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On the possibilities to apply indices of industrial coal-rank classification to determine hazardous characteristics of workable beds

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Abstract

Purpose is to identify behaviour of the graded indices as well as their correspondence to grades, groups, and subgroups of similar coal metamorphic degrees to determine hazardous characteristics of workable beds while mining.

Methods. Rank scale and changes in the graded index values help define the coal grades, groups, and subgroups having comparable characteristics as well as ultimate composition of organic mass. Coal ranking involves the intensified metamorphism manifestation in the process of transition from lignite to black coal, and then to anthracite.

Findings. Analysis of the total of the fusainized components has shown that coal grading is within less than 10 and more than 69% range. However, in the majority of cases its values are recommended as those being less than 39 or more than 40% which prevents from determination of reliable correlation relationships. Free heaving ratio is considered together with the plastic layer thickness making it possible to determine quantitively only LF, LS, LC, and L grades. In terms of vitrinite response index, being 0.8-1.4%, LS, LC, and L grades may be considered as coal in the central ranking series. The fact supports available changes in the internal structure.

Originality. Behaviour of the graded indices of industrial coal-rank classification has been determined to identify hazardous characteristics of workable beds while mining.

Practical implications are the possibilities to improve the regulatory system for safe mining of workable beds while determining differences in characteristics of vitrinite coal and fusainized coal.

Keywords: *metamorphism, spontaneous ignition, ultimate composition, coal*

Nomenclature

V^{daf} is volatile-matter content in terms of airtight thermal coal decomposition (dry ash free), %;

V_v^{daf} is volume volatile-matter yield (dry ash free), cm^3/g;

R_o is vitrinite response index, %;

lg ρ is logarithm of specific electrical resistivity of coal;

y is plastic layer thickness, mm;

Q_s^{daf} is high heat value used for wet ash-free state, MJ/kg;

ΣFC is total of the fusainized components per pure coal, %;

W_{max}^{af} is maximum water capacity per ash-free state, %;

T_{sk}^{daf} is semi-coking resin yield, %;

SI is free heaving ratio;

A_R is index of anisotropic vitrinite response, %;

I, I_{R_0}, $I_{V^{daf}}$ and I_y are conventional indices of R_o, V^{daf}, and y ratios respectively;

"l", and "u" indices are lower and upper boundaries of changes in the indices.

1. Introduction

Globally, problems of safe coal seam mining have always been the topical ones [1]-[3]. The fact is supported by regular emergency situations with drastic consequences in mines [4]. In many cases, such catastrophes result from manifestations of hazardous characteristics of coal workable beds during mining operations.

To identify hazardous characteristics of workable beds while mining, Ukrainian regulatory system applies limited number of the graded indices of mineral coal. Logically, the graded indices should characterize changes in coal composition and properties in the process of its metamorphism. For the purpose, industrial classification [5] involves 10 indices. In terms of the indices, all coal types have been graded ac-

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cording to a metamorphism degree. They are systemized in three kinds; 49 coal grades; 8 categories; 31 types (six of them are for lignite; 21 are for fossil coal; and four types are for anthracite); and 33 subtypes (four of them are for lignite; 23 are for fossil coal; and six types are for anthracite). Such ranking of mineral coal helps identify 17 coal grades; 27 groups; 44 subgroups; and 81 types and subtypes. Such rather particularized coal gradation helps observe disadvantages of its industrial use in terms of technological criteria [6]. More than 20 graded criteria are known helping characterize thoroughly any changes in coal composition and characteristics in the process of its geological transformations [7].

Classification parameters, being typical for the whole range of coal metamorphism degree, have been analyzed. The parameters are as follows: the basic components of organic mass [8]-[10]; weight and volume yields of airtight coal thermal decomposition products [11], [12]; moisture content [13], [14]; thermal power [15]; mechanical strength [16]-[18] etc.

Specification documents [19]-[21] use only four indices to characterize manifestation of the majority of hazardous properties of coal workable beds while mining. Mass devolatization in terms of airtight thermal coal decomposition (V^{daf}) is the key factor. In addition, volume yield of volatile substances (V_v^{daf}); logarithm of specific electrical resistivity of anthracite (lg ρ); and plastic layer thickness (y) for black coal have been taken in certain cases. Comparison of the list of the graded indices with their probable number (being more than 20), and with their number (10) applied by industrial classification [5], spawns doubts concerning the reliable accuracy to identify the whole variety of hazardous characteristics of workable beds (i.e. gas content; tendency to gas dynamic phenomena as well as to spontaneous ignition; coal dust explosibility etc.) in terms of one factor. Taking into consideration the arisen operation situation, the efforts aimed at the improvement of specification documents to safe coal seam mining are quite topical for Ukrainian coal industry.

Object of the research is the coal metamorphism process as well as its influence on the manifestation of hazardous characteristics of workable beds.

