Research on Anti-reflection Measures of Hydraulic Reaming of Low Permeability Soft Coal Seam in Goutou Coal Mine

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Abstract: According to the C₅ coal seam of gully head coal mine complex geological conditions Poor permeability gas pressure is big Coal seam gas content is high Soft coal extraction from standard time is long, etc., combined with high pressure water jet force reaming technology principle and characteristics of the gully head coal mine is put forward using the method of integration of bottom hole drill wear layer expansion technical measures to increase coal seam permeability, and within the scope of the field to carry out the experimental study. In soft coal seam through field experiment research shows that the drilling construction process, through the integration of enlarging anti-reflection technology measures, can effectively improve the exposed area of a single layer of bore, change of coal seam and the stress distribution state of joints, thus improve the wear layer drilling drainage concentration and smoke volume, shorten the wear layer drilling extraction from standard time to the success of the test for the mine and similar mine to improve coal seam permeability is to provide the basis.

1. Introduction
In Yunnan and Guizhou provinces in southwest China, coal mining enterprises are an indispensable part of local economic development. In recent years, with the increase of coal mining depth, coupled with the geological survival characteristics of coal seam gas in southwest China, the vast majority of coal seams belong to low-permeable soft coal seams, so the difficulty of coal mine gas disaster management has increased, gas has become a key problem restricting the efficient development of coal mining enterprises. At the same time, the current gas treatment technology is mainly the use of mining protection layer and underground drilling two programs. Especially in some single coal seam mines, underground drilling gas pumping (draining) coal seam gas is the main measure to prevent coal and gas prominent, to prevent the work surface wind flow gas over the limit [1].

However, in the process of drilling pre-pumped coal seam gas, due to the soft coal quality, poor breathability of coal seams and other reasons, on the one hand, leading to on-site drilling construction difficulties, mainly reflected in the serious collapse of the hole, slag discharge difficulties, the length of the lower layer drilling construction is short. At the same time, due to the poor breathability of the coal seam, coupled with the serious hole collapse, drilling gas pre-pumping effect cannot achieve the desired effect. If the mechanical increase of drilling diameter, but also faced with drilling induction protrusion, drilling rig load geometric multiplied and other technical problems. Especially in perforated drilling,
effective control of the diameter of the rock section, increase the diameter of the coal hole section, has become the mainstream trend of extraction efficiency, it is under such basic conditions, high-pressure water flow drilling expansion integration process has been greatly used[2-4]. In order to improve the pumping effect of perforated drilling, shorten the pumping time, combined with the characteristics of C5 coal seam, the corresponding experimental research was carried out.

2. Basic overview of the test mine

Goutou Coal Mine is located in Zhaotong City, Weixin County, is an infrastructure mine, design production capacity of 300kt/a, the main coal seam is C5 coal seam, the mine belongs to coal and gas prominent mine, C5 coal seam is outstanding coal seam. The coal seam has the characteristics of high gas pressure, high content, soft coal and poor breathability, and the gas parameters of coal seam gas are seen in Table 1. Mine work surface area anti-burst measures are: transport and return smooth groove using the bottom plate through the layer strip pre-pumping, the work surface using the down-layer drilling pre-pumping.

However, in the construction and pre-pumping process of perforated drilling strip, due to the influence of coal seam gas pressure and collapse, the pre-pumping effect can not achieve the anti-burst effect, the drilling flow is small, the attenuation speed is fast, and the extraction time is long. Some drilling can not even achieve anti-burst effect. In order to solve the above problems, combined with hydro-chemical measures and the characteristics of coal seams, the mine decided to carry out "drilling expansion integration" test research in the 1151 working surface transport along the bottom of the tank pumping lane.

![Table 1 Basic parameters of C5 coal seam in coal mine](image)

| The parameter name                  | