

## **MILKING MACHINE RESEARCH: PAST, PRESENT AND FUTURE**

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We have been milking cows with the same basic assembly of teatcup shell and liner for the past 100 years. The body of published literature covers this entire span, and more. One might well ask why we are still doing research on machine milking: Is there anything new under this sun?

The basic concepts of milking cows quickly, cleanly and gently have, indeed, remained unchanged. There has been a steady advance, however, in our understanding of the milking process from the perspective of the cow and the machine. Many of these advances have occurred because the challenges of performing “successful” milking have increased as milk production and milking frequencies have steadily increased over the past 100 years. These challenges have been the mother of invention and the advance of science and practice has resulted in milking machines and milking procedures that can successfully milk cows with a wider range of teat size and producing over 10 times more milk than when teatcup and liners were first introduced. As a matter of necessity, advances in milking technology and milking procedures have also resulted in considerably faster milk removal that is at the same time gentler on the cow.

Despite these advances in research and understanding it is not uncommon for farmers, field technicians and veterinarians to cling to inaccurate or outdated concepts of the role of the milking machine in the success of the milking process. Our question to the reader is: Do you represent the past, the present or the future of milking? We hope that this review will challenge you to review your understanding of machine milking, reaffirm the tested wisdom, reject outdated concepts, and be part of the advance of knowledge and application into the future.

There are several notable publications that form an excellent summary of the history and development of thought on machine milking:

- 1987 - Machine Milking and Mastitis. Bulletin of the International Dairy Federation, No. 215.
- 1992 - Machine Milking Lactation. Insight Books. Bramley, Dodd, Mein and Bramley Editors.
- 1994 - Machine-induced changes in the status of the bovine teat with respect to the new infection risk. Bulletin of the International Dairy Federation, No. 297.
- 1995 - Milking Machine Effects on Mastitis: Progress 1985-1995. M.W. Woolford, Proc. IDF 3<sup>rd</sup> International Mastitis Seminar.

A more recent collection of studies on machine milking and mastitis can be found in

- 2001-NMC, Proceedings, AABP-NMC International Symposium on Mastitis and Milk Quality

The present world of milking research is dominated by the development and implementation of automatic milking systems. There are now more than 1000 farms using automatic milking systems (AMS) around the world. This technology is still, however, in its developmental stage. The introduction of AMS has created the need to reassess the basic principles of milking for application to this new situation. This body of research is summarized in the proceedings of two major conferences:

- 2000-Robotic Milking. The International Symposium held in Lelystad, the Netherlands,
- 2002-The First North American Conference on Robotic Milking, held in Toronto, Ontario, Canada.

There are several major research efforts underway to address the concerns relating to regulation of automatic milking systems. New information is becoming available at a rapid pace. The very latest information on the European Union Automatic Milking Project is available on the Web site:

[www.automaticmilking.nl](http://www.automaticmilking.nl)

The results of this major research effort will be presented at a Symposium scheduled for 2004 in Lelystad.

Woolford (1995) reported that a CAB International keyword search from 1985 to 1995 found 265 papers published related to milking machines and mastitis. The conclusions from this review were:

- The resources to address milking and mastitis had declined.
- The detail of key teat/machine interaction remained undefined.
- Important progress had been made in teat canal keratin dynamics, reverse pressure gradients, and teat tissue reactions.
- Interest in automatic milking may result in advances in milk sensing, associated data processing and mastitis management.
- Several important advances in milking research had not resulted in changes in milking machine design (specifically methods to reduce of cross-quarter infection).
- The closing statement in this review indicates that the considerable effort expended on improving vacuum stability in receivers and milklines from 1985 to 1995 has been misdirected.

The focus of this 1995 literature review was the role of the milking machine on mastitis. We repeated the CAB search to update the reference list on milking machines and mastitis. We also expanded our search to include milking machine and milk quality issues beyond mastitis such as; bacterial quality of raw milk, the effectiveness and efficiency of milking procedures, general aspects of milking machine design, and cleaning and sanitation of milking machines. This exercise resulted in a list of over 800 references which exceeds the space limitations of these proceedings. A review of these references indicates that while some things have changed since 1995, others have not.

