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JUSTIFICATION OF PARAMETERS OF COMPONENT ROLLER OF CHAIN OF TRANSMISSION

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Abstract

The article presents the analysis of the amplitude and frequency of oscillations of the composite roller of the transmission chain of the recommended chain transfer. Graphic dependencies are obtained according to the change in the parameters of the chain transfer. The recommended values are given.

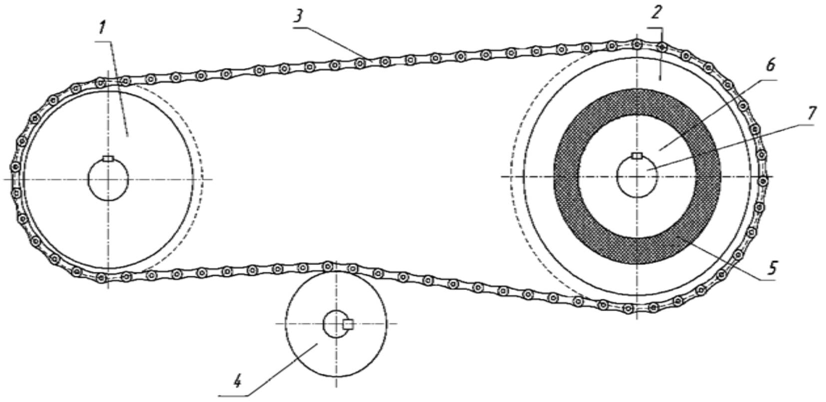
Keywords: Chain transmission, tension roller, composite roller, elastic bushing, angular displacement, vibration frequency, stiffness, wear, noise, frequency, amplitude.

Introduction

The design of the recommended chain drive includes a drive 1 and a driven 2 sprocket, a chain roller covering their chain 3, the idler roller 4. The driven star 2 is made of a composite consisting of the outer part 2 with teeth, the base 6 with the output shaft 7, and an elastic ring sleeve 5. The chain 3 includes the outer 8 and the inner 9 links, the roller 10, the sleeve 11 and the composite roller 12 consisting of the outer 13 and inner 14 sleeves, between which a rubber (elastic) sleeve 15 is installed. The outer surface 16 of the rubber sleeve 15 is made concave curvilinear shape corresponding to continuously inner surface of the outer sleeve 8 is curved convex form [1,2].

Chain transmission works as follows. The rotational movement from the drive sprocket 1 is transmitted to the driven sprocket 2 through the chain 3. Next, the movement from the asterisk 2 is transmitted to the base 6 with the output shaft 7 through the elastic annular sleeve 5. while changing the angular displacements of the driven sprocket 2, resulting from gaps between chain 3 and the teeth of the sprocket 2, as well as due to changes in friction and wear and the gearing, etc., are to some extent aligned (absorbed, absorbed) by an elastic ring sleeve 5. In this case, the rotation of the base 6 with the output shaft 7 of the sprocket 2 becomes more avnomernym and smooth.

When the teeth of the sprockets 1 and 2 interact with the roller 12 due to the deformation of the rubber sleeve 15, the wear of the sleeve 13 and the teeth of the stars 1 and 2 is significantly reduced. This also reduces the friction between the sleeve 11 and the roller 10. This leads to an increase in durability and reliable operation of the chain transmission



