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COMPARATIVE ANALYSIS OF THE APPLICATION OF STEEP CONVEYOR LINES ON QUARRIES

Abstract. The aim of the research is to identify methods of adaptation of cycle and flow technology, using steeply inclined conveyors, in the development of ore deposits in an open way.

Determination of efficiency and conditions of preferable application of steeply inclined conveyor lifting is carried out using scientifically based principles of versions comparison taking into account relationship of adjacent links of cycle-flow technology according to selected evaluation criteria trying to calculate according to economic and mathematical model, taking into account operation mode, technical parameters and operational characteristics of equipment.

Analysis of dependencies of change of evaluation criteria on the main influencing factors when using traditional and steeply inclined belt conveyors in systems of cycle-flow technology has been carried out.

Influence of inclination angle of conveyor lift route and height of rock mass lifting on main indices of crushing-conveyor complexes is determined. Results of technical and economic analysis of application of cycle-flow technology complexes with steeply inclined conveyor lifts and conventional ones are given. Comparative values of capital and operating costs are determined at different angles of installation of steeply inclined conveyor lift at lifting height of transported material 100 - 600 m and lifting angles up to 50 - 60 °.

Effective conditions for the application of steeply inclined belt conveyors were established on the basis of an analysis of estimated indicators including total and specific capital costs, total and specific operating costs, labor productivity, specific metal consumption and specific heat saturation, which were determined in general for the complex of cycle-flow technology.

The results of the studies show that the steeply inclined conveyor lifts at the angles of their installation are more than 35° more efficient than conventional belt conveyor lifts, which under the conditions makes it possible to reduce total capital costs by 20-100 million rubles, and total operating costs - by 3.5-4.5 million rubles per year.

Key words: cycle and flow technology, deep quarries, mobile crushing and reloading plants, steeply inclined conveyor, concentration horizon, unit costs, research.

The problem and its relationship to scientific and practical tasks. Development of open extraction of mineral raw materials is accompanied by continuous increase of quarries depth, deterioration of mining-geological and mining technical conditions of development, concentration of mining operations. The main volume of a production of ores is the share of large pits of 250-300 m in depth and more which final design depth of development of 700-800 m. In the long term the main volume of dredging of mountain weight on pits will be carried out by development of deep horizon [1-6].

With increasing depth of quarries, conditions of transportation from lower horizons are complicated, which are characterized by increase of range and height of rock mass lifting, increase of weighted average slopes and limitation of capacity of intracarrier transport communications and reduction of reliability of mining and transport equipment. The reduction of equipment productivity for every 100 m reduction of mining operations is: in excavating and automobile complexes, excavators - 10-15%, trucks - 25-39%; In excavator-railway complexes - 17- 19% excavators, locomotive units - 8.5-20%. Height of working zone

increases to 250-300 m, width of working platforms decreases, availability of reserves ready for extraction decreases to 0.4-1.0 months, angle of repayment of quarry sides increases [7]. Research confirms that it is possible to compensate for the negative impact of the factor of increasing the depth of development on the economic indicators of mining enterprises, to ensure maintenance and increase of ore production volumes by reconstruction of mining and transport systems of quarries and introduction of flexible technological schemes of development with high-manmade and productive mining and transport equipment, which is as adapted as possible to the intra-car infrastructure[8-10].

The efficiency of further development of large quarries is determined by the correctness of the strategy of selection of technology and technology during mining works on deep horizons. For most quarries the priority direction of development of deep horizons of quarries is cycle-flow technology (CFT), the efficiency of which is proved by numerous scientific and design developments, experience of operation of systems of cycle-flow technology on foreign quarries[11-14].

One of the main ways to increase work efficiency is to use cyclic-flow technologies based on automobile conveyor transport, using the flow link of cyclic-flow technologies of a steeply inclined conveyor. Currently, the use of cyclic-flow technologies in a quarry in Muruntau (Republic of Uzbekistan) is 30-40%, and by dump trucks by 50-70%, and dump trucks by 30% [15].

Application of cycle-flow technology(CFT) in conditions of continuous deepening of open developments makes it possible to achieve high concentration of production, to improve indicators of use of mining and transport equipment, to provide high degree of automatic control of technological processes and to increase efficiency of mine operation as a whole. The studies carried out have so far shown that the specific energy consumption of cycle-flow technology used in the quarries of Russia and Ukraine is lower by 14 - 16% compared to cycle technology. Distribution of power consumption by the main technological processes of cycle-flow technology on average provides: transportation of mining mass 75 - 80%, crushing 8 - 10%, excavation 16 - 18% [7].

