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RESEARCH OF PARAMETERS AT THE APPEARANCE OF SHEARING FORCES IN THE COMPOUND TENSION ROLLER OF TRANSPORTATION AND TECHNOLOGICAL MACHINES

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ИССЛЕДОВАНИЕ ПАРАМЕТРОВ ПРИ ВОЗНИКНОВЕНИИ СРЕЗАЮЩИХ СИЛ В СОСТАВНОМ НАТЯЖНОМ РОЛИКЕ ТРАНСПОРТНЫХ И ТЕХНОЛОГИЧЕСКИХ МАШИНАХ

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ABSTRACT

This scientific article discusses the development of a new design of a composite tension roller to prevent lateral slipping of the belt in transporting and technological machines, as well as theoretical studies of a raw cotton loader.

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АННОТАЦИЯ

В данной научной статье рассматривается разработка новой конструкции составного натяжного ролика для предотвращения бокового схода ленты транспортирующих и технологических машинах, а также теоретические исследования перегружателя хлопка-сырца.

Keywords: roller, linear speed of the conveyor belt, required power on the drum shaft, power consumption of the electric motor, driving and driven pulleys, covering belt, signaling sensors, K.P.D. conveyor drive, tension forces, shear force, habasit belt, poli belt, rubbirized belt, resultant force.

Ключевые слова: ролик, линейная скорость конвейерной ленты, требуемая мощность на валу барабана, потребляемая мощность электродвигателя, ведущий и ведомый шкивы, защитная лента, датчики сигнализации, K.P.D. привод конвейера, силы натяжения, сила сдвига, лента хабасита, лента поли, прорезиненная лента, равнодействующая сила.

Introduction. Composite tension rollers are used mainly in conveying and technological machines, as well as drives with large gear ratios and small center distances. They make it possible to transmit more power with the same overall dimensions of the transmission. The compound idler is in a heavier condition due to additional bending in the opposite direction.

In this case, the variable component of the stress cycle will be greater than in a transmission without a tension roller. Fig. 1 shows a kinematic diagram of a composite tension roller with an automatic adjusting device for a flat-belt transmission when the axes of rotation of the pulleys and the angle of inclination of the axis of the side parts are not parallel when the composite tension roller rotates.

Literature review. Knowing that the power and rotational speed of the electric motor are known, we can determine the calculated speed of movement for different diameters of the drive pulley:

$$V_1 = \frac{\pi \cdot D_1 \cdot n}{60},\ V_2 = \frac{\pi \cdot D_2 \cdot n}{60} \qquad (1)$$

where D1, D2 are the diameters of the driving and driven pulleys. [1].

The circumferential force Ft and the resultant F_B force in the belt drive according to the kinematic diagram shown in Fig. 1 are determined by the formulas:

$$F_B = \frac{60 \cdot k \cdot P}{\pi \cdot D \cdot n_{ДВ}} \qquad (2)$$

where P - is the power consumption of the electric motor;

K - is the coefficient taking into account the type of belt.

