Are Robotics Ready for Large Dairy Herds?

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INTRODUCTION

Adoption and application of robotics in the US dairy industry is gaining strength and numbers. Industry estimates that about 2 % of the dairy cattle in the US and Canada are currently being milked via robotic milking methods. In some European countries, over 30 % of the dairy cattle are milked with robots. Currently many US dairy farms are building and planning these types of facilities. Some industry experts expect sales of robotic milking equipment to account for more than 30 % of the total milking equipment sold in the next decade. Barkema et al. (2015) estimated that the number of dairies with robotic milking parlors worldwide exceeded 25,000 in 2015. This represented a three-fold increase from estimates made 6 y earlier (De Koning, 2010). At this point, most of the sales of robotic equipment has been in herds of less than 300 cows. However, interest within the larger herds is growing rapidly. In the US, over 50 % of the dairy cattle are housed in herds larger than 1,000 head and nearly 35 % of the total herd is housed in herds with 2,000 or more cattle (USDA, 2012).

In the past 18 mo several US facilities have been constructed or existing facilities modified with robotics in herds of 500 to 1,500 cattle. Facilities outside the US located on a single farm are successfully milking over 3,000 head. Additional facilities for larger dairy farms are in the planning stage and it is very likely that the US will see a large increase in the number of larger dairy farms building new facilities and modifying existing facilities to accommodate robotic technology. The purpose of this paper is to help producers and farm advisors understand some of the key issues associated with the adoption of robotic technology.

TYPES OF ROBOTIC TECHNOLOGY

Robotic technology can be divided into 2 major categories, milking and feeding. Robotic technology for milking includes a complete system which performs all the manual operations of a conventional milking parlor. These systems are able to perform these operations without the presence of an operator. While operator assistance may be necessary for initial training of the cow and the robot, further human contact is not usually necessary for a normal milking. In most systems, the cow travels to the milking system without human aid. Most of the systems installed worldwide are individual box stalls where one robot milks an individual cow. There are also other examples where a single robot services 2 - 4 stalls. In 2010, the first automatic rotary milking system was opened in Sweden. This system featured a 24-stall rotary with 5 robots performing various functions of the milking process. This system was predicted to milk up to 90 cows per hour (Jacobs and Siegford, 2012).

More recently, robotic milking parlors have been installed with single robots at each stall and larger wheel sizes. This type of technology is very appealing to large scale producers as it would allow farms to keep their other management practices and continue to manage cows in groups. Humans would be needed to move cows to the milking parlor in these systems.

However, there are challenges to the speed of teat cleaning and attachment that result in slower wheel times than found on current conventional rotary parlors. There are also issues associated with equipment maintenance and repair that render the rest of the milking stations unavailable while these activities are performed. This is also true for the routine cleaning of the teat detection equipment. With single box stalls and multiple boxes per pen, only one milking station is closed for repair, maintenance, or cleaning while the remaining stalls continue to be available for milking. There has also been equipment designed for conventional rotary milking parlors to apply pre- and post-teat dip. This can reduce the required labor by 25-40 % depending on the size of the rotary parlor. There are also examples of teat dip applicators that can be mounted in parallel milking parlors.

Feeding application of robotics range from systems that automatically push up feed at preset times to fully automated systems that mix, deliver, and push-up feed on a schedule or when the feed bunk requires additional feed. While there are not a tremendous number of these feeding systems being utilized in the US, it is an option that could be considered. Currently the application is for herds of less than 1,000 cows, but this could change in the future.

APPLICATION OF ROBOTICS ON LARGE DAIRY FARMS

Application of robotics on large dairy farms is gaining interest in the US as a way to increase labor efficiency and to standardize the milking process. Many smaller farms have chosen automatic milking systems (**AMS**) as a way to achieve lifestyle goals (Rodenburg, 2017) as an additional benefit. Jacobs and Siegford (2012) suggested that smaller farms may find more economic benefit from the AMS than larger farms. It was also suggested that larger farms may have a greater ability to hire labor for conventional parlors and may do this at a cheaper rate. However, recent changes in the immigration practices of the US government and a robust economy have resulted in a smaller potential labor pool for US dairy farms, removing the potential advantage that existed a few years ago. While these factors may push larger farms toward robotics, there are many paradigms that must be addressed as robotics are adopted.

BREAKING THE PARADIGMS

One of the major barriers of the adoption of AMS on large dairy farms is the efficient utilization of capital. Capital investment per cow for an AMS is likely about 10-fold more than the equipment for a conventional milking parlor for a large dairy farm. This represents a significant barrier and sometimes results in a total rejection of the AMS concept without exploration. A major factor in the profitability of the AMS is the amount of milk harvested per box or robot. Currently, many farms harvest less than 5,000 lb of milk on a daily basis from each robot. There are some more intensely managed farms that are harvesting 6,000 to 7,000 lb/robot/d. Obviously, this changes the economics as an extra 1,000 lb of milk/d can add $58,000 to $68,000 to the annual gross income of each AMS. Designing facilities and management schemes to provide for excellent cow comfort and flow along with appropriate nutrition are important to allow for greater amounts of milk harvested daily per robot.

If one simply thinks of the AMS as a method to milk cows, as we do for conventional milking systems, then we are not evaluating the total value of the AMS. The AMS provides additional data that can be effectively utilized to manage the cattle. When making the comparison, keep in mind that an AMS can provide individual data daily concerning milk production, activity, concentrate intake, rumination, etc. So it is more than just a system to milk cows.

