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# VACUUM-PULSATION CHARACTERISTICS OF NEW AND USED MILKING LINERS

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**Abstract:** The milking units equipped with new and used milking liners were tested. Both types of milking liners are with triangular shape. The data obtained are related to the structure of pulsogramme describing the respective samples. The pressure from the milking liners on artificial teat was measured. The relationship between the pressure and the wear out of milking liners has been studied. It has been found that used milking liners show shorter transition processes and longer true phases of the pulsation system. The conclusions are related to the period of use of milking liners.
**Keywords:** Milking liners, pulsogramme, pressure, depreciation.

## 1. Introduction

It is generally known that the milking liner (and in particular the milking unit) is the main element of the milking machine which comes into direct contact with the animal. The goal of each milking machine is to milk cows safely, gently, quickly and completely [1, 2]. The movement of milking liners has a particularly important effect on milk yield and udder health [9, 12, 13]. For this reason the prevention of mastitis caused by milking techniques has become increasingly important in recent years.

Research in the scientific literature is directed entirely at the top of teats due to its interaction with the milking liner [5, 6, 12, 14]. Scientists from the TCI (Teat Club International) describe this complex "phenomenon" as the influence of the mechanical action of the milking liner on the efficiency of machine milking and the health of the top of teats and the teats as a whole [7].

The degree of milking liner compression applied to the teat during the pulsation phase **d** (massage) has a significant influence on the teat condition, the cows comfort and the milk flow. The influence of milking liner pressure is at least as large as the pulsation rate and ratio [13].

Other authors deal with changes in the material properties of milking liners. G. Mein et al. [7] claims that the wear out of milking liners has a great effect on milking characteristics.

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Davis [3] proves that used milking liners reduce the peak value of milk flow, increase vacuum fluctuations and increase milking duration. The decreased peak value of the milk flow may be the best indicator of the milking liner condition. In this connection the aim of the present study namely the study of the vacuum-pulsation characteristics of new and used milking liners has been set.

## 2. Material and Methods

The object of this study is new and used milking liners of Milk Rite company. They have the same form of the (tri-circle) of pulsation chamber and of the same material (nitrile rubber). Used liners have worked in practice for 4 months. The subject of the study is on the one hand the time components of the pulsogramme and on the other hand the pressure from the milking liners on the artificial teat.

The experiment includes the registration of the standard pulsation phases **a**, **b**, **c** and **d** (in absolute and relative units) in the frequency range from 1Hz to 2 Hz in a vacuum mode of 40 kPa and 50 kPa at a 50/50% pulsation ratio. Processing and interpretation of experimental data is consistent with the common graphic profile of pulsogramme at ISO 5707 [7] shown in Figure 1.

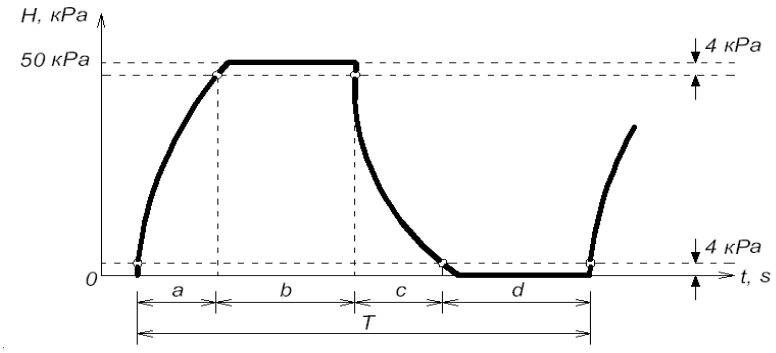


**Fig. 1.** Common graphic profile of pulsogramme at ISO standard 5707:

a - the duration of the transition process from atmospheric pressure to a nominal vacuum (front edge of the pulse);b – the duration of the phase "a real milking" (vacuum highlands);c - the duration of the transition process from the nominal vacuum to atmospheric pressure (rear edge of the pulse);d - the duration of the phase "real massage" (atmospheric highlands).

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

$$T = t1 + t2, \text{ ms} \qquad (1)$$

where t1 - duration of tact "milking", ms

t2 - duration of tact "massage", ms.

The duration of tact "milking" ($t_1$) is described by the amount of:

$t1 = a + b$, ms (2)

Within the time pressure into pulsation and milking chamber is aligned and milking liner is in equilibrium - performed tact "milking".

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

$t2 = c + d$, ms (3)

In the period $t_2$ pressure into pulsation and milking chamber is different ($\Delta H$ = 50 kPa), a consequence of which the milking liner collapses and makes tact "massage".

The pulsation phases are recorded with a standard pulsation tester from Alfa-Laval. For the change of pulsation rate and ratio an adjustable electronic pulsator of the company "Flaco" was used. It enables pulsation rate and ratio to be set by the jumpers. The repeatability of the experiments for each pulsation characteristic is five times and all data received averaged.

An Arduino Uno measuring device was used to determine the pressure exerted by the milking liner. The device was designed and developed at the Technical College of Lovech with the support of the Department of Agricultural Engineering at the Thracian University in Stara Zagora [4]. The pressure is measured in an artificial teat of 85 mm length. The same is closed at the top where a hole is attached with a nipple for attaching a flexible pipeline. A differential pressure sensor is connected to it. Possible measured parameters of the device are: pressure on artificial teat, power vacuum value, time component of pulsogramme and vacuum value in the milking chamber of a milking units. The received data is submitted to a personal computer for visualization and recording. Parameters are displayed on the monitor by either writing to a spreadsheet or displaying as a graph. Characteristically, all parameters are output simultaneously and the frequency and speed at which they are recorded can be changed. The data obtained allows a comparison of the influence of the individual parameters on the measured parameters of the artificial teat.

