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EXPERT SYSTEM FOR ASSESSMENT OF RISK FROM SPONTANEOUS COMBUSTION

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INTRODUCTION

Estimation of spontaneous combustion risk in mining of mineral resources, liable to self-heat, should start in the pilot stage of design and carry on during the whole lifecycle of a mine. Even after mine closure the self-heating risk remains an issue of environmental expertise.

Experience in many countries as well as experience in Bulgarian coal mining proved that underestimation or absolute lack of prediction for risk of self-heating in the stage of design had developed the application of exceptionally effective technological and other special preventive methods for self-heating risk mitigation either technologically impossible or economically unadvisable.

Number of technological parameters of methods for development and mining, laid down in the pilot stage of design, together with mine life-assuring systems specify the preliminary basis of the investment project. Right in the pilot stage, not only a prediction of risks but also a preliminary risk analysis of spontaneous combustion in the future mine is needed according to modern concepts for safety. This procedure is compulsory as it specifies requirements toward construction and detailed technological design of mine systems in the next stage.

In next conceptual stages of design, an optimization of different systems is required by comparing the $\frac{benefit}{risks}$ ratio for each option and selecting the system of maximum ratio. Each of the risks should be brought to an acceptable level in advance. However, materialization of spontaneous combustion risk involves hazard of not only economic but also severe human losses, and it may not be neglected in optimizing and decision making.

Real consequences of each spontaneous combustion depend on efficiency of methods applied to control its development. That is why assessing future consequences at the pilot stage of design seems unrealistic. The only reasonable approach at this stage is focussing the efforts on minimization of risk, i.e. reducing the probability or frequency of spontaneous combustion at the mine. Acting safety guides regulate a general principle for downward mining of coal seams liable to self-heat. Developing a specific instruction for prophylactics and extinguishing of spontaneous combustion in the mines is an obligation for each coal basin.

After a comprehensive analysis of the systems operating in other countries, the present article suggests a new system **SES** (SPONCOM EXPERT SYSTEM) for assessment of spontaneous combustion risk.

RECENTLY EXISTING EXPERT SYSTEMS

Severe consequences of underground mine combustions directed efforts of researchers toward investigating the reasons for high combustion risk in coal mines. As a matter of tradition, each country started its investigation by categorizing coal seams according to their natural predisposition to oxidation under low temperatures by analyzing coal ability to self-heat.

Later investigations were directed to influence of other natural factors on spontaneous combustion risk. Variety of methods of mining and technological parameters, which effected combustion risk, involved a search of approaches for categorising the mining technologies and ventilation schemes, according to combustion risk. Attempts for statistical differentiation of these factors into different groups of combustion risk did not provide a sufficiently reliable reason for applying this approach for categorization even in countries of extremely powerful mining industry. Modeling the effect of those factors on intensity of self-heating and a comparative expert estimation of combustion risk related to mining systems, ventilation schemes, abandoned coal losses, air leakage though fractures and porous media were the categories for grouping of mining and technological factors, at a particular grade level, in modern systems for spontaneous combustion risk analysis.

The system of the National Coal Board (NCB) (*Gill et al., 1971*) for estimation of self-heating risk included 6 natural characteristics F_i of the coal seam. The estimation itself of spontaneous combustion risk F_E was calculated by the dependency:

$$F_E = \left(\sum_{i=1}^{4} F_i \right) . F_5 . F_6 \qquad (1)$$

where: F1 – rate of coal metamorphism [grade];
F2 – pyrite mineralization of coal [grade];
F3 – hardness of coal [grade];
F4 – humidity of coal [grade];
F5 – natural temperature of coal [grade];
F6 – thickness of coal seam [grade];

There were 3 categories for risk of coal self-heating ability – low, medium and high risk. The system of former NCB, in spite of claiming to allow an estimation of spontaneous combustion risk in mines did not take into consideration the natural liability of coal seams to self-heat. Evidently, the authors definitively connect the natural liability of coal to oxidation under low temperature to the first four $\left(F_1 ... F_4\right)$ characteristics. However, mining practice did not confirm an analogy like that one. An example would be the comparison of spontaneous combustion risk of lignites at the West Maritsa basin to combustion risk of brown coal at the Bobov dol basin. This conceptual omission, in the NCB system, of the only characteristic that might be directly determined made impartial analogies to already developed coalfields impossible. The absence of coal seam ability to self-heat made the system rather approximate and even an analogous verification of expert results was not possible.