Objective is to identify behaviour of the graded indices as well as their correspondence to grades, groups, and subgroups of similar coal metamorphic transformations to identify hazardous characteristics of workable beds while mining.

Following problems have been set to prevail:

– making interconnections between the main graded indices (particularly, those ones, characterizing hazardous characteristics of workable beds) inclusive of coal tendency to spontaneous ignition;

– determining the factors making it possible to describe mineral coal characteristics within the range of metamorphic transformations.

2. Methods

The research methods rely upon a traditional definition of metamorphism concept characterizing changes in coal composition and properties [22].

Rank scale (i.e. grades, groups, and subgroups) as well as changes in the graded indices helps identify the coal grades, groups, and subgroups being similar in characteristics and in ultimate composition of organic mass. Conditional indexation was performed depending upon the coal arrangement in terms of its grade characteristics. Conditional index one (I) corresponds to lignite according to Interstate Standard (B grade; 1B group); conditional index two also corresponds to lignite (B grade; 2B group; and 2BB subgroup) etc. in accordance with probable intensification of a coal metamorphism degree. Terminal conditional index 81 corresponds to anthracite (A grade; 3A group; and 3AF subgroup) [5].

To compare with the current specification documents, the abovementioned will correspond to a more nuanced identification of hazardous characteristics of workable beds in the context of certain scopes of the graded coal series. Coal ranking in terms of its grades, groups, and subgroups involves intensified manifestation of metamorphic transformations while transiting from lignite to black coal, and then to anthracite. Reliability of the assumption for the whole ranked series or its certain ranges may be either supported or invalidated on the basis of close correlation dependences between definite graded indices as well as conditional ranking indices.

3. Results and discussion

The degree of coal metamorphic transformations is evaluated [5] depending upon changes in vitrinite response (R_o). Its quantitative values are available for the whole ranked series. Hence, R_o increase in some cases, resulting from the effect of metamorphic transformations, varies proportionally the ultimate composition of organic coal mass as well as its internal structure. It is quite obvious that despite certain versatility of R_o index, it cannot characterize synchronously and adequately both changes in ultimate composition and coal properties at different stages of its metamorphic transformations. Extra graded indices have been applied to determine distinguishers of changes in coal composition and characteristics [5]. Usually, their quantitative values are available in certain ranges of series of coal metamorphic transformations ranked in terms of R_o. Industrial classification applies high heat value per ash-free state $\left(Q_s^{daf}\right)$; volatile-matter content (V^{daf}); total of the fusainized components per pure coal (ΣFC); maximum water content per ash-free state $\left(W_{\max}^{af}\right)$; semi-coking resin yield $\left(T_{sk}^{daf}\right)$; plastic layer thickness (y); free heaving ratio (SI); volume volatile-matter yield $\left(V_v^{daf}\right)$; and index of anisotropic vitrinite response (A_R) to complement R_o.

Such a set of additional graded indices is intended to demonstrate technological characteristics of coal as well as substantiate tendencies of their industrial use. However, not many of the listed additional factors can favour identification of hazardous characteristics of workable beds. Thus, it is senseless to consider Q_s^{daf} index while determining hazardous characteristics of workable beds. The classification [5] uses it to distinguish fuel types – lignite or black coal. Changes in other additional graded indices [5] have been considered in the context of ranking to define specific variations in coal composition and characteristics resulting from the metamorphic transformations.

In some cases, difficulties in the determination of role of the additional indices depend upon the lack of description of lower and upper boundaries of changes in them. They are: V^{daf}, ΣFC, $W_{\max}^{af}$, T_{sk}^{daf}, y, SI, V_v^{daf}, and A_R.

Maximum water content $\left(W_{\max}^{af}\right)$ is required to separate lignite into five types. The gradation has been performed according to $W_{\max}^{af}$ values being less than 30, 30-50, and more than 60%. Such an index variation prevents from using it to identify closeness of correlation relationships. Coal moisture may influence heavily the manifestation of hazardous characteristics of workable beds. In contrast with the standard documentation [5], the water content indices should be considered for the whole coal ranking depending upon a degree of its metamorphic transformations.

Volume yield of volatile matters $\left(V_v^{daf}\right)$ also characterizes anthracite types marginally. Such changes in ranges as 200 cm^3/g and more; 100-150 cm^3/g and more; and 100-200 cm^3/g are not sufficient to define changes in anthracite composition and characteristic. It is a problematic idea to use V_v^{daf} index in the listed gradation to determine hazardous characteristics of workable beds.

The total of the fusainized components (ΣFC) separates lignite, black coal, and anthracite into categories. ΣFC index varies within less than 10 and more than 69% range (Fig. 1). In the majority of cases, its values being less than 39 or more than 40% are recommended.

