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# Developing the design of an open-pit steep incline belt-wheel conveyor

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***Abstract***
***Introduction.*** *The article considers the design of an improved belt-wheel conveyor for hauling loads from open pits. The depth of the present-day active open pits reaches 400–700 m. At great open-pit depths the load lifting to the surface constitutes the main part of the cost of work. Field testing of the belt-wheel conveyor have confirmed the possibility of transporting chumps up to 1200 mm in size, which eliminates expensive second-stage crushing of rock in crushers. The belt-wheel conveyor of standard design can move loads at an angle up to 20°. The possibility of installing an incline conveyor at angles corresponding to the pit slope angle, which can be 40–45°, obviates the need to build transport trenches. The proposed design of the belt-wheel conveyor uses permanent magnet strips at conveyor transition sections to significantly reduce the required conveyor length and bench width.*
***Research objective*** *is to optimize the lifting of loads from deep open pits with an improved belt-wheel conveyor with permanent magnet strips on the conveyor route transition sections located on pit benches.*
***Results and discussion.*** *As a result of a comparative analysis of the incline conveyor designs and parameters, the most optimal design of a belt-wheel conveyor with permanent magnet strips on transition sections was established.*
***Conclusions.*** *The design of an improved belt-wheel conveyor with permanent magnet strips on transition sections has been studied. It has been established that permanent magnet strips on conveyor transition sections significantly reduce the required conveyor length and bench width. It therefore yields a significant economic effect by reducing the cost of the conveyor and capital mining.*

***Keywords:*** *deep open pit; coarse loads; belt-wheel conveyor; haul chains; running rollers.*

**Introduction.** The article considers the design of an improved belt-wheel conveyor for hauling loads from open pits. The depth of the present-day active open pits reaches 400–700 m. At great open-pit depths the load lifting to the surface constitutes the main part of the cost of work. Field testing of the belt-wheel conveyor have confirmed the possibility of transporting chumps up to 1200 mm in size, which eliminates expensive second-stage crushing of rock in crushers [1–9].

The belt-wheel conveyor of standard design can move loads at an angle up to 20°. The possibility of installing an incline conveyor at angles corresponding to the pit slope angle, which can be 40–45º, obviates the need to build transport trenches. The proposed design of the belt-wheel conveyor uses permanent magnet strips at conveyor transition sections to significantly reduce the required conveyor length and bench width.

**Research objective** is to apply the improved belt-wheel conveyor with permanent magnet strips on the conveyor route transition sections to haul coarse loads.