Analysis of research and publications. When analyzing the work of various quarries of the countries, it was revealed that the following complexes of cyclic-flow technologies with steeply inclined conveyors are currently used. The history of the development and use of the steeply inclined «sandwich» conveyor is known in the «Maidanpek» quarry and in Canadian diamond quarries[16-17].

Previously performed by the Institute of Mining of the Ural branch of the Russian Academy of Sciences of scientific research defined parameters of a steeply inclined belt conveyor with a pressure belt and tubular steeply inclined belt conveyors in relation to conditions of deep mining quarries. The results of the design work showed that the tubular steeply inclined belt conveyor is significantly lower in the main parameters than the steeply inclined belt conveyor with pressure belt: in the maximum lifting height by 2-3 times (the limit lifting height - 80-85 m); 1.8-3.2 times (maximum performance is 6.5-7.0 million tonnes/year. In addition, the construction of the tubular conveyor involves the use of special cables with increased abrasion resistance, Limitations on minimum permissible values of spiral vertical curve radii along the conveyor route require the arrangement of horizontal platforms in the quarry to accommodate conveyor loading units up to 75-80 m wide. Taking into account the set of said factors, As well as a number of complex design solutions for individual components of the conveyor, Elimination of possibility of effective application of tubular steeply inclined belt conveyors in deep quarries.

Studies have found that for quarries, the most preferred type of steeply inclined lifting of the rock mass is double-loop belt conveyors of the sandwich type with forced pressing of the upper run of the belt by special mechanical devices[18-23].

A typical practical application of this conveyor design is the "Muruntau" gold mine (Republic of Uzbekistan), where since 2011 the crushing and conveyor complex with a steeply (CCC) inclined belt conveyor of sandwich type.

The commissioning of the steeply inclined belt conveyor in March 2011 reduced the distance of transportation of the rock mass by road on average by 3,5 km, lifting height by 285-320 m.

As the practice of Muruntau 's quarry shows, the use of the complex with a steeply inclined belt conveyor allows to increase the productivity of motor vehicles by 30%, reduce the annual mileage of cars by 30.4%, reduce the number of motor vehicles, drivers and repair workers by 27.2%, the consumption of petrol and lubricants - by 37% [4]. Thus, the introduction of a cycle-flow technology scheme with a

steeply inclined conveyor has low running costs associated with reduced demand for dump trucks, drivers, and maintenance personnel [15].

Presentation of material and results. The results of the technical and economic comparison are given below, which give a general idea of the feasibility of using steeply inclined conveyors in comparison with traditional belt conveyors in cycle-flow technology complexes. Double-loop conveyor with moving pressure elements is considered as steeply inclined lift.

Determination of the field of rational application of steeply inclined conveyors is carried out for conditions of use of cycle-flow technology complexes in process load flows of rocks and ores with volume of 5-30 million tons per year at height of lifting of transported material of 100 - 600 m and angles of lifting up to 50 - 60°. At selection of conveyor equipment parameters rational speed of conveyor belt movement 3.15 m/s is accepted at movement of rock large-rolled rock mass. The selection of the assembly road transport equipment was carried out on the basis of the rational lifting height of the rock mass by the motor trucks equal to 60 - 80 m at the weighted average transportation distance of not more than 2 km.

The conditions for effective application of steeply inclined belt conveyors were determined on the basis of an analysis of estimated indicators including total and specific capital costs and operating costs, labor productivity, specific metal consumption and energy saturation, which were determined in general for the complex of cycle-flow technology (table).

Analysis of the structure of capital expenditures for cycle-flow technology(CFT) complexes shows that in the total cost of equipment the main share of expenditures is accounted for by assembly road transport, which reaches 40 - 60% depending on the annual volume of transportation and height of lifting of transported material by conveyors. Capital costs for excavating link equipment 15 - 20%, for crushing-conveyor equipment 20 - 45% of total costs for main equipment of cycle-flow technology complexes. The share of costs for crushing and conveyor equipment increases significantly (1.6 - 1.7 times) with increasing height of mining mass rise (from 100 to 600 m) and decreases (by 20 - 23%) with increasing volume of traffic (from 5 to 30 million tons per year).

