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SUBSTANTIATION OF PARAMETERS HIGH ANGLE CONVEYOR WITH BOARDS AND PARTITIONS AT LARGE PRODUCTIVITY IN OPEN CAST MINES

UTVRĐIVANJE PARAMETARA VISOKO NAGIBNIH TRANSPORTERA SA IVICAMA I PREGRADAMA NA POVRŠINSKIM KOPOVIMA VELIKOG KAPACITETA

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Abstract: *In the report the basic parameters of high angle conveyors with boards and partitions for open cast mines with large productivity are analyzed. The data on height of partitions and distance between them are resulted. The large attention is given to dependence of factor of filling of a linen of the conveyor on parameters of exploitation. The recommendations for increase of factor of filling of a linen are given.*

Key words: *high angle conveyor, boards, partitions, factor of filling of a linen*

Apstrakt: *U radu se analiziraju osnovni parametri visoko-nagibnih transportera sa ivicama i pregradama koji se koriste na površinskim kopovima velikog kapaciteta. Dobijeni su podaci o visini pregrada i razmaku među njima. Posebno se ističe značaj koeficijenta punjenja trake transportera i njegov uticaj na eksploatacione parametre. Takođe se preporučuju metode za povećanje koeficijenta punjenja trake.*

Ključne reči: *visoko-nagibni transporter, ivice, pregrade, koeficijent punjenja trake*

1. INTRODUCTION

Many of open cast mines of our country especially ore pits as a result of long and intensive development with downturn of mining works more than on 400 meters send to a category deep and now provide production 90 % of mineral raw materials taken by an open way.

The world practice is guided by the nearest prospect on use high angle rise of mining material from depths up to 1000 m, especially on the high angle conveyor. Analysis of the constructive scheme of conveyors established, that the conveyor with boards and partitions, in the certain conditions can appear competition capable with other kinds high angle conveyors, as most reliable.

1. UVOD

Mnogi površinski kopovi u našoj zemlji, naročito površinski kopovi metala, primorani su, posle dugogodišnje intenzivne eksploatacije, da otpočnu otkopavanje ispod nivoa od 400 m, što ih svrstava u kategoriju dubokih površinskih kopova. Ovakvi kopovi trenutno daju oko 90% od ukupne proizvodnje mineralnih sirovina koja se dobija površinskom eksploatacijom.

Rudarska praksa u svetu zasniva se na razvoju novih tehnologija koje omogućavaju transport mineralnih sirovina pod velikim nagibom sa velike dubine, do 1000 m. U tom smislu, visoko-nagibni transporteri su od posebnog značaja.

The basic parameters of such conveyors are: height of boards and partitions distance between theirs, speed of movement, height of rise by one unit factor of filling of a cloth.

The conditions of loading, size of material, conveyor speed influence on a degree of filling of the conveyor, so on its productivity and all basic parameters.

Height of partitions of the conveyor gets out of a condition of stability at transportation of a cargo with the maximal size of a piece, and stability of the partition itself.

The accounts have shown, that maximum height of a partition makes 0.2-0.4 meters. Distance between partitions also is defined by the maximum piece and for transportation of a material size 350÷400 mm it should not be less than 600÷800 mm.

1. Factor of filling of a cloth of conveyor

Factor of filling of a cloth was investigated by many scientists, basically representing a cargo on a cloth as a correct prism (Panin, 1975). In the work we were based on a number of operational and theoretical researches, which have shown, that the cargo settles down in a plane of a partition on a parabola.

In a figure 1 the prospect of half portion of a cargo in cell of a cloth is shown. The axis X is directed along a cloth of the conveyor, Y - is directed in a plane of a partition. The surface of a cargo in cells is limited to the parabolic cylinder and is described by the equation:

$$z=h-p\cdot y^2-x\cdot tg(\delta), \qquad (1)$$

where:
$\delta = \beta - p$; β - angel of an inclination of the conveyor,
h - maximum height of bulk material on a partition,
p - a corner of a natural slope conveyed material in movement. Parameter p in the equation from the equation of a parabola of a surface, forming of at cross section on the a plane y0z.

Angular factor $tg\ (p)$ tangent to curve in the given point is derivative from ordinate z on abscissa y.

As $tg\ (p) = 2\cdot p\cdot a$, $p = tg\ (p)\ /\ (2\cdot a)$,
where a - half of belt width. Maximum height of a bulk material on a partition is equal may be found: $h=b+0.5atg(p)$ where b - height of a board.

Osnovni parametri ovih transportera su: visina ivica i pregrada, razmak između pregrada, brzina kretanja trake i visina uspona po jediničnom koeficijentu punjenja trake.

