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DEVELOPMENT OF AN EFFECTIVE PERIODIC FLOW TECHNOLOGICAL SCHEME IN THE CONDITIONS OF DAUGIZTAU QUARRY

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Annotation: The article discusses the periodic flow technological scheme in the conditions of Daugiztau mine. The problem of increasing the efficiency, reliability, low power and transport distance of the main conveyor is considered. An efficient periodic flow technological scheme will be developed.

KEYWORDS: conveyor, belt, roller, periodic flow technological scheme.

INTRODUCTION

Currently, about a hundred mineral deposits are being developed in the territory of the Republic of Uzbekistan. These include the Muruntau, Kokpatas, Daugiztau, Auminzo-Amantay deposits of the Navoi Mining and Metallurgical Combine, the Kalmakir deposit of the Almalyk Mining and Metallurgical Combine, and the Angren coal deposit, the largest coal deposit of the Uzbekkomir JSC, as well as many oil and gas companies.

In these quarries, trucks are designed to transport minerals and cladding rocks as well as the main loads in the quarries. With the deepening of quarries, the demand for conveyor transport, which is characterized by high economic efficiency and environmental friendliness and high productivity of transport vehicles, is growing. Important conditions for the normal operation of belt conveyors are their proper installation (assembly), proper loading and unloading, careful constant monitoring of the belt, rollers, drums and the entire conveyor, and timely repair work. In addition, one of the main points to be taken into account is that the correlation of conveyor and quarry parameters in the installation of conveyor transport is carried out on the basis of calculations.

The Main Part

We consider the normal transport of freight flows, the installation of the conveyor in an energy-efficient mode on the example of the periodic flow technological scheme (CCT) of the Daugiztau deposit owned by NMMC (Figure 1). The supplier is the supplier of the load from the 1 bunker shown in this diagram to the crusher. The load passing through the crusher goes through the main conveyor 3 to the main conveyor 4 (KLM-1200). The 600 m long main conveyor delivers the load flow to the 400 m long supply conveyor 5 (KL-1200) and 6 (kuznechik). In turn, the supplier conveyor load flow is formed through the coupling (otvoloobrazovatel) 7. Based on this periodic flow technological scheme, the total capacity required as a result of the increase in the number of assemblies and the increase in the number of supply conveyors. In addition, the increase in the number of electric drives and reducers does not exclude the emergence of repair work and problems with the connections on the belts.

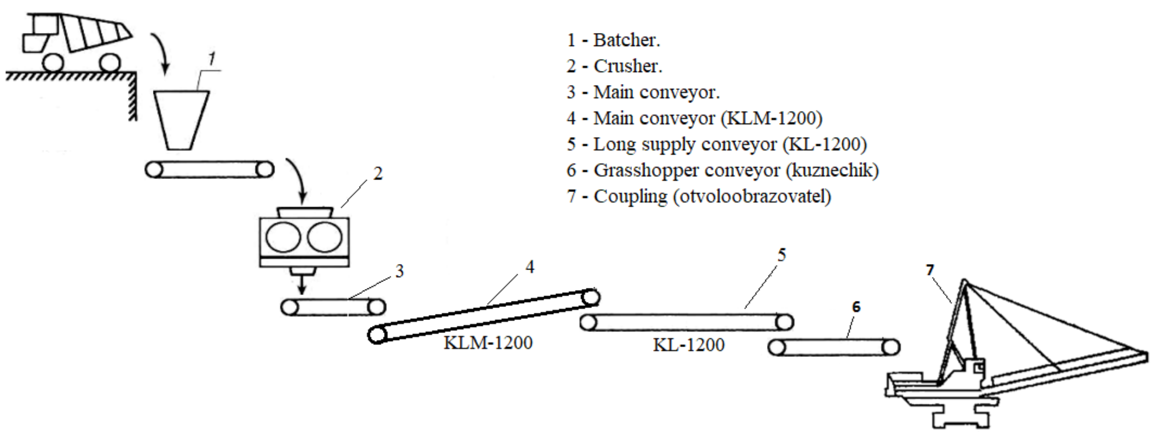


Figure 1: Technological scheme of periodic flow transport of Dagiztau deposit.

The reduction of the solution of these problems will be possible to find a solution first of all by simplification of the periodic flow technological scheme. We calculate the drive capacity of KLM-1200 rubber cable and KL-1200 rubber fabric conveyors marked with 4 and 5 in the periodic flow technological scheme. In this case, we use the scheme of calculation of the main conveyor "on the contour" (Figure 2).

