

Milking equipment: How it works in our world

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Abstract

The first patents for mechanized milking were issued in the mid-19th Century, and since their introduction they have been blamed for the development of mastitis in dairy cattle. Machine milking can lead to the development of mastitis, but poor management practices also result in reduced milk quality. Veterinarians are uniquely qualified to comprehensively evaluate milk quality problems as long as a systematic approach is taken which considers all risk factors. Once a comprehensive evaluation has been completed, recommended changes should be prioritized to improve milk quality along with establishing a realistic timeline for progress.

Key words: dairy, milking machine, milk quality, mastitis

Résumé

Les premiers brevets émis pour la traite mécanique datent du milieu du 19^e siècle. Depuis son introduction, la traite mécanique a été blâmée pour le développement de la mammite chez les vaches laitières. La traite mécanique peut entraîner le développement de la mammite mais de mauvaises méthodes de gestion réduisent aussi la qualité du lait. Les vétérinaires sont bien placés pour l'évaluation globale des problèmes de qualité du lait en autant qu'une approche systématique soit adoptée tenant en compte tous les facteurs de risque. Lorsqu'une évaluation globale a été complétée, les changements recommandés devraient devenir la priorité pour améliorer la qualité du lait tout en établissant un échéancier réaliste pour le progrès.

Introduction

It has been known for hundreds of years that milk from cows and other ruminants provides an important nutritional resource. As population growth occurred throughout the world during the early 1800s, continuous attempts were tried to make the collection of milk more efficient. Early attempts included locating farms in close proximity to population centers. During these times, labor was cheap and plentiful, so the idea of mechanization was not considered practical. It was only when the countries of Australia and New Zealand became territories that the mechanization of the milking

process began. In the early 1800s, the first devices to mechanize milking were simple cannulas placed in teats to drain milk into attached buckets. The power for such devices was provided by gravity and intra-mammary pressure. The first patent for this type of device was granted to Burton in 1836. However, the technology was fraught with problems, especially the transfer of mastitis pathogens from cow to cow.

Use of vacuum for milk collection was first introduced in Britain in 1851, with the first US patent being issued in 1860. Until 1881, numerous patents were filed for machines that used vacuum, while others used positive pressure (called lactators) to simulate hand-milking cows. In 1881, the first device that utilized pulsation in a single-action fashion was introduced in Scotland but was reported to cause "udder troubles". In 1892, the first double-action pulsator (the predecessor to today's modern pulsator) was introduced in order to address the udder troubles of previous machines. Although 4 different types of machines were being manufactured by 1900, the simplest and cheapest models were soon found to be unsatisfactory due to problems with mastitis spread and complexity. Their production soon ceased, leaving the models utilizing pulsation as the viable options.

From these developments, commercial manufacturing of double-action milking units began in 1917 with introduction of the Delaval Bucket Milking Machine and Babson Bros., who manufactured the first Surge milker later that year. These units remained in production for over a quarter-century, with utilization by about half of the dairy farmers in the United States who had machine milkers.

Slow improvement of milking systems continued through the 1950s. Although most milking was still done utilizing bucket milkers, single and double parlors were developed that milked cows directly into pipelines. In 1930, the first rotary milking parlor appeared in the United States. Also in 1930, electronics were introduced by Delaval with the release of the electromagnetic pulsator. The electromagnetic pulsator was utilized through the 1950s with great success until it was replaced by more sophisticated models. Since then, electronics have been incorporated into just about every aspect of milking and milking management. Also in the 1950s, methods for evaluation of milking system performance began to appear along with improved methods for cleaning milking systems.

No records were available of how widely machine milking was being utilized around the world until 1940.

