OPTIMIZING SERVICE LIFE OF CONVEYOR BELTS
WHILE TRANSPORTING BULK LOAD

[1]Monastyrskyi V.F., [1]Monastyrskyi S.V., [1]Mostovyi B.I.

[1]*Institute of Geotechnical Mechanics named by N. Poljakov of National Academy of Sciences of Ukraine*

ОПТИМІЗАЦІЯ ТЕРМІНУ СЛУЖБИ СТРІЧКИ КОНВЕЄРА
ПРИ ТРАНСПОРТУВАННІ НАСИПНИХ ВАНТАЖІВ

[1]Монастирський В.Ф., [1]Монастирський С.В., [1]Мостовий Б.І.

[1]*Інститут геотехнічної механіки ім. М.С. Полякова НАН України*

ОПТИМИЗАЦИЯ СРОКА СЛУЖБЫ ЛЕНТЫ КОНВЕЙЕРА
ПРИ ТРАНСПОРТИРОВАНИИ НАСЫПНЫХ ГРУЗОВ

[1]Монастырский В.Ф., [1]Монастырский С.В., [1]Мостовой Б.И.

[1]*Институт геотехнической механики им. Н.С. Полякова НАН Украины*

Abstract. The paper considers problems concerning optimization of service life of a conveyor belt in terms of its bulk material loading. To solve the problem of the optimization of conveyor belt life, correlation dependences between the belt factors and parameters were studied; the obtained coefficients made it possible to select significant ones resulting in considerable effect upon the belt life. It was defined that they include granulometric composition of bulk load, its loading height, type of the applied loading devices, conveyor parameters, type and properties of the belt material, and physical and chemical properties of the load. Statement of the problem of belt life optimization is in the determining minimum of difference between squared velocity of a conveyor belt and projection of horizontal component of the load velocity when it contacts a belt onto the belt motion plane. Cases of direct-flow loading and loading with the help of special devices with straight and curved trough profiles have been analyzed. When belt is loaded with granular fractions, its wear mechanisms are similar within both loading station and linear section at the expense of sliding distance while load moving relative to a belt. It should be noted that within a loading station, load slides down the belt at the inclination angle of a conveyor; within the linear section, it slides along the generator line of a side roller under gravity in the process of load ascending and descending while passing the idlers. While calculating belt wear due to the effect of granular fractions, we take the highest one of the two – within a loading point or within a linear section being equal to maximum. Belt wear due to lumps coming from a loading device during operation time depends upon the amount of lumps contained within the total volume of bulk load on a casual basis. The problem was solved numerically taking into consideration the objective function, varied parameters, and their limitation. Regularities of changes in the belt service life due to significant factors in terms of direct-flow loading and loading with special device have been obtained to perform comparative analysis of different variants in terms of similar value of the objective function. The variants with maximum belt life and minimum objective function have been selected. It has been defined that for short conveyors, in terms of direct-flow loading, belt life decreases by 1.5–2.0 times comparing to the use of a loading device, and in terms of long conveyors, it decreases by 5–6 times, if value of the objective function is 0.5–1.0 m^2/s^2.

Keywords: bulk cargo, belt, conveyor, wear, loading device, belt resource, target function.

Analysis of the operation of conveyors transporting bulk load has demonstrated that the service life of a belt depends on numerous factors: operational conditions, quality of the belts being used, structure of loading devices, physical and mechanical properties of the load, uniformity of its supply, and climatic conditions. Determining the reasons for conveyor belt wear [1–5] aimed at its further elimination is the basic task while solving general problem of improving reliability and performability of belt conveyors. Complexity of the task is in the fact that many factors among the indicated ones are in weak correlation with the parameters of both belt and

conveyor preventing from developing adequate mathematical model of the optimization of conveyor belt service life. Paper [6] substantiates and solves the problem of conveyor belt wear under the effect of bulk load in the probability form. In this context, it has been adopted that a conveyor belt is the part (being nondivisible in terms of operational conditions) which reliability indices depend on its structure, type, size, parameters, and size of the load material. It has been determined that probability of failure-free operation of the belt (up to its wear-out) 0.4–0.6 corresponds to its service life within the range of 1.5–5 years depending on the conveyor length [7]. Results of the belt life optimization are represented in [8, 9] depending upon the load pressure on the belt in a loading station as well as its abrasiveness. In this context, important factors effecting considerably the belt life and its wear within the linear section of a conveyor were not taken into consideration.

To solve the problem of the optimization of conveyor belt life, correlation dependences between the belt factors and parameters were studied; the obtained coefficients made it possible to select significant ones resulting in considerable effect upon the belt life. It was defined that they include granulometric composition of bulk load, its loading height, type of the applied loading devices, conveyor parameters, type and properties of the belt material, and physical and chemical properties of the load.