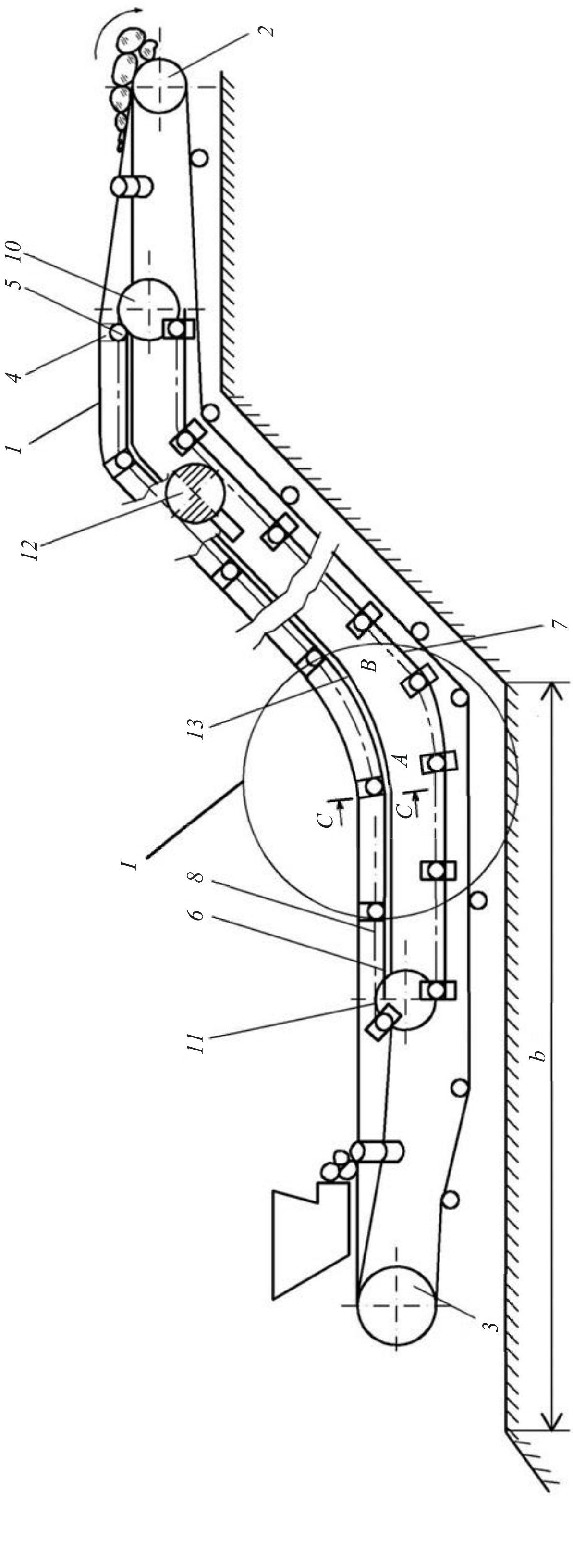


Figure 1. Schematic general view of a belt-wheel conveyor
Рисунок 1. Схема крутонаклонного ленточно-колесного конвейера

**Methods of research** include a comparative analysis of incline conveyor designs and parameters [10–15].

**Results and discussion.** The article considers the design of an improved belt-wheel conveyor for hauling loads from open pits. The permanent magnet strips at conveyor transition sections significantly reduce the required conveyor length and bench width.

The design of the belt-wheel conveyor is illustrated in Figure 1 and Figure 2 [16–19].

The belt-wheel conveyor consists of a load-carrying belt *1* which goes around the tail pulleys *2* and *3* (Figure 1) [20–24]. The loaded arm of the conveyor is mounted on movable supports which consist of traverses *4* with running rollers *5* moving along the upper *6* and lower *7* guide paths. Traverses *4* are interconnected by two haul chains *8* and *9* forming contours closed in the vertical plane when going around the end sprockets *10* and *11*. Interposing driving sprockets *12* transfer traction force to the haul chains *8* and *9* (Figure 1, 2).

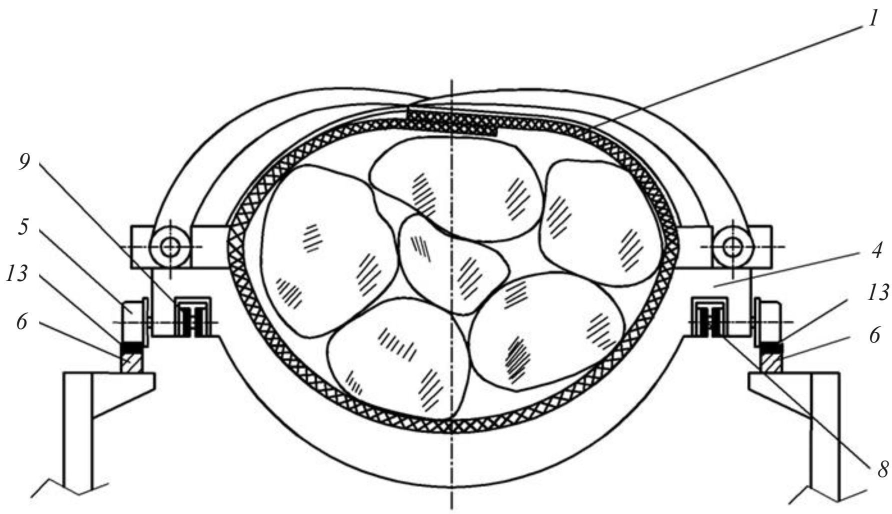


Figure 2. Cross-section of the conveyor according to flight *C–C*
Рисунок 2. Поперечное сечение конвейера по ставу *C–C*

The belt-wheel conveyor works as follows. When the drive *12* is turned on, the haul chains *8* and *9* are set in motion. The load-carrying belt *1* is set in motion due to frictional interaction with the traverses of the movable supports *4*. Open-pit mining is carried out in steps and in successive layers. The effective width of the bench platform is determined by the possibility of placing equipment, including the incline conveyor. Increased required width of bench (*b* in Figure 1) results in increased cost of capital mining. When the conveyor moves from a horizontal section to an inclined section, it is necessary to maintain contact between the running rollers and the guide paths. When the running rollers loose contact with the guide paths, the load spills out and an emergency occurs.

