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Analysis of Changes in Tension in Leading Branch Belt Drive

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Abstract

This paper presents method of determination in the regularity change in the branches of a belt drive with an eccentric tensioning roller. On the basis of analysis in the research results identified the recommended belt transmission parameters.

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:

$$\Delta l_1 = \Delta\sigma_1\left[\frac{1}{E}+\frac{D_2}{2fE}\left(1-e^{-f\phi_0}\right)\right],$$

$$\Delta l_2 = \Delta\sigma_2\left[\frac{1}{E}+\frac{D_1}{2fE}\left(e^{-f\phi_0}-1\right)\right] \quad (1)$$

Where, $\Delta\sigma_1$, $\Delta\sigma_2$ - changes in belt stress transmission branches Pa; E- modulus belt, Pa; D_1, D_2 - the diameters of the guiding and driven pulleys, mm; *f*- the coefficient of friction of the belt on the pulley surface; ϕ_0 - elastic slip angle. Furthermore, lengthening pulleys branches can be determined by the angular displacement of pulleys:

$$\Delta l_1 = \left(D_1\varphi_1 - D_2\varphi_2\right),$$

$$\Delta l_2 = \left(D_2\varphi_2 - D_1\varphi_1\right) \quad (2)$$

Thus according to Figure 1 can be determined

$$l_2 + \Delta l_2 = l_2^{/} + \Delta l_2^{/} + R_p \sin\alpha + l_2^{//} + \Delta l_2^{//} \quad (3)$$

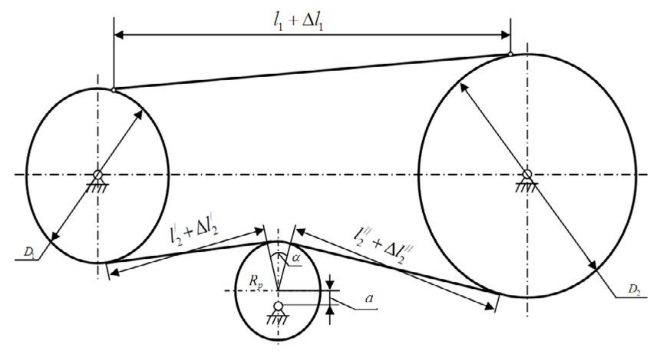

Figure 1: Scheme of belt drive with an eccentric tensioning roller.

or $\Delta l_2 = \Delta l_2^{/} + \Delta l_2^{//}$

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

$$J_1\frac{d^2\varphi_1}{dt^2}+\frac{k_3FD_1^2}{4}\varphi_1-\frac{k_3D_1D_2F}{4}\varphi_2 = M_g,$$

$$J_2\frac{d^2{}_2}{dt}-\frac{k_3D_1D_2F}{4}\varphi_1+\frac{k_3D_2^2F}{4}\varphi_2 = M\sin\omega t \quad (4)$$

Where, $k_3=(k_1+k_2)\frac{1}{k_1k_2}$; $k_1=\frac{1}{E}+\frac{D_2}{2fE}(1-e^{-f\phi_0})$; $k_2=\frac{1}{E}+\frac{D_1}{2fE}(e^{f\varphi_0}-1), M_g = M_1\sin jt\cdot$

M_g-drive moment to the drive pulley shaft, $M_1 M_0$ –the amplitude hesitation of the driving and disturbing moments. Decision of system (4) differential equations belt drive found in the form:

$$\varphi_1=\varphi_{10}\sin\omega t,\ \varphi_2=\varphi_{20}\sin\omega t \quad (5)$$

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

$$\varphi_{10}=\frac{A}{B}\left[\frac{B\left(\frac{M_1\sin jt}{\sin\omega t}+J_1\omega^2\right)+A\left(J_1\omega^2+M_0\right)}{A^2-B^2}\right]-\frac{J_2\omega^2+M_0}{B},$$

$$\varphi_{20}=\frac{B\left(\frac{M_1\sin jt}{\sin\omega t}+J_1\omega^2\right)+A\left(J_1\omega^2+M_0\right)}{A^2-B^2} \quad (6)$$

Where, $A=K_3\frac{D_1^2F}{4}$; $B=K_3\frac{D_1D_2}{4}F$

When this tension will change

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$$\Delta\sigma_{10} = \frac{R_1\varphi_{10} - R_2\varphi_{20}}{k_1},$$

$$\Delta\sigma_{20} = \frac{R_2\varphi_{20} - R_1\varphi_{10}}{k_2} \quad (7)$$

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

$$\sigma_1 = \sigma_{10} + \Delta\sigma_{10}\sin\omega t,$$
$$\sigma_2 = \sigma_{20} + \Delta\sigma_{20}\sin\omega t \quad (8)$$

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:

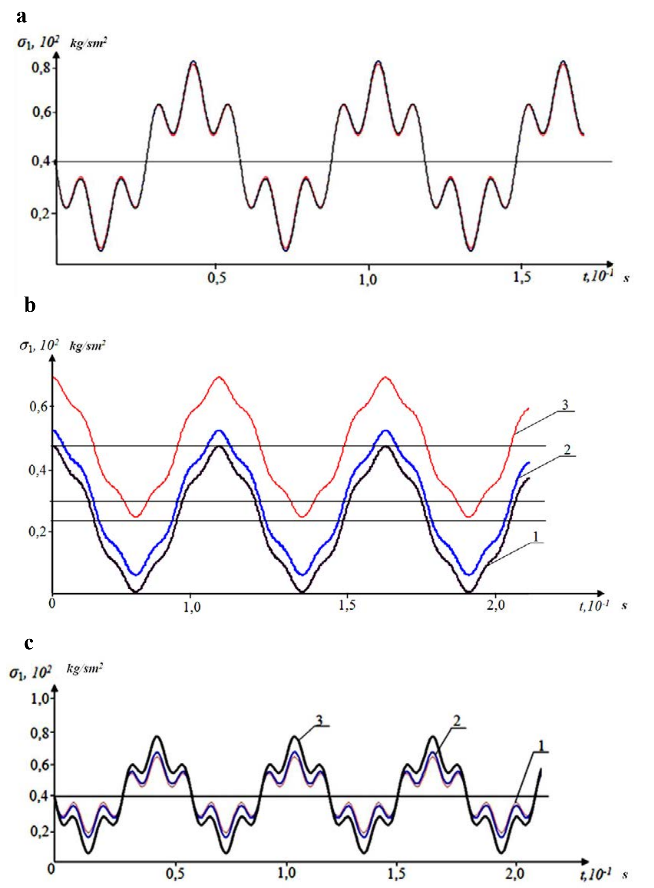
$R_1=1{,}5\cdot10^{-3}$ m; $R_2=2{,}0\cdot10^{-3}$ m; $I_1=0{,}02$ kgm²; $I_2=0{,}033$ kgm²; $F=2{,}5$ sm²; $\sigma_0=22$ kg/sm²; $\omega = 0{,}75_{p_2}$; $\sigma_{10}=40$ kg/sm²; $\sigma_{20}=40$ kg/sm²; $M_0=25$ Nm; $E=12\cdot10^2$ kg/sm²; $l=0{,}185\cdot10^{-3}$ sm; $M_1=8{,}5$ Nm.

Figure 2 shows a graphic pattern of the belt tension changes in the leading branches on the transfer at $\sigma_{10}=40$ kg/sm² $M_1=5{,}2$ Nм, $M_0=18$ Nм.

Analysis of the resulting pattern shows that the amplitude of the low component match, depending on the disturbing M_0 resistance force and frequency ω, high-frequency components is dependent on the value of M_1 and *j*.

The amplitude of the ripples reaches $0{,}373\ 10^2$ kg/sm², low frequency rippling occur in the range of $(9{,}0....11)s^{-1}$. It should be noted that the value of σ_{10} not affect the nature of the change in time σ_1 in time (Figure 2b). Thus, from the graphs in Figure 2b. It is seen that the graphs 1, 2 and 3 are shifted in parallel relative to the axis t. Figure 2 presents the patterns of change in σ_1 changing M_0 and $\sigma_{10}=40$ kg/sm².

From the graphs show that the variation of σ_1 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 $I_1=0{,}02$ kgm² and $I_2=0{,}035$ kgm² with an increase in the amplitude of the resistance torque values from $0{,}12\cdot10^2$ Nm before $0{,}56\cdot10^2$ Nm voltage oscillation amplitude in the lead belt branches