The obtained results have allowed to formulate a problem of the optimization of conveyor belt life in terms of its bulk loading: conveyor belt of B_b width , $2L$ length and V_b velocity moves along the idlers; bulk material with diverse grain size composition is loaded at loading velocity V_{ld} within the loading station, at distance K_2 from the idler. Granular material is loaded onto a belt continuously while lumps are loaded with the interval varying on a casual basis. Top cover of the belt is subject to constant wear within its central part and side rollers; wear intensity due to the effect of granular fractions within a loading station and conveyor flight is determined using following expressions:

$$\Delta h_{load} = I_l \cdot S_{f_l} \psi ; \qquad (1)$$

$$\Delta h_{lin} = I_{lin} \cdot S_{f_{lin}} \psi \cdot l_i / l_r , \qquad (2)$$

where I_l, I_{lin} are linear intensity of belt wear within a loading station and on a conveyor flight respectively; S_{fl}, S_{flin} are route of load friction against the belt within a loading station and on a linear section of a conveyor respectively; ψ is coefficient taking into consideration load pressure on a belt; $l_i/l_r = n$ is number of idlers within section l_i being subject to wear; and l_r is spacing of idlers on a conveyor.

When belt is loaded with granular fractions, its wear mechanisms are similar within both loading station and linear section at the expense of sliding distance while load moving relative to a belt. It should be noted that within a loading station, load slides down the belt at the inclination angle of a conveyor; within the linear section, it slides along the generator line of a side roller under gravity in the process of load ascending and descending while passing the idlers. Wear of a conveyor belt depends considerably

upon kinetic energy of the falling load that is transformed into friction work within the braking path

$$S_{br} = \frac{(V_b - V_{ld}^0)^2}{2g(f_{fr}\cos\beta - \sin\beta)},$$
(3)

where V_{ld}^0 is projection of the velocity of falling load-belt interaction onto the belt motion plane; f_{fr} is coefficient of load friction on a belt; and β is angle of belt conveyor inclination.

While calculating belt wear due to the effect of granular fractions, we take the highest one of the two – within a loading point or within a linear section being equal to Δh_{max}. Belt wear due to lumps coming from a loading device during operation time t_o depends upon the amount of lumps K_i contained within the total volume of bulk load on a casual basis. Lumps interact with a belt by means of granular load filling of H_{ld} height. A layer of granular fractions H_{ld} is loaded locally while maximum stresses are found within the contact area stipulated by a lump size. Each lump interacts with a belt within a loading station just once; in terms of linear section of a conveyor, the interaction takes place on each idler while its falling after lump-idler interaction. Paper [6] determines that conveyor belt wears out within a linear section of a conveyor owing to the load movement on a belt; that movement is generated under the effect when a belt with the load is pulled through the cross-section of idlers under the drive action. In this case, value of belt wear is determined similarly (3) taking into consideration the number of idlers and inclination angle of a conveyor

$$S_{lin} = \frac{(V_b - V_{ld}^0)^2 L}{2gl_r(f_{fr}\cos\beta - \sin\beta)},$$
(4)

where V_{ld}^0 is projection of the velocity of falling load-idle interaction onto the conveyor motion plane; and L, l_p are conveyor length and spacing of idlers correspondingly.

We consider that load position on a belt experiences no changes after lump falling within a loading station; thus, it is possible to take following expression for belt wear

$$\Delta h = \Delta h_{ld} + \Delta h_{lin},$$

where Δh_{ld}, Δh_{lin} are linear wear of the conveyor top cover within a loading station and linear section respectively.

Each lump-belt interaction is accompanied by the occurrence of a contact patch on the belt surface; value of stresses within that patch is determined from expression [10]:

$$\sigma = \frac{2P_{in}}{\pi} \cdot \frac{\cos^4\Theta}{H_j},$$
(5)

where $P_{in}=qm_jK_d\varphi$ are force of lump-belt interaction within a loading station or lump-

idler interaction within a linear section; q is linear load of granular fraction; m_j is lump mass; K_d is coefficient of dynamic interaction with a belt or idler; φ is coefficient considering decrease of the interaction force owing to the material filling [7]; H_j is height of granular fraction filling; and Θ is angle of stresses distribution within the area of lump-filling contact; angle value was determined experimentally [10].

Value of angle Θ was determined experimentally under laboratory conditions. It is defined [4] that angle Θ varies from 15° to 45° in terms of lumps interaction within a loading station and from 2° to 10° on a conveyer flight while interacting with idlers. Maximum values of contact patch $\pi H^2_{ld} \text{tg}^2\Theta$ are 0.151 m^2 within a loading station and 0.036 m^2 within a conveyer flight.

