Research and application of gas drainage technology by downward drilling holes

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Abstract. Aiming at the undesirable phenomenon of low drainage concentration and poor effect in the downward boreholes in Panjiang mining area, the gas drainage technology of “full casing, two plugs and one injection, sealed hole under pressure” and pressurized air and water was proposed. And the on-site implementation was carried out in 21126 transportation jacking lanes of Tucheng mine. The research results show that the pressurized air blowing water technology effectively solves the problems of down-drilling slag and water accumulation, improves the gas drainage effect of the down-draining drilling, effectively solves the problem of regional outburst prevention, improves the efficiency of excavation, and promotes the safety of mine production.

1. Introduction
The mines of Panjiang Clean Coal Co., Ltd. are all coal and gas outburst mines. The occurrence of coal seams is "two highs, one low, and one complex", that is, high gas content, high gas pressure, low coal permeability coefficient, and complex geological structure. 10~17 coal seams are mined in the mining area, and the average thickness of the minable coal seams is 18~27.7m. There is a danger of coal dust explosion when mining coal seams. The coal seam gas content is 3.6~27.1m³/t. The coal seam permeability coefficient is 0.0017~9.58m²/(MPa².d), the coal seam gas pressure is 0.32~3.76MPa, the geological structure in the mining area is complex, due to the small distance between the coal seams, it is difficult to find a suitable location for the roof and floor gas control roadways. In Shanjiaoshu mine, Moonfield mine, Xiangshui mine and other mines, roof drainage lanes are deployed for regional strip pre-draining. Since most of the holes are downholes, the initial drainage concentration is high, and then the branch drainage concentration drops rapidly, and finally it gets poor results. Due to the low drainage concentration and poor drainage effect, after the penetration pre-drainage is adopted, when the roadway is tunneling, the supplementary regional outburst prevention measures must be constructed in the working face. This results in a low excavation rate and unreliable safety. This results in a more tense situation for the connection. At present, the gas drainage technology of down-crossing boreholes has been developed to varying degrees[1-4], so we can learn from the existing experience to explore methods and measures suitable for the mine's down-boring drainage effect.
2. Layout of roof drainage tunnels and drill holes
In order to improve the effect of roof penetration pre-drainage, Tucheng mine has improved the drainage drilling and sealing technology in the 21126 roof drainage road in the 21 mining area. The 21126 roof through-layer drainage road is arranged in the roadway. The working face length is 482m. It is supported by bolts, mesh and cables. The shape of the roadway is semicircular. The designed clear width is 4.8m, the clear height is 3.0m, and the net section area is 11.93m². The working face is 27.9m from the overlying 10# coal seam, 6m from the 12# coal seam, and 9.4m from the Xianfu 13# coal seam. The 12# coal seam roof is light gray fine sandstone and siltstone with a thickness of 23.7m, and the bottom plate is fine sandstone with a thickness of 9.6m, but there is a layer of argillaceous rock (expanded with water) with a thickness of 0.6m. Therefore, the 21126 gas drainage road is arranged on the roof of the 12# coal seam, with a horizontal distance of 33m from the 21126 transport roadway (inside the roadway), and a distance of 6m from the 12# coal seam.

3. The implementation of the downward drilling pressure and water blowing process of the 21126 roof through the layer

3.1. Drilling construction
In the 21126 roof drainage lane, a set of cross-layer drainage boreholes will be constructed every 5m to control the contour line of the 21126 transportation lane to be 20m lower and 20m upper, with the final hole spacing of 5m. 1#, 2# boreholes pass through 15# coal seam floor, 3#, 4#, 5# pass through 13# coal seam floor, 6# boreholes pass through 12# coal seam floor, 6# boreholes pass through 12# floor, and 1~5# holes are downward drilling.

