INFLUENCE OF NEGATIVE FEEDBACK IN THE PULSATION CHAMBER CLUSTER ON PULSATION PHASES

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ABSTRACT

A method is proposed for experimental verification of the existence of negative feedback in the pulsation chamber but milking clusters that suppresses the dynamics of transition processes of pulsation. The influence of negative feedback at various pulsation frequencies ranging from 1Hz to 2,5Hz on the pulsation phases **a, b, c** and **d** were tested.

Experimental proof that at 1 Hz phase **a** of pulsation chamber with an elastic element (milking liner) is longer by about 80% compared to the phase **a** of pulsation chamber with a constant volume (without milking liner). With increasing frequency of 2,5 Hz to the influence of negative feedback weakens to 30%. The influence of negative feedback on the transition phase is negligible. At a frequency of 1Hz pulsation phase c of pulsation chamber with an elastic element is about 40% longer compared with the phase c of the pulsation chamber with constant volume and at a frequency of 2,5 Hz the influence of negative feedback decreases.

Generalized indexes ka+b and kc+d also were examined, which show how many part of the technological cycle a+b (respectively c+d) has a transitional nature. Experimentally proved that index ka+b in pulsation chambers with reactive element is 38% at the frequency of 1Hz, and pulsation chamber with a constant volume is 20%, ie almost twice as small. With increasing frequency ka+b reaches 72% in the reactive chamber and 50% in passive chamber, which again shows that the frequency increases the influence of negative feedback decreases. In the reverse transition process (phase c) trends are similar but the phase c is insensitive to the influence of negative feedback.

***Keywords**: cluster, pulsation chamber, negative feedback, generalized indexes*

Introduction

In recent years, research in pulsation mode of milking clusters has focused on comparative studies of so-called pulsograme (graphic interpretation of the change in pulsation pressure in chamber) but on so-called LWM (LWM - Liner Wall Movement) which shows the movement of the walls of milking liner changes in differential pressure. The problem is that the dynamic of the pulsation system and dynamic of milking liner do not match resulting in movement of the liner should synchronously during pulsograme (Butler M.C. and Adley A.J.D., 1993; Mayer M. and Grim H., 2003). This raises two questions: first the feasibility of using pulsograme as a criterion for assessing the mode of the cluster and secondly the experimental demonstration of a milking liner as an elastic element which is opposed to reason which causes its deformation. In practice, the movement of the walls of milking liner (LWM) during the pulsation cycle changes pulsation chamber volume. This change in volume plays the role of negative feedback that slows the transition processes (phase **a** and phase **c**) between established conditions "milking" and "massage".

The aim of this study is to verify experimentally the hypothesis (Banev B. and Bechev B., 2009) of the existence of negative feedback during the change of pressure pulsation chamber milking clusters due to the elastic response elements in pulsation system.

Material and Method

To prove the influence of elastic elements in pulsation system and the existence of negative feedback using experimental setup shown in figure 1.

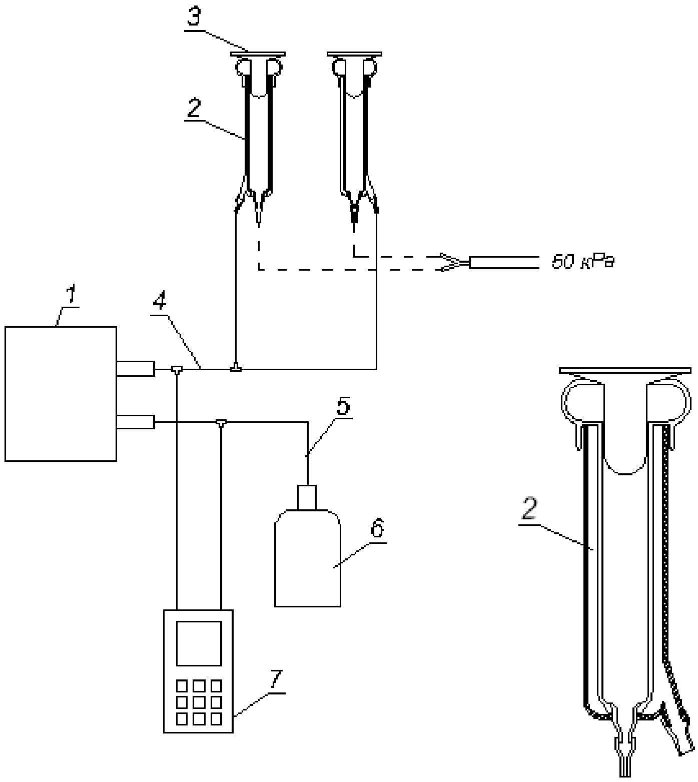


Fig. A. Experimental design: 1 - programmable pulsator, 2 - pulsation chamber cluster with variable volume Va; 3 - stopper, 4 - pulsation tract channel 1; 5 - pulsation tract channel 2; 6 - pulsation chamber with constant volume Vc; 7 - pulsotester.

