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Influence of Saw Cylinder Parameters and Support Rigidity on Vibration Amplitude

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ABSTRACT: The article discusses the results of research on the analysis of analytical expressions to determine the amplitude of vibrations, the reaction force of the bearing support, and the system dynamic coefficient. The graphical dependences of the change in the amplitude of oscillations of the saw cylinder with an elastic conical bearing support on the change in the angular velocity of the saw cylinder and on the coefficient of total stiffness of the elastic support are constructed. Recommended values of the bearing support with conical rubber bearings of the gin saw cylinder are given.

KEYWORDS: Saw cylinder, gin, shaft, bearing, conical rubber bearing, vibration, amplitude, reaction force, dynamic coefficient, frequency, mass.

I. INTRODUCTION

During operation of the saw gin, vibrations occur mainly due to the bending of the saw cylinder [1]. But, in the recommended design of the saw cylinder, its bending is minimized. In this case, the vertical oscillations of the gin saw cylinder occurs due to unbalanced masses, mainly from the mass of the fiber of the gin cylinders captured and carried away by the teeth of the saws. The value of this fiber mass varies between (0.31 ÷ 0.55) kg.

Then the centrifugal force from this mass will be according to [2]:

$$P_ц = m_{xв}\omega_ц^2 \frac{D_ц}{2} \quad (1)$$

where, m_x-is the mass of fiber simultaneously captured and dragged by the saw cylinder during ginning, $\omega_ц$is the angular velocity of the saw cylinder, $D_ц$is the diameter of the saw cylinder.

Given the variability of the mass of the fibers trapped and dragged by the saw cylinder at n =730 rpm, $D_ц$=0.16 m, the centrifugal force varies in the range (409÷467) N. It should be noted that the stiffness coefficient of the cylindrical bearing of the saw cylinder bearings varies in proportion to the load [3]. But, when using conical rubber bearings of the saw cylinder bearings, the deformation of the support will have a nonlinear character depending on the load change (see Fig. 1).

In the second version of the elastic support (see Fig. 1.b) with increasing load, the deformation of the elastic support becomes interfered by the conical elastic sleeve. In the static position of the saw cylinder, the deformation of the conical bearing support of the saw cylinder is determined according to [4] from the following expression:

$$a_{cm} = \frac{G_ц}{2c_n}; \quad (2)$$

where, $G_ц$is the weight force of the saw cylinder, c_n is the stiffness coefficient of the support.

Given the nonlinear stiffness characteristics of a tapered bearing, we have:

$$a_{cm} = \frac{m_ц g}{2(c_1+kc_2)}; \quad c_n = (c_1 + kc_2) \quad (3)$$

where, c_1 is the linear component of the stiffness coefficient of the conical elastic bearing, and kc_2 is the nonlinear component of the stiffness of the bearing.

Moreover, according to the methodology given in [3], we determine the amplitude of oscillations of the saw cylinder vertically, taking into account the mass of cotton fiber captured by the teeth of the saw blades:

$$A = \frac{(m_ц+m_{xв})}{2(c_1+kc_2)\left|1-\frac{\omega_ц^2}{p_0^2}\right|} \quad (4)$$

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where, $\rho_0 = \sqrt{\frac{c_1 + kc_2}{m_ц + m_{хв}}}$

k - is the coefficient of nonlinearity of stiffness of the conical rubber sleeve of the bearing support of the shaft of the saw cylinder.

