

ABSTRACT

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

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“Development of technological solutions for managing the quality of coal and products of its processing during mining and storage”

Relevance of the work. The modern or the latest stage of mining science is aimed at solving complex problems, in particular, the development of technologies for underground and open-pit coal mining in conditions of depletion of mineral and fuel resources and the prevalence of environmental and social factors in the world economy.

Product quality management is an integral aspect of a mining enterprise and affects every stage of the production cycle, starting with the opening of a mine field, from roof work during open pit mining, mining and continues at the stages of dumping, storage of minerals.

All efforts to improve mining technology and coal quality management should be directed, first of all, to the profitability of the development of deposits, increasing the integrated use of the extracted raw materials with the maximum extraction of valuable components contained in them. Integrated use, reduction or utilization of industrial waste provides, first of all, a reduction in the cost of mineral raw materials and an improvement in the ecological situation in the region. Resolutions on the importance of maintaining the pace of coal-fired energy generation and, at the same time, the need to advance in the fields of coal chemistry and deep processing of coal in order to increase the use of the country's coal potential were put forward at the first Kazakh Coal Industry Forum "New opportunities of the coal industry in the context of technological modernization."

It is impossible to develop a new and rationalize the existing processing industry without maintaining or improving the quality of the extracted raw materials. Thus, coal mining enterprises are faced with the task of revising each stage of the production cycle and introducing methods for selective mining of coal rocks and preserving the consumer qualities of coal and coal products.

The mining industry is a set of industries, and includes the exploration and production of minerals as the main processes, as well as the processes of primary processing with the receipt of their semi-finished products, conditionally referred to as auxiliary.

The main and auxiliary technological processes are carried out sequentially and the production cycle of coal mining should be divided into two stages.

The first stage includes the following steps:

- 1) Preparation of rocks for excavation;
- 2) Excavation and loading works;
- 3) Transportation of rock mass;
- 4) Waste rock dumping;

5) Unloading and storage of minerals.

The second stage ends already with the shipment of coal to the consumer or primary processing of coal.

In open pit mining, great efforts are spent on the preparation of open pits, which is accompanied by the accumulation of waste rock mass, often comparable to the amount of coal rock mass supplied for processing and shipment to consumers, when as overburden materials are sent to cover and complete mined-out areas, which is no less an important part of mining operations and the quality of backfill operations directly affects the safety and continued mining activities.

Thus, the work will consider the problems and ways of preserving the consumer properties of coal and products of its processing in the process of mining, storage and transportation to other production sites.

Practice has shown that during development and the storage of coal from a number of deposits in Kazakhstan (Karaganda, Ekibastuz, Shubarkolskoe, Sharynkolskoe, Karazhyrinskoe, Maikubenskoe, etc.), oxidative processes occur under certain conditions, leading to the destruction of the calorific value and other characteristics of coal products and often to their spontaneous combustion.

Spontaneous combustion of coal during the opening of coal seams, the processes of excavation, primary processing and storage in emergency or temporary open sites cause significant damage to the economy of the enterprise and the environment. When coal spontaneously ignites, a large amount of coal resources is burned, the calorific value of coal decreases and, as a result, a significant amount of toxic and greenhouse gases is emitted. Combustion products are mechanical suspensions in the form of soot, as well as poisonous and toxic substances, including carbon monoxide (CO), sulfur dioxide (SO₂), hydrocarbons, etc.

Spontaneous combustion of coal accounts for more than 90% of fires occurring in coal fields in China. According to incomplete statistical data, for the period from 2001 to 2014, about 32 cases of gas explosion or fire in underground coal mines were registered in China, which led to the death of 614 people, and over the history of the operation of the Karaganda coal basin, about 170 cases of spontaneous combustion of coal during mining operations were recorded. In August 2019, coal was ignited in a depleted mountain ledge of the Zapadny open pit of the Shubarkol deposit. Spontaneous combustion of coal and special coke is the cause of colossal financial losses for users, as cases of ignition were recorded at the Aktobe Ferroalloy Plant in temporary storage bunkers.

Due to the burning of waste dumps, the content of carbon monoxide, sulfurous anhydride and hydrogen sulfide at a distance of up to 2 km from the dumps exceeds the permissible sanitary standards.

In our country and abroad, a large amount of research work has been carried out to find measures to prevent spontaneous combustion of coal. The choice of methods and means of combating spontaneous combustion for each specific enterprise is carried out taking into account local conditions and economic feasibility.

The relevance of the development of technical solutions for the preservation of coal and coal products, including, is confirmed by the tasks:

1) Concept for the development of the fuel and energy complex of the Republic of Kazakhstan until 2030: development of technologies and alternative use of coal

2) Message to the people of Kazakhstan "Kazakhstani way-2050: Common goal, common interests, common future";

3) Concept of innovative development of the Republic of Kazakhstan until 2020:

- use of the country's raw material potential;
- attraction of the latest technologies and the creation of high-tech industries.

The purpose of the dissertation is to obtain a technology for preserving the consumer properties of coal and products of its processing during the period of production and storage.

