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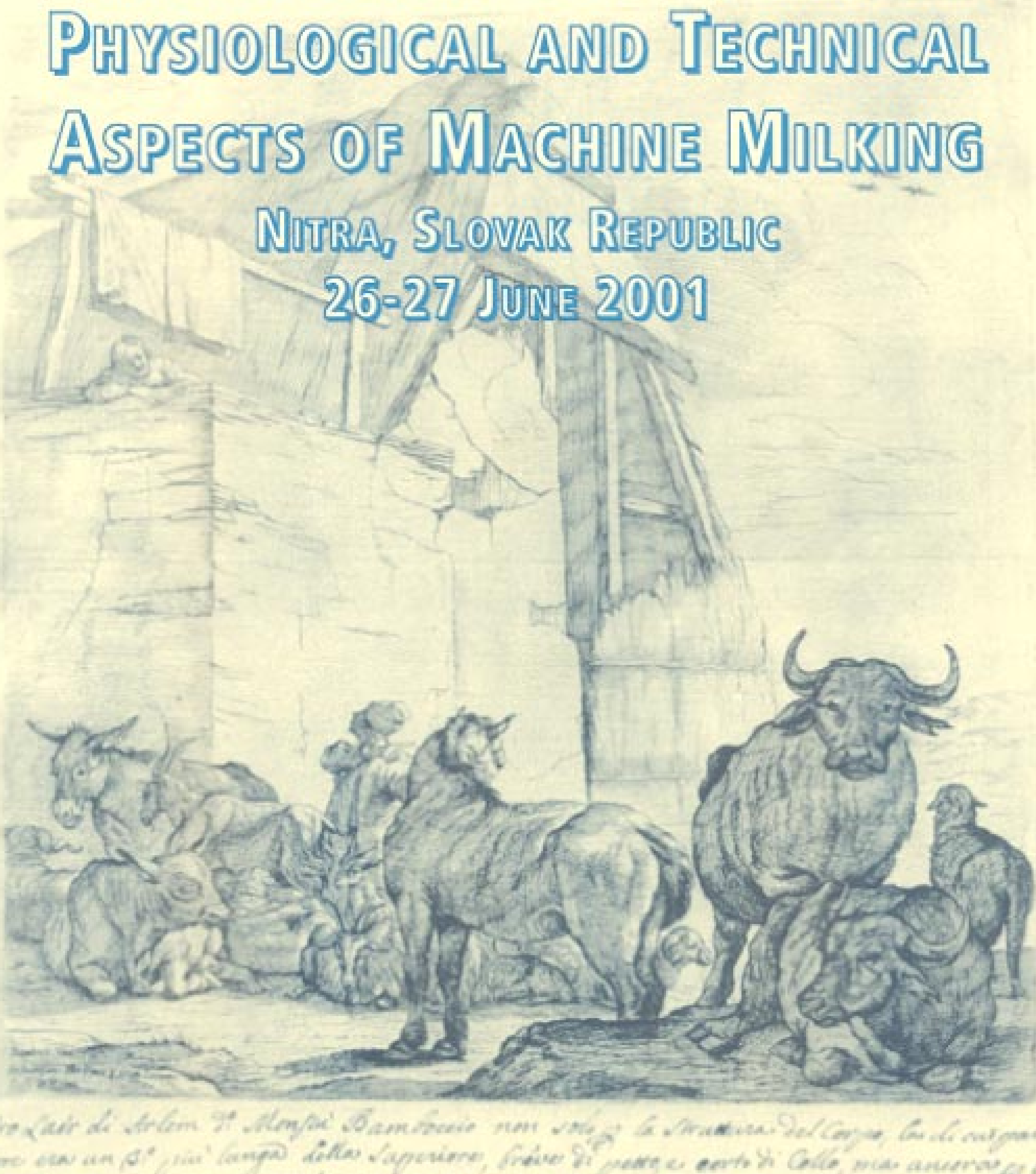

Editors: A. Rosati, S. Mihina & C. Mosconi

November 2001

Cover page: 17th century engraving by Pieter Jacobsz van Laer of Haarlem, dit Bamboccio, (1599-1642), representing a livestock farm in the Latium region of Italy

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Physiological and Technical Aspects of Machine Milking

Proceedings of the International Conference held in Nitra, Slovak Republic, 26-27 June 2001

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Foreword

Ladies and Gentlemen,

Welcome to Slovakia, welcome to Nitra a centre of the Slovak agriculture. Our agriculture undergoes a very difficult period of transformation. Its course can be speeded up and probably also facilitated by the supply of topical knowledge. Since 1989 we go for them out into the whole world. However, we are glad if the knowledge comes to us. Thank you for accepting the invitation of the organisers and taking part in this conference. I was informed that one half of the guests came from abroad and most of them came from the countries of EU and the USA. Even this fact gives evidence of our struggle to be associated to the European Union. I am convinced that the authority of our scientific workers and institutes stimulated you to participate in this conference.

Our research institutes take active part in the international scientific and technical co-operation. The Research Institute for Animal Production, in the facilities of which this conference takes place, has also great experience with international activities. It is the seat of the international laboratory for bio-technologies. It co-operates with many outstanding scientific institutions abroad. A number of research workers from Nitra take part in short-lasting as well as long-lasting experiments abroad, and foreign researchers are often here. The Institute works at a project within 5th Frame program although the researchers from Nitra would like to be more successful in it.

International film festival Agrofilm is organised in the Institute every year. There were presented more than 2300 films with agricultural, food and ecological topic from 72 countries.

The Institute is also represented in international organisations. The director of the Institute was member of the Council of the European Association for Animal Production for 9 years, out of them 4 years its Vice-President. Chairman of the organising committee of this conference is the member of the Sub-committee of the International Committee on Animal Recording under the auspices of which is this conference realised. I would like to express my thanks for it to the Vice-President of ICAR Mr. Andrea Rosati who is present in person.

The second half of the participants are the Slovaks. It also shows our interest in knowledge. Welcome to Nitra.

The area of Slovakia is very heterogeneous. If you came from Vienna, you saw its fertile part. Here at Nitra is the first small hill and from here to the north and east run the ranges of our mountains. Agricultural land represents about 50 % of the area of our country. Only 32 % is arable land. I come from a submontane region and I can tell you that the agricultural production is performed there with great difficulty. Our agricultural policy established by law respects the geographico-climatic conditions. It is our interest the agriculture be a part of the landscape, its co-creator. Therefore we devote great attention to the ecological influence of agriculture. However, at the same time we are able to produce products of competitive price in intensive regions. The structure of our agricultural subjects is heterogeneous. There are large enterprises with the average area 1 200 ha, which cover 71 % of total acreage of our agricultural land, and individual farmers with average acreage 10.5 ha.

It is not possible to explain the whole philosophy of transformation of our agriculture in this short address. Nevertheless, I hope the Slovak participants of the conference will be able to do so during the discussions between the sessions and during the social evening.

Allow me some remarks on the conference topic. I esteem persons who are engaged in obtaining of milk. I am a politician, however, I was engaged in the agricultural production more than 20 years and therefore I know it very well. I consider milking a very exacting process mainly from the social and economic point of view. You will deal first of all with the relation of biology and technique during the conference. I hope that the results of your research will become evident in the social and economical sphere also. I wish you a nice stay in Slovakia and success for the sessions.

Pavel Koncos
Minister of Agriculture of the Slovak Republic

The activities of ICAR

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Introduction

ICAR (International Committee for Animal Recording) is the worldwide organization for the standardization of animal recording and productivity evaluation. ICAR is registered in Paris as a non-profit international non-governmental organization, in accordance with French law. The Secretariat, under the direction of the Secretary general, is located in Rome (Italy). The official languages of ICAR are English, French and German.

ICAR history

First animal genealogy registration was performed on horse breeding for military cavalry, about two hundreds years ago. The first dairy performance recording was performed in USA in 1883 when the Holstein-Friesian Association was created. Routine milk recording began in Vejen in the Jutland peninsula (Denmark) in 1895. Denmark was, far ahead of the other countries, adopting milk recording. Between 1910 and 1925 milk recording systems diffused in many countries. The methodology was not yet firmly fixed, however, and there was much controversy over errors due to use of periodic testing as compared to daily tests. Early Attempt to Internationally Standardize Milk Recording was discussed at the International Congress in Agriculture held in Paris in 1923. The International Institute of Agriculture in 1924 listed twenty countries practicing milk recording, with a combined total of 1.8 million cows tested. The same Institute in 1935 updated the list showing that there were thirty-four countries and 4.5 million cows in 285 000 farms. After the Second World War some meetings of European livestock experts together with F.A.O. technicians prospected the unification of a cattle herd book methods. After a gestation period of almost thirty years, the International Organization designed to harmonize milk-recording methods and the “European Milk / Butter Recording Committee” was created. This was the first core of ICAR. The first attempt to introduce early computerized system was done in the early sixties. Milkability recording standards were then introduced in 1963. Further standards of new traits were approved to harmonize recording in each member country, and in 1968 was introduced the importance of recording devices for milk recording accuracy. In 1970 the European Milk / Butter Recording Committee changed itsname in “International Committee for Recording the Productivity of Milk Analysis” (ICRPMA). In 1972 the first studies and relative application of simplified recording methods were discussed. Later on the ICRPMA enlarge its activities to other types of animal production. In 1982 Beef cattle performance recording was introduced. In early nineties due to many members countries from other continent then Europe and due to inclusion of other traits then milk, a new name was introduced "International Committee for Animal Recording" (ICAR). In 1988 the Interbull became operative as Sub-Committee. All new technological developments are currently sharply changing the traditional methods of milk recording; ICAR activities will change consequently.

Missions of ICAR

One of the ICAR main tasks is to provide information and services to help its member organizations to develop, operate and manage their business. Providing ICAR information and services will promote benefits of recording and evaluation, thereby breeders demand for the services, provided by ICAR member organizations, is consequently increasing. Guidelines and standards ICAR not only facilitate the provision of services, but also help the exchange of information by member organizations both nationally and internationally. Furthermore ICAR is a body through which member organization can work together to achieve shared objectives.

ICAR today

The associated members of ICAR are fifty-seven from forty-five countries. Technical activities are performed through technicians participating to three Sub-Committees, one Task Force and twelve Working Groups. While Sub-Committees are permanent and give a specific service to ICAR members, the working groups are formed for a specific mission and mainly when the purpose is fulfilled the group ceases the activity. Every technician, about one hundred, participate and work voluntarily in the Sub-Committees, Task Force and working groups, to fulfill ICAR objectives.

The oldest and probably the most known Sub-Committees is "Interbull", whose main goal is to develop international comparison for dairy cattle. The other two Sub-Committees are "Meters and Jars", for testing, approving and controlling recording devices, and "Identification", for testing, approving and controlling identification devices.

The task force named "Development Fund" works to expand ICAR activities beyond developed countries. Such activity is very important, not only to enlarge the membership of ICAR but because the introduction of animal production recording helps rural developments in particular areas of developing countries. For this reason ICAR task force often cooperates with international organizations, as FAO, which are active in developing countries.

The ICAR Working Groups are twelve. The "Quality Assurance" working group was established in 1998 to develop standards and guidelines for ensuring proper features of animal recording for each member organizations. The “Lactation Calculation Methods” goal is to identify the accurate estimation procedures for obtaining the lactation yield. The “Animal Data Recording” helps to develop industry standard data model for animal recording and also to establish protocols for farm data management. The “Functional Traits” is a group recently establishes (1998) to stimulate development of functional traits recording. The group began working with five traits but the goal is to give standards for more traits.

“Milk Testing Laboratories” working group serves to improve efficiency and effectiveness of milk testing laboratories. A relevant coordination among all participating laboratories was established to homogenize accuracy level of analysis. The “Milk Recording in Goats” group was established in 1990 to ensure milk recording standards for goats. This group is particularly useful for Mediterranean countries where goat breeding is wide spread. The year after, in 1991, the “Milk Recording in Sheep” was formed to fulfill the same objectives of the goats group, but for sheep. The “Milk Recording of Buffalo” acts like the two previous groups, with the difference that buffaloes are bred in a partially different environment that is mainly Asian and European countries. Dairy buffaloes are bred in a belt that goes from Italy, in the west, to India in the east.

The working group of “Beef Performance”, established in 1982, is one of the oldest and traditionally, one of the more active especially because the subject to cover is very wide. The group acts to facilitate beef recording development. The “Artificial Insemination and Relevant Technologies” is active to improve data collection associated with artificial insemination and with all linked technologies. To stimulate recording of conformation traits in each breeds and species was recently created the “Conformation Recording” working group. A different industry, very important in the Southern hemisphere, but also somewhere in the Northern, is the lamb meat, as well as the animal fiber. Thus in the year 2000 was decided to establish the “Sheep Meat, Fiber and Reproduction Traits Recording” to develop guidelines and standards for meat, fiber and reproduction traits in sheep.

What ICAR provides

ICAR services, programs and activities assist each member in developing a sound basis for rules and legislation relative to animal production industry. The international goal of ICAR services is to promote uniformity of animal recording and genetic evaluation practices. Services mainly consist in furnishing technical information for each single aspect of animal performance recording for each trait of cattle, goats, sheep and buffaloes. ICAR do not deal with poultry and swine industries. Just recently began to consider the possible implication in performance recording of horse breeding. About genetic evaluation, ICAR, through its Sub-Committee Interbull, renders available not only the international performance recording standards, but also the international guidelines of genetic evaluation. ICAR also provides newsletter with on-going research, standards development, technical meetings and everything else related to activities of “ICAR groups”. There have been already five numbers of ICAR technical Series that mainly are proceedings of workshops organized by ICAR to develop animal recording industry. Furthermore ICAR organizes biennial technical meetings that are considered an essential rendezvous for all technicians related to the animal industry activities. In the last meeting held in Bled (Slovenia) in May 2000, more than 400 technicians participated to the meeting. The proceeding of the meetings are also very interesting giving a “state of the art” of animal recording around the world.

Performance recording activities

Both the international agreement of recording practices and the ICAR guidelines represent minimum requirements to ensure a satisfactory degree of uniformity of recording and maximum flexibility in the choice of methods. In other words ICAR tries to homogenize the recording activities methodologies among different countries and breeding types ensuring a minimum level of recording accuracy. Furthermore ICAR wants to inform its members what type of recording methodology is applied for each species in each member country. Each record should be a true indication of the identity, sex, breed, ancestry and date of birth of the recorded animal. Recording organization is, of course, free to decide the particular recording methodologies provided agreement with ICAR rules. The recording organization has a wide range of type of recording among which to choose the one that best fits with the local animal industry conditions.

The used identification device systems must have specific technical requirements ensuring accuracy and trustworthiness of collected data. ICAR manages testing and, eventually, approving of the identification devices. Approval is needed to utilize the device for official recording used in herd book keeping. All ICAR member organizations are obliged to use, for official recording, only approved identification devices. Tests for identification device are conducted following detailed testing procedure in specific laboratory test centers cooperating with ICAR. As for identification devices, also recording device systems must fulfill minimum technical requirements for milk yield measurement and for obtaining a correct milk sampling. All milk yield records must be taken by an approved recording device. Recording devices are tested by one of the ICAR six test centers, specialized in milking devices that are currently working in cooperation with ICAR. The test centers are located in Denmark, France, Germany, Italy, the Netherlands and USA. If the test of the recording devices is positive the milk meter can be approved by the relevant ICAR Sub-Committee and by the ICAR Board, so that the recording device can be used for official performance recording.

The recording standard method adopted by ICAR is the A4, that is, one day of recording on the average every four weeks. Recording can be done at one or more milkings of the day. The standard method observes both milkings of the recording day. Only ICAR approved devices can be used to guarantee correctness of sampling. Milk samples should represent the production of the twenty-four hours milking period. Once the records are obtained for the day milk yield and milk composition, the total lactation yield in milk, fat and protein shall be calculated by using one of the methods described in the ICAR guidelines. Only ICAR approved lactation periods can be considered. Results publication should also be done by an approved method to furnish a true indication of an animal's performance. Only member organizations are allowed to produce and distribute the parentage and genetic merit official records and certificates.

ICAR recording practices rules

ICAR is currently revising the general rules of animal performance recording, to adjust the complete body of rules to the new technological developments and to the modifications expressed and approved in the last years. The complete book of rules is currently available in the ICAR web site. It is divided in several chapters, each one dealing with a different subject of animal performance recording, like methods of identification, parentage recording methods, methods of recording, performance individual certificates, supervision of recording, registration of recording methods, general milk recording rules, recording intervals, symbols used on records, methods of lactation calculation, lactation period, missing results and abnormal intervals.

Besides the general chapters, ICAR rules have more specific chapters as the special recording rules for milk recording for dairy sheep and the rules for milk recording for goats. When, in 1982, ICAR began to deal to other than dairy traits, then recording standards for meat recording, or beef performance recording, were issued. Therefore the beef traits, as other production traits, have specific chapters in the book. Conformation recording of cattle is also contemplated, but at the moment only for black and white cattle. The book also will consider the fertility traits recording rules in cattle as well as the health recording and other non-productive traits recording.

More specific aspects of animal recording are also tackled as data definitions and data transfer. The list of breed for cattle and semen straw identification is the chapter tied to the activities of the working group "Artificial Insemination and Relevant Technologies". "Interbull" instead should manage the chapter relative to methods of genetic evaluations in cattle. Approval of test centers, devices and equipment approval and checking of milk recording equipment belong to the rules assuring a correct working level of the recording devices to utilize for official milk recording as milk meters and jars. Regarding the identification system devices there is a chapter about equipment electronic identification guidelines for transponder injects and attachments.

Technological development

ICAR is recently tackling many technological developments and the most important effort that is currently trying to fulfill is to keep up-to-date standards and services. Electronic recording devices, for instance, are rendering possible to store data in a more efficient way than in the past. Such electronic devices also reduce working-time for every recording activity and increase accuracy of recorded milk yield. In presence of the automatic milking systems cows are milked without the presence of an operator, therefore new technique of data collecting and storing is required. Milk samples collection seems to be the main issue for herds with a milking robot.

With the new electronic identification systems the animals identification procedure is easier and the identification systems are often more durable and resistant. Such systems are quite frequently connected with a farm computer system. In fact farm computer systems connect together advanced technological devices as electronic identification system, electronic milk meter and, whenever present, automatic milking system. The main purposes for a well-equipped farm computer system are: herd management and milk data recording. The already available new computer technologies allow a more efficient data management for data recording, as well as the Internet application for data transferring to and from farms, data management centers, milk laboratories, etc. New devices for milk analysis and conformation recording, that are already in the market, will sharply change the animal recording system. The devices are, for example, new milk analyzers for fat, protein, protein fractions, somatic cells, urea, etc., as well as, ultrasound scanner, photogrammetry and other devices to better get conformation records.

Planned future of ICAR and milk recording

The fast development of animal industry renders uneasy to keep up-date ICAR activities. Nevertheless, all institutional bodies, Board, sub-committees and working groups, are working to reach this goal. Among the many new aspects nowadays present in animal industry there are new traits to consider, both productive and non-productive, as health traits, reproduction traits, conformation traits, fiber, etc. In the future ICAR will need to give more efforts to species, traits and type of recording more specifics to countries potentially new ICAR members, like some developing or South American countries. To reach this goal ICAR organizes, often jointly with FAO and other relevant organizations, workshops related to specific animal production recording problems in definite environments.

Nowadays ICAR delivers to its member organizations interesting information about current animal industry and recording systems. Annual inquires of milk and beef performance recording are produced. Every two years there is the ICAR General Assembly; the proceedings of the technical meetings, held during the General Assembly, are issued having title “Performance Recording of Animals”. To achieve delivering of important information relative to development of animal production and recording

ICAR also sponsors books belonging to a technical series. At the moment five books have been issued: “International workshop on animal recording for smallholders in developing countries”, “Cattle identification and milk recording in central and eastern European countries”, “Developing breeding strategies for lower input animal production environment”, “Animal recording for improved breeding and management strategies for buffaloes” and “The role of the state and breeders’ organization in animal identification and recording in central and eastern Europe”. Another book is going to be published in few months, regarding “Automatic milking systems and their impact on animal recording”. Another interesting publication is the “Interbull Bulletin“ and above all the “Interbull” meetings proceedings. ICAR plans to increase the information activity. The ICAR Web site (*www.icar.org*) is already active. Specific space for each sub-committees, task force and working groups will be organized. At the moment only some groups, on a pilot basis, are available. Most of the publications, among which those books belonging to Technical Series, are available on-line. Technical information about approved recording and identification devices are also available on line, to inform world-wide which devices can be used to perform official records. Among the increased amount of information that will be delivered in the future there is the new edition of the Newsletter, which will be issued three times per year. The Newsletter contains information on recent activities, on-going research, performance recording standards development, technical and scientific meetings, vacancy announcements, etc.

Besides the improvement of information delivery ICAR plans to increase other types of services. The massive development of technology relative to animal production recording promotes also the firm request to reduce recording costs. Farmers wish to acquire more and more immediate information from data management centers, and from recording organizations. ICAR will give new and different service to its members also for the model of organizations is sharply changing: different organizations, often private companies, became recently members, as well as organizations from countries that are new for the “ICAR world”. The benefits of recording requested by ICAR member are going beyond genetic progress, in fact improvement in herd management is often considered, by breeders, the biggest and most immediate benefit of herd recording.

The main ICAR mission remains to assist members to develop a sound basis for rules and legislation relative to animal production industry. Working together and sharing experiences with technicians coming from worldwide animal breeding conditions is also a very important benefit of each expert participating to ICAR activities.

Technical developments in machine milking and their application in Slovak conditions

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Introduction

No other machine in livestock farming has such a close biological association as the milking machine (1). In this context, the milking machine when in use has specific requirements which can be characterised as follows:

- it must complete its task in a given time without undue delay;
- it can milk the cow only if she actively co-operates, but not before let-down is induced; and
- it is instrumental in extracting and transporting a human foodstuff which can be quickly contaminated by environmental factors.

The above characteristics have always influenced the development of milking machines. Therefore their designs have corresponding features. Their development is endless because the conditions under which milking machines are used are continually changing. The main factors involved are:

- genetic improvement in the biological material;
- increasingly strict requirements with regard to the quality of liquid milk and milk products;
- the desire for a better standard of living for the breeder;
- new technical developments in milking equipment generally, e.g. in materials, hardware, software, etc.

Technical developments

The development of milking machines is, to all intents and purposes, only a little over 100 years old (1). Most of the current technology was developed in the post-war period, although there are elements which were developed in the first half of the 20th century and are still used with certain modifications today, e.g. two-chamber teat cups, and milking parlours. It is said that all dairy cows in larger herds were milked by machine after 1950. The situation was similar in Slovakia, too. After the agricultural co-operatives were established and the former large estates were nationalised, larger herds were gradually created in Slovakia (9). In the fifties, cow sheds were built for approximately 100 dairy cows. There were usually 2 or more on any one farm. Later, mainly in the seventies, specialized farms were built already incorporating modern milking parlours. Unfortunately, or thankfully, the phases of building dairy cow farms were always undertaken after political events. Enterprising Western suppliers were able to take advantage of this and they not only supplied the latest equipment but took the liberty of performing many “prototype tests on a grand scale”. So one can say that the Slovak herds of dairy cows, especially those which were always among the first to respond to innovation, never fell behind in the application of the latest technology, particularly milking technology.

As with other equipment, developments in milking technology occurred in definite cycles. Always there arose a totally new idea which did not basically change during the next period. It was only technically and materially improved. Some components or their principles which were found out very long ago survive to the present day. Of course, there have always been attempts to bring about change in the afore-mentioned basic principles. For example, the two-chamber teat cup can be used as an illustration. Its beginning dates back to the end of 19th century. Attempts to introduce the pulsationless or hydraulic milking, three-phase pulsation, did not catch on. So today we can still see basically the same two-chamber teat cup. However, it has changed considerably according to the needs of cow milkability and available materials. Similar cycles can also be observed in milking parlour development, but within a shorter time period. It is well known that the first milking parlours had already appeared between the wars. However, their wider use was not apparent before the increase in the capacity of farms. Even now, it is not known whether the invention of milking parlours accelerated the development of loose housing of dairy cows or if the need for natural free movement of animals led the designers to the idea of milking outside the place of housing.

The adoption of milking parlours was very much influenced by the need to decrease the quantity of work involved in milking. The number of cows milked per hour per milker was at one time one of the most important parameters according to which milking machines, mainly milking parlours, were sold. The quality of milking parlours used in Slovakia was also evaluated in a similar way (6). However, there was a difference between the performance claimed by the manufacturers and the real productivity of labour. In addition to this shortcoming, there was the fact that they evaluated the number of cows milked and not the quantity and quality of milk in relation to the cost of the investment. Concentrating on the number of cows milked per hour also deprives the cows of the opportunity of satisfying their physiological needs (11).

The variety of milking parlour types was also influenced by this pursuit of increased number of cows milked per hour. At the beginning of milking parlour use, there were abreast and tandem milking parlours, later on herring-bone, and then rotary milking parlours. All of these types are, with various modifications, still used today. We, in Slovakia, as well as people elsewhere, yielded to the trends in fashion. We tried everything. In the past, and also at present, the herring-bone milking parlours were the most widespread ones among breeders because of their simplicity and particularly their operational reliability. At the turn of the sixties and seventies, they were already being imported. Later on, the former Czechoslovakia also manufactured rotary milking parlours. Mainly at this time, it was evident that experimentation was taking place at the expense of our farms. The suppliers of the technology used various modes of drive for rotating the milking parlour platform. The aggressive environment, the shortcomings in design, but mainly the poorly-organised service and the impossibility of a substitute milking system, pushed the rotary milking parlours aside for a certain period. The numbers of dairy cows on Slovak farms determine the type of milking system, parlours being the only possible alternative at present. The most common herd size is 300-800 dairy cows in one location (3).

The biggest developments in milking technology were observed following intensification of research into the following spheres:

- hygiene in the milking process;
- physiology of milk let-down; and
- on-line measurements of parameters of the milking equipment (1).

These spheres of interest have influenced the development of milking technology up until now, and the call for new research knowledge in them still persists. First of all, knowledge on the “co-operation” of the dairy cow at milk removal, which we call let-down, is in constant demand. Therefore the organisers of this conference decided to pay great attention to this problem within the sessions.

The research institutes became involved in the development of milking equipment as late as the post-war period. Thanks to the very quick construction of large-scale farms, some original pieces of knowledge were gained which influenced the development of milking technology not only in the former Czechoslovakia but also abroad.

A very important part of the development process for milking equipment in the world was aimed at determining the optimal parameters for pulsation and vaccuum level. At the outset, and for many years thereafter, the rates in general use had been determined empirically. Therefore it was said in scientific circles that they must be checked in relation to the milkability of cows which are being dealt with at a given time (5). Ideas were also applied aimed at regulating the parameters of pulsation and vaccuum in the course of milking according to the speed of milk release. Regulation was introduced at certain critical values, and there were attempts to change the parameters continuously. The milking equipment used at present enables various changes of the pulsation parameters. There is imported equipment in Slovakia, too, which offers the breeder the possibility of setting various lengths of suction phase. It is not possible to use it in practice because of the variability of milkability parameters in individual cows. The systems of udder stimulation by accelerated pulsation at the beginning of milking partially succeeded, although this technical solution rather extends the time of milking compared with adequate manual massage (11). At first it was believed, and it was also incorporated in milking equipment, that the level of vacuum should be set according to the speed of milking. It was expected that the increased level of vacuum would provide quicker milking. On the other hand, towards the end of milking, when milk flow speed decreased, a decrease in the vacuum level was expected to reduce the amount of stripping out required (8). The so-called „duovac“ was used in our country, too. All the systems mentioned were aimed at changing the nominal value of the vacuum. However, of greatest importance in the search for the optimum method of vacuum control at milking was the large amount of research aimed at the possibilities of greater stabilization of vacuum in the under-teat chamber of the teat cup (7; 12). The principal changes in the design of milking equipment were done on the basis of these results. The parameters of milk pipes (diameters and position), size and shape of collectors and of teat cups, etc., were adjusted. These features also appeared on the Slovak market. Fortunately, simplicity won here again. Two basic constructional adjustments proved to be the most effective for achieving stability of the operating vacuum. The first was the location of milk pipes below the level of the milking stand, and the second was adequate air inlet into the milking cluster. It is necessary also to mention the enlargement of the inner size of milking clusters (short milk tubes and collector) which was conditioned by the increasing amount of milk and milk flow.

Slovak conditions

The parameters of milking equipment should take into account the milkability of the cows which are bred in a given country at a given time. Milkability is closely connected with the genetic make-up of dairy cows. In Slovakia, there are three basic breeds at present: the Slovak Pied (Simmental), Slovak Pinzgau and Holstein and their crosses. Changes in breed structure were influenced by fashion and political changes in Slovakia as well as by the import of milking equipment. To improve efficiency of milk production and milkability, the Danish red, Ayrshire, Lowland Black and black or red Holstein breeds were successivly used in our country. A significant change in the proportion of Holstein cows has occurred over the last 10 years (2). In 1989 there were in Slovakia 121 000 dairy cows of the Slovak Pied breed, 40 000 of the Pinzgau breed and 26 000 Holstein cows. The number of the Slovak Pied breed has decreased to 36 000 cows and of the Pinzgau breed to 9 000 cows at present. There are 118 000 Holstein cows together with crosses with a high proportion of Holstein blood at present. The efficiency and milkability of cows rose in this way. However, the demands for quality of milking technology also rose.

The importance of milkability also becomes evident when using automatic cut-off milking. Automatic indicators together with automatic milking cluster take-off became a common part of the milking equipment on modern farms. However, our measurements show the different responses of the various breeds (5 - see table1). Cows of the Holstein Friesian breed and their crosses with the Slovak Pied (HF more than 50 %) have low machine strippings. There were only small numbers of cows which had greater machine stripping than 0.5 kg, measured at a critical rate of flow of 0.5 kg.min^{-1}. Quite high values were measured in the Slovak Pied and Pinzdau dairy cows. After automatic removal of the teat cup at a critical value of 0.2 kg.min^{-1}, the control hand stripping was low in the dairy breeds as well as in the Slovak Pied breed. There were problems with automatic end of milking in cows of the Slovak Pinzgau breed.

Table1. Evaluation of automatic end of milking in cows of various breeds.

	Machine stripping		Control hand stripping	
Breed	Average	Percent of herd over 0.5 kg	Average	Percent of herd over 0.2 kg
Holstein	0.17	5.0	0.08	17.5
Crosses over 50 % HF	0.21	6.6	0.07	7.4
Slovak Pied (Simmental)	0.41	23.3	0.13	11.2
Slovak Pinzgau	0.30	16.3	0.28	35.0

The effect of machine milking on eversion of the teat duct was evaluated in the breeds, too. Holstein cows and their crosses had several times greater eversions of the teat duct than the cows of the Slovak Pied breed (Simmental).

The pressure for innovation in milking technology in Slovakia, besides milkability improvement, is caused mainly by demands for milk quality. During the last 15 years the criteria for milk quality evaluation have changed several times. First, the outdated evaluation criteria (Resasurin test) were changed, and then the criteria used in EU countries were gradually made stricter. Somatic cell counts and total bacterial counts are at present the main criteria used for milk quality evaluation (10). The standards are 300 000 SCC and 50 000 BC for Q class, and 400 000 SCC and 100 000 BC for 1st class. In addition, the milk must not contain inhibitory substances. In the year 2000, milk of Q and 1st quality was produced in 92 % of herds. In herds with milking parlours and newer pipeline milking equipment, there are in use devices for automatical control of cleaning and disinfecting which positively influence milk quality.

During the last 10 years, quite a lot of modernisation has occurred on Slovak dairy farms. In 1989, only 12 % of cows were kept in loose housing and milked in milking parlours (3). At present, this figure is approximately 50 % .

After 1989, there were 18 suppliers of various makes and types of milking equipment on the Slovak market. Although their number decreased and the existence of those that remained stabilised, the previous large number of suppliers of the technology still affects the quality of maintenance of the milking equipment and consequently the quality of milk as well. We experienced a similar situation after 1968 (4). However, the market did not stabilise at that time. Equipment was left without service, and the milking technology at that time was not so reliable. A process of unification of the technology followed. On almost all farms, milking technology emanating from the former Czechoslovakia (Agrostroj Pelhrimov) was used until 1989. Servicing was performed by machine and tractor stations which created a common network of repair centres with good measuring equipment to adjust the technical set-up, and they were equipped to renovate parts. Many of the present private service companies arose from them. The only disadvantage of the compact system mentioned was the absence of competition. However, that applied to all facets of life.

At present, the level of service with respect to milking equipment depends not only on the quality of the product itself but also to a large extent on the abilities of the in-country dealer and service companies. Most of them keep to the ISO standards at installation and technical measurements are carried out using accurate equipment.

Near future

The development of milking technology has passed through a not very long but very intensive period. The latest milking technology beside automatic milking systems (AMS) has come into use on our dairy farms. Up until now, AMS have not been adopted either in our country or in the neighbouring countries with similar conditions (the Czech Republic and Hungary). Their use in our countries is limited by a number of factors: the price of milk, the price of labour and the size of farms. However, there is a possibility of research verification of AMS and other technical innovations in milking equipment. The research capacity is still present in all three countries.

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The Dutch Quality System for milking machine maintenance

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Without doubt, the milking machine is one of the most intensively used machines on a dairy farm. A well functioning milking machine is a prerequisite for good udder health and excellent milk quality. As a consequence, each milking system should be serviced and checked at least once a year.

Summary

In the eighties and nineties ISO standards were developed for milking machines. In the Netherlands these standards were implemented in a quality system for the maintenance of milking machines and the accuracy check on milk meters and jars. These checks are conducted by certified technicians of the milking machine dealers. An independent organisation KOM, established as result of an agreement between the National Farmers Union, Milking machine manufacturers union and the National Breeding and milk recording organisation, is responsible for the quality control. The system guarantees the farmer that the maintenance of his milking machine and the necessary accuracy checks of milk meters and jars are performed well against minimal costs. The system has been incorporated in the quality system for dairy producers by the Dutch dairy industry.

Key words: *Quality system, maintenance, milking machines, milk meters, recorder jars, accuracy, calibration.*

Introduction

With the introduction of milking parlours in the early seventies, it became clear that milking machines need regular testing and maintenance for good milking. Testing was done by advisors from the dairy industry, animal health services or governmental extension services on request of the farmer or when problems with milk quality or udder health occurred on the farm.

In the case of malfunctioning, a technician of the milking machine dealer was asked to perform the necessary repairs, and the milking machine was checked again by the dairy advisor or extension officer.

In the early eighties the Dutch farmers union, governmental extension service and the milking machine manufacturers developed a national maintenance system. The basic idea behind this system was that all regular testing and maintenance should be integrated and performed by the technicians employed by dealers of the manufacturers to reduce the costs for the farmer and to improve the quality of maintenance. The national extension service became responsible for the training and evaluation of the technicians to guarantee their quality of work. The testing method was described in a national guideline for technicians. From that time on, all manufacturers used the same testing method, an uniform Maintenance and Advice Report (MAR) and farmers paid a fixed price for the yearly test. At the end of the eighties over 80% of the Dutch farmers participated in this maintenance system. Today about 100% of the farmers participate in the system.

International standards

In the seventies and early eighties manufacturers and experts from various countries, prepared the first international standards for milking machines which were more or less based on the Dutch system. The most recent ISO standards are from 1996. ISO 3918 describes the vocabulary, ISO 5707 describes the standards for construction and performance of milking machines and ISO 6690 deals with the testing methods. At this moment a new revision is considered. The standards apply to both new installations, and machines in use, to check the performance of operation periodically. In the same time ICAR developed guide lines for the approval and the use of milk meters and jars for milk recording purposes (ICAR, 1995).

Quality system

In the mid nineties the national extension service was reorganised and had to end these activities. Together with the Dutch farmers union and the Dutch organisation of milking machine manufacturers, plans were developed to start a quality system for milking machine maintenance (KOM). This was a logical step in the further development of the preventive maintenance system. The quality system was expanded with certification of the technicians, calibration of test equipment and by special courses for machine on time testing. The ultimate goal of course was to guarantee the farmer that the milking machine is working properly, without having a negative effect on milk quality or udder health. Another prerequisite was that the KOM system should fit in to the total quality management system for dairy farms (KKM, 1998) as developed by the Dutch dairy industry and the national farmers union. The KKM system is permissive to the national and EU legislation aspects, and obligatory for all Dutch dairy farmers since 2000. Farmers who want to deliver milk to one of the dairies, have to meet the requirements of the six modules of KKM. These modules are Medicines, Animal health and welfare, Foodstuff and water, Milking and milk storage, Cleaning and disinfection and Environment and waste products. The module Milking specifies that the milking machine should be tested yearly by a KOM-certified technician.

Institution KOM

In 1998 the project KOM was transformed from a project into an independent institution, because quality systems should be independent from the parties involved. The KOM organisation is responsible for the entire quality system. The Dutch breeding and milk recording organisation decided to incorporate the routine accuracy check of electronic milk meters and recorder jars into the KOM responsibilities. This check is necessary for meters used for the official milk recording system as stated by the ICAR rules. The technicians from the manufacturers combine the yearly service on the milking machine and the routine tests on the functioning and accuracy of electronic milk meters and jars. The reason to do so was to reduce the costs for the farmer by combining control systems and maintenance.

The KOM quality system

KOM has developed several activities to control the quality system. These activities and the procedures are recorded in the KOM guide lines (KOM, 1999):

- Registration and evaluation of all test reports made by the technicians including reports on the accuracy of milk meters and jars;
- Yearly control and calibration of the test equipment used by technicians;
- Performing random checks on the ‘quality of work’ of the technician including milk meters and jars;
- Certification of (new) technicians;
- Development of standard reports (MAR) and tests (based on ISO);
- Studies on the relation between milking machines and milk quality;
- Development of guide lines for new areas, like automatic milking systems.

Registration of all test reports

During the yearly check on the milking machine, all components are checked and tested. If necessary, repairs are made or devices like pulsators are adjusted to the right value. Vacuum level, reserve capacity, air inlet, air consumption, air leakage and pulsation curves, are measured by using test equipment like airflow meters, vacuum testers and pulsation testers. The test results are recorded in a standard test report, which is equal for all manufacturers. The technician can also write down his comments. A copy of the report is handed over to the farmer, another copy is sent to KOM. The reports are registered per technician and evaluated at random using an evaluation protocol. The evaluation report is discussed with each technician once a year.

Control and calibration of the test equipment in use

At Waiboerhoeve experimental station, the research facility of the Institute for Animal Husbandry, a training and test centre was established. This centre has a special test installation suited to test and calibrate vacuum gauges, air flow meters and pulsator test devices. The test installation (Figure 1) has two test rigs, one with a high pipe line (stanchion barn type) and one with a low pipe line (milking parlour type), both with a vacuum pump. The vacuum pumps can be connected such that the vacuum pump capacity can be varied from 1 000 to 2 500 litres per minute. The low pipe line is also equipped with several types of milk meters to perform the routine tests for milk meters.

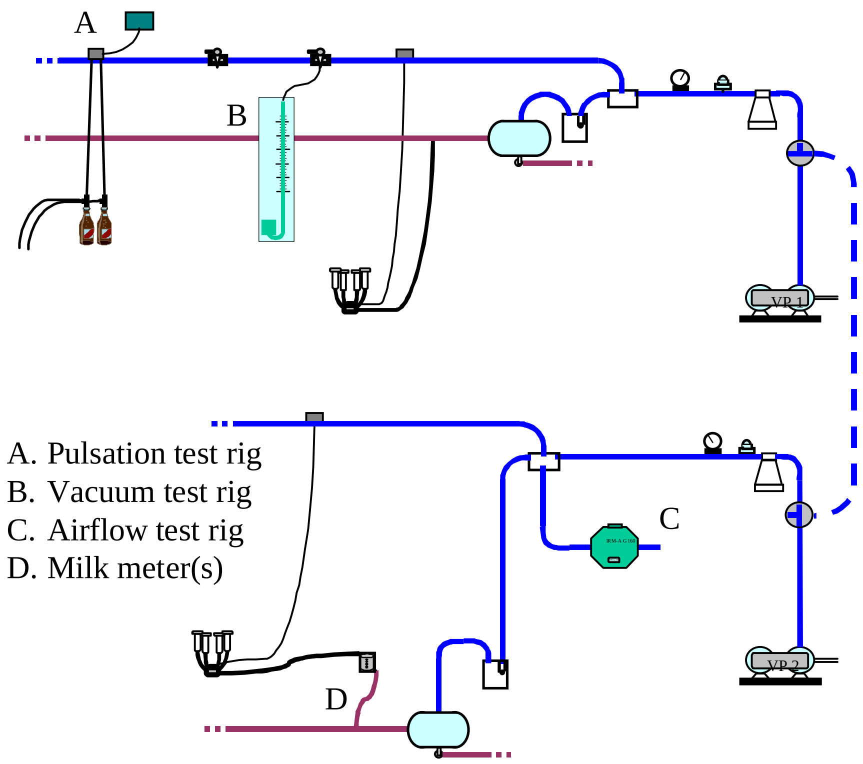

Figure 1. Scheme of the test installation for testing equipment.

The test rig is equipped with the following components: a vacuum regulator, an IRM-A G160 gas meter (Instromet), a mercury vacuum meter, a digital vacuum meter (Digitron), an electronic relay pulsator controlled by an electronic pulsation controller with variable pulsation ratios and pulsation rates, connection points for vacuum gauges and valves to (dis)connect vacuum lines. The IRM-A G160 gas meter has a maximum capacity of 4166 l / min to calibrate the air flow meters. Air flow is measured by reading the number of pulses produced by the meter when air is passing the meter. The meter is connected to a PC system with an airflow control program (AFC) to control the flow settings and the test program.

The pulsation controller has simultaneous, alternating and cascade features. Pulsation rates and ratios can be adjusted continuously. To simulate the air consumption of a milking cluster during milking, two half litre bottles are used for both channels. In this way, results will not differ due to the temperature and the ageing of liners.

The centre has also equipment to test temperature meters, balances and other equipment. The milking parlour side is equipped with almost every approved electronic milk meters available. They are used for training courses, to explain and practise the routine test for milk meters.

Random checks

Since 1998 the KOM institution also performs random checks on farms to evaluate the quality of work by the technicians, both for milking machine maintenance and for the routine test of milk meters. Each technician will get at least one random check per year by one of the KOM-officers. This re-test is carried out at soon as possible after the technician has done the yearly test. It consists of a check on vacuum level, reserve capacity, regulator leakage, the pulsation system partially, cleaning temperature and the presence of the test report. If necessary the whole test will be performed. If the technician is not doing a good job, KOM may decide to withdraw his certificate, so that he is not allowed to do any testing anymore.

Certification of the technicians

According to the requirements of KOM and KKM, all technicians should be well qualified. Because there is no general education for this type of work, KOM together with the Research Institute for Animal Husbandry, has set up a special education program for milking machine technicians. The course consists of several modules varying from udder physiology, milking routines, milk quality, Mastitis, machine milking and testing, milk meter routine testing to dialogue techniques with the farmer. For the already more skilled technicians a modified course was developed. Over 350 technicians joined these courses and approximately 85% succeeded and obtained a certificate, so they are allowed to test milking machines within the KOM system. A special course was designed for those technicians who do regular maintenance of automatic milking systems.

Other activities

Due to the growing number of farmers using an automatic milking system, there was a need for standards for these machines. So on request of KOM, a new testing method was developed for automatic milking systems by the Research Institute for Animal Husbandry. This system is largely based on the current ISO standards for milking machines, but completed with some special requirements for the reserve capacity and air inlet for teat cups. Also a new test report for AM-systems was developed.

Results of evaluation and test equipment calibration

One of the first activities of the KOM –project was to evaluate the technicians by reviewing an at random selection of ten maintenance and advice reports for each technician. The reports were evaluated on several aspects, like completeness of the report, measurements, interpretations and remarks and advises. A final score from 0 to 10 was given to the technician. Figure 2 shows the results of this evaluation from 1995 to 1997. The average results improved clearly over these years. In 1998 it was decided to change the way of evaluation. Now the MAR reports have to fulfil the KOM requirements and the evaluation is incorporated into the random check system.

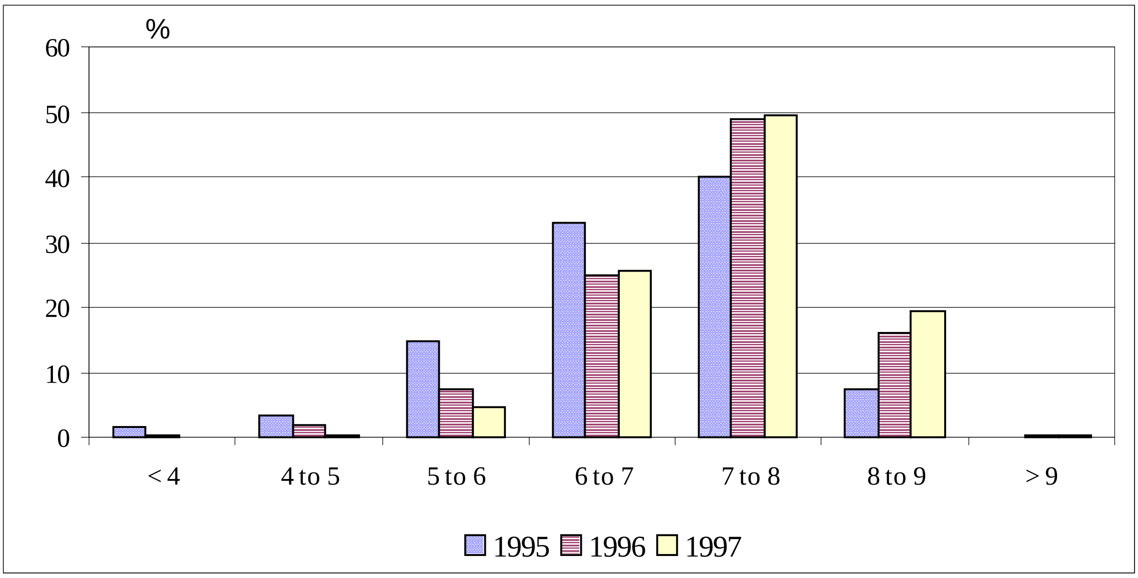

Figure 2. Frequency distribution of the rating of technicians (n=205).

Accuracy requirements

Technicians use different types of test instruments. Bourdon gauges and digital vacuum meters are used to check the vacuum level. Because of health risks, it is forbidden to use mercury vacuum meters when testing on a farm. Vacuum meters shall have an accuracy of at least ± 0.6 kPa and a repeatability of at least 0.3 kPa (ISO 6690). Vacuum gauges of class I usually will meet these requirements. Air flow meters shall have a maximum error of less than 5% of the measured value and a repeatability of 1% of the measured value or 1 l/min, whichever is the greater over a vacuum range of 30 to 60 kPa and for levels of atmospheric pressure from 80 to 105 kPa (ISO 6690). Different types of air flow meters are used by technicians, like air flow meters with a metering tube and a floating device, orifice air flow meters and electronic air flow devices. Pulsation testers including connection tubes shall have an accuracy of 1 pulse/min for measuring the pulsation rate and an accuracy of 1% (10 ms) for measuring the pulsation phases and pulsation ratio.

Balances which are used for milk meter tests shall have an accuracy of 20 grams. Angle measurement instruments are used to check the position of recorder jars. Recorder jars are calibrated with water to ensure an accurate reading, but this procedure is quite time consuming. After calibration with water the position of the recorder jar is measured with the angle measurement instrument and the data are stored. Next time the routine test will be done with this instrument and the same values should be measured again. The instrument shall have an accuracy of 0.1 degrees.

Results

The test results are shown in figure 3. In the year 2000 85% of the vacuum meters, air flow meters and pulsation testers was approved immediately, compared to 83% according to De Koning (1994). About 14% was approved after adjustment and 1% was rejected. For the other test devices like balances and temperature meters, the results were very well within the acceptable limits. The angle measurement instruments however were tested for the first time and 34% needed adjustments to get approved. This was mainly caused by improper calibration methods by the technicians concerned.

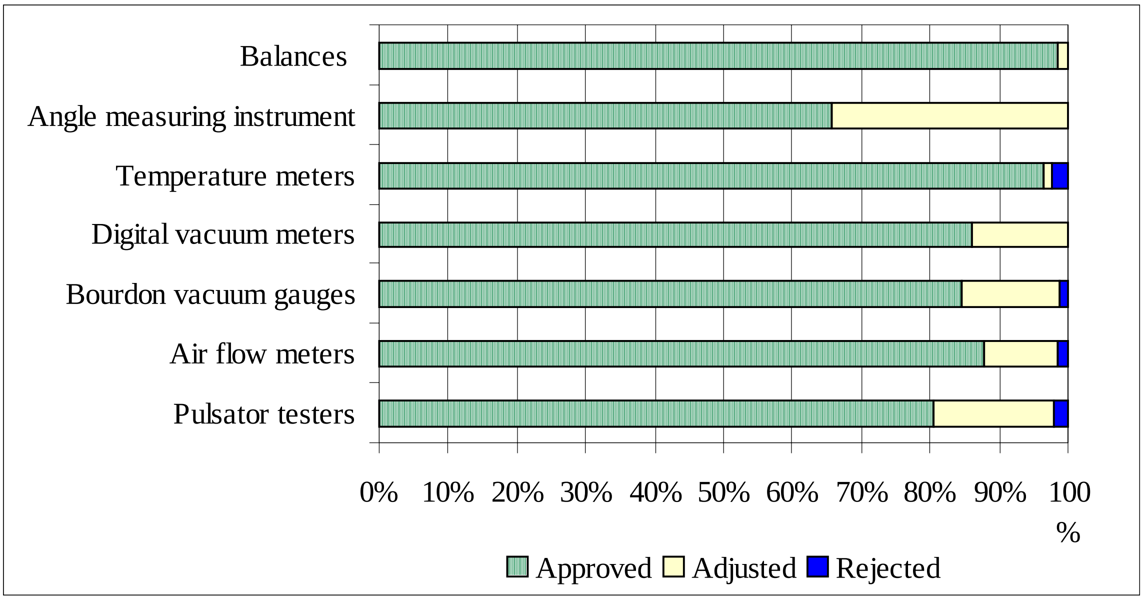

Figure 3. Results of the calibration test in 2000 for different devices.

The results clearly show that calibration is necessary to guarantee accurate testing in practice to prevent wrong interpretations on the functioning of milking machines and or milk meter devices. Therefore it was decided to calibrate the test equipment of the technicians at least once a year. Each approved device will get an approval sticker of KOM, so farmers can see whether the technician is using calibrated equipment.

Random checks

Table 1 presents the results for the random checks performed by KOM in 2000. Almost 13% of the random checks resulted in a remark concerning one or more aspects. The majority of the remarks was on the data entry up on the test report and the maintenance. In a few cases the technician was ordered to repair some things, like pulsation system or repair of air leakage's. About 18% of the farms had a deviation on the accuracy of the recorder jars. In 2001 extra attention will be paid to this aspect.

Table 1. The number of random checks (farms and meters) in 2000.

	Milking parlours	Milk meters		Recorder Jars	
		Farms	Meters	Farms	Meters
Total number	410	162	1 590	56	497
Number with comments[1)]	53	20	35	10	33
% deviation with comments	12.9%	12.3%	2.2%	17.8%	6.6%

[1)]There has been a comment due to deviation in the test results, or over the procedure used, or on the report itself.

Future developments

The fast development and introduction of portable PC's, e-mail services and Internet offer interesting perspectives to improve the quality system. A big step further can be made by improving the speed, for example by sending the MAR reports electronically to KOM. Another interesting aspect is the expected integration of test equipment, so one device is able to measure the different functions and to complete the data into a digital MAR report. New data could be checked for mistakes but could also be compared automatically with the historical data.

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Physiology of milk let-down during machine milking

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Summary

The release of oxytocin and occurrence of milk ejection in response to teat stimulation is crucial for fast and complete milk removal. Milk ejection and removal can be disturbed at a central or peripheral level. The central disturbance represents the lack or insufficient ejection of the alveolar milk into the cistern due to inhibited oxytocin release from pituitary. Possible effect of endogenous opioids in the oxytocin release is discussed. However their active role in the oxytocin inhibition was not confirmed. The central inhibition of oxytocin release has been often observed in dairy practice during milking of primiparous cows after parturition, suckling by alien calf, during milking after calf removal, milking of cows in the presence of own calf, relocation and milking in an unknown milking place. If sufficient oxytocin can not induce the transfer of milk from alveoli to cistern peripheral mechanisms are involved. Peripheral mechanisms are mainly related to increased activation of sympathetic nervous system.

Key words: *Dairy cows, milk removal, oxytocin, catecholamines.*

Introduction

Milking techniques, routine and cow significantly affect the milking process of dairy cows. During the last years the techniques developed significantly. Techniques reliability improved and many of routines were partial or fully automated. The effect of people on milking process is minimised. So much more efforts must be put on the relationships between cow and machine as it was before. The high technical progress has to easily adapt the machine to the needs of the cow physiology related to milk ejection. From animal science and dairy practice requirements it is clear that milk yield, time of milking and udder health are the most important parameters of good relationships between machine and cow. The aim of this paper is to discuss the importance of milk ejection for fast and complete milk removal from the view of the central and peripheral regulation.

Milk ejection reflex

Availability of milk before milking is an explanation why the milk ejection reflex is important for fast and complete milk removal. Before milking about 80% of total milk in the udder is present in alveoli and small ducts (Pfeilsticker *et al.,* 1996). Milk from this part is not available for milking and milk ejection must occur.

The milk ejection reflex is an innate reflex that is not under conscious control of the animal and occurs in response to tactile stimulation of the udder. The milk ejection reflex arc consists of two components: a neural and a hormonal (Crowley & Armstrong, 1992). The neural component is responsible to transfer the impulse from the udder to brain resulting in the oxytocin release into the blood circulation - the endocrine way. Oxytocin induces contraction of myoepithelial cells and thus increases the transfer of milk from the alveoli to the cistern resulting in a rapid increase of pressure within the cistern (Mayer *et al.*, 1991). It is necessary to emphasise that the release of oxytocin not only in response to prestimulation but also throughout whole milking is necessary for fast and complete milk removal (Bruckmaier *et al.*, 1994). Therefore, synchrony between milk ejection and milk removal has to be considered in good milking management.

The importance of oxytocin in the milk ejection is based on the threshold theory that the release of oxytocin must succeed a certain concentration (about 3-5 ng / l is efficient) to induce full milk ejection (Schams *et al.*, 1984; Bruckmaier *et al.,* 1994). It means there is no correlation between the oxytocin concentration in blood and milk flow if milk ejection occurred during normal milking.

Modulation of milk ejection

Within the same milking environment milk removal can be influenced at a central (brain) or peripheral (udder) level (Goodman & Grosvenor, 1983). Under such conditions milk from the alveoli can not be completely removed causing economical loss and increased incidence of mastitis.

Oxytocin release is influenced by different kinds of tactile stimulation and environmental conditions at milk removal. Despite threshold level, the variation of oxytocin release could be an important information. It is clear that central regulatory mechanisms are involved but their relation to milk flow pattern from teat has to be answered. When treatments are compared the higher flow rate is always concomitant or induced by higher oxytocin levels (Mayer *et al.,* 1984; Svennersten *et al.*, 1995). It seems to be an important question if the higher oxytocin release represents the readiness and willingness of cows to be milked. Recently it was found that cows milked in the automatic system are less nervous that in milking parlour (Hopster *et al.,* 2000).

In the dairy practice disturbed oxytocin release was found during milk removal in primiparous cows immediately after parturition (Bruckmaier *et al.*, 1992), during milking (Bruckmaier *et al.*, 1993) or suckling (Tancin *et al.*, 2001a) in unfamiliar surroundings, during milking after calf removal (Tancin *et al.*, 1995), during suckling by alien (Silveira *et al*., 1993) or first suckling of cows conditioned only to machine milking (Kraetzl *et al*., 2001). Also under the conditions of more often milking per day the milk flow disturbances are increased due to reduced the amount of milk in udder. There fore the duration of pre-milking preparation should be adapted to the expected milk yield at each individual procedures (Bruckmaier & Hilger, 2001).

Thus measuring of the oxytocin concentration together with other hormones indicating stress response are important indicators of the internal reaction of organism to the milking environment.

Possible central mechanism - opioid system may have a physiological role in controlling of the oxytocin release. The presence of opioid receptors and opioids in the bovine hypothalamus and neurohypophysis (Pesce *et al.* 1987) supports the assumption that endogenous opioids could influence oxytocin secretion during milking in dairy cows as it was observed in rats. The importance of opioid and sympathetic systems in the central inhibition of oxytocin release is still not solved in dairy cows (Wellnitz *et al*., 1997; Kraetzl, *et al*., 2001). We have recently proved that the endogenous opioid system is an effective modulator of the oxytocin release during milking of dairy cows (Tancin *et al.*, 2000). When oxytocin is suppressed by stressor the opioid antagonist naloxone was not able to abolish this inhibition (Wellnitz *et al.*, 1997, Kraetzl *et al.*, 2001). All mentioned factors influenced oxytocin release but the mechanisms seem to be different. Possibly the signal from udder does not reach the CNS or oxytocin is actively inhibited within the CNS (Tancin *et al.*, 2001b).

Peripheral mechanisms of milk ejection

Another important mechanism modulating the milk removal after occurrence of milk ejection is the *symapathomedullary nervous system* in the mammary gland.

The activity of smooth muscles in the udder is influenced by catecholamines released from sympathetic nerve terminals or released form adrenal medulla. The presence of alpha and beta receptors in smooth muscles of the teat was detected by Peeters *et al.* (1977) and in tissue around the gland cistern where large milk ducts are numerous by Hammon *et al.*, (1994). Almost no receptors were found in the mammary parenchyma (Hammon *et al*., 1994). The administration of alpha - adrenergic agonist reduced the milk yield and maximum milk flow, but the secretion of oxytocin was not reduced. Administration of beta-adrenergic agonist only caused teat relaxation resulting in the higher milk flow during milking (Bruckmaier *et al.*, 1991). But the exact mechanism of increased milk flow after beta-receptor stimulation it is still unclear. Is it the relaxation of teat sphincter or better release and flow of milk from alveoli throughout the mammary ducts?

The autonomic reflex plays an important role in the regulation of milk transfer within mammary gland especially related to conditioning of ejection reflex like stereotype of milking routine. There is no cleat evidence for conditioning of oxytocin release before teat stimulation.

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The effects of machine milking on teat condition

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Summary

The teat is an important barrier against invasion of mastitis pathogens into the udder. Tissue changes affecting teat opening allow penetration of bacteria into the udder.

Calf suckling is nature's way of cow milking which induces little teat swelling or teat end callosity. This should be our reference. Milking machine techniques can influence (short and long-term) teat condition and milk-flow-profiles independently.

Short-term effect of milking on teats is swelling, which can be measured by ultrasound. Long-term effects are changes in teat-end tissue, resulting in a callous ring around the teat orifice. Teat-end callosity can be classified visually, e.g. by the PV-classification system. With some machine settings, cows differ in response. For example longer suction phase of the pulsator will in general decrease machine-on time, but in a substantial part of the cows will show an increase. Different liners can cause different degrees of teat swelling but not always differences in milk flow profiles.

Automated milking systems allow for more frequent milking, resulting in increased machine-on time per day and less recovery time. This development and the different reactions of cows to machine settings, cause a need for milking adapted to individual cow characteristics.