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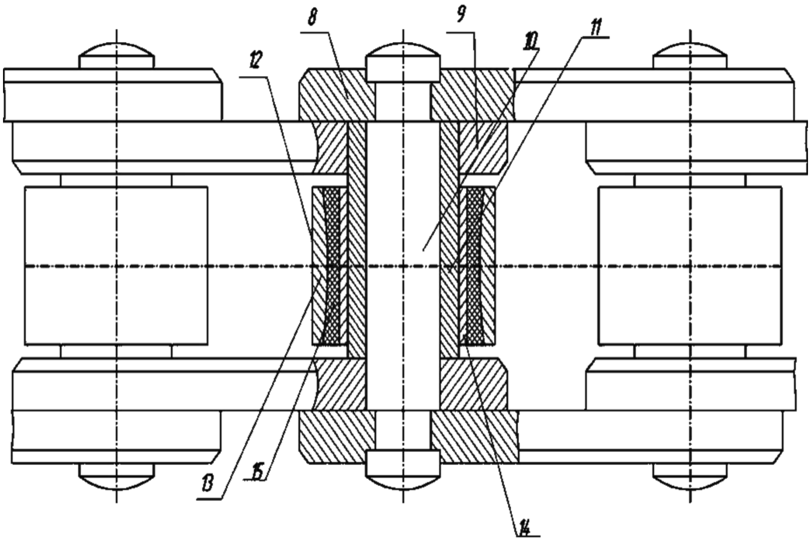

Fig. 1 - Scheme of chain transmission with composite rollers.

In the process, due to the outer surface 16 of the rubber bushing 15, when interacting with the teeth of sprockets 1 and 2, the necessary deformations of the bushing 15 occur, especially along its edges, a kind of centering of pressure on the roller 12 from the teeth of sprockets 1 and 2 occurs. load over the entire length of the roller 12, allowing increased reliability, thereby increasing the resource chain 3 transmissions.

When the sprocket teeth impact the transmission chain's composite rollers, the elastic sleeve is instantaneously deformed. It is important to determine the frequency of vibrations of composite rollers that affect wear, noise and service life.

In this case, we assume [3] that when determining the deformation values of the supports of the composite roller, the kinetic energy of the sprocket together with the roller in the process of striking the chain transfer roller passing into the potential energy of the deformable rubber support we have:

$$T = \frac{mV_y^2}{2}, \qquad \Pi = \int_0^{x_{\max}} \left(c_1 x + c_2 x^3\right) dx \qquad (1)$$

where T is the kinetic asterisks and composite roller; t is the mass of the roller; V_y - speed of the asterisk on the roller; C_1 is the linear component of the stiffness coefficient of the elastic support of the roller; C_2 is the nonlinear component of the stiffness coefficient; P is the potential energy of the deformable elastic sleeve of the composite transmission chain roller.

You can determine the speed:

$$V_y = \sqrt{\frac{2}{m}\int_0^a c_1 x dx + \int_0^a \frac{c_2}{\mu} x^3 dx} \qquad (2)$$

where, a - the maximum value of the deformation of the rubber sleeve of the transmission chain roller.

If we consider the oscillations of a composite roller as a single-mass system, then under conditions from x = 0 to x = a, the oscillations will be

$$t = 4\sqrt{\frac{n}{\alpha}} \cdot \frac{1}{\alpha^{n-1}} \int_0^1 \frac{d\xi}{\sqrt{1-\xi^{2n}}} \qquad (3)$$

where, α and n – permanent, $n-1,2...,$; $\xi = X/a$, with a restoring force equal αx^{2n-1}.

Then the frequencies of free oscillations, taking into account $\rho_2 = 2\pi / T$, we obtain:

$$\rho_k = \frac{0{,}25a\sqrt{c_1 c_2/\mu}}{\sqrt{m}(2\pi\alpha\sqrt{c_2/\mu} + 1{,}85\sqrt{c_1}} \qquad (4)$$

where, μ - coefficient taking into account the nonlinearity of the elastic characteristics of the rubber support of the composite roller chain.

From (4) it can be seen that the natural frequency of oscillation decreases nonlinearly with increasing mass of the composite roller of the transmission chain.

The analysis revealed that with an increase in the amplitude of oscillations and stiffness coefficients c_1 and c_2, the natural frequency changes in a non-linear manner.

