Keys to successful robotic milking systems

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Abstract

The use of robotic milking systems is growing rapidly in North America. Most installs have been on smaller farms that desire an improved lifestyle and to minimize the need to hire labor. The majority of robotic milkers are single box systems where one robot arm services one milking box, but some newer designs are multi-box where one robotic arm will service two to five milking boxes.

The two types of cow traffic in robotic milking systems are guided flow and guided flow. In free flow cow have free access to feed, the lying area and the milking robot. Guided flow systems have pre-selection gates that help guide cows that need milking to the robot.

There are several keys to making robotic systems successful. One major factor is that successful producers really like working with cows. Robotic milking systems require excellent management for success. Other major factors that drive success include feeding management and well-designed facilities that facilitates excellent cow flow and efficient labor management. It is important that producers develop realistic cash flows. Taking a whole system approach in design and management will maximize the RMS performance.

Résumé

L'utilisation de systèmes de traite robotisée augmente rapidement en Amérique du Nord. La plupart des installations ont été sur les petites fermes qui désirent un meilleur style de vie et de réduire la nécessité d'embaucher de la main-d'oeuvre. La majorité des trayeurs robotiques sont les systèmes à boîte unique où un bras robot services une boîte à traire, mais certains dessins et modèles plus récents sont multi-box où un bras robotique assurera le service de deux à cinq boîtes de traire.

Les deux types de trafic de vache en sont les systèmes de traite robotisée Guided Flow et Guided Flow. En Libre circulation vache ont libre accès à nourrir, l'aire de couchage et le robot de traite. Guided Flow Systems ont pré-sélection gates qui contribuent à guider les vaches qui ont besoin vers le robot de traite.

Il existe plusieurs clés pour réaliser des systèmes robotiques réussie. Un facteur important est que les producteurs prospères aiment vraiment travailler avec les vaches. Les systèmes de traite robotisée nécessitent une excellente gestion de la réussite. D'autres facteurs importants qui déterminent la réussite comprennent Gestion de l'alimentation et les installations bien conçues qui facilite l'excellent débit de vache et efficace de gestion de main-d'oeuvre. Il est important que les producteurs à développer les flux de trésorerie réaliste. En prenant une approche système entier dans la conception et la gestion permettra de maximiser les performances de RMS.

Introduction

Robotic milking systems (RMS) or Automatic milking systems (AMS) are becoming more common in the US with a steady growth taking place throughout the US. It is estimated that there are ~12,000 RMS farms in the world. In North America there are over 2,500 RMS on over 1,000 farms. Most of these are located in the upper Midwest and Northeastern US.

Because of the growth in this technology and the lack of data from the Upper Midwest US, we decided to conduct a field study at the University of Minnesota to describe these systems and learn about best management practices. We have been working with 52 RMS farms in MN and WI and collected housing information, description of management practices (using a questionnaire), and downloaded robot software data. We also scored cows for locomotion, severe hock lesions and hygiene. We have started to summarize and evaluate the daily data downloaded from the robot computer for every cow on every farm for 2013-2014. Along with describing what is happening day-to-day on the farm, this data will allow us to further investigate factors associated with productive parameters on the dairy and make some inferences about cow preferences and behavior.

Why are producers installing automatic milking systems?

The milking process is well suited for robotic technology. It is a repetitive process where the teats are found and cleaned, abnormal milk identified, cows are milked and post dipped. Most farms are already using some automation in the milking process, such as take offs.

Producers had many reasons for installing robots. The three most often mentioned reasons were:

- Time flexibility/improved lifestyle – most common reason by all producers
- Labor management – either the desire to expand without adding employees or the challenge with hiring and managing labor
- Human health issues – some would be out of the business with health issues if they had not installed RMS units

Other reasons included:

- Enjoyed cows, but no longer enjoyed the monotony of milking
- More time for other activities such as cropping or herd management
- Wanted to stay with latest technology

Our results agree with other surveys conducted in Europe.[4]

Overview of robotic milking systems

The majority of RMS in operation today are single box systems, with a robotic arm serving one, or two to five boxes, depending on the manufacturer. Most common RMS in operation in North America are Lely and DeLaval (one box systems), but GEA Farm Technologies and AMS-Galaxy are growing their RMS market share. There are also several companies designing automated milking systems for rotary and parallel parlors. Within the next year there will be partially or fully automated rotary parlor systems installed in the US. Robotic milking systems automatically collect large amounts of information on each cow daily including milk production, milk conductivity, milk clarity, cow activity and even individual cow rumination data. If used by the dairy farmer, this information can greatly assist with management of the herd.

