PRORAČUN I PRIMJENA TRAKASTOG TRANSPORTERA U RUDNIKU „KAKANJ“

CALCULATION AND APPLICATION OF BELT CONVEYOR IN THE KAKANJ MINE

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REZIME

Savremena tehnologija eksploatacije odredila je značaj i ulogu kontinuiranog transporta, a naročito transportnih traka kao glavnog predstavnika kontinuiranog transporta.
Transport trakama omogućuje primjenu kompleksne tehnologije pri eksploataciji, utovaru i istovaru svih vrsta čvrstih mineralnih sirovina i postizanje visoke produktivnosti i ekonomičnosti rada. Primjena traka omogućuje da se cijeli proizvodni proces organizira kontinuirano i potpuno automatizirano.
Proračun gumenih transportera koji se koriste u Rudniku „Kakanj“ tema su ovoga rada.

Professional paper

SUMMARY

Modern exploitation technology has determined the importance and role of continuous transport, and especially conveyor belts as the main representative of continuous transport.
Transportation with belt conveyors enables the application of complex technology in exploitation, loading and unloading of all types of solid mineral raw materials and achieving high productivity and economy of work. The application of belt conveyors allows the entire production process to be organized continuously and fully automated.
The calculation of belt conveyors used in the Kakanj Mine is the topic of this paper.

1. UVOD

U okviru rada dat će se prikaz proračuna trakastog transportera sa gumenom trakom koji se primjenjuje u Rudniku „Kakanj“, ukupne dužine od 135 m.
Da bi se izvršio pravilan odabir gumenog trakastog transportera, vrši se provjera samo onog koji radi u najtežim uslovima rada. Ostali gumeni trakasti transporteri se računski ne provjeravaju, jer rade u lakšim uslovima [1].
Za prijevoz radnika i materijala u jami „Begići-Bištrani“ Rudnika mrkog uglja u Kaknju je odabran gumeni trakasti transporter tipa HKA 800/1300/150, L=135m, proizvod firme ERNST HESE, GmbH & Co iz Njemačke. Proračunom će se provjeriti bitni parametri transportera [2-5].
U ovom radu dati su kontrolni proračuni sila zatezanja u konturnim tačkama transportera, proračun snage motora, broj uložaka u gumenom transporteru i minimalno potrebno zatezanje.

1. INTRODUCTION

In the paper the calculation of the belt conveyor used in the Kakanj Mine with a total length of 135 m will be presented. In order to make the correct choice of the belt conveyor, only the one that works in the most difficult working conditions is checked. Other rubber belt conveyors are not calculated and checked, because they do not work in as much hard conditions [1]. A belt conveyor, type HKA 800/1300/150, was selected for the transport of workers and materials in the pit of "Begići-Bištrani" of the Coal Mine in Kakanj, L = 135 m, product of ERNST HESE, GmbH & Co from Germany. All important parameters of the conveyor will be calculated and checked [2-5].
In this paper, control calculations of tensile forces in the contour points of the conveyor, calculation of motor power, number of inserts in the rubber conveyor and the minimum required tightening are given.

2. PODACI ZA PRORAČUN

Osnovni tehnički podaci za proračun su dati kako slijedi:

- dužina transportera $L = 135$ m
- brzina trake $v = 1{,}70$ m/s
- kapacitet transporta uglja $Q = 300$ t/h
- nasipna gustoća materijala $\rho = 1{,}56$ t/m^3
- nagib transportera (prosječno) $\beta = 2{,}5^o$

3. PRORAČUN

3.1 Određivanje širine trake

$$b_1 = \sqrt{\frac{A \cdot 3600}{f}} \qquad ...(1)$$

gdje je:

f – koeficijent oblika poprečnog presjeka materijala nasutog na traku (tabela 1.).

A – površina poprečnog presjeka materijala nasutog na traku.

$$b_1 = \sqrt{\frac{0{,}0351 \cdot 3600}{465}} \Rightarrow b_1 = 0{,}52 \text{ m}$$

2. CALCULATION DATA

The basic technical data for the calculations are given as follows:

- Conveyor length $L = 135$m
- Belt speed $v = 1{,}70$ m/s
- Coal transport capacity $Q = 300$ t/h
- Bulk density of material $\rho = 1{,}56$ t/m^3
- Conveyor inclination (average) $\beta = 2{,}5^o$

3. CALCULATION

3.1 Determining of the belt width

$$b_1 = \sqrt{\frac{A \cdot 3600}{f}} \qquad ...(1)$$

where are:

f – coefficient of cross-sectional shape of the material placed on the belt (Table 1).

A – cross-sectional area of the material placed on the belt.

$$b_1 = \sqrt{\frac{0{,}0351 \cdot 3600}{465}} \Rightarrow b_1 = 0{,}52 \text{ m}$$

Tabela 1. Koeficijent oblika poprečnog presjeka materijala nasutog na traku

Table 1 *Coefficient of cross-sectional shape of the material placed on the belt*

Poprečni presjek transportera ***Conveyor cross section***	**Ravan** ***Flat***	**Oblik V** ***V Shape***	**Koritasti** ***Trough***	**Koritasti** ***Trough***
Vrijednost faktora f *Factor value f*	240	450	465	550

Odabrano: užlijebljeni (koritasti) oblik s nagibom bočnih valjaka od 30°.

3.2 Presjek materijala nasutog na traku

$$A = \frac{1}{k_1 \cdot k_2} \cdot \frac{Q}{3600 \cdot \rho \cdot v} = \qquad ...(3)$$

$$\frac{1}{0{,}90 \cdot 0{,}995} \cdot \frac{300}{3600 \cdot 1{,}56 \cdot 1{,}70} = 0{,}0351 \text{ m}^2$$

$\rho = 1{,}56$ t/m^3 – nasipna gustoća materijala.

$k_1 = 0{,}80 \div 1{,}00$ – koeficijent smanjenja teoretskog kapaciteta zbog neravnomjernog nasipanja materijala na traku.

Usvojeno:

Selected: grooved (trough) shape with side roller inclination of 30 °.

3.2 Cross section of material loaded on the belt

$$A = \frac{1}{k_1 \cdot k_2} \cdot \frac{Q}{3600 \cdot \rho \cdot v} = \qquad ...(3)$$

$$\frac{1}{0{,}90 \cdot 0{,}995} \cdot \frac{300}{3600 \cdot 1{,}56 \cdot 1{,}70} = 0{,}0351 \text{ m}^2$$

$\rho = 1{,}56$ t / m^3 – bulk density of the material.

$k_1 = 0{,}80 \div 1{,}00$ – coefficient of reduction of theoretical capacity due to uneven placing of material on the strip.

$k_1 = 0{,}90$

$k_2 = 0{,}995$ – koeficijent smanjenja teoretskog kapaciteta zbog nagiba transportera od 2,5º.

