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Distribution Analysis Of Conveyor Roller Tension

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ABSTRACT

The level of conveyorization of mining enterprises is constantly increasing. This article determines the distribution of the forces applied to the cross-sectional surface of the belt, when rocks are transported by belt conveyors, the effect of dynamic forces on the bending of the belt and middle roller length rocks on the basis forces the roller supports.

KEYWORDS

Belt Conveyor, Belt, Roller, Roller Base, Damper, Power.

INTRODUCTION

Vehicles used in the mining industry must have high production productivity, high capacity and durability, and ensure uninterrupted delivery of minerals over significant long distances.

One of the most efficient types of continuous transport machines is belt conveyors because they transport minerals over long distances with minimal labor and energy costs (Figure 1).

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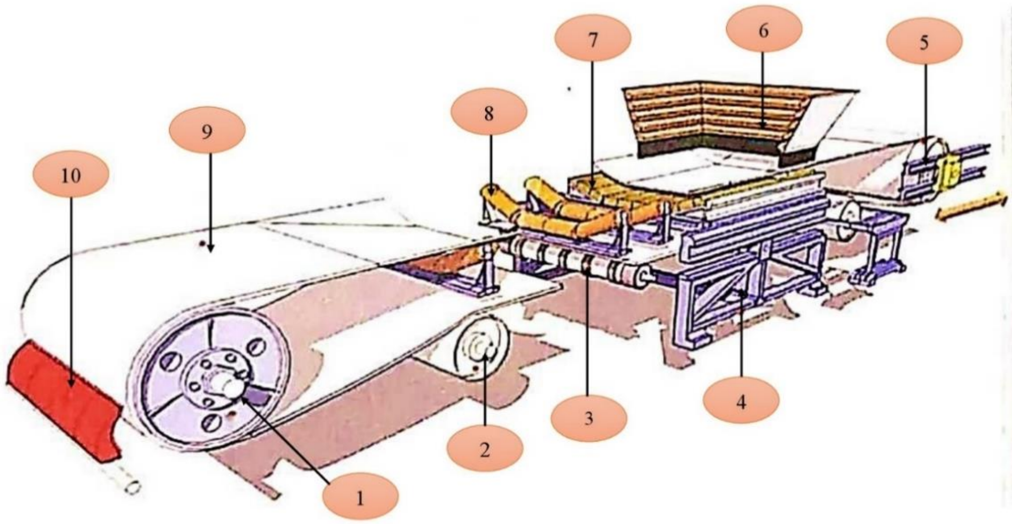

Figure 1. Belt conveyor

1-driving drum; 2-turning drum; 3-lower rod roller supports; 4-base construction; 5-tensioning drum (tensioning station); 6-loading device; 7-damper station; 3-upper rod roller supports; 9-conveyor belt; 10-cleaning device

The level of conveyorization of mining enterprises is constantly increasing, and the development of new large deposits will undoubtedly require the widespread introduction of more powerful belt conveyors and long-distance conveyor belts [2,3,6,11].

Numerous studies have shown that transport loads in mining enterprises vary greatly and are usually random, so studies have studied belt and roller stress states depending on the characteristics of the load flows [1,3,7]. One of the main tasks is to consider the specific approach to the calculation of distributed resistances to the belt movement and the influence of external factors on them, as well as the various design features of the belt conveyor.

When rocks are transported by belt conveyors, large pieces of rock are subjected to dynamic forces on the bending of the belt and the resulting roller and roller bearings (Figure 2).

As a result of experimental studies of the effect of dynamic forces, the forces acting on the belt and the roller bearing are felt when the speed of the belt exceeds 2 m/s.

The conveyor belt is stretched under the influence of force S_l, and between the q load and the P_k load, large pieces of rock are distributed along the belt and move along the roller with ϑ_t speed. During the movement, vibrations occur in the belt and the vibrations are determined according to the following formula.

$$\rho_c \frac{d^2 y}{dt^2} - S_l \frac{\partial^2 y}{\partial x^2} = f(x,t) \qquad (1)$$

Here, y - the vertical motion of the belt, m; ρ_c - Rock and belt weight in 1 m, kg/m; $f(x,t)$ - impact of moving load on the belt, H/ m.

