

ABSTRACT

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

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Technology Development of Supporting Mine Workings on the Basis of Controlling Stress-and-Strain State of the Contour Rock Massif

Relevance. More than half of the underground mine workings in the mines of the Karaganda coal basin are in the unstable state (displacement of the roof, bed and side rocks) and are supported with significant laboriousness of work and material costs due to the absence of justification for correspondence of their supporting parameters to operating conditions in specified mining, geological, technical and production conditions. To make justified technological decisions on determining the parameters of the support for its effective operation, there is needed a geomechanical predictive assessment of the deformed state of the enclosing rock massif around the workings. Developing and implementing the technology and tools, taking into account the stress-strain state of the enclosing rocks, will reduce material and labor costs and justify the parameters of supporting mine workings when operating mine workings.

Therefore, one of the current trends in the coal industry development is the development and pilot industrial testing of high-tech resource-saving methods and active tools of supporting mine workings and stabilizing the massif while maintaining them in the reference pressure zone ahead of the long-wall face for the achievement of a high technical and economic effect and improving safety of mining.

The objects of studies are underground mine workings of coal mines that are driven and supported in different mining-geological and mining technical conditions of operation including the ones with complicating factors: zones of increased and reference rock pressure ahead of the long wall face with different schemes of mining operations development.

The purpose of the work is developing the technology of supporting development workings ahead of the long-wall face in the reference pressure zone based on controlling the stress-strain state of the contour rock massif.

The idea of the work consists in developing the technology of driving mine workings taking into account the stress-strain state of the coal-rock massif for establishing the optimal parameters of the support that is achieved by the use of methods and tools of metal rods with screwed surface and deep-laid rope anchors mounted in the zone of reference rock pressure ahead of the long wall face and is needed with contour resin injection.

Methodology of performing operations. The methods used are as follows: monitoring the mine workings stability in the mines of the Karaganda coal basin with determining the patterns of rock pressure manifestations depending on geological factors and mining operating conditions, taking into account computer

simulation of geomechanical processes in the enclosing coal-rock massif; digital simulation of the stress-strain state of the rock contour massif; the development of innovative technological decisions and testing technical decisions in experimental industrial mine conditions.

The tasks of the studies are as follows: analyzing the practical use of roof bolting and resin fixing compounds in coal mines; studying the parameters of deformation processes in mine workings; assessing the technological parameters of the use of roof bolting depending on the geological and mining conditions of driving mine workings; studying the stress-strain state of the rock massif around the workings through analytical modeling; establishing the anchoring technology impact on the mine performance; developing technological schemes of roof bolting and stabilizing unstable rocks with synthetic resins.

Feasibility and significance of the work. The developed methods and tools of supporting and stabilizing the enclosing rock massif will allow controlling geomechanical processes to reduce the intensity of forming stratification zones, crack formation and zones of discontinuity, weakened zones, and to reduce increased deformations of the coal-rock massif in the breakage face and around the development mine workings, and to avoid forming zones with the excessive stress-strain state of the massif to increase stability and to reduce defectiveness of the massif.

The economic effect of a preventive two-level support ahead of the reference pressure zone is 796 500 tenge per month or 9 558 thousand tenge per year, excluding the loss of production in the working face.

Participation in R&D, grant funding as an executor:

R&D on the topic: No. AR05135535 “Development of the contour technology for supporting workings with controlling the anthropogenic state of the coal-rock massif of the enclosing rocks”, grant funding for scientific research of the Ministry of Education and Science of the Republic of Kazakhstan for 2018-2020.

R&D on the topic: “No. AR05135203 “Development of intellectual information systems for calculating technological parameters of mining processes”, grant funding for scientific research of the Ministry of Education and Science of the Republic of Kazakhstan for 2018-2020.

R&D on the topic: “Development and implementation of the technology, systems and tools of active supporting mine workings, taking into account the stress-strain state of the contour rock massif”, program-targeted financing of scientific research for 2018-2020 with K. Satpayev KazRTU.

Main scientific provisions to be defended:

- the integrity of the roof reinforced with anchors 2.4 m long is maintained at horizontal stresses up to 15–16 MPa, and at stresses of 16–19 MPa and higher the integrity of the roof is ensured by mounting rope anchors (5-7 m long);
- with increasing vertical stresses (more than 20 MPa), it is performed by linking the contour massif of weak rocks with upstream rocks using deep-laid anchors, which leads to the suspending the formed support beam of rocks to the stable massif and balancing the load on the support of the mine working;
- the angle of inclination of the contour rope anchor with the reduced

advance equal to 1.0 m for workings of the rectangular shape is recommended to be equal to $75-77^\circ$ at minimum normal stresses, when mounted in the zone of mining (stopping) operations ahead of the long-wall face.