The idea is to compare pulsograme in pulsation chambers classic cluster (which changes its volume due to movement of the elastic element - milking liner) and control of closed container with a constant volume equal to the sum of the volumes of both chambers of pulsation milking cups from fig. 1, i. e.:

$$Vc=2Va, \quad (1)$$

where Vc is the constant volume of the control container 6;

Va - volume pulsation chamber milking cups 2, measured at rest (static) state of milking liner.

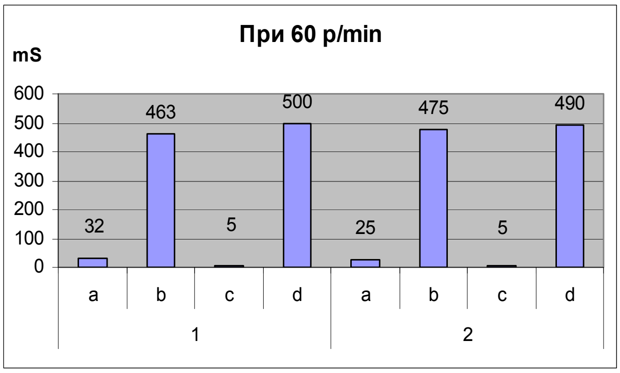
Using the experimental setup from fig. 1 register four phases of the milking cycle (**a**, **b**, **c** and **d**) for four different frequencies (f_1=1Hz, f_2=1.5Hz, f_3=2Hz, f_4=2.5Hz) in ratio 50/50% and vacuum of 50 kPa.

Frequencies are set with a programmable electronic pulsator 1. Registration is done with pulsotester 7.

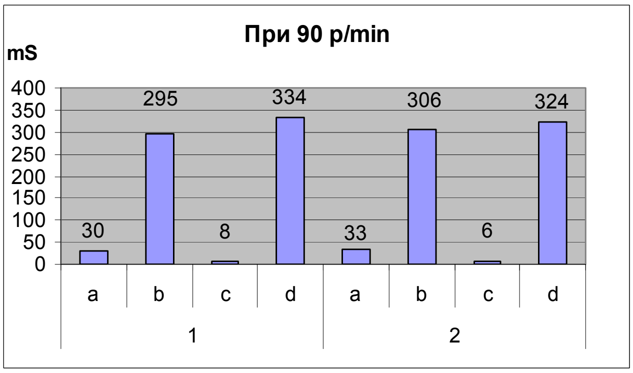
Results and Discussion

In order to eliminate the influence of pulsators on the results of counterfactual single factor experiment between the characteristics of pulsation chamber with variable volume and constant volume that initially register their parameters (phases **a**, **b**, **c** and **d**) a load pulsator.

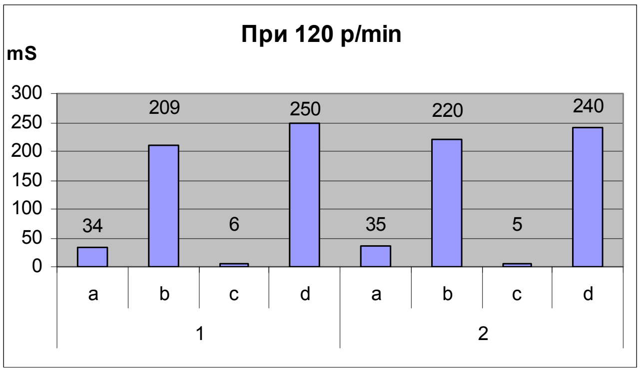
Diagrams of figure 2 illustrate the duration of transient processes (phase **a** and phase **c**) and the established conditions (phase **b** and phase **d**) respectively for frequencies f_1=1Hz, f_2=1.5Hz, f_3=2Hz, f_4=2.5Hz.