The effect of the moving load on the conveyor belt is determined as follows.

$$f(x,t) = q + (P_k + \frac{P_k}{g}\frac{d^2y}{dt^2})\sigma(x - \vartheta_l t)$$

(2)

q - weight of rock at 1 m, kg/m; P_k - weight of coarse-grained rocks, kg.

$x - \vartheta_l t$ the expression is the sum of the gravitational and inertial forces of the load piece that appear as it moves along the belt and is directed vertically downward.

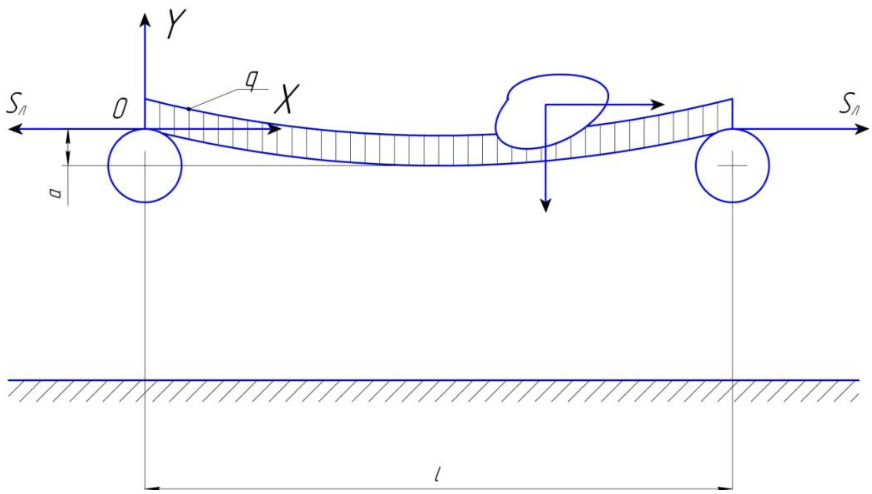

Figure 2. Scheme of movement of load sections on roller bearings

The dynamic force acting on the roller bearing as a result of the movement of a large load piece along the conveyor belt is determined by the following formula.

$$F_{\partial 1} = P_k + \frac{P_k}{g}\frac{d^2y}{dt^2} \quad (3)$$

As a result, the dynamic coefficient equal to the weight ratio of the load part of the dynamic force $F_{\partial 1}$ acting on the roller bearing P_k and caused by the movement of a large load piece along the conveyor will be κ_{d1} and is determined by the following formula.

$$k_{\partial 1} = \frac{F_{\partial 1}}{P_k} = 1 + \frac{2\vartheta_l^2}{gl_p} \cdot \frac{\left(P_k + \frac{2ql_p}{\pi}\right)}{\left(S_l - \frac{\vartheta_l^2}{g}(q + \frac{4P_k}{l_p})\right)} \quad (4)$$

It follows from the analysis of formula (4) that if the denominator of the fraction is close to zero, then the dynamic coefficient tends to infinity. In this case, a resonance occurs in the system. To avoid resonance, the speed of the conveyor belt should not exceed the critical speed.

The critical velocity is determined according to the following formula.

$$\vartheta_{kr} = \sqrt{\frac{S_l g}{q + \frac{4P_k}{l_p}}} \text{ м/с} \qquad (5)$$

Applying the Ritz method, the dynamic coefficient is determined as follows when the rock moves along the roller supports.

$$k_{\partial 2} = 1 + \frac{2\vartheta_t^2}{gL} \cdot \frac{\left(P_k + \frac{4q_t L}{\pi} + 2G' \sin\frac{\pi l_p}{2L} + G'' \sin\frac{3\pi l_p}{L}\right)}{\left(S_l - \frac{4\vartheta_t^2 P_k}{gL})\right)} \qquad (6)$$

Here, L - distance between conveyor supports, m; q_t - weight of the belt in 1 m, H/m; l_p - distance between roller bearings, m; S_l -tension power of the belt, H; G - gravity of roller bearings, H.