Based on the general equation of motion, the power of the conveyor drive is used to overcome the forces of resistance to motion. The resistance in the straight-line section of the conveyor is due to the friction in the movement of the belt along the rollers and the gravitational forces that form longitudinally on the conveyor running on the slope.[1,2,13]
Conveyor KLM-1200 has the following parameters: conveyor belt width B = 1.2 m, conveyor length L = 600 m, conveyor slope angle β =6º, belt brand 1200St-2000.

For the direction of conveyor load installed at an angle of inclination, the forces of resistance to movement are determined by the following formula:

$$\begin{aligned} W_{con.load} &= (q + q_{belt} + q_p^{'})L\omega^{'}\cos\beta \pm (q + q_{belt})L\sin\beta = \\ &(218{,}12 + 45{,}6 + 47{,}5) * 600 \cdot 0{,}023 \cdot 0{,}99 + (218{,}12 + 45{,}6) * 600 \cdot 0{,}104 = \\ &= 4251{,}88 + 16456{,}128 = 20708{,}008..kg.power \end{aligned} \tag{1}$$

The forces of resistance to movement in the unloaded direction of the conveyor are determined by the following formulas:

$$\begin{aligned} W_{unloaded} &= (q_{belt} + q_p^{''})L\omega^{'}\cos\beta \pm q_{belt}L\sin\beta = \\ &= (45{,}6 + 13{,}3)600 \cdot 0{,}023 \cdot 0{,}99 - 45{,}6 \cdot 600 \cdot 0{,}104 = \\ &= 804{,}69 - 2845{,}44 = -2040{,}75..kg.power \end{aligned} \tag{2}$$

We can determine the weight of a conveyor belt 1 m long:

$$q = \frac{Q_Э}{3{,}6V} = \frac{2340}{3{,}6 \cdot 2{,}98} = 218{,}12 \text{ kg.power/m;}$$

where: $Q_Э$ = 2340 m^3/h, conveyor operating capacity;

V = 2.98 t/m^3, rock density;

q_{belt} -The weight of a 1 m long strip, kg.power/m, is taken from Table 1.

Table 1:

Rubber bands		Rubber-cord straps	
Number of layers	**Weight, kg.power/m^2**	**Tape type**	**Weight, kg.power/m^2**
4	18	РТЛ-1600	38
5	20	РТЛ-2000	38
6	22	РТЛ-3500	43
8	25	РТЛ-4000 РТЛ-5000 РТЛ-6000	48 55 65

q_p' - the weight of the moving parts of the rollers in the loaded network, corresponding to the length of the conveyor 1 m, kg.power / m and q_p'' - the weight of the moving parts of the rollers in the unloaded network, corresponding to the length of the conveyor 1 m, kg.power/ m, are given in Table 2.

Table 1 shows the weight of 1 m2 of tape. From the information in the table, the weight of a 1 m long strip can be calculated according to the following formula:

$q_{belt} = G_л' \cdot B = 38 \cdot 1{,}2 = 45.6$, kg.power/m (3)

The weight of the rollers and the resistance forces of their moving parts depend on the width of the belt, the diameter and structure of the rollers. Table 2 shows the values of the weights of the rotating parts of the roller bearings in the loaded (three-roller) and unloaded (single-roller) networks of conveyors.

The weights of the moving parts of the rollers in the loaded and unloaded networks, corresponding to a length of 1 m of the conveyor, are determined using the data given in Table 2 by the following formulas:

$q_p' = \frac{G_p'}{l'} = \frac{57}{1{,}2} = 47{,}5$, kg.power/m (4)

$q_p'' = \frac{G_p''}{l''} = \frac{40}{3} = 13{,}3$, kg.power/m (5)

here

Gp’and Gp” - weight of rotating parts of roller bearings in loaded and unloaded directions, kg.power;l’ i l” is the distance between the roller supports in loaded and unloaded networks, usually l'= 0.8-1.2 m (a small number is obtained when transporting heavy and large pieces of cargo), l" = 2 - 4 m.

Table 2: The weight of the rotating parts of the roller bearings.

Tape width, mm	Three-roller roller bearings				One roller	
	Normal		Heavy			
	Roller diameters, mm	Weight, kg.power	Roller diameters, mm	Weight, kg.power	Roller diameters, mm	Weight, kg.power
1000	127	25	159	50	127	21,5
1200	127	29	**159**	**57**	**159**	**40**
1400	159	50	194	108	159	40
1600	-	60	194	116	-	-
1800	-	82	194	122	159	47
2000	-	-	219	190	-	-

The size of the conveyor belt's coefficient of resistance to movement depends on many factors: roller quality, conveyor assembly, belt thickness, load size, and so on.