To achieve this goal in the dissertation work, the following tasks are set:

- to study geological and mining conditions and factors of oxidation and spontaneous combustion of coal products;
- to study the mechanisms of oxidative processes and the world experience of preventive measures for the deterioration of coal properties;
- to establish the reasons for the reduction in size and cases of spontaneous combustion of coal at the open-pit mines "Central", "Zapadny" JSC "Shubarkol Komir" and special coke on the basis of the Aktobe Ferroalloy Plant;
- to carry out field experimental studies of the effectiveness of antipyrogenic materials in preventing the oxidation of coal and special coke during storage at the production site of the Shubarkol deposit;
- to investigate the qualitative characteristics of coal and to identify the components that promote and catalyze oxidative processes, which, in turn, lead to spontaneous combustion of coal and products of its processing;
- to test existing and newly developed polymeric antipyrogenic coating, which increases the shelf life of coal from secondary production products;
- to develop technological solutions to maintain the consumer properties of coal and special coke during storage in open closed areas, bunkers and wagons during transportation.

The idea of the dissertation. The consumer, technological properties of coal and coal products can be preserved from the effects of weathering, spontaneous combustion in working faces, mountain ledges and increase the shelf life by using effective insulating materials to cover the surface of minerals during underground and open mining, stacks during storage at work sites and warehouse areas for storage until shipment to the consumer.

Research methods at work. A number of techniques were used in the dissertation work, including the assessment and analytical review of research papers and technical documentation; laboratory and pilot industrial tests, mathematical modeling.

The main scientific provisions for the defense:

- the use of polymer coatings and a mixture of 5% liquid glass and 1% surfactant (Progress) in the extraction and storage of coal allows to reduce the violation of the fractional composition within 50-300 mm on average to 17% and prevents grinding to fractions of 0-6 mm by 5%;

- newly produced polymer insulating material (fire retardant) based on secondary raw materials of coke production effectively prevents the destruction of the technological properties of coal products and maintains the level of fixed carbon at 85%, and the ash content on average up to 4.8% in a period of 6 months.

Main scientific results:

- the effectiveness of the use of insulating coatings in maintaining the size of coal within the given fractional boundaries during mining and storage was evaluated;
- received a polymeric antipyrogeic material from by-products of coke-chemical production;
- proved the effectiveness of the developed antipyrogeic material on the basis of mathematical modeling;
- kinetic indicators and patterns of self-heating and spontaneous combustion of special coke were established, including the effective activation energy and the dynamics of changes in the adiabatic rate of spontaneous combustion;
- a set of technological solutions and recommendations has been developed for implementation in the production process of mining, primary processing and deep processing of coal.

The scientific novelty of the work consists in the development of a polymeric antipyrogeic material from secondary waste of coke-chemical production; development of a set of technological solutions and recommendations for carrying out pilot work to prevent spontaneous combustion and extend the shelf life of coal and products of its processing.

The practical significance of the work. The implementation of ideas and scientific provisions of the work will allow to create effective technological solutions for improving the quality of mining products by solving the problem of spontaneous combustion and passivation of factors that contribute to the destruction of minerals in open and underground methods of mining coal seams in mining and geological conditions of the Karaganda coal basin and other deposits of the Republic of Kazakhstan ... The research results can be used to improve stowage operations during coal mining. Scientific and experimental-industrial tests within the framework of the project will offer opportunities for improving the environmental situation and labor protection conditions due to the technology of processing secondary waste of coke production in the framework of solving the problem of spontaneous combustion of coal and special coke.

The expected social effect of the development is to improve the safety level of mining operations in coal mines in connection with a decrease in the risk of coal ignition in underground, open sites and mined areas.

The expected economic effect of technological solutions is to reduce the loss of extracted raw materials and manufactured products, which has a complex effect on the stabilization of costs and effective planning of production operations.

Objects and subjects of research. In this work, the influence of weathering and oxidation processes on the quality of coal and special coke is studied. Calculations, a number of studies have been carried out, allowing the development of regulations for storage and use. Coal grade D from the Shubarkol deposit was selected to study

the physical and chemical factors. The special coke of Sary-arka Spetskoks LLP was also used for the research.

Implementation of work. The results of field, laboratory tests and the main conclusions were published in 5 scientific articles, in 2 abstracts of scientific conferences and 1 utility model.

Participation in research work, economic contractual work:

- Contract No. 286/17 dated 05/18/2017 with Shubarkol Komir JSC "Study of factors affecting spontaneous combustion of special coke produced from Shubarkol coal and development of recommendations on the storage conditions for special coke in containers, warehouses and open areas";

- Contract No. 45-NIR / 17 dated 05.09.2017 by the corporation with ERG "Study of the influence of weathering factors, methods and technologies for storing raw coal, and the development of measures to increase and preserve its size."

Work structure. The dissertation work consists of an introduction, 5 sections, a conclusion and contains 116 pages of text, 68 figures, 24 tables, a list of sources used from 118 titles

Approbation of work. The main provisions of the work were reported and approved: at scientific seminars of the Department of RMPI KTU and scientific and technical councils of KTU, international scientific and practical conferences "Saginovskie readings-10", "Saginovskie readings-12". The results of scientific research obtained in the course of the dissertation work were accepted by the ERG corporation and Shubarkol Komir JSC for consideration and inclusion of scientific results in the production process and the newly developed technical regulations.

Gratitudes. The doctoral student thanks Kazakhstani and foreign scientific consultants for their recommendations and assistance in conducting experimental work and performing individual stages of the dissertation work, as well as the management of Shubarkol Komir JSC for providing an experimental site and research subjects.