Calculations were carried out with the following values of the initial parameters:

$$m = (0{,}1 - 0{,}2)\,кг;\ c_1 = 0{,}6\ Н/мм;\ c_2 = 0{,}04\ Н/мм;$$

$$\mu = (0{,}27 \div 0{,}4)м^2.$$

Figure 2 shows the graphical dependences of the change in the relative value of the natural frequency of oscillations of a composite chain of a chain to increase its mass. Analysis of the graphs shows that the relative value of the natural frequency with increasing mass of the composite roller decreases according to a nonlinear pattern. The magnitude of the amplitude (deformation of the elastic support) does not actually affect this pattern, that is, an increase in the amplitude leads to a parallel movement upwards of the regularity curve with the difference $\rho_k/\rho_н$=0.15-0.08 (with increasing a from 0.3 • 10^{-3} m to 0.8 • 10^{-3}).

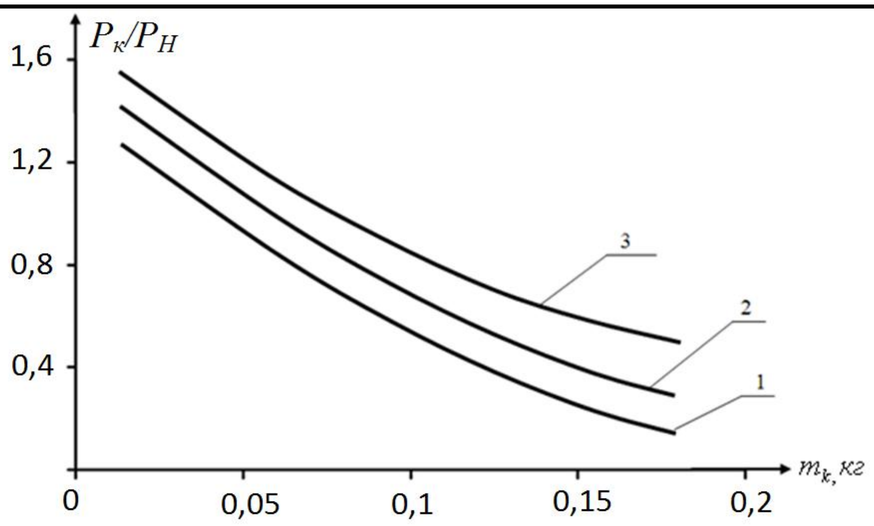

Fig.2 - Graphic dependences of the modified relative value of the natural frequency of oscillation of a composite chain roller from increasing its mass.

1- at $a = 0{,}3 \cdot 10^{-3}$ *м*; *2*- at $a = 0.5 \cdot 10^{-3}$ *м*; *3*- at $a = 0.8 \cdot 10^{-3}$ *м*

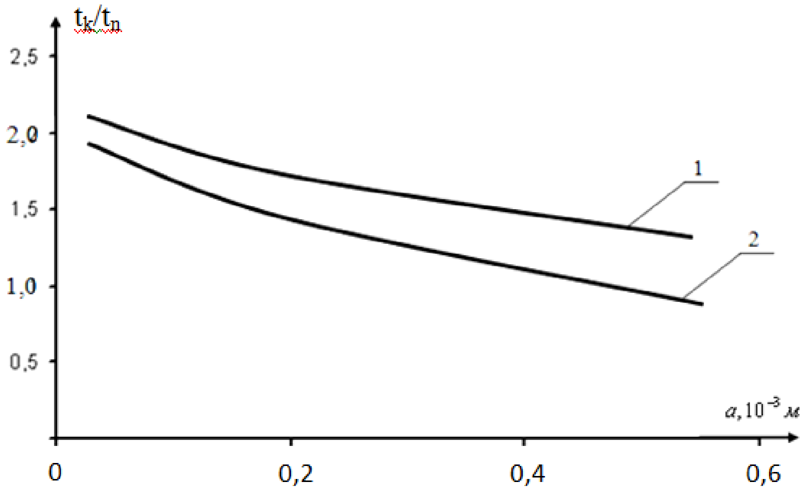

Fig.3 - Graphic dependences of the change in the relative value of the oscillation period of the composite roller of the chain from the change in the maximum amplitude.

where,1 - m_k= 0,15 kg; 2 - m_k= 0,11kg

Figure 3 presents graphs of the change in the relative magnitude of the oscillation period of a chain roller on an elastic support with a nonlinear characteristic as a result of a change in the amplitude of natural oscillations. So, with the amplitude value, the oscillation period is t_k/t_n=1.9, with m_k=0.15 kg, and with a=0.6•0.11 kg and m_k=0.11 kg, the oscillation period is t_k/t_n=1.49. This means that the amplitude of oscillations of the composite roller of the chain slightly affects the period and frequency of oscillations.