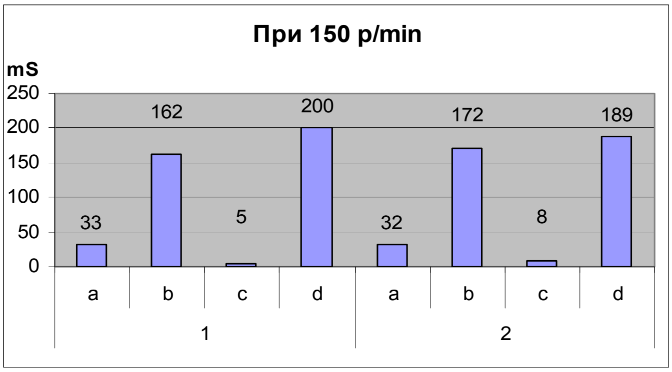
a)



b)



c)



d)

Fig. 2. Absolute values of the phases **a**, **b**, **c** and **d** for load pulsator: a) at a frequency of 60 min^{-1}, b) at a frequency of 90 min^{-1}, c) at a frequency of 120 min^{-1}, d) at a frequency of 150 min^{-1}.

The results clearly show that the whole range of the experimental frequency from 1Hz to 2,5Hz phase **a** and phase **c** remain almost the same duration the order of 30-34 ms respective, 5-8 ms which indicates that the time constant of the pulsator is not affected by frequency. The reduction in phase **b** and **d** of 475 ms to 162 ms respectively from 500 ms to 189 ms for increasing frequency is deterministic process that is explained by the physical reduction of the period of the pulses increase in frequency.

The graphical interpretation of the data from the experiment with a load of pulsators with both milking cups with variable volume pulsation chamber and constant volume pulsation chamber are shown in figure 3 (in absolute values). In figure 4 shows the graphical interpretation of these data in relative values. The graphs reflect differences in the transition processes of the two channels of pulsation system for each frequency.

The graphics in figure 3 clearly shows that transition processes **a** and **c** for channel 2 of pulsators (the pulsation chamber with constant volume) have lower values i.e. run around 80% faster for **a** and 40% faster for **c** than transition processes **a** and **c** for channel of a pulsator which included the two milking cups with variable volume pulsation chambers.

In the chamber with a constant volume over the whole frequency range from 1Hz to 2,5Hz phase **a** slightly fluctuates around 100 ms (that fits the experimental error) indicating that it is independent of frequency. The same reasoning can be extended to phase **c** which fluctuates around 45 ms. It is important to note that the phase **c** is quite insensitive to changes in frequency than phase **a**.

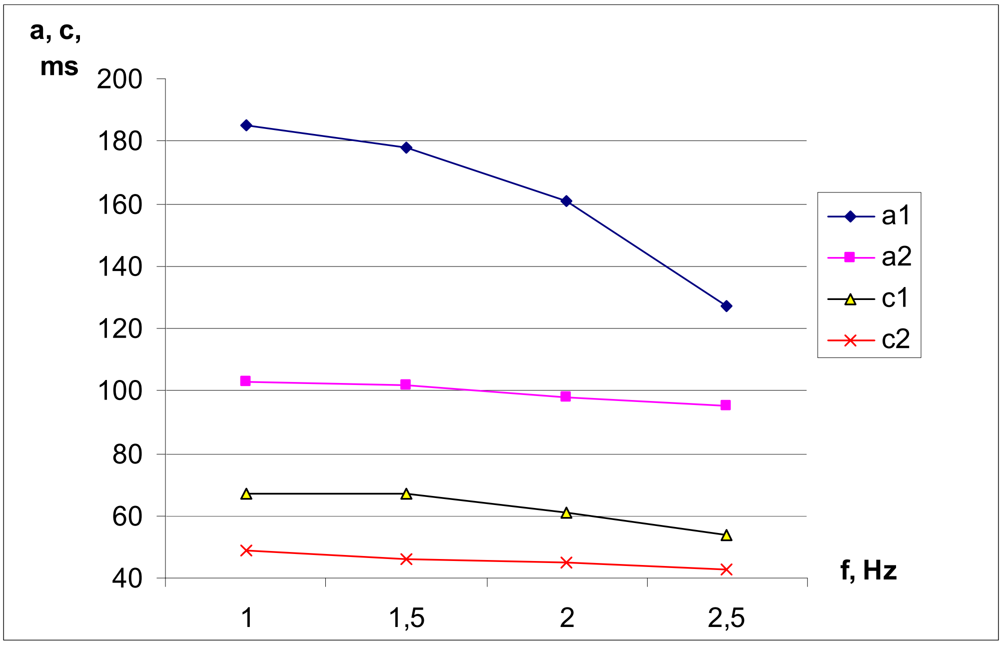


Fig. 3. Absolute values of the transition processes **a** and **c** in the two channels of pulsation system depending on the frequency.

