

Milking management

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Paper presented at the 2010 IDF Mastitis Conference, Christchurch, New Zealand

Abstract

This paper describes the milking work routine and implications of the automation of parts or all of the milking processes. The manual work performed in the milking process makes up a large percentage of the labour on conventional farms. Premilking teat preparation poses an increasing risk of repetitive stress injury to milking operators as the milking shift gets longer. Farmers generally recognise the importance of pre and post milking management but often try to minimise the manual work load as much as possible. Premilking teat preparation can be omitted but, in most situations, will result in poorer udder health and milk quality and milking empty teats just after attachment. The cups-on time becomes more efficient when teat cups are attached to a stimulated udder, but the overall manual work time per cow increases. Fully automated systems can milk more cows per hour by leaving out teat preparation but introduce greater risk of milk quality and mastitis problems. Detachment of the cluster has been fully automated with great success. Flow thresholds for detachment can be set up to 0.6 kg/min without loss of milk yield for cows milked twice daily and even higher for cows milked more frequently. Individual quarter milking can provide some improvements in the milking process. The udder health of the cows must still be checked periodically by some means. Detection systems based on milk conductivity work well for generating attention lists but more precise sensors are needed for fully automated detection and diversion of abnormal milk. There is a growing need for systems that provide intelligent data analysis and summary to provide timely, concise, and useful management information to support the management decisions of future dairy managers.

Introduction

Milking management has always been regarded as an important factor in achieving high milk production, efficient milking, excellent milk quality, and good teat and udder health. History has shown that while many farmers recognise the importance of milking management, they often try to minimise the manual work of milking as much as possible. Automation has been adapted to the milking process to varying degrees up to and including fully automated milking, but most cows are still milked using some manual procedures. Automatic milking systems (AMS) have been designed to perform pre and post milking tasks in a similar way to the recommended procedures for human workers. Removing some of the steps from the milking routine may improve the efficiency of the milking process measured in cows milked per hour. It is also interesting to consider automation of the different parts of the milking process as an alternative to fully automated milking.

In a survey on 10 New Zealand farms Jago et al., (2007) reported parlour throughput ranging from 93 to 217 cows per hour (a high milking capacity compared with European conditions). Of the total time for the entire milking process (from fetching cows to returning them to pasture), the time spent on milking accounted for only 61% of the total time and attaching milking units accounted for 19 to 39% of the total time. Thus the benefits of automating pre-milking

procedures or unit attachment would only reduce the labour requirements by these percentages under typical New Zealand conditions.

. While the subject of AMS is broader than just the topic of milking procedures, it is interesting to compare how much attention is paid to AMS versus the sound procedures of milking management. This is illustrated by asking Dr. Google about the popularity of items on the internet. Figure 1 describes the current generation of information but not of the true historical importance.

