Scientific quarterly journal ISNN 1429-7264

Agricultural Engineering

2014:1(149): 29-38

Homepage: http://ir.ptir.org

DOI: http://dx.medra.org/10.14654/ir.2014.149.003

FUNCTIONAL PROPERTIES OF THE COMPUTER SYSTEM FOR TEMPERATURE DIAGNOSIS OF COWS[1]

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ARTICLE INFO

Article history:
Received: February 2014
Received in the revised form: March 2014
Accepted: March 2014

Keywords:
diagnosis of cows
milking system
temperature
disturbances

ABSTRACT

The objective of the paper was to analyse thermographs of the milk flow from quarters of cows' udders on account of initial separation of disturbing factors which influence the conditions of milk temperature measurement during a machine cow milking. Research was carried out in cowshed conditions with the use of a special milking device, equipped with thermistor temperature sensors mounted in teat cups and microprocessor recorder of measurement signals. Based on the analysis of thermographs obtained during the cowshed tests, the impact of the health conditions of cows' udder quarters, individual physiology of milking in cows, milking phase, correctness of the sensor operation on the shaping of temperature in teat cups of milking machines were reported.

Introduction

In the Institute of Biosystem Engineering at Poznan University of Life Sciences and the Department of Cattle Breeding at the University of Agriculture in Kracow research and construction works were carried out. Some of them constituted a part of the governmental project funded by the Polish Ministry of Science "Diagnostics of physiological states and health of cows with the usage of intelligent milk temperature sensors" (No N N313 787040). The research has led to construction of a modern milking system with diagnostic functions. To construct the device four temperature sensors mounted in teat cups were used. Owing to the values of milk temperature recorded automatically during quarter milk flow and the use of diagnostic algorithm it is possible to detect heat, early pregnancy and udder quarters condition in cows (Jędruś and Gil, 2011). A detailed structure as well as selected technical and metrological parameters of the computer system components for cows' temperature diagnostics were described in literature (Beba, 2013; Jędruś, 2013a,b).

[1]This work has been funded by the Polish Ministry of Science. This study presents initial work started within the framework of governmental projects "Diagnostics of physiological states and health of cows with the usage of intelligent milk temperature sensors" (No N N313 787040)

As already indicated by Jędruś (2013c), the issue of temperature measurement during cow machine milking remains an insufficiently analysed problem in literature. The impact of disturbances occurring during machine milking on the shaping of temperature in teat cups has not been analysed so far. It is only Gil (1988) who reported that milk temperature fluctuation appearing during cow milking process is a direct result of anomalies taking place in the quarter milk flow.

The aim of the research was to analyse the thermographs of quarter milk flow in order to single out disturbing factors which influence the conditions of milk temperature measurement during cow machine milking.

Materials and methods

The study done with the use of a computer system for cow temperature diagnostics was carried out in a cowshed in Wławie near Kościan in Wielkopolskie Voivodship. The cowshed was equipped with a conventional pipeline milking machine that was a hybrid between constructional solutions of DeLaval and Polanes companies. Dairy cattle consisted of twenty Holstein-Friesian high-yield cows, normally milked with four milking apparatuses. In the cowshed alternating pulsation system was used. The pulsation rate and ratio were 60 cycles·min^{-1} and 60:40%, respectively. The system working vacuum level was adjusted to 50 kPa. The new milking system used during the study consisted of following elements and components (fig. 1):

- conventional milking cluster (Classic Vestfalia 300) manufactured by GEA Farm Technologies equipped with four thermistor temperature sensors type TT4-5KC3-25-3500-UPP. The sensors are additionally covered with stainless steel where walls are 0.2 mm thick. Thermistors accuracy in shields equals ±0.1ºC in the temperature range of 30-45ºC. Temperature sensors mounted in transparent inspection glasses for two-piece liners;
- stainless-steel hanger with integrated connector Trico II and electronic pulsator Duo (all the devices manufactured by Polanes company in Bydgoszcz) where pulsation parameters are the same as those normally applied in a cowshed, microprocessor recorder of measurement signals and accumulator;
- other milking equipment: milk tube, long pulse tube, conductors placed in a second long pulse tube that connect temperature sensors with a measurement signals recorder, and others.

This milking device was used in summer 2013 to milk twenty high-yield Holstein-Friesian cows. In order to evaluate the health condition of udder quarters in cows, quarter milk samples were taken for microbiological analyses. The analyses, carried out in a laboratory in Krotoszyn, allowed it to define somatic cell count (SCC) in milk.

