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Research on the application of directional drilling machine in gas control of upper corner

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Abstract

In order to study the effect of directional drilling rig in the corner gas control of coal mine, the source of gas in the upper corner and the influence range of single coal seam mining are analyzed, and it is proposed to use a kilometer directional drilling rig to conduct directional high position drilling to the gas source channel in the fixed layer. By intercepting gas from adjacent layers, surrounding rocks, goaf and other channels, directional extraction is implemented, ultimately achieving the goal of eliminating gas overruns in the working face. The research results provide effective reference for efficient gas control in the upper corner.

Keywords

Coal mine; Directional drilling rig; Upper corner gas; Overrun.

1. Introduction

During the corner operation of a single coal seam mining face, the upper corner is prone to gas exceeding limit accidents due to poor ventilation system, which is an important problem that restricts the safety production of coal mines. The upper corner is located in the triangular area of the upper side of the return air roadway and the edge of the goaf in the coal mining face. This area has poor ventilation, high temperature and humidity, and is prone to gas accumulation and exceeding the limit. It is a key area for the "one ventilation and three prevention" management of coal mines [1,2]. At present, the main methods for controlling the accumulation of gas in the upper corner at home and abroad include specialized high drainage tunnels, buried pipes, high-level drilling and other drainage technologies, which greatly reduce the frequency of coal mine gas exceeding limit accidents. However, these extraction technologies also have some problems, such as the long construction cycle and high construction costs of specialized high extraction tunnels, the high maintenance costs of buried pipe extraction, the most obvious advantages of high level drilling extraction technology, and the simple construction method. The main disadvantage is that the collapse of the goaf causes the drilling to be blocked, resulting in short time and fast attenuation of gas extraction, and affecting the effectiveness of gas treatment in the upper corner [3-6]. Therefore, the urgent task is to research new processes, technologies, and equipment to make up for the shortcomings of the current upper corner gas control technology, enhance the ability of mine gas control, and actively carry out research on kilometer drilling rig gas control in the upper corner.

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2. Analysis of gas sources in the upper corner

Hongyan Coal Mine belongs to a single coal seam mining. During the mining process of the working face, the supporting stress balance of the in-situ coal and rock mass is disrupted. Under the action of gravity, the rock above the goaf sinks and collapses violently, causing the surrounding rock to fracture during the sinking and stretching process, and forming a large number of cracks. These cracks communicate with the goaf to form a channel for gas migration. The rock layers and coal seams within the zone are in a state of pressure relief under the influence of mining stress, and the cracking and permeability of the coal rock layers increase. The residual coal from the goaf and the coal seam are "activated" by pressure relief adsorption gas desorption, showing a free state, flowing towards the return air and corners of the mining area along the longitudinal cracks, causing gas concentration to exceed the limit or accumulate locally [7,8].

3. Analysis of the impact range of single coal seam mining

Under the influence of mining, the severe subsidence of the coal and rock mass on the roof of the goaf leads to the migration, damage, and collapse of the overlying rock mass. Vertically, according to the degree of rock damage and displacement status (Figure 1), it can be divided into "vertical three zones" from bottom to top, namely the caving zone, fracture zone, and curved subsidence zone. The curved subsidence zone is the coal and rock mass above the fracture zone, which is less affected by mining. The coal and rock mass is relatively well preserved, with only a small number of fractures developed, and has little impact on the overall pressure relief effect of the coal seam [6]. The overlying coal rock mass can be divided into "horizontal five zones" along the advancing direction of the mining face, namely the coal wall support influence zone, separation zone, and re compaction zone.

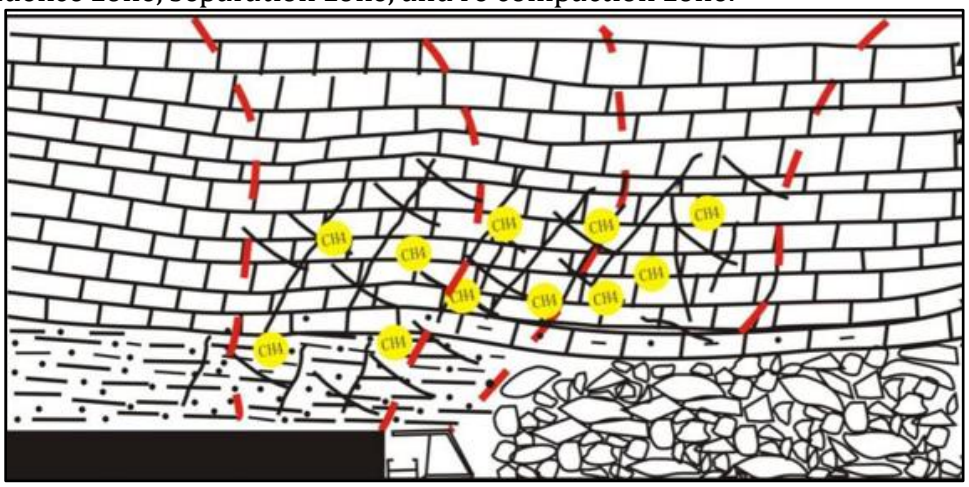

Figure. 1 schematic diagram of mining influence range and gas accumulation in single coal seam mining in Hongyan coal mine

