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BELT CONVEYERS ROLLERS AVERAGE TERM OF SERVICE

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СЕРЕДНІЙ ТЕРМІН СЛУЖБИ РОЛИКІВ СТРІЧКОВИХ КОНВЕЄРІВ

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СРЕДНИЙ СРОК СЛУЖБЫ РОЛИКОВ ЛЕНТОЧНЫХ КОНВЕЙЕРОВ

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Abstract. Conveyor framework with roller support is an important part of a belt conveyor, the technical condition of which determines the reliability of the conveyor as a whole. Reliability of the framework is determined by the reliability of the rollers of the roller supports, as the reliability of the supporting metal structures is much higher. An important indicator for assessing the reliability of a roller is its term of service, depending on the type, parameters of roller supports and operating conditions. The paper is proved to one of the important conveyer transport system task – to dynamic factor and roller's term of service (TS) determination. The task solving permit to evaluate the different designs belt conveyers reliable. The article represent the tasks of belt conveyers roller's average TS determination were set and solved for the different types of roller supports. Dynamic efforts arised with the loading motion and caused with belt bend are principal factor for the calculation of TS rollers. The graph of dependence roller's average TS from belt velocity for different roller's types were obtained. The service life of the conveyor rollers depends on the linear load, the parameters of the conveyor, the composition of the transported load and the type and parameters of the roller support. At the same time, with an increase in the speed of the conveyor belt for the considered types of rollers, the average term of service of the rollers decreases. When the belt speed changes to certain values, the service life of the rollers for hard roller supports is somewhat higher than for overheard roller supports, and the term of service of rollers for damping roller supports is somewhat higher than for damping overhead roller supports. At the same time, the term of service for damping overhead and damping roller supports is significantly higher than for hard and overhead. In addition, when the belt speeds are higher than some values for all considered types of roller supports, the roller's term of service can sharply decrease due to the appearance of resonant phenomena associated with belt vibrations during the movement of pieces of large fractions. Achieved results may be applied in mining, metallurgical and building industry.

Keywords: roller's, bearing, term of service, belt conveyer, roller supports, belt velocity.

Conveyor framework with roller support is an important part of a belt conveyor, the technical condition of which determines the reliability of the conveyor as a whole.

Reliability of the framework is determined by the reliability of the rollers of the roller supports, as the reliability of the supporting metal structures is much higher.

An important indicator for assessing the reliability of a roller is its term of service, depending on the type, parameters of roller supports and operating conditions.

The task of determining the term of service of belt conveyor rollers was studied by L. H. Shakhmeister, V. H. Dmitriev, V. F. Monastyrsky, A. I. Dodatko and other researchers. Their works showed that the main cause of roller failure is the failure of the bearing unit, the loads on the rollers during transportation of the rock mass are determined and, on the basis of this, formulas for calculating their term of service are proposed. When this load on the bearings of the rollers, arising from large pieces of load, not considered accurately enough.

In [1, 2], formulas are proposed for calculating the average term of service of belt conveyor roller bearings. However, when describing the load on the roller bearing, the authors did not take into account the dynamic forces arising from the movement of the load on the conveyor belt and due to the bending of the belt.

Analysis of the failures of the belt conveyor framework showed that the main reasons for the failure of the rollers are increased radial clearance in the bearing due to abrasive wear and fatigue failure of bearing elements from the effects of dynamic loads [3]. Therefore, the term of service of one roller is determined by the term of service of the bearings.

The purpose of this work is to determine the term of service of belt conveyor rollers for various types of roller supports.

The durability or 90 % service life of rolling bearings L_{09}, measured in hours, is determined according to [3]:

$$L_{09} = \left(\frac{C_n}{P_m}\right)^p \cdot \frac{10^6}{60n} k_o, \tag{1}$$

where C_n is the dynamic load capacity, N, (the load at which the durability is 1 million revolutions, this value for each particular bearing is selected from the directory); P_m is the equivalent dynamic load on the roller bearing, N; n is the bearing rotation frequency, 1/s; p is the power index (p = 3 for ball bearings and p = 10/3 for roller bearings); and k_o is the coefficient taking into account the operating conditions.

The average term of service of the bearing, according to [4], is determined from the ratio

$$t_a = 4.08 \cdot L_{09}. \tag{2}$$

The frequency of rotation n is determined by the formula:

$$n = \frac{60 v_b}{2\pi r}, \tag{3}$$

where v_b is the speed of the conveyor belt, m/s; r is roller radius, m.

