Keywords: Belt drive; Tension; Roller; Extension; Leading branch; Voltage; Fluctuation; The moment; Resistance

Introduction

On a number of technological machines, in particular of small cotton cleaners litter is important in kolkova drum rotation angular speed of a variable at a certain frequency and amplitude, allowing effect intensification cotton cleaning [1,2].

Therefore, in the drive of the machine used belt transmission with belt tension [3]. Thus in the belt drive (Figure 1) is mainly driven pulley is rotated at variable angular speed.

The theoretical task of the problem: In the process of transmission branches are extended on the values depend on the change of angular speeds pulleys. According to the work of the branches in the belt drive extension determined from the expression:

\[
\Delta l_1 = \Delta l_{10} \left[ 1 + \frac{D}{E \omega} \left( (e^{-f \phi}) - 1 \right) \right],
\]

\[
\Delta l_2 = \Delta l_{20} \left[ 1 + \frac{D}{E \omega} \left( (e^{f \phi}) - 1 \right) \right]
\]

Where, \( \Delta l_{10}, \Delta l_{20} \) - changes in belt stress transmission branches Pa; \( E \) - modulus belt, Pa; \( D, D_1 \) - the diameters of the guiding and driven pulleys, mm; \( f \) - the coefficient of friction of the belt on the pulley surface; \( \phi \) - elastic slip angle. Furthermore, lengthening pulleys branches can be determined by the angular displacement of pulleys:

\[
\Delta l_1 = (D_1 \phi_1 - D \phi_1),
\]

\[
\Delta l_2 = (D_2 \phi_2 - D \phi_2)
\]

Thus according to Figure 1 can be determined

\[
I_1 + \Delta l_1 = I_1' + \Delta l_1' + R_p \sin \alpha + l_1' + \Delta l_1'
\]

or \( \Delta l_1 = \Delta l_1' + \Delta l_2' \)

Differential equations describing the motion of the belt drive pulleys are of the form

\[
j_1 \frac{d^2 \phi_1}{dt^2} + \frac{k_1 D_1 F_1}{4} \phi_1 - \frac{k_1 D_1 F_1}{4} \phi_2 = M_{e1},
\]

\[
j_2 \frac{d^2 \phi_2}{dt^2} - \frac{k_1 D_1 F_1}{4} \phi_1 + \frac{k_1 D_1 F_1}{4} \phi_2 = M_{e2}
\]

Where, \( k_1 = (k_1 + k_2) \frac{1}{k_k} \); \( k_1 = \frac{1}{E} \left( \frac{D_1}{2E} (1 - e^{-f \phi}) \right); \)

\( M_{e} \)-drive moment to the drive pulley shaft, \( M_{e} \) - the amplitude hesitation of the driving and disturbing moments. Decision of system (4) differential equations belt drive found in the form:

\[
\phi_1 = \phi_{10} \sin \omega t, \phi_2 = \phi_{20} \sin \omega t
\]

Supplying (5) with respectively, in the equation (4) we obtain the expression for determining the values the amplitudes ripple of the belt drive pulleys

\[
\varphi_{10} = \frac{B \left( M_{e} \sin \omega t + J_{o} \omega^2 \right) + A \left( J_{o} \omega^2 + M_{e} \right)}{A^2 - B^2},
\]

\[
\varphi_{20} = \frac{B \left( M_{e} \sin \omega t + J_{o} \omega^2 \right) + A \left( J_{o} \omega^2 + M_{e} \right)}{A^2 - B^2}
\]

Where, \( A = \frac{K_1 D_1 F_1}{4}; B = \frac{K_1 D_2 F_1}{4} \)

When this tension will change

Figure 1: Scheme of belt drive with an eccentric tensioning roller.
Δσ_{10} = \frac{R_{p_{10}} - R_{p_{20}}}{k_1},

Δσ_{20} = \frac{R_{p_{20}} - R_{p_{30}}}{k_2}

(7)

Then, full of tension in the branches of a belt drive get

σ_1 = σ_{10} + Δσ_{10} \sin \omega t ,

σ_2 = σ_{20} + Δσ_{20} \sin \omega t

(8)