It should be noted that in the total costs of complexes the costs of mining and capital works related to the placement of crushing and reloading points and conveyor lifts in the quarry are very significant. The general trend of changing the share of costs for them is a significant increase in them with the increase in the height of rise of the transported material and a less intense decrease with the increase in the annual volume of transportation of the mountain mass. In this connection, the share of the passive part of capital investments in the cycle-flow technology with conventional belt conveyors is 14-78%, and with steeply inclined conveyor lift - within the limits of 12.5 - 47%.

The operating costs of cycle-flow technology (CFT) complexes are similar to those of capital expenditures.

The studies have established trends and intensity of change of specific indicators depending on the annual volume of transportation and height of lifting to conveyor transports of mountain mass. In systems of cycle-flow technology (CFT) with conventional belt conveyors with capacity of 5 - 30 million tons per year with increase of height of mining mass lifting from 100 to 600 m, specific capital costs for main equipment change by 4.9 - 2.1 times, and specific operating costs by 2.1 - 1.6 times. When used in systems of cycle-flow technology (CFT) of steeply inclined conveyors, the intensity of change of specific capital costs and specific operating costs is significantly lower and is, respectively, 3.3 - 1.7 and 1.8- 1.5 times (figure 1).

For every 100m increase in lift height the specific values are increased: when conventional belt conveyors are used in conveyor lines, respectively, by 35 - 16% and 16 - 10%; When used in conveyor lines, steeply inclined conveyors, respectively, by 25 - 12 and 12 - 8%. The intensity of increasing costs decreases with the growth of annual productivity of cycle-flow technology complexes.

On the other hand, with the increase in the volume of transport of the rock, the specific capital and operating costs are reduced (figure 2): when conventional belt conveyors are used in conveyor lines, respectively, by 1.4 - 3.0 and 1.3 - 1.7 times; When used in conveyor lines, steeply inclined conveyors are 1.3 to 2.5 and 1.2 to 1.5 times respectively. Intensity of cost reduction increases with increase of height of transported material.

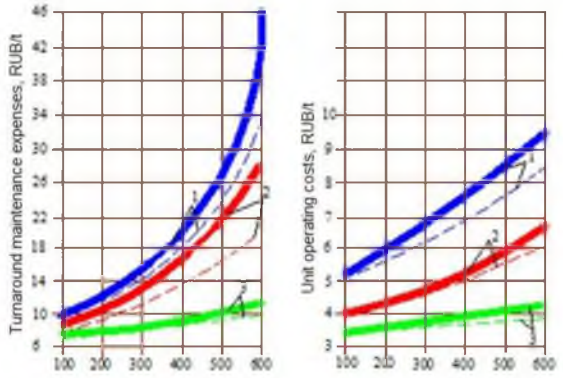

Figure 1 –
Change in specific capital costs and operating costs for cyclic-flow technology complexes depending on the height of the rock mass: 1,2,3, - respectively, with the annual productivity of the complex 5, 10, 30 million tons; solid lines - with conventional conveyors, dashed lines - with steeply inclined double-circuit conveyors

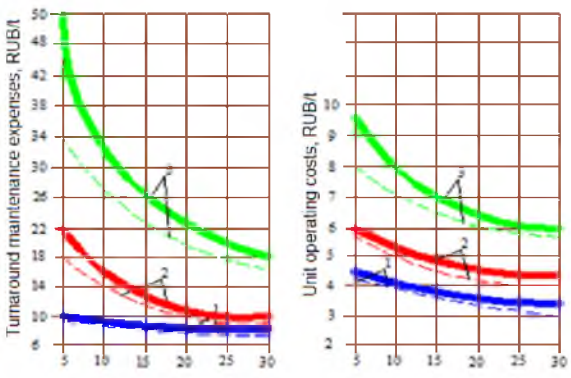

Figure 2 –
Change in specific capital costs and operating costs for cyclic-flow technology complexes depending on annual productivity: 1,2,3, - respectively, when the height of the rock mass is 100, 300, 600 m; solid lines - with conventional conveyors, dashed lines - with steeply inclined double-circuit conveyors

The total energy saturation of cycle-flow technology (CFT) complexes, determined by the required installed capacity of the main technological equipment, increases significantly with the increase in the height of mining mass rise and annual productivity. The most energy-saturated is the link of road transport, the largest share of which in the total installed capacity of equipment of systems of cycle-flow technology reaches 77% and slightly decreases (to 51 - 57%) with increase of height of mining mass lifting by conveyor transport and increase of installed capacity of equipment of the complex. The share of the latter in the total installed capacity of equipment of cycle-flow technology (CFT) complexes varies within 13 - 37% depending on the height of mining mass lifting and annual productivity. The least energy intensive process is mining and loading. The share of excavating link in the total installed capacity of investigated complexes of cycle-flow technology is 8-15%.