Such a situation prevents from performing statistic processing of the material to identify reliable correlation relationships. At the same time, ΣFC index makes it possible to divide the coal into vitrinite type and fusainite type since it is always lower for vitrinite coal to compare with fusainite one. In turn, independent statistic processing in terms of ΣFC index with the use of other graded indices will favour differentiation between the coal types as for the manifestation of hazardous characteristics of workable beds. Semi-coking resin yield T_{sk}^{daf} divides lignite into subtypes. Less and more than 20% gradation prevents from T_{sk}^{daf} use to analyze changes in coal composition and properties during the metamorphic transformations.

Anisotropic index of vitrinite response A_R divides anthracite types into subtypes. It is recommended to assume its values [5] within a range of less than 30 and more than 70%; however, that prevents from the differentiated consideration of changes in anthracite composition and characteristics while its dividing into subtypes.

Free heaving ratio *SI* is considered together with the plastic layer thickness *y*. It has its own quantitative determination (i.e. less than 1 or more than 1) for coal of LF grade (conditional indices of ranking series 6-12) and LS, LC, and L grades (62-75 indices). If one relies upon changes in *y* and *SI* indices then at the beginning of the ranged series of black coal metamorphism and at its end of it LF grade coal LS, LC, and L grades have certain similar characteristics. The indices *y* and V^{daf} have almost comparable other classification criteria in the context of the listed coal grades. The fact supports the idea of roughly the same ultimate composition of organic mass. Concerning the basic graded index (i.e. R_o = 0.80-1.40%), coal of LS, LC, and L grades may be considered as the coal being practically in the central part of the ranking series (Fig.1; 32-48 indices). Hence, there are differences taking place in the internal structure transformation of LS, LC, and L coal grades.

Six more series of ranking in terms of changes in lower and upper boundaries of R_o, V^{daf}, and *y* indices have been compiled according to [5] based upon the arrangement of the indices along with the increase in their values. Table 1 demonstrates the correlation results between conditional indices *I*, I_{R_0}, $I_{V^{daf}}$, and I_y.

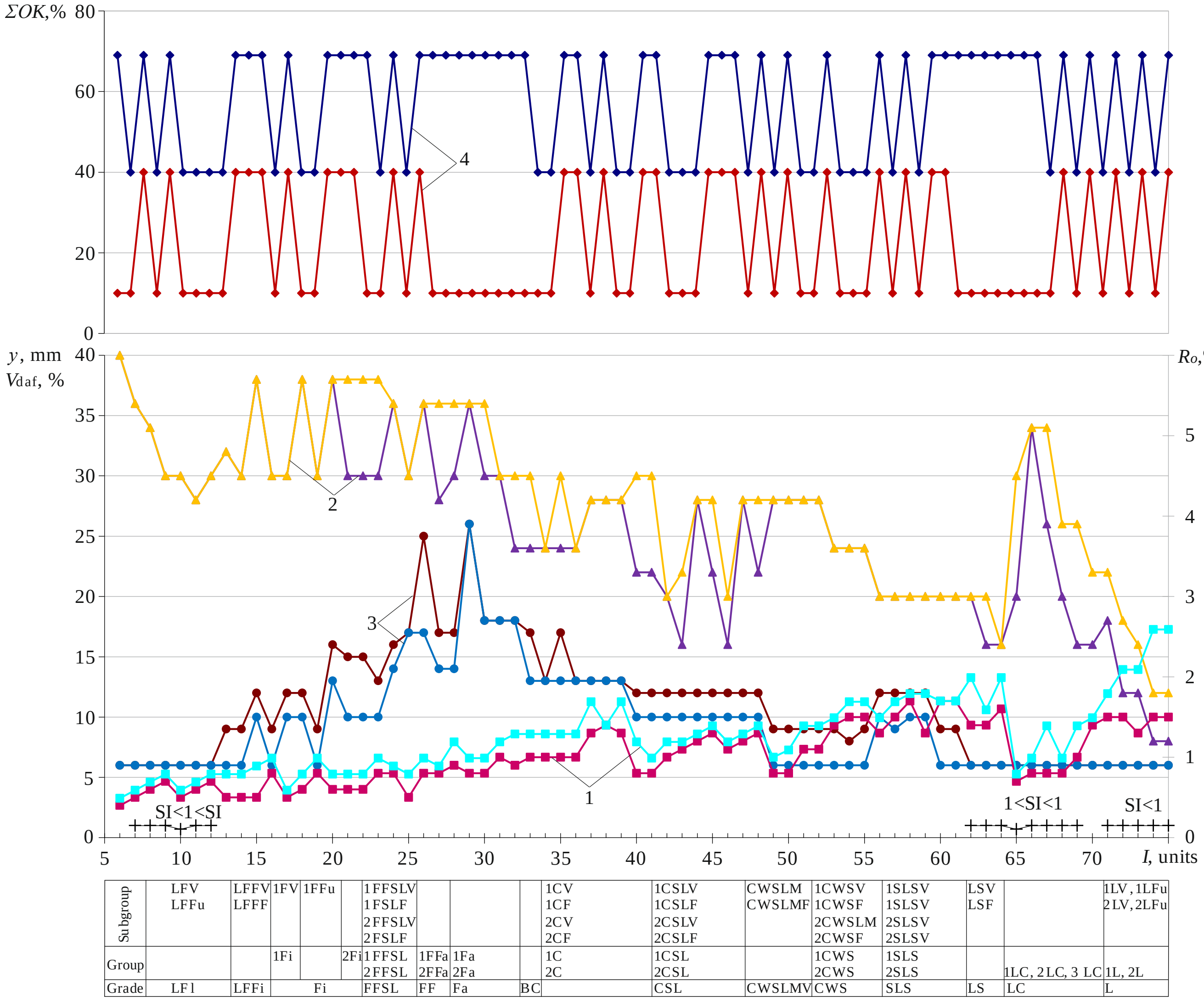
Table 1. Coal ranging according to a metamorphism degree as well as genetic and technological parameters based upon [5]