Just like a milking parlor, RMS have an ideal throughput per day. Below is a range of some of the parameters to expect when an AMS is operating at peak efficiency (per robot):

- 140 to 190 attachments (milkings) per 24 hour period
- Average of 2.4 to 3.0 milkings/cow/day. However, dairy producers are able to dictate milkings/cow for each cow every day.
- 4000-5500 lb of milk/AMS/day. This number can be widely variable depending on milk production per cow and other factors. Several of these will be discussed below.

Below is a brief summary of some of our results:

- Farms averaged 2.8 AMS/farm (1 to 8 RMS/farm)
- 58% of the barns were new and 42% were retrofitted RMS units in existing barns
- 47% of the farms had automatic alley scrapers, 21% had slatted floors, 6% had bedded packs and 26% scraped alleys manually
- 75% of the farms had exclusively free flow cow traffic, 23% had exclusively guided flow traffic and 2% had both a free flow and guided flow cow traffic system in separate barns
- 85% of the farms had mechanical rotating brushes
- 21% of the farms had robotic feed pushers that pushed up the ration on a pre-determined schedule
- 41.5% of the farms had mattresses, 26% sand, 13% waterbeds, 9.5% mattress and grazing
- Lameness prevalence was 40.9% for mattress, 21.5 for pasture, 22.5 for sand, 19.0 for bedded pack, and 35.3 for waterbeds
- Average feed bunk space was 20 inches/cow (range 10.2 to 42)
- Average number of milkings/day was 2.6; it has been suggested that greater than 2.4 is best
- Average milk production per robot per day was 4,325 lb (Figure 1); it has been suggested that greater than 4,500 lb is best. The range was from 2765 lb to 5568 lb per robot. Five herds averaged over 5000 lb per robot daily for over a year.