At that time, 55% of farmers in New Zealand and Australia were utilizing machine milking, while only 10% of the farms in the US utilized the technology. That changed dramatically between 1940 and 1970, initially due to the labor shortage caused by World War II. From 1940 until 1970, milking machines were installed as fast as they could be made. By 1970, almost 100% of US farms utilized machine milking.¹

The Contribution of Milking Systems to New Intramammary Infections

Since the first milking systems were introduced, it appears they have been habitually blamed for the creation of mastitis in dairy cattle. When evaluating milking systems, it is imperative that the evaluator understands the risk factors the milking machine poses that are critical in the development of new intramammary (IMM) infections. At the 2004 National Mastitis Council (NMC) Annual Meeting, in a talk entitled “Milking Machines and Mastitis Risk: Storm in a Teat Cup”, Graeme Mein summarized the 1987 International Dairy Federation (IDF) document (IDF 215:1987) defining 5 main milking-related mechanisms for new IMM infections, and presented new information and perspectives to support these mechanisms. In that talk, he indicated that while much time is spent evaluating milking systems to troubleshoot mastitis problems, milking systems only cause 6 to 20% of all new IMM infections. The majority of the problems relating to new IMM infections come from 1) milking time management and 2) herd and farm management.⁴

When looking at the milking system’s contributions to new IMM infections, approximately half of new infections are caused by the machine moving bacteria to the teat or inside the teat by cross contamination or from impacts caused by irregular vacuum fluctuations in the claw. The remaining half are related to teat issues caused by milking machines such as congestion or edema, too little or excessive removal of keratin, slow closure of the teat canal post-milking, or the development of hyperkeratosis at the teat-end.

In 1996, the NMC published the first version of *Procedures for Evaluating Vacuum Levels and Air Flow in Milking Systems* in an attempt to standardize the method by which individuals evaluate milking systems. Although this document did a great job of standardizing milking system evaluation, it tended to focus the user of the document towards regulator efficiency and system vacuum stability and not towards what was happening in the milking claw, which is really where the rubber meets the road. To re-direct the scope of the user of the document, NMC released revised versions of the document in 2004 and 2012.

It has been known since the 1960s that unstable vacuum is related to new IMM infections. At the time

of publication of the first NMC document in 1996, it was not made clear that vacuum instability in different parts of the system would have different effects on new IMM infections. In reviewing much of the original research evaluating changes occurring in the milking system and claw, and their impact on the teat, researchers began to re-evaluate research dating back to the 1960s. A study by Thiel et al showed that endotoxins require air speeds in excess of 1.9 m per second to penetrate the teat and reach the teat sinus.⁶ Factors that create pressure differences capable of driving milk droplets at speeds fast enough to penetrate the teat include liner slips, abrupt cluster detachment, and vigorous machine stripping. Factors such as low pump capacity, poor vacuum regulation, limited capacity of milklines, and liner movements cannot directly generate these types of speeds due to their remote location and slow wind speeds.

NMC’s second edition of the airflow document incorporated the perspectives on necessary air speeds inside the claw and the importance of pulsator function in the development of new IMM infections. At the 2004 NMC Annual Meeting, Norm Schuring and Doug Reinemann presented a talk entitled *Update on the NMC Guidelines for Evaluating Vacuum Levels and Air Flow in Milking Systems*,⁴ in which the authors state that a system evaluation should focus on milking time tests for “evaluating the adequacy of milking systems to maintain the average vacuum in the claw within the intended range during milking and the ability of the pulsation system to operate with the manufacturer’s specifications.” Only during the third portion of the document is the evaluator taken through diagnostic tests that are used to determine the reason for deficiencies identified in the first 2 portions of the form, if any.

The most recent version of the NMC document included revisions to the airflow guidelines to reflect recent changes by ISO and ASABE. The changes make the document more useful to the international market, and take into account variations in system performance that may be present due to variations in design.

It should be noted that NMC guidelines are often misinterpreted as being standards for dairy equipment function by consultants. This leads to an enormous amount of animosity between dairymen, their equipment dealers, and the consultants that utilize the NMC document. When performing an equipment evaluation using the NMC guidelines, be careful not to over-represent their authority.

Milking Time Tests

While milking-time tests can be completed during any portion of the milking, it is preferable to undertake these tests while cows that are the highest producers are being milked. This allows the system to be evalu-

ated for performance at the cow level while the system is under load. These evaluations represent the most important equipment tests that will be completed during the evaluation of a milk quality problem.

Measurements to determine average claw vacuum, average vacuum fluctuation, and pulsation function should be done. Milkline and receiver vacuum instability can also be measured to determine whether milkline slugging is occurring or inadequate vacuum production or regulation is present. It is advisable to evaluate pulsator function while units are on the cow in order to determine what is happening during milking, but this is technically challenging and dangerous in some milking installations.