I	I_{R_0}		$I_{V^{daf}}$		I_y		I	I_{R_0}		$I_{V^{daf}}$		I_y	
	l	*u*	*l*	*u*	*l*	*u*		*н*	*l*	*u*	*l*	*u*	*l*
1	2	3	4	5	6	7	1	2	3	4	5	6	7
1	1	1	-	-	-	-	42	45	39	55	61	49	45
2	2	2	-	-	-	-	43	47	40	66	58	50	46
3	3	3	-	-	-	-	44	51	47	36	43	51	47
4	4	5	-	-	-	-	45	55	49	53	44	52	48
5	5	6	-	-	-	-	46	48	41	67	62	53	49
6	6	4	6	6	6	6	47	52	48	37	45	54	50
7	7	7	10	13	7	7	48	56	50	54	46	55	51
8	14	10	14	20	8	8	49	33	34	38	47	17	32
9	20	12	17	24	9	9	50	34	35	39	48	18	33
10	8	8	18	25	10	10	51	49	51	40	49	19	34
11	15	11	31	39	11	11	52	50	52	41	50	20	35
12	21	13	19	26	12	12	53	61	56	48	55	21	36
13	9	14	16	23	13	28	54	65	62	49	56	22	27
14	10	15	20	27	14	29	55	66	63	50	57	23	37
15	11	22	7	7	41	40	56	57	57	56	63	56	52
16	23	25	21	28	15	30	57	67	64	57	64	40	53
17	12	9	22	29	42	41	58	73	67	58	65	57	54
18	16	16	8	8	43	42	59	58	68	59	66	58	55
19	24	26	23	30	16	31	60	74	65	60	67	24	38
20	17	17	9	9	59	64	61	75	66	61	68	25	39
21	18	18	24	10	44	62	62	62	70	62	69	26	13
22	19	19	25	11	45	63	63	63	59	68	70	27	14
23	25	27	26	12	46	56	64	72	71	69	72	28	15
24	26	23	11	14	67	65	65	22	21	63	38	29	16
25	13	20	27	31	70	66	66	35	32	15	21	30	17
26	27	28	12	15	71	74	67	36	53	42	22	31	18
27	28	24	32	16	68	67	68	37	33	64	51	32	19
28	38	36	28	17	69	68	69	46	54	70	52	33	20
29	29	29	13	18	75	75	70	64	58	71	59	34	21
30	30	30	29	19	72	71	71	68	69	65	60	35	22
31	40	37	30	32	73	72	72	69	72	72	71	36	23
32	39	42	43	33	74	73	73	59	73	73	73	37	24
33	41	43	44	34	60	69	74	70	74	74	74	38	25
34	42	44	45	53	61	57	75	71	75	75	75	39	26
35	43	45	46	35	62	70	76	76	76	–	–	–	–
36	44	46	47	54	63	58	77	77	77	–	–	–	–
37	53	60	33	40	64	59	78	78	78	–	–	–	–
38	60	55	34	41	65	60	79	79	79	–	–	–	–
39	54	61	35	42	66	61	80	80	80	–	–	–	–
40	31	38	51	36	47	43	81	81	81	–	–	–	–
41	32	31	52	37	48	44							

Correlation values R^2 speak for the quality of each index determination according to [5] as for the lower boundaries (l) and upper ones (u). R_o values (R^2 = 0.9559) have experienced the most accurate determination. Moreover, R^2 values are rather high for V^{daf} and *y* indices, being 0.8138 and 0.7859 respectively.

Ideally, if values of the indices have been identified definitely (i.e. when their lower variation boundaries are equal to the upper ones) then conditional ranging indices should coincide with bisectors (1) of coordinate grids (Fig. 2).

In the context of the considered cases, such coincidences are almost impossible.



