Academic leadership. ISSN 1533-7812 Vol: 21 Issue 3
http://academicleadership.org/
DOI 10.5281/zenodo.7138635

ANALYSIS OF VERTICAL AND FLUSHING VIBRATION OF BELT ELEMENT BEARINGS OF BELT CONVEYOR ROLLER MECHANISMS

Jumaev Akbarjon Sayfullaevich
Almalyk branch of Tashkent State Technical University named after Islam Karimov
Doctor of Philosophy in Technical Sciences (PhD), Associate Professor
E.mail: akbarjon.jumayev@mail.ru
Ibragimova Nodira Ilkhomovna
Almalyk branch of Tashkent State Technical University named after Islam Karimov
Assistant
E.mail: nodirapardaboyeva@gmail.com
Turdaliyeva Makhliyo Yo'ldoshevna
Almalyk branch of Tashkent State Technical University named after Islam Karimov
Assistant
E.mail: mahliyoturdaliyeva@gmail.com

Abstract: In the article, solutions and graphs of dependence on the importance of the rotation frequency of belt conveyor roller mechanisms, angular velocities to the horizontal and vertical planes are given. In this case, when the transported load rises to a certain height, it has different effects on the belt element bearing. In particular, when the outer shell of bearings with belt elements have different coefficients of stiffness, their deformations are also different. Therefore, information and solutions are presented on the importance of choosing the sizes of bearing belt bushings.

Keywords: deformation, eccentricity, angular velocity, amplitude, frequency, bearing, belt element, roller, belt, conveyor.

INTRODUCTION

If we look at the global scale, today, in the development stage of mechanical engineering, it is important to improve the machines and mechanisms, accelerate the production of resource-efficient, long-term, high-performance equipment and technologies and further increase product quality and competitiveness. At the same time, it is necessary to improve the technical and economic indicators of production, to ensure the quality of transportation devices in the fields. Conveyors account for 60-70% of transport devices, and new generations of them should be created and introduced into production. Scientific research is one of the important tasks of kinematic and dynamic modeling of technological machines' drive processes, justification of operating modes and parameters.

In production enterprises, special attention is paid to the use of kinematic and dynamic analysis methods in the design of high-efficiency structures of product transportation, loading and unloading mechanisms, in the justification of their parameters. In particular, by developing improved constructions of resource-efficient belt conveyor roller mechanisms, comprehensive research and development works are being carried out to increase the productivity of technological machines and achieve high product quality. In this direction, as a result of the creation of new constructions of belt conveyors that transport products in all production enterprises, it is an important task to achieve long-term operation of conveyor spare parts, high

Academic leadership. ISSN 1533-7812 Vol: 21 Issue 3
http://academicleadership.org/
DOI 10.5281/zenodo.7138635
work efficiency, prevention of deformation of spare parts from vibration and friction, and high quality of the obtained product.

LITERATURE REVIEW

The mechanical vibration of belt conveyor roller mechanisms is caused by the oscillating motion of the conveyor belt. It is recommended to consider the vibration phenomenon from low frequency to ultrasonic frequency. Imbalance of the eccentricity rotating masses, incorrect adjustment of the working elements of the guide roller mechanism, including incorrect centering of the rolling bearings in the installation, cause frequent occurrence of low-frequency vibrations (from 0 to 300 *Hz*). The appearance of medium-frequency vibrations (from 200 to 2000 *Hz*) is observed as a result of the interaction of the rotating and stationary elements of the rolling bearing, as well as due to high vibrations that occur during the transportation of loads.

The main reason for the low-frequency vibration of the roller mechanism, including the vibration of rolling bearings, is caused by various vibration components. In a detailed analysis of the spectrum of low-frequency vibrations of the roller mechanism with a guide element, it was found that there are other components that differ in the quality of assembly of working elements and the quality of installation of rolling bearings, as well as the influence of various operating factors on rolling bearings [1].

With lubricant products, due to quality lubrication of the sliding parts of the mechanism, with low radial loading, it smoothest its non-symmetrical edges, which leads to a decrease in the medium-frequency vibration of the bearing. At the same time, in details that act as a loaded sliding support, medium-frequency vibration may increase [2].

DISCUSSION

The performance of the belt conveyor mainly depends on the parameters of the roller mechanisms, diameter, rotation frequency, vibration amplitude and angular speed. In this case, the angle of deviation of the roller mechanism to the horizontal plane also plays an important role. When the transported load rises to a certain height, the effect on the parts of the belt element bearing is different. In particular, in the lower roller mechanism, the bearing belt bushing is more deformed than the upper one. Also, when the load is transported along the horizontal axis, the deformation coefficients of the bearings and belt bushings are different. In this case, the roller mechanisms also vibrate in a certain angular range along their axis. Depending on the physical and mechanical properties of the material to be transported and the application of technological requirements, it is possible to determine how the value of the gap between the belt element bearing and the shell changes in the direction of movement. That is why it is important to choose the specifications of the bushings of bearings with a belt element.

