ROBOTIC MILKING: CURRENT SITUATION

Douglas J. Reinemann
University of Wisconsin
Madison, Wisconsin, USA

The population of farms using automatic milking systems (AMS) has grown from the first installation a dairy farm in the Netherlands in 1992 to more than 8000 milking units on more than 2400 farms today The vast majority of these farms are in north-western Europe, with the Netherlands having the largest installed base and Scandinavia showing the fastest growth rate in the past few years (Lind, 2007).

Regulation and Standards

The International Standards Organization (ISO) created a standard for automatic milking installations (AMI), which was approved in 2007. The machine milking group of the International Dairy Federation (IDF) suggested that, while many aspects of AMI are different than conventional milking machines, many aspects are also shared. It was decided to simultaneously create a new standard for AMI containing those aspects unique to this new technology and to revise the milking machine standards to update them and revise them to allow seamless reference from the AMI standard. This International standard specifies requirements for construction including specific safety and hygiene aspects and minimum performance requirements and testing for AMI. It does not contain requirements for the design of the building in which the milking installation is installed.

Appendix Q to the Pasteurized Milk Ordinance (PMO) governing the Operation of Automatic Milking Installations (AMI) for the Production of Grade "A" Raw Milk for Pasteurization was approved at the 2003 meeting of the National Conference on Interstate Milk Shipments. Highlights of this apprendix are as follows:

- AMI shall have the capability to identify and discard milk from animals that are producing milk with abnormalities.
- Odor is currently evaluated on a bulk tank basis and is not different for a herd using AMI technology.
- Animals producing milk with abnormalities milked immediately prior to system cleaning, or the points of contact with abnormal milk will be cleaned and sanitized after milking such an animal.
- The AMI milker box shall be kept as clean as any milking and equipment cleaning area.
- All ventilation air must come from outside the cattle housing area.
- AMIs shall be shut down to clean at an interval sufficient to prevent the milking system from building up with soils (8 hrs recommended).
- AMI manufacturers shall submit data to FDA to show that "Teats shall be treated with a sanitizing solution just prior to the time of milking and shall be dry before milking."
- The teat cups of the milking cluster need to be adequately shielded during the udder prepping process to assure that contaminants may not enter through the teat cup and get into the milk.

- Adequate separation of milk and CIP solution shall be provided to minimize the risk of cross contamination of milk with cleaning and sanitizing solutions.
- Milk shall be cooled to 10°C (50°F) within four hours or less after starting the milking operation and the milk shall be cooled within two more hours to 7°C (45°F).

AM has been generally accepted by regulatory agencies although in some countries they are subject to a higher degree of surveillance as a new technology and several countries have developed guidelines or good management practices (GMP) for application of AM technology while specific of regulations are being developed. These GMP are an invaluable aid to producers considering, as well as those already using, AM machines to identify the critical management tasks required to produce quality milk. They also serve as an educational tool for the variety of farm advisors helping solve milk quality problems. GMPs have been used with success in other areas of agricultural production systems and strike a workable compromise between rigid regulations and lack of guidelines in areas of rapidly evolving practice. A GMP for automatic milking was developed as an aid in providing quality assurance in milk production as an extension on EU and national regulations and codes (Jepson et al, 2001). The basic principle of the code is that AMI shall provide the same minimum guarantees of quality milk production as traditional milking systems.

Milk Quality and Sensors

The overall goal of the rules and regulations regarding milk quality and safety are to ensure that 'abnormal milk' does not enter the raw milk supply system. The normal screen for abnormal milk is visual inspection of the cow and/or the foremilk by a human being while performing the tasks of udder and teat preparation and milking unit attachment. Automatic milking systems typically rely on some form of sensor to measure various aspects of milk quality. This has created the need for a better definition of 'abnormal milk'.

Visual inspection is capable of detecting gross abnormalities in milk composition (clots, flakes, or 'wateriness') and some substantial change in color due to blood in the milk or other gross changes due to changes in lactation physiology. The primary emphasis in the development of AM systems has been on mastitis detection. The practical implementation in the field results in a cow being 'flagged' at one milking using a combination of data from milk quality sensors and deviations in yield and behavior. Human inspection of the cow, foremilk, or milk quality data is generally required to make the final decision to divert the milk from this cow at the next milking and until the milk quality problem is resolved.

