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THE EXPERIENCE OF USING A VOLATILE MATTER INDEX TO PREDICT THE RISK OF ENDOGENOUS FIRE OF COAL SEAMS

The article verified the conformity of the gradation of coal seams into three groups according to their endogenous fire hazard, according to regulatory documents, with the actual conditions of accidents that have occurred over the past twenty years during the development of 66 coal seams of the Donetsk basin. The degree of metamorphism of coals of the considered coal seams, where endogenous fires occurred or they were absent, was estimated in terms of the release of volatile matters index during their thermal decomposition without air access (V^{daf}).

Keywords: *coal seams, endogenous fire, hazard of group, metamorphism, regulatory framework, forecast.*

Introduction

The volatile matter from thermal decomposition of coals without access to air (V^{daf}) is one of the main indicators for predicting the level of coal seems hazard factors during underground coal mining. It is used in regulatory framework for the gas emission forecasting [1], gas dynamic phenomena [2], dust production [3], as well as for the development of measures for the prevention and extinction of endogenous fires in coal mines of Ukraine [4]. According to these instruments, the indicator V^{daf} assumes that the characteristics and composition of fossil coals change because of metamorphic transformation over geological periods. As a classification indicator of the degree of metamorphism V^{daf} has been developed over the past few decades to characterize the consumption properties of coals and is being successfully applied for this purpose in many countries as an inter-State standard [5]. According to a commonly accepted definition of metamorphism it is the successive transformation of brown coal into hard coal and anthracite as a result of changes in the chemical composition, structure and physical properties of coal in the subsoil, mainly under the influence of increased temperature and pressure.

To better determining coal's consumer properties, other nine indicators were added to the list and successfully used V^{daf} [5]. The effectiveness of usage these 10 classification indicators for evaluation of consumer properties has been tested and proven by the experience of coal use on an industrial scale. Such testing of the usage V^{daf} effectiveness of volatile matters, as a basic indicator of the degree of coals' metamorphism, is difficult in predicting the occurrence of coal seams' hazards under regulations [1–4] because such experiments are not possible. The need and relevance of evidence of the appropriateness of the use volatile matter index V^{daf} as a key indicator of the hazard characteristics of coal seams is based on the following assumptions:

1) One of the main properties of solid fuels is the ability to decompose (destroy) their organic mass when heated without access to air. Under heated conditions without access to air, gaseous and vapor-like decomposition products – volatile substances – are formed. The yield of volatile substances depends mainly on the temperature of the sample. The bulk of volatile matter is formed when coal is heated to 850–900°C. This indicates that thermal decomposition of coal is essentially another artificial stage of coal conversion in laboratories and is not directly related to earlier metamorphic processes under natural conditions;

2) The indicator V^{daf} is designed to characterize the consumer properties of coal [5]. In laboratory terms, it does not correspond to the natural state of coal in mining. In particular, as a result of coal sample's prepatation for testing, moisture is removed completely and the ash content decreased to less than 10 percent;

3) Different forms of moisture presence in coal are associated with their metamorphic transformations. The significant role of moisture has also been identified in the processes of endogenous fires occurrence [6]. The determination of the moisture presence in different forms and the assessment of its impact on the hazard behavior of coal seams are still among the unresolved problems of mining production. The role of moisture and changes in the properties of coals in the process of their metamorphic transformation have not been adequately reflected in Ukraine's existing regulatory environment;

4) The total amount of volatile matter emitted during thermal coal destruction depends to a large

extent on its ash content – the higher it is, the more distorted the value V^{daf} [7]. At the same degree of metamorphism, the volatile matter index V^{daf} of the coal may differ by more than 20 per cent, which corresponds to a difference of about one coal grade and exceeds the allowable difference between laboratory definitions by more than nine times;

5) Thermal decomposition of coal without air access emits different amounts of volatile matter from organic mass (CO_2, C_mH, O_2, CO, CH_4, H_2, N_2) and mineral part (vapors of crystalline hydrate moisture H_2O, CO_2, H_2S, etc.) [7]. The indicator V^{daf} reflects only the total amount of substances emitted without identification, making it impossible to consider in more detail their relation to the hazardous properties of coal seams in the process of mining operations.