It should be noted that the amplitude of the oscillation of the reaction force of the bearing support will be proportional to the amplitude of the deformation of the rubber sleeve of the bearing, while;

$$R_a = \frac{R_{cm}}{\left|1 - \frac{\omega_ц^2}{\rho_0^2}\right|} \qquad (5)$$

It is important to determine the dynamic coefficient of the system according to [4,5]:

$$K_{дин} = \frac{R_{дин}}{R_{cm}} = \frac{c_1 + kc_2}{\left|(c_1 + kc_2) - \omega_s^2(m_ц + m_{хв})\right|} \qquad (6)$$

The numerical solution (4) on a PC was made with the following parameter values:

$$\omega_ц = 76{,}4\ s^{-1};\ n = 730\text{rpm};\ D_ц = 2;\ R_ц = 0{,}32\ m;\ m_ц = (400 \div 500)kg;$$

$$m_{хв} = 0{,}3 \div 0{,}6kg;\ k = 0{,}2 \div 0{,}6;\ c_1 = 4{,}5 \div 6{,}0 \cdot 104\frac{N}{m};$$

$$c_2 = 0{,}5 \div 0{,}8 \cdot 104\ Nm;\ \pi = 3{,}14.$$

Based on the numerical solution of the problem, graphical dependences of the system parameters were constructed. Figure 2 shows the constructed graphical dependences of the change in the amplitude of oscillations of the saw cylinder on elastic supports on the variation of the angular velocity of the saw cylinder for various gin performance.

At the same time, an increase in the angular velocity of the gin saw cylinder leads to an increase in its oscillation amplitude according to a nonlinear regularity. So, when $\omega_ц$ changes from 68 s^{-1} to 80.2 s^{-1}, the oscillation amplitude increases from $0.205 \cdot 10^{-3}$m to $0.61 \cdot 10^{-3}$m with a mass of cotton fiber trapped and dragged by the teeth of the saw cylinder of 0.35 kg, and when $m_{хв} = 0{,}75$ kg, the amplitude A increases from $0.42 \cdot 10^{-3}$ m to $1.409 \cdot 10^{-3}$ m. Taking into account the results of experimental studies, the maximum bending of the saw cylinder shaft taking into account the elastic bearing support is within $(0{,}3 \div 0.38) \cdot 10^{-3}$m. To ensure these values, the recommended values are: $m_{хв} = (0{,}35 \div 0{,}4)kg$; $\omega_ц = (7{,}4 \div 7{,}8) \cdot 10s^{-1}$.

