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CUMULATIVE INFLUENCE OF INFORMATIVE FEATURES ON THE ASSESSMENT OF THE CONDITION OF THE FIRE SITUATION IN THE SEALED AREAS OF COAL MINES

Abstract. The analysis of various ways of discernment of low-temperature coal oxidation and possibility of prevention of its transition to self-ignition is made. The feature of determination of a stage of coal self-heating in the isolated volumes of the mined-out spaces of coal mines is noted. The known informative signs of self-ignition, a possibility of their practical application are considered. The cumulative way of determination of oxidation temperature and self-heating of coal on composition of tracer fire gases in the mine atmosphere is offered.

Keywords: coal mine, mined-out spaces, coal oxidation, self-heating, self-ignition, the endogenous fire, tracer gases.

Introduction.One of the serious problems of fight against the endogenous fires is the search of ways and methods of their discernment at early stages that draws attention of scientists and experts not only in the Republic of Kazakhstan, but also in other coal-mining countries. The danger of emergence and development of the endogenous fires at underground coal mining is aggravated with a possibility of explosions of gas-dust-and-air mixture consequences of which, as we know, are catastrophic.

Active processes of coal oxidation in the mined-out spaces of extraction areas of coal mines are the most dangerous and hardly distinguished. At a combination of certain conditions the sources of oxidizing processes can pass into the self-ignition places.

One of the approaches to determination of a stage of coal self-heating in the mined-out and isolated spaces on the basis of results of the laboratory analysis of tests of air-gas mixture in the mine atmosphere is considered in [1]. In basin instructions on prevention and suppression of the underground endogenous fires the content of fire tracer gases – carbon oxide, hydrogen and carbon dioxide – as features of the fire is specified, and the corresponding actions of technical services of coal mines, rescue services of the region are regulated.

Authors [1] recommend to use the feature of active coal self-heating - a steady lack of the assigned value of oxygen in the samples which are selected from the considered isolated area, in comparison with its calculated value in an assumption of simple mechanical replacement with impurities (methane, hydrogen, oxide and carbon dioxide) which are contained in the sample. Calculated assay of oxygen in the sample in an assumption of simple mechanical replacement is determined by a formula

$$c(O_2)_p = \left(100 - \sum of\ gases\right) \cdot 0,209 \quad (1)$$

where $\sum of\ gases$ - is the sum of percentage (on volume) content of gases-impurities in the sample (the oxygen percentage in the sample isn't considered). Further the lack of oxygen as the difference between the calculated assay and assigned value of oxygen in the sample is determined by a formula

$$\Delta C(O_2) = C(O_2)_p - C(O_2)_\phi \quad (2)$$

The fulfillment of the condition $\Delta C(O_2) > \Delta C(O_2)_{крит}$ demonstrates the existence of the source of intensive low-temperature oxidation in a coal congestion of space from where the studied sample of air-gas mixture is taken. This method of discernment of intensity of low-temperature oxidation is approved in the Karaganda basin in case when two neighboring mines were aerodynamically connected in the process of conducting mining operations. By researches of gas samples of the mine atmosphere for the continuous period it was established that in the isolated space of one of the mines where access is inaccessible, there is an active oxidizing process, with features of self-ignition.

The task also becomes complicated with the fact that the endogenous fire danger of coal changes regionally even within the same extraction area. Therefore in the certain areas of the mine field implementation of measures is inexpedient, and in others they have to be strengthened. Thus, creation of an effective method of discernment of a stage of endogenous fire danger of extraction areas in the process of conducting mining operations is relevant.

Authors of the article [2] also consider that control of concentration of oxygen is the most sensitive indicator of early emergence of the source of coal self-heating as it gives the chance to track all the process of low-temperature oxidation. It is necessary to consider that influence of oxygen content in the mine atmosphere sharply increases with raise of temperature: the higher it is, the smaller concentration oxidation process can proceed at it. Dependence of self-heating on the content of oxygen in the mine environment is one of the main factors influencing the endogenous fire danger of mining operations during development especially flammable coal layers.

However, the authors specify that the complexity of calculations and at times inadequacy of the received decision on the developed program because of instability of a numerical method complicate the use of this method in the process of production.

The famous scientists in the field of the endogenous fires in the article [3] consider that modern practice of early - on time and temperature - detection of the endogenous fires is based on gas and temperature control of the atmosphere in zones of potential formations of coal and coal dust congestions. As the most informative tracer gases for this purpose carbon oxide and hydrogen are used. Increase in reliability of control on these gases is caused by inertness at the low temperatures which are distinctive for the stages of self-heating and coal ignition, their low sorption by the loosened coal and breeds in the mined-out space and weak solubility in water.