It is taken in [6] that lumps interaction within a loading station is distributed over the central roller width according to the normal law; thus, after n belt rotations, its surface will wear by value $\Delta h = \Delta h_{ld} + \Delta h_{lin}$. Conveyor belt life up to the wear-out of its cover under the effect of bulk load will be as follows, taking into account $\Delta h_{\max}$ and Δh, [6]:

$$T_l = \frac{\delta_b}{n_h \cdot (\Delta h_{\max} + \Delta h/n)t_o},$$ (6)

where δ_b is thickness of working cover of a conveyor belt; t_o is time of the conveyor on-load operation; and $n_h = 3600\, V_b/(2L)$ is the number of belt rotations per hour.

Analysis of expressions (3), (4), and (6) has shown that the expression in terms of the problem dealing with conveyer-belt life optimization may be selected in the following form:

$$\Phi = (V_b - V^0_{ld})^2 \to \min .$$ (7)

There are following limitations in the problem of conveyer-belt life optimization:

$$q_{\min} < q_{ld} < q_{\max};$$
$$0.1 < f_{fr} < 0.6;$$ (8)
$$1.0 < H < 5.0,$$

where $q_{\min}$, $q_{\max}$ are minimum and maximum possible linear loads; f_{fr} is coefficient of load friction on a belt; and H is loading height.

There are following varied parameters to be taken: H is loading height; l_r is idlers spacing шаг; γ_b is angle of attack; β is inclination angle of a conveyer; V_f is feeder velocity; D is diameter of a feeder drum; V_b is belt velocity; m_l is lump mass; φ_0 is angle of load separation from a feeder belt; and $q_{\min}$, $q_{\max}$ are minimum and maximum possible linear loads.

A problem concerning optimization of conveyer belt life was solved numerically using equations (7), (8), and varied parameters. Two cases of belt conveyer loading were considered: direct-flow and with the help of loading devices with straight and curved troughs. In [11] represents a scheme of bulk load-conveyer belt interaction in general terms; the scheme means that cargo is loaded onto a belt in terms of velocity V_f

and initial angle of bulk load attack φ_0. In this case, lumpy load moves along a parabolic trajectory up to its interaction with a conveyor belt at angle of attack Θ. In terms of horizontal conveyor ($\beta = 0$), angle of bulk load attack varies within the range of

25–30° depending upon the loading height or parameters of a loading device and its configuration. If inclination angle of a conveyor changes up to $\beta_{max} = 12$–14°, then angle of bulk load attack decreases; it may be represented in general terms as:

$$\Theta = 90 - (\gamma_{tr} + \beta), \tag{9}$$

where γ_{tr} is angle of bulk load trajectory inclination relative to the horizontal.

When bulk load interacts with a conveyor belt, its wear is caused by considerable effect of the projection of horizontal component of absolute velocity of contact with a belt on the belt motion plane [6–8] (vertical component effects the stresses resulting in the loss of strength of the conveyor elements). While optimizing conveyor belt life, projection of the velocity of load-belt interaction onto the belt motion plane was determined using expressions [11]:

– for direct-flow loading within a loading station and within a linear section

$$V_{ld}^0 = V_f[\cos\beta\cos(\varphi_0 - \psi) - \sin\beta\sin(\varphi_0 - \psi) - g\Delta t\sin\beta]; \tag{10}$$

– for a loading device with a trough

$$V_{ld}^0 = \cos\gamma_b\sqrt{V_0^2\cos^2\gamma_b + (V_0\sin\gamma_b + g\Delta t)^2}, \tag{11}$$

where V_f, V_0 are velocity of a feeder at the moment of load separation from a feeder belt or from a trough respectively; β, φ_0, γ_b are inclination angle of a conveyor, angle of load separation from a feeder belt, and angle of belt attack with a load respectively; g is acceleration of free fall; and Δt is time of load falling onto a belt.

To determine projections of velocities (10) and (11), velocity of load separation from a feeder belt and trough should be determined depending upon the parameters of loading devices and trough configuration. Paper [6] determines theoretically and proves experimentally the angles and velocities of load separation from a feeder belt; in terms of loading devices, certain experimental studies have been performed which results are represented on Figure1 where *a* is a straight trough profile and *b* is a curved trough profile.

