ABSTRACT

of the dissertation for the degree of Doctor of Philosophy PhD
in the specialty 8D07202 – "Mining"

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RESEARCH AND DEVELOPMENT OF NEW METHODS OF IMPACT ON THE COAL SEAM TO INCREASE GAS RECOVERY, TAKING INTO ACCOUNT ITS STRESS AND STRAIN STATE

Relevance of the research. The strategy "Kazakhstan-2030" of the program of development of Kazakhstan till 2030 provides development of the coal industry as a basis of energy security and stability of production of metallurgical raw materials.

Prospects for the development of coal mining are associated with the fact that coal is the main energy raw material and a raw material for obtaining coke, special coke, carbonaceous reducing agents used in slag-free production of metals, such as silicon.

Coal deposits represent a large resource base of Kazakhstan with the ability to export coal and products of its processing. These factors are determined by its relatively low price among other energy sources.

To create safe working conditions, reducing the impact of mining and geological conditions during underground mining, it is necessary to develop methods of impact on the coal seam aimed at reducing its methane content, taking into account the stress and strain state. To do this it is necessary to study the combined effect of such factors as: gas content and gas yield of the coal seam; physical and mechanical properties of coals and host rocks; mining and geological factors that create conditions for the manifestation of dangerous gas dynamic phenomena during coal mining and excavation (sudden release of coal and gas, swelling of bedrock, etc.).

According to the Concept for Kazakhstan's transition to a "green economy", the country has developed a comprehensive project for the production of methane from coal seams for the years 2013-2020. An action plan was developed to organize exploration and production of coal bed methane. In terms of coal bed methane resources Kazakhstan is in the top ten countries of the world. The Karaganda coal basin is one of the most highly gas-bearing among the coal-producing countries of the world. According to preliminary calculations, it contains about 490 billion m3 of methane to a depth of 1,500 m and about 500-550 billion m3 to a depth of 2,000 m.

It is possible to increase the load on the bottom-hole by reducing the gas content of the formation by means of advance and preliminary degassing with consideration of its stress-deformed state. Preliminary extraction of methane from coal seams is the basis of complex development of coal and gas fields, reduction of natural gas content to the required values and as a consequence reduction of absolute

gas content in the working faces, and increasing productivity of formation degassing wells in 3 and more times.

Thus, developed new methods of action on the coal seam should be aimed at reducing gas content of coal seams in the areas of planned mining operations, by increasing their gas output in wells and mines. Performed research is relevant both in terms of ecology and industrial safety of coal mining.

The aim of the work is to develop new methods of impact on the coal bed to increase its gas release, taking into account the stress and strain state.

The idea is to substantiate new methods of impact on the coal seam to increase its gas recovery based on the analysis of mining and geological conditions, physical and mechanical properties and gas content of the reservoir, methane-rich mine workings, taking into account the stress and strain state of the coal seam.

The object of the study: Coal seams of the Karaganda basin.

Research objectives:

1. To analyze modern methods of impact on the coal seam, taking into account its stress-strain state
2. To develop new methods of impact on coal bed to increase gas recovery.

3 Substantiate new methods of impact on coal bed to increase gas production in conditions of stress and strain state.

4 Substantiate criteria defining the attribution of coal seams to high gas-bearing on the basis of correlation of gas content and gas production with resistivity, intensity of gamma-radiation absorption, changes in the elastic properties of coals.

5. To develop a mathematical model of the influence of nanostructures of the surface layer of coal matter on gas content, methane diffusion and gas emission.

Research methodology: on the basis of the analysis of domestic and foreign experience, literary and stock materials, results of theoretical and experimental observations, modern methods of computer modeling to substantiate new methods of influence on coal bed for increase of gas production taking into account its stress-strain state, influence of nanostructure of a surface layer of coal substance on gas production, methods of estimation of gas content of coal beds of Karaganda pool.

The main scientific statements put on protection:

1. The effectiveness of the impact on the coal seam to increase gas production is determined by the change in the stress and strain state of the coal seam with the depth of occurrence.
2. An increase in gas production by 80%, taking into account its stress-strain state, is achieved by influencing the coal seam through a directional well and carrying out fracturing in it with acid treatment.
3. The application of the technology of driving gas-drainage excavation, for degassing and relief of mountain pressure and drilling of degassing wells from it into the bed, when conducting excavations on the highly gas-bearing layers, reduces the methane content by 30-40% and increases the average daily production by 26%.
4. thermal impact on the coal bed to activate the process of destruction of the molecules of coal-methane solution, increases the intensity of methane transition to a free state.