To evaluate completeness of milk-out, strip yields can be performed, but these must be completed immediately after unit removal. Note inconsistencies in milk-out of 1 quarter compared to the others, in addition to the amount of milk left in the udder when the unit is removed. If milk-out is complete, most cows will have less than 50 mL of milk left in the udder. Cows are considered milked out if there is less than 100 mL in each quarter or 250 to 500 mL of milk left in the udder when hand stripping. If machine stripping is being completed, less than 1500 mL (~3.5 lb or 1.6 kg) should be present.^{2,3,5}

In parlors with milk meters, average milk flow rates, time to peak flow, milk collected in the first 2 minutes, and time in low flow can all be determined. In addition, some parlor software can graph sequence and timing for which milking units have been attached during previous milking sessions. This data allows evaluators to concentrate their efforts in areas that have a higher risk for problem development.

After the milking session has been completed, further diagnostic tests should be performed, if indicated. Pulsators should be re-evaluated with comparable results to the milking time pulsator tests.

Evaluating Milking Systems – The Art of Doing (and Seeing)

In order to determine the underlying cause for a milk quality problem, a complete evaluation of all aspects of the farm should be completed. In addition to an equipment evaluation, this should include cow management, milking-time management, mastitis and dry cow therapy, and culture information from bulk tank and individual milk samples.

While doing the milking-time evaluation of milking equipment, several observations should be completed. These observations are often more revealing than the actual evaluation of the milking equipment, and include:

- evaluating the milk-harvest technicians and their udder prep procedures

- evaluating milk-harvest technicians' handling of cows and cow behavior
- evaluating timing of procedures
- observing how quickly continuous milk flow begins
- assessing alignment of units and frequency of liner slips
- observing correction of slipping units
- evaluating quality of pre- and post-milking teat dipping
- scoring cow cleanliness
- scoring teat condition of at least 20% of the cows, and
- evaluating completeness of milk-out.

It is difficult to observe what normally happens in a milking barn when evaluators are standing by with a clipboard and a stopwatch evaluating milking procedures. However, if this milking evaluation is done as part of an equipment evaluation, milkers are more apt to perform their normal activities.

Milking-time evaluations that really have an impact on improvement of milk quality encompass the entire operation. Too often, milking equipment dealer representatives have been through the equipment multiple times. However, observations of what is occurring during milking time are often neglected. Many people do not fully understand how and when new intramammary infections occur. By simply looking for risk factors for the development of mastitis (i.e. dirty teat ends at unit attachment) and then observing what happens within the claw during milking, many improvements in milk quality can occur without expensive milk testing equipment.

Recommending Changes to Management

After completing observations and tests, prioritize any changes that need to be made to the milking system, milking procedures, and cow management. Be sure to prioritize changes that will have positive effects on milking performance, cleaning performance, or mastitis reduction over aesthetic changes.

Regular system evaluation is an important component to a complete milk quality program. When utilizing the NMC's Procedures for Evaluating Air Flow and Vacuum Levels in Milking Systems, a complete systematic approach will be undertaken. It is important for milk quality consultants to put more into the evaluation than just the milking equipment. Observations of the entire milking process are needed to unroot the cause of milk quality problems. Successful outcomes occur when management follows through with recommendations and monitoring is put in place to measure success or lack thereof. Sometimes this may require several visits

to accomplish all necessary changes. Dairymen must understand that their problems did not develop in 1 day and it will be difficult to resolve a problem with a single consulting visit. Oftentimes it is best to concentrate on 1 or 2 problems per visit as opposed to suggesting multiple changes all at once.

Conclusions

Evaluation of milking systems, milking procedures, and cow management are services that many veterinarians and other dairy consultants perform in order to offer complete herd health services. Unfortunately, after recommendations have been made by veterinarians, other consultants, dairy equipment company personnel, and dairy farm management, there is much confusion about what's been done and what to do now. Milk quality consultants must understand the risk factors associated with milking equipment for the development of new intramammary infections. More importantly, they must also understand that management practices

may have a larger impact on milk quality. Setting up a milk quality program that gives the dairy time to work through problems is often more successful than a single visit with no follow-up.

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