Relation between characteristic of natural ability of coal to self-heat and mining and technological factors, effecting on spontaneous combustion risk might be found out in the Polish system for estimation *(Karpov et al., 1981*). In the estimation (*PS*) the grade values S_i of the following factors were summed up:

S1 - Method of Mining [^{o}C/min];
S2 - rate of coal recovery [^{o}C/min];
S3 - Direction of mining the coal seam [^{o}C/min];
S4 - Approach for isolating the goaf area [^{o}C/min];
S5 - humidity of coal [^{o}C/min];
S6 - Rock stress and fractures in the coal seams [^{o}C/min];
S7 - intensity of ventilation of mine workings in the coal seams [^{o}C/min],

With the characteristic of ability to self-heat, as follows:

$$PS = S_z^b + \sum_{i=1}^{7} S_i \text{ , [}^o\text{C/min]} \qquad (.2)$$

Coal fields were subdivided into non-combustion risky, semi- and combustion-risky according to propensity for spontaneous combustion **PS**. The criterion of Olpinski (S_z^b) was accepted as a characteristic of coal ability to self-heat. It was determined by speed of temperature rise of heated coal for 1 min under laboratory conditions (*Maciejasz Z., 1972*). There were four categories for self-heating ability – lower, intermediate, upper intermediate and higher according to the value of S_z^b .

The described system made an attempt for binding natural liability of coal seams to self-heat to the technological factors for combustion risk estimation. Even more, the expert system reflected also factors, which reduced spontaneous combustion risk. A more common application of the system was restricted due to the following difficulties:

- Results of the method of Olpinski were not reliable for ability to self-heat of brown and lignite coals;
- The enormous weight appropriated to the factor S_z^b of ability to self-heat of coal in the overall estimation (2) of combustion risk was unrealistically high. Furthermore, all the methods for determining coal ability to sel-heat gave results, which varied within a wide range along the coal seam. The method of Olpinski was not an exception.

Not avoiding above remarks about significance of S_z^b it was worth emphasizing that factors S_i of that system provided an estimation of spontaneous combustion risk more complete than any other one.

The German system for estimation of spontaneous combustion risk (*Sudilovskii et al., 1988*) appropriated higher weight to the ventilation scheme and ten geological and technological factors B_i. Estimation was calculated for each ventilation scheme by the dependence:

$$D_e = \sum_{i=1}^{10} \left(B_i \bullet W_i \right) \qquad (3)$$

The expert appropriated to each factor B_i a weight W_i within the range from 1 to 10 and selected estimation B_i within discretely defined boundaries of the system. The expert gave his estimation for the following ten $(i = 1...10)$ factors B_i:

B1 - grade of metamorphism of coal [grade];
B2 - angle of coal seam dip [grade];
B3 – thickness of coal seam [grade];
B4 - pyrite content [grade];
B5 - tectonic faults [grade];
B6 - presence of admixtures in the roof [grade];
B7 - pillars [grade];
B8 - filling up of the goaf [grade];
B9 - filling up of caved out area in the shafts [grade];
B10 – air leakage [grade];

That system was more realistic in the aspect of technical factors. Weight, appropriated by the expert to each factor made incomparable the estimations of different experts. In this sense, the insufficiency of information for formalizing the estimation was substituted by the expert estimation, which was heavier than unbiased grades of factors in it. The system took indirectly into account the type and concentration of losses of coal along the caved out area, where most of spontaneous combustion originated, but that consideration was not relevant to modern mining technologies.