Bio-sensing systems, in general, respond to some change in the chemical composition, or changes in the visible or non-visible light transmission or reflection of the milk. The basis for detecting abnormal milk with biosensors is thus quite different than for visual inspection. Biosensors have the ability to detect smaller changes in the visible light spectrum than the human eye. Visual inspection cannot be used to detect changes in chemical composition or the non-visible light spectra. Biosensors thus have the capacity to be a much more sensitive detection system for milk quality than human visual inspection. At present we do not have a well-developed set of criteria for identifying 'abnormal' milk using biosensors.

A review of the state-of-the-art sensing technology for AMS suggests that while the sensing systems currently being used lack the sensitivity for automated diversion of 'abnormal' milk, they do provide sufficient information for motivated dairy producers to achieve milk quality that meets or exceeds national averages. Electrical conductivity and milk color are the most widely used on-line milk sensing methods and deviation in milk yield and milking interval are widely used supporting diagnostic techniques. A number of other methods using visible and other light spectra have shown promise in detecting milk abnormalities and measuring various components of milk. Several methods of measuring the somatic cell count (SCC) of milk at cow-side are being applied to AM. Developments in AMS milk sensing systems point toward the use of inputs from a number of sources including milk composition, animal behaviors, and milking characteristics combined and analyzed by centralized 'smart' system to improve diagnostic accuracy. (Reinemann and Helgren, 2004)

Following the International Symposium on Automatic Milking, Koning & Meijering (2004) concluded based upon results from commercial farms that milk quality is somewhat negatively affected after introduction to automatic milking. There were small significant increases in bacterial counts, (TPC), somatic cell counts, freezing point and free fatty acids. The highest increase was for TPC and somatic cells in the first six months after introduction. After this period it improved and stabilized around the level of conventional farms (Koning et al., 2004). German, Danish and Dutch farms (262) were included in the study.

Helgren & Reinemann (2006) studied milk quality of 12 AM farms in the USA for three years as part of a pilot study of AM technology in the USA. Daily records of bulk tank somatic cell count (SCC) and total bacterial count (TBC) data were analyzed and compared to corresponding data from a cohort conventional farms in Wisconsin as well as data from European AM installations. The geometric means for all farms were 268,000 cells/mL SCC and 13,300 cfu/mL TBC. There was no significant difference in SCC between AM farms and the cohort of conventional farms, but a clear and significant seasonal effect was evident for SCC for both farm types, with higher values observed during the summer months (July, August, and September). The TBC of milk from AM farms was lower than that for a cohort of conventional farms, and there was some evidence of a seasonal effect on TBC for both types of farms. Both SCC and TBC decreased as the amount of time that a farm utilized AM increased.

Herd Management and Views of AM Users

A survey was conducted of 10 farms in the USA and 15 farms in Canada using automatic (or robotic) milking systems (AMS) to determine how AMS facilities were being designed and managed in the North American setting. Surveys were conducted in-person with the farm manager during visits to the farm. All of the AMS users surveyed indicated that, overall, they were satisfied to very satisfied with their AMS. Most users indicated that AMS has allowed them more time for managerial tasks, and more importantly, more time for themselves and their families and has decreased stress levels for both cows and themselves (deJong, et al., 2003)

Karttunen (2003) carried out an interview study in Finland among AMS users. In general the users were satisfied with the system: flexibility of working time and reduction of physical work load were among the most appreciated advantages. Other mentioned advantages were health of personnel, improved safety for the personnel, and quality of milk extraction. Mentioned disadvantages were dependence of electricity, high investment costs and higher consumption of water.

AM combined with grazing has been successfully demonstrated in several countries (Jagtenberg & Dooren, 2001; Karlsson, 2001; Jago et al., 2002). Concentrates are typically fed in the AM station and milking frequencies as high as 2.3/cow/day have been obtained using special motivational strategies to encourage visits to the automatic milking installations.

Future Challenges of AM

The experience of AM clearly indicates that it is possible to produce milk of the same or better quality than conventional methods of milk harvesting. AM systems relieve the dairy farmer from the physical labour of milking and also provide a wealth of information for herd management. These systems use a higher level of technology than conventional milk harvesting techniques and, therefore, will require a higher level of management skill to use this technology successfully.