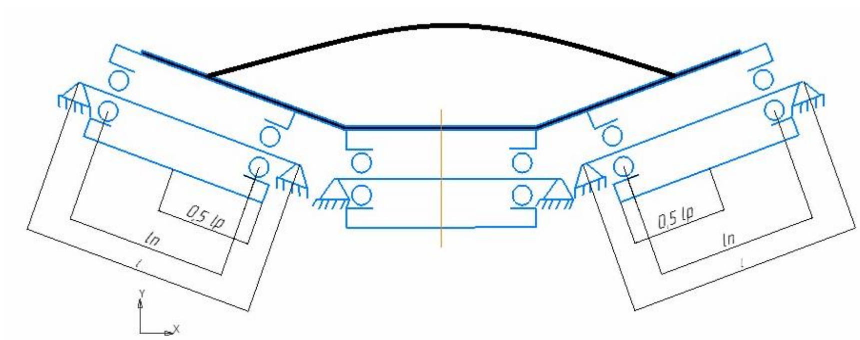

Figure 3. Basic parameters of rollers

Determining the effect of gravity on the belt conveyor rollers and the distribution of forces will depend on the dimensions of the roller, the angle of inclination of the side rollers, the weight of the belt and the mass of rock at 1 m (Figure 3).

MATERIALS AND METHODS

During the load movement of the belt conveyor, the reaction forces for the balance of the rollers were considered according to

the Dalamber principle. Based on Figure 4, the forces acting on the conveyor side rollers were determined by projecting the forces on the *x*, *y* axes.

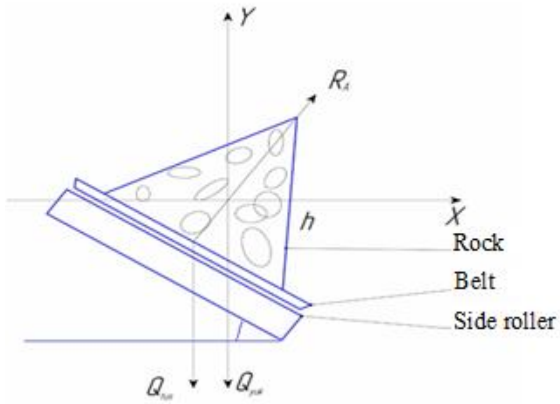

Figure 4. Forces acting on the side rollers

The reaction force acting on the roller is projected relative to the axis as the gravitational forces of the belt and the load are directed in a horizontal position.

$$\sum F_y = R_A \cdot \cos\beta - Q_{yuk} \cdot g - Q_{tas} \cdot g = 0$$

The reaction force acting on the side roller is found as follows.

$$R_A = \frac{k_t \cdot l \cdot h \cdot \sin(90-\beta) \cdot \upsilon \cdot \gamma \cdot k_t + G_{tas} \cdot B}{\cos\beta} \cdot g\ ;\ (N) \qquad (7)$$

Based on Figure 5, the gravitational force of the rock and the reaction forces acting on the medium roller are determined basing on the belt and their effect on the roller.

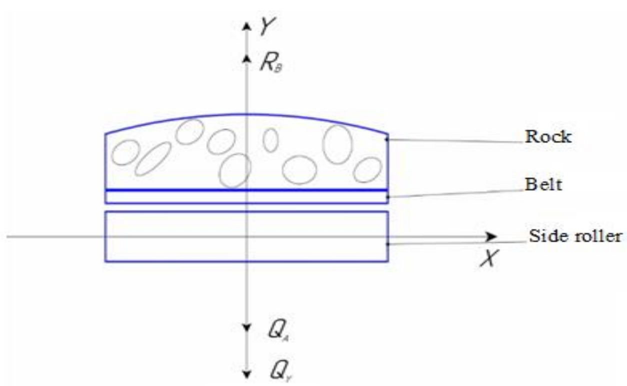

Figure 5. Forces acting on the middle roller

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The reaction force falling on the middle roller

$$R_B = G_{tas} \cdot Bg + h \cdot l \cdot \upsilon \cdot \gamma \cdot k_{t2} g \text{ ; H}$$