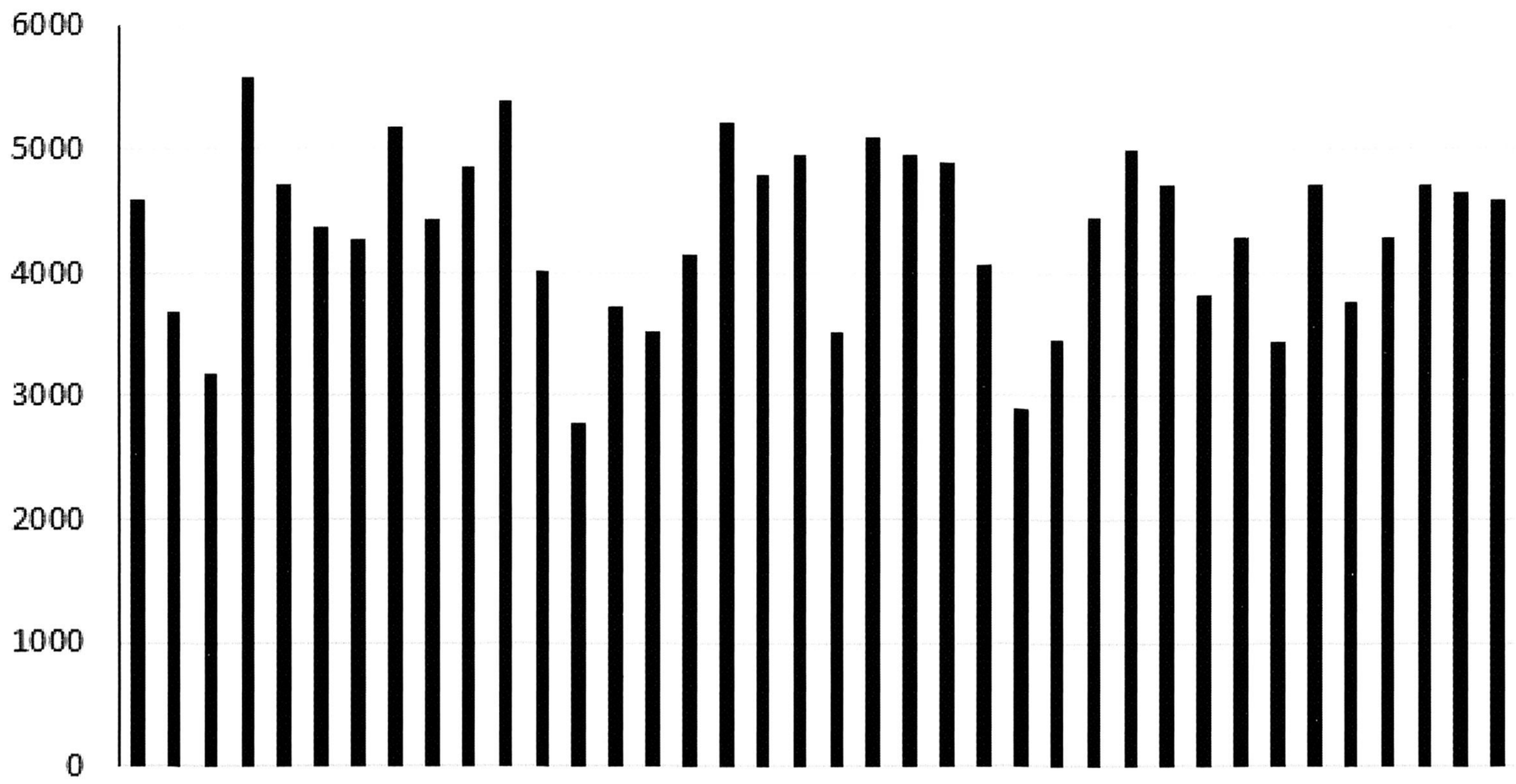

Figure 1. Daily pounds of milk per robot.

- Amount of concentrate fed in the AMS unit was 2 to 25 lb per day depending on stage of lactation and type of system (free flow 2 to 25 lb, average 11.2; guided flow 2 to 18 lb, average 7.9)
- Partial Mixed Ration (PMR) in guided flow systems was higher in energy (0.015 Mcal/lb) and lower in NDF (2.1%) than in free flow systems
- In free flow herds the PMR was balanced for milk production levels of 10 to 30 lb less than the herd's average production
- In guided flow herds the PMR was balanced for 9 to 20 lb less than the average production

Like any successful dairy, the entire management system must be considered if maximum performance is desired. Unlike a parlor system where cows are herded to the milking center and milked whether they like it or not, RMS must facilitate cows having a good milking experience every time so she voluntarily returns to be milked again. Barn design, feeding system, cow handling and manure systems must all focus on making it easy and a good experience for cows to be milked by the robot.

Cow traffic systems

There are two types of cow traffic in RMS systems, free flow and guided flow. In barns with free flow traffic, cows can access all areas of the barn without restriction. In guided flow traffic, one way gates and selection gates are used to guide cows to milking, feeding and resting areas.

There are two types of guided flow traffic – feed first and milk first. In the milk first system, cows leaving the resting area must pass through a pre-selection gate that determines if she is eligible for milking. If she meets the requirement to be milked she is guided to a commitment pen that contains the RMS. If she is not eligible for milking she is allowed to enter the bunk area and can only enter the resting area through a one way gate. In the feed first system, cow traffic is the reversal of the milk first system. After eating, the cows enter a selection gate that determines if she is eligible for milking. The gate either guides her to the commitment pen for milking or to the resting area.