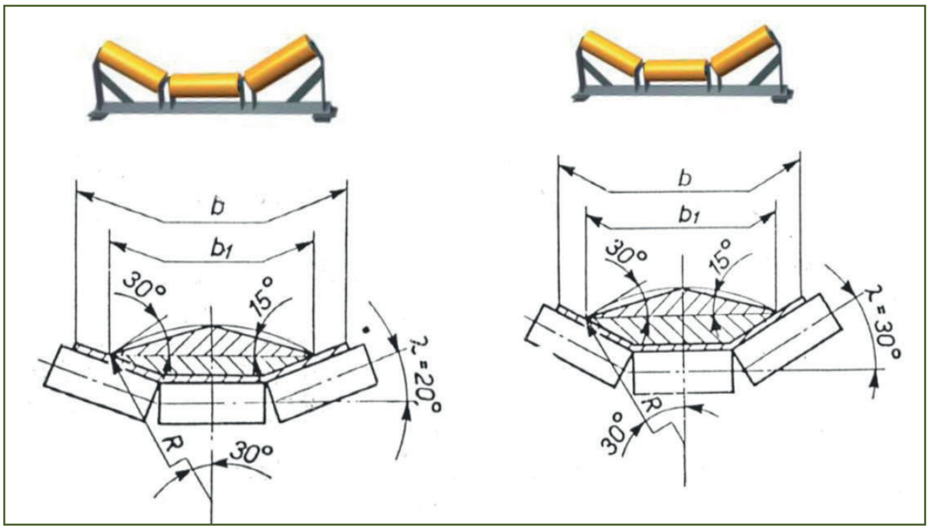
Selected:

$k_1 = 0{,}90$

$k_2 = 0{,}995$ – coefficient of reduction of theoretical capacity due to the inclination of the conveyor of 2.5º.

Tabela 2. Koeficijent smanjenja teoretskog kapaciteta zbog nagiba transportera (k_2)
Table 2 *Coefficient of reduction of theoretical capacity due to inclination of the conveyor (k_2)*

Ugao nagiba β ***Tilt angle*** *β*	*2°*	*4°*	*6°*	*8°*	*10°*	*12°*	*14°*	*16°*	*18°*	*20°*	*22°*
Koeficijent k_2 ***Coefficient*** k_2	*1,0*	*0,99*	*0,98*	*0,97*	*0,95*	*0,93*	*0,91*	*0,89*	*0,85*	*0,81*	*0,76*



Slika 1. Presjek materijala nasutog na traku
Figure 1 *Cross section of material loaded on belt*

3.3 Stvarna širina trake

$$b = \frac{b_1 + 0{,}05}{0{,}9} = \frac{0{,}52 + 0{,}05}{0{,}9} \text{ m} \quad ...(4)$$

$b = 0{,}63$ m

Odabrano: $b = 1{,}00$, m = 1000 mm

Najduži rub komada za ovu širinu trake je 400 mm ⇒ tabela 3., za $b = 1000$ mm.

3.3 Actual belt width

$$b = \frac{b_1 + 0{,}05}{0{,}9} = \frac{0{,}52 + 0{,}05}{0{,}9} \text{ m} \quad ...(4)$$

$b = 0{,}63$ m

Selected: $b = 1{,}00$, m = 1000 mm

The longest edge of the piece for this belt width is 400 mm ⇒ Table 3, for b = 1000 mm.

Tabela 3. Najduži rub komada
Table 3 *The longest edge of the piece*

Najduži rub komada (mm) ***The longest edge of the piece*** *(mm)*	**Najmanja širina trake** (mm) ***Minimum belt width*** *(mm)*	**Najduži rub komada** (mm) ***The longest edge of the piece*** *(mm)*	**Najmanja širina trake** (mm) ***Minimum belt width*** *(mm)*
100	*400*	*400*	*1000*
150	*500*	*500*	*1200*
200	*650*	*600*	*1400*
300	*800*		

3.4 Vrsta tkanine za transportnu traku

Izrađena je sa poliester–poliamidnim ulošcima, tipa EP 1250/4 ZK 4/2, DIN 22102, širine b = 1000 mm.

Odabrano: traka EP 1250/4 ZK 4/2, DIN 22102, širine b = 1000 mm s ulošcima iz poliester – poliamidnog prediva $\Rightarrow$ tabela 4.

3.4 Type of fabric for conveyor belt

It is made with polyester-polyamide inserts, type EP 1250/4 ZK 4/2, DIN 22102, width b = 1000 mm.

Selected: tape EP 1250/4 ZK 4/2, DIN 22102, width b = 1000 mm with inserts made of polyester - polyamide yarn $\Rightarrow$ Table 4.

Tabela 4. Tehničke karakteristike tkanine
Table 4 *Technical characteristics of the fabric*

Tip platna ***Canvas type***	**Prekidna čvrstoća** (N/m) ***Breaking strength*** *(N/m)*		**Težina gumiranog platna** (gr/m^2) ***Weight of rubberized canvas*** *(gr/m^2)*	**Debljina gumiranog platna** (mm) ***Rubberized canvas thickness*** *(mm)*
B – 50 B – 60B – 80	49305 58842 78456	24518 31382 44132	1300 1500 1730	1.65 1.95 2.20
PA – 120 PA – 160 PA – 250 PA – 315	117684 156912 245175 308921	58842 78456 98070 98070	930 1100 1350 1520	1.00 1.30 1.65 1.70
EP – 125 EP – 160 EP – 250 EP – 315	122588 156912 245175 308921	49035 63745 78456 78456	920 1050 1320 1470	1.00 1.30 1.65 1.80
RP – 125 RP – 160 RP – 250 RP – 315	122588 156912 245175 308921	49035 63745 78456 78456	1100 1300 1800 2100	1.40 1.70 2.30 2.50

Ukupna debljina uložaka (gumena traka s 4 uloška) određena je iz tabele 5. i iznosi 4 mm (za EP-125 i 4 uloška).

The total thickness of the layers (rubber band with 4 cartridges) was determined from Table 5 and it is 4 mm (for EP-125 and 4 layer).

Tabela 5. Ukupna debljina uložaka
Table 5 *Total thickness of layers*

Tip platna *Canvas type*	**Broj uložaka** *Number of layers*						
	2	3	4	5	6	7	8
B – 50	3.30	4.95	6.60	8.25	9.90	11.55	13.20
B – 60	3.90	5.85	7.80	9.75	11.70	13.65	15.60
B – 80	4.40	6.60	8.80	11.00	13.20	15.40	17.60
PA – 120	2.00	3.00	4.00	5.00	6.00	7.00	8.00
PA – 160	2.60	3.90	5.20	6.50	7.80	9.10	10.40
PA – 250	3.30	4.95	6.60	8.25	9.90	11.45	13.20
PA – 315	3.40	5.10	6.80	8.50	10.20	11.90	13.60
EP – 125	2.00	3.00	4.00	5.00	6.00	7.00	8.00
EP – 160	2.60	3.90	5.20	6.50	7.80	9.10	10.40
EP – 250	3.20	4.80	6.40	8.00	9.60	11.20	12.80
EP – 315	3.60	5.40	7.20	9.00	10.80	12.60	14.40
RP – 125	2.80	4.20	5.60	7.00	8.40	9.80	11.20
RP – 160	3.40	5.10	6.80	8.50	10.20	11.90	13.60
RP – 250	4.60	6.90	6.20	11.50	13.80	16.10	18.40
RP – 315	5.00	7.50	10.10	12.50	15.00	17.50	20.00