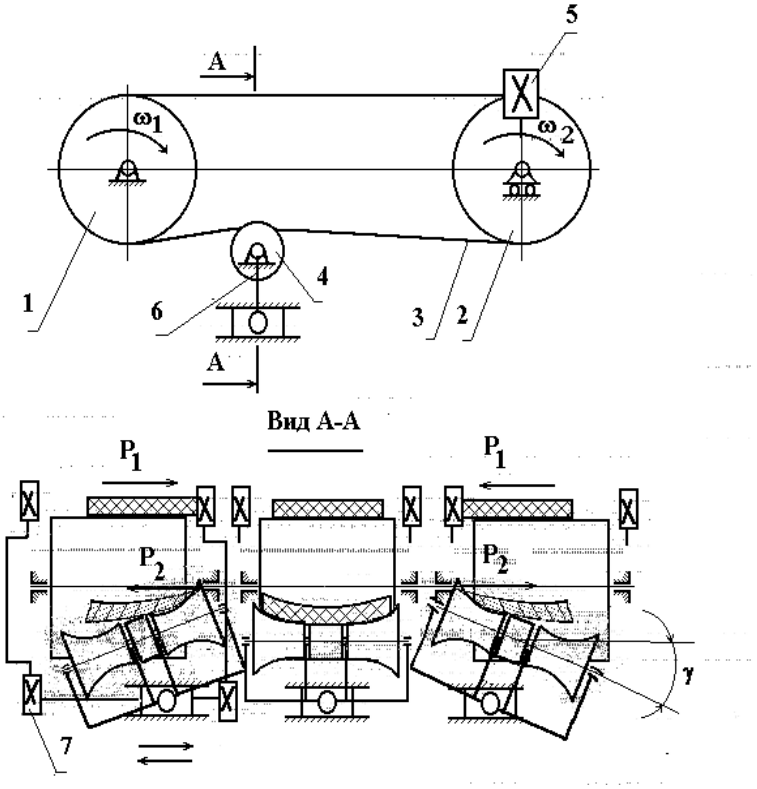

Figure 1. Kinematic diagram of a compound idler roller

1, 2-driving and driven pulleys, 3- covering belt, 4-integral tension roller, 5- signaling sensors, 6- roller axis tilt mechanism, 7- automatic adjusting device.

According to the kinematic diagram in Fig. 1, the shear force arising from the non-parallelism of the axes of rotation of the pulleys is determined

$$F_{СД} = \frac{60 \cdot k \cdot P}{\pi \cdot D \cdot n} \cdot \sin\beta \quad (3)$$

where η is the angle of deviation of the axis of rotation of the driven pulley relative to the axis of the driving pulley.

Methodology. In the future, we will consider the derivation of the formula for determining the shear force for the raw cotton loader when the drum axes are not parallel. Shear force in the conveyor of the raw cotton loader.

$$F_{„Б} = \frac{k \cdot P_T}{\eta \cdot V} \cdot \sin\beta \quad (4)$$

where η - K.P.D. conveyor drive;

V - linear speed of the conveyor belt;

P_T - required power on the drum shaft:

$$P_T = \frac{\lambda \cdot T_{‡} \cdot \omega}{1000} \quad (5)$$

where λ is a coefficient taking into account the nature of the convey or operation .

The torque is determined according to:

$$T_{‡} = (S_{из} - S_{„з}) \cdot \frac{D_{‡}}{2} \quad (6)$$

where SНБ, SСБ - tension forces in the incoming and outgoing branches of the conveyor. Table 1 shows similar calculations for determining the shear force in a composite tension roller with an automatic regulating device for a flat-belt transmission according to (3).

Research results. Analysis of the calculation results given in Table 1 shows that the value of the shear force varies within 80 ... 200 N. With an increase in the linear speed of the conveyor belt of the raw cotton loader, the shear force decreases, so at V = 6 m / s FSD = 80 n, and at V = 8 m / s FCД = 77 n. It was revealed that the load from raw cotton has an insignificant effect on the change in the shear force. The main parameter affecting a significant change in the shear force of the conveyor of the raw cotton loader is the change in the angle of inclination of the rotation axes of the working drums, so at β = 4 °, V = 6 m / s, FCД = 80 n, and at β = 10 °, FCД = 210 n. Analysis of the results of calculating the shear force for a composite tension roller of a flat-belt transmission showed that the change in the magnitude of the shear force not only depends on the change in the angle of inclination of the pulley axis and speed modes, but also on the type of belt. type of belts. When the angle of deviation of the axis of rotation β of the driven pulley for the Habasit belt

$$\beta = 4\ °,$$

FCД = 31.63 n, and for the "Rubberized" belt FCД = 37.13 n. In other cases, the difference between the sheave sheaves at the same angles of misalignment of the pulleys for the types of belts under consideration does not exceed 3.5 ... 4.0 n. The maximum value of the shear force at □ = 4 ° (rubberized belt), V1 = 5.58 m / s. This is due to the fact that the coefficient of friction of the belt with the pulleys is higher for the rubberized belt relative to “Habasit”. It can be seen from the table that a change in the angle of non-parallelism of the axes of the pulleys significantly affects the magnitude of the shear force. It was also revealed that with an increase in the linear speed of the belt, the magnitude of the shear force decreases, the kinetic energy increases, as well as the inertia of the system.

Table 1.