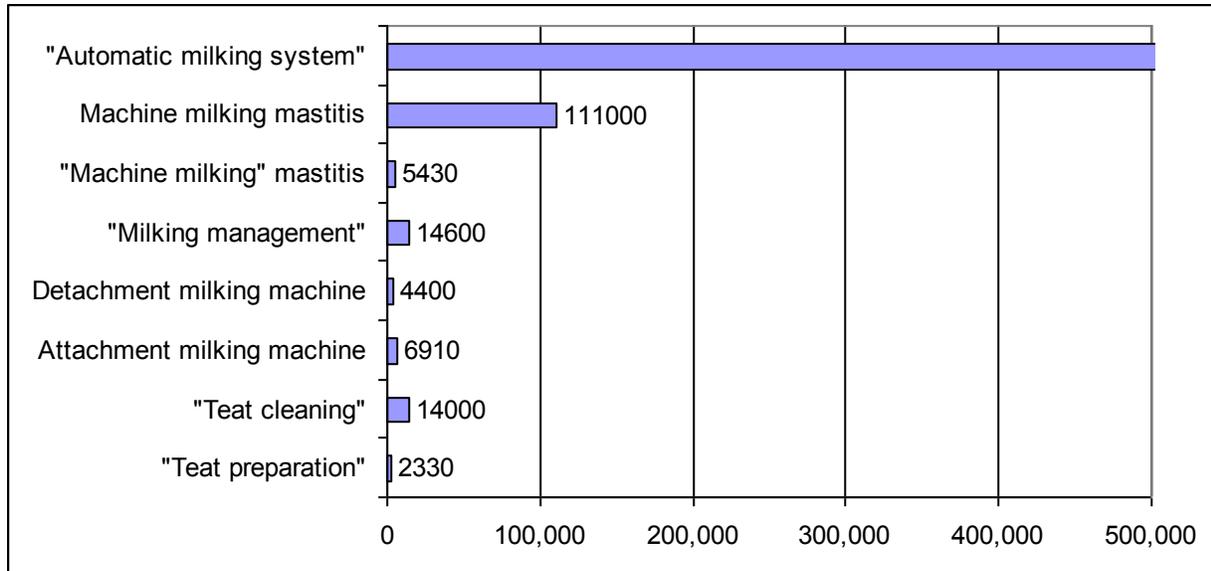


Figure 1. Number of hits at Google (October 2009) for different words associated with milking management. Automatic milking system ended at 786,000 hits.

This paper considers which parts of the milking procedure are most critical to achieving the goal of milking quality and the benefits and drawbacks of automating or eliminating specific parts of the milking routine

Evaluation of the milking process

Milking management includes all of the processes involved in milking of cows. Evaluation of the process can be made during milking by observing the interaction between the cow, the operator and the equipment. Collection of information can be rather complex and time consuming and the evaluator must therefore focus on a few of the main concerns rather than assessing all aspects of the milking process during any evaluation. Reinemann et al. (2005) collected relevant literature and gave a practical overview of some problems associated with the milking process, their causes and tests that can be done to evaluate each (Table 1). The tests done on the milking machine are categorized as simple machine checks, milking-time observations, basic tests of the milking equipment, and complete professional machine evaluations. The focus in this paper is on the manual work carried out during milking.

Any good milking begins with calm and gentle handling of cows. Aversive handling of cows can increase the amount of residual milk and thereby lower the milk production (Munksgaard et al.,

2001; Rushen et al., 2001). Entrance to the parlour may be stressful to the cows and especially for cows lower on the social hierarchy. A calm atmosphere is essential and successful operators talk *with* the cows rather than *to* the cows and experience less dunging in the parlour (Seabrook, 1994). Milking cows in milking parlours or by AMS has not revealed significant differences in stress levels as measured by milk cortisol concentrations (Gygax et al., 2006). Complete automation of the milking process can, therefore, be done in such a way as to achieve this important first goal of milking: calm cows.

The most time consuming part of a traditional milking routine is pre-milking teat preparation. The purposes of teat preparation are to clean the teats, extract foremilk, check for abnormalities of the milk, and stimulate the milk ejection reflex. Pre-milking teat preparation has a positive effect on milk ejection and results in shorter machine-on time. Teats must be clean and dry before unit attachment in order to keep bacterial contamination of the milk as low as possible. Any procedure that wets the udder surface without proper drying afterwards will result in transport of bacteria towards the teat end (Figure 3), more bacteria drawn into in the cluster during milking, and reduced milk quality. In addition, milking wet teats has been shown to be associated with more clinical cases of *Streptococcus dysgalactiae* mastitis (Barkema et al., 1999a) and poorer udder health in general (Neave et al., 1969). Pre-milking teat preparation may also be a vector for transfer of pathogenic bacteria within and between cows (Figure 4) even when hygienic precautions are taken (Grindal and Bramley, 1989).



Figure 2. Use the towel with one corner for each quarter.



Figure 3. Leaving the teat surface wet will increase bacterial count in milk.



Figure 4. Foremilking must avoid transfer bacteria within and between cows.

The occurrence of clinical mastitis can range from one case in 10,000 milkings (0.01%) to more than 1 case per 100 milkings (1%). Foremilking and detection of clinical mastitis can lower bulk milk SCC by segregation of high SCC milk. Consequently, herds with a high prevalence of clinical mastitis can improve the quality of bulk tank milk by examining foremilk and diverting milk from infected cows or quarters. Barkema et al. (1999a) also found this practice positively correlated with the incidence rate of clinical *Staphylococcus aureus* mastitis. Foremilking

induces milk ejection removes bacteria from the teat canal and sinus, but is time consuming and can be a demanding ergonomic task for the workers in large herds. Foremilking, has been largely eliminated in pasture systems such as in New Zealand and Australia and likely results in more milking of empty teats at the beginning of milking, especially cows in later stages of lactation, and more cases of clinical mastitis will remain undetected than in herds who practice foremilk.