In 1995 the Pittsburgh Research Centre (PRC) of the former US Bureau of Mines put into practical use a computer program for estimation of spontaneous combustion risk, called **SPONCOM** (Spontaneous Combustion). Risk within that program was assessed according to grade effect of the following factors:

- ⇨ ***Characteristics of coal***, which effected on the rate of heat generation – reactivity, moisture content, pyrite and other inclusions. Three categories for ability to self-heat of coals were introduced: higher, medium and low. Coal critical self-heated temperature (SHT) was used for categorizing the relative reactivity of coal for spontaneous combustion. Black coal of different coal basins and seams revealed significant correlation between content of oxygen and spontaneously heated temperature SHT, and therefore the critical temperature was (*Guide on occupational …, 1992*). Humidity of coal was also considered an important factor for development of self-heating.
- ⇨ ***Geological factors*****,** considered as decisive for the system are: depth and angles of dip of the coal seam, thickness of coal seam, geothermal gradient, number and frequency of coal seams in the coal formation (seam density), availability of geothermal sources and old combustion sources, availability of geological faults, availability of an over-layer and pyrite formations immediately close to the mined out seam.
- ⇨ ***Mining conditions****:* method of mining; functions of pillars (supporting or isolating); rate of fitting of ventilation flow to the caved out area and refreshing of the ventilation scheme; slope of bottom of mined out area; sizes of panel and longwall, quantity of air for ventilating the longwall and leakage in the caved area; sources of spontaneous combustion in mined out areas or working zones, incoming or outgoing openings in mines, in pillars, hoppers or other mines exploiting the same seam; air temperature and humidity.

An undoubted advantage of the SPONCOM program was the attempt for specifying in details the mining and technical factors and involving of data about factual combustion risk of coal seams. The unrealistically high weight of self-heating ability, which had been defined in the Polish system, was overcome in the SPONCOM program. Disadvantages of the system for estimation, employed as a SPONCOM basis, were the high precision of formalisation of some of the factors without allowing their natural variation and the genetic impossibility for determining spontaneous combustion risk of mines, operated by different mining technologies. As all other systems of that kind it suggested an expert opportunity for determining self-heating risk as a probability. In spite of the evident advance it did not allow an estimation of sel-heating risk, because it did not present an approach for predicting the consequences of spontaneous combustion. Referring to brown and lignite coals that will be of increasingly higher interest in the future, obtaining of stable and formalized average estimations of SHT will be a serious difficulty.

FACTORS IN THE SES SYSTEM FOR ASSESSMENT OF RISK FROM SPONTANEOUS COMBUSTION

The **SES** system is especially useful for development of new deposits, sectors and coalfields in the case of insufficient statistical data for assessment of self-heating ability risk under similar conditions. It might be successfully applied into the search of technological changes, schemes for uncovering and mining in the aspect of prediction.

The following important natural and technogenic factors for estimation of spontaneous combustion risk were selected and incorporated in the suggested system.

1. Self-heating ability of coal seams

Self-heating ability of coals S^1	Factor *S* depending on coal metamorphism, determined by temperature interval				Grade estimation S^1
	Anthracites (150 – 200)°C	Black (150 – 200)°C	Brown (125 – 175)°C	Lignites (100 – 150)°C	
Lower ability	**< 8**	**< 9**	**< 10**	**< 4**	**1 - 2**
Intermediate ability	**8 - 12**	**9 - 15**	**10 - 16**	**4 - 8**	**2 - 6**
Higher ability	**> 12**	**> 15**	**> 16**	**> 8**	**6 -10**

2. Thickness of coal seam

m	< 1.20	1.20 - 2.40	2.40 - 3.20	> 3.20
S^2	**1**	**2 - 3**	**3 - 5**	**6 - 10**

3. Slope of coal seam

deg	0 - 15	15 - 30	30 - 45	45 - 90
S^3	**1**	**2**	**3**	**4 - 5**

4. Release of methane

$q,\ m^3 / Mg$	0	less than 5	5 - 10	10 - 15	> 15
S^4	**0**	**1**	**2 - 3**	**3 - 5**	**6 - 8**

5. Tectonic faults

faults	Not available	Low frequency	High frequency
Frequency along the strike	0	Less than 2/500m	More than 2/500m
S^5	**0**	**1 - 3**	**4 - 6**

6. Fitting of ventilation flow to the caved area

Rate of fitting	Ventilation schemes	S^6 for speed of air, *m/s*		
		≤ 0.5	> 0.5 ≤ 1	> 1
Single fitting	UR, WR	**1**	**1.5**	**2**
Double fitting	YR, ZR, ZA	**3**	**3.5**	**4**
Triple fitting	HA, HR,YA, UA	**6**	**6.5**	**8**
Four-time fitting	WA	**8.5**	**9**	**10**