The amplitude of natural oscillations depends on the magnitude of the deformations of the elastic support, that is, on its stiffness characteristic. Figure 4 shows the graphical dependences of the change in the relative magnitude of the natural frequency of oscillation (the ratio of the current value of the natural frequency to the calculated one) on the change in the coefficients of the stiffness of the elastic support. It can be seen from the graphs that an increase in the stiffness of the elastic support leads to an increase in the natural frequency of the system according to a non-linear pattern. The nonlinearity of the elastic support depends on the difference in the diameters of the rubber sleeve of the transmission chain's composite roller.

When calculating the stiffness coefficient C_1 and C_2 is given for rubber bushings attributable to one roller of the chain. When the stiffness coefficient is C_2=0.04 N/mm, the increase in the stiffness coefficient C_1 from 0.2 N/mm to 0.8 N/mm, the value of the relative frequency increases almost twice from $\rho_k/\rho_н$=1.12 to. 2.21 With a decrease in the value of C_2 to 0.02 N/mm, the intensity of increase in the natural frequency of oscillation of the grates decreases (see Fig. 4, curve 2).

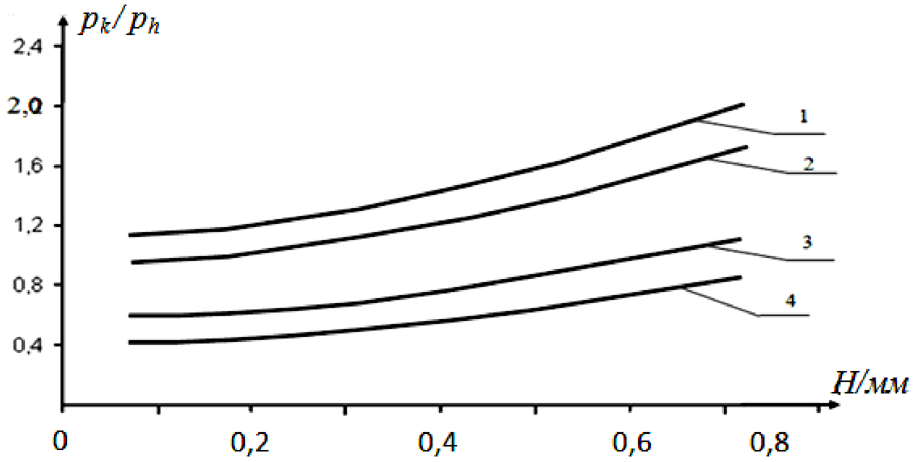

Fig.4 - Graphic dependences of the change in the relative values of the natural frequency of oscillations of the composite roller of the chain from the change in the stiffness coefficients of an elastic support with a nonlinear characteristic.

where,1- at $\rho_к / \rho_н = f(c_1),\ c_2 = 0.04\ H/мм$; 2- at $\rho_к / \rho_н = f(c_1),\ c_2 = 0{,}02\ H/мм$;

3- at $\rho_к / \rho_н = f(c_2),\ c_1 = 0.03\ H/мм$; 4- at $\rho_к / \rho_н = f(c_2),\ c_1 = 0.02\ H/мм$;

With a constant value of C_2 with an increase in C_1 from 0.2 N/mm to 0.8 N/mm, it leads to an increase in ρ_k/ρ_n from 0.55 to 1.15, also twice. This means that in order to increase the limit of the values of the natural frequency of oscillations of the composite roller, it is expedient to increase the stiffness of the elastic support. It is expedient to consider the oscillation system considered as C_2=0.03 ÷ 0.05 N / mm C_1=0.5 ÷ 0.8 N/mm with m_k=0.15 ÷ 0.2 kg.

