UDC 629.014.5

The application features of conveyor trains at mining on deep horizons

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Abstract
The article describes the design features of the conveyor trains, their technological ability to perform transport operations in train and lines designs, productivity and efficiency of application, which are superior to the traditional modes of transport. The necessary development measures of the domestic version of this mode of transport are described.
The material presented in this article refers to the possibilities, benefits, and ways of implementation of transport systems based on the conveyor train and substantiates the urgent need for rapid implementation of this mode of transport in the practice of domestic mining enterprises.
Keywords: CONVEYOR TRAIN, DEEP OPEN PIT, SHAFT, IRON ORE RAW MATERIALS, MINE CONVEYING, SKIP WINDING AND CONVEYOR HOISTING

Relevance of the problem

In Ukraine, the mining and processing of raw materials (ores, coal and lignite, etc.) is performed intensively. [1] The mining is carried out with open and underground methods. The high intensity of reserves processing is accompanied by an increase in deep mining. By the 2000s almost all the highly productive quarries and mines of Ukraine became classified as "deep" [2]. Quarries reached a depth of 350-460 m and shaft of 1400-1500 m and a tendency to further increase of their depth is maintained. This leads to further complication of the transport schemes on mining enterprises. Transportation costs reach 35-45% of the prime cost of produced products.

On the mining enterprises road, rail, conveying transport is used; on the mines we use railway, skip and conveying transport. When mining at deep levels the effectiveness of these types of transport is reduced due to the increase in transportation distances and as a consequence productivity is reduced.

Analysis of the problem researching

In a number of countries researches and practical developments are conducted intensively in order to create more efficient modes of mining transport, productivity of which would be significantly less dependent on the distance of transportation. One of the most promising modes of mining transport is a conveyor train [4, 5].

Such organizations as IGTM NAS of Ukraine, Kryvyi Rih National University (Ukraine), Ukrgiproruda (Ukraine), Dnipropetrovsk National Mining University (Ukraine), A.A. Skochinsky Institute of

Mining (Russia), Institute of Mining, Ural Branch of Russian Academy of Sciences (Russia), SEDL companies(France), «Dachawayor» (USA), «Hemshayd-Grebe» (Germany), «Merlin Gerin» (France), ASBZ (Germany) [6, 7] are developing the conveyor train.

Review of international practice of using this mode of transportation showed that despite a number of significant advantages conveyor train has not yet been widely used either in domestic or foreign companies. However, its usage performance and parameters showed the perspective of its use in mining operations.

Work objective

To acquaint experts with international experience of using conveyor trains in terms of transportation technology, vehicles and economic indicators which determine the potential of this mode of transport.

The exposition the basic material

The conveyor train (Fig. 1) [6] is a transport complex, which combines a number of advantages of rail and conveor transport. The train consists of a set of carriages 2 joined by double-hinged couplers and connected with flexible load-carrying travelling apron 3. The main pulling drives of the train are suspended on the driving axles of carriages located next but one in the carriages coupling and auxiliary drives are located on the very track.

The peculiarity of the train is the large load capacity: up to 1500 t with small dimensions in cross section (no more than 2×2 m). The main advantage of the train is that it eliminates the need to create one powerful and large-sized drive unit in the transport system, for example, which are the locomotives at railway transport and drive end in the conveyor. The drive is weelset of axle pulling carriages (Fig. 2) or a system of linear motors located under the carts.

This makes possible to evenly distribute the pulling force over the entire length of the load-carrying part of the transport system, which makes the autonomous each load-carrying element and excludes the presence of nodes experiencing extremely high loads on the development of pulling force of a driving device. This determines the combination of high capacity of the train with the small dimensions of its design components. Furthermore, since the length of each small carriage it becomes possible to give high flexibility, which reduces the requirements for the degree of linearity of tracks.

Knuckle joint of the trolleys allows you to move the train on the tracks with the angles of slope in the vertical plane from 0 ° to 40 ° with turning radius of 16 to 25 m. When the angles of slope are over than 25 ° additionally static engines with frictional or electromagnetic drive are installed. These engines are switched on only when train is passing such section (Fig. 3).

This design solution reduces the influence of the configuration of track on the productivity of the transport system and reduces the amount of necessary financial costs to perform work on changing the surface relief on which the track passes.