While selecting velocity for load to leave a feeder of loading device, it is considered that it depends upon the trough configuration: it is uniformly variable in terms of a straight trough; in terms of a curved trough, it is uniformly variable within a straight-line section and decelerated within a curvilinear one due to loss of energy for movement and friction forces (Fig. 1). Granular fractions of bulk loads reduce its transportation velocity owing to the expense of energy losses for movement which is taken into consideration by means of Chezy's velocity factor. In terms of bulk load consisting of separate portions of granular fractions and lumps being found within their volume and distributed on a casual basis, lumps move within a loading device trough

faster than granular fractions; however, at specific trough areas, they decelerate, and, within the trough outlet, bulk load velocities become more equable 7.5 m/s may be taken for a straight profile and 5.0 m/s may be adopted for a curved profile (Fig. 1).
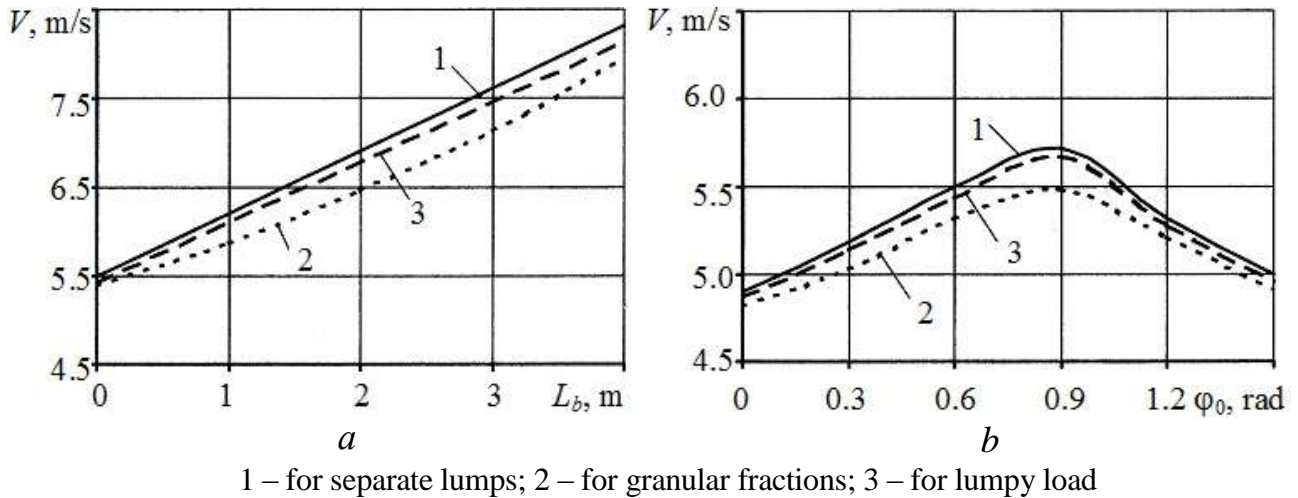

a   b

1 – for separate lumps; 2 – for granular fractions; 3 – for lumpy load

Figure 1 – Dependences of changes in load transportation velocity in a trough of a loading device

Figures 2 and 3 demonstrate dependences of values of the objective function upon different varied parameters. It has been determined that diameter of a feeder drum has practically no effect upon the objective function value (Fig. 3, a). If feeder velocity if from 0.2 to 1.2 m/s for fixed angles of belt conveyor inclination (Fig. 3, b, curves 1, 2, 3, 4, and 5), then objective function is the minimum within the range of 0.6–0.8 m/s and its value drops in terms of increasing feeder velocity and decreasing angle β. If inclination angle is β =- 16°, the objective function tends to zero.

a   b
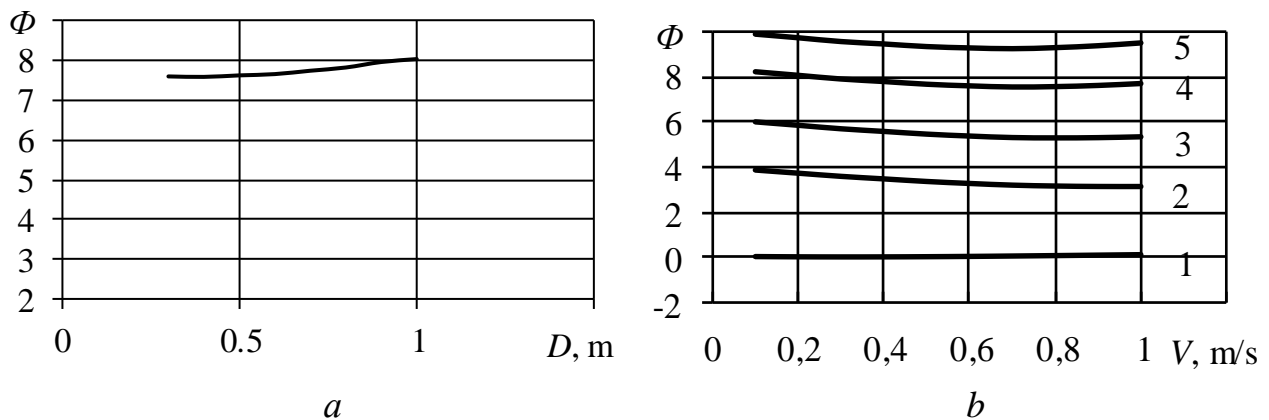
a – upon the drum diameter; b – upon the velocity of belt motion (curves 1, 2, 3, 4, 5 for inclination angles of a conveyor being –16°; 0°; 5°; 10°; 14° respectively)