Specific energy saturation per 1 t of rock mass developed using cyclic-flow technology varies within the range of 1.3 - 1.9 W/t. The value of this indicator increases with the height of the rise and is practically independent of the annual volume of traffic. The influence of the inclination angle of the belt conveyors on the specific energy saturation of the cycle-flow technology complexes has not been established. When completing cycle-flow technology complexes, equipment with lower installed capacity should be accepted. This determines less power consumption during operation.

Annual productivity of one operating complex of cycle-flow technology is 28 - 87 thousand tons of mining mass. To a large extent it depends on the volume of transported rock mass and used equipment in the excavation and automobile complex. Thus, the increase in the annual volume of traffic from 5 to 20 million tons when used in the excavating and automobile complex of excavators ECC-5 and trucks with a load capacity of 42 tons gives an increase in labor productivity per worker by 28 - 32%. On the other hand, the increase in the annual volume of traffic under the cycle-flow technology from 20 to 30 million tons and the use of excavators on the loading of the mountain mass is ECC-8E, and as an assembly transport of trucks with a load capacity of 100 - 110 tons allows to increase labor productivity by almost 2 times.

At the height of rock lifting by conveyor and 100 m, the number of workers in the excavating and automobile complex reaches 76-90% of the total number of workers in the complexes of cycle and flow technology. With the increase of the height of the mountain mass rise to 600 m, the share of the service personnel of excavating and automobile complexes decreases to the 60 - 82% of the total number of workers, at the same time the link of assembly road transport serves the 45 - 65% of all working in the system of cycle-flow technology. Number of maintenance personnel of crushing-conveyor complexes varies slightly with increase of annual volume of transportation and increases with increase of height of lifting of rock mass by conveyor lift up to 6 - 7%.