Key words: *Teat condition, machine milking, teat end callosity, teat swelling, mastitis.*

Introduction

The mechanical forces during machine milking will result in changes in teat end tissue. Vacuum opens the teat canal and milk flows out but also blood and lymph are drawn to the teat end. The collapsing liner exerts a mechanical force on the teat end, causing the teat canal closure and transport of blood and lymph back to the udder (Hamann and Østeras, 1994). Teat tissue changes by machine milking can be seen as teat swelling (teat end, base or top), teat flattening, colour changes, openness of the teat orifice, vascular damage (haemorrhages) and teat end callosity (Hamann, 1987). Milking removes keratin out of the teat canal, which seems to be essential to the teat canal defence (Lacy-Hulbert & Woolford, 2000).

Bacteria that cause clinical mastitis must enter the udder through the teat. Therefore, the teat is an important barrier against invasion of mastitis pathogens into the udder. Tissue changes affecting teat opening allow penetration of bacteria into the udder. Changes in teat skin can also enhance bacterial colonisation on the teat. Recent developments like more frequent milking, cows with higher yields and automatic milking may increase the load exerted on teat tissue. This paper focusses on the effects of machine milking on teat swelling and teat end callosity with calf suckling as a reference.

Teat end callosity

After repeated use of the milking machine, the long-term effects are changes in teat-end tissue, resulting in a callous ring around the teat orifice. Already in 1942, observations of everted teat sphincter in machine milked teats, which became eroded, has been made (Espe and Cannon, 1942). Teat-end callosity can be classified visually. Several systems have been developed like a system of Sieber and Farnsworth in 1981 and more recently by Shearn and Hillerton in 1996. The adapted classification system developed in The Netherlands is based on marked differences in the thickness of the callosity ring, which is transformed to five classes: none [N], slight [A], moderate [B], thick [C] and extreme [D]. Average teat end callosity thickness of teats is calculated by using the unit scores from 1 to 5. Additionally the ring is classified as smooth [1] or rough [2] (Figure 1, Neijenhuis *et al*., 2000b).

Factors influencing teat end callosity

Several factors influence the amount of teat end callosity; cow factors cause the biggest difference. Important cow factors are: teat shape, teat position, parity and days in lactation (Neijenhuis *et al*., 2000b). Teat shape was shown to be the most important factor. Pointed and round teat ends are very likely to show callosity, flat or inverted teats are less susceptible. Teat end callosity increases over parity. Cows in early and late lactation show less callosity than cows in mid lactation. This might be explained by the high milk yield during mid lactation. High yielding cows are more often affected, probably because machine-on time is longer.

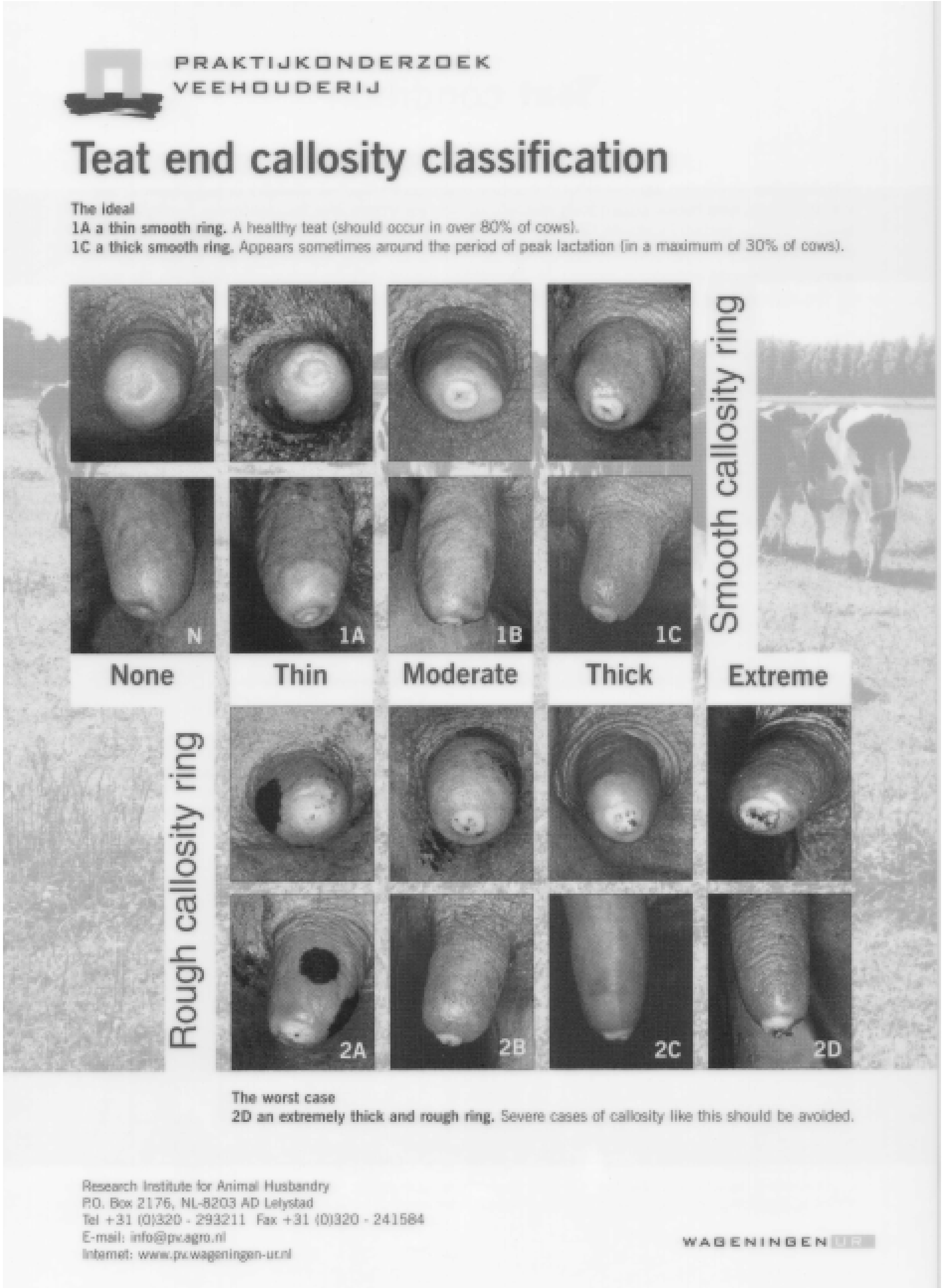

Figure 1. Teat end callosity classification system.

Between farms big differences in teat end callosity appear which can only be partly explained by differences in cow characteristics. Farms differ in teat end callosity roughness from 10 to 90% and in teat end thickness from 2.01 to 2.70. A minor part of the difference can be explained by the characteristics of the milking machine, milking method and management.

Mastitis

There is a good similarity between the macro- and microscopic ranking of the teat end callosity rings (Figure 2). Teat end callosity consists of hyperkeratose (Stratum corneum). Thicker callosity rings show parakeratosis; nuclei are still shown. Teats with a higher score for teat end callosity show perivascular reaction; infiltration of lymphocytes, granulocytes or erytrocytes (Utrecht University, 1998).

With thick callosity, the teat canal can not close as tight and micro-organisms may penetrate the teat easier. These callous ring can also get rough (category 2). The rougher it is, the easier it is for bacteria to anchor and reproduce, another factor affecting mastitis. Not all research was able to proof the relationship between teat end callosity and mastitis (Farnsworth and Sieber, 1980). In our research we found that clinical mastitis cows had more teat end callosity than their healthy pairs, particularly when clinical mastitis occurred between the second and fifth month of lactation (Neijenhuis *et al.*, 2000a). The probability of clinical mastitis increases on average more than 2 times when the teat end callosity is an extreme thick rough ring (class 2D).

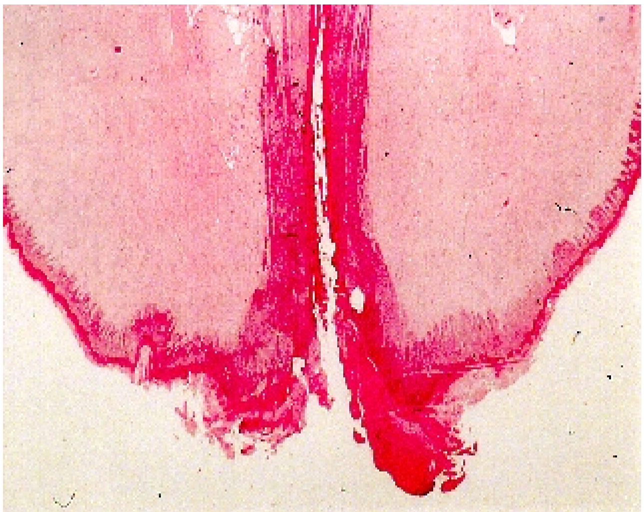

Figure 2. Microscopic view of a teat end with a thick rough callosity ring (2C). Photo: Utrecht University. Drs A. de Man, Dr Y.H. Schukken & Drs J.P. Koeman.

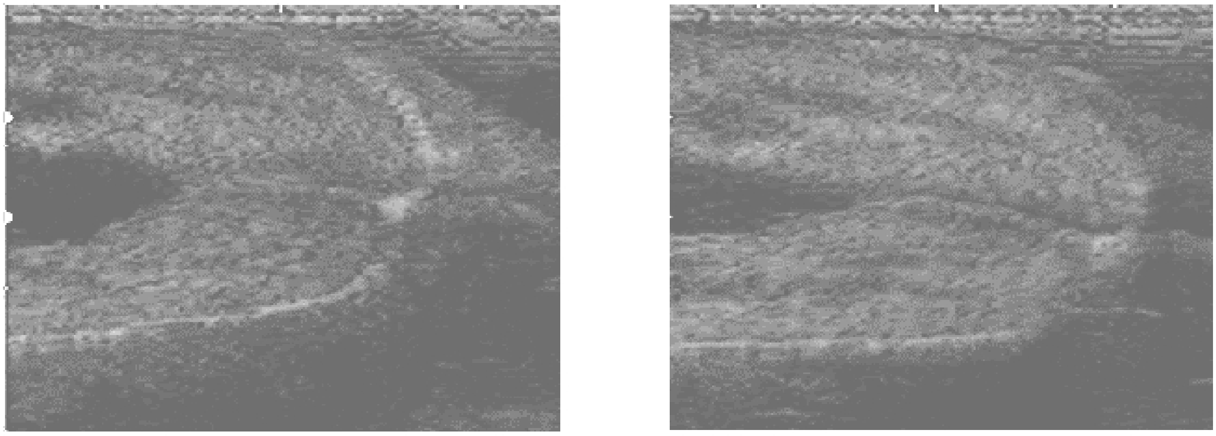

Figure 3. Ultrasound view of teat before and after milking.

Teat swelling

Short-term effect of milking on teats is swelling. A calliper instrument called the cutimeter can be used to measure the swelling of the complete teat end before and just after milking (Hamann and Mein, 1990). Another method is measuring by ultrasound (Neijenhuis *et al*., 1999, 2001). Under vacuum, strain is generated in the teat wall, which induces dilation of blood vessels and expandable compartments in the peri-vesicular tissue. This results in accumulation of fluid in the teat: blood and lymph. During the rest (massage) phase of the pulsator the liner collapses and massages the teat, relieving the congestion. Such swelling of the teat may influence the resistance of the teat canal to bacterial invasion during the recovery period after milking. Compared to machine milking, calf suckling stresses the teat tissue only slightly (Neijenhuis, 1999). Calf suckling is nature's way of cow milking which induces little teat swelling or teat end callosity. This should be our reference.

To make an ultrasonographic view, the teat is immersed into a plastic bag of warmish water before and just after milking. The probe is held against the plastic bag. A picture is made from the teat before and just after milking (Figure 3). Several teat parameters are measured from this view: teat wall thickness, teat end width, teat cistern diameter and teat canal length. For different milking machine settings the average relative change in teat parameters were: teat canal length from 10 to 30%, teat end thickness from 2 to 10%, teat cistern width from –50 to 3% and teat wall thickness from 20 to 50%. Hamann and Mein (1990) stated that the relative change in teat swelling from different milking techniques measured with the cutimeter (a calliper instrument that measures the teat end width) ranges from –10% up to more than 20%.

Table 1. Relative change in teat parameters, measured on ultrasonographic views, after machine milking and calf suckling.

	Machine milking	Calf suckling
Wall thickness	26 - 50	6
Cistern diameter	-27 - -65	-9
Duct length	19 - 28	7

Mastitis

A relative increase of teat end thickness measured with a cutimeter of more then 5% increases the new infection rate and teat duct colonization (Zecconi *et al*. 1992). However this method is different from the ultrasonographic technique.

Calf suckling

Calf suckling influences the teat swelling less than machine milking (Table 1; Neijenhuis, 1999). Hamann and Stanitzke (1990) also found with the cutimeter technique less increase with calf suckling than machine milking.

Milk flow

Milking machine techniques may influence (short and long-term) teat condition and milk-flow-profiles independently. As we found in our research, fast opening and closing of the liner causes more swelling and does not decrease milking time (Neijenhuis, 1993; Neijenhuis *et al*., 1999). With some machine settings, cows differ in response. For example longer suction phase of the pulsator will in general decrease machine-on time, but in a substantial part of the cows (25%) will show an increase (Koning and Klungel, 1998). Different liners can cause different degrees of teat swelling but not always differences in milk flow profiles (Koning and Ipema, 2000).

Recovery time

At 8 hrs after milking, teat end width and teat canal length still differed from before milking. Teat wall thickness and teat cistern width were recovered after 6 and 7 hrs (Neijenhuis *et al*., 2001). Hamann and Stanitzke (1990) found with the cutimeter technique a recovery time of 1 to 4 hrs for machine milking and only 30 minutes for calf suckling.

The results indicate that cautiousness is necessary when milking more frequently. Shorter milking intervals by increased frequency of milking, as can be found in automatic milking, may lead to incomplete recovery of teats. This may lead to a build up of teat damage.

Conclusion

Machine milking has more effect than calf suckling on teat swelling and teat end callosity. The effect of machine milking differs between cows. Negative changes in teat condition, like severe teat end callosity and teat swelling, increases mastitis incidence. Teat swelling after milking stays on for 6 to over 8 hours.

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Measurements of vacuum stability conditions in mid-level and low-level milking units

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Summary

The vacuum applied to the teat end when the milking liner is open has a major influence on the efficiency of milk extraction. In present study the vacuum levels and vacuum fluctuations were recorded on a milk flow simulator with mid-level and in a low-level milking units. Tests were carried out on six cluster types in mid-level system, with three water flows 4, 6, 8 litres / min; a pulsation rate of 60 cycles / min; three pulsator ratios 60, 64 and 68%, two pulsation phases simultaneous-1 and alternate-2 and with 13.5 and 16mm i.d long milk tubes. Four of the six clusters were evaluated in a low-level system. Large differences in liner open vacuum were recorded for milking units that gave similar vacuum losses measured over complete pulsation cycles. By increasing the LMT internal diameter the liner open vacuum was increased. For both types of milking unit the losses in vacuum when the liner was open were lower with wide bore tapered liners than with narrow bore liners ($p<0.001$). Simultaneous pulsation gave lower vacuum losses than alternate pulsation in all cases except in a low-level milking unit fitted with a cluster with a large claw with angled entry nozzles. With simultaneous pulsation and a wide bore tapered liner an increase in claw volume reduced the liner open vacuum at the three water flows ($p<0.001$). The lowest level of vacuum fluctuations was recorded with narrow bore liners in conjunction with alternate pulsation. There was a good correlation between liner open vacuum and flow rate through the artificial udder.

Key words: *Milking machine, vacuum, simulator.*

Introduction

Generally most modern parlour milking systems have large bore milk pipelines and the vacuum variations or losses in the milk pipelines are low. The main vacuum losses occur from frictional losses in the connecting system from the teat to the milk pipeline during milk flow, in commercial milking on farms these losses are difficult to measure as the flow through individual liners is not known. For this reason the losses in vacuum in milking systems are usually measured in laboratories where water is used instead of milk and the flow conditions from the teat are simulated by inserting artificial teats into the liners and water flow is controlled. Nordegren (1980), Osteras (1980), Woyke (1993), Wiercioch (1994), Luczycka (1993) and Stewart (1997), developed milk flow simulators for recording vacuum losses.

Operating vacuum should be related to the liner open vacuum and not as is common practice to the mean vacuum measured over complete pulsation cycles. While most milking machine manufacturers supply milking systems that give minimum fluctuations during the full liner movement cycles the alternative design approach of reducing vacuum losses when the liner is open and allowing vacuum drops to occur during liner closure can give satisfactory milking characteristics with specific liner designs (O'Callaghan, 1997). It is important that drops in vacuum during liner closure do not cause liner slippage, the milking cluster should be designed to avoid excessive teat penetration into the liner and liner movement curve should follow the pulsation curve. The objective of the present study was to investigate the vacuum stability conditions in mid-level and low–level milking systems using different designs of milking clusters.

Materials and methods

Tests were carried out with a new design of flow simulator (O' Callaghan, 1997). The opening on the artificial teat was placed in the plane of collapse of the liner and the collapsed liner discontinued the flow of water. The maximum, minimum and mean value of vacuum level in a full pulsation cycle and during the four phases of a pulsation cycle was also computed for each measurement sensor.

Tests were carried out on mid-level and a low-level milking systems with six and four designs of milking unit respectively, with three water flows 4, 6.8 litres / min; a pulsation rate of 60 cycles / min; three pulsator ratios 60, 64 and 68% and two pulsation phases simultaneous and alternate. For the mid-level milking system each claw was connected to a 48.5 mm milk pipeline, the milk lift of 1.4 metres and a system vacuum level of 50 kPa were used. With the low-level milking unit a long milk tube with a bore of 16mm and 0.8 m long was used, this was connected to a 20 litre receiver vessel located 300 mm below the claw. The mean vacuum in this receiver was set at 40 kPa.

Table 1. Details of milking units used for mid-level (cluster 1-6) and low-level (cluster 1,4,5,6) tests.

Cluster	Liner	Claw vol.	SMT diam.	Bore(upper)	Bore(lower)
1	Wide bore - tapered.	150	8.5	31.5	20
2	Wide bore - tapered.	150	13.5	31.5	20
3	Wide bore - tapered.	420	13.5	31.5	20
4	Wide bore - tapered.	420	8.5	31.5	20
5	Narrow bore.	323	11.1	22.0	19.5
6	Narrow bore.	275	12	25.0	21.0

Results and discussion

The overall effects of cluster type, long milk tube (LMT) internal diameter, water flow, pulsation pattern and pulsator ratio on liner open vacuum are presented in table 2. Increasing the long milk tube to 16mm from 13.5 mm increased the liner open vacuum. Also simultaneous pulsation-1 gave higher liner open vacuum than alternate pulsation –2. The interactions between cluster type, pulsation phase and flow for liner open vacuum is presented in Table 3. For the six cluster types the liner open vacuum was significantly higher with simultaneous than with alternate pulsation. An increase in the diameter of the short milk tube (SMT) from 8.5 mm to 13.5 mm for cluster 1 had a minimal affect on the liner open vacuum. With simultaneous pulsation and a wide bore tapered liner increasing the claw volume reduced the liner open vacuum at the three water flows. The data indicates that level of liner open vacuum is affected by flow and the measurement can be a useful indicator of flow capacity of a milking unit in association with other measurements.

Table 2. Effects of cluster type, long milk tube internal diameter, water flow, pulsation pattern and pulsator ratio on liner open vacuum in a mid-level milking unit.

Cluster	1	2	3	4	5	6	s.e.d
	42.2	41.2	40.0	40.1	38.4	40.4	0.10
LMT (i.d bore)	13.5	16.0					
	38.9	42.1					0.06
Flow (l/min)	0.0	4.0	6.0	8			
	47.6	41.2	38.2	34.9			0.09
Pulsation phase	1.0	2.0					
	42.2	38.8					0.06
Pulsator ratio %	60.0	64	68.0				
	40.5	40.4	40.5				0.08

Table 3. Liner open vacuum - clusters x pulsation x flow interactions for a mid-level milking unit.

Cluster	Flow (l/min) Pulsation	0		4		6		8		s.e.d
		1	2	1	2	1	2	1	2	0.30
1		48.5	48.2	46.3	39.8	44.3	36.0	41.8	32.6	
2		48.4	48.3	45.0	40.5	42.9	36.6	40.0	33.5	
3		47.4	48.0	42.7	39.2	39.5	35.5	35.6	31.7	
4		47.5	47.6	42.8	39.2	39.9	35.9	36.1	31.7	
5		46.2	47.0	38.7	38.3	37.1	34.1	34.1	31.9	
6		47.2	47.0	42.9	39.3	40.2	35.9	37.7	32.5	

The interaction between cluster type, pulsation and flow and mean and minimum vacuum measured over a complete pulsation cycle are shown in Table 4 and Table 5 respectively. Again the mean and minimum vacuum was reduced with increases in water flow rate. The differences in mean vacuum measured over complete pulsation cycles were small in practical terms for the six clusters with either simultaneous or alternate pulsation. Measurements of minimum vacuum over a full cycle differ considerably with cluster type and also are influenced by flow rate. With the wide bore tapered liner a increase in the diameter of either the short milk tube (SMT) above 8.5mm or the claw volume above 150ml increased the minimum vacuum. The low minimum vacuum recorded with a wide bore taper liner used in clusters 1 to 4 when the liner was closed does not affect the frequency of liner slips or milking characteristics (O'Callaghan, 1989, 2000). Alternate pulsation gave higher minimum vacuum than simultaneous pulsation for the six clusters. However there is a definite advantage in using simultaneous pulsation with the six cluster types for a milk extraction perspective.

Table 4. Mean vacuum over full cycle - cluster x pulsation x flow interaction for a mid-level milking unit.

Cluster	Flow (l/min) Pulsation	0		4		6		8		s.e.d
		1	2	1	2	1	2	1	2	0.24
1		47.9	48.0	37.9	39.2	35.0	35.1	32.3	31.1	
2		48.0	47.8	39.0	40.2	36.0	36.6	32.9	33.5	
3		47.4	47.8	38.7	39.1	34.9	35.4	30.9	31.7	
4		47.6	47.6	38.2	39.1	34.6	35.4	30.9	31.1	
5		47.0	47.0	38.5	38.5	35.3	34.2	32.0	31.3	
6		47.4	46.9	38.6	39.2	35.6	35.7	32.7	32.3	

Table 5. Minimum vacuum in full cycle - cluster x pulsation x flow interaction for a mid-level milking unit.

Cluster	Flow (l/min) Pulsation	0		4		6		8		s.e.d
		1	2	1	2	1	2	1	2	0.60
1		38.0	44.0	14.4	25.5	12.2	19.3	10.4	14.6	
2		39.1	43.9	22.5	36.5	18.9	32.5	15.5	28.9	
3		41.1	45.0	27.6	36.0	23.0	32.0	19.1	27.9	
4		41.7	44.9	22.2	33.2	17.9	26.9	15.2	19.6	
5		43.3	43.7	30.4	34.5	25.2	27.7	21.8	23.1	
6		41.4	44.0	27.8	36.4	24.4	32.5	20.9	28.2	

The vacuum fluctuation or the difference between the maximum and the minimum vacuum over a complete pulsation cycle is presented in Table 6. With simultaneous pulsation the vacuum fluctuations did not increase progressively with flow. With alternate pulsation the vacuum fluctuation increased with flow, the relationship was however not linear. Rating of clusters for flow capacity based on vacuum fluctuation is of limited value.

Generally the claw and teat-end vacuum during the liner open phase were similar. Analogue plots of teat-end and claw vacuum indicate differences particularly during the liner closing phase of the pulsation waveform. The maximum and minimum readings of claw and teat-end vacuum do not always occur simultaneously and the potential for reverse flow requires analysis of synchronised values of teat-end and claw vacuum.

Table 6. Vacuum fluctuation in a full cycle - cluster x pulsation x flow interaction for a mid-level milking unit.

Cluster	Flow (l/min) Pulsation	0		4		6		8		s.e.d
		1	2	1	2	1	2	1	2	0.70
1		13.0	6.5	37.3	21.4	37.0	25.6	37.8	28.2	
2		11.8	6.2	28.2	10.0	29.0	11.5	29.0.	13.0	
3		8.7	4.5	18.9	8.2	19.8	8.6	19.7	10.1	
4		8.3	4.5	24.2	11.5	25.4	14.9	24.2	19.1	
5		6.2	5.3	15.7	8.9	18.4	12.9	19.8	15.0	
6		8.6	5.2	18.1	7.9	18.4	8.9	19.4	10.3	

For low level milking units the losses in liner open vacuum were lower with clusters 1, 4 and 6 with simultaneous compared to alternate pulsation (Table 7). These differences were not evident from measurements of vacuum over full pulsation cycles (Table 8). The claw in cluster 4 had angled milk nozzles and gave less vacuum loss with alternate pulsation than with simultaneous. Generally vacuum losses were low with the four clusters for low-level tests. The low minimum vacuum and large vacuum fluctuation recorded with wide bore tapered liner in cluster 1 and 4 were due to the large volume change during liner closure (Table 9 and 10). The high levels of liner open vacuum that occur with simultaneous pulsation are due to the peak in vacuum during liner opening particularly with wide bore tapered liners.

Table 7. Liner open vacuum - clusters x pulsation x flow interactions for a low - level milking unit.

	Flow (l/min)	0		4		6		8		s.e.d
Cluster	Pulsation	1	2	1	2	1	2	1	2	0.21
1		39.5	39.0	39.2	36.8	38.6	34.8	37.5	33.3	
4		39.0	38.9	37.4	36.5	37.5	35.8	36.4	33.9	
5		39.1	39.4	37.0	38.1	35.8	37.5	34.9	37.5	
6		39.0	38.7	37.0	36.7	36.6	35.3	36.0	34.2	

Table 8. Mean vacuum over full cycle - cluster x pulsation x flow interaction for a low - level milking unit.

	Flow (l/min)	0		4		6		8		s.e.d
Cluster	Pulsation	1	2	1	2	1	2	1	2	0.19
1		39.6	38.9	36.4	36.4	34.9	34.9	33.2	33.6	
4		39.1	38.9	36.7	36.4	35.0	35.2	33.4	33.7	
5		39.3	39.3	37.6	37.1	36.6	36.3	35.8	35.9	
6		39.1	38.6	36.3	36.0	34.8	34.8	33.8	33.8	

Table 9. Minimum vacuum in full cycle - cluster x pulsation x flow interaction for a low-level milking unit.

	Flow (l/min)	0		4		6		8		s.e.d
Cluster	Pulsation	1	2	1	2	1	2	1	2	0.45
1		37.6	36.8	21.4	24.7	18.7	23.0	16.2	21.3	
4		37.4	37.3	26.6	27.7	20.4	24.7	18.0	22.9	
5		38.4	37.9	32.7	31.5	30.0	28.4	28.3	27.0	
6		37.0	36.6	28.2	31.9	24.5	30.4	22.6	29.5	

Table 10. Vacuum fluctuation in a full cycle - cluster x pulsation x flow interaction for a low-level milking unit.

Cluster	Flow (l/min) Pulsation	0		4		6		8		s.e.d
		1	2	1	2	1	2	1	2	0.61
1		3.0	2.8	21.4	16.9	24.4	18.7	27.0	21.0	
4		2.4	2.3	14.8	13.8	20.8	17.4	23.1	18.9	
5		1.6	2.0	8.8	8.6	11.9	12.0	13.4	13.4	
6		2.8	2.9	11.9	7.0	15.8	7.9	17.5	7.9	

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Comparative study of physiological responses of cows to classical versus automatic system of milking

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Summary

Eight cows were controlled during 2 weeks of classical milking technique in a side by side parlor and the first 4 succeeding weeks of adaptation to an automatic milking system (AMS). Milk production and composition, milk emission kinetics, oxytocin release and teat end reaction were measured 4 times per week during all the experiment. The milk production and lactation persistency, the milk composition and the C.C.S are not significantly affected during the adaptation period to the AMS. There is a good massaging of the teat during milking. That suggests a normal function of the liner in the special cup of the AMS. The mean flow rate have just a tendency to be lowered by AMS that confirm the good quality of the milking machine of the AMS. Therefore, there is a significant reduction of the oxytocin release when cows are milked by the AMS with a corresponding increasing number of bimodal milk emission kinetics. This result remain significant even when we take only in account the good milking procedures in the AMS (without any failure, delay in cup attachment or cluster fall). That suggests a poor efficiency of the udder pre-stimulation in our AMS. Additionally, we cannot eliminate a potential chronic inhibition of the milk ejection reflex by the robotic surroundings during the 4 weeks despite a clear improvement of the AMS efficiency with a reduction of more than 15% of the second, third and fourth trials for attachment procedures of the teat cups.

***Key words**: Machine milking, milk production, milk flow, teat reaction, oxytocin*.

Introduction

It is well known that the most important stimuli are pre-milking preparation and the action of the machine milking (Woolford, 1987). In an AMS, the pre-milking preparation consists in mechanical cleaning of the teats and foremilking by the machine. When the udder or the teat are brushed, a positive effect on milk let down and oxytocin release have been described (Shuiling, 1992, Macuhova and Bruckmaier *et al.*, 2000). However, no data exists about the stimulation efficiency of foremilking with water cleaning in a liner. When teat cup attachment needs more than 3 minutes after the cows entering the stall (Ipema *et al.*, 1997) or when the lag time between udder stimulation and attachment of the cups increases (Labussière *et al.*, 1999), there is negative effect on milk yield and milking duration. In AMS, the time needed for teat cup attachment is generally around 2 min (2.8 in Kremer and Ordolff, 1992) suggesting that a significant number of milking could be less efficient than possible with AMS. At the opposite, AMS have some advantages as allocation of concentrate at milking that is well known to optimize milk ejection (Labussière *et al.*, 1999; Svennesten-Sjaunja *et al.*, 1995). There is also little evidences of lack of major “stressors” in an AMS by means of behavioral and physiological data (Hopster *et al.*, 2000). Finally, there is only scarce data about the global effect of AMS and its surroundings (automatic gate, stall size adjustment, specific noise...) on the stimulation of the animals and physiological adaptation of cows. To complete these data, this work aims to compare the physiological and zootechnical adaptations of cows subjected to a transfer from a classical milking parlor to an AMS during the beginning of their lactation.

Material and methods

Eight multiparous Holstein cows were milked in a classical milking parlor from to their 10 to 12th week of lactation. It was a 2*6 side by side parlor and milking procedure included 30 s washing and massaging, manual cup attachment and simultaneous manual cups removal when milk flow decrease under 200 ml / min. Milking parameters were 37 KPa of vacuum, 60.2 pulsation frequency and 61.2 % pulsator ratio. Then cows changed to an AMS (Prolion-Manus) as the resting part of the breed and without relocation of animals. Milking procedure differs only by concentrate allocation in the stall, automatic cup attachment and a 30-s period of automatic teat cleaning and milking by AMS. Simultaneous cups removal where performed as in classical parlor. Milking parameters were 46KPa of vacuum, 60.2 pulsation frequency and 60.2 % pulsator ratio. Cows were milked 2 times per day (6h and 17h) in the two systems of milking in order to eliminate the effect of milking frequency. Cows were fitted with indwelling intra-jugular catheters 2 weeks before experiment. The measurements during the period of adaptation to AMS lasted 4 weeks.

Milk production and quality (fat, protein and CCS) content were measured at each milking from parturition. Milk emission kinetic was recorded with an automatic prototype device during 4 milkings / week. Simultaneously, blood was sampled for oxytocin assay. Residual milk was measured after IV injection of 2.5UI of oxytocin after the last two morning milkings of each week. Teat-end thickness was recorded before and after milking using spring-loaded calipers during 4 milkings / week.

Statgraphics software was used for ANOVA and succeeding mean comparison (confidence interval). For the milk flow data, the effect of milk production and time of milking were considered as co-variables. Milk production during the AMS and classical milking system periods were compared after extrapolation of milk production during the period in classical parlor (Wood model).

Results

The milk production, fat, protein and cellular concentration of the milk never differed significantly between classical parlor and AMS excepted for one cow with mastitis at the end of the control period (24.99 ± 0.32 versus 23.86 ± 0.94 L / Day; 31.2 ± 1.7 versus 32.1 ± 2.1 %; 29.1 ± 1.1 versus 29.7 ± 1.5 %; 67274 versus 72471 C / ml, respectively for classical milking system and AMS).

The milk production and the time of milking mainly affect the parameters of milk emission kinetics. These parameters are not significantly different between AMS and classical system (Table 1). However, a tendency exists for a lower milk flow and an increased number of bimodal milk flow curves (>15%) with AMS. The percentage of residual milk is not significantly greater during the AMS period (8.0 ± 0.1 % of machine milk) than in the classical milking period (6.52 ± 0.9 %).

At the opposite, the oxytocin release pattern differs significantly (Table 1 and Figure 1) between the two milking systems even if the oxytocin release induced by AMS remain significant. There is also significant difference in the teat-end status resulting from the milking with classical milking system and AMS (Table 1). Therefore, there is no evolution of oxytocin concentrations and teat-end thickness between the different weeks of adaptation to AMS.

Table 1. Milk emission parameters, oxytocin (OT) release and teat-end reaction between classical milking system and AMS.

	Classical Milking parlor	n	AMS	n	Statistics (Anova)
Max flow (l / min)	3.68 ± 0.10	53	3.61 ± 0.05	126	NS
Mean flow (l / min)	2.2 ± 0.06	53	1.91 ± 0.04	126	P<0.075
Milking duration (min)	6.51 ± 0.21	53	6.25 ± 0.15	126	P<0.055
OT Control level (pg / ml)	29.6 ± 3.9	40	25.4 ± 2.1	123	NS
OT Maximum level (pg / ml)	102.8 ± 10.4	40	73.5 ± 5.1	123	**
OT Discharge (AUC unit)	423.6 ± 57.2	40	299.8 ± 32.6	123	P<0.065
Teat-end thickness (mm)	9.63 ± 0.11	53	10.16 ± 0.07	126	***
Teat-end reaction (mm)	0.55 ± 0.07	53	-0.35 ± 0.04	126	***

Anova use milk production and time of milking as co-variable for milk flow, milking duration and teat end thickness. Incomplete oxytocin patterns were not taken in account for ANOVA.
Teat-end reaction correspond to teat-end thickness difference (after milking minus before milking).
Data are means ± standard error means. NS: non-significant, * : p<0,05; ** : p<0,01; *** : p<0,001
AUC = area under the curve.

Table 2. Percentage of milking without problem and with infructuous trials in the AMS.

Attachment of cups	Direct	One infructuous trial	Two infructuous trials	More infructuous trials
First week in robot	68.9	5.4	1.8	25
Second week in robot	56.3	0.0	12.5	35.9
Third week in robot	73.4	10.9	0.0	15.6
Fourth week in robot	84.4	4.7	0.0	10.9

The evolution of AMS efficiency for the cup attachment is shown in table 2. When we retained only the perfect milking with AMS, there is no modification of all the results presented before.

Discussion

The first conclusion of our work is that the AMS and the classical milking system have very close results. With a similar number of milking per day, the production parameters never differed significantly suggesting a comparable efficiency of the two systems. The low percentage of residual milk and the normal milking duration confirm this point.

Nevertheless, there is a lower stimulation of the milk ejection reflex in the cows when milked by our AMS. This lower oxytocin release is in agreement with the lowered milk flow recorded with robotic unit and the increased number of bimodal emission of milk. The more probable explanation is that the stimulation is delayed with AMS because of the lack of real

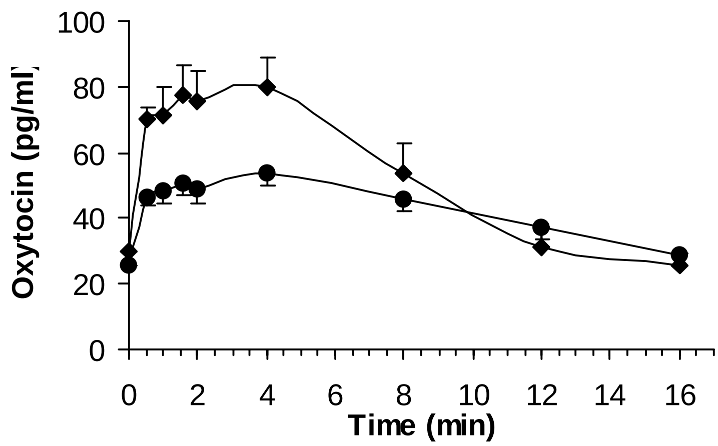

Figure 1. Oxytocin pattern of release induced by classical milking system (◆) and AMS (●).

prestimulation by the washing procedure as previously described by Bruckmaier & Blum (1996). There is also a lower total amount of oxytocin released with AMS. It is not a result of reduction of oxytocin storage by the multiple pre-stimulations by the previous trials of cup attachment: oxytocin release in the cows with immediate cup attachment is not significantly different than when all the milking where taken in account. The lower discharge could be explained for a part by a lower stimulation capability of the cluster. The fact that the massaging of the teat is really efficient (more important decongestion of the teat apex than with the classical milking system despite a very high vacuum level in our installation) suggests a good liner movement and stimulation of the teat and do not reinforce this hypothesis. The last explanation could be that the robotic surroundings are potential stressors for the animals. The teat-end thickness before milking is generally linked to the milk production and or sympathetic tone of the muscular bundles of the sphincter. Here, the more important teat thickness with AMS could be due to a stress of the cows before entering the box. We have to be aware that this stress is less acute and could be of different nature than that described by Rushen *et al.* (2001) when cows are milked in unfamiliar surroundings (24% of residual milk against 8% in our experiment). This chronic inhibition during the 4 first weeks of milking in our robot is in accordance with observations of different breeders whose notify a perturbation of cows for at least 2 months after the beginning of milking with AMS. A longer period of study with measurements of stress indicators will be necessary to conclude to a chronic perturbation of cows or to a lower stimulation capability of our AMS. This lower stimulation capability is to compare with the relative inefficiency of the AMS to produce the same rate of increase in milk production (globally 3% of increase and 55% of French producers have no significant increase in milk production, see paper of Veysset *et al.*, 2000 in this book) than with an increased number of milking in a classical milking system (see revue of Amstrong, 1997).

Concerning the adaptation of the robotic unit to the animals, it is clear that the AMS improve its efficiency for teat cup attachment with time. But the remaining 11% of total failure confirm that the animals and robotic unit are not well adapted after one month. It is clear that in a totally free access AMS, the speed of adaptation of the machine and the animals could be faster than in our experimental protocol.

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Effects of liner buckling pressure and teat length on pulsation chamber a- and c-phases

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Summary

6 x 4 silicone liners covered buckling pressures from 6.5 to 17.9 kPa. Hard PVC teats provided penetration depths from 50 - 110 mm. Teat length increased liner stiffness by 39 - 55% which decreased a- and c-phases by 34, 83, 58 ms and 45, 48, 60 ms at 40 kPa alternate pulsation, 40/32 kPa alternate (8 kPa vacuum drop) and 40 kPa simultaneous, respectively. A- phases were shortest with vacuum drop and stiff liners while c- phases were generally shortest with soft liners and vice versa.

Key words: *Machine milking, liner, teat penetration, pulsator phases*

Introduction

The milking machine pulsator controls the pulsation chamber wave form but liner wall movement is determined by differential pressure (1,4,9). Liners open and close, respectively, when the latter falls short of or exceeds liner buckling pressure (6,7). With fairly stable liner vacuum, differential pressure is a more or less inverted pulsation curve. Under milking conditions, however, high capacity clusters with alternate pulsation show more or less a parallel shift of liner vacuum in combination with an increasing dip between b- and c- phase. By contrast, simultaneous pulsation alters the shape of the cyclic fluctuation with increasing flow rate (5,8) requiring measurement under actual “wet” conditions. ISO testing is based on teatcup plugs of 59 mm length. Longer teats, however, exist and teatcups are manufactured in different lengths. Pulsation failure will occur if teat penetration is too high (2,3). The present paper analyses interactions of liner buckling pressure and teat penetration.

Material and Methods

Liners and teatcup plugs

For the laboratory trials, 6 x 4 silicone liners (SL M23, Siliconform, D 86842 Türkheim) with 42, 51, 58 Shore and 2.80 / 3.25 mm barrel wall, respectively, were mounted in transparent 147 mm shells (# 457800897, Impulsa, D 4910 Elsterwerda). To study teat penetration effects, a series of hard PVC teatcup plugs was tooled on a CNC lathe. The construction based on the ISO 6690 specification, but the cylindrical shaft was modified in steps of 10 mm resulting in total plug lengths of 49 - 109 mm.

Nominal and effective buckling pressure

For conditioning, all liners were stored at room temperature for more than 24 h and pulsated for 10 min (40 kPa, 60 c / min, 60%) before measurement. Nominal buckling pressure (BP_n) is defined as touch point of opposite walls of liners closed by a glass plate (6). Effective buckling pressure (BP_{eff}) was defined as measurement with a teatcup plug in place. The touch point was observed through the transparent shell and liner held against a lamp. For slow evacuation, a small hand pump (Mityavac II, Neward Ent. Inc., Cocamonga CA) was connected to the short milk tube with the pulsation nipple open. BP was measured by strain gauge equipment (Pulsotest II, Bitec Engineering, CH 8590 Romanshorn). Measurement frequency was 1 kHz, pressure readings (better than class 0.6) were displayed in intervals of 0.5 s, time recording was better than 1 ms.

Measurement of pulsator phases

Electronic pulsators supplied alternate (Autopuls P, Westfalia Landtechnik, D 59302 Oelde) and simultaneous pulsation (Flow Processor, Lemmer Fullwood, D 53797 Lohmar). A dry laboratory milking plant provided constant vacuum conditions (40 kPa) and vacuum drop (40/32 kPa), respectively. The latter was restricted to alternate pulsation, because simultaneous pulsation would have required specific wet conditions, exceeding this basic study. Short pulse tubes (230 x 7 mm i.d.) and 2.40 m long pulse tubes were applied for alternate (2 x 7.5 mm i.d.) and simultaneous pulsation (1 x 9 mm i.d.), respectively. Pulsator phases were recorded by Pulsotest. Nominal pulsator phases (PP_n) were measured with ISO plugs in place while effective pulsator phases (PP_{eff}) were measured with 50 and 70 -110 mm teat penetration depth (TPD). The difference of +1 mm to the teat length accounts for liner head deformation under vacuum. Each set of liners was run 3 min for conditioning to the actual plug length before measurement.

Results and discussion

Nominal and effective buckling pressure.

Table 1 summarises mean buckling pressure data of all tested liners without teat (zero TPD; BP_n) as well as for 7 teat lengths (BP_{eff}), measured twice. The BP_n figures indicate a selection from very soft to fairly stiff liners. The standard deviation increased with Shore hardness and was dominated by differences between liners, while repeated measurements typically lay within 0.1 kPa. BP_{eff} remained unchanged or was even lower than BP_n for TPD 50 and 60 mm, respectively. The slight decrease is attributed to different liner deformation: When the mouthpiece is covered by a glass plate, the entire shaft deforms while a teat limits the buckling area to the space underneath. Starting from 70 mm TPD, liner stiffness increased progressively by max. 39 - 55%. As expected, Shore hardness and liner wall thickness acted together and partly interchangeable.

Table 1. Buckling pressure (kPa) and teat penetration depth (TPD) of liners with different Shore hardness (4 x 48 x 2 measurements).

TPD	42 ShA			51 ShA			58 ShA		
(mm)	BP	SD	Δ %	BP	SD	Δ %	BP	SD	Δ %
Swingliner SL M23, 2.80 mm barrel wall									
0	6.49	0.12	-	8.71	0.14	-	12.50	0.61	-
50	6.49	0.16	0	8.65	0.17	- 0.1	12.49	0.45	0
ISO 60	6.41	0.11	- 0.1	8.61	0.25	- 0.1	12.46	0.49	0
70	6.76	0.12	+ 0.4	8.91	0.12	+ 0.2	12.79	0.43	+ 0.2
80	6.95	0.15	+ 0.7	9.28	0.11	+ 0.7	13.69	0.26	+ 1.0
90	7.48	0.23	+ 1.5	9.88	0.30	+ 1.3	14.74	0.52	+ 1.8
100	8.18	0.29	+ 2.6	10.99	0.22	+ 2.6	16.39	0.80	+ 3.1
110	9.43	0.33	+ 4.5	12.68	0.57	+ 4.6	19.35	0.77	+ 5.5
Swingliner SL M23, 3.25 mm barrel wall									
0	9.18	0.11	-	13.81	0.20	-	17.88	0.45	-
50	9.01	0.15	- 02	13.55	0.35	- 0.2	17.36	0.31	- 03
ISO 60	9.09	0.27	- 01	13.88	0.33	0	17.39	0.49	- 03
70	9.35	0.15	+ 0.2	14.24	0.30	+ 0.3	18.38	0.33	+ 0.3
80	9.74	0.17	+ 0.6	15.11	0.46	+ 0.9	19.26	0.48	+ 0.8
90	10.41	0.20	+ 1.3	16.38	0.43	+ 1.9	20.64	0.43	+ 1.5
100	11.11	0.37	+ 2.1	18.18	0.47	+ 3.2	22.99	0.50	+ 2.9
110	12.75	0.26	+ 3.9	21.31	0.50	+ 5.4	27.64	0.96	+ 5.5

Effects of teat penetration depth on a- and c-phases.

Generally, BP_{eff} increased with TPD causing less liner deformation and volume change during the pulsator a- and c- phases (PP_{eff}). For alternate pulsation at 40 kPa, an increase of BP_{eff} from 6.5 to 27.6 kPa caused a pulsator a- phase reduction from 141 to 107 ms. This is a maximum difference of 3,4% and a relative change of -18 to -30% for soft and hard liners, respectively. For simultaneous pulsation at 40 kPa, the a- phase reduced from 199 to 141 ms (5,8%). For alternate pulsation with 8 kPa vacuum drop, the a- phases reduced from 185 to 102 ms (Figure 1). The length of the a- phases decreased with increasing TPD and BP_{eff} forming an undisturbed BP-sequence.

Figure 2 illustrates the c- phase reduction with increasing TPD at 40 kPa for simultaneous and alternate pulsation, respectively. Data for 12.5 kPa BP_{eff} was omitted for clearness because of overlapping with 13.6 kPa. The

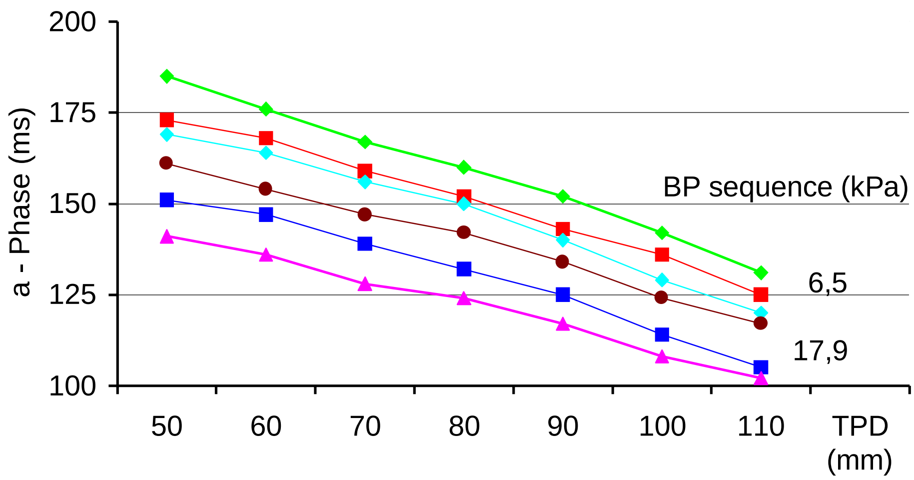

Figure 1. A-phase reduction with increased liner Shore hardness and teat penetration depth (60 c/min, 60% alternate, 40 kPa, 8 kPa vacuum drop).

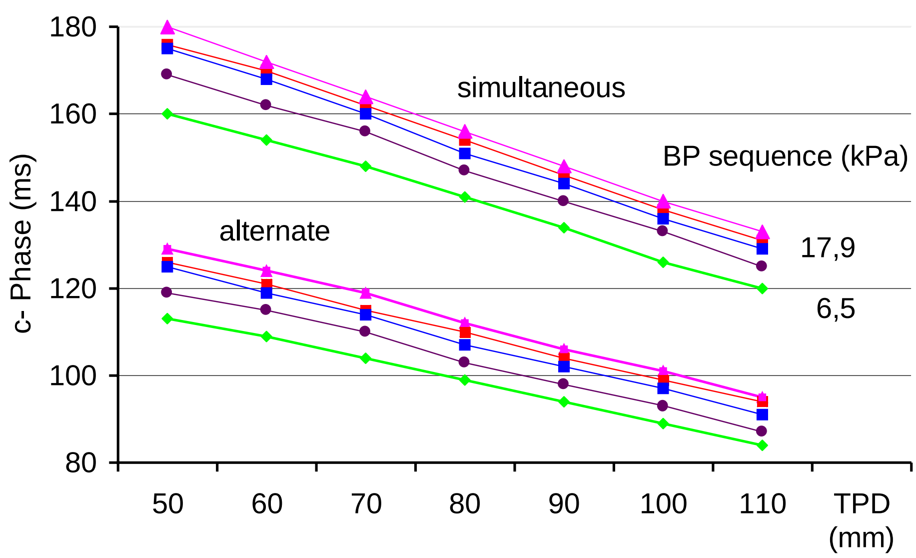

Figure 2. C-phase reduction with increased liner Shore hardness and teat penetration depth (60 c/min, 60%, 40 kPa).

series 40/32 kPa had profiles very similar to alternate pulsation without vacuum drop and is not shown either. All recordings yielded parallel lines ranked with BP_n. C-phases were shortest for 6.5 kPa BP_n and longest 17.9 kPa BP_n . This sequence is opposite to its influence on the a- phase with vacuum drop (Figure 1).

Implications

ISO tests are carried out with standard teatcup plugs of 59 mm length. While short teats are common in the field, longer teats exist and penetration increases during milking (3,9). In the present analysis, teat length increased liner stiffness and reduced a- and c- phases due to less volume change. Caution is commanded when shortening teat cups to increase cluster flexibility or milkability of low udders because pulsation failure must be excluded. Effects of a- and c- phase changes will be analysed with regard to liner-open phase and release (10).

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Differential staining of milk somatic cells and the udder health

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Introduction

Differential counting of milk somatic cells can be a useful diagnostic tool in bovine mastitis research because each cell type has its own more or less specific function in the immune response. Panoptic staining with Pappenheim, Giemsa, Wright or Leishman stains is a standard technique in haematological diagnostic procedures and, based on these, the direct smear method commonly used for observing somatic cells in milk is usually similar to blood smear technique. Similarly, the May-Grünwald stain may be used to observe milk somatic cells.

Material and methods

Milk samples were obtained from the Lajta-Hanság State Farm dairy herd which consists of ~ 600 Holstein cows aged 2 to 10 years with most animals being 4-5 years of age. To verify the stability of cells in milk, samples (n=16) were collected from individual quarters by hand stripping and were examined within 1-2 hours.

Smears of raw milk from healthy cows were air-dried, fixed and stained according to May-Grünwald (Reanal R6 - R3). Alternatively, 5 ml of milk was added to a centrifuge tube containing 3 ml of ice-cold isotonic salt solution. Aliquots were centrifuged at room temperature for 10 min at 2000 rpm in order to multiplicate cells. The supernatant, including the butterfat layer, was removed from the walls of the tube by cotton-tipped applicators and the pellet was resuspended in 0,5 ml isotonic salt solution. Smears were air-dried, fixed and stained as described before.

On each slide 100 (or 200) cells were counted at magnification and identified as neutrophils, eosinophils, basophils, lymphocytes, monocytes or macrophages.

Results

Overall means of somatic cell count (SCC) and percentages of different cell types are given in table 1.

Table 1. SCC and ratio of cell types (lymphocytes, granulocytes and monocytes).

			Mean		
Cow no.	n	SCC	Lymph %	Granul %	Mono %
1	4	372.000	13	25	53
2	4	184.000	10	23	62
3	4	269.000	14	37	48
4	4	437.000	18	46	35
Σ / mean	16	315.500	13,75	32,75	51

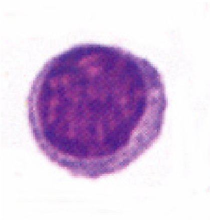

Figure 1. Lymphocyte.

Figure 2. Granulocyte.

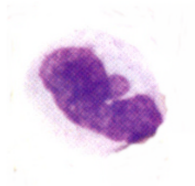

Figure 3. Monocyte.

The lymphocyte (Figure 1) was the least frequent, granulocyte (Figure 2) the most variable and monocyte (Figure 3) the most common cell type in the samples.

This rapid staining procedure is appropriate for processing relatively large numbers of samples and sufficient to allow identification of cell populations in milk.

Conclusions

Application of this simple and cheap procedure provides additional information about cell types for understanding the udder health status, treating mastitic cases and several characteristics of cells in milk can be evaluated. It is conceivable that not only the quantity of cells but also their functionality should be taken into account.

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Comparison of different diagnostic measures to identify bovine mastitic quarters at milking time

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Summary

A precise diagnosis of bovine mastitis is only possible by examination on quarter level. The pre-selection of quarters with changes in quarter milk yield and electrical conductivity depending on inflammatory processes, will be useful under economical aspects, particularly concerning the following cyto-bacteriological examination. These parameters are already available, especially in automatic milking systems.

Sensitivity, specificity and probability of misclassification to predict the diagnosis of clinical and sub-clinical mastitis were calculated, using a retrospective analysis of both parameters in comparison to a cyto-bacteriological reference based on quarter foremilk samples. Ninty-six cows on two farms were part of the survey, over a period of at least one lactation per cow.

Using analyzing techniques, based on consecutively or momentary orientated surveys of the parameters, up to 70 % of all sub-clinical mastitis can be identified, with a specificity of approximately 80 %.

The results indicate that these techniques can be used as early automatic warning systems, although they are not sufficiently precise to replace the cyto-bacteriological examination.

Key words: *Bovine, mastitis, diagnosis, milking, quarter yield, electrical conductivity.*

Introduction

The early identification of mastitic quarters is essential for all dairy farmers, to ensure animal welfare, milk quality and farm productivity. The most precise diagnostic categorization in this respect can be obtained by cyto-bacteriological analysis of quarter milk samples (Table 1). Nevertheless, this procedure is not economic for a continuous screening of udder health. For this reason, alternative parameters, which however indicate an inflammation only, are used for an assessing categorization of the udder health. In this context, most systems employed in milking devices up to today (especially automatic milking systems), measure the electrical milk conductivity and milk yield at quarter level. This study offers the possibility for a retrospective assessment of the diagnostic quality of the parameters mentioned above, by using the cyto-bacteriological and clinical examinations parallel.

Material and methods

Ninty-six German Holstein cows, originated in two different production systems (loose house system and fixed stanchion barn) were sampled over at least one lactation. During lactation, sampling was carried out 18 times. The sampling pattern included weekly survey for the first eight and the last three weeks of lactation, and monthly intervals for the period in between. At morning milking, cows were milked with a quarter milking machine, after foremilk sampling had occurred for cyto-bacteriological analysis. In addition to this, all udders were clinically examined. Bacteriological examination was performed according to IDF recommendations (IDF, 1981). Somatic cell count (SCC) was determined by fluorescent microscopy (Fossomatic®, Foss Electric™, Denmark, precision: Cv < 5%; Schmidt-Madsen, 1975). The quarter milk yield was determined by weighing electronically (DNP15 SNR 2116076262, Ohaus™; precision: Cv 0,5 %). Furthermore, electrical conductivity was measured in quarter machine samples (LF 539, WTW, precision: Cv < 0,5 %). Udder health was determined according to the categorization scheme shown in table 1. Physiological ranges on quarter level were determined (Figure 1), using data from cows, healthy on all four quarters throughout the whole lactation. Milk yield data could be corrected lactation-related, with these ranges (Grabowski, 2000). The statistic processing of diagnostic data was carried out by means of the procedure Freq (SAS, 1987). The thresholds

Table 1. Mastitis definition (DVG, 1994).*

Cell content [cells / ml milk]	Pathogens Not identified	Identified
< 100.000	Normal secretion (NS)	Latent infection (LI)
> 100.000	Unspecific mastitis (UM)	Mastitis (M)

*based on cyto-bacteriological examination of udder quarter foremilk samples were calculated using the principle of least probability of misclassification (PM) (Krömker et al., 1998). The diagnostic test criteria sensitivity, specificity, and PM were determined with Win Episcope 2.0® (Epidecon).

Results

The data of 96 cows with 382 quarters was used in the present study. Udder health of animals and quarters involved was determined at the beginning of the survey on both farms, with constant monitoring during the trial. Table 2 shows the prevalence of mastitis at the onset of the investigation for both production systems.

Udder health was defined by SCC less than 100,000 cells / ml and the absence of pathogenic bacteria in foremilk samples (DVG, 1994). By this definition merely six animals were considered as udder-healthy on all quarters throughout the whole lactation. The physiological development of quarter milk yield and electrical conductivity during lactation is depicted in figure 1.

During the survey, 684 new cases of sub-clinical mastitis (NS becoming M or UM) and 44 clinical cases of mastitis were recorded. In order to assure comparability, a similar number of non-disease cases (NS remaining NS) was used along with the new cases.

Because of the retrospective analysis of the electrical conductivity and quarter yield data, thresholds for the individual parameters and a combination of both were established separately. Analysis methods associated with ‘moment’ and ‘time’ were also tested. Those associated with the momentary survey considered only the actual value, whereas those associated with consecutive survey compared the actual value with the preceding values. Table 3 presents the methods of analysis employed in the present study, along with their thresholds; table 4 shows their corresponding values for sensitivity, specificity and PM.

The results of the analyses show that between 12 and 70 % of all newly diseased quarters can be readily identified, using these parameters. The combination of different thresholds increases the sensitivity. In particular it is interesting that the decrease of relative quarter yield from one sampling to the subsequent one by 10 %, alone and in combination with other parameters is the method with the best identification rates. The specificity

Table 2. Udder health status (%) at the onset of sampling.

Farm	NS	LI	UM	M
1 (n = 54 cows)	27,8 / 68,2*	3,7 / 1,9	55,6 / 25,7	13,0 / 4,2
2 (n = 42 cows)	35,2 / 70,2	7,1 / 3,0	31,0 / 18,5	26,2 / 8,3

*= The first value refers to the cows, the second to the quarters.

