Study of the influence of the parameters of the belt drive on the stiffness of the elastic element of the composite tension roller

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Abstract :- The article provides definitions of the stiffness coefficient of the elastic bushing of the composite tension roller of the belt drive. The influence of the parameters of the belt drive on the deformation characteristics of the elastic element of the composite driven pulley is studied. The dependences of the change in the stiffness coefficient of the elastic sleeve of the tension roller with the change in the radius and angle of the belt wrapping of the tension roller are plotted.

Keywords: belt drive, driving pulley, driven pulley, composite tension roller, elastic bushing, stiffness coefficient.

Introduction

It is known that the traction capacity of belt drives with a tensioner is greater than in transmissions without tensioners [1]. Usually, in belt drives with constant belt tension, the gear ratio is constant. In this case, the tensions of the leading and driven branches are also constant. But, in technological machines, the load in the belt drive will be variable [2, 3]. In this case, the tension of the belt branches will also change. In order to maintain the tension of the belt within certain limits, to increase its durability, we recommend a belt drive, the tension roller of which is made integral with an elastic element. In this case, the outer sleeve of the tension roller is made of rubber with a certain rigidity. It is important to determine the stiffness of the elastic sleeve of the composite tension roller, depending on the parameters of the belt drive. Figure 1.a shows a diagram of the recommended belt drive, from which the elastic bushing 5 to some extent dampens the vibrations of the driven belt branch. The degree of interaction of the belt 3 with the sleeve 5 depends on the transmission parameters, especially on the rigidity of the sleeve 5 of the tension roller 4. From work [2] it is known that the initial tension of the belt is determined from the expression:

$$S_0 = \frac{\gamma_p \cdot в_p \cdot h_p}{g} \vartheta^2 \qquad (1)$$

where γ_p is the specific entire belt, $в_p$ is the width of the belt, h_p is the thickness of the belt, ϑ is the circumferential speed, g is the acceleration of gravity.

Consider the design scheme shown in Fig.1. b According to this scheme, we determine the force of interaction of the roller with the belts, considering (1):

$$Q_p = \frac{\omega_3^2 R_3^2 \cdot \gamma_p \cdot в_p \cdot h_p}{g \cos \Delta_p} \cdot \left(\sin \alpha_3' + \sin \alpha_3''\right)$$

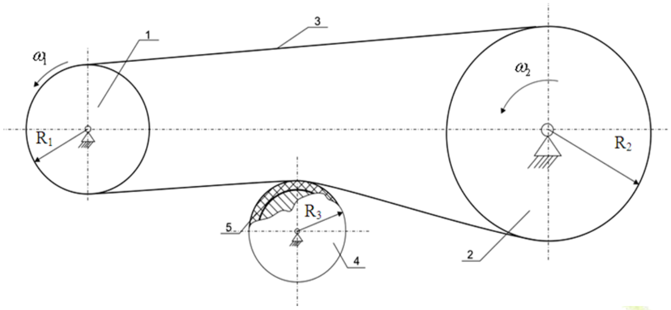
Consider the design scheme shown in Fig.1. b According to this scheme, we determine the force of interaction of the roller with the belts, considering (1):

where Δ is the deformation of the elastic sleeve in the vertical direction.

When the belt interacts with the elastic sleeve of the tension roller, the elastic sleeve is deformed in the vertical direction.

Based on this, it is possible to determine the stiffness coefficient of the elastic sleeve when the belt acts on the sleeve by force :

$$C_s = \frac{\omega_3^2 R_3^2 \cdot \gamma_p \cdot \varepsilon_p \cdot h_p}{\Delta g \cos \Delta_p} \cdot \left(\sin \alpha_3' + \sin \alpha_3''\right) \qquad (2)$$

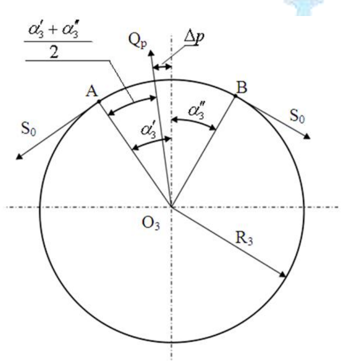


where *1*-driving pulley, *2*-driven pulley, *3*-belt, *4*-composite tension roller, *5*-elastic bushing.

Fig. 1. a). Belt drive with integral tension roller

the operation of the belt drive, as can be seen from expression (2), the stiffness coefficient of the elastic sleeve of the composite tension roller depends mainly on the radius and speed of rotation of the roller, belt parameters, wrap angle, etc. bushings from changing the value of the radius of the tension roller and the angle of the belt wrap around the tension roller of the transmission. The analysis of the graphs obtained shows that with an increase in the radius of the tension roller, the increase in the stiffness coefficient has a nonlinear character.