In terms of relative values (in %) of phase **a** and phase c (fig. 4) can say that they increase with increasing frequency but the sensitivity of the increase was higher in pulsation chambers with variable volume.

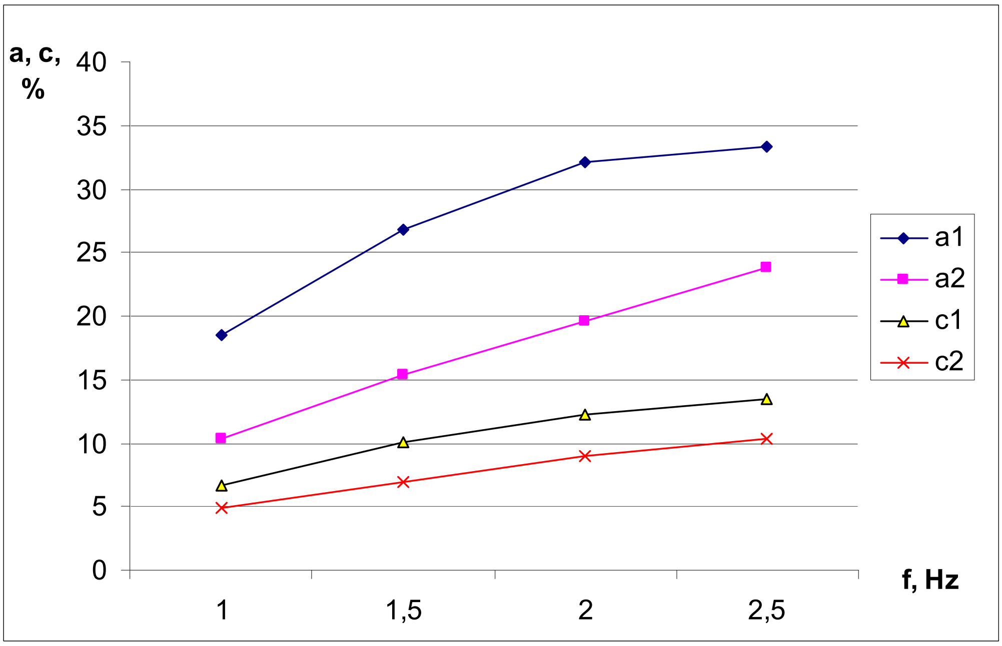


Fig. 4. Relative values of the transition processes **a** and **c** for the two channels of pulsation system depending on the frequency.

The values (phases **b** and **d**) both in absolute (figure 5) and relative values (figure 6) strongly influenced by the increasing frequency as quickly regress but on different levels. In the whole frequency range from 1Hz to 2,5Hz phase **b** of the pulsation chamber with a constant level remains higher values than variable volume pulsation chambers. The same applies to phase **d** but the differences are insignificant.

