How milking machines & mastitis damage cows and the environment

Climate activists seek to eliminate the dairy industry. Water shortages threaten dairies in the western US and the Netherlands plans to force the closure of 3,000 farms. There is a common factor in all these which is excess replacement rates driven primarily by mastitis.

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Mastitis has been an issue in dairy for decades creating an entire industry dedicated to addressing it.

It is the subject of thousands of studies, articles and conferences and has become accepted as a complex problem caused by a variety of factors including environment, cleanliness, nutrition, and management.

Many offer solutions focused on bedding, liners, dips, vaccines and of course your management of the dairy. Everyone has lost sight of the fact that the milking machine is directly responsible for the milking experience for every cow with the liner action being the animal to machine interface that is the real physical experience.

The focus here is how to directly address the basic milking performance issues causing high mastitis and replacement rates with the solution avoiding the closure of dairies.

Milking machines and bacteria

The unspoken reality is that the milking machine is directly responsible for the treatment of the teat and the forcible shoving of bacteria up the teat canal and into the udder. It is effectively the delivery mechanism for the bacteria responsible for most of the mastitis cases and harm to the teats that leaves the door open to bacteria.

Most intramammary infections (mastitis) are caused by non-motile bacteria. There must either be a physical mechanism by which the are carried across the teat canal or they must grow through the teat canal.

This harsh view of milking equipment is one few have heard or considered with the reaction to ask why not?

The truth is many researchers have considered this fact and published studies pointing to the same conclusion – milking machines are responsible for the transport of bacteria that cause cows to get mastitis. However, no one wants the dairy farmer to know the extent of the problem.

Syringe extraction of milk.

Milk extraction

The udder is a well-protected biological environment where milk is created to feed a calf that we take advantage of by extracting that milk each day with a machine. The calves' approach is to suckle the teat such that a combination of vacuum applied to the teat end and overpressure from the tongue results in flow of milk from the teat canal.

This approach causes unidirectional milk flow outward from the teat allowing it to be fully rested between each sucking event. Multiple studies published in the Journal of Dairy Science (JDS) show the vacuum applied ranges from 34kpa to 54kpa depending on how easily the calf can extract milk from the teat.

The calf also applies an overpressure of around 7kpa adding to the vacuum resulting in a net pressure differential across the teat canal of 41kpa to 61kpa. JDS research also documented average teat wall thickness increases of 26% to 50% with milking machines and only 6% with calf suckling.

A similar teat cistern diameter decrease is found with machines indicating milk flow is being choked off by machine induced swelling. It takes six to eight hours for teat tissue to recover after machine milking and only 30 minutes for calf suckling despite the higher vacuum applied by the calf.

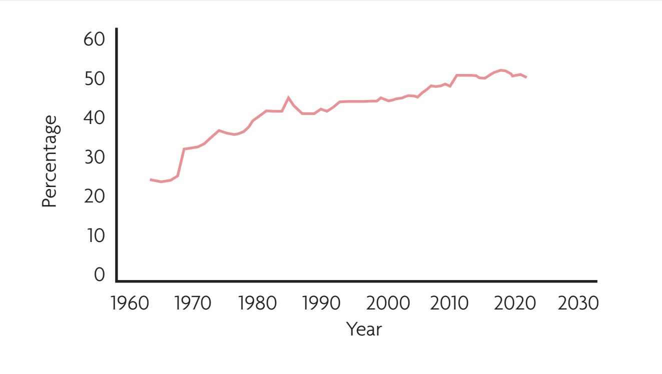

Fig. 1. US dairy cow annual replacement rates.

Nature has established the range of vacuum required by a machine to milk a cow suggesting a milking system vacuum needs to be around 51kpa to ensure most cows being milked have sufficient vacuum applied to reasonably milk the udder fully. It is very possible to milk many cows at 41kpa although as pressure in the udder diminishes with milk extraction some amount of milk must remain in the udder after machine removal for harder milking cows.

Note that the ease of milking a teat depends on how many epithelial folds are in the teat canal. Those with more are more easily dilated and thus more easily milked at lower vacuum.

The Five Point Plan

Milking machines were first invented in the late 1800s with an early modern machine being the Surge belly pail with vacuum operated pulsation. Mastitis was recognised as a serious problem throughout the first half of the 1900s resulting in the introduction of the electric alternating pulsator and the Five Point Plan for management of mastitis.

Alternating pulsation was designed to milk front quarters at a 50:50 ratio and rear at 60:40 to address the belief that a primary mastitis cause was overmilking the front quarters. The industry quickly adopted this technology, however it soon discovered mastitis remained the same problem.

