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Transient processes of the milking cluster pulsation system depending on pulsation rate

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Abstract. *In the study was determined the factors that define the inertia of the pulsation system of milking cluster. Moving of milking liner is playing a role of a negative feed-back that visibly makes longer transient processes and decreases the times of actual* ***b*** *and* ***d*** *phases (milking and massage). The Milking* ***b*** *phase decreases 1,45 times and* ***d*** *phase 2,79 times faster than the second experimental configuration (respectively 5,5 times and 9,3 times faster according to the first base experimental configuration). The negative influence of the rate and variable volume of the pulsation chamber is two times higher during* ***d*** *phase (massage) according to* ***b*** *phase (milking) and this must be taken in mind in creating a high-rate milking clusters, as* ***d*** *phase has a crucial role for healthy animals during machine milking. A comparative experiment for defining the inertia of the pulsation system of milking cluster proved that the basic factors which influence on the transient processes are the constant volume of the pulsation line. A negative feed-back was observed during a moving a milking liner.*

Keywords: milking machine, pulsation system, transient processes.

Introduction

In process of improving the milking machines, the basic aim was always to create a milking clusters, that must be adequate to the nature process of calf sucking, that is: low-vacuum sucking of milk, high rate of sucking cycles (about 90 to 150 suction in minute), harmless (without mastitis) process of pulling out the milk. It's a pity, that milking clusters according to its principal of working can not imitate fully the natural sucking of the calf. The best way to notice this, according to the velocity of pulling out the milk, respectively the number of the sucking movements: with milking cluster they are maximum 60-70 min^{-1}, i. e. two times less than the rate possibilities of the calf during its natural sucking. Until now to this problem hasn't given careful consideration although there has been made numerous trials over the parameters of the pulsation system of the milking machines (McGrath and O'She, 1972; Caruolo, 1983; Spencer, 1989; Butler and Adley, 1993; Peris, 1994; O'Callaghan, 1997 and O'Callaghan, 1998).

Serious attention should be paid to the researches of Markus and Grimm (2003), who prove that "the percentage of the real suction phase (based on liner movement) is usually 10 to 20 % less than the percentage of the suction phase according ISO 3918". This fact put again the problem for predefinition of the factors influence over the inertia of the pulsation systems of the milking clusters. The aim of the study is to determine the factors that define the inertia of the milking cluster pulsation system.

Material and methods

Reaching the aim it was made a comparative experiment for four different configurations of the pulsation system of a milking cluster (Figure 1). Measuring of the transient processes and registration of the pulsation graphs is made with a device for differential diagnostic of a milking cluster. The research has taken place in the Laboratory of Machine Milking in the Department of Agricltural Engineering in Trakia University – Stara Zagora.

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Results and discussion

Graphical dependence of the **a, b, c,** and **d** phases of the pulsation system are regression equation from type $Y=b_0 + b_1x$, which are determined by experimental data with a software Statistica 8. The graphics of the transient processes for **a** phase (in %) depending on rate ***f*** (in pulses per minute) are given in Figure 2.There are worked out the following regression equations:

$$
\begin{aligned}
Y_{1a} &= 2,24+0,0163.x \\
Y_{2a} &= 3,32+0,0690.x \qquad (1) \\
Y_{3a} &= 2,46+0,0823.x \\
Y_{4a} &= 2,32+0,1107.x
\end{aligned}
$$

It can be clearly seen that with increasing the pulsation rate, the pulsation system become more inert. This effect is lower in the first experimental configuration (just with pulsator) and is clearer in the fourth configuration (normal connection of milking shell). In connection with equivalent volume (second experiment configuration) the inertness is four times higher according to first configuration, which is due to bigger volume of air that the pulsator must take in and out into pulsation line in every pulsation cycle. It is interesting that in third and fourth experiment configuration the air volume into pulsation line is the same as in the second experiment configuration, but the inertness of the system here is bigger than second configuration, 1,19 times and 1,6 times. The explanation for this phenomenon can be find only in variable volume of the pulsation

