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Production Systems

The effect of the milking liner design on the parameters of the milking machine pulsation system

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Abstract. *The analysis of nitrile rubber milking liners with triangular and circular cross section has been performed. Dependencies between surrounding surfaces and volume of pulsation chambers of the tested specimens and the effect of squeezing the teat have been determined. The obtained data have been related to the structure (the time-frequency components) of the pulsation curve describing the mode of the samples. The functional relationships between the spatial parameters of the teatcup and the frequency components of the identified pulsation curves have been studied. Pressure exercised by the milking liner on artificial teat has been measured with various parameters of the pulsation system.*

Keywords: milking machine, pulsation system, milking liner.

Introduction

There are additional opportunities to increase milk production in machine milking. One of them is the unconditional reflex stimulation of cows, which is in directly related to the nature of mechanical action performed by the milking liner on the teat (Babaev, 1988; Kochman et al., 2008). The milking liner deforms under the effect of the pulsating vacuum by exercising pressure on the teat (Gehm, 2000; Gleeson et al., 2004). This irritation has crucial effect for milk production, the normal functioning of the breathing organs, the stomach, the heart, the genitals, etc. (Babaev, 1988; Kochman et al., 2008).

Recently in the scientific literature articles appear on the design of milking liner which claims that it strongly influences the pulsation parameters and hence the health of animals (Kochman and Laney, 2009).

The objective of this study is to investigate the effect of the different design of milking liners on the milking machine pulsation system and the pressure.

Material and methods

The study was conducted in the Machine milking laboratory of the Department of Agricultural Engineering at Trakia University - Stara Zagora, on Impulsa M624 milking plant. Milking liners with circular cross-section of the companies K&S - Bulgaria, Impulsa anc Spaggiari - Italy and with triangular cross-section of the company Milk Rite Ultraliner - England placed in the same shells of inox have been studied.

For conducting the experiments an electronic pulsator FLACO is used whereby the pulsation arte is changed.In the course of survey 5 trials have been carried out for each milking liner at different pulsation frequency f = 60, 90 and 120 min^{-1}, stroke to γ = 50/50% and the vacuum level 50.6 kPa. The resultig data have been collected and recorded in a table. By the obtained average values for the five trials the pulsation curve in the system has been constructed. Pulsation parameters of teatcups fitted with different types of milking liners have been tested with an instrument for integrated diagnostics of milking machine type DIDMM (Banev, 2002) and the experimental system shown in Figure 1.

In experimenting the size of pressure an artificial teat contained in its upper part was used, where the hole is left with a nipple for attaching a flexible conduit connected to a differential pressure transducer in DIDMM. The data from DIDMM are submitted to a PC (Laptop), where they are recorded in a table. All experiments have been performed with the same artificial teat surface (60cm^2).

To get an idea about the effect of the volumes of the pulsation chamber and the surface of the milking liner, we calculate their relationship R in cm^{-1} in the equation:

$$R = \frac{S_l}{V_{pc}} \qquad (1)$$

where S_l is the surface of the milking liner, adjacent to the pulsation chamber, in cm^2;

V_{pc} – volume of the pulsation chamber, in cm^3.

To calculate the outer surface S_l° of the milking liners, subject to alternating vacuum, the following equations have been used:

1) For milking liners with circular design the outer surface S_l° in cm^2

$$S_l^o = L_м \pi D_l \qquad (2)$$

where $L_м$ is mounting length of the milking liner, in cm;

D_l - average diameter of milking liner with a conical design, in cm.

2) For milking liners with triangular design the outer surface S_l^{Δ}

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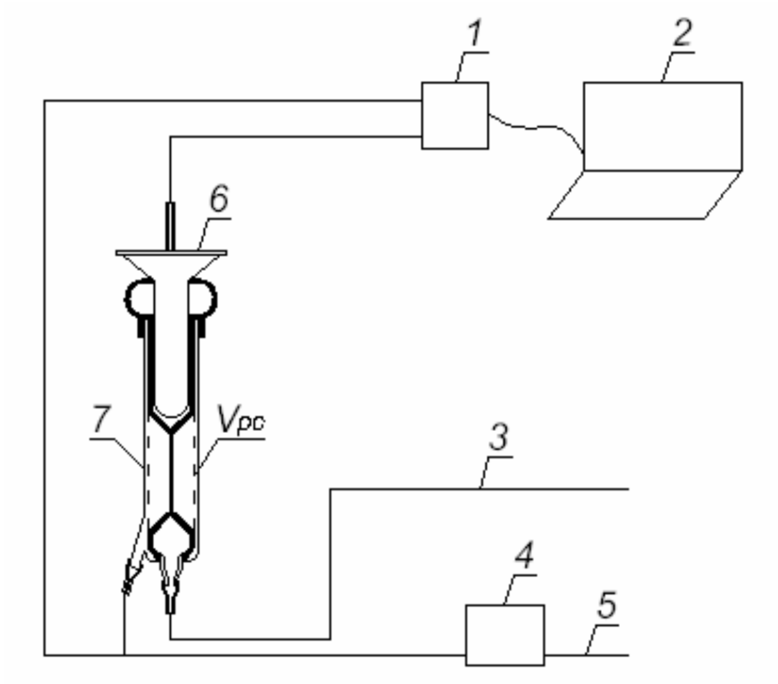