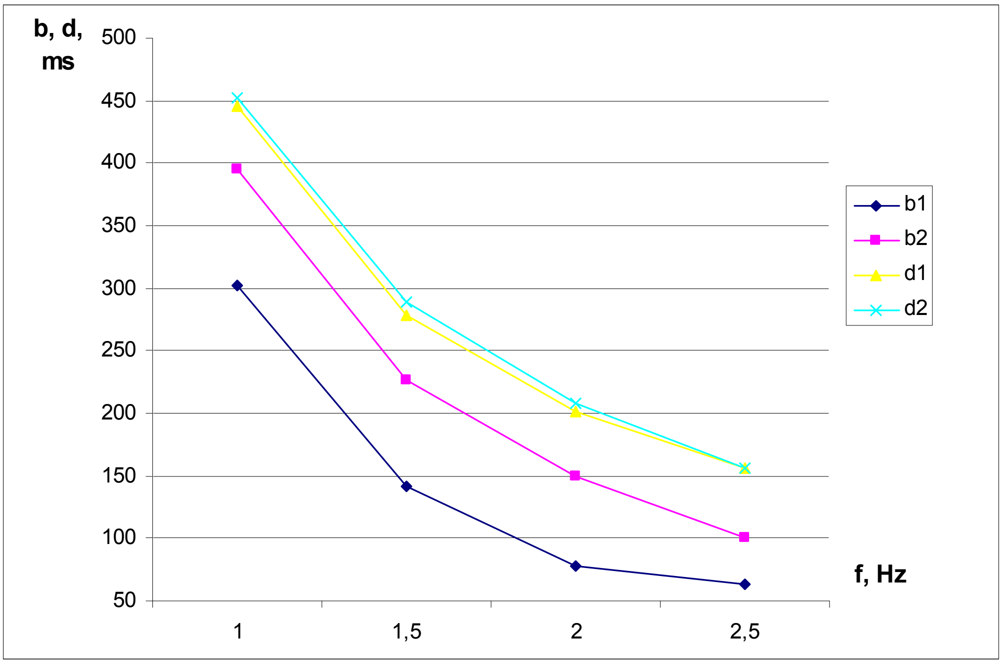


Fig. 5. Absolute values of stationary processes **b** and **d** for the two channels of pulsation system depending on the frequency.

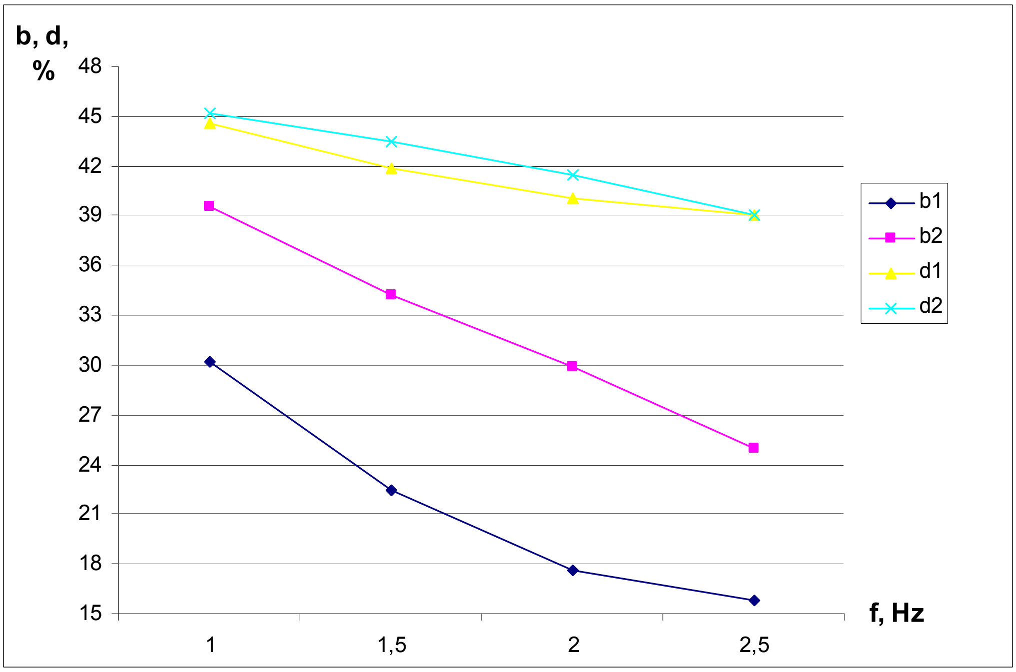


Fig. 6. Relative values of stationary processes **b** and **d** for the two channels of pulsation system depending on the frequency.

If the system include a longer tube length as 2.60 m, i.e. if you add a constant volume, the reasoning does not change. The only difference (figure 7 and figure 8) is the proportional increase in value due to change in time constant of the new system. In this case the differences of phases c_1 and c_2 become insignificant.

