Study the sealing pore technique of the nearly horizontal gas drainage hole in-seam

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Abstract: Through analyzing the influencing factors of hole sealing effect, the “eccentric drilling- pressure grouting” sealing pore technique was put forward, and was practiced in Yonghong coal mine. By contrasting its effect and, and verifying its reasonableness, the gas concentration in the drainaging pipelines was improved.

1. Introduction
Coal is the most important energy source in China. For a long time, coal energy accounts for a high total national energy source, and it is also the country with the most serious coal mine disasters. Coal mine gas accidents account for a large proportion in coal mine accidents. With the exploitation of coal mines in China, there are more and more high-gas mines in China, and coal mine safety problems will become more and more serious. The state has always stressed that coal mine safety is "people-oriented, safety first". The fundamental measure to solve the gas accidents in high gas mines is to reduce the gas content in coal seams so as to reduce its danger. Gas drainage is the most fundamental and effective measure. However, most mines in our country have poor gas drainage effect and low gas drainage concentration. According to statistics, about 65% of our country's coal mining face along the drainage borehole pre-drainage gas concentration is less than 30%. The main reason for the low concentration of gas drainage is the poor sealing effect of gas drainage boreholes.

2. Analysis of Factors Affecting the Quality of Hole Sealing Technology for Near-horizontal Bedding Drainage Boreholes
Most of the drainage boreholes in mining face in China are near horizontal bedding boreholes. The main factor affecting the drainage effect is the sealing of coal wall fissures after pore formation. The formation of coal wall cracks is mainly the loosening circle cracks during roadway excavation and the cracks during drilling construction.

After the formation of the roadway, the coal body around the roadway forms "Three Belts", which are pressure relief belt, stress concentration belt and original stress belt from outside to inside. Fractures are relatively developed in the roadway pressure relief zone and are easy to communicate with the outside, thus affecting the quality of borehole sealing. Because of the high stress, the coal fracture in the stress concentration zone has dense pore and poor gas tightness, so the sealing depth of borehole should be within this range, which is beneficial to sealing quality.

In the process of drilling construction, the high speed rotation and vibration of drill bit and drill pipe, and the pressure relief of coal around drilling hole make the original cracks of coal body develop
further, thus producing crack zones around drilling hole, which is not conducive to drilling sealing. Therefore, it is necessary to plug the cracks around the borehole to improve the sealing quality.

In the near horizontal drilling of cement sealing holes, the shrinkage of cement tends to cause a horizontal pore channel at the top of the borehole to communicate with the outside, thereby affecting the quality of the sealing.

3. Proposal of New Sealing Technology

The crack width formed during roadway excavation is located in the roadway pressure relief zone, and only the approximate range of the "three zones" of the roadway needs to be determined to determine the hole sealing depth, thus ensuring sufficient hole sealing depth and being located in the stress concentration zone, thus improving the hole sealing quality.

Cracks generated during drilling and roadway formation can be plugged by cement pressurized grouting. The cement is in close contact with the coal body and is not easy to fall off, and the cement enters a part of cracks around the borehole under a certain pressure, which is favorable for sealing and plugging the borehole.

In the cement sealing of near-horizontal boreholes, it is easy to form a horizontal pore channel at the top of the boreholes after the cement shrinks and solidifies so as to communicate with the outside world, thus affecting the sealing effect. In order to solve this problem, two eccentric circular construction drilling holes can be used, that is, a large diameter drill hole is first constructed, and then a small diameter gas drainage hole is drilled in a small diameter hole (as shown in Figure 1).

Through the above analysis, the eccentric drilling-pressure grouting hole sealing process is proposed, i.e. a small section of large diameter drilling hole is first constructed in the coal body, and then a small drainage drilling hole is constructed by replacing the drill bit. Finally, polyurethane is used at both ends to plug the drainage boreholes, and cement slurry pressure grouting is used in the middle to plug the drainage boreholes and ensure that the depth of the sealing holes exceeds the pressure relief range of the roadway. The sealing process chart is shown in Figure 2.