7. There are pillars, unmined coal seam, co-seams that belong to the zone of caving in the caved out area

Loss of coal	No	Limited	High
S^7	0	1 - 4	5 - 10

8. Natural temperature of coal in the massif

t^n_{coal}	15-20	20-25	25-30	30-35	> 35
S^8	**1**	**2 – 3**	**3 - 5**	**5 - 8**	**8 - 10**

9. Temperature and humidity of ventilation flow in risky zones for self- heating ability

t_{air}	S^9 for relative humidity of air, %		
deg C	< 65	65 - 80	> 80
15 - 19	**-3**	**-2**	**-1**
20 - 25	**0**	**1**	**2**
26 - 30	**2-3**	**3-4**	**3-5**
> 30	**5-6**	**6-7**	**6-10**

10. Prophylactic work for the caved area - S^{10}

Hydraulic filling	**- 10**
Inertizing of media	**- 8**
Pneumatic filling	**- 7**
Injection of frothed structures	**- 7**
Blocking with slurry	**- 5**
Powdering, blowing and injection of antipirogens	**- 3**
Necessary but not applied	**0**

11. Prophylactic work for pillars and ventilated contour of the caved area - S^{11}

Construction of artificial pillars for the shafts	**-10**
Filling of caves behind the support with hydraulic binding materials	**-8**
Filling of caves behind support with frothed materials	**-7**
Construction of artificial isolating pillar in the entry	**-6**
Injection of antipirogens in the shafts	**-4**
Necessary but not applied	**0**

The following conditions should be considered in the estimation of significant factors. Self-heating ability S^1 was estimated by the apparatus of Maevskaya (*Maevskaya et al., 1972*). Some unpublished data are presented below from investigations on gaseous characteristic of coal seams from the West Maritsa basin and the Dobroudja basin, which were used for determining the S^1.

In the type of schemes for ventilation, coded in the characteristic S^6, where indexes of schemes have the following two meanings:

* Inverse order of excavation -"R";
* Direct order of excavation - "A".

The characteristic S^2 showed the average thickness of coal seam within the boundary or coal field. High variations in the thickness of coal seam were shown by the characteristic S^5.

Last two characteristics have a negative grade value, corresponding to rate of reduction of spontaneous combustion risk in the sites of the most frequent self-heating. Those sites form a significant portion of the risk from spontaneous combustion, which is assessed in the aspect of prediction.

Categories, introduced by each of those 11 factors may be supplemented under observation of relative grade distance of the new category from the known and fixed ones.

FORMALIZING THE ESTIMATION AND CATEGORIZATION OF COMBUSTION RISK IN SES

These characteristics are used for calculating the spontaneous combustion risk according to the dependence :

$$D_S = \sum_{i=1}^{11} S^i \qquad (4)$$

Depending on the value of D_E fields and sites are categorized as:

$$\left.\begin{array}{ll} \textit{lower risky} & D_S < 22 \\ \textit{threathened} & 23 < D_S < 39 \\ \textit{risky} & 40 < D_S < 60 \\ \textit{higher risky} & D_S > 60 \end{array}\right\} \qquad (5)$$

When a spontaneous combustion is registered in the same seam in the vicinity of planned for mining field, the planned field appropriates a category of spontaneous combustion risk one unit higher than the category, determined by (5).

An example of the application of the system is shown in table 1. The threatened seam should be referred to the category "Risky" if an spontaneous combustion is registered in the same seam close to the projected field. The threatened seam from table 1 with a value $D_S = 24$ may be re-categorized in the aspect of prediction, as low risky if some antipirogens or blocking with slurry is applied - see tables of values for S^{10}.

Similarly to each other expert system, the SES also involves specifying the reliability of estimation of different experts. Critical is the case, when different experts put the projected site into different categories by their estimation (5). In those, and only those cases, experts are allowed to give different value Đå of analyzed factors, as this is shown in table 2. During the re-estimation experts re-order factors, according to their view about importance of factors and give them a consecutive number, from one to the number of factors in the table – for the example in the table – from 1 to 9.