The definition of abnormal milk will likely evolve as biosensor technology develops and offers the possibility of on-line measurement of more aspects of milk quality. This is an area of rapid technological development. These developments are fueled by the prospect of a commercially viable product (providing the market with management information at a price justified by the benefits) and are also highly influenced by the regulatory climate (what types of technology are allowable and/or mandatory). The challenge to regulatory agencies will be to ensure the quality and safety of the raw milk supplied from automatic milking systems while not stifling the development of new technologies that could significantly improve milk quality and safety.

The types of AMS currently available on the market were developed primarily to meet the needs and market and social conditions of single-family owner/operator dairy farms in Europe and the traditional dairy states in the USA. These farms are generally located near population centers where the urban pressures of higher land prices, higher price for labor and increasing environmental regulations are significant factors in the future economic viability of these farms. Health issues, unusual work hours, and working conditions have made obtaining reliable milking labor a major concern of these dairy producers. AMS technology can provide an option for these farms to reduce the labor requirements of milking and allow some of these farms to continue dairy production and make them more attractive to new producers.

At present, AMS technology is more costly than other methods of harvesting milk. It is clear, however, from the adoption rate in Europe and high degree of interest in the USA that this is not the sole factor in the decision to purchase an AMS. It appears that many producers are willing to pay a premium for the improved quality of life offered by AMS. The economics of milk production using AM technology must be able to compare favorably to large farms to be viable in the long term. The owner/operator will need to acquire higher-level management skills of cows, business and technology to optimize the investment in automation.

There has been considerable interest in using AM technology on large farms. The most common concept is to multiply the type of modules already in use on small farms. One large farm operation in the USA has discontinued the use of AM technology while another has begun to implement AM on a large scale. An intermediate option for AM technology, which may be particularly attractive on large farms, could be as an assistant to a human operator. The way and extent to which AM will be implemented on large farms remains a question and is an area of research and development.

A major public education effort will be required to ensure that AMS users clearly understand the management skills and economics required for its successful implementation and that legislative bodies clearly understand AM so that the resulting rules and regulations achieve their desired goals (Reinemann, et al., 2002).

References

de Jong, W., A. Finnema, D.J. Reinemann, 2003. Survey of Management Practices of Farms Using Automatic Milking Systems in North America. ASAE Annual International Meeting Technical Paper No. 033017

Helgren, J.M., D.J. Reinemann, 2006. Survey of Milk Quality On U.S. Dairy Farms Utilizing Automatic Milking Systems. Transactions of the ASABE, 49(2)551- 556.

Jago, J., P. Copeman, K. Bright, D. McLean, I. Ohmstad, M. Woolford. An innovative farm system combining automated milking with grazing. Proceedings of the New Zealand Society of Animal Production 62, 115-119 (2002).

Jagtenberg, K., H.J. van Dooren. De melkrobot: weiden naar keuze. Praktijkonderzoek Rundvee 14, 23-25 (2001)

Jepsen, L., B. Everitt, C. Cook, R.H. Oost, H. Hogeveen, J.B. Rasmussen, 2001. Good Management Practice Code for Milking with Automatic Milking Systems. Draft Documents March 2001.

Karlsson, M. Betesdrift i kombination med automatisk mjölkning. En fältstudie på tre gårdar. Examensarbete 150. Institutionen för husdjurens utfodring och vård. Swedish University of Agricultural Sciences. Uppsala. 39 pp. (2001).

Karttunen, J. 2003. Robotic milking will change work routines. Teho No. 5, 4-6, 38-39.

Koning, K. de, A. Meijering. 2004. Excepts from main papers www.automaticmilking.nl

Koning, K. de, B. Slaghuis, Y. van der Vorst. 2004. Milk quality on farms with an automatic milking system. www.automaticmilking.nl

Lind, O., 2007. Personal communication.

Reinemann, D.J., O. Lind, J. Rodenberg, 2002. A Global Perspective on Automatic Milking Systems Rules and Regulations. Proc. First North American Conference on Robotic Milking, March 20-21, 2002, Toronto, Ontario, Canada.

Reinemann, D.J., J.M. Helgren. 2004. Online Milk Sensing Issues for Automatic Milking. Paper Number: 04-4191, Presented at the 2004 ASAE/CSAE Annual International Meeting, Ottawa, Ontario, Canada