In our case, the roller bearing unit is loaded with a load flow, with a radial and axial load on the bearing. The axial load on the bearing is neglected, because the impact of the load on the bearing is transmitted through the metal cup and the share of the axial component is small. Therefore, radial and radial thrust bearings are used in the rollers of the considered conveyors. For ball radial and radial thrust bearings, as well as roller radial thrust bearings, the dynamic radial load is calculated using the formula [5]:

$$P_m = V K_t K_s F_r,$$

where F_r is the radial load on the bearing; V is the coefficient of rotation (when the outer ring of the bearing rotates with respect to the load V = 1.2); K_t is the temperature coefficient chosen from the tables [5] (in our case $K_t = 1$); and K_s is the safety factor chosen from the tables [5] (in our case, we assume $K_s = 1$, since the influence of the nature of the load on the bearing is taken into account when calculating F_r).

On this basis, the total dynamic radial load on the roller bearing is:

$$P_m = 1.2F_r, \tag{4}$$

The radial load on the bearing F_r can be represented as the average load on the bearing:

$$F_r = \frac{1}{2}M\left[x(t)\right], \tag{5}$$

where $M[x(t)]$ is the mathematical expectation of the load on the central roller of the roller support; and $x(t)$ is a random function of the load on the roller support.

In [6], a statistical model of the load flow is presented, which is considered as a small fraction and large pieces located in it.

According to this work, $M[x(t)]$ is determined by the formula

$$M\left[x(t)\right] = 0.5\sum_{i}^{s} gk_{di}\tau_l QP_i + q_l l_r \ , \tag{6}$$

where P_i is the weight fractions of pieces of the i-th fraction in the total weight of the load delivered to the conveyor; Q is the conveyor capacity, kg/s; k_{di} is the coefficient of dynamism in the interaction of a piece of load i-th fraction with roller; l_r is the distance between rollers (pitch rollers), m; τ_l is the time of interaction of a large piece of load with roller, s; q_l is the linear load on the bearing unit, N/m; g is the gravitational acceleration, m/s^2; and s is the number of fractions.

A large piece interacts with the roller for two spans between the rollers, therefore, τ_l is defined as

$$\tau_l = \frac{2l_r}{v_b}. \tag{7}$$

Load q_l taking into account the uneven load on the side and middle rollers is determined by the formula [7]

$$q_l = 0.7\,k_d' \cdot (q_s + q_b) + q_r, \tag{8}$$

where q_s is the linear load on the belt from the small fractions (i.e., with the exception of the percentage of large fractions considered separately), N/m; q_b is the linear weight of the belt, N/m; q_r is the weight of the rotating parts of the roller, N; and k_d' is the coefficient of dynamism in the interaction of the small-sized fraction with the roller support.

In formula (8), the coefficient 0.7 takes into account the part of the load perceived by my middle roller.

The dynamic factor k'_d accordant [8] is determined on a formula

$$k'_d = 1 + \frac{v_b^2}{g} \cdot \frac{q}{\left(S_b - q v_b^2 / g\right)},$$

where $q = q_s + q_b$; and S_b is tension of the belt, N.

The conveyor capacity Q, according to [1], is determined by the formula

$$Q = \frac{q_f v_b}{g}, \tag{9}$$

where q_f is the unit weight of load, including small and large fractions, N/m.

When determining the load on the roller, pieces of those fractions are taken into account, for which the average distance between the pieces l_i is greater than the distance between the roller supports l_r ($l_i > l_r$), that is, it is assumed that at the moment only one large piece interacts with the roller support.

From the formula (6) it can be seen that the average load on the roller of the roller supports depends on the dynamic factor k_{di} when interacting with a piece of each fraction and the composition of the transported load. As studies have shown [8], k_{di} depends on the design of the roller and the parameters of the conveyor.

Substituting (4) into (1), taking into account (5) – (9), and then substituting the resulting expression for the resource L_{09} into (2), we finally determine the average term of service of the bearing.

The analysis showed that the term of service of the conveyor rollers depends on the linear load, the parameters of the conveyor, the composition of the transported load and the type and parameters of the roller conveyor.

Figures 1 and 2 show the dependences of the roller t_a average term of service on the belt speed v_b for two types of rollers: on a hard framework (hard rollers) (Fig. 1) and overhead on a cable framework (overhead roller supports) (Fig. 2). For comparison, the selected rollers with a diameter of 133 mm (r = 0.0665 m), used in type 1L100K conveyors. In these rollers bearings № 304 are used. In this case, the conveyor parameters were taken as follows: belt tension S_b = 20000 N, linear weight of load q_f = 1500 N/m, roller pitch l_r = 1 m, cable tension S_c = 30000 N.