The objectives of the study

The idea of the work is to check that the grading of coal seams in three groups for their endogenous fire hazard, as set out in the regulatory document [8], is in conformity with the actual conditions of the accidents that have occurred in the last twenty years, with 66 coal seams in the Donetsk basin [9]. The degree of metamorphism of the coal mines in question, where endogenous fires occurred or were absent, was evaluated by the volatile matter V^{daf} index. Its values are given both in article [9] and in official reference documents [3, 10].

The objective of the work is to establish the conformity of coal seams according to the regulation [8] with the conditions of the occurrence of the endogenous fires over twenty years [9] with the assessment of the degree of metamorphism of coal with volatile matters indexes according to different sources [3, 9, 10].

Methodology

The methodology provides for two samples of coal seams. In one (table. 1) the coal seams considered those for which [9] the number of endogenous fires that had occurred in previous years or such fires were absent, and the volatile matters index was available from other sources [3, 10]. The second sample is based on the data [8] of coal seams belonging to the most dangerous groups I and II (table 2), for which information about VM index is available V^{daf} [3, 10].

By comparing these samples, it is possible to establish a correspondence between the identified fire risk groups of coal seams [8] the number of accidents that have occurred according to [9] over the past twenty years or so. Thus processed statistical material also allows us to compare the V^{daf} values that have been identified in different years for each considered coal seams [9, 10]. This provides a measure of change in V^{daf} index as the coal seams were worked out, as a consistent measure for each coal seam in the sample.

Main part

In 1996, only four coal seams (table 2) were classified as Special Risk (I) under [8]:

- "Tonkij" coal seam (m_2), mine im. Izotova;
- "Mazurka" coal seam (l_3) of the Gagarin Mine.
- Coal seam "Mazur" (l_1) of Mines «Krasnyj Profintern»;
- Coal seam "Tolstyj" (m_3) of Mine «Uglegorskaja».

In the following years, no endogenous fires were recorded during the mining operations. The largest number of endogenous fires since 1996 occurred when the Kapustin Mine was working out the seam m_3 (29 accidents) and in the Mine named after Artema where were coal seam l_2' mining (17 accidents).

Of the fifteen miners surveyed (table 1), spontaneous combustion occurred in most cases (60 times) in seams previously classified as low-risk (Group III). During the second group of coal seams, 49 spontaneous combustion occurred, 29 of them were during the working out coal seam m_3 of the mine named after Kapustin. For two coal seams ($k_8^н$ the "Novodruzheskaja" mine and l_2' the Artema mine) the propensity of coal for spontaneous combustion according to [8] in 1996 was not established (33 cases of spontaneous combustion in subsequent years). Do from this analysis, it is clear that the distribution of coal seams among the three groups of fire hazard has, in general, an element of randomness, and the incidence or absence of endogenous fires follows a pattern.

In particular, this pattern is related to the angle of occurrence of the seams. Of the fifteen Coal seams surveyed, spontaneous coal combustion took place during the operation of nine steeply dippings seam (table 1). This, all things being equal, is due in large part to coal mining technology and storaging coal in the mines galleries. More than half (71) of the self-combustion of coal occurred in six gentle seams, indicating the possible influence of factors other than coal mining technology. One of the main factors is the degree of metamorphic transformation of coals. The main criterion for assessing the degree of coal metamorphism in order to predict the occurrence of mining hazards in all cases [1–4, 9] is the yield of volatile substances.