Coal type

BC - bituminous coal;
C - coking;
CF - coking fusainite;
CSL - coking semi-lean;
CSLF - coking semi-lean fusainite;
CSLV - coking semi-lean vitrinite;
CV - coking vitrinite;
CWS - coking weakly sintering;
CWSF - coking weakly sintering fusainite;
CWSL - coking weakly sintering low-metamorphized;
CWSLMF - coking weakly sintering low-metamorphized fusainite;
CWSLMV - coking weakly sintering low-metamorphized vitrinite;
CWSV - coking weakly sintering vitrinite;
Fa - fat;
FFa - fiery fat;
FFu - fiery fusainite;
FFSL - FFSL;
FFSLV - fiery fat semi-lean vitrinite;
Fi - fiery;
FSLF - fiery semi-lean fusainite;
FV - fiery vitrinite;
L - lean;
LC - low-caking;
LFu - lean fusainite;
LFl - long-flaming;
LFFF - long-flaming fiery fusainite;
LFFi - LFFi;
LFFu - long-flaming fusainite;
LFFV - long-flaming fiery vitrinite;
LFV - long-flaming vitrinite;
LS - lean sintering;
LSF - lean sintering fusainite;
LSV - lean sintering vitrinite;
LV - lean vitrinite;
SLS - semi-lean sintering;
SLSF - semi-lean sintering fusainite;
SLSV - semi-lean sintering vitrinite.

Figure 1. Changes in boundaries of the graded indices in terms of coal ranking on its grades, groups, and subgroups [5] depending upon a conditional index of metamorphism degree (I); 1, 2, 3, and 4 – boundaries of variations in the coal grading: R_o, V^{daf}, y, and ΣFC respectively

The most natural interconnection between the conditional indices of ranging series in terms of lower and upper boundaries of the recommended values has been identified for vitrinite response index R_o (Fig. 2a). The points are arranged evenly near a bisector of coordinate grid (1) and empiric straight line (2). In this context, they almost coincide.

There is a difference in the arrangement of the points determining the ratio between ranging indices in terms of lower and upper variations of V^{daf} index (Fig. 2b) and *y* index (Fig. 2c). In the majority of cases, the points are grouped in parallel either upwards of bisectors of coordinate grids or downwards of them. Thus, it is quite possible that R_o and *y* values were formulated experimentally in connection with other indices to determine both coal grades and their useful qualities.

To support the assumption, interconnection between conditional indices within the ranging series and indices of ranging series of R_o, V^{daf}, and *y* indices has been considered in accordance with industrial classification (*I*) in terms of their lower and upper boundaries (Fig. 3). The fact of synchronous changes in the indices of lower and upper boundaries of each index draws attention.