Figure 2 – Dependence of the value of objective function upon the feeder parameters

Loading height is of dramatic impact upon the objective function value in terms of fixed inclination angles of a conveyor (Fig. 2). Minimum values of the objective function are possible, if loading height is from 0.5 up to 1.0 m within a loading station and if drop height is from 0.2 to 0.3 m on the linear section of a conveyor in terms of inclination angle of a conveyor being lower than zero (incline conveyors).
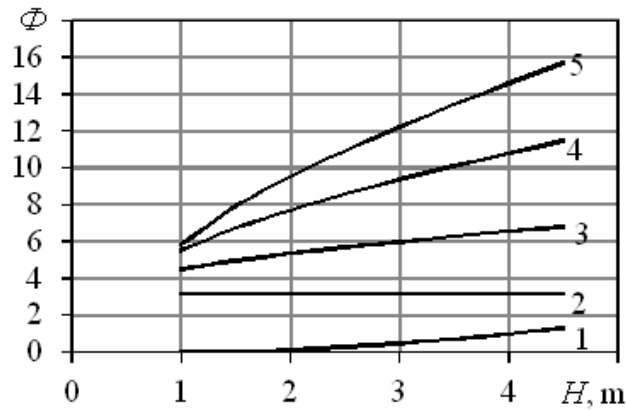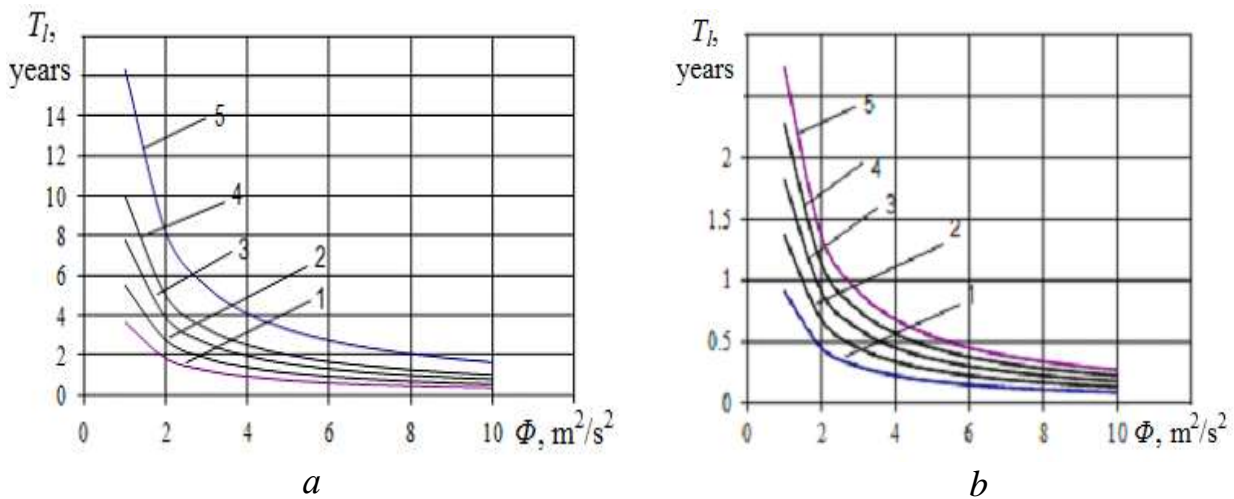
Figure 3 – Dependence of the value of objective function upon the height of load drop
where curves 1, 2, 3, 4, 5 correspond to inclination angles of a conveyor being -16°; 0°; 5°; 10°; 14°

Thus, within a loading station, velocity of load sliding on a belt depends considerably upon the inclination angle of a conveyor, feeder velocity, and loading height; in terms of linear section, it depends on inclination angle of a conveyor, height of lump drop on granular fractions filling, and forces of their interaction.