The recorded temperature values were the source for creating a few hundred thermographs of quarter milk flow. The thermographs, created with the use of Microsoft Office Excel, became a subject of further analyses.

Figure 1. Milking device used in cowshed tests: 1 – milking apparatus with embodied thermistors 2 – microprocessor recorder of measurement signals

Results

Figures 2-6 present exemplary thermographs of quarter milk flow obtained during cowshed tests. On their basis, it was possible to single out a group of disturbances that influence conditions for milk temperature measurement in teat cups while machine milking is in progress.

The first factor that might contribute to the disturbances of temperature shaping in teat cups is mastitis. It is a problem thoroughly analysed in literature (Gil, 1988). According to Gil (1988), inappropriate milk flow may be also a result of disturbances occurring during milking, caused by illnesses of quarters of subclinical character.

Figure 2 presents an exemplary thermograph of milk flow for ill quarter characterised by high somatic cell count in quarter milk.

Figure 2. Thermograph of milk flow in back right quarter for cow with cowshed number 7595 and number of somatic cells equal to 5035 thousand in 1 ml of quarter milk

The analysis of quarter milk flow thermographs made it possible to single out a group of fluctuation courses for which somatic cell count in quarter milk was less than 400 thousand, and frequently even below 100 thousand in 1 ml of quarter milk, which is characteristic of a healthy udder quarter (Jarmuż and Skrzypek, 2006). An exemplary thermograph has been presented in figure 3.

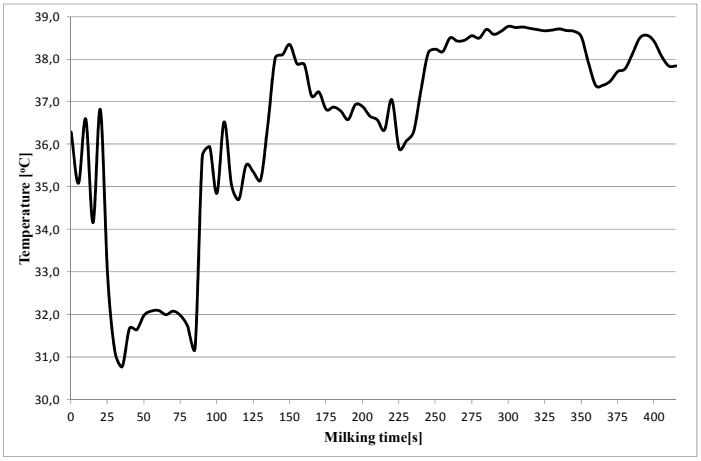

Figure 3. Thermograph of milk flow in rear left quarter of cow with cowshed number 1160 and the number of somatic cells equal to 161 thousand in 1 ml of quarter milk

The causes of fluctuation occurrences in milk flow have not been reported. They might have been a result of inappropriate preparation in a premilking phase, a health condition of udder quarter (value of somatic cell count might have been wrongly defined in a lab) or a result of vacuum level oscillation typical for pipeline machine milking. It seems almost impossible that the disturbances occurring were a result of milk secretion, which may occur when somatic cell count ranges between 100-200 thousand in 1 ml of milk, as Jarmuż and Skrzypek (2006) indicate.

In figure 4 another thermograph of quarter milk flow for a healthy udder quarter has been shown.

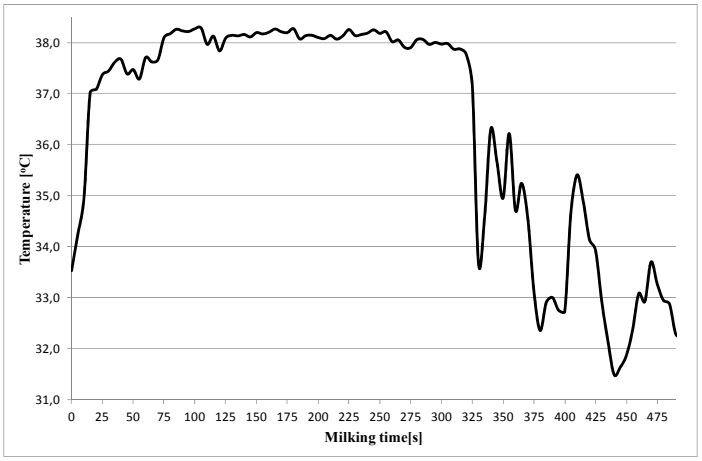

Figure 4. Thermograph of milk flow in rear right quarter of cow with cowshed number 0816 and number of somatic cells equal to 15 thousand in 1 ml of quarter milk

Temperature values recorded in the ascending phase revealed a correct heating process for a temperature sensor. In a time of plateau there occurred disturbances in milk flow observed through fluctuations appearing in quarter milk flow (but of a lower amplitude than in the previous cases). After the descending phase, a correct process of thermistor's cooling have been registered. It was followed by fluctuations of greater amplitude. First of all, they were a result of stripping and air inlet taking place during the milking unit removal. However, these are common phenomena appearing during cow machine milking.