Parameters of compared conveyor's types

Production, million t /year	Lifting height, m	Capital expen ditures, RUB/t	Expluat xpen ses, RUB / t	Productivity of labor, t per l	Specific metal-capacity, kg / t	Specific energy saturation, W / t	Weight of equipment, t			Installed power, kW		
							CCC	autotransport	excavator	CCC	autotransport	excavator
5	100	11,3 / 10,8	4,6 / 4,5	37037 / 37879	0,33	1,25 / 1,27	590,2 / 588,1	351,6	714,9	825 / 925	4416	990
	200	15,4 / 13,4	5,3 / 5,0	35211 / 37037	0,36 / 0,35	1,39 / 1,34	728,4 / 675,3	351,6	714,9	1525 / 1275	4416	990
	300	21,4 / 17,2	6,0 / 5,6	33557 / 36232	0,38 / 0,37	145	828,6 / 779,4	351,6	714,9	1825	4416	990
	400	29,2 / 21,9	9,6 / 6,3	32051 / 37514	0,40 / 0,39	1,52 / 1,51	931,8 / 858,6	351,6	714,9	2215 / 2155	4416	990
	500	39,1 / 27,9	8,2 / 7,1	29240 / 34965	0,43 / 0,40	1,63 / 1,61	1078,9 / 948,8	351,6	714,9	2725 / 2625	4416	990
	600	51,1 / 35,1	9,6 / 8,1	28090 / 34247	0,45 / 0,42	1,75 / 1,72	1205,2 / 1049,8	351,6	714,9	3325 / 3215	4416	990
10	100	8,9 / 8,7	4,1 / 4,1	44643 / 45045	0,30 / 0,03	1,18 / 1,17	1088,6 / 1077,1	673,9	1191,5	1650 / 1600	8464	1650
	200	11,1 / 10,1	4,4 / 4,3	43290 / 44643	0,31 / 0,31	1,27 / 1,26	1234,4 / 1212,3	673,9	1191,5	2540 / 2530	8464	1650
	300	14,2 / 12,2	4,9 / 4,7	40486 / 44053	0,33 / 0,32	1,38 / 1,37	1431,6 / 1347,4	673,9	1191,5	3650 / 3540	8464	1650
	400	18,2 / 14,9	5,4 / 5,3	39370 / 39841	0,34 / 0,34	1,45 / 1,53	1562,8 / 1520,6	673,9 / 732,5	1191,5	4430 / 4410	8464 / 9200	1650
	500	23,5 / 17,9	6,2 / 5,7	36232 / 39370	0,37 / 0,36	1,68 / 1,61	1816,9 / 1642,8	703,2 / 732,5	1191,5	6320 / 5250	8832 / 9200	1650
	600	29,9 / 21,5	7,1 / 6,2	32468 / 38911	0,41 / 0,37	1,78 / 1,73	1959,2 / 1790,8	732,5	1429,8 / 1191,5	6650 / 6430	9200	1980 / 1650
20	100	7,4 / 7,4	3,7 / 3,8	48426 / 47281	0,27 / 0,27	1,14 / 1,17	1647,8 / 1624,8	1318,5 / 1377,1	2383,0	2865 / 2805	16560 / 17296	3300
	200	9,2 / 8,3	4,1 / 4,0	45352 / 46948	0,29 / 0,28	1,27 / 1,25	1939,5 / 1832,1	1377,1	2383,0	4755 / 4755	17296	3300
	300	11,1 / 10,3	4,5 / 4,6	43384 / 42827	0,32 / 0,33	1,40 / 1,46	2683,3 / 2598,9	1406,4 / 1465,0	2383,0 / 2621,3	6970 / 7080	17664 / 18400	3300 / 3300
	400	13,2 / 11,7	4,8 / 4,8	42735 / 42644	0,34 / 0,35	1,49 / 1,53	2929,1 / 2825,3	1406,4 / 1465,0	2383,0 / 2621,3	8800 / 8600	17664 / 18400	3300 / 3300
	500	16,2 / 13,7	5,5 / 5,3	39293 / 40242	0,37 / 0,37	1,65 / 1,74	3237,8 / 3234,8	1465,0 / 1552,9	2621,3	10900 / 11740	18400 / 19504	3630
	600	19,5 / 15,5	6,1 / 5,6	37383 / 40000	0,39 / 0,38	1,80 / 1,80	3568,9 / 3374,4	1523,6 / 1552,9	2621,3	13300 / 12850	19136 / 19504	3630
30	100	7,8 / 8,1	3,6 / 3,7	87464 / 83333	0,21 / 0,23	1,18 / 1,14	1586,3 / 1602,0	1914,0 / 1972,0	2816,8 / 3219,3	3450 / 3710	25476 / 26248	3640 / 4160
	200	9,0 / 9,0	3,9 / 4,1	79365 / 77320	0,24 / 0,24	1,22 / 1,29	1956,4 / 1993,6	1914,0 / 2088,0	3219,3	6150 / 6730	26248 / 27792	4160
	300	10,3 / 9,8	4,3 / 4,2	75188 / 76727	0,25	1,36 / 1,39	2370,4 / 2310,5	2030,0 / 2088,0	3219,3	9500 / 9750	27020 / 27792	4160
	400	12,0 / 11,3	4,6 / 4,7	70423 / 69444	0,27	1,48 / 1,60	2750,4 / 2719,2	2088,0 / 2262,0	3219,3 / 3621,3	12350 / 13100	27792 / 30108	4160 / 4680
	500	14,2 / 12,4	5,2 / 4,9	65934 / 69124	0,29 / 0,3	1,63 / 1,68	3231,1 / 2988,8	2204,0 / 2262,0	3219,2 / 3621,6	15200 / 15500	29336 / 30108	4160 / 4680
	600	16,7 / 14,1	5,7 / 5,4	61728 / 65076	0,32 / 0,32	1,79 / 1,86	3692,1 / 2378,0	3692,1 / 3479,1	3621,6	18950 / 19350	30108 / 31652	4680

Note. In the numerator are indicators of conventional conveyors, in the denominator are indicators of steeply inclined conveyors.