Tabela 6. Ukupna masa uložaka (kg/m^2)
Table 6 *Total weight of layers (kg/m^2)*

Tip platna *Canvas type*	**Broj uložaka** *Number of layers*						
	2	3	4	5	6	7	8
B – 50	2.60	3.90	5.20	6.50	7.80	9.10	10.40
B – 60	3.00	4.50	6.00	7.50	9.00	10.50	12.00
B – 80	3.46	5.19	6.92	89.65	10.38	12.10	13.84
PA – 120	1.86	2.79	3.72	4.65	5.58	6.50	7.44
PA – 160	2.20	3.30	4.40	5.50	6.60	7.70	8.80
PA – 250	2.70	4.05	5.40	6.75	8.10	9.45	10.80
PA – 315	3.04	4.56	6.08	7.60	9.12	10.64	12.16
EP – 125	1.84	2.76	3.68	4.60	5.52	6.44	7.36
EP – 160	2.10	3.15	4.20	5.25	6.30	7.35	10.56
EP – 250	2.64	3.96	5.28	6.60	7.92	9.24	10.56
EP – 315	2.94	4.41	5.88	7.35	8.82	10.29	11.76
RP – 125	2.20	3.30	4.40	5.50	6.60	7.70	8.80
RP – 160	2.60	3.90	5.20	6.50	7.80	9.10	10.40
RP – 250	3.60	5.40	7.20	9.00	10.80	12.60	14.40
RP – 315	4.20	6.30	8.40	10.50	12.60	14.70	16.80

3.5 Kvalitet obloge za transportnu traku

Odabrano: NZ 4/2
- debljina obloge gornjeg pokrovnog sloja je 4,0 mm
- debljina donjeg pokrovnog sloja je 2,0 mm ⇒ tabela 7.

q_o = 7,74 kg/m^2– masa gumenih obloga za odabranu traku ⇒ tabela 7.

3.5 Conveyor belt lining quality

Selected: NZ 4/2
- The thickness of the lining of the upper cover layer is 4.0 mm.
- The thickness of the lower cover layer is 2.0 mm ⇒ Table 7.

q_o =7,74 kg/m^2 – mass of rubber linings for the selected belt ⇒ Table 7.

Tabela 7. Masa gumenih obloga (kg/m^2)
***Table** 7 Mass of rubber linings (kg/m^2)*

Debljina obloge (mm) *Lining width (mm)*	**Kvalitet gumene obloge /** ***Quality of rubber lining***				
	M	**N**	**VM**	**NZ**	**G**
2/1 = 3	3,36	3,39	3,99	3,87	4,17
2/2 = 4	4,48	4,52	5,32	5,16	5,56
3/1 = 4	4,48	4,52	5,32	5,16	5,56
3/2 =5	5,60	5,65	6,65	6,45	6,95
4/2 = 6	6,72	6,78	7,98	7,74	8,34
4/3 = 7	7,84	7,91	9,31	9,03	9,73
5/2 = 7	7,84	7,91	9,31	9,03	9,73
5/3 = 8	8,96	9,04	10,64	10,32	11,12
5/4 = 9	10,08	10,17	11,97	11,61	12,51
6/2 = 8	8,96	9,04	10,64	10,32	11,12
6/3 = 9	10,08	10,17	11,94	11,61	12,51
6/4 = 10	11,20	11,30	13,30	12,90	13,90
8/3 = 11	12,32	12,43	14,63	14,19	15,29
8/4 = 12	13,44	13,56	15,96	15,48	16,68

3.6 Promjer valjaka

Odabrano: Ø = 108 mm ⇒ tabela 8.

3.6 Roller diameter

Selected: Ø = 108 mm ⇒ Table 8.

Tabela 8. Referentne vrijednosti promjera nosećih valjaka u zavisnosti od širine i brzine trake
***Table 8** Reference values of the diameter of the bearing rollers depending on the width and speed of the belt*

v (m/s)	**Širina trake B** (mm) ***Belt width B*** *(mm)*									
	300	**400**	**500**	**650**	**800**	**1000**	**1200**	**1400**	**1600**	**1800**
1,05	51	51	51	90	90	90	108	108	108	133
1,31	51	51	65	90	90	108	108	108	108	133
1,68	51	65	90	108	108	100	108	108	133	133
2,09	51	65	90	108	108	100	108	108	133	133
2,62	65	65	108	108	108	108	133	133	133	159
3,35	65	65	108	108	108	108	133	133	133	159
4,19	65	90	108	133	133	133	133	133	133	159
5,24	90	90	108	133	133	133	133	133	133	159
6,70	90	90	108	133	133	133	133	133	159	159
8,38	90	90	133	133	133	133	159	159	159	159
10,5	90	90	133	133	133	133	159	159	159	159

3.7 Noseći valjci

$$g_v' = \frac{q_v' \cdot n'}{L} \quad [kg/m] \qquad ...(5)$$

g_v' – masa rotirajućih dijelova nosećih valjaka po jednom metru dužnom transportera [kg/m'].

$q_v' = 18,0$ kg – masa rotirajućih dijelova nosećih trodijelnih valjaka u jednom slogu ⇒ tabela 9.

n' – broj nosećih slogova:

$$n' = \frac{L - l_v}{l'} + \frac{l_v}{l_1'} = \frac{135 - 3}{1,20} + \frac{3}{0,60} = \qquad ...(6)$$

= 115 komada nosećih trodijelnih slogova.

l_v = 3 m – dužina utovarnog tijela transportera (dužina usmjerivača).

l' =1,20 m – razmak slogova nosećih valjaka ⇒ tabela 10. (nasipna gustoća 1,56 t/m^3).

$l_1' = 0,5 \cdot l' = 0,5 \cdot 1,2 = 0,60$ m – razmak slogova na utovarnom mjestu. ...(7)

$$g_v' = \frac{q_v' \cdot n'}{L} = \frac{18,0 \cdot 115}{135} = 15,333 \text{ kg/m'} \qquad ...(8)$$

3.7 Bearing rollers

$$g_v' = \frac{q_v' \cdot n'}{L} \quad [kg/m] \qquad ...(5)$$

g_v' – mass of rotating parts of bearing rollers per one meter long of the conveyor [kg/m'].

$q_v' = 18,0$ kg – mass of rotating parts of bearing three - part rollers in one set ⇒ Table 9.

n' – number of supporting sets:

$$n' = \frac{L - l_v}{l'} + \frac{l_v}{l_1'} = \frac{135 - 3}{1,20} + \frac{3}{0,60} = \qquad ...(6)$$

= 115 pieces of supporting three-part sets.

l_v = 3 m – length of the loading part of the conveyor (length of the router).

l' = 1,20 m – distance of bearing rollers ⇒ Table 10, (bulk density 1,56 t/m^3).

