ESTIMATION OF METHANE EMISSION FROM A LONGWALL PANEL

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Abstract

The purpose of the study is the clarification of the theoretical knowledge about the mechanisms of gasdynamic and geomechanical processes at goafs of coal mines during the intensive mining of formations of gas-bearing layers by means of longwall panels. The study presents the analysis of modern approaches to the evaluation of gasdynamic and geomechanical processes at goafs of coal mines, which are based on the conceptions of the wave nature of the change of methane-richness along the length of an extraction pillar. The analysis of the data from gas control instruments is carried out, and the relationships between gas emission at longwall panels and goafs and daily production in longwall panels are established. New relationships of the frequency of gas- and geomechanical processes in rock massif for the conditions of the Kotinskaya mine of JSC "SUEK Kuzbas" are established. The study demonstrated the need for the consideration of the distance to the upper gaseous seam for the prognosis of gas emission into excavations of goafs.

Keywords: underground mining, coal seams, longwall panel, methane emission, goaf.

Introduction

High frequency and severity of industrial accidents, which are related to explosions of methane-air mixes during the production of coal in coal mines, determine the need for the study of the mechanisms of gas emission in goafs. Moreover, coal mines are one of the main (the fourth largest) sources of methane emission, which is a greenhouse gas with global warming potential 28-34 times higher than carbon dioxide [3], which requires development and use of effective methods and means of utilization of methane of coal mines. Due to the carried out technical upgrading of coal industry companies in Russia, in the recent years, studies of the control of gas emission into excavations of goafs are carried out for the conditions of goafs with high production, which can reach 25-30 thousand tons per day. During the working of gaseous seams, even the high efficiency of degassing doesn't provide a decrease of gas emission into excavations to a safe level. One of the unsolved problems is frequent gas contamination of excavations of goafs, which is related to the unpredictable rapid increase of gas emission. The feature of gas regimes of goafs of high-
production mines of Kuzbas is the high level of methane in excavations, which can reach 90% of gas emission of a goaf. The main source of gas emission is juxtaposed undermined and overworked gaseous seams. At that overlaying seams, generally, amount for more than 60% of gas emission from satellite seams, which is related to the significant propagation (up to the height of 30 thicknesses of a worked seam) of intensive fracture into roof rocks. It must be noticed that in calculation methodologies [5] the nonuniformity of gas emission is considered by means of the corresponding coefficient of nonuniformity; however, the values of this calculation coefficient are decreasing with the increase of intensity of gas emission, while from practice it is known that in high-production longwalls during working of gaseous seams, the nonuniformity of gas emission is increasing. The mentioned nonconformity of calculated and actual values of gas emission leads to the inability to make a correct prognosis of gas emission and select efficient methods and means of control of gas emission in the excavation of goafs. In the authors' opinion, the discussed nonconformities are related, first of all, to the increased intensity of geomechanical processes at modern coal mines. A significant increase of the intensity of gas- and geomechanical processes at goafs of coal mines, in which gaseous seams are worked, is related to the continuous increase of production of worked seams, the constant increase of lengths of longwall panels and extraction pillars, and the increase of productivity and speeds of movement of longwalls. Applied methodologies of prognosis of gas emission [5] and parameters of geomechanical processes [7] are based on empirical relationships, which were established in the 1980s for the parameters of goafs and intensity of underground coal mining, which was different from current ones by orders of magnitude. A variety of mining, geological and engineering conditions of mining works at active mines complicates the creation of an integrated methodology of prognosis of gas- and geomechanical processes. The study of the features of gasdynamic processes in particular geomechanical conditions of modern high-productive goafs is necessary for providing the safety of working of gaseous seams.

**Methodology**

The necessity of the consideration of the level of stresses for the prognosis and calculation of methane emission at a goaf was pointed out in a number of works [4, 10]. The consideration of dynamics of gas emission during mining as an indicator of the intensity of geomechanical processes is recommended as the main approach to the evaluation of air- and gasdynamic and geomechanical processes during working of seams by means of longwalls [11-12]. This approach is quite prospective for the prognosis of gas and geomechanical processes and the development of efficient methods of the control of gas emission into excavations of goafs of coal mines, in which suites of gaseous seams are
worked. As a result of the previous studies [11, 13] of the features of methane-richness of high-production goafs in the conditions of working of a suite of gaseous coal seams by means of longwalls with collapse of roof, it was established that methane-richness change along the length of an extraction pillar is of wavy nature with periods up to hundreds of meters (gas-kinetic pattern of massif of gaseous rocks). The analysis of the data for 18 goafs of 5 coal mines of the Kuzbas [13] allowed to obtain relationships of amplitude and period of the dynamic component, on which basis the method for the prognosis of dynamics of gas-richness of a goaf is developed. At that, the results of the previous studies [12, 14] and the conclusions that the processes of unloading and displacement of rocks along the length of an extraction pillar has waved nature with period of hundreds of meters for all mining and geological conditions doesn't correspond to the actual data on gas-richness of goafs of high-productive longwalls; in this regard, for the conditions of the Kotinskaya mine of JSC "SUEK Kuzbas" the study of the changes of gas-richness of both extraction pillars and excavation of goafs was carried out. In the discussed conditions of the Kotinskaya mine, the working of the seam 52 of 4.3 m thickness was carried out by means of longwalls (230-300 m). The control of gas emission in the discussed goafs 5208, 5209, 5210 was carried out using a U-shaped scheme of ventilation, degassing of excavation by means of vertical wells (with a diameter of 273 mm), which were bored from the ground surface, as well as by means of wells, which were bored from the mine.