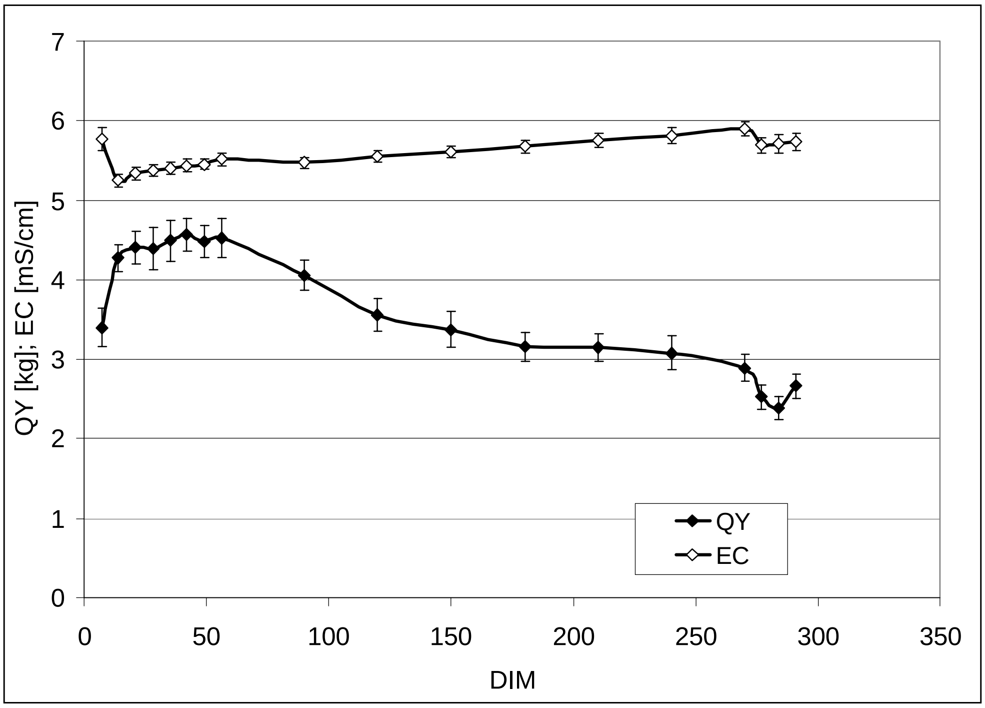

Figure 1. Physiological course of quarter milk yield (QY) [kg] and electrical conductivity (EC) [mS/cm], mean and standard error of the mean; DIM = days in milk (n = 6 cows).

is usually above 70 %. The PM's demonstrate, that considering this material, 30 to 40 % of all quarters are always misclassified. The number of PM's for clinical mastitis, that are particularly low, do not indicate a high recognition rate of clinical cases, but are the result of the high number of non-clinical cases.

Discussion and conclusion

Using a retrospective analysis of electrical conductivity and lactation corrected yield data, from quarter machine milk samples and corresponding cyto-bacteriological findings, the diagnostic value of these parameters in single usage or in combination, was calculated, in order to identify mastitis cases, omitting clearly the influence factor of the milking interval. By means of these parameters on quarter machine milk level and using appropriate analysis procedures, the identification of ca. 70 % of all sub-clinical new infections and of 40 % of all clinical mastitis cases is feasible. Zero to 20 % of all non-diseased quarters were misclassified with this method. Although an extension and consecutively an optimization of the analysis systems should promise better results, automatic analysis systems – integrated in milking devices – can not be expected to provide a secure early diagnosis of mastitis under the tested conditions. Actually,

Table 3. Summary of analysis methods employed

Method No.	Analysis	Threshold healthy / not healthy
1	EC, sub- clinical	6,5 mS/cm
2	EC, sub- clinical	15 % of difference between quarters
3	EC, sub- clinical	Combination No. 1 & No. 2
4	EC, sub- clinical	Value before vs. value after + > 10%
5	EC, clinical	8 mS/cm
6	EC, clinical	9 mS/cm
7	QY, sub- clinical	15 % of decrease of QY in relation to the previous sample after lactation correction
8	QY, sub- clinical	10 % of relative QY reduction in one quarter in relation to the previous sample
9	EC, QY sub- clinical	Combination No. 1 and/or No. 7
10	EC, QY sub- clinical	Combination No. 4 and/or No. 7
11	EC, QY sub- clinical	Combination No. 1 and/or No.4 and/or No. 7
12	EC, QY sub- clinical	Combination No. 1 and/or No.4 and/or No. 7 and/or No.8

Table 4. Misclassification of different analytical methods.

Method No.	*Sensitivity (%)*	*Specificity (%)*	*PM * (%)*
1	26.7	99.4	37.0
2	21.2	95.6	41.6
3	11.9	99.1	44.4
4	54.9	77.5	33.8
5	37.2	98.8	3.0
6	17.9	99.5	2.5
7	44.4	76.9	39.7
8	68.6	72.2	29.6
9	52.8	63.5	41.9
10	54.9	77.5	41.1
11	58.3	77.5	32.1
12	67.1	76.0	29.4

* Probability of misclassification [percentage of false (+) & false (-) diagnoses].

these techniques should be regarded as alarm systems that require verification by a cyto-bacteriological examination before any therapeutic measure is taken.

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Evaluation of milking routine by using LactoCorder in combination with cytobacterial analysis of the milk of Holstein Frisian

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Summary

Due to the economic conditions and an efficient and fast milking process many farmers use automatic stimulations and take-offs. In addition to these facilitations there may be a positive effect on udder health. This is caused by the fact that automatic support leads to a constant work flow in difference to the manual job that can change temporarily. In the experiment included were four farms with 60 to 240 Holstein Frisian cows with at least 8.000 kg milk output per year. All farms were free of contagious germs. Milk flow curves were registered at three times per farm by LactoCorder (n=1589). Additionally parameters of the milking routine, time "first touch until attaching the unit", blind milking times and other parameters were identified. Foremilk samples were taken antiseptically and were analysed by Fossomatic 360â(SCC) and the samples were bacteriologicaly examined according to IDF-standard. The share of bimodal milk flow curves - an indication for insufficient stimulation - were different on the farms. Also the blind milking times were different, even between the farms with automatic take off. There is a significant effect of the bimodal milk flow curves, time "first touch until attaching the unit" and the blind milking time on the milk quality especially on the somatic cell count.

***Key words**: Milk quality, stimulation, bimodality, milking routine, somatic cell count, LactoCorder.*

Introduction

Economic conditions push to a drastic reduction of production costs for milk. Important in this context is an efficient and fast milking process. If all preparing transactions are achieved manually this is very time-consuming. If all preparing processes are completed by hand, must be counted on an expenditure of time by 60 seconds per cow (Worstorff, Dethlefsen, 1994). Accordingly only milking of 60 cows per working hour is possible. This expenditure of time cannot be agreed however with the quest for higher throughputs of cows per hour in the parlor. Therefore many farmers use automatic stimulations and take-offs. In addition to these facilitations there may be a positive effect on udder health. This is caused by the fact that automatic support leads to a constant work flow in difference to the manual job that can change temporarily.

Data acquisition

For the attempt 4 farms with 60 to 240 lactating cows (Holstein Frisian) were available. The herd average efficiency of all farms was situated over 8 000 kg milk / year. The cows were held in loose housing stables with lying box, which were cleaned twice day; feeding was made totally or partly by mixed rations; the herd management of the farms is most comparable. The operations were free of contagious streptococcus (*S. agalactiae, S. canis*) and the quarterly infection rate with *Staphylococcus aureus* was below 5%. The farms used milking machines of different manufacturers, design and configuration. For the investigation the milk flow curves of all cows were recorded by LactoCorder at all work stations. In addition to each measurement and to each animal a milking log was made, in that among other things the milking routine, the udder form, the blind milking times on quarterly level, the time from the first contact with the udder up to fixing milking units and the behavior of the cow was held during milking. From all lactating cows an quarters antiseptical foremilk samples were taken and analysed in the by Staatliches Medizinal-, Lebensmittel- und Veterinäruntersuchungsamt Mittelhessen means of Fossomatic 360â after IDF standard (IDF, 1981). Each farm was measured three times in the distance of three months.

Results

A complete milking routine begins with the foremilking of the first milk jets, checking of the milk and cleaning of the teats, teats crests and udder floor. By these handles at the udder the cow is already stimulated. Additionally a mechanical stimulation can be used. In this study one farm used a vibration stimulation. As parameter for a not sufficient stimulation of the cows and the associated milking readiness the bimodal milk flow curve is considered. The farms differ clearly in their proportion of bimodal milk flow curves (Figure 1).

The highest proportion (32%) could be found on the farm that uses the vibration stimulation. On this farm the cows are milked in an autotandem parlor, so that milking things were fixed directly after foremilking and udder cleaning. For these processes on the average 10 seconds were needed. On the other three farms cows were milked in group parlors. Here all details of milking routine were not completed directly one after another (like in the autotandem system), but in groups of three or five cows. By the waiting period, in which the neighbour cows are foremilked and cleaned, it lasted from the first contact of the udder up to fixing the milking units on these farms between 60 to 130 seconds. The farm with the longest time from beginning of routine up to fixing had also the highest proportion of

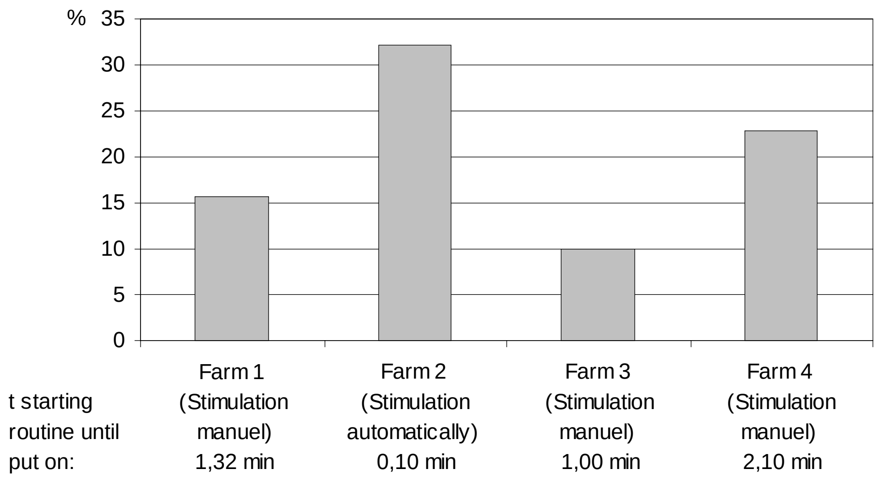

Figure 1. Share of bimodal milk flow curves in per cent (n=1590).

bimodal milk flow curves (23%). The smallest proportion of bimodal milk flow curves could be found on the farm, which manually prepared the udder and had exactly 1 minute between beginning of routine and fixing the milking unit.

The bimodal process of the milk flow curve highly significant correlates with the time of the first contact up to fixing with r = 0.166 (Table 1). Exactly the same negative high significant correlation exists for stimulation and to the milk flow before stimulation. No connection between the behavior during milking and bimodal milk flow curves could be found, however a

Table 1. Correlation of bimodality with selected parameters.

	Milking place	MF before stimu-lation	Stimu-lation	t until attaching	Fit of the unit	Behaviour	Post milking	Somatic cell count	Micro-biology
Bimodality	-0,042**	-0,076**	-0,062**	0,166**	-0,188**	-0,026	-0,086**	0,102**	0,045**
	Lactation	Stadium of lactation	Milk yield	HMF	tMHG	tPL	tAB	tBMG	DMHG
Bimodality	-0,081**	0,142**	-0,182**	0,182**	-0,158**	-0,299**	-0,058**	-0,026**	-0,061**

strong correlation between stepping during milking and bimodality. Assertion for the fact is that animals, which are exposed to stress and therefore step during milking, keep the milk and thus have a bimodal curve. Bimodal curves are very strongly correlated with the parameters of milking. A bad beginning of milking affects thus the entire milking process negatively. The time for the main milk flow (tMHG), the plateau phase (tPL) and phase of descent (tAB) is reduced. Also milk quantity and bimodality are high significantly correlated. Further lactation and stadium of lactation have a high-significant influence on bimodality of the milk flow curve.

The effects of the bimodality on udder health can be detected by means of antiseptical quarter foremilk samples. Parameter for udder health is among other things the number of cells, whereby a cow is considered as udder healthy, if it has a cell content less than 100 000 cells / ml on all four quarters (Deutsche Veterinämedizinische Gesellschaft, 1994). A cell content between 100 000 and 200 000 is already considered as health and also quality impairing; higher cell contents must be defined as pathological. Of the animals, which had a one peak milk flow curve, 35% were udder healthy. If one regards against it the cows with bimodal curve due to stimulation lacking, then here the proportion of healthy animals (29%) is smaller.

These results are acknowledged by the highly significant correlation (r = 0.102) of the bimodal curves and the cell numbers. For further analysis the data were calculated over the analysis of variance. In figure 2 the effects from stimulation and time to fixing are represented on the cell content of the milk. For this the time up to fixing was divided in classes. The smallest

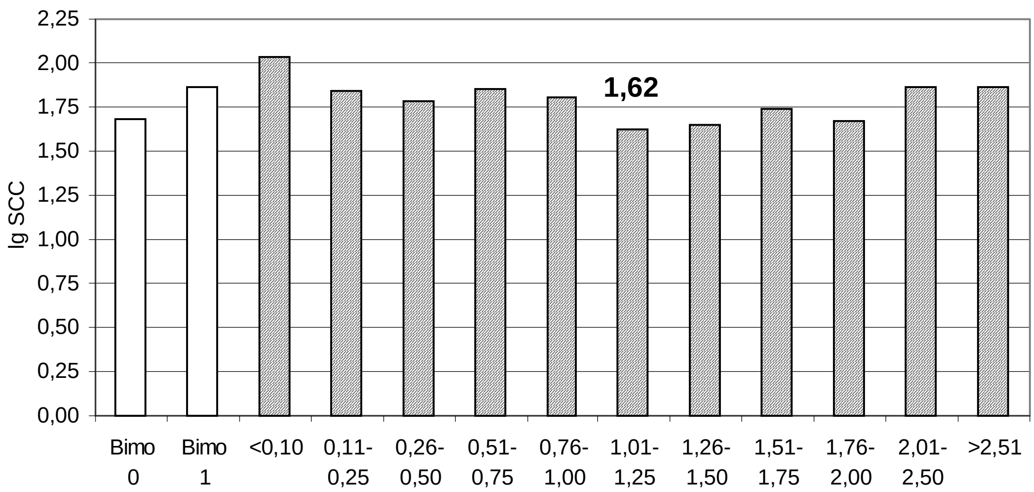

Figure 2 Effects of Stimulation and time "first touch until attaching the unit" on SCC.

cell content was found with a time from the first contact to fixing between one minute and 1.25 minutes. If the time up to fixing is too short or longer than 2 minutes, this affects the udder health negatively. A constant milking routine, with a time of one minute between first contact of the udder and fixing of the milking unit, affects udder health thus positively. In this minute however the udder does not have to be continuously stimulated or touched.

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The assessment parameters of the vacuum regulating device with reducing valve

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Summary

Using special reducing valve enables reducing the energy consumption of vacuum pumps. The vacuum pump may be controlled by changes in rotation speed or by switching on and off. This assignment is dealing with the problems in vacuum tank volume assessment, the values of switch on and switch off vacuum, the vacuum pump efficiency and the pressure differential on the reducing valve – the parameters affecting the period of the switching cycle.

Key words: *Milking machines, vacuum regulating, vacuum pump control.*

Introduction

Research and development in the field of milking technology is usually focused on internal links of the biotechnical system *man-dairy cow organism-milking machine-environment*. There has been a lot of success in this field, which can be documented by the existence of functional milking robots and by the fact that the process of machine milking itself gets accommodated to the individuality of the dairy cow. A considerably less attention was so far paid to energy demands of milking machines. And it is exactly these problems that recently appear in the limelight, particularly in connexion with ecological and economic aspects. Electric energy consumed in vain does not represent only increased costs for the operator, but also an unnecessary environmental load relating to the generation of electric energy. One of the weakest points from the viewpoint of energy utilization is the method of vacuum control.

Material and method

In the classical method of vacuum magnitude regulation the vacuum pump is passed through by a far greater air volume than required for the operation of milking machine. The method of vacuum control by pressure reducing valves issues from the pump characteristic at constant speed. It follows that should we wish to achieve a constant vacuum, the pump must be passed through by a constant air volume. Regarding the fact that the air volume sucked in by the milking machine is variable in time, the pressure reducing valve has to add such a volume of atmospheric air into the vacuum system that would make the sum of air volume sucked in by the milking machine and pressure reducing valve per unit time constant. It further follows that the vacuum pump goes on working at full performance with no regard to the actual consumption of air by the milking machine.

This is the reason why a unit has been designed for vacuum control, in which no atmospheric air would be additionally sucked in. The vacuum pump is passed through only by air from the milking machine, and its operation is controlled in dependence on the instantaneous consumption of air. The unit is illustrated in the figure 1. The vacuum pump set is connected directly to the large-volume air-chamber (big air-chamber). The connection tubing between the pump and the big air-chamber is provided with a back-pressure valve to prevent reversed motion of the pump when the electric motor is switched-off and thus undesirable suction of air occurring due to the action of vacuum from the big air-chamber. The big air-chamber vacuum is maintained by the pump within a selected range p_{n1} to p_{n2} ($p_{n1} > p_{n2}$) so that the minimum value (p_{n2}) is higher than the working vacuum in the milking machine (p_{np}) (Figure 2).

This function is then provided by the vacuum transducer which scans the instantaneous value of vacuum in the big air-chamber and controls the contactor of vacuum pump electric motor via the electronic control member. The contactor would switch-on when vacuum falls to the minimum value

1-electric motor;
2-vacuum pump;
3-big air chamber;
4-pressure reducing valve;
5-small air chamber;
6-vacuum probe;
7-back-pressure valve;
8-electronic control unit;
9-contactor.

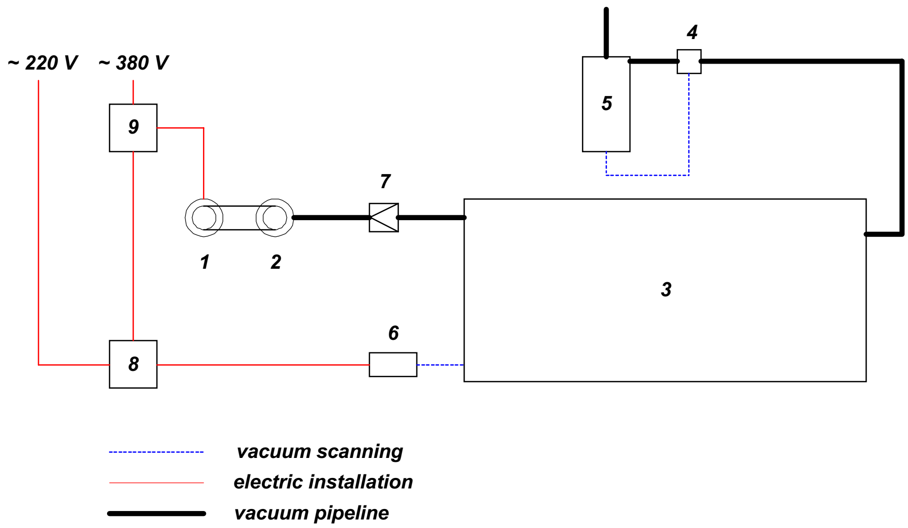

Figure 1. Functional diagram of unit with pressure reducing valve.

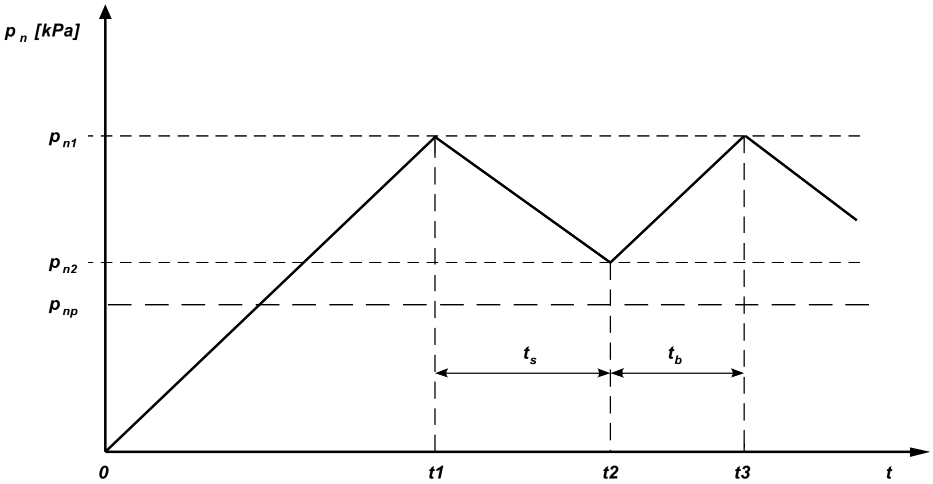

Figure 2. Vacuum control in big air-chamber

p_{n1} – switch-off vacuum;
p_{n2} – switch-on vacuum;
p_{np} – working vacuum in milking machine

(p_{n2}) and switch-off after the maximum adjusted value (p_{n1}) has been reached. This means that the pump operation is not continual; there are alternating time intervals when the pump is in/off the operation. These time intervals depend on pump efficiency, volume of big air-chamber, range of pressures between the contactor switching ons and offs, and on the instantaneous air flow sucked from the milking machine into the big air-chamber. There is a special pressure reducing valve inserted between the big air-chamber and the proper vacuum distribution system, with a small air-chamber whose task is to reduce the variable vacuum from the bih air-chamber to the adjusted value p_{np} and to ensure at the same time its stability. The valve was designed by the author and its prototype manufactured in workshops of the Department of Agricultural, Food and Environmental Technology at the Faculty of Agronomy, Mendel University of Agriculture and Forestry in Brno; its principle and technical solution are protected by patent.

The goal of the measurements was to assess the effect of individual variables on the regime of operation of the proposed equipment and to define their optimum values. Individual variants of measurements were made by an air-flow meter connected onto the input of the control unit and by its gradual opening to adjust the increasing values of air-flow rate. Each of values adjusted in this way was measured for time intervals when the vacuum pump was in/off the operation with simultaneous measurements being also made for vacuum values. The vacuum pump employed in the tests was Model DVL 220 with an output of 7.5 $dm^3.sec^{-1}$ (450 l/min.).

Results

The very first measurements to be carried out were those concerning the value of switch on / off vacuums. We know from experience that vacuum pump input power is increasing in linear way with the increasing vacuum at a simultaneous reduction of pump performance It followed from the dependences that the difference between working pump vacuum occurring within the chosen range $p_{n1} - p_{n2}$ and working vacuum in the milking machine p_{np} should be as small as possible The larger is the difference, the lower is the vacuum pump efficiency.

The first measurement was focused on the determination of minimum difference between the switch-on vacuum p_{n2} and the working vacuum in the milking machine. It was found out that if the difference drops below 2 kPa, the vacuum fluctuation in the milking machine is increasing. This is why the value was proposed to be 3 kPa.

Other two factors (volume of big air-chamber and difference between switch on / off vacuums) have a fairly similar impact on the operation regime. Since an increase in the difference between switch on / off vacuum values is undesirable, it was adjusted to 5 kPa and an influence was studied of the volume of big air-chamber on the length of time intervals between the vacuum pump switch-ons (t_b) and offs (t_s) in dependence on air-flow

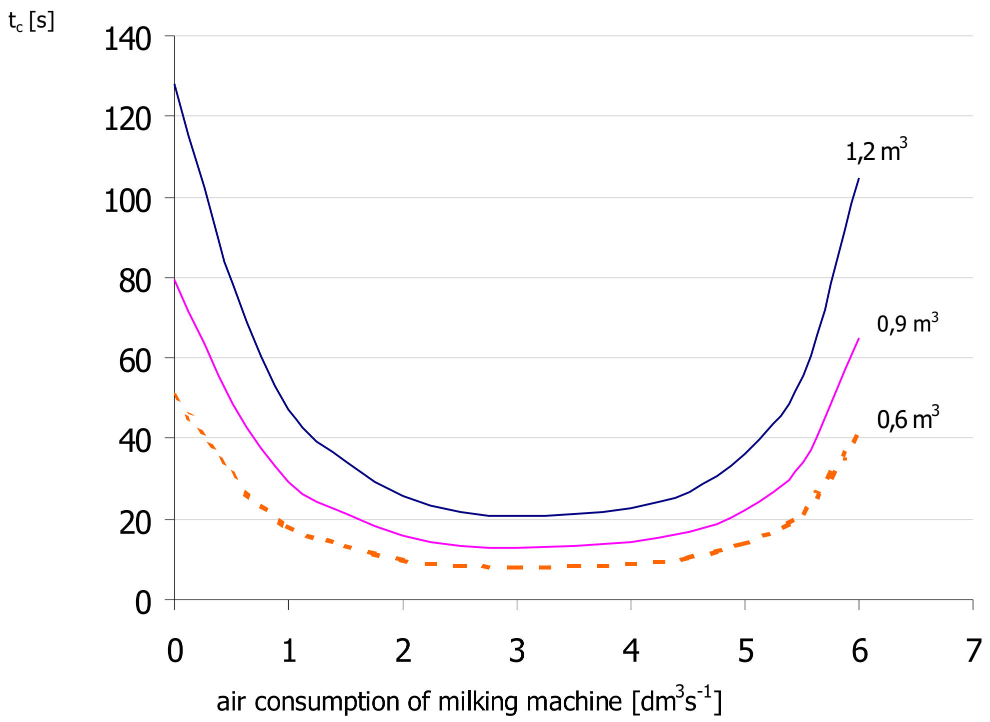

Figure 3. Dependence of switch-on cycle length on air-flow rate at different volumes of big air-chamber.

rate. There were three sizes of air-chamber used in the experiment: 0.6 m^3, 0.9 m^3 and 1.2 m^3. ¨The time interval t_b (t_s) is increasing (decreasing) with the increasing air-flow rate. In order to make a complex assessment of both time intervals, a switching cycle time (t_c) was used, for which it holds that:

$$t_c = t_b + t_s.$$

The measured values are illustrated in figure 3. The switching cycle interval reaches minimum at the moment when the time intervals t_b and t_s are equal. The condition occurs at the flow rate of 2.9 $dm^3.sec^{-1}$ (174 l / min.) regardless of the volume of the big air-chamber. At using the big air-chamber of 0.6 m^3, 0.9 m^3 and 1.2 m^3, the minimum switching cycle will be 8.3 sec, 13.2 sec and 21.4 sec, respectively.

Conclusion

The above measurements evidenced functionality of the control unit with pressure reducing valve within the whole range of vacuum pump efficiency. A minimum difference was assessed between the switching-on vacuum and working vacuum in the milking machine. For the given installation it should be 3 kPa. Also, minimum intervals of switching cycle were determined for different volumes of big air-chamber. From the viewpoint of vacuum pump set operation the number of switching cycles per minute should not exceed 2 or 3. This requirement is corresponded to by a volume of 1.2 – 1.5 m^3 provided that the difference between the switch on / off vacuums is 5 kPa. The effect of a larger difference between the switch on / off vacuums was not tested as the change would have impaired the pump efficiency.

Acknowledgement: The problem was studied by the Project.

The effect of milking device disturbance on SCC in milk of dairy cows

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Summary

Control of the technical condition of pipeline milking systems DZ 100, DZ 100R, DZ2-020 and DZ2-030 was the object of the study. The apparatus Milko Test 2000 was used and 85 equipments were tested. We evaluated: vacuum of milk transfer and milking vacuum line, losses, caused by leakage in milk and vacuum lines, average free air capacity of pumps, pulsation rate, capacity of pipelines and performance of vacuum pump. The state of health in mammary gland was evaluated according to the somatic cell count in bulk samples of milk.

We found increased values of vacuum in 51.8 % equipmenst, leakages in 34.1 % equipments, and 52.8 % pulsators did not show the necessary pulsation rate. We found significant differences in SCC increase with leakage of milking vacuum line and poor capacity of vacuum line. Accumulated occurrence of faults influenced the SCC in milk negatively.

It is without doubt that the quality and function of the milking equipment create a part of the operation reliability for the breeder and participate in production of high quality milk. Well adjusted milking equipment performs milking of good quality and it contributes to acceptable frequency of occurrence of subclinical and clinical mastitis. With the polyfactorial character of mastitis can a possible effect of milking equipment on udders result in higher frequency of mastitis occurrence as a result of more numerous bacterial infections. In our country prevail tying stalls with milking into pipes performed on the standing during the period of decrease in dairy cows population in spite of reconstructions of stables and investments in the milking technique at present.

Klátik (1987) mentioned that if the process of milk gaining is not in line with the needs of dairy cows its components operate inhibitively and it affects negatively the release of milk from the milk gland and the transfer of infectious mastitis is more often. Škarda *et al.* (1990) give that bad functioning of the milking equipment participates with 7 % in the rise of mastitis. Worstorff (1976) mentioned in his work that the fluctuation of underpressure in the milk circuit of the milking equipment causes the rise of back flows which can enable the inner transfer of mastitis. Bradnová and Ryšánek (1989) observed the negative dependence (r=-0.25 to 0.31) between the reserves of performance in the vacuum pump of the milk and underpressure circuit in the pipeline milking equipment and SCC in bulk samples of milk. Zitrický *et al.* (1990) set the level of function parameters in the pipeline milking equipments by the apparatus Milkotest 2000 and studied worsening of milking abilities in them in dependence on period of operation.

***Key words**: Cows, milking, pipeline, milking equipment, somatic cell count, pulsation rate*

Introduction

The level of underpressure recommended for the use in practice changes considerably in consequence of relations between the milking efficiency (performance of milking parlours, etc.) and health condition in dairy cows (Hamann *et al.*, 1994 and Mihina *et al.*, 1998).

Material and methods

Results of thechnic controls of milking equipments in randomly selected agricultural enterprises in SR are embraced in the evaluation. We evaluated totally 85 pipeline equipments (DZ 100, DZ 100R, DZ 2-020, DZ 2-030) in 2 - 4 line tying stalls with milking on the standing. The construction and function of the mentioned types of milking equipments are on the same level, therefore they were evaluated as one type characterizing the pipeline system of milking. The apparatus Milko-Test 2000 was used for the measurements.

We studied:

- the values of underpressure in the milking equipment for the milk circuit and underpressure distributor (kPa) during milking;
- accuracy of measurement by vacuometer (deviations in kPa);
- losses of underpressure caused by leakage in the milk circuit and underpressure distributor (l/min);
- average air consumption per 1 set (l/min);
- number of impulses per minute;
- capacity of underpressure distributor (l/min);
- output of the vacuum pump of milk and air circuits (l/min).

Health condition of the mammary gland in the studied herds was characterized by the somatic cell count (SCC) in bulk samples of milk. SCC was assessed by the apparatus Fossomatic 90.

The results were evaluated by the basic statistical methods and significance of differences between averages was tested by t-test. The values of functional parameters of the milking equipment were classified according to the recommended values with respect to their distribution and relative frequences of disorders were calculated. The so called "more serious disorders" which cause deterioration of the mastitis situation were selected on the basis of t-values from the tests of differences in SCC. The milking equipment was classified according to the number of these disorders.

Results and discussion

Underpressure in milk circuit and in underpressure distributor

Results in table 1 show that the increased values of underpressure in the milk circuit occur quite often (51.8 %). Lower values were noticed only in 3.1 % milking equipments. The average value of the set 54.6 kPa in the equipment we studied was higher than the recommended value. SCC was tested at the underpressure 54 kPa and higher. Increased SCC was noticed with higher underpressure, it was statistically nonsignificant.

Underpressure in the underpressure distributor also exceeded on average the recommended values slightly. High values of underpressure were noticed in 83.5 % cases, only 2.9 % and 13.6 % cases approached the recommended values. Statistically nonsignificant rise of CSS was observed at milking with higher underpressure, too.

Table 1. Underpressure in milk circuit and in underpressure distributor.

Vacuum of milk transfer				
Recommended value 50.0 kPa	Whole set	< 51 kPa (a)	51-54 kPa (b)	> 54 kPa (c)
n	88	3	41	44
	85	3	41	44
$x \pm s_x$	54.6 ± 2.5	49.6 ±3.1	52.8 ± 2.1	57.6 ± 2.6
%	100	3.1	45.1	51.8
SCC thousand / ml				
n	88	3	41	44
$x \pm s_x$	323 ± 80	320 ± 63	319 ± 74	329 ± 82

Significance of differences in SCC- non significant

Vacuum line				
Recommended value 50.5 kPa	Whole set	< 50.5 kPa (a)	50.5-51.1 kPa (b)	>51.1 kPa (c)
n	85	2	12	71
	85	2	12	71
$x \pm s_x$	53.8 ± 2.7	49.8 ± 2.0	50.9 ± 1.8	52.8 ± 1.9
%	100	2.9	13.6	83.5
SCC thousand / ml				
n	85	2	12	71
$x \pm s_x$	319 ± 78	313 ± 69	314 ± 77	320 ± 78

Significance of differences in SCC- non significant

Losses of underpressure caused by leakage in milk circuit and in underpressure distributor

Table 2 shows that average losses of underpressure caused by leakage in the milk circuit were lower than those which are the maximum tolerated. Higher losses were noticed in 36.8 % cases. Important is the significant increase of SCC with greater air leakage in the underpressure distributor (SCC 308 ths / ml or 309 ths / ml with standard level of leakage, it rose to 361 ths / ml, losses rose to more than 40 l / min.; the difference was 21 %).

Table 2. Losses caused by leakage in milk circuit and in underpressure distributor

Milk transfer				
Recommended value max. 67 l / min.	Whole set	< 20 l / min. (a)	21-40 l / min. (b)	>40 l / min.(c)
n	85	29	25	31
$x \pm s_x$	48.5 ± 39.8	18.3 ± 9.8	32.6 ± 29.8	43.2 ±16.9
%	100	34.2	29.0	36.8
SCC thousand / ml				
n	85	29	25	31
$x \pm s_x$	322 ± 75	300 ± 69	301 ± 71	341 ± 82

Significance of diferences in SCC a:c+, b:c+

Vacuum line				
Recommended value 50 l / min.	whole set	≤ 20 l / min. (a)	21-40 l / min. (b)	>40 l / min.(c)
n	85	42	14	29
$x \pm s_x$	49.3 ± 59.5	19.7 ± 31.6	33.8 ± 42.8	43.9 ± 39.6
%	100	49.5	16.4	34.1
SCC thousand / ml n		42	14	29
$x \pm s_x$		308 ± 59	309 ± 64	361 ± 93

Significance of diferences in SCC a:c++, b:c++
+ P<0,05 ++ P<0,01

Average consumption of air per machine

The values in table 3 show that the average consumption of air in the studied equipment was 20.6 l / min., i.e. in the middle of recommended span. Undesirable lower consumption was in 19.9 % studied equipments, higher in 18.5 %. The differences in SCC were nonsignificant.

Table 3. Average consumption of air per one set.

Recommended value 15-25 l/min.	Whole set	<15 l/min. (a)	15-25 l/min. (b)	>25 l/min.(c)
n	85	17	52	16
$x \pm s_x$	20.6 ± 7.5	13.9 ± 6.9	20.1 ± 7.9	27.3 ± 8.3
%	100	19.9	61.6	18.5
SCC thousand/ml				
n		17	52	16
$x \pm s_x$		310 ± 57	323 ± 76	319 ± 80

[3]Significance of differences in SCC - nonsignificant

Number of pulses in milking machines

From 340 tested pulsators pulsed 35.7 % on lower and 17.1 % on higher than recommended frequency (Table 4). It means that 52.8 % pulsators did not show the necessary frequency. Higher frequency in pulsators increased SCC to 331 ths/ml (nonsignificant). The analysis of this state shows further reserves in maintenance of milking technique in practice.

Table 4. Average number of pulses.

Average pulsation rate Recommended value 50±4	Whole set	< 46 (a)	46-54 (b)	> 54 (c)
n	340	121	160	59
$x \pm s_x$	48.3 ± 6.5	44.8 ± 7.9	50.3 ± 5.9	58.3 ± 6.8
%	100	35.7	47.2	17.1
SCC thousand/ml				
n	85	30	40	15
$x \pm s_x$	321 ± 71	324 ± 63	314 ± 73	331 ± 80

Significance of differences in SCC - nonsignificant
-P>0,05

Capacity of underpressure distributor

The average capacity of underpressure distributor exceeded markedly the tolerated minimum (Table 5); 13.4 % cases did not meet this request. It is an important effect as SCC increases markedly with insufficient capacity (359 vs. 314 ths/ml, P<0.01).

Table 5. Capacity of underpressure distributor.

Recommended value min.200 l/min.	Whole set [2]	< 200 l/min. (a)	>200 l/min. (b)
n	85	11	74
$x \pm s_x$	329 ± 129	189,0 ± 89	428 ± 131
%	100	13,4	86,6
SCC thousand/ml			
n	85	11	74
$x \pm s_x$	320 ±72	359 ± 73	314 ± 72

Significance of differences in SCC a:b++

Performance of vacuum pump in milk circuit and in underpressure distributor

Table 6 shows that 13.1 % milking equipments worked with insufficient performance of the vacuum pump. It did not affect the occurrence of CSS significantly.

Table 6. Performance of vacuum pump in milk circuit.

Recommended value min.700 l/min.	Whole set	< 700 l/min. (a)	>700 l/min. (b)
n	85	11	74
$x \pm s_x$	854 ± 159	698 ± 132	998 ± 169
%	100	13,1	86,9
SCC thousand/ml			
n	85	11	74
$x \pm s_x$	321 ± 75	324 ± 50	320 ± 79

Significance of differences in SCC - nonsignificant

Effect of parallel occurrence of more serious defects on mastitis frequency in herd

The so called “more serious faults” of milking equipments were selected during the study of effects of defects on SCC. The choice shows that the underpressure changes and mechanical stressing of tissue in udder and teat are the most common faults:

1. underpressure in milk circuit >54 kPa;
2. losses by leakage in milk circuit and underpressure distributor >40 l/min.;
3. average number of pulses <46 and >54;
4. capacity of underpressure in air distributor <200 l/min.

We analysed the effect of parallel occurrence of these faults on SCC (Table 7). Without these four more serious faults worked only 16.6 % milking equipments. Two parallel faults were observed in 34.6 %, and in 2.8 %

Table 7 Mastitis occurrence in dairy cows (SCC) according to the occurrence of faults on milking equipment (ME).

Number of defects	Number of ME		SCC thousand / ml	
	ks	%	$x \pm s_x$	t
0	14	16.6	311 ± 62	
1	25	28.9	309 ± 70	
2	29	34.6	333 ± 80	
3	15	17.1	346 ± 87	
4	2	2.8	344 ± 77	+++
Total	85	100.0	325 ± 75	

+++ P<0,01

milking equipments were all 4 present. SCC shows continuous, marked to statistically significant rise with rising number of faults. Cumulation of faults manifests itself as a marked risk factor.

The results show quite high number of faults on milking equipment and their often accumulated occurrence and effect on SCC in milk. It is necessary for the agricultural practice not to depreciate the effect of milking equipment on mastitis occurrence and to perform the maintenance and repair of the milking equipment to prevent disorders in dairy cows.

Milking variables in relation to teats preparation and unit attachment delay in cows

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Summary

Milking routines observations were carried out on 84 black and white dairy cows randomly chosen. The effect of the time taken to manually stimulate the teats (cleaning and drying) before the unit is attached "prep-time" divided into two classes (to 30 and >30 seconds) and the time delay from the beginning of the cow preparation process until unit attachment "prep-lag time" also divided into two classes (to 60 and >60 seconds) on milk flow time, total milking time, first minute milk flow rate, average milk flow rate, milk yield and somatic cell counts in milk was investigated. The longest milk flow time was observed in rear teats, for all classes of prep-time and prep-lag time. The greatest difference ($P \leq 0.05$) between front and rear teats was observed for a prep-time and a prep-lag time respectively of 30 and 60 sec.

Prep-time had a significant effect on milk flow time ($P \leq 0.01$), total milking time ($P \leq 0.01$) and first minute milk flow rate ($P \leq 0.01$), this effect was also observed on average milk flow rate ($P \leq 0.05$). However no significant effects were observed on milk yield and somatic cell counts. Total milking time, first minute milk flow rate, average milk flow rate and milk yield decreased as prep-lag time increased. Milk yield was influenced by prep-lag time ($P \leq 0.05$). No significant effects of neither prep-time nor prep-lag time was observed on somatic cell count in milk.

***Key words**: Prep-time, prep-lag time, dairy cow, milk flow rate, milking time.*

Introduction

To withdraw milk efficiently from the bovine mammary gland, the cow must be included as an active partner in the milking process by evoking the milk ejection reflex (Hamann, 1991). Studies have shown that milk ejection is not entirely dependant on the action of oxytocin and that there are also many other factors that control the effectiveness of oxytocin response (Mayer et al., 1984; Svennersten and Claesson, 1990). According to Lefcourt (1982), the effect of teat stimulation on sympathetic tone in the mammary gland is a second milk letdown mechanism. In addition to oxytocin causing milk letdown, the nervous system also plays a role in rate of milk flow through the teat canal (Bruckmaier and Blum, 1998). A minimum of 12-15 seconds of teat contact time is required for sufficient nerve stimulation to ensure adequate oxytocin release and a good milk ejection response (Mein and Reid, 1996). Premilking cow preparation is proven to be an important step in achieving maximum milk yield, quality and udder health. Units should be attached within a window of 60 to 90 seconds from beginning of udder preparation process to take advantage of oxytocin stimulated by good teat manipulation (Rasmussen *et al.*, 1992).

The purpose of this experiment was to investigate the effect of the time taken to manually clean and dry the teats before the unit is attached and the time from the beginning of the cow preparation process until unit attachment on milk flow time, first minute milk flow rate, average milk flow rate, milk yield and somatic cell count in milk.

Material and methods

A field study was carried out on 84 black and white dairy cows randomly chosen. Cows were held in a two tie-stall barn and milked to a pipeline by a set of four milking units MilkMaster with automatic teatcups detachers. All cows were milked using the same milking routine consisting of fore stripping of three to five squirts from each teat followed by teat cleaning with a different total duration.

The machine was attached in a different time for each cow after preparation. The time taken to manually clean and dry the teats before the unit is attached is referred to as “Prep time” and the time from the beginning of the cow preparation process until unit attachment is referred to as “Prep lag time” (Reneau and Chastain, 1995).

Time studies were conducted for three consecutive days at evening milking. Prep time, Prep lag time, milk flow time from individual quarters, first minute milk flow rate, average milk flow rate, total milking time and milk yield were recorded. On the fourth day milk samples were taken during evening milking in order to determinate somatic cell counts using Fossomatic 4000.

The effect of prep time divided into two classes (to 30 sec., >30 sec.) and prep lag time into two classes (to 60 sec., > 60 sec.) on first minute milk flow rate, average milk flow rate, total milk yield and total milking time was investigated.

Results are presented tables as means ± SD. For statistical evaluations STATISTICA 97 software was used. Mean differences of different classes were tested for significant differences using the Duncan’s Test.

Table1. Milk flow time from in individual quarters in relation to prep-time and prep-lag time.

Seconds			Front teats		Rear teats		
Prep-time ranges	Prep-lag time ranges	Number of cows	Left	Right	Left	Right	Quarter effect
	0-60	31	230±34^{AB}	249±48^{AB}	290±74^{Aa}	303±78^{A}	X
0-30	> 60	29	244±44^{CD}	234±52^{CD}	269±77^{BC}	272±92^{Ba}	X
	0-60	11	307±72^{AC}	310±56^{AC}	362±76^{AB}	389±123^{AB}	X
> 30	> 60	13	284±40^{BD}	308±82^{BD}	343±62^{Ca}	350±76^{a}	X
Prep-time effect			XX	XX	XX	XX	-
Prep-lag time effect			NS	NS	NS	NS	-
Lactation effect			XX	XX	XX	XX	-

Means in columns designated by the same capital letter are significantly different at P≤0,01.
Means in columns designated by the same small letter are significantly different at P≤0,05.
NS- means not significant.

Results and discussion

Average milk flow time (MFT) increased significantly in all quarters ($P \leq 0.01$) as prep time increased (Table 1), however no significant effect of prep-lag time was observed even though as cow prep lag time increased, (MFT) decreased. According to Eicker *et al.*, (2000), a well-prepped cow will letdown her milk rapidly and completely and her average flow rate will be higher. The longest (MFT) was observed in rear teats, for all classes of prep-time and prep-lag time. The greatest difference ($P \leq 0.05$) in (MFT) between front and rear teats was observed for a prep-time and a prep-lag time ranging respectively from 0 to 30 and from 0 to 60 sec. The quarter effect was significant ($P \leq 0.05$). Rear teats normally have higher milk yield and take longer to milk than the front ones (Rassmusen, 1993).

First minute milk flow rate (FMMFR) ($P \leq 0.01$) and average milk flow rate (AMFR) ($P \leq 0.05$) were influenced by prep-time and prep-lag time (Table 2). (FMMFR) and (AMFR) were the highest for a prep-time from 0 to 30 sec. and a prep-lag time from 0-60 sec. As prep-time and prep-lag time increased, (FMMFR) and (AMFR) decreased. According to Gorewit and Gassman (1985) a stimulation for 60 or 120 sec. did not achieve higher peak milk flow rates than 15 or 30 sec., and the average milk flow rate increased and machine-on time decreased with duration of stimulation. Milk yield was not affected by prep-time, however it was influenced significantly ($P \leq 0.05$) by prep-lag time. According to Bruckmaeir and Blum, (1996) milk yield was not significantly lower in milking without than with stimulation, whereas machine-on time was prolonged and peak milk flow rate was reduced during milking without stimulation.

Total milking time (TMT) increased ($P \leq 0.01$) as prep-time increased and decreased as prep-lag time increased. The longest (TMT) was observed for a prep-time and a prep lag-time respectively over 30 sec. and ranging from 0 to 60 sec. This is probably due to an inadequate stimulus of the udder. According to Rasmussen *et al.*, (1992) the ideal prep-lag times are 1.3 minutes, or 1.18 minutes. They found that a range of 1 to 1.5 minutes is accepted as the optimal prep-lag time for all stages of lactation. Gorewit and Gassman (1985) concluded that it takes longer to milk out the last kg of milk if premilking teat preparation is conducted inefficiently or even omitted. On the other hand the shortest (TMT) was observed when prep-time ranged from 0 to 30 sec. and prep-lag time was over 60 sec. Better milking preparation causes faster let-down and better milk-out and allows shorter unit-on times (Stewart, 1993). Merill *et al.*, (1987) tested the effects of premilking preparation (full stimulation and minimum stimulation) on milk flow rates and machine-on time. They found that cows receiving full stimulation had significantly higher average milk flow rates and shorter machine on-times starting at week 32. Milk flow rate and yield determine the unit-on time and can have a significant effect on throughput (Reneau and Chastain, 1995). According to Pfeilsticker *et al.* (1995), the time from the start of teat stimulation until maximal pressure (ejection pressure) is 115 seconds. However, milkers, compelled by the speed of premilking cow prep rather than thoroughness, often fail to

Table 2. First minute milk flow, average milk flow, milk yield and total milking time in relation to Prep-time and prep-lag time.

Seconds			(kg/min)				
Prep-time ranges	Prep-lag time ranges	Number of cows	First minute milk flow	Average milk flow	Milk yield (kg)	Total milking time (sec.)	Ln SCC
0-30	0-60	31	2.905 ± 0.800^{AB}	2.476 ± 0.823^{a}	8.263 ± 2.182	313 ± 78^{A}	10.504 ± 1.256
	> 60	29	2.429 ± 0.735^{CD}	2.122 ± 0.514	7.240 ± 2.290	282 ± 92^{BC}	10.655 ± 1.207
> 30	0-60	11	1.903 ± 0.967^{AC}	2.024 ± 0.685	8.042 ± 2.314	399 ± 73^{AB}	11.654 ± 0.752
	> 60	13	1.507 ± 0.384^{BD}	1.789 ± 0.691^{a}	6.641 ± 1.926	360 ± 80^{C}	10.772 ± 1.248
Prep-time effect			XX	X	NS	XX	NS
Prep-lag time effect			XX	X	X	NS	NS
Lactation effect			X	NS	XX	XX	NS

Marks as in table 1.

achieve either adequate teat sanitation or consistent milk letdown stimulus. No significant effects of neither prep-time nor prep-lag time was observed on somatic cell count in milk.

Conclusion

Average milk flow time increased significantly in all quarters ($P \leq 0.01$) as prep time increased, on the other hand no significant effect of prep-lag time was observed on milk flow time. The longest milk flow time was observed in rear teats, for all classes of prep-time and prep-lag time.

First minute milk flow rate and average milk flow rate were influenced by prep-time and prep-lag time. As prep-time and prep-lag time increased, first minute milk flow rate and average milk flow rate decreased.

Milk yield was not affected by prep-time, however it was influenced significantly by prep-lag time.

Total milking time increased as prep-time increased and decreased as prep-lag time increased. The longest total milking time was observed for a prep-time and a prep lag-time respectively over 30 sec. and ranging from 0 to 60 sec.

No significant effects of neither prep-time nor prep-lag time was observed on somatic cell count in milk.

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Milk recording in Germany

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Summary

Cattle production in Germany in special respect of milk recording is described in this paper. The extent of milk recording is 60 % of all dairy herds and 80 % of all dairy cows. Herd sizes are varying from 36 cows in the western part and 192 cows in the eastern part of the country. The average production in 2000 is 7019 kg milk with 4,21 % fat and 3,43 % protein with distinct differences depending on the breeds. Milk recording methods have developed in the last ten years strongly to AT- and B-Methods, also due to the development of modern Milkmeters espicially the Lacto Corder. 118 farms are using automatic milking systems.

Situation

Cattle production in Germany covers 14.5 million animals; 4.5 millions of them are dairy cows to fulfill the national milk quota of about 27.7 million tons. Regular und systematic cattle breeding and milk recording in Germany have a long history. The first herdbook was founded in 1876 in Fischbeck (Sachsen-Anhalt) and the first milk recording organization in 1896 in Schleswig-Holstein.

Table 1 shows the momentary extent of milk recording; 60.1 % of all dairy farms and 80.4 % of all dairy cows. The different herd sizes attract attention. In the western part of Germany the herd sizes get smaller from North to South and amount to nearly 36 cows and in the eastern part 192 cows, this is due to the industrial milk production in the to former German Democratic Republic (DDR).

Table 1. Extent of milk recording.

Region	Recorded Herds Absolut	Herds (%)	Cows Absolut	Cows (%)	Average cows recorded herds	Av. age of recorded cows Year
Schleswig-Holstein	5 050	74.9	301 583	84.7	59.7	4.7
Hannover-Bremen	6 834	69.9	312 360	82.5	45.7	5.0
Weser-Ems	7 324	70.6	305 819	80.5	41.8	5.0
Westfalen-Lippe	4 412	52.9	167 790	74.9	38.0	4.7
Nordrhein	2 872	68.7	145 421	86.9	50.6	2.1
Hessen	3 574	53.3	127 079	78.1	35.6	4.9
Rheinland-Pfalz	2 421	62.6	101 329	77.7	41.9	4.8
Saarland	251	74.0	12 304	81.8	49.0	5.0
Baden-Württemb.	10 338	51.4	309 200	72.1	29.9	5.2
Bayern	35 696	57.4	1 039 040	73.4	29.1	5.0
Mecklenburg-Vorp.	977	78.9	186 033	95.5	190.4	4.6
Brandenburg	809	77.0	184 030	93.7	227.5	4.5
Sachsen-Anhalt	791	79.7	138 837	90.2	175.5	4.6
Thüringen	569	61.6	131 505	93.1	231.1	5.2
Sachsen	1 258	75.3	206 836	93.8	164.4	4.4
Total	*83 176*	*60.1*	*3 669 166*	*80.4*	*44.1*	*4.8*

Table 2 shows the average production of all recorded cows. Milk Recording in Germany is done by 15 regional Milk Recording Organizations-combined in the German Cattle Breeders Organization (ADR, Bonn) - according to the rules of ICAR and national regulations. Looking at the milk yield it is meaningful, that the cows in Eastern Germany raised their yield on an average of 270 kg per year in the last 10 years after the political reunion, mostly due to intensive efforts in breeding, feeding, housing etc.

Table 3 shows the average production of all recorded cows by different breeds; Dairy breeds as for e. g. Holsteins have the highest yield followed by the dual purpose and local breeds.

In table 4 you can see the use of ICAR-approved milk recording methods. Until 10 years ago more than 95 % of all cows were tested with the A4-method. At the moment only 53 % of all cows are tested with the A4-method and nearly 14 % with the B4-method, further 17 % are tested by the AT4- and nearly 2 % by the BT4-method. In Bayern (small herds, high costs) nearly 40 % of all milk recorded cows are tested by the AM4-system, that means milk yields at every milking time but alternating sampling. In the field of AM4- and BM4-testing the Lacto Corder is used, in Bayern about 8 000 meters.

Table 5 shows the milking equipment in recorded herds, which depends strongly on the herd size.

According to this we have to see the use of milk meters, which is shown in table 6. Of course, every assistant of the milk recording organizations still has scales. However in the case of Milk-Line-Systems and also in Milking

Table 2. Average production of all recorded cows by milk recording organization.

		Milk	Fat		Protein	
Region	Cows	kg	%	kg	%	kg
Schleswig-Holstein	297 293	7 430	4.28	318	3.42	254
Hannover-Bremen	314 960	7 946	4.26	338	3.41	271
Weser-Ems	311 384	7 803	4.28	334	3.38	264
Westfalen-Lippe	169 029	7 715	4.22	326	3.37	260
Nordrhein	146 207	7 430	4.20	312	3.35	249
Hessen	129 080	7 077	4.22	299	3.35	237
Rheinland-Pfalz	104 463	6 693	4.25	285	3.32	222
Saarland	12 494	6 556	4.22	277	3.32	218
Baden-Württemb.	305 111	6 156	4.15	256	3.41	210
Bayern	1 029 460	6 192	4.12	255	3.49	216
Mecklenburg-Vorp.	185 605	7 486	4.25	318	3.47	260
Brandenburg	184 604	7 293	4.24	309	3.47	253
Sachsen-Anhalt	139 144	7 551	4.23	319	3.46	261
Thüringen	132 946	7 198	4.26	307	3.44	247
Sachsen	207 887	7 393	4.30	318	3.46	256
Total 2000	*3 669 667*	*7 019*	*4.21*	*296*	*3.43*	*241*
Total 1999	*3 742 685*	*6 752*	*4.22*	*285*	*3.43*	*232*

Table 3. Average production of all recorded cows by breed.

Breed	Cows	Milk. days	Milk kg	Fat %	Fat kg	Protein %	Protein kg
Holstein-Sbt	2 039 209	317	7 624	4.24	323	3.41	260
DSB[2])	2 177	313	6 397	4.28	274	3.53	226
Holstein-Rbt	315 080	316	6 901	4.25	294	3.37	233
RDN[3])	61 201	304	6 408	4.24	272	3.45	221
Rotvieh	17 626	318	6 655	4.84	322	3.63	241
Rotvieh alter Zuchtrich.	396	289	6 185	4.34	268	3.46	214
Jersey	2 953	313	4 998	5.93	297	4.08	204
Fleckvieh	932 751	316	6 046	4.12	249	3.48	210
Braunvieh	207 733	322	6 182	4.13	255	3.56	220
Gelbvieh	9 315	314	5 372	4.13	222	3.52	189
Vorwälder	6 954	315	5 047	4.13	208	3.31	167
Hinterwälder	672	304	3 392	4.05	137	3.40	115
Pinzgauer	527	307	4 649	3.89	181	3.35	156
Murnau-Werdenfelser	208	302	4 242	3.63	154	3.28	139
Limpurger	143	311	4 301	4.02	173	3.32	143
Sonstige[1])	72 722	316	6 530	4.23	276	3.42	224
Total 2000	*3 669 667*	*317*	*7 019*	*4.21*	*296*	*3.43*	*241*
Total 1999	*3 742 685*	*315*	*6 752*	*4.22*	*285*	*3.43*	*232*

[1]Also cows in mixed herds
[2]Holstein-Sbt, Dual purpose
[3]Holstein-Rbt, Dual purpose.

Table 4. Use of ICAR-approved milk recording methods (cows).

Region	AS[1)]		BS[2)]		AT[3)]		BT[4)]		AM[5)]		BM[6)]	
	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
Schleswig-Holstein	59 614	19.8	103 293	34.2	70 518	23.4	34 840	11.5	9 618	3.2	23 700	7.9
Hannover-Bremen	268 749	86.9	6 471	2.1	30 399	9.8	966	0.3				
Weser-Ems	280 842	91.9			24 886	8.1						
Westfalen-Lippe	148 505	88.5	16 066	9.6	3 219	1.9						
Nordrhein	112 972	77.7			32 443	22.3						
Hessen	116 983	92.0	10 158	8.0								
Rheinland-Pfalz	101 329	100.0										
Saarland	12 095	98.1	240	2.0								
Baden-Württemb.	235 776	76.3	63 345	20.5	7 081	2.3	2 998	1.0				
Bayern	188 376	18.2	2 289	0.2	419 773	40.6	91		410 183	39.7	12 183	1.2
Mecklenburg-Vorp.	25 787	27.9	66 548	72.1								
Brandenburg	96 843	52.6	84 511	45.9	115	0.1	2 561	1.4				
Sachsen-Anhalt	73 661	53.1	46 585	33.6	219	0.2	10 417	7.5	396	0.3	5 475	3.9
Thüringen	50 619	38.5	50 896	38.7	452	0.3	7 589	5.8	1 189	0.9	20 760	15.8
Sachsen	115 153	55.9	32 585	15.8	16 324	7.9	6 616	3.2	17 292	8.4	18 138	8.8
Total	*1 887 304*	*53.0*	*482 987*	*13.6*	*605 429*	*17.0*	*66 078*	*1.9*	*438 678*	*12.3*	*80 256*	*2.3*

ICAR approved milk recording methods in Germany in 1999:

1) AS: 4 weeks, assistant
2) BS: 4 weeks, farmer
3) AT: 4 weeks, alternating, assistant
4) BT: 4 weeks, alternating, farmer
5) AM: 4 weeks, alternating sampling, assistent
6) BM: 4 weeks, alternating sampling, farmer

Table 5. Milking Equipment in recorded herds (percent).

Region	Bucket sets Abs.	%	Milk-line-system Abs.	%	Milking parlors Abs	%
Schleswig-Holstein	61	1.11	1 664	30.28	3 771	68.61
Hannover-Bremen	558	7.10	4 010	48.42	3 684	44.48
Weser-Ems	486	6.00	4 067	50.24	3 542	43.76
Westfalen-Lippe	236	4.72	2 841	56.83	1 922	38.45
Nordrhein	71	2.24	1 350	42.68	1 742	55.07
Hessen	345	8.82	2 360	60.34	1 206	30.84
Rheinland-Pfalz	98	3.84	1 312	51.35	1 145	44.81
Saarland	-	-	110	41.51	155	58.49
Baden-Württemb.	2 040	18.67	5 710	52.25	3 179	29.09
Bayern	4 897	13.36	24 813	67.70	6 941	18.94
Mecklenburg-Vorp.	37	3.58	146	14.12	851	82.30
Brandenburg	22	2.59	154	18.10	675	79.32
Sachsen-Anhalt	40	3.98	205	20.40	760	75.62
Thüringen	82	12.69	229	35.45	335	51.86
Sachsen	74	5.89	351	27.95	831	66.16
Total 1999		*10.18*		*55.33*		*34.48*
Total 1998		*11.30*		*57.19*		*31.51*

Parlors mostly the Tru Test Milkmeter is in use, nearly 48 000 all over the country. Milk jars are installed mainly in the north-western part of Germany, espicially in Weser-Ems.

Bigger farms with loose housing systems, milking parlors and modern herd management systems have electronic milk meters, mostly in the northwestern part of Germany (Schleswig-Holstein, Niedersachsen) and especially in the eastern part of Germany with the big herd sizes of approximately 200 cows, at the moment more than 50 % of all milk recorded herds in Eastern Germany have such techniques.

Table 6. Use of milk meters.