The maximum benefit of premilking stimulation will be achieved is milking are attached after teat preparation but allowing enough time for the milk ejection response to reach its peak. Consistent attachment about 60-90 s after the beginning of teat preparation improved milk yield when compared to an inconsistent milking routine in a study by Rasmussen et al. (1990) and made the milking more efficient. First lactation cows, especially in early lactation, have relatively small cisternal capacity that makes them more susceptible to bi-modal milking and changes in preparation lag time. Older cows have relatively larger cistern capacity and in all but late lactation, cisterns contain enough milk for the first 30 seconds of milking until milk ejection is fully evoked, thereby avoiding milking of empty teats early in milking.

Removal of the milking unit has changed over time from a manual operation; which often included machine stripping as well as hand stripping, to a fully automated procedure with the possibility of individual settings for individual cows or group of cows. Traditionally, the cow was regarded as fully milked when the total udder milk flow rate fell below 200 g/min. Studies have shown that increasing detachment flow thresholds from 200 g/min to 400 g/min resulted in no loss of milk production, reduction in cups-on time and improved teat end condition (Rasmussen, 1993). In an Australian study on cows milked twice per day (Clarke et al., 2004) higher detachment thresholds (400 vs 200 g/min) and a fixed maximum cups-on time not have a negative influence on milk yield for mid to late lactation cows. Field experiments with even higher thresholds (up to 900 g/min) were carried out successfully in large herds milking three times per day (Reid and Stewart, 1997). In these studies cups-on time decreased without milk yield loss and the parlour performance improved. Cows bred for high milk yields have more alveolar tissue but also a relatively large cisternal capacity. Such cows are less influenced by variations in milking interval and emptiness of the udder. Leaving some milk in the udder does not appear to influence the effectiveness of the alveolar tissue of cows milked three times per day. For cows milked twice a day Magliaro and Kensinger (2005) showed a 2.5% milk yield loss with detachment at 800 g/min. Thus there is a point at which progressively early unit detachment will start to suppress milk yield. This point is not entirely defined, although we do have an idea of its boundaries.

Post milking teat disinfection is an important task and especially whenever teat condition is poor or contagious mastitis pathogens are present. The routine can be automated which saves a few seconds of manual work per cow. Whether the dipping or spraying system is used the efficiency can be measured by assessing the number of teats covered with teat disinfectant and the effectiveness of that coverage.

Quarter or Udder Management

While quarter milking is not a new idea, it has become the norm in automatic milking machines and it is interesting to consider the benefits of milking management on a quarter level as

compared to the traditional udder level. Rothshild et al. (1980) looked into differences in milk flow and yield between quarters and concluded that producers of milking machines could take account of differences between quarters in developing newer milking machines.

The tactile stimulation of teats during pre-milking teat preparation induces the release of oxytocin from the pituitary gland with the final effect at the udder level. The release of oxytocin is necessary throughout most of the milking and the pulsating liners normally cause sufficient stimulation. The stimulatory effect of single teat cups is also sufficient to maintain adequate oxytocin release and maximum milk ejection (Bruckmaier et al., 2001). The udder does have some local regulatory mechanisms as shown by comparison of hand and machine stimulation (Svennersten-Sjauna et al., 2004). The practical effects seem to be small, however. Early detachment based on total udder milk flow may suppress production in slow milking quarters through locally regulated feedback mechanisms.

Tancin et al. (2006) showed that rear quarters have higher milk yield, peak flowrate and average flowrates and milk for longer, and than front quarters. With clusters detached at a whole-udder flow threshold of 0.3 kg/min, the duration of overmilking was almost twice as great for front quarters compared to rear quarters. Ipema and Hogewerf (2008) defined four distinct phases of the milking of an individual quarter: 1. Increasing flow, 2. steady flow, 3. declining flow, and 4. overmilking. In this study the duration of phases 1, 2 and 3 decreased when the vacuum was increased from 42 to 45 kPa, with the main reduction in phase 2. A further increase in vacuum to 48 kPa did not reduce the duration of any of the phases. Previously Ipema and Hogewerf (2002) showed that an increase in the ACR threshold from 0.05 to 0.15 kg/min reduced the machine-on time of the individual quarter of about 10% i.e. a reduction of duration of both phase 3 and 4 with no reduction in the milk yield. In a study by Hillerton et al. (2002), limited overmilking was not detrimental to the teat condition or to the udder health under normal milking conditions whereas overmilking for 2 to 5 minutes caused discolouring and ringing of teats.