The "Hengwu District" summarizes the practical experience of pre mining and post mining pressure relief gas extraction based on the gas extraction law of coal mining working faces. Based on the analysis of gas occurrence and extraction amount at different distances and ranges, the gas extraction of the longwall retreating coal mining face is divided into the "horizontal five zones", namely:

(1) A stress stable zone is located more than 8 meters away from the working face, which is outside the range of mining influence and has a relatively stable gas occurrence.

(2) The coal wall support area is 0-8m in front of the work face. This range is affected by the mining of the working face. Under the action of mining stress and crustal stress, the seam

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fractures are developed, most of the adsorbed gas becomes free gas, and the gas expansion is large.

(3) 3.0~8m is the pressure relief zone of the working face, which is in a fully depressurized state and contains a small amount of residual free gas extracted. At this stage, the gas generated by coal falling from the working face is discharged with the wind.

(4) The range of about 8~30m behind the working face is the roof separation zone. The false roof collapses as the support moves forward, causing the direct roof to sink and the old roof to bend. At this point, a large number of cracks are generated on the direct roof, which serves as a pathway for gas migration in the surrounding rock.

(5) 30m away from the working face is the area for re compaction. In the "Hengwu District", the support area of the tile coal wall, the pressure relief area, and the roof separation area are most affected by mining. The impact of strike mining and the vertical fractures in the goaf are very developed, making it a gas enrichment zone and a key area for gas extraction.

In summary, the main targets of gas extraction are the fracture zones in the support area of the coal wall, pressure relief area, and roof separation area within the mining face.

4. Gas control technology in upper corner of kilometer directional drilling rig

Kilometer directional drilling rig is used to control the gas in the upper corner, which is to use the technology of kilometer directional drilling rig in coal mine underground to arrange the boreholes in the roof fracture zone, so as to reduce or even avoid the drawbacks of high level directional drilling being blocked and leaking gas due to roof caving. It can also be targeted to extract the gas in the upper corner, so that the utilization rate of boreholes is higher. Using high level directional drilling rig to control the gas in the upper corner can also reduce the number of drilling equipment handling. This improves work efficiency.

4.1. Brief introduction of kilometer directional drilling technology

At present, there are many kinds of directional drills in China, and ZDY4000LD kilometer directional drill and supporting equipment are proposed to be used in the mine. The technical principle is mainly to use the deviation making ability of screw drill to change the hole deviation angle and azimuth angle (the deviation rate of oil directional drilling rig is also called "dogleg degree") to achieve the design purpose. Measurement while drilling (MWD) instrument is the core component of the directional long hole drilling system in coal mines. It is the basis and key to achieve directional drilling by accurately measuring and calculating the geometric parameters of the borehole in real time, so as to accurately control the borehole trajectory.

The technical advantage lies in controllable drilling trajectory, high drilling accuracy, and no blind spots; The target layer has a high effective ratio, low engineering quantity, and low comprehensive cost; The implementation of "parallel exploration and excavation operations" has solved the contradiction between time and space [9-11]. Many domestic coal mines have introduced and used high-power directional drills for gas control and water control, and small Directional drilling for advance detection [12,13].

At present, the conventional underground drilling rig used in Hongyan Coal Mine has small capacity, short construction hole length and poor directional effect. The conventional drilling can only be carried out after the formation of the roadway, and the pre drainage period is short. Therefore, it is necessary to carry out the application research of kilometer directional drilling rig in the gas control work of Hongyan Coal Mine.

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4.2. Drilling arrangement

The Hongyan Coal Mine is a single coal seam mining, with two working faces, 3604 Section 2 and 3605 Section 2, arranged at the north and south wings of the ±0m level of the mine to extract the K_1 coal seam. As previously analyzed, gas extraction from the upper fractured zone of the goaf is a key task in preventing gas accumulation in the upper corner from exceeding the limit. The fractured zone is located 15~30m below the ventilation tunnel and 34.37m~52.17m above the working face, which is the target for gas extraction. Therefore, Hongyan Coal Mine plans to set up a drainage drilling site along the return air channel of the 3605 second section, and carry out underground high level directional gas drainage drilling construction on the 3605 second section working face to achieve gas extraction in the fractured zone of the working face, increase gas extraction volume, and control gas from the source to ensure safe production.