The scientific novelty of the work is as follows:

1. The mechanism of influence of vertical wells used for hydraulic fracturing of coal seam through the formation of horizontal (subhorizontal) cracks of the radial component and vertical (subvertical) cracks due to the axial component, which determine the effectiveness of the impact on the coal seam to increase gas recovery, depending on the laws of change of VAT with increasing depth of bedding.

2. The relationship between the nanostructure of the surface layer of coal matter and the value of gas content, heat capacity, physical and mechanical properties of coals, methane diffusion and gas release has been revealed.

3. It has been revealed that thermal influence on the coal bed to activate the process of destruction of the coal-methane molecules accelerates the methane transition to a free state.

Scope. Coal mining, underground coal mining, coal bed methane production.

Author's personal contribution. The work was done by the author personally, including setting goals and objectives, performed theoretical, experimental and industrial research, compiled algorithms for solving problems, made recommendations for the use of new methods of impact on the coal seam.

The validity and reliability of the scientific statements, conclusions and recommendations are confirmed by the application of methods of mathematical modeling of the processes of coal seam gas release under the stimulating action of mechanical, thermal and chemical energy, mathematical statistics to a large volume of experimental data, sufficient convergence of the results, developed methods of action on the coal seam to increase gas release, using standardized methods, equipment and instruments for conducting research, industrial

The practical significance of the work lies in the following:

- criteria of allocation of coal seams with high gas-bearing capacity, referred to dangerous and sudden coal and gas emissions, received on the basis of connection of gas-bearing capacity of coal seams with their electric, nuclear and acoustic characteristics have been developed;
- a new method of impact on the coal seam to increase gas extraction, taking into account the stress and strain state;
- a physical model of the process of methane mass transfer in coal, taking into account the nanostructures of the surface layer of coal matter, which determines methane diffusion in the coal nanopores and methane transfer in coal, was developed;
- a numerical model of the impact on the coal bed of hydraulic fracturing, taking into account the NAM at different depths of occurrence, which determines the formation of horizontal and vertical fracturing of the bed has been developed;
- energy consumption for hydraulic fracturing using aqueous acid solutions was calculated, an equation for estimating the critical rate of solution flow was obtained, and the regularity of fracture length growth as a function of fracture pressure changes was determined;
- A mathematical model of the impact of thermal energy on the coal seam to increase gas recovery was developed;

- the problem determining the relationship of nanometer thicknesses of the surface layer of coals of different grades with methane diffusion and desorption, heat and moisture capacity, and gas permeability under uniaxial loading was solved.

Work approbation. The results of the work were reported and discussed at conferences: LIII International scientific-practical conference "Technical sciences: problems and solutions", Moscow, 2021; International scientific-practical online conference "Integration of science, education and production - the basis for the implementation of the plan of the nation", dedicated to the 30th anniversary of independence of the Republic of Kazakhstan, Sagin readings, 2021; VI International conference AGRITECH-VI - 2021: Agrotechnology, environmental engineering and sustainable development, Krasnoyarsk, 2021 International scientific forum "Science and innovation - modern and sustainable development", Krasnoyarsk, 2021. The research internship was held in the period from 01.02.2020 to 01.05.2020 at the enterprise "Research and Engineering Center "GeoMark" Ltd, research internship in the Kyrgyz State University of Geology, Mining and Natural Resources Development named after academician U.Asanaliev (Bishkek, Kyrgyz Republic) during the period from 10 to 27 May 2022.

Publications. The main provisions of the dissertation work are reflected in 9 scientific papers, including 4 (four) articles in peer-reviewed scientific journals on the scientific direction of the thesis theme, indexed in Science Citation Index Expanded database Web of Science (Clarivate Analytics) and CiteScore database Scopus (Elsevier), 1 (one) article in the editions, recommended by the Committee for Control in the sphere of Education and Science of the MES, 4 articles in the collections of International and National scientific conferences.

Structure and volume of the dissertation work. The dissertation work consists of an introduction, four chapters, a conclusion, a list of references and appendices. The work is presented on 136 pages, contains 66 figures, 31 tables and 167 references.