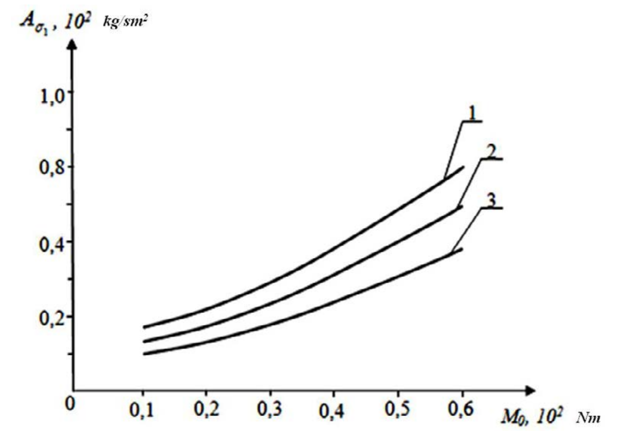
Where,

a-before $\sigma_{10}=0{,}9\cdot10^2$ kg/sm²

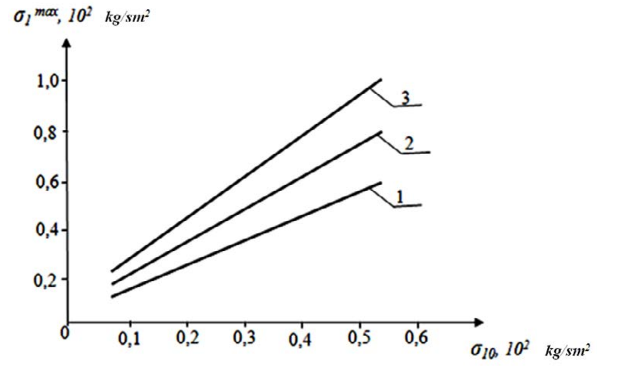
b-before $\sigma_{10}=0{,}28\cdot10^2$ kg/sm² (1- curve); before $\sigma_{10}=0{,}33\cdot10^2$ kg/sm² (2- curve); before $\sigma_{10}=0{,}54\cdot10^2$ kg/sm² (3- curve)

c-before $\sigma_{10}=0{,}4\cdot10^2$ kg/sm²; 1-$M_0=19{,}5$ Nm; 2-$M_0=25{,}0$ Nm; 3-$M_0=28{,}5$ Nm.

Figure 2: Laws of change of tension in the leading branches of the belt drive from time to time σ_1 fluctuations.



Where, 1-th $I_1 = 0{,}050$ kgm²; $I_2 = 0{,}075$ kgm²; 2-nd $I_1 = 0{,}035$ kgm²; $I_2 = 0{,}055$ kgm²; 3-rd $I_1 = 0{,}02$ kgm²; $I_2 = 0{,}035$ kgm²



Where, 1-st $M_1=4{,}5$ Nm; 2-nd $M_1=8{,}5$ Nm; 3-rd $M_1=12{,}0$ 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 $0,115 \cdot 10^2$ *kg/sm* ^{2} to $0,38 \cdot 10^2$ kg/sm^2 for nonlinear patterns.

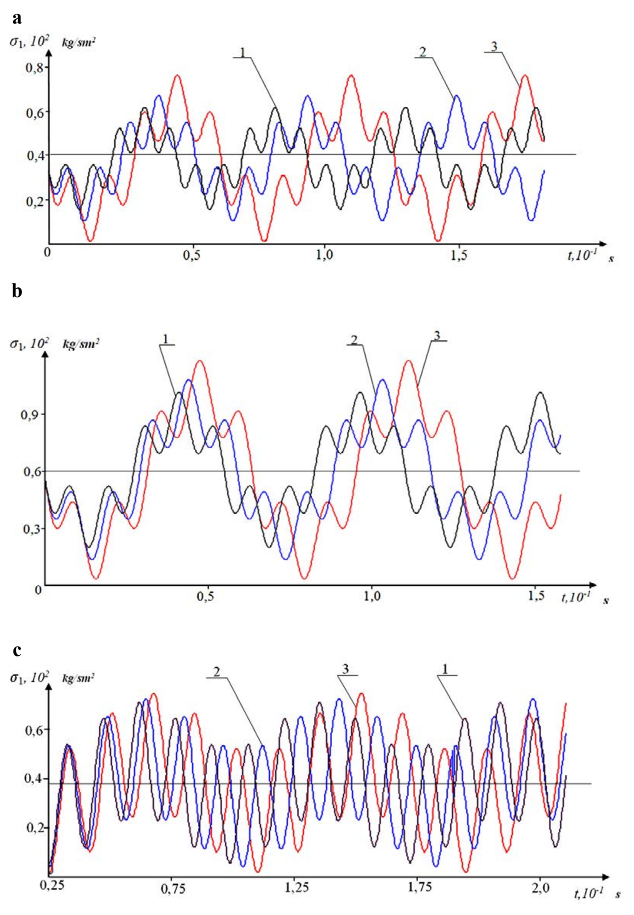
When $I_1=0,050$ kgm^2 and $I_2=0,075$ kgm^2 A_{σ_1} increases to $0,785 \cdot 10^2$ kg/sm^2.

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 σ_{10} at the amplitude of the disturbing drive torque $M_1=12,0$ *Nm* leads to an increase σ_1^{max} from $0,426 \cdot 10^2$ kg/sm^2 to $1,48 \cdot 10^2$ 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 $0,93 \cdot 10^2$ 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 ω, 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 ω resistance on the shaft of the driven pulley is also changed form σ_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 σ1 as the high-frequency and low-frequency components (Figures 4a and 4b). It should be noted the phase shift with increasing fluctuations σ_1 j with respect to ω.



Where, 1-st *ω=451 1/s, j=60 1/s, M1=15 Nm, M0=12 Nm.*
2-nd *ω=45 1/s, j=60 1/s, M1=20 Nm, M0=25 Nm.*
3-rd *ω=35 1/s, j=40 1/s, M1=15 Nm, M0=18 Nm.*

Figure 4: The dependence of the belt ripple in the leading branches of the transmission with variation ω, j, M_1, M_0.

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.

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