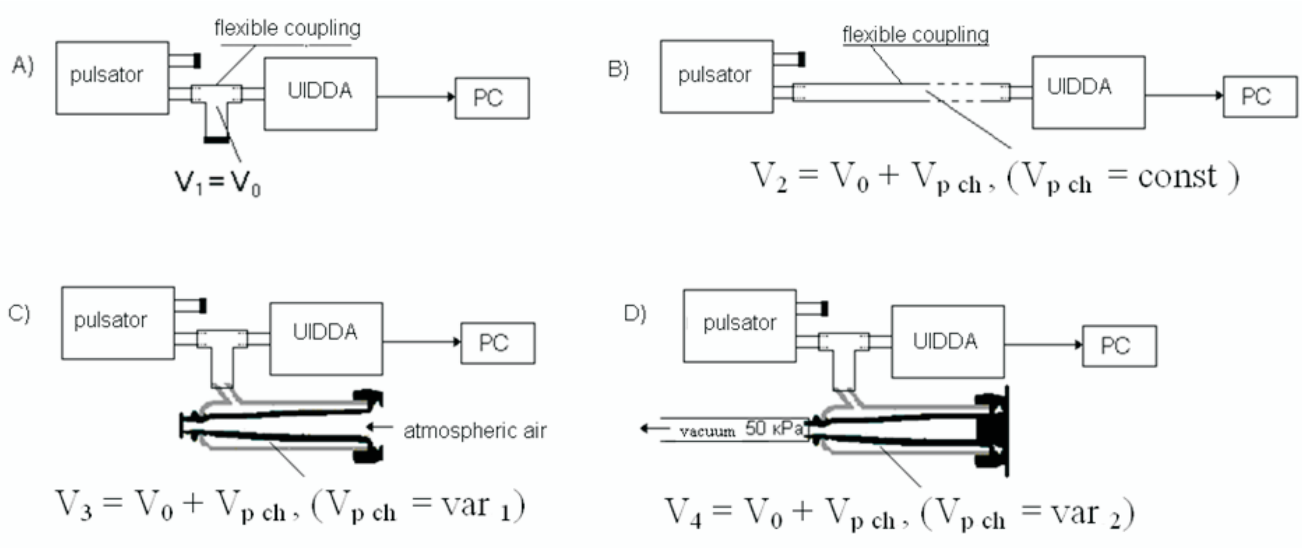

Figure 1. Experimental configurations for comparatively study of pulsation characteristics depending on pulsation rate:
A) first configuration (volume of the pulsation system V_1): direct measuring (without milking shell) of pulsation characteristics of the pulsator during minimal volume of pulsation line V_0, which includes just the volume of the added coupling between pulsator and measuring device UIDDA;
B) second configuration (volume of the pulsation system V_2): direct measuring (without milking shell) of the pulsation characteristics, where the volume of pulsation line is equal to a minimal volume V_0 plus volume of pulsation chamber of the milking shell $V_{p.ch.}$;
C) third configuration (volume of the pulsation system V_1): measuring of the pulsation characteristics with milking shell, that is connected inversely (in its lower part the milking line is isolated from the atmosphere and vacuum pump, and in its upper part is connected with atmosphere (in this coupling the milking liner will start ballooning instead of shrinking);
D) fourth configuration (volume of the pulsation system V_1): normally connected pulsator to milking shell.