Figure. 1. Experimental system.

in cm[2], (Figure 2a) is

$$S_l^{\Delta} = L_м(3l_a + 3l_b) \quad (3)$$

where *Lм* is mounting length of the milking liner, in cm;
l_a - side length of the milking liner, in cm;
l_b - length of the oval of the milking liner, in cm.
To calculate the volume of the pulsation chamber the following equations are used:

1) For milking liners with circular design the volume of the pulsation chamber V_{pc}° in cm^3 is

$$V_{pc}^{o} = V_s - V_l^{o} \quad (4)$$

where *Vs* is volume of shell, in cm^3;
V_l° - volume of milking liner with circular design, in cm^3.

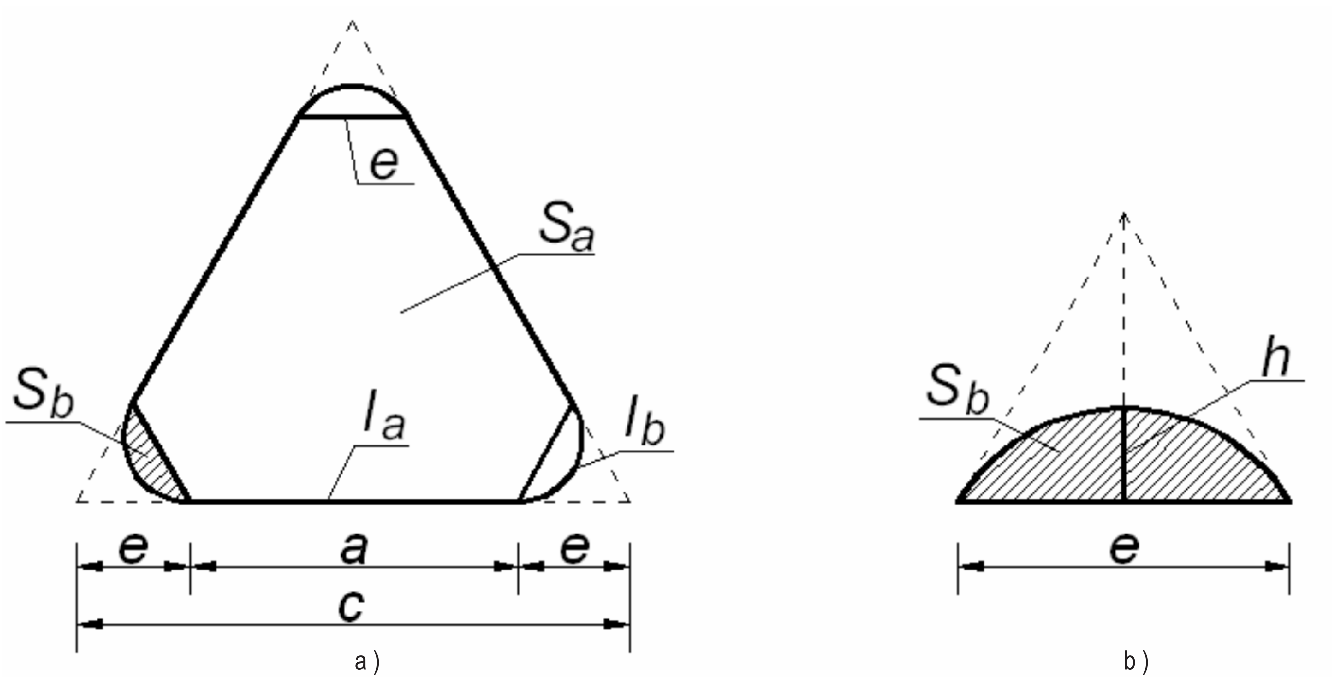

Figure 2. Diagram for calculation of area and volume of a triangular milking liner.

$$V_l^o = L_M \frac{\pi D_l^2}{4} \quad (5)$$

2) For milking liners with triangular design the volume of the pulsation chamber V_{pc}^{tr} in cm^3 is

$$V_{pc}^{\Delta} = V_s - V_l^{\Delta} \quad (6)$$

where *Vs* is volume of shell, in cm^3;
V_{pc}^{Δ} - volume of milking liner with triangular design, in cm^3.

$$V_l^{\Delta} = L_M (S_a + 3S_b) \quad (7)$$

where L_M is mounting length of milking liner, in cm;
S_a - face of inscribed polygon, in cm^2;
S_b - face of the sector, in cm^2.

$$S_b = \frac{2}{3} e.h \quad (8)$$

where *e* is part of the polygon, in cm;
h - height of the sector (according to Figure 2b), in cm.