3.2. Investigation and analysis of drainage parameters of drainage boreholes
At the beginning of August 2015, before the construction of the 21126 top-draining roadway for gas drainage, the maximum original gas content of the 12# coal seam was determined to be 11.2m³/t, and the original gas pressure was 1.01MPa. Before the water pressure blowing process was implemented, the following problems were found in the gas drainage process:

(1) The gas decay rate in the borehole was fast, and within a week of drainage, the single hole concentration dropped from 50~60% at the beginning of the drainage to around 10%.

(2) The borehole has large water accumulation, and security inspectors are arranged to release the water in each shift, but it is still not clean.

(3) After the drilling construction is completed, the two-plug and one-injection casing process is used to seal the borehole. In the process of casing running, the casing can only be lowered to the 12# coal seam, and it is impossible to extract the 13# and 15# beneath the 12# coal seam.

3.3. Proposal of the "pressurized wind and water" process
Through repeated field inspections and tests, the main reasons for the above problems were found:

(1) The fast gas attenuation rate is an illusion. The main reason is that the 1#–5# borehole is a negative angle borehole during the water inspection during the drilling process. Water and drill cuttings are deposited in the drill hole. Over time, the water and drill cuttings filled in the drill hole sink into the hole, causing the hole to be blocked.

(2) During the drilling process, the water contacts the hole wall and part of the water penetrates into the fissures around the borehole through the hole wall, thereby blocking the gas gushing channel of the 12# coal seam.

(3) During the drilling construction process, the water combined with the mudstone of the 12# coal seam floor to expand, destroying the hole wall, causing the casing to fall below the 12# floor.

In view of the fact that the downward drainage boreholes are easy to be blocked by sediment and accumulated water, resulting in poor drainage effects, the "pressurized air and water" drainage technology is adopted after research and demonstration. After the drilling construction is finished and the rod is withdrawn, when sealing the hole, install a 4-division pipe with the suction pipe into the bottom of the drill hole (the distance between the pipe mouth and the top of the suction pipe is less than...
After the casing is run in the whole process, the process of "two plugs and one injection, sealed hole under pressure" is implemented to connect the 4-branch pipe with the extraction pipe. The compressed air is manually pressed in from the 4-branch pipe to remove the water and sediment in the borehole. The bottom of the hole is blown out along the drainage pipe before drainage. Under the action of high negative pressure, the accumulated water deep into the hole wall is pumped into the borehole, and the compressed air is continued to blow it out. After repeated pressure air drainage and drainage, the borehole water and drill cuttings are reduced, and the gas drainage effect obviously improved. The pressure air pipe, the extraction pipe and the sealing process are shown in Figure 1.

![Figure 1. Schematic diagram of the down-drilling and sealing process](image)

4. Analysis of the effect of "pressing wind and blowing water" gas drainage

4.1. Analysis of the amount of water drained from the drainage borehole

Observation of pressure wind and water blowing began on November 13, 2015. During the observation period, 3 shifts were arranged for water blowing every day, and the drainage volume of each test hole was measured and counted through a graduated cylinder. After the holes are sealed with pressurized water, the water accumulated in the first two days is relatively large. According to statistics, the total amount of water blown out by a single hole in a week can reach at least 35.4L and up to 67.2L. With the passage of time, the amount of water blown shows a decreasing trend. After the water is blown by pressurized air, the drainage concentration is high and the flow rate is stable. However, the drainage boreholes that do not use pressurized air blow increase with the accumulation of water in the borehole and block the gas. In the flowing channel, the concentration of gas drainage has always been low.

4.2. Analysis of gas drainage concentration

After implementing the process of "down-boring pressure, wind and water", the mine organized personnel to inspect the gas concentration of 56# drilling site and 6 diverters from November 13th to December 12th, 2015. After using compressed air to blow water, the gas concentration of a single hole is generally above 50%, and the drainage effect is significantly improved. When the pressurized air was not used to blow water, due to serious water accumulation in the borehole and low gas concentration in a single hole, the drainage concentration of the 1# splitter was all around 11%, and the drainage effect was not ideal. It can be seen from the back 2~6# diverter that the gas in the hole is effectively extracted after blowing out the accumulated water in the borehole with compressed air, and the average extraction concentration is about 48%. After comparison, the compressed air blowing process is used for gas extraction. The extraction rate has been increased by more than 4 times, effectively solving the problem of difficult coal seam gas extraction, providing safety guarantee for later roadway excavation and mining face, and realizing rapid excavation and mining.