The depth of mining was from 220 to 394 m. The natural gas content of the worked seam was up to 10 m³/ton. At the distance of 36 m above the worked seam 2 there was the seam 53 of 1.5 m thickness, and below it at the distance of 32 m there was the seam 51 with a thickness of 1.8 m. The immediate roof of the seam 52 consisted of siltstone of a thickness from 5 to 21 m with the strength coefficient of 2.8-4. The main roof of the seam 52 is coarse siltstone with medium caving, which gradually changes to sandstone with a thickness of 12 to 25 m with the strength coefficient of 3.6-5.8.

During the study, the data of the measurements from the instrumentation of gas control for methane concentration and airflow of excavations of goafs was used, as well as data on the use of methane-air mix and concentration of methane by degassing equipment. The analysis of the data was carried out for the goafs 5208, 5209 and 5210 from January 2011 to September 2015.

**Results**

The carried out analysis of the data from the gas control instrumentation allowed to establish the relationship of gas emission in a longwall for the extraction pillars 5208, 5209, 5210 of the Kotinskaya mine. As the example of the
obtained results, in Figure 1 there are the relationships of the average daily values (blue color) and the maximum values (red color) of the concentrations of methane in the longwall (2015). As it can be seen from Figure 1, there is a tendency for an increase of gas emission in a longwall with an increase of daily production of a longwall. The maximum concentrations of methane allowed by safety rules (1%) were achieved at production on longwall of about 15 thousand tons per day. However, at the same production, the concentration of methane in different days was from 0.2 to 0.9% (the average value was 0.77%).

**Figure 1 – Relationship between methane emission in longwall and daily average production of the longwall.**

Total gas emission, which was removed by ventilation, degassing and isolated takeoff systems, was also increasing with an increase of daily production of a longwall (Figure 2). As it can be seen from Figure 2, for the daily production of 15 thousand tons total gas emission was from 40 to 120 m³/min (from 667 to 2000 l/sec). A significant range of the values of gas emission at constant production disprove the conclusion about the direct relationship of the production of longwall and the volume of gas emission, which was based on the basis of the results of the studies carried out in the Kotinskaya mine conditions [8-9].

**Figure 2 – Relationship between total gas emission at longwall and daily production.**
For the discussed extraction pillars 5208, 5209 and 5210, the relationships of gas emission by moving of breakage faces were established (Figure 3). As it can be seen from Figure 3, for all three of the longwalls the periodic change of total volumes of methane, which is removed by means of ventilation and degassing systems, is observed. At that, the distance between the maximum values of gas emission is from 20 to 50 m. The obtained values correspond to the step of the collapse of the main roof, which was calculated using the methodology applied for the mines of the Kuznetsky coal field [7]. The established wide range of values even in one extraction pillar is related to the influence of physical and mechanical properties and speed of movement of a breakage face. The discussed conditions of the Kotinskaya mine are of high variability of lithologic composition and the properties of rocks of the main roof and low rhythm of work of breakage faces at the extraction pillars 5208, 5209 and 5210, which leads to the change of production of longwall from 5 to 27 thousand tons per day and the movement of breakage face from 2.5 to 16 m per day. The applied methodology of the calculation of the step of collapse of the roof [7], for the discussed conditions, demonstrated the capability of change of step of collapse of the main roof in 1.8 m times, which is explained by the wide range of values of the established period of gas emission along the length of an extraction pillar. The collapse of the main roof leads to the propagation of the zone of intensive fracture above the excavated space to the gaseous seam and the increase of gas emission. The increase of the speed of movement of a breakage face and strength of rocks of the main roof is the reason for the increase of the step of the collapse of the main roof and the nonuniformity of gas emission at a longwall.

![Figure 3 – Dynamics of gas emission.](image)

Thus, the carried out studies allowed to establish the relationships between gas emission at longwalls and the step of the collapse of the main roof, which proved the relationship of gasdynamic and geomechanical processes, which, however, demonstrated the possibility of these processes with a periodicity significantly different from those established by other authors [11-14].
4. Discussion

It must be noticed that the conclusions about the possibility of the processes of gas emission with step along the length of an extraction pillar of 50 m, which were obtained in this study, are confirmed by the data from other researchers (Figure 4). In the authors’ opinion, the period of processes of gas emission is related not only to the step of the collapse of the main roof, but also to the distance to the undermined gaseous seam. Thus, the collapse of the main roof might be insufficient for the increase of gas emission, in the case the above seam is at the distance higher than 6 of exacted thicknesses of the worked seam, which can lead to an increase of the period of gas emission and can connect it with the collapse of strong layers of the roof, which are located above the main roof of a seam. It must be noticed that in this case an increase of gas emission will be observed with a delay in time and distance from the breakage face. The study of the development of a collapse zone with movement of a longwall [1] showed that a collapse zone in an excavated space reaching the maximum height at distance of 60-90 m from a breakage face. The delay of the process of gas emission in time can be considered using the calculation equation [6].

![Figure 4](image_url)

**Figure 4 – Gross Longwall Gas Emission (Ventilation plus goaf drainage)** [2].

5. Conclusions

The carried out studies confirmed the correctness of the conclusions about the periodic (wavy) nature of geomechanical and gasdynamic processes at longwalls of coal mines during working of suites of gaseous seams by means of longwalls [11, 13]. However, the obtained results showed the possibility of gas- and geomechanical processes in a rock massif with a period of 20-50 m, which is significantly (2-10 times) smaller than the period, which was established in the previous studies [12, 14]. The established period was confirmed by the data from other studies [2]. Thus, the period of gasdynamic processes can be from several tens to several hundred of meters and is
significantly determined by the distance to an undermined gaseous seam, which is the main source of gas emission during working of a suite of gaseous seams by means of longwalls.

References


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