Region	Scales	Tru Test	Waikato	Milko Scope	Jars	Electronic MM Meters	farms
Schleswig-Holstein	133	3 500	13	12	3 292	2 539	478
Hannover-Bremen	298	5 103	126	-	1 303	3 183	284
Weser-Ems	622	4 708	-	-	8 507	4 029	444
Westfalen-Lippe	130	2 400	-	-	823	1 468	180
Nordrhein	340	3 188	-	-	568	617	60
Hessen	500	2 480	-	6	128	745	82
Rheinland-Pfalz	250	1 200	-	-	-	34	k A
Saarland	6	200	-	-	450	73	8
Baden-Württemb.	1 215	5 747	-	147	569	2 282	270
Bayern	3 650	9 700	-	-	1 179	14 988	21 760
Mecklenburg-Vorp.	25	2 508	118	20	98	6 954	337
Brandenburg	21	1 835	22	32	6	7 484	394
Sachsen-Anhalt	20	1 569	40	32	38	5 723	362
Thüringen	30	1 527	168	20	42	5 791	330
Sachsen	65	2 175	198	86	108	8 395	435
Total 1999	*7 305*	*47 840*	*685*	*355*	*17 111*	*64 305*	*25 424*
Total 1998	*8 110*	*50 698*	*643*	*412*	*16 431*	*53 804*	*4 487*

8 000 of nearly 15 000 electronical milk meters in Bayern are Lacto Corder, they are mobile meters and are used for milk recording, more and more for testing milkability and also for advising the dairy farmers in milk production.

Recently the ADR made a survey of the extent of automatic milking in Germany. We found that at the moment 118 dairy farmers use robotic milking systems of 6 producers, most of these farms are located in North-western Germany, (Niedersachsen 20 farms and Bayern 22 farms).

Main fields of activities of the German milk recording organisations

- Official Milk recording of cows, sheep and goats;
- Analyzing milk samples both for milk recording and milk quality for payment;
- Cattle marking with ear tags according to EU-rules;
- Tasks in Quality Dairy Production and advising the farmers.

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Influence of the duration of a and c phase of pulsation on the milking characteristics and on udder health of dairy cows

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Summary

Two experiments were carried out at the experimental farm of Derval (France) in order to study the influence of the duration of the a and c phases of pulsation on the milking and udder health of dairy cows.

The first experiment compared (in a Cross-over experimental design) three durations of a and c phases (a = 13, 15 and 22 % and c = 8, 12 and 16 % of the pulsation cycle) at three vacuum levels (39, 42 and 42 kPa). The experiment lasted 3 periods of 6 weeks during which milk ejection parameters were recorded.

The second experiment compared two groups of animals, the first one milked with the following phases: a = 14 and 23 % (adjustment A) and c = 9 and 15 % (adjustment B) during 5 months. Udder health parameters were essentially recorded: clinical mastitis, somatic cells counts and teat end conditions.

Milking time and milk flow rates are the parameters widely dependent on the duration of a and c phases. The shortest phases produced the longest milking times (+ 4.7 up to +10.1%) and the lowest flow rates (- 3.3 up to -7.8%).

Neither of the two experiments showed a marked effect of the duration of a and c phases on udders health and teat end conditions were also relatively similar to the different treatments. A small tendency was found in which teat end conditions were worse especially those cows with sharp teat ends shapes when they were milked with the shortest phases.

A c phase of 12 % and an a phase of 14-16 % of the pulsation cycle should be a good compromise in order to avoid increasing milking times and to prevent any sanitary problems, with the current liners vacuum levels.

Introduction

Pulsation is well known to be one of the most important elements of milking machines which has a great influence on milking and on udder health. Many scientific studies and a lot of field observations have shown that pulsation failures are directly implicated in mastitis and high somatic cell counts.

The main pulsation parameters are the frequency, the ratio, and the four phases, (a, b, c and d) as described in ISO 3918 (1996). ISO Standard 5707 (1996) specifies that "*phase b shall be not less than 30 % of a pulsation cycle. Phase d shall be not less than 15 % of a pulsation cycle and shall be not less than 150 ms*". However, a and c phases are not included in the above mentioned ISO Standard especially because of a lack of scientific results on their influence on the milking and udder health of dairy cows.

In France some field technicians and farmers advisers think that too short a and c phases, but especially the c phase, are involved in udder troubles and particularly clinical mastitis and high somatic cell counts.

Therefore, two studies were undertaken in an experimental farm in Derval (France) in order to investigate the effects of a and c phases duration at different vacuum levels on the milking and udder health of dairy cows.

Materials and methods

The first study was carried out in a tunnel parlour with 3 stalls and 3 units in low line and 27 cows were used in a Cross-Over experimental design. Pulsation rate was 60 cycles/min and pulsators ratio 60%. Three a and c phases were studied:

- adjustment 1: a = 13 % and c = 8 %;
- adjustment 2: a = 15 % and c = 12 %;
- adjustment 3: a = 22 % and c = 16 %),

all at three vacuum levels: 39, 42 and 45 kPa.

Three groups of 3 cows were milked during 3 periods of 6 weeks with the three adjustments and each vacuum level.

Milking units were Harmony clusters from DeLaval with the liner number: 999007-03. Pulsation parameters as a and c phases were adjusted by a special device at each unit. All parameters were checked before the beginning of the study and between each period.

The recorded parameters were the following: total milk yield, machine milk yield, machine stripping yield, total milking time, machine milking time, stripping time, average and maximum milk flow rates. These parameters were recorded 4 times a week (2 in the morning and 2 in the evening). Once a week teat end thickness before and after milking were measured with a cutimeter (Haupner) and somatic cell counts for each cow were analysed.

The second study was carried out in the herringbone milking parlour of the experimental farm 2 x 5, 10 units in low line and lasted 5 months. Two groups of 20 cows, matched for number and stage of lactation, milk yield and SCC, were milked twice a day at 41 kPa and a pulsation rate of 60 cycles / min and a ratio of 60 %. The first group was milked twice a day with a and c pulsations phases respectively of 14 % and 9 %, and the second group respectively of 23 % and 15 %. The recorded parameters were: SCC once every two weeks, teat end thickness before and after milking and teat end conditions twice a month.

Results

All data analysed in experiment 1 with the 3 vacuum levels together do not show any statistical difference on total milk yield (TMY), machine milk yield (MMY) and machine stripping yield (MSY). TMY was around 26,3 litres / day for each adjustment, MMY around 25.7 l / day and MSY around 0.60 l / day.

On the contrary, statistical differences were found for total milking time (TMT) and machine milking time (MMT) but not for machine stripping time (MST) (Table 1).

Because cows milked at different vacuum levels were not exactly matched on milk production before the experiment, we could not compare milk yield between each vacuum level. It was only possible to study the influence of the three adjustments at each vacuum level.

Table 1. Milking times during experiment 1 (seconds/cow/day).

Adjustment	1	2	3
TMT	736,9 [a]	716,7 [a b]	707,7 [b]
MMT	670,6 [a]	648,4 [a b]	631,8 [b]
MST	66,3 [a]	68,3 [a]	70,9 [a]

Values with different letters within the same line indicate significant differences (P<0.05).

When a and c phases were decreased from adjustment 3 to adjustment 1, TMT and MMT respectively increased of 4.1 % and 6.1 %. The same tendency was found when analysing results at each vacuum level (Table 2).

TMT and MMT had a bigger increase with the lower vacuum levels. For example, MMT raised from 11.2 %, 8.7 % and 6.4% respectively at 39, 42 and 45 kPa between adjustment 3 and adjustment 1 .

Table 2. Total milking times (TMT) for each vacuum level (seconds/cow/day).

Vacuum level (kPa) Adjustment	39	42	45
1	767,4 [a]	748,1 [a]	695,0 [a]
2	748,1 [a b]	729,1 [a b]	695,9 [a b]
3	695,0 [b]	700,2 [b]	663,8 [b]

Values with different letters within the same column indicate significant differences (P<0.05).

Raising milking times when milk yield does not vary in the same proportion means that the short phases have a negative effect on average flow rate (AFR) as shown in table 3. They also have the same tendency on the maximum milk flow rate (MAXFR) at different vacuum levels but no significant differences were found. MAXFR decreased from respectively 3.3 %, 7.8 % and 6.4 % at 39, 42 et 45 kPa. The effect seems bigger at the higher vacuum levels.

Table 3. Flow rates in experiment 1 (litres/min).

Adjustment	1	2	3
AFR	2.319 [a]	2.425 [a b]	2.488 [b]
MAXFR	3.704[a]	4.242 [b]	3.942[b]

Values with different letters within the same line indicate significant differences (P<0.05).

SCC were recorded during both experiments but neither in experiment 1 nor in experiment 2 were any significant differences found. It seems that there is no specific relationship between udder infection and duration of the a and c phases of pulsation. in experiment I SCC vary 93 000 and 139 000 the adjustment and the vacuum level. Similar results were noticed in experiment 2 (Figure 1).

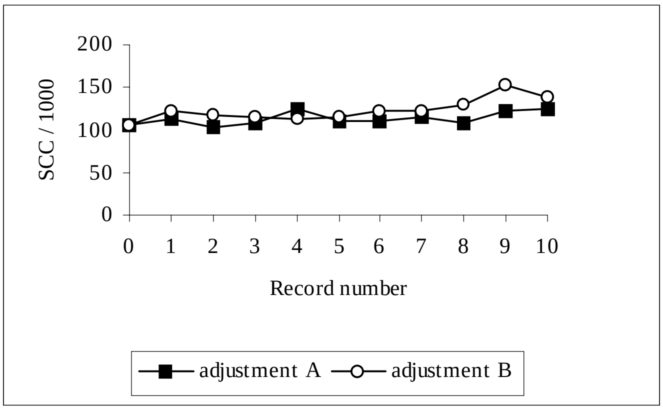

Figure 1. Evolution of SCC of the two groups of animals in experiment 2 (geometric means).

Changes in teat end thickness (relative to pre-milking thickness) were not statistically different between the 2 groups of animals in experiment 2. We only noticed that the difference is higher (softer teats?) when cows are milked with the longest phases between record 3 and 8. In addition, the number of teats with differences (after – before milking) equal or more then 5 %, suggested as an acceptable limit before high sanitary risks (Zeconni and Hamann, 1992), was similar in the two groups of cows (72 with short phases and 74 with long phases).

During experiment 2, teat end conditions were assessed for two teats (one front and one rear) as following: 0 = good conditions (normal teats) to 6 = very bad conditions (subcutaneous haemorrhages, hyperkeratosis, sphincter eversions, congestion and oedema).

In average teat end conditions were good, between 1.5 and 2.3, and similar in the two groups of cows. However, a significant difference was found only for the front teat for cows milked with the shortest phases as shown in figure 2.

Discussion

Milking time and milk flow rates are the parameters widely dependent on the duration of a and c phases. Results obtained by various authors are very similar to ours (O'Shea, 1983, Rosen *et al.*, 1983, Neijenhuis *et al.*, 1999). Comparable results found in different milking conditions indicate the existence of a relationship between milk flow rates and duration of a and c phases. The shorter the phases, the lower the flow rates and the longer milking times are.

In our study, teats stimulation was good and vacuum under teats was controlled during the experiment. However, it is possible that short phases induced animals reactions (pain and / or discomfort) because of faster

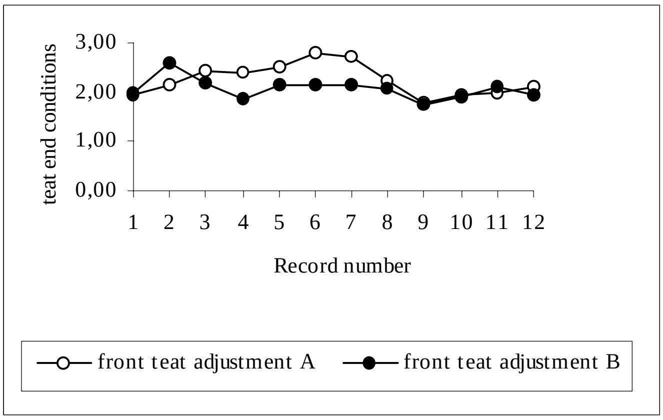

Figure 2. Teat end conditions of the front teat during experiment 2.

movements of the liner and then a certain degree of congestion. Neijenhuis (1999) observed that animals were more nervous on the platform when they were milked with short a and c phases with a small reduction of the diameter of the steak canal and a significant increasing of the teats wall thickness.

Nevertheless, neither of our two experiments showed a marked effect of the duration of a and c phases on udders health and teat end conditions were relatively similar to the different treatments. A tendency was found in which teat end conditions became worst especially for cows with sharp teat ends shapes milked with the shortest phases.

We also have to say that the two experiments were carried out with healthy cows and that experiment 2 lasted only 5 months.

Conclusion

The a and c pulsation phases are surely involved in the liner movements and compressive loads applied by the liner on the teat. Loads particularly depend on the shape, the internal diameter of the barrel and the flexibility of the liner, milk flow rate and pulsation characteristics and the teat itself. Investigations should be made on liner movements related to the studied phases in order to obtain more precisions on their action on milking and udder health.

In any case the two experiments did not produce any proof that milking with short a and c phases will automatically increase clinical mastitis, SCC and damage teat end conditions.

A final proposal with a c phase at 12 % and an a phase at 14-16 % of the pulsation cycle should be a good compromise in order to avoid to increase milking times and to prevent any sanitary problems, with the current liners and at vacuum levels within the range of 39 – 44 kPa.

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Vibrations and vacuum stability in milking equipment

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Lately, the number of large and complex milking systems installed in practice has increased. Farmers make major investments hoping that the new milking system will reduce labour requirements and improve milk quality. Despite the fact that the installation of such milking systems is carried out according to the ISO norm 5707, problems relating to milking and the health of the mammary glands of the animals have occurred. For this reason, we launched a project with the following aims:

- Work out measuring techniques and determine assessment criteria
- Identify the causes for the malfunction of the milking systems and work out measures to eliminate them
- Verify the impacts of the measures taken
- Work out a diagnostic method suitable for practical application
- Work out recommendations for the practice

Vibrations on the construction of the milking parlour

First investigations have shown that incorrect installation (unintended and unknown) can cause vibrations on different surfaces (construction) of the milking parlour, which may be transferred to the animals.

With regard to human beings, the ISO norm 2631-1 indicates that a vibration intensity varying between 0,8 m/s^2 and 1,6 m/s^2 is considered to be unpleasant.

In our numerous investigations, we measured the following values *inter alia*:

- Outlet of the receiver 9,7 m/s^2
- Neck bar 6,2 m/s^2
- Construction of the milking parlour 3,9 m/s^2
- Dung channel 6,1 m/s^2

We assume that cows are at least as sensitive to vibrations as human beings. Therefore, it is obvious that, given the above mentioned values, the cows do not like to be milked in the milking parlour or that they do not release all their milk.

Figure 1 shows how vibrations can be reduced by modifying the installation.

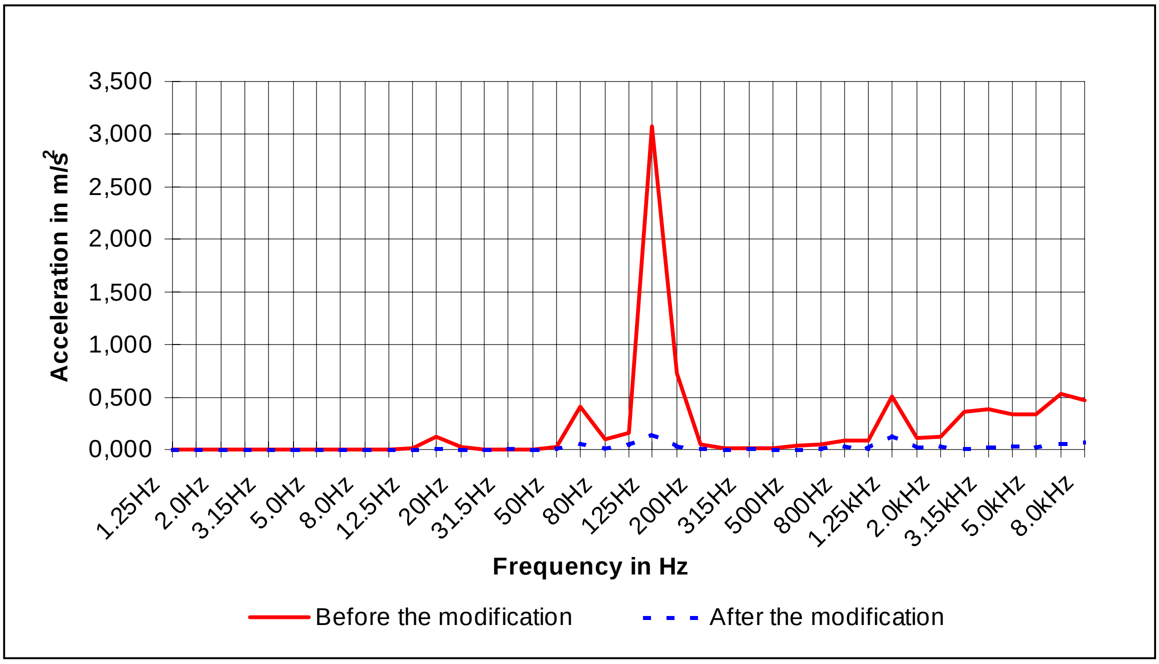


Figure 1. Vibrations measured in the milkline.

Transfer of the vibrations to the vacuum system

The major aim of every milking system is to reach a stable vacuum from the air pipe to the claw and the top of the teat. The vibrations of the construction of the milking parlour are also transferred to the vacuum system and intensified by wrong installation or additional devices (pulsator, regulator valve). Figure 2 and 3 illustrate the impacts of the technical modifications on the vacuum stability in the air pipe and the milk line respectively.

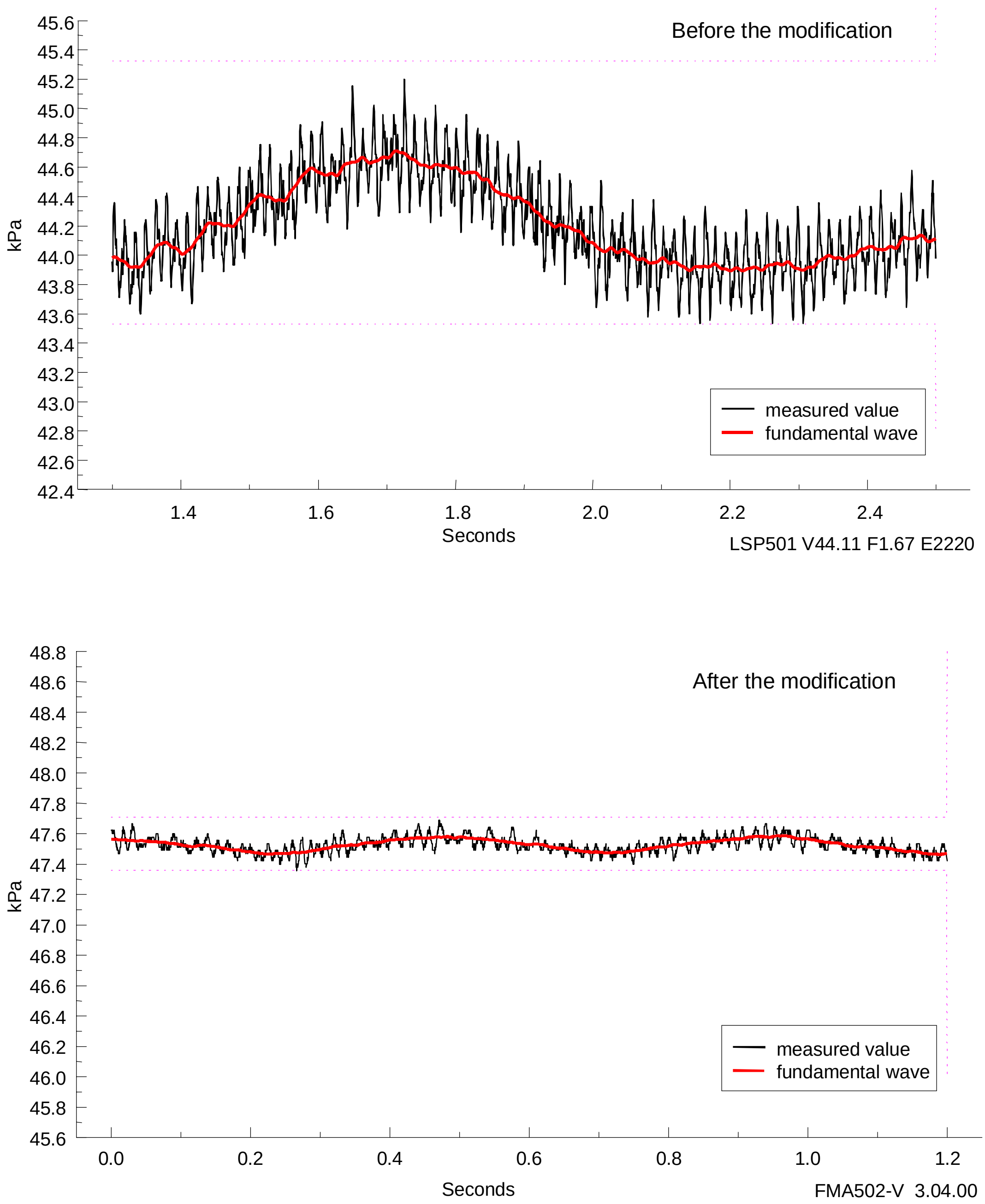
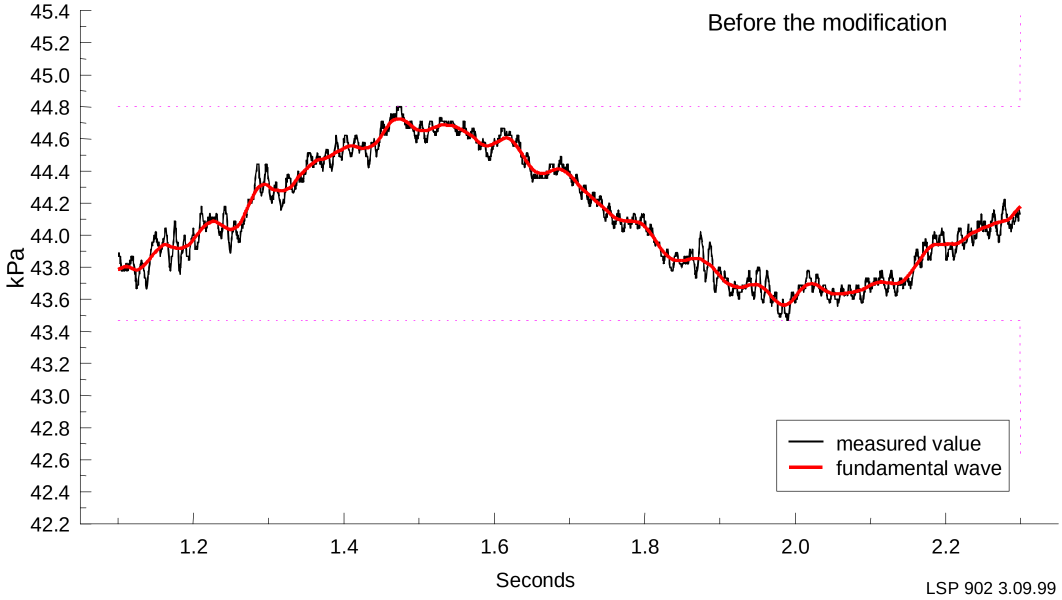


Figure 2. Vacuum stability in the air pipe before and after the modification.



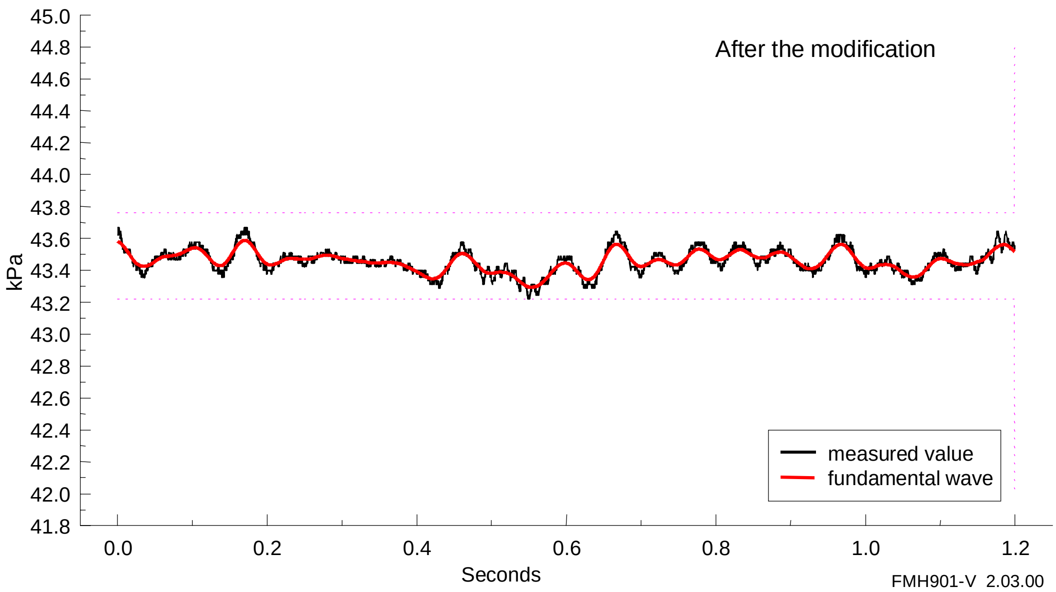


Figure 3. Vacuum stability in the milkline before and after the modification.

Conclusions

In case of problems with milking and the health of the mammary glands, it is particularly important to answer the following questions:

- Do the vibrations transferred to the cows cause discomfort to the animals?
- Are the vibrations also transferred to the vacuum system ?
- Does wrong installation cause problems with regard to the milk flow or fluctuations in the vacuum system ?

On the basis of the answers to these questions, it will be possible to work out measures and to proceed to a stepwise modification of the installation.

Testing of vacuum during milking

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Abstract

Knowledge of the milking equipment working under normal conditions provides a good tool for evaluation of the influence of the equipment in relation to the risk for mastitis. With the computer system MT30 / MT2000 and similar systems, it is possible to use the testing equipment on the individual farm during milking. Testing during milking provides valuable information on both the technical condition of the milking machine and the ability of the milker to use the system. Changes in operator habits are cheap and may improve vacuum stability. Visualisation of vacuum fluctuations can be convincing.

Key words*: milking, test instruments, test methods.*

Introduction

It is well known that milking procedure and techniques are factors with a major influence on the udder health. However, mastitis is a multifactor disease and the search for single factors that cause mastitis outbreak is normally unsuccessful, but measurements during milking has shown account for 26% of the variation in new infection with mastitis between herds. (M. D. Rasmussen, Proceedings of 25th IDF Congress 1998). In fact, milking is a co-operation between three parts, viz. the cow, the milking machine and the milker.

Criteria to be considered during the milking evaluation include: (J. Hamann; Bulletin of the IDF 321):
1. Operator action and behaviour.
2. Animal factors and behaviour.
3. Machine characteristics.
4. General housing and management conditions.

Evaluation of the milking equipment - or the machine characteristics - is traditionally performed as dry and wet tests. The tests give information about the milking equipment upon machine running but not in connection with milking (ISO 5707, 1996; ISO 6690, 1996).

With the new measuring equipment, vacuum measurement of milking machine, liner and mouthpiece at the same time is now possible, and consequently, throws light on the interaction between cow, milking machine and milker. This provides a good basis for detection and evaluation of faults which may influence both milking and udder health.

Previously such tests were only carried out in a laboratory. With the computer system MT30 / MT2000, developed in co-operation between the Danish Dairy Board and the Danish Institute for Animal Science in Foulum, Denmark, it has been possible to use the testing equipment on the individual farm during milking since 1996.

Measuring equipment

MT30 is a portable computer with five transducers for the vacuum gauges. At the moment, the Danish Dairy Board and the Danish Institute for Animal Science in Foulum, Denmark are developing the new generation of measuring equipment, MT2000, which is handier and has the possibility of mounting at least eight transducers. MT2000 is expected to be ready for use in the autumn of 2001.

At present as a standard procedure, testing is carried out at the: (M. D. Rasmussen *et. al.*, N. M. C. 1996)
1. short milk tube (beneath the teat end);
2. mouthpiece;
3. short pulsator tube;
4. milk line;
5. pulsator line.

In the event that testing should be carried out under special circumstances, it is possible to mount the transducers elsewhere. For instance different types of liner could be mounted at the same milking unit, making it possible to measure the type of liner that is suitable for that type of cow. With the new generation of testing equipment, MT2000, simultaneous information recording from eight different transducers is possible. Both MT30 and MT2000 provide the opportunity of changing between different input frequencies from the transducers. The minimum sample frequency required depends on the circumstances of measurement. (D. J. Reinemann *et al.*, 2001) In Denmark - under practical conditions, application of at least 200 Hz for all vacuum transducers is recommended.

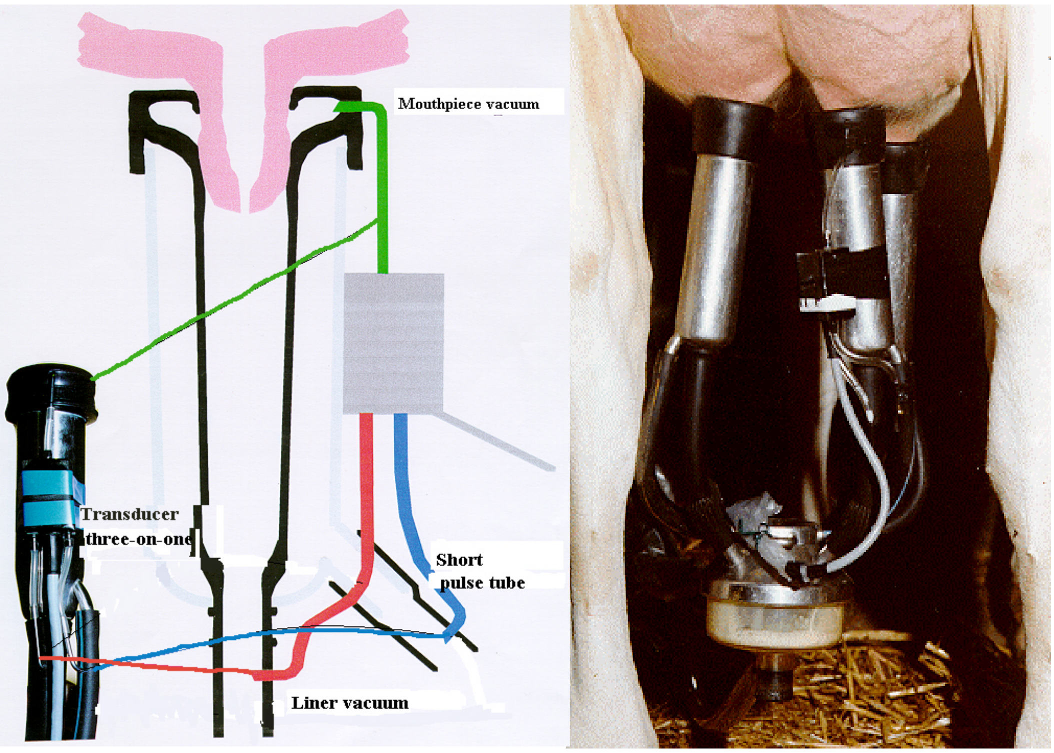

Fig. 1. Milking unit test points by means of dynamic testing.

The advantages of testing during milking

Both vacuum level and vacuum stability of the "fixed milking machine" are evaluated during practical testing conditions. The vacuum stability of the milking section is of special interest. The stability depends on dimensioning / drop, milk flow and the amount of air used during attachment / detachment of the milking units. An evaluation of the optimum functionality of the milking routine chosen is also obtained and in addition it is possible to have an impression if the removers remove at the correct time.

The testing expresses in which way the teat and the liner fit together in the herd. The dimension of the liner in interaction with the teat size of the cows is in focus. It is important that the cows tested represent the average cows of the herd.

Observations during milking

One unit is followed during the milking of the heard. During the testing, observations of the milking in practice can be achieved.

Observation / registration of the milking routine is important in connection with a vacuum testing during milking because the evaluation of the testing during milking with an MT30 indicates in which way the milking machine, the cows and the milker interact. Usually, the milker will not notice that he or she is in focus. This is a great advantage to the subsequent evaluation. Improvements can often be suggested that can relieve the work.

Testing during milking will provide valuable information on both the technical condition of the milking machine and the ability of the milker to use the system.

This information is a valuable supplement to the ordinary service. It will also be of current interest to carry out a testing in connection with the start of a new-installed milking machine in order to define the correct vacuum level and to find possible faults.

Evolution of the measurements

Milking equipment: Vacuum increase in the pulsator or milk line above 1 kPa indicates a slow regulator function. A stable vacuum in the milk line within 2 kPa indicates that slugs are not formed in the milk line. Vacuum drops at the milk line independent of operator functions indicate the use of more milking units or a larger milk flow than the milk line is designed for. High milk flow rate cause large vacuum fluctuations beneath the teat end, resulting in poor dimensions of the short milk tube. Pulsator function is tested before the measuring during milking.

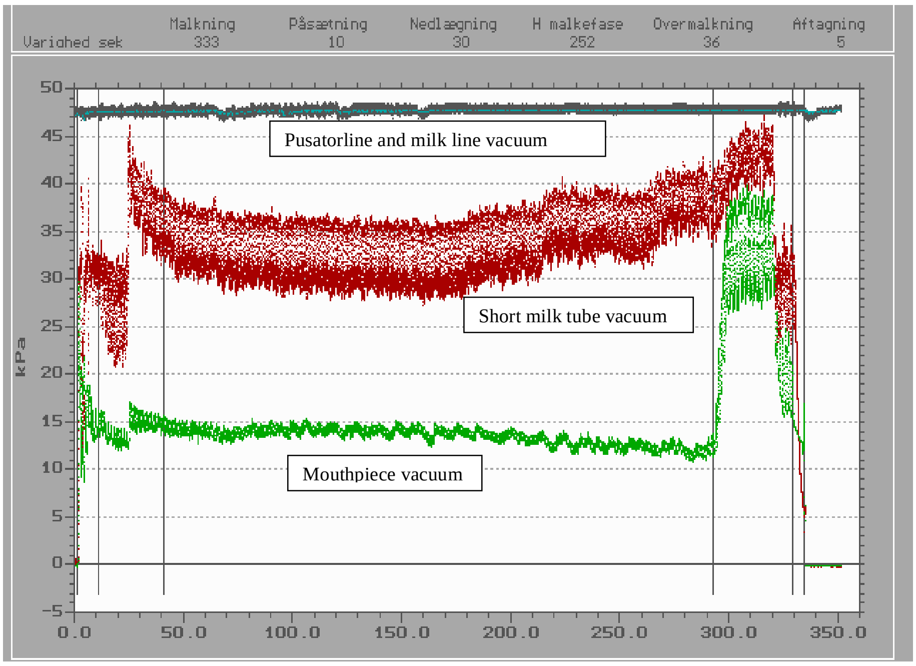

Fig. 2. Recording of vacuum during milking in a stanchion barn.

The cow: The operating milking machine is divided into 5 phases:

1. attachment - the first 10 sec.;
2. milk ejection - 90 sec.;
3. peak flow;
4. over milking - change in mouthpiece vacuum;
5. detachment – decline in vacuum in the short milk tube and in the mouth piece chamber.

Operator: Vacuum fluctuations caused by attachment or detachment of other milking units can be noted and may be compared with periods without operator functions. Changes in operator habits are cheap and may improve vacuum stability but arguments are often lacking. Visualisation of vacuum fluctuations caused by operator functions can be convincing.

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Vacuum fluctuation in short milk tube during peak milk flow

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Summary

This paper reports results of field tests on milking units of 16 milking machines installed in low-level milking systems of herring bone, auto-tandem and parallel parlours of which 3 were equipped simultaneous and 13 with alternate pulsation. Vacuum was measured with MILKOTEST 2004 (Gebrüder Bilgery, Switzerland) connected to the short milk tube at the time of peak milk flow. The results were processed by correlation analysis taking nominal vacuum, air vent admission, claw volume, and short milk tube bore as independent variables and maximum vacuum in the short milk tube and vacuum fluctuation range as dependent variables. The frequency of excessive vacuum (vacuum maximums exceeding nominal vacuum) and signs of teat injury (teat tip cyanosis, local ischaemia, teat canal eversion, and hyperkeratosis,) were assessed by nonparametric correlation. Significance of differences was tested for all variables in milking units with simultaneous and alternate pulsation. Significant difference ($P < 0.05$) was found only for the occurrence of excessive vacuum which was higher in units with simultaneous pulsation. Therefore, only variables found in systems with alternate pulsation were subjected to correlation analysis. Highly significant positive correlation was demonstrated between nominal vacuum and maximum short milk tube vacuum ($r = 0.983$; $P < 0.01$). Significant negative correlation was found between air vent admission and the range of vacuum fluctuation in the short milk tube ($r = -0.648$; $P < 0.05$). Significant positive correlation coefficient (0.500) of nonparametric analysis was obtained only for the frequency of excessive vacuum occurance and hyperkeratosis of teat orifice.

***Key words**: Milking machine, natural milking, vacuum fluctuation, short milk tube, teat injury, dairy cows.*

Introduction

Short milk tube vacuum, its mean value, and dynamics are factors decisive for rapid, considerate and complete milking. Many years ago, Thiel and Mein (1977) summarised their own results of experimental studies focused on functional mechanics of milking machines and formulated principles of vacuum dynamics during a pulsation cycle. Our first experimental approach to this problem dates back to 1973 (Ryšánek *et al*., 1973). Since that time, the construction of milking machines has underwent considerable changes the principles of which have been codified (ISO 1996). This process was imbued with an effort to explain effects of structural and functional characteristics of milking machines on the occurrence of teat injury due to milking (Hamann, 1994). Our earlier papers, too, dealt with the relationship between functional characteristics of milking machines and development of clinically apparent teat injuries (Ryšánek *et al*. 1968; Ryšánek, 1974; Ryšánek and Babák, 1996).

The objective of this study was to assess differences and relationships among selected structural and functional characteristics of clusters of contemporary milking machines, as well as the relationship between functional characteristics and frequency of teat injuries.

Materials and methods

Our measurement were carried out on 16 milking machines (3 with simultaneous and 13 with alternate pulsation) manufactured by Agrostroj Pelhrimov, Alfa Laval, Bou-Matic, Fullwood, Gascoigne-Mélotte, Melk Systeme, Miele, Manus, No-pulse, Strangko, and Westfalia and installed in herringbone, auto-tandem, or parallel parlours. The measurements were carried out in 1996 through 2000.

Structural characteristics, i.e. pulsation system, claw volume, and short milk tube bore were adopted from manufacturers' documentation and tested by own measurements. Functional characteristics, including air vent admission, maximum short milk tube vacuum, range of short milk tube vacuum fluctuations, nominal vacuum, and frequency of excessive vacuum were established by own measurements and are expressed as arithmetic means of measurements on six milking units of each machine. The term excessive vacuum is used to describe short milk tube vacuum exceeding the nominal value; its frequency was expressed in terms of percentage. Air vent admission was established by measurements on 10 milking units of each machine using the standard ISO 6690 procedure (1996).

Vacuum dynamics were measured using the MILKOTEST 2004 apparatus (Gebrüder Bilgery, Switzerland) connected to the short milk tube. The measurements were done at the peak milk flow. The obtained values were expressed as arithmetic means of measurements on 6 milking units of each machine.

Teat injuries were assessed visually in each parlour in 25 randomly selected cows immediately after cluster removal. Findings of the following signs of injury were recorded: teat tip cyanosis, local ischaemia (sponge cake-shaped ischaemic patches corresponding to the teat surface area exposed to permanent vacuum as a result of incomplete closure of liner walls during the rest phase), teat canal eversion, and teat orifice hyperkeratosis. The findings are expressed in percentages.

Statistical processing included determination of significance of differences in arithmetic means of structural and functional characteristics was done by the Students' t-test. Further, calculation of correlation coefficients incl. significance assessment, and Spearman's test of nonparametric correlation incl. calculation of Spearman's correlation coefficients and significance assessment were done. Data were processed using the software STAT Plus (Veterinary Research Institute, 1993).

Results

Characteristics of the individual milking machines are defined by arithmetic means ±S.D. given in table 1 which also shows the significance of differences between milking machines differing in pulsation systems. Since significant difference was demonstrated only for excessive vacuum, further analyses were done only on data obtained in milking machines with alternate pulsation.

Table 1. Significance of differences between characteristics of milking installations with alternate and simultaneous pulsation.

	Simultaneous pulsation			Alternate pulsation			t_{calc}	Signi-
Characteristics	n	Mean	±S.D.	n	Mean	±S.D.	t_{tab}	ficant
Nominal vacuum [kPa]	3	43.0	2.3	13	43.6	3.1	0.294 2.145	no
Air vent admission [l/min]	3	5.2	2.3	13	6.4	2.2	0.886 2.145	no
Claw volume [ml]	3	326.0	172.0	13	352.0	50.8	0.252 2.145	no
Short milk tube bore [mm]	3	9.3	1.1	13	9.9	1.5	0.850 2.145	no
Short milk tube vacuum maximum [kPa]	3	44.9	2.4	13	43.3	3.3	0.795 2.145	no
Short milk tube vacuum fluctuation-range[kPa]	3	11.9	4.5	13	6.2	1.4	2.158 4.254	no
Excessive vacuum occurrence [%]	3	89.2	18.6	13	29.6	35.1	2.800 2.160	$P<0.05$

Correlations among selected structural and functional characteristics are shown in table 2. Highly significant positive correlation ($P < 0.01$) was found between nominal vacuum and maximum short milk tube vacuum and significant negative correlation ($P < 0.05$) between air vent admission and range of fluctuation of short milk tube vacuum.

Table 2. Correlation among selected structural and functional characteristics of milking installations with alternate pulsation.

Design and functional characteristics Variables				
Independent	Dependent	r	t_{calc} t_{tab}	Significant
Nominal vacuum	Short milk tube vacuum maximum	0.983	12.781 3.106	P<0.01
	Short milk tube vacuum range	0.180	0.599 2.201	no
Air vent admission	Short milk tube vacuum maximum	0.291	0.969 2.201	no
	Short milk tube vacuum range	-0.648	2.370 2.201	P<0.05
Claw volume	Short milk tube vacuum maximum	0.162	0.537 2.201	no
	Short milk tube vacuum range	0.057	0188 2.201	no
Short milk tube bore	Short milk tube vacuum maximum	0.029	0.097 2.201	no
	Short milk tube vacuum range	-0.284	0.946 2.201	no

Table 3. Correlation between selected structural characteristics of milking installations with alternate pulsation and occurrence of excessive vacuum.

Design and functional characteristics Variables				
Independent	Dependent	Spearman´s correlation coefficient	S_{calc} S_{tab}	Significant
Nominal vacuum	Extensive vacuum occurrence	-0.065	387 188	no
Air vent admission	Extensive vacuum occurrence	-0.308	328 188	no
Claw volume	Extensive vacuum occurrence	0.218	398 188	no
Short milk tube bore	Extensive vacuum occurrence	0.030	342 188	no

Particular attention was paid to the frequency of excessive vacuum. As can be seen in table 3, no significant correlation was demonstrated between this parameter and any of the selected structural characteristics. Negative correlation approaching the significance level was observed only between air vent admission and the frequency of excessive vacuum.

Data on correlations between selected functional characteristics and occurrence of teat injuries, given in table 4, indicate that significant relationship described by a positive correlation coefficient can be expected only between the frequency of excessive vacuum and the occurrence of hyperkeratosis.

Discussion

Functional characteristics of the up-to-date milking machines were rather uniform. This finding reflects the unification of designs resulting from the codification of the individual construction elements. It is rather surprising that the difference between milking machines with simultaneous and

Table 4. Correlation among selected functional characteristic of milking installations with alternate pulsation and signs of teat injury.

Functional characteristics Independent variables	Signs of teat injury Dependent variables	Spearman´s correlation coeffitient	S_{calc} S_{tab}	Significant
Short milk tube vacuum maximum [kPa]	Cyanosis	-0.162	423.0 188.0	no
	Local ischaemia	-0144	416.0 188.0	no
	Teat canal eversion	-0.396	508.0 188.0	no
	Hyperkeratosis	0.015	358.0 188.0	no
Short milk tube vacuum range [kPa]	Cyanosis	-0.180	429.0 188.0	no
	Local ischaemia	-0.091	397.0 188.0	no
	Teat canal eversion	0.170	302.0 188.0	no
	Hyperkeratosis	0.368	230.0 188.0	no
Extensive vacuum [kPa]	Cyanosis	0.081	334.0 188.0	no
	Local ischaemia	0.210	287.0 188.0	no
	Teat canal eversion	0.221	283.0 188.0	no
	Hyperkeratosis	0.500	182.0 188.0	P<0,05

alternating pulsation were only inconsiderable. Significant difference was found only for the occurrence of excessive vacuum that was higher in machines with synchronous pulsation. The difference in vacuum fluctuation range approached statistic significance. Both the findings are consistent with the data published by Thiel and Mein (1977), although their measurements were done in machines that have already become obsolete.

The highly significant positive correlation between nominal vacuum and vacuum maximums in the short milk tube was not surprising. On the other hand, rather unexpected in the up-to-date machines was the significant negative correlation between the air vent admission and the range of vacuum fluctuation in the short milk tube. This finding was particularly surprising when the fact is considered that only milking machines with alternating pulsation were tested. We see the explanation in the low air vent admission. Minimum values of this parameter were lower than the codified limit of 4 l per min.

Particular attention was paid to the occurrence of excessive vacuum. Surprisingly, no significant correlation was found between selected structural and functional characteristics of milking machines and the occurrence of excessive vacuum. Only negative correlation between air vent admission and the occurrence of excessive vacuum approached the significance level. Of principal importance is the demonstration of excessive vacuum in up-to-date milking machines and the fact that the occurrence of excessive vacuum was the only functional characteristic showing significant positive correlation with the occurrence of teat orifice hyperkeratosis.

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Automatic milking: Chances and challenges

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Summary

In automatic milking systems (AM-systems) cows are milked by a robotic milking system without direct human supervision. The number of farms with an AM-system is growing, especially in those countries where the costs of labour are relatively high, such as in many West European countries. Many technical problems especially concerning attachment of teat cups have meanwhile been solved, but new problems arose with the spreading adoption of AM-systems by commercial farmers. Since cows visit the AM-system more or less voluntarily, a large variation in milking intervals can be observed between cows. Special attention should be paid to the design of the barn and should be based on the principle eating – lying – milking. When the first prototypes of AM-system were introduced on farms, milk quality deteriorated compared to conventional milking systems. Special emphasis should be given to free fatty acids and bacterial counts. Automatic milking systems require a higher investment than conventional milking systems. However increased milk yields and reduced labour requirements may lead to a decrease in the fixed costs per kg milk. The introduction of automatic milking has a large impact on the farm, the management and the social life of the farmer. A successful use of automatic milking depends largely on the management skills of the farmer and the barn layout and farming conditions.

Key words: *Automatic milking, AM-systems, management, barn-layout, capacity, milk quality, annual costs, room for investment, labour.*

Introduction

The first ideas about fully automating the milking process were generated in the mid seventies. The growing costs of labour in several countries was the main reason to start the development of automatic milking. The final step in the automation of the milking process seemed to be the development of automatic cluster attachment systems. However it took almost a decade to convert the techniques for locating teats and attaching teat cups to fully integrated and reliable automatic milking systems. The first milking robots were installed on commercial dairy farms in the Netherlands in1992. The breakthrough of automatic milking came at the end of the nineties and at the end of 2000, over 750 farms world-wide milked their cows automatically.

Automatic milking systems

AM-systems can be divided into single stall systems and multi-stall systems. Single stall systems have an integrated robotic and milking system, while multi-stall systems have a transportable robot device. Each stall has its own milking devices, like in a milking parlour. A single stall AM-system is able to milk 55-60 cows up to three times per day on average. Multi stall systems have 2 to 4 stalls and are able to milk a herd of 80 to 150 cows three times per day. Automatic milking relies on the cow’s motivation to visit the AM-system more or less voluntarily. The main motive for a cow to visit the AM-system is the supply of concentrates, therefore all AM-systems are equipped with concentrate dispensers. An automatic milking system has to take over the ‘eyes and hands” of the milker and therefore these systems should have electronic cow identification, cleaning and milking devices and computer controlled sensors to detect abnormalities in order to meet (inter)national legislation and hygiene rules from the dairy industry.

The current teat cleaning systems can be divided into three main types; cleaning with brushes or rollers, cleaning inside the teat-cup and cleaning with a separate ‘teat cup like’ device. Present AM-systems do not have sensors to detect the amount of dirt on the teats. Little information is available about the efficacy of teat cleaning devices. Several trials showed that cleaning with a cleaning device is better than no cleaning, but not as good as manual cleaning by the herdsman (Schuiling *et al.*, 1992). AM-systems are equipped with a variety of sensors to observe and to control the milking process. Data are automatically stored in a database and the farmer has a management program to control the settings and conditions for cows to be milked. Attention lists and reports are presented to the farmer by screen or printer messages. However, the AM-system only notifies, the farmer has to take action.

Management and labour

One of the main benefits of automatic milking is an increase in milk yield from more frequent milking. Recent figures from the Dutch herd improvement organisation NRS showed an increase in lactation yield of 11.4 % one year after the introduction of the AM-system (unpublished). Changing over from a milking parlour to automatic milking will lead to big changes for both herdsman and cow. In the transition from conventional to automatic milking, cows have to learn to visit the AM-system at other times than before. This needs special attention and in the first weeks human assistance will be necessary. Another important aspect is the barn layout and design. Using the cows motivation for eating, the milking system should be situated in the route towards the feeding area. To minimise problems with udder health, it is generally recommended that cows stand for some time after the milking to allow the teat sphincter to close. So after visiting the milking system, the cow should have free access to the feeding area. Using this milking-feeding-lying principle, the cows are motivated to use the AM-system.

Since cows visit the AM-system more or less voluntarily, a large variation in milking intervals can be observed from cow to cow. In practice the average number of milkings per day varies from 2.5 to 3.0 and more, but rather big differences in individual milking intervals are reported. There does not seem to be a big difference in average milking frequency between the one way and the free cow traffic systems in practice (Ipema, van't Land). De Koning found that almost 10% of the cows realised a milking frequency of 2 or lower over a two year period milking with an single stall AM-system. This occurred even though cows with a too long interval were fetched three times per day. These cows will not show any increase in yield or may even show a decrease.

The effect of automatic milking on labour requirement is not very clear and depends largely on the management approach, barn layout and herd characteristics. Ipema et al (1998) and Van't Land reported labour demands for AM-systems from 32 minutes up to 3 hours per day. On average a 10% reduction in labour required is reported. Moreover the character of the labour left will change from manual work to managerial activities and observations of the cows and their behaviour. Management is the key-factor in a successful application of automatic milking.

Capacity

The capacity of an automatic milking system is often expressed as the number of milkings per day. The number of milkings per day will depend on the configuration of the AM-system, like number of stalls and the use of selection gates, herd size, barn layout and the characteristics of the herd, like milk yield and flow rate. Increasing the number of milkings per cow per day, does not necessarily contribute to a higher capacity in terms of kg milk per day. This is due to the more or less fixed handling time of the automatic milking system per milking and the decreasing amount of milk per milking with smaller milking intervals.

A milking visit to the AM-system consists of several activities. The cow walks to the AM-system, will be identified and if the cow is allowed to be milked, the AM-system will start the udder preparation and teat cleaning. The teats are localised and the four teat cups will be attached. The milking process will start and after teat cup take off, the teats are disinfected and the cow is allowed to leave the milking station. Each milking visit has in fact two main parts: the handling time of the AM-system and the machine on time. Handling times between 2 to 4 minutes are reported in various studies. The machine on time depends largely on the yield and flow rate of the individual cow. Between herds and between cows, the average flow rates will differ due to genetic differences. Various figures are reported from research with AM-systems. De Koning & Ouweltjes found an overall average flow rate, which could be modelled by 2.51 kg / min + 0.051 * (Yield – 11.8). Other data showed average flow rates between 1.4 and 1.9 kg / min in various experiments with AM-systems (Devir, Sonck).

Daily capacity

The maximum number of milkings per day and the capacity in kg per day can be calculated for one stall AM-systems by using the handling time per milking visit, the machine on time per visit and the occupation rate of the automatic milking system. For example an occupation rate of 80% means that the automatic milking system operates for 19.2 hours per day and the remaining 4.8 hours are used for rinsing and cleaning of the milking machine, refused milking visits and so on. In figure 1 results are presented for different yields per milking and flow rates. Increasing the average yield per milking will result in less milkings, but in an increased capacity in kg per day. Milk flow rate and yield have a large impact on capacity in kg per day. By changing the milk criteria settings in the AM-system for individual cows, the AM-system can be optimised to realise a maximal capacity in kg per day.

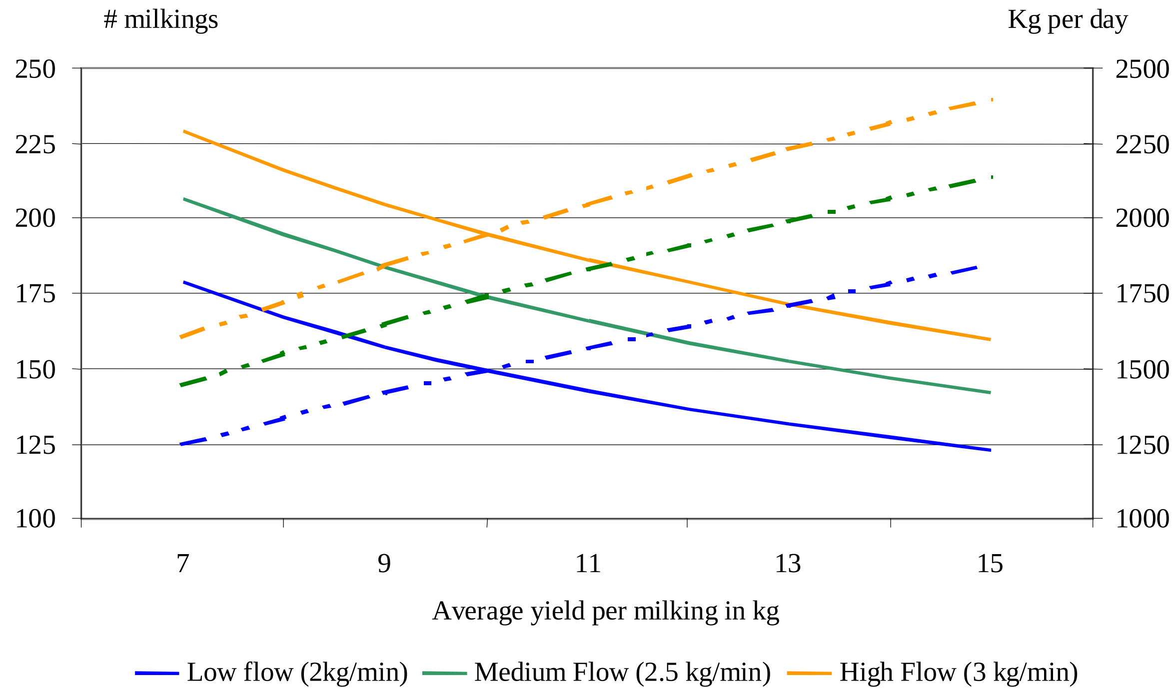

Figure 1. The calculated number of milkings per day and production per day at different yield and flow rates

Milk quality and cooling

Milk quality is without doubt one of the most important aspects of milk production on modern dairy farms. Milk payment systems are based on milk quality and consumers aspect a high quality level of the milk products they buy. Although automatic milking uses more or less the same milking principles as conventional milking, there are some big differences. The 24 hour continuous operation of the AM-system requires special cleaning procedures. Visual control during the milking process is not possible. Also teat cleaning cannot be adjusted to the degree of dirtiness. Furthermore the milking intervals will differ from cow to cow. All these aspects may influence the quality of the milk.

Bacterial counts and freezing point

At the start of automatic milking on commercial dairy farms, it was a general assumption that milk quality would be equal or even be improved after the change to automatic milking. However, results from commercial farms indicate that in many cases milk quality is negatively effected (Klungel et al, Van der Vorst). Results are presented in table 1 and show a doubling of the bacterial counts, although the levels are still relatively low and far within the penalty levels. The cleaning of the milking equipment and the cooling of the milk seem to be the most important factors regarding the increase in bacterial counts. Attention should be paid to the hygienic design of the milking machine in the AM-system, but research also showed that complete cleaning and disinfection should be carried out at least three times per day. Cleaning is also necessary after milking treated, diseased or fresh calved cows, to prevent contamination of milk. Most AM-systems also use a short rinsing between two consecutive milkings, to reduce the risk of transfer of pathogens from cow to cow. However the many cleaning and rinsing cycles in AM-systems will increase the risk of an increased freezing point. Special attention should be given to the draining of the system after cleaning, the slope of pipe lines and the use of draining valves.

Table 1. Milk quality results for farms before and after introduction of AM-system (Van der Vorst et al.*, 2000).*

	Dairy farmers		First generation		Second generation	
	2 times milking	3 times milking	Before	After	Before	After
Number of farms	60	45	39	39	62	62
Bacterial count (*1000 / ml)	8	8	8	17	8	12
Cell count (* 1000 / ml)	181	175	202	203	175	190
Freezing point (^{o}C)	-0,520	-0.521	-0.520	-0.517	-0.521	-0.516
Free fatty acids (meq / 100 gr fat)	0.44	0.54	0.49	0.63	0.41	0.59

Cell counts, butyric acid spores

Also for cell counts a decrease was expected due to more frequent milking. Although little information is available, it seems that cell counts are not reduced in the first 12 months after the change to automatic milking. It is not clear if these changes are related to the AM-system or to the changes in management. Special attention should be given to the housing conditions of the cows, especially to the hygiene of the bedding in the cubicles and the hygiene of the slatted floors in order to keep the cows clean. Automatic manure scrapers on the slatted floors are used to keep the walking areas clean. Hygienic conditions and clean udders are also important to prevent an increase in butyric acid spores.

Free fatty acids

It is generally known that the content of free fatty acids (FFA) in milk will increase with shorter milking intervals (Ipema & Schuiling), the more so if the yield per milking is rather low. All studies with AM-systems show a significant increase in FFA levels. This increase cannot be explained solely by the shorter intervals, because the increase of FFA with AM-systems is even bigger than with conventional milking parlours milking three times per day. Another explanation may be the increased air inlet by attachment of teat cups, during milking and at take off. Also the cooling system may play a role.

Cooling of milk

It is generally recommended that the milk should be cooled within 3 hours to, and stored at, a temperature below 4 ^{o}C. In conventional milking, cows are milked twice a day and therefore also twice a day a big volume of milk has to be cooled. In automatic milking, however, the system operates 24 hours and a relatively small amount of milk is flowing more or less continuously to the bulk tank. The average flow rate will range between 50 and 250 kg per hour from 1 to 4 milking stalls. Furthermore there may be some periods without any milk flow because of a low activity of the cows, for example in the night.

Milk can be cooled either directly or indirectly. With direct cooling of milk, the cooling process is not allowed to be started before approximately 10% of the tank capacity is filled with milk. This to prevent the risk of freezing and deterioration of milk quality. In conventional milking this 10% filling will take 1-2 hours. In automatic milking this period may increase up to 10 hours. Such a delay of cooling will increase the risk of bacterial growth, and is not allowed.