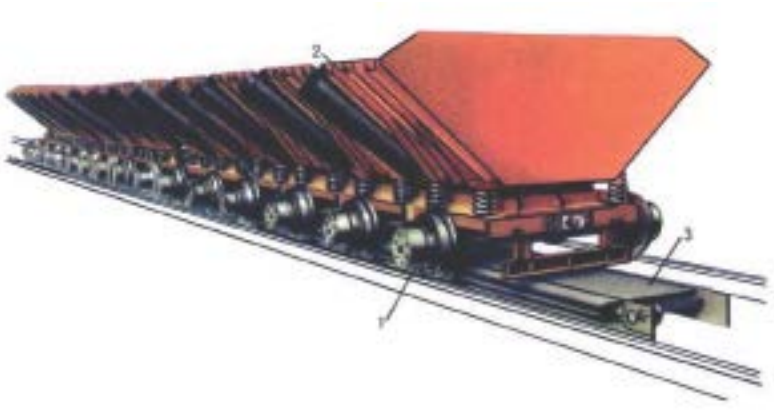

Figure 1. General view of the conveyor train: 1 - drive motor cars; 2 - undercarriage; 3 - load-carrying travelling apron

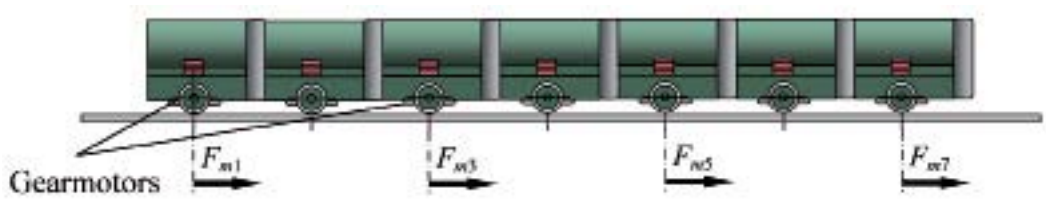

Figure 2. Scheme of distribution of tractive forces in the conveyor train

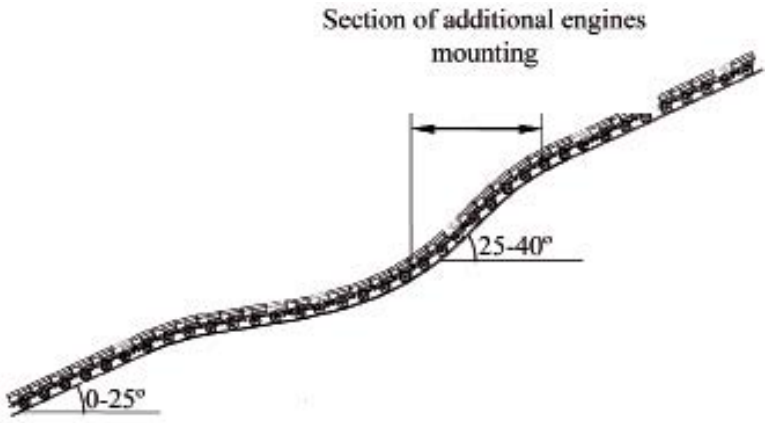

Figure 3. Scheme of the conveyor train track with variable slope angle

The design allows the transport trolleys unload them, for example by means of dump tipper or by tipping the train (Fig. 4).

Benefits of conveyor trains are as follows: 1.Creating of continuity traffic. 2. Rock mass can be transported over any distance with any configuration of the track and to any destination without overloading. 3. The ability to quickly change the direction of tracks with remounting of transport equipment, which is important in the context of rapid changes in the tracks configuration in the quarries and mines with increasing of the development depth and high dynamics of the mining operations. 4. System control of the conveyor train is adapted to the centralization and full automation. 5. Conveyor train can not only transporting ore and rock, but also delivering the materials, equipment, and people. 6. High performance of the system is provided by large and variable speed control (up to 100 km / h), the number of trains and cars section. 7. The conveyor trains system has an accumulating capacity. In cases of temporary discontinuation of cargo reception at the unloading stations it can accumulate loaded train. The subsequent supply of these trains to the gangway reduces the loss in time with the uneven flow of cargo.

The disadvantages of the conveyor trains include the relative complexity of the drives technology, both external and independent. There are only a few examples of the use of conveyor trains. Experience of their exploitation has shown the following results.

In New Caledonia (Australia) in the ore center "Tio" conveyor trains line was built with «Seccam» system by SEDL Company. At this mine track length is 22 km with a height differences of 550 meters and maximum slope is 40%. This mode of transport at the train speed of 25 km / h provides productivity of transportation of 400 t / h.

At the mine "Ningva" (Australia) 22 conveyor train is used with length of 330 m each. At the maximum slope of 40%, the height difference of 500 meters and a speed of 25 km / h productivity of the transport system is up to 500 t / h.

At the mine "WhitePine" (USA), «Dachaveyor» conveyor train is operated. At this mine track length is 8.8 km, the corner radius is 30 m, the slope is up to 36%. Conveying productivity is 570 m / h. Maximum train speed is up to 80 km / h.

In Germany, the company «ASBZ» (Aachen) has developed transport system of conveyor trains with such characteristics: the length of train can range from 420 m to 2500 m, the drive power of 260 kW, the train speed is 72-95 km / h, the performance of transportation is 35.0 t / h at maximum capacity of 80.0 thousand t /h.