The dynamic load capacity C_n for bearing № 304 was selected from tables [5]. For this bearing, C_n = 5500 N. The weight fractions of pieces of the i-th fraction P_i were taken from table 1 [6]. Also from this table, the values of the average distance between the middle of the pieces of the i-th fraction li were chosen.

Figures 1 and 2 show that with an increase in the speed of the conveyor belt for hard and overhead roller supports, the average term of service of the rollers decreases. The value of the average term of service of the rollers in the range of change of the speed of the conveyor $0<v_b<3$ m/s for hard roller supports is slightly higher than the term of service of rollers for overhead rollers.

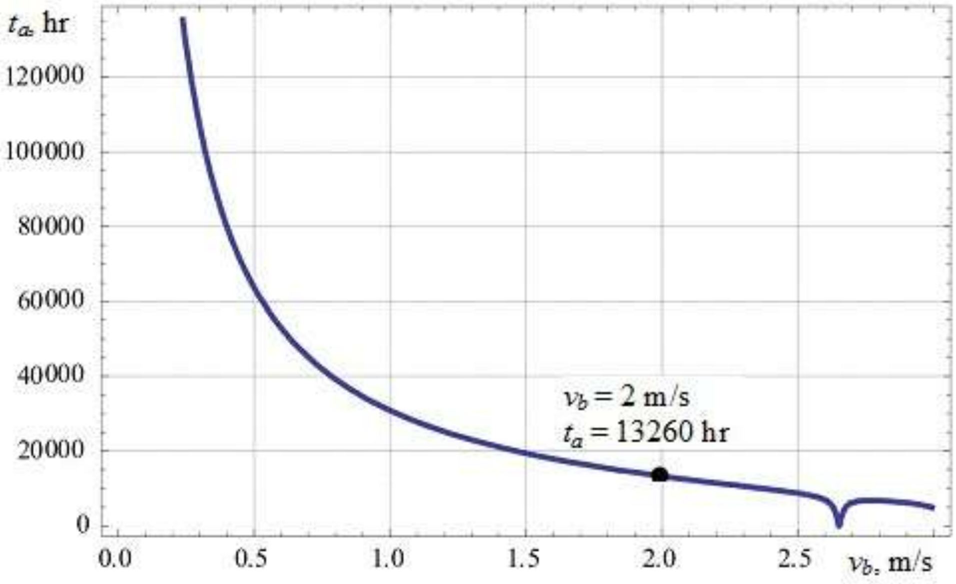

Figure 1 – Graph of the average term of service of the roller on conveyor belt speed for hard roller supports

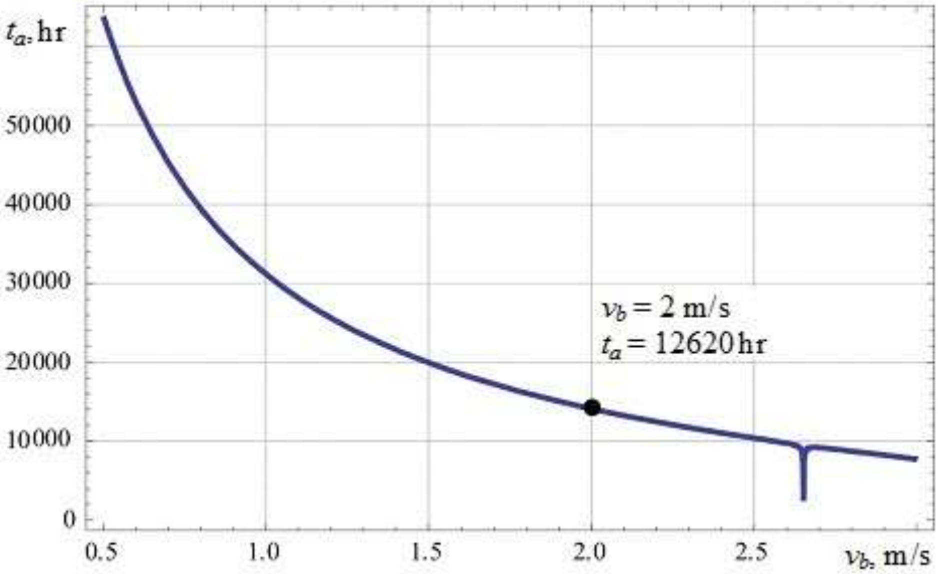

Figure 2 – Graph of the average term of service of the roller from the speed of the conveyor belt for overhead roller supports on a cable framework

In addition, from Figures 1 and 2, it can be seen that for hard and overhead roller supports, as the belt speed approaches the value of 2.65 m/s, the average roller resource decreases sharply. This is due to the fact that for these rollers, when moving pieces of load of the largest fraction together with the conveyor belt with this speed, a resonance of the belt causes a resonance at which the dynamic force on the roller rises sharply.

