AGRICULTURAL SCIENCE AND TECHNOLOGY, VOL. 13, No 3, pp 288-291, 2021
Published by Faculty of Agriculture, Trakia University, Bulgaria
ISSN 1313-8820 (print)
ISSN 1314-412X (online)
http://www.agriscitech.eu
DOI: 10.15547/ast.2021.03.047

Pulsation parameters of new and used milking liners with round cross section

G. Dineva*, K. Peychev, D. Georgiev

Department of Agricultural Engineering, Faculty of Agriculture, Trakia University, 6000 Stara Zagora, Bulgaria

(Manuscript received 4 June 2021; accepted for publication 26 July 2021)

Abstract. *Milking machines equipped with new and used milking liners with a round cross section were studied. The used milking membranes were operated for 3 months on a farm for rearing 60 cows (Holstein cattle) with double milking per day. The experiment involved recording the standard pulsation phases "a", "b", "c" and "d" (in absolute units) in the frequency range from 1 Hz to 2.5 Hz, in a vacuum mode of 40 kPa and 50 kPa and at a pulsation ratio of 50/50%. It was found that the transients (phase "a" and phase "c") are faster and the established phases (phase "b" and phase "d") are longer in milking units equipped with used milking liners. The conclusions are related to the service life of the milking liners.*

Keywords: depreciation of liners, milking liner, pulsation phases

Introduction

In recent years, there has been a tendency to improve milking techniques but researchers are still working to eliminate problems related to udder health and milk hygiene. Scientists from TCI (Teat Club International) focus on research on the health of milk papillae due to their interaction with the milking liner (Neijenhuis et al., 2001; Mein et al., 2003; Ronningen, 2003; Kochman and Laney, 2009a,b). They describe the relationship between the mechanical action of the milking liner and the efficiency of complete machine milking of the animals. According to them, this is the key factor guaranteeing the healthy status of the udder.

The element of the milking machine that is in direct contact with the teats is the milking liner. The exercise of stimulating massage and the complete extraction of milk depend on its technical and operational indicators (Davis et al., 2000; Schukken et al., 2006; Kochman and Laney, 2009a,b; Wieland et al., 2020). Under the action of the pulsating vacuum the milking liner deforms periodically, pushes the blood from the teat tip and restores normal blood circulation in it (Davis et al., 2000).

Various methods have been used to determine the efficiency of the milking process. Spencer and Jones (2000) focused on measuring the phases of pulsation in the movement of the walls of the milking liner. Mein et al. (2003) and Ronningen (2003) focused on measuring the magnitude of the pressure applied by the milking liner to the teat.

Mein et al. (2003) claim that small changes in the geometry, material properties and depreciation of the liner or minor changes in size have a large effect on milk flow during milking. Davis et al. (2000) proved that used milking liners reduce the peak value of milk flow, increase vacuum fluctuations, increase the duration of milking. This thesis is confirmed by Knizkova et al. (2001). Reduced peak milk flow may be the best indicator of the condition of the liner (De Koning et al., 2001; Galik et al., 2001; Paliy, 2016).

Maintaining a healthy mammary gland in ruminants plays a significant role in modern animal husbandry to obtain quality products and ensure their wellbeing (Uzunova et al., 2017). Disorders whether of a technical or metabolic nature, causing a decrease in dairy production are a major problem in dairy farms (Marutsova et al., 2019). For these reasons, rapid and accurate diagnosis of the milking technique (in particular the milking machine) is extremely important in diseases of the mammary gland. In this regard, the aim of the present study is to investigate the pulsation parameters of new and used milking liners with a round cross section.

Material and methods

The object of the study was new and used milking liners made of nitrile rubber with a round cross-section. The subject of the study were the temporal components of their pulsograms. The experiment involves recording the standard pulsation phases "a", "b", "c" and "d" (in absolute units) in the pulsation rate range 1 Hz to 2.5 Hz, at a vacuum mode of 40 kPa and 50 kPa, and a ratio 50/50%. For the experiments a standard pulsation analyzer device of the company α-Laval was used which has the possibility for its own calibration and corresponds to the International standard for diagnostics of milking machines (ISO 5707, 2007). An adjustable electronic pulsator of the "Flaco" company was used to change the pulsation rate and the ratio. It allows you to adjust the pulsation rate and ratio through the

*e-mail: galinats@abv.bg

so-called jumpers (microkeys). The used milking liners were operated for 3 months on a farm for rearing 60 cows (Holstein cattle) with double milking per day. Used milking liners were used for about 1800 milkings.

The processing and interpretation of the experimental data conforms to the overall graphic profile of a pulsogram by the ISO 5707 standard (2007) shown on Figure 1.

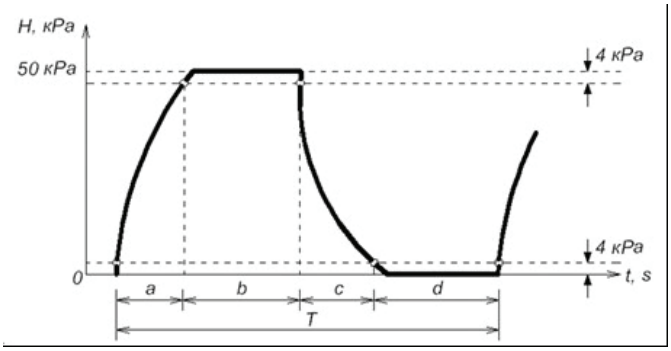

Figure 1. Overall graphic profile of a pulsogram by the ISO 5707 (2007) standard
Legend: a- the duration of the transitional process from atmospheric pressure to nominal vacuum in the volume of the milking cup pulsation chamber (front of the pulsogram); b- duration of the "true milking" phase (vacuum mode within the pulsation chamber volume); c- duration of the transitional process from nominal vacuum to atmospheric pressure in the volume of the pulsation chamber (back of the pulsogram); d- duration of the "true massage" phase (atmospheric pressure within the volume of the pulsation chamber).