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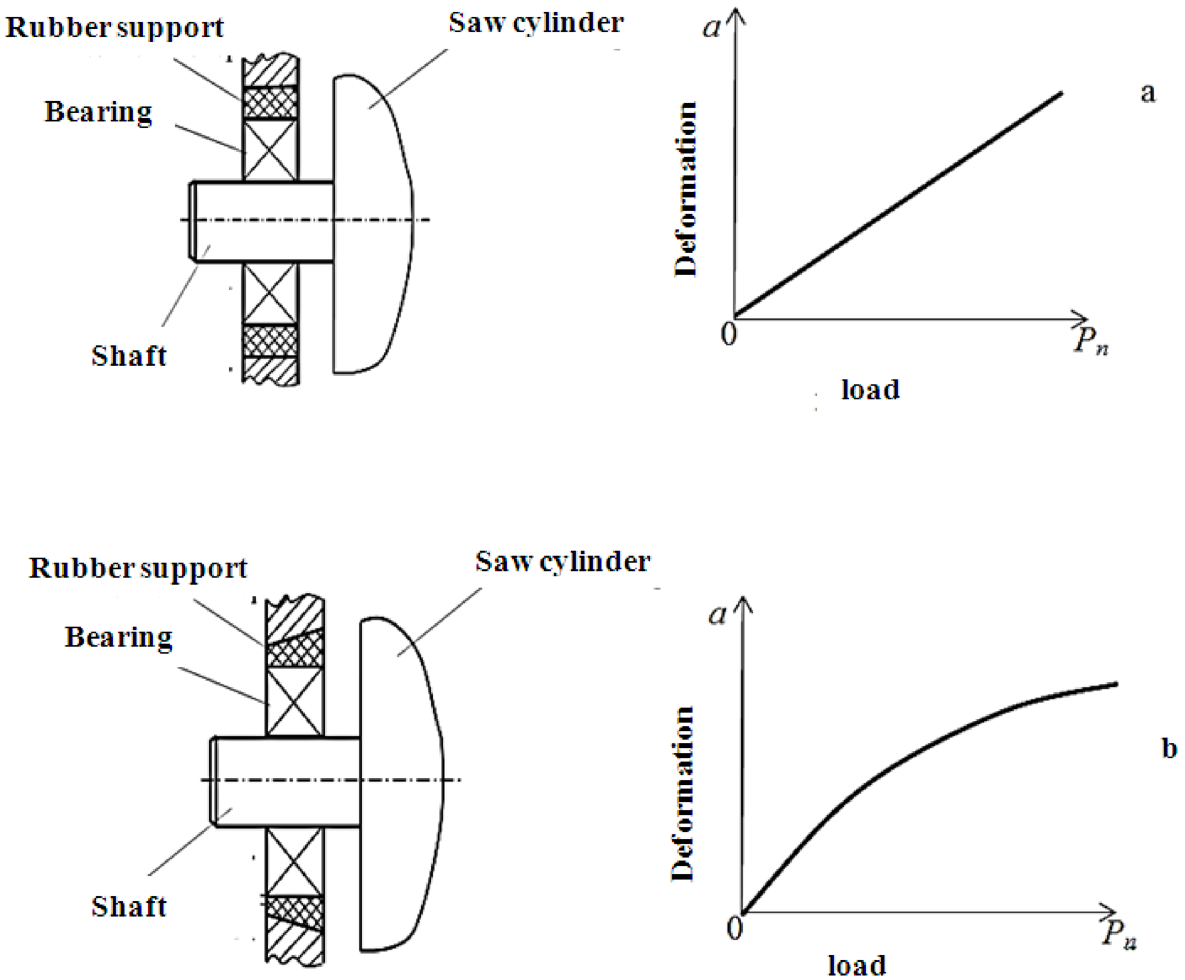

Fig. 1. Schemes of a bearing support with elastic elements
a - with a cylindrical rubber sleeve;
b - with a conical rubber sleeve.

It is important to study the influence of the rigidity of the elastic supports on the amplitude of oscillation of the saw cylinder. In fig. 2.b presents graphical dependences of the change in the amplitude of oscillations of the saw cylinder on the variation of the stiffness coefficient of the elastic rubber bearing support of the gin saw cylinder.

An analysis of the constructed graphical dependences shows that with an increased stiffness coefficient of the elastic bearing support from $4.61 \cdot 10^4$ N/m to $6.0 \cdot 10^2$ N/m, the amplitude of oscillations of the saw cylinder decreases from $1.315 \cdot 10^{-3}$ m to $0.39 \cdot 10^{-3}$ m according to a nonlinear regularity at $\omega_ц=80$ s^{-1} and k= 0.6. With a decrease in $\omega_ц$ and coefficient to k=0.2 and $\omega_ц=70$s^{-1}, the oscillation amplitude of the saw cylinder decreases to $0.11 \cdot 10^{-3}$ m.

To ensure the oscillations of the saw cylinder within $(0.3 \div 0.38) \cdot 10^{-3}$ m, taking into account the elastic bearing support with a conical shape, it is recommended: $c_п=(5.4 \div 6.0) \cdot 10^4$ N/m, $\omega_ц=(7.4 \div 7.8) \cdot 10$ s^{-1}; k = 0.2 ÷ 0.4.