Figures 3 and 4 show the dependences of the average term of service of the roller on the belt speed for the damping (Fig. 3) and damping overhead (Fig. 4) roller-supports with the same conveyor parameters as for the previous types of roller-bearings. The stiffness of the shock absorbers took the value of c = 20000 N/m^2. From these figures it is seen that, as in the previous case, with increasing belt speed, the roller's term of service decreases. At the same time, the term of service for the damping roller supports is more than for damping overhead by 3 %. In addition, these figures show that for certain values of belt speeds (v_b>2 m/s), the service life of the rollers sharply decreases. It is also associated with the phenomenon of resonances as a result of oscillations of the belt when moving pieces of load of large fractions.

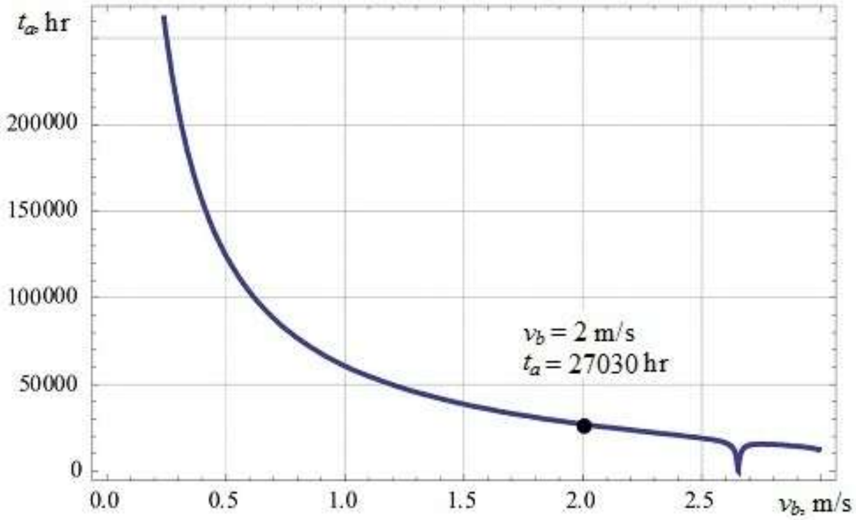

Figure 3 – Graph of the average term of service of the roller from conveyor belt speed for damping roller supports

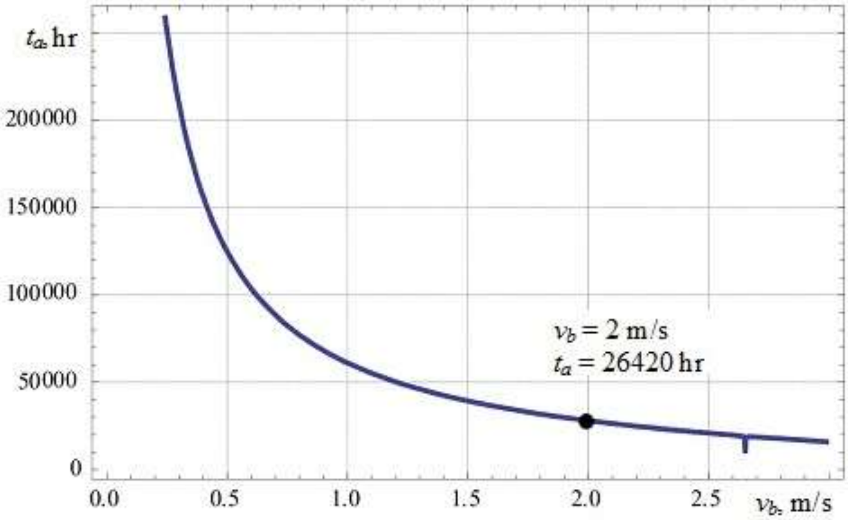

Figure 4 – Graph of the average term of service of the roller on the conveyor belt speed for overhead roller supports on a cable framework with damping suspensions (for overhead damping roller supports)

The service life of the conveyor rollers depends on the linear load, the parameters of the conveyor, the composition of the transported load and the type and parameters of the roller support. At the same time, with an increase in the speed of the conveyor belt for the considered types of rollers, the average term of service of the rollers decreases. When the belt speed changes to certain values, the service life of the rollers for hard roller supports is somewhat higher than for overheard roller supports, and the term of service of rollers for damping roller supports is somewhat higher than for damping overhead roller supports.