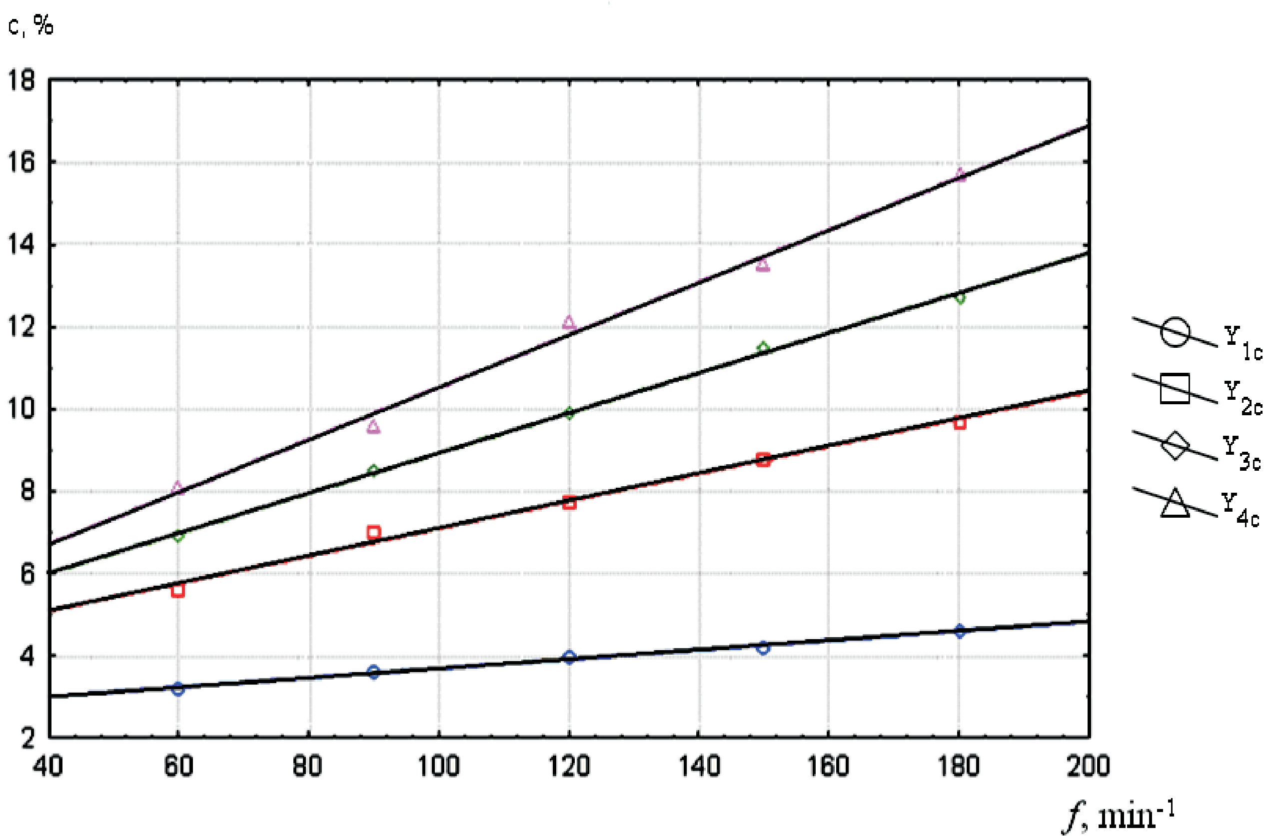

Figure 2. Dependency of **a-**phase from pulsation rate ***f*** on four different working regimes

chamber of the milking shell, which is changed from higher to smaller during the time of transient process from “massage” to “milking” phase (**a**-phase) (Figure 3).

The phenomenon is a result of a principal work of a milking cluster. This is a necessity of a periodically contraction and dismissing of the milking liner during the time of each milking cycle. In time of contraction of the liner into pulsation chamber is pushed atmospheric air from pulsator and the pressure increases gradually, but the increasing volume of the chamber delay this process. During dismissing of the liner it can be observed the opposite phenomenon. It can be seen that the movement of the milking liner is a negative feed-back, which delays the transient processes as in time of phase **a** and also in time of transient phase **c**. For phase **c** the graphics of transient processes depending on rate (Figure 4) are received from the following regression equations:

$$Y_{1c}=2,56+0,0113.x$$
$$Y_{2c}=3,76+0,0333.x \qquad (2)$$
$$Y_{3c}=4,06+0,0487.x$$
$$Y_{4c}=4,16+0,0637.x$$

In Figure 4 can be seen the opposite transient process (**c** phase) that flows faster, in a consequence of a bigger differential pressure, that provokes transient, but the trends according to the rate of pulsator are the same, as in the transient process of Figure 2. The explanation can find again in variable volume of the pulsation chamber during the process from “milking” to “massage” phase – Figure 3.