ϑ - belt speed ($\frac{m}{s}$); γ - the density of the rock $\frac{kg}{m^3}$; k_t - coefficient of completeness; G_{tas}- belt weight (kg); the weight of the strip in q – 1 m^2; B-the width of the conveyor belt (m); β - the angle between the side rollers; l_x - roller length (m); h - the height of the load on the belt (m);

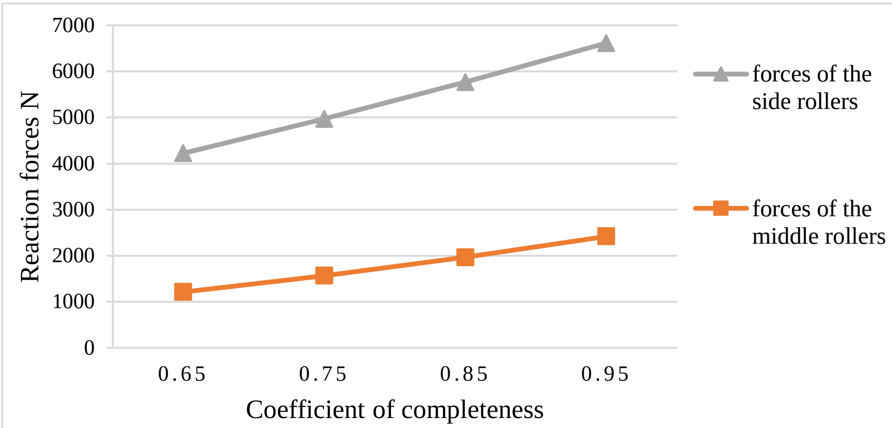


Figure 6. Graph of the dependence of the reaction forces of the middle and side rollers on the coefficient of completeness

In Figure 6, based on the dependence of the reaction forces of the middle and side rollers on the completeness coefficient, it was found that the reaction force on the middle roller is large and the reaction force on the side rollers is small.

The formula for the distribution of rocks of middle roller length was determined based on the effect of forces applied to the cross-sectional surface of the belt.

$$l_p = K_{prop} \cdot B - \frac{G_{tas} \cdot B \cdot \sin\beta}{K_t \cdot h \cdot \cos\beta \cdot \gamma} \text{ m}$$

(8)

In Equation (8), the results of the distribution of the length of rollers rocks based on the effect of forces applied to the belt cross-sectional surface are given in *Table 1.*

Table 1.

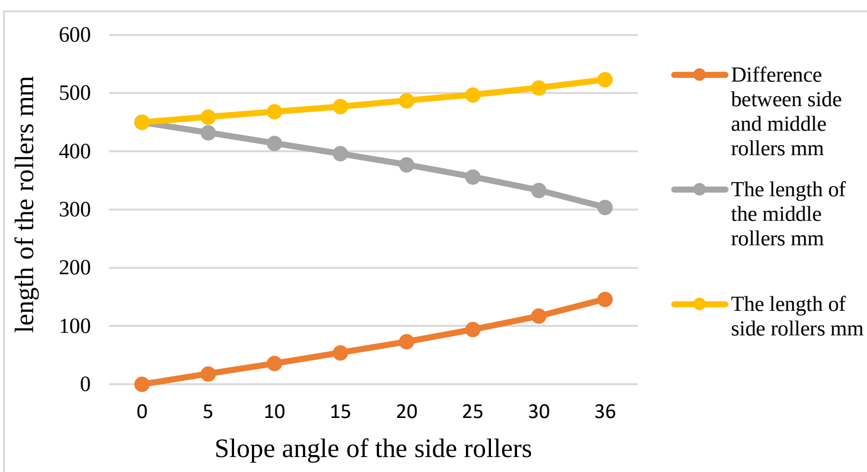
Results of the distribution of rocks of the length of rollers based on the effect of forces applied to the cross-sectional surface of the belt