In conclusions authors [3] note that the existing gas-analytical method not always allows to classify unambiguously the endogenous fire at the stage and to determine source temperature. At the emergence of the fire in the fulfilled part of layer and impossibility of control of air-break, excess of background content of carbon oxide of hydrogen can be fixed already at a decay stage with stabilization of their percentage at a low level. Additional researches on the search of the indicators allowing to find the sources with a temperature not above the critical temperature of coal self-heating are necessary.

In this regard it is necessary to notice the researches carried out in the former Karaganda department of All-union Scientific Research Institute of Mine Rescue Work, and explicitly directed to determination of a stage of low-temperature coals oxidation of the Karaganda basin on natural measurements of tracer gases content in the mine atmosphere [4]. The results of researches in the form of dependences of percentage volume content of tracer fire gases on temperature of coal self-heating for the most flammable coal layers are given in table 2.

In figures 1 and 2 in more graphic form diagrams of dependences of concentration of tracer gases on temperature of coal self-heating in the process of oxidation by oxygen of the incoming air are represented.

As it is seen from the figure 1, the concentration of carbon monoxide 0,1 volume % (it is considered critical for initiation of efficient measures for prevention of coal self-ignition) appears at a temperature of coal heating of 110°C.

Table 2 – Empirical formulas of dependence of percentage volume content of tracer fire gases on temperature of coal self-heating of K_{12} and D_6 layers of mines of the Karaganda basin

Index of coal layer	Dependences of percentage contentof carbon oxide (CO), hydrogen (H_2) and carbon dioxide (CO_2) on coal self-heating temperature
K_{12}	$C(CO) = 0{,}0004 \cdot \exp(0{,}186 \cdot t^{0,72}),\%$
	$C(H_2) = 0{,}0002 + 0{,}0078 \cdot \exp(-0{,}59 \cdot 10^{-6} \cdot (300 - t)^{2,98})),$ %
	$C(CO_2) = 0{,}02 \cdot \exp(0{,}0401 \cdot t^{1,33}),$ %
D_6	$C(CO) = 0{,}0001 \cdot \exp(0{,}0103 \cdot t^{1,3}),$ %
	$C(H_2) = 0{,}0002 + \exp(-0{,}026 \cdot (300 - t)^{1,7} / (t - 100)),$ %
	$C(CO_2) = 0{,}01 \cdot \exp(0{,}406 \cdot 10^{-4} \cdot t^{2,26}),$ %

It is known from practice of observations and researches that release of hydrogen begins to be shown considerably at a temperature above 250 - 300°C that, by the way, is visible from an empirical formula and the diagram in the figure 2.

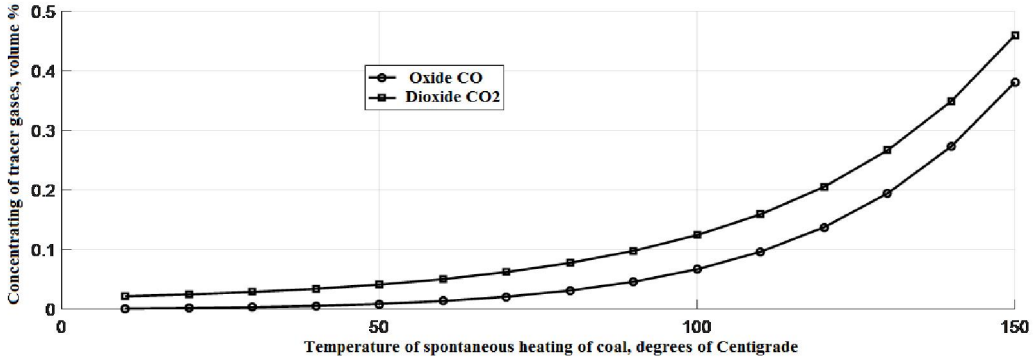

Figure 1 – Diagram of dependence of volume concentration of oxide (CO) and dioxide (CO_2) of carbon on temperature of coal self-heating, °C

