

6D073100 - "Environmental protection and life safety"

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for the degree of Doctor of Philosophy (PhD)

Thesis on the topic "Estimation of endogenous fire hazard in coal mines by the composition of gases in the mine atmosphere"

ANNOTATION

General characteristics of the dissertation research. Determination of the temperature in the coal self-heating hearth on the basis of numerical criterion ratios of the content of fire indicator gases in the composition of the mine atmosphere.

The relevance of the dissertation. Endogenous fire hazard – the possible spontaneous combustion of substances with the presence of organic components - is a serious danger in all areas of industrial and economic activity of enterprises. The most severe consequences are caused by spontaneous combustion of industrial materials and solid combustible minerals.

Spontaneous combustion of solid minerals - coal, sulfide ores, oil shale - at all stages of extraction, enrichment, storage and transportation still poses new challenges for scientists to predict and prevent it in a timely manner. Especially this process can lead to catastrophic consequences in underground coal mining, when an endogenous fire causes an explosion of a dust-gas-air mixture.

Theoretical methods and instrumental methods for predicting spontaneous combustion of coal have been developed and practically used, mainly designed for the conditions of certain coal deposits or basins. The most common, theoretically justified and proven methods are based on the analysis of indicator gases in samples of the mine atmosphere. In the absence of access to possible foci of endogenous fires, this is the only way to at least indirectly assess the situation.

Despite the successes achieved, the scientific justification of the signs and recognition of the early stages of spontaneous combustion of coal is still considered one of the most pressing problems of the mining industry.

The purpose of the study: Development and substantiation of methodological provisions and criteria for evaluating the stages of self-heating of coal based on the analysis of the composition of the mine (mine) atmosphere for the timely prevention of endogenous fire hazard in the mine.

Research objectives:

- based on the chemical and thermodynamic nature of the process of oxidation of coal with oxygen, to establish the most stable gaseous products at the stages of low-temperature oxidation, intensive self-heating and spontaneous combustion;

- to establish and analyze, on the basis of known theoretical and experimental methods of coal spontaneous combustion studies, quantitative ratios of gaseous oxidation products that can be used in procedures for identifying the stages of occurrence and development of endogenous fires;

- perform a quantitative and qualitative assessment of the stages of self-heating and spontaneous combustion of coal based on the analysis of the composition of the mine atmosphere;

- to test the obtained research results on known cases of spontaneous combustion of coal in mines;
- to develop practical recommendations for the fire protection services of mines (mines) to determine the stages of occurrence and development of endogenous fires.

Subject of study. The subject of the study is the identification of foci of self-heating and spontaneous combustion of coal seams, prevention and prediction of temperature changes.

Research methods. The work was carried out with the analysis of open literature sources on the topic of the dissertation, using theoretical and experimental research methods, numerical modeling methods, using modern packages of applied programs for scientific research, mathematical and statistical methods of data processing and the construction of predictive numerical models.

Scientific novelty of the dissertation:

- for the first time, correlation equations were obtained for calculating the temperature in order to predict and recognize the stage of self-heating of coal in the fire-hazardous formations of the Karaganda basin on the basis of criteria including the ratios of indicator gases;

- the possibility of modeling by the finite element method of temperature propagation in a coal cluster from self-heating of coal using the fundamental equations of thermal conductivity has been established.

- the thermodynamics of successive processes of oxidation, self-heating and spontaneous combustion of solid combustible minerals has been sufficiently studied at a qualitative level. The temperature boundaries of these processes are determined, theoretical and experimental methods for establishing these boundaries are developed.

- an important boundary characteristic of the oxidation process is the critical temperature of spontaneous combustion and the incubation period of its achievement for different grades of coal, methods for its determination have been developed, which is very important for planning fire safety of coal mining processes.

- developed and tested methods of mathematical modeling of processes of self-heating and spontaneous combustion of coal, methods of numerical solution of complex differential equations, specialized software products allow calculating the temperature field with sufficient accuracy for practice, predicting the origin and occurrence of foci of possible endogenous fires in coal accumulations.

The practical significance of the work. The results obtained in the dissertation are that the use of the proposed methodological recommendations, correlations between temperature and integrated criteria for the content of indicator gases make it possible to identify the stages of self-heating or spontaneous combustion of coal with acceptable reliability, on this basis it is reasonable to make decisions on the prevention of endogenous fire hazard and, ultimately, to increase the level of safety of mining operations in a coal mine in parts of fires or explosions.

The main results recommended for protection:

- criteria, including quantitative ratios between indicator gases in samples of the mine atmosphere, make it possible to more accurately predict the temperature of self-heating of coal in comparison with individual indicators of gas concentration;

- correlation equations obtained on the basis of processing of known experimental studies and tested in real mine conditions make it possible to identify the stage of self-heating of coal for taking timely measures to prevent endogenous fires in coal mines;

- gas-analytical methods for controlling spontaneous combustion of coal are accepted and used as the most proven and uncomplicated in the theory and practice of preventing endogenous fires in mines in many coal-producing countries;

- at mines and mines, the regulations for periodic monitoring of the mine (mine) atmosphere should be defined in order to comply with the normative safe composition of the air of the working area and the prediction of fire-hazardous situations;

- detailed processing of previously performed experimental studies has shown the presence of a close correlation between the amount of indicator gases released and the temperature during self-heating of coals.