The use of front to back ratios that necessitated alternating pulsation was abandoned and the story changed to one of claw vacuum stability. This makes little sense given dump style meters instantly release more milk than four quarters are yielding at any given time. Few realised the added problem alternating pulsation had created in worsening the mastitis problem – pulsation induced vacuum fluctuation.

The opening or closing of one pair of liners while the other is open, and milking causes a sudden change in vacuum within the claw creating an impact on the milking pair including a washing with milk. Not a desirable situation as research has shown.

The Five Point Plan was conceived about ten years after the introduction of alternating pulsation in another attempt to "clean up" the mastitis problem still flourishing in the industry.

This plan focused on cleanliness and management of the problem. In years following the introduction of that plan mastitis rates and average SCC did improve however at the expense of the dairy cows with a coincidental rise in replacement rates. Mastitis rates were reduced by a third while replacement rates doubled – cows now slaughtered at a rising rate to 'solve' the mastitis problem driving a need for sexed semen. This high slaughter rate persists today driving the need for additional forage, more land, water and other resources just to satisfy the Five Point Plan. Not a favourable trade for the environment, the cow or the finances of the dairy farmer.

Research and evidence

It is appropriate after so many decades of battling mastitis and now facing the scrutiny of animal and climate activists to consider how the industry got into this situation and what research and evidence exists to honestly begin to prevent mastitis and address demands of the current political/social environment.

It has already been noted that calf suckling suggests a different milking action is needed with the calf providing an effective average pressure differential of 51kpa. The calf also provides a unidirectional milk flow through the teat that does not result in reverse flow into the teat sinus and does not cause backwash of the teat.

It is reasonable to consider how modern milking machines fail to provide a healthy environment for the teat during the milking process.

Research by Dr Derek Forbes at the University of Reading focused on understanding how non-motile Staph aureus bacteria migrates from the teat exterior into the teat sinus.

Dr Forbes inserted a sterile needle through the side of a teat directly into the teat sinus to extract milk. The same cows were also milked with a conventional milking machine to compare milk samples.

The conclusion was that the pinching action of a liner during the milking process was forcibly pushing the Staph aureus bacteria up the teat canal and into what had been a bacteria free teat sinus.

This shoving of bacteria opposite to the direction of milk flow resulted in udder infections and mastitis. Dr Forbes determined that the milking machine was the delivery mechanism for bacteria into the udder from the direct action of the liner on the teat while milking.

This does not occur with calf suckling as a calf does not create an upward pinching action on the teat and milk flow is only towards the exit of the teat.

Presentation on milking machines and mastitis

A paper presented at the 2004 NMC annual meeting titled "Milking Machines and Mastitis Risk: A Storm In A Teatcup" by Mein et al. aptly describes the role milking machines play in the ongoing mess we call mastitis.

The paper elaborates on the many ways milking machines can contribute to new mastitis events and then works to sweep them all away to focus on poor management techniques of the dairy farmer as the cause.

One key point in the paper is: "one third of the milk volume present in a teat sinus just before the liner starts to close, is 'pumped' back up into the udder cistern by the closing liner".

A rather interesting disclosure when also considering another statement in the paper when referencing an older study: "In marked contrast, 33 of 172 quarters became infected when bacteria were placed within the teat sinus and the teats were manipulated to 'milk' the sinus contents up into the udder cisterns before machine milking."

The paper then attempts to deflect this concern by referring to more recent research noting that: "This elegantly simple study provides a further demonstration of the value of an effective liner and pulsation in minimising the risk of moving any pathogens, which may have contaminated the teat-end, into or through the teat canal under normal milking conditions."

What is not considered in the NMC presentation is the prior research by Dr Forbes that provides the proof that liner action is indeed pushing bacteria up the teat canal during the milking process and then further moved up the teat sinus as disclosed in the presentation.

The NMC presentation also contains a discussion of liner design evolution from large to medium and then small bore along with the intended milking performance improvements that were expected. In the years since the industry has seen a rapid expansion in the offering of liner designs and features. Nearly every conceivable shape is available ranging from round to triangle to square and various geometry combinations.

This evolution continued to include adding liner venting in different locations on the liner along with the many shapes. This leaves open the question of how can the industry possibly need so many hundreds of options to simply milk a cow?

Liner design

What is needed is to be able to milk a cow quickly, efficiently, comfortably without teat damage or liner slip, squall, or crawl. Recognising that you cannot get all these attributes in one liner with a conventional milking machine one US company directly states that it is not possible.