The peak flow period of milking can be reduced to some degree in any milking machine by increasing milking vacuum and/or adjusting the pulsation settings to increase the milk-to-rest ratio. This increase in the peak milk flow rate will not result in a commensurate decrease in the total machine-on time (Bade et al, 2009). Reducing the machine-on time will increase the total number of milkings per day in an AMS, but because the machine-on time is only part of the time that a cow is in the milking stall the total milkings per day will not be increased in direct proportion to the reduction in machine-on time. More aggressive milking settings will increase the stress on the teat tissue, mainly during overmilking phase. Early detachment of the individual teat cup can limit the effects of overmilking on teat condition. Teats are milked individually in automatic milking systems mainly because of the practical problems associated with attachment (it is not possible at present to attach 4 teatcups simultaneously). The system may also offer the possibility of setting different milking speeds for the different quarters and cows. However even on farms using AMS, front quarters still have most teat end hyperkeratosis and rear quarters have the highest milk yield and most cases of mastitis. Post stimulation (e.g. massage by the liner or post milking by hand) may increase milk yield either through a better emptying of the quarter or through some local regulatory mechanisms (Svennersten-Sjauna et al., 2004) and early detachment on a quarter basis quarters may therefore increase differences in milk yield between quarters.

Detachment of all teat cups at the same time is, in general, a compromise between undermilking of rear teats and overmilking of front teats. There are some benefits and some possible drawbacks to quarter milking. The literature shows that cows can be milked adequately and will adapt easily to either quarter or whole-udder based milking management. Field experience and research has shown that a considerable amount of milk can be left in the cisterns of cows milked more than twice per day without any effect on milk yield. Some studies, using twice per day milking have shown that leaving milk in the udders of early lactation cows has suppressed milk yield.

Automatic milking or automation of the milking process

Will lack of teat preparation reduce milk yield in cows milked automatically? The history of conventional milking in New Zealand and Australia has shown that cows can be milked successfully without pre-milking teat preparation (Jago et al., 2006). Cups-on time increased from 8.44 min to 9.02 min but overall box time decreased from 10.30 min to 9.76 min by omitting teat brushing in an New Zealand AMS study. There was no difference in milk yield. In this study cows were milked 1.2 times per day on average and there was probably a large amount of cisternal milk available at attachment. An Australian study was carried out with two treatments being No Wash or Washing of teats for 0.8 min (Davis et al., 2008). Washed cows had a higher milk flow rate but not when calculated for the full time they occupied the milking box where the washed cows spent 1.1 min more in the box than unwashed cows. There were no differences in milk yield or SCC of washed and unwashed cows. The Australian study was carried out with pastured cows that on average were milked 1.6 times per day. European AMS cows are normally milked 2.5 to 2.8 times per day in intensive production systems which leave less time between milkings and less available cisternal milk, especially for cows in late lactation (Bruckmaier et al., 2001).

Oxytocin release and quarter milk flow curves were recorded in an AMS testing five treatments from no brushing up to brushing of teats pre-milking for 96 s (Dzidic et al., 2004). The likelihood of a bimodal milk flow curve decreased with an increasing number of brushing cycles. The teat cleaning device in the AMS was sufficient to induce oxytocin release and milk ejection before the start of milking when teats were brushed for at least 32 s. The main difference in milking regimes between the New Zealand and the European trials is the milking frequency. A low milking frequency and long intervals between milkings should result in more available cisternal milk at attachment and probably sufficient enough to avoid milking on empty teats. By the time cisternal milk has been removed milk ejection will have occurred and bimodal milk flow avoided. Cows milked more frequently will have less available cisternal milk.

It is possible with an AMS to aim for a cow-specific amount of cisternal milk that was just enough to keep milk flowing until full milk ejection was achieved. This may, however, affect the milk yield of slow milking cows or cows with a high stimulation requirement. Several milking systems provide mechanical stimulation of the teat at the beginning of the milking (e.g. fast pulsation, change in pulsation ratio and lowered vacuum) and this makes cisternal milk last longer. The teats of the cows will still be exposed to vacuum with the risk of affecting the teat condition. Cows in late lactation will only for milking intervals exceeding 12 hours have sufficient cisternal milk to avoid bimodal milk flow. But such long intervals could lower the milk

yield. Another option could be very early detachment preferably just when the last milk from the alveoli has shifted towards the cisterns or leaving one quarter under-milked and starting next milking with the attachment to this teat. Stimulation of the milk ejection reflex will begin at attachment of any of the teat cups. Because it is not known when cows will attend to milk in an AMS emptying the udder as much as possible at every milking is actually essential.