So, with an increase in the radius of the tension roller from $1.0 \cdot 10^{-2}$ m to $3.85 \cdot 10^{-2}$ m, the rigidity of the elastic sleeve of the tension roller increases from $0.85 \cdot 10^3$ N/m to $5.65 \cdot 10^3$ N/m.



where α_3' ,α_3'' are the components of the belt wrap angle of the elastic sleeve of the tension roller; Δ_p -angle between the force Q_p and the vertical axis of the belt.

Fig. 1. b). Design diagram of the interaction of the belt with the tension roller

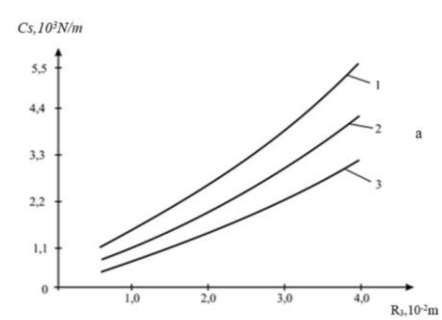
This is since with an increase in the radius of the tension roller, the force of interaction of the elastic sleeve with the belt increases, and therefore the rigidity of the sleeve increases accordingly. An increase in the angle of the belt wrap around the surface of the elastic transmission sleeve also leads to an increase in the rigidity of the elastic sleeve according to a nonlinear pattern.

The nonlinearity of the graphs is also because with a change in $\alpha_3' + \alpha_3''$ the angle of action of the force Q_p changes accordingly.

With $(\alpha_3' + \alpha_3'')$=1,65 rad and ω_3=44,3 s^{-1}, the stiffness coefficient reaches $3.92 \cdot 10^3$ N/m.

It is important to select the values of the stiffness coefficient of the elastic sleeve at small values of the roller radius and the largest values of the wrap angle. In this case, for the belt drive under consideration, the recommended parameters are: $(\alpha_3' + \alpha_3'')$=1,1÷1,3 rad, R_3=(2,5÷3,5)$\cdot 10^{-2}$ m; C_s=(4,1÷5,3)$\cdot 10^2$ N/m.

In several technological machines, in particular in cotton cleaners from fine litter, it is important to rotate the peg drums with a variable angular velocity with a certain frequency and amplitude, allowing the intensification of the cotton cleaning effect [3, 4]. Therefore, in the drive of the machine, belt drives with variable belt tension are used [5]. In this case, in this belt drive, the driven pulley mainly rotates with a variable angular velocity.



where 1-$(\alpha_3' + \alpha_3'')$=1,65; 2-$(\alpha_3' + \alpha_3'')$=1,23; 3-$(\alpha_3' + \alpha_3'')$=0,568

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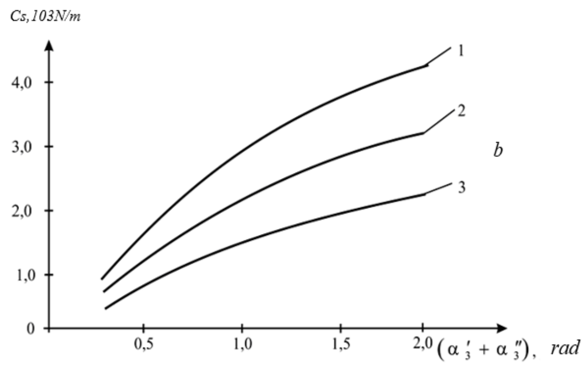
Fig. 2, a). Dependences of the change in the stiffness coefficient of the elastic sleeve of the tension roller on the variation of its radius



1- Δ =0,5·10^{-3} m; 2- Δ =1,0·10^{-3} m; 3- Δ =1,4·10^{-3} m.

Fig. 2. b) Dependences of the change in the stiffness coefficient of the elastic sleeve of the tension roller on the variation of the belt wrap angle of the elastic sleeve surface

Conclusion

Expressions are obtained for determining the stiffness coefficient of the elastic sleeve of the composite tension roller of the belt drive. The dependences of the change in the stiffness coefficient of the elastic sleeve of the tension roller when changing the radius and angle of the belt wrapping of the tension roller are plotted. The recommended parameters are: $\left(\alpha_3^1+\alpha_3^{11}\right)=1{,}1\div1{,}3$ rad; $R_3=\left(2{,}5\div3{,}5\right)\cdot10^{-2}$ m; $c=\left(4{,}1\div5{,}3\right)10^2$ N/m;

The influence of the parameters of the belt drive on the deformation characteristics of the elastic element of the composite driven pulley is studied. The formula for calculating the stiffness coefficient of the elastic element of the driven pulley of the belt drive is derived. For the drive of the sewing machine, the recommended values of the stiffness coefficient are (3.5-4.0) ·10^2 Nm/rad (rubber brand 3820 MVCS).

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