Service life of conveyor belts was determined according to formula (6) taking into account (1)–(5) for following initial data: conveyor length from 200 to 600 m, belt velocity is 2 m/s, inclination angle of a conveyor is from -16° up to 14°; cover thickness is 0.005 m; and mass of lumps is from 40 to 80 kg. Figure 4,a, b demonstrates regularities of changes in conveyor belt life depending upon the value of objective function, inclination angle of a conveyor, and conveyor length.

a – use of loading devices; b – direct-flow loading; 1, 2, 3, 4, 5 – conveyor length being 200; 300; 400; 500; 600 m correspondingly

Figure 4 – Regularities of changes in conveyor belt life depending upon
the value of objective function

Comparative analysis of the conveyor belt life as for direct-flow loading (Fig. 4, b) and from the loading device trough (Fig. 4, a) was performed according to calculated data in terms of the parameter (H, L_b, R_l, φ_0, α, β, V_0, D) set searching. We considered that calculation variants, where belt life was maximum at minimum value of the

objective function, were the best ones. It has been determined that use of loading devices with straight or curved trough profile makes it possible to increase service life of belts of short conveyors by 1.5–2 times and the ones of long conveyors – by 4–5 times (Fig. 4,b, objective function is equal to 2) comparing to the direct-flow loading (Fig. 4,a). If inclination angle of a conveyor is up to 14°, inclination angle of the loading device trough is up to 60°, height of load drop onto a belt is from 0.5 to 1.0 m within a loading station and from 0.1 to 0.2 on a conveyor flight, and projection of load velocity on the belt motion plane calculated according to analytical expressions (10) and (11) involving regularities of Figure 1; then service life of belts for short conveyors increases by 20–30 % while the one for long conveyors grows by 60–70 %.

Conclusions.

A complex multiparameter problem concerning optimization of conveyor belt life in terms of loading its top cover with bulk load of different granulometric composition has been solved. It has been defined that the belt service life depends on various factors: load size, type of the involved loading devices, inclination angles of both conveyor and trough as well as difference of squared belt velocity and projection of horizontal component of the load onto the belt motion plane – objective function. Optimal (maximum) belt service life is reached in terms of value of the objective functions being close to 0.5–1.0 m^2/s^2.

REFERENCES

1. Galkin, V.I., Dmitriev, V.G., Dyachenko, V.P. (2005), *Sovremennaya teoriya lentochnykh konveyerov gornykh predpriyatiy* [Modern theory of belt conveyers of mining enterprises], MSMU, Moscow, Russia.

2. Monastyrsky, V. F., Monastyrskaya, N. N., Monastyrsky, S. V. (2003), "Features of calculating loading devices during their interaction with bulk load", *Proceedings of the symposium "Miner's Week – 2003"*, Moscow, Russia, February, pp. 184–185.

3. Zaostrovtsev, V. N., Mukhamedyanov, I. S., Monastyrsky, V. F. (2000), "Practices of operating belt conveyors in terms of factory №12 of Udachninsk mining and processing plant", *Mining Journal*, no. 7, pp. 40–44.

4. Ostrovsky, M. S., Radkevich, YA. M., Timeryazev, V. A. (2004), "Criteria to control technical conditions of machines", *Mining machines and automatics*, no. 6, pp. 40–42.

5. Monastyrsky, V. F., Monastyrsky, S. V. (2004), "Scientific substantiation of the initial data to determine consumer-oriented quality of the enterprises of ALROSA SC", *Proceedings of the International Scientific and Practical Conference "Problems and prospects of complex development of cryolithozone mineral deposits"*, Yakutsk, vol. 3, pp. 175–184.

6. Monastyrsky, V. F. (1990), "Development of methods and tools for managing the reliability of high-power belt conveyors", D. Sc. Thesis, Mining Machines, Institute of Geotechnical Mechanics named by N. Poljakov of National Academy of Sciences of Ukraine, Dnepropetrovsk, Ukraine.

7. Polunin, V. T., Gulenko, G .N. (1986), *Ekspluatatsiya moshchnykh konveyyerov* [Exploitation of powerful conveyers], Nedra, Moscow, Russia.

8. Kiriya, R.V. (2004),"Optimization of the Parameters of Passive Shifting Knots of Belt Conveyers of Mining Enterprises", Ph. D. Thesis, Mining Machines, Institute of Geotechnical Mechanics named by N. Poljakov of National Academy of Sciences of Ukraine, Dnipropetrovsk, Ukraine.

9. Kuksa, V.P. (1968), "Studying earth movement within the transfer units of conveyor line", Ph. D. Thesis, Mining Machines, Kyiv, Ukraine.

10.Timoshenko, S.P., Yang, D. KH. and Uiver, U. (1985), *Kolebaniya v inzhenernom dele* [Vibration on engineering], Fizmatlit, Moscow, Russia.

11. Monastyrsky, S. V. (2007), "The Scientific Substantiation of Tape Conveyors Quality Adaptation to Various Conditions of Operation" Ph. D. Thesis, Mining Machines, Institute of Geotechnical Mechanics named by N. Poljakov of National Academy of Sciences of Ukraine, Dnipropetrovsk, Ukraine.

СПИСОК ЛІТЕРАТУРИ

1. Современная теория ленточных конвейеров горных предприятий / В. И. Галкин, В. Г. Дмитриев, В. П. Дьяченко [и др.]. – М.: МГГУ, 2005. – 543 с.