Taking into account the above, the calculation scheme of the belt conveyor was created (Fig. 1). It should be noted that when drawing up the calculation scheme, the deflection is taken into account, given that the roller mechanism is very small compared to the deformation of the belt bushings.

Academic leadership. ISSN 1533-7812 Vol: 21 Issue 3
http://academicleadership.org/
DOI 10.5281/zenodo.7138635

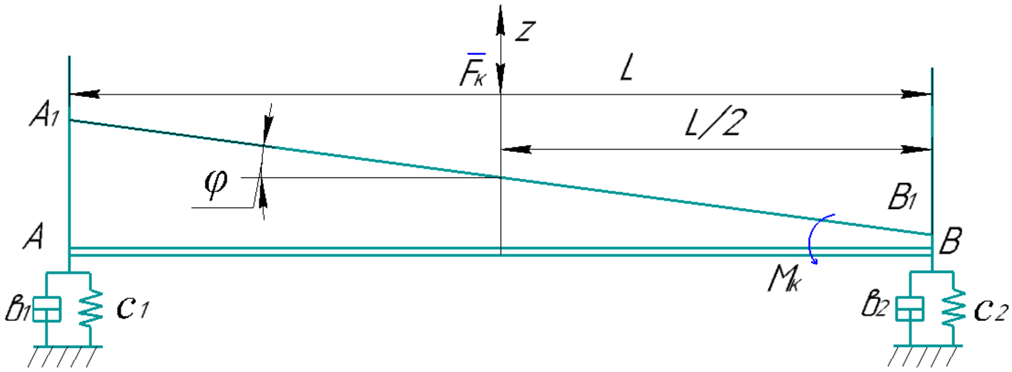


Figure – 1. Calculation scheme for determining vertical and horizontal vibrations of belt conveyor roller mechanisms

RESULTS

The forces that cause the vertical displacement of the axis of the roller mechanism and the pivoting position are the following: weight, tension of the belt bushings, and dissipation and inertial forces. Lagrange's II-order equation was used to create a system of differential equations representing the vibrations of roller mechanisms with a belt element bearing [3];

$$\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{q}_i}\right)-\frac{\partial T}{\partial q_i}+\frac{\partial \phi}{\partial \dot{q}_i}+\frac{\partial \Pi}{\partial q_i}=Q(q_i), \tag{1}$$

where qi are the generalized coordinates of the system, *T*, *P* are the kinetic and potential energies of the system; *F* – dissipative function of relay; Q (q_i) are forces corresponding to generalized coordinates [4].

Two generalized coordinates of vertical and horizontal vibrations of conveyor roller mechanisms were taken as *z* – vertical displacement and *φ* – deviation angle of the screw axis. Taking into account these generalized coordinates, we determine those corresponding to Lagrange's II-order equations [3, 4] Kinetic and potential energies of the system, respectively:

$$\Pi=\frac{c_1\left(z-\frac{\varphi l}{z}\right)^2}{2}+\frac{c_2\left(z+\frac{\varphi l}{z}\right)^2}{2},$$

$$T=\frac{m\dot{z}^2}{2}+\frac{J\dot{\varphi}^2}{2}, \tag{2}$$

where m is the mass of the roller; c_1, c_2 – are coefficients of uniformity of rubber bushings with belt elements; *l* – screw length; *J* – is the moment of inertia of the screw.

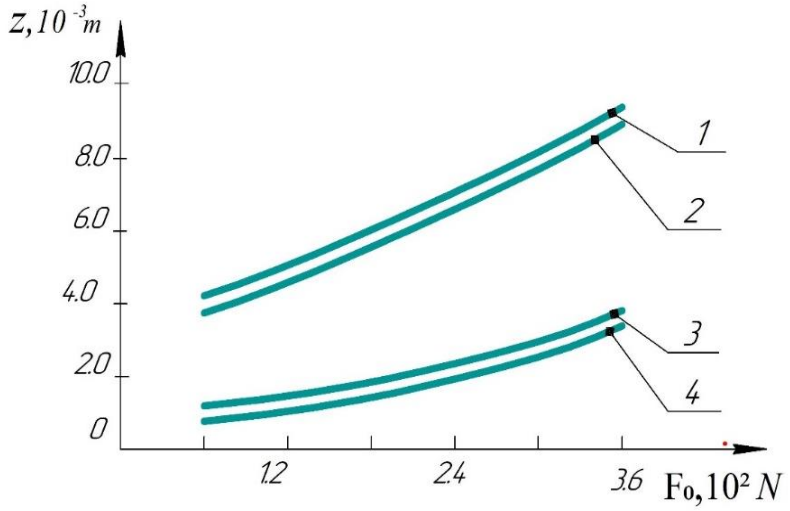
The formula of the dissipative function of Rayleigh is as follows [5, 6]