What is the value of this additional information? It depends if the information is utilized. This will require that the dairy producer and employees understand how to obtain information and react to the information received on each cow. This changes the management scheme from a group-based focus to an individual cow focus. The focus needs to be on the animals that are not performing well or those that need attention. The data can be very helpful in identifying animals that might need human intervention. Understanding the data and the logarithms that help identify the correct animals for focus is key to adding value to the information and the AMS.

Management of large dairy herds is generally based on efficient handling of large groups of dairy cattle based on parity, reproductive status, stage of lactation and/or level of milk production. Currently, almost all of the robotic milking facilities feature box type milking systems with smaller group sizes and only parity may be considered when assigning animals to groups. Some larger farms house 400 – 800 animals in a single pen to efficiently utilize large conventional milking parlors. Group size in a conventional system is often determined by the capacity of the milking parlor to milk a group of cows in 45 – 60 min. Some of the current rotary parlors can milk over 800 cows in one hour. With the current box robotic technology, each individual box can milk 60 - 80 cows/d. It is dependent on the level of milk production and the number of desired milkings per day. Multiple boxes can be installed in a single pen, but generally, the efficiency of each individual box is reduced when additional boxes are added to the pens. Current designs contain no more than 4 boxes per pen and most generally 2 - 3. Thus group sizes generally range from 60 - 240 animals depending on the number of milking units in the pen. A single stall will generally allow for 180 - 200 milkings in a 24-h period. The actual number per box is dependent on the number of animals in the pen and the desired number of daily milkings for each cow. Barn design may impact this number based on the work of Bach et al. (2009) showing that guided traffic barns may be able to milk more cows per robot than free flow traffic barns.

Handling more and smaller groups of cows is a major shift in management paradigm found on most large dairies today. In addition, performing normal practices such as breeding in all the lactating pens on the dairy, may create some questions about labor efficiency of the system. Again, one must change the management paradigm. In the AMS, cows can be sorted upon exit from the AMS to a smaller pen. The system can be set to sort animals only during certain times of the day and a text message can be sent to a telephone to notify the producer that the cow has been sorted. If the pen size is 200, the normal breeding herd would be about 35 % of the pen or 70 animals. If one only utilizes the heat detection systems based on activity, then there would be 2 - 3 average daily services per pen. If reproductive synchronization programs are utilized, cows can be sorted for injections and larger numbers of cows will be serviced on certain days. This can be managed by determining how many pens are synchronized for breeding on a certain day. Again, the paradigm of animal management must shift to accommodate the management of cattle in an AMS.

Changes in our thinking of animal flow must change as well. On a conventional dairy, animal flow is largely created by humans moving the cattle to the milking parlor 2 or 3 times/d. This has impacts on feeding behavior, heat detection, animal health detection, and many other aspects associated with the management of a large dairy. In the AMS, cows move independently to the milking system without the aid of a human. Animal flow is often interrupted by human presence in the pens of cows milked with an AMS. Thus, removal of manure, stall maintenance, and other routine management practices may disrupt the animal flow in a pen. The work day on conventional dairies is largely structured around the milking schedule. Feeding, stall maintenance, reproductive tasks, etc. all revolve around the milking schedule. Consequently, significant changes in how work is arranged on the dairy must occur. With the AMS, animals develop their own flow pattern that is not associated with the milking activity. Cows must be motivated to come to the AMS 2 - 5 times/d without human intervention. This requires additional attention and understanding of the nutrition program.

Nutrition focus and methods change significantly when adopting the AMS. Rather than feeding a total mixed ration (**TMR**) the nutritional program is split between the feed bunk, partial mixed ration (**PMR**), and the pellet or concentrates fed in the AMS. In the AMS, feed in the milking station may help with the motivation of the cow to present for milking. Animals that do not present on a regular interval become a fetch animal and require human intervention to achieve milking. Hunger may be a major motivator for the cow to move and circle between the AMS and the feed bunk. Hunger in dairy cattle is typically driven by either gut fill or metabolic factors. In early lactation, distension of the rumen is the major limiting factor to intake. Thus, the rate at which feedstuffs exit the rumen allows for additional intake of nutrients. Forages, and in particular the fiber of forages, are the slowest to ferment in the rumen. Forages also represent the greatest amount of variability in the ration. Thus, slowly fermented forages will have increased rumen retention times which could lead to reduced drive to move from the stall to the AMS or feed bunk. Owners of the AMS generally desire higher levels of milk production from their herd. Thus, attention to forage quality and the increased complexity of feeding a PMR along with concentrates in the AMS increases the attention required to properly balance the total nutritional program. It is also complicated by the fact that if cattle do not present for milking, they do not have access to a portion of the feed from the AMS. Thus commitment to training and fetching in early lactation may have an important impact on individual cow performance as well as overall herd performance.

SUMMARY

Are robotics ready for large dairy farms? Advances in the technology and equipment in the past 2 decades has resulted in very reliable equipment that can efficiently milk dairy herds. While application to this date has largely been on smaller dairies, that is about to change. Herds of over 1,000 cows can and are being milked with robotics. Several projects are in the planning phase that will handle 3,000 to 10,000 cows. One unit in another country currently milks over 3,000. In the next 10 y we will see significant interest in the further application of robotic technology on large dairy farms.

In order to be successful, dairy farm owners and managers will need to rethink the total management of the dairy. Many of our existing paradigms on personnel and cattle management will need to change to fit the new system of production. Activities that currently revolve around the milking schedule can now be accomplished at other times of the day. Additional attention will be possible for individual cattle and higher levels of productivity are possible by utilizing the vast amount of data generated by these systems. The technology is ready for application; however we will continue to develop and learn how we more efficiently utilize the technology on large scale dairy farms.

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