- in the absence of opportunities for direct instrumental measurement of temperature in the proposed coal spontaneous combustion, the use of the obtained and tested empirical dependencies can provide practical assistance for making informed decisions and developing effective measures to prevent emergencies.

The contribution of the doctoral student in the preparation of publications. On the topic of the dissertation published 20 articles. The total contribution of a doctoral student is 55-60%. The contribution to the articles is represented by such components as conducting experimental studies, processing the results in the form of tabular values and graphical dependencies, obtaining computational equations. The research results are presented in the International Journal of Engineering Research and Technology, included in the Scopus database: "computerized analytical system for assessing fire and environmental safety in the mines of the Karaganda coal basin", 2020, Volume 13, Issue 6, pp. 1133-1136; In the journal Proceedings of the National Academy of Sciences of the Republic of Kazakhstan Series of Geological and Technical Sciences "numerical modeling of temperature distribution in the process of self-heating coal in the worked-out spaces", 2021, 2 (446), pp. 167-173.; - Only 2 articles have been published. In journals submitted by the Ministry of Education and Science of the Republic of Kazakhstan: Scientific Republican Journal. Proceedings of the University. KarSTU published two articles - "The use of the concentration of gases in air samples to assess the temperature of self-heating of coal in the developed spaces" (2019, No.2, pp. 46-50) and "Komir shakhtalarynda endogendik ortin paida bolu zhane damu satylaryn anyktau" (2019, No. 4, pp.64-67), Bulletin of the National Academy of Sciences of the Republic Kazakhstan "On recognition of the stages of occurrence and development of endogenous fires in coal mines" (2018 pp.107-112), Proceedings of the National Academy of Sciences of the Republic of Kazakhstan "the cumulative effect of informative signs on assessing the state of the fire situation in isolated rooms of coal mines" (2018, pp. 56-61) Published in the Collections of the Republican Conference:

in the scientific and practical International Conference "Industrial Technologies and Mechanical Engineering" dedicated to the 75th anniversary of the South Kazakhstan state University named after Academician Sultan Tashirbaevich Suleimenov conducting the Industrial Revolution within the framework of 4.0.ICITE- "Experimental determination of thermophysical properties of sulfide ores of the Oryol deposit of East Kazakhstan" 2018, Volume I., IV, November 28, Shymkent-2018. (Shymkent, 2018) Materials of the International Scientific and Practical Conference "Saginovsky Readings-No. 11" of the International Scientific and Practical Conference "Integration of science, education and production - the basis implementation of the National Plan", "Totygu processin thermodynamics zhane komirdin ozdiginen kyzuy" (2019, pp.188-190); "Zher asty zhagdailarynda kenish atmosphasyn kuramyn taldau zhane synamalar alu tasilderi men maksattary" (2019, pp.186-187); "Komirdin zhane ozdiginen zhanatyn materialdardyn totyguyn himiyalyk process" (2019, pp.183-185); "Definition stages of self-ignition of coal for the conditions of the mines of the Karaganda basin" (2019, p.206-208); Foreign conferences: International scientific and Practical conference.- Prospects for the development of science and technology.-Przemysl, Poland, "Thermodynamics of the oxidation process and self-heating of coal" (November 2018, pp.103-105), "Methods and objectives of sampling and analysis of the composition of the mine atmosphere in underground conditions" (November 2018, pp.106-108), scientific and Practical International Conference.- Science and education.-Prague, "Chemical process of oxidation of coal and self-igniting materials" (Czech Republic, November 2018, pp.7-10.); Materials of the 1st International Scientific and Practical Conference "New opportunities for the development of scientific partnership in Europe" "Computerized analytical system for assessing the endogenous fire hazard of the mines of the Karaganda coal basin", (April 20-21, 2020); "Management of innovative processes in the context of modernization of education and science" Materials of the II International Scientific and practical Conference "Numerical simulation modeling of temperature propagation during self-heating of coal in the developed spaces ", Munich, Germany (April 8-10, 2020); Scientific and Practical International Conference.- The latest scientific achievements "study of the dependence of the content of indicator gases at the stage of spontaneous combustion of coal" - Sofia, Bulgaria (March 2022, p.91-93); "study of self-heating and spontaneous combustion of coal plates according to grades K12 and D6 based on the analysis of the content of indicator gases" - Sofia, Bulgaria (March 2022, p.94-98); "criteria for calculating oxygen consumption during sampling of the composition of indicator gases and the dependence equation model– - Sofia, Bulgaria (March 2022, pp.99-102);

Information about publications. The main provisions, results, conclusions and conclusions of the dissertation are presented in 20 publications, including international scientific publications included in the Scopus database - 2; In journals recommended by the CESB MES RK - 4; In the materials of international conferences - 6 articles, foreign - 8 articles.

The structure and scope of the dissertation. The dissertation is typed on 112 pages, includes 30 figures and 14 tables. List of references 118. The content of

the dissertation consists of an introduction, literature review, research materials and methods, research results and their discussion and conclusions.