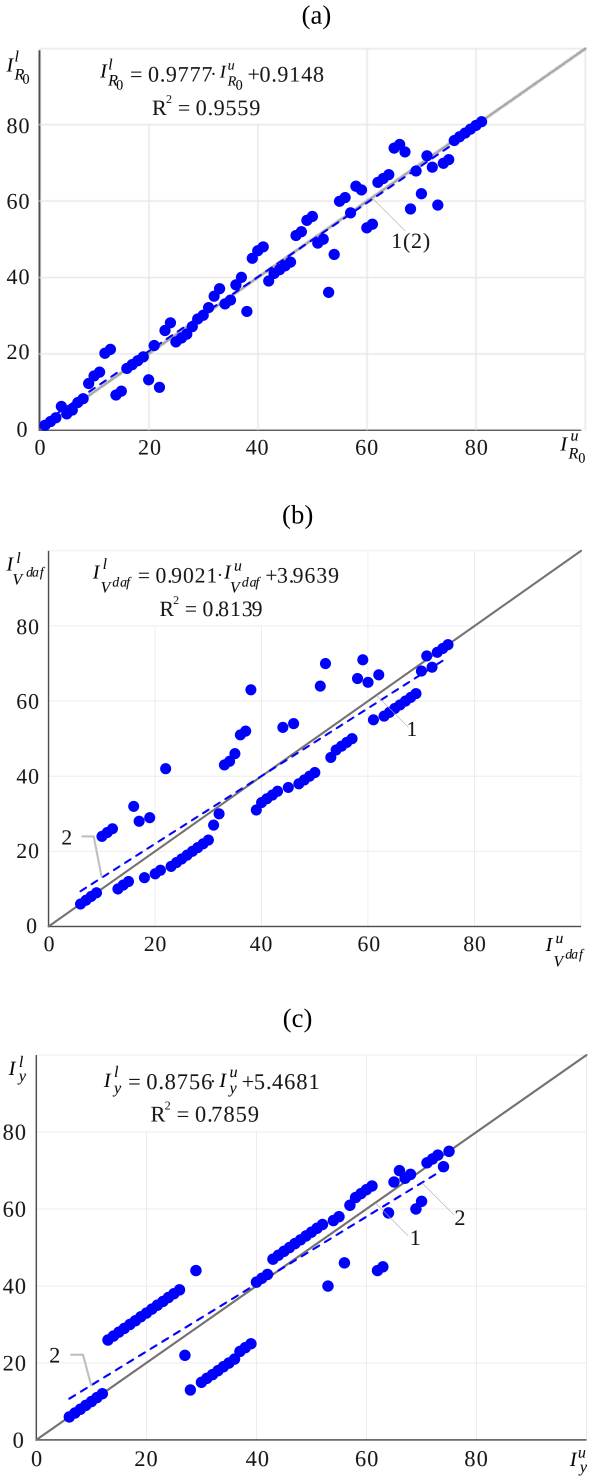


Figure 2. Interdependence between the indices of series ranged in terms of lower and upper values according to recommendations [5]:: (a) in accordance with R_o index; (b) in accordance with the graded index V^{daf}; (c) in accordance with the graded index y; $I^l_{R_0}, I^l_{V^{daf}}, I^l_y$ – conditional ranging indices of R_o, V^{daf}, and y on their lower values respectively; $I^u_{R_0}, I^u_{V^{daf}}, I^u_y$ – conditional ranging indices of R_o, V^{daf}, and y on their upper values respectively; 1 – bisectors of coordinate grids; 2 – linear regression lines; 3 – values of indices determined depending upon the ranging series of the appropriate performance variables

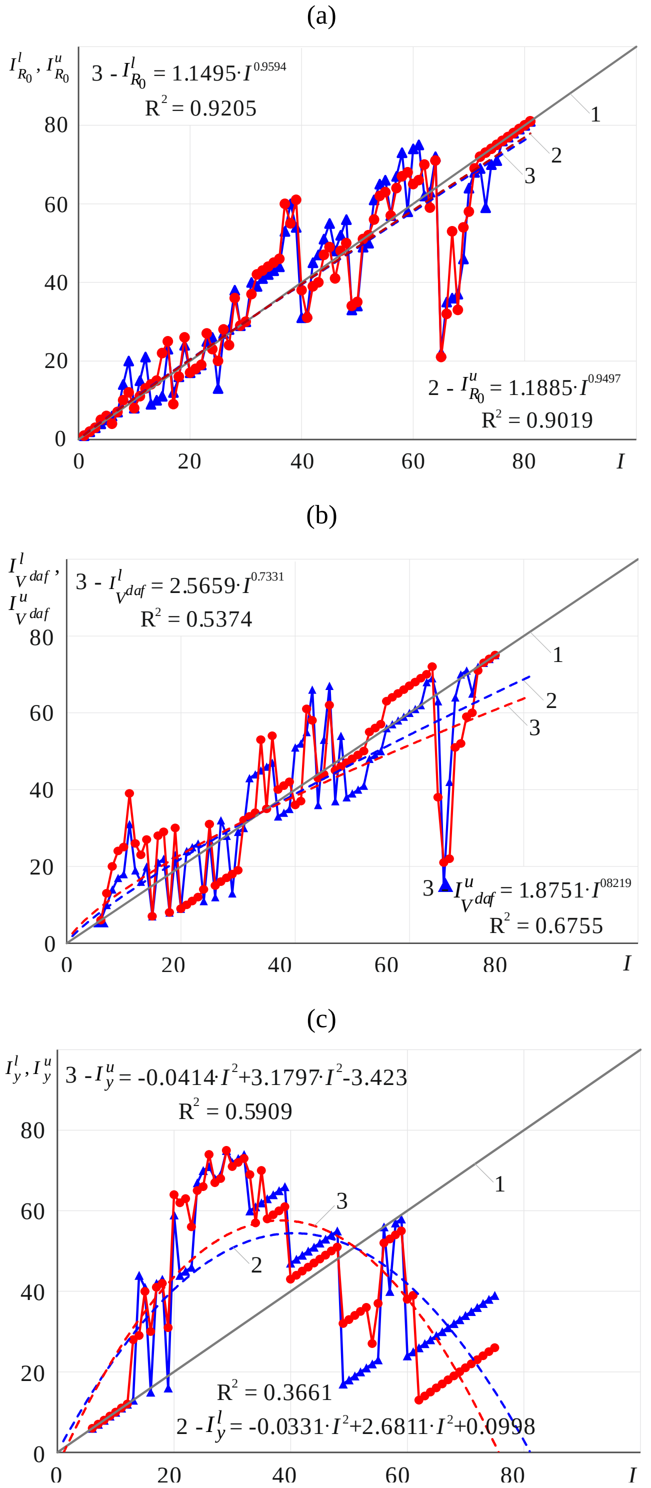


Figure 3. Dependence of the indices, ranged according to lower and upper boundaries of changes in I indices in the graded coal series according to [5]:: (a) classified R_o index; (b) classified V^{daf} index; (c) classified y index; $I^l_{R_0}, I^l_{V^{daf}}, I^l_y$ – conditional ranging indices of R_o, V^{daf}, and y in terms of their lower values; $I^u_{R_0}, I^u_{V^{daf}}, I^u_y$ – conditional ranging indices of R_o, V^{daf}, and y in terms of their upper values; 1, 2, 3 – bisectors of coordinate grids (1) of linear regression lines of indices determined according to values of lower (2) and upper (3) boundaries of changes in the criteria; — conditional indices of series ranged in terms of their lower values; and — conditional indices of series ranged in terms of their upper values

