ANNOTATION

of dissertation for the degree of Philosophy Doctor (PhD) in specialty 6D070700 - "Mining"

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Dissertation topic: «Innovative methods of restoration of temporary non-working walls of deep open-pits»

Aim of research - development of a design methodology for the mine development in working areas along the steep walls of deep open-pits, which ensures the de-conservation of non-working walls of the open-pit in the deposits of Kazakhstan.

Tasks of research. The tasks that need to be solved in this research in accordance with the aim:

1) development of technological schemes for conducting mining operations on steep walls in open-pit of a rounded and elongated shape, methods of switching to it, and technologies for de-conservation temporarily non-working areas of deep open pits;

2) creation of a methodology for de-conservation of a temporarily non-working walls in deep open-pits, including the justification of rational transport schemes, 3-D modeling of stages of a mine life through optimization of the stripping ratio and mining stages, especially on open-pit fields of a rounded shape;

3) approbation of the technology of de-conservation of a non-working walls below the border of use of railway transport at the existing large iron mine "Kacharsk" through the creation of three-dimensional models of steeply inclined layers;

4) approbation of a new way of the mine development in ore and coal open-pits in Kazakhstan.

Research methods. The general theoretical and methodological basis of the dissertation is an integrated approach, including analysis and generalization of fundamental research in the field of open-pit design. The main methods used were: geoinformatics and mathematical modeling; analysis of the work of local and foreign deep open-pits; dynamic programming. The research methodology included the optimization of the stage volumes of stripping and minerals through the creation of a 3D model of the open-pit mining of steep dipping rounded and oval deposits, also the determination of the optimal stages of the open pit based on digital models of deposits using integrated mining and geological information systems based on methods nonlinear and dynamic programming, spline equations of the first and second order, as well as a comparative analysis of the calculated calendar schedules of

mining operations with the data of existing projects for the operation of real facilities in Kazakhstan.

Scientific statements. Scientific statements are following:

1. The transition to the de-conservation of temporarily non-working walls by transverse panels with two excavation levels when the direction of the working benches of working area is oriented perpendicular to the direction of the steep wall`s benches in deep open pits will reduce the volume of stripping work lagging by up to 25% and increase the productivity of excavator-truck equipment by 25-30%. It happens by increasing the reserves to be opened and using looping schemes of truck turns on wide working benches. It will decrease spacing of walls and compensates for the intensity of the stripping of the ore deposit from top to bottom.

2. The transition to the mining by transverse panels in inclined deposits will reduce the average operating stripping ratio for every 100 m of the depth of mining operations by 27-32%, and in steep dipping deposits - by 16-19%.

3. The proposed order of the mine development of the working area in the open-pit mining of steep dipping deposits of a round (oval) shape will ensure the concentration of mining operations on an ongoing basis with the minimum required volumes of stripping without the formation of temporarily non-working walls and monthly regulation of the stripped ore reserves directly in the open pit. In this case, the reconstruction of the mining transport system of deep open pits during the development of steep dipping deposits of a round (oval) shape will not be required in the generally accepted understanding.

The main results of research.

1. An algorithm has been developed to optimize the values of the current stripping ratio by optimizing the volumes of stripping and ore by stages of mining. The versatility of the methodology provides a solution to the problem of nonlinear optimal control by Bellman's dynamic programming method. At each step of the conditional optimization, the fulfillment of the sufficient optimality condition at the stationary points of the objective function is proved. In this case, at each iteration step, the optimal solutions of the problem do not leave the region of admissible values. As a result, an algorithm for optimizing the schedule of mining operations was obtained, which was simplified for designing a dynamic model of a pit;

2 A methodology has been developed for the design of the reconstruction of open pits for elongated and rounded deposits, including methods of transition to the development of high benches with transverse panels from two levels of excavator standing and the formation of a front of work of benches of working zones perpendicular to the front of work of benches of steep sides during the period of its implementation and mathematical 3D models for establishing the position of stage-by-stage their contours in relation to the digital model of deposits through optimization of the volumes of overburden and mineral

3. The creation of a 3D model of the stage-by-stage mine development was completed for rounded open-pits by using new technologies. Using the equations of

the splines, the calculation formulas were derived for the optimal value of the radii of the side surfaces of the stages of mining, depending on the configuration of the ore deposit. The shape of the ore deposit and the slope of the pit walls was taken into account in the 3D model of the stage-by-stage open-pit by using a one-dimensional spline of the second order along the horizontal sections, and a two-dimensional spline when describing the lateral surfaces of the ore body.

4. The proposed procedure for the development of working zones along steep walls in the mine development of steep dipping deposits of a round (oval) shape will ensure the concentration of mining operations on a permanent basis with the minimum required stripping volumes without temporary non-working walls and monthly regulation of the exposed ore reserves directly in the open pit.

