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ABOUT MAXIMUM UTILIZATION OF SUPPORTING CAPACITY OF MINE BELT CONVEYORS

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ABSTRACT
Possibilities to increase the productivity of belt conveyors without considerable change of their construction are treated. Calculations of the area of conveyor cross sections of transported material for five different forms of the belt and their protective widths with belt width B=1600 mm are made. The results show, that productivity could be increased about 40%.

1.INTRODUCTION

Belt conveyors are used in mining industry for haulage of bulk freight mineral resources and rock mass.

Increasing productivity of mining machines – combines, excavators etc. the belt conveyors are the only transporting machines that could cope with increased load flows. That is why their utilization in mining is great.

Possibilities to increase the productivity of belt conveyors without considerable change of their construction will be treated in this report. Capacity productivity of conveyors depends on two quantities: cross section area of the material, that is on the belt F, m^2, and motion speed of the belt V , m/s, i.e.

$$Q=F.v,\ m^3/s \quad (1)$$

The belt speed is regular and depends on the type of conveyor. For conveyors, used in underground mines the speed is 1,5 - 2 m/s, and for open cast mines - 4 - 6 m/s.

The cross section area of the material on the belt depends on the width, the type and the construction of supporting roller bearing.

In the belt conveyors theory [Schahmaister etc., 1978] it is the custom, that loaded in the belt material do not gain the belt ends in order to get protective strips, which avoid lateral falling of the material. It is assumed also that the upper surface of the material is in the form of triangular prism with inclination of side faced φ (Fig.1). The angle φ is side to be the natural slope in transportation and is about a half of the angle of natural slope of the material at steady state.

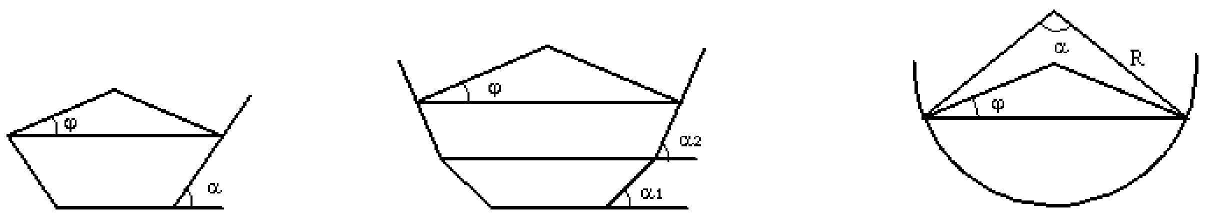

Figure 1.

2.DETERMINATION OF MAXIMAL AREA OF MATERIAL SECTION

We investigate loading of four types belt conveyors, used in "Maritsa – Istok" [Stoev, Marhor, 1991]. Two of them are with three-roller supports and angles of inclination of side rollers α respectively 30^0 and 36^0 (Fig.1, a), and the other two are with five-roller supports and angles of setting of side rollers α_1 and α_2 respectively $\alpha_1=31^0$ and $\alpha_2=38^0$ and $\alpha_1^1=36^0$ $\alpha_2^1=43^0$ (Fig.1, b).

Sectional areas of the material are determined by using of the formula, subtracted by Prof. S.Deevski [Deevski, 1996]:

- for three-roller supports:

$F_3=(x_1^2-x_0^2)\text{tg}\,\alpha + x_1^2.\ \text{tg}\,\varphi$, m², (2)

- for five roller supports:

$F_5=(x_1^2-x_0^2)\text{tg}\,\alpha_1+(x_2^2-x_1^2).\ \text{tg}\,\alpha_2+ x_2^2\ .\text{tg}\,\varphi$, m²; (3)

where x_0, x_1 and x_2 are the lengths of segments, obtained by projecting of cross section angles on the abscissa (Fig.2).

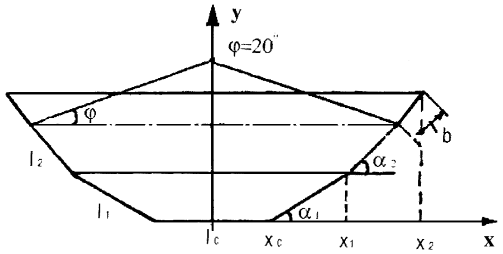

Figure 2.

