Analysis of overburden transportation by conveyor transport as part of a cyclic-flow technology

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Abstract. This article discusses the use of belt conveyors for transporting overburden from open pits. The main technical and economic parameters of powerful belt conveyors that operate as part of a cyclic-flow technology for the development and transportation of rocks are given. The main conclusions on the effective use and further development of belt conveyors for transporting rocky rocks are given.

1 Introduction

Conveyor transport as a part of cyclic flow and flow technologies is becoming more and more developed in the transportation of soft and rocky overburden, which is characterized by lower energy costs compared to other modes of transport. Thus, when using road and rail transport, the specific energy consumption (the consumption of standard fuel for lifting 1 ton of rock mass per 1 m) is 4.5-5.2 and 3.4-4.4 g, respectively, while with conveyor transport - 1.7-2.3 g c.e./t·m [1].

At present, according to the design, belt, belt-carriage, multi-drive belt with intermediate friction drives, belt-rope, plate conveyors have been developed. All types of conveyors are divided according to the conditions of rock mass transportation. The parameters of conveyor transport and its design are described in detail in [2-9], but the issue of creating conveyors for transporting lumpy rocks remains relevant. When it comes to transporting large lumpy rocks, it is recommended to use powerful self-propelled mobile screening and crushing units with a capacity of at least 4000 t/h, which will allow complete conveying of transport from the faces to the receiving points.

2 Materials and methods

Belt conveyors are used in many open pits around the world and their number depends on the technological structure and production capacity.

In [5], a technical and economic comparison of the cost of transportation of rocks, trends in the development of conveyor transport and examples of its operation were carried out. In

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Table. 1 shows the areas of effective use of conveyor equipment, which predetermine the feasibility of using one or another conveyor equipment in combination with road transport.

The most powerful belt conveyors suitable for transporting large crushed rock mass are manufactured at OJSC "Tyazhmash". In Table 2 shows the parameters of belt conveyors for the conveyor-haul complexes, manufactured at OJSC Tyazhmash. It should be noted that for some important parameters the given conveyors do not fully correspond to the mining conditions of open pits.

Table 1. Areas of effective application of conveyor equipment [5].

Type of equipment	Application conditions			Application efficiency*
	The angle of inclination of the route, hail.	Travel distance, km	Productivity, t/h	
When moving coarsely crushed rock mass				
Belt conveyors	0	Less than 1-1.5	1000-3000	–
	0	All surveyed distances	4000-6000	
	18	Same	1000-3000	
	18	Less than 1-3	4000-6000	
Multidrive conveyors with friction drives	18	More than 3-4	4000-6000	Reducing transport costs per 1 tkm by 10% or more
Belt and rope conveyors	0	More than 1-1.5	1000-3000	Reducing transport costs per 1 tkm by 30%
When moving large-sized rock mass				
Belt and wheel conveyors	0	Up to 3 or more	1000-6000	Reducing transport costs per 1 tkm by 10-40%
Belt and wheel conveyors	18	Less than 5-2	1000-6000	Reducing transport costs per 1 tkm by 25-35%

* Compared to belt conveyors

The parameters of the technical level of belt conveyors of foreign manufacturers are given in Table 3. When comparing belt conveyors (Tables 2 and 3), it can be seen that the technical level of conveyors of OJSC Tyazhmash is lower than required by mining conditions and inferior to foreign analogues [5]. But at the same time, the conveyors manufactured by OJSC Tyazhmash have a higher reliability of operation: their availability factor reaches 0.98 - 0.99, the drum life is up to 80,000 hours, the roller life is up to 30,000 hours, and the total service life is more than 20 years [8-14].

Table 2. Parameters of belt conveyors for automobile conveyor transport [5].

Options	Conveyor brand		
	T-200160-I	T-200160-II	T-1601160-II
Tape width, mm	2000	2000	1600

Tape type	1RTL-5000	1RTL-5000	1RTL-3150
Belt speed, m/s	2,5	3,15	3,15
Productivity, m3/h	4000	4700	3000
Drive power, kW	3x800	3x1250	800
type of drive	Double drum head		single drum

Table 3. Parameters of the technical level of belt conveyors.

Main settings	Analogue product	Unit rev.	Parameter value		
			According to analogues accepted for the world level	Achieved by analyzed parameter	Required for the mining technical conditions of open pits
Satisfaction with mining and technical conditions for the width of the belt	Belt conveyors Germany, USA, Canada	%	100	83	100
Maximum length of the conveyor at an inclination angle of 16°	Same	m	600	600	1100
Availability factor	Same	–	0,96	0,96	0,96
Ability to work at low temperatures	Same	%	100	50	100
Auxiliary equipment	Belt conveyors by Krupp (Germany)	%	60	30	100
Durability of conveyor belts	Conveyor belts Klut (Germany)	year	5	2	5

3 Discussion

As part of the conveyor-haul complexes for transporting rocky rock mass, the Azovmash plant (Ukraine) manufactured powerful belt conveyors, the productivity of which reaches 2100-6800 t / h at their speed of 1.5-3.7 m / s, the width of the conveyor belts is 1600- 2000 mm and power of drive stations 3780 kW. These conveyors can be operated at air temperatures from +40 to -45°C. Also, two belt-wheel conveyors were manufactured as part of a conveyor-haul complex with a capacity of 2100 t/h. The first conveyor delivers the large-sized rock mass to the crushing and screening transfer station, and the second conveyor delivers the coarsely crushed rock mass to the dump conveyor [15,16].

