



RESEARCH OF THE CONDITION OF REGIONAL PARTS OF MASSIF AT LONGWALL MINING OF PRONE TO SPONTANEOUS IGNITION COAL SEAMS

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ABSTRACT

Main objective of the executed researches was assessment of the strain-stress condition of regional parts of pillar for definition of a possibility of formation of coal congestions, prone to spontaneous ignition, in goafs of extraction longwall panels. Analytical researches were carried out for the wide range of geological and mining conditions of mining of flat coal seams by longwall. When performing researches equations for definition of the strain-stress condition of regional parts of the coal pillar were used. As a result of researches the sizes of zones of critical condition for various conditions are determined and the conclusion is drawn on need of accounting of a condition of regional parts of coal pillars for an exception of conditions for emergence of the endogenous fires. The novelty of research consists in taking note of a condition of regional parts of coal pillar and establishment of dependence of the strain-stress condition of regional parts of coal pillars on the major mining-and-geological factors.

Key words: underground mining, coal seams, spontaneous ignition, longwall, coal pillar, strain-stress condition, zone of coal sloughing, analytic investigation

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1. INTRODUCTION

Underground coal mining remains one of the most dangerous types of activity of the person in Russia. In the last decade on coal mines of Russia there were more than 10 major accidents which claimed several hundreds of the human lives. In this regard questions of ensuring safe mining of coal seams remain very important and are considered in works of many scientists [1-15]. The problem of safe mining of coal seams, prone to spontaneous ignition, is one of the most important problems of the coal-mining industry of Russia. Now more than 70% of seams of the Kuznetsk coal basin (to which share more than 65% of all coal mining in Russia fall), belong to prone to spontaneous ignition. More than 30% of all accidents in mines and up to 60% of damage of their emergence are the share of the endogenous fires. The complexity of fight against the endogenous fires is caused by their emergence mainly in the goaf of mines. It is necessary to emphasize that the endogenous fires significantly increase danger of ignition of methane and, according to a number of scientists, are the prime cause of a number of the accidents with catastrophic consequences caused by explosions of mine methane.

According to modern scientific ideas of the nature of emergence and the mechanism of course of self-ignition of coal, the endogenous fire danger of mine fields is defined by a complex of natural and mining factors. Treat natural factors: chemical activity of coal and a geological structure of the field (seam height, seam inclination, etc.), and to mining - factors which are directly connected with coal seam mining (longwall speed, a ground control, coal loss, etc.). At the same time it is noted that the chemical activity of coals is important, but the possibility of self-ignition of coal is defined not only chemical activity, but also external conditions in which there is a congestion of the disintegrated coal. Thus, the significant effect on possibility of the endogenous fire at mining of the seam inclined to self-ignition, is rendered by the concrete mining situation defined, first of all, used by option of a system of mining and the scheme of ventilation of the longwall panel (and their parameters) [16-24]. At the same time the complexity of definition of extent of influence of various factors and considerable divergences at expert assessment of degree of their importance cause need of creation and scientific justification of a technique of assessment of the impact of mining and geological factors on the probability of emergence of self-ignition of coal and forecasting of possibility of the endogenous fires at mining of the seams prone spontaneous to ignition.

Considering the conditions promoting coal self-ignition it is necessary to emphasize that emergence and development of the endogenous fire is defined by positive thermal balance in a coal congestion, presence of sufficient volumes of such congestions and chemical activity of coal. In this regard definition of a condition of the regional parts of massif and pillars formed in the goaf after longwall, especially at application of the schemes of ventilation providing removal of firedamp through the goaf is of considerable interest. Questions of the choice and justification of parameters of schemes of ventilation and methane management are in detail considered in other works [16-24]. Transition of regional parts of the massif and pillar (or their parts) under the influence of bearing pressure brings to critical condition to development of jointing and permeability of the massif, a coal sloughing with formation of considerable congestions of the disintegrated masses that is the reason of increase in speed of course of thermochemical reaction between coal and oxygen. The special attention is required by

questions of a research of temperature fields, the system analysis and management of process of self-ignition of coal [25-31]. It should be noted that the large number of authors [32-49] who made the significant contribution to ensuring geomechanical safety of underground mining operations were engaged in geomechanical justification of parameters of technological schemes.

2. METHODS

For the purpose of ensuring endogenous fireproof mining of the seams prone to spontaneous ignition, the analytical researches directed to establishment of influence of the major geological and mining factors on the strain-stress condition of regional parts of the coal pillars and a possibility of formation of congestions of coal in zones of the goaf with the increased gas permeability at mining of the seams prone to spontaneous ignition were conducted.

When carrying out researches as initial the following geomechanical parameters were accepted:

- - seam height (m) from 1 m to 3.5 m, seam inclination to 35 degrees;
- - the average volume density of rock formation: 2.5 t/m³;
- - parameters of the strength certificate of coals (by results of laboratory researches): strong coals – K=25-40 of kgf/cm²; ρ=30-37 degrees; the broken coals K=1.0-6.0 kgf/cm²; ρ= 12-30 degrees; for seams of the non-uniform building (the disturbed and strong packs alternate) parameters of strength certificate were determined as average by the height of the packs presented in it.
- - constant of friction (f): coal-coal is f=0.2-0.3; coal rock is f =0.25-0.4;
- - stress concentration factor (χ) vertical components (σ_l) of tension in corresponding to the maximum value of bearing pressure at the set mode of a longwall: - in the presence of the main roof of hard roof type: $\chi=3.0$; at "other" main roofs: $\chi= 2.0$;
- - depths of mining (H) were from 100 to 1000 m;
- - mining of seams by longwall.

