Gas emission law and control method of working face in extra thick coal seam

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Abstract. Aiming at the problem of abnormal gas emission in fully mechanized caving face during mining, the law of gas emission from coal and rock in front of working face is studied, and the main factors of gas emission from coal wall and goaf are analyzed. This paper puts forward the method of gas drainage by surface drilling, which provides a new way to solve the gas overrun of upper corner, return air roadway and working face under the condition of high-intensity fully mechanized caving mining in extra thick coal seam, which has great engineering significance to ensure the safety and efficient production of the mine.

1. Introduction
Coal in China’s disposable energy structure in the main position, is an important basic energy. For extra thick coal seam, in order to achieve high-yield, high-efficiency and intensive production, these mining areas mostly adopt the mining technology of fully mechanized top coal caving [2]. During the mining of extra thick coal seam, the problem of gas disaster has become increasingly prominent [3]. High mining intensity leads to large absolute gas emission in the working face. Therefore, it is urgent to study the gas emission law and gas control technology during the mining of extra thick coal seam with low gas content.

Li Shugang et al. [4,5] analyzed the general relationship between permeability and abutment pressure, and according to the measured abutment pressure distribution law of fully mechanized top coal caving face, comprehensively obtained the influence law of abutment pressure on gas emission from coal body in front of working face to mining space. Xie Heping et al. [6,7] proposed that in the process of fully mechanized top coal caving mining, the mining stress generated by the advancing of working face causes the vertical stress of coal and rock mass to gradually increase and then rapidly decrease, while the horizontal stress continues to decrease.

In this paper, Tashan coal mine is taken as the research object, aiming at the problem of abnormal gas emission, the law of coal and rock gas emission in working face is studied, and the method of gas drainage by surface drilling is proposed, which provides a new way to solve the gas overrun of upper corner, return air roadway and working face under the condition of high intensity fully mechanized top coal caving mining.
2. Law of gas emission in fully mechanized top coal caving face

2.1. Introduction of 8214 working face in Tashan coal mine
Tashan coal mine is located in Shanxi province, with a design capacity of 15 million tons / year. 8214 fully mechanized top coal caving face is located in the middle of No.2 panel area, bounded by the auxiliary transport lane of the second panel in the East, adjacent to 8212 working face in the northeast, 8216 working face in the southwest, and heading to the protective coal pillar of Kouquan railway in the north. The dip angle of coal seam is 1~4° and the average is 3 ° which is near horizontal coal seam. The thickness of coal seam is 8.04~11.73m, with an average thickness of 12m, belonging to extra thick coal seam. The inclined length of the working face is 230m, the coal cutting height is 3.5m, and the caving height is 8.5m.

2.2. Introduction of 8214 working face in Tashan coal mine
A total of 8 measuring stations were set up along the air flow direction at 8214 working face of Tashan mine, with an interval of about 30m, which were respectively located at supports No. 4, 21, 38, 55, 72, 89, 106 and 123. Each station is arranged with 5 measuring points from coal wall to goaf, a is 0.5m away from coal wall, B is 2m from coal wall, C is 3.5m from coal wall, D is 5m from coal wall, e is 6.5m from coal wall, height of measuring point is 1.5m from floor; one measuring point is arranged at 15m from coal face in inlet and return air roadway, and the height of measuring point is 1.5m from floor; gas monitoring probe data is used for gas concentration of high drainage roadway, and layout of each measuring point is shown in figure 1. The wind speed and gas concentration under different conditions are measured, and each measurement is carried out in the maintenance team. At this time, there is no coal mining or drawing operation in the working face, and the gas emission is relatively stable.

![Figure 1. Layout plan of working face.
The gas distribution along the air flow direction is shown in figure 2.](image-url)
Figure 2. Distribution curves of gas concentration along air flow.

The average gas concentration is 0.036% near the air inlet and 0.134% near the return air lane. The gas concentration at the return air side is about 3.72 times of the gas concentration at the inlet side. The average gas concentration increased from 0.036% to 0.067% in front of the mining face, and the change was relatively gentle, because a part of the gas emitted from the coal wall entered the goaf with the air flow. The average gas concentration in the second half of the working face increased rapidly from 0.067% to 0.134%, which was due to the fact that part of the air leakage into the goaf flowed into the working face from the corner of return air and brought out the gas inside the goaf.

The gas distribution along the working face section is shown in figure 3.

Figure 3. Distribution curves of gas concentration along section of working face.

The gas concentration in the goaf increases first and then decreases. The average gas concentration near the coal wall is the largest, reaching 0.153%, the average gas concentration near the goaf side is the second, which is 0.825%, and the average gas concentration near the middle of the section is the lowest, which is 0.051%. The gas concentration near the coal wall is the largest and the change is obvious, while the gas concentration near the goaf is small, which indicates that the gas concentration in the goaf is significantly affected by high drainage roadway, and the gas in the working face is greatly affected by the goaf.

The gas source of working face can be divided into coal wall gas emission, mining coal gas emission and goaf gas emission. During the maintenance period, the gas in the working face is mainly composed of coal wall and goaf. The gas emitted from the coal wall can be considered as fully
entering the return air flow of the working face. The gas in the goaf is discharged through two parts: high pressure drainage and return air roadway. The gas emitted from the coal wall and the gas from the goaf flowing to the return air roadway are collected in the working face, which jointly affect the gas distribution of the working face. The accumulation of gas at the upper corner leads to the gas overrun of the working face. Therefore, the gas drainage method should be adopted to fundamentally reduce the gas emission from the goaf and the coal wall.