The values ω of the norms are set as follows, depending on the condition of the conveyor

Very good	0.18-0.02
Good	0.02-0.022
The straight linearity of the stave is not high-precision and is strongly contaminated	0.023-0.027

The drive power of the conveyor device can be determined by the point method along the rotational contour of the belt. The contour formed by the conveyor belt is divided into straight and curved sections (Fig. 2). From the point of exit of the belt from the driving drum, the points where all the direction is changed are numbered. Then, the voltages and driving forces of the incoming and outgoing networks in series along the contour rotation are determined.

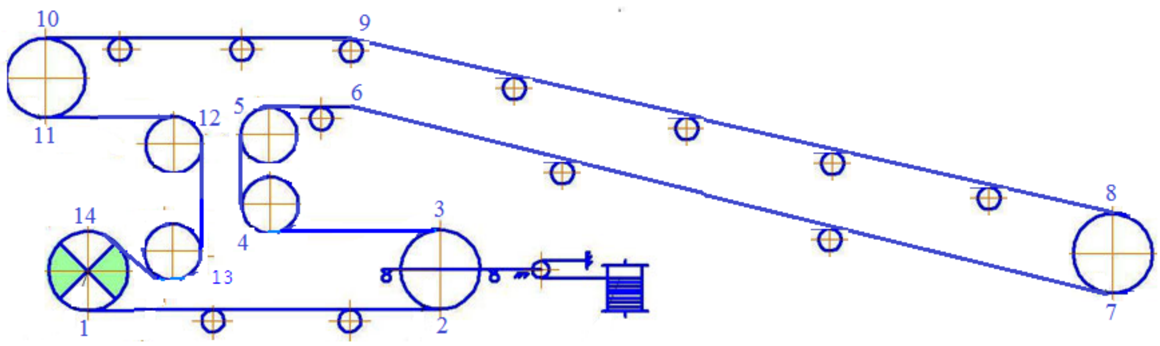


Figure 2: Scheme of calculation of the conveyor "by contour".

The rule for calculating tension is as follows: the tension of a traction body at a given point is found by the sum of the resistance forces in the section to the tension at the previous point (the resistances between the two points).

$S_i = S_{i-1} + W_{(i-1)-i}$, kg.power (6)

According to the diagram shown in Figure 2, the tension at the exit point of the belt from the drive drum is equal to S1. The tension at point 2 is

$S_2 = S_1$, kg.power (7)

Tension at 3 points

$S_3 = 1{,}06 S_2 = 1{,}06 \cdot 4176{,}3 = 4426{,}879$, kg.power (8)

Tension at 4 points

$S_4 = S_3 = 4426{,}879$, kg.power (9)

Tension at 5 points

$S_5 = 1{,}04 S_4 = 1{,}04 \cdot 4426{,}879 = 4603{,}954$, kg.power (10)

Tension at 6 points

$S_6 = 1{,}04 S_5 = 1{,}04 \cdot 4603{,}954 = 4788{,}112$, kg.power (11)

Tension at 7 points

$S_7 = S_6 + W_{unloaded} = 4788{,}112 - 2040{,}75 = 2747.362$, kg.power (12)

Tension at 8 points

$S_8 = 1{,}06 S_7 = 1.06 \cdot 2747.362 = 2912.203$, kg.power (13)

Tension at 9 points

$S_9 = S_8 + W_{con.load} = 2912.203 + 20708{,}008 = 23620.211$, kg.power (14)

Tension at 10 points

$S_{10} = S_9 = 23620.211$, kg.power (15)

Tension at 11 points

$S_{11} = 1{,}06 S_{10} = 1.06 \cdot 23620.211 = 25037.424$, kg.power (16)

Tension at 12 points

$S_{12} = S_{11} = 25037.424$, kg.power (17)

Tension at 13 points

$S_{13} = 1{,}04 S_{12} = 1{,}04 \cdot 25037.424$, kg.power (18)

Tension at 14 points

$S_{14} = 1{,}04 S_{13} = 1{,}04 \cdot 25037.424 = 26038{,}92$, kg.power (19)

On the other hand, there is a connection between the tensions of points 14 and 1 (at the points of entry and exit of the belt to the driving drum) as follows:

$S_{14} = S_1 \cdot e^{\mu\alpha} = S_1 \cdot 2.71^{0.35 \cdot 5.34} = 6.48 \cdot S_1$ (20)

where μ is the coefficient of adhesion between the belt and the drum surface, the value of which depends on the operating conditions of the conveyor and the surface of the driving drum, the value of which is taken from Table 3;

α - angle of winding of the belt on the driving drum, grad.