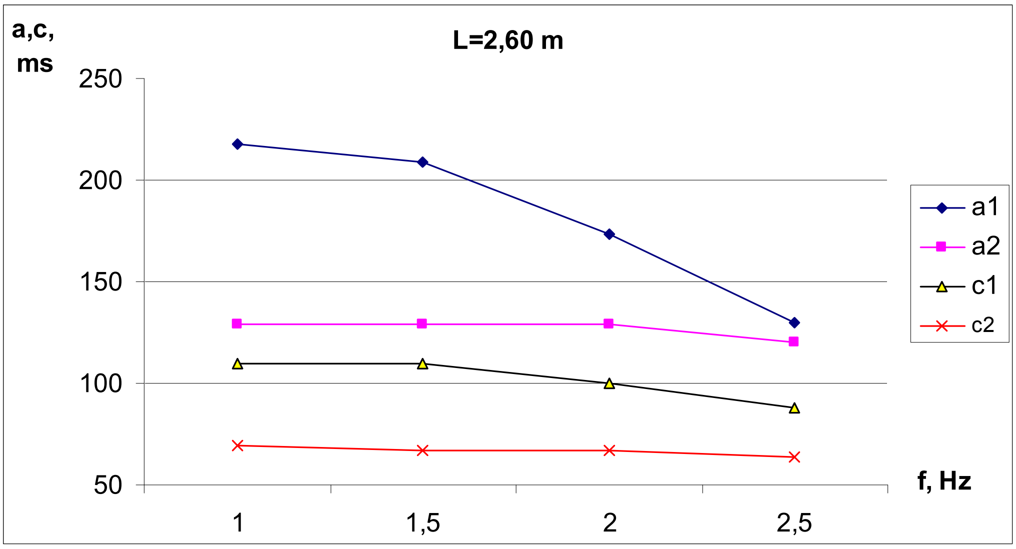


Fig. 7. Absolute values of the transition processes **a** and **c** for the two channels of pulsation system depending on the frequency (with pulsation tube L = 2,60 m).

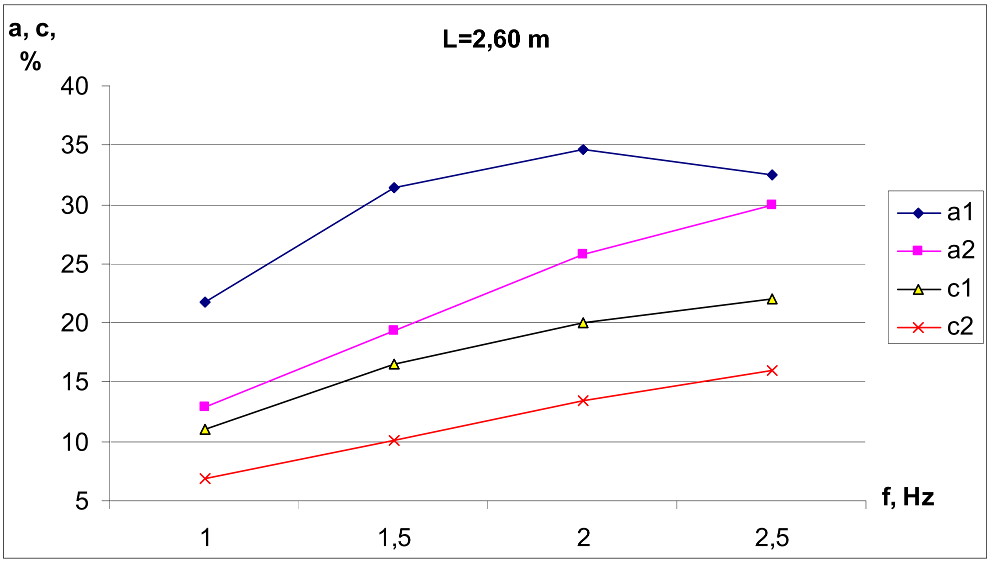


Fig. 8. Relative values of the transition processes **a** and **c** for the two channels of pulsation system depending on the frequency (with pulsation tube L = 2,60 m).

The adding a constant volume change of the overall pulsation system time constant which increases the phases **b** and **d** in absolute and relative units but regressive trends shown in fig. 9 and fig. 10 are similar to those of fig. 5 and fig. 6.