Different systems for milk storage and cooling can be applied with automatic milking systems (Wolters *et al.*). The basic requirement is that the system can handle the specific conditions of automatic milking. It may also be useful to have a cooling system which is able to store the milk

when the bulk tank is emptied and cleaned. This enables the AM-system to continue milking, thus increasing the capacity of the system. In general there are four principles to adjust the cooling system to automatic milking:
1) indirect cooling with an ice-bank tank;
2) combination of bulk and buffer tank;
3) storage tank with fractional cooling, and
4) instant cooling.

Economy

Investments required for automatic milking systems are much higher than for conventional milking systems and thus the fixed costs of milking with an AM-system will be higher. However more milk will be produced per cow and per herd with less labour than before. More milk means that the costs of milking per kg of milk will decrease. The same applies to the labour costs per kg milk. Theoretically, with an AM-system more cows can be kept with the same labour force than with the conventional milking system. But this may involve additional investments in buildings, land or feed and perhaps even milk quota. On a farm with more than one full time worker the possibility exists to reduce labour input and thus costs. However quite often that does not happen and the time saved as a result of lower labour requirement will be used for personal activities: sports, family and other. These social aspects are often very important for farmers and their families. The reasons to invest in automatic milking are quite diverse for

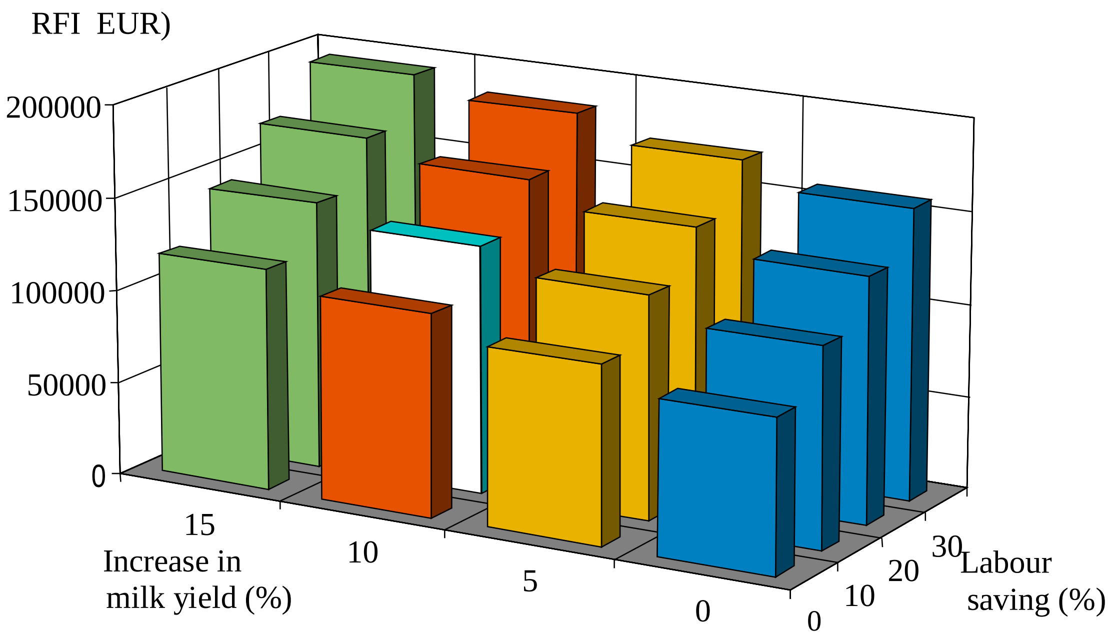

Figure 2. Room for Investment (RFI) due to labour saving and milk yield increase with annual costs for AM-system of 25% of investment.

farmers (Ipema et al, 1998) and therefore the introduction of an AM-system on a farm will effect the farm and farm management in several ways. Till now little economical information is available from commercial herds using an AM-system. Several simulation models have been developed to calculate the economical effect.

One of the basic models used, is the Room for Investment model (Mandersloot, Arendzen). This model computes the amount of money that can be invested in an AM-system, without any change of the net return compared with the conventional milking system. The RFI-value is calculated by accumulating the annual returns from increase in milk yield, annual savings in labour costs, annual savings in not investing in the conventional milking parlour and then dividing this total by the annual costs of the AM-system. The model is able to use the farm specific factors and circumstances to calculate the RFI-value. In figure 2 the results of a combined sensitivity analysis are presented. The figure shows clearly that increase in milk yield and labour savings are essential factors regarding the economy of AM-systems. The RFI-value for the basic farm with 10% milk yield increase, 10% labour saving, medium automated milking parlour and 25% annual costs of the AM-system amounts to Euro 134 000. The differences between the extremes are rather large, almost equal to the investment of a single stall AM-system.

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Automatic milking systems: Characterising the farms equipped with AMS, impact and economic simulations

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Summary

In France, approximately one hundred dairy farms are equipped with automatic milking systems (AMS) and according to the manufacturers of the systems, this market is likely to expand. However, we do not have any information about these farmers and their motivations for buying an AMS. In order to characterise these farmers, nearly half of the total population (44) were surveyed. The farms surveyed are much larger (surface area and herd) than the national average. Their milk production is often in competition with other productions, which leads to labour constraints. The dilapidated state of the milking equipment meant that it almost obligatorily had to be replaced. The choice of the AMS rather than a conventional milking parlour was made in view of lightening the workload. The AMS offers greater flexibility as far as time is concerned but also has an impact on herd management: increased production per cow, zero grazing. Economic simulations show that the annual additional cost of AMS compared to a conventional milking parlour is mainly influenced by four parameters: the cost of labour, the increase in production per cow, the depreciation period and the options of the milking parlour. According to these simulations, the AMS seems more adapted economically to farms of 50 to 75 cows for a quota of 400 000 to 550 000 litres of milk. These considerations must of course be further documented in the future with new references.

***Key words**: Automatic milking system (AMS), dairy farms, work, investment.*

Introduction

Dairy farmers have always been subjected to the perpetual constraint of two daily milkings at set times. The milking machine constituted technological progress, continually being improved and adapted to farmers' needs, which has considerably reduced the arduousness of their work. But today, work become a limiting factor on a large number of dairy farms which have got bigger and more diversified in response to milk quotas (1984) and to the common agricultural policy (1992) in order to maintain their income.

The automatic milking system (AMS) may be a significant innovation as it theoretically takes charge, partly or completely, of milking as well as certain herd management functions.

This technology has benefited from more than ten years of research. Its real expansion in farming began two years ago and about 150 farms in France are now (mid 2001) equipped. But this expansion could be slowed down, among other reasons, because of insufficient information (in particular in France) concerning farmers who have invested, the reasons which pushed them to invest and the role played by the socio-economic aspects. Farmers wanting to invest in this technology therefore have trouble obtaining information and advice. It is urgent to establish some initial guidelines to help future buyers and this is the aim of our study.

Description of farms equipped with AMS

Large structures with diversified production

The 44 farms surveyed are situated in zones of mixed cropping and animal farming: Lorraine (9), Pays de Loire (19), Normandy (9), Burgundy (3), Brittany (4) and are distributed in the same way as all the farms equipped with AMS.

Overall, they are large farms, with greater surface areas and milk production than the national average (Table 1) and than their respective regional averages (RICA 1998).

However, these farms are relatively diversified since non fodder crops represent 42% of the total surface area. Before the arrival of the AMS, a little more than half the farms (55% of the sample) include at least a second animal production unit (fattening of baby beef from the dairy herd or housed rearing unit).

The fodder system is based essentially on maize silage and the systems use little grass.

Work productivity is also higher than the national average (47.7 ha of usable farm area and 177 400 litres of milk per male worker unit against respectively 34 ha and 126 000 in the RICA sample). But almost half the sample is or will be concerned by voluntary or involuntary reductions in manpower.

A desire to change equipment

The age and condition of the equipment (18 years on average) as well as standardising farm buildings as part of the Pollution from Agriculture Management Plan encouraged farmers to invest. Two thirds of the farmers would have wanted to change their equipment even if the AMS had not existed.

Table 1. Structures of the 44 farms surveyed before investing in the AMS.

	AMS 44 Farms	RICA* France 1998
Labour (male worker unit)	3.10	1.56
Including employees	*0.50*	*0.05*
Usable farm area (ha)	148	53
Main fodder area (ha)	86	44
% of usable farm area	*58*	*83*
Maize silage (% main fodder area)	38	20
Number of dairy cows	77	36
Production of milk per cow and per year (kg)	7 950	5 540
Volume of milk produced per year (l)	550 000	197 000

*Réseau d'Information Comptable Agricole OTEX 41.

The quantity of work

The dairy unit requires on average 7.4 hours of work per day, that is 2700 hours per year. Milking represents two thirds of the dairy unit's work, that is 4.8 hours per day or 1750 hours per year.

91% of farmers became equipped with an AMS because of labour difficulties and particularly to reduce the workload and have more flexibility as far as time is concerned. Few farmers (fewer than 10%) express the desire to have free time for another activity.

The purchase of an AMS therefore does not correspond to a desire for intensification, but rather to the desire to maintain the system in place without extra labour, or even fewer workers. In 16% of cases (7 farmers), the AMS "saved" the dairy unit which was in an unfavourable equilibrium with other units.

Consequences of the AMS

On average, the AMS have been set up on the farms in our sample for only 14 months.

Impact on grazing

Before the AMS, fewer than a half of farmers put their herds to graze, without any extra fodder distribution in the barns. One third practised zero grazing and 27% used a simple outdoor grazing run distributing all their ration in the barn.

After installing the AMS, zero grazing increased to half the farms. Grazing is maintained on 34% of farms, but in all cases, fodder is distributed every day at the trough.

The practice of grazing is therefore not easily compatible with AMS since the cows frequent the system less (Ketelaar-de Lauwere and Ipema, 2000).

Impact on the dairy herd

The average milk production before installing the AMS reached 7 950 kg per cow. After installing the AMS, according to the farmers, the milk production per cow and per year increased by an average of 3%. However, 55% of farmers had no variation in the production level of their herd. The installation date of the AMS may explain this point. The productivity per cow increases more for the AMS installed for longer: +3% for farms equipped for less than two years and +9% for the farms equipped for more than two years. The increase in the production per cow, for a given production quota, results in a reduction in the size of the herd. This increase in production per cow can be linked to the AMS (Hillerton and Winter, 1992) but also to a greater comfort for the animals due to adjusting or reconstructing the building.

When the AMS is put into operation, certain cows (between 5 and 10% of the herd) have to be culled due to the unsuitable conformation of their udder or also to their stance.

Attention must also be paid to grouping of calving: the AMS may be running on overload over a period, which could lead to a drop in its performances (number of milkings per cow and per day).

Impact on milk quality

An increase in the number of leucocytes was observed on some farms when the AMS was installed. This increase seems to be temporary. However, the farmer must take daily care of the cleanliness of the animals and take preventive measures and especially minimise risks of contamination by butyric spores (Pomies and Bony, 2000).

Impact on work

86% of the farmers surveyed consider that their workload has decreased (arduousness, constraints) and also, in particular, they have obtained more flexibility as far as time is concerned. On the other hand, the fact that the farmer must be able to be contacted at any hour of the day, ready to respond to an alarm if the AMS breaks down, is not considered a major constraint.

On the INRA experimental domain of Le Roc in Orcival, the AMS was timed and the results showed that the AMS reduced the duration of work by 2.5 hours per day, which amounts to 900 hours a year. These 900 hours in relation to the 1750 hours of milking per year represent a 50% time saving.

The physical arduousness of the work also decreases. The proportion of manual labour decreases considerably and is replaced largely by the task of observing the animals, by office work (consulting the listings and the data recorded by the AMS) and by technical maintenance work.

According to all accounts, the farmers must prepare themselves for a difficult period of adaptation and possibly to cope with the economic and / or human consequences.

Economic advantages of AMS

Presentation of the method.

The method which we used involves calculating partial budgets of the dairy unit. The method is similar to that used by Dijkhuisen *et al.* (1997), Favre *et al.* (1998), Arendzen and Van Scheppingen (2000). We attempt to determine the additional cost of the AMS:

$$\mathbf{S = R_{SdT} - R_R}$$

Where S = extra cost of the AMS

R_{SdT} = profit made by the dairy unit with a milking machine

R_R = profit made by the dairy unit with an AMS

With : $\mathbf{R = (MB_{al} + MB_{sl}) - (A + MO)}$

Where R = profit made by the dairy unit

MB_{al} = dairy unit gross margin

MB_{sl} = vacated area gross margin

A = annual repayments on the investment in milking machinery

MO = labour cost

We carried out simulations on three farm types (“60 DC”, “80 DC” and “100DC”) defined from our sample by selecting according to the volume of milk produced. The flock of 60 dairy cows of the “60 DC” farm type corresponds to the optimum announced by the manufacturers for a single stall robot. The 100 dairy cows of the farm type “100 DC” requires two robots of the Lely concept and three milking stalls of the Prolion concept. As far as the “80 DC” farm type is concerned, it constitutes an intermediate case which requires two stalls for the Prolion concept and two robots for the Lely concept.

Hypotheses

We placed ourselves in a situation where the farm operated at cruising speed rather than in the first year of installation which is rather disrupted. These disruptions are very difficult to calculate since they are mainly linked to individual factors.

- **Price of the AMS and price of the equipment of the new milking parlour: catalogue price**
  From 730 000 F to 960 000 F for a single stall AMS, 1 250 000 F for a two stall AMS and 1 500 000 for a three stall AMS of the Prolion concept, 1 350 000 for two AMS of the Lely concept.

  250 000 F for a milking parlour 2 x 6 (herds with fewer than 80 cows) and 350 000 F for a 2 x 10 (herds with more than 80 cows). Each time we envisaged a milking parlour without options and a milking parlour with all options in order to obtain, as far as possible, the same information as with the AMS.

- **Work on the building**
  The only difference calculated was the size of the milking block.

- **Depreciation (linear) and reimbursement of loan**
  It is difficult today to predict how long an AMS will last (rapidity of technological progress, second-hand market?). Two cases will be studied: the depreciation period and reimbursement over 7 years, and a long period of 10 years.

  The interest rate on the loans is 6% for an investment financed 100% by the loan.

- **Milk production level of the cows**
  In the case of a milking parlour, no modification in milk production is envisaged. We will study three hypotheses in the case of the AMS: no increase in milk production, a 5% increase and a 10% increase. The land areas used for fodder production which will be left free will be used for cash crops.

- **Costs linked to milk production and the selling price of milk and animals**
  The costs of milk production depending on the level of production of the cows, the prices of milk and animals are the average prices in 1999 of milk producers' groups monitored in ECOLAIT by the BTPL (766 farmers throughout France). The selling price of milk produced by the AMS is penalised by two centimes to take into account the risk linked to butyric spores.

- **Operating costs, hygiene costs and maintenance costs**
  The cost of maintenance retained is the cost announced by the manufacturers. However, as there was no reference concerning operating and hygiene costs of the AMS, we retained almost double that of a milking parlour since it would seem that the AMS consumes more energy (Artmann and Bohlsen, 2000) and cleaning products.

- **Cost of salaried labour**
  We took into account the labour costs linked to the presence of an employee who milks the cows in a milking parlour. In the case of an AMS there is no employee, it is the farmer who carries out the necessary work (various verifications, maintenance), which amounts to 1.5 hours a day (timed at the INRA farm at Orcival). The work of the farmer was not counted, it has to be remunerated by the farm's profits.

  From the milking times announced by the farmers in milking parlours, we deducted the 1.5 hours each day necessary for the AMS. It is this difference in hours worked which must be carried out in part or completely by an employee.

  We considered three cases: milking is carried out by an employee during the week and weekend (A), by an employee during the week and by the farmer the weekend (B), by the farmer during the week and an employee during the weekend and during two weeks of holidays (C).

  The hourly cost of labour corresponds to that of a herdsman paid 8500 francs net per month, which is 88.76 francs an hour, all social security costs included.

Results of the 3 types of farms

The extra cost of the AMS is minimal for the “60 DC” farm since the single stall AMS is used to its full capacity. The extra cost is maximum for the “80 DC” farm since the purchase of a second stall or a second robot, which do not operate to full capacity, leads to increased costs that the volume of milk produced does not manage to compensate for (Table 2). The volume of milk produced by the “100 DC” farm makes it possible to limit the extra cost of the AMS compared to the “80 DC” farm.

For all the types of farms, the extra cost of the AMS can be explained in large part by the difference in the levels of investment but also by the gross margin of the dairy unit which drops by about 10 centimes per litre of milk produced (selling price of milk lower because of a penalty due to butyric spores, cost of maintaining the equipment and higher costs linked to hygiene).

Five parameters have a greater influence

- **The price of the AMS, the increase in productivity per cow and the cost of labour.**
  In all cases, the AMS is only valid if an employee does the milking every day of the week. The AMS is not a good alternative for farmers looking for a lighter workload during the weekend. In this case, it would be better to employ someone to replace himself. Otherwise the extra cost represents the farmer's consent to pay for the lightening of his workload and access to this technology.

Table 2. Extra cost of the AMS (in Francs) paid back over 7 years compared to a milking parlour with all options, depending on its price, the increase in production per cow and labour.

Farm type price of the AMS	Increase in the production per cow	Type of labour replaced by the AMS *(hours per year of an employee in milking parlour)* Excluding labour	A	B	C
			(876)	*(618)*	*(279)*
	0	71 484	- 5 164	16 668	46 714
730 000 F	5 %	55 996	- 20 652	1 180	31 226
	10 %	41 915	- 34 733	- 12 901	17 145
60 DC					
	0	112 686	36 038	57 870	87 916
960 000 F	5 %	97 197	20 549	42 381	72 437
	10 %	83 116	6 468	28 300	58 346
			(1 194)	*(854)*	*(385)*
	0	182 121	76 166	106 351	147 872
1 250 000 F	5 %	162 782	56 827	87 012	128 533
	10 %	145 202	39 247	69 432	110 953
80 DC					
	0	206 215	100 260	130 445	171 966
1 350 000 F	5 %	186 876	80 921	111 106	152 627
	10 %	169 296	63 341	93 526	135 047
			(1 495)	*(1 069)*	*(483)*
	0	176 703	44 017	81 819	133 813
1 350 000 F	5 %	147 120	14 434	52 236	104 230
	10 %	120 226	- 12 460	25 342	77 336
100 DC					
	0	203 573	70 887	108 689	160 683
1 500 000 F	5 %	173 990	41 304	79 106	131 100
	10 %	147 097	14 411	52 213	104 207

For herds of more than 60 cows requiring a second stall or a second AMS, the extra cost brought about by this overequipping is not compensated for by the labour cost. The AMS does not seem adapted for these farms and the farmers would be better advised to invest in conventional equipment and to take on a competent and well paid herdsman. For large herds of 100 cows, the AMS may be economically interesting on condition that the milk production increases by more than 5% per cow.

Concerning the purchasing price of an AMS, our simulations show that for all types of farms, a reduction of 100 000 F reduces the extra cost by 17 900 F per year for an investment paid back over 7 years.

- **Options of the milking parlour**
  Equipping the milking parlour with all the options leads to an increase in annual repayments compared to a simple milking parlour. The extra cost of the AMS compared to a simple milking parlour is from 30 000 to 40 000 F higher than a milking parlour with all the options.

- **The depreciation period of the investments**
  Increasing the depreciation period from 7 to 10 years makes it possible to lower the annual repayments. Since investing in an AMS is more onerous, it thus benefits from a greater reduction in annual repayments in absolute value than that of the milking parlours, hence an extra cost reduced by 10 000 to 40 000 F depending on the price of the equipment.

Conclusion

Acquiring references on the motivations behind the purchase of AMS and especially on the conditions of the technical, economic and human success of its installation is essential to help future potential buyers in making a decision before investing.

The structures which have become equipped with an AMS are large structures where milk production is often in competition with other animal or plant production units. This diversity of production leads to choices in how to use labour. Labour therefore plays a major role in deciding on the investment and the issue of labour must not be considered solely from the point of view of milking but as part of an overall assessment (Dedieu *et al*. 1993).

Despite the fact that they have a higher production volume than the national average, the most suitable farms for making the AMS profitable are family structures of fewer than 65 dairy cows.

The milking parlour certainly remains adequate for a large majority of dairy farms (farms which are too small for such a large investment, grazing-based systems, farmers who are reluctant about computers…).

Some hypotheses have been put forward and time is needed to see whether they can be validated: technological innovations on the next generation of AMS and milking parlours, life expectancy of an AMS, maintenance and operating costs, second-hand market, evolution in the prices of different types of milking machinery. The more references which are available, the more potential buyers will be informed objectively and we will have a true idea of the AMS market.

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Designing the optimal robotic milking barn

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Summary

The PhD project was intended to make a three-way contribution:
1) To the development of a science-based methodology for designing the layout of the robotic milking barn (RMB), taking into account the many factors that directly influence the layout design, such as existing physical layout of the barn, cow behaviour, management practices, potential capacity and actual utilisation, and feeding routine.
2) To translate the methodology into a practical design tool, embedded in a user-friendly software application, ready for use in the farmer's home during a consultation;
3) To set up examples that demonstrate the proposed methodology, show a way through the complexity of finding an optimal solution, and indicate how a solution may be generalized to other cases. This PhD study has been completed and published by IMAG and Wageningen University; no further research on the same issue is necessary - the onus is now on the industry to implement this proposed design methodology on a daily basis.

Introduction

Nowadays, the number of dairy farms has decreased while the remaining farms have grown in size and have modernized, often by purchasing a milking robot. These robots affect farm labor, cow productivity, animal welfare, feeding routines, building construction and management practices. All these aspects need to be taken into consideration when designing the layout of a robotic milking barn (RMB).

The traditional barn has a milking parlor oriented design and should be redesigned according to the robotic milking concept when a milking robot is to be integrated. The actual capacity (performance) of a robot depends on access of the cow to the robot. The entire system (barn design, its layout, feeding and cow-traffic routines, management practices) should encourage 'voluntary milking', i.e. it should ensure sufficiently frequent visits of the cows to the robot. Facility (or space) allocation is an important consideration and it determines system layout; an optimal layout balances adequate facility capacity against over capacity. It should balance animal welfare on the one hand and facility utilization on the other. So, the two conflicting requirements (to be optimized) are the economical need for high facility utilization and animal welfare and these two should be incorporated into the management practices and physical layout. However, the actual capacity of each facility (such as robot, forage lane, concentrate feeder) in the RMB depends on its accessibility to the cow (animal behavior). There is also wide diversity among farmers and local conditions, therefore, the optimal layout may vary among farms. In addition, milking robots are relatively new, there are only few precedents and little experience to draw upon when designing robotic milking barns. Therefore there is clearly a need for a design methodology for RMBs that is based on scientific rules (as opposed to subjective experience), animal behavior and welfare, interactions among cows, facilities and management practices, and parameters that are adjustable to every farmer or site. Thus, creating an RMB layout is a multidisciplinary field, requiring an interdisciplinary approach.

The newly developed methodology has been implemented into a practical design tool (a software application) intended for research as well as practical application that can be used daily by engineers, researchers, advisors and robot manufacturers. *The objective* of this study was to develop a design methodology for determining the optimal layout for a robotic milking barn before the barn is built. The optimal RMB layout (the solution) has to be adjusted for individual farm conditions, unique to any farmer or site, but the design methodology should be universally applicable.

Materials and Methods

Experimental investigation

Four experiments were conducted, two under research conditions and two in commercial farms. In the first experiment, we gave the animal freedom of choice and assumed that its activities would not be such as to impair its own welfare. This experiment aimed to explore the stochastic nature of the facility utilization in a robotic milking barn - independent of the barn layout. To minimize restrictions on the cows' access to the facilities, the barn contained less than half the number of cows for which it was designed, to ensure maximum availability of facilities (over allocated capacity) and the cows were fed continuously round the clock. The activity of each cow in the group was monitored on an individual basis. The intensity and sequence of use of the facilities and cow behavior was studied and statistically quantified. It results in a tremendous database for instance, recording 10 cows for two weeks provides around 36 000 events (milking, eating, lying, etc), each one including variety of information (entering and exit time, milk yield, food consumption and so on). Consequently, the first engineering/mathematical challenge was to develop an efficient data processing algorithm and software application capable for handling such a huge database.

In the second experiment, forage food was given twice a day, and the number of cows in the group was increased to the maximum capacity of that barn. This experiment aimed to validate the model under conditions that were different from those for which that the model was developed (mainly different layout, feeding routine and number of cows). Groups of 10, 20 and 30 cows were kept in a loose housing system with cubicles originally designed for 30 cows. Each group was monitored for 3-4 weeks (excluding the start-up periods). The third and fourth experiments were conducted in two commercial barns in farms typical of those to be found in the Netherlands. These experiments aimed to validate the model under commercial conditions and with a different type of robot. In the first farm the robot had been installed in an existing barn after refitting. In the second farm an entirely new barn had been designed specially for robotic milking, with the aim of installing more than one robot (in the near future). During the 4-5 week experiment period, each farm had milked around 60 cows by using a single robot. The forage food was distributed in the morning by a mixing wagon and whatever remained in the evening was pushed toward the cows. The four experiments are described in detail by Halachmi (1999).

Developing the queuing network model

A closed queuing network model, a mathematical representation of a robotic milking barn was developed (Halachmi *et al*., 2000a). We use an approximate mean-value algorithm to evaluate important performance criteria such as the number of waiting cows, their waiting time and the utilization of the facilities in the barn. The model incorporated farmer 'aspiration levels', animal welfare in terms of queue length and waiting time; cost in terms of facility utilisation, and visual analysis of the barn performance.

Developing computer simulation model and validation

A behavior-based simulation (BBS) model, which enables a designer to optimize facility allocation in a barn, has been developed (Halachmi 2000) and validated (Halachmi *et al.*, 2001a). The BBS requires fewer simplifying assumptions than the queuing network model. Simulation experiments allow equipment, layouts and management practices to be evaluated in combination. We conducted two types of validation experiments:

a) observation of cow behavior in real (non-simulated) barns, and
b) computer simulation.

The measurements from three real robotic barns were statistically compared with simulation data under a variety of scenarios, including commercial barns. The simulation model appear to be a valid, accurate representation of the real system under commercially feasible conditions. This hypothesis was tested statistically and was not rejected at a=2.5%. So the conclusion is that the model is a practical design tool, enabling the designer to optimise facility allocation and barn layout.

Metamodel and optimization algorithms

The BBS model was integrated with regression metamodel, full factorial design, and optimization algorithms (Halachmi *et al.*, 2001c). The Metamodel transformation appeared to be a first-order polynomial, so that Kuhn-Tucker conditions are both necessary and sufficient for a global optimum point to be found by ordinary algorithms such as projection methods or Simplex. Since the integration allowed a global optimum to be found, it completed the mathematical development of that integrated design methodology.

Results and discussion

The main finding of the experimental investigation in the RMB facilities were:

a. The cows' access (arrival time) to any of the RMB facilities and the duration of each visit (service time) can be represented as Exponential, Normal, Weibull, Log-Normal and Beta distributions (Halachmi *et al.*, 2000b).
b. The robotic barn is actually a closed queuing network, i.e., it contains a series of service facilities (robots, concentrate feeder, forage lane, cubicles, water troughs, etc.), at some or all of which, cows must receive service. After having been serviced in facility i, the cow proceeds to facility j, i.e., a transition probability matrix which represents the interrelations between facilities utilization (Halachmi *et al.*, 2000a).
c. From the transition matrix it can be seen that in 90% of the cases, a concentrate feeder visit follows a robot visit. Thus the concentrate feeder (stand-alone or in the robot) is an effective device to force the cows into a particular cow-traffic routine. The transition matrix also indicates that there were many movements between the forage lane and the cubicles and between the forage and water troughs. If a forced routine prevented these movements, it could impair animal welfare and feed intake.
d. Two peaks during forage feeding times dominated the time pattern of the cows' feeding behavior and influenced the entire system performance.
e. In our experiments the observed cubicle utilization never exceeded 75%, which suggests that it would be feasible to have fewer cubicles than cows without adversely affecting cow behavior.
f. Robot utilization in the two commercial RMBs was rather high (about 85% throughout the 24 hours) and its attachment performance met practical requirements (attachment failures occurred in only 1.25% of the visits occupying 1.00% of the robot's time). This suggests that robotic-milking has progressed from its development phase to having sufficient reliability for mass production.

Operational research into facility utilization (Halachmi *et al.*, 2000b) forms the central theme of this thesis: quantifying animal behavior in relation to facility utilization as a continuous-time stochastic process has opened the way for the application of systems engineering and theories (such as: queuing-network models, Markov chain, and computer simulation) to the design of robotic milking barns. The closed queuing network model (Halachmi *et al*., 2000a) cannot be solved exactly, but the arrival theorem and mean-value analysis produced good approximations (the accuracy was 99.5-99.9% for the facility utilization and 98-99% for the mean waiting time) and by use of the aspiration-level model, RMB design can meet both economic and animal welfare needs. The findings also suggest a possible approach to defining animal welfare "ISO" standards.

Conclusions

The main conclusions of the simulation development and experiments were:

a. The simulation model appears to be a valid, accurate representation of the real system, under commercially feasible conditions (Halachmi *et al*., 2001a).
b. The simulation model and its animation improve communication between barn operators and designers. It allows the farmer to integrate his chosen factors into the model and highlights potential design options before the barn is built. The farmer can gain assurance before building that the proposed design would actually meet his specified requirements and the model tends to be trusted since it looks like a valid representation of the farmer's barn. Halachmi (2000) presents the user-friendly interface, and its animation.
c. An initial layout can be fine-tuned to produce a balanced system, a so-called 'local optimum' specific for a given farm within a reasonable time on the farmer dining table. A simulation run took only 1½ minutes on a 200 MHz Laptop PC (Halachmi, 2000).

Having been validated, the simulation model becomes a practical design tool for optimising a barn layout. Under the given conditions of two specific farms, the model provided the optimal facility allocations: farm A, 1 robot: 36 forage lane positions, 60 cubicles and 71 cows; and Farm B, 2 robots: 3 water troughs, 103 forage lane positions, 105 cubicles and 132 cows. The optimal layout calculated in the case study is unique for a specific farmer, but the methodology developed in this thesis is universally applicable; the parameters can be adjusted to other farmers, sites or milking robots.

In the past, modelling, systems engineering, operational research and computer simulation have revolutionised the design of complex industrial systems. Likewise, this study may be said to be a contribution to a further revolution, this time in the design of livestock systems. Using the proposed design methodology, a model of a future barn can be created which will help to make effective decisions. Before the barn is actually built, it is possible to predict how the barn will respond to changes in design or operation and compare what will happen under a variety of scenarios. Among other things it is now possible:

a. to predict facility utilisation and cow queue length;
b. to calculate the optimal facility allocation: the necessary numbers of cubicles, forage lane positions, water troughs, concentrate feeders and robots;
c. to advise the individual farmer on the choice of robot location, cow traffic routine, required floor space in front of each facility (waiting area), feeding routine, separation area and automatic cleanings; and
d. to gain the assurance before building that the proposed design would actually meet pre-specified requirements.

In general this research has shown that behaviour-based simulation is adjustable for any farmer or site, so there is no necessity for further data acquisition under research conditions.

The research enables us to use the simulation as a practical tool in the dairy business arena. Some examples :

- Evaluating different layout structures based on the farmer's individual preferences or different layout concepts while balancing the whole operation.
- Calculating future needs in cases where the dairy intends to expand the herd size.
- Costs calculations can be done based on various scenarios, taking into account investment needed for the different plan.
- The simulation applies for robotic and non robotic diaries.

The simulation software is ready to be picked-up by a robot manufacturer or a dairy business global player that may purchase the know-how. More information can be accumulated in order to address the full range of practical situations and additional data from more farms may also improve the model validity. Data can be collected by the industry in the course of day-to-day designing and the RMB designs, layouts and operational data can be stored in the public domain (such as an Internet site) accessible to other firms, in accordance with the principles of free dissemination of science. The onus is now on the industry to implement this proposed design methodology on a daily basis.

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The effects of automatic milking with single box facilities on animal behaviour and milk performance on larger farms

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Summary

On the basis of data from two farms with a total of five automatic milking systems[1], the use of the facilities, animal behaviour, frequency of milking and the influence of multiple milkings on the milk yield were analysed. Daily Data was available from 312 days, and was supplemented with data for the monitoring of milk yield. The individual MS are assigned to fixed groups of cows. Cows not appropriate for the MS, were milked in the old herringbone milking parlour. The results show, that with a net milking time of about 14 hours (not including the time required for application, animal change and periods without milkflow) the systems capability was reached. It was also shown, that with more than 42 cows, the milking frequency in the automatic system went down. The cows did not use the system enough in the period from 2 a.m. to 10 a.m. With a mean of 2.89 milkings per cow per day, good values were achieved. With the estimation ability gained through this study, it can be seen that milk performance improvements of about ten percent are realistically attainable, if a good management of the whole system is ensured.

***Key words**: Automatic milking, milking capacity, animal behaviour, milk yield.*

Introduction

Automatic milking processes are a future technology for milk producers as a solution for labour, or socio-economic problems. They have a significant impact on animal behaviour, milk yield, labour organisation and agricultural structure. Practical experiences with the implementation of automatic milking systems have been reported by different authors in Schön (2000) or Hogeveen & Meijering (2000). Bohlsen (2000) conducted long-term analyses of several farms using the multiple box system "MS

[1]MS = (Automatic) Milking System(s)

Liberty." His work was part of a larger study (Artmann *et al*., 2000). The publications on single box facilities were based mostly upon short observation periods and small herds. Subsequently, initial results from long term observations from five single box facilities (Trademark "Astronaut") used in two larger closely-co-operating farms were compared. Installation and especially, the first results obtained from single box facilities are presented here.

Farms and installation of the automatic milking systems in the buildings

Two larger commercial (GbR and GmbH) farms in former East Germany serve as the basis for this study. Dairy cattle are the main focus of animal husbandry on the farms. At this time the farms hold a total of 140 and 290 cows respectively. The milk quota is about 1.09 and 2.5*106 litres, respectively. The average yield is 8 500 kg with 3.45 % protein and 4.12 % fat. An annual yield increase of 700 l/ cow and year is expected. The decision to implement an automatic milking system was made because the proximity of the farms to a high-paying industrial area (Volkswagen production centre) made it increasingly difficult to find workers for the farm. Also, to increase yield, the cows were to be milked three times daily. The automatic milking systems were installed on one farm in November and December 1999.

The dairy cows spend the whole year in two L-203 type stables, built during the Communist period. Both stables were remodelled as laying box stalls (one per farm) with slatted floors. Each stable has three laying boxes on the side with feed entrance, and a complete row of boxes on the opposite side. Between the two stables is the milking centre. The room behind the milking parlour is roofed and is used as a deep free yard stall for calving or sick cows.

The automatic milking system is installed in the row of double lying boxes. With a one way gate, the cows can achieve the MS only from the laying area. Due to the givens of the stable, at some points, the cows must pass over the feeding lane. Feed concentrate and water serve as incentives to visit the automatic milking system. The cows are separated into different groups with simple barriers. In the automatic system, only "system conforming" cows are milked. All other cows are milked in the available 2*6 parlour. The reintroduction of cows which have calved or recovered from an illness takes place mostly in the automatic milking systems 1 or 3 of the different farms. In the fourth MS, the cows of the GmbH are milked during their high yield periods, and low performing cows from this farm are milked in the fifth MS. The deciding parameters determining how often the cows are milked each day are tuned differently in each system. During the observation period, a mean of about 230 cows were milked.

Data material and evaluation

Data was collected on the main computer of the MS with an additional program. The files were copied onto ZIP diskettes and transferred to own computers where they were studied and evaluated. Data from the GmbH was available from Feb. 1, 2000, and from the GbR from April 2, 2000 for evaluation. The daily data from the automatic milking system was available from June 6, 2000. Smaller data gaps – due to forgetfulness – could be reconstructed. The last data evaluated is from April 5, 2000. Obtained Data was inspected and evaluated with Access, Excel and SAS. For the calculation of the estimation of milk with the GLM – (General Linear Models) procedure with SAS the following data sets was eliminated: In the case of data without a milk quantity but with a positively or negatively evaluated application, the current and subsequent value; Data with a milking level of <2,5; Data with a calculated interim milking period of <3 or >36 hours; Data from cows lactating more than 450 days.

Results

The following results are based on an evaluation of the files for 312 days (Table 1). The functioning of the facilities could not be observed due to the distance between the two farms. The users described it as good. A view to the evaluation of the length of milk withdrawal (measured from the beginning of the milk flow) no problems occurred during the observation period which could not be solved within one day. Occasional disturbances in the length of milking time indicate short term failures, but these can be attributed to inactive periods due to system tasks. Calculated from the mean values a net milking time[2] of between 576 and 791 minutes per day (without time for application, change of animals, and empty periods).

Table 1. Main data from the MS.

Number of MS	1	2	3	4	5
Number of milkings	41 705	37 770	42 825	42 123	37 715
Number of cows on the MS	47.6	44.6	47.9	45.2	45.7
Milking frequency	2.88	2.80	2.93	3.09	2.87
Milking interval (h)	8.33	8.57	8.19	7.77	8.36
Milk quantity	33.10	22.89	31.73	30.01	19.69
Milking time (min / day)	714	524	699	641	503
Dead milking time(min / day)	77	74	80	86	73

[2]Rising net milking time are only possible by more efficient attachment, faster animal change or reduction of the dead times by cleaning or unoccupied MS.

Since the combination of maximum length of milking time and maximum inactive time for the third MS (Cows in the high phase of lactation) is only 921 minutes and the farmer reports that the MS 3 sometimes reached peak performance levels, it can be concluded that a net milking time of about 14 hours is the current highest capacity level on the studied system. In figure 1, the distribution of the milkings over the course of a day is presented.

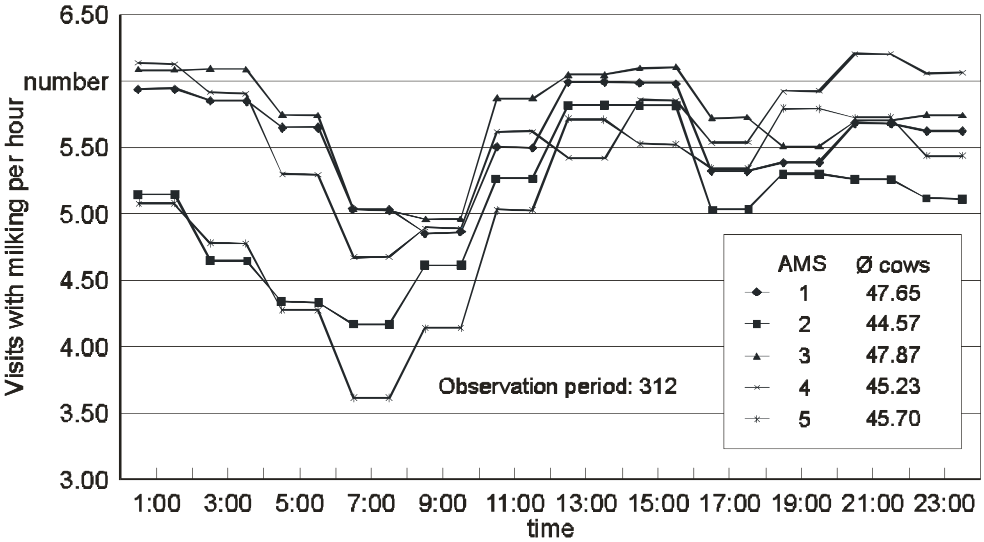

Figure 1. Distribution of milking visits on the MS.

The curves show significant reductions in the visits to the stations from about 2 a.m. to 10 a.m. On the one hand biological resting periods and greater tiredness in advanced lactation stages play a role here (at MS 2 and 5). On the other hand, such management factors as feed presentation, milking of cows which do not voluntarily enter the system, or the instruction of new cows in the system also play a role. A mean of 5.4 milking per hour were carried out. The milking frequency with 2.7 to 3.1 milkings per cow per day is good. A view to the course during the observation period shows that cows lactating longer (MS 2 and 5) are milked less frequently. From a trend function can be seen that the milking frequency declines with an increasing number of cows, it increases with an increasing daily performance of the cows, or rather the amount of daily amount of milk in the MS. The certainty of these estimations are, however, not very secure. With a subsequent GLM function, where the MS number is introduced as a co-variable, a R^2 of 0.65 was achieved.

Milk frequency = f (MS_Nr., Number of Cows, ln (Number of Cows), Daily Amount of Milk, Daily Amount of Milk², ln (Daily amount of milk), daily milk yield)

The differences of the co-efficients of the co-variables are interesting. They show that in comparison to MS 1, the milking frequency of the MS 2 to 5 are above those of MS 1 by 0.3955; 0.1074; 0.2149; and 0.5830 respectively. On the one hand, these values reflect the influence of non-documented cow characteristics, and on the other hand are at least partially related to differing settings in the systems. If one uses the estimated parameters from this model, and varies the number of cows from 35 to 57 cows, and set the daily milking yield to the mean herd performance (27.5 kg / day), then an increase in the mean milking frequency to 3.04 with 42 cows with a subsequent progressive decline is obtained. With 55 cows the frequency was declined to 2.74. This relationship indicates the capacity levels of the system.

In relation to the implementation of MS it has not yet been clearly defined, what effects multiple milkings have on the milk yield. To clarify this question, all available daily data and milk yield data, taken before the daily data, were used. After data preparation 228 043 data sets were available for an estimate of the regression function (GLM) (Table 2). For the Estim- tion the following approach was chosen. It proved to be significant in all parameters

Milk quantity = f (Lactation Number, MI, MI², MI³, Day of Lactation, (Day of Lactation)², ln (Day of Lactation))

Table 2. Description of the most important influence factors.

Variable	Unit	Mean	s	Minimum	Maximum
Milk Quantity	kg	9.92	3.29	2.5	31.1
Milking interval (MI)	h	8.41	2.50	3.02	34.57
Days in Lactation	days	170.51	101.24	4	450

The lactation number was introduced as a co-variable. Only the difference between the first and all further lactations at a level of 5 percent were significant. On the basis of the regression coefficients it was calculated how the milk quantities behave during the course of a lactation under the assumption of different milking intervals (Figure 2). The lactation courses principally show that with an increasing milk frequency (the higher curve is 3.5 milking prow cow and day) the milk performance increases. If the performance for two milkings with 12 h milking interval is set to 100 %, then a very high milking frequency shows a yield increase from almost 20 % and for three daily with the same interval an increase of about 15 %. If a cow visits the MS regularly twice a day, and the milking intervals are not advantageous (8 hours or 16 hours MI) then the milk yield decrease of 2.6 %.

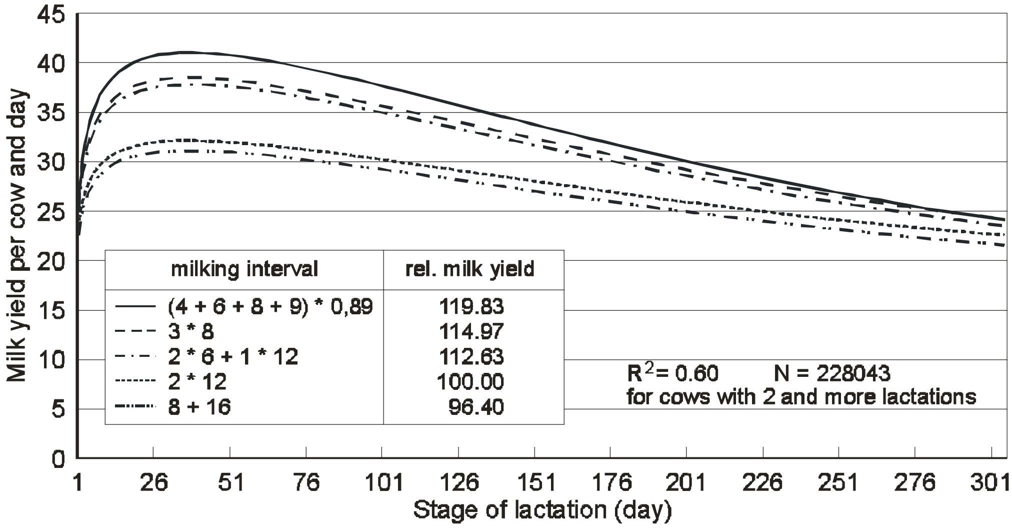

Figure 2. Estimated milk yield by assumed milking intervals.

The calculated milk yield curves assume a consistent milking interval over the course of the lactation. For a realistic estimate, the actual visiting performance of the cow is more important. These evaluations are planned on the basis of the available data, supplemented with future data. The influence of multiple milking on the content of the milk must also be clarified.

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Evaluation of somatic cell count under automatic milking conditions

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Summary

Investigations under standardised conditions (6 cows, milked and sampled for 16 days with varied milking interval, MI) showed, that increasing MI of 4, 8 and 12 hours lead to decreasing somatic cell count (SCC) of 499, 360 and 297 cells per ml ($P \leq 0{,}016$), respectively. In contrast to our study, some authors observed increasing SCC with MI if cows were sampled in automatic milking systems. Further investigations in herds milked automatically confirmed both observations. SCC increased with increasing MI per herd, as determined by the management program. By contrast SCC decreased if it is evaluated per cow. The relationship between subclinical mastitis, lowered milk yield and yield based MI explains the differences.

Key words: *Milking interval, somatic cell count, mastitis detection.*

Introduction

Milk recording under robotic milking conditions collects milk samples after different MI. It is known that this must be taken into account for the evaluation of some milk constituents. SCC of milk is an established parameter to supervise udder health, its analysis in monthly recorded milk samples is common practice. Thus the affection of SCC by MI gains new importance.

Material and methods

Investigations were carried out under standardised conventional as well as under robotic milking conditions.

6 cows were milked and sampled in a stanchion barn over a period of 16 days in two trials (8 days each). MI were 4:8:12 and 8:4:12 hours, respectively. Quarter milk samples were analysed for SCC. Methods of milking and sampling are already described elsewhere [1].

Quarter milk samples gained during robotic milking were not available. Therefore, a herd of 47 cows, usually milked by an automatic system, was sampled in a herringbone parlour three times over a period of 14 days [2]. The MI between the last robotic milking and the parlour milking was noticed. Based on this value the three days of sampling were ranked per cow into shorter, intermediate and longer MI. This allowed the direct comparison within cow and quarter. Robotic milking was continuously supervised during these days, and real MI determined as well as the MI of the management program (= minimum of time between two milkings).

Evaluation of cyto-bacteriological analyses followed the standards recommended by DVG [3]. Statistical analysis was based on SPSS 10.0 for Windows.

Results and discussion

Investigations under standardised conditions showed that increasing MI cause decreasing SCC (Figure 1) and confirm observations by other authors [4, 5].

These results are in contrast to the information gained from the herd milked automatically. Fixed MI and real conditions are shown in table 1.

SCC tends to increase with longer MI if SCC data are evaluated according to the MI as determined by the management program (Figure 2). This corresponds to studies by other authors [6].

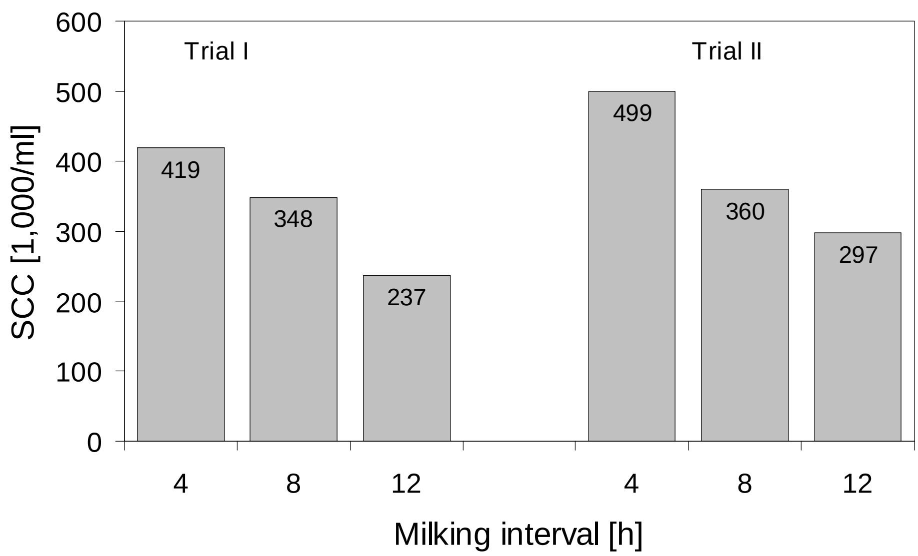

Figure 1. Somatic cell count (SCC) after varied milking intervals (delogarithmic means of 24 quarters of 6 cows, P≤ 0.016).

Table 1. Determined and real milking intervals in a herd milked automatic automatically.

Milking interval [h]				
Defined	Real (mean)	s	Milkings	Cows
< 6	7.3	1.9	1 030	7
< 7	8.4	1.8	659	5
< 8	9.9	2.2	870	8
< 9	11.4	2.6	555	6
< 10	11.6	2.5	256	3
< 11	12.3	2.4	327	4
≤ 12	13.6	2.7	750	11

The comparison between SCC of sampling days within each udder quarter revealed that SCC is really lower after longer MI (Figure 3). The calculated differences between MI classes were highly significant ($P < 0.001$). Thus, the reported increase of SCC has to be caused by the defined MI.

Management programs usually calculate MI based on the expected milk yield. Higher milk yields lead to shorter MI, and low yielding cows are not milked as often as they visit the milking robot. Lower milk yields may be caused by stage of lactation as well as udder disease. A lowered milk

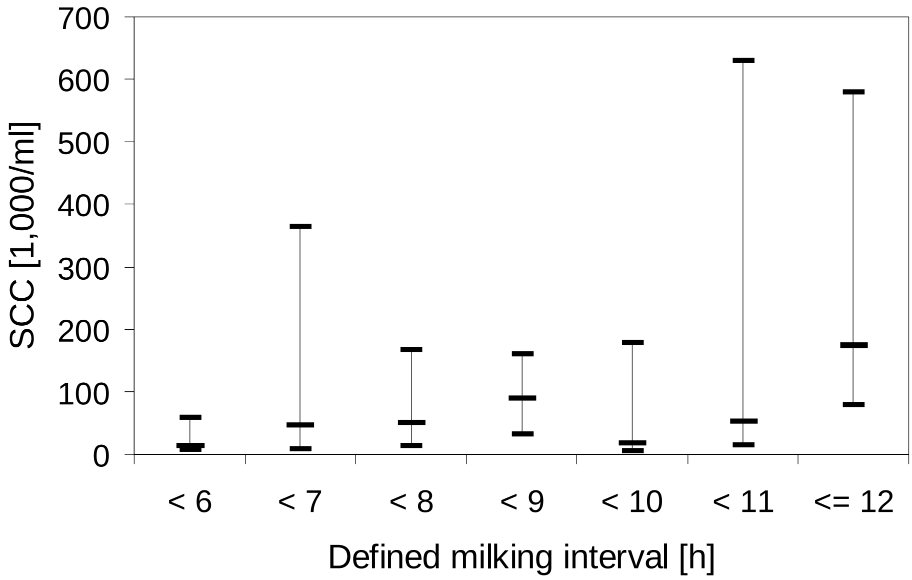

Figure 2. SCC quartiles according to the milking interval as determined by the management program (176 quarters of 44 cows).

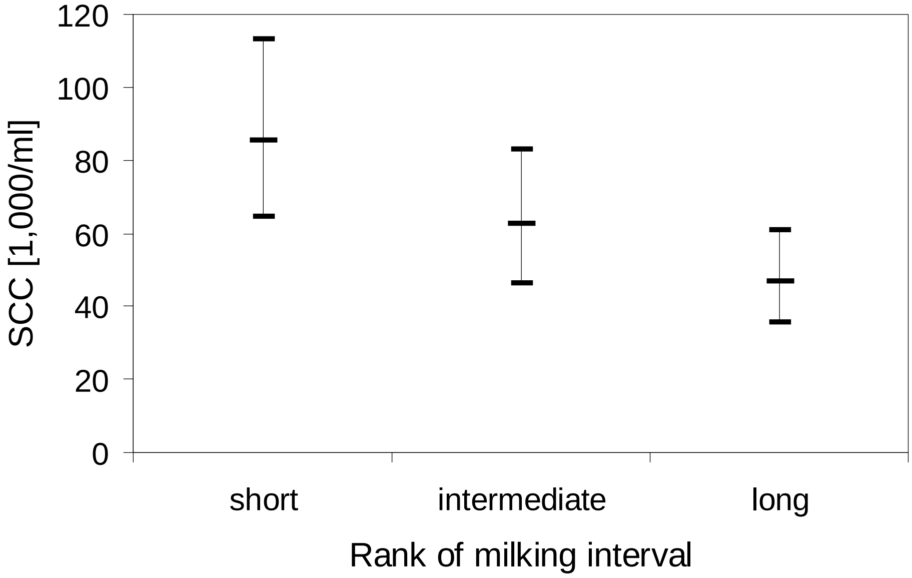

Figure 3. Mean and 95% interval of confidence of SCC for ranked milking intervals before quarter milk sampling in a milking parlour (176 quarters of 44 cows).

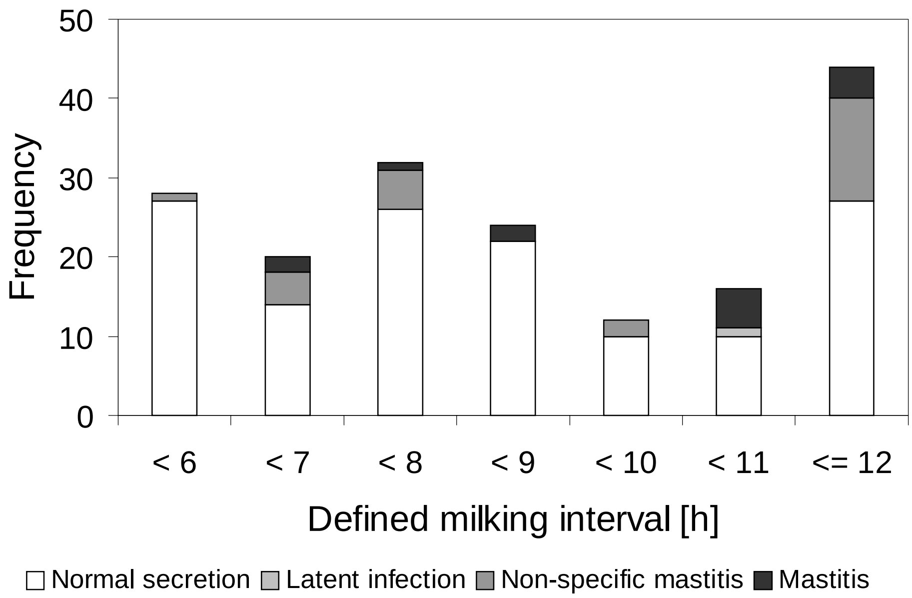

Figure 4. Frequencies of quarter health status according to the milking interval determined by the management program.

yield is often a side effect of subclinical mastitis. Therefore, cows with subclinical mastitis (and higher SCC compared to healthy cows in the same herd) were milked in longer intervals. Figure 4 shows the distribution of healthy and disturbed quarters based on the defined MI classes. Obviously, the major part of mastitis quarters was milked after more than 10 hours.

Conclusions

Increasing MI causes decreasing SCC readings. The reported increase of SCC connected with wider MI under robotic milking conditions is no contradiction. Mastitis is often accompanied by a lowered milk yield. Therefore, mastitis cows usually get longer MI from the management program. This gives the impression that SCC increases with MI. Scientific investigations concerning udder health in herds milked automatically should take into account that correct data must be based on MI within cow or quarter to avoid false conclusions.

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Evaluation of milking parameters by quarter in an automatic milking system with modified milkmeters

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Summary

Four milkmeters, designed for milk yield recording with sheep or goats, have been used for monitoring the settings of flow sensing devices in an automatic milking system. In two sessions data were recorded including the milking of 25 cows and of 28 cows. Parameters evaluated were total milk yield, milking time per cow and per quarter, various milk flow patterns, time for overmilking and the milk yield of manually stripping all quarters individually. For statistical treatment analysis of variance was used. Based on results of the first session the milk flow sensors of the AMS were readjusted. The average milk yield was 12.3 kg / cow respectively 12.2 kg / cow. Average and peak milk flow in both sessions were found to be at a reasonable level. The parameters "flow at take off" and "stripping yield" in the first session were more uniform after readjustment of the AMS. The time recorded for overmilking in most quarters was considerably reduced. These results indicated that milkmeters with an appropriate sensitivity for low rates of milk flow may be helpful for evaluation and adjustment of milking behaviour of AMS.

***Key words**: Automatic milking systems, milking parameters, milkmeters.*

Introduction

Milking procedures in automatic milking systems generally are controlled by quarter. For this purpose sensing devices are required with identical settings of parameters related to milk flow patterns of individual quarters.

Not only for practical but also for scientific reasons (Weiss and Worstorff, 2000) it therefore is helpful to look for possibilities to check the milk flow monitoring devices of automatic milking systems, to make sure they are working correctly and to optimize their operation if necessary. One option is using four milkmeters for individually monitoring the milking procedure of each quarter. This solution has been adopted already, e.g. by

Umstätter and Kaufmann (2001). They used a type of milkmeter ("Lactocorder", Foss Electric, DK) which is continuously measuring flow rates and calculates the total yield by integrating milkflow over time. Due to powerful software several parameters to individually characterize milking behaviour of cows can be calculated. Since milkmeters are designed to handle full milk flow of an udder they have to work at the very low end of their range of operation when they are connected just to one quarter. This may result in a rather low resolution, mainly at the beginning and at the end of milking. To obtain reliable information Umstätter and Kaufmann (2001) therefore over a period of 72 hours had to collect a relatively high amount of data.

Materials and methods

To overcome these problems and to reduce the amount of time required for investigations prototypes of the above mentioned milkmeter, designed for milk recording with sheep and goats, have been used in connection with an automatic milking system (AMS) ("Merlin", Fullwood-Packo, B / D / GB / NL), with the goal to use information obtained by this equipment for checking and eventually correcting the operation of the system.

In two sessions data were recorded including the milkings of 25 cows in the first and of 28 cows in the second session. The AMS provided listings of milking time per cow and per quarter and of the total milk yield. The actual flow rate displayed by the milkmeter was manually recorded at the moment when the teat cup of the respective quarter was taken off. After the end of each session data recorded by the milkmeters were read out and printed using the software provided with the device. For further evaluation data on milking time, peak milk flow, average milk flow and overmilking were used. When all teat cups were taken off the efficiency of each milking procedure was evaluated by manually stripping all quarters individually and by weighing the amount of milk obtained. For statistical treatment of data analysis of variance was used.

Based on information obtained during the first session the milk flow sensors of the AMS were readjusted to obtain more regular control of milking procedures. The efficiency of the adjustment was checked using the results of the second session.

Results and discussion

In session 1 an average milk yield of 12.3 kg per milked cow was obtained. Average milk flow and peak flow (Table 1) were found to be at a reasonable level when the results per quarter were summed up. However, the parameters "milking time", "overmilking", "flow at take off" and "stripping yield" indicated some irregularity with respect to the quarter "front left". It therefore was decided to readjust the flow sensors controlling the milking procedure.