We determine the gravitational force on the conveyor drive as follows:

$W_0 = S_{nb} - S_{sb} = S_{14} - S_1 =$ 26038,92-4176,3=21862,62 kg.power (21)

Based on gravity, we find the driving force:

$N = K_M \frac{W_0' \cdot V}{102 \cdot \eta} = 1.1 \frac{21862{,}62 \cdot 2.98}{102 \cdot 0.85} = 826{,}59$ kW (22)

We determine the number of electric drives as follows

$n = \frac{N_A}{N_D} = \frac{826{,}59}{337.5} = 2.44 \approx 3$

Table 3: Values of $e^{\mu\alpha}$

Drum type and atmospheric conditions	Adhesion coefficient	The angle of winding of the tape on the drum, grad. or radianda							
		180	**210**	**240**	**300**	**360**	**400**	**450**	**480**
		3,14	**3,66**	**4,19**	**5,24**	**6,28**	**7,0**	**7,85**	**8,38**
Cast iron or steel:									
- our atmosphere	0,20	1,87	2,08	2,31	2,85	3,51	4,04	4,84	5,34
- dry atmosphere		2,56	3,00	3,51	4,81	6,59	8,17	10,50	12,35
Wood lined, dry atmosphere	0,35	3,00	3,61	4,33	6,27	9,02	11,62	15,60	18,78
Rubber lined, dry atmosphere	0,35	3,51	4,33	5,34	8,12	12,35	16,41	23,00	28,56

Thus, the calculations show that the operation of a 600 m long conveyor will require an energy consumption of 826.59 kWh or 3 drives. In addition, we will carry out the calculation of the second 400 m KL-1200 rubber fabric conveyor. In carrying out this calculation, the modulus of elasticity and stress state of the tape, as shown by the authors of [3, 4, 9], and the connection of the tapes to each other were taken into account.

$$W_{con.load} = (q + q_{belt} + q_p{}')L\omega' = (185{,}71 + 24 + 47{,}5)600 \cdot 0{,}023 = 3549.498$$ kg.power (23)

The forces of resistance to movement in the unloaded direction of the conveyor are calculated according to the following formulas:

$$W_{unloaded} = (q_{belt} + q_p')L\omega' = (24 + 13.3)600 \cdot 0.023 = 514.74$$ kg.power (24)

Table 1 shows the weight of 1 m^2 of tape. From the information in the table, the weight of a 1 m long ribbon can be calculated according to the formula:

$$q_{belt} = G_b{}' \cdot B = 20 \cdot 1{,}2 = 24$$, kg.power (25)

We determine the power of the conveyor device drive by the method of points along the rotational contour of the belt (Fig. 3).

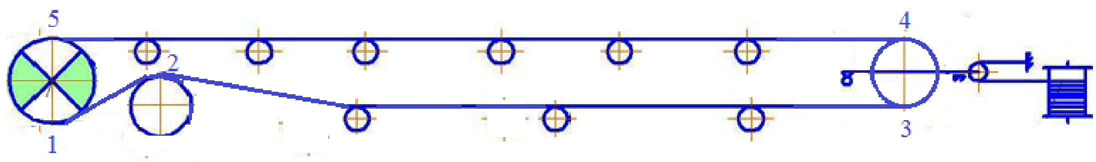


Figure 3: Scheme of calculation of the conveyor "by contour".

The rule for calculating tension is as follows: the tension of a traction body at a given point is found by the sum of the resistance forces in the section to the tension at the previous point (the resistances between the two points). The results are presented in Table 4.

Table 4:

S_1	S_2	S_3	S_4	S_5
1187.26	1234.75	1749.49	1854.45	5403.957

Gravity in the conveyor drive,

$W_0 = S_{nb} - S_{sb} = S_5 - S_1 = 5403{,}957 - 1187{,}26 = 4216{,}69$, kg.power (26)

Engine power

$$N = K_M \frac{W_0' \cdot V}{102 \cdot \eta} = 1.1 \frac{4216{,}69 \cdot 3.5}{102 \cdot 0.85} = 187{,}24 \text{ ,} \qquad \text{kW (27)}$$

Number of engines

$$n = \frac{N_A}{N_D} = \frac{187{,}24}{132} = 1{,}41 \approx 2$$

In the technological scheme shown in Figure 1, the 6 supplier conveyors (kuznechik) belt brand is 1200-5-TK-200. As a result of the calculations, it was determined that 48.25 kW for one supplier conveyor and 144.72 kW for a total of three.

