free across the spaces, and it is expected that they will enter voluntarily in the AMS to be milked. In the AMS farms with free traffic, the cow's access to the feed line may be reduced. To encourage animals to enter the milking stall, a couple of methods are used, like offering water or preferred food or a possibility for a rest.

Fetching cows: In the free cow passage, there is a possibility for fetching cows if the animal does not enter the milking stall for a certain time (usually about 12 hours). In this way, all the cows are milked at least two times daily.

Directed (selectively guided) cow traffic: The feeding time and frequency may also be reduced, and thus, milk-first-cow traffic is established. The cows have to pass through the milking stall to access the feed line [8, 13]. The traffic is regulated with smart automatic gates.

2.2 Milking Frequency

Cows that are milked more than twice a day produce a higher amount of milk. According to [14 and 15], the third milking in one day increases the amount of milk obtained by 20% on average. If a cow is milked four times daily, the milk yield increases by 5 to 10% more. The authors point out that the reason for the additional amount of milk is better feeding and farm management.

Cows have two periods: a dry period in which cows do not produce milk and days in milk (DIM). On average base, DIM is about 160 to 170 for one year on farms with good management. Longer or shorter DIM is an indication of a problem [16].

The milking frequency has a more constant value in AMS with directed traffic than those in AMS with free traffic. The reason is that cows pass through the milking stall regularly. Research comparing AMS with free and with directed cow traffic finds out that the milking frequency is higher in the first one [17].

2.3 Feeding

Another significant condition for the milk yield is the feeding of the cow. In AMS farms, cows often are fed with a part of the daily concentrate feed ration, so they are encouraged to pass regularly through the milking area to reach the next portion of the food [17]. The total mix ratio is usually distributed twice daily. The additional concentrated food is provided individually in the milking stall [11].

For the complete feeding of the cows, they must take a variety of food. On different farms, the food has a different composition and may include: grass (grazing from a pasture), legume (soybeans), and high nutritive value forages. Cows show various preferences for them, which may vary depending on the time of the day [18, 19], physical distance, and season. The farms applying a free cow passage should consider these preferences, as additional food encourages animals for voluntary milking [20].

2.4 Rotatable Platform

Some dairy barns apply an innovative approach for arraigning the milking stalls. A plurality of milking stalls is situated on a rotatable platform (carousel) supplied with robots-manipulators. The robots-manipulators can work simultaneously in the neighboring milking stalls. They are placed locally and can move their arms according to the rotation of the platform. One robot-manipulator can attach to a single cow with the available number of teat-cups (at least two). The application of this innovative technology requires using a certain method of operating the system, such as the method described in [21].

3 Most Frequently Used Elements of Dairy Barns

The dairy barns can be designed in different manners applying or not a wide set of technical equipment and management solutions. Configurations of barns can change the cows' daily regime, and thus, the milk yield. This section presents the most frequently used elements in AMS farms.

A milking stall (AMS) is a specialized box for milking cows. After a cow enters the AMS, several activities are carried out: cleaning and massaging the udder, attaching the teat cups, milking, and storing the teat cups. Additionally, food or water may be provided to the animal. The elements of AMS are shortly described in the next section.

Milking parlor (Milking room) – a room or construction designed for milking a group of cows. It may include different amounts of milking stalls depending on the sizes of the herd and the barn.

Resting area – A space in which cows can lay down and have a rest between feeding and milking.

Feeding area – A room for providing cows with food [22].

Feeding Line – The food is placed in a long feeder, which is usually separated into sections for a single cow.

Waiting area – The cows are passed from the resting area through access gates to the waiting area that is established in front of the AMS. After that, they are directed to a milking stall to be milked. The waiting area is not mandatory for every farm. It is recommended that the time spent in this area be minimal, as it is wasted instead of resting, and in addition, it can cause problems with cows' feet and nails. These issues reduce the milk produced and thus the income of the farm [23, 24].

Exit area – Cows enter the exit area after milking in the stall, and after that, they are passed to a separation area through another smart gate.

Separation area – In this room, if the cow has health problems or requires a care procedure, a sorting gate directs it to a separate area (infirmary), and if it does not need treatment or care, the gate gives it access to the feeding area.