Table 1. Results of session one.

Quarter	Hind left	Hind right	Front left	Front right
Milking time (min)	5.3	5.3	5.3	4.4
Aver. milk flow (kg/min)	0.6	0.5	0.5	0.7
Peak milk flow (kg/min)	0.8	0.7	0.7	0.8
Overmilking (min)	1.08	0.96	1.57	0.44
Flow at take off (kg/min)	0.07	0.12	0.07	0.18
Stripping yield (g)	59.3	64.6	20.3	28.4

Table 2. Results of session two.

Quarter	Hind left	Hind right	Front left	Front right
Milking time (min)	6.4	7.2	3.9	3.8
Aver. milk flow (kg/min)	0.7	0.7	0.7	0.6
Peak milk flow (kg/min)	0.9	0.9	0.9	0.8
Overmilking (min)	0.16	0.11	0.17	0.37
Flow at take off (kg/min)	0.22	0.24	0.28	0.16
Stripping yield (g)	44.5	67.7	42.6	42.8

In session 2 the average milk yield was 12.2 kg per milking. The levels of average milk flow and of peakflow per quarter had increased and were more uniform over quarters (Table 2). In most quarters the time recorded for overmilking was considerably reduced, only quarter “front right” did not show much difference to session 1. “Flow at take off” and “Stripping yield” were higher than in session 1, but more uniform and still at acceptable levels.

The results obtained indicated that milkmeters with an appropriate sensitivity for low rates of milk flow may be helpful for evaluation and adjustment of milking behaviour of AMS. However, to do this efficiently the manufacturer of the AMS should define suitable procedures.

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The development of udder health of a dairy cow herd in an automated milking system

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Summary

The influence of an improved hygiene management on udder health of cows in an automated milking system has been studied. The results are based on data, which were collected over a period of 17 months. The Farm had two groups of dairy cows which were divided according to the milking variants. The examined cows (about 50) have been milked by a one-box-robot, produced by Lely. Through the examination period, the udder health has clearly improved and stayed steady. With regard to mastitis, the predictive value of electrical conductivity as the main diagnostic parameter was compared to the appearance of clots in milk. There was no relation between both criteria. It is concluded that brilliant milking hygiene is necessary and a special udder health examination at regular intervals is needed.

Key words: *Automatic milking, udder health, management, peracetic acid.*

Introduction

The expected advantages of milking with a milking robot are the saving of working time, easement of work and improvement of udder health. The improvement of udder health occurs not offhand. With a view on the specific properties of a milking robot, it is to remark, that, if there are about 180 milkings with one milking module per day, a high mastitis risk exists. Special sources of infection are the contact points between udder and robot. At one hand there are the brushes which clean the teats before milking and on the other hand there are the teatcups. SPOHR (2001) could observe that the new-infection-rate has been decreased from 100 percent to 60 percent in herds with mastitis problems under utilisation of peracetic acid

(PAA) disinfection. That is why the influence of an improved hygiene management on udder health of cows kept in an automated milking system (AMS) was examined. The diagnostic parameters of mastitis, which are measurable in the robot are the electrical conductivity and the milking volume. A comparison between mastitis signs and conductivity deviation was carried out.

Material and methods

The herd consisted of around 50 Holstein-Friesian-cows. These were kept in a free stall barn. A one-box-robot (Lely–Astronaut) for about 60 cows worked around the clock. The cows went to the robot voluntarily. They were fed with a partial-mixed-ration. Through the investigation period (March 2000 until June 2000) the management of the AMS was more intensive. This caused especially cleaner cubicles as well as a steady and effective disinfection of the teat-cleaning-brushes with PAA-solution. In addition, a teatcup disinfection (PAA) at the beginning of June 2000 was installed. The investigation of herd's udder health took place in an interval of 4 weeks for 17 months. A special clinical examination of the udder and the bacteriological examination of quarter samples were carried out. The somatic-cell-count-data from the monthly milk recording and conductivity data were collected. For the presentation descriptive statistics were used. To verify the predication of electrical conductivity as a diagnostic parameter of mastitis special notes ("alarm") were utilized. These occur if there are to high deviations in milk conductivity (adjustment: absolute threshold, inter-quarter-ratio 15percent each).

Results and discussion

Clinical findings

Six percent to 28 percent of all quarters were found to be clinical changed (atrophic quarters from 1 to 5 percent, tough quarters from 1 to 12 percent). The cases of acute mastitis decreased per month through the examination period [arithmetic mean: 4,3 cases / month (8 / 99 to 10 / 99) decresed to 2.3 cases / month (4 / 00 to 6 / 00)].

Figure 1 shows a continual decrease of the percentage of infected quarters (from 17 percent to 3 percent). 95 percent of these quarters were infected with coagulase-negative staphylococci (CNS). Sometimes there were *Streptococci* (aesculin-negative and aesculin-positive) and seldom *Corynebacterium bovis*, *Escherichia coli* and yeasts. The sources of CNS are the environment and the udder skin. That is why a brilliant hygiene in the cow shed and an effective infection-prophylaxis is needed. This can be realised with the usage of PAA-disinfection which has been reported by other authors (Model, 1995; SPOHR, 2001). In our studies, PAA has been used successful for the disinfection of cleaning brushes and teatcups. The cleaner udders had a positive influence on the efficiency of the disinfection. These were achieved with more cubicle care. That caused that the film of dirt was low on brushes and teatcups. In this way the disinfection efficiency of PAA against pathogens could be improved.

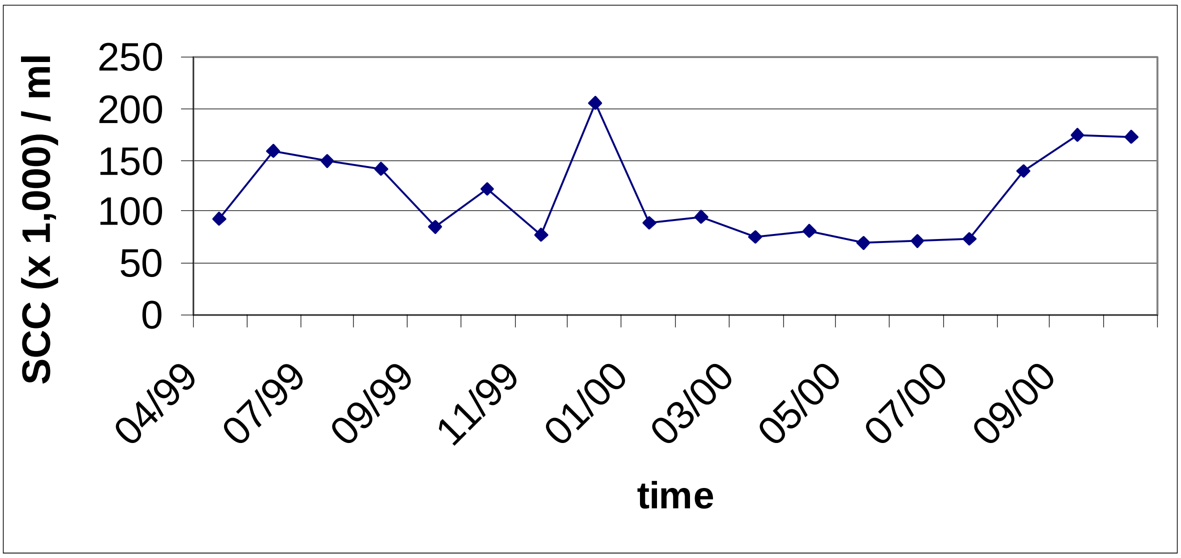

Figure 1. Percentage of infected quarters.

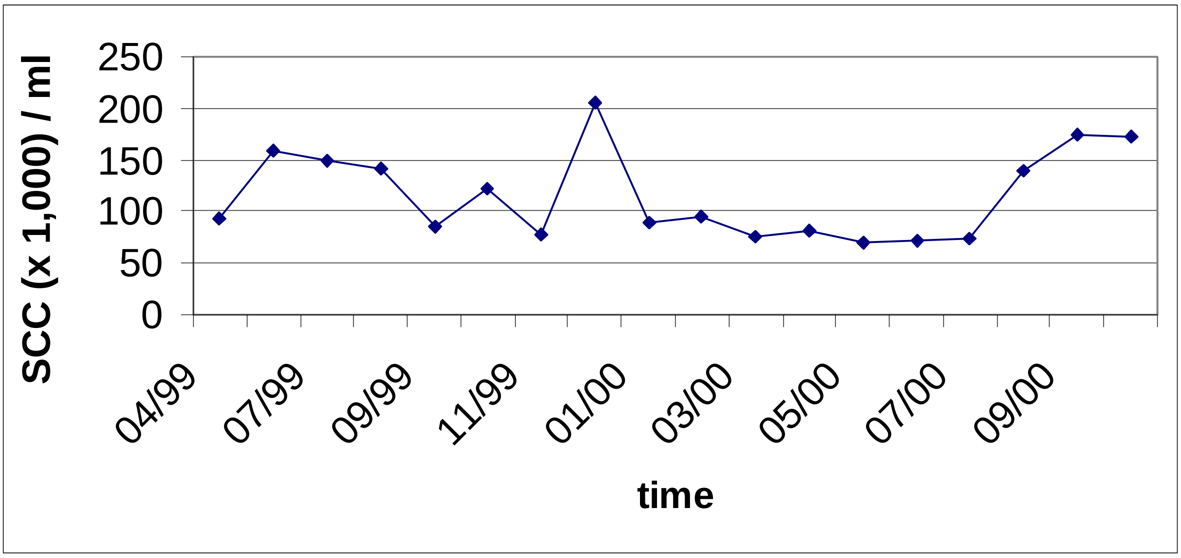

Figure 2. Development of somatic cell count over the time.

Figure 2 shows the development of the arithmetic mean of herd's somatic cell count (monthly milk recording). At the beginning there was a continual decrease of the value. Then a stabilisation of somatic cell count mean at the level below 100 000 cells / ml was observed. The reason for this can be the improved milking- and cubicle hygiene.

Investigation of the electrical conductivity

It has to be considered that the electrical conductivity is a variable for the measuring of deviations in the permeability of the blood-udder-barrier but not for findings of clots in the milk. The electrical conductivity is only an additive diagnostic parameter. In spite of this a comparison between conductivity "alarm" and clots in milk was carried out. In a milking robot there is no possibility to observe the first squirts of milk. Clots were assessed as a visible sign of acute mastitis. There were 4 true positive (6.8 percent), 27 false negative and 55 false positive results. It can be concluded that there is only a loose relation between both parameters. Similar facts are reported by Schwarzer, 2000; Trilk and Münch, 2001. With this comparison it could be seen that at this time there are no reliable udder health information.

Conclusion

The safeguarding of udder health can not be achieved in an AMS without effective prophylactic measures. From this point of view the important measures are the disinfection of teat-cleaning-brushes and teatcups with PAA as well as the spray-dipping with jodophors. The best possible cleanliness of udders is the precondition for a very low brush- and teatcup-contamination. This is the base for an effective disinfection. The uncertainties in the robot mastitis diagnostics are the cause for the necessity for an additional udder health monitoring. It has to include the clinical and bacteriological examination of the herd in regular intervals. Out of the available somatic cell counts of the herd, a detection of cows with high mastitis risk (> 300 000 cells / ml) must be done and measures have to be met. The saving of working time, easement of work and improvement of udder health are advantages which not offhand occur but also require a straight daily management.

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Automatic milking systems: Udder health and milk flow profiles

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Summary

Automatic milking systems (AMS) enable voluntary milking up to more than three times a day. This fact should not only increase the milk yield but also improve the status of udder health in automatically milked herds. The aim of the present study was the investigation of udder health and milk flow profiles and possible relations between these parameters. Data were collected on two practical farms using single-box-systems. One herd had 70 dairy cows which have been milked by one AMS, the other herd had a stock of 110 dairy cows and used two AMS. Over a period of six months both herds were examined three times. This investigations include antiseptical foremilk-samples for bacteriological analyses and the recording of milk flow profiles. Environment-associated pathogens had been the main cause for subclinical mastitis. In one herd the incidence increased during the period of investigation. But also udderassociated (contagious) pathogens can spread out in an automatically milked herd. Subclinical infected quarters in average have a higher maximum milk flow and longer overmilking times.

Key words: *Automatic milking systems, ,udder health, somatic cell count, milk flow profiles, management.*

Introduction

One of the most important technological innovations in dairying during the last years is automatic milking. Worldwide more than 1000 dairy farms are using this new technique. Most of the systems used in Europe are installed in family farms with 50-150 dairy cows. Beside the reduction of physical labour and the free organisation of working processes an improvement of the udder health status is suggested, because automatic milking systems enable voluntary milking and some systems are allowing a quarter milk flow controlled milking process.

Aim of the study is the investigation of quarter milk flow profiles, somatic cell count, bacteriological status and possible relations between these parameters. The examination is taking place in two dairy farms, one with 70 dairy cows and one AMS (herd 1), the other with 110 dairy cows and two AMS (herd 2). Both farms are using single-box–systems.

Material and methods

During the milking process single quarter milk flow profiles were recorded with the Lacto Corder^{R} (by Foss), which measures total amount of milk, rate of maximum milk flow, overmilking time and total time of milk flow. At the same time single quarter foremilk-samples were taken antiseptically from all lactating cows directly before the milking process started. The somatic cell count of each sample was determined by fluorescence-optical method (Fossomatic^{R} 360). According to the somatic cell count the quarter foremilk samples were subdivided into two groups. Samples with a somatic cell count up to 100 000 cells / ml were classified as samples from healthy quarters. Samples with more than 100 000 cells / ml were suspected to come from quarters with subclinical mastitis (1). These samples were cultured for bacteriological examination according to IDF standard (2). Each herd was at least investigated three times in intervals of three months.

Results

The herds were free of *Streptococcus agalactiae*, and only a few quarters were found to be infected with *Staphylococcus aureus* (<5%). Environment-associated pathogens (environmental streptococci and Coagulase-negative staphylococci) were diagnosed as the main cause for subclinical and clinical mastitis under robotic milking in these two herds. The rate of subclinical, by environmental pathogens, infected quarters in herd 2 rose from 7.5% to 17.7%, whereas in herd 1 it decreased in the second investigation and after six months it reached a level of about 30% of infected quarters that was comparable to the situation at the beginning of the investigation (Figure 1). In herd 1 the udderassociated (contagious) pathogen Staphylococcus aureus was the reason for a certain number of subclinical infections (Figure 2).

A maximum quarter milk flow in the range of 0.78 up to 1.24 kg / min was found. Hind quarters in comparison with front quarters had a higher average maximum milk flow. Over the period of six month robotic milking, the average maximum milk flow decreased in herd 1. The overmilking times of single quarters were in average between 7.2 and 32.8 seconds. They decreased in both herds in the period of six month. The average maximum milk flow and the overmilking time of quarters with cell counts over 100 000 cells per ml were higher than those with cell counts below this threshold value.

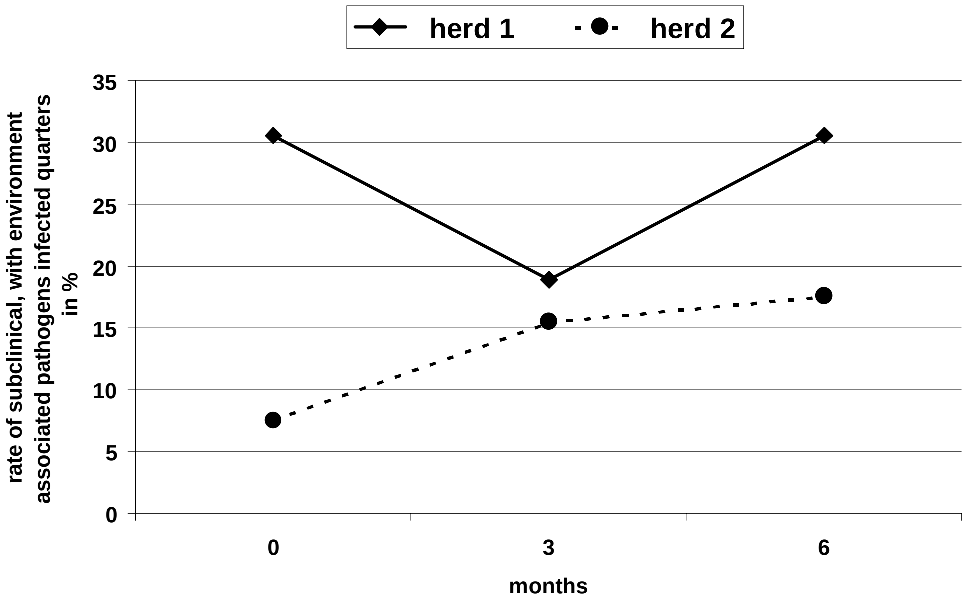

Figure 1. Prevalence of subclinical, with environment-associated pathogens infected quarters (n=1 088).

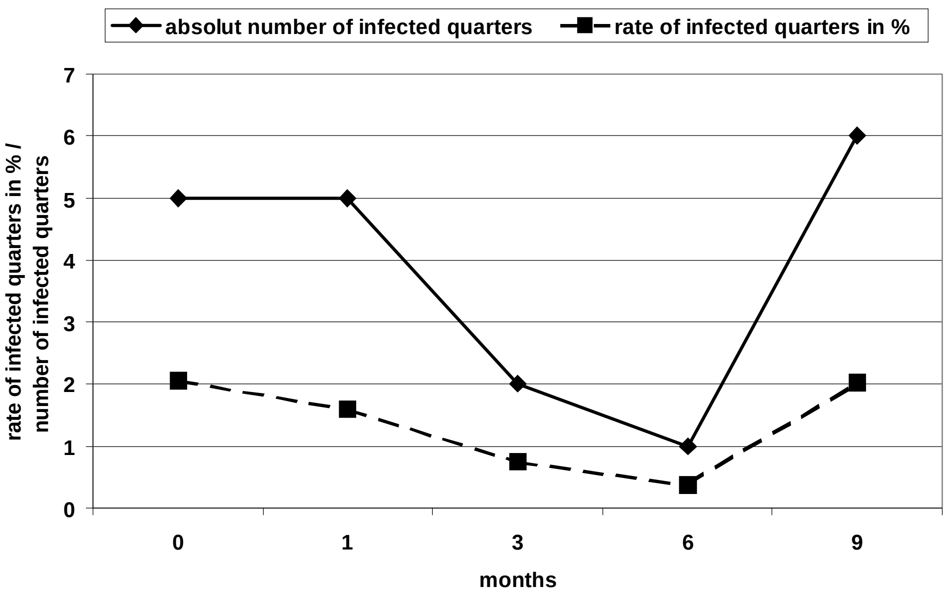

Figure 2. Rate and total number of quarters infected with Staphylococcus aureus (n=1 376).

Discussion and conclusions

The rate of subclinical mastitis caused by environment associated pathogens increased in one herd. Cause for this may be on the one hand the frequency and intensity of cubicle cleaning, on the other hand the disability of the AMS to distinguish between clean and dirty udders and as a result of this a non sufficient cleaning of the teats.

New-infections caused by udderassociated (contagious) pathogens are favoured by long intervals of cluster desinfection and a non sufficient teat dipping.

The decrease of the maximum quarter milk flow may be the result of a higher milking frequency with lower milk yield per single milking.

The remarkable decrease of the overmilking time is the result of the increased threshold value for the automatic teatcup take-off up to 150 gram per minute.

An increase of the maximum milk flow and overmilking time of single quarters is associated with an increasing risk for subclinical mastitis.

Our results once more show, that the relations between every kind of milking technique and udder health are very complex. In farms using AMS the direct contact between dairy cow and farmer is reduced to a minimum, so that technique and management are getting more important. The use of an automatic milking system did not improve udder health automatically.

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Automatic milking systems and their chances in the Czech Republic

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Summary

Two stables for 300 dairy cows were compared in model, one with milking in herringbone milking parlour 2 x 12 with rapid exit and automated data collection and the second equipped for milking by two AMS LEONARDO. The costs of stable with milking in milking parlour including milking parlour and milk store room are by 7% higher than similar costs for stable with milking in AMS. In contrast to this the costs for technical equipment of stable are by 185% higher in stable with milking in AMS than those in stable with milking parlour. The highest share of the increased costs represents the AMS price, which is by 361% higher than price of milking parlour. Total investment costs of stable for 300 dairy cows with milking in AMS are by 17.35 mil. CZK (i.e. by 62.6%) higher than those of stable with milking parlour. These costs are then shown in total operational costs of stable and costs per production of 1 litre of milk so that total annual costs on farm for 300 dairy cows with milking in AMS are under similar conditions by 9.9% higher in comparison with identical farm but with milking in milking parlour. In comparison of the both milking systems is necessary to take into account, that at 3-time daily frequency of milking there was reached same effect of milk yield increase as at voluntary milking in AMS. A certain problem seems to be deterioration of reproduction parameters in consequence of milking increased frequency. Due to change into 3-time daily milking the conception has deteriorated (insemination index has increased by 0.4), the interval has extended by 18.1 days and service period has increased by 6.3 days.

Key words*: Robotic milking, parlour milking, production costs.*

Introduction

In the 90’s was finished the basic development of AMS (Automatic Milking System) and now it is rapidly extending within European farms for dairy cows keeping. It concerns mainly the farms with relative low number of dairy cows. On the Czech farms is normally kept 200 – 800 dairy cows.

This farm size has considerable problems when using current AMS. These problems have to be analysed in details (Vegricht, 1999). It regards particularly:

- Constructional and disposal design of current stables in relation to the AMS demands and real possibilities of their reconstruction.
- AMS performance with respect to total number of dairy cows in one stable and on farm.
- Dairy cows milk yield and possible benefits resulting from change to AMS milking.
- AMS benefits in social sphere on dairy farms in CR.
- Economical aspects of AMS utilisation in comparison with milking in milking parlour.

The real performance of current AMS is for single – box system max. 60 dairy cows and for multi – box system max. 150 dairy cows per day (Schön, 2000). In larger stables and on large - size farms it calls for installation of some AMS to reach total output corresponding with number of housed dairy cows. With respect to requirements on dairy cows free movement to AMS, to feeding place and to box bed it seems that the most simple and the cheapest solution for application of this milking system will be construction of new, light stable providing AMS requirements for size and constructional and disposition solution (Vegricht, 2000).

The average milk yield of dairy cows in CR in 2 000 has reached about 5 300 l. Considering the lowest limit of milk yield for AMS application 8 000 l / year which is a condition for achievement of milk yield increase in consequence of multiple milking, this system application may be thing over for about 10% of dairy cows in CR. The similar effect can be reached for parlour milking as found out e.g. during experiments carried – out by Dolezal (Table1), who found the milk yield increase by about 18.9% when milking process has changed to 3 – time daily. The contributions obtained by milk yield increase have to balance the wages, energy and feedstuffs costs increase, deteriorated reproduction indicators, increased wear of milking apparatus, disinfections etc. A certain problem seems to be deterioration of reproduction parameters in consequence of milking increased frequency. Due to change into 3-time daily milking the conception has deteriorated (insemination index has increased by 0.4), the interval has extended by 18.1 days and service period has increased by 6.3 days (Dolezal, 1999).

The social benefit of the AMS milking application is not so expressive under conditions of larger farms with shift work character compared with family “single – man” farms. Higher amount of workers on farm enables to maintain adequate working time and change of workers enabling them to have a free time in regular intervals. Just this aspect of AMS application (elimination of energy day presence of farmer at morning and evening hours in stable during milking) is in many cases decisive for AMS purchase on small dairy farms. The milk production economy is on the Czech farms the most important criterion for all investment decisions. Conditions of the Czech farmers are at present considerably different from situation of farmers in the EU countries. For example, when the single – box AMS price will be expressed by amount of milk which the Czech has to sell compared with e. g. German farmer, than at this AMS price 300 000 DEM and milk realisation price 0.60 DEM / l and 7.50 CZK / l and currency rate 18.50 CZK / DEM the German farmer has to sell 500 000 litre of milk, but Czech farmer 740 000 litre, i. e. by 48% more.

Methods

For purposes how to determine economical aspects of AMS utilisation for milking on large farms corresponding with needs and requirements of the Czech Republic there were compared in model two stables for 300 dairy cows of which one was equipped for milking by herring – bone parlour 2 x 12 with rapid exit and automated data collection and the second stable equipped by two AMS LEONARDO, of which each has 4 milking stalls and 1 preparation box.

The ground plan scheme of these stables is shown in figure 1 and 2. In this connection is necessary to emphasise the model character of these stables design, where e.g. stable with AMS is extremely long. Therefore before eventual realisation it would be suitable to solve many details and to cooperate with the AMS manufacturer. For this study purposes this design is quite sufficient.

For these stables were determined in model the necessary investment costs and computed costs per 1 litre of milk production. The calculation was based on the basic milk yield 9 000 litre per 1 cow and year. In consequence of the milking increased frequency using AMS it is presumed to increase milk yield by 15% to 10 350 l per cow and year. Because according to experiences the same effect can be reached at milking 3-time daily in milking parlour, the calculation was completed also by this case, i.e. milk yield increase to 10 350 l at 3 – time daily milking on farm with herring – bone milking parlour 2 x 12.

In the calculation was involved as well saving of one milker for AMS milking in comparison with parlour milking, because recent experiences show that even milking system in AMS needs certain man activity.

Results and discussion

In table 2 are presented investment costs and their composition in stable for 300 dairy cows with parlour milking (Figure. 1) and in table 3 are presented similar costs for stable with milking in AMS (Figure. 2)

The construction costs per stable with parlour milking including parlour and milk room store are by 7% higher than those per milking in AMS. This can be explained by milk store room situated in stable and by absence of dairy cows gathering place before milking in stable with milking in AMS.

Table 1. Effect of milk yield change during standardised lactation (Dolezal, 1999).

Group	Number of finished lactions	Unit	Milking frequency in one day 2x	3x	Change %
A	148	kg	5 422 ± 720	5 498 ± 595	1.4
B	102	kg	6 228 ± 782	6 776 ± 801	8.8
C	48	kg	7 122 ± 788	8 468 ± 922	18.9

In contrast with this, the costs per stable technical equipment are for stable with milking in AMS by 185% higher than for stable with milking parlour. The highest share of increased costs has the AMS price, which is by 361% higher that the milking parlour price. Total investment costs per stable for 300 dairy cows with milking in AMS are by 17.35 mil. CZK (i.e. by 62.6%) higher than, those for stable with milking parlour.

These costs will appear in total operational costs of stable and production of 1 litre of milk presented in table 4. Total annual costs on farm for 300 dairy cows with milking in AMS are under almost identical conditions by 9.9% higher compared with similar farm with parlour milking. Comparison

Table 2. Investment costs per stable for 300 dairy cows with milking in herring; bone parlour 2 x 12 with rapid exit, 10^3 CZK.

Item	Description	Investment costs
Stable construction	6 –row stable with central feeding corridor and number of feeding places at trough 1:1.5, ground plan 32 x 72 m	9 216
Milking parlour with milk store room	Herring – bone milking parlour with 2 x 12 milking stalls and waiting room (1.5m^2/cow)	4 976
Slurry and waste water reservoir	Storage capacity 6 months, 3 500 m^3	3 500
Construction costs in total		17 692
Internal equipment of stable	Fence, drinking, mattress	1 800
Manure removal	2 x 2 scrapers	1 000
Milking parlour	Herring (bone 2 x 12 with rapid exit, milk flow) meters, pedometer, PC, fence, el. driver	4 910
Milk cooling and storage	2 cooling tanks, 2 x 6 500 l, recuperation	1 200
Feeding	Feeding wagon with auger, 12 m^3	1 100
Total technology costs		10 010
Total investment costs		27 702
Total investment costs over – calculated to 1 housing stall		92.34

Table 3. Investment costs of stable for 300 dairy cows with milking in 2x AMS LEONARDO, 10^3 CZK.

Item	Description	Investment costs
Stable construction	4 – row stable with 2x AMS Leonardo, feeding stall situated laterally, ratio of feeding places at through 1:2, ground plan 22 x 124.8 m	11 704
Milk store room	Storage capacity 13 000 l	1 326
Slurry and waste water reservoir	Storage capacity 6 months, 3 500 m^3	3 500
Construction costs in total		16 530
Internal equipment of stable	Fence, drinking, mattress	1 800
Manure removal	2 x 2 + 2 scrapers	1 800
Milking	2 x AMS Leonardo, each 4 + 1 box, pedometers	22 620
Milk cooling and storage	2 cooling tanks with recuperation, 2 x 6 500 l	1 200
Feeding	Mixing feeding wagon with auger, 12 m^3	1 100
Total technology costs		28 520
Total investment costs		45 050
Total investment costs over – calculated to 1 housing stall		150.17

of the both systems needs to take into account that the 3 – time daily frequency of milking allowed to reach the same effect of milk yield increase as in voluntary milking in AMS.

A certain problem seems to be the reproduction parameters deterioration in consequence of increased milking frequency. During tests in VÚ•V (Dolezal, 1999) the conception has deteriorated with change to the 3 – time daily milking (insemination index has increased by 0.4), the interval has extended by 18.1 days and service period has increased by 6.3 days. Explanation of these problems will need priority attention.

In connection with the AMS also development of partial milking devices was significantly sophisticated, particularly the automated monitoring of mammary gland health status and milk quality. This has a positive effect on technical level improvement of other milking devices.

For stables with higher number of animals will be purposeful to focus the next development to the multi-box systems of AMS with arrangement of milking stalls, e. g. within the circle perimeter enabling to reach better animals passage.

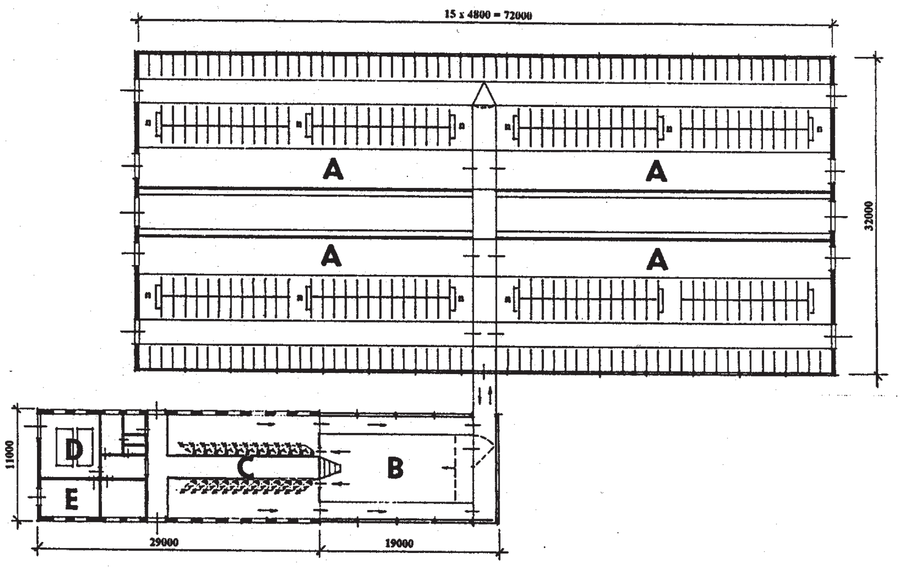

Figure 1. Stable for 300 dairy cows and herringbone parlour milking with rapid exit:
A- stable part for 150 cows,
B- dairy cows gathering places before milking,
C- milking parlour 2x12,
D- milk store room 2 x 6500 1,
n- watering place

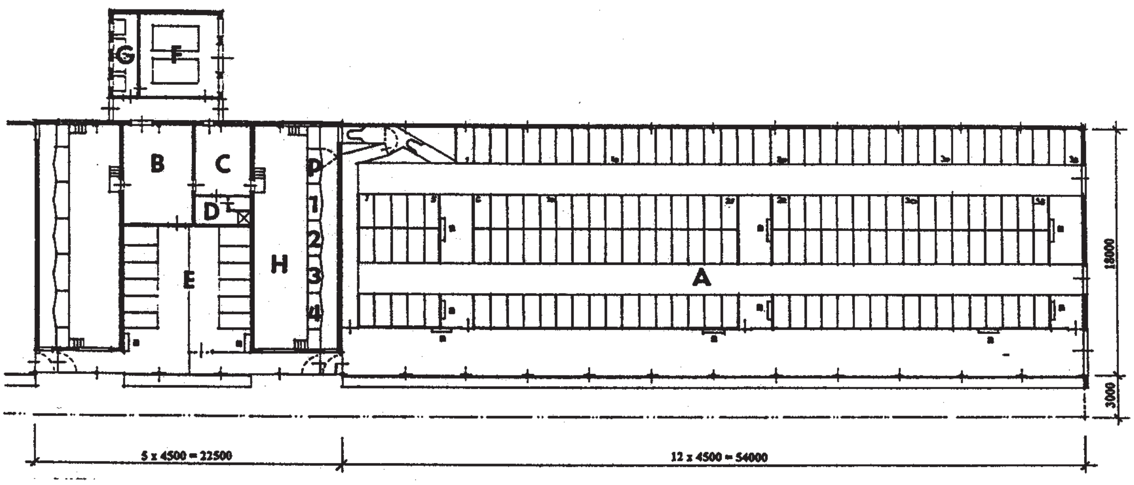

Figure 2. Stable for 300 dairy cows with milking in AMS Leonardo:
A- stable part for 150 cows,
B- machine room,
C- office room,
D- washing room WC,
E- pens for trouble cows,
F- milk store room 2 x 6500 l,
G- cooling aggregates,
H- AMS Leonardo,
P- preparation box,
n- watering place

It also would be useful to reduce the time for AMS milking apparatus application as one of presumption to increase their performance and better utilisation of robotized arm what will bring relative price cut down of 1 milking process.

On the large – size farms the positive contributions can be considered in the replacement of milker tiresome work and introduction of milking standard quality and milk high quality without human factor.

The basic condition for AMS application will be economy, i. e. AMS effect on the milk production costs and its realisation price. It considers mainly the high purchase price of AMS, which is so far the invincible obstacle for the Czech farmer. Therefore in near future we do not expect application of this milking method in conditions of Czech farms.

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Specific aspects of milk ejection in automatic milking system

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Summary

Milking routines in automatic milking systems (AMS) differ from those in conventional milking. While milking intervals are constant and teat cups are attached simultaneously in conventional milking, in AMS milking intervals are variable and attachment of teat cups can be sequentially delayed. Experiments were performed to test effect of pre-milking teat cleaning, of different milking intervals in different lactational stages, of delayed teat cup attachment and individual teat cup removal on oxytocin release, milk ejection and milk removal. Teat cleaning caused oxytocin release and induced milk ejection. Lag time from start of teat stimulation until start of milk ejection increased with decreasing milking interval and was longer in late than in early lactation. Sequentially delayed attachment of teat cups every 20 s or every 60 s did not reduce oxytocin release. However, total interruption of milk ejection for 2 min between prestimulation and start of milking resulted in transiently decreasing oxytocin concentration and increasing amounts of residual milk. The stimulatory effect of single teat cups during sequentially delayed attachment is sufficient to maintain adequate oxytocin release and maximum milk ejection.

Key words: *Automatic milking systems, milk ejection, oxytocin, teat stimulation.*

Introduction

Milking routines in automatic milking systems (AMS) differ considerably from those in conventional milking. In AMS milkings are performed throughout the day and the visits of the AMS are voluntarily determined by the cow albeit it is up to human control if milking is performed during these visits. The time needed for teat cup attachment in AMS is usually longer (up to several minutes) than cluster attachment by the milker in conventional milking. Furthermore, the start of teat cup attachment after the end of teat cleaning in the AMS can be delayed due to technical reasons.

In multi-box systems, this delay cannot be avoided because the cow has to walk to another box between cleaning and milking (Macuhová & Bruckmaier, 2000).

Oxytocin (OT), the essential hormone to induce milk ejection, is released into circulation in response to tactile (i.e. manual or mechanical) teat stimulation. The lag time from the start of stimulation until the onset of milk ejection usually lasts 1 to 2 min (Bruckmaier *et al.*, 1994). Timing of release of OT and milk ejection before the start of milk removal can be crucial for succeeding milking performance. Delayed milk ejection at the start of milking is indicated by bimodal milk flow curves, i.e. transiently reduced or interrupted milk flow after removal of the cisternal milk before alveolar milk is available (Bruckmaier and Blum, 1996).

The intention of this paper is to review the current knowledge including recent results on milk ejection and milk removal in AMS milking routines after different milking intervals and lactational stages, during sequentially or totally delayed teat cup attachment after udder preparation.

The stimulatory effect of pre-milking teat cleaning

Alveolar milk ejection at the beginning of milking is essential for fast and complete milk removal. In conventional milking tactile teat stimulation (manual or mechanical by the liner) before the start of milking is often performed to avoid delayed milk ejection (Bruckmaier and Blum, 1998). In AMS teats are cleaned by water, towel or brush. This cleaning period is ideal for prestimulation, provided that the type of teat and udder cleaning induces sufficient release of OT to induce milk ejection.

We have investigated the stimulatory effect of cleaning by rolling brush or towels. Brushing of teats and udder for 60 s induced release of OT and hence alveolar milk ejection (Macuhová and Bruckmaier, 2000). Similarly, teat cleaning by rolling towels induced milk ejection (Bruckmaier, unpublished data). Thus, mechanical teat cleaning of various AMS types causes release of OT and induces milk ejection. However, duration of cleaning must be long enough to provide a sufficiently long period of pre-stimulation without the removal of milk.

Effects of lactational stage and milking interval on milk ejection

Only the cisternal milk, stored in teat and gland cisterns and in large milk ducts, is removed by the milking vacuum already before milk ejection. This fraction usually amounts to less than 20 % of the total milk after a milking interval of 10-14 h (Pfeilsticker *et al.*, 1996). The alveolar milk fraction must be actively shifted into the cisternal cavities by milk ejection to be available for milking. Towards the end of lactation cisternal milk yield and fraction decreases with reduced milk production and often becomes close to zero (Pfeilsticker *et al.*, 1996). A similar effect is to be observed after short milking intervals. Until few hours after milking almost no cisternal milk is present (Knight *et al.*, 1994). Milk ejection is delayed towards the end of lactation (Mayer *et al*., 1991). A similarly delayed milk ejection as in late lactation is observed after short intervals from previous milking. Intervals shorter than 8 h usually don not occur in conventional milking systems but are common in AMS milking. It could be shown that the lag time until occurrence of milk ejection in response to teat stimulation is a function of degree of udder filling. Milk ejection was delayed if less milk was stored in the udder, independent if due to reduced production in late lactation or due to short interval from previous milking (Bruckmaier and Hilger, 2001).

The lag time until occurrence of milk ejection does not depend of the amount of stored milk per se. Thus, milk ejection occurred after a similar lag time in animals of different production levels at the same stage of lactation (Wellnitz *et al*., 1999). In this case the degree of filling of the individual udder was similar, because lower producing udders had lower storage capacity. We assume that in partially filled alveoli more contraction of the myoepithelial cells and therefore more time is needed until milk is ejected in milk ducts and cistern. Therefore, at low degree of udder filling, i.e. after short intervals from previous milking and in late lactation, milk ejection occurs later (Bruckmaier and Hilger, 2001). If no specific pre-stimulation is applied, cisternal milk is removed during the lag time until occurrence of milk ejection. Because cisternal milk yield is particularly low after short interval from previous milking (Knight *et al*. 1994) and in late lactation (Pfeilsticker *et al*. 1996), i.e. at low udder filling, the negative effect of delayed milk ejection is even enhanced by low amounts of cisternal milk (Bruckmaier and Hilger, 2001). Milking empty teats is the consequence. Therefore, the duration of teat cleaning in AMS should be adapted to the actual interval from previous milking, under consideration of the lactational stage of each individual cow.

Delayed teat cup attachment and interruption of teat stimulation

Experiments were performed in a conventional parlour to simulate AMS milking routines (Bruckmaier *et al*., 2000). Effect of sequential teat cup attachment and delayed teat cup attachment after end of pre-stimulation on OT release and amounts of residual milk was tested. Sequentially delayed attachment of teat cups every 20 or every 60 s did not reduce OT release. Stimulation of less than four teats has been shown to be sufficient to maintain OT release and alveolar contraction, i.e. sequential attachment of teat cups does not have negative effects on milk ejection and milk removal. However, total interruption of teat stimulation (delayed of teat cup attachment) for 2 min between pre-stimulation and start of milking resulted in transiently decreasing OT concentration and increasing amounts of residual milk.

After interruption of teat stimulation the transient decrease of intramammary pressure was compensated by renewed stimulation (Bruckmaier, 2000). In confirmation of this finding we have demonstrated during experiments in a multi-box AMS that negative effects on milk removal of interrupted milk ejection between teat cleaning and teat cup attachment are avoided, if milk ejection is newly induced after the interruption by a pre-stimulation before milk removal starts (Macuhová and Bruckmaier, 2000).

Effects of individual teat cup removal

In most AMS teat cups are removed at the end of milk flow in each individual quarter. The advantage is that overmilking of single quarters can be avoided. On the other hand it may be assumed that the reduced stimulation of less than 4 teats causes reduced release of oxytocin and therefore incomplete emptying of the quarters which are still milked. We could, however, show that the quarters in which teat cups were last removed had the smallest amounts of stripping and residual milk, albeit differences were not significant (Bruckmaier *et al.*, 2000). Obviously stimulation of only one teat causes.

Conclusions and indications for practical AMS milking

The presented results demonstrate that teat cleaning devices in AMS are suitable for pre-stimulation. Pre-stimulation seems to be even more important in AMS than in conventional twice daily milking, because very short intervals between milkings can occur. As a consequence, late occurrence of milk ejection and concomitantly low amounts of cisternal milk require long stimulatory periods before the removal of milk to avoid milking of empty teats. Sequentially delayed attachment of teat cups and quarter-specific removal of teat cups at the end of milking seem to be without negative consequences for milk ejection. Delayed teat cup attachment after pre-stimulation cannot be avoided in multi-box AMS. Negative effects on milk ejection and milk removal are abolished if a further pre-stimulation is applied before milk removal is started. In summary, AMS can fulfil the physiological requirements of dairy cows to induce milk ejection as a prerequisite for complete milk removal.

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Teat end callosity and clinical mastitis

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Introduction

Mastitis is still one of the economically most important diseases in dairy farming. The incidence rate of clinical mastitis ranges, according to several researches, from 12.7 to 30% per cow-year at risk. Bacteria that cause clinical mastitis usually enter the udder through the teat canal. The first line of defence against clinical mastitis is therefore the teat canal, and changes in teat tissue around the teat canal may favour penetration of bacteria into the udder (O'Shea, 1987).

Mechanical forces during machine milking may induce changes in teat end tissue. Teat end callosity builds up until approximately 4 months of lactation and decreases thereafter (Neijenhuis *et al*., 2000). Cow factors like teat end shape, teat position, teat length, milk yield, stage of lactation and parity are associated with the degree of teat end callosity (TEC) (Neijenhuis *et al*., 2000; Sieber and Farnsworth, 1981).

The goal of this study was to examine the relationship between the occurrence of clinical mastitis and TEC in more detail.

Material and method

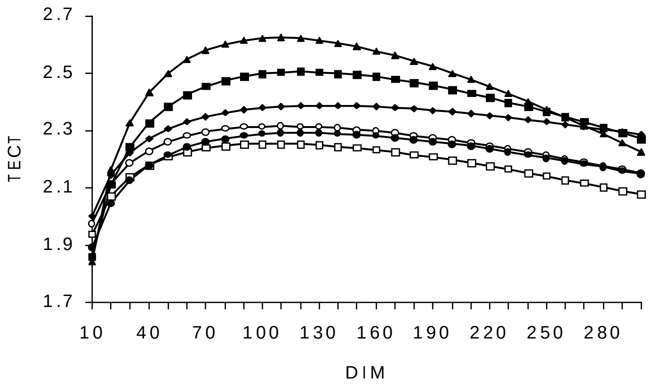
Teat end callosity (TEC) was scored monthly for 1½ year at 15 farms according to the Dutch teat end callosity classification system (Neijenhuis *et al*., 2000). The teat end callosity classification system consists of 5 callosity thickness classes and distinguishes between smooth and rough rings. The farmers diagnosed clinical mastitis. Teat length and teat end shape were recorded twice a year.

We determined differences in TEC between quarters within clinical mastitis cows, and the differences in TEC between clinical mastitis cows and paired herd mates without clinical mastitis, taking into account days in milk and the lactation month in which clinical mastitis occurred.

Results

Teat end callosity thickness (TECT) of clinical mastitis quarters was on average higher than of lateral quarters without clinical mastitis of the same cow. Clinical mastitis cows scored higher TECR and TECT than their paired healthy herd mate when the mastitis occurred after the first and before the sixth month in lactation (Figure 1).

The probability of clinical mastitis in the next lactation month is increased by more then 2 times when the callosity rings are rough and thick (Figure 2). Teat ends without any callosity ring also cause a higher probability of mastitis. A teat with a thin smooth callosity ring causes the least probability of clinical mastitis.



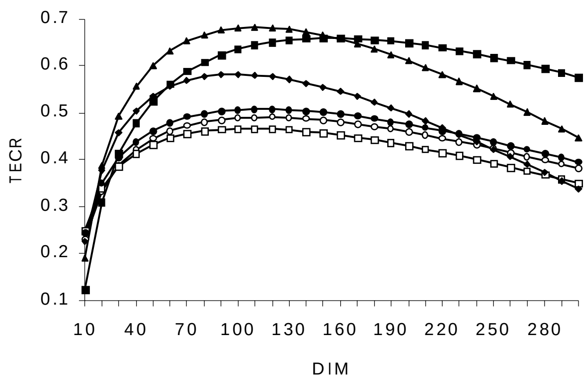


Figure 1. Teat end callosity thickness (TECT) and roughness (TECR) during lactation for cows without clinical mastitis (-○-), or with clinical mastitis in the first (-¨☐-), second (-▲-), third (-■-), fourth and fifth (-◆-) and ≥6 (-●-) month of lactation, calculated from the final regression models.

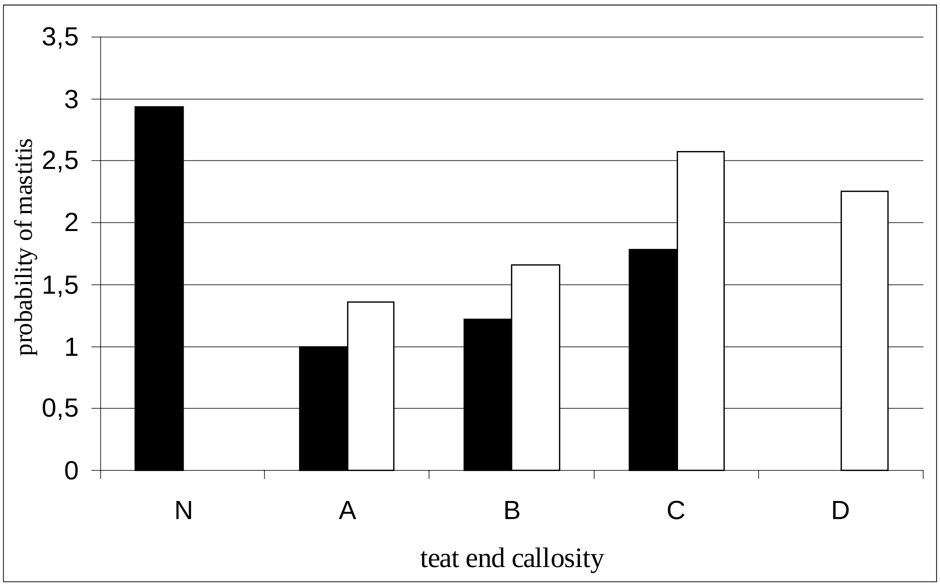


*Figure 2. The probability of clinical mastitis in the next lactation month for teat ends with no (N), thin (A), moderate (B), thick (C) and extreme thick (*D*) smooth (■) and rough ( ) callosity rings.*

Pointed teat ends had higher TECT and TECR scores than flat or inverted teat ends. TECT and TECR increased by 0.11 score points and 9 %, respectively, per 10 kg higher daily milk yield at peak production.

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Milking characteristics of two liners

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Summary

The Research Institute for Animal Husbandry in Lelystad and the IMAG institute in Wageningen have combined their milking machine research in the Dutch Expertise Group Machine Milking. The Expertise Group focuses on generating knowledge on the milking process. Improvement and fine-tuning of the milking process are key-issues. One of the research topics is liner research. On request of a milking machine manufacturer, two liners with the same type and dimensions, but different compounds, were compared with regard to milking time, average and maximum milk flow and teat end deformation.

Key words*: Milking characteristics, liners, milking, teat condition, teat end deformation*

Materials and method

The tests were carried out at the experimental station "De Vijf Roeden" of IMAG-DLO at Duiven in 1998. The milking parlour is equipped with a quarter milking installation for each stall including facilities for accurate recording of the milk evacuation process per quarter. Machine milking parameters are adjustable per stall (milking and pulsation vacuum) or per quarter (pulsation rate and ratio). Switch off levels are adjustable per stall (udder) as well as per quarter. Teat end deformation is measured with a 200 VET scanner with a linear Array 7.5 MHz probe ultrasound scanner 200 VET, Pie Medical (Neijenhuis, submitted). For best probe application, the presence of air between probe and tissue examined must be avoided. Therefore the teat was immersed into water in a plastic bag and the probe with sufficient contact jelly was held against the bag. The water used had a temperature of approximately 35 ºC. The scanning device was connected to a computer. The real time scanning was shown on the terminal of the scanning device. When the picture of the teat was satisfying, the picture was frozen and exported to the PC. The measurements on the image of the teat were done with special software of Pie Medical - Eview - Echo Image Viewer. Teat dimensions were determined at four different points: teat canal length, teat end diameter, teat wall thickness and teat cistern width as shown in figure 1.

The experiment was carried out with 12 HF cows. The liners were placed on the Babson RX-milk claw (internal diameters short milk tubes connection 10mm). Pulsation settings were in according with the guide lines of the manufacturer, e.g. 60 P / min and a 60 / 40-ratio at 42 kPa nominal vacuum.

The trial started with an adaptation period (standard liner), followed by two test periods. As far as milking characteristics were concerned, all data were collected on quarter level. The trial was set up as a split udder design with a cross-over. The milking characteristics were collected automatically by the milking parlour data recording system. Data were analysed by ANOVA (Genstat). Teat scans were carried out at one evening and one morning milking both in period 1 and period 2. The teat scans were carried out directly after pre-treatment, so before attachment of the milking cluster, and directly after cluster removal. Changes in teat diameters were analysed using a generalised linear model (REML-Genstat).

Results

Milking intervals and quarter position showed significant effects on milking characteristics, so they were included in the statistical model. The results of the model are shown in table 1. Milking machine parameters like average and maximum milk flow rate, milk yield 3 minutes after attachment and machine on time did not differ between both liners.

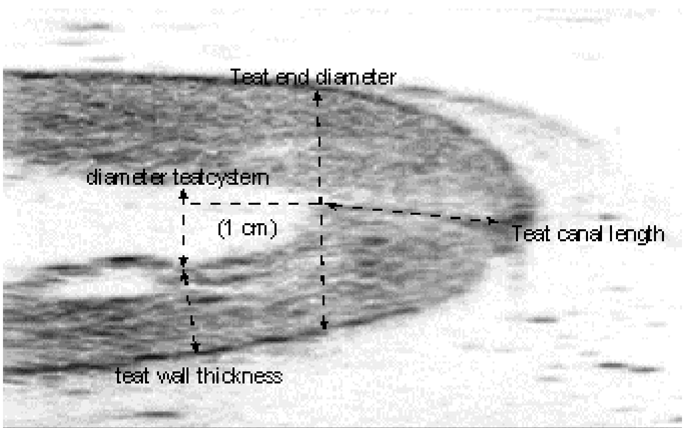

Figure 1. Teat scan: explanation of parameters.

Table 1. Statistical results on milking parameters for two types of liners.

Parameter	Liner A	Liner B	s.e.d.	F-prob.
Milk yield (g)	3 522	3 519	26.6	0.931
Milk yield 3 min after attachment (g)	2 296	2 295	30.5	0.976
Mean milk flow (g/min)	598	598	6.3	0.983
Max milk flow (g/min)	1 127	1 109	13.0	0.160
Milking duration per quarter till flow < 50 g (s)	329	334	4.0	0.189
Mean milk flow till flow < 50 g (g/min)	674	666	7.9	0.309

Table 2. Change of teat parameters after milking (in %).

Parameters	Liner A	Liner B	s.e.d.	F.prob.
Teat canal length	29.01	29.69	4.23	0.874
Teat end diameter	6.81	7.46	0.45	0.645
Teat cistern width	-34.08	-49.98	1.41	0.008
Teat wall thickness	50.73	62.48	6.30	0.062
Surface area teat cistern	-48.66	-67.40	6.90	0.015
Surface area teat wall	25.43	31.47	3.78	0.196
Surface area teat end	0.19	0.48	2.76	0.932

However there were some changes in the teat parameters after milking (Table 2.) Liner A showed a smaller increase (P<0.1) in teat wall thickness after milking than with liner B. There was a difference (P<0.01) between the two liners with respect to teat cistern diameter after milking. Teat cistern diameter after milking was bigger with liner B (P<0.05) than with liner A. So it was concluded that liner A exerted less pressure on the teat but with the same milking characteristics of liner B.

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The influence of mechanical, chemical and biological ageing of liners on change their properties

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Summary

The work showes the results of physical and mechanical characteristics of liners and condition their of inner side. These liners from two producers of milk technique were used in the working conditions. Hardness of liners is changing during the operational time statistically significant (high correlative coefficient r = -0,751; r = -0,5643).

The microstructure on inner side surface of liners verified the changes in expored after 600 hours of service.

Key words: *Operating time, liners, hardness, surface film.*

Introduction

Many authors have been busy with observation of physical and mechanical properties in their labours (Prikryl, 1988; Karas, 1996). These authors mention, that changes in the physical and mechanical properties are very small comparing the starting values.

Rough, hard and craced liners traumatized the peak of teat (Malík *et al.*, 1989). By influence of mechanical strain is be coming on inside surface of liners to creating microcrack, whose by time of usage growing and enlarget to all directions.

Materials and methods

Depending on working time of tested liners we detected the followed indexes (in the regular intervals after 300 hours of operation):

1. Physical and mechanical characteristics of liners in laboratories of Researching center of processing and aplication of syntetics in Nitra.

1.1. Hardness [Sh A] by STN 62 1431.

1.2. Resistance by broaking [MPa] by STN 62 1436.

1.3. Tensibility [%] by STN 62 1436.

The results will be evaluated by methods of variety analysis, calculation of correlative relationships and regressive analysis.

2. Condition of inner side of liner tested on raster scan scope.

Results and discusion

The measured results of physical and mechanical properties of liners produced by differend producers after different function times are showed in table 1 and 2.

Following the achieved results the hardness of liners, expressed in Sh A, increased during the operating time till 300 hours, later decreased (besides sample number 1, new rubber, by which the hardness changed only minimally after 600 operating hours). The hardness increased achieved the significant differences between the variats of individual rubber samples.

Following the statistical evaluation, the hardness of sample number 1 decreased opposite the all other operating times statistically significantly after 600 hours.

Table 1. Physical-mechanical characteristics of liners (sample n. 1).

Operation time, hours	Thickness, mm		Resistance, MPa		Tensibility, %		Hardness, Sh A	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
New	2.00	0.11	10.9	1.32	448	22.8	54.9	0.71
300 h	2.18	0.12	9.8	1.21	428	59.3	54.5	0.41
600 h	1.74	0.11	12.1	1.75	416	41.0	53.9	1.56
900 h	2.14	0.14	9.3	0.62	432	17.9	45.9	1.18
1 200 h	2.18	0.12	10.4	1.34	480	28.3	49.7	2.36

Table 2. Physical-mechanical characteristics of liners (sample n. 2).

Operation time, hours	Thickness, mm		Resistance, MPa		Tensibility, %		Hardness, Sh A	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
New	2.18	0.06	12.3	1.67	456	8.9	47.7	1.63
300 h	1.98	0.12	15.0	1.15	408	11.0	54.8	1.01
600 h	2.49	0.08	11.7	0.26	448	11.0	44.9	1.82
900 h	2.12	0.09	13.7	0.56	420	24.7	43.1	1.57
1 200 h	2.49	0.08	12.3	0.87	476	21.9	45.1	0.86

Alike by the sample number 2 we registered the statistically significant by differences in hardness, where the highest hardness was found out after 300 hours and the differences were significant opposite, the other variants of sample number 2 (a new rubber, after 600 hours, after 900 hours and a rubber after 1 200 hours of function).

Our results show, that the hardness of researched samples the liners increased during the operating time untill 300 - 600 hours, then decreases, what is in certain contradiction with cited author (Prikryl, 1988). According to samples of liners and their operating time the average value of hardness was in the scale 43.1 - 54.9 Sh A.

By the calculation of correlative relationships between operating time and hardness we found out the significant and statistically certified correlative coeficient. Because of the high correlative coefficient by samples number 1 and 2 ($r = -0.751$; $r = -0.5643$) we realized the calculation of regressive analysis by the multi-nominal function of third class.

Following the regressive analysis the indipendent variable (operating time) influaces the dependent variable (hardness) by the expression of used regressive function on 83.55 % resp. 85.38 %.

Evaluation of microphotographs by method of sqare grid we discovered, that the cracks ratio by liners after 600 hours usage is 9.4 %, by liners after 900 hours usage is 13.4 % (accumulation 42.6 %). The results is that the cracks are growing on all directions with operational time.

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Milking intervals and teat recovery

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Introduction

The teat is an important part of the cow's defence mechanisms against intra-mammary infection (IMI) (O'Shea, 1987). Therefore the teat is also referred to as first line defence against IMI. Functioning of the teats as barrier against IMI can be negatively influenced through husbandry circumstances.

During automatic milking, because of voluntarily attendance, cows may be milked with rather short intervals. Machine milking generates a strain on the teat wall. This strain induces swelling of the teat that may influence the resistance of the teat canal to bacterial invasion during the recovery period after milking. Penetrability of teats and the teat canal diameter are recovered within 2 hrs after milking (McDonald, 1975; Schultze and Bright, 1983). Also the teat end thickness, as measured by the cutimeter, was the lowest at 2 hrs after milking (Hamann, 1987). The recovery time of the teat is important to determine a minimum milking interval. When a cow is milked when the teat tissue is not yet recovered, irreversible chronic changes of the teat tissue may occur (Hamann and Østerås, 1994).

The aim of this study was to determine if ultrasonic measurements of teat size and shapes after milking could reveal the recovery time of teats.

Material and method

The ultrasonic measurements (scans) were carried out with a 200 VET scanner with a linear-array 7.5 MHz probe (Pie Medical, Maastricht, the Netherlands). The teats were immersed in water in a latex bag. Two teats of 18 Holstein-Friesian cows were scanned before milking, immediately after milking and 1 to 9 hours after milking. Teat characteristics were measured in duplicate: teat canal length, teat wall thickness, teat cistern width and teat end width. Milking interval before the measurements were made was 14 hours, machine-on time was on average 6.8 min (ranging from 4.2 to 12 min). Average milk flow rate during the morning milking was 1.9 kg / min (ranging from 0.9 to 3.1 kg / min).

Results

Teat recovery after milking took a considerable amount of time (Figure 1). Teat wall thickness returned to its premilking state within 6 hours. Teat end width took more than 8 hours to recover. Teat canal length did not recover within 8 hours of milking. Teat cistern width returned to its premilking state within 7 hours.