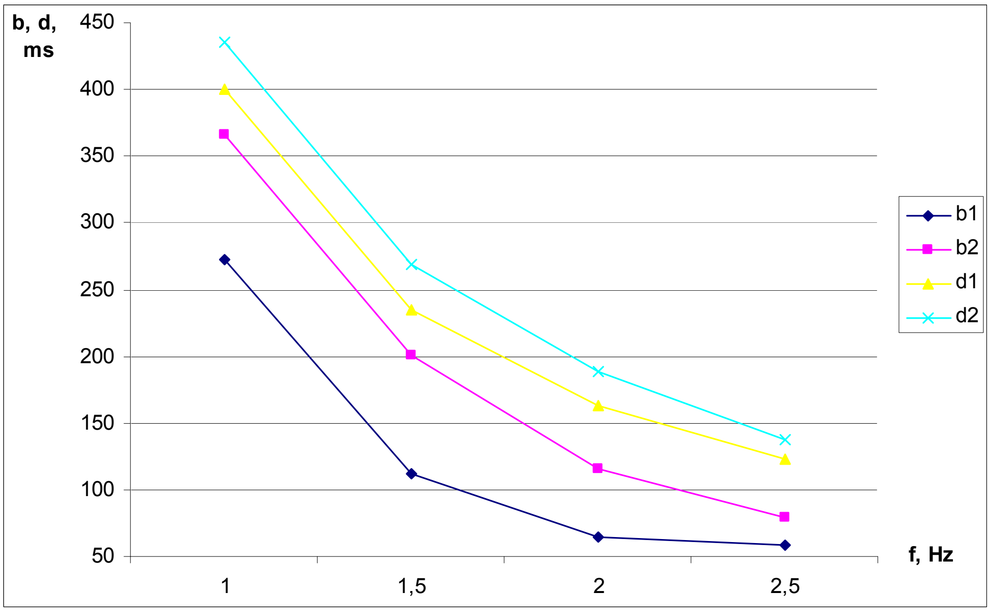


Fig.9. Absolute values of stationary processes **b** and **d** for the two channels of pulsation system depending on the frequency when adding a constant volume in pulsation system.

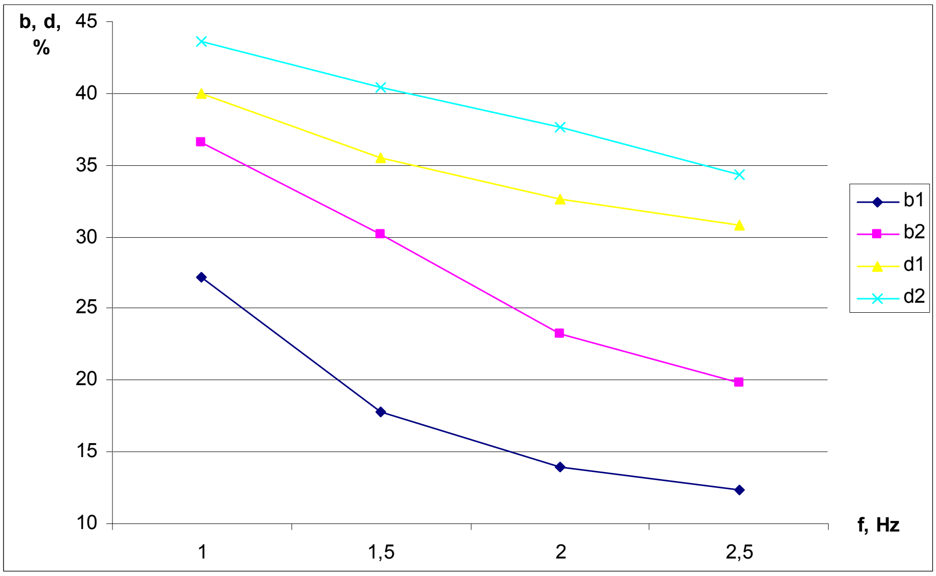


Fig.10. Relative values of the stationary processes **b** and **d** for the two channels of pulsation system depending on the frequency when adding a constant volume in pulsation system.

In figure 11 are shown by generalized performance indexes k_{a+b} and k_{c+d} respectively for the two channels of the experimental design (relative contribution of transition processes **a** and **c** in the general technological cycles “a+b” and “c+d”).