$$\phi=\frac{в_1(\dot{z}-\dot{\varphi}\frac{l}{2})^2}{2}+\frac{в_2(\dot{z}+\dot{\varphi}\frac{l}{2})^2}{2}, \tag{3}$$

where $в_1$, $в_2$ – are rubber bushings dissipation coefficients.

It should be noted that the axis of vibration of the roller mechanism is shifted by the value z_{cm} relative to its axis of symmetry (axis of initial rotation). The fact that the random component of vibrations is in the range of (8.0 ÷ 15) *m/s* relative to the

Academic leadership. ISSN 1533-7812 Vol: 21 Issue 3
http://academicleadership.org/
DOI 10.5281/zenodo.7138635
main amplitude is mainly due to the effect of the wavy surface of the vibration amplitude. They are taken into account when determining F_0 values. Connection graphs were constructed as a result of processing the obtained patterns. Fig. 2 shows graphs of dependence of the amplitude values of the up and down movement of the belt element bearing and shell of the roller mechanism on the average value of the impact force of the transported material.



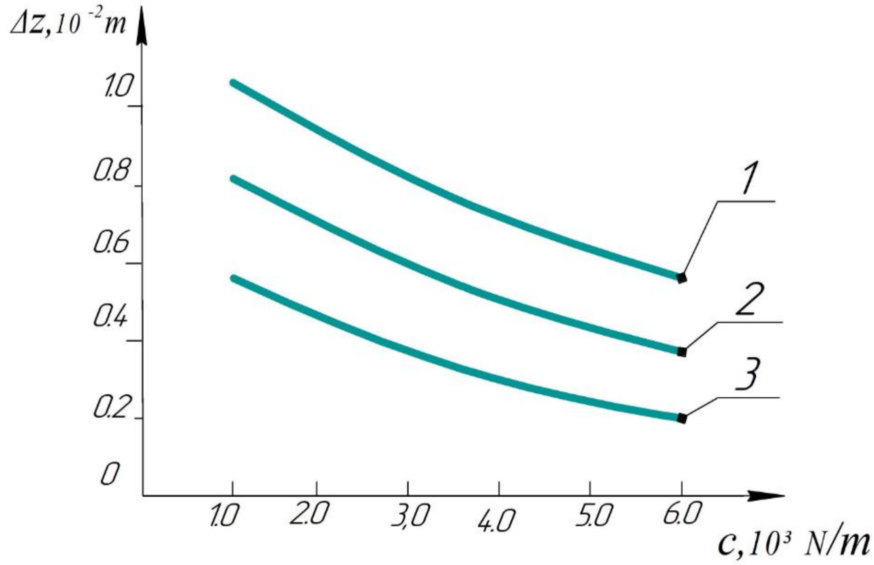
1, 3 – $z'' = f(F_0)$; 2, 4 – $z' = f(F_0)$; 1, 2 – c = 3,0·10^3 *N/m*; 3, 4 – c = 4,0·10^3 *N/m*

Figure – 2. Graphs of the dependence of the change of the amplitude of the vertical vibrations of the belt conveyor roller mechanisms on the performance and the stiffness of the shock absorber

When the coefficient of friction of the bearing belt supports is 3.0·10^3 *N/m* and the impact force increases from 0.75·10^2 *N* to 3.6·10^2 *N*, the upward displacement amplitude z' values are from 3.8·10^{-3} *m* to 9.1·10^{-3} *m* Increasing non-linearly, z'' values increase from 4.45·10^{-3} *m* to 10.1·10^{-3} *m*. Their difference determines the value of z_{cm} (Fig. 2, graphs 1, 2). Correspondingly, the values of *z*' increase linearly from 0.745·10^{-3} *m* to 2.67·10^{-3} *m* when the stiffness coefficients of the supports are 5.5·10^3 *N/m*, while the values of *z*'' are respectively it increases from 1.61·10^{-3} *m* to 3.92·10-3 *m* (Fig. 2, graphs 3, 4).