$l_1' = 0,5 \cdot l' = 0,5 \cdot 1,2 = 0,60$ m – distance of sets at the loading place. ...(7)

$$g_v' = \frac{q_v' \cdot n'}{L} = \frac{18,0 \cdot 115}{135} = 15,333 \text{ kg/m'} \qquad ...(8)$$

Tabela 9. Približne mase nosećih i povratnih valjaka u kg
Table 9 *Approximate masses of bearing and return rollers in kg*

Promjer nosećih valjaka/ ***Diameter of bearing rollers***	**Tip nosećih valjaka/** ***Type of bearing rollers***	**Širina trake B** (mm) ***Belt width B*** *(mm)*										
		300	**400**	**500**	**650**	**800**	**1000**	**1200**	**1400**	**1600**	**1800**	**2000**
38	Vodoravan / *horizontal* Dvodijelni / *two-part* Trodijelni / *three-part*	1,25 1,50 1,80	1,4 1,7 2,0	1,6 1,9 2,2	1,9 2,3 2,6	2,3 2,7 3,1						
51	Vodoravan / *horizontal* Dvodijelni / *two-part* Trodijelni / *three-part*	1,7 2,0 2,5	1,9 2,3 2,7	2,1 2,6 3,1	2,7 3,1 3,5	3,3 3,7 4,1						
63	Vodoravan / *horizontal* Dvodijelni / *two-part* Trodijelni / *three-part*	2,2 3,0 3,8	2,6 3,4 4,6	3,0 3,8 4,6	3,7 4,5 5,9	4,4 5,2 6,0	5,4 6,2 7,0					
89	Vodoravan / *horizontal* Dvodijelni / *two-part* Trodijelni / *three-part*		4,1 5,5 7,0	5,0 6,5 7,9	6,4 7,8 9,3	7,8 9,3 10,7	9,4 10,5 12,5	11,2 12,7 14,1	13,0 14,5 15,9			
108	Vodoravan / *horizontal* Dvodijelni / *two-part* Trodijelni / *three-part*			8,6 10,9 13,1	10,0 12,3 14,5	11,4 13,7 15,9	13,5 15,8 18,0	15,6 17,9 20,1	17,7 19,9 22,2	20,1 22,3 24,6		
133	Vodoravan / *horizontal* Dvodijelni / *two-part* Trodijelni / *three-part*					14,8 17,4 20,0	18,4 21,3 24,2	22,0 24,9 27,8	25,6 28,5 31,4	29,2 32,2 35,0		
159	Vodoravan / *horizontal* Dvodijelni / *two-part* Trodijelni / *three-part*							28,8 33,4 38,0	32,3 36,9 41,5	35,8 40,4 45,0	39,3 43,9 48,5	42,8 47,4 52,0

Tabela 10. Razmak slogova nosećih valjaka
Table 10 *Spacing in bearing rollers*

Nasipna gustoća transportiranog materijala (t/m^3) ***Bulk density of transported material*** *(t/m^3)*	**Razmak između valjaka *l'* kod širine trake B** (m) ***Distance between rollers* l' *at belt width B*** *(m)*						
	500 mm	650 mm	800 mm	1000 mm	1200 mm	1400 mm 1600 mm	1400 mm 1600 mm
do / *up to* 1,1	1,5	1,4	1,4	1,3	1,3	1,3	1,1
od / *from* 1,1 do / *to* 2,0	1,4	1,3	1,3	1,2	1,2	1,1	1,0
od / *from* 2,0 naviše / *up*	1,3	1,2	1,2	1,1	1,1	1,0	0,9

3.8 Povratni valjci

$$g_v''=\frac{q_v''}{l''}=\frac{13,5}{3}=4,5\text{kg/m'} \quad ...(9)$$

g_v'' – masa rotirajućih dijelova povratnih valjaka po jednom dužnom metru transportera [kg/m'].

q_v''=13,5 kg – masa rotirajućih dijelova povratnih vodoravnih valjaka u jednom slogu ⇒ tabela 9.

l'' = 3 m – razmak slogova povratnih valjaka uzima se konstruktivno $(2\div3)\cdot l'$

$G_t = 2\cdot q_{tr} + g_v' + g_v'' + g_b = 2\cdot 11,42 + 15,333 + 4,5 + 5,407 = 48,08$ kg/m' ...(10)

$$q_{tr} = b\cdot(q_u + q_o) = 1,0\cdot(3,68+7,74) = 11,42\,\text{kg/m}'$$

gdje su:

b = 1,0 m – stvarna širina trake.

q_u = 3,68 – masa tekstilnog kostura (4 sintetička uloška kvaliteta EP–125) u kg/m^2.

q_o = 7,74 – masa gumene obloge (kvalitet NZ, debljine 4/2 = 6 mm) u kg/m^2.

$$q_b = 9,81\cdot g_b = 9,81\cdot 5,407 = 53,047 \text{ N/m}'$$

– linijska težina svih bubnjeva osim pogonskih.

$$g_b = \frac{\sum m_b}{L} = \frac{730}{135} = 5,407 \text{ kg/m} \quad ...(11)$$

$$\sum m_b = n\cdot m_b = n_1\cdot m_{b1} + n_2\cdot m_{b2} = 2\cdot 325 + 1\cdot 80 = 730\,\text{kg}$$

...(12)

gdje su:

q_b – linijska težina svih bubnjeva osim pogonskih (N/m).

g_b – linijska masa svih bubnjeva osim pogonskih (kg/m).

n_1 = 2 – ukupan broj bubnjeva na transporteru bez pogonskih bubnjeva.

n_2 = 1 – ukupan broj otklonskih bubnjeva na transporteru.

m_{b1} = 325 kg – očitana masa bubnja prečnika Ø 400 mm i dužine 1150 (do 1200) mm iz tabele.

m_{b2} =80 kg – očitana masa otklonskog bubnja do prečnika Ø250 mm i dužine 1150 mm iz tabele.

L = 135 m – dužina transportera.

3.8 Return rollers

$$g_v''=\frac{q_v''}{l''}=\frac{13,5}{3}=4,5\text{kg/m'} \quad ...(9)$$

g_v'' – mass of rotating parts of return rollers per one meter long conveyor [kg/m'].

q_v''=13,5 kg – mass of rotating parts of return horizontal rollers in one set ⇒ Table 9.

l'' = 3 m – the spacing of the return roller sets is taken constructively $(2\div3)\cdot l'$

$G_t = 2\cdot q_{tr} + g_v' + g_v'' + g_b = 2\cdot 11,42 + 15,333 + 4,5 + 5,407 = 48,08$ kg/m' ...(10)

$$q_{tr} = b\cdot(q_u + q_o) = 1,0\cdot(3,68+7,74) = 11,42\,\text{kg/m}'$$

where are:

b = 1,0 m – the actual width of the belt.

q_u = 3,68 – textile construction weight (4 synthetic inserts of EP-125 quality) in kg/m^2.

q_o = 7,74 – mass of rubber lining (quality NZ thickness 4/2 = 6 mm) u kg/m^2.

$$q_b = 9,81\cdot g_b = 9,81\cdot 5,407 = 53,047 \text{ N/m}'$$

– line weight of all drums except drive ones.

$$g_b = \frac{\sum m_b}{L} = \frac{730}{135} = 5,407 \text{ kg/m} \quad ...(11)$$

$$\sum m_b = n\cdot m_b = n_1\cdot m_{b1} + n_2\cdot m_{b2} = 2\cdot 325 + 1\cdot 80 = 730\,\text{kg}$$

...(12)

where are:

q_b – line weight of all drums except drive ones (N/m).

g_b – line mass of all drums except drive ones (kg/m).

n_1 = 2 – total number of drums on the conveyor without drive drums.

n_2 = 1 – the total number of deflection drums on the conveyor.

m_{b1} = 325 kg – read mass of drum diameter Ø 400 mm and length 1150 (up to 1200) mm from the Table.

m_{b2} = 80 kg – the mass of the deflection drum up to a diameter of Ø250 mm and a length of 1150 mm from the Table.

L = 135 m – conveyor length.