For instance, maximum deviation of the indices of lower and upper boundaries of vitrinite response values $I_{R_0}^{l}$ and $I_{R_0}^{u}$ from a bisection of coordinate grid (1) is observed to the higher side for I = 39 (Fig. 3a). Such an index value corresponds approximately to a central part of a probable coal metamorphism series from the viewpoint of grades. Coal of C grades, 2C group, and 2CF subgroup correspond to the index. Values of lower and upper boundaries of R_o value are 1.30 and 1.69% respectively. In terms of metamorphism degree, the values of variation boundaries should range the coal to the end of the probable series of geological transformation of coal. In the context of the case, their indices are 54 and 61 respectively.

Maximum deviation of $I_{R_0}^{l}$ and $I_{R_0}^{u}$ indices to the downside from a bisector of coordinate grid (1) was observed in terms of I = 65 (Fig. 3a). Coal CC grade of 1CC group corresponds to it. Values of R_o lower and upper boundaries are 0.70 and 0.79% respectively.

According to ranging, they should belong to coal with low metamorphism degree. Their indices within the ranging series in terms of lower $I_{R_0}^{l}$ and upper $I_{R_0}^{u}$ boundaries are 22 and 21 respectively (Table 1).

Similar abnormal deviations of conditional indices from a bisector of coordinate grid are observed while ranging V^{daf} criterion in terms of both lower and upper variation boundaries (Fig. 3b). For instance, if V^{daf} = 28%, then in terms of ranging scale, coal of LF grades, LFFU subgroup obtain I = 11 corresponding to a low metamorphism degree. As for the ranging in terms of lower and upper boundaries, $I_{R_0}^{l} = 31$ and $I_{R_0}^{u} = 39$ indices correspond to an average degree of coal transformation.

Significant differences in the indices of series ranging depending upon their metamorphic transformation degree with the use of V^{daf} index is typical for CSL coal degree, 1CSL group, and 2CSLV subgroup (V^{daf} = 16%; I = 43; $I_{V^{daf}}^{l} = 66$; and $I_{V^{daf}}^{u} = 58$); CSL grades, 1KSL group, and 2CSLF subgroup (V^{daf} = 16%; I = 46; $I_{V^{daf}}^{l} = 67$ and $I_{V^{daf}}^{u} = 62$); and LC grades and 1LC group (V^{daf} = 34%; I = 66; $I_{V^{daf}}^{l} = 15$ and $I_{V^{daf}}^{u} = 21$). In other cases, such differences are less sensible.

It is impossible to identify a tendency of coal metamorphic degree variance according to y criterion indices relying upon graphs (Fig. 3c). In the first half of coal ranging series (I < 30), I_{y}^{l} and I_{y}^{u} indices increase while decreasing in the second half (I > 30). In this case, there is no unilateral change in y index in terms of the intensified metamorphic transformations which is supported by the increase in conditional indices I. In this context, such graded index R_o increases and V^{daf} index decreases. The unilateral directivity of changes in R_o and V^{daf} indices is verified by their changes within the ranging series with the use of conditional indices I (Fig. 1).

At the same time, unilateral change in y index has been determined depending upon the conditional ranging indices $I_{V^{daf}}^{l}$ which is not typical for changes in I_{y}^{l} and I_{y}^{u} indices depending upon I (Fig. 3c). The abovementioned supports differences in coal metamorphism degrees in terms of their graded criteria R_o, V^{daf}, and y as well as in terms of their grades determined by the industrial classification [5].

The random selection (by experiments) while combining such graded indices as R_o, V^{daf}, and y to identify useful quality is supported by the decreased correlation criteria R^2 as well as consideration of features of changes in indices within the ranging series (Figs. 2 and 3). Close correlations have been determined between conditional indices of the ranging series in terms of minimal and maximal values of the graded criteria (Fig. 2).

In terms of R_o, V^{daf}, and y, they are 0.9559, 0.8138, and 0.7859 respectively. The correlation indices experienced their significant decrease while considering indices of lower and upper boundaries depending upon I criteria and taking into consideration coal grades (Fig. 3).

Hence, R^2 = 0.9019-0.9205 for R_o; 0.5374-0.6755 for V^{daf}; and 0.3661-0.5909 for y.

The data support the idea that determination of useful quality involved mainly metamorphic coal transformations according to a change in one of the basic indices, i.e. R_o. Above all, values of V^{daf} and y criteria are used to specify useful quality of coal rather than to characterize metamorphic processes during the previous geological periods.

