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Improving the technology parameters of drivage workings by the high – performance equipment considering geomechanical and organizational factors

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Abstract
The features of the construction of mine workings at the mines of Krivoy Rog basin are described in the article. The main problems of poor performance of tunneling equipment are identified and substantiated. The characteristics of geomechanical condition of rock mass behind the face of horizontal mine working are analyzed. The study of stress distribution of the natural field for the conditions Kryvbas mines based on computer simulation are described.
Keywords: MINE, HORIZONTAL MINE WORKINGS, TUNNELING EQUIPMENT, THE STRESS-STRAIN STATE OF THE MASSIF, ORGANIZATION OF DRIVAGE

The significant backlog in terms of preparation and commissioning of new horizons is one of the essential problems of some mines of Krivoy Rog iron-production area. This is not only due to the objective reasons of general economic nature, but the use until recently of obsolete tunneling equipment developed in the second half of the last century. Realizing the urgent need to increase the pace of preliminary works, the enterprises have used every effort in the technical re-equipment of mining equipment stock. However, with the appearance of modern imported complexes the question of improving their efficiency by adjusting the technical capabilities of the equipment with the parameters of applied drivage technology was raised.

Analysis of the production activity of mines of Public Joint Stock Company "Krivoy Rog Iron Ore Plant" (PJSC "KRIOP") showed the close relationship between the technical performance of tunneling equipment and coefficient of its use (CIU). This indicator characterizes the degree of productive use of equipment as an active part of fixed production assets. [1] In most cases, CIU is calculated as the ratio of the duration of the actual equipment operation to the planned labor time reserve. It is found that the greater technical production of the self-propelled equipment is, the lower the coefficient of its use. This can be explained by multioperation of the interconnected systems of parameters and operations that make up the production process, as well as by the probability and natural duration of their implementation.

Not insignificant reason for the low CIU is also a mismatch of traditional parameters of dass to the possible drilling depth of the round of holes. However, attempts to increase the dass depth in some cases led to a decrease in efficiency of the explosive rock destruction within the drivage contour. Analysis of publications and authors' own researches have shown that the use of deep dasses is impossible without preliminary geomechanical assessment of the rock massif behind the plane of the roadhead.

Considering the almost complete absence in Kryvoi Roh basin of tectonic stresses [2] for the near contour area of horizontal drivage massif the computer simulations of the character of the redistribution of stresses of natural field provided by gravity was carried out. From a number of programs including the static structural analysis, which allows us to calculate displacements, strains, stresses and internal forces that occur in the physical body under static load ANSYS Workbench software package was decided to use. It takes into account multi-directional loads summed to obtain the equivalent stresses involving in the subsequent calculations.

Software ANSYS is based on the finite element method in which to calculate the static stress the strength theory of Huber - Mises - Hencky is used, also known as the fourth theory of the highest specific potential energy of forming. It reads as follows that the material depending on the type of the stress state can behave brittle as well as ductile. [3]

The researches of the deformation process of static stressed rock massif with passed horizontal mine working were carried out on the model in the form of a block built according to Saint-Venant principle. Its dimensions were calculated individually for each section.

When formulating the problem the following boundary conditions that are typical for rock massifs of Kryvoi Roh Basin have been accepted [4]: Poisson's ratio $\mu = 0.25 – 0.55$, rocks elasticity modulus $E = 14.9 \cdot 10^3 – 33.1 \cdot 10^3$ MPa, rock hardness $f = 9 – 18$, unit specific gravity $\gamma = 2.6 – 3.2$ t/m^3, horizontal stress coefficient $\lambda = 0.25 – 0.6$. Based on the actual conditions of building horizons in the mines of Kryvbas when modeling the laying depth of mine working is considered within $H = 850 – 1450$ m.

The studies have found that in the process of rock excavation when workings the redistribution of static stresses takes place and in the massif face area of the zone of unequally componential stress state (extension strain zone) occurs it is adjacent immediately to the plane of the face area having the length of L_{ez}, followed by compression zone. Figure 1 shows a variant

of a computer model for the mine working with cross-sectional area of S = 15.36 m² located on the depth of H = 1450 m.

The figure shows that the unequal componential stress state zone has three types of stresses: P_{start} – initial stress near the wall face, P_{max} – maximum stress located at a certain distance from the face, the length of which varies depending on the section size and horizontal stress coefficient, P_{finish} – final stress corresponding to the extreme point of the considered zone at a distance from the working face plane constituting L_{ez} = 3.14 m. Then the zone of compressive stresses begins which intensity with the distance from the working tends to the natural stress state level of the massif.