Uslovi utovara, gabariti materijala koji se transportuje i uticaj brzine kretanja trake na stepen punjenja trake utiču na produktivnost i na sve osnovne parametre.

Visinu pregrade uslovljava stabilnost transporta tereta maksimalnog gabarita i stabilnost same pregrade.

Proračuni su pokazali da maksimalna visina pregrade iznosi od 0.2 do 0.4 metra. Razmak između pregrada, takođe, je definisan maksimalnim gabaritom komada i za transport komada veličine ≈ 350 ÷ 400 mm razmak ne sme biti manji od 600 ÷ 400 mm.

1. Koeficijent punjenja trake transportera

Koeficijent punjenja trake izučavali su mnogi naučnici uzimajući teret na traci kao pravilnu prizmu (Panin 1975). U radu se razmatra niz praktičnih i teoretskih istraživanja koji pokazuju da teret naleže na pregradu u ravni koja čini parabolu.

Na slici1 prikazana je polovina dela tereta na jednom segmentu trake. Osa X je usmerena duž trake transportera, a osa Y je usmerena na ravan pregrade. Površina tereta po segmentima ograničena je na parabolični cilindar, a opisana je jednačinom:

$$z=h-p\cdot y^2-x\cdot tg(\delta), \qquad (1)$$

gde je:
$\delta = \beta - p$; β - ugao nagiba transportera,
h - maksimalna visina rasutog materijala u pregradi,
p - ugao prirodnog nagiba transportovanog materijala u pokretu. Parametar p u jednačini, iz jednačine parabole površine, čini poprečni presek u ravni y0z.

Koeficijent ugla $tg\ (p)$ koji je tangentan na krivu u datoj tački izvodi se sa ordinate z na apcisu y.

Kao $tg\ (p) = 2.p.a$, $p=tg\ (p)/(2.a)$,
gde je a - polovina širine trake. Maksimalna visina rasutog materijala na pregradi je jednaka: $h=b+0.5.atg(p)$ gde je je h - visina ivice.

We shall consider the volume of a bulk material between partitions on a cloth as variable size dependent on the characteristics of a working cloth.

$$V_{mat} = 2\int_0^x dx \int_0^y dy \int_0^z dz + 2\int_y^a dy \int_0^x dx \int_0^z dz \qquad (2)$$

After a number of mathematical transformations of the equation (2) the volume of a bulk material is received:

$$V_{mat} = 2 \cdot \left[b + a \cdot \frac{tg(\rho)}{2} - \frac{tg(\rho)}{2 \cdot a} \cdot r \right]^2 \cdot \frac{a}{tg(\delta)} \qquad (3)$$

Here $r = a^2 + 2 \cdot \frac{b}{tg(\rho)} - 2 \cdot x \cdot a \cdot \frac{tg(\delta)}{tg(\rho)}$,

where x - distance between partitions borrowed by a bulk material.

As the cargo on a belt does not borrows all distance between partitions, there is a site of a belt free from a cargo (figure 1).

Zapremina rasutog materijala između pregrada na traci uzima se kao promenljiva vrednost koja zavisi od karakteristika trake.

$$V_{mat} = 2\int_0^x dx \int_0^y dy \int_0^z dz + 2\int_y^a dy \int_0^x dx \int_0^z dz \qquad (2)$$

Nakon niza matematičkih operacija iz jednačine (2) dobija se zapremina rasutog materijala:

$$V_{mat} = 2 \cdot \left[b + a \cdot \frac{tg(\rho)}{2} - \frac{tg(\rho)}{2 \cdot a} \cdot r \right]^2 \cdot \frac{a}{tg(\delta)} \qquad (3)$$

Ovde je $r = a^2 + 2 \cdot \frac{b}{tg(\rho)} - 2 \cdot x \cdot a \cdot \frac{tg(\delta)}{tg(\rho)}$,

gde je x - razmak između pregrada ispunjenih rasutim materijalom.

S obzirom na to da teret na traci ne zauzima čitav razmak između pregrada, na traci postoji segment slobodnog prostora (slika 1).