Basic parameters affecting the lateral displacement of the conveyor belt of the raw cotton loader at idle and load conditions

			Without load			With load		
№	**V, m/s**	**b, grad**	**$F_В$, N**	**P, Vt**	**$F_{СД}$, N**	**$F_В$, N**	**P, Vt**	**$F_{СД}$, N**
		4			77			80
1.	6	6	1100	2286	80	1130	2359	123
		8			153			158
		10			210			217
		4			65			67
2.	7	6	925	2151	105	953		110
		8			130			133
		10			212			220

Dependence of the shear force $F_{сд}$ on the deflection angle of the axis b^0 of rotation of the driven drum at idle and load conditions.

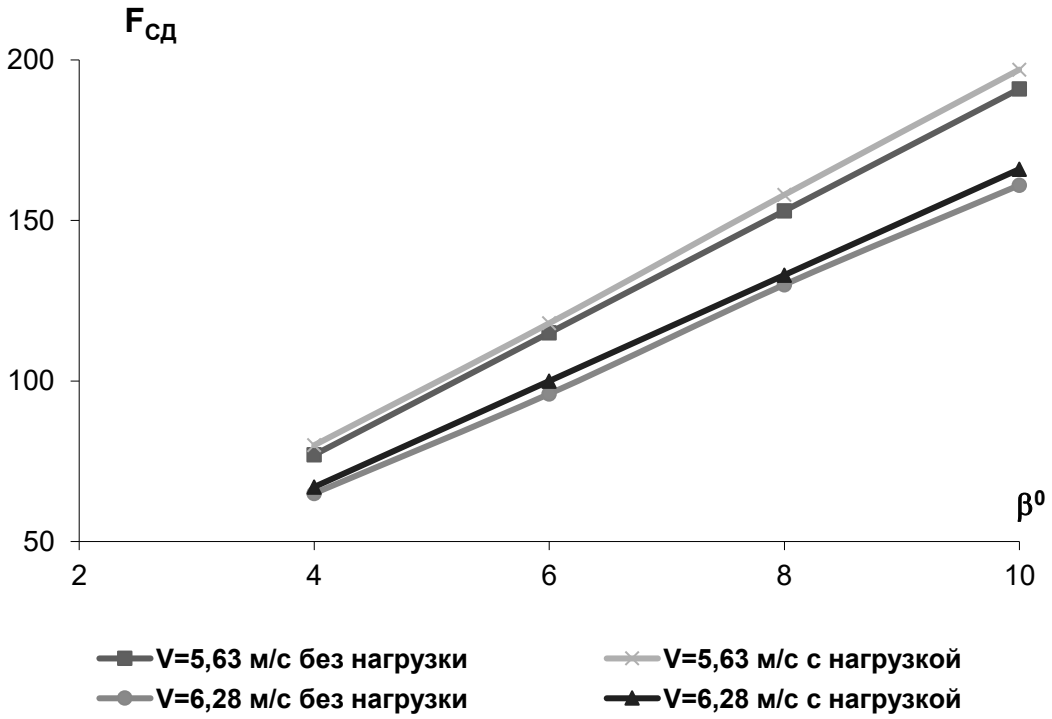

Table 2.

Theoretical dependence of the shear force FCД on the change in the deviation angle of the driven pulley axis relative to the driving pulley axis at different speed modes of movement

Types	Deviation–	Shear force $F_{СД}$ (N) at		
Belts	angle, grad	V_1	V_2	V_3
1. Habasit	1	8	7	5,82
	2	15,8	14	11,6
	3	23,7	20,85	17,38
	4	31,63	27,83	23,2
2. Poli-belt	1	8,62	7,6	6,3
	2	17,2	15,13	12,6
	3	25,8	22,7	18,9
	4	34,4	30,3	25,2
3.Rubberized	1	9,3	8,2	6,83
	2	18,6	16,34	13,6
	3	27,8	24,5	20,4
	4	37,13	32,7	27,2

In order to balance or eliminate the shearing force that occurs due to the non-parallelism of the axes of rotation of the drums (pulleys), the axis of the recommended composite tension roller must be installed obliquely in the opposite direction from the skew angle of the drum axes.

The resultant force is equal to:

$$\overline{F}_B = \overline{F}_B^n + \overline{F}_B^t \quad (7)$$

$\overline{F}_B^n$ и $\overline{F}_B^t$ – respectively, the normal and tangential components of the resultant force.