Analysis of the calculated data showed that the annual productivity of one operating complex of cycle-flow technology with steeply inclined conveyor lift in most cases is higher than that of complexes of cycle-flow technology (CFT), conveyor lines of which are equipped with conventional belt conveyors. The general trend of reduction of labor productivity (by 10-25%) with increase of lifting height from 100 to 600 m will continue regardless of annual volumes of processing of mining mass by complexes of cycle-flow technology (CFT). It has been found that at their annual capacity of up to 10 million tonnes, steeply inclined conveyors should be used at a rock lifting height of more than 100 - 200 m. Under these conditions, at lower specific operating costs (per 5-15%), the specific capital costs of cycle-flow technology complexes with steeply inclined conveyors are significantly lower (per 13-30%) than with conventional belt conveyors. In addition, the use of steeply inclined conveyors is preferable in productivity per worker (higher per 8 - 20%). With increase of productivity of cycle-flow technology (CFT) complexes up to 20 - 30 million tons per year, it is expedient to use steeply inclined conveyors at height of rock mass lifting more than 200 - 300 m. Under these conditions, at practically equal specific operating expenses, specific capital costs for cycle-flow technology (CFT) complexes with steeply inclined belt conveyors are lower by 6 - 20%.

From the point of view of environmental protection, the use of steeply inclined double-loop conveyors on quarries is also more preferable: additional volumes of rock mass are reduced by 1.4 - 1.6 times along the extension of quarries sides, and therefore the need for land withdrawal for empty rocks is reduced; Dust and gas emissions to the atmosphere are significantly reduced.

Conclusions and further directions of research.

1. The results of the performed studies show high efficiency of application on deep quarries of complexes of cycle-flow technology with steeply inclined conveyors.

2. Technological parameters and composition of the equipment should be determined taking into account the dynamics of mining operations and the transport system of the quarry as a whole.

3. When selecting the equipment of the crushing-conveyer complex, priority should be given to the equipment of the block-modular open design, which will allow to ensure technological flexibility of the used complexes of cyclic-flow technology in changing mining technical conditions.

4. In the future, the development of personal and flow technology on deep quarries should be based on progressive technological and technological solutions, ensuring increased efficiency, competitiveness, as well as expansion of the sphere of its application.

5. The solution of the problem of development of deep horizons of quarries is closely connected with improvement of technological schemes in cycle-flow technology, transition to flexible technologies. The requirements of deep pit development are best met by cycle-and-flow technology(CFT) systems using mobile crushing and reloading plants and steeply inclined belt conveyors, which ensure rapid installation and dismantling of complexes. Technical and economic calculations and data on foreign firms show high efficiency and prospects of cycle-flow technology with application of steeply inclined conveyor lifting.

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ТІК ЕҢКІШТІ КОНВЕЙЕРЛЕРДІ КАРЬЕРДЕ ҚОЛДАНУДЫ САЛЫСТЫРМАЛЫ ТАЛДАУ

Аннотация. Зерттеулердің мақсаты – кенді кенорындарын ашық тәсілмен қазу кезінде тік еңкішті конвейерлерді қолдана отырып, үзілмелі-толассыз технологияның бейімделу әдістерін анықтау.

Тік еңкішті конвейерлі көтерудің тиімділігі мен қолдану жағдайларының артықшылығы таңдалған бағалау критерийлері бойынша үзілмелі-толассыз технологияның ірғелес бөлімшелерінің өзара байланысын ескере отырып, ғылыми негізделген қағидалардың нұсқаларын салыстыра отырып анықталады. Тік еңкішті конвейерлі көтерудің тиімділігі жабдықтың жұмыс режимін, техникалық параметрлерін және пайдалану сипаттамаларын ескере отырып, экономика-математикалық модельдеу арқылы есептеледі.

Бағалау критерийлерінің өзгеруінің әдеттегі және тік еңкішті конвейерлі үзілмелі-толассыз технологияның кешендерінде пайдалану кезіндегі неғізгі әсер етуші факторларға тәуелділігі талданған.

Қысқыш ленталы тік еңкішті конвейерлер мен құбырлы тік еңкішті конвейерлердің параметрлері кен өндірудің терең аршықтарда қолдану жағдайларына сәйкес анықталған.

Конвейерлі көтергіш трассасының еңкею бұрышы мен кен массасын көтеру биіктігінің, ұсатқыш-конвейерлі кешендерінің негізгі көрсеткіштеріне әсері анықталған.