An analysis of fire conditions [9] did not confirm the direct dependence of coal combustion on the volatile matters index V^{daf}. This is evidenced by the co-processing relationship graphs for coal seams with endogenous fires or not observed (fig. 1). Also included in the joint statistical treatment are the volatile matter index V^{daf} data for Group I and II formations for their fire hazard according to Group [8].

For all coal seams considered, the volatile matter indexes V_1^{daf} and V_2^{daf} are defined in terms of regulatory

references [10, 3]. A close directly-proportional relationship has been deteted between V_1^{daf} and V_2^{daf} (fig. 1a). A high correlation coefficient r=0.989 (line 2) indicates the great majority of confidence in the determining of values V_1^{daf} and V_2^{daf}, given in different reference documents [10, 3]. On the other hand, this shows that it is not possible to determine the apparent difference between coal seams where endogenous fires have occurred or have not been. It is also not possible to distinguish from the criteria V^{daf} between coal seams classified in Fire Risk Groups I and II under the regulation [8].

Table 1

Information on the number of endogenous fires that have occurred [9], volatile matters [9, 10, 3], and the attribution of coal seams to spontaneous ignition groups [8]

No	Mine, mine administration	Coal seam		Volatile matters index, %			Information on the propensity for spontaneous combustion		Mined coal seam
		Name	Geological symbol	V_3^{daf} [9]	V_1^{daf} [10]	V_2^{daf} [3]	Number of fires [9]	Fire risk group [8]	
1	im. Kalinina	Aleksandrovskij	k_7	17.0	18.6	19.7	12	II	steep-footed
2	im. Svjatitelja Vasilija Velikogo (№ 40, "Kurahovka", "Gornjak")	–	l_7	38.0	41.0	41.0	14	III	gentle
3	im. Kapustina ("Privolnjanskaja-Severnaja")	Golubovskij	m_3	34.0	43.7	43.7	29	II	gentle
4	"Novodruzheskaja"	Lisichanskij VII	$k_8^н$	42.1	42.2	42.2	15	– *	gentle
5	im. Artema	Kirpichevka	l_2'	13.0	32.6	31.9	17	–	steep-footed
6	"Uglegorskaja"	Mazur	l_1	8.0	11.5	9.6	16	III	steep-footed
7	im. Lenina	Mazurka	l_3	29.0	32.7	30.8	8	III	steep-footed
8	"Kremennaja"	Lisichanskij VII	$k_8^н$	38.0	41.5	41.5	8	III	gentle
9	im. Zasjad'ko	Aleksandrovskij	m_3	36.0	35.5	35.5	3	II	gentle
10	im. Lenina	Kirpichevka	l_2'	28.0	32.2	30.6	5	II	steep-footed
11	«Butovka-Doneckaja»	Butovskij	n_1	38.0	39.0	39.0	2	III	gentle
12	im. Gagarina	Tonkij	m_2	25.0	32.4	32.3	1	III	steep-footed
13	im. Lenina	Andreevskij	k_4'	21.0	26.3	26.3	2	III	steep-footed
14	im. Rumjanceva	Solenyj	l_5	22.0	30.6	27.7	5	III	steep-footed
15	im. Kalinina	Solenyj	l_5	20.0	21.7	22.0	4	III	steep-footed
16	im. Lenina	Solenyj	l_5	32.0	31.6	33.5	0	–	
17	im. Lenina	Jul'evskij	k_7'	27.0	29.0	30.3	0	–	
18	im. Lenina	Rudnyj	k_4	22.0	26.7	23.7	0	–	
19	im. Rumjanceva	Mazurka	l_3	23.0	24.0	25.0	0	–	
20	"Aleksandr-Zapad"	Jul'evskij	k_7'	8.0	18.2	19.0	0	–	
21	"Panfilovskaja"	Babakovskij	k_8	37.0	37.9	36.0	0	–	
22	"Panfilovskaja"	Aleksandrovskij	m_3	42.0	32.1	37.9	0	–	
23	im. Svjatitelja Vasilija Velikogo (№ 40, "Kurahovka", "Gornjak")	Vyshelezhashhij	l_8'	38.0	42.5	42.5	0	–	
24	"Kommunist"	Natal'ja	$q_8^н$	5.0	5.3	4.8	0	–	

