The robot uprising: Successfully embracing technology to produce high quality milk

Brandon K. Treichler, DVM
Select Milk Producers, Canyon, Texas, 79015, Phone: 610-442-3429, Email: qmlkdoc@gmail.com

Abstract

As more and more dairies in North America and globally turn to robotic milking, the same technology that reduces labor and allows the cows to milk at the times and intervals they choose can also separate us from the cow. The integration of robotic milking technology also tends to make practitioners and consultants less likely to feel capable and qualified to help robotic milking herds produce high quality milk and diagnose production and milkability issues. By remembering that robotic milking functions with the same principles of milk harvest as conventional milking facilities, and that the same factors that lead to high quality milk production in conventional milking facilities will also lead to high quality milk in robotic milking, practitioners and consultants can stay focused on the key areas that matter most to milk quality. Practitioners and consultants can play a role in helping robotically milked dairies succeed through observation and testing that ensures the dairy is milking clean teats, gently, quickly, and completely in order to maintain teat health.

Key words: dairy, robotic milking, milk quality, milkability

Résumé

Alors que de plus en plus de fermes laitières en Amérique du Nord et ailleurs dans le monde se tournent vers la traite robotisée, cette même technologie qui réduit la main d'œuvre et qui permet aux vaches de donner leur lait au moment et à la fréquence de leur choix nous sépare aussi des vaches. L'intégration de la technologie de traite robotisée fait aussi en sorte que les praticiens et les consultants se sentent moins à l'aise et moins qualifiés pour aider les troupeaux avec traite robotisée à produire du lait de grande qualité et pour diagnostiquer les problèmes de production et de traite. En se souvenant que la traite robotisée utilise les mêmes principes de récolte de lait que les installations avec traite conventionnelle et que les mêmes facteurs qui mènent à une grande qualité du lait dans les installations avec traite conventionnelle vont aussi mener à une grande qualité du lait avec la traite robotisée, les praticiens et les consultants peuvent rester concentrés sur les secteurs clés qui ont le plus d'impact sur la qualité du lait. Les praticiens et les consultants peuvent jouer un rôle pour aider les fermes laitières avec traite robotisée à réussir par l'entremise d'observations et de tests qui font en sorte que la ferme laitière récolte le lait de trayons propres, doucement, rapidement et complètement pour assurer la santé du trayon.

Introduction

The first robotic milking installation occurred in 1992 in the Netherlands.[3] Since that time, milking robots have advanced significantly, and the pace of advancement continues to accelerate. There can be no doubt that it is possible to produce very high quality milk in Robotic Milking Systems (RMS) facilities. Yet the dairy industry continues to learn that there are several key factors with robotic milking that contribute to producing consistently high quality milk, as well as several key areas where improvement can be made.

Robotic Milking Systems have served in some ways to separate the person from the cow, and the reality is that separation is 1 of the selling points that drives dairymen to invest in robotic milking technology. Yet the consequence of that increased separation from the cow is less chance for actual observation and what some would call application of good cow sense. What has replaced seeing the cow daily in RMS herds is a wide array of sensors, counters, alarms, and vast quantities of data. RMS dairies are swimming in a sea of metrics and algorithms. Despite this instant access to multiple numerical data points, action lists and alarms, when it comes to the nuts and bolts of milk quality we are data rich, but too often information poor! Management by data can cultivate a more removed and passive herd management style where dairies and advisors wait for alarms before looking for the problem or opportunities. There is still no substitute for some manure on your boots as part of management. There are certain pieces of information that a dashboard alone cannot give us. Advisors that are willing to make the observations, checks, and testing discussed here can be a highly valuable component of a successful milk quality program in robotically milked dairies.

Assessing "Milkability" and Cow Comfort During Robotic Milking

One of the critical differences between robots and conventional parlors is that robots are dependent on the cow wanting to be milked in order to succeed. If the milking experience is poor, visits per cow per day go down, which is bad for production, and the number of fetch cows goes up, which is bad for labor. In conventional systems, consideration of the milking experience is related solely to whether the cows allow the unit to stay on and how much effort and time it takes to load the parlor with cows. Because of this, it benefits us to consider more than just that the cow came to the box and was milked (the metric provided by the herd software), but how the actual result of the milking experience was for the cow (the judgement made by observation).

One of the ways practitioners and consultants might achieve this is to monitor cow behaviors that indicate a level of pain or discomfort. Observe the level of kicking at the teat cups at unit attachment and throughout milking. It is also valuable to observe for kicking at the unit at the end of milking, or what would be called cow assisted take-offs. This is frequently a sign of over-milking, while cows that kick shortly after attachment of the cups could indicate bi-modal milk letdowns.

