

Research and application of L-shaped ground well gas drainage technology in mining area

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Abstract. By law mining fracture morphology analysis, based on coal face gas flow characteristics, obtain the L-shaped surface well layout area in the mining area under the influence of mining. Analysis of overlying strata "three zones" distribution, the calculation method of the height of overburden rock "three zones" designed in mining area ground well structure proposed safety drainage system construction plan. In Sihe Mine was L-shaped ground mining area well engineering practice, the average gas production at a concentration of 80%, with an average drainage net amount 22 000 m³ / d, a total of more than 300 days running, draining 6.5 million CBM m³. After the implementation of drainage work surface corner gas content fell 46.5%, to effectively improve production efficiency, for the surface treatment gas play a key role. Successfully removed Mining Face Gas for safe production constraints, to protect the mining of coal mine safety, and achieved good social and economic results, with good promotional value.

1. Introduction

At present, some domestic coal mines are faced with the confusion of high difficulty and high pressure of gas control in the working face. Surface coalbed methane wells can alleviate the pressure of gas control in coal mines [1-3]. After long-term exploration and research by researchers, the purpose of using surface wells in mining affected areas to control gas overrun in the upper corner of coal face has been basically achieved [4-5]. Zhang[6] et al. presented that the coal mine gas (coalbed methane) is a high-quality clean source of energy and a good industrial, chemical, power generation and residential fuel. Zhou[7] et al. presented that the coalbed methane drainage is quite important for the safe production in coal mines and the utilization of gas resources. It is proven significantly important to study the coalbed methane drainage in the mining area. DNWhittles[8] et al. conducted a research on the borehole boring casing failure with the coal mining process in the collapsed area. The damage effect of casing and the effect of lithological parameters were analyzed. Pierre-Jean[9] of France utilized an experimental method to study the failure characteristics of the surrounding rock, pointing out that the principal stress on the borehole wall has an important effect on the borehole wall stability. Song[10] et al. studied the quantitative relationship between the geological borehole failure characteristics and the geostresses, initially obtaining the relationship among different geostresses and deformations of the ground drills[11].

Considering that the gas extraction range of CBM vertical surface wells is limited and the mining area covered is

small, it is necessary to consider adding a section of horizontal hole on the basis of vertical surface wells to form the CBM extraction mode of "L" surface wells, and study the surface wells in the "L" mining affected area through reasonable optimal layout. In order to achieve the purpose of wide coverage and excellent gas drainage effect, so as to improve the gas drainage efficiency, alleviate the gas control pressure of the mining face, reduce the gas overrun risk of the mining face, and enhance the safety guarantee of high yield and high efficiency of the coal mine.

2. Horizon analysis of horizontal section of L-shaped surface well in mining area

2.1 Distribution law of mining fractures

After the coal seam is mined out, the original stress balance around the goaf is damaged, resulting in the redistribution of stress, resulting in the deformation, rotation and fracture of the rock stratum, which develops from bottom to top to the surface. When there is a key layer in the overburden, it may develop to a key layer and stop. Large fractures are generated in the rock stratum below the key layer. The fractures can be clearly seen through similar simulation tests, as shown in Figure 1. It can be seen from the figure that after pressure relief, the rock stratum above the cut hole and working face will rotate under the action of gravity, resulting in vertical fractures [12].

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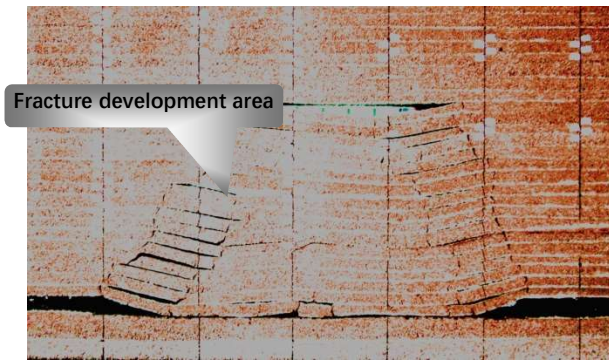


Figure1. Distribution pattern of overburden fractures

Starting from the opening of the cut hole, with the advance of the working face, the mining fracture continues to develop. The mining fracture in the middle of the goaf is the most developed, which is the first stage of mining fracture development. When the goaf area reaches a certain value, it enters the second stage of mining fracture development. At this time, the mining fracture in the middle of the goaf tends to be compacted, and there is a connected mining fracture development area around the goaf, that is, the mining overburden fracture "O" ring. The mining fracture "O" ring can be maintained for a long time and is the storage space and flow channel of pressure relief gas.