25	"Zapadnaja" (№ 1 "Jugo-Zapadnaja")	Suhodol'skij	i_3	25.0	24.1	1.7	0	–	
26	"Doneckaja"	Lisij	$k_2^{н}$	28.0	26.6	3.1	0	–	

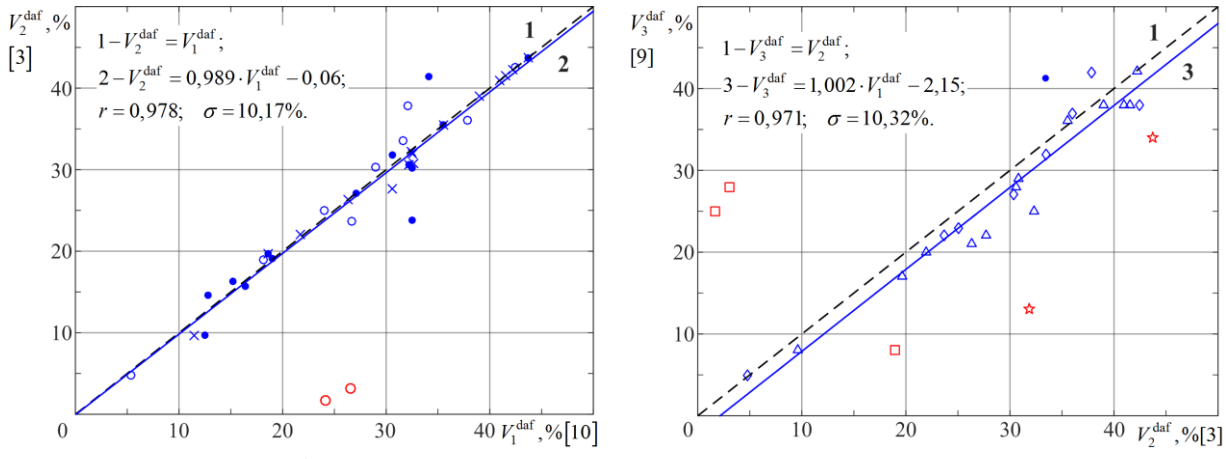
*Not available according to [8]

Table 2

Identification of coal seams in high risk (I) and hazardous (II) endogenous fire risk groups according to [8] and volatile matter index data [3, 10]

No	Mine, mine administration	Coal seam		Volatile matters index, %		Fire risk group [8]
		Name	Geological symbol	V_1^{daf} [10]	V_2^{daf} [3]	
1	im. Izotova	Tonkij	m_2	– *	25.8	I
2	im. Gagarina	Mazurka	l_3	32.5	30.2	I
3	"Krasnyj Profintern"	Mazur	l_1	15.2	16.3	I
4	"Uglegorskaja"	Tolstyj	m_3	–	10.0	I
5	im. Zasjad'ko	Aleksandrovskij	m_3	35.5	35.5	II
6	"Kochegarka"	Mazurka	l_3	32.5	23.8	II
7	im. Lenina	Kirpichevka	l_2'	32.2	30.6	II
8	"Komsomolec"	Kirpichevka	l_2'	30.6	31.8	II
9	im. Kalinina	Aleksandrovskij	k_7	18.6	19.7	II
10	im. Rumjanceva	Tonkij	m_2	–	25.4	II
11	"Kondrat'evka"	Tolstyj	m_3	–	17.0	II
12	"Krasnyj Oktjabr' "	Mazurka	l_3	16.4	15.7	II
13	"Krasnyj Oktjabr' "	Mazur	$l_1^{в}$	15.4	– *	II
14	"Junkom "	Mazur	l_1	12.8	14.6	II
15	"Junkom "	Aleksandrovskij	k_7	12.5	9.7	II
16	im. K.Marksa	Mazurka	l_3	19.0	19.1	II
17	im. Kapustya ("Privolnjanskaja-Sever.")	Golubovskij	m_3	43.7	43.7	II
18	im. Il'icha	Ataman	$l_6^{в}$	27.1	27.1	II