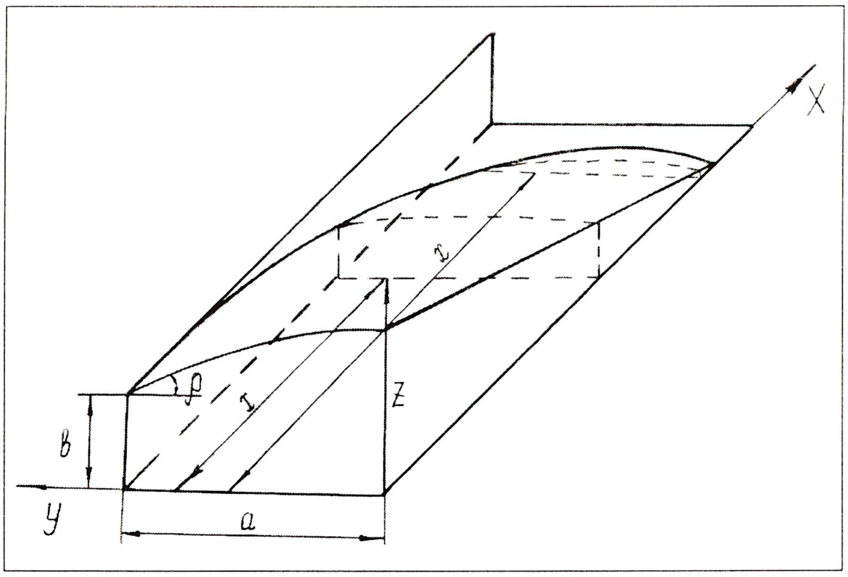

Figure 1 Half of portion of a cargo on a cloth
Slika 1 Poprečni presek tereta na traci

The size of a site of a belt occupied by a cargo is equal:

$x = l - g \cdot (\sin\beta - k \cdot \cos\beta) \cdot l^2 / (2 \cdot v^2)$, (4)

Where:
l_p - distance between partitions,
k - factor of friction of a cargo about a belt,
v - speed of movement of a cloth of the conveyor.

Veličina prostora koji zauzima teret jednaka je:

$x = l - g \cdot (\sin\beta - k \cdot \cos\beta) \cdot l^2 / (2 \cdot v^2)$, (4)

gde je :
l_p - razmak između pregrada,
k - koeficijent trenja tereta o traku i
v - brzina kretanja trake.

As it is visible from the equation (4) x depends on speed of movement of a belt, corner of installation of the conveyor and material conveyed.

Kao što se vidi is jednačine (4), x zavisi od brzine kretanja trake, ugla pod kojim je postavljen transporter i vrste materijala koji se transportuje.

Factor of filling of a cloth is determined as the attitude of volume occupied by a cargo to all volume of a cell.

Koeficijent punjenja trake određuje se kao ponašanje zapremine tereta u odnosu na zapreminu segmenta trake.

$K_f = V_{mat}/V_{cell}$ or

$K_f = V_{mat}/V_{cell}$ ili

$$K_f = \frac{2 \cdot (b + 0.5 \cdot a \cdot tg(\rho) - tg(\rho) \cdot c)^2}{2 \cdot b \cdot l \cdot tg(\delta)} \quad (5)$$

$$K_f = \frac{2 \cdot (b + 0.5 \cdot a \cdot tg(\rho) - tg(\rho) \cdot c)^2}{2 \cdot b \cdot l \cdot tg(\delta)} \quad (5)$$

where $c = f(a, b, l_p, \beta, \upsilon)$.

gde je $c = f(a, b, l_p, \beta, \upsilon)$.

2. FACTOR OF FILLING DEPEND ON BELT SPEED

2. KOEFICIJENT PUNJENJA ZAVISI OD BRZINE TRAKE

The dependence K_f from belt speed is submitted at various corners of installation of the conveyor is shown in a figure 2. Distance between partitions is equal 1 meter, at height of boards $b=0,3$ m, corner of a natural slope p $=25°$. As it is visible from the diagram with increase of belt speed K_f grows, however there is an area of speeds, at which factor of filling decreases. It is caused by that at the certain speeds the loading of new portions of material take up position where the previous portions too. It results to accumulate great mass of material before partition and to pour off it.

Zavisnost K_f od brzine trake primećuje se u nekoliko tačaka duž trase transportera, kao što je prikazano na slici 2. Razmak između pregrada je 1 m, visina ivica b=0,3 m, ugao prirodnog nagiba p=25°. Kao što se može zapaziti sa dijagrama, sa porastom brzine trake, takođe, raste i K_f. Međutim, postoje izvesne brzine na kojima koeficijent punjenja opada. Ta pojava prouzrokovana je utovarom novog materijala koji, takođe, treba da zauzme iste pozicije kao i materijal koji se već transportuje. U tom procesu dolazi do akumulacije velikih količina materijala na jednom mestu, gde se materijal prosipa pre nego što se on podeli u pregrade.

The belt speed is necessary choose for provision of the greatest factor of filling. However increase of speed of moving of a cargo predetermines occurrence of dynamic forces on a partition. There are two areas, at which the factor of filling has the maximum meaning, as shown in figure 2. Speeds laying in a range 1-1.5 m/s do not satisfy on productivity, dynamic forces limit belt speed to 3-3.5 m/s, therefore the rational zone–1.8 – 3 m/s.

