Method of gas emission control for safe working of flat gassy coal seams

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Abstract. The main problems at intensive flat gassy coal seam longwall mining are considered. For example, mine Kotinskaja JSC "SUEK-Kuzbass" shows that when conducting the work on the gassy coal seams, methane emission control by means of ventilation, degassing and insulated drain of methane-air mixture is not effective and stable enough. It is not always possible to remove the coal production restrictions by the gas factor, which leads to financial losses because of incomplete using of longwall equipment and the reduction of the technical and economic indicators of mining. To solve the problems, the authors used a complex method that includes the compilation and analysis of the theory and practice of intensive flat gassy coal seam longwall mining. Based on the results of field and numerical researches, the effect of parameters of technological schemes on efficiency of methane emission control on longwall panels, the non-linear dependence of the permissible according to gas factor longwall productivity on parameters of technological schemes, ventilation and degassing during intensive mining flat gassy coal seams was established. The number of recommendations on the choice of the location and the size of the intermediate section of coal heading to control gassing in the mining extracted area, and guidelines for choosing the parameters of ventilation of extracted area with the help of two air supply entries and removal of isolated methane-air mixture are presented in the paper. The technological scheme, using intermediate entry for fresh air intake, ensuring effective management gassing and allowing one to refuse from drilling wells from the surface to the mined-out space for mining gas-bearing coal seams, was developed.

1. Introduction

Increasing the depth of mining operations, increasing the per face output leads to an increase in gas content of excavation sites. In such conditions the per face output by the gas factor often exceeds the load according to the technical features of the treatment mechanized complexes. This leads to the losses from underutilization of the capabilities of modern mining equipment, which significantly increase in the presence of only one longwall face in the mine [1, 2].

The questions of mining gas-bearing coal seams and management of methane working areas were considered in A.T. Ayruni, B. V. Boki, V. S. Zaburdyaev, N. O. Kaledina, O. I. Kazanin, N. M. Kachurin, G. I. Korshunov, A.A. Myasnikov, L.A. Puchkov, A.D. Ruban, S. V. Slastunov, Yu.V. Shuvalov's works, and in others. According to the research, normative documents, regulating questions of designing methods and gas emission controls, have been developed. At the same time, in conditions of intensive development of coal seams, gas emission controls do not always provide an opportunity to remove restrictions on the gas factor [12]. As the majority of mines of Russia work out gassy coal
seams, a growing number of businesses move to the structure “mine-lava” with one working face. The questions of justification of parameters of the technological schemes, ensuring efficiency and safety of mining operations with full use of the technical capabilities of the treatment mechanized complexes, are relevant. A significant part of the methane enters the roadway from the goaf. At the same time, the used in the mines of Kuzbass schemes of withdrawal of a methane-air mixture from the goaf by means of surface degassing units through wells, drilled from the surface, are costly and do not provide the required level of stability of the control gas evolution. With increasing depth of mining operations, such schemes become even more costly and less sustainable [3].

2. Materials and methods
In order to justify the technological schemes of intensive development of flat gassy coal seams, providing management efficiency gas emission without the use of surface degasification systems, a complex research was conducted. The main objectives of the study are:

- Analysis of international experience intensive mining gassy coal seams.
- Field observations of the influence of technological schemes parameters on the efficiency of gas emission controls on working areas.
- Experimental and analytical study of the effect of management methods of gassing and ventilation modes, with different parameters of technological schemes of the per face output.
- Development of recommendations on the definition of the parameters of technological schemes in mining gassy coal seams in the longwall mining.
- An assessment of efficiency and definition of the range of application of the developed recommendations working face.

Mine "Kotinskaja" JSC "SUEK-Kuzbass" has been chosen to carry out field research. Investigations of the gas situation in the working areas 5209 and 5210 during the period from January 2014 to September 2015, using an automated monitoring sensors, recording the exact measurement of time, the concentration of the main mine gases and the amount of the air supplied. Measurements were made by the sensor several times per minute, which allows one to quickly and accurately assess the situation at the excavation site in real time, or restore events using historical data. The total working area layout and management of gas emission are shown in Figure 1.