* Not available according to [3, 10]



a) b)

Fig. 1. Graph of correlation of values according to data V^{daf} [3, 10] (a) and [3, 9] (b). V_1^{daf}, V_2^{daf}, V_3^{daf}, respectively, the volatile matter index according to [10], [3] and [9]; 1 - bissectris of the coordinate grid; 2, 3 - averaging lines respectively of dependencies $V_2^{daf}=f\left(V_1^{daf}\right)$ and $V_3^{daf}=f\left(V_2^{daf}\right)$.

×,○ – V_1^{daf} and V_2^{daf} data [10, 3] for coal seams where endogenous fires have occurred or are absent respectively [9] (table 1); ● – values V_1^{daf} and V_2^{daf} [10, 3] for coal seams assigned to Fire Risk Groups I and II according to Fire Hazard Statement [8] (table 2); Δ, ◊ – values V_3^{daf} and V_2^{daf} [9, 3] for coal seams where endogenous

fires have occurred or haven't been observed respectively [9] (table 1); ☆ – values V_3^{daf} and V_2^{daf} [9, 3] for coal seams (m_3 named after Kapustin Mine) and (l_2' named after Artema Mine) where 29 and 17 endogenous fires occurred respectively during the operation (Board. 1); □ – values V_3^{daf} and V_2^{daf} [9, 3] for coal seams (k_7' "Aleksandr-Zapad" Mine), i_3 ("Zapadnaja") and ($k_2^н$ "Doneckaja" Mine), where endogenous fires were not observed (Tab. 4); r, σ – correlation coefficient and standard deviation respectively.

The graph (Fig. 1, b) showed, in addition to the above, inconsistencies in the values between V_1^{daf} and V_2^{daf} according to the legal reference documents of different years [10, 3]. There are cases where the values V_1^{daf} and V_2^{daf} have significant differences in several or a few dozen times, eteblished for a particular mine and for a particular coal seam. Such differences, in particular, are found for coal seams i_3 ("Zapadnaja" Mine) and $k_2^н$ ("Doneckaja" Mine, GP "Gukovugol'"), which undoubtedly affected the reliability of the estimation of fire hazard of these coal seams [9]. According to the document [10] for V^{daf}=24.1−26.6% the coal of the seam is classified as a coal and according to recommendations [3] as an anthracites. Similar discrepancies between [10] and [3] data have been identified for other coal seams, which cannot but lead to significant differences in the assessment of the propensity of coal seams to spontaneously combust. According to the generally accepted industrial classification [5] V^{daf}<8% characterised as anthracite. According to [10], the anthracite are not potentially dangerous. This is confirmed by the experience of such coal seams in the Mine Groups "Shahterskantracit", "Torezantracite", "Snezhnoeantracite", where no endogenous fire has been registered in 24 mines for 25 years. According to the data of NIIGAD «Respirator» in Donbass from 1979 to 2004 only four endogenous fires were registered during the development of anthracite formation l_3. They all originated in the working lava space.

Miners whose coals are formally part of the anthracites were considered in the analysis of accident conditions [9]. For some of them, the values V^{daf} ranged from 4 to 8 % and, based on the requirements of the Regulation [8] and the experience of the anthracite strata, were a priori not prone to spontaneous combustion of coal. The miners $q_8^н$ («Natalya» of the «Communist» mines) and k_2^2 ("Nadronovsky") should be included.