2. Монастырский В. Ф. Особенности расчета загрузочных устройств при взаимодействии с насыпным грузом / В. Ф. Монастырский, Н. Н. Монастырская, С. В. Монастырский // Неделя горняка – 2003: Материалы симпозиума, 31 января – 4 февраля 2003 г. – М.: МГГУ, 2003. – С. 184-185.

3. Заостровцев В. Н. Опыт эксплуатации ленточных конвейеров в условиях фабрики №12 Удачнинского ГОКа / В. Н. Заостровцев, И. С. Мухамедъянов, В. Ф. Монастырский // Горный журнал. – 2000. – № 7. – С. 40–44.

4. Островский М. С. Критерии управления техническим состоянием машин / М. С. Островский, Я. М. Радкевич, В. А. Тимерязев // Горные машины и автоматика. – 2004. – № 6. – С. 40–42.

5. Монастырский В. Ф. Научное обоснование исходных данных для определения потребительского качества предприятий АК «АЛРОСА» / В. Ф. Монастырский, С. В. Монастырский // Сб. трудов Международной научно-практической конференции «Проблемы и перспективы комплексного освоения месторождений полезных ископаемых криолитозоны». – Якутск: из-во СОРАН. – 2004. – Т.3. – С. 175–184.

6. Монастырский В. Ф. Разработка методов и средств управления надежностью мощных ленточных конвейеров: дис… д-ра техн. наук: 05.05.06 / В. Ф. Монастырский. – Днепропетровск: ИГТМ НАН Украины, 1990. – 345 с.

7. Полунин В. Т. Эксплуатация мощных конвейеров / В. Т. Полунин, Г. Н. Гуленко. – М.: Недра, 1986. – 343 с.

8. Кирия Р. В. Оптимизация параметров пассивных перегрузочных узлов ленточных конвейеров горных предприятий: дис… канд. техн. наук: 05.05.06 / Р. В. Кирия. – Днепропетровск: ИГТМ НАН Украины, 2004. – 205 с.

9. Кукса В. П. Исследование движения грунта в узлах перегрузки конвейерных линий: дис… канд. техн. наук: 05.05.06 / В. П. Кукса. – Киев, 1968. – 260 с.

10. Тимошенко С. П. Колебания в инженерном деле / С. П. Тимошенко, Д. Х. Янг, У. Уивер. – М.: ФИЗМАТЛИТ, 1985. – 474 с.

11. Монастырский С. В. Научное обоснование показателей качества ленточных конвейеров для адаптации их к различным условиям эксплуатации: дис. … канд. техн. наук: 05.05.06 / С. В. Монастырский. – Днепропетровск: ИГТМ НАН Украины, 2005. – 190 с.

––––––––––––––––––––––––––––––––––––––

About the authors

Monastyrskyi Vitalii Fedorovych, Doctor of Technical Sciences (D. Sc), Senior Researcher, Senior Researcher in Department of Geomechanics of Mineral Opencast Mining Technology, Institute of Geotechnical Mechanics named by N. Poljakov of National Academy of Sciences of Ukraine (IGTM, NAS of Ukraine), Dnipro, Ukraine, sly3@i.ua

Monastyrskyi Serhii Vitaliiovych, Candidate of Technical Sciences (Ph. D), Junior Researcher in Department of Geomechanics of Mineral Opencast Mining Technology, Institute of Geotechnical Mechanics named by N. Poljakov of National Academy of Sciences of Ukraine (IGTM, NAS of Ukraine), Dnipro, Ukraine, sly3@i.ua

Mostovyi Borys Ivanovych, Master of Science, Principal Specialist in Department of Geomechanics of Mineral Opencast Mining Technology, Institute of Geotechnical Mechanics named by N. Poljakov of National Academy of Sciences of Ukraine (IGTM, NAS of Ukraine), Dnipro, Ukraine, sly3@i.ua

Про авторів

Монастирський Віталій Федорович, доктор технічних наук, старший науковий співробітник, старший науковий співробітник відділу геомеханічних основ технології відкритої розробки родовищ, Інститут геотехнічної механіки ім. М. С. Полякова Національної академії наук України (ІГТМ НАН України), Дніпро, Україна, sly3@i.ua

Монастирський Сергій Віталійович, кандидат технічних наук, молодший науковий співробітник відділу геомеханічних основ технології відкритої розробки родовищ, Інститут геотехнічної механіки ім. М. С. Полякова Національної академії наук України (ІГТМ НАН України), Дніпро, Україна, sly3@i.ua

Мостовий Борис Іванович, магістр, провідний інженер відділу геомеханічних основ технології відкритої розробки родовищ, Інститут геотехнічної механіки ім. М. С. Полякова Національної академії наук України (ІГТМ НАН України), Дніпро, Україна, sly3@i.ua.