![Figure 1. Working area scheme of panel on «Kotinskaja» mine: 1 - degassing wells drilled from surface; 2 - in-mine linked wells; 3 - wells out of service; 4 - degassing pipe.](image)

For an isolated drain of the methane-air mixture from the goaf, the wells drilled from the surface to the rock cavity are applied. At the same time, 5 wells were in the operation, connected to the mobile degassing unit and the total air flow of 230 m³/min. Also for the removal of methane-air mixture from goaf, the wells, drilled through the pillar of the conveyor roadway, are used. The wells are connected to the gas drainage pipeline and vacuum pumps, located on the surface.

For experimental and analytical research of the influence of parameters of technological schemes on control gassing stability in the working areas, a numerical model in complex Ansys CFX was
created. The calculated area is divided into a certain number of disjoint control volumes so that each junction point is contained in one control volume [4, 5]. During creation of the numerical model, the long-term experience of domestic scientists was considered, in whose works a systematic approach to solving problems of the dynamics of gas release at mining panel was demonstrated.

3. Results and Discussion

Figures 2 shows the results of numerical modeling of failure of one of 5 working wells, drilled from the surface. As can be seen from the figures, the drop out of one of 5 wells immediately causes marked changes in the distribution of methane in the working areas and leads to an increase in the concentration of methane in the methane income zone of the goaf into the face.

The concentration of methane in local congestions in a face exceeds 1% (maximum permissible concentration of methane in this zone by the Russian safety rules), and in a belt road it increases from 0.65%, with all working wells, up to 0.9%. The results of modeling are confirmed by comparison with results of natural supervision that proves low stability of management of gas emission with the use of the wells, drilled from a surface when using of the scheme of management of gas emission, accepted in mine. The situation with disconnected or non-working wells allows us to estimate the effect on the gas atmosphere, produced by isolated removal of the methane-air mixture and the air input through the airway (figure 2b)

![Figure 2](image)

**Figure 2.** Distribution of methane over the working area in case of the loss of working capacity a) by one of the wells; b) by all wells.

To improve the management efficiency of gas emission and removal of restrictions on the working face by the gas factor, the technological scheme of preparation of working areas by double entries and the intermediate roadway for supplying a fresh air stream in the face was proposed as an alternative to the use of wells, connected to the surface degassing unit (Figure 3).

![Figure 3](image)

**Figure 3.** The flowsheet for the preparation and mining for gassy coal seams with a face output of 25 000 tons per day.
The key parameters are the intermediate roadway-sectional area, the distance to the belt road and the amount of air supplied [6]. The cross section of the intermediate 12 m² roadway enables feeding the correct amount of air at the lowest possible costs for construction and maintenance.

Various options for the development and management of gas emission in the working area with different values of the supply air, of an isolated drain methane-air mixture and per face output were considered [13]. The options and features of the proposed technological scheme are in table 1.

Table 1. Parameters of technological schemes when developing the working area by double entry and the intermediate roadway at a distance of 70 m from the belt roadway

| Per face output | 17000-25000 t/day |
|-----------------|------------------|
| The quantity of air supplied through airway | 1500-2000 m³/min |
| The quantity of air supplied through intermediate roadway | 750-1000 m³/min |
| Consumption of isolated drain through linkage wells | 320-400 m³/min |
| The length working face | 250-300 m |
| The length of working area | 1000-4500 m |
| Development method | double entry and intermediate roadway |
| Seam liability to spontaneous ignition | prone to spontaneous ignition |

It is anticipated that the isolated outlet will be through underground boreholes, drilled from the neighboring roadway through the chain pillar. In different situations, wells can be drilled parallel to the bed or in the rock cavity [7]. The simulation results are presented in Figure 4.

Figure 4. Distribution of methane in working areas with a face output of 25,000 tons per day during preparation of three roadway.