Indexes ka+b and kc+d is calculated as:

$$k_{a+b} = \frac{a}{a+b}.100,\% \qquad (2)$$

$$k_{c+d} = \frac{a}{c+d}.100,\% \qquad (3)$$

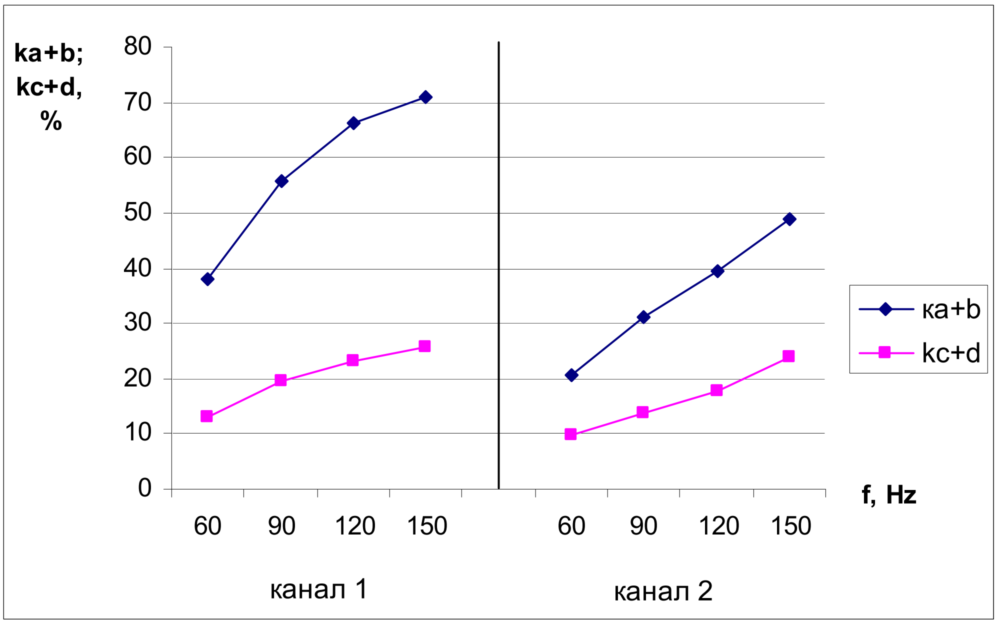


Fig. 11. Influence of frequency **f** on the generalized indexes k_{a+b} and k_{c+d} in channel 1 (for variable volume pulsation chamber) and channel 2 (for constant volume pulsation chamber).

From fig.11 clearly shows noticeable influence of the elastic elements in pulsation variable-volume chamber on the percentage contribution of transients and in a total time of technological cycles a+b respectively c+d. For the frequency range of 60 min^{-1} to 150 min^{-1} ka+b changes almost doubled from 38% to 66.8% and kc+d also doubled from 13.1% to 25.7% l in pulsation chamber with a constant volume change for ka+b of 20.7% to 48.7% and kc+d is from 9.8% to 23.9%, ie more than double the much lower levels, since there is no elastic element that extends the transitional processes - in this case the growth rates ka+b and kc+d is due solely to the reduction of the period T with increasing frequency.

Conclusions

A. time constants of the variable-volume chamber and the chamber of constant volume recorded by the phases of the transition process but also to significantly vary throughout the range of experimental frequencies from 1Hz to 2,5 Hz which can only be explained by the reaction of the elastic element - milking liner. In the implementation phase **a** pulsator switches from high pressure (atmospheric air) to a lower pressure (vacuum), hence the pressure pulsation chamber begins to decrease. At the same time milking liner begins to leave the volume of pulsation chamber decreases which slows down the rate of change of pressure. There is a negative feedback which extended phase **a**. This process helps to increase milking volume chamber due to the expansion of milking liner. Similar reaction processes but in reverse order to develop the flow of phase **c**.

2. For the whole range of frequencies from 1Hz to 2,5 Hz phase **a** and **c** in chambers with variable volume response of 185 ms to 127 ms for phase **a** and from 67 ms to 54 ms for phase **c**, while the camera constant volume time constant (phase **a** and **c**) are hardly affected by frequency. This indicates that the variable-volume chambers increase frequency weakens the strength of the response of the elastic element - milking liner. This is due to the inertia of milking liner which at higher frequencies collapses with lower amplitude which weakens the strength of negative feedback.

3. Adding a constant volume also weakens the influence of negative feedback due to the relatively low participation of the variable volume of pulsation system to its continuous part.

4. Generalized indexes ka+b and kc+d the relative contribution of transients **a** and **c** the general technological times a+b («milking») and c + d ("massage") markedly affect the frequency but pulsation cambers with variable volume of this influence is appreciably from the constant

volume chamber which is due not only shortening the period of the pulses increase in frequency, but also the extension of transients due to negative feedback in pulsed chambers elastic element.

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