Тік еңкішті конвейерлі көтергілермен жабдықталынған үзілмелі-толассыз технологиялық кешендер мен әдеттегі конвейерлі көтергілермен жабдықталған үзілмелі-толассыз технологиялық кешендерді пайдалануның техника-экономикалық талдау нәтижелері келтірілген.

Терең кенді аршықтар, қолдану жағдайларына сәйкес, қысатын таспалы тік еңкішті конвейерлер мен құбырлы тік еңкішті конвейерлердің шама шарттарын салыстыру нәтижелері келтірілген.

Ғылыми-техникалық және патенттік ақпаратты талдау нәтижелері, кен массасын және басқа да сусымалы материалдарды тік еңкішті көтеру үшін қолданылатын таспалы конвейерлердің құрылмасының түбегейлі айырмашылығы жүкті 18 °-тан жоғары шамада көтеру барысында, оларды домалап кетпеуін сақтау үшін қабылданған техникалық шешімде жатады. Кенді көтеру тәжірибесінде келесі таспалы тік еңкішті конвейерлерді қолданады: кенді 25-27 ° бұрышпен көтеруді қамтамасыз ететін кедір-бұдырлы конвейерлер; көлденең бөгеттері бар (90 ° дейін); түрлі құбырлы (30-50 ° дейін); қысым таспасы бар (50-90 ° дейін).

Ресей ғылыми академиясының Орал бөлімшесінің тау-кен институты алғашқыда жүргізген ғылыми зерттеулерде, терең кен өндіру аршықтарының жагдайларына сәйкес, қолдануда қысатын таспалы тік еңкішті конвейерлер мен құбырлы тік еңкішті конвейерлердің шама шарттары анықталған.

Құрылымдаушы зерттеулерінің нәтижелері көрсеткендей, құбырлы тік еңкішті конвейерлер, қысатын таспалы тік еңкішті конвейерінен негізгі шама шарттары бойынша едәуір төмен екені анықталды, ягни көтерудің максималды биіктігі – 2-3 есе (көтерудің максималды биіктігі – 80-85 м); өнімділігі бойынша 1,8-3,2 есе (мүмкін болатын максималды өнімділігі жылына 6,5-7,0 млн. тонна) төмен.

Сонымен қатар құбырлы конвейердің құрылмасы қажалуга төзімділігі жоғары арнайы сым арқанды қолдануды қарастырады.

Аталған факторларды және конвейердің жеке құрамдас бөліктерін ескере отырып, терең аршықтарда құбырлы тік еңкішті конвейерлерін тиімді пайдалану мүмкіндігі жоққа шығарылады.

Тік еңкішті конвейерлі көтергілердің әртүрлі орнату бұрыштарына сәйкес 50-60° және тасымалданатын материалдың көтеру биіктігі 100-600 м аралығындағы, күрделі және пайдалану шығындарының салыстырмалы шамалары анықталынган.

Тік еңкішті конвейерлерін пайдаланудың тиімді жагдайлары күрделі үлесті шығындар мен жалпы шығындар, пайдалану үлесті шығындар мен жалпы шығындар, еңбек өнімділігі, үлесті металсыйымдылыгы және үлесті энергиясыйымдылыгын қоскандағы есептік көрсеткіштерді талдау негізінде анықталды.

Зерттеу нәтижелері көрсеткендей, тік еңкішті конвейерлі көтергілердің орнату бұрыштары 35°-тан жогары болган жағдайда, әдеттегі конвейерлік көтергіштерден гөрі тиімді және зерттеу жагдайларда жалпы күрделі шығындарды жылына 20-100 млн.руб., ал жалпы пайдалану шығындарды жылына 3,5-4,5 млн.руб. азайтуга мүмкіндік береді.

Түйін сөздер: үзілмелі-толассыз технология, терең аршықтар, мобильді ұсақтау және қайта-тиеу қондырғылары, тік еңкішті конвейер, шогырлау денгейжиек, үлестік шығындар, зерттеу.

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СРАВНИТЕЛЬНЫЙ АНАЛИЗ ПРИМЕНЕНИЯ КРУТОНАКЛОННЫХ КОНВЕЙЕРОВ НА КАРЬЕРАХ

Аннотация. Целью исследования является определение методов адаптации циклично-поточной технологии с применением крутонаклонных конвейеров при разработке рудных месторождений открытым способом.