Gravity in the conveyor drive,

$W_0 = S_{nb} - S_{sb} = S_5 - S_1 = 1455{,}74 - 320{,}47 = 1135{,}3$, kg.power (28)

Engine power

$$N = K_M \frac{W_0' \cdot V}{102 \cdot \eta} = 1.1 \frac{1135{,}3 \cdot 3{,}35}{102 \cdot 0.85} = 48{,}25 \text{ , kW (29)}$$

Calculations showed that the total driving power was 826.59 kW for the main conveyor, 187.24 kW for the supply conveyor and 48.25 * 3 = 144.72 kW for the supply conveyor (boiler). The total power of 4,5,6 conveyors in the periodic flow technological scheme under consideration was 1158.58 kW. We will consider efficient, reliable, energy-saving schemes to reduce this overall capacity and extend the transport distance.

There are defined schemes for these cases in the world, which are given in Table 5 [5, 8].

Calculations were made on the basis of the schemes given in this table, and the authors proposed a KLM-1200 rubber cable conveyor scheme with a capacity of 1200 m instead of the 600 m long rubber cable KLM-1200 and 400 m long rubber cloth KL-1200 conveyors with low capacity. (Figure 5).

Based on the proposed scheme, we determine the resistance force for a horizontally mounted conveyor:

$$W_{con.load} = (q + q_{belt} + q_p')L\omega' = \\ = (218{,}12 + 45{,}6 + 47{,}5) * 600 \cdot 0{,}023 = 4294{,}83 \ldots kg.power \quad (30)$$

For the direction of conveyor load installed at an angle of inclination, the forces of resistance to movement are determined by the following formula:

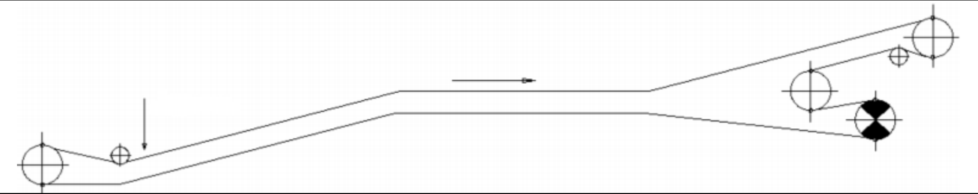
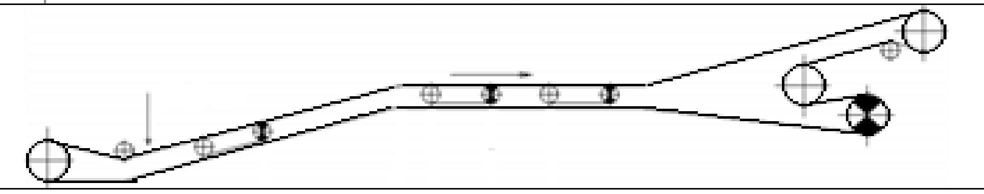
$$W_{con.load} = (q + q_{belt} + q_p')L\omega' \cos\beta \pm (q + q_{belt})L \sin\beta = \\ = (218{,}12 + 45{,}6 + 47{,}5)600 \cdot 0{,}023 \cdot 0{,}99 + (218{,}12 + 45{,}6) * 600 \cdot 0{,}104 = \quad (31) \\ = 4251{,}88 + 16456.128 = 20708.008 \ldots kg.power$$