Their one liner offers speed with low slip, another gentle at low vacuum while, another offers low slip with fewer squawks and yet another simply offers consistent performance.

What dairy farmer wants to be limited to only achieving one or two of those? Would you want to look for a new car and choose between quality, safety, reliability, and ride comfort and not have all those options in one car? Would you buy a car without safety or quality? And yet the industry routinely accepts that in dairy milking equipment expecting your management to make up for what is missing.

The basic theory behind liner design in recent decades is the liner action needs to address 'liner slap' while keeping the bacteria away from the teat canal opening. The intended purpose of the non-round liners is to intentionally maintain a constant suction on the teat canal from machine attach to detach to 'vacuum' away the bacteria.

Non-round liners by design do not close below the teat canal and instead leave an opening for the constant application of vacuum. Effectively never allowing the teat canal to be rested or relieved of the pull of vacuum.

Clearly this does not work as even automated milking machines started incorporating steam cleaning of liners between cows attempting to ensure the liners are free of bacteria.

The liner designs not only fail to vacuum the bacteria away they also fail to prevent the upward rolling pinch (slap) on the teat canal that shoves the bacteria up the canal to cause the infections. To make matters even worse, JDS research has shown non-round liners milk more slowly.

Dr Sybren Reitsma published research in the 1960s documenting a possible method by which milking machines can impact teat end vacuum fluctuation. Dr Reitsma compared the milking action of simultaneous, alternating, and sequential pulsation to evaluate the teat vacuum fluctuation events during milking.

His research shows the number of fluctuation events increases from simultaneous to alternating to sequential while the size of fluctuation decreases. His research also shows that the fluctuations are perfectly timed with the milk/rest phase with simultaneous and are out of step for alternating and sequential. With simultaneous the vacuum increases as the liners open aiding in re-opening the teat canal to re-start milk flow and vacuum decreases as the liners close to aid in reducing teat end vacuum for a proper rest action.

Alternating causes vacuum to fluctuate under the teat during the milking process which partially slows flow as well as increases backwash and risk of mastitis as other research has concluded.

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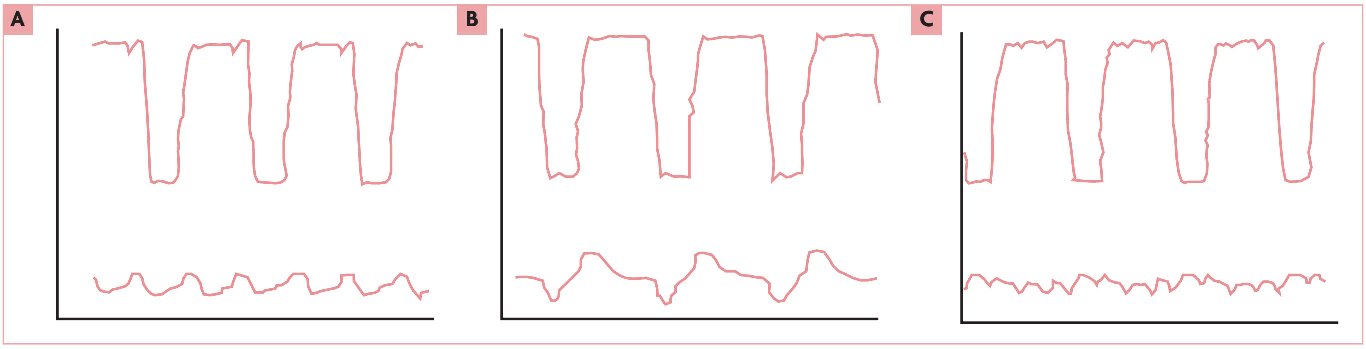
Fig. 2. Reitsma research: A – alternating, B – simultaneous, C – sequential.



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Modern milking machines

Decades of research all suggest that the typical modern correctly functioning milking machine is responsible for teat swelling, canal damage, forcible pushing of bacteria up the canal into the sinus/udder and backwashing of the teat.

It is the delivery mechanism for the bacteria and ultimately the cause of much of the mastitis and udder/teat harm.

Research shows the path to achieving machine milking that addresses known problems to provide a method that is fast, efficient, and gentle.

Turning away from the failings of alternating pulsation is the first step as it eliminates the fluctuations under the teat that cause backwash and milk flow interruptions. Elimination of the continuous application of vacuum on the teat canal is the next step by allowing proper rest of the canal.

The final piece is to prevent the upward pinch action of the liner which has been incorrectly called 'liner slap'. This issue was a primary motivation in the creation of so many different liner designs and shapes.