Установление эффективности и условий предпочтительного применения крутонаклонного конвейерного подъема проводится с использованием научно обоснованных принципов сравнения вариантов с учетом взаимосвязи смежных звеньев циклично-поточной технологии по выбранным критериям оценки, рассчитываемых по экономико-математической модели, учитывающей режим эксплуатации, технические параметры и эксплуатационные характеристики оборудования.

Проведён анализ зависимостей изменения оценочных критериев от основных влияющих факторов при использовании в комплексах циклично-поточной технологии традиционных и крутонаклонных ленточных конвейеров.

Приведены результаты сравнения параметров крутонаклонных конвейеров с прижимной лентой и трубчатых крутонаклонных конвейеров применительно к условиям глубоких горнорудных карьеров.

Результаты анализа научно-технической и патентной информации свидетельствуют, что принципиальное отличие в конструктивном исполнении ленточных конвейеров, используемых для крутонаклонного подъема горной массы и других сыпучих материалов, заключается в принятом техническом решении по удержанию груза от скатывания при углах подъема более 18°. Существуют следующие виды крутонаклонных ленточных конвейеров с рифлеными лентами, обеспечивающими подъем груза под углом до 25-27°; с поперечными перегородками (до 90°); трубчатого типа (до 30-50°); с прижимной лентой (до 50-90°).

Одним из главных направлений повышения эффективности работы глубоких карьеров является применение циклично-поточной технологии на основе автомобильно-конвейерного транспорта, с использованием в поточном звене ЦПТ крутонаклонного конвейера. В настоящее время применение ЦПТ на карьере Мурунтау (Республика Узбекистан) позволило сократить расстояние транспортировки руды автотранспортом на 30-40%, снизить высоту её подъёма автосамосвалами на 50-70%, сократить количество автосамосвалов, работающих карьере и уменьшить загазованность на 30%.

В ранее выполненных Институтом горного дела Уральского отделения Российской академии наук научных исследованиях определены параметры крутонаклонного ленточного конвейера с прижимной лентой и трубчатых крутонаклонных ленточных конвейеров применительно к условиям глубоких горнорудных карьеров. Результаты конструкторских проработок показали, что трубчатый крутонаклонный ленточный конвейер по основным параметрам значительно уступают крутонаклонному ленточному конвейеру с прижимной лентой: по максимальной высоте подъема в 2-3 раза (предельная высота подъема - 80-85 м); по производительности в 1,8- 3,2 раза (максимально возможна производительность – 6,5-7,0 млн т/год. Кроме того, конструкция трубчатого конвейера предполагает использование специальных тросов с повышенной устойчивостью на истирание, а ограничения по минимально допустимым величинам радиусов переходных вертикальных кривых по трассе конвейера требуют устройства в карьере горизонтальных площадок для размещения узлов загрузки конвейера шириной до 75-80 м. С учетом совокупности указанных факторов, а также ряда сложных конструктивных решений по отдельным составным частям конвейера исключается возможность эффективного применения трубчатых крутонаклонных ленточных конвейеров в глубоких карьерах.

Определено влияние угла наклона трассы конвейерного подъемника и высоты подъема горной массы на основные показатели дробильно-конвейерных комплексов. Приведены результаты технико-экономического анализа применения комплексов циклично-поточной технологии с крутонаклонными конвейерными подъемниками и обычными. Определены сравнительные величины капитальных и эксплуатационных расходов при различных углах установки крутонаклонного конвейерного подъемника при высоте подъема транспортируемого материала 100 - 600 м и углах подъема до 50 - 60°.

Эффективные условия применения крутонаклонных ленточных конвейеров устанавливались на основании анализа оценочных показателей, включающих суммарные и удельные капитальные затраты, суммарные и удельные эксплуатационные расходы, производительность труда, удельную металлоемкость и удельную энергонасыщенность, которые определялись в целом для комплекса циклично-поточной технологии.

Результаты исследований показывают, что крутонаклонные конвейерные подъемники при углах их установки более 35° эффективнее обычных ленточных конвейерных подъемников, что в рассматриваемых условиях дает возможность уменьшить суммарные капитальные затраты на 20–100 млн руб., а суммарные эксплуатационные расходы – на 3,5-4,5 млн рублей в год.

Ключевые слова: циклично-поточная технология, глубокие карьеры, мобильные дробильно-перегрузочные установки, крутонаклонный конвейер, концентрационный горизонт, удельные затраты, исследование.

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