By changing, the distance from the intermediate roadway to the belt road, the nature of the distribution of methane in the working face and surrounding roadways is changing. Analysis of the distribution of methane in the working face when using the intermediate roadway for gas emission in the working area allows one to make conclusions about the limits of application of different schemes of gas-bearing coal seams in the mine-wall and to define the limits of changing the parameters of the working area preparation and the parameters of gas emission control means [8, 9].
Figure 5 shows a graphical diagram for determining the parameters of the proposed technological scheme. The presented graphical diagram includes such parameters as the per face output, the distance between the intermediate roadway and the belt roadway, the amount of the removed methane-air mixture by isolated drain means.

![Graphical Diagram]

**Figure 5.** The graphical diagram of technological parameters of working out gas-bearing coal seams with the use of the intermediate roadway and isolated drain of the methane-air mixture.

The graphical diagram allows one, by means of elementary geometric operations, to determine the values of the above-mentioned parameters of the technological scheme for intensive development of gas-bearing coal seams.

Based on the conducted studies, it was concluded that to ensure the coal production of about 17000 ton per day for the conditions of the "Kotinskaya" mine of JSC "SUEK-Kuzbass", it is enough to conduct an intermediate roadway at a distance of 40 m from the belt roadway.

The increase in the distance between the belt and the intermediate roadway from 40 m to 70 m with the adjustment of the parameters of the gas-emission control means allows increasing the per face output to 25000 ton per day for the conditions of the mine "Kotinskaya" JSC "SUEK-Kuzbass" or for enterprises with similar mining conditions. The distance between the belt and the intermediate roadway of 70 m is more preferable since it allows one to provide per face output, ranging from 17000 ton per day to 25000 ton per day by operative regulation of the parameters of the gas control means. Using a circuit with a value of 100 m is not practical, since it requires an increased drain of the methane-air mixture through the wells and leads to an increase in the amount of driving of connecting holes. In order to ensure the necessary coal mining by the time of working-out the area, a new similar working area should be fully prepared, that is, the entire complex of contour drifts must be traversed [10].

Table 2 shows the required speeds (the required rate of penetration implies the total volume of penetration per month) of the preparation of workings for different variants of the preparation of the working area, taking into account the margin for a possible increase of per face output as compared to the planned ones. To ensure the drifting rate of penetration of the working area at the planned loads, decisions are made for this purpose on the feasibility of using one or two tunneling combines with a set of appropriate transport equipment.
Table 2. Required indicators of headworks for different types of preparation of working areas

| Method of preparation | Planned output per face, tons per day | Estimated time of section working-out, months | Indicators of headworks in preparation |
|-----------------------|--------------------------------------|-----------------------------------------------|---------------------------------------|
|                       |                                      |                                               | The volume preliminary entries, m     | Required driving speed, meters per month |
| Double entries        | 17000                                | 12-13                                         | 8000                                  | 600-650                                 |
| Double entries and intermediate roadway | 17000-25000                        | 9-13                                          | 12700                                 | 950-1400                                |

Thus, the proposed control schemes for gas emission, using an intermediate roadway in combination with an isolated drain methane-air mixture through wells drilled from underground roadways allow producing 25,000 tons per day without the use of wells drilled from the surface [11].

4. Conclusion.
Summarizing the research results. It is possible to draw the following conclusions:
• with increasing the depth of working-out, the cost of drilling wells from the surface increases, and the stability of the schemes is reduced, since increased gas emission leads to the emergency stop of the working face;
• simulation of the working area allows one to determine the influence of the preparation method on the possibility of managing gas emission and the effect of the gas control means on the maximum per face output during intensive mining of gas-bearing coal seams;
• The use of technological schemes of preparation of working areas double entries and the intermediate roadway to supply fresh air stream in combination with the isolated tap methane-air mixture through a hole, drilled through the pillar and contour degassing through wells, drilled from the local workings, allows removing the face output by gas factor without the use of mobile degassing units.
• For effective management of gas emission by using the proposed flow sheet at the mine "Kotinskaja", the intermediate roadway should be placed at a distance of 70 m from the belt road and provide an isolated drainage of the methane mixture through a hole drilled through the pillar of at least 350 m³/min;
• The selection of parameters for the preparation of the working area and the load on the working face must be made taking into account the use of the minimum values of the gas control parameters.

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