In some cases, nonavailability of certain boundaries in changes of the graded indices may factor into various discrepancies in the correlation analysis results.

4. Conclusions

The detailed analysis of the ideas to develop industrial classification of coal grades according to their genetic and technological parameters has made it possible to identify their features while making conclusions to apply certain issues of the classifications to identify hazardous characteristics of workable beds in the process of mining:

– nonavailability of recommendations concerning selection of specific boundaries of changes in the graded indices for maximum water content per ash-free state; total of fusainized components per pure coal; semi-coking resin yield; volume volatile-matter yield; anisotropic vitrinite response; and free heaving ratio prevent from their use to identify hazardous characteristics of workable coal beds;

– relationship between the basic graded indices of vitrinite response and mass devolatization is available only within certain ranges of the changes. The research results have helped identify both lower and upper boundaries of changes in the mass devolatization;

– values of the plastic layer thickness together with a vitrinite response index make it possible to single out five typical zones in the series of coal metamorphic transformations;

– in the process of geological transformations, anthracite characteristics are the least understood. Specific boundaries of changes in additional criteria are not available in the context of maximum range width of changes in vitrinite response;

– availability of free heaving ratio for coal grades, occurring within the antipodal shares of metamorphic series of black coal, denotes the availability of similar characteristics in the context of different degrees of their metamorphic transformation.

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Щодо можливості застосування показників промислової класифікації вугілля для встановлення небезпечних властивостей шахтопластів

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Мета. Встановити характер зміни класифікаційних показників та їх відповідність маркам, групам і підгрупам однаковою мірою метаморфічних перетворень вугілля для виявлення небезпечних властивостей шахтопластів при веденні гірничих робіт.

Методика. За ранговою шкалою та зміною значень класифікаційних показників можна встановити марки, групи і підгрупи вугілля, що мають однакові властивості та однаковий елементний склад органічної маси. Градація вугілля передбачає посилення прояву ступеня метаморфічних перетворень при переході від бурого вугілля до кам'яного, а від нього – до антрациту.

Результати. Аналіз показника суми фюзенізованих компонентів показав, що ділення вугілля на категорії знаходиться в діапазоні менше 10 і більше 69%. При цьому в більшості випадків рекомендується його значення менше 39 або більше 40%, що не дозволяє встановити достовірні кореляційні зв'язки. Показник вільного спучування розглядається спільно з товщиною пластичного шару, що дозволяє мати кількісне визначення лише для вугілля марки Д і марок ТС, СС, Т. За значенням середнього показника відбиття вітриніту (0.8-1.4%), вугілля марок ТС, СС, Т можна віднести до вугілля, що займає середину ряду ранжирування. Це свідчить про наявні відмінності перетворення внутрішньої структури.

Наукова новизна. Виявлено характер зміни класифікаційних показників промислової класифікації вугілля для визначення небезпечних властивостей шахтопластів при проведенні гірничих робіт.

Практична значимість. Можливість вдосконалення нормативної бази безпечного відпрацьовування шахтопластів шляхом встановлення відмінностей у властивостях вітринітового та фюзинітового вугілля.

Ключові слова: *метаморфізм, самозаймання, елементний склад, вугілля*

О возможности применения показателей промышленной классификации углей для установления опасных свойств шахтопластов

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Цель. Установить характер изменения классификационных показателей и их соответствие маркам, группам и подгруппам одинаковой степени метаморфических преобразований углей для выявления опасных свойств шахтопластов при ведении горных работ.

Методика. По ранговой шкале и изменению значений классификационных показателей можно установить марки, группы и подгруппы углей, обладающие одинаковыми свойствами и элементным составом органической массы. Градация углей предусматривает усиление проявления степени метаморфических преобразований при переходе от бурых углей к каменным, а от них – к антрацитам.

Результаты. Анализ показателя суммы фюзенизированных компонентов показал, что деление углей на категории находится в диапазоне менее 10 и более 69%. При этом в большинстве случаев рекомендуется его значения менее 39 или более 40%, что не позволяет установить достоверные корреляционные связи. Показатель свободного вспучивания рассматривается совместно с толщиной пластического слоя, что позволяет иметь количественное определение только для углей марки Д и марок ТС, СС, Т. По среднему показателю отражения витринита (0.8-1.4%), угли марок ТС, СС, Т можно отнести к углям, занимающим середину ряда ранжирования. Это свидетельствует об имеющихся различиях преобразования внутренней структуры.

Научная новизна. Установлен характер изменения классификационных показателей промышленной классификации углей для выявления опасных свойств шахтопластов при ведении горных работ.

Практическая значимость. Возможность совершенствования нормативной базы безопасной отработки шахтопластов, путем установления различий в свойствах витринитовых и фюзинитовых углей.

Ключевые слова: *метаморфизм, самовозгорание, элементный состав, уголь*