Table 1

F A C T O R	0	1	2	3	4	5	6	7	8	9	10	Estimation of system S^i
1. Self-heating ability of coal seam						5						5
2. Thickness of coal seam				3								3
3. Slope of coal seam			2									2
4. Release of methane			2									2
5. Tectonic faults		1										1
6. Fitting of ventilation flow to the caved area		1.5										1.5
7. There are pillars, unmined coal seam, co-seams that belong to the zone of caving in the caved out area				3								3
8. Natural temperature of coal in the massif			2									2
9. Temperature and humidity of ventilation flow in risky zones for spontaneous combustion					4							4
TOTAL		**2.5**	**6**	**6**	**4**	**5**	**0**	**0**	**0**	**0**	**0**	**23.5**
ESTIMATION OF SPONTANEOUS COMBUSTION RISK	**T H R E A T E N E D**											**24**

Table 2

F A C T O R	Expert opinion Pe	Pe x S^i	0	1	2	3	4	5	6	7	8	9	10	Estimation of system S^i
1. Self-heating ability of coal seam	**7**	*49*								**7**				**7**
2. Thickness of coal seam	**6**	*30*						**5**						**5**
3. Slope of coal seam	**2**	*2*		**1**										**1**
4. Release of methane	**8**	*32*					**4**							**4**
5. Tectonic faults	**3**	*9*				**3**								**3**
6. Fitting of ventilation flow to caved area	**1**	*2*			**2**									**2**
7. There are pillars, unmined coal seam, co-seams in the caved out area	**9**	*54*							**6**					**6**
8. Natural temperaure of coalin the massif	**5**	*25*						**5**						**5**
9. Temperaure and humidity of ventilation flow in riskous areas	**4**	*16*					**4**							**4**
TOTAL	**45**	**21**	**0**	**1**	**2**	**3**	**8**	**1**	**6**	**7**	**0**	**0**	**0**	**37**
ESTIMATION OF SPONTANEOUS COMBUSTION RISK	**43.8**		**R I S K Y**											**37**

In those cases calculation of re-estimation is carried out according to the dependence:

$$DE = i \times \frac{\sum_i \left(S^i \times \left| P_i^E \right| \right)}{\sum_i P_i^E} \qquad (6)$$

For the example in table 2, two experts refer the analyzed seam to two different categories – threatened and risky. In the last column of the table, the estimation of the expert referring to a lower category is shown as an estimation of system.

After re-ordering of factors in column two according to their significance, and dividing the total $\sum_i \left(S^i \times \left| P_i^E \right| \right)$ in column 3 to the total $\sum_i P_i^E$ of column two and multiplying to the number of factors, used in the estimation $i = 9$ the re-estimation adopts the value DE = 43.5 and the threatened seam transfers into the category of risky ones.

The described procedure was performed by at least two experts as follows. First of all, each of the two experts completes his estimation S^i in the last column of table 1. If the total estimation D_s calculated by (4) refers the seam to one and the same category (5) the final estimation is adopted within boundaries of variation of individual estimations of the experts.

However, engineering prophylactic decisions – groups S^{10} and S^{11} have to be transferred to a lower risk category from a higher one.

When the total estimation D_s of two experts, calculated according to (4) refers the seam into different categories (5) the data, the have completed into sample-table 1 are re-copied in the last column of the sample of table 2. Each expert is given a table, which contains the estimation of the other expert and he has to re-order the factors in the second column, according to his own opinion. This crossing of estimations usually brings the re-estimation closer to only one category (5). If there is no bringing closer, the re-estimation is repeated and each expert works with his own initial estimation.

SELF-HEATING ABILITY OF COAL SEAMS

In the period 1979-1986, according to requirements of (*Guide on occupational …, 1992*) the employed coal seams in Bulgaria were categorized according to Self-heating ability (*Markov et al., 1989; Hristov et al., 1982, 1984; Michaylov et al.., 1984, 1980; Nanovska et al., 1985*), by the method of gaseous characteristic. Later, in 1993 the same method was applied for analyzing also samples from the deposit near the town of Bitolia in the Republic of Macedonia. The method of investigation (*Markov et al., 1989*) and data about self-heating ability of coal seams from the Bobov dol basin, which showed the highest value of the gaseous characteristic S, were published in (*Markov et al., 1989*).