Years ago the industry recognised 'liner slap' (pinch) is a problem but failed to understand it was not a slapping action but rather a pinching action as Dr Forbes had proven.

The industry move to long C phases and non-round liners worsened the problem which then led to lowering of vacuum levels.

The lower vacuum levels cause many cows to not milk out completely as flow slows resulting in longer milking durations in which oxytocin levels fall, further slowing milking.

Longer milking times lead to more teat stress and greater risk of mastitis, all documented in many JDS studies. Each step in the wrong direction resulted in more action in the wrong direction.

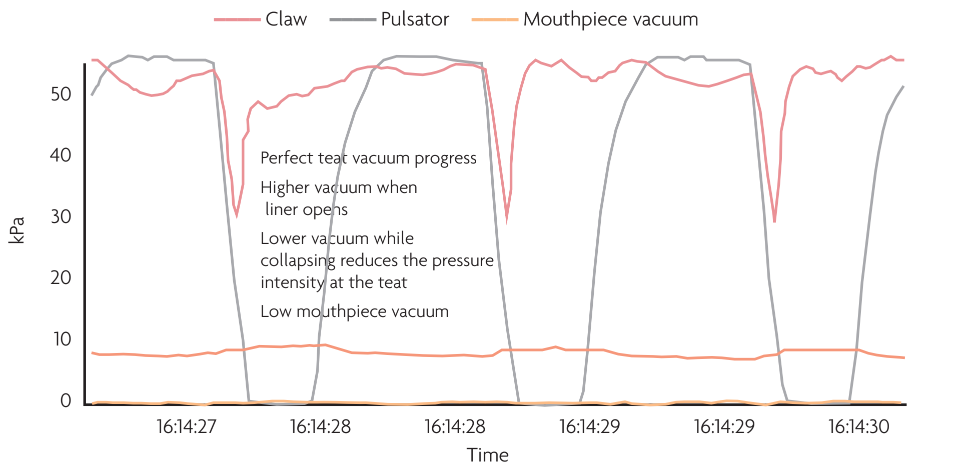

Fig. 3. Simultaneous pulsation with short C phase.

Design based on research

A properly designed milking system based on all known research is one that incorporates a simultaneous pulsator with a small bore round liner operated with a short A and C phase with sufficient system vacuum to close the liner below the teat and to provide a full teat length massage.

This action is further aided with a positive pressure fresh air supply to effectively turbocharge the C phase. This eliminates the pinch providing a gentle compressive massage action along the length of the teat while closing the liner below the teat to relieve the teat canal from the milking vacuum. The liner should also be held fully open on attach to ensure a well attached liner on all teats.

The resulting milking action is sustained peak flows from attach to detach as the teat is fully rested with each liner closure that is like compression socks used to aid in blood flow circulation rather than an action that just pinches the teat end. Shorter milking durations further aid in teat health with a milking system that is now much closer to that of a calf than a rather harsh vacuum milk extractor.

A JDS study shows a significant reduction in Staph aureus with the elimination of the pinch. Comparative farm data shows 20% higher flow rates with a 70% first two-minute milk yield. Long term gains prove that replacement rates can be halved to return to the lower rates of decades ago.

Labour and energy savings from faster milking bring another bonus to the dairy farm. We now live in a world where social change is demanding dairy farms reduce labour, improve animal welfare, and reduce land/water use while improving the environment. These challenges will not be met with the milking systems commonly in use.

They have driven a near doubling of cull rates causing a need for more forage, land, and water. For example, the water waste in the US State of California alone due to a doubling of the cull rate is 1.4 million acre-feet which is three times the total volume used annually by the city of Los Angeles with a population of 12.5 million people. In the Netherlands there is now a demand to eliminate 3,000 farms to reduce emissions.

An alternate option is to halve the number of replacements on all Dutch dairy farms rather than eliminate 3,000 while achieving the same environmental goals.

Across the world cows are being blamed for excess methane production. Each issue raised can be substantially reduced by simply halving cull rates achieved with proper milking equipment design.

Conclusion

The dairy industry has struggled for decades with mastitis, udder health and achieving quality milk. One must ask how many more hundreds of studies; mastitis conferences and management approaches are needed before someone simply steps back and choses another path? The obvious solution is to change the fundamental way cows are milked to yield a different result.

Continuing to pursue more of the same is likely to result in a significant number of dairy farms ceasing to exist before the end of the decade. The first step is accepting you have been provided incorrect information and to then seek a solution as the future of the dairy industry depends on it. ■