Special is the choice of the stiffness of the elastic sleeve of the composite chain roller, and thus the brand of rubber. Consider the deformation scheme of the elastic sleeves of the composite roller of the transmission chain (see figure 5). It is known [4] that the greatest load falls on the first teeth of the asterisks. Therefore, the greatest deformation of the elastic sleeve also occurs between the first and second teeth of sprockets. Each subsequent composite video is experiencing less force than the previous one.

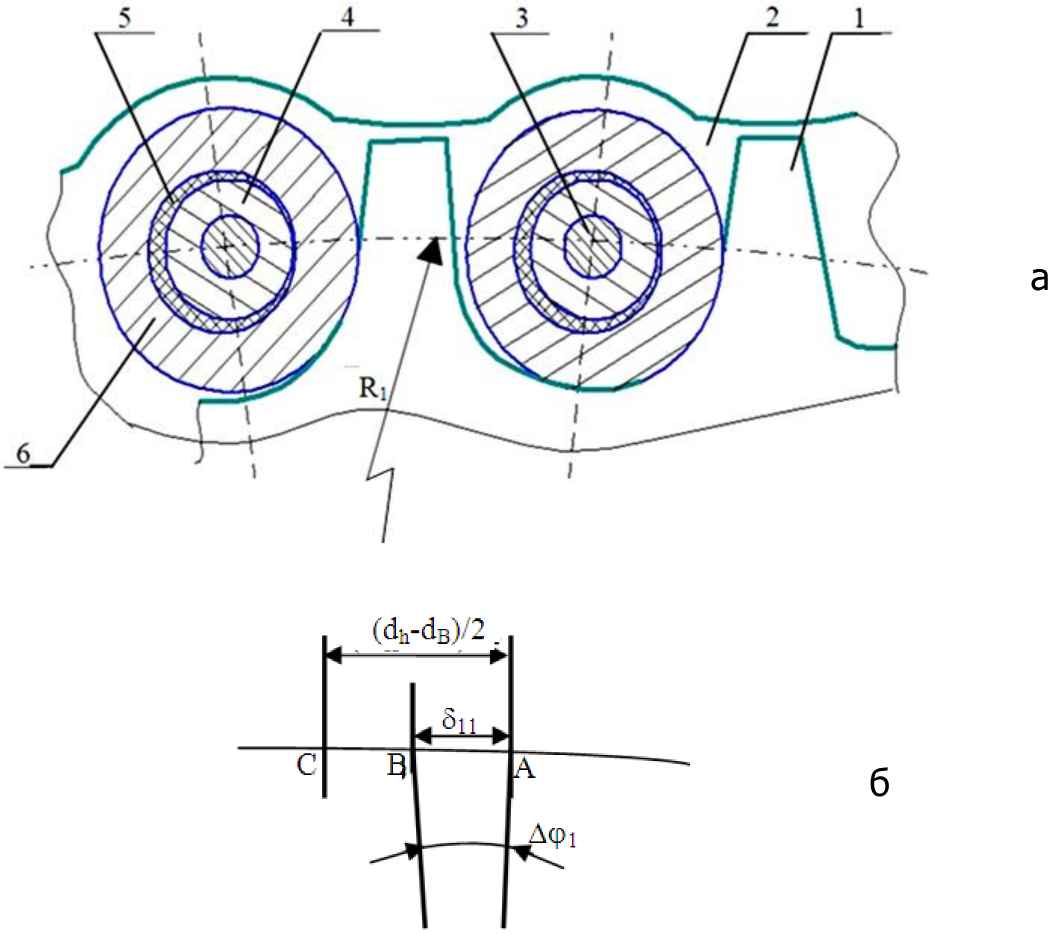

Fig.5. a-diagram of the chain with an asterisk when the elastic sleeve of the roller is deformed; b - scheme for calculating the deformation of the elastic roller sleeve.

where, 1-star, 2-chain, 3-axis, 4-sleeve, 5-elastic rubber sleeve, 6-ring outer sleeve.