The yield of volatile substances according to different sources for the formation was 5.0% [15], 5.3% [16] and 4.8% [3], respectively, which raises doubts as to the determination and attribution of the mine to anthracite. There is a slight variation in the data for the seam k_2^2, V^{daf}=8.0% [9] and V^{daf}=4.9% [10, 3]. Here again, there is good reason to consider the seam k_2^2 as anthracite and not to consider it as potentially hazardous by spontaneous combustion.

In parallel with these data, sixteen endogenous fires (table. 1) took place during working out of the seam l_1 («Mazur» of the "Uglegorskaya" Mine) and the value of V^{daf}=8.0% [9]. In this case, they may have been caused by both storing of the cuted-off coal while working on the steeply dipping seams and by an inaccurate estimate of the index value V^{daf}. Its value according to [10] and [3] respectively is 11.5% and 9.6%, which allows the coal of the seam to be classified as hard coal and the seam to consider the potential hazards of spontaneous combustion.

In the scientific work [9] supposed that coal seam h_4 mine “Doneckaja” is anthracite and V^{daf}=17%. Similar assumptions were made in studies of the methane risk of anthracites, where data with an output of volatile matter of up to 17.35% [12] were used. The Anthracite Quality Manual [13] presents even more different values for weight release of volatile matters. With some exceptions, the coals of the Tunguska field with an average volatility yield of 32% are classified as anthracites. For the other indicators (volumetric output of volatile matters V_V^{daf}=235÷314 g/sm^2, logarithm of the specific electrical resistance lgρ=6.52÷8.75, the specific gravity of the organic mass γ=1.38÷1.42 g/sm^2 and the reflective capacity in the air R_0=11.45÷13.70%), these coals can be classified as anthracites indeed. In the present case, the thermal impact of the intrusions resulted in a sharp and unexplained variability in the mass release of volatile matters and in the elemental composition of coals, ranging from brown to anthracites and graphite [8]. [This proves the inadvisability of using a single classification parameter for characterizing the degree of coals' metamorphism to predict the hazards of coal seams and indicates the need of using a group of classification parameters, which directly reflect the changing composition and properties of coal in the process of geological transformation.

The above facts show that it is not possible to establish reliably the boundary between hard coals and anthracite on the basis of a single classification indicator when predicting the hazards of coal seams, even using official regulations reference sources. For this reason, classifying coal seams as dangerous or not susceptible to spontaneous combustion on the basis of a single criterion V^{daf} and the fact of belonging to an anthracite or hard coal is not scientifically sound and may lead to contradictory conclusions. For example, coal seams $k_2^н$ of mines ("Doneckaja" Coal Mine GP «Gukovugol») and i_3 ("Zapadnaja" Coal Mine "Gukovugol") according to the directory [10] refer to hard coal (V^{daf}=24.1÷26.6%), and according to the

catalogue [3] (V^{daf}=1.7÷3.1%) to anthracites (tab. 1). According to the experience of working out these coal seams, endogenous fires did not occur V^{daf}=25.0÷28.0% [9]. The reasons for the absence of endogenous fires remain unclear. In one case, this may be due to a high degree of metamorphism (V^{daf}=1.7÷3.1%) and coal seams are inherently anthracite. In the second, there are other factors that inhibit spontaneous combustion at values V^{daf}=25.0÷28.0% and do not cause fires. Significant differences between [10, 3] data may have been influenced by different coal sampling sites in the mine field, their location in relation to geological disturbances and the boundary of the gas-weathering zone, etc. In general, in most cases, is relatively permanent for an individual coal seam, but in all cases, clarification is needed for specific mining conditions.

The coal seam h_4 of the ("Doneckaja" Mine (V^{daf}=17%) in the analysis of causes of endogenous fires is classified as anthracite [9] and, therefore, was considered not dangerous in the occurrence of endogenous fires. A more detailed analysis of the regulatory reference data [10, 3] confirmed the validity of the coal seam h_4 for anthracite. At the same time, difficulties were encountered in determining the location of the ("Doneckaja" Mine wich were working out the coal seam $h_4^{'}$, as such information is not available in the original source [9].