A generalization of results and conclusions from investigations (*Markov et al., 1989; Hristov et al., 1982, 1984; Michaylov et al.., 1984, 1980; Nanovska et al., 1985*) is done in the table of the first factor S^1 of the SES system. The effective use of SES requires publishing of available data for the factor of gaseous characteristic S from investigations on coal basins in Bulgaria. Nevertheless of conservation taking place nor closure of some mines and sectors, reserves that may not be extracted in an economically acceptable way now, are supposed to be utilized in the future by either traditional or innovative methods. Due to restrictions of this edition only bench marking data for self-heating ability of coal from the West-Maritsa basin and Dobroudja coalfield will be presented.

Lignite coals, mined at the West-Maritsa basin, according to results in (*Michaylov et al., 1980*), are characterized with significantly lower propensity for oxidation. The gaseous characteristic S is calculated in the temperature interval 100 – 150 °C. This temperature interval is confirmed by the analysis of self-heating ability of coal from the East-Maritsa basin and the Sofia basin. The highest is self-heating ability of the "roof" seam, followed by "extra" seam and "bottom" seam. The lowest self-heating ability of coal, according to average data, in the West-Maritsa basin has the "Shompol".

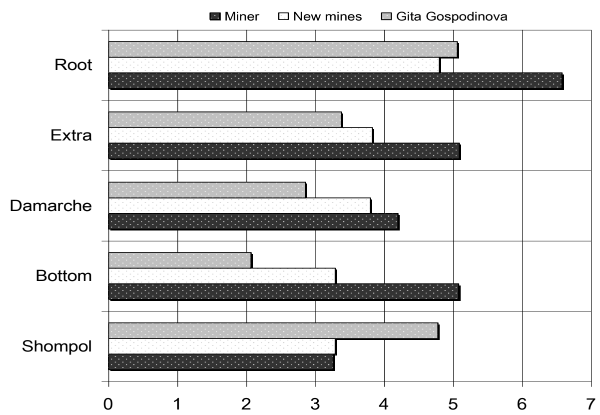


*Figure 1. Minimum values of **S** (on the x-axis) in the mines of the West-Maritsa basin*

A comparison of minimum and maximum values of self-heating ability is shown in figures 1 and 2. In the scale of generalization it may be considered that there is a tendency of reduction of self-heating risk along the thickness. Minimum values of spontaneous combustion risk vary within the boundaries from 2.1 to 6.5. The lowest spontaneous combustion propensity (absolute minimum observed) has the "bottom" seam at the "Gita Gospodinova" mine (fig. 1).

Maximum values of self-heating ability is shown by the coal seam in the field of "Miner" mine, as a whole and especially the first two sub-seams (fig. 2). Similar, but a little lower are the values, established in control analyses at the "Zfravets" mine.

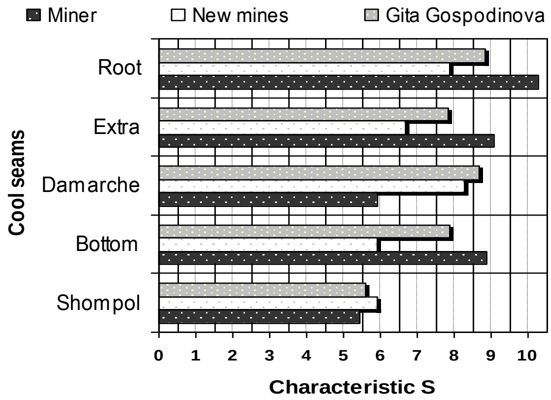


*Figure 2. Maximum values of **S** (on the x-axis) in the mines of the West-Maritsa basin*