The flow of coal seam pressure relief gas is a continuous process: first, in the form of diffusion, the gas flows from the coal body without cracks to the surrounding cracks; In the second step, in the form of seepage, the gas flows along the fracture to the drainage borehole, and the mining fracture is the channel for gas flow. Obviously, arranging the drainage boreholes in the area where the fractures are developed and can be maintained for a long time is conducive to the flow of pressure relief gas into the drainage boreholes. It can be seen from Figure 1 that the "O" ring shape can be obtained by cutting the ellipsoidal polishing surface with the horizontal plane within the crack height, as shown in Figure 2. The "gas River" formed by the "O" ring is mainly reflected in the separation fractures. There is more gas storage space in the separation fractures, and the mining vertical fractures are more used as the gas flow channel between rock layers. The "O" ring fracture space of mining fracture will exist for a long time and will be used as the storage space for pressure relief gas. However, with the advance of the working face, the "O" ring will continue to extend along the strike direction of the working face.

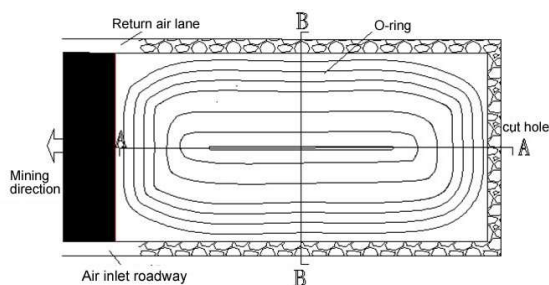


Figure 2. O- ring shape of stope overburden

2.2 Distribution characteristics of "three zones" of stope overburden

By combining the actual geological conditions and mining technical conditions of Sihe mine, we appropriately modify the empirical formula of "three zones" height given by predecessors, so as to analyze the distribution characteristics of "three zones" suitable for Sihe mine.

(1) Height of caving zone

Suppose that the primary mining thickness of the coal seam is m , after the mining area reaches a relatively large area, the height of the caving zone is h , and the crushing expansion coefficient of the caving rock block is K . When the volume of the caving rock block is equal to the sum of the mining space and the space of the caving rock layer itself, all the mining space disappears. At the same time, the overlying non caving rock layer is supported by the caving rock block, and the caving process stops. As the falling rock blocks are stacked and compacted, the overlying non falling rock stratum bends and sinks, resulting in cracking and damage. Considering that when the overburden is not a hard roof, the overburden will generally sink continuously during the occurrence and development of overburden caving, which reduces the volume of caving rock block required to fill the mining space and will lead to the reduction of caving height. The falling height can be expressed as:

$$H_m = \frac{M - \Delta M}{(K-1) \cos \alpha} \quad (1)$$

Where, H_m is the height of caving zone, ΔM is the subsidence of overburden before caving, M is the mining height, and K is the crushing expansion coefficient of caving rock block; α is the dip angle of coal seam.

(2) Fracture zone height

According to "GB12719-91 code for hydrogeological and engineering geological exploration of mining area", and according to the condition that the overburden of Sihe mine is medium hard rock stratum, the calculation formula of water diversion fracture zone is as follows:

$$H_t = \frac{100 \times M}{3.3n + .8} + 5.1 \quad (2)$$

Where, H_t is the height of water conducting fracture zone, M is the mining height, and N is the number of coal layers.

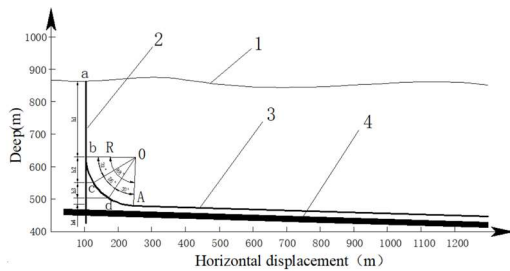
(3) Bending subsidence zone

According to the definition of bending subsidence zone, bending subsidence zone is a continuous and integral moving rock stratum from the top boundary of fracture zone to the surface. But it is at least a function of time. After full mining, the curved subsidence zone must develop to the surface. If the mining is not sufficient, the curved subsidence zone may stop when it develops to a key layer of overburden.

3. Wellbore structure design of L-shaped surface well in mining area

Based on the analysis of drilling deformation and failure characteristics and in combination with the characteristics of gas surface wells in the mining area, the surface wells in the mining affected area are arranged approximately

0.2 ~ 0.4L away from the return air side (L is the length of the working face). The well body structure needs to be determined according to the characteristics of overburden movement. Generally, the well body structure of three openings is adopted. The first opening is designed to be about 20m below the bedrock, and the casing adopts J55 API casing, The second spud is arranged from below the surface to the upper part of the fracture zone, N80 casing with good shear resistance is adopted, and the third spud is arranged with open holes, as shown in the figure.



(1 is the surface, 2 is the vertical well section, 3 is the horizontal section, and 4 is the coal seam.)