Scientific novelty of the work consists in justification of qualitative and quantitative parameters of the contour supporting of mine workings, taking into account geomechanics of the coal-rock enclosing massif, based on the developed technological approaches, to provide safe conditions and increase labor efficiency in high-performance stopping and development faces; studying the stress-strain state of the rock massif when supporting the workings in the zone of the reference pressure ahead of the long-wall face; establishing the technological factors impact on the conditions of supporting the contours of mine workings: the angle of inclination of the contour anchors on the stress state of the rock massif; the location of the contour support relative to the bedding of rock layers; determining the parameters of a single-level beam roof bolting; the location of the contour support relative to the elements of the development with heaving bed rocks; the development of a supporting contour beam over the working with establishing the impact of the enclosing rock strength on the magnitude of stresses and stratifications of the contour rocks;

- the bearing anchor beam provides reducing the stresses perpendicular to the layering of rocks with a single-level anchor support by 10 - 15% and a smaller spacing on the working sides by 20%; reduction of heaving of the working soil by up to 5%;

- the effect of the enclosing rocks strength on the magnitude of stresses and stratifications of contour rocks: 2.4 m for strong rocks (compressive strength 40–60 MPa); 2.6 m for medium-strength rocks (compressive strength 35–40 MPa); 2.8 m for low-strength rocks (compressive strength less than 35 MPa) and 3.8 m — for unstable rocks;

- regularities of the effect of the anchor length, the depth of development and the thickness of the unstable layer (for example, mudstone) on the stability of a rectangular mine section.

Scientific significance of the work consists in the following:

- establishing the justified parameters for maintaining stability of workings supported with roof bolting in the front zone of reference pressure of the breakage face at the mine of the Karaganda coal basin with determining the parameters of deformation processes (the results of production observations);

- establishing parameters with one-and two-level working support based on the regularities of developing the zones of strains and stresses around the working depending on the geological-and- technological parameters along the length of the acting reference rock pressure ahead of the long wall face.

Practical significance of the work consists in the following:

- developing the technology and tools of supporting, taking into account the geomechanical state of the massif and mining development schemes (a patent application filed; there are two certificates of intellectual property: a computer program and a tutorial);

- forming progressive technological decisions, manufacturing a pilot batch of the tools for the contour hardening of rocks and monitoring of the implemented technologies of supporting mine workings (testing pilot batches for various purposes);

- pilot industrial testing and implementing the research results for the improvement of technological schemes of driving mine workings with cable and composite anchors in the conditions of the mine (act of mine pilot tests);

- developing progressive methods of supporting when driving workings in zones of geological disturbances, zones of high rock pressure (technological schemes), including those with the use of synthetic resins (two-component polyurethane, BlockpurS).

Practical value of the work consists in the development of progressive technological solutions for implementing the technology of roof bolting for the workings ahead of the long-wall face and the rock mineralization to strengthen the disturbed (or weakened) massif to ensure efficient and safe operation of the of coal mines.

Implementation of the work. Recommendations have been developed on the effective use of the technology of roof bolting when driving development workings in the zones of tectonic disturbances and resinization of the disturbed rock massif at the junctions and in the long-wall face of the mining divisions of the Karaganda coal basin mines.

The dissenter's personal contribution is developing the technology and tools of supporting the contour massif when driving mine workings.

The validity and reliability of scientific provisions, conclusions and recommendations are confirmed by the convergence of the results of theoretical studies and experimental tests.

The structure of the work. The dissertation consists of an introduction, 5 sections, a conclusion and contains 132 pages of text, 110 figures, 11 tables, references of 99 titles.

Implementation and testing of the dissertation. The research results are published in 3 scientific articles in editions included in the Scopus database; in 3 articles in editions recommended by the authorized body (CCSES), 11 abstracts of international scientific conferences.

In English there has been developed a tutorial on the subject "Oil and Gas Basics", the authors are Zhumabekova A.E., Demin V.F., Baideldinova G.M., Kurmanov S.T.; a textbook on the subject "Basics of Mining", the authors are Demin V.F., Maussymbayeva A.D., Zhumabekova A.E.; CIP on an electronic textbook on the subject "Basics of Mining", the authors are Demin V.F., Maussymbayeva A.D., Zhumabekova A.E.; CIP on an electronic textbook on the subject "Professional English in Informatics and Computer Science", the authors are Tishmaganbetova B.S., Zhumabekova A.E. The results of scientific research obtained in the thesis are embedded in the educational process in the disciplines of baccalaureate degree 6B07202 and master's degree 7M07203 programs "Mining". Applications for patents of the Republic of Kazakhstan were filed, one application

for a patent received a notification of a positive result of a formal examination of the invention.

As a part of implementation of grant financing projects with the Ministry of Education and Science of the Republic of Kazakhstan, the Act of Introducing in the Educational Process and the Letter of Intent for introducing were received.

The main provisions of the work were reported and received approval at scientific seminars of the DMD at KSTU, Scientific and Technical Council of KSTU.

The doctoral student thanks the scientific advisers for their recommendations and assistance in carrying out the experiments and performing separate stages of the dissertation.