4. Field Application and Investigation

Yonghong Coal Mine is located in Jiafeng Town, southeast of Qinshui County, Jincheng City, Shanxi Province. The mine adopts inclined shaft development method to develop and mine No. 3 coal seam horizontally with an annual output of 1.2 million t/a, which is a coal and gas outburst mine. Minefield No. 3 coal seam is located in Qinshui coalfield. It is a near horizontal coal seam. Most of the pre-drainage boreholes are near horizontal along the coal seam. The effect of gas drainage is not ideal. The concentration of gas drainage is below 30%, generally about 10%.

In order to investigate the drainage effect of eccentric drilling-pressurized grouting sealing technology, four boreholes were constructed in 3305 working face of underground mine. First, a drill with a diameter of 113 mm was used to construct a drill with a diameter of 6 m, and then a drill with a diameter of 94 mm was used to construct a drainage drill. In order to ensure that the hole sealing depth exceeds the pressure relief range of the roadway, the hole sealing depth is determined to be 11m, bagged polyurethane is respectively tied to the drainage pipe 11m away from the orifice and the end of the orifice, and polyurethane AB material is mixed and twisted to be inserted into the drainage borehole together with the drainage pipe, the grouting pipe and the slurry return pipe. When the reaction is complete, the expansion and non-shrinkage cement slurry is injected into the grouting pipe.
After the return slurry pipe is returned, the return slurry pipe is blocked by a plug and grouting is continued for a period of time. The sealing technology is shown in Figure 2.

The above four boreholes were tracked and inspected, and the variation of gas drainage concentration in boreholes with time is shown in the following Figure 3:

In order to investigate the drainage effect of eccentric drilling and pressurized grouting hole sealing process, the gas concentration of another group of 4 drainage holes (polyurethane hole sealing was adopted by the mine side with a hole sealing depth of 8m) was observed near the above 4 holes constructed at 3305 working face. The variation of gas drainage concentration in boreholes with time is shown in Figure 4 below.

From the comparison of Figure 4 and Figure 5, we can see:
1) Both of them have high extraction concentration in the early stage, and the gas concentration gradually decreases with the passage of time.
2) Early stage: the gas concentration of eccentric drilling-pressure grouting hole sealing process is close to that of polyurethane hole sealing process; later stage: the gas concentration in eccentric drilling-pressurized hole sealing process decreases slightly and decays slowly. The gas concentration is about 60% after 46 days of drainage, while the gas concentration in boreholes of polyurethane sealing process decreases greatly and attenuates rapidly. Basically, the gas concentration falls below 30% after 30 days of drainage and 20% after 40 days of drainage.

From the above data, it can be seen that the gas concentration of the two is equal in the early stage. Because the gas emission from coal seam boreholes in the early stage is large and fast, the gas tightness of borehole sealing has little effect on it. With the gradual decrease of gas emission from the borehole over time, the negative pressure ratio in the borehole has just started to increase, requiring a higher hole sealing effect. However, polyurethane hole sealing material cannot bond well with coal body, cracks around the borehole are easy to conduct with the outside, and polyurethane is easy to delaminate with coal body to form crack channels over a long period of time, so the gas concentration decays rapidly in the later period. Eccentric drilling-pressurized grouting can gradually infiltrate into the surrounding cracks of coal body, which can well block the surrounding cracks and external passages. Eccentric drilling, expansion and non-shrinkage cement slurry pressure solidification are adopted again to block the prone level of near-horizontal drilling grouting sealing. Fracture channels, therefore, the sealing effect is good and the gas concentration decays slowly, even after 46 days of drainage, the gas concentration is still about 60%.

5. Conclusion
1) Measures such as eccentric drainage boreholes and pressure-bearing solidification of expansive non-shrinking cement slurry are adopted to prevent the horizontal fissure channel, which is easy to occur when grouting and sealing the near-horizontal boreholes, from being communicated with the outside. Pressure grouting can make part of cement slurry penetrate into the surrounding cracks of coal
body slowly, which can well block the surrounding cracks and external passages of boreholes, ensure the sealing quality and improve the air tightness of drainage boreholes.

2) Eccentric borehole-pressurized grouting sealing technology is adopted to increase the gas drainage concentration from below 30% to about 60%, which slows down the attenuation of gas concentration in boreholes and improves the drainage effect.

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