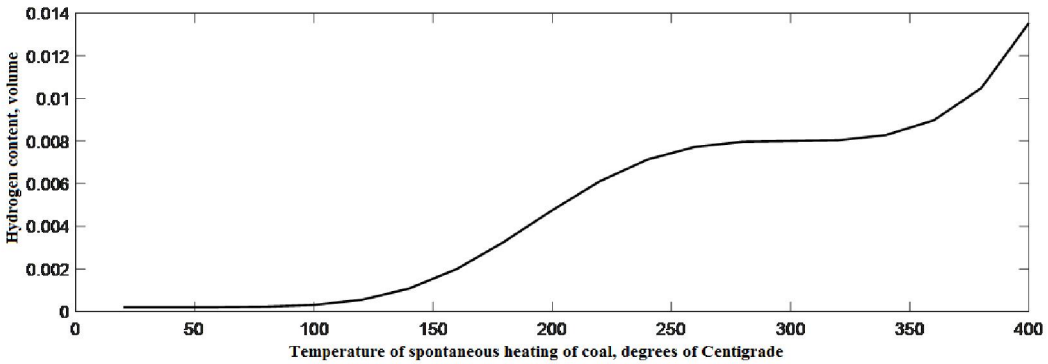

Figure 2 – Diagram of dependence of volume concentration of hydrogen (H_2) on temperature of coal self-heating, °C

The presented formulas and graphic dependences are received by authors [4] only for K_{12} and D_6 layers as these layers of coal are most inclined to self-ignition, were repeatedly used for expert estimates at investigations of fire-dangerous situations in the mines of the basin. Laboratory analyses of samples of the mine atmosphere on unsaturated hydrocarbon for comparison and correlation of these ways were carried out at the same time. Positive experience confirmed acceptable reliability and the practical importance of the dependences received on researches.

Conclusion. 1. The practical experience of researches (investigations) of possible self-ignition of coal in mines showed that it isn't enough to use only one criterion of danger of the endogenous fire emergence for reasonable acceptance of difficult and expensive measures. It is necessary to operate with a number of the known informative features allowing to estimate more adequately the degree of endogenous fire danger.

2. Laboratory researches of dependences of content of fire tracer gases and oxygen in the mine atmosphere depending on self-heating temperature in the result of oxidation need to be continued on all coal layers inclined to self-ignition.

3. To enter into basin methodical documents on prevention of the underground endogenous fires in coal mines the section of discernment of a stage of coal self-heating on cumulative features.

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КӨМІР ШАХТАЛАРЫНЫ ОҚШАУЛАНҒАН АЙМАҒЫНДАҒЫ ӨРТ ЖАҒДАЙЫНЫҢ БАҒАСЫНА АҚПАРТТЫ ҚАСИЕТТЕРДІҢ ТҰТАСТАЙ ӘСЕР ЕТУІ

Аннотация. Көмірдің төменгі температурада қышқылдану үрдісін анықтаудың әр түрлі әдістерінің сараптамасы жасалды және оның өздігінен жануы мүмкін туралы ескертпелер айтылды. Көмір шахталарының өңделген кеңістіктерінде көлемі бойынша көмірдің өздігінен жану кезеңдерін анықтау ерекшеліктері ескерілді. Өздігінен жанудың белгілі ақпаратты қасиеттері және оларды қолдану мүмкіндіктері қарастырылды. Қышқылдану температурасын анықтаудың біріңғай әдісі мен шахталы атмосферада индикаторлы өрт газдарының құрамы бойынша көмірдің өздігінен қызуын анықтау ұсынылды.

Түйін сөздер: көмір шахтасы, өңделген кеңістіктер, көмір қышқылдануы, өздігінен қызу, эндогенді өрт, индикаторлы газдар

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СОВОКУПНОЕ ВЛИЯНИЕ ИНФОРМАТИВНЫХ ПРИЗНАКОВ НА ОЦЕНКУ СОСТОЯНИЯ ПОЖАРНОЙ СИТУАЦИИ В ИЗОЛИРОВАННЫХ УЧАСТКАХ УГОЛЬНЫХ ШАХТ

Аннотация. Выполнен анализ различных способов распознавания процесса низкотемпературного окисления угля и возможности предупреждения перехода его в самовозгорание. Отмечена особенность определения стадии самонагревания угля в изолированных объемах выработанных пространств угольных шахт. Рассмотрены известные информативные признаки самовозгорания, возможность их практического применения. Предложен совокупный способ определения температуры окисления и самонагревания угля по составу индикаторных пожарных газов в шахтной атмосфере.

Ключевые слова: угольная шахта, выработанные пространства, окисление угля, самонагревание, самовозгорание, эндогенный пожар, индикаторные газы.