Concentrate Self Feeder (non-mandatory element) – the concentrated feed stations can be placed in the barn, and cows with high milk yields are allowed to reach them.

Troughs for drinking water are usually placed in resting, feeding, waiting, and separation areas. Their number in the barn depends on the herd size.

Different types of **smart gates** (one-way gate, selective gate, and cross-over gates): Cows are directed through different areas through smart gates, which can pass or not cows according to their condition (milking of feeding permission, health, and care needs).

Other elements of AMS barns are **trimming storage** for trimming hoofs, **scratching brushes** in the feeding area, and **manure scraper** for removing cows' dung (usually every hour) [10].

4 Elements of a Milking Stall

This section describes the elements of a milking stall, as some of them are requirements for every AMS, and others are not mandatory.

Robot arms (manipulators) are the part of AMS which manipulate the cow's udder. It contents several tools to perform the necessary activities for the milking (teat-cleaning brushes, teat-location device, and teat cups).

Teat cups – They attach to the cow's teats to collect the produced milk. The teat cups must be well attached to cow's teats because their detachment causes milk leakage and thus revenue reduction. There are two main ways for attaching the teat cups: manually by an operator and automatically by a robotic arm directed by a video camera.

Cleaning system – It cleans the cow's teats and udder before attaching the teat cups for milking. The aim is to remove the different types of pollution, so they will not enter the milk. The cleaning device can be mounted on a milking robot or at the side of the milking stall.

Cameras focused on the udder – Depending on the AMS, they may have one or two purposes: 1. determining the location of the cow's teat for automatic attachment of the teat cups (main purpose), and 2. Video observations on the milking process and measuring the time of milking phases (additional nonobligatory purpose). In the second case, the cameras record the activities all the time, and on farms with auto-tandem milking parlors, they can observe all milking stalls simultaneously. A software program analyses the video records according to manually entered data for the milking phases [17]. However, cameras are not a mandatory element of the milking parlors. In some AMS, the teat cups are attached manually by a dairy farm operator, which is a possible solution on smaller farms.

Milk tank – A tank for storing and cooling the collected AMS milk. It can have a different volume according to the system. When it is full, the milk is transferred to another storage, and the tank is cleaned for further usage.

Spare (buffer) milk tank – The AMS is not working during cleaning and discharging the milk tank, which decreases its capacity and is economically unprofitable. For this reason, in some types of AMS, a spare milk tank with a smaller volume is available.

Feeder or water trough – The faster milk flow means a shorter time for milking a cow, and thus, a possibility for enlarging the AMS capacity. The stimulation of oxytocin secretion is one of the ways to increase milk flow. This effect can be achieved by feeding or watering the cow during milking [25].

Flooring in AMS – According to [17], the type of flooring in AMS also influences the time that cows spend in the milking stall. The more comfortable flooring (such as rubber) decreases the exit time compared to metal flooring with a profiled surface.

The pressurized-air jet is applied on some farms to encourage cows to exit the AMS after being milked. Another technical solution, the **electric exit drive**, is rarely used nowadays as it is forbidden in countries like Switzerland [17].

5 Conclusion

Dairy farms apply different contemporary solutions aiming to achieve better economic efficiency. The high price of the technical equipment necessitates its optimal usage (highest possible capacity). The different possible configurations of the parlor necessitate a different set of the above-described elements. The optimal solution depends on the following factors: milking frequency, herd size, feeding regime, and milk transfer from the tank.

The parlor configurations also lead to the application of different types and configurations of the milking robots. The daily regime of the cows, and thus, the milk yield also depends on the technical solutions used in the dairy barn. Thus, farm management is a crucial factor for overall profit.

The features of the selectively guided cow traffic make it appropriate for herds with a higher number of animals. It can decrease the farmers' labor and therefore lower the expenses. It also leads to increasing the milking frequency and enlarging the milk yield.

Acknowledgment:
The research leading to these results has received funding from the Ministry of education and science under the National science program INTELLIGENT ANIMAL HUSBANDRY, grant agreement n°Д01-62/18.03.2021.

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