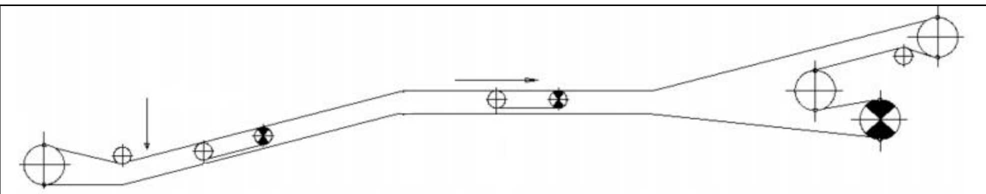
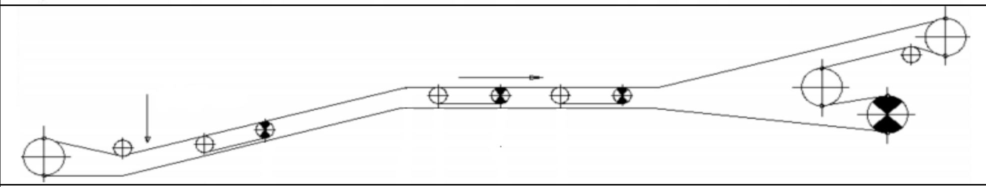
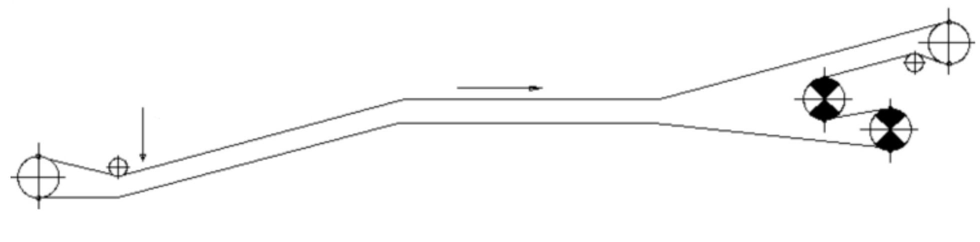
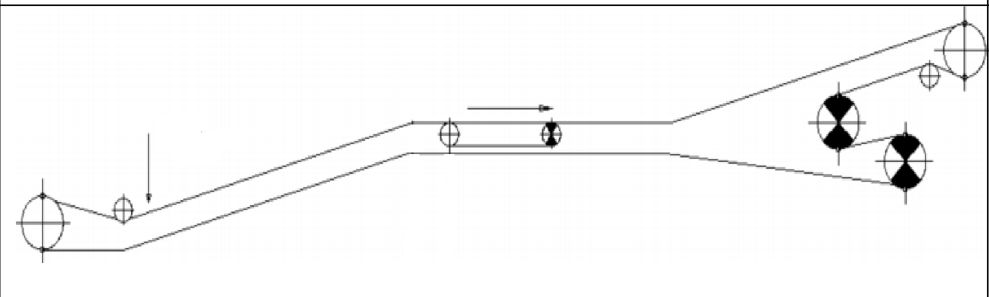
The resistance forces in the unloaded direction of the conveyor are as follows:

$$W_{unloaded} = (q_л + q_p'')L\omega' = (45{,}6 + 13{,}3)600 \cdot 0{,}023 = 812{,}82 \text{ kg.power} \quad (32)$$

$$W_{unloaded} = (q_{belt} + q_p'')L\omega' \cos\beta \pm q_{belt} L \sin\beta = \\ = (45{,}6 + 13{,}3) * 600 \cdot 0{,}023 \cdot 0{,}99 - 45{,}6 \cdot 600 \cdot 0{,}139 = \quad (33) \\ = 804{,}69 - 2845.44 = -2040.75 \ldots kg.power$$

Table 5: Schemes in which electric drives can be installed.

		$N_{\sum}$ kW	$W_{\sum}$ kN
1		2*1600	703,4
2		8*400	665,3

3		6*500	569,6
5		8*400	607,5
6		4*800	665,3
7		6*500	649,7

Based on the point method on the rotational contour of the belt, we can number the points at which the conveyor drive is changed in all directions from the point of exit of the belt from the drive drum. We then determine the voltages and driving forces of the series input and output networks along the contour rotation (Figure 5).

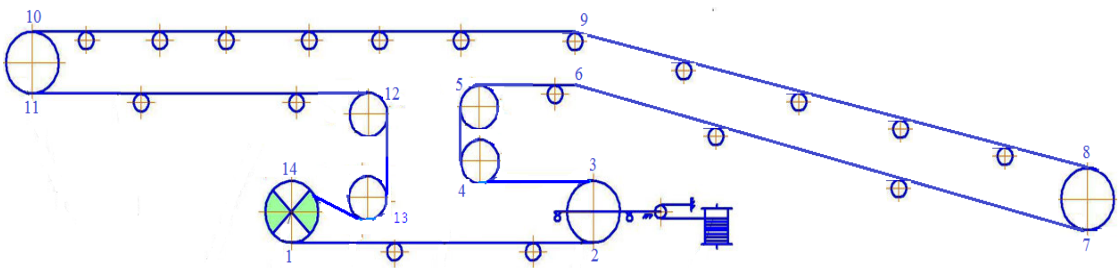


Figure 5: KLM-1200 conveyor "contour" calculation scheme.

We perform the following calculations, ie determine the voltage:

$S_i = S_{i-1} + W_{(i-1)-i}$, kg.power (34)

According to the scheme shown in Figure 4, the tension at the exit point of the belt from the drive drum is equal to S1.