$G = 3600 \cdot A \cdot v \cdot \rho = 3600 \cdot 0{,}0351 \cdot 1{,}70 \cdot 1{,}56 = 335{,}01$ [t/h]. ...(13)

G – teoretska masa transportiranog materijala za jedan sat [t/h].

$H = L \cdot \sin\beta = 135 \cdot \sin 2{,}5^o = 5{,}89$ m ...(14)

gdje su:

$\rho = 1{,}56$ t/m^3 – nasipna gustoća materijala.

H – visina dizanja ili spuštanja tereta, tj. visinska razlika krajnjih tačaka transportera [m].

$G = 3600 \cdot A \cdot v \cdot \rho = 3600 \cdot 0{,}0351 \cdot 1{,}70 \cdot 1{,}56 = 335{,}01$ [t/h]. ...(13)

G – theoretical mass of transported material in one hour [t/h].

$H = L \cdot \sin\beta = 135 \cdot \sin 2{,}5^o = 5{,}89$ m ...(14)

where are:

$\rho = 1{,}56$ t/m^3 – bulk density of material.

H – height of lifting or lowering the load, i.e. height difference of the end points of the conveyor [m].

3.9 Dužinsko opterećenje transportovanog materijala

$$q_m = \frac{G}{3{,}6 \cdot v_t} = 54{,}74 \ \text{kg/m}^1;$$

gdje je:

G = 335,01 t/h – časovni kapacitet. ...(15)

3.9 Length load of transported material

$$q_m = \frac{G}{3{,}6 \cdot v_t} = 54{,}74 \ \text{kg/m}^1;$$

where is:

G = 335,01 t/h – time capacity. ...(15)

3.10 Dužinsko opterećenje od trake

$q_t = B \cdot (z \cdot \delta_n + \delta_1 + \delta_2) \cdot \gamma_t$ (N/m^1) ...(16)

$q_t = 1 \cdot (4 \cdot 0{,}001 + 0{,}004 + 0{,}002) \cdot 9000$

$q_t = 90$ N/m^1

gdje su:

$B = 1{,}0$ m – širina trake.

$z = 4$ – broj uložaka.

$\delta_n = 0{,}001$ m – debljina jednog uloška.

$\delta_1 = 0{,}004$ m – debljina radne obloge.

$\delta_2 = 0{,}002$ m – debljina oslanjajuće obloge.

$\gamma_t \cong 9000$ N/m^3 – zapreminska težina trake.

Broj uložaka (z) treba na kraju provjeriti i verifikovati sa maksimalnom silom (S_n).

3.10 Belt length load

$q_t = B \cdot (z \cdot \delta_n + \delta_1 + \delta_2) \cdot \gamma_t$ (N/m^1) ...(16)

$q_t = 1 \cdot (4 \cdot 0{,}001 + 0{,}004 + 0{,}002) \cdot 9000$

$q_t = 90$ N/m^1

where are:

$B = 1{,}0$ m – belt width.

$z = 4$ – number of layers.

$\delta_n = 0{,}001$ m – thickness of one insert.

$\delta_1 = 0{,}004$ m – working lining thickness.

$\delta_2 = 0{,}002$ m – the thickness of the supporting lining.

$\gamma_t \cong 9000$ N/m^3 – bulk density of the belt.

The number of layers (z) should finally be checked and verified with maximum force (S_n).

3.11 Dužinsko opterećenje nosećih i povratnih valjaka

$$q_{vo} = \frac{G_{vo}}{l_{vo}} \ (\text{N/m}^1) \rightarrow q_{vo} = \frac{360}{1{,}2} = 300{,}00 \ \text{N/m}^1$$

...(17)

$$q_{vp} = \frac{G_{vp}}{2 \cdot l_{vp}} \ (\text{N/m}^1) \rightarrow q_{vp} = \frac{220}{2 \cdot 3} = 36{,}67 \ \text{N/m}^1$$

...(18)

gdje su:

3.11 Length load of bearing and return rollers

$$q_{vo} = \frac{G_{vo}}{l_{vo}} \ (\text{N/m}^1) \rightarrow q_{vo} = \frac{360}{1{,}2} = 300{,}00 \ \text{N/m}^1$$

...(17)

$$q_{vp} = \frac{G_{vp}}{2 \cdot l_{vp}} \ (\text{N/m}^1) \rightarrow q_{vp} = \frac{220}{2 \cdot 3} = 36{,}67 \ \text{N/m}^1$$

...(18)

$G_{vp} = 80+140 \cdot B$ ...(20)

$l_{vo} = 1{,}925 - 0{,}625 \cdot B - 0{,}16 \cdot \rho$ (m)

$l_{vo} = 1{,}05$ m – usvajam se $l_{vo} = 1{,}2$ m – tabela 10.

$l_{vp} = (2 \div 3) \cdot l_{vo}$ – usvaja se $l_{vp} = 3$ m.

l_{vo} – rastojanje između nosećih valjaka.

l_{vp} – rastojanje između povratnih valjaka.

G_{vo} = 360 N – redukovana težina nosećih valjaka.

G_{vp} = 220 N – redukovana težina povratnih valjaka.

$G_{vo} = 130+230 \cdot B$ ...(19)

$G_{vp} = 80+140 \cdot B$ ...(20)

$l_{vo} = 1{,}925 - 0{,}625 \cdot B - 0{,}16 \cdot \rho$ (m)

$l_{vo} = 1{,}05$ m – selected $l_{vo} = 1{,}2$ m – Table 10.

$l_{vp} = (2 \div 3) \cdot l_{vo}$ – selected $l_{vp} = 3$ m.

l_{vo} – the distance between the bearing rollers.

l_{vp} – the distance between the return rollers.

G_{vo} = 360 N – reduced weight of bearing rollers.

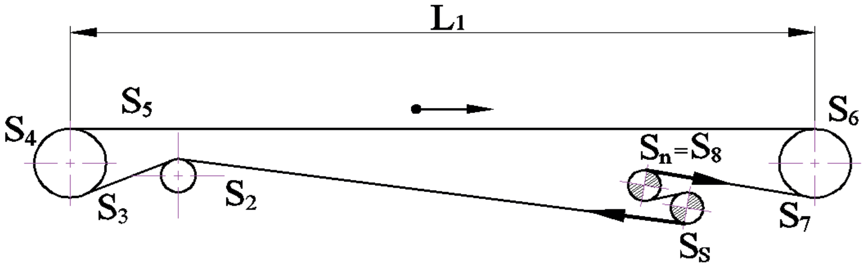
G_{vp} = 220 N – reduced weight of return rollers.

4. KONTROLA I PRORAČUN SILA U TAČKAMA TRANSPORTERA METODOM OBILASKA PO KONTURI

Raspored konturnih sila na trasi trakastog transportera prikazan je na slici 2.

4. CONTROL AND CALCULATION OF FORCES AT CONVEYOR POINTS BY CONTOUR TRAVERSAL METHOD

The distribution of contour forces on the route of the belt conveyor is shown in Figure 2.