From October 2015 to February 2016, the gas concentration of the downhole main pipeline was maintained above 30%, the negative pressure of single hole drainage was maintained between 13~15KPa, and the drainage flow rate was maintained at about 25~35m³/min. Behind the ground, the main gas concentration is still above 20%, the drainage flow rate is maintained at about 40m³/min, and
the daily gas drainage volume is 16,400 m³. From October to February of the following year, the total gas drainage volume is 1,477,400 m³.

4.3. Analysis on the effect of 21126 transport roadway during driving

The gas content in this area was measured after 2 months of pre-draining through the top-draining tunnel and the downward drainage borehole, and the residual gas content was determined to be 3.3168 m³/t. It fully shows that the downward gas drainage borehole implements pressure air and water blowing work, which effectively improves the gas drainage effect.

The 21126 transportation lane truly realizes production after outburst elimination. During the tunneling process, the maximum regional verification index is \( S_{\text{max}} = 1.7 \text{Kg/m, } K_1 = 0.26 \text{mL/g·min}^{1/2} \), normal index \( S_{\text{max}} = 1.7 \text{Kg/m, } K_1 = 0.11 \text{mL/g·min}^{1/2} \) up and down. From the Figure 2, during the tunneling in February, the working face gas was basically stable at around 0.10%, and the return air gas was basically stable at around 0.40%. To ensure the safety during the excavation of the 21126 transportation lane, the record of single entry was 236m in February, and the highest single entry of the round shift was 15.3m. At the same time, the monthly excavation footage in the 13129 transportation lanes and 151213 transportation lanes of the mine is more than 200 meters, and the monthly maximum footage is 300 meters.

![Figure 2. The gas concentration of 21126 transport roadway during driving](image)

5. Conclusion

(1) The "pressurized wind and water" process effectively solves the problems of sediment and water accumulation in downward drilling. Through the 21126 top-draining roadway, the downward gas drainage borehole pressure wind and blowing water successfully solved the problems of downward drilling sludge, stagnant water, and low drainage concentration, increased the branch pipe drainage concentration and drainage volume, and completely solved the outburst elimination in the transportation lane to ensure safe production and improve the efficiency of tunnelling work.

(2) Strengthen the implementation of responsibilities and improve the drainage effect. One is to press the wind and water in a timely manner. After the construction of the extraction and drilling is completed, during the first week after the sealing and extraction, there must be a staff member in each shift to be responsible for the air pressure and water blowing. If the deposit is blocked, it will be difficult to blow out the deposited cinder. The second is to strengthen the implementation of work responsibilities. If the responsibility is not fulfilled, the on-site work is not in place, the sediment and water in the borehole are not removed in time, the concentration of gas drainage will be low for a long time, and the purpose of regional outburst elimination will not be achieved.

(3) Actively promote the use and comprehensively improve the drainage effect. Successfully solved the problem of water-blocked drainage concentration and unstable drainage volume of the downward
boreholes through the 21126 top-draining tunnel downward gas drainage borehole pressure wind-blowing test. Tucheng mine has been fully promoted and used, and other mines are also actively promoting applications. Apply this result to the construction site of the downward drilling to continuously improve the drainage effect of the downward drainage drilling.

(4) Improve the process, realize automation and intelligence. Further improve the downward drainage drilling and sealing and pipeline connection technology, realize the timing of pressurized air and water, automatically remove the water and sediment in the drainage borehole, realize the automation and intelligent pressurized air and water technology, reduce labor intensity, and further improve the drainage effect.

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