## 3. Results and discussion

The absolute values of pulsation phases for new and used milking liners are shown in Table 1. All registrations were performed with a 40kPa vacuum, a 50/50% pulsation ratio and pulsation rate 60, 90 and 120 $min^{-1}$.

**Table 1.** Pulsation phase values (ms) recorded on new and used milking liners at 40k Pavacuum supply

| Pulsation rate | New milking liners | | | | Used milking liners | | | |
|---|---|---|---|---|---|---|---|---|
| | Pulsation phases | | | | | | | |
| | a | b | c | d | a | b | c | d |
| $min^{-1}$ | ms | ms | ms | ms | ms | ms | ms | ms |
| 60 | 119 | 369 | 67 | 443 | 112 | 382 | 56 | 453 |
| 90 | 118 | 206 | 64 | 279 | 106 | 220 | 57 | 286 |
| 120 | 111 | 129 | 64 | 196 | 107 | 136 | 56 | 201 |

The high-frequency mode of the pulsation system of milking units is associated with a reduction in the duration of the actual milking phase **b**. The rate of reduction varies with increasing frequency. The highest one is when increasing the pulsation rate from 60 to 90 $min^{-1}$.

Analogous reasoning can be made for the values of phase "d". As the pulsation rate increases the duration of the **d** phase decreases. The established phases have a longer duration for milking units complete with used milking liners.

The duration of transition processes (phases **a** and**c**) are running faster in milking units complete with used milking liners. Some authors [9,10] which are concerned with the transition process prove that reducing the phase **a** reduces milking time and increases the milk flow. Conversely, the reduction of the phase **c** would result in "impact" on the teat tissue. This means that regardless of the pulsation settings we must strive to achieve a longer transition process from "milking" to "massage" (i.e. phase **c**). This will provide better teat stimulation. Conversely, in order to increase the throughput of the milking units and reduce the time of milking we need to provide a short phase**a**.

The increase in the vacuum (Table 2) of the pulsation system leads to an increase in the duration of the transient processes and to the reduction of the duration of the actual phases in both milking liners. The reason for this is the increased pulsation amplitude that changes the time constant of the pulsation systems.

The tendency for shorter transition processes for milking units complete with hours worked resources milking liners is preserved. This is most likely due to the depreciation of milking liners.

**Table 2.** Pulsation phase values (ms) recorded on new and used milking linersat50 kPasupply vacuum

| Pulsation rate | New milking liner | | | | Used milking liner | | | |
|---|---|---|---|---|---|---|---|---|
| | Pulsation phases | | | | | | | |
| | a | b | c | d | a | b | c | d |
| $min^{-1}$ | ms | ms | ms | ms | ms | ms | ms | ms |
| 60 | 150 | 336 | 70 | 442 | 135 | 345 | 63 | 456 |
| 90 | 140 | 180 | 69 | 277 | 133 | 192 | 61 | 280 |
| 120 | 137 | 100 | 70 | 194 | 125 | 117 | 59 | 199 |

The tendency for shorter transitions and longer phases for used milking liners is retained. This is most likely due to the wearing out of milking liners.

Table 3 shows the experimental data on measured pressure for new and used milking liners.

**Table 3.** Measured pressure values (kPa) in artificial teat in new and used milking liners

| Pulsation rate | Pulsation ratio | Pressure | |
|---|---|---|---|
| | | New milking liner | Used milking liner |
| $min^{-1}$ | % | κPa | κPa |
| 60 | 50/50 | 7,1 | 5,5 |
| | 60/40 | 7,5 | 5,6 |
| | 65/35 | 7,4 | 5,8 |
| | 70/30 | 8,4 | 5,9 |
| 90 | 50/50 | 7,9 | 6,1 |
| | 60/40 | 8,1 | 6,1 |
| | 65/35 | 8,3 | 6,3 |
| | 70/30 | 8,3 | 6,3 |
| 120 | 50/50 | 8,5 | 6,4 |
| | 60/40 | 8,6 | 6,5 |
| | 65/35 | 8,7 | 6,5 |
| | 70/30 | 8,7 | 6,4 |

The results of Table 3 show that the pressure in the artificial teat is not influenced by the pulsation settings. Reported pressure values are in the range of 7.1-8.7 kPa and 5.5-6.5 kPa respectively for new and used milking liners. Greater influence is the wear out of the milking liner. Differences are in the range of 2-3 kPa. On the one hand, the greater compression force would positively affect the teat tissue during the massaging phase **d** but on the other hand, this would affect the formation of hyperkeratosis. It is only known in the literature that the force with which the calf presses the tissue is weaker than the presses force of the milking

liner in modern milking machines. No literary data has been found about what the teat compressing force should be.

## 4. Conclusions

Transitional processes (phase **a** and phase **c**) occur more rapidly in milking devices complete with used milking liners which would lead to a "sudden hit" on the milking papilla.

The actual phases of the milking process (phase **b** and phase**d**) have a longer duration for milking devices complete with used milking liners. The prolonged action of vacuum during phase **b** would result in the presence of mammary diseases.

The pressure in the artificial teat is not influenced by the pulsation system settings. Greater influence is attributed to the wearing out of milking liners.

It is necessary the diagnostics of the milking units to be performed more often taking into account the wearing out of milking liners and if it is urgent to replace them in a shorter time.

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