Slika 2. Shema transportera sa gumenom trakom za proračun zateznih sila na traci

Figure 2 *Scheme of a conveyor with a rubber belt for the calculation of tensile forces on the belt*

4.1 Otpori na punoj strani transportera

4.1 Resistances on the full side of the conveyor

$$W_t = g \cdot \left[(q_m + q_{tr}) \cdot L \cdot c \cdot t \cdot \cos\beta + (g_v') \cdot L \cdot c \cdot t \pm (q_m + q_{tr}) \cdot L \cdot \sin\beta \right] \quad ...(21)$$

$$W_t = 9{,}807 \cdot \begin{bmatrix} (54{,}74 + 11{,}42) \cdot 135 \cdot 1{,}62 \cdot 0{,}022 \cdot \cos 2{,}5^\circ + (15{,}33) \cdot 135 \cdot 1{,}62 \cdot 0{,}022 \\ \pm (54{,}74 + 11{,}42) \cdot 135 \cdot \sin 2{,}5^\circ \end{bmatrix}$$

$$W_t = 7663{,}04 \text{ N} \quad ...(22)$$

4.2 Otpori na praznoj strani transportera

4.2 Resistances on the empty side of the conveyor

$$W_p = g \cdot \left[q_{tr} \cdot L \cdot c \cdot t \cdot \cos\beta + (g_v'') \cdot L \cdot c \cdot t \mp q_{tr} \cdot L \cdot \sin\beta \right] \quad ...(23)$$

$$W_p = g \cdot \left[11{,}42 \cdot 135 \cdot 1{,}62 \cdot 0{,}022 \cdot \cos 2{,}5^\circ + (4{,}5) \cdot 135 \cdot 1{,}62 \cdot 0{,}022 \mp 11{,}42 \cdot 135 \cdot \sin 2{,}5^\circ \right]$$

$$W_p = 91{,}18 \text{ N}$$

...(24)

gdje je:

t = 0,022 – koeficijent trenja (ležišta bubnjeva i valjaka) za teške uslove rada (mogućnost prodiranja prašine u ležajeve, ljepljiv materijal itd.) – tabela 11.

c = 1,62 – faktor povećanja vučne sile koji uzima u obzir sporedne otpore ovisan o dužini transportera - tabela 12.

where is:

t = 0,022 – a coefficient of friction (bearings of drums and rollers) for difficult working conditions (possibility of penetration of dust into bearings, adhesive material, etc.) - Table 11.

c = 1,62 – a traction force increase factor that takes into account secondary resistances depending on the length of the conveyor - Table 12.

Tabela 11. Vrijednosti koeficijenta trenja "*t*"
Table 11 *Friction coefficient values "t"*

0,016 do / *to* 0,018	Za stabilna, dobro izrađena postrojenja sa kotrljajućim ležajevima, za transport, za transport materijala sa neznatnim unutarnjim trenjem. *For stable, well-made rolling bearing plants, for transport, for transport of materials with low internal friction.*
0,018 do / *to* 0,020	Za postrojenja s prosječnim uslovima rada. *For plants with average operating conditions.*
0,020 do / *to* 0,025	Za teške uslove rada (mogućnost prodiranja prašine u ležajeve, ljepljiv materijal). *For difficult working conditions (possibility of dust penetrating the bearings, adhesive material).*
0,05	Za postrojenja s kliznim ležajevima. *For plants with sliding bearings.*

Tabela 12. Vrijednosti faktora "c" u zavisnosti od transportne dužine
Table 12 *Factor "c" values depending on the transport length*

L (m)	**c**	**L (m)**	**c**	**L (m)**	**c**	**L (m)**	**c**	**L (m)**	**c**	**L (m)**	**c**	**L (m)**	**c**
<4	9	8	5,1	20	3,2	50	2,2	125	1,64	320	1,29	800	1,12
4	7,6	10	4,5	25	2,9	63	2	160	1,53	400	1,23	1000	1,1
5	6,6	12,5	4	32	2,6	80	1,85	200	1,45	500	1,19	1250	1,08
6	5,9	16	3,6	40	2,4	100	1,74	250	1,37	630	1,15		

$S_s = S_1$ (N) ...(25)

$$S_8 \le S_1 \cdot e^{(\mu_1\alpha_1 + \mu_2\alpha_2)}$$ ...(26)

$S_s = S_1$ (N) ...(25)

$$S_8 \le S_1 \cdot e^{(\mu_1\alpha_1 + \mu_2\alpha_2)}$$ ...(26)

Računajući da je:
$S_8 = 1{,}06 \cdot (S_1+W_p) + W_t$ i iz uslova (25), dobije se:

$$S_1 = \frac{W_t + 1{,}06 \cdot W_p}{e^{(\mu_1\alpha_1+\mu_2\alpha_2)} - 1{,}06} =$$

$$= \frac{7663{,}04 + 1{,}06 \cdot 91{,}18}{4{,}33 - 1{,}06} = 2363{,}89 \text{ N} \qquad ...(27)$$

$\mu_1 = \mu_2 = 0{,}2$ – koeficijent klizanja između trake i bubnja.

$\alpha_1 = \alpha_2 = 210^o$ – obuhvatni ugao trake oko bubnjeva (tj. izražen u radijanima $\alpha_1 = \alpha_2 = 3{,}6652$).

$$e^{(\mu_1\alpha_1+\mu_2\alpha_2)} = e^{1{,}46608} = 4{,}33 \qquad ...(28)$$

$k_1 = 1{,}015$, $k_2 = 1{,}025$

Calculating that:
$S_8 = 1{,}06 \cdot (S_1+W_p) + W_t$ and from condition (25), the following is obtained:

$$S_1 = \frac{W_t + 1{,}06 \cdot W_p}{e^{(\mu_1\alpha_1+\mu_2\alpha_2)} - 1{,}06} =$$

$$= \frac{7663{,}04 + 1{,}06 \cdot 91{,}18}{4{,}33 - 1{,}06} = 2363{,}89 \text{ N} \qquad ...(27)$$

$\mu_1 = \mu_2 = 0{,}2$ – the slip coefficient between the belt and the drum.

$\alpha_1 = \alpha_2 = 210^o$– the coverage angle of the strip around the drums (i.e., expressed in radians $\alpha_1 = \alpha_2 = 3{,}6652$).

$$e^{(\mu_1\alpha_1+\mu_2\alpha_2)} = e^{1{,}46608} = 4{,}33 \qquad ...(28)$$

...(29)

$S_1 = S_s$ (N) $\rightarrow$ $S_1 =$ 2363,89 N ...(30)

$S_2 = S_1 + W_p$ (N) $\rightarrow$ $S_2 =$ 2455,07 N ...(31)

$S_3 = k_1 \cdot S_2$ (N) $\rightarrow$ $S_3 =$ 2491,89 N ...(32)

$S_4 = k_2 \cdot S_3$ (N) $\rightarrow$ $S_4 =$ 2554,19 N ...(33)

$S_5 = S_4 + W_{ut}$ (N) $\rightarrow$ $S_5 =$ 2625,02 N ...(34)

$$W_{ut} = \frac{Q_u \cdot v_t^2}{2 \cdot 3{,}6 \cdot v_t} = \frac{300 \cdot 1{,}7^2}{2 \cdot 3{,}6 \cdot 1{,}7} \text{ N} \rightarrow W_{ut} = 70{,}83 \text{ N} \qquad ...(35)$$

$S_6 = S_5 + W_t$ (N) $\rightarrow$ $S_6 =$ 10288,06 N ...(36)