The period of the pulse (T) is determined by the following expression:

$$T = t_1 + t_2, \text{ ms}, \quad (1)$$

Where: t_1 - duration of milking stroke, ms;

t_2 - duration of massage stroke, ms.

The duration of the milking stroke (t_1) is described by the amount of:

$$t_1 = a + b, \text{ ms} \quad (2)$$

Within the time pressure into pulsation and milking chamber is aligned and the milking liner is in equilibrium – milking stroke is performed.

Time massaging effect (t_2) on the teat tissue is defined by the amount:

$$t_2 = c + d, \text{ ms} \quad (3)$$

In the period t_2 pressure into pulsation and milking chamber is different (ΔH=50 kPa), as a consequence of which the milking liner collapses and performs the massage stroke.

The repeatability of the experiments for each pulsation characteristic is ten-fold and all data obtained are averaged.

Results and discussion

The absolute values of the phases of the milking process in new and used milking liners are illustrated in Table 1. All registrations were performed at a supply vacuum of 40 kPa, clock ratio 50/50% and pulsation rate 60, 90, 120 and 150 min^{-1}.

Table 1. Values of the pulsation phases (ms) recorded for new and used milking liners and a supply vacuum of 40 kPa

Pulsation rate	New milking liners				Used milking liners			
	Pulsation phase							
	a	b	c	d	a	b	c	d
min^{-1}	ms	ms	ms	ms	ms	ms	ms	ms
60	127	365	80	423	121	370	78	426
90	126	201	82	258	119	208	79	264
120	123	117	79	117	117	123	76	124
150	119	75	79	128	112	77	75	131

Transitions are faster with milking units equipped with used milking liners. Some authors (Mein et al., 2001; Neijenhuis et al., 2001) who study transients have shown that reducing phase "a" reduces milking time and increases milk flow. Conversely, reducing the "c" phase would lead to a "bump" on the teat tissue, i.e. the milking sock "crushes" the milking papilla. This means that regardless of the pulsation settings we must strive to achieve a longer transition process from "milking" to "massage" (phase "c"). The same would ensure better stimulation of the mammary gland (Paliy, 2016). Conversely, in order to increase the throughput of the milking machine and to reduce the milking time, we must provide a short process "a".

The high-frequency mode of the pulsation system of the milking units is associated with a reduction in the duration of the established milking phase "b". From a practical point of view, this would have a negative effect on the total milking time of the animals. As the frequency load increases, the duration of phase "d" decreases. This would lead to insufficient time to exercise full massage of the mammary glands.

The established phases ("b" and "d") are longer in milking units equipped with used milking liners. On the one hand, the increased duration of phase "b" would have a positive effect on the milking time of the animals. On the other hand, the prolonged action of the vacuum on the mammary glands has a negative effect on the health of the udder tissues.

The increase of the vacuum mode (Table 2) of the pulsation system leads to an increase in the duration of the transients and a reduction in the duration of the established phases in both variants of milking liners. The reason for this is the increased pulsation amplitude which changes the time constant of the pulsation systems (Banev, 2001).

Table 2. Values of the pulsation phases (ms) reported for new and used milking liners and a supply vacuum 50 kPa

Pulsation rate	New milking liners				Used milking liners			
	Pulsation phase							
	a	b	c	d	a	b	c	d
min^{-1}	ms	ms	ms	ms	ms	ms	ms	ms
60	165	332	85	418	154	351	82	424
90	160	169	84	253	149	180	80	258
120	154	91	83	171	148	97	79	181
150	122	77	79	123	115	84	77	127

The tendency for shorter duration of transients and longer duration of actual phases in used milking liners is maintained. This is a consequence of depreciation and changes in the physico-mechanical characteristics of milking liners (Davis et al., 2000; Galik et al., 2001). Unjustified shortening of phase "c" leads to an increase in pressure on the teat. This is accompanied by discomfort for the animals during machine milking and leads to the presence of new mastitis infections (Kochman et al., 2008; Worstorff and Bilgery, 2002).

The established phases ("b" and "d") are longer in milking machines equipped with used milking liners. Providing sufficient time for massage helps restore peripheral blood circulation in the teat (Kochman et al., 2008; Kochman and Laney, 2009a). On the other hand, prolonged exposure to vacuum during phase "b" would lead to the presence of teat disease.

Conclusion

The increase of the vacuum regime of the pulsation system leads to an increase in the duration of the transient processes and a reduction in the duration of the established phases, both in the new and in the used milking liners. Transitions (phase "a" and phase "c") are faster in milking units equipped with used milking liners which would lead to a "sudden blow" to the teats. The established phases of the milking process (phase "b" and phase "d") are longer in milking units equipped with used milking liners. Prolonged exposure to vacuum during phase "b" would lead to the presence of teat disease. Recommendation: It is recommended to diagnose the milking machine more often taking into account the depreciation of the milking liners. If necessary they should be replaced regardless of the recommendations for the period of use of the manufacturer.

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