№	Side roller slope angle	Completeness coefficient	Side roller length, mm	Medium roller length, mm

1	0	0.75	450	450
2	5	0.75	459	432
3	10	0.75	468	414
4	15	0.75	477	396
5	20	0.75	487	377
6	25	0.75	497	356
7	30	0.75	509	333
8	36	0.75	523	304

Figure 8a shows the difference in the lengths of the middle and side rollers on the roller bearings, the graph of the dependence of the slope angle of the side roller, and the difference in the lengths of the middle and side rollers as the side roller slope increases.

Figure 8b shows the dependence of the slope angle and the coefficient of completeness of the side roller, and the higher the coefficient of completeness, the smaller the difference between the lengths of the middle and side rollers.



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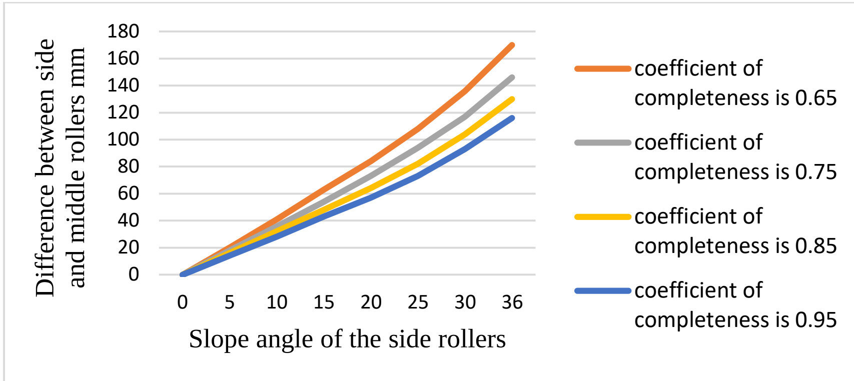
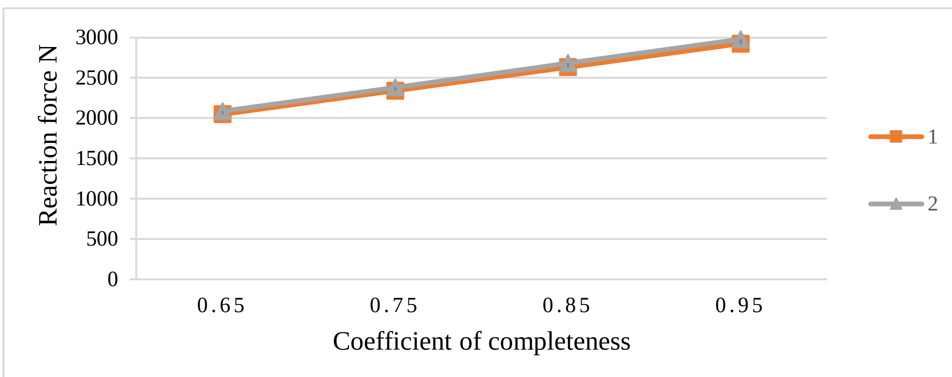


Figure 7. Graphs of dependence on the angle of the lengths of the middle and side rollers

The difference in the lengths of the side rollers and the middle rollers was found to depend on the rock density, the coefficient of completeness, the weight and width of the belt, and the slope angles of the side rollers.



1- Middle roller reaction force; 2 - Side roller reaction force

Figure 8. The dependence of the reaction forces of the middle and side rollers on the coefficient of completeness

CONCLUSION

The tension on the conveyor belt and rollers was determined on the basis of mathematical developments, the distribution of the belt, side rollers and middle rollers, and the variation of the length dimensions of the belt conveyor support rollers in the range of impact forces, the slope angles of the falling rollers in the range of 0-360, the length of the middle roller in the range of 450-304 mm, the length of the side rollers in the range of 450-523 mm.

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