––––––––––––––––––––––––––––––––––––––

Анотація. У цій статті розглянуто питання оптимізації ресурсу конвеєрної стрічки при навантаженні насипним вантажем. Спочатку були виконані дослідження кореляційної залежності між факторами і параметрами стрічки, за значенням коефіцієнтів яких відібрано значущі, що викликають істотний вплив на термін служби стрічки. Встановлено, що до них відносяться гранулометричний склад насипного вантажу, висота його завантаження, тип застосовуваних завантажувальних пристроїв, параметри конвеєра, тип і властивості матеріалу стрічки і фізико-механічні властивості вантажу. Постановка завдання оптимізації ресурсу стрічки полягає у визначенні мінімуму різниці між квадратами швидкості стрічки конвеєра і проекцією горизонтальної складової швидкості вантажу при зустрічі зі стрічкою на площину її руху. Розглядалися випадки прямоточного завантаження і через завантажувальний пристрій з прямолінійним і криволінійним профілем жолоба. При цьому механізми зношення стрічки в пункті завантаження і на лінійній частині однакові – за рахунок шляху тертя при русі вантажу відносно стрічки. Причому в пункті завантаження вантаж ковзає вниз по стрічці під кутом нахилу конвеєра, а на лінійній частині – по твірній бічного ролика під дією сили тяжіння при підйомі та опусканні вантажу під час проходження роликоопори. Зношення стрічки в пункті завантаження і на лінійній частині конвеєра від дрібношматкового вантажу приймався найбільшим, для великих шматків взаємодія зі стрічкою через підсипку дрібношматкових вантажів – локально, а максимальні напруження виникали в області контакту, обумовленого формою шматка. Завдання вирішувалося чисельним способом з урахуванням функції мети, варійованих параметрів та їх обмежень. Отримано закономірності зміни ресурсу стрічки від значущих чинників при прямоточному завантаженні

та через завантажувальний пристрій, за допомогою яких було виконано порівняльний аналіз різних варіантів при однакових значеннях функції мети. Відбиралися варіанти, при яких термін служби стрічки був максимальний, а функція мети – мінімальною. Встановлено, що для коротких конвеєрів ресурс стрічки при прямоточному завантаженні знижується в 1,5–2,0 рази в порівнянні із застосуванням завантажувального пристрою, для довгих в 5–6 разів при значенні функції мети 0,5–1,0 м^2/с^2.

Ключові слова: насипний вантаж, стрічка, конвеєр, зношення, завантажувальний пристрій, ресурс стрічки, функція мети.

Аннотация. В настоящей статье рассмотрены вопросы оптимизации ресурса конвейерной ленты при нагружении насыпным грузом. Первоначально были выполнены исследования корреляционной зависимости между факторами и параметрами ленты, по значению коэффициентов которых отобраны значимые, вызывающие существенное влияние на срок службы ленты. Установлено, что к ним относятся гранулометрический состав насыпного груза, высота его загрузки, тип применяемых загрузочных устройств, параметры конвейера, тип и свойства материала ленты и физико-механические свойства груза. Постановка задачи оптимизации ресурса ленты заключается в определении минимума разности между квадратами скорости ленты конвейера и проекцией горизонтальной составляющей скорости груза при встрече с лентой на плоскость ее движения. Рассматривались случаи прямоточной загрузки и через загрузочное устройство с прямолинейным и криволинейным профилем желоба. При этом механизмы износа ленты в пункте загрузки и на линейной части одинаковые – за счет пути трения при движении груза относительно ленты. Причем в пункте загрузки груз скользит вниз по ленте под углом наклона конвейера, а на линейной части – по образующей бокового ролика под действием силы тяжести при подъеме и опускании груза во время прохождения роликоопоры. Износ ленты в пункте загрузки и на линейной части конвейера от мелкокускового груза принимался наибольшим, для крупных кусков взаимодействие с лентой через подсыпку мелкокусковых грузов – локально, а максимальные напряжения возникали в области контакта, обусловленного формой куска. Задача решалась численным способом с учетом функции цели, варьируемых параметров и их ограничений. Получены закономерности изменения ресурса ленты от значимых факторов при прямоточной загрузке и через загрузочное устройство, с помощью которых был выполнен сравнительный анализ различных вариантов при одинаковых значениях функции цели. Отбирались варианты, при которых срок службы ленты был максимальный, а функция цели – минимальной. Установлено, что для коротких конвейеров ресурс ленты при прямоточной загрузке снижается в 1,5–2,0 раза по сравнению с применением загрузочного устройства, для длинных в 5–6 раз при значении функции цели 0,5–1,0 м^2/с^2.

Ключевые слова: насыпной груз, лента, конвейер, износ, загрузочное устройство, ресурс ленты, функция цели.