3. Test on gas drainage effect of surface borehole
Through the study of gas distribution and source in fully mechanized top coal caving face, the gas overrun caused by gas emission in goaf is determined. Therefore, the method of surface drilling gas drainage is put forward and its drainage effect is analyzed and studied.

3.1. Layout of ground gas drainage boreholes
According to the calculation, the gas drainage radius is 30m. Seven surface boreholes are arranged to drill to the final hole 10m away from the floor of 3-5#coal seam, and the drilling depth is about 520m. The well is open hole completion, and gas drainage is carried out through the drainage equipment after completion. The specific location is as follows:

1) The ground extraction boreholes are arranged at 24.4m away from the cut-off of 8204 working face and 21.2m away from Lane 5204.

2) The ground extraction boreholes are arranged at 68m away from the cut-off of 8204 working face and 21.4m away from Lane 5204.

3) The ground extraction boreholes are arranged at 120.3m away from the cutting hole of 8204 working face and 30.1m away from Lane 5204.

4) The ground extraction boreholes are arranged at 170.2m away from the cut of 8204 working face and 44.6m away from Lane 5204.

5) The ground extraction boreholes are arranged at 219.0m away from the cut-off of 8204 working face and 11.3m of neicuo 5204 lane.

6) The ground extraction boreholes are arranged at 273.5m away from the cut-off of 8204 working face and 15.9m away from Lane 5204.

7) The ground extraction boreholes are arranged at 314.3m away from the cut-off of 8204 working face and 38.1m away from Lane 5204.

During the production process of the working face, 1# borehole is 10 m away from the working face, 2# hole is 50 m away from the working face, and 3# hole is 100 m away from the working face. At this time, 1# hole, 2# and 3# hole are extracted at the same time; when 1# hole is 110m away from the goaf behind the working face, the extraction is stopped and 4# drilling is started. At this time, 2#/3 # drilling hole extraction is started. According to the specific drainage effect and site conditions, three boreholes are simultaneously used for gas drainage.

3.2. Analysis on gas drainage effect of surface borehole
According to table 1 system structure size considering cutting nozzle diameter range from d1=1.5mm, d3=1.5~4.5mm, considering the bucket is connected with the entrance of abrasive abrasive, the diameter of 8mm, axial distance 15mm abrasive mouth throat, jet pump diffuser outlet to the cutting nozzle entrance distance of 200mm, in order to solid modeling, including pipeline, entrance jet pump, a middle pipe, nozzle and cutting nozzle flow field, the establishment and division of flow model were carried out in the pretreatment module of GAMBIT in FLUENT. The system flow model used in this paper is shown in figure 3.
The distance between 1# boreholes is 24.4m away from the cut-off hole, and the extraction starts at 10 m away from the working face. With the mining of the working face, the gas concentration increases gradually. The maximum gas concentration reaches 28% when the borehole is located at the goaf 10 m away from the working face. When the distance is 10~20 m, the gas concentration in the borehole decreases rapidly, and then with the advance of the working face, the gas concentration of the borehole keeps fluctuating around 4%. The analysis shows that within the range of 20m away from the working face, the gas concentration is relatively high due to the large gas emission from the coal caving and the large disturbance to the goaf during the mining process. Within the range of 20~110m, due to the shallow goaf, there are less coal gangues left and the gas concentration is low.

The gas concentration of 2# drilling hole is 68m away from the cut-off hole, and the gas concentration gradually increases at 30m from the front of the working face. With the advance of the working face, the coal body in front of the working face enters the initial weighting area, resulting in the gas pressure relief and flow increasing effect. The gas concentration of the borehole increases. Within the 10m range of the working face passing through the borehole, the gas concentration reaches the maximum of 13%, and then the gas concentration of the borehole gradually decreases to 3%.

The 3# borehole is 120m away from the cut-off hole, and the borehole is located in the coal body in front of the working face. Because the coal body is relatively complete, the gas content is low by 0.5%. When the working face is pushed forward through the borehole, the gas concentration gradually increases, and the maximum gas concentration can reach 4.5%.

The gas concentration fluctuated in the range of 5% when the 4# borehole was 170m away from the cut-off hole, and the maximum gas concentration was 10 m away from the working face, and then gradually decreased. The lowest gas concentration is between 3.5% and 5.5% in the working range of 20~45m.
The 5# borehole starts to extract at 50m away from the working face, and the gas concentration is 5.8%. Within 15m away from the working face, due to the gradual increase of coal bearing pressure, the coal body is compressed and the gas channel is closed, and the gas concentration is gradually reduced. The borehole is located within 20m behind the working face, and the gas concentration increases to 6%. With the increasing distance from the working face, the gas concentration increases gradually.

6# borehole is 273m away from the cutting, and the drilling hole is 50m away from the front of the working face. The gas concentration fluctuates around 1% from 50m in front of the working face to 30m behind the working face, and the gas concentration is low.

Figure 10. The relationship between the amount of gas extracted and the position of working face.
After 40m, the pure amount of gas drainage increases instantaneously, and the working face enters the first weighting area, which causes the coal body in front to be broken, and the gas channel is connected to increase the drainage amount. Therefore, it is possible to control gas emission to the mining face by drilling holes on the ground.

4. Conclusions
The law of coal and rock gas emission is studied. This paper puts forward the method of dynamic gas drainage by surface borehole drainage, which provides a new way to solve the gas overrun of upper corner, return air roadway and working face under the condition of high intensity fully mechanized top coal caving mining in extra thick coal seam.
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