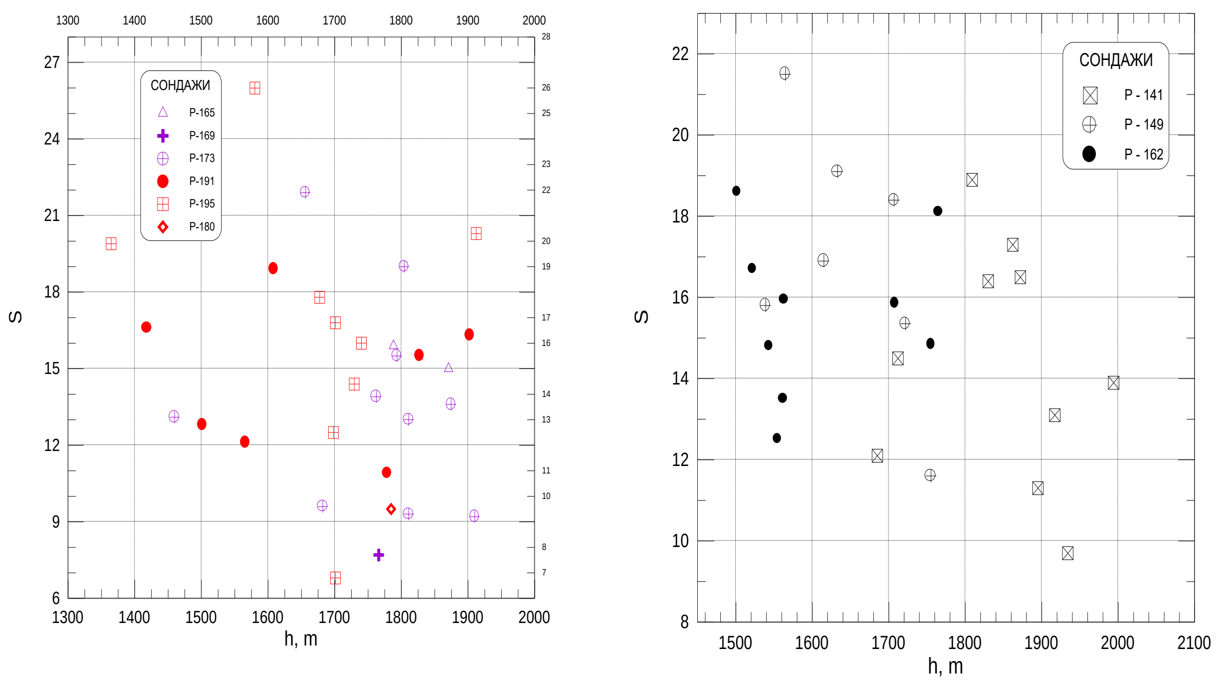
Even generally lower than ability of Bobov dol brown coal, self-heating ability of lignites from the West-Maritsa basin are variable enough for their categorization. The value of the characteristic S of that propensity varies for the sub-seams of coal layer from 2.07 to 10.28, i.e. 5 times. This is a rather wide range for their categorization.

The highest variation is shown by the "bottom" sub-seam. The highest variation of self-heating ability of coal seams is shown in the field of "Gita Gospodinova" mine, followed by the "Miner"mine.

The characteristic of self-heating ability S of coal samples (*Michaylov et al., 1980*) from the Dobroudja coal deposit varies as it is shown in fig. 3 – fig. 5. Denotations in fig. 3 and fig. 4 show the numbers of relevant wells.