At the same time, the term of service for damping overhead and damping roller supports is significantly higher than for hard and overhead. In addition, when the belt speeds are higher than some values for all considered types of roller supports, the roller's term of service can sharply decrease due to the appearance of resonant phenomena associated with belt vibrations during the movement of pieces of large fractions.

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Анотація. Став конвеєра з роликоопорами - важлива частина стрічкового конвеєра, від технічного стану якої залежить надійність конвеєра в цілому. Надійність става визначається надійністю роликів роликоопор, так як надійність несучих металоконструкцій на порядок вище. Важливим показником для оцінки надійності ролика є його термін служби, що залежить від типу, параметрів роликоопор і умов експлуатації. У даній статті поставлена і вирішена задача визначення середнього терміну служби роликів стрічкового конвеєра для різних типів роликоопор: жорстких, на канатному ставі, підвісних і амортизованих. Вирішення цієї задачі дозволяє дати оцінку надійності става стрічкових конвеєрів, а також прогнозувати технічний резерв роликів і систему планових ремонтів. У даній роботі визначено коефіцієнт динамічності і запропоновано розрахунок терміну служби роликів з урахуванням динамічних зусиль, що виникають при русі вантажу по ставу конвеєра і обумовлених вигином стрічки, побудовані графіки залежності середнього терміну служби ролика від швидкості конвеєрної стрічки для різних конструкцій става стрічкових конвеєрів. Встановлено, що термін служби роликів конвеєра залежить від погонного навантаження, параметрів конвеєра, гранскладу вантажу і типу та параметрів роликоопор. При цьому, зі збільшенням швидкості стрічки конвеєра для розглянутих типів роликоопор середній термін служби роликів зменшується. При зміні швидкості стрічки до певних значень термін служби роликів для жорстких роликоопор трохи вище, ніж для підвісних, а термін служби роликів для амортизованих роликоопор трохи вище, ніж для підвісних з амортизацією. У той же час термін служби для підвісних амортизованих і амортизованих роликоопор істотно вище, ніж для жорстких і підвісних. Крім того, при значеннях швидкості стрічки вище деяких значень для всіх розглянутих типів роликоопор термін служби ролика може різко знижуватися через появу резонансних явищ, пов'язаних з коливаннями стрічки при русі шматків великих фракцій. Результати можуть бути використані у гірничій, металургійній та будівельній галузях промисловості.

Ключові слова: ролики, підшипники, термін служби, стрічковий конвеєр, роликоопори, швидкість стрічки.

Аннотация. Став конвейера с роликоопорами – важная часть ленточного конвейера, от технического состояния которой зависит надежность конвейера в целом. Надежность става определяется надежностью роликов роликоопор, так как надежность несущих металлоконструкций на порядок выше. Важным показателем для оценки надежности ролика является его срок службы, зависящий от типа, параметров роликоопор и условий эксплуатации. В данной статье поставлена и решена задача определения среднего срока службы роликов ленточного конвейера для различных типов роликоопор: жестких, на канатном ставе, подвесных и амортизированных. Решение этой задачи позволяет дать оценку надежности става ленточных конвейеров, а также прогнозировать технический резерв роликов и систему плановых ремонтов. В данной работе определен коэффициент динамичности и предложен расчет срока службы роликов с учетом динамических усилий, возникающих при движении груза по ставу конвейера и обусловленных изгибом ленты, построены графики зависимости среднего срока службы ролика от скорости конвейерной ленты для различных конструкций става ленточных конвейеров. Установлено, что срок службы роликов конвейера зависит от погонной нагрузки, параметров конвейера, грансостава транспортируемого груза и типа и параметров роликоопор. При этом, с увеличением скорости ленты конвейера для рассмотренных типов роликоопор средний срок службы роликов уменьшается. При изменении скорости ленты до определенных значений срок службы роликов для жестких роликоопор несколько выше, чем для подвесных, а срок службы роликов для амортизированных роликоопор несколько выше, чем для подвесных с амортизацией. В то же время срок службы для подвесных амортизированных и амортизированных роликоопор существенно выше, чем для жестких и подвесных. Кроме того, при значениях скорости ленты выше некоторых значений для всех рассмотренных типов роликоопор срок службы ролика может резко снижаться из-за появления резонансных явлений, связанных с колебаниями ленты при движении кусков крупных фракций. Результаты могут быть использованы в горной, металлургической и строительной отраслях промышленности.

Ключевые слова: ролики, подшипники, срок службы, ленточный конвейер, роликоопоры, скорость ленты.

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