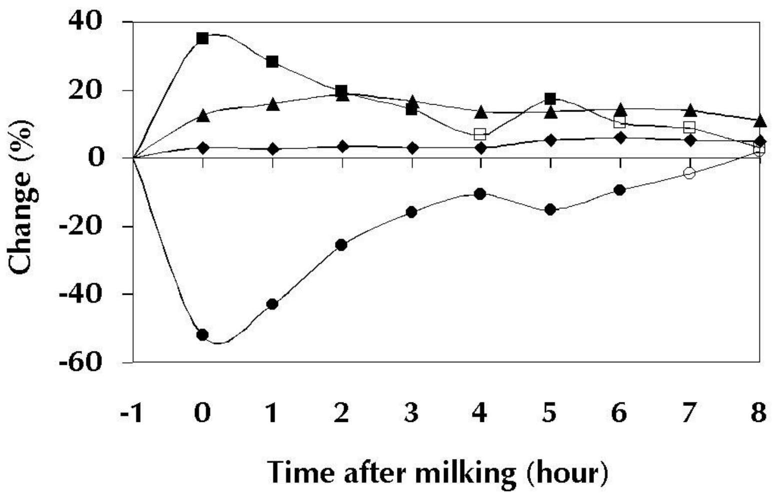

Figure 1. Relative changes (%) of teat end width (◆), teat cistern width (●), teat canal length (▲), and teat wall thickness (■) measured just after milking (0), and at each consecutive hour after milking (1 to 8) compared to the measurement before milking (-1).

Conclusion

The ultrasonic scanning technique may be a useful research tool to monitor changes in teat parameters by machine milking. The results showed that complete recovery of teats after milking takes 6 to more than 8 hours. Shorter milking intervals as can be found in automatic milking, may lead to incomplete recovery of teats. This may lead to a build up of teat damage.

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Effect of old and new rubber liners on teats evaluated by thermographic method

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Summary

The objective of this study was to compare the effect of old (before exchange) and new (after exchange) rubber liners by means of the changes of teat surface temperature. Thermographic measurements were conducted in milking parlour 2 x 10 (rapid exit herringbone, vacuum 42.6 kPa) in 64 dairy cows. Scheme of measurement was following: 1st day: evening milking - old liners, 2nd day: morning milking - old liners Þ exchange of liners, 2nd day: evening milking - new liners, 3rd day: morning evening - new liners. Thermal responses of teats were recorded: before milking, after milking immediately, 1st minute postmilking, 2nd minute milking postmilking and 3rd minute postmilking. The results showed that milking increased the temperature of teats. The highest values were obtained after milking immediately. New liners increased temperature of teats more then old liners, but the differences were not significant. The highest decline in teat surface temperature was obtained to 1 minute after milking then the decline was gradual (2nd and 3rd minute). But surface teat temperature was not recovery to staring value before milking. The recovery time to initial temperature of teats will be longer than 3 minutes after milking. The significant injuring of the teats evoked by tested liners was not recorded. Thermography can produce important information where conventional diagnostic techniques have exhausted their possibilities.

***Key words**: Liners, machine milking, teat surface temperature, thermography.*

Introduction

The most stressed part of the udder are the teats, because milking changes their condition. Repeated teat compressions may cause mechanical and circulatory changes in teat tissues and hyperaemia in teat wall (Hamann 1992, Isaksson and Lind 1992, Burmeister *et al.* 1998). Such changes may even lead to pathological traumatization manifested by, e.g., congestion, oedema, cracks of mucous membrane, induration, etc. (Králícková 1984, Ryšánek and Babák 1986). Machine milking, however, will often produce specific traumatized zones even when all technical parameters of the milking machine used meet to relevant standards and the producer's recommendations (Kejík and Mašková 1989, Kunc *et al.* 2000a). These zones, which cannot be detected visually, are manifested by elevated temperatures and slow recovery (Kunc *et al.* 2000 b). They cannot be accurately localised even by contact thermometers. For all these reasons it seems that the most suitable method of detection is thermography. The changes of teat temperature are then used to evaluate the effects on clinically undetected teat traumatization.

There are a number of factors in machine milking that may influence the condition of teats. Literary sources emphasise the importance of the milking vacuum, and also pulsation rate, pulsation ratio and the quality of teat cups. The liners are in direct contact with very sensitive organ, i.e. mammary gland. Using the thermoghraphic method, Kejík and Mašková (1989) and Malík *et al.* (1989) took udder thermograms and evaluated relationship between its traumatised zones and the quality of teat rubber. Thermography was used by Mašková (1991) in her evaluation of a prototype of a milking machine. Basing her evaluation on an assessment of teat surface temperature during milking. The author concluded that the shape of teat rubber used in the new type of milking machine does not significantly stress the teat. Kunc *et al.* (1999) studied the influence of the liners with circular section and the liners of triangular section on teats. Thermographic measurements showed that the liners with triangular section affected the teats negatively.

The objective of this study was to compare the effect of old (before exchange) and new (after exchange) rubber liners on the teats by means of the changes of teat surface temperature.

Matherial and methods

Thermohraphic measurements (thermographic system AGA 570 DEMO) were conducted in milking parlour 2 x 10 (rapid exit herringbone, vacuum 42.6 kPa) in 64 healthy dairy cows (Holstein, milk yield 8 200 l).
Set of measurements was following:

- 1st day: evening milking – old (worn-out) rubber liners;
- 2nd day: morning milking - old (worn-out) rubber liners;

⇒ exchange of rubber liners;

- 2nd day: evening milking – new rubber liners;
- 3rd day morning milking – new rubber liners.

Thermograms of the teats were obtained in following intervals:

- premilking immediately;
- postmilking immediately;
- 1st minute postmilking;
- 2nd minute postmilking;
- 3rd minute postmilking.

The special computer program IRwin 5.3.1 was used for evaluation of thermograms and data analyses.

Table 1. Temperature status of teats in dependence on used rubber liners.

Liners	Premilking	Postmilking	1min	2min	3min
Old	31.20±1.46	33.04±0.78	32.51±0.62	32.41±0.62	32.33±0.73
New	30.74±1.55	32.87±0.85	32.19±0.78	32.03±0.76	31.91±0.82

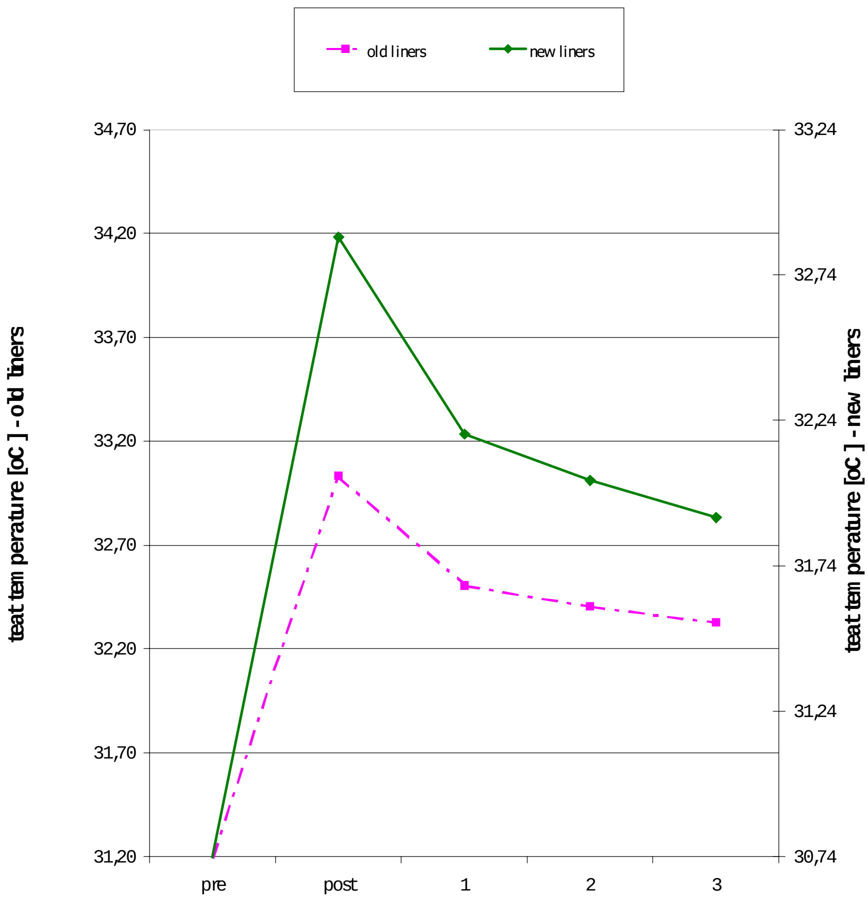

Figure 1. The course of temperature changes of teats

Results and discussion

The results are showed in table 1, the course of temperature changes of teats is illustrated in the figure1. The results showed that milking increased the temperature of teats. The highest values were obtained after milking immediately. That supports the findings of Hamman (1985) and others. New liners increased temperature of teats more then old liners, but the differences were not significant. The highest decline in teat surface temperature was obtained to 1st minute after milking (0.53 °C in old liners and 0.68 °C in new liners) then the decline was gradual (2nd and 3rd minute). But surface teat temperature was not recovered to initial value before milking in both. The difference in old liners was found out 1.13 °C, the difference in new liners was found out 1.17 °C. Kunc *et al.* (1999) found out that teat temperature after milking does not decline to initial value until 2 minutes. Basing this experiment, the recovery time to initial temperature of teats will be longer than 3 minutes after milking. The significant injuring of the teats evoked of tested liners was not recorded. Thermography can produce important information where conventional diagnostic techniques have exhausted their possibilities.

Acknowledgement

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Effect of postmilking teat disinfecting on teat skin temperature status

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Summary

In 10 dairy cows the effect of postmilking disinfecting on teat temperature status was observed in tandem milking parlour by thermography. The teat temperatures were recorded in non-disinfected (NDT) and disinfected teats (DT). Thermograms were obtained before and after milking immediately and 1st – 5th minute after milking. The different course of the temperature changes was found out for NDT and DT. The temperature in NDT declined gradually, 5 minutes after the teat cup were removed, the teat temperature was still higher than it was prior to milking. The results showed that the teat temperature did not recovery until 5 minute. The recovery time will be longer than 5 minute. Other temperature evolution was recorded in DT. The temperature in DT decreased rapidly until 3 minute compared with NDT, the teat temperature dropped below initial value as early as 1st minute. The decline was finished in 3rd minute, than the teat temperature was increased gradually. Disinfecting evoked a significant chilling effect in the teats ($P<0.01$, $P<0.05$), thereby teat traumatization caused by machine milking was reduced. Used disinfectant did not evoke undesirable thermal responses in teat tissue.

***Key words**: Postmilking disinfecting, machine milking, teat surface temperature, thermography.*

Introduction

Postmilking teat disinfecting is widely considered to be perhaps the most effective and important component of any program to prevent the spread of contagious mastitis pathogens in a milking herd (Pankey *et al.*, 1984). The management of teat antisepsis to maintain healthy teat skin is important for the welfare of the cow, both for cow comfort and to maximize the effectiveness of teat dips in the prevention of mastitis (Bushnell, 1985).

But machine milking may cause an increase in teat temperatures (Hamann, 1985; Caruolo *et al.*, 1989; Eichel, 1992; Kunc *et al.*, 2000a; Barth, 2000). These temperature, which cannot be detected visually, are manifested by elevated temperatures and slow recovery Kunc *et al.* (1999b) found that 3 minutes after machine milking the teat temperature was still higher than it was prior to milking.

Assessment of teats and udder before and after milking is usually based on visual observations. For such assessments, a cutimeter (Isaksson and Lind, 1992) or classification systems (Neijenhuis, 1998; Rasmussen and Larsen, 1998; Neijenhuis *et al.*, 2000) are used. But teat temperature responses on milking is the most suitable to detect by thermographic method.

There are a number of factors in machine milking that may influence the condition of teats. Literary sources emphasize the importance of the milking vacuum, and also pulsation rate, pulsation ratio and the quality of teat cups. But the state of the mammary gland and teats may be significantly influenced by milking routines including postmilking disinfecting. The majority of studies focuses on what impact disinfecting have on mastitis, irritation, bacteria, visual teat skin condition etc. (Rasmussen *et al.*, 1990; Burmeister *et al.*, 1998; Johansson *et al.*, 1998; Kruze, 1998), but their role in the onset of temperature zones on teats or the disappearance of the response as a result of machine milking is still largely unexplained (Hamann, 1992). The objective of this study was to find out the effect of postmilking disinfecting on teat temperature status.

Matherial and methods

Thermographic measurements (thermographic system AGA 570 DEMO) were conducted in tandem milking parlour 2 x 5 (vacuum 42.6 kPa, postmilking disinfectant – Deosan (chlordexidine / gluconate, 4250 ppm) in 10 healthy dairy cows (Czech Spotted cattle, milk yield 6 500l).

Set of measurements was following:

- 1st day: evening milking – until 5 minutes without disinfecting;
- 2nd day: morning milking - until 5 minutes without disinfecting;
- 2nd day: evening milking – disinfecting immediately after milking;
- 3rd day morning milking – disinfecting immediately after milking.

Thermograms of the teats were obtained in following intervals:
- premilking immediately;
- postmilking immediately;
- 1st minute postmilking;
- 2nd minute postmilking;
- 3rd minute postmilking;
- 4th minute postmilking;
- 5th minute postmilking.

The special computer program IRwin 5.3.1 was used for evaluation of thermograms and data analyses.

Results and discussion

The changes of teat temperatures between non-disinfected (NDT) and disinfected teats (DT) are detailed in figure1. This diagram shows the course of teat temperature with and without disinfectant until 5th minutes. The increased teat temperature was recorded immediately after milking. That supports the findings of Hamann (1985), Eichel (1992), Kunc *et al*. (1999a) and Barth (2000) in dairy cows. But the different course resp. the differences between teat temperature with and without disinfecting were found out. The temperature in NDT declined about 0.56±0.64 °C, in DT about 2.06±0.78 °C until 1st minute after milking. The difference between decline of NDT and DT was significant (P<0.01). The temperature in NDT declined about 0.08±0.44 °C, in DT about 0.67±0.51 °C between 1st and 2nd minute, the difference between decline of NDT and DT was significant again (P<0.01). The temperature in NDT declined about 0.04±0.45 °C, in DT about 0.4±0.61 °C between 2nd and 3rd minute, the difference between decline of

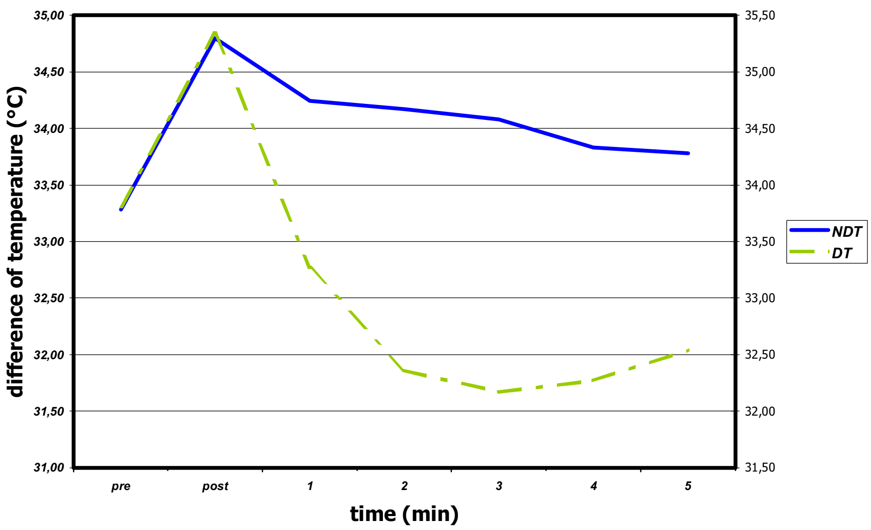

Figure 1. The course of temperature changes of teats

NDT and DT was significant ($P<0.05$). The temperature in NDT declined about 0.28±0.46 °C, but in DT increased insignificantly about 0.07±0.42 °C between 3rd and 4th minute, the difference between decline of NDT and DT was significant ($P<0.01$). The temperature in NDT declined about 0.06±0.58 °C, in DT an insignificant increase about 0.27±0.55 °C was recorded between 2nd and 3rd minute, the difference between decline of NDT and DT was significant ($P<0.01$).

The different course was found out for NDT and DT. The temperature in NDT declined gradually, 5 minutes after the teat cup were removed, the teat temperature was still higher than it was prior to milking. Kunc *et al* (1999a,b) found, that teat surface temperature did not recovery to initial value before milking until 2 resp. 3 minute. The results of this experiment showed, that teat temperature did not recovery until 5 minute. The recovery time will be longer than 5 minute. Other temperature evolution was recorded in DT. The temperature in DT decreased rapidly until 3 minute compared with NDT, teat temperature dropped below initial value as early as 1st minute. The decline was finished in 3rd minute, than teat temperature was increased gradually. Disinfecting evoked a significant chilling effect in the teats, thereby it reduced teat traumatization caused by machine milking. Used disinfectant did not evoke undesirable temperature responses in teat tissue.

Acknowledgement

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Teatcup hardness after ageing in laboratory and plant usage

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A crucial hygienic measure in primary milk production is the elimination of microbiological contamination. The most stringent requirements are therefore imposed on the quality of liners, which as the only ones come into the contact with the living organism (teats) and with milk.

The liners made by two different manufacturers (L1, L2) were used in two rotary milking parlour Melotte 9 employing milking machines with milking units BDS-378.3 made by Agrostroj Pelhrimov, a.s. Cleaning and disinfection were made by automated washers AMA 227.1 (Agrostroj Pelhrimov, a.s.). The changes of liner rubber hardness were evaluated using various disinfectants and detergents (S1, S2). The releasing of carbon blacks from rubber parts into milk and the CPM (count of coliform bacteria) for lifetime determination were used. A time schedule was set up for observation and sampling of liners and milk tubes in order to verify the capacity of liners and milk tubes to be cleaned. Each sampling contained 4 liners of each type. The samples were then analyzed in accredited laboratories and obtained results subjected to a further statistic evaluation by UNISTAT 5.1 program.

It is possible to conclude on the basis of the correlations that hardness would be increasing with the increasing usage time in the application of L2 and the cleaning and disinfection system S2. In other combinations of liners and cleaning / disinfection systems the hardness of liners decreases with the increasing time of their usage (see Figure 1).

It was evidenced that the hardness of liners is highly significantly influenced only by the cleaning agent ($P < 0.01$). No significant influence on the value of hardness was evidenced in other factors or their interactions. The highest hardness values were reached in L2 combined with the cleaning / disinfection system S1 (average 55.43° Sh A).

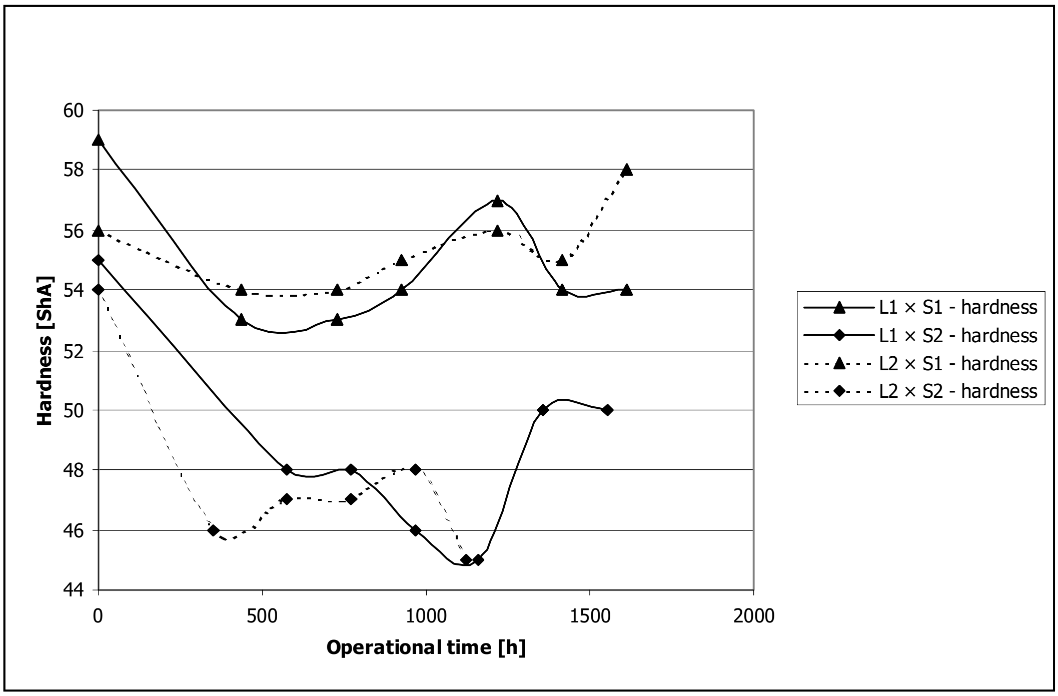

Figure 1. Liners hardness changes in various cleansing agents.

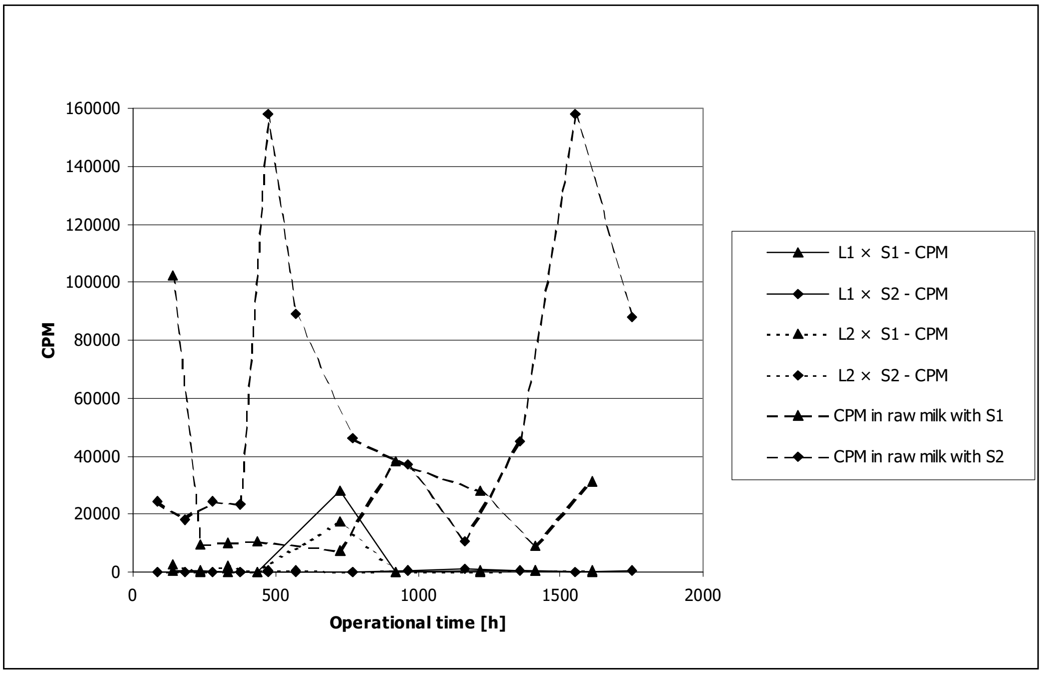

Figure 2. Count of coliform bacteria in raw milk and on liner inner surface.

It follows from the above analyses and their results that the studied mechanical properties were most affected by the type of the cleaning agent and considerably less by the type of the liner. The values of liner hardness after swelling in given detergents and disinfectants in laboratory and in milking parlour were compared, and its values don't corresponding to the milking plant usage.

The number of CPM after main cleaning is very good in both cases, and the number of CPM in raw milk rise over 100000 in two cases, therefore the water quality were really bad (see Figure 2).

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The latest knowledge and trends in the development of milking systems

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Summary

The most represented trend is characterized by construction of milking unit, quality of used materials increase of transport ways with an aim of vacuum stability and with high volume exploitation of microelectronic and computers for management of milking and also automatic capture of data.

The most remarkable trend were achieved in the development of milking robots (AMS – Automatic Milking System).

Key words*: Milking units, stimulation, milking parameters, automatization, robotization.*

Introduction

Milking is one of the most important and demanding working operations in dairy cows breeding. It is a complex biological-technological process in which four factors are active: man - dairy cow – machine – environment (Kovác, Š., 1996).

In recent years, the development of milking equipment has continued intensively. Considerable attention has been paid to constructional and technological improvement, quality of materials being used, to design, functionality, technical parameters of milking process automatization (Dolezal, O. *et al*., 2000) and robotization (Kic, P. and Nehasilová, P., 1997; Vegricht, J., 1999).

Materials and methods

The aim of the latest knowledge and trends in the development of milking equipment has been to reduce the needs of man power, to optimize milking process and achieve data required for dairy cows breeding management.

The final objective of this development is to fully exclude a man from milking process by exploiting AMS (Automatic Milking System).

Among an important operating step belongs preparation of a diary cow (mammary gland) before the milking process itself. A fully value stimulation of mammary gland is important for achieving the highest milking intensity possible, reducing the total milking time and achieving full stripping of a cow.

The vibration stimulation is convenient for a quick starting of milk and smooth milking.
The principle of the matter is that at the beginning of milking process pulsation frequency is significantly increased (up to 200 pulses per minute), with actual change of pulsation ratio being 60 : 40 or 70 : 30.

The automatic stimulation is recommended in cows which are milked hard and in those being at the end of lactation period.

By changing dimensional and constructional parameters there is a tendency to decrease nominal value of vacuum from 50 to 45 – 42 kPa (even company AGMECO has been using vacuum 35 kPa).

Simultaneously by decreasing nominal value of vacuum to improve vacuum stability and milk flow velocity results in increased socket and hose diameters (in a short rubber milk hose from 10 to 14 mm, in long rubber milk hose from 16 to 18 mm, the volume of milk claw from the value of 120 – 150 cm^3 to 300 to 500 cm^3).

An important functional part of milking device is a rubber teat. The standard cylinder shape is replaced by the conical. It is extended an offer for silicone teat rubbers which are distinguished by better surface quality and a longer operating life.

For good milking process it is important that mammary gland should be equally loaded by a milking set. Some manufactures apply an adjusting arm which prevents the milking unit from twisting.

From the point of view of sparing milking extension of suction phase (maximum for 65 to 70 % pulse time) is not recommend. As very important is considered to keep a sufficient time of pressing providing teat massage. High flows tend to prolong suction time by decreasing pulsation rate.

World producers pay a great attention to automation of milking process, to automatic data collection which is based on a systematic monitoring of dairy cows, by measuring physiological parameters chosen (body temperature, milking quantity, milk conductivity, milk colour, weight, pulse frequency, feed conversion, motion activity, number of visits and the time of their staying in a feeding box).

In sanitation of milking equipment the development trends are aimed at decreasing sanitation costs and multiple utilization of sanitation preparations in relation to environment protection.

Research and AMS development (Automatic Milking System) of milking robots has been under way in the world for more than 20 years.

Its goal is to reduce the need of man labour in milking, to remove the need of a man being present during the milking, to provide dairy cows with a possibility of choosing time to be milked, number of milking, what contributes to increase performance (15 to 20 %) and improve the state of health of mammary gland. Using the robot are automatically acquired the data regarding the dairy cows´ state of health, by measuring conductivity, temperature, milk colour and the quantity of milk taken as well as motion activity of dairy cows.

Solutions being known so far differ in their concept chosen, in technical solution of individual node elements, number of milking stands operated by a single equipment and by technical solution of setting on teat cups.

According to a number of milking stands and their arrangement (AMS), milking robots can be classified as folows:
1. One-place intended for milking in a single milking box.
2. Multi-place intended for milking in one to four boxes.

Setting on the teat cups of milking robots is solved:
a) Teat cups are caught up on a special holder and they are set on and monitored individually.
b) Teat cups are caught up on an operating arm and set on jointly.

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Milking and milk quality in two breeds of sheep

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Summary

Milking time studies and milk quality were carried out on 15 dairy ewes from the breed line 05 (13/16 East Friesian sheep, 3/16 Polish Merinos) and 14 meat white head ewes. This experiment concerned only ewes, which milk fed their lambs for two months and which had a healthy udder. Ewes were milked mechanically in a 14 Westfalia milking parlor stands with a set of 6 milking units.

The time from the first udder stimulation to milking unit attachment, milk flow time from each half of the udder, machine stripping, overmilking, total milking time and the time from the first stimulation of the udder to unit detachment were recorded for three consecutive days during morning milking. On the 75th day of lactation of both breeds of ewes, milk samples were taken from each half of the udder. Milk components and somatic cell counts were determined using Milkoscan and Fossomatic 90 respectively.

No significant differences were observed in milking variables of both breeds. The breed of sheep did not have a significant effect on milk components and somatic cell counts, however the protein percentage content of milk from the left half of the udder was influenced ($P \leq 0.05$).

***Key words**: Ewes, breed, milking course, milk components.*

Introduction

Dairy use of sheep can be cost effective in the low regions of Poland. However the high milking potential of ewes and the appliance of methods that unable to increase commercial milk production are the factors that decide about it. In such herds, lambing is conducted in different times in order to insure a continuous milk production throughout the year (Wazna and Gut, 2000). Ovine milk quality depends mainly from the udder health (Olechnowicz and Steppa, 2000) on what the milking technique has a great effect (Romeo *et al*., 1996; Bruckmaier *et al*., 1997).

The purpose of this investigation was to establish the elementary milking activities in sheep as well as to evaluate milk quality in relation to milking parameters.

Material and methods

Milking time studies and milk quality were carried out on 15 dairy ewes from the breed line 05 (13/16 East Friesian sheep, 3/16 Polish Merinos) and 14 meat white head ewes in the experimental farm in Zlotnik (Poland) that belongs to the Agricultural University of Poznan in the year 2000. Ewes of both groups were qualified to milking after they milk-fed their lambs for two months and had clinically healthy udders. Ewes were milked mechanically in a 14 Westfalia milking parlor stands with a set of 6 milking units. The time from the first udder stimulation to milking unit attachment, milk flow time from each half of the udder, machine stripping, overmilking, total milking time and the time from the first stimulation of the udder to unit detachment were recorded for three consecutive days during morning milking. On the 75th day of lactation (mid April) of both breeds of ewes, milk samples were taken from each half of the udder. Milk components and somatic cell counts were determined using Milkoscan and Fossomatic 90 respectively.

For statistical evaluations STATISTICA 97 software was used. The sheep breed (dairy and meat), lactation (1,2,3 and further) and overmilking ranges (0-100; 101-180 and > 180 sec.) were taken into consideration in this analysis Means difference between groups were tested for significance Duncan's Test. Results are presented in tables as means ± SD.

Table 1. Milking parameters of dairy and meat breed ewes in seconds.

Sheep breed	Milk flow		Overmilking		Machine stripping	Total milking time	From udder stimulation to milking unit detachment
	Left	Right	Left	Right			
Dairy	61 ± 23	62 ±19	182 ± 61	181 ± 67	35 ±14	246 ±52	552 ± 157
Meat	66 ± 22	69 ± 18	163 ± 66	159 ± 61	40 ± 37	242 ± 63	512 ± 148
Breed effect	NS	NS	NS	NS	NS	NS	NS
Lactation effect	X	NS	NS	NS	NS	NS	NS

X-significant at P≤0.05.
NS-not significant.

Table 2. Milk components and somatic cell counts in relation to the sheep breed.

Sheep breed	Number of ewes	Milk components (%)								Ln SCC	
		Fat		Protein		Lactose		Dry matter			
		Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Dairy ewes	15	3.36±0.83	3.32±0.98	5.39±0.39[a]	5.58±0.51	5.29±0.85	5.50±0.27	14.68±1.22	15.10±1.26	12.23±1.98	11.80±1.73
Meat ewes	14	3.40±0.98	3.57±1.07	5.90±0.40[a]	5.84±0.37	5.39±.015	5.43±0.14	15.38±1.07	15.54±1.16	12.36±1.51	12.08±1.32
Breed effect		NS	NS	X	NS	NS	NS	NS	NS	NS	NS
Lactation effect		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Overmilking effect		X	NS	NS	NS	NS	NS	NS	NS	NS	NS

Marks as in table 1

a- means significant at P≤0.05

Results and discussion

No significant differences were observed in the milking parameters in both breeds (Table 1). Almost all the parameters related to milking did not depend either on the number of lactation. Bruckmaier *et al*., (1997) found that the time of machine stripping in all lactations in dairy ewes Lacune breed and Ostfriesian breed was 37 sec. and 52 sec. respectively, however total milking time respectively was 144 and 211 sec.

A long overmilking time of 180 sec for dairy ewes and of 160 sec. for the meat breed did not have a significant effect on milk components and on somatic cell counts (Table 2) . The only significant difference ($P \leq 0.05$) was observed for milk protein content in the left halves of the udder between the two breeds (5.58 and 5.84 %).

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Effect of some selected operations connected with machine milking on the quality of milk raw material

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Introduction

It is essential for Poland, in her attempts to become a full member of the European Union, to take appropriate steps to be well prepared for sanitary requirements in force in this organisation. This also refers to dairy industry whose raw material varies widely with regard to its hygiene quality. Farmers, who are the main suppliers of milk raw material, have a special role to play in ensuring its appropriate hygiene quality.

Good conditions existing on the marketplace for dairy products affect the profitability of milk production in agricultural farms and decisions taken by farmers associated with their long-term planning of the size of dairy cattle herds as well as the improvement of technical conditions for dairy rearing and milk production. Opinions on milk quality tend to alter with the development of milk processing and our knowledge in the field of nutrition (Nowakowski 1996).

The maintenance of high quality in the chain of milk production, storage, transport, processing and distribution is the major prerequisite to be fulfilled in the course of manufacturing of the highest quality milk articles. These are the requirements of modern dairy processing markets and markets of dairy products distribution. Low milk shelf life as a raw material and potential changes affected by various factors make it necessary to maintain particular caution during milking, transport and processing.

Research

The objective of the investigations was the assessment of milk quality collected from individual farmers to be used by dairy industry. The experiments were carried out in the former Sieradz Voivodeship in the area covered by the activities of Wielun Dairy Cooperative. The study was supported by the PHARE fund secured in the result of an earlier decision of the EU Commission, which decided to support transformations taking place in Poland and Hungary with a special non-repayable assistance fund. The investigations comprised 76 farms specialising in milk production in which the assessment of technical condition of milking equipment and milk quality was conducted.

The evaluation of the technical equipment included:

- Measurements of the negative pressure;
- Errors in vacuometer readings;
- Pump output;
- Perviousness of pipes and valves;
- Valve leakage;
- Air consumption by milking machines;
- Stress of teat rubbers;
- Tests of pulsators;
- Evaluation of washing and disinfection of equipment;
- Quality of milk cooling.

A very simple point test was applied to evaluate the work quality of milking machines. The test consisted of eight characteristic features from the field of milking machines understood by all milk producers. One point was awarded for each positive result, i.e. whenever the machine met the appropriate ISO or factory standard. No point was awarded when the assessment was negative. The following parameters were assessed:

- Negative pressure;
- Vacuometer error;
- Pump output;
- Pipe leakage;
- Output reserve,
- Difference in negative pressure;
- Valve leakage;
- Air consumption by all milking machines.

Total of 8 points.

It is evident from the performed investigations (Table 1) that out of the examined 76 farms, only 50 reached the maximum number of points. The lowest score of 3 points occurred only in one farm.

Table 1. Point score of some selected parameters of milking machine.

No	Number of farms	Score
1	30	8
2	15	7
3	5	6
4	2	5
5	3	4
6	1	3

Milk hygiene quality was estimated after collecting milk samples of 250-300 ml at the purchase point, which were then delivered, to the Dairy Cooperative laboratory in containers cooled by ice. The following quality parameters were determined:

- Total number of micro organisms;
- Coliform count;
- Whiteside test;
- Milk acidity;
- Milk density.

The performed investigations showed that:
- none of the examined farms fulfilled standards of milk raw material required for milk extra class;
- 12 % of milk producers delivered milk whose quality allowed its classification to class I;
- 24% of milk producers delivered milk classified as class II;
- 64% of milk producers delivered milk classified as class III.

The most frequent source of contamination of raw milk with bacteria was poorly washed and disinfected equipment for machine milking. Approximately 90% of bacteria in raw milk derived from milking equipment and only 10% from other sources such as mastitis or airborne bacteria. In unwashed or poorly washed equipment used for machine-milking, bacteria adjust to such environment and multiply very rapidly between milkings and later quickly contaminate freshly obtained milk.

Therefore, effective washing and disinfection of milking machines is essential if farmers want to maintain the number of bacteria in milk at a low level. In addition, it helps to reduce the danger of transferring microorganisms, which cause udder diseases. The performed investigations showed that the majority of milk suppliers washed and disinfected their milking machines properly and only in 14 dairy farms parts of milking machines were found to have been washed poorly.

The performed investigations also evaluated milking techniques, i.e. such activities as:
- udder training;
- pre-milking;
- hand stripping;
- machine stripping with udder training.

It is well known that udder training causes irritation of nerve ends sensitive to touch. They receive outside stimuli and transmit them to the central nervous system from which signals are sent to the udder stimulating milk secretion. When teat cups are mounted onto non-stimulated teats, then they are sucked deep into cups. This leads to a premature closure of the outlet of the teat cistern into the teat canal and hence to more milk being left in the udder which may result in mastitis (Winnicki, 1995).

The proper milking begins with pre-milking, which prevents mixing of the milk from teats, and the teat cistern left from the previous milking with milk practically free from micro organisms coming from milk bearing ducts and secretion tissues.

In order to perform mechanical milking dry, it is necessary to load the milking machine with one hand and train the udder with the other. As a rule, if machine stripping is performed quickly and efficiently, hand stripping is not necessary.

The performed investigations showed that;
- udder training was used at 60% of farms;
- pre-milking was used at 40% of farms;
- hand milking dry was used at 36% of farms;
- machine stripping with udder training was used at 39% of farms.

From the point of view of milk technological suitability as a raw material delivered to a dairy plant, its chilling and transport are also very important. According to current purchase standards, milk can be accepted for processing at the dairy plant if its temperature does nor exceed 8 ^{o}C. As it is well known, the temperature of milk directly after milking ranges from 25-30 ^{o}C. At this temperature, the speed of bacteria multiplication in milk is so rapid that their numbers double every 25 minutes (Janicki, 1996). The most common cooling systems among the examined farms were basin coolers (52% farms), while the remaining 48% of farms used can coolers.

Polish standards [PN 1992] indicate that the final temperature of cooled milk from the evening milking should not exceed 4^{o}C, while that from the morning milking - 10 ^{o}C. This difference in the required milk temperature is associated with the time the obtained milk must stay on the farm. In the case of evening milking, this period amounts to approximately 14 hours, while in the case of morning milking – only about 2 hours. According to the above-mentioned standard, the cooling time to the temperature of 10 ^{o}C should not be longer than 2 hours. Farms equipped in basin milk coolers fulfilled the requirements of the PN standard, while those, which had only can coolers were capable of cooling their milk to the temperature of 15 ^{o}C. Average distance of the examined farms from purchase points was 1.97 km and 43% of the dairy farms delivered their milk to purchase points using their own transport and the remaining producers used services of haulage firms.

Conclusions

1. The technical and hygiene conditions of components of milking machines in the examined farms situated in the area of operation of the Dairy Cooperative in Wielun was found satisfactory.

2. The majority of the examined dairy farms did not carry out treatments associated with pre-milking and hand and mechanical stripping. Only 60% of the examined farms conducted udder training.

3. The milk cooling conditions found on the examined farms as well as its transport to purchase points was evaluated as unsatisfactory.

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The effect of two milking systems on bovine teat condition

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Summary

The objective of the study was to measure the effect of wide-bore and narrow-bore milking principles on bovine teat condition and milking performance over a complete lactation. Teat-end hyperkeratosis (T.H), teat colour and teat textures are indicators of teat condition and were used to evaluate the effectiveness of the milking principles. Cows (n = 56) were milked as one herd with all milking units removed at a milk flow-rate of 0.2 kg / min. There was no significant difference shown in teat condition between the two milking principles. TH scores increased with stage of lactation, for front teats as compared to rear teats and where post-milking teat-disinfectant was applied. Differences in machine yield were recorded between the two milking principles at the AM milking. Where teat condition is used to evaluate different milking systems, the time of cluster removal should be controlled before accurate comparison can be made.

***Key words**: Teat hyperkeratosis, machine milking, liner type.*

Introduction

Maximum milk yield and reduced liner slip levels can be achieved using heavy clusters and wide-bore tapered liners (O'Callaghan,1989). An alternate milking principle incorporates a light cluster weight and narrow-bore liners. A survey of milking machines by Hillerton *et al.*, 1998 showed poor teat condition where machines used the wide-bore liner milking system. Teat-end hyperkeratosis (TH) is a commonly observed condition in dairy cows and can result from mechanical damage from machine milking (Sieber, 1980). Wide-bore tapered liners with simultaneous pulsation give higher levels of milking vacuum than narrow bore liners with alternate pulsation (O'Callaghan and Gleeson, 1999). The objective of this study was to measure the effect of these vacuum conditions on teat condition and milking performance over a full lactation using two cluster types.

Materials and methods

Autumn calving Friesian type dairy cows (n = 56), were assigned post calving to two milking treatments. Treatment 1 consisted of a heavy cluster weight (3.20 -kg) with a claw volume of 150 ml, wide bore tapered liners (31.6 mm –21.0 mm) and used simultaneous pulsation. Treatment 2 consisted of a light cluster weight (1.65 -kg) with a claw volume of 275 ml, narrow–bore liners (25.0 mm – 20.0 mm) and alternate pulsation. Cows were milked in a 14-unit swing-over side by side milking parlour, with the milk elevated into a 60 mm milk-line 1.4 m above the cow standing. The clusters were removed automatically when the milk-flow rate dropped to 0.2 -kg/min. The AM and PM milking interval was 18 and 6 hrs respectively. Teats were washed with running water and dried with paper towels before cluster application. Milk production (kg), milking time kg/min and peak milk flow-rate was recorded daily. A Chlorohexidine teat disinfectant was applied post milking to right-sided teats and left-sided teats were left untreated.

Teat hyperkeratosis, teat texture and colour

Teats were scored for hyperkeratosis (TH) using five classifications scores (0=normal, 1=slightly raised smooth or broken ring, 2=moderate raised smooth or broken ring, 3=large smooth or broken ring, 4=extreme broken ring). Teat classification was carried out monthly after PM milking by the author using a miner's headlamp and a personal organiser to store data.

Machine milking can cause short-term changes in teat hardness and colour. Teats generally have a pink colour after milking, but some teats become reddened or blue. One operator unfamiliar with the milking treatments, classified teat barrels for teat texture by manual palpation and teat colour by visual assessment. The teats were scored for texture as soft, firm or rough. All cows teats were examined twice on consecutive days during mid lactation, and teats were classified within one minute of cluster removal. Statistical analyses were done using a Kruskal-Wallis one way analysis of variance test to compare teat scores between treatments. Teat score comparisons were also made for front and hind teats using the Wilcoxon matched pairs test.

Results and discussion

There was no significant difference in TH scores for the two treatments at each month of classification or over the complete lactation (Figure1). TH increased with stage of lactation and was higher for front teats as compared to rear teats. TH was significantly higher for right-sided teats as compared to left-sided teats. An increased prevalence of TH has been reported to occur in dairy cattle during winter months particularly during cold weather (Timms, *et al.*, 1997). Weather changes during the autumn/winter-milking period and wet teats due to teat-dip application, may explain the higher TH scores recorded with right-sided teats. The percentage of teats classified as soft, firm or rough and with pink or red colour are presented in table 1. The number of pink and reddened teats is presented as a percentage of light coloured teats. There was no difference

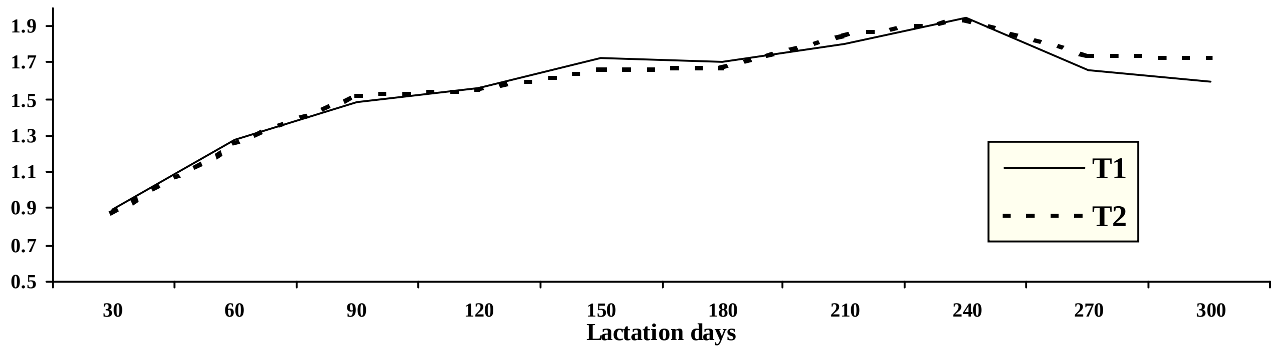

Figure 1. Monthly teat-end scores for two milking systems.

shown in teat texture or colour between milking treatments. Teat colour changes shown in previous studies were probably more related to over-milking rather than the teat-cup liner type used. The percentage of teats classified as soft was 19% and 47 % and rough was 34 % and 11 % for front and rear teats respectively. The poor teat texture found with front teats is probably due to some level of over-milking with front teats as compared to rear teats. Right-sided teats showed had higher percentage soft teats (43% v 24%) as compared to left-sided teats. The post milking disinfectant used on right-sided teats contained high levels of emollients and this may explain the better teat texture shown with these teats. The mean total lactation milk yields recorded were 5 465 kg and 5 267 kg for Treatments 1 and 2, respectively. Treatment 1 gave 5.2% and 0.5% higher milk yields at the AM and PM milking respectively, as compared to Treatment 2. The peak milk flow-rate was 3.6 and 3.2 kg / min at AM and PM respectively for both milking treatments. Peak milk flow-rate was higher for T1 during the 1st twelve weeks of lactation and for T2 during the last 12 weeks of lactation.

Table 1. Effect of milking treatment and teat position on teat texture and teat.

	Teat texture			Teat colour	
	Soft %	Firm %	Rough %	pink %	Red %
T1	34	45	20	78	22
T2	32	44	24	73	27
Front Teats	19	47	34	78	22
Rear Teats	47	42	11	82	18
Right sided Teats	43	38	18	83	17
Left sided Teats	24	51	26	76	24

Conclusions

Milking systems with different levels of milking vacuum gave the same level of TH, colour and texture. This study unlike other studies compared milking systems under the same milking and herd management over a complete lactation. Differences in teat condition were shown where post-milking disinfecting was omitted, with front teats as compared to rear teats and stage of lactation. When teat condition is used to evaluate milking systems, stage of cluster removal, lactation days and post-milking disinfection should be considered. Machine yield and peak milk flow-rate obtained with specific types of milking units is effected by the magnitude of the milk yield per cow per milking.

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Managing the quality of milk by means of mastitis monitoring

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On the basis of our previous experiments a mathematical model was created which enables to trace the influence of ill cows on the total milk quality of produced milk (Tongel and Mihina, 2000).

The model is represented with mathematical equation, which can model a situation when more cows with mastitis in various stage of illness are in the various herd size. For the purpose of the faster and easier evaluation of effect of ill cows on BTSCC a normogram was created .

At present we use the model for managing of produced milk quality on the farm where the model was experimentally tested in practice.

A herd of 423 dairy cows was monitored on mastitis by means of the electrical conductivity (EC) measurement of the milk (Tongel *et al.*, 1994) in our experiment . For this purpose we used the REM test (Rapid electronic mastitis test) (Tongel and Mihina, 1995). After all cows had been monitored for three times, we split them into two groups. In the first group there were placed all cows that did not show any signs of mastitis (the differences of EC between quarters were in tolerance). In the second one were cows that had some problems in one or more quarters. There were 167 cows in the first group and 256 in the second one.

When cows from the first group were milked only, the BTSCC was under 45 000 in average. Milking first and second group together resulted in BTSCC 653 000.

Because the farm needed to deliver milk in Q class quality (SCC less than 300 000) to cancel previous bad quality results we decided to discard milk from all cows with mastitis in two and more quarters. These cows were 35. After the discarding the resulting BTSCC was 427 000.

Because it was not enough for our purpose, another 30 cows with mastitis in one quarter of the udder were separated (they were cows which have the highest difference of EC in ill quarter opposite the quarter with the nearest value of EC of the examined cow). The resultant BTSCC after the separation was 275 000.

From previous experiment (Tongel and Mihina, 1999) we knew that it is uneconomical and not needed to separate all milk from cows with one mastitis quarter. That was why we tried to separate milk from ill quarters only. The result of this was SCC 293 000.

At the end it is possible to say that the model have shown to be a very effective one for managing of produced milk quality, but it must be mentioned that for the purpose of separation of milk from ill cows (quarters) it is very suitable to make us sure that the quarters with high EC have really high SSC because only about 80% of cows with the highest difference of EC have the highest SCC, too (Tongel and Mihina, 1998).

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Participation of Research Institute for Animal Production Nitra in the interlaboratory proficiency studies of ICAR

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Summary

The laboratory for milk quality of Research Institute for Animal Production (RIAP) as a member of ICAR Reference Laboratory Network every year takes part in Interlaboratory proficiency studies, also called international ring tests, with determination of fat, protein, lactose and somatic cell counting. Improving analytical practice shows the last differences between reference mean and laboratory mean (Δ), which are for every method not higher than 0.5 g / kg for milk composition and $20x10^3$ / ml for somatic cells count.

Key words: *Milk, analysis, interlaboratory study*

Introduction

The laboratory for milk quality of Research Institute for Animal Production (RIAP) as a member of ICAR Reference Laboratory Network every year takes part in Interlaboratory proficiency studies, also called international ring tests. This laboratory works as a national ring test organiser and reference material supplier since it has been authorised as a master laboratory for centralised calibration of infrared milk analysers by Ministerium of Agriculture of Slovakia.

ICAR (International Committee for Animal Recording) laboratory network was created in 1996 and from this year the number of members has grown up to 33 from 28 countries. The participation in interlaboratory study programme is the occasion to favour and generalise good analytical practices. International network constitutes an effective tool to develop Quality Assurance and harmonise analytical practices in milk recording laboratories.

Since 1996, two interlaboratory studies have been carried out each year. They are organised by the French organisation CECALAIT (Centre d'Étude et de Controle des Analyses en Industrie Laitiére) that operates under the umbrella of ICAR. During the past ten years CECALAIT, as an association of dairy laboratories, has developed and offered dairy laboratories services to optimise their performance and help in improving their quality systems.

Table 1 Statistical treatment of the results concerning proficiency interlaboratory study.

	Fat (g / kg)			Protein (g / kg)		
	Limit IDF	RIAP lab. 3 / 2000	RIAP lab. 9 / 2000	Limit IDF	RIAP lab. 3 / 2000	RIAP lab. 9 / 2000
Δ		-1.67	0.457		0.03	0.489
$\bar{d}$	+ / -0.2	-0.67	0.45	+ / -0.25	0.03	0.49
Sd	0.3	1.01	0.11	0.2	0.93	0.46
D	0.36	1.21	0.47	0.32	0.93	0.67
SL	0.1	0.05	0.09	0.2	0.68	0.55

	Lactose (g / kg)			Somatic cells count (10^3 / ml)		
	Limit IDF	RIAP lab. 3 / 2000	RIAP lab. 9 / 2000	Limit IDF	RIAP lab. 3 / 2000	RIAP lab. 9 / 2000
Δ		-0.01	0.48		-5	21
$\bar{d}$	+ / -1	-0.01	0.48	+ / -35	-5	-64
Sd	1	1.52	0.32	35	13	56
D	1.41	1.52	0.58	50	14	85
SL	0.77	0.06	0.39	36	23	10

Δ - Difference of averages (mean of reference values - mean of RIAP laboratory results)

$\bar{d}$ - Mean of differences (individual sample reference value - RIAP laboratory result)

Sd - Standard deviation of the differences per sample

D - Euclidian distance to $\bar{d}$ - *Sd* axes origin

SL - Repeatability (standard deviation of absolute differences between laboratory duplicates)

Material and methods

In 2000 interlaboratory studies concerned the determination of fat, protein, lactose and somatic cell counting by our laboratory. Two trials were scheduled on March and September. Whole milk samples, preserved by bronopol, were sent by international delivery express carrier in isolated boxes with ice, with dispatching delay 1 to 3 days. According to our registration we received:

- 10 samples for determination of fat by Röse-Gottlieb, and protein by Kjeldahl;
- 10 samples for polarimetric determination of lactose;
- 10 samples for somatic cells counting by Fossomatic 90.

After the performing of analyses, the results in duplicates were reported on the appropriate report sheets and returned to CECALAIT. The results of the statistical data treatment (analysis of the laboratory's repeatability and accuracy) were sent anonymously to each participating laboratory, knowing only his identification number. As the reference values were taken the average values of 10 - 15 laboratories after elimination of extremes by Grubbs test at 5 % level.

Results

Statistical treatment of the results concerning proficiency interlaboratory study is shown in table 1. Limit for Euclidian distance *D* define an acceptability area of the laboratory performances. Comparison of March and September RIAP laboratory *D*-value with IDF limit for used methods shows the step-by-step improvement of analytical practices. September differences between the reference mean and laboratory mean (Δ), are for every method not higher than 0.5 g / kg for milk composition and 20×10^3 / ml for somatic cells count.

At the presentation on poster will be shown the graphical evaluation of accuracy.

Effect of ultrasound in circular disinfection of milking equipment

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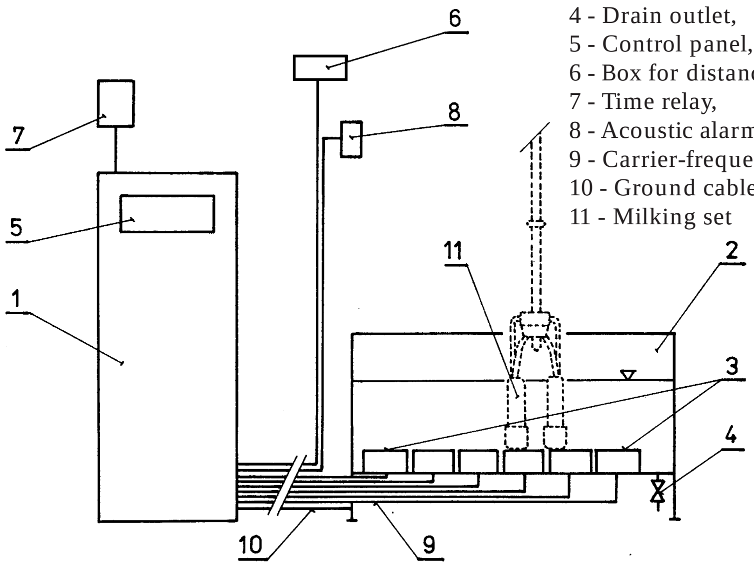
Aim, material and methods

The effects of circular cleaning of the pipeline milking equipment ZD 2-020 by means of ultrasound and its influence on the cleanness of milking units were evaluated.

The results were compared with the effects of the traditional way of sanitation. An ultrasonic cleaning equipment with a small trough was constructed for this purpose (Figure 1).



1 - Ultrasonic generator,
2 - Ultrasonic trough,
3 - Underwater ultrasonic emitters,
4 - Drain outlet,
5 - Control panel,
6 - Box for distance control,
7 - Time relay,
8 - Acoustic alarm of failure,
9 - Carrier-frequency cables,
10 - Ground cable,
11 - Milking set

Figure 1. Design of ultrasonic trough equipment for circular cleaning of the pipeline milking equipment.

The cleanness of the milking sets was evaluated on the basis of results of the microbiological control of the inner surface of teat cups (mouth of liner and liner wall), claw-piece, long milk tube, milk-flow indicator and jointing cock. The samples were wipped off and the total number of microorganisms (TNM) expressed in number of colony creating units per dm^2 area (CCU / dm^2) was determined.

Results

All parts of the milking set cleaned by the ultrasonic circular disinfection were better cleaned than with the traditional way of sanitation (Table 1). The share of satisfactory degree of cleanness was higher by 23.2 % (TNM to 500 dm^{-2}). The determined values of the microbial contamination in the parts of milking units were the highest in the teat cups, and jointing cock. The share of conditioned satisfactory degree of cleanness (TNM 500 to 2 500 dm^{-2}) was lower by 15.7 %.

Table 1. Total number of microorganisms in milking set parts within the individual degrees of microbiological cleanness at various ways of sanitation in CCU/dm^2.

Way of sanitation		Traditional			With ultrasound	
Degree of microbial cleanness	I.	II.	III.	I.	II.	III.
Teat cup - mouth of liner	41	1 194	5 640	78	813	0
- liner wall	33	1 138	4 418	86	940	0
Claw-piece	75	1 043	3 992	252	709	0
Milk tube	255	1 062	2 804	220	845	0
Indicator of milk flow	178	1 020	3 890	162	631	0
Jointing cock	175	1 004	2 512	291	986	2 757

Note:
I. Satisfactory degree of cleanness (TNM to 500 CCU / dm^2)
II. Conditioned satisfactory degree of cleanness (TNM 500 to 2 500 CCU / dm^2)
III. Unsatisfactory degree of cleanness (TNM over 2500 CCU / dm^2)

The values of contamination of all parts of milking sets were also lower at the same time. The inconvenient degree of cleanness decreased by 80 %. The teat cup - its liner wall - was contaminated at least when cleaned traditionally as well as with the ultrasound. The highest contamination was noticed in the long milk tube after the traditional sanitation and in the jointing cock after the ultrasonic sanitation.

Conclusion

Better cleanness of all parts of the milking sets was achieved by the ultrasonic circular cleaning of the pipeline milking equipment then with the traditional sanitation.

Change of udder conformation traits during lactations in a Holstein Friesian herd

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The aim of this study is to establish how change the conformation traits during lactations. We made our investigations on the dairy farm of Agrár Rt, Enying in Kiscséripuszta. The conformation traits based on minimal two consecutive scorings with a 50-point scale were evaluated in a Holstein Friesian herd with 739 cows. The two evaluations were at the first and second lactations.

The scores of conformation traits at the first and second evaluation are reported in table 1. During the lactations the scores of fore udder attachement were decreased slightly (with 1.6 points) and for rear udder hight increased with 0.9 point (by 20-24 cm). The scores for udder width were better with 1.1 points but were under by 15 cm, and udder suspension were better with 0.3 point. As for udder depth, the udder floors were above the hocks at the first scoring by 7.5 cm and by 5 cm at the second. At the first evaluation the rear teat placements were scored as normal but during the second lactations the scores for trait of side teat placements increased.The udder system generally was evaluated for "good" level but later its score (77.6-77.0 points) decreased with 0.6 point.

Table 1. The scores of conformation traits at the first and second scoring.

Udder conformation	1st scoring			2nd scoring			
traits	Average	Deviation	CV%	Average	devIation	CV%	Diff.
Udder placement	24.7	4	17	23.1	6	28	-1.6
Udder hight	30.5	4	14	31.4	4	13	+0.9
Udder width	26.7	5	17	27.8	5	19	+1.1
Udder attachment	31.2	5	16	31.5	6	21	+0.3
Udder depth	30.9	7	22	22.8	9	38	-8.1
Teat placement	24.0	6	26	22.8	8	35	-1.2
Udder system	77.6	4	5	77.0	5	7	-0.6

By the distribution of scores we can established that the number of cows with weak udder attachment were slighty increased but also increased the number of cows with strong attached udder (Figure 1).