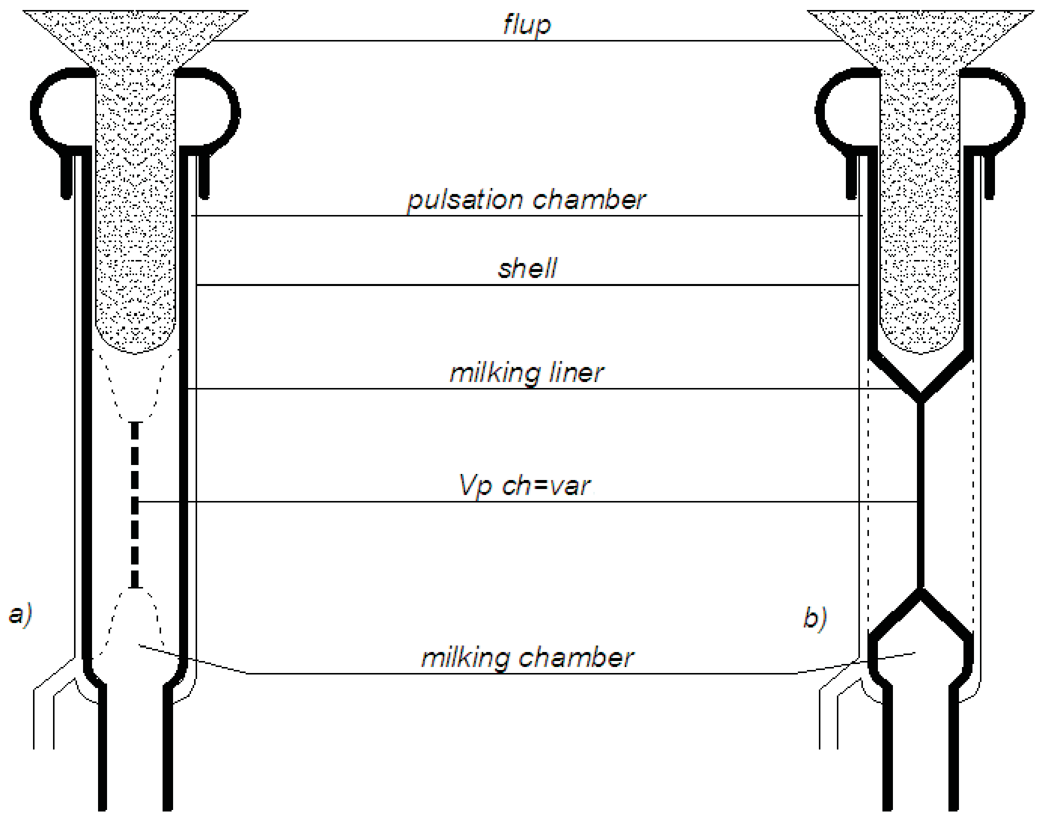

Figure 3. Pulsation chamber with variable volume: a) from “milking” to “massage” phase, b) from “massage” to “milking” phase.

The rising of the transient processes times, as could be expected, lead to undesired decrease of the **b** phase (milking) and **d** phase (massage) – Figure 5 and Figure 6.

Regression equations for phase **b** are:

$$Y_{1b}=57,16+0,022.x$$
$$Y_{2b}=57,56+0,083.x \qquad (3)$$
$$Y_{3b}=58,22+0,094.x$$
$$Y_{4b}=58,18+0,121.x$$

From the coefficients can be calculated, that in experimental configuration with normal connection of the milking cluster phase **b** decreases 1,45 times faster in dependence from rate compared to second experimental configurations and 5,5 times faster compared to base configuration.

For **d** phase the regression equations are:

$$Y_{1d}=38,02+0,0057.x$$
$$Y_{2d}=35,26+0,0190.x \qquad (4)$$
$$Y_{3d}=35,28+0,0373.x$$
$$Y_{4d}=35,38+0,0530.x$$

From equations (4) can be estimated, that **d** phase decreases 2,79 times faster according to second experimental configuration and 9,3 times according to first base configuration.

From here can be made the following conclusion, that the negative influence of the variable volume of the pulsation chamber and the rate is nearly two times higher during phase ”massage” than in phase ”milking”. This is a fact that is too unfavorable, because “massage” phase has a decisive role for health condition of the animals during the time of milking and this must be taken in mind during the creation of high pulsation milking machines.

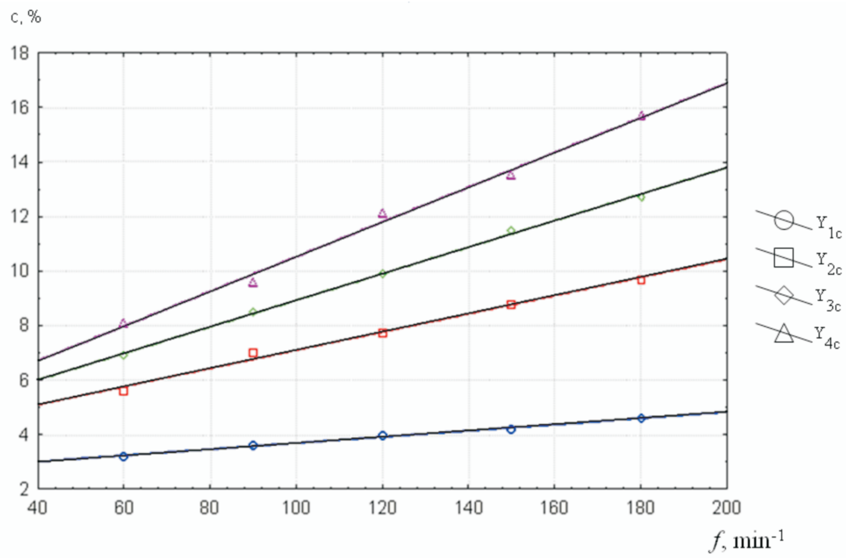

Figure 4. Dependency of **c-**phase from pulsation rate ***f*** on four different working regimes.