Results and discussion

Sizes, surfaces and volumes of milking liners, measured and calculated, are shown in Table 1, which shows that milking liner with a triangular design has the biggest outer surface of 158,4 cm^2, which is nearly 1.3 times greater than the surface of the other milking liners. The ratio of surface of milking liner to the pulsation chamber is also the greatest in milking liner with triangular design, which is almost 1.4 times higher than the others.

The ratio R gives possibility for comparison of teatcups with different volume of pulsation chambers and surfaces of milking liners. It is seen that milking liners with triangular design have the greatest index R = 1,57 cm^{-1}. The resulting pressure in the artificial teat placed in the milking liner is a function of the type of material, wall thickness, shape and other factors. The magnitude of pressure exercised on the artificial teat expressed by the measured pressure created inside it is shown in Figure 3.

In Table 2 maximum values of the resulting pressure in the artificial teat are given. Frequency f of the pulsation system with 90 min^{-1} gives pressure of greater value in which fluctuations from the pulsation system and own fluctuations of the milking liner mounted with tension of 60 kN in the shell are probably accumulated. The resulting resonance is the likely cause for greater pressure and that increases the measured pressure.

Table 1. Dimensions of surfaces and volumes of milking liners, volume of the pulsation chamber and the ratio R.

Make and model of milking liner	D_l, cm	Ds, cm	LM, cm	S_l, cm^2	V_l, cm^3	Vs, cm^3	Vpc, cm^3	R, cm^{-1}
Impulsa NW25	2.8	4.2	13.5	118.7	83.4	187	103.6	1.15
K&S	2.9	4.2	13.5	122.9	89.3	187	97.7	1.26
Spaggiari 0-658	2.8	4.2	13.5	118.7	83.4	187	103.6	1.15
Milk Rite Ultraliner	-	4.2	13.5	158.4	86.27	187	107.0	1.57

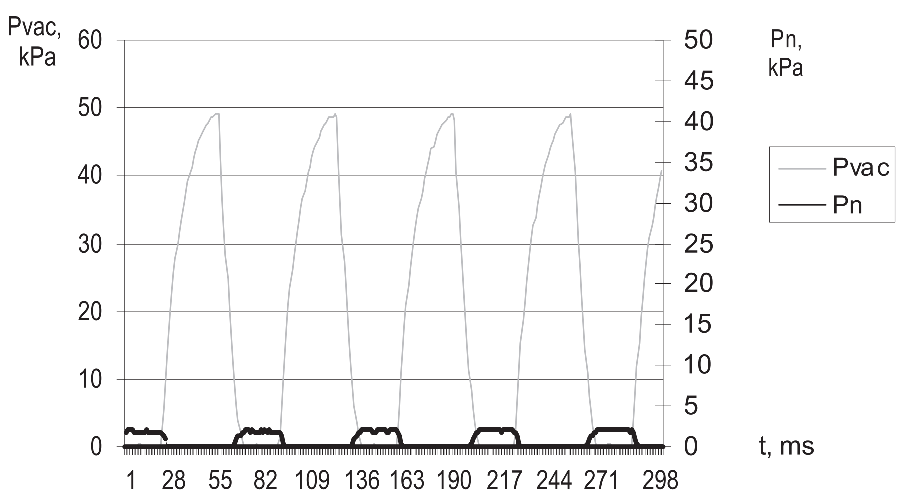

Figure 3. Overview of pulsation curve with the resulting pressure in the artificial teat: Pvac – vacuum, Pn - pressure.

Table 2. Maximum value of measured pressure in the artificial teat at different pulsation frequency

Make and model of milking liner	Pmax, Pa		
	f = 60 min^{-1}	f = 90 min^{-1}	f = 120 min^{-1}
Impulsa Nw25	870	870	430
K&S	430	870	430
Spaggiari 0-658	870	1300	870
Milk Rite Ultraliner	1740	2170	1740

Conclusion

The design and size of the studied milking liners significantly affect the magnitude of pressure on the artificial papilla – from 430 to 2170 Pa.

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CONTENTS

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Penkov D, 2008. Estimation of metabolic energy and true digestibility of amino acids of some feeds in experiments with muscus duck (Carina moshata, L). Thesis for DSc. Agrarian University, Plovdiv, 314 pp.

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