BULLETIN OF NATIONAL ACADEMY OF SCIENCES
OF THE REPUBLIC OF KAZAKHSTAN
ISSN 1991-3494
Volume 3, Number 373 (2018), 107 – 112

UDC 622.453

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RECOGNITION OF STAGES OF EMERGENCE AND DEVELOPMENT OF THE ENDOGENOUS FIRE IN COAL MINES

Abstract. The nature and the main stages of emergence and development of the endogenous fires on coal mines are shown. The analysis of the main theoretical methods of researches of chemical process of self-heating and self-ignition of coal is made. It is noted that the main objective of experts of fire-prevention protection of coal mines consists in the most reliable establishment of a stage of oxidation and self-heating of coal. It is offered to accumulate and systematize results of natural data on control of structure of the mine atmosphere of problem sites for justification of signs of development of oxidizing processes in coal congestions.

Keywords: coal mine, oxidizing process, chemical reactions of oxidation of coal, stage of the endogenous fire, signs of self-ignition, carbon oxide, hydrogen, oxygen decrease.

Introduction. The problem of self-ignition of coal exists from emergence of the first coal mines. Self-ignition of coal is observed in mines and in warehouses where it is stored, on external and internal dumps of coal mines. The fires arising for various reasons including and from ignition of coal in the dug-out spaces, are found the special automatic equipment, signals from which arrive to the mountain dispatcher. On the basis of this information timely precautionary measures for an exception of their development and consequences are taken.

The endogenous fires have the specifics of development and methods of detection of the centers of self-heating and self-ignition of coal [6, 10]. The situation is aggravated with the fact that the underground endogenous fires often arise in hard-to-reach spots, such as the developed space, in the toes, in coal deposits behind insulating crossing points, in layers satellites [1, 16]. Coal layer, as a rule, in such conditions is in the deformed state, and it increases probability of self-ignition of coal. Suppression of the centers of burning in such conditions is complicated, than the highest duration of elimination of this type of underground accidents is caused. Besides, in gas mines to which the majority of coal mines of the coal-mining countries including coal basins of the Republic of Kazakhstan, the endogenous fires can cause explosions of methane-air mix that leads to catastrophic consequences belong.

The efficiency of fight against the endogenous fires arising in the developed space and in other hard-to-reach spots of coal mines, substantially depends on timeliness of detection and completeness of information on coal self-ignition process.

For this reason workers of coal mines very are interested in a question whether it is impossible by results of the analysis of air in certain places in the mine to define the beginning of self-ignition of coal, in particular, carbon monoxide availability is sign of the fire. For the answer to this question theoretical justifications of process of self-heating and self-ignition of coal are necessary.

Now are developed and a number of the theories of self-ignition based on use of kinetics of sorption of oxygen by small fraction classes of coals of different extent of metamorphism and a heat transfer in the destroyed coal [4, 5, 12] have found broad application.

The developed and known theories and methods define the beginning of ignition of coal at rather high temperature when coal has already lit up. Some researchers consider that real process of self-ignition of coal begins in mines already at 12-15 °C [5]. Therefore, the most important direction is the research of an initial stage of process. At the first stage it is necessary to begin studying of a surface of coal for the purpose of definition e è characteristics and their influence on chemical activity of coal at a temperature, usual for the mine. On the second it is necessary to study kinetics of oxidation of coal at low temperatures.

$$C_{(solid)} + O_{2(gase)} = CO_{2(gase)} + 94kkal; \quad (1)$$

at the second stage carbon dioxide interacts with carbon with formation of carbon oxide and absorption of heat

$$CO_{2(gase)} + C_{(solid)} = 2CO - 41{,}2 \text{ kkal}. \quad (2)$$

As both stages (both reactions (1)-(2)) occur at the same time, under Hess's law the total thermal effect of chemical process of oxidation of coal is determined by total reaction

$$2C_{(solid)} + O_{2(gase)} = 2CO + 52{,}8 \text{ kkal}. \quad (3)$$

Founders of the theory of self-ignition of coals on the basis of the analysis of nature of influence of separate factors have formulated three conditions necessary for process of origin and development of self-ignition [15]:

coal has to be capable to oxidation at low temperatures, so-called low-temperature oxidation;

the amount of oxygen has to be sufficient for reaction course;

the amount of the warmth which is marked out as a result of oxidation has to prevail over his branch to the environment, i.e. there has to be a positive balance of thermal energy.

In development of the endogenous fire allocate a self-heating stage, an early stage of self-ignition and a stage of burning of coal [7]. Self-heating of coal begins as soon as conditions for warmth accumulation are created. The self-heating stage generally determines duration of the incubatory period of process of self-ignition and proceeds in the range of temperatures, since the values characteristic of conditions of these mining-and-geological conditions, and up to the critical temperature of self-ignition. On reaching critical temperature the early stage of self-ignition of coal begins.

Analytical expression of this dependence in ignition zones in emergency sites for coals of the Donetsk basin is presented by a formula [7]

$$T = 456 \cdot (C_{co}/\Delta C_{O_2})^{0{,}076}, \quad (4)$$

where C_{co} – the content of carbon oxide in tests of the mine atmosphere, about. %; ΔC_{O_2} – a decrease of content of oxygen in tests of the mine atmosphere, about. %; T – temperature in the self-heating center, K°.

The temperature condition of layer caused by coal oxidation reaction by oxygen and a heat transfer in surrounding breeds and the atmosphere acts as the main condition of process of transition of self-heating to self-ignition and formations of the center of the endogenous fire.

In development of the endogenous fire, except change of temperature in the seat of fire, there are essential changes as a part of air in a coal self-ignition zone: content of oxygen decreases release of carbon oxide, hydrogen, saturated and unsaturated hydrocarbons which content considerably exceeds background values increases. These changes in structure of the mine atmosphere are also a basis for recognition of stages of development of processes of self-heating of coal.

It has practically developed so that miners took existence in the atmosphere of the site of carbon oxide in certain quantities for the main sign of origin of the endogenous fire. The theory explaining self-ignition of coals with fast oxidation of nonlimiting connections did probable that carbon monoxide is emitted only at quite high, characteristic only of the fire, temperatures [1, 4].

On the controlled site steady excess of a volume fraction of SO carbon oxide and H2 hydrogen over their background contents is accepted by other sign of intensive self-heating of coal: $CO_F \gg (6\text{-}10)\cdot 10^{-7}$ vol.%