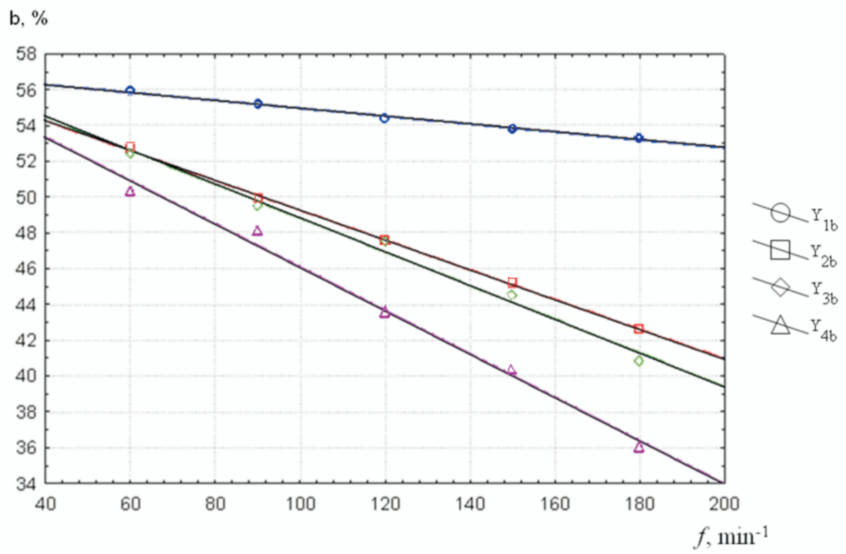

Figure 5. Dependency of **b**-phase of rate ***f*** of a pulsator on four different working regimes.

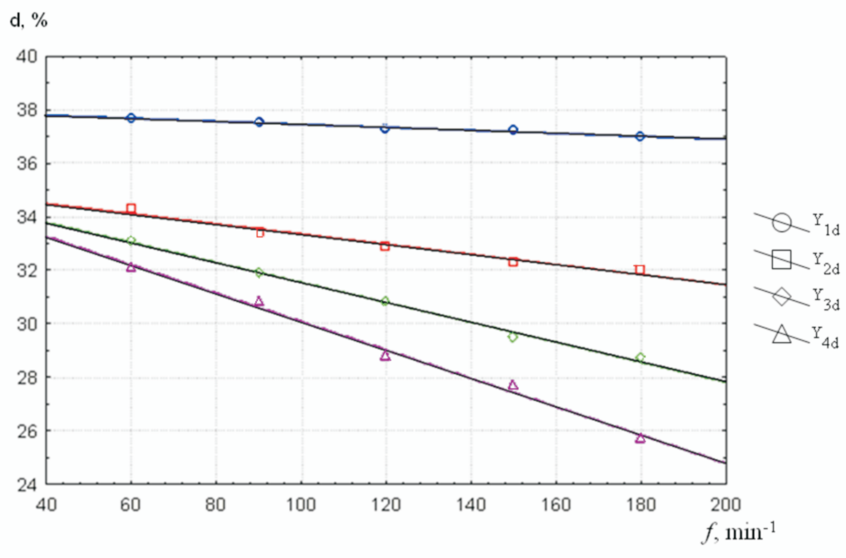

Figure 6. Dependency of **d-**phase from pulsation rate ***f*** on four different working regimes.

Conclusion

It was done a comparative experiment for defining the inertia of the pulsation system of milking cluster, with which it was proved, that the basic factors which influence over the transient processes are the constant volume of the pulsation line and variable volume of pulsation chamber.

Moving of milking liner is playing a role of a negative feed-back that visibly makes longer transient processes and decreases the times of actual **b** and **d** phases (milking and massage). The Milking **b** phase decreases 1,45 times and **d** phase decreases 2,79 times faster than the second experimental configuration (respectively 5,5 times and 9,3 times faster according to the first base experimental configuration).

The negative influence of the rate and variable volume of the pulsation chamber is two times higher during **d** phase (massage) according to **b** phase (milking) and this must be taken in mind in creating a high-rate milking clusters, as **d** phase has a crucial role for healthy animals during machine milking.

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