In the Donetsk Basin several mines with the same name – ("Doneckaja", but only one of them (the association "Torezaranhtracit") worked out the coal seams $h_2^{'}$, h_3, h_4^{v} belonging to the coal seams group c_2^3. The coals of all the working seams of this mine are almost identical (V^{daf}=2.3÷3.5%, table 3) according to the regulatory reference documents [10, 3]. This clearly confirms that they belong to anthracites. It is this fact that is the most reliable about the reasons for the absence of fires, and not the value V^{daf}=17% specified in [9].

It should be noted that during the processing of anthracite seams by the mines "Communist" and "Doneckaja" (table. 3) the coal seam moisture was quite high (more than 5%), which did not lead to the emergence of endogenous fires. This is due to the greater stability of the inner structure of the anthracites compared to the hard coals. In the metamorphic transformations of the coal seams, there was also a change in the ratio between the elements of organic mass and mineral impurities (table. 3), which cannot be considered by the indicator V^{daf}. The most reactive organic matter element is oxygen. In addition, moisture [6] and sulfur content [8] affect the likelihood of spontaneous combustion. These factors must be taken into account first and foremost when predicting the fire hazard of coal seams.

Table 3

Information about miners for mines with the same name "Doneckaja" from different groups of coal mines

Group of coal mines	Coal seam		V^{daf}, %		Ingredients per combustible mass [10], %				Moisture [3], %	Ash content, % [10]		Content total sulfur, %	Coal Seam capacity, m [10]	
	Name	Geological symbol	[10]	[3]	$C^{г}$	$H^{г}$	$S^{г}$	$N^{г}+O^{г}$		reservoir sample	enriched sample		general	recoverable reservoir thickness
Krasnodon-ugol'	Ivanovskij	m_3	35.5	35.5	84.7	5.3	4.3	5.7	2.7	30.6	8.2	3.0	0.85	0.85
	Tonkij	l_2^1	32.5	32.5	85.7	5.2	4.7	4.4	–	20.5	7.8	3.3	0.84	0.84
Gukovugol'	Gundurovskij	$k_2^{в}$	29.0	6.0	86.5	5.2	5.3	3.0	3.1	25.5	7.3	6.0	0.91÷ 0.85	0.91÷ 0.85
	Lisij	$k_2^{н}$	26.6	3.1	86.9	4.9	2.6	5.6	1.9	14.5	6.3	3.1	0.98	0.98
Torez-antracit	Usovskij	$h_4^{в}$	2.3	2.3	***	–	–	–	5.2	24.8	8.2	2.3	0.85÷ 0.95	0.88÷ 0.90
	Removskij	h_3	2.5	2.5	–	–	–	–	3.0	14.4	8.0	1.2	0.60	0.60
	Podremovskij	$h_2^{'}$	3.5	3.2	93.9	4.8	2.6	1.7	3.3÷ 6.6	26.7	8.4	2.8	0.70÷ 1.50	0.70÷ 1.50
Shahtersk-antracit	–	l_7	8.9	–	91.2	3.9	1.6	3.3	–	15.4	8.2	1.5	1.15	1.05
	–	l_6	8.6	8.6	90.6	3.8	2.8	2.8	2.4	14.9	8.4	2.5	1.10	0.90
	–	l_3	7.5	7.5	90.9	3.6	2.8	2.7	2.3	17.7	8.4	2.6	1.50	1.50

*** No data

It is fashionable to judge the possible error of the indicator V^{daf} as a criterion for assessing the degree of coals' metamorphism by the ratio of coal ash in the stratum to enriched samples, which differ several times (table 3). The method of determining V^{daf} the dry ash-free mass is designed to establish the consumer properties of coal and does not take into account its humidity and ash content in the real extraction

conditions. Experience and methods of V^{daf} determination indicate the need to improve the methodology of determining the propensity of coal seams to spontaneously combust.