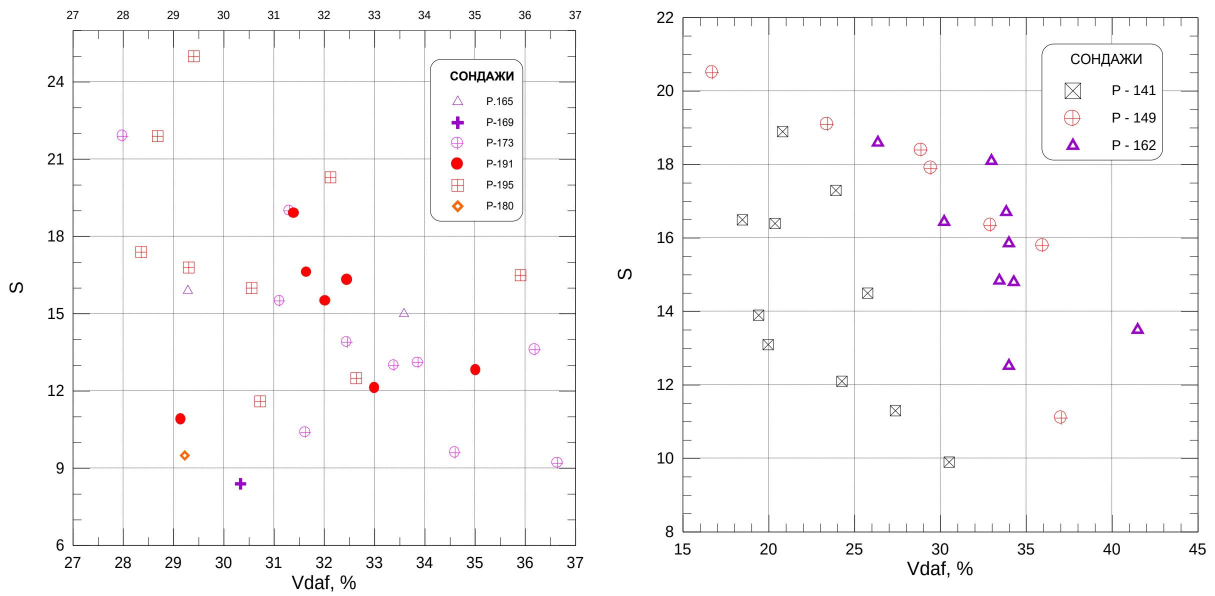
With the increase of depth from the surface self-heating ability (fig. 3) decreases. This tendency is important and favorable but it should not be forget that S^1 is only one of the factors, determining the estimation of combustion risk.

The tendency, even a fuzzy one, for reducing the factor S was observed and it increases with the increase of volatile content (Fig. 3).



a *b*

Figure 3. Effect of the depth of occurrence h on the characteristic S for wells of ID numbers, shown in the denotations



a *b*

Figure 4. Effect of volatile content V_{daf} on values of S for wells of ID numbers, shown in the denotations

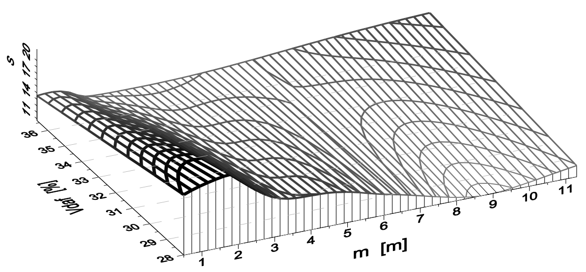


Figure 5. Effect of volatile content and seam thickness on self-heating ability

This tendency is more typical than unexpected. Its fuzz, according to data from analysis (Nanovska et al., 1985) may be explained by the differences of endogenous fracturing of coal and less with the character of pyrite mineralization.

Deviation from that tendency is observed for coal seams and sub-seams of thickness lower than 2.5 m (fig. 5) for which the natural propensity for oxidation under normal temperatures remains higher and reduces very little with the increase of content of volatiles.

CONCLUSION

A System for estimation of spontaneous combustion was developed in the aspect of prediction. The system overcame some disadvantages of well known similar methods for estimation by a selection of factors and definition of their importance, reasoned by experience of coal mining in Bulgaria. Two of the factors considered also the mitigation of combustion risk due to engineering prophylactic decisions. Two categorizations were suggested: categorizing of coal according to liability to self-heat depending on class of metamorphism and exploitation sites – according to spontaneous combustion risk. A procedure for approximating the estimations of two groups of experts was developed in the case of significant differences in the categorization of sites according to spontaneous combustion risk.

Data from studies on gaseous characteristic S of coal from the West-Maritsa basin and borehole samples from the Dobroudja coal basin were revealed. Data illustrated typical tendencies in the differentiation, variation and influence of different factors on coal ability to self-heat.

The SES system allowed an estimation of spontaneous combustion risk for mining of new coal deposits, fields and sectors. In recently acting mines it may be applied to estimating the efficiency of changes in technology and application of new methods for prophylactics of spontaneous combustion in the aspect of prediction. The system is universal enough and the only requirement to be adapted for application into other countries is the way of calculation of S^1 according to the method for investigating the self-heating ability of coal.
No matter if potentially prospective deposits and abandoned reserves in Bulgaria will be developed by traditional mining technologies or non-traditional methods, without coal excavation, will be applied the spontaneous combustion risk will significantly effect the selection of future method of exploitation and its parameters.

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