In figure 5 a milk flow thermograph with a single break in milk flow recorded in the ascending phase of milking was shown.

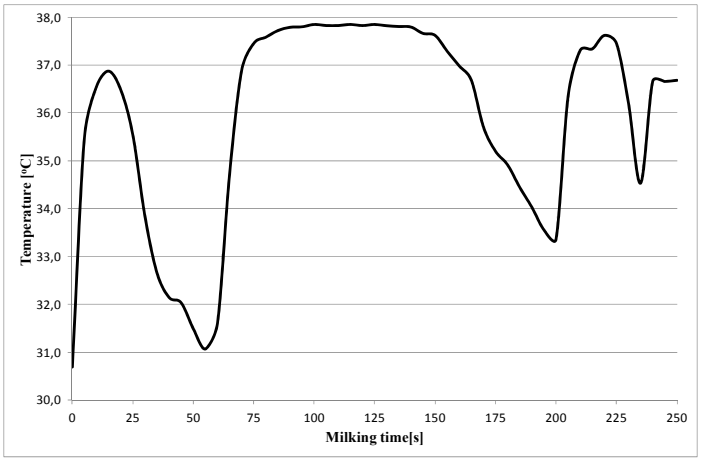

Figure 5. Thermograph of milk flow in front right quarter of cow with cowshed number 0816 and number of somatic cells equal to 15 thousand in 1 ml of quarter milk

In literature, breaks occurring in milk flow in the ascending phase of milking have been reported. They are believed to be an effect of an atypical physiology of milk flow in cows (Jędruś and Lipiński, 2008). However, the disturbances might also result from insufficient udder preparation for milking. Analysis of the quarter milk flow thermographs needs to take into account individual characteristics of cows: disturbances taking place in milk production, milking process or physiological changes depending on age, lactation phase, heat and others (Gil and others, 1993; Jędruś and Lipiński, 2008).

Still another reason for disturbances occurrence are the breaks in temperature sensors power supply. Jędruś and Lipiński (2007) observed supply breaks in 'hot-wire' sensors, which made a proper operation of the quarter milking process impossible. High-stable integrated current sources were used to supply thermistors. They are mounted in a cover of microprocessor recorder and connected to the sensors through a conductor that is 2.5 metres long (inside a long pulse tube). The crucial part of a measuring circuit is the connection conductor-metal cover. At this stage some problems with connection continuity were observed.

In figure 6 an exemplary temperature course when there is a temporary break in thermistors power supply has been shown.

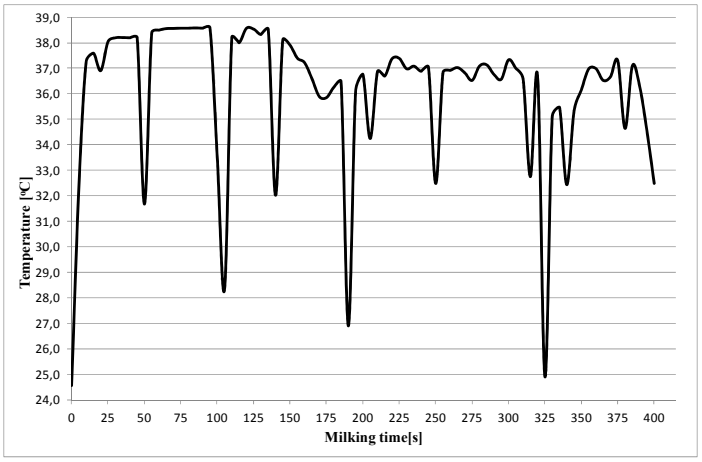

Figure 6. Thermograph of milk flow from exemplary quarter of cow's udder at incorrect supply of temperature sensor

Since the run of thermistors during cow machine milking is incorrect, the values of milk temperature recorded during milking cannot be used for a diagnostic purpose. They are particularly useless for determining the health condition of cows' udder quarters.