Farmer comments and our observations indicate that the milk first system is superior with the US style of dairying where economics demand high production. Our observation is that in feed first systems, cows fill up on the PMR and tend to loiter in the feed alley or commitment pen and chew cud without entering the selection gate or visiting the RMS. Producers in these systems had the same observations. Feed first systems work best in farms where the PMR is very low in energy and there is a drive for cows to consume the concentrate in the milking box.[a]

Both guided flow and free flow systems can be successful. In our study, we had herds that averaged over 90 lb/cow/day over an entire year of production with each system. The best system is determined by the goals of the producer and their management style. In general research has shown that there are fewer fetch cows with guided flow systems than free flow systems.[2,7] Capital investment tends to be a little higher in guided flow systems because of the additional pre-selection gates. Cow management complexity can be higher in guided flow systems. In free flow systems cows have access to the robot, stalls and feed at all times. In guided flow systems, managers must be aware of cows that are confined to the commitment pen for long periods of time and choose not visit to the robot. Cows also may choose not to pass through the selection gate on their own on a regular basis. However, feeding management can be more challenging in the free flow system. There are no pre-selection gates to help guide cows to the milking box so ration changes that affect visits are exacerbated.

Keys to success with robotic milking systems

Based on our research and interactions with producers and advisors, we have learned there are several keys that increase the likelihood of success and satisfaction when installing robotic milking systems. These observations are based on research, producer surveys, and current field observations with newer installations.

1. Enjoy working with cows

If you install a RMS, you must still need to work hard and pay close attention to your cows. We have seen in our research that the most successful producers enjoy working with cows and don't have the attitude of putting a robot in the barn and leaving cows to their own. The barn and stalls need to be cleaned daily, cows bred and treated, cows fetched, cows fed, etc. It just makes one chore – the tedious milking chore – automated, giving the producer more work time flexibility. That is very helpful especially for smaller operations run with family labor. As one of our successful project collaborators, Doug Kastenschmidt, said: "Management makes milk. Robots only harvest it!"

2. Excellent ration/feeding management

How and what cows are fed in a RMS farm is one of the most important keys for success. The interaction between cow behavior, activity, her diet, feed consumption and cow health and production is complicated.[5]

In our study, we asked nutritionists to rank five feeding factors they thought were keys to RMS feeding success: PMR energy content, PMR starch content, consistency of the PMR (consistent mixing and delivery), consistent push up of PMR, and palatability of the pellet. Nutritionists working with these dairies indicated that consistent mixing and pellet quality (palatability and hardness of the pellet) were the two biggest feeding factors contributing to RMS success. These results agree with comments made by dairy producers on our visits and existing research. Rodenburg and Wheeler showed that in a free flow system when feeding a high quality pellet vs a low

quality pellet, voluntary milkings increased from 1.72 to 2.06/cow/day.[8] Many producers in our survey had tried feeding a meal instead of a pellet in the milking box. Overall this proved unsuccessful and most reverted back to feeding a pellet. Pellets should be hard, free from fines and made from palatable ingredients. At farm start-up nutritionists and farmers focused on developing a pellet formula that encouraged milking box visits. Once they had a pellet that worked well, other factors became more important. Many producers commented that even minor changes in the PMR moisture, consistency of the mix (i.e. long hay that is difficult to process to a consistent length) and changes in forage quality affected visits.

These complicated interactions between feeding management, voluntary visits and milk production can be challenging, especially in free flow barns. High forage/low energy PMR helps drive cows to the robot, but may limit milk production. A high energy PMR may increase the number of late lactation fetch cows. If feed moisture changes and rations are not adjusted promptly, visits may drop. This drop in visits will result in a decrease in milk production and an increase in number of fetch cows (cows that did not visit the robot voluntarily during a specified time period and need to be brought up to the milking box). The increase in fetch cows may disrupt other cow behaviors resulting in even a bigger decrease in visits and decrease in milk production leading to a downward spiral creating much frustration for the producer.

3. Well-designed comfortable facilities

Cow comfort is important in any dairy production system. For RMS, it is even more important that cows are healthy and willing to come to the milking station. Research has shown that lame cows visit the robot less frequently and must be fetched more often that non-lame cows.[1,3] It is necessary to have good cow flow (be it free or guided) so that we don't hinder attendance to the robot.

Some design attributes that will improve labor efficiency and improve cow flow:

- Automatic manure removal system
- Split entry for free flow traffic
- Adequate exit lane length (at least one cow length). This protects cows as they exit the robot and reduces the likelihood of approaching the exit side of the milking box searching for robot feed.
- Drovers (transfer) lanes
- Sort pens near the robot for special needs cows and cow management activities or headlocks
- Excellent ventilation
- Consider all right or left handed robots or both in each pen. Some cows do not adjust well to switching robot orientation.