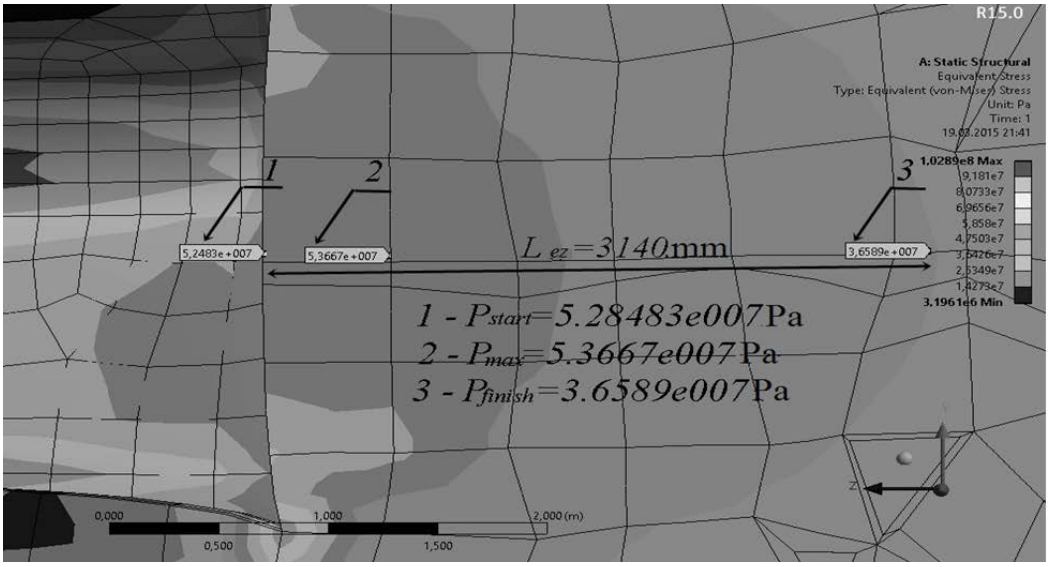

Figure 1. The size of unequal componential stress state zone and equivalent stresses

Based on the analysis of the data it is found that the change in Poisson's ratio values, module of rocks elasticity, density, strength of rocks and their volumetric weight within the range of their variation typical for Kryvbas conditions has no significant effect on the parameters of the testing zones beyond the plane face of the working. However, the main factors affecting them are the laying depth and the working cross-sectional area, as well as the horizontal stress coefficient. Based on the data received and analyzed, it can be argued that when place driving with cross sectional area of 9 – 17m², located at a depth of more than 1000m, the length of the unequal componential stress state zones varies from 2.3 to 3.5 m as can be seen from the graphs in Fig. 2.

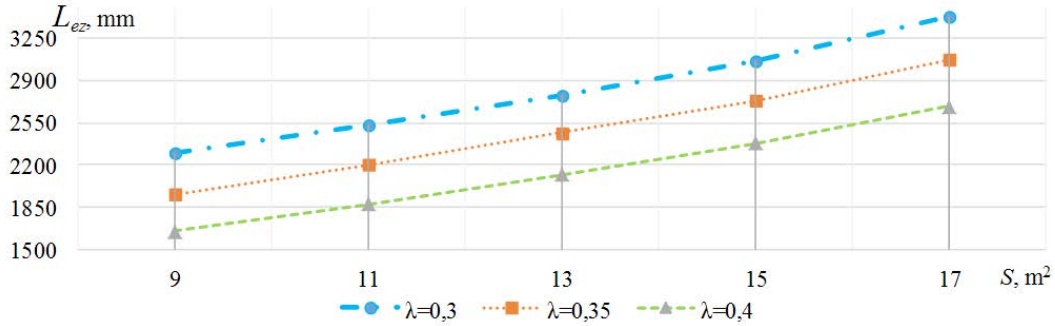

Figure 2. Graphs of the dependence of the unequal componential stress state zone length from the cross-sectional area of working and horizontal stress coefficient (H = 1450 m)

Analysis of technical and economic indicators of drivage in deep horizons of PJSC "KRIOP" mines has shown that when placing explosive charges within the zone of unevenly componential stress state the high efficiency of the rocks explosive destruction is accomplished when reducing the overall costs of the explosives. In the area of compression destruction conditions of the massif deteriorate and require addi-

tional quantity of explosives for its qualitative destruction.

Thus, in conditions of constructing the deep horizons of mines of Krivoy Rog basin as the optimal can be considered the round of holes with depth of 2.5 - 3.5 m. At the same time explosive charges are located in the tension strain area, where conditions of rock mass destruction are very favorable.

Transition to the dasses of the increased depth has led to necessity of solving another current scientific and technical problem that involves developing an effective strategy for the organization of tunneling works, which will allow us to combine maximally the possibilities of modern technique and geomechanical factors. In this regard for the conditions of PJSC "KRIOP" mines the drifting cycle parameters during the drivages with depth of 2.5- 3.5 m have been investigated using the purchased high-performance drilling outfit of «Atlas Copco» and «Sandvik Tamrock» companies.

As a result of calculations the optimal durations of drifting cycle operations during the workings by the imported equipment considering the geomechanical factors have been determined. The basis of calculation includes 16 drivage cycles with the equipment maintenance and rail laying. Analysis of the results has shown that the duration of drivage for 16 cycles is 377 hours. This is 19 working days respectively. The value of CIU is 2.8 shifts, and the total length of the passed working is 53 m, which is more than 2 times higher than the traditional indicators. If we take as a basis the work within 30 days, the complex of modern equipment will provide for this period 28 drifting cycles with a total face advance of 95 m.

Thus, improving the parameters of the construction technology of extended workings, taking into account the geomechanical and organizational factors enables more efficient use of modern tunneling equipment increasing the productivity of mining-building works by more than 2 times. This makes it possible to increase the intensity of preparation the horizons and to reduce the total amount of equipment and personnel.

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