The preliminary analysis of disturbances that influence the shaping of temperature in teat cups will make it possible to improve the design of the computer system for cow temperature diagnostics. It will mainly enable to improve the software responsible for measurement signals processing in order to evaluate the health condition of udder quarters.

The analyses of quarter milk flow thermographs recorded during cowshed tests revealed that there are numerous factors that disturb the shaping of temperature in teat cups. Strong fluctuations in milk flow have been observed both in cows with healthy and unhealthy quarters. Some disturbances have been recorded in every phase of milking: ascending, plateau and descending. The cases of disturbances occurrence in cows with healthy udder quarters simply confirm the difficulties in proper monitoring of milking process during everyday operation of milking machines. Still another issue is evaluation of health condition on the basis of somatic cell count in a milk quarter. As Jarmuż and Skrzypek (2006) indicated, only SCC up to 100 thousand in 1 ml of milk allows to treat a quarter as a healthy one. In earlier research (Gil, 1988), the assessment of the udder quarter condition was a resultant of SCC as well as measurement of milk conductivity and the chlorine content in milk. When palpation research was added, it gave a more precise evaluation of the health condition of the examined cows' udder quarters.

In literature, there is no information about the impact of vacuum level fluctuation and other phenomena taking place during machine milking on the shaping of temperature in a milking cluster's teat cup. As Ślipko and Wiercioch (2000) reported, because of muscle weakness we observe constriction in a teat canal, which leads to a temporary reduction of

milk flow and takes the shape of oscillation. Such factors as individual characteristics of cows, a working vacuum level, and constructional solutions in a milking cluster have a great influence on the duration of milk flow fluctuation in cows' teats. Still another phenomenon taking place particularly in the descending phase (when a teat gets limp) is a process of air inlet between a mouthpiece and a teat (Krzyś and Szlachta, 2001). A too high value of air stream sucked by the leak around a teat may lead to the vacuum drop much below the value necessary for a correct milking process, such as holding the milking machine on teats. Jędruś and Lipiński (2007) also pointed out the turbulent nature of quarter milk flow as a disturbing factor in a proper controlling of quarter milking.

To conduct further analysis of the problem of impact of the phenomena occurring during machine milking on the shaping of temperature in the milking cluster's teat cups a laboratory stand needs to be constructed. The use of water instead of milk for the research in a laboratory conditions possesses a number of advantages (Szlachta et al., 2000). Vacuum parameters both in the case of milk and water have been indicated as similar (Wiercioch, 1998). In the Institute of Biosystems Engineering at Poznan University of Life Sciences there are works being carried out aiming at construction of a new stand. It is going to possess a unique measuring and milking equipment. Thanks to this solution it will be possible to create conditions typical for machine milking in a laboratory. Temperature measurement in teat cups will be realised with the use of this stand.

Conclusions

1. The analysis of milk flow thermographs in cow udder quarters recorded during cowshed tests showed that there are numerous factors which affect the conditions of temperature measurement in teat cups.
2. Once the disturbances influencing the shaping of temperature in teat cups are singled out, it will be possible to improve the diagnostic software responsible for the processing of milk temperature values in order to evaluate the health condition of cow's udder quarters.
3. To be tested precisely, the issue of the impact of the disturbances occurring during machine milking process on the shaping of temperature in teat cups requires a new laboratory stand to be designed. Current normalised methods of assessment of metrological properties of temperature sensors need to be applied.

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WŁAŚCIWOŚCI FUNKCJONALNE KOMPUTEROWEGO SYSTEMU DIAGNOSTYKI TEMPERATUROWEJ KRÓW

Streszczenie. Celem pracy była analiza termogramów spływu mleka z ćwiartek wymion krów pod kątem wstępnego wyodrębnienia czynników zakłócających wpływających na warunki pomiaru temperatury mleka w czasie doju maszynowego krów. Badania przeprowadzono w warunkach oborowych z wykorzystaniem specjalnego urządzenia udojowego, wyposażonego w termistorowe czujniki temperatury zamontowane w kubkach udojowych oraz mikroprocesorowy rejestrator sygnałów pomiarowych. Na podstawie analizy termogramów uzyskanych w trakcie badań oborowych stwierdzono wpływ stanu zdrowotnego płatów wymion krów, osobniczej fizjologii oddawania mleka przez krowy, fazy doju krów, poprawności działania czujnika na kształtowanie się temperatury w kubku udojowym dojarki mechanicznej.

Słowa kluczowe: diagnostyka krów, system udojowy, temperatura, zakłócenia