The lengths of the segments are::

$x_0=\dfrac{l_0}{2}$,

$x_1=x_0+ l_1.\cos\alpha_1$,

$x_2=x_1+ l_2.\cos\alpha_2$,

where l_0, l_1 and l_2 are the lengths of cross section of the belt, m.

In order to compare obtained results, we determine maximal area that could be obtained if the belt is supported by infinitely number of rollers. According to the Luilie theorem that says: "From all plan figures, which contour has the l, the greatest area has the circle" we assume that the belt is bended on circular curve with radius R (Fig.1, в). The form of the material section is circular segment with a triangle on top, which area is:

$$F_0=\frac{R^2}{2}\left(\frac{\pi\alpha}{180}-\sin\alpha\right)+\frac{1}{4}a^2 tg\,\varphi, \qquad (4)$$

where α is the central angle,

R – circle radius, m;

a - chord of the figure, m.

The central angle α, in which the figure of the material has maximal area, is 180⁰. It is determined by investigation of maximum of the function (4) according to the method of digit-by-digit approximation.

3.DETERMINATION OF THE PROTECTIVE WIDTHS

When the belt conveyors are designed, the size of the protective widths is determined according to the following dependences:

- for conveyors with small productivity

$$\Delta b_1 = 0{,}1.B, m \qquad (5)$$

- for conveyors with great productivity

$$\Delta b_2 = 0{,}05.B + 0{,}025, m \qquad (6)$$

Recommended by formulas (5) and (6) protective widths are subtracted as a result of empirical obstructions [1].

Prof. Deevski [1996] subtracts formulas for determination of the needed protective widths and assumes that the upper surface of the triangle prism becomes plane and it draw level with the edge of the pan-like belt as a result of shaking down during the material motion.

The formulas of protective widths are:

$$\Delta b_3 = \frac{B-\sqrt{B^2-4AC}}{2A}, m, \qquad (7)$$

where $A=\cos\alpha_n.\sin\alpha_n+\cos\alpha_n.\text{tg}\,\varphi$;

$B=a.(\sin\alpha_n+\cos\alpha_n.\text{tg}\,\varphi)$;

$C=\dfrac{1}{4}a^2 tg\,\varphi;$

α_n is inclination of the highest side rollers, ⁰;

a – distance between upper edges of pan-like belt, m.

4.CALCULATION RESULTS

Calculation results of areas of cross sections of transported material for different belt forms by using the formulas (2), (3) and (4) and their protective widths, determined by using the formulas (5), (6) and (7) for belt width B= 1600 mm and angle of the natural slope during the transportation φ =20⁰ are given in Table 1.

Table 1

Type of roller support	Protective widths $\Delta b, mm$	Area of the material	
		F,m2	F, %
Three-roller support with inclination of side rollers $\alpha = 30^0$	$\Delta b_1 = 160$ $\Delta b_2 = 105$ $\Delta b_3 = 186$	0,276 0,331 0,253	68 81 62
Three-roller support with inclination of side rollers $\alpha = 36^0$	$\Delta b_1 = 160$ $\Delta b_2 = 105$ $\Delta b_3 = 162$	0,291 0,348 0,290	71 85 71
Five-roller support with inclination of side rollers $\alpha_1 = 31^0$ and $\alpha_2 = 38^0$	$\Delta b_1 = 160$ $\Delta b_2 = 105$ $\Delta b_3 = 154$	0,309 0,367 0,317	76 90 78
Five-roller support with inclination of side rollers $\alpha_1 = 36^0$ and $\alpha_2 = 43^0$	$\Delta b_1 = 160$ $\Delta b_2 = 105$ $\Delta b_3 = 138$	0,317 0,376 0,342	78 92 84
Semi-circular (ideal) section	$\Delta b_1 = 160$ $\Delta b_2 = 105$ $\Delta b_3 = 90$	0,335 0,390 0,407	82 96 100

5.CONCLUSIONS

Calculation result allows us to make the following conclusions:

1. When conveyors are fully loaded their productivity could be increased about 40% without change of their constructions only by replacement of roller support with such ones, which makes pan-like belt deeper. The driving power should be confirmed with increased productivity.

2. For most cases, protective widths calculated by using the formulas (5) (6) and are prove to be insufficient to avoid the material falling from side edges of the belt. That is why it should to be used the formula (7) when determine the limits of loading.

As the most of the protective widths, calculated by using the formulas (5) and (6) are inadmissible from exploitation point of view, comparison of the results concerning material areas is right only for these areas who corresponds to the protective widths calculated by using the formula (7).

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