Studies and analyses of the conditions of endogenous fires happened in the past indicate the need to take into account the influence of factors of three unconnected blocks.

The first block refers to the chemical activity of coals. It is the result of the metamorphic transformations of coal seams and is associated with a change in the composition of organic and mineral constituents of coal. The presence of moisture and sulphur, as well as the maternal ash of coal, must be taken into account.

The second cluster of factors characterizes the mining and geological conditions of miners: their capacity; coal seams angle; Depth of work; Characteristics of the host rock, etc.

The third block is related to mining technology, which is largely determined by the mining and geological conditions of the second block. The technological design is carried out at the stage of the design of the coal enterprise and the drawing up of Mining Passports. The influence of the three blocks must be taken into account for a reliable assessment of the possible occurrence of endogenous fires.

Conclusion

Methods for determining the volatile matter index to the dry and ash-free mass of coal under laboratory conditions do not correspond to the condition of coal seams in mining operations, which does not guarantee the reliability of the prediction of the hazards of miners when this indicator is used.

The accidents did not confirm the special fire risk of the Group I miners, previously established by regulation. Endogenous fires occurred only in Groups II and III.

The use of Volatile Matter Index as an indicator of the degree of metamorphic transformation of coal does not allow for a reliable grading of coal seams according to the number of accidents that have occurred or assigning them to different fire hazard groups.

Three units have been identified, which are independent of each other in determining the number of accidents that have occurred while individual coal seams are working:

1) Factors related to the degree of coal metamorphism.
2) Mining and geological conditions for miners.
3) Technological aspects of mining.

The chemical activity of coals needs to be determined taking into account structural changes and changes in coal composition due to previous metamorphic processes. For this purpose, it is possible to use previously obtained results of technical, element and petrographic analyses of fossil coals.

The occurrence of spontaneous combustion fires, other things being equal, is related to oxygen, moisture and Sulphur. In this case, the carbon content may serve as a criterion for the degree of transformation of the parent organic matter.

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ДОСВІД ВИКОРИСТАННЯ ПОКАЗНИКА ВИХОДУ ЛЕТКИХ РЕЧОВИН ДЛЯ ПРОГНОЗУ ЕНДОГЕННОЇ ПОЖЕЖОНЕБЕЗПЕКИ ВУГІЛЬНИХ ШАХТОПЛАСТІВ

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Встановлено відповідність градації вугільних шахтопластів за ступенем їх ендогенної пожежонебезпеки відповідно до вимог нормативних документів умовам пожеж, що відбулися за двадцять років з оцінкою ступеня метаморфізму вугілля за значенням виходу летких речовин при їх термічному розкладанні без доступу повітря.

Проведені результати аналізу умов виникнення ендогенних пожеж, що вже відбулися, вказують на необхідність враховувати вплив факторів трьох блоків, кореляційно не пов'язаних між собою. Такими є: хімічна активність вугілля, гірничо-геологічні умови відпрацювання шахтопластів (їх потужність, будова, кути їх залягання, глибина робіт, властивості порід, наявність геологічних порушень тощо) та технологія ведення гірничих робіт.

Вперше доведено, що виникнення ендогенних пожеж або їх відсутність не пов'язане зі значенням показника ступеня метаморфізму V^{daf}, а безпосередньо залежить від елементного складу органічної маси вугілля, у тому числі вміст кисню, вологи та сірки. Вміст вуглецю при цьому служить критерієм ступеня перетворення органічної речовини.

Результати досліджень дозволяють дати пропозиції щодо вдосконалення нормативної бази безпечного ведення гірничих робіт у частині прогнозування ендогенної пожежної небезпеки шахтопластів.

Ключові слова: *шахтопласти, ендогенні пожежі, група небезпека, метаморфізм, нормативна база, прогноз.*