Figure 3. Schematic diagram of L-shaped surface well in mining area

4. Construction of safe extraction system

According to the effect and purpose of ground coal seam test, five types of equipment are mainly required to be purchased: safety monitoring and control equipment, pumping and mining basic equipment, pumping and mining data acquisition equipment, fire-fighting equipment and power supply and power auxiliary equipment. The layout of safety pumping system is shown in the figure. At the same time, carry out the research on the matching of pumping equipment and process adaptability, including calculating the pipe diameter wear resistance of mining fracture field, casing and pumping pipeline, selecting the water ring vacuum pump installed on the ground, arranging explosion-proof and data monitoring equipment, continuously monitoring pumping data, and evaluating the adaptability of pumping equipment in combination with the changes of pumping data.

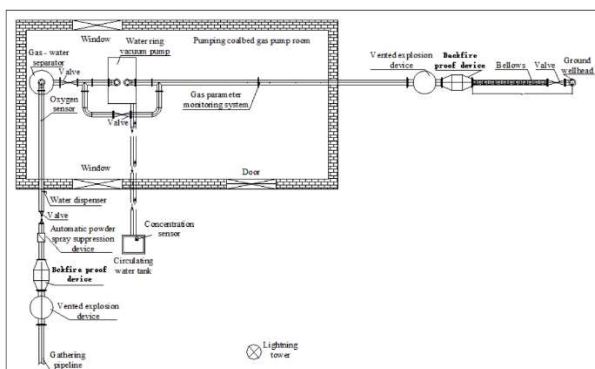


Figure 4. Layout of surface borehole coalbed methane drainage system

5 Engineering application

The test working face of L-shaped surface well in the mining area is 3313, the panel name, the working face elevation is 394 ~ 466m in the east third panel, the ground elevation of 3303 fully mechanized mining face is 788 ~ 960m, and the working face elevation is 405 ~ 486m. This working face is a fully mechanized mining face with one-time mining height. The mining thickness is about 6.13m, the coal seam dip angle is 0~12°, the average dip angle is 6°, and the strike length is 1239.88m, The working face is 301.50 m long. The coal seam structure is simple, and the L-shaped surface well in the mining area is arranged 45m near the return air side. The absolute gas emission during mining in the working face is 29.73m³/min.

It can be seen from Figure 5 that continuous extraction is realized in the mining affected area and goaf of the coal seam, and the drilling structure is intact; The average produced gas concentration is 80%; The average net extraction volume is 20000 m³ / D, the cumulative operation is more than 300 days, and the extraction of coalbed methane is more than 6.5 million m³.

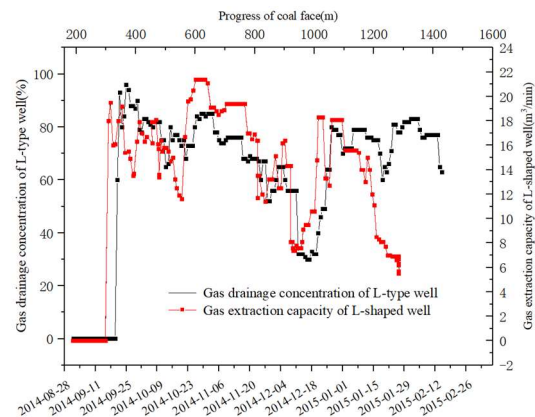


Figure 5. Relationship between gas purity, gas concentration and distance from coal mining face to well

LocationAfter the implementation of drainage, the gas concentration in the upper corner of the working face decreases by 46.5%, as shown in Figure 6. Effectively improve production efficiency and play a key role in gas control in this face. Successfully eliminate the restriction of goaf gas on safety production of working face.

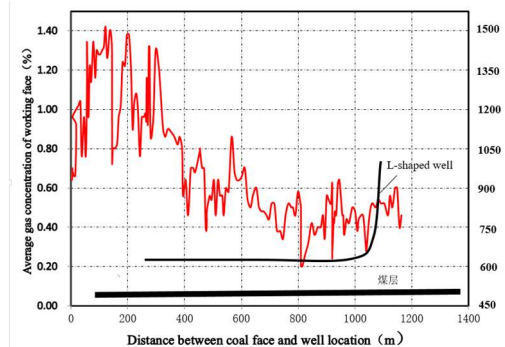


Figure 6. Change of gas concentration in working face after drainage

6 Conclusion

- 1) Through the analysis of the mining fracture shape law and according to the gas flow characteristics of the coal mining face, the basic principle of L-shaped surface well layout in the mining area under the influence of mining is obtained: it should be arranged near the return roadway side and in the "O" ring.
- 2) The distribution characteristics of "three zones" of overburden in stope are analyzed, and the calculation method of "three zones" height of overburden is put forward, which provides a basis for the horizontal horizon height of L-type surface wells in mining area.
- 3) The well structure of L-shaped surface well in mining area is designed, and the construction scheme of safe pumping system is put forward.
- 4) The engineering practice of L-shaped surface well in mining area is carried out in Sihe mine, which has achieved good gas drainage effect, solved the problem of difficult gas control for coal mining face, ensured the safety of coal mining, achieved good social and economic effect, and has good popularization value.

Acknowledgments

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