Frictional force during belt descent

$$F_{TP} = f \cdot F_B^n \quad (8)$$

where f is the coefficient of friction between the belt and the composite tension roller.

$$F_{сд}^l = F_B^t = F_B \cdot \sin\alpha, \quad (9)$$

where □□ is the angle of inclination of the axes of rotation of the composite tension roller relative to the vertical plane

Condition for compensation of the belt coming off the pulley

$$F_{тр} + F_{СД} \cdot \cos(\alpha + \beta) \geq F_{СД}^{1}, \qquad (10)$$

where □ -is the angle of rotation between the axes of rotation of the driving and driven pulleys.

The formula for determining the angle of inclination of the axis of the composite tension roller relative to the vertical plane has the form [3]:

$$\alpha \geq \operatorname{arcctg}\left(\frac{1+\sin^2\beta}{f+\frac{1}{2}\cdot\sin 2\beta}\right) \qquad (11)$$

To clarify the calculated indicators of the belts of foreign firms "Habasit", "Poly Belt", Table 3 is given. It can be noted from the table that all data are indicative values under normal climatic conditions, i.e. t = 20 ° C and air humidity 65% [2].

Table 3.

Estimated indicators of conveyor belts of foreign firms "Habasit" and "Poly Belt"

Indicators		Habasit	Poli Belt
1.	Ribbon types	SNB–5E	SAB–5E
2.	Transport side, material	PVC	PVC
3.	Transport side, surface	Гладкая	Гладкая
4.	Running side, material: fabric	PES	PES
5.	Tickness, mm	1,6	1,6
6.	Mass of belt, кg/m^2	1,9	1,9
7.	Pulling force for 1% stretching per unit width, к1% (н/мм)	5	5
8.	Permisibble pulling force per unit of width, $К_{ДОП}$ (н/мм)	9,5	9,5
9.	Tensile strength per unit of width (н/мм)	75	75
10.	Friction index on the drive drum made of steel μ_a	0,15	0,15
11.	Friction index for the drive drum with adhesion coating, μ_G	0,35	0,35
12.	Friction value on a sliding base made of pickled sheet metal ,μ_G	0,2	0,2
13.	Friction index on a sliding base made of Duroplast, μ_G	0,25	0,25
14.	Coefficient of Puasson	0,4	0,45
15.	Shear modulus, satin weave fabric, G, н/м^2	20…35	20…35

According to the obtained conditions for determining the angle of inclination of the axis of the composite tension roller, a calculation was carried out for different types of belt, the results of which are given in Table 4.

Conclusion. The results of the calculations established the necessary values of the angle of installation of the axis of the composite tension roller, depending on the angle of non-parallelism of the conveyor pulleys of the raw cotton loader ... So, for **β** = 5 °, **α** = 22; at **β** = 7 °, **α** = 24 ° 26 'for Habasit and, accordingly, **α**= 21… 22 ° 30' for a rubberized belt. It should be noted that the results obtained make it possible to select the necessary parameters of the composite tensioner to prevent the belt (belt) from coming off the pulleys, depending on the modes of movement and the angle of non-parallelism of the drums.

Table 4.

Dependences of the angle of inclination of the axis α° of the composite tension roller by the critical angle of the belt descent β° at normal load T = Tnom

Type of belts	Friction coefficient, f	β, grad	α, grad
Habasit	**0,34**	**5** **6** **7** **8** **9**	**22°20′** **23°42′** **24°26′** **25°06′** **25°45′**

Type of belts	Friction coefficient, f	β, grad	α, grad
Poli belt	**0,32**	**5** **6** **7** **8** **9**	**22°06′** **22°45′** **23°30′** **24°00′** **24°48′**
Rubberized	**0,30**	**5** **6** **7** **8** **9**	**21°00′** **21°36′** **22°30′** **23°12′** **24°00′**

The technical and economic efficiency of the proposed belt conveyor with a tensioning device is to increase the reliability and efficiency of the conveyor by eliminating the side slip of the belt.

To study the efficiency of the effective design of the centering tensioner, a prototype was made from the Kaprolon-V material and installed on a conveyor belt of the TLKh-18 type (Fig. 3). The tests were carried out from 04/24/2018 to 04/23/2019.

Figure 4 shows a general view of the installation of a prototype of the recommended design on a conveyor belt of the TLH-18 type.

Production tests were carried out in a cotton ginning plant at “Expokoller Prin Teks” LLC in the Tashlak region of the Fergana region.

Figure 3. General view of the belt conveyor

Figure 4. General view of a prototype tensioner

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