Novokramatorsk Machine Building Plant (NKMZ, Ukraine) manufactures belt conveyors with a maximum capacity of 5000 to 12000 t/h, a belt speed of 2-5 m/s, a conveyor inclination angle of 0 to 18°, a conveyor belt width of 1600 -2000 mm, horizontal line of one conveyor - from 400 to 1800 m and installed engine power - from 1260 to 4000 kW.

The Polevsk Engineering Plant (Russian Federation) manufactures stationary belt conveyors with a capacity of up to 2450 m3/h and a belt width of 400-1400 mm. The travel

speed, depending on the belt width, is 0.5-3.15 m/s, and the maximum drive power is 315 kW. The most powerful are local and main conveyors [17].

Improving the reliability of conveyors in various climatic and mining conditions, creating and mastering technological systems with conveyors of great length and power, equipping conveyors with high-strength and wear-resistant belts predetermines the development of conveyor transport.

The most productive belt conveyors were used in coal mines in Germany, the productivity of which exceeded 30,000 m3 / h, and the width of the belt was 3000 mm.

Powerful conveyors are considered to be conveyors with a capacity of 2000 to 40000 t/h, the main principle of which is to provide the best conditions for the operation of the conveyor belt, because it is the most scarce and expensive part of the conveyor (40-50% of the cost of the conveyor installation). In this regard, the issue of the durability of the tape is one of the paramount.

Under light working conditions, a conveyor belt with a strong synthetic base or rubber cord belts can be used. At the same time, belt conveyors can have a length of up to 10 km per step, a belt speed of up to 10 m / s and a belt width of up to 3.6 m.

Powerful high-performance conveyor lines are successfully operated in the world for transporting rock mass from open pits to processing and processing plants. For example, in the Russian Federation in the Kursk magnetic anomaly, a conveyor line with a length of 14 km is operated, in Morocco - 15 km, in Germany - up to 206 km with a capacity of up to 10 million tons per year, a speed of 4.5 m/s and a rubber cable width tapes up to 4 m [17].

Uzbekkumir JSC purchased the main technological lines of conveyor transport with a total length of over 14 km, with a width of main conveyors of 1400-3000 mm. Conveyors are equipped with flexible and daisy roller bearings, drive drums with increased coefficients of adhesion to the belt. Electrical equipment meets all the requirements for the operation of conveyors in the open air and reliable means of automatic control, operational control and regulation of the operation of long conveyor systems have been created [18-25] .

The increase in productivity of open pits, their depth and distance of transportation are one of the characteristic features of the near future for open pit mining and will mainly determine the volume of transportation and parameters of open pit transport.

In the Muruntau gold mine of the Navoi Mining and Metallurgical Combine, due to a significant increase in the depth of mining, the main direction for increasing the efficiency of the enterprise is the use of a CCT with a crushing and conveyor complex (DCC), which makes it possible to reduce the distance of transportation of rocks by road transport up to 40%, to reduce the height of the mining mass up to 70%, reduce operating costs, reduce the gas contamination of the quarry [22]. In recent years, the cycle-flow technology - ore complex, which has no analogues in the world, has been put into operation, consisting of a steeply inclined conveyor, a crushing and transfer point and a loading and storage complex with an ore lifting height of 270 m at an angle of 370. The productivity of the complex is 3500 t / h [18].

In open pit mining, in order to increase the efficiency of conveyor transport as part of the cycle-flow technology, it is necessary to make scientifically based decisions on the organization of DCC work for the accepted mining and technical conditions, the choice and combination of the main mining and transport equipment.

The use of mobile and mobile crushing plants allows to increase the efficiency of conveyor transport operation. For example, at the Poltava GOK, when operating a mobile crushing unit manufactured by Krupp Fordertechnik, 9 dump trucks were released and the height of rock lifting by vehicles was reduced to 107 m [19]. The mobile crushing unit was moved along with the development of mining operations and was located on the non-working side of the quarry [20,21]. Decisions were made on the use of mobile crushing plants in technological schemes with conveyor transport and the possibility of transferring part of the

equipment to a new location of the transshipment point as mining develops and the quarry deepens.

In connection with the recent increase in the volume of transported rocks, there is a need to increase the productivity of the belt conveyor, which can be achieved by increasing the width of the belt, optimizing its profile and increasing the speed. However, an increase in the width of the belt will lead to an increase in the structural size of the conveyor elements, the replacement of roller bearings and other parts, as well as an increase in capital investments.

4 Results and conclusion

Thus, for the further development of the belt conveyor, it is necessary:

- to investigate the smoothness of the flow of rocks;
- to investigate the dynamic impact of rocks on the structural elements of conveyors;
- to investigate the durability of roller bearings and belts;
- increase the power and speed of the drive;
- depending on the actual performance, create drives with automatic control of the tape speed;
- in one drive to get several speeds of movement;
- to increase the reliability and simplify the maintenance of conveyors in difficult mining conditions, go to full automation of control.

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