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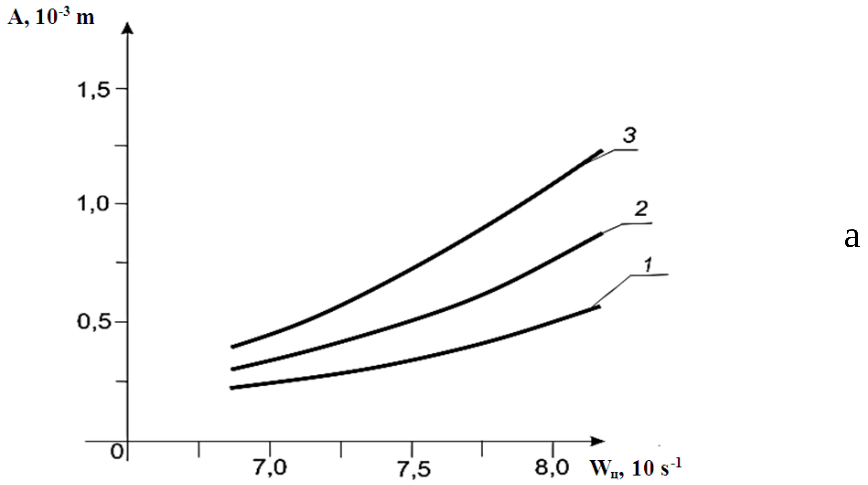
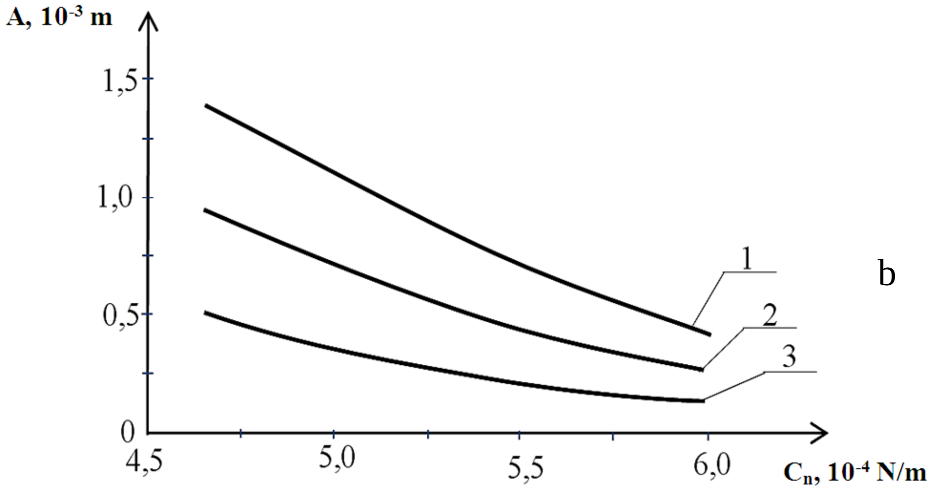


where, 1- and$m_{x6} = 0.35\ kg$; 2- and$m_{x6} = 0.55\ kg$; 3- and$m_{x6} = 0.75\ kg$



where, 1- and k=0,6; $\omega_{ц} = 80\ s^{-1}$; 2- andk=0,4; $\omega_{ц} = 76\ s^{-1}$; 3- andk=0,2; $\omega_{ц} = 70\ s^{-1}$;

a - patterns of change in the amplitude of oscillations of the saw cylinder with an elastic conical bearing of the bearing from a change in the angular velocity of the saw cylinder;

b - patterns of change in the amplitude of oscillations of the saw cylinder with an elastic conical bearing of the bearing from a change in the coefficient of total stiffness of the elastic support.

Fig. 2.Graphical dependence of the amplitude of oscillations of the saw cylinder.

II. CONCLUSION

Graphical dependencies of changes in the amplitude of fluctuations in the speed of the saw cylinder from changes in load from cotton are constructed. At the same time, an increase in F_0 from 0.25 n to 1.8 n at mc = 3.75 амп 102 kg, the amplitude of the oscillations in the speed of the saw cylinder can increase to 2.1 m / s. It was revealed that an increase in the stiffness coefficient of an elastic bearing support leads not only to a decrease in the amplitude of oscillations of displacement and speed, but also to an increase in the frequency of oscillations of the saw cylinder. In this case, the value of the static deformation of the elastic bearings is also reduced.

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