According to the results of experimental studies, it is recommended that the values of *z*'' do not exceed (4.5 ÷ 6.0)·10^{-3} *m* when strap supports are taken at the same height. In this case, the speed of movement of the transported material will increase, and mechanical damage will be maximum. Therefore, the following parameters are recommended: F_0 = (1.5÷2.5)·102 *N*; *c* = (3.5 ÷ 4.0)·102 *N/m* $n_в$ = = (150 ÷ 160) *rpm*. The values of the vertical vibration amplitudes of the belt element bearing directly depend on the mass of the bearing shell and the bearing outer belt element shell, the impact force F_0, and the stiffness of the supports.

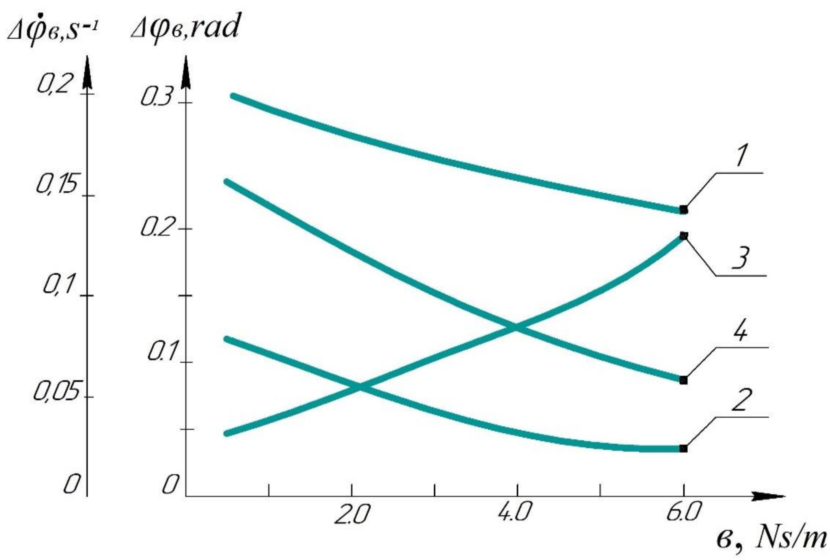
Fig. 3 shows the graphs of dependence of the vertical vibration range of the belt conveyor roller mechanisms on the friction coefficients of the rubber bushings of the bearings.



1 – F_0 = 350 *N*; 2 – F_0 = 300 *N*; 3 – F_0 = 250 *N*

Figure – 3. Shows the graphs of dependence of the vertical vibration range of the belt conveyor roller mechanisms on the friction coefficients of the rubber bushings of the bearings

In this case, it is important to determine the values of the total range of vibration of the bearing with a belt element. Because the volume, speed, and wave values of the bearing shell and surface of the materials transported on the belt conveyor should be selected in such a way that the braking and damage of the transported material is minimal. In the calculation values of the parameters, when the stiffness of the roller mechanism belt element bearing supports increases from $1.0 \cdot 10^3$ *N/m* to $6.0 \cdot 10^3$ *N/m*, the vertical vibration range of the roller mechanism when F_0 = 350 *N* is from $1.06 \cdot 10^{-2}$ *m* to $0.61 \cdot 10^{-2}$ *m*, decreases in a non-linear value. Accordingly, when the load is reduced to 250 *N*, the *Δz* values decrease by almost two times, that is from $0.71 \cdot 10^{-2}$ *m* to $0.2 \cdot 10^{-2}$ *m*. An increase in the rotation frequency leads to a significant increase in the value of *Δz*. Therefore, the following parameter values are recommended: $\Delta z \leq (10 \div 12) \cdot 10^{-3}$; F = $(1.5 \div 2.5) \cdot 10^2$ *N*; $c \geq (3.5 \div 4.0) \cdot 10^3$ *N/m*);



Academic leadership. ISSN 1533-7812 Vol: 21 Issue 3
http://academicleadership.org/
DOI 10.5281/zenodo.7138635

$$1-\Delta\dot{\varphi}_{в} = f(в_1);\ 2-\Delta\dot{\varphi}_{в} = f(в_1);\ 3-\Delta\dot{\varphi}_{в} = f(в_2);\ 4-\Delta\dot{\varphi}_{в} = f(в_2);$$

Figure – 4. Graphs of the dependence of the rotation angle and speed ranges of the Konveyer roller mechanisms on the variation of the dissipation coefficients of the bearing belt bushings