At the same time, the values of the deformation of the subsequent elastic bushings of the chain which are meshed are also reduced accordingly. Therefore, you can write:

$$\delta_{11}>\delta_{12}>\delta_{13}>\ldots>\delta_{1n} \qquad (5)$$

$$\delta_{21}>\delta_{22}>\delta_{23}>\ldots>\delta_{2n};$$

where, $\delta11$, $\delta12$, ... $\delta1$, $\delta21$, $\delta22$, ... $\delta2n$ are the transverse linear deformations of the elastic sleeves that engage, respectively, with the master and the driven asterisks.

$AC = \frac{d_H - d_B}{2}$ - δ_1 = AB – the value of the deformation of the elastic rubber sleeve when interacting with the tooth with an asterisk.δinitial thickness of the elastic rubber sleeve;

Linear deformations δ_{1n} and δ_{2n} along the axis of the location of the rollers in engagement with asterisks are determined from the following expressions:

$$\delta_{11}=\Delta\varphi_{11}R_1;\ \delta_{12}=\Delta\varphi_{12}R_1,\ldots\delta_{1n}=\Delta\varphi_{1n}R_1 \qquad (6)$$

$$\delta_{21}=\Delta\varphi_{21}R_2;\ \delta_{22}=\Delta\varphi_{22}R_2,\ldots\delta_{2n}=\Delta\varphi_{2n}R_2$$

where, $\Delta\varphi_{11}$, $\Delta\varphi_{12}$,…$\Delta\varphi_{1n}$, $\Delta\varphi_{21}$, $\Delta\varphi_{22}$,…$\Delta\varphi_{2n}$ - are the angular displacements during the deformation of the elastic sleeves, respectively, meshed with the teeth of the driving and driven sprockets. R_1, R_2 - the radii of the stars of the location of the axes of the rollers.

The total deformations of the elastic sleeves of the composite chain rollers when engaged with the driving and driven stars should be equal to each other:

$$\delta_1=\delta_2, \delta_1= R_1\Delta\varphi_1;\ \delta_2= R_2\Delta\varphi_2 \qquad (7)$$

or with

$$\Delta\varphi_1 = \Delta\varphi_{11} + \Delta\varphi_{12} \dots + \Delta\varphi_{1n} = \sum_{i=1}^{n} \Delta\varphi_{1i} \qquad (8)$$

$$\varphi_2 = \Delta\varphi_{12} + \Delta\varphi_{22} \dots + \Delta\varphi_{2n} = \sum_{i=1}^{n} \Delta\varphi_{2i}$$

We have

$$U_{12} = \frac{R_2}{R_1} = \sum_{-n}^{n} \Delta\varphi_{1i} \,/ \sum_{-n}^{n} \Delta\varphi_{2i} \qquad (9)$$

On the shaft of the drive sprocket is applied the driving moment:

$$M_{\text{д}}=R_1\cdot F_m \qquad (10)$$

where, F_m is the tractive force of the chain transmission.

Taking into account the total deformation of the elastic sleeves of the composite chain rollers that are in engagement with the teeth of the sprockets, we have:

$$M_{\text{д}}= C_1\cdot\Delta\varphi_1;\ M_2=C_2\cdot\Delta\varphi_2 \qquad (11)$$

where, C_1, C_2 is the total circular reduced stiffness of the elastic bushings of the composite rollers of the transmission chain, respectively, in the driving and driven sprockets.

In the course of operation of the recommended chain transmission, for high values of the deformation of the elastic bushings, a violation of the clutch may occur. Therefore, the maximum total value of the deformation around the axis of the chain rollers in the sprockets should not exceed the gaps between the rollers and the teeth of the sprockets. This gap, according to [5], is within 0.15 ... 0.225% of the sprocket spacing. The values of the circular circular rigidity of the elastic sleeves for the corresponding asterisks are determined from the following expressions:

$$C_1 = \frac{R_1 M_{\text{Д}}}{(0{,}15\dots0{,}225)t};\ C_2 = \frac{R_2 M_{\text{Д}} U_{12}}{(0{,}15\dots0{,}225)t} \qquad (12)$$

Figure 6 shows the results of calculating the values of C_1 and C_2 for the chain transmission in the drive of the saw cylinder of the raw cotton cleaner from coarse litter. In this case, the initial values are:

$U_{12}= 1{,}25$, $R_1=74\cdot10^{-3}$ м, $R_2=92{,}5\cdot10^{-3}$ м, $M_{\text{д}}=19{,}28$ Нм, $M_2=24{,}10$ Нм, $t=2{,}6410^{-2}$ м.