Consumer perception requires teats to be visibly clean at attachment of the milking unit. This can be managed by providing a clean cow environment between milkings. Some type of premilking teat preparation will be required to achieve this goal for confined cows and for cows on muddy pastures or tracks. “Quick and dirty” farmers deliver milk with higher bulk tank SCC and bacteria counts than farmers that are “clean and accurate” (Barkema et al., 1999b). Farms with confined cows must devote time and effort to keeping stalls, alleys and feeding areas clean in order to achieve the goal of high quality milk.

Checking for clinical mastitis before cluster attachment is important in manually operated milking systems. This process has been automated in AMS. The typical AMS system provides an attention list of cows suspected of clinical mastitis. The sensitivity of these systems depend on the milk sensors, supportive measurements and decision algorithms. Several AMS detection systems have been shown to easily meet the same sensitivity standard of 70% as for good manual systems (Kamphuis et al., 2008). The biggest challenge in AMS systems is to attain high enough specificity so that the attention lists do not become unmanageable. The most common systems are based on measurement of conductivity but none of them have proven sufficient sensitivity and specificity to allow milk to be sorted automatically. Mein (2006) suggested “more reliable sensors for detecting clots in foremilk” as one of the subjects that needed more attention. Small improvements have been made but sensors for automatic and safe diversion of abnormal milk are not available.

Conclusions

Future milking facilities, both parlours and automatic milking systems, will continue to be information centres for cow management and the amount of data and the breadth of cow diagnostics coming from milking operations will surely continue to increase. At present good dairy managers spend much time on analysing data. There is a growing need for systems that provide intelligent data analysis and summary to provide timely, concise, and useful management information to support the management decisions of future dairy managers.

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Table 1. Evaluation of the milking performance is complex but can be broken into signs, causes and tests (Reinemann et al., 2005).

Concerns related to milking performance.								
Slow Milking		Milk Quality		Milk Yield	Teat Condition	Cow Behaviour	Unhappy Workers	
Symptoms and tests to quantify the situation								
Machine-on time	Cows milked per hour	Somatic cell count (Bulk tank SCC)	Bacterial \count / Other (Bulk tank SPC, TBC, or Bactoscan)	(kg/cow/milking) (kg/cow/day)	Teats rough, swollen, discoloured, or lesions	Stepping, kicking, urinating, defecating	Injuries, complaints	
Possible Causes and Tests (see text for test numbers)								
Cows	High yield, Damaged teat canal, Small diameter teat canal	High yield, Cow behaviour (see behaviour section)	Genetic predisposition	<i>Streptococcus agalactiae</i> , <i>Streptococcus uberis</i> mastitis	Genetics	Pointed teat end, Slow milking cow (see slow milking section)	Breed	Poor cow behaviour (see behaviour section)
Operator	Late manual removal, poor preparation	Work routine efficiency	Pre/post milking teat sanitation, separating infected cows	Pre-milking cow sanitation, unit fall-off, equipment cleaning routines	Animal handling, Milking Routine unit balance	Late manual unit removal teat dip coverage	Cow handling in parlour and in housing area	Control over work environment, level of pay, unit slips and falls
Milking Machine	ACR setting, milking vacuum level, pulsation, liner design. Maintenance	Too few clusters, milking unit slips and falls, unit balance	Milking vacuum level, pulsation, liner design,	Effectiveness of equipment cleaning, milking unit fall-offs	Completeness of milking	Milking vacuum level pulsation, liner design, ACR setting	High milking vacuum, over milking, uncomfortable liner, pulsation	Machine working properly, ease of use, educated workers, milking unit slips and falls
Environment	Cow comfort in holding area and parlour	Cow cleanliness, ease of cow movement, gates, lanes, etc.	Clean, dry cow housing and exercise areas	General level of farm sanitation	Nutrition, access to water, cow stress, temperature, humidity, disease	Clean dry housing environment, chemical contact, change in climate	Ease of cow movement, lighting, dogs, other stresses	Ergonomics and light levels in work areas, risk of injury, working hours / breaks, expectations, communication