5. A geometrical analysis was performed and stage-by-stage volumes of loose and rocky overburden was calculated, total overburden and ore were obtained based on the rebuilt stage-by-stage steeply inclined layers until the final open-pit of Kacharsk deposit. The highest stage-by-stage stripping ratio was defined at stages 1 and 2 (8.9 and 8.7 t / t). The conditions of progress in depth of mining operations from 475 m to 490 m are provided only at stage 3, and stripping ratio is reduced 2.1 times in the stage 2. The volume of loose overburden decreases at stage 9, and there are no longer any at stage 11 and depth of 625 m.

6. The looping schemes of turns of truck and a single installation of a truck for loading are the most expedient in studied technology of mining when the width of the transverse panel is within 60-80 m. Compared to the dead-end turn of trucks with longitudinal panels, the transition to mine development with transverse panels with looping turn of trucks for loading will increase the productivity of excavators by 25-30%. It will decrease spacing of walls and compensates for the intensity of the stripping of the ore deposit from top to bottom.

7. The transformation of the results of mining-geometric analysis in the implementation of the technology with transverse panels in steeply inclined layers by a single open pit made it possible to obtain a calendar schedule of mining operations. In the period 2020-2022, within the boundaries of stages 1 and 2, the annual productivity of the Kacharsk iron open-pit for ore is taken equal to 15 million tons. The current stripping ratio in this period will be 8.9, 8.76 and 8.7 t / t, respectively. To reduce it relative to the overburden lagging by almost 25%, part of the volume of loose overburden rocks was transferred to stage 3. These 25% take into account the transition to mining overburden rocks with transverse panels in steeply sloping layers.

Scientific novelty and importance of the results obtained.

1. The developed technology of the safe intensive mine development of the working area along the steep walls allows to eliminate the stripping work lagging in a shorter time than traditional methods. It allows to refuse the formation of temporarily non-working walls to reduce the current volume of stripping operations in deep open-pits. By using powerful excavator and truck system, the proposed order of the mine development of working areas in each technological stages of mining will ensure a

consistent rhythmic production of stripping operation and extraction. It will help to create the required reserve of mined ore on the industrial stock-piles of processing plants with a much smaller volume of current stripping and will also simplify the process of ore averaging before its processing in comparison with the well-known analogues of the leading countries of the world.

2. A 3D model has been developed for the stage-by- stage formation of optimal open-pits in the development of steep dipping round-shaped deposits, on the basis of which a 3D model has been created for oval-shaped open pits. The 3D model of the stage-by-stage open-pits takes into account the shape of the ore deposit and the slope of the walls of the open-pit by using a one-dimensional spline of the second order along the horizontal sections. In describing the side surfaces of the ore deposits a two-dimensional spline is used. The determination of the optimal value of the radius of the contours of the open pit is achieved by the Newton method, when the desired accuracy is obtained after several iterations.

3. An algorithm has been developed for optimizing of the stage-by-stage open-pits with implementing a new order of the mine development of working area, which achieves an objective assessment of the transition to the development of high benches by transverse panels with two excavation levels when the direction of the working benches of working area is oriented perpendicular to the direction of the steep wall`s benches. One algorithm combines mining-geometrical analysis and transformation of its results into an optimal realistically feasible mining schedule. As a result of mining and geometrical analysis, the optimal values of the stage-by-stage volumes of stripping works and ore extraction are obtained. After the transformation of the stage volumes into calendar schedule, it is established what volumes of ore can be extracted by each year and how much overburden must be mined out for this. Thus, it is possible to evaluate the proposed order of mine development of working area, depending on the demand for mineral raw materials at the design stage and to approach from the created dynamic model of the formation of optimal stage-by-stage open-pist to the dynamic model of the mine development of the working area along these stage-by-stage open pits, taking into account the direction of excavators` movement of a certain productivity and tracing of stripping workings.

Compliance with directions of development of science or government programs. The research is based on the results of fundamental research on the topic No.751 MN.GF.12.17 "Development of a methodology for the optimization and implementation of breakthrough technologies in open pit mines with inclined and steep fall of layers" (2012-2014, scientific supervisor - Doctor of Technical Sciences, Professor Moldabaev S .K.), No.1686/GF4 "Intensification of construction, reconstruction and improvement of the efficiency of open pit operation with the use of two-level development of benches with an equal length of the front of their work" (2013-2015, scientific supervisor - Doctor of Technical Sciences, Professor Moldabaev S. TO.).

описание вклада докторанта в подготовку каждой публикации По теме диссертации опубликовано 16 публикаций:

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