USE OF INCLINED LIFTS IN THE DEVELOPMENT OF ENVIRONMENTALLY FRIENDLY TRANSPORT TECHNOLOGIES FOR DEEP QUARRIES

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Received:	March 10th 2021	Effective operation of transport systems deep open -cast mine demands an all-round estimation of their quality on the basis of economic, ecological and mine technical factors. Development of mathematical model of functioning of the transport systems is necessary for this purpose, allowing to estimate in concrete conditions of operation various types career lifts and to define interrelations between operational and ecological characteristics of transport system and conditions of their operation. The final research problem – to prove rational types of lifts of mountain weight and area of their effective application.
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Many active open pits of coal, ore and non-metallic deposits in Russia and the CIS have moved into the category of deep (more than 300 m) and currently provide the extraction of 90% of mineral raw materials. Deep quarries are distinguished by significant volumes of transported rock mass, as well as by the specifics of mining and technical conditions. Over the past 10 years, the operating conditions of technological vehicles have significantly changed for the worse due to the increase in the depth of open pits. Experience shows that per 100 m of lowering of mining operations, the cost of transportation increases by 1.4-1.5 times, which requires a search for opportunities to reduce the unit costs of transporting rock mass. The ecological situation has deteriorated especially sharply in these quarries[1-5].

Currently, there is no economically viable alternative to road transport, which is explained by its efficiency, however, it is transport that is the main source of excess pollution of the atmosphere of deep quarries. In addition, exhaust fumes impair visibility on the highway on the most unfavorable weather days, especially in winter, when smog forms and the equipment partially or completely stops working. Due to the gas content of the quarry space, the duration of downtime in deep quarries sometimes exceeds 1000 hours per year. Air pollution with harmful emissions not only negatively affects the health of the personnel working in the quarry, but also the financial situation of enterprises, since in accordance with the current legislation, enterprises pay fines for environmental pollution. With an increase in the depth of a quarry, it becomes necessary to revise the traditional methods of delivering rock mass to the surface, since the types of transport used cannot always provide the required productivity of the quarry without a significant increase in the number of transport vehicles[6-8]. In connection with the expansion and stricter requirements for the development of subsoil, the reconstruction of technological transport systems using modern transport equipment, including the means of steeply sloping rock mass lifting, is becoming a priority task in deep open pits.Therefore, the study of ways to reduce transportation costs and improve the environmental situation in the open pit is relevant.

On the basis of system analysis and mathematical modeling, existing and prospective vehicles and systems that can operate in deep quarries have been studied. From the alternative options, the following inclined career lifts were selected and verified by calculation:

typical conveyor, with the maximum possible angle of inclination of transportation 18°;
- conveyor steeply inclined with a clamping contour;
- automobile with a lifting machine;
- automobile with an autonomous drive;
- rail in dump cars;
- monorail.

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The main criteria for the applicability of lifts are determined - energy and environmental indicators, which allow at the final stage to choose a lift that is optimal in terms of economic indicator[9-14]. To achieve this goal, a mathematical model of the functioning processes has been developed and generalized indicators have been formulated for the selection of rational types of hoists in specific operating conditions;the relationship between the characteristics of the transport system and the mining and technical conditions, the main operational and environmental characteristics of the lifts have been established, and rational types of mountain mass lifts have been substantiated in terms of the environmental factor. The computer program for calculating the indicators of the operation of lifts in various mining and technical conditions is based on the developed software package on a PC computer and takes into account the energy costs of transportation and the environmental factor.

a)   b)

Lifting height, mLifting height, m
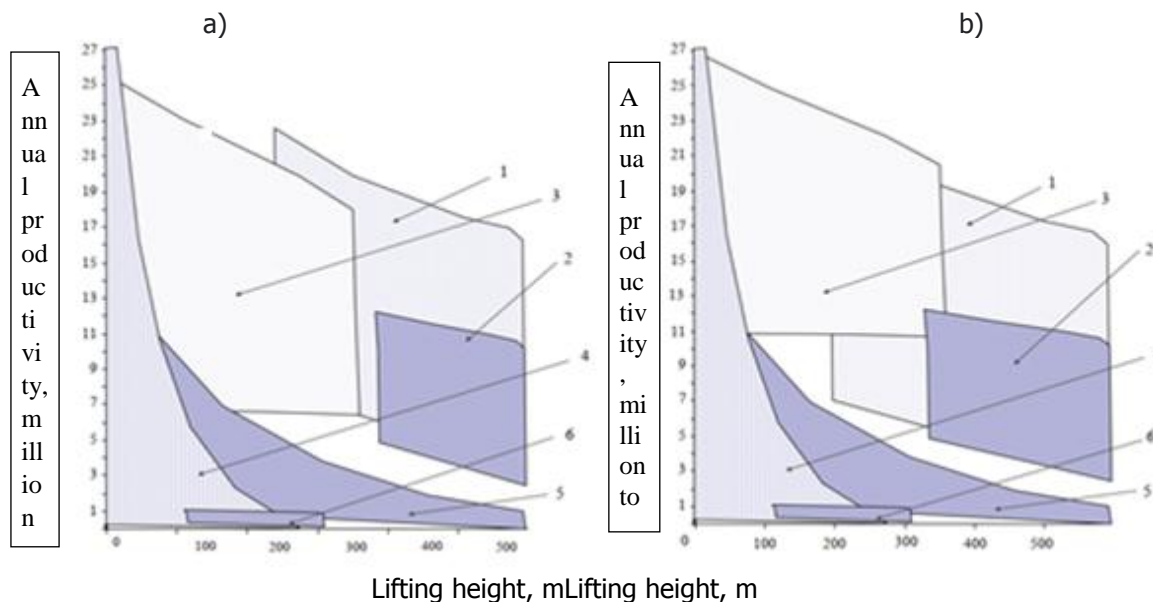
Recommended areas of rational use of open pit lifts in rocks with
a strength coefficient f = 10 (a) and f = 15 (b)

1 - cage with a lifting machine; 2 - skip with a lifting machine; 3 - conveyor and conveyor steeply inclined; 4 - automobile (monotransport); 5 - a car lift with an autonomous drive; 6 - lift with traction unit

The environmental characteristics are taken into account according to the developed complex methodology that evaluates the damage caused to the environment by the exhaust gases of diesel engines and dust, the possibility of disposing of worn out machine components and losses from leaks and spills of lubricants, oils and fuel. Indirectly taken into account are electromagnetic radiation and electrostatic fields from operating electrical equipment, noise and vibration of machines during operation.

The results of the work in the form of recommended areas for the rational use of the most promising hoists are shown in the figure, which makes it easy to establish the possibility of rational use of hoists, depending on the annual productivity of the quarry and the height of the load. For example, a conveyor hoist has the best performance at 300 m lifting height and annual quarry productivity.

era from 10 million tons / year. An autonomous car lift is more rational for quarries with the same capacity up to 10 million tons/year, but with a significantly longer transportation length. With a higher lifting height (300-600 m) and a productivity of 5-20 million tons/year, cage and skip hoists of the rock mass are more efficient. Large mining enterprises, such as NMMCand JSC "Almalyk MMC", showed interest in the results of the work.

The developed methods and a computer program are used to improve the qualifications of engineering and technical workers (at relevant courses), in coursework and diploma projects, in methodological instructions for students of all forms of training in the specialty 170100 "Mining machines and equipment", published at the institute.

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