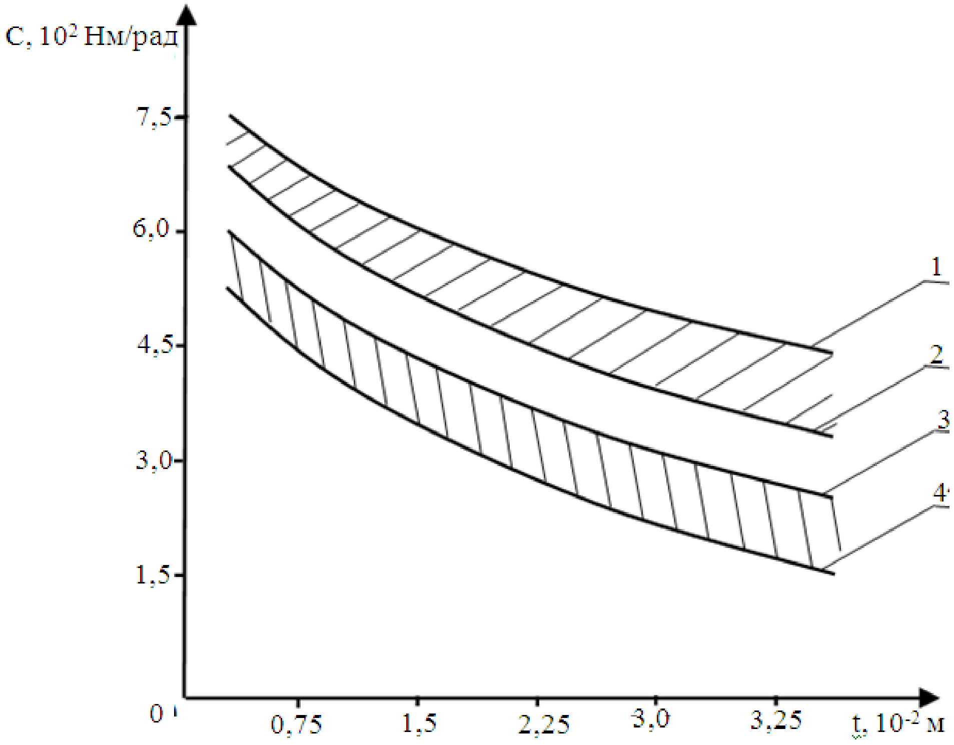

Fig. 6. Graphic dependences of the change in the reduced total stiffness of the elastic sleeves of the composite rollers of the chain when engaged with the drive and driven stars to change their pitch.

where, 1,2- for the driven star; 3.4 for leading sprocket, 1,3-at-0.15t; 2,4-at - 0,225 t, t-spacing between the teeth of sprockets.

From the graphs in Fig. 6, it can be seen that, with an increased sprocket pitch, the reduced circular total stiffnesses of the elastic rollers of the rollers meshed with the teeth of the sprockets are reduced according to a nonlinear attern. For the considered chain drive, the recommended values of the total circular stiffness of the elastic bushings meshed with the teeth of the chain drive sprockets are $C_1=(2.84\ldots\ 3.52)\cdot 10^2$ Nm/rad. $C_2=(4.42\ldots\ 5.3)\cdot 10^2$ Nm/rad. In addition, according to the specified hardness, rubber brand 7B-14MVS is recommended for the manufacture of elastic sleeves of a composite transmission chain roller when using cotton cleaner in the drive.

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