Analysis of the Results of the Numerical task of the Problem

Numerical solution and analysis of results in σ_1 and σ_2 changes implemented under the following initial values of the parameters belt drive with variable gear ratio:

\begin{align*}
R_1 &= 1.5 \cdot 10^{-3} \text{ m;} \\
R_2 &= 2.0 \cdot 10^{-3} \text{ m;} \\
I_1 &= 0.02 \text{ kgm}^2; \\
I_2 &= 0.033 \text{ kgm}^2; \\
F &= 2.5 \text{ sm}^2; \\
σ_0 &= 22 \text{ kg/sm}^2; \\
ω &= 0.75, \sigma_{10}=40 \text{ kg/sm}^2, \sigma_{20}=40 \text{ kg/sm}^2, M_0 = 25 \text{ Nm; } \\
M_1 &= 8.5 \text{ Nm}. \end{align*}

From the graphs show that the variation of σ_{10} actually is not treason. However, the amplitude changes Based on the results of processing graphics are constructed according to the changes in the leading branches of the belt M_0, changes in ripple fluctuation amplitude variations at the moment of inertia in pulleys, which are shown in Figure 3a. Analysis of the relationship shows that the moment of inertia in pulleys I_1 = 0.02 kgm^2 and I_2 = 0.035 kgm^2 with an increase in the amplitude of the resistance torque values from 0.12 \cdot 10^2 \text{ Nm} before 0.56 \cdot 10^2 \text{ Nm} voltage oscillation amplitude in the lead belt branches.

Where, 1-th M_1 = 4.5 \text{ Nm; } 2-nd M_1 = 8.5 \text{ Nm; } 3-rd M_1 = 12.0 \text{ Nm.}

Figure 3: Graphic changes depending on the amplitude of the vibrations on the belt tension in the leading branches of the transmission changes in amplitude on the disturbing force to the driven pulley (a) and the maximum belt tension on the voltage variation of the pre-tensioning of the belt (b).
increasing from $0.115 \times 10^2$ kg/sm$^2$ to $0.38 \times 10^2$ kg/sm$^2$ for nonlinear patterns.

When $I_1=0.050$ kgm$^2$ and $I_2=0.075$ kgm$^2$, $\sigma_1$ increases to $0.785 \times 10^2$ kg/sm$^2$.

It is common knowledge the amplitude of the disturbing moment increases the deformation of the belt, and by the tense Ascending. Besides the increase in the moments of inertia of pulleys in the variable driving modes lead to cyclic changes in load in the branches of a belt drive (Figure 3a). Therefore, the recommended value is $I_1=(0.03...0.04)$ kgm$^2$ and $I_2=(0.05...0.06)$ kgm$^2$.

Increased tension $\sigma_1$ at the amplitude of the disturbing drive torque $M_1=12.0$ Nm leads to an increase $\sigma_1^{\text{max}}$ from $0.426 \times 10^2$ kg/sm$^2$ to $1.48 \times 10^2$ kg/sm$^2$, and $M_1=4.5$ Nm maximum value of the voltage fluctuations in the leading branches of the transmission It comes only to $0.93 \times 10^2$ kg/sm$^2$.

It is common knowledge that driving with increasing force values and accordingly increases the belt tension deformation particularly in the leading branch, which transmits the motion from the driving pulley to the driven (Figure 3b). Figure 4 shows the pattern of the belt voltage fluctuations in the leading branches of the transmission by varying the values of $\omega$, $j$, $M_1$, and $M_0$. An analysis of the laws shows that with the change in the frequency of the driving values of $j$ and the frequency $\omega$ resistance on the shaft of the driven pulley is also changed form $\sigma_1$ voltage fluctuations in the leading branches of the belt drive.

At the same time with the increase in $M_1$ and $M_0$ increases the amplitude of the fluctuations $\sigma_1$ as the high-frequency and low-frequency components (Figures 4a and 4b). It should be noted the phase shift with increasing fluctuations $\sigma_1$ with respect to $\omega$.

**Conclusion**

An analytical method for determining the laws of the belt voltage fluctuations in the leading branches of the belt drive with tensioning roller. Substantiates the numerical values of the parameters in the belt transmission.

**References**