Running rollers tightness against the guide paths only due to the gravity of the movable supports, haul chains and load-carrying belt requires a significantly larger transition section radius, and, consequently, larger conveyor length and higher cost.

In the proposed belt-wheel conveyor design, the running rollers on the transition section of the route are pressed by the magnetic forces pressing the running rollers to the guide paths. For that purpose, the guide paths *6* in the transition section (points *A* and *B* in Figure 1) are equipped with permanent magnet strips *13* (Figure 1, 3).

Contact between running rollers and guide paths in the transition section can be ensured by guardrails. In this case, the running rollers are subject to increased wear due to changed direction of running rollers rotation. Changed tension in the haul chains can result in load-carrying belt descending, which requires a small gap between the lower guide paths and the running roller circumference. The motion of running rollers with flanges in such conditions results in emergencies due to movable supports transfer and descent from the guide paths.

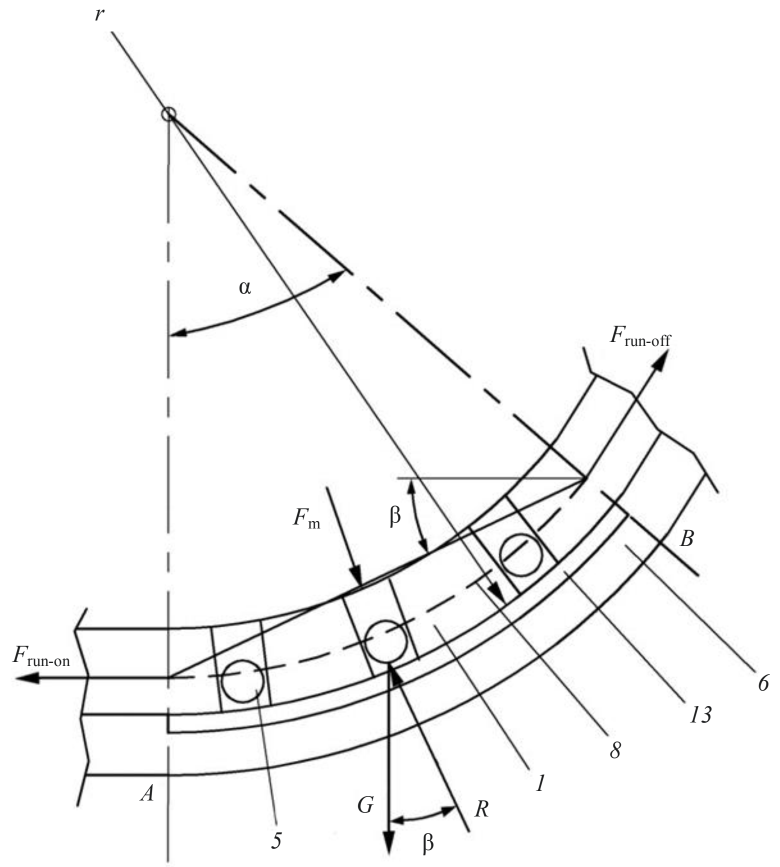


Figure 3. Design scheme of the conveyor transition section (detailed view *I* of Figure 1)
Рисунок 3. Расчетная схема переходного участка конвейера (укрупненный вид *I* с рис. 1)

Let us carry out the analysis of forces for all forces acting on the transition section of the conveyor [25, 26].

The ratio of forces in the tight and slack sides of the conveyor haul chains in the transition section is expressed by the equation (Figure 3):

$$F_{\text{run-off}} = F_{\text{run-on}} + \left(q_{\text{load}} + q_0\right)\left(l\sin\beta + l\cos\beta\omega\right),$$

where $F_{\text{run-off}}$ is the force in the haul chains at the point of running off the transition section, N; $F_{\text{run-on}}$ is the force in the haul chains at the point of running on the transition section, N; $q_{\text{load}}$ is the load gravity per unit length, N/m; $q_0$ is the total load per unit length from the gravity of the haul chains, movable supports and load-carrying belt, N/m;

$l$ is the length of the transition section curve, m, $l = r\alpha$; $r$ is the radius of the guide paths curvature in the transition section, m, α is the route bend angle in the transition section, degrees; β is the angle of inclination of the transition section, degrees; ω is the overall drag coefficient of the conveyor movable part (ω = 0.025–0.035).