Practitioners and consultants should also observe and count/record teat changes that may indicate detrimental milking characteristics. Observe the teats at unit detach for the presence of teat rings or firmness/fluid build-up as well as discoloration. The 2 areas where we often see firmness post-milking are the teat end, related to issues with the effectiveness of pulsation, and the teat base when related to issues with the mouthpiece of the liner relative to the teat itself. Whereas in a conventional parlor setting, these observations could be made at the time of post dip application, dairyman and consultants will need to now actively seek out this data.

Teat Observation Strategies and Considerations with Robotic Milking

It can be very difficult to observe or score teats in robotic milked herds. Even when observation is possible, there may be serious risks to the personal safety of the observer from both the cow being milked and also potentially from the robot arm. Remember that robotically milked cows will not be used to having their teats handled, and practitioners and consultants should not work in the area of the robotic arm without first pausing the arm or moving it to a maintenance position. Despite this, the teat is still the business end of the dairy cow and the teat end the most valuable real estate when it comes to milk quality. This means that observing teats in robotically milked herds is not only valuable, but is still critical to the mission of producing high quality milk. One potential way around the hazards described above, that I have found useful, is to utilize a cellular phone in conjunction with a 'selfie stick' to take pictures of the teats and udder rather than attempt to view the teats directly. A picture can be taken at any step in the milking process, without pausing the milking function, and when not using the flash, typically creates minimal disturbance to the cow.

Teat Cleanliness

Using teat end swabs as a way of monitoring the efficacy of the teat cleaning component of cow prep is a common practice for consultants in conventional milking parlors.[1] While it is somewhat more complicated in an RMS facility, assessing the cleanliness of the teat end after teat preparation is nevertheless just as valuable and often overlooked. This is because most brands of robotic milking systems can struggle to effectively clean the teats effectively. This means that the cleanliness of the cows, and more specifically the teats to be milked, dictates how clean the teats will also be after they are prepped by the robot.[4] We also know that the New Infection Rate (NIR) is reduced by keeping bacterial numbers low on or near the cows' teat-ends.[9] With this in mind, there are parameters that can be altered on each of the major RMS brands to optimize teat cleaning. Taking a picture of the teats after cleaning is completed, as described above, is a much safer yet still effective way to assess the efficacy of cleaning, and can indicate that changes may be needed with teat cleaning settings or if maintenance is required of cleaning components. In addition, I will frequently swab the inside of the inflations themselves, especially the liner mouthpiece chamber to assess the cleanliness of the teats being milked. Other less specific ways of monitoring teat end cleanliness would be to examine the milk filters and to perform routine bulk-tank cultures.[1]

For the brands included in this paper, the general procedure for examining teats following the completion of teat preparation is to pause the milking event after the prep has completed, so that the teat end can be pictured or swabbed for presence of visible debris and organic matter. When working with *GEA*™ robotics[c], because teat cleaning is performed within the milking liner itself, the teat cups must be removed from the teat upon completion of the cleaning phase before the teat end cleanliness can be assessed. To do this, during the prep procedure when the screen changes from light green to green, press the yellow button for 3 seconds to remove the teat cups.[6]

Teat End Scoring and Post Milking Teat Observation

RMS milking installations can be both a pro and a con when it comes to teat end health. Most RMS manufacturers utilize quarter level detachment, which has the potential to help limit over-milking when the manufacturer offers take-off settings that can be set to be detached at a "wet" enough flow threshold. Unfortunately, many RMS installations are set up to milk the cows very dry, raising the level of over-milking and the risk of teat end hyperkeratosis.

RMS installations also have the potential to negatively impact teat end health when liners are utilized that are of a larger dimension than the teats they are intended to milk. Dr. Doug Reinemann has stated: "The liner dimensions relative to the size of the teat, or in other words, liner fit to the teat, is the primary machine factor that affects teat health." He also states that depth of the mouthpiece and liner bore are the 2 most important liner factors to consider.[8] Partially because many of the major robotic milking manufacturers are based in Europe, and because robotic milking has a high level of penetration into the dairy marketplace in Europe, many of the liners available for RMS are of a larger liner bore and larger area under the mouthpiece.

Because of these factors, and because teat changes will more easily go unnoticed by producers in RMS as opposed to conventionally milked herds, scoring teat ends on robot dairies is highly valuable but frequently overlooked. Like with other parameters, this is perhaps because in RMS installations it can be very challenging to get a good view of the udder while maintaining personal safety from both the robot arm and the cow.