It is known that an increase in the dissipation coefficients of the supports leads to a decrease in the vibration amplitudes. Figure 4 shows graphs of dependence on the variation of the dissipation coefficients of the bearing belt bushings. From the analysis of the graphs, it can be determined that when the values of the dissipation coefficients $в_1$ and $в_2$ increase from 0.8 *Ns*/*m* to 6.0 *Ns*/*m*, the range of vibration of the roller mechanisms decreases from 0.125 *rad* to 0.038 *rad* for $в_1$, and the values of $\Delta\varphi_в$ for $в_2$ It decreases linearly from 0.245 *rad* to 0.092 *rad*. The main reason for this is that the difference between z_1 and z_2 is mainly when the dissipation coefficient $в_1$ is small and $в_2$ is large. An increase in $в_1$ and $в_2$, respectively, causes a decrease in the speed of oscillations of the roller mechanism. In this case, when the dissipation coefficient of the strap support increases from 0.8 *Ns*/*m* to 6.0 *Ns*/*m*, its values decrease from 0.21 s^{-1} to 0.14 s^{-1}, and as $в_2$ increases, its values decrease from 0.0223 s^{-1} to 0. 12 s^{-1}, increases in a nonlinear law. Therefore, in order for the roller mechanism to be within the range of (0.05 ÷ 0.15) *rad*, $в_1$ = (2.5÷3.0) *Ns*/*m* and $в_2$ = (3.5÷4.5) *Ns*/*m* it is desirable to obtain.

CONCLUSION

A mathematical model representing the vertical and transverse vibrations of roller mechanisms with a bearing support with a belt element was obtained. The formula for determining vibration frequencies was obtained. Vibrations of a roller mechanism with a belt bearing support were determined analytically. On the basis of the numerical solution, the laws of change of vertical vibrations of the roller mechanism were obtained. Graphs of dependence of the vertical vibration range of the roller mechanism of the conveyor on the friction coefficients of the bearings and rubber bushings were constructed. An increase in the rotation frequency leads to a significant increase in the value of Δz.

REFERENCES

[1]. Баркова Н.А. Вибрационная диагностика подшипников качения: Методические указания к лабораторной работе / Баркова Н.А., Е.И. Крапивский, А.В. Шалыгин, В.В. Шорников // Санкт Петербургский горный ин-т. СПб, 2010. 38 с.

[2]. Сергеев Ю.С. Моделирование вентильно-индукторного электровибропривода / Сергеев Ю.С., Сандалов В.М., Карпов Г.Е. // Вестник Южно-Уральского государственного университета. Челябинск: 2017. С. 90 – 98

[3]. Артоболевский И.И. Теория механизмов и машин.- М.: Наука, 1988. – с.640.

[4]. Фролов К.В. Теория механизмов и машин. -М.: Высшая школа, 1987. – с.496.

[5]. Джўраев А. ва бошқ. Машина ва механизмлар назарияси. Ғофур Ғулом номидаги нашриёт-матбаа уйи, – Тошкент. 2003. – б. 593.

[6]. Баубеков С.Д., Джураев А. Динамика машин и механизмов // Учебник, изд. «Эверо», Тараз, Казахстан 2014. – с.200.

[7]. A.Djurayev, A.S.Jumayev. Tasmali konveyerlar konstruksiyalarini takomillashtirish va parametrlarini hisoblashning ilmiy asoslari / Monografiya. «HUMO PRINT 2020» MCHJga qarashli matbaa bo`limi. – Navoiy. 2022. – 180 b.

[8]. A.Djuraev, B.N.Davidbaev, A.S.Jumaev. Improvement of the design of the belt conveyor and scientific basis for calculation of parameters / Global Book Publishing Services is an International Monograph & Textbook Publisher. Copyright 2022 by GBPS. All rights reserved.
[9]. A.Dj.Djuraev, A.S.Jumaev. Study the influence of parameters of elastic coupling on the movement nature of support roller and rocker arm crankbeam mechanism. International Journal of Advanced Research in Science, Engineering and Technology (IJARSET) //ISSN: 2350-0328 Vol. 6, Issue 6, June 2019, 9795 – 9800.
[10]. A.Djuraev, A.S.Jumaev. Providing the Development of New Designs for the Design of the Roller Mechanism Transmitting Rotational Motion in Belt Conveyors. International Journal of Emerging Trends in Engineering Research (IJETER) // ISSN 2347–3983 Volume-8. No.9, September 2020. 6609 – 6617.
[11]. A.S.Jumaev, A.J.Juraev, N.N.Juraev, B.B.Qayumov. Parameters of choice and calculation of materials by the guiding composite roller mechanisms of tape conveyors. International Journal of Engineering and Information Systems (IJEAIS) // ISSN: 2643-640X, Vol. 4, Issue 8, August – 2020. 235 – 240.