Some of the major trends in the milking machine research literature in the past seven years have been:

- The preoccupation with vacuum stability in receivers and milklines has been moderated somewhat. Research and field experience over the past seven years has underscored the fact that vacuum stability in modern milking machines is a relatively unimportant factor in the success of the milking process. New standards have been published by both ISO and ASAE which have shifted emphasis from generic components such as pumps and line sizes to evaluating the performance of milking clusters.
- Research has continued to better understand milking machine effects on teat tissue and teat canal keratin dynamics.
- A considerable international effort was launched to develop and standardize methods for evaluating the condition of teat tissues after milking, in recognition that teat canal defenses play a major role in the risk of mastitis infections.
- Research on the benefits of higher threshold settings for Automatic Cluster Removers (ACR) for teat condition and cow behavior has been implemented in the field.
- Considerable efforts have been directed at combining the tried and true concepts of providing adequate teat and udder hygiene while simultaneously providing adequate stimulation and cluster attachment timing (prep/lag) into an efficient work routine in milking parlors.
- Social concerns over food quality and safety have resulted in resources committed to milk quality issues, particularly the reduction of bacterial contamination of raw milk and cleaning and sanitation of milk handling equipment.
- Major advances have been made in the reduction of energy used by milking machines through more sensible design guidelines and development of energy saving vacuum regulation and cleaning systems.
- Animal welfare concerns have resulted in research on dairy cow behaviors which have advanced our understanding of the importance of positive human/cow interactions to the success of the milking process.
- Numerous studies on 'stray voltage' have confirmed previous results that exposure of less than 1 volt of cow-contact voltage results in no harm to cows nor adverse effects on milking performance.
- The study and application of good milking practices to mammals other than high producing dairy cows has resulted in numerous publications and standards. A standard was developed for milking small ruminants and surveys of udder and teat morphology and milking physiology of sheep, goats and buffaloes have improved our understanding of these species as well as advanced our understanding of the physiology of high producing cows.

The largest influence on milking research in the last seven years was undoubtedly the deployment of automatic milking systems in large numbers. The appearance of AMS on farms has required regulatory agencies to take action. This has resulted in a rethinking of the basis for

regulations to ensure milk quality and safety. Some of the major areas of study stimulated by AMS have been:

- There has been increased effort applied to on-line sensing of various milk components as predicted by Woolford in 1995. These can be divided into the two general categories of:
  1. Detection of ‘abnormal’ milk at the time of milking for purpose of diverting it from the bulk tank, and,
  2. Sensing milk components for improved dairy herd management.
- Efforts have been undertaken to improve the management of the enormous amount of data collected by AMS to improve the efficiency and effectiveness of dairy herd management for all types of dairy production systems.
- Studies of cow behavior in voluntary milking situations have improved our understanding of cow psychology with associated benefits for all types of milking systems.
- The challenges of automatically cleaning teats and applying teatcups automatically have resulted in advancements in the understanding of the physiology of the milk let-down response in dairy cows.

These are some of the major currents in milking machine research and practice at present. There are many more interesting streams and tributaries in the rather large body of published literature. A complete list of references, many with abstracts, and a more detailed summary of important advances in milking research is available at the UW milking lab web site:

[www.uwex.edu/uwmril](http://www.uwex.edu/uwmril)

Our intention is to make this a living document which is updated as new material is published.

#### Major Reviews and Conference Proceeding Cited

AABP-NMC International Symposium on Mastitis and Milk Quality, Proceedings of the symposium held in Vancouver, BC, Canada. September 2001.

The First North American Conference on Robotic Milking, 2002. Proceedings of the conference, Toronto, Canada, 20-22 March 2002. J. McLean, M. Sinclair, and B West (editors).

Machine Milking and Mastitis, 1987. Bulletin of the International Dairy Federation, No. 215.

Machine Milking and Lactation, 1992. Insight Books. AJ Bramley, FH Dodd, GA Mein and JA Bramley (editors).

Machine-induced changes in the status of the bovine teat with respect to the new infection risk, 1994. Bulletin of the International Dairy Federation, No. 297.

Robotic Milking, 2000. Proceedings of The International Symposium held in Lelystad, the Netherlands, 17-19 August 2000. H. Hogeveen and A. Meijering (editors).

Woolford M.W, 1995. Milking Machine Effects on Mastitis: Progress 1985-1995. Proc. IDF 3<sup>rd</sup> International Mastitis Seminar, Tel-Aviv, Israel.