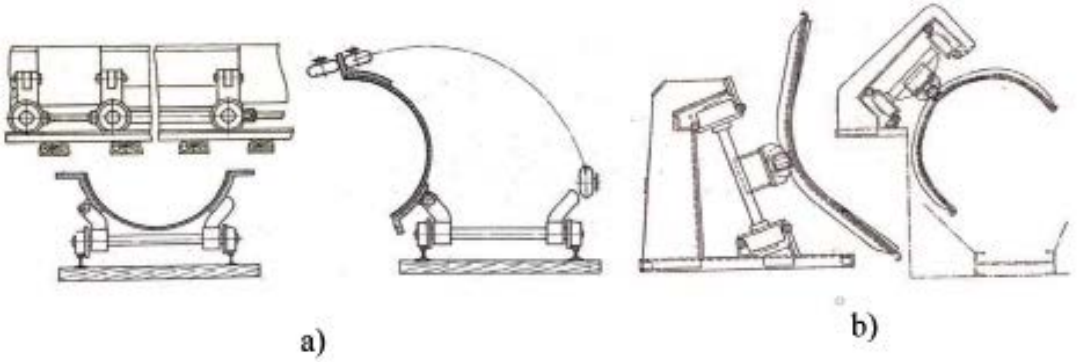

Figure 4. Schemes of unloading of the conveyor train: a – dump tipping; b – train tipping

The «Secam» company developed a conveyor train with the performance of 450-900 t / h at a distance of transportation of 19-48 km.

By the company «Merlin Gerin» (France) at the mine "Giordani " conveyor train with linear motion is operated. Track length is 2.3 km, train length is 330 m, the maximum speed is 50 km / h. Operation of four of such trains provide transportation productivity of 760 t / h.

The data show that the performance of conveyor train transportation is not inferior to either railway or conveyor belts.

Is important to note that the conveyor train, in addition to its high operational characteristics, has sufficiently strong economic performance, which can significantly exceed these figures in other modes of transport [7].

Comparison of the financial expenses on realization of the various modes of transport when the required capacity is 500 t / h and the distance of transportation is 1.5 km showed the following results: rail transport - $ 400 thous. (USF); belt conveyor - $ 470 thous.; road transport - $ 340 thous.; conveyor train of «Seccam» system - $ 205 thous.

As the analysis of the various modes of transport use (rail, conveyor and conveyor trains) for lifting ore from deep pits to a height of 250-400 meters at an track angle of slope from 0-15 ° to 37-40 °, with distance of transportation of 2.5 km and the necessary productivity of 1500 t / h, typical for the local quarries, the conveyor trains have advantages. Their application can reduce the costs of transport operations by 10-15%.

On the basis of the analysis of existing designs of conveyor train and the results of their industrial applications according to institutes such as " Giproruda" , "Yuzhgiproruda", DonUGI, IGTM, KGRI, « Seccam » and« Dashaveyor » companies, as well as industrial enterprises, the authors carried out study of conveyor train designs taking into account mining and geological characteristics of local deep quarries (with the mining deep of more than 350 m). Load-carrying elements design of the train (cars) is elaborated. These elements are leading drive module, traction-driven drive module, transport module [8, 9].

For the conditions of the domestic quarries the most rational is a design of the conveyor train. Chassis is a standard railway car wheel pair (with rail gage of 1524 mm) and has a load-bearing body capacity of 1.8 m^3 and 0.8 m height. Each load-carrying body has a version with the last hood providing the safe loading and transportation of mined rock. Each car is connected to the subsequent with fastened coupling elements. Thus the coupling device arranged so that allow to make turns of adjacent cars in the horizontal and vertical planes within the angles stipulating geometric parameters of the track. The difference between the freight and drawing cars is reduced to the absence or presence of traction motors, gearboxes drive gears on the axes.

To ensure a high degree of unification of the car chassis and the stability of motion of the conveyor train standard design of the wheelsets trolleys is accepted (track width, wheel diameter, its conicity). At the same time pairs of driving wheels and the individual performance of the drive are characteristic of the MPS motorized cars.

In order to ensure reliable transportation of the rock mass on the steeply inclined sections depending on the characteristics of the track the mountain of extra stationary drives(on the viaduct) or individual drives (on the trolleys) is provided. It ensures the development of the additional traction force by means of rack and pinion linkage.

Conclusions and perspectives for further research

Based on the above material, we can draw the following conclusions:

1. Analysis of the world experience in the use of such trains has shown that their technical characteristics allow almost completely replace rail, conveyor and road transport, which are the main modes of transport.

2. Conveyor trains have significant economic advantages over the other modes of transport providing a reduction of 10-15% of the financial expenses amount for implementation of transport operations, and their cost-effectiveness increases with the distance of transportation.

3. Constructive solutions to adapt the conveyor train to the conditions of mining enterprises in Ukraine were adopted. These solutions allow us use this type of transport widely in terms of various domestic quarries and mines.

4. It is necessary to work on the determining of technical and economic efficiency of the conveyor train application in the specific conditions of quarries and mines.

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