$S_7 = S_6$ (N) $\rightarrow$ $S_7 =$ 10288,06 N ...(37)

$S_8 = 1{,}06 \cdot (S_1+W_p) + W_t$ $\rightarrow$ $S_8 =$ 10240,86 N ...(38)

$$S_8 \le S_1 \cdot e^{(\mu_1\alpha_1+\mu_2\alpha_2)} \qquad ...(39)$$

$$10240{,}86 \le 2363{,}89 \cdot e^{1{,}46608} = 10240{,}86 \qquad ...(40)$$

Obodna sila:

$W = S_{max} - S_{min}$ (N) ...(41)

$W = 10288{,}06 - 2363{,}89 = 7924{,}17$ N ...(42)

Circumferential force:

$W = S_{max} - S_{min}$ (N) ...(41)

$W = 10288{,}06 - 2363{,}89 = 7924{,}17$ N ...(42)

4.3 Provjera potrebnog broja uložaka

Broj uložaka od umjetnih vlakana računa se po obrascu:

$$z = \frac{k_t \cdot S_{max}}{\mathrm{B} \cdot \sigma_t} + 1 = \frac{9{,}8 \cdot 10288{,}06}{1 \cdot 122588} + 1 = 1{,}82 \rightarrow z = 4 \Rightarrow \text{usvojeno} \qquad ...(43)$$

4.3 Check the required number of layers

The number of artificial fiber layers is calculated according to this:

$$z = \frac{k_t \cdot S_{max}}{\mathrm{B} \cdot \sigma_t} + 1 = \frac{9{,}8 \cdot 10288{,}06}{1 \cdot 122588} + 1 = 1{,}82 \rightarrow z = 4 \Rightarrow \text{adopted} \qquad ...(43)$$

gdje su:
B – širina trake (m).
S_{max} – najveća sila na trasi trakastog transportera (N).
k_t – koeficijent sigurnosti (k_t = 9,8).
σ_t – prekidna čvrstoća trake (σ_t = 122588 N/m).

4.4 Provjera minimalne sile zatezanja iz uslova dozvoljenog ugiba trake

$$S_{min} = 9{,}807 \cdot \frac{(q_m + q_{tr}) \cdot l'^2}{8 \cdot f_{doz}} = $$
$$= 9{,}807 \cdot \frac{(54{,}74 + 11{,}42) \cdot 1{,}2^2}{8 \cdot 0{,}024} \quad ...(45)$$
$$S_{min} = 4866{,}23 \text{ N} \quad ...(46)$$

gdje su:
S_{min} - minimalna sila napinjanja trake potrebna da bi progib ostao u dozvoljenim granicama.
f_{doz} - dozvoljeni progib trake između dva noseća sloga.

$$f_{doz} = 0{,}02 \cdot l' = 0{,}02 \cdot 1{,}2 = 0{,}024 \text{ m} \quad ...(44)$$

4.5 Snaga potrebna za pogon opterećenog transportera bez dodatnih otpora

$$P_{bo} = F_{bo} \cdot v = 8012{,}85 \cdot 1{,}70 = $$
$$= 13621{,}84 \text{ W} = 13{,}62 \text{ kW} \quad ...(47)$$
$$F_{bo} = g \cdot \left[c \cdot t \cdot L \cdot \left(G_t + \frac{G}{3{,}6 \cdot v} \right) \pm \frac{G \cdot H}{3{,}6 \cdot v} \right] \quad ...(48)$$

where are:
B – belt width (m).
S_{max} – maximum force on the belt conveyor route (N).
k_t – safety factor (k_t = 9,8).
σ_t – breaking strength of the belt (σ_t = 122588 N/m).

4.4 Checking the minimum tensile force from the conditions of the allowed deflection of the belt

$$S_{min} = 9{,}807 \cdot \frac{(q_m + q_{tr}) \cdot l'^2}{8 \cdot f_{doz}} = $$
$$= 9{,}807 \cdot \frac{(54{,}74 + 11{,}42) \cdot 1{,}2^2}{8 \cdot 0{,}024} \quad ...(45)$$
$$S_{min} = 4866{,}23 \text{ N} \quad ...(46)$$

where are:
S_{min} - the minimum tensioning force of the belt required to keep the deflection within the permitted limits.
f_{doz} - permissible deflection of the belt between two supporting sets.

$$f_{doz} = 0{,}02 \cdot l' = 0{,}02 \cdot 1{,}2 = 0{,}024 \text{ m} \quad ...(44)$$

4.5 Power required to drive a loaded conveyor without additional resistance

$$P_{bo} = F_{bo} \cdot v = 8012{,}85 \cdot 1{,}70 = $$
$$= 13621{,}84 \text{ W} = 13{,}62 \text{ kW} \quad ...(47)$$
$$F_{bo} = g \cdot \left[c \cdot t \cdot L \cdot \left(G_t + \frac{G}{3{,}6 \cdot v} \right) \pm \frac{G \cdot H}{3{,}6 \cdot v} \right] \quad ...(48)$$

$$F_{bo} = 9{,}807 \cdot \left[1{,}62 \cdot 0{,}022 \cdot 135 \cdot \left(48{,}08 + \frac{335{,}01}{3{,}6 \cdot 1{,}70} \right) + \frac{335{,}01 \cdot 5{,}89}{3{,}6 \cdot 1{,}70} \right] \quad ...(49)$$
$$F_{bo} = 8012{,}85 \text{ N} \quad ...(50)$$

gdje je:
F_{bo} – vučna sila na obodu pogonskog bubnja (N).

where is:
F_{bo} – traction force on the circumference of the drive drum (N).

4.6 Dodatna snaga zbog dopunskih otpora uslijed skidača materijala i čistača

$P_d = 1{,}6 \cdot v \cdot b \cdot n = 1{,}6 \cdot 1{,}70 \cdot 1{,}00 \cdot 3{,}0 = 8{,}16$ kW ...(51)

$n = 3$ – broj čistača.

4.7 Dodatna snaga zbog otpora uslijed bočnih vodilica

$P_v = 0{,}08 \cdot l_1 = 0{,}08 \cdot 3 = 0{,}24$ kW ...(52)

$l_1 = 3$ m – dužina vodilica (usmjerivača).

4.8 Snaga motora za pogon transportera

$$P_m = \frac{P_{ef}}{\eta} = \frac{22{,}02}{0{,}80} = 25{,}91 \text{ kW} \quad ...(53)$$

$P_{ef} = P_{bo} + P_d + P_v = 13{,}62 + 8{,}16 + 0{,}24$ ...(54)

$P_{ef} = 22{,}02$ kW – efektivna snaga motora za pogon transportera.

$\eta = 0{,}80 \div 0{,}85$ – koeficijent korisnog učinka mehaničkog prijenosa između elektromotora i bubnja.

Shodno gore navedenom, na spomenuti transporter bit će ugrađena pogonska jedinica instalirane snage elektromotora 45 kW.

4.9 Vučna sila u traci na bubnju

$$F_b = \frac{P_{ef}}{v} = \frac{22{,}02}{1{,}70} = 12954{,}02 \text{ N} \quad ...(55)$$

4.10 Ukupna vučna sila u traci na punoj strani

4.6 Extra power due to additional resistances due to material removers and cleaners

$P_d = 1{,}6 \cdot v \cdot b \cdot n = 1{,}6 \cdot 1{,}70 \cdot 1{,}00 \cdot 3{,}0 = 8{,}16$ kW ...(51)

$n = 3$ – number of cleaners.