4. Expect higher repair costs

These systems are hi-tech and expensive. A sophisticated piece of equipment requires money to maintain and repair. If producers learn how to fix little things, it will help make AMS more affordable in the long run and reduce the number of failures and problems that can affect robot efficiency. This will keep repair costs low and improve RMS performance. You can't just go to the local hardware store to get all the parts you need.

5. Excellent dealer support

What is the service provider's assistance at start up? Do they have skilled technicians for major repairs and routine maintenance? If the RMS breaks down for a long period of time, things can get really out of control and create a 'train wreck' very fast. Keep it at top performance!

6. Enjoy technology

Robots take more technical skill than other milking systems. The manager should enjoy using software for the greatest benefit. There is so much information about every cow that you can use to optimize performance and health. RMS companies are developing even more decision making tools that will help organize your day and create a task list every morning.

7. Develop realistic cash flows

Even though the motivating factor of most producers installing robots is to improve lifestyle, it is important to develop a realistic cash flow and carefully think about how much capital you want to tie up in your milking system. We have developed a couple of partial budget spreadsheets looking at the economics of robots. These spreadsheets are available online at: http://z.umn.edu/lazarus. They will perform an economic analysis based on user inputs. There are tabs that create sensitivity graphs, compare multiple scenarios, and show a yearly cash flow graph based on loans. These can allow you to do a quick assessment on how robots may affect profitability.

The biggest factors that affect the profitability of switching to a robotic milking system are the change in milk production and labor. Most herds switching from 2X to a RMS will experience an increase in production of 3-5% per cow per day, but 3X herds will likely see a decrease in production.[6] The amount of labor saved varies depending on barn design and producers goals. Another factor affecting the financial success are the activities that replaces the milking labor. Investing the labor savings in activities such as harvesting higher quality forage, improving youngstock management or improving crop yields has the potential to improve overall farm profitability.

8. Consider future expansion.

Currently the box type robots on the market are able to milk about 50 to 70 cows per box. If future expansion is planned, expansion must be in 60-cow increments and increased investment in robots will be required for each subsequent expansion. In parlor systems, increasing milking hours is often all that is required.

Mindset change with automatic milking system

Robot time is very valuable in RMS. The focus should be on milk per robot per day. This is done by maximizing the milk per minute of box time and optimizing the percent of time the robot is idle. There is a wide range between farms in these parameters. Our research had an average milking time of 5.5 minutes per milking, with a range of 4.5 minutes to 6.5 minutes/cow/milking. The percent time the robots were idle averaged 19%. Most manufacturers recommend a goal of about 10% idle time to allow for maintenance and optimize visits per cow.

The main factors affecting milk per minute of box time include:

- Prep and attach time – this is affected by cow co-operation, teat placement, udder balance, udder singeing and the ability of the laser and/or cameras to find the teats
- Cow milking speed
- Milking permission settings – not allowing cows to milk until predicted milk production is higher will increase milk per minute of box time. However this may decrease milk/cow/day and visits/cow/day.
- Machine settings and maintenance – clean lasers and cameras and prep settings can minimize prep and attach time
- Optimum free time – suggested free time is 10%, but some dairies have excellent visits and milk per cow with less free time
- Optimize milking refusals per cow
- Ideal cow confirmation – robot milking systems have difficult attaching to cows with crossed rear teats, deep udders and severe reverse tilt

The focus is to balance milk/cow/visit (milking permission), milk/cow/day and number of cows per robot. To optimize RMS performance long term, cull cows with slow milking speed, and slow prep and attach time. This will make your robotic system much more efficient.

Conclusions

The milking process fits well with robotic technology. Robotic technology is getting better and there will be more options in the future. Taking a whole system approach in design and management will maximize the RMS performance. Focusing on feed management and good cow management are two major factors to RMS success. It is important to develop realistic cash flows for financial success.

Endnote

[a]Rodriguez F. DeLaval VMS Specialist. Personal communication, 2013.

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