Considering factors such as mining speed, mining efficiency, and the impact of goaf roof subsidence on mining, it is proposed to construct 2~3 high extraction holes every 150m in the return air roadway of the working face, with the final holes being 34.37m~52.17m above the K_1 coal seam roof. Firstly, pre extract the gas from this coal seam and K_2 coal seam (this layer is located about 20m above the K_1 coal seam, with an average coal thickness of 0.21m), and then control the corresponding section of coal seam gas in the upper corner. When designing high-level directional drilling, the drilling must be controlled within the effective gas drainage range of the fracture zone, and the designed final hole position is generally the position where the roof is relatively stable. This design can effectively solve the problem of short service time for drilling in fractured zones, thereby achieving good drainage effect, with the ability to discharge high concentration gas and stable drainage volume.

4.3. Drilling construction technology

The supporting equipment used for this construction mainly includes: ①ZDY4000LD crawler type full hydraulic tunnel directional drilling rig. ②Φ102mm high-strength center cable drill pipe and Φ102mm beryllium copper non magnetic drill rod. ③Φ102mm imported screw motor with a 1.25° structural bending angle. ④Φ120mm flat bottom sintered tire PDC drill bit. ⑤3NB-300 mud pump. ⑥YHD1-1000T drilling measurement system.

Directional drilling technology refers to a drilling method that uses special tools to extend the drilling path to the predetermined target according to the design requirements, that is, purposefully change the drilling axis from curved to straight or from straight to curved. When the screw motor with a 1.25 ° bend angle is used for directional drilling construction, the entire drilling tool does not rotate. Only the screw drill rotor drives the drill bit to rotate and break the rock for drilling. The on-site technicians adjust the angle of the screw drill tool in real time according to the design track and the specific conditions of the coal seam, so as to achieve the goal of controlled and precise orientation of the drilling track.

4.4. Analysis of gas extraction effect

After drilling is finished according to the design requirements, a sieve tube with a diameter of 100mm is put into each hole, and the hole is sealed by combining Malisan winding and grouting hole sealing. The hole sealing length is not less than 150m, and the hole orifice is sealed with cement mortar to ensure the air tightness of the hole. After the hole sealing, a suction pipe with a diameter of 100mm is used for suction, and the suction negative pressure is greater than 5kPa. In order to comprehensively analyze and compare the gas drainage effect of high-level directional long borehole, a special person is arranged to collect the gas drainage data of high-level directional long borehole and high-level pumping borehole during the working face advancement.

According to the extraction parameters of conventional high-level drilling holes at present, the extraction concentration of conventional high-level drilling holes can reach 35%~80%, with an

average concentration of 57%. The single-hole pure flow rate is 0.098m^3/min ~ 0.37m^3/min, and the average single-hole pure flow rate is 0.25m^3/min. Using the kilometer directional drilling rig to control the gas in the upper corner and extract the gas from the rich area in the fracture zone of the working face, the diameter of the single-hole suction pipe is increased to 100mm, which is twice that of the original suction pipe. Therefore, it is predicted that the single-hole pure flow of the directional high-level drilling can be increased to at least 0.5m3/min, and the drainage capacity can be at least doubled, so that the return gas in the working face can be reduced from 0.23%~0.35% to 0.05%~0.15%. Through comparison and calculation, about 65% of the gas emission in goaf is pumped away by high-level drilling, and the gas emission by wind is only about 30%. The application of high-level drilling solves the problem of gas accumulation and overrun in the upper corner of Hongyan coal mine working face.

5. Conclusion

(1) In the process of coal mining, affected by mining, the fractured zone formed in the upper part of goaf is a favorable area for gas accumulation. When the ventilation is not smooth, it is easy to cause the gas in the upper corner and the return air lane to exceed the limit, while the high-level directional drilling is just constructed in the fractured zone. Under the negative pressure of drainage, a large amount of gas flows into the drainage system, forming a virtuous circle, and the gas in the goaf and the upper corner will be continuously pumped into the drainage system through the high-level fractured hole, thus solving the problem that the gas concentration in the upper corner exceeds the limit during mining.

(2) After the implementation of high-level directional drilling rig to control the gas in the upper corner, it is necessary to collect the gas drainage data of high-level directional long drilling hole and high-level pumping drilling hole, and analyze the advantages and disadvantages of the two technologies, so as to clarify the control factors of gas drainage in the fractured zone and its influencing mechanism, and provide the basis for taking targeted measures to control the gas in the upper corner on the spot.

(3) Further strengthen the research on high directional drilling layout, optimize the spacing of drilling layout, realize efficient gas extraction in fracture zone, and solve the problem of gas overrun in upper corner once and for all.

(4) During the drainage process, with the advance of the working face, the directional drilling casing is at risk of being cut off by caving rocks or faults, causing a large amount of air to enter the drainage hole, reducing the drainage concentration, and causing spontaneous combustion in the goaf.

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