4.7 Extra power due to resistance due to side guides

$P_v = 0{,}08 \cdot l_1 = 0{,}08 \cdot 3 = 0{,}24$ kW ...(52)

$l_1 = 3$ m – length of guides (routers).

4.8 Engine power to drive the conveyor

$$P_m = \frac{P_{ef}}{\eta} = \frac{22{,}02}{0{,}80} = 25{,}91 \text{ kW} \quad ...(53)$$

$P_{ef} = P_{bo} + P_d + P_v = 13{,}62 + 8{,}16 + 0{,}24$ ...(54)

$P_{ef} = 22{,}02$ kW – effective motor power to drive the conveyor.

$\eta = 0{,}80 \div 0{,}85$ – the efficiency of the mechanical transmission between the electric motor and the drum.

Given the above, a drive unit with electric motor power of 45 kW will be installed on the mentioned conveyor.

4.9 Traction force in the belt on the drum

$$F_b = \frac{P_{ef}}{v} = \frac{22{,}02}{1{,}70} = 12954{,}02 \text{ N} \quad ...(55)$$

4.10 Total traction force in the belt on the full side

$$F_t = F_{b1} + F_{b2} \quad ...(56)$$

$$F_{b1} = F_b \frac{1}{e^{\mu\alpha_r} + 1} = 12954{,}02 \cdot \frac{1}{2{,}08 + 1} = 4205{,}85 \text{ N} \quad ...(57)$$

$$F_{b2} = F_b - F_{b1} = 12954{,}02 - 4205{,}85 = 8748{,}17 \text{ N} \quad ...(58)$$

$$F_t = F_b \cdot \left(1 + \frac{1}{e^{\mu \cdot \alpha_r} - 1}\right) = 12954{,}02 \cdot (1 + 0{,}93) = 25001{,}26 \text{ N} \quad ...(59)$$

$$e^{\mu \alpha_r} = 2{,}08 \text{ za } \mu = 0{,}20 \text{ i } \alpha = 210^{\circ} \quad ...(60)$$

$\mu = 0{,}20$ – koeficijent trenja između bubnja i trake ⇒ tabela 13.

$\mu = 0{,}20$ – coefficient of friction between the drum and the belt ⇒ Table 13.

Tabela 13. Koeficijent trenja između bubnja i trake za bubanj
Table 13 *Coefficient of friction between the drum and the belt*

μ	**Vrijednost izraza $e^{\mu \alpha_r}$ za α** *The value of the expression $e^{\mu \alpha_r}$ for α*											
	180°	**210°**	**240°**	**270°**	**300°**	**330°**	**360°**	**380°**	**400°**	**420°**	**450°**	**480°**
0,1	1,37	1,44	1,52	1,60	1,69	1,78	1,87	1,94	2,01	2,08	2,19	2,31
0,15	1,60	1,87	1,87	2,03	2,19	2,37	2,57	2,71	2,85	3,00	3,25	3,51
0,2	1,87	2,31	2,31	2,57	2,85	3,16	2,51	3,77	4,04	4,33	4,84	5,34
0,3	2,56	3,51	3,51	4,11	4,81	5,63	6,69	7,31	8,14	9,00	10,50	12,35
0,35	3,00	4,33	4,33	5,20	6,27	7,51	9,02	10,19	11,50	13,00	15,60	19,22
0,4	3,51	5,34	5,34	6,59	8,12	10,01	12,33	14,35	16,30	18,50	23,00	28,51

4.11 Prijelazna dužina trake

Odabrano: za $b = 1{,}00$ m i nagib valjaka $\lambda = 20^{\circ} \Rightarrow L_p = 0{,}85$ m

L_p – prijelazna dužina trake od zadnjeg nosećeg sloga do pogonskog bubnja [m] ⇒ tabela 14.

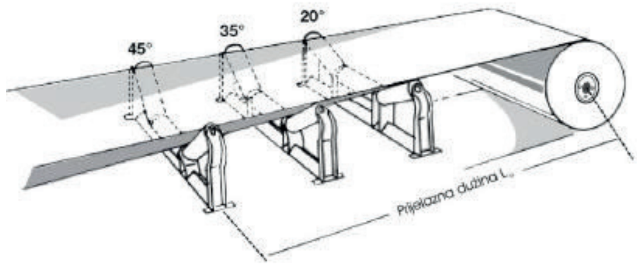
4.11 Transition strip length

Selected: for $b = 1{,}00$ m and roller inclination $\lambda = 20^{\circ} \Rightarrow L_p = 0{,}85$ m

Lp – transition length of the strip from the

Tabela 14. Prijelazne dužine transportnih traka
Table 14 *Transition lengths of conveyor belts*

Širina trake B (mm) ***Belt width B*** *(mm)*	$\lambda = 20^{\circ}$	$\lambda = 30^{\circ}$
300	0,25	0,35
400	0,35	0,50
500	0,40	0,60
650	0,55	0,85
800	0,65	1,00
1000	0,85	1,25
1200	1,00	1,50
1400	1,20	1,80
1600	1,40	2,10
1800	1,60	2,40
2000	1,75	2,60
2200	1,95	2,90



Slika 3. *Prijelazne dužine*
Figure 3 *Transition lengths*

5. ZAKLJUČAK

U ovom radu dati su: kontrolni proračuni sila zatezanja u konturnim tačkama transportera, koji se koristi u jami „Begići-Bištrani“ Rudnika Kakanj, proračun snage motora, broj uložaka u gumenom transporteru i minimalno potrebno zatezanje. Brzina trake bira se na temelju vrste materijala koji se transportira, dužine puta i namjene transportera. Najčešće upotrebljavani oblici poprečnog presjeka transportera s gumenom trakom su transporteri s ravnom trakom, transporteri s trakom u obliku slova V, transporteri s koritastom trakom sa bočnim valjcima pod nagibom 20º i transporteri s koritastom trakom sa bočnim valjcima pod nagibom 30º. Zavisno od uslova rada, transportne trake se izrađuju u različitim konstrukcijama. Debljina trake zavisi od konstrukcije trake i računa se debljina obloga i broj umetaka.

Gumene transportne trake spadaju u transportna sredstva kontinuiranog načina djelovanja i rade na principu trenja između gumene trake, koja je noseći elemenat, i pogonskih bubnjeva.

5. CONCLUSION

This paper presents: control calculations of tensile forces in the contour points of the conveyor, which is used in the pit "Begići-Bištrani" of the Kakanj Mine, calculation of engine power, number of inserts in the rubber conveyor and the minimum required tension. The speed of the belt is chosen based on the type of material being transported, the length and the purpose of the conveyor. The most commonly used cross-sectional forms of rubber belt conveyors are flat belt conveyors, V-belt conveyors, 20° side roller conveyors with side rollers and 30° side roller conveyors with side belt trough. Depending on the working conditions, conveyor belts have different constructions. The thickness of the belt depends on the construction of the belt, and when calculated, the thickness of the lining and the number of inserts are taken into account. Rubber conveyor belts are the means of transport for continuous mode of operation and they work on the principle of friction between the rubber belt, as the supporting element, and the drive drums.

6. LITERATURA – REFERENCES

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