As for udder depth there were by16% more cows with udder floors below hocks and by 23% more cows with udder floors above hocks (but no reached 5 cm). Besides the number of cows are decreased by 5% which udder floors above hocks (by 5-7.5 cm) and also decreased where this distance were 7.5-17.5 cm (Figure 2).

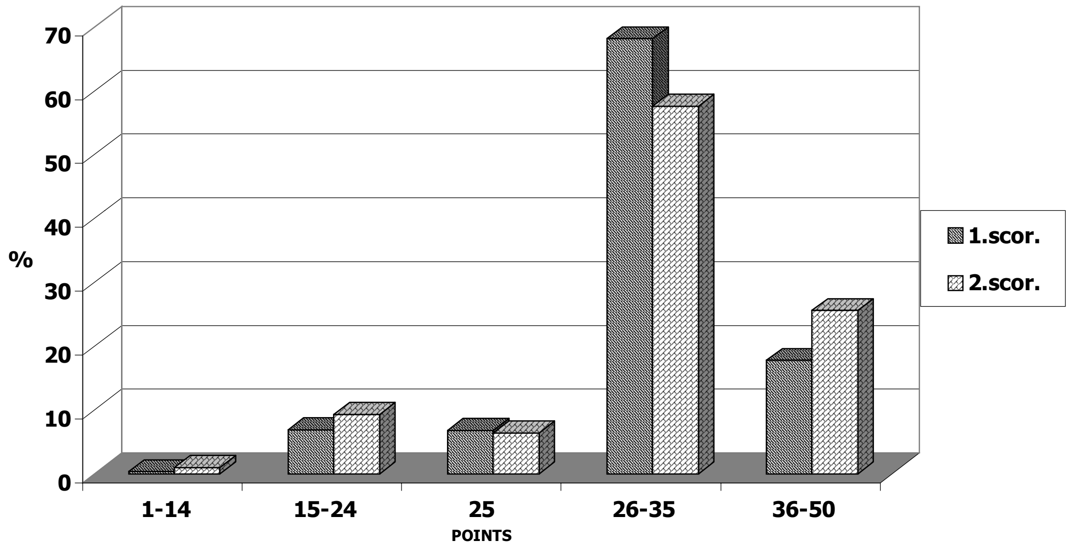

Figure 1. The distribution of udder attachement in two scorings.

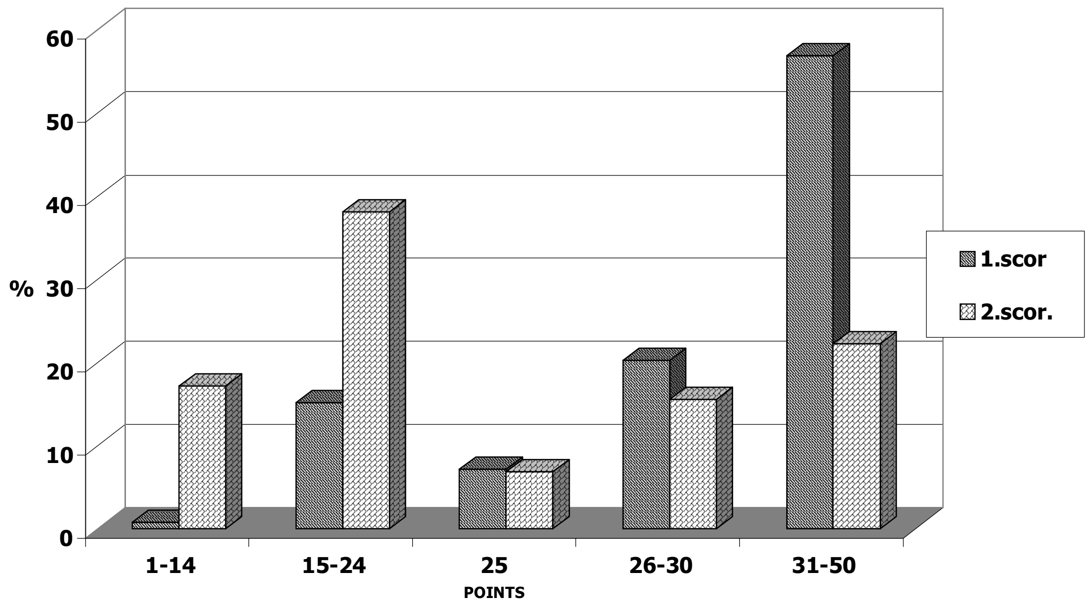

Figure 2. The distribution of udder depth in two scorings.

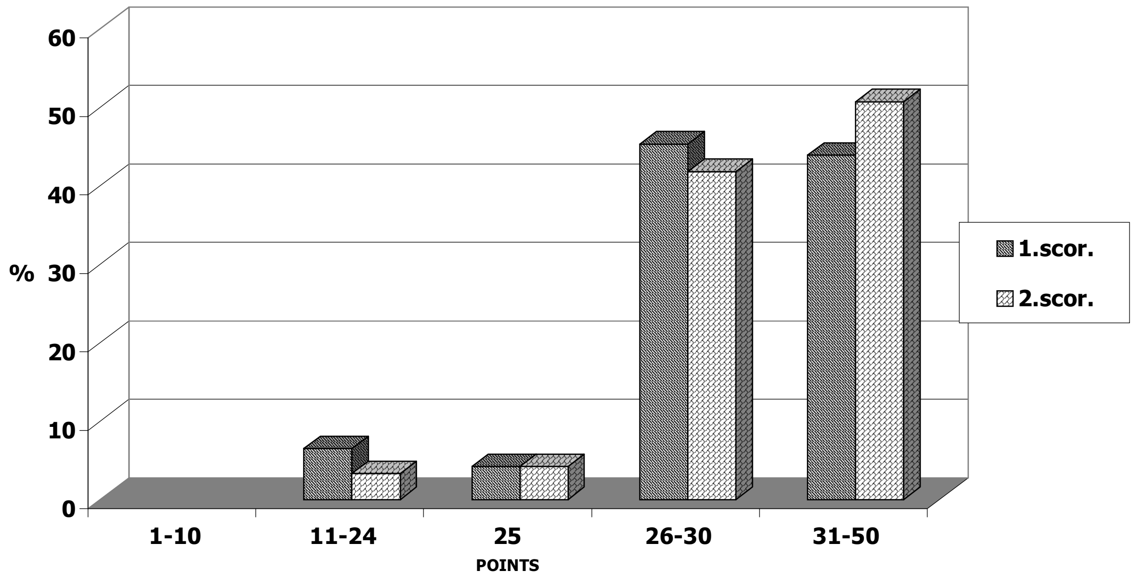

Figure 3 The distribution of udder height in two scorings.

At rear udder hight at the second scoring there were by 7% more cows which were evaluated „very good" level.(Figure 3). The average of udder width were better at the second evaluation because the number of cows with narrow udder were slighty decreased (by 4%) and largely (by 11%) were increased the cows with wide udder (Figure 4).

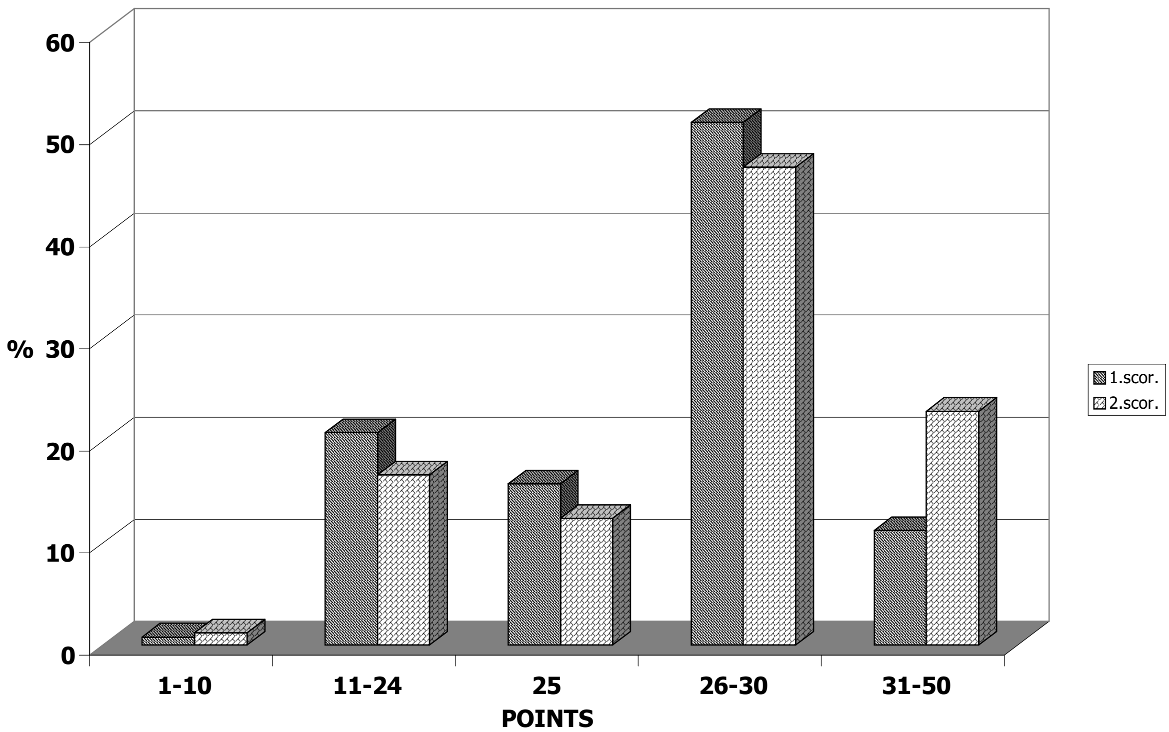

Figure 4. The distribution of udder width in two scorings.

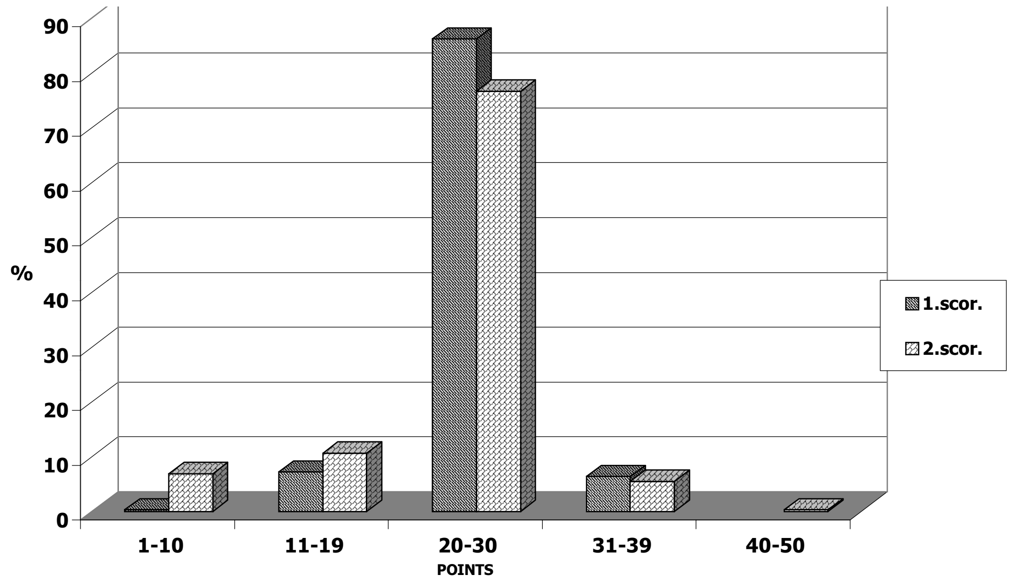

Figure 5. The distribution of udder placement in two scorings.

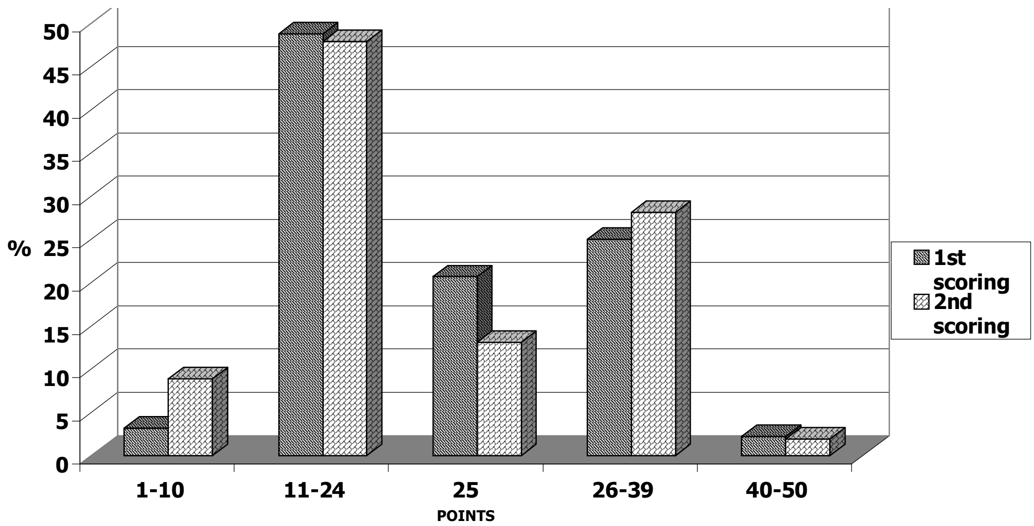

Figure 6. The distribution of teat placement in two scorings.

Fore udder attachment were worse at the second evaluation because the rate of evaluated cows with extremely loose attachment were increased by 7% and the number of cows with loose udder increased by 3%. The number of evaluated cows with intermediate scored were decreased by 10% and there were a few cows with very strong udder (Figure 5).

Teat placement also changed during lactations, centrally placed were decreased (by 5%) and inside teats were increased (by 3%) (Figure 6).

Effect of inclination and vacuumlevel on the recording accuracy of portable milkmeters

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Summary

The examination enclosed five different portable milkmeters. The milkmeters were chosen as a result of their prevalence in Austria (Table 1).

Table 1. Devices in trial.

Devices	
Device No. 1	LactoCorder
Device No. 2	Waikato Mark 5
Device No. 3	MilkoScope II
Device No. 4	Tru - Test HI
Device No. 5	Tru - Test FD

The meters were checked under laboratory conditions with water. The test procedure has been carried out in accordance to the "Recording Guidelines" (ICAR; 1995). The examination of each device surrounded 2 directions of inclination , 4 angles of inclination (0,5, 10, and 15 degrees) and two different vacuumlevels (40 kPa and 50 kPa). The study showed significant differences on recording accuracy by vacuumlevel and also by angle of inclination.

***Key words**: Milkmeters, recording accuracy, test with water, inclination, vacuum level*

Introduction

The portable milkmeters for the examination are taken to the farms for recording by the official representatives of the provincial milk recording association. This portable milkmeters are used on farms with pipline milking machine systems as well as on farms with milking parlours. There is a big difference between the normal position of the milkmeters (perpendicular) and the deviation of the perpendicular positions. A further problem is concerning the recording accuracy emerges due to the different rates of vacuum on the different farms.

Results

To limit the examination´s extent in a practical range some pilot tests were done to get the direction of inclination with the highest specific failure.

For this reason the milkmeters were inclinated in four directions (right - left, front – back) with 15 degrees each. The two positions dividing the most from the real value were taken into account in the experiment´s plan.

To approximate the practical situation, the effect on the recording accuracy of simultaneous inclination in both directions was additional checked.

The project contains, in addition to the optimal position (perpendicular), the inclination angles of 5, 10, 15 degrees in all directions, commited in the pilot test.

Even all examinations were performed with a systemvacuum of 40 kPa and 50 kPa. The evaluation was done with the "Mixed Model Least - Squares and Maximum Linkelihood" Computer program (in the version PC – 2 of HARVEY, 1990).

Results according to all devices (Total experiment) are summarised in table 2.

High significant differences (P< 0,001) in the recording accuracy between all devices were observed.

Table 2. Recording accuracy of each device in % (LSQ).

	Recording accuracy in %						
	Devices						
	1	2	3	4	5	S	P
No.	132	200	200	200	200		
Recording accuracy in %	-3.80a	5.74bd	-3.79a	3.77c	5.1d	6.64	0.0000

a, b, c, d, bd, … different letters show significant (P<0.1) differences.

There is no difference between device 1 and device 3, but a significant difference to all the others. Further more there is a significant difference between device 4 and device 5. Between device 2 and device 5 no significant differences could be observed.

Although high significant differences between the both vacuum levels (P < 0.001) could be observed (Table 3).

Table 3. Recording accuracy of both vacuum levels in % (LSQ).

	Recording accuracy in %			
	Vacuum		S	P
	40 kPa	50 kPa		
No.	460	472		
Recording accuracy in %	-0.14	2.94	6.64	0.0000

Results according each device are reported in table 4 and 5.

Table 4. Recording accuracy of all directions of inclination and all angles of inclination in % (LSQ).

	Recording accuracy											
	0/0	0/5	0/10	0/15	5/0	10/0	15/0	5/5	10/10	15/15	S	P
	Recording accuracy in %											
Device no. 1	-3.34	-3.92	-4.55	-4.55	-3.42	-4.50	-3.57	-3.27	-3.64	-3.27	0.73	0.0000
Device no. 2	-4.24	-0.70	1.46	44.02	-2.72	-2.65	12.06	-0.10	1.51	8.72	6.95	0.0000
Device no. 3	-0.91	-1.11	-2.08	-3.47	-2.00	-4.53	-6.34	-2.88	-6.47	-8.06	0.74	0.0000
Device no. 4	3.45	3.92	4.82	6.52	3.23	3.06	3.86	3.30	3.27	2.17	1.17	0.0000
Device no. 5	1.56	2.73	6.84	8.50	2.58	2.48	2.72	5.46	5.73	12.40	0.93	0.0000

Table 5. Recording accuracy of all devices in both vacuum levels in % (LSQ).

	Recording accuracy			
	Vacuum			
	40 kPa	50 kPa		
	Recording accuracy in %		S	P
Device no. 1	-3.61	-3.99	0.73	0.0039
Device no. 2	-0.07	11.54	6.95	0.0000
Device no. 3	-4.33	-3.24	0.74	0.0000
Device no. 4	3.80	3.74	1.17	0.7402
Device no. 5	3.51	6.68	0.93	0.0000

All 5 examinated devices showed significant differences in the recording accuracy between the different positions.

Both different vacuumlevels result in 4 devices in significant differences of recording accuracy, only device 4 showed no significant differences in this chase.

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Modelling of liner behaviour using finite element analysis

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Summary

A finite element model was developed to model the response of a liner to changes in liner material, geometry, tension and differential pressure. Liner tensile tests were used for preliminary validation of the results, which compared well with experiments.

Key words: *Machine milking, finite element analysis, liner.*

Introduction

Based on milk flow simulation data it is possible to predict the influence of various component dimensions on the teat end vacuum and liner differential pressure. However if a new liner is being developed it is not possible to predict the deformation or liner wall movement in response to a given differential pressure. It was proposed to develop a model based on finite element analysis (FEA), which could accurately model the liner wall movement profile for a number of discrete points on the surface of the liner.

Liner wall movement has elsewhere been indicated (O'Callaghan, 1997; Spencer and Jones, 1999). It has also been shown that poor liner wall movement as a consequence of pulsation failure can double the rate of new infection and also lead to an increase in petechial haemorrhaging of the teat. (Mein *et al*., 1983).

The objective was to model the liner response to an applied differential pressure using finite element analysis so that liner behaviour can be predicted based on *a priori* knowledge of the geometry and material characteristics.

Material and methods

Geometry and material characteristics

The liner material properties were measured for three similar liners by carrying out tensile tests on the materials in accordance with BS903:A2 (BSI, 1995).

The liner geometry was obtained from both part drawings and internal mould impressions. The internal mould impressions were taken using a surface impression compound, Technovit 3040, which was subsequently poured into the liner barrel. After a few hours when the compound had solidified the liner was split and the internal liner impression was removed. Dimensions were measured from the liner impression.

Finite element analysis

A nonlinear finite element model was developed with 8 noded solid elements using Ansys 5.6 to model the collapse of the liner. The model geometry was defined parametrically in terms of upper barrel bore, lower barrel bore, barrel length, wall thickness, axial stretch and radial stretch. The elastic modulus for the material was also entered as a parameter. The Poisson’s ratio was fixed at 0.49. A two dimensional section of half the liner was constructed by defining various keypoints and areas.

These areas were meshed with a special element (MESH200), which is intended for multi-step meshing operations that require a lower dimensionality mesh to be used for the creation of a higher dimensionality mesh, i.e. sweeping a 2-D mesh into a 3-D mesh. Model meshing was additionally parameterised which included the number of elements through the wall thickness, the element size and the number of elements in a 180° rotation.

This mesh was rotated about 180° and the mesh elements converted to solid 8 noded elements (SOLID45) used for 3-D models with materials obeying linear material constitutive laws. The materials were linear and isotropic in the strain area of interest. Despite the axisymmetric liner geometry it was necessary to model half the liner as the deformed model should only have one plane of symmetry. Specific groups of nodes were defined as components C1 to C5 within the geometry to simplify the application of loads and constraints.

Since the geometry and loading pattern are symmetrical the finite element model has no material imperfections and will not deform correctly when loaded. This is because the liner barrel will contract in the radial and circumferential directions and the material will compress therefore it was necessary to introduce an imperfection. Eigenvalue buckling analysis determined the initial buckling mode shape upon which miniature nodal offsets were applied to introduce the imperfection. The nodal offset was computed as 10% of the normalised buckling mode shape, i.e. a maximum offset of 0.1mm.

A solid plane was constructed so that deflections would not penetrate the plane of symmetry. The elements CONTA174 and TARGE170 were used to model contact between the internal liner barrel and the solid plane. The contact elements overlaid the solid elements describing the internal liner barrel.

Initial loading consisted of the radial and axial stretch when a liner is placed in the shell. Nonlinear geometry options were enabled due to the large deflections expected. Ansys solution control options were enabled. The model was then solved at the initial time step because loading may be path dependent and the principle of superposition would not apply. Differential pressures between 45kPa and –25kPa were placed across the liner barrel and the solution was obtained.

Validation experiment

Three liner types were held in an Instron tensile testing machine and stretched to 50mm at a rate of 100mm / min. The load was then relaxed at the same rate. The load versus displacement curve was obtained and linear regression was carried out on these curves.

Results and discussion

The measurements of the axial forces on the liner from experiments were compared with the F.E. model and are shown in figure 1. The comparison for the soft and medium material types are within result tolerances due to material properties, but the results for the hard material show a larger difference between the model and the tensile tests. During the tensile tests the hard material was stretched beyond its elastic limit and it deformed

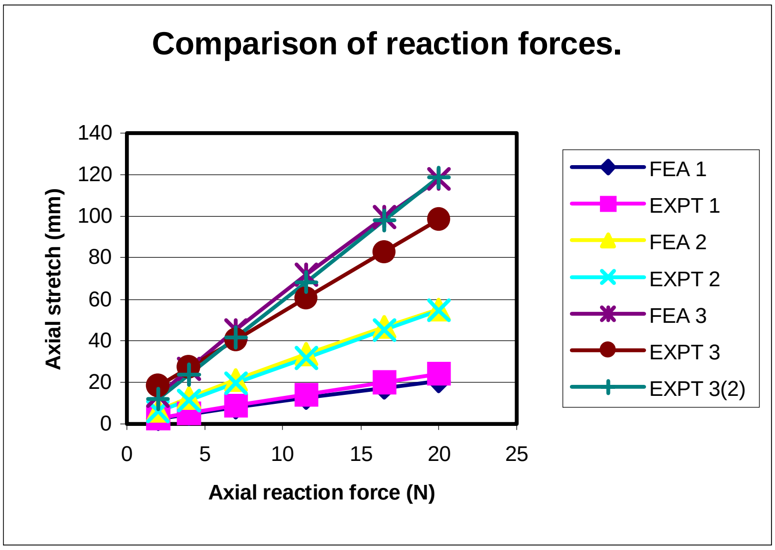

Figure 1 Comparison of reaction forces.

plastically. When linear regression was performed on the extension results with the regression line fixed through the Cartesian origin the comparison (FEA 3 vs. EXPT 3(2)) was better.

Displacement due to a differential pressure of 45kPa is shown in figure 2, although results can be viewed at any differential pressure.

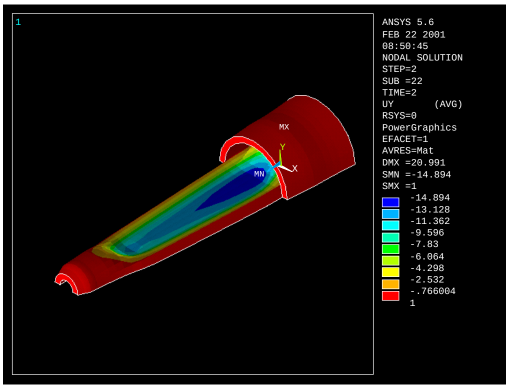

Figure 2 Displacement due to a differential pressure of 45kPa.

Conclusion

Liner behaviour can be predicted for a range of geometries and material properties with excellent accuracy using FEA without the need for expensive prototyping processes.

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Using daily data from electronic milkmeters: First results of field tests

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Foreword

Electronic milkmeters, installed in traditional milking parlours or in robotised ones, make it possible to estimate the milk yield for each cow and each milking. It is thus interesting to test what is the required level of precision, considering that data from the electronic equipment are supplied milking after milking and how to use them for milk recording purposes. Moreover it is not advisable to use an electronic milkmeter as if it were a pair of scales.

Materials and methods

The test was carried out in 1990 on the “Ghezzi” farm near Milan, equipped with a 6-unit tandem milking parlour, in which 70 cows are usually milked. The low-line milking parlour was provided with electronic milkmeters (“Metrolat 2”, manufactured by Proseat).

The test spanned over 30 days. Data concerning milk yield for each cow and for each milking were provided by the milkmeters and by the weight of milk collected in a pail connected downstream in relation to the milkmeter, for each individual milking. The milk weight was determined by means of a pair of scales.

Results

Data were grouped under:
- milkmeters;
- cows;
- milkings.

Graphs were made of the error (in%) of the milkmeter in comparison with the scales (Figure 1) and related real milk yield (Figure 2) considering all the milkmeters.

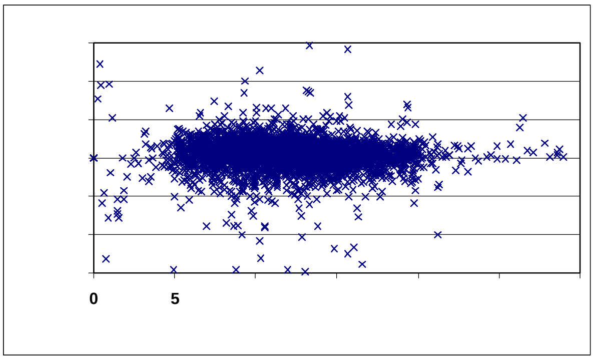


Figure 1. Error (in%) of the milkmeter in comparison with the scales.

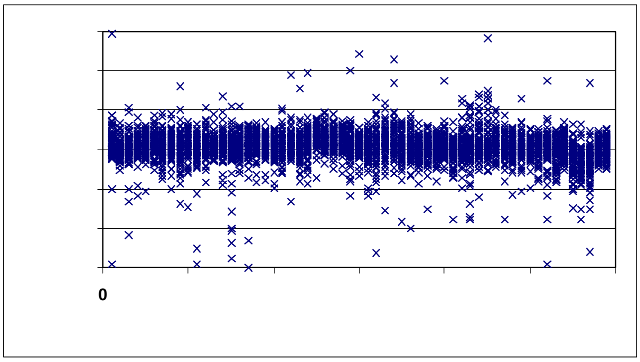


Figure 2. Error (in%) of all the milkmeters during the month (2 milkings a day for 30 days).

The average concerning milk yield for each day of milking was calculated in order to obtain the herd's average daily yield (Figure 3) in relation to real yield and the one read off the milkmeter.

Afterwards the monthly (30 days) yield was assessed by using an ever increasing number of daily data (1 to 30) and by comparing it with real yield.

Figures 4 and 5 were made of the errors obtained (in % and in kg) in relation to the number of days on which the estimate of monthly yield was based.

Figures from 6 to 9 refer to four individual cows taken as examples.

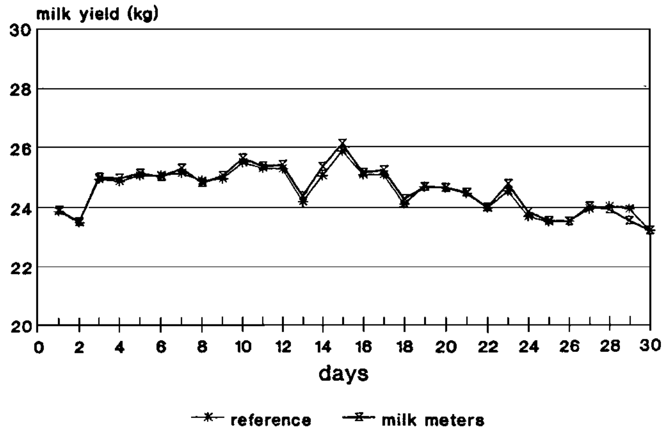


Figure 3. Average daily yield recorded by scales and milkmeters.

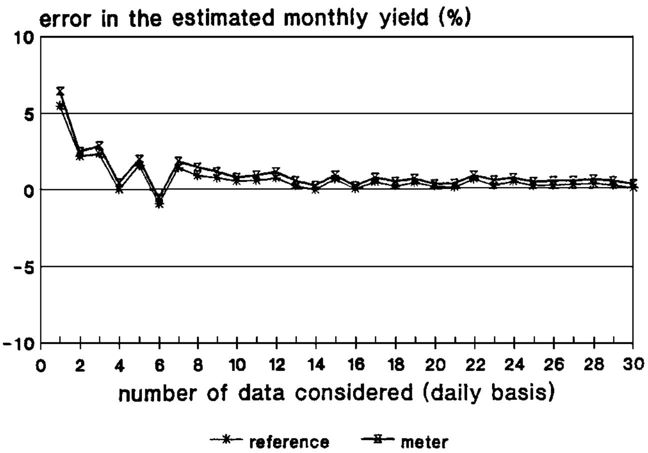


Figure 4. Error in the estimated montly yield (in %) both for scales and milkmeters by using increasing numbers of data (daily basis), taken at regular intervals.

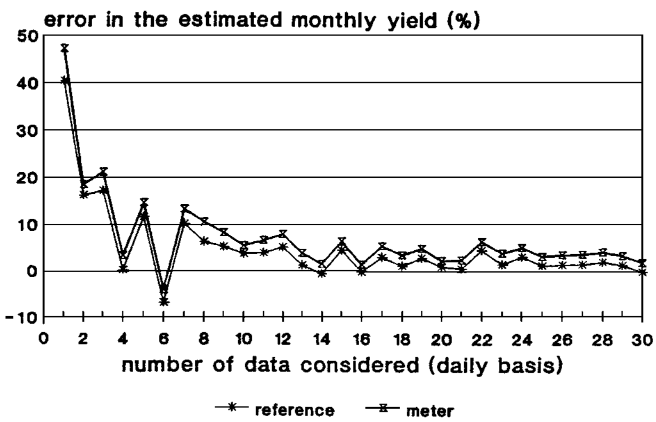


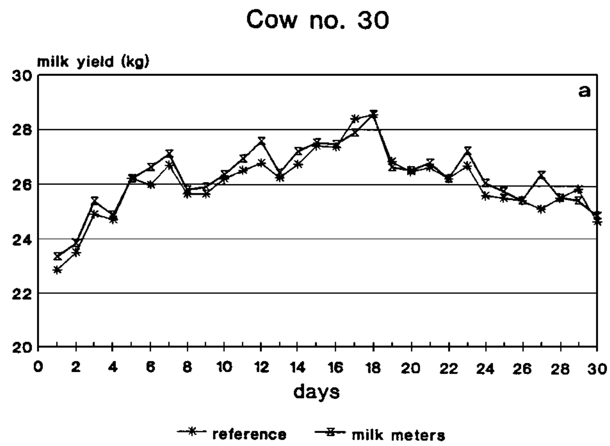
Figure 5. Error in the estimated montly yield (in kg) both for scales and milkmeters by using increasing numbers of data (daily basis), taken at regular intervals.

Discussion

As for real milk yield the analysis of milkmeter errors shows that all electronic milkmeters perform in the same way. That is to say that the mean error being small, some data indicate a considerable random error, which is sometimes as much as 15 %.

If only one daily datum, provided by these instruments, was used for milk recording there would be a risk.

In fact the monthly yield estimate would depend on one datum only with a likely considerable error. On the other hands it should be pointed out that even if the datum concerning the real yield of only one day a month is used, it may entail an estimate of the monthly milk yield, in excess of 5 %.



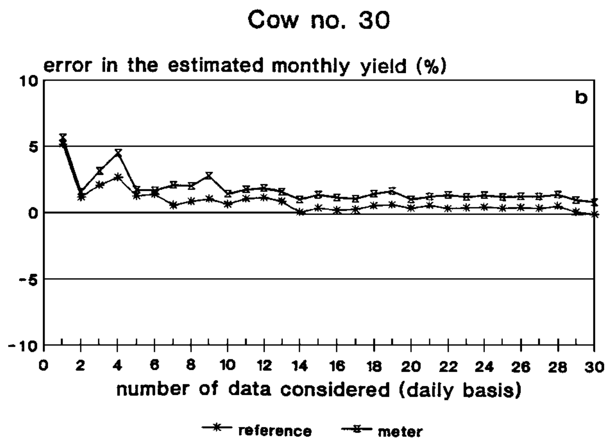


Figure 6. Cow no. 30.
a) Daily milk yield data recorded from scales and milkmeters
b) Error in the estimated montly yield (in %) both for scale and milkmeters by using increasing number of data (daily basis), taken at regular interval.

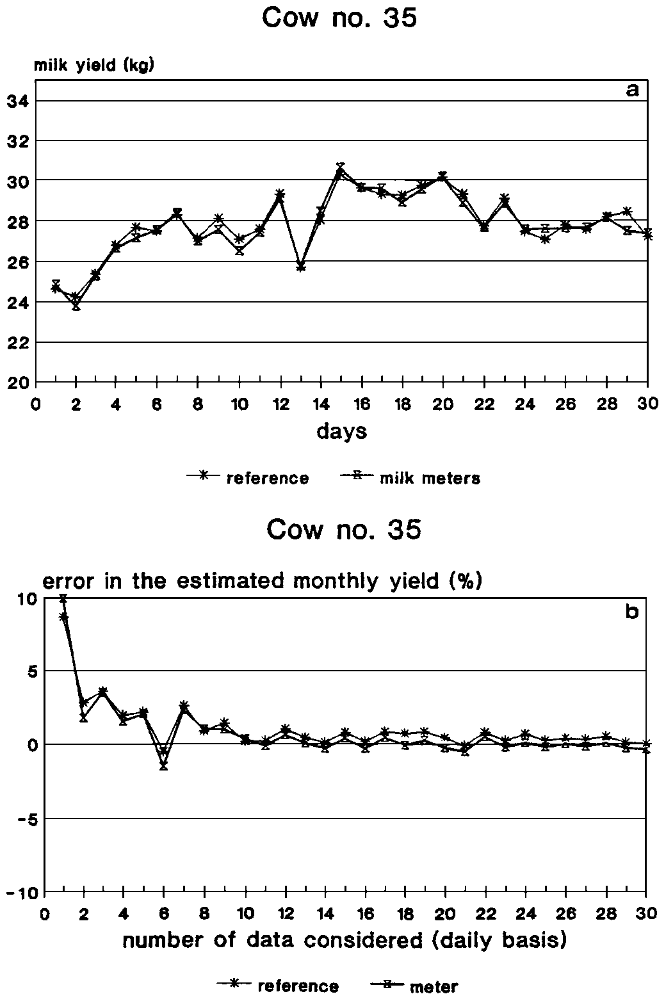


Figure 7. Cow no. 35
a) Daily milk yield data recorded from scales and milkmeters
b) Error in the estimated montly yield (in %) both for scale and milkmeters by using increasing number of data (daily basis), taken at regular interval.

If a greater number of daily data are used it is possible to reduce their errors (less than 1 % for 10 monthly data or more) by taking into account figures provided both by the scales and milkmeters.

Considering the estimate related to each individual cow characterised by different production levels and physiological conditions we can observe:

- from figure 6 that cow n° 30 shows an increase in milk production during the month. With just 4 - 5 daily data it is possible to keep the error below 2.5 %;
- from figure 7 that with cow n° 35, 8 daily data are necessary to keep the error below 2.5 %;
- from figure 8 that with cow n° 37, characterised by an even production curve, also with only one datum is sufficient;

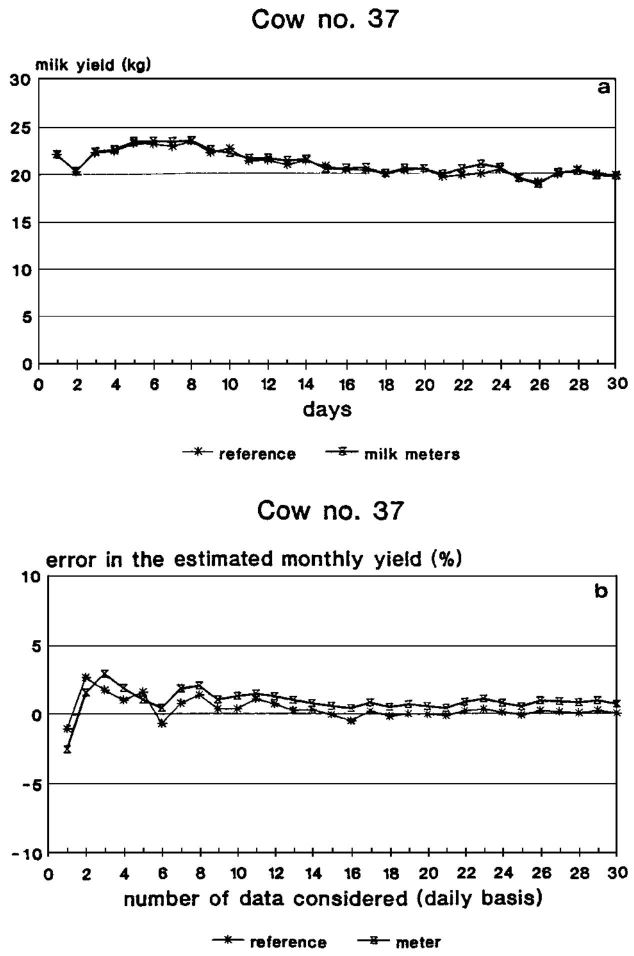


Figure 8. Cow no. 37
a) Daily milk yield data recorded from scales and milkmeters
b) Error in the estimated montly yield (in %) both for scale and milkmeters by using increasing number of data (daily basis), taken at regular interval.

- from figure 9 that with cow n° 52, that shows high variation in milk production due to udder health problems, it is necessary to gather at least 10 daily data.

Conclusions

In conclusion it seems possible to make use of data coming from cows with different production patterns or characterised by considerable random errors (due to e.g. transient currents etc.) obtained from electronic milkmeters, only if a substantial number (>10) of daily data are gathered within the month. Moreover such number of data accounts for any occasional malfuctioning of milkmeters which can occur in their everyday use. In order to achieve this aim, it is necessary to determine what characteristics electronic milkmeters must have and to agree on a standardisation of data collecting (e.g. equipment for data trasmission). Due to the variability shown by different cows it is also important that the software should consider the milking pattern of each cow and consequently considers, if not always available, the minimum number of data for each condition.

Daily recording with electronic milkmeters gives a far better estimate of the lactation curve than any other means.

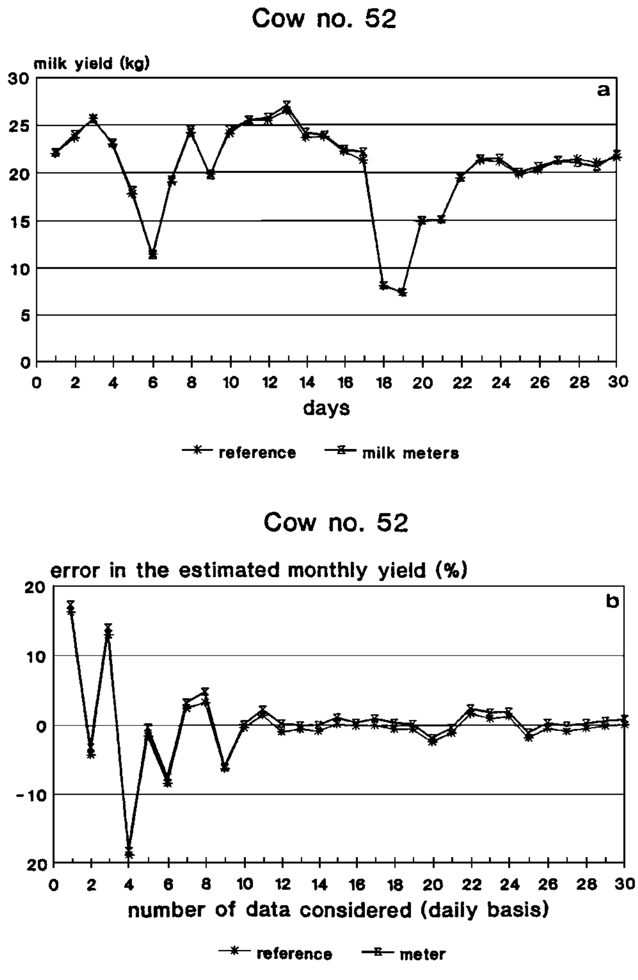


Figure 9. Cow no. 52
a) Daily milk yield data recorded from scales and milkmeters
b) Error in the estimated montly yield (in %) both for scale and milkmeters by using increasing number of data (daily basis), taken at regular interval.

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Inhibition of oxytocin release during repeated milking in unfamiliar surroundings: importance of opioids and adrenal cortex sensitivity

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In practical dairying, cows can be exposed to various emotionally stressful situations. Milking in unfamiliar surroundings can centrally suppress the milk ejection reflex accompanied by increased levels of cortisol and β-endorphin (Bruckmaier *et al.* 1993). Endogenous opioids inhibit OT secretion in response to various stimuli in rats (Bicknell and Leng, 1982). Administration of the opioid antagonist naloxone abolished inhibition of OT release in the rat (Pumford *et al.* 1991), but not in cows during milking in unfamiliar surroundings (Wellnitz *et al.*1997). Thus the importance of the opioid system in the central inhibition of oxytocin release during milking under stress conditions in dairy cows is still unclear.

The response of the hypothalamic-pituitary-adrenal (HPA) axis to novel stimuli can characterise the individual sensitivity of animals to stress (von Borell and Ladewig, 1992). Possible relationships between reaction of individual cows to novel surroundings and sensitivity of the adrenal cortex to exogenous ACTH could help to explain the mechanisms of central inhibition of OT release.

The aim of this study was to test if the opioid antagonist naloxone has a beneficial effect on normalisation of oxytocin (OT) release during repeated milking of cows in unfamiliar surroundings. Experiments were performed during the usual evening milking time. One control milking without naloxone treatment in all cows was performed in the familiar parlour. For four successive evening milkings cows were transported to and milked in the operating theatre of the research station without (control group) or with naloxone administration (1mg/kg BW) (naloxone group) before milking. After cessation of spontaneous milk flow, but not before three min of milking, vaginal stimulation was applied for 2 min. After milk flow ceased again 10 IU of OT was injected intravenously to remove the remaining milk including residual milk. Milk flow was recorded continuously and blood samples were collected via jugular vein cannula at 1-min intervals from 1 min before start of milking until i.v. injection of OT. The inhibition of milk ejection and its normalization during repeated milking in unfamiliar surroundings was not influenced by naloxone treatment. Therefore, any role of endogenous opioids in the inhibition of milk ejection in unfamiliar surroundings could not be demonstrated. There were not differences in cortisol release during control milking and all relocations between naloxone and control group.

In addition, the effect of exogenous $ACTH_{1-24}$ (8 IU) i.v. on the release of cortisol related to the response of cows milked in unfamiliar surroundings was studied. Cows with totally inhibited milk ejection in response to vaginal stimulation during milking after first relocation had numerically lower cortisol levels (8.8±3.4 ng / ml; AUC / min) in response to ACTH than cows with at least partial milk ejection (38.7±12.9 ng / ml). Thus animals with higher adrenal response to ACTH seemed to have less severe inhibition of milk ejection.

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Milk flow patterns: interrelationship with somatic cell counts

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The present concept of machine milking is based on the acceptance that the cow is having the leading role in the interplay between her, the milker, the milking machine, and the environment. This acceptation of biological potentials and limitations of dairy cows allows us to milk them fast and complete and reduce or exclude any adverse effects on the cows. The development of new technologies gives us a new opportunity to understand and include biological responses of dairy cows into the milking process.

On the basis of the milk flow profiles analysed at the quarter and udder level the possible relationships between the duration of decline phase of milk flow and SCC (somatic cell count) were investigated. 40 Holstein cows, free of clinical mastitis and on their first to third lactation, were used. In total 1760 quarter and 440 udder milk flows were recorded during six consecutive days. At the last evening and morning milking of this period the milk samples from all quarters for SCC were collected. For the analysis all quarters and cows were classified in three different groups based on the duration of the decline phase – less than 40 s, between 40 and 80 s, and more than 80s for quarter analysis and less than 120 s, between 120 and 200 s and more than 200 s for udder analysis. The statistical analysis was carried out with the Genstat package (Genstat 5 Comittee, 1999).

At the udder level no effect of the duration of decline phase on SCC was found. With the increase of the decline phase the milk yield also significantly increased. The plateau phase increased only slightly when the decline phase increased.

At the quarter level there was a significant effect of the duration of decline phase on SCC (5.03±0.05 log SCC at < 40s as compared with 5.42±0.04 log SCC at >80s). With the increase of decline phase the peak flow rate increased but the time to reach the peak flow and the duration of plateau phase decreased. During decline phase the vacuum and its fluctuation appears in the teat sinus in each pulsation when the pulsation chamber is evacuated and it stops when teat sinus is restricted at the teat bases. It is not clear whether this fluctuation results in a higher SCC.

The duration of decline phase at the quarter level was not related to the duration of blind phase (overmilking) and milk production. Also, there was no correlation found between duration of blind phase and SCC. Probably overmilking of the single quarters within the udder is not harmful to secretory tissue but a negative effect on the teat ends and blood circulation in teats has to be considered.

At the udder level there was no effect of peak flow rate on SCC but at the quarter level the peak flow rate was higher in a group of quarters with longer duration of decline phase. Are cows with higher peak flow more susceptible for mastitis because of a high peak flow or longer decline phase?

The stage of lactation, time of milking, position of teat and peak flow rate did not influence the effect of the duration of decline phase on SCC at the quarter level.

In conclusion: the cows with longer duration (over 80s) of quarter decline phase had significantly higher SCC in their milk. Whether longer duration of decline phase from quarter is reason or consequence of higher SCC has to be investigated. To improve the interplay between cow requirements and machine parameters the quarter milk flow patterns have to be considered. The possible effect of quarter flow controlled milking on milk ejection and udder health has to be studied.

The influence of pulling force in the liner and teat penetration into the liner on basic vacuum parameters of a milking unit

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Summary

The influence of high liquid flow rate Qm=0-8kg/min, teat penetration and pulling force in the liner on vacuum milking parameters for Harmony milking unit was analysed and the empirical formulae were adopted. As has been observed, such milking parameters as average vacuum during the milking phase (pss), average vacuum decrease during a complete pulsation cycle (dp) and the pressure difference between the end of teat and the claw (dp1max1) change its value significantly with the increasing Qm. The best value of vacuum fluctuations parameters and dp1max1 were observed for pulling force in the liner being in the range of 40-70N. This range of pulling force is also suitable for dp1max1, which oscillates between –0.1 and –0.2 kPa.

***Key words**: Milking units, liner, measurements, vacuum parameters.*

Introduction

Stable vacuum in the teat cup chamber and elimination of the back flow has the very important requirements influencing the course and conditions of milking of cows with high milk productivity(Szlachta, 1997; Haman & Dück, 1984; Hamann, 1989).

The analysis of vacuum level and teat end pressure during milking shows differences in the milk flow rate (O'Shea J. *et al.*, 1976; Nordegren, 1980; Williams and Mein, 1980; Mayntz, Laidig & De Toro, 1990; Szlachta & Wiercioch, 1994; Szlachta *et. al*., 2000**)**. It should be noticed that stabilisation of vacuum under the teat end demands attention from researchers, especially when it comes to cows with high milk productivity (Szlachta & Wiercioch, 1997). The above-mentioned basic aspects of work of a milking unit allow us to notice that vacuum is a factor of a great importance. The conditions of milking also depend on the construction of a milking unit, especially the milk claw volume, liner characteristics and massage pressure and stimulation. Taking into account what has been said heretofore, it should be noticed that milking units often work improperly**,** especially when the cows milked, exhibit high milk productivity, i.e. when the intensity of liquid flow > 4-8 kg / min. The aim of the study was to evaluate the influence of pulling force in the teat liner and teat penetration on the change of basic parameters in milking units used for milking of cows with high milk productivity. The basic criteria of assessment were level of pulling

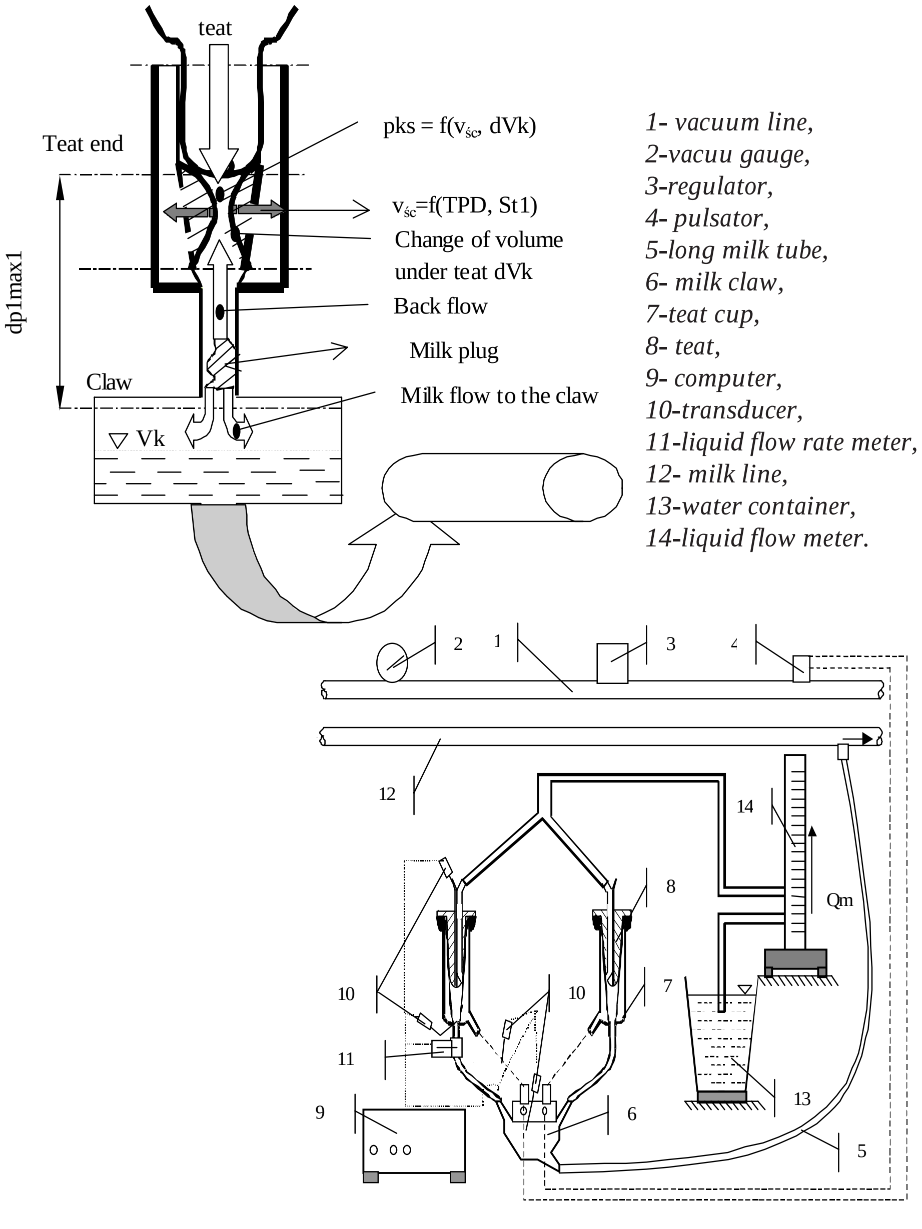


Figure 1. Methods and test procedure: a-problem illustration, b-scheme of test installation.

forces in the liner and vacuum stability at the teat end during laboratory empirical test. Very interesting was the influence of liquid flow rate (Qm) on the average vacuum during milking phase (pss), average vacuum decrease during a complete pulsation cycle (dp) and pressure difference between the end of teat and claw (dp1max1, Figure 1), as factors causing back flow (Szlachta *et. al.* ,2000).

Material and test procedure

The research was carried out using test installation of the Institute of Agricultural Engineering, Agricultural University of Wroclaw (Figure 1). The Harmony milking unit with claw TF450 was examined. The liner Harmony was pulled in teat cup chamber with the force of 30-80N. The vacuum parameters were measured for liquid flow rate Qm=0-8kg/min and for teat penetration 50, 62, 75, 100 mm. The basic technical data of milking units are shown in the table 1. The work of the milking unit was recorded by a system of computer registration and analysed for chosen milking parameters (Wiercioch & Szlachta, 1994).

Table 1. Basic technical data of the milking units tested.

Milk chamber capacity of claw, cm^3	Pulsator type	Diameter of short milk tube, mm	Diameter of long milk tube, mm,	The volume under the teat by the teat penetration into liner:				
				0 mm	50 mm	62 mm	75 mm	100 mm
450	EP-100	14	16	76 cm^3	58.7 cm^3	54.5 cm^3	44.8 cm^3	30.8 cm^3

The influence of liquid flow rate Q_m on changes in average vacuum during the milking phase pss was very similar for all examined teat penetration and pulling forces. With changing Q_m from 0 to 8 kg/min, the drop of the average vacuum during the milking phase pss is less impetuous (Figure 2).

Results and discussion

The influence of liquid flow rate Qm on changes in average vacuum during the milking phase pss was very similar for all examined teat penetration and pulling forces. With changing Qm from 0 to 8 kg/min, the drop of the average vacuum during the milking phase pss is less impetuous (Figure 2).

This parameter decreases for all teat penetrations in the liner. In the case of pulling force in the range of 30-40N and little teat penetration (50-62mm) a high drop of average vacuum during the milking phase (pss) was observed. This situation is a result of big changes of the volume under the teat (dVk, fig.1a). To eliminate the back flow, the difference pressure between the end of teat and claw (dp1max1) should have a negative value or oscillate around zero. For Qm=8kg/min (Figure 3) negative values of

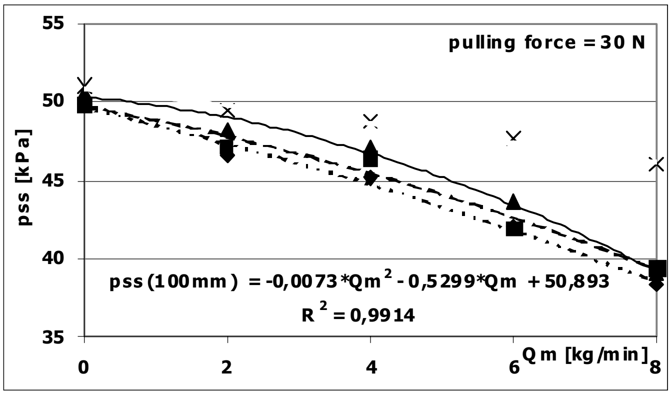
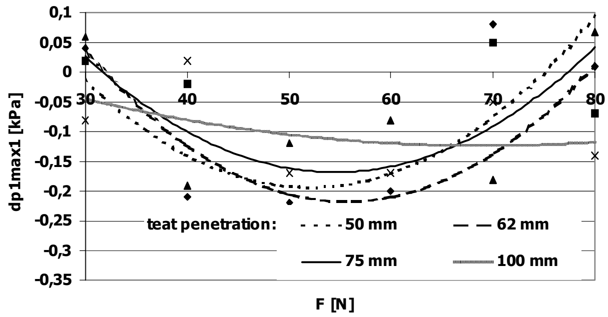


Figure 2. Influence of liquid rate on the average vacuum level during the milking phase, pss.

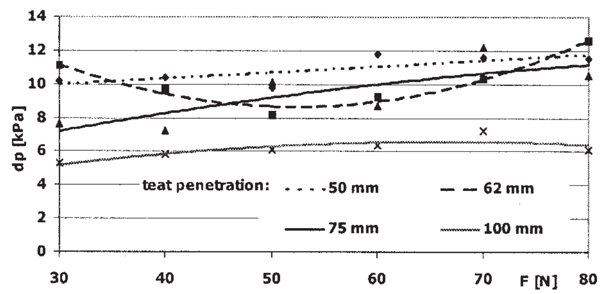


$dp1max1(50mm) = 0{,}0004*Qm^2 - 0{,}0383*Qm + 0{,}8059 \quad R^2 = 0{,}5897$

$dp1max1(62mm) = 0{,}0004*Qm^2 - 0{,}0429*Qm + 0{,}976 \quad R^2 = 0{,}4286$

$dp1max1(75mm) = 0{,}0003*Qm^2 - 0{,}0352*Qm + 0{,}7925 \quad R^2 = 0{,}603$

$dp1max1(100mm) = 5E\text{-}05*Qm^2 - 0{,}0072*Qm + 0{,}1234 \quad R^2 = 0{,}1644$



$dp(50mm) = 0{,}00001*Qm^2 + 0{,}0342*Qm + 8{,}9495 \quad R^2 = 0{,}5948$

$dp(62mm) = 0{,}0051*Qm^2 - 0{,}5325*Qm + 22{,}535 \quad R^2 = 0{,}9614$

$dp(75mm) = -0{,}0007*Qm^2 + 0{,}1561*Qm + 3{,}1381 \quad R^2 = 0{,}6275$

$dp(100mm) = -0{,}001*Qm^2 + 0{,}1399*Qm + 1{,}9268 \quad R^2 = 0{,}7054$

Figure 3. Influence of pulling force in the liner and teat penetration on the pressure difference between the end of teat and claw (dp1max1) and average vacuum decrease during a complete pulsation cycle (dp) for liquid Qm=8kg/min.

pressure difference between the end of teat and claw (dp1max1) were obtained with pulling force ranging from 40 to 70 N. The dp1ma1 had negative value for whole range of pulling force (30-80N).

Conclusion

The best value of parameter pss and dp1max1 was observed for pulling force in the liner ranging from 40 to 70N. This range of pulling force is also suitable for dp1max1, which oscillates between -0,1 and -0,2 kPa. The research showed that the Harmony liner causes back flow in small degree.

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