MECHANIZATION AND AUTOMATION OF PRODUCTION

METHOD OF DETERMINING THE MAIN PARAMETERS OF A STEEPLY INCLINED CONVEYOR WITH CLAMPING ELEMENTS

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The increasing complexity of mining conditions in the development of the deeper levels of quarries is making it necessary to use steeply inclined hoists to haul rock to the surface. Their use makes it possible to develop highly efficient, low-waste technologies for working deep mineral deposits by opencast mining. In particular, the use of steeply inclined conveyors in cyclic-continuous production schemes reduces the amount of preparatory work that must be done in quarries and lowers the equipment and energy costs of the haulage operation compared to conventional belt conveyors.

The need to use steep conveyors in cyclic-continuous opencast mining in turn makes it necessary to find and substantiate the most efficient design and parameters for the conveyor.

One of the most important requirements of steep conveyors is that they reliably hold the material being transported on the belt under different service conditions. With allowance for the technical-economic aspects of the problem, a promising solution might be to increase the frictional force present in the interaction of the rock and the belt. This can be done by additionally pressing the rock into the trough that envelops the belt.

It has been established that given the nonuniform loading of the belt along the conveyor, the clamping elements which press against the rock should have elastic properties. Conveyor belts themselves have such properties. The rock can be kept from rolling off the conveyor by corrugating the elastic material that is used. Studies conducted by the Mining Institute (Ural Branch of the Russian Academy of Sciences) determined that these conditions are realized if the conveyor belt is actually made of two belts: one flat (load-bearing) belt, and a second belt attach to its inside surface in the form of a corrugation. As part of the same studies, a description was given of the main features of a method devised to determine the parameters of a new steep mine conveyor with moving clamping elements in the form of corrugations.

By a corrugation, we mean that part of the corrugated belt between adjacent sections attached to the flat load-bearing belt (Fig. 1).

The following are the main parameters of the corrugation: height \( h \) on the empty branch of the belt of the load-restraining loop and the height \( h_1 \) of the working branch of the belt; length \( l_r \), width \( B \) and the thickness \( t_1 \) of its middle part. The height of a corrugation is the maximum distance between its outside surface and the flat load-bearing belt. Corrugation height on the empty branch is determined by the depth of the trough \( h_t \) of the belt of the load-bearing loop on the inclined transport section, i.e. \( h = h_t \). Corrugation height on the working branch of the belt depends on the thickness of the layer of material being transported \( h_m \) in the trough of the load-bearing belt, which is in turn a function of the nonuniformity of feed of the material onto the conveyor and can change over the length of the linear segment, i.e. \( h = h - h_m \). The length of a corrugation is the distance between adjacent sections where it is attached to the flat load-bearing belt of the load-restraining loop. The middle part of a corrugation of the width \( B \) creates the necessary compressive force on the material being transported, preventing it from rolling off the conveyor on the inclined sections. The value of \( B \) is determined by the length of the middle roller \( l_r \) of the set of supporting rollers for the working branch of the belt of the load-bearing loop \( B = l_r \). The load-restraining loop is designed so as to make use of a corrugated belt of variable thickness in the transverse direction. The maximum thickness of this belt (the thickness in its middle part) is determined by the parameters of the rubber-cloth belts used on such conveyors.

Fig. 1. Basic design of the belt of the load-restraining loop: 1) flat load-bearing belt; 2) corrugated belt; 3) section on which the corrugated belt is attached to the flat load-bearing belt.

In the interaction with the rock, the corrugations are deformed by an amount equal to the height of the load in the trough of the load-bearing belt. The pressure from the corrugations is transmitted to the flat belt and the rollers, which keep the flat belt pressed against the sides of the belt of the load-restraining loop. Thanks to the development of a certain pressure and the interaction with the rollers, the flat load-bearing belt and the corrugations (the load-restraining loop) balance the thrust created by the rock mass. In determining the force that must be exerted on the pressing elements in order to keep the rock from rolling on the inclined sections, it is necessary to take into account the load from the natural weight of the belts of the load-restraining loop.

If the angle $\beta$ at which the load is being transported is known, the force with which the load-restraining loop must press against the rock can be found from the expression

$$q_{pl} = \frac{0.5 q \tan \beta}{2f_1} - (0.5q + q_{bp}),$$

where $q_{bp}$ is the load on the rock from the weight of the belts of the load-restraining loop, daN/m; $q$ is the load from the rock, daN/m; $f_1$ is the corrected coefficient of friction between the rock and the belt.

In addition to the angle $\beta$ and the productivity of the conveyor $Q$, the speed of the conveyor belt has a substantial effect on the necessary value of $q_{pl}$ (see Table 1). Consideration of this factor is extremely important in choosing the main parameter of conveyors — the width of the belts of the load-bearing and load-restraining loops.

The corrugations on the transitional section between the corrugated belt from the empty branch to the working branch begin to be acted upon by a normal pressure on the rock side (Fig. 2). The pressure (equal to the compressive force $q_{pl}$) gradually increases to a value sufficient to prevent the rock from sliding on the inclined section of the conveyor route. A redistribution of the increasing force on the surface of the corrugation changes its shape. The pressure on the corrugation reaches a maximum and then remains constant over a certain period of time. This is accompanied by a change in the form and parameters (length and height) of the corrugation. To determine the pressure necessary to compress the corrugation, we conditionally divide the corrugation into sections separated by planes normal to its surface and parallel to the axis of the conveyor. The distance between successive planes is taken equal to the thickness of the corrugated belt. Then in accordance with the theory of stability, in calculations of pressure the section $AB$ of the corrugation can (with certain assumptions)