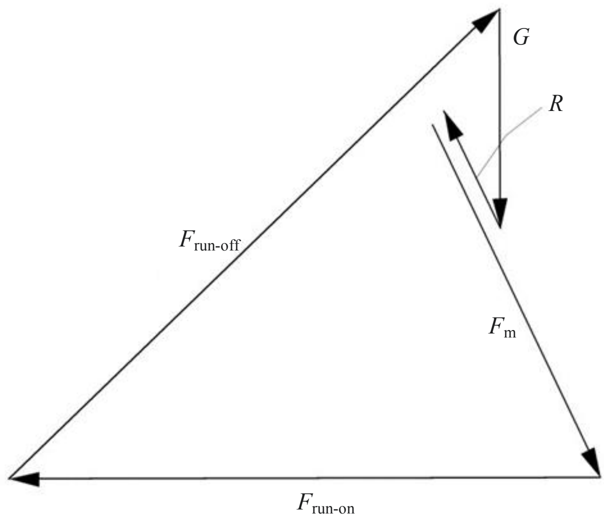


Figure 4. The plan of forces acting on the conveyor transition section
Рисунок 4. План сил, действующих на переходном участке конвейера

The vector equation for the equilibrium of all forces acting on the transition section is as follows (Figure 3):

$$\overline{F}_{\text{run-on}} + \overline{F}_{\text{run-off}} + \overline{G} + \overline{R} + \overline{F_{\text{m}}} = 0, \quad (1)$$

where $G = (q_{\text{load}} + q_0)l$ is the gravity of the transition section, N; $R = G\cos\beta$ is the overall response transmitted from gravity to the running rollers, N; $F_{\text{m}}$ is the overall force of magnetic pull transmitted to the running rollers, N.

The graphical solution of equation (1) is shown in Figure 4 as a plan of forces constructed in compliance with the scale factor of forces.

The plan of forces makes it possible to obtain the minimum required force of running rollers pressing against the guide paths due to magnetic pull.

**Conclusions.** The design of an improved belt-wheel conveyor with permanent magnet strips on transition sections has been studied.

It has been established that permanent magnet strips on conveyor transition sections significantly reduce the required conveyor length and bench width.

It has also been determined that permanent magnetic strips on transition sections yield a significant economic effect by reducing the cost of the conveyor and capital mining.

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# Совершенствование конструкции карьерного крутонаклонного ленточно-колесного конвейера

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***Реферат***

***Введение.*** *В статье рассматривается конструкция усовершенствованного ленточно-колесного конвейера, предназначенного для подъема горных грузов из карьеров. Глубина современных действующих карьеров достигает 400–700 м. С увеличением глубины открытых разработок подъем грузов на поверхность составляет основную часть затрат на проведение работ. Опытно-промышленные испытания ленточно-колесного конвейера подтвердили возможность транспортирования кусков размером до 1200 мм, что позволяет исключить использование дорогостоящего вторичного измельчения грузов в дробилках. В обычном исполнении ленточно-колесный конвейер способен перемещать грузы под углом наклона до 20°. Возможность установки подъемного конвейера под углами, соответствующими углам откоса борта карьера (40°–45°), позволяет исключить необходимость сооружения транспортных траншей. В предлагаемой конструкции ленточно-колесного конвейера используются полосы из постоянных магнитов на переходных участках конвейера, которые существенно сокращают необходимую длину конвейера и ширину уступов.*

***Цель исследований*** *– оптимизация подъема горных грузов из глубоких карьеров с помощью усовершенствованного ленточно-колесного конвейера с использованием полос из постоянных магнитов на переходных участках трассы конвейера, расположенных на уступах карьеров.*

***Результаты исследований и обсуждение.*** *В результате сравнительного анализа конструкций и параметров подъемных конвейеров установлен наиболее оптимальный вариант ленточно-колесного конвейера с использованием полос из постоянных магнитов на переходных участках.*

***Выводы.*** *Проведены исследования конструкции усовершенствованного ленточно-колесного конвейера с использованием полос из постоянных магнитов на переходных участках. Установлено, что использование полос из постоянных магнитов на переходных участках конвейера значительно сокращает необходимую длину конвейера и ширину уступов. Это в свою очередь обеспечивает существенный экономический эффект за счет сокращения стоимости конвейера и проведения горно-капитальных работ.*

***Ключевые слова:*** *глубокий карьер; крупнокусковые горные грузы; ленточно-колесный конвейер; тяговые цепи; ходовые катки.*

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