When carrying out researches the following settlement scheme of assessment of parameters of bearing pressure in regional parts of the pillar (massif) (figure 1) was used. As the estimated parameters in a zone of bearing pressure are considered:

- - extent of area of critical condition (lp);
- - extent within lp of a zone of coal sloughing (l_{OT});

The size of a zone of critical tension (lp parameter) can be determined by an equation:

$$l_{CC} = \frac{1}{a} \cdot \ln \left[\frac{\chi \cdot (\gamma \cdot H)}{k' \cdot \nu} \right], \text{ (cm)} \quad (1)$$

where: $a = \frac{2 \cdot f \cdot \lambda}{m}$, (1/cm); f – constant of friction coal-coal; $\nu = \frac{2 \cdot \cos \rho}{1 - \sin \rho}$, $\lambda = \frac{1 + \sin \rho}{1 - \sin \rho}$

ρ - angle of internal friction (градусы);

$k' \approx 0,75 \cdot k$ – adhesion factor of coal in critical zone, kgf/cm²;

k – adhesion factor;

m – мощность пласта; см;

$(\gamma \cdot H)$ – vertical components (σ_l); ($\sigma_z \approx \gamma \cdot H$) overburden pressure (kgf/cm²);

χ - stress concentration factor.

In figure 3 results of calculation of extent of zones of a coal sloughing and critical stands at various values of parameters are presented: depth of mining and height of the seam. Follows from figure 3, A that depth of mining has significant effect on extent of the considered zones. At change of depth of mining from 200 to 1000 m, value of the considered parameters increase approximately four. Increase in height of seam (figure 3, B) in the range of 1-3.5 m leads to growth of size of the l parameters and l_{CC} by 3.5 times.

The received results testify to need of accounting of a number of factors which are among: depth of mining, height of seam, coal strength on a condition of regional parts of seam and probability of self-ignition of coal.

The executed researches of influence of geological factors on the extent of zones of critical condition and coal sloughing in regional parts of the massif allow to draw a conclusion that decree parameters, with other things being equal, are defined, first of all, by stress-strain behavior of seam, depth of mining, height and the structure of seam (figures 2-3).

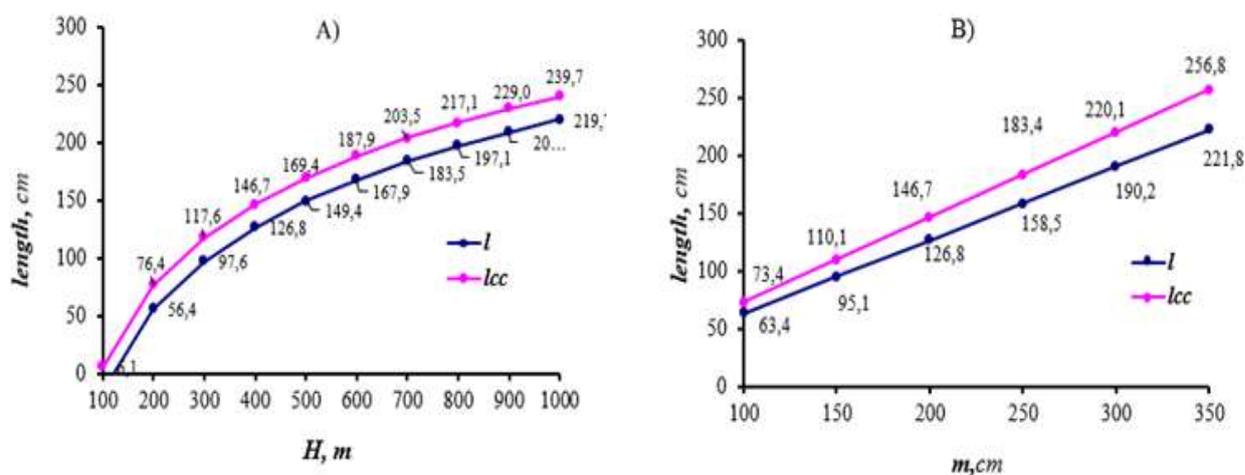


Figure 3. Influence of various factors on the extent of zones of critical condition and coal sloughing: A) - depth of mining (H); B) - height of seam (m)

4. CONCLUSIONS

The obtained data on essential difference of conditions of coal in regional parts, confirm need of accounting of the geological and mining factors defining these states for ensuring endogenous fire safety, especially at application of the schemes of ventilation providing removal of firedamp through a part or all goaf of the longwall panel at mining of the prone to spontaneous ignition seams.

It should be noted that the received results are fair only for regional parts of the massif in this connection assessment of a condition of coal pillar demands carrying out additional researches. At the same time the condition of pillars will also be defined by a complex of the mining-and-geological factors considered by us and will only be aggravated, owing to imposing of two zones of bearing pressure: from earlier extracted longwall panel and mining panel.

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