The tension at point 2 is

$S_2 = S_1$, kg.power (35)

Tension at 3 points

$S_3 = 1{,}06 S_2 = 1{,}06 \cdot 5317{,}22 = 5636{,}26$, kg.power (36)

Tension at 4 points

$S_4 = S_3 = 5636{,}26$, kg.power (37)

Tension at 5 points

$S_5 = 1{,}04 S_4 = 1{,}04 \cdot 5636{,}26 = 5861{,}71$, kg.power (38)

Tension at 6 points

$S_6 = 1{,}04 S_5 = 1{,}04 \cdot 5861{,}71 = 6096{,}18$ kg.power (39)

Tension at 7 points

$S_7 = S_6 + W_{unload} = 6096{,}18 - 2040{,}75 = 4055{,}43$ kg.power (40)

Tension at 8 points

$S_8 = 1{,}06 S_7 = 1{,}06 \cdot 4055{,}43 = 4136.53$ kg.power (41)

Tension at 9 points

$S_9 = S_8 + W_{con.l} = 4136.53 + 20708{,}008 = 24844.54$ kg.power (42)

Tension at 10 points

$S_{10} = S_9 + W_{con.l} = 24844.54 + 4294{,}93 = 29139.47$ kg.power (43)

Tension at 11 points

$S_{11} = 1{,}06 S_{10} = 1{,}06 \cdot 29139.47 = 30305.05$ kg.power (44)

Tension at 12 points

$S_{12} = S_{11} + W_{unloaded} = 30305.05 + 812{,}82 = 31117.87$ kg.power (45)

Tension at 13 points

$S_{13} = 1{,}04 S_{12} = 1{,}04 \cdot 31117.87 = 32362.59$ kg.power (46)

Tension at 14 points

$S_{14} = 1{,}04 S_{13} = 1{,}04 \cdot 32362.59 = 33657.09$ kg.power (47)

$S_{14} = S_1 \cdot e^{\mu\alpha} = S_1 \cdot 2.71^{0.35 \cdot 5.34} = 6.48 \cdot S_1$ (48)

Determine the gravitational force on the conveyor drive:

$W_0 = S_{nb} - S_{sb} = S_{14} - S_1 = 33657.09 - 5317{,}22 = 28339.87$, kg.power (49)

Electric drive power

$N = K_M \dfrac{W_0' \cdot V}{102 \cdot \eta} = 1.1 \dfrac{28339.87 \cdot 2.98}{102 \cdot 0.85} = 1071.48$, kW (50)

We determine the number of electric drives as follows

$n = \dfrac{N_A}{N_D} = \dfrac{1071.48}{337.5} = 3.17 \approx 3$ you will need to drive.

The total power of 4, 5, 6 conveyors in the periodic flow technological scheme under consideration was 1158.58 kW. Instead, as a result of the calculations, the total power of the proposed circuit was 1,071.48 kW, and the possibility of transporting rock through a single conveyor leads to an expansion of space to form a heap when the supplier conveyor is laid continuously. If we make full use of the efficiency of the bunker and the supplier, the fill coefficient of the main conveyor belt can be used in case 1 if the rock is crushed to the required level.

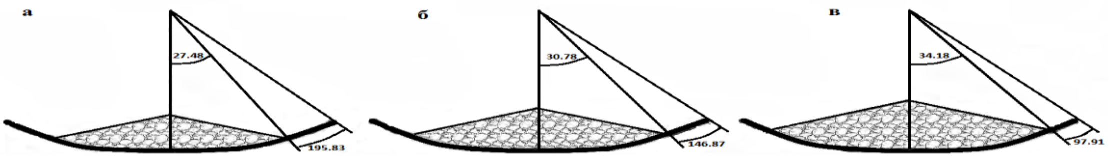


Figure 6: Types of conveyor loading: a - 60%; b - 80%; v - 100% - loading width of conventional belt conveyors.

Figure 6 shows the percentage of conveyor width filling, and the authors [3, 4, 5] consider the effect of strain state and power on the belt for cases where this fill factor is specified. According to the authors, mainly the filling of the tapes works in the range of 60-100%. Hence, the above conveyor capacity can also be related to the belt filling coefficient. That is, for a 60% filled tape, it is necessary to calculate by reducing its capacity:

$N_k = N \cdot 0.7 = 1071.48 \cdot 0.6 = 642.88$, kW $N_k = 643 \div 1070$ kW

RESULTS

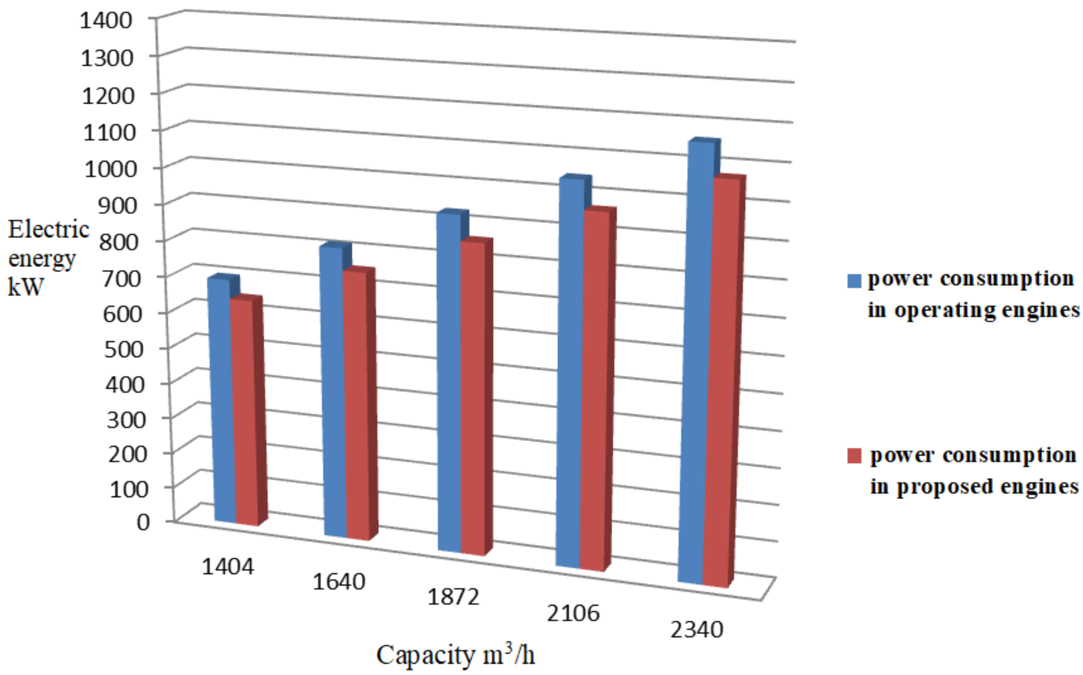


Figure 7: Graph of productivity and power dependence of the conveyor used on the basis of periodic flow technological scheme.

It can be concluded from the calculations that, firstly, the belt of the supplier conveyor is a rubber fabric, which causes the belt to wear out quickly under the influence of the hardness and weight of the rock. Second is the lack of transportation distance. Third is the increase in the number of supplier conveyors (kuznechik). To overcome these factors, the economical and efficient option we offer can be used on the basis of the technological periodic flow diagram shown in Figure 8 and as a result of calculations, the length of a single main conveyor shown in Figure 5 is 1200 m.

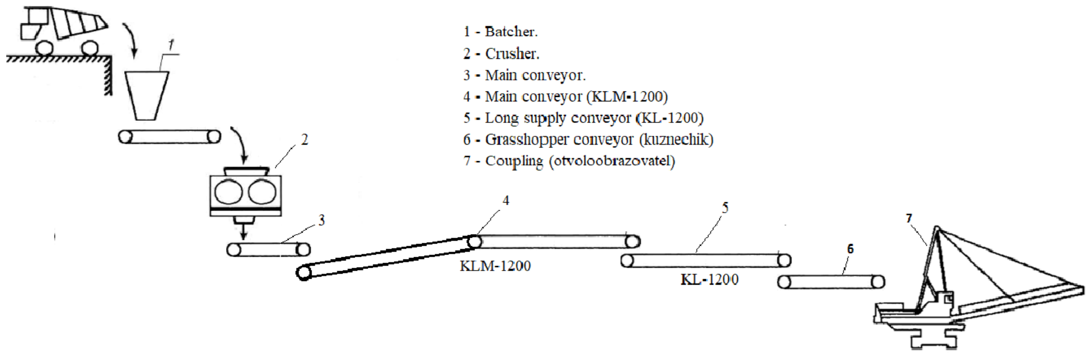


Figure 8: Technological scheme of proposed periodic flow transport for Dagiztau deposit.

Annual electricity consumption

E=403*∑E*Tсм*n*N=403*1158.59*11.24*2*305=3201306228,536 sum

Annual electricity consumption according to the proposed option

E=403*∑E*Tсм*n*N=403*1071,48*11.24*2*305=2960637675,216 sum

E=3201306228,536-2960637675,216=240668553,32 sum gives efficiency in 1 year.

Based on this proposal, the conveyor transport distance and equipment life have been extended, leading to increased resource and energy savings.

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