Brzina trake je neophodna za određivanje najvećeg koeficijenta punjenja. Međutim, povećanje brzine kretanja tereta uslovljava pojavu dinamičkih sila u pregradi. Postoje dva segmenta u kojima koeficijent punjenja ima najveću vrednost, kao što je prikazano na slici 2. Brzina od 1 do 1.5 m/s nije dovoljna da zadovolji kapacitet, dinamičke sile ograničavaju brzinu trake od 3 do 3.5 m/s, pa je, prema tome, optimalan opseg od 1.8 do 3 m/s.

The dependence of factor of filling of a belt on distance between partitions is shown, at various corners of an inclination in a figure 3 (the belt speed of is equal 2 m/s, corner of a natural slope 25°). As it is visible from figure with increase of distance with 0,7 m up to 1,2 m factors of filling decreases approximately in 1,5-2,5 times, when corner of installation 40 – 60°.

Zavisnost koeficijenta punjenja od razmaka između pregrada prikazana je na slici 3 u nekoliko segmenata nagiba (brzina trake je 2 m/s, ugao prirodnog nagiba je 25°). Kao što se može zapaziti sa slike, sa povećanjem razmaka, sa 0,7 na 1,2 m, koeficijent punjenja opada približno od 1,5 do 2,5 puta, ako je transporter postavljen pod nagibom od 40 do 60°.

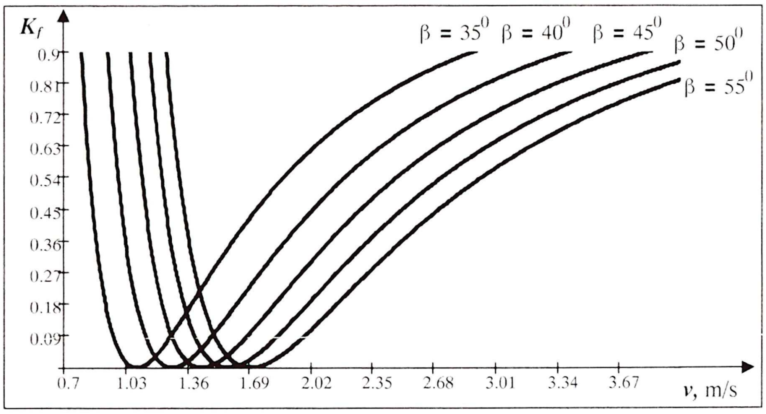

Figure 2 Dependence of factor of filling on speed of movement of a cloth
Slika 2 Zavisnost koeficijenta punjenja od brzine kretanja trake

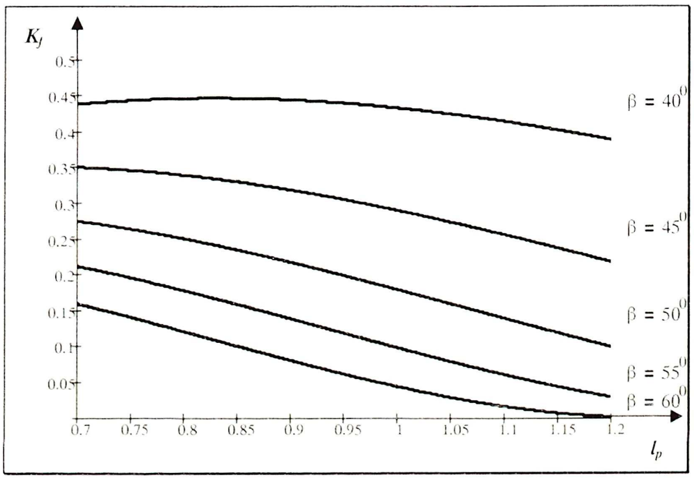

Figure 3 Dependence of factor of filling on distance between partitions
Slika 3 Zavisnost koeficijenta punjenja od razmaka između pregrada

3. CONCLUSION

High-angle conveyor with support elements can transport the maximal piece by the size up to 400 mm. The optimum range of corners of an inclination makes 35°-45°, at belt speed 1,8-3 m/s.

The impossibility of installation of a two-drum-type drive limits maximum height of rise in one flight up to 100 m.

3. ZAKLJUČAK

Visoko-nagibni transporter sa nosećim elementima može da transportuje komade čiji gabariti dostižu 400 mm. Optimalan ugao nagiba kreće se od 35 do 45°, pri brzini trake od 1,8 do 3 m/s.

Nemogućnost instaliranja pogona sa dva bubnja ograničava visinu uspona na 100 m u jednoj etapi.

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