Strip Yields and Residual Milk

Trying to assess the end of milking settings via strip yield on robot dairies is a daunting task. There are several reasons for this beyond the obvious safety risks already discussed. It becomes very difficult to assess cow behavior or resistance to stripping when cows are not used to having their teats touched. It also is challenging to strip the teats within a reasonable time following unit detach when robots utilize individual quarter take-off. If and when I perform strip yields in robotically milked herds, the best value of them, in my opinion, is the chance to observe and feel the firmness of the teat immediately post milking. Wherever possible, I try to use alternate pieces of information besides strip yields to determine the correctness of end-of-milk settings and over-milking in robotically milked herds. This includes data from the milk meters or sensors on time in low flow and flow rates by duration where I have that data. I also frequently utilize data from my vacuum recording of the mouthpiece and teat end vacuum throughout the course of the milking event as well as my visual assessment of teat changes during milking (after teat cup detach), such as changes in color and the teat end scores themselves. Although this paper will not directly address end-of-milk settings, my experience across the manufacturers is that the settings options, especially at the defaults, are quite "dry" relative to parlors with milk meters in North America.

Assessing Teat Dip/Germicide Coverage

The adequacy of germicide coverage is an important factor in milk quality on robotically milked dairies. Dohmen et al found that the annual average percentage of new cows with a high SCC was positively related to the proportion of milkings where teats were not covered with teat disinfecting spray by the RMS. In addition, in 18% of milkings on automatic milking farms, teats were not covered with spray at all.[3] It should be noted that advancements in the most current generation of several brands of robotic milking have improved the application of teat dip by using the camera to find the teats and spraying them individually.

With robotic milking, the methods of assessing teat dip coverage are similar to that of conventional parlors. To assess teat dip coverage in an RMS setting, the robot must be paused after teat dipping, and the cow retained in the stall. The easiest method of assessing post-milking teat dip coverage is simple visual observation. As in conventional parlors, a more demonstrable way to assess coverage is to wrap a paper towel around the teat barrel to see that all surfaces of the teat are covered, or expose areas that are not covered.[2] A second option would be to blot the teat end of each teat to see that dip has covered this area. Blotting and then manually re-dipping teats on cows that are not used to having their teats handled can have its own perils. Similar to teat end swabs and strip yields, blotting teats to assess dip coverage is difficult, but there are alternatives available. Another major consideration with conventional assessment of teat dip coverage in an RMS unit is that you will need to be prepared with a traditional dip cup or spray bottle as there is not likely to be one at the robot as there would be in a parlor. This is required so that you can re-apply the post-dip manually after performing the test.

Lely[d,e] robots utilize a teat spray system to dispense and apply post-milking teat dip. Lely[d,e] allows for altering the pressure to the pump used to dispense the product in order to provide more or less dip to the nozzles. Lely[d,e] also allows the producer to install a slightly larger diameter teat dip delivery tube. The dip spray nozzle can be changed to alter the teat coverage pattern.[h] It should be noted that the latest version of the Lely Astronaut robot, the A5,[e] locates the teat to spray the post dip, which provides somewhat more accurate and consistent coverage of the teats compared to its predecessor the A4.[d]

The DeLaval VMS[a,b] unit also utilizes a teat spray system to dispense and apply teat dip. With the VMS™ Classic,[a] the spray pattern is programmable to be either a "U" pattern (9 to 10 mL of product), or a "W" Pattern (12 to 13 mL of product). The spray nozzle can be changed to provide a narrower or wider dip spray pattern. The newest generation V300 VMS[b] robot now uses the camera to locate each teat before spraying product and offers either centering on the teat, short spray pattern over the teat, or a fast loop over all 4 teats.[5]

It is possible to "pattern" the teat dip spray of Lely[d,e] and DeLaval[a,b] systems. This can be performed by holding a piece of paper or cardboard up against the udder before the dip is sprayed. When spraying teat dip, it is important to remember that product viscosity alters both the volume dispensed and the patterns of the spray. Because of this, it should be understood that the temperature of the dip alters the viscosity and it is important to try to maintain the temperature of the product being applied at a constant level.

GEA robots apply the post dip in the mouthpiece of the inflation. The amount of product dispensed is still dependent on the physical characteristics of the dip, including viscosity and the pressure in the line. It is possible to measure the amount of dip dispensed to a teat by disconnecting the sanitizer line and placing it into a measuring vessel. An additional length of hose will be needed to be able to perform this.[g]

Equipment Maintenance

Robotic milking does differ from conventional milking in that the RMS systems are far more complex, with many more valves, gaskets, diaphragms, and other components than a typical milking parlor. Maintenance of milking equipment has long been known to affect milk quality.[3,10] Because of the complexity of the equipment, maintenance is beyond critical with RMS installations. Yet maintenance is an area of milk quality where we can see management paralysis in RMS herds. If the dairy relies solely on the cow counter/milking counter to calculate the maintenance interval or for an alarm to be triggered, milk quality opportunities can and will be missed. No 2 dairies are alike, and maintenance of wear components will be dependent on use conditions. RMS dairies can benefit by customizing their maintenance schedules to meet the needs of their cows and facilities. In addition, while dairies may not feel empowered to perform anything beyond daily maintenance, they should try to gain enough understanding of the equipment to verify that the required maintenance is being completed by the dealership through performing routine systematic visual wear exams.

In addition, daily maintenance functions that include cleaning and upkeep of the robot and adjacent areas are highly valuable to the production of quality milk. As an example, maintenance checklists should include items such as:

- Inspect the prep cup or cleaning brushes for cleanliness inside and out and for wear or damage.
- Clean the laser or camera.
- Wash down the arm and the outer box area.
- Check inflations for signs of wear or twisting.
- Check jetter manifolds or cups.
- Scrape the cow que or holding area and the stall floor, stall entrance and stall exit areas free of manure.
- Check the level of chemical in each of the barrels.
- Change milk filter.
- Observe several milking events from start to finish.

"Wet" and "Dry" Milking Machine Testing

Practically, in the field, I do not believe RMS systems receive the equivalent level of testing we would in many conventional milking parlors. While this is true for tests like graphing the pulsators, it is particularly true for items like air flow testing, which often does not even occur at system commissioning. There are likely several reasons for this. Firstly, the analysis is not very straightforward. Some robots deploy a combination of a variable speed vacuum controller and a regulator. Facilities with multiple robot "boxes" are often sited in multiple different rooms separated by significant distance, and each box has to be treated as its own receiver. I also have been told by dealers that because the box robot concept is more modular, that this testing is somehow not necessary. In some cases, simply knowing how to navigate the software and understanding the complex plumbing and valve configurations can also become an impediment to performing routine testing for practitioners, consultants, and even the equipment dealership personnel themselves.

Because most RMS manufacturers make a visual vacuum level available at the milking stall on a management software dashboard, and also have alarms tied to vacuum level, dairy owners can develop a false sense of security when it comes to vacuum stability performance. Unfortunately the vacuum level that is displayed, and that could trigger an alert, is frequently sensed at the receiver and not at the cow. Although newer generation milking robots, especially the DeLaval V300 VMS,[a] have taken significant steps to improve the milk path over previous generations, robotic milking in general still utilizes a significantly higher amount of hosing, valves, and connections between the cow and the receiver that can cause potential restrictions or vacuum leaks.

Performing dynamic or "wet" testing on RMS installations requires some significant pre-planning and experience to understand how and where to set up testing equipment. In many cases, vacuum analyzers that stay with the robot arm are the best option I have found. This is primarily due to safety for myself and a desire to minimize the disturbance to cow flow through the robot. Care must be taken, however, as these stand-alone vacuum diagnostics can be challenging to mount without impacting the milking or sanitizing capabilities of the teat cup. It is also imperative that diagnostic equipment be protected from sprayed water and have some type of in-line filters to protect from liquid (water/milk/teat dip) being introduced into the tubing. Some robot manufacturers offer steam sanitizing as an optional setting on their models, and this can have serious detrimental effects on vacuum testing equipment if this setting is not disabled before equipment is hooked up. Hand-held vacuum testing equipment can also be utilized, but when doing so be sure to use long enough runs of tubing that you can stand safely away from the robot arm. I recommend detaching or disconnecting the sensing tubes from the hand-held vacuum analyzers between cows, as standing by the box is a strong deterrent to the next cow entering the stall.

One much-needed area where the industry can collectively have a positive impact on robotic milking would be to develop an RMS specific set of guidelines to help make testing and interpretation more uniform across the manufacturers. It would also help the industry to standardize the system commissioning of RMS installations.

Endnotes

[a] Delaval VMS™ "Classic" Milking Robotics-Delaval, Tumba, Sweden

[b] DeLaval V300 VMS™ Milking Robotics-DeLaval, Tumba, Sweden

[c] GEA Pro Q Milking Robotics-GEA Farm Technologies Inc, Napierville, IL USA

[d] Lely Astronaut Robotic Milking Model a4- Lely, Massluis, the Netherlands

[e] Lely Astronaut Robotic Milking Model a5- Lely, Massluis, the Netherlands

[f] Personal communications with Delaval technical support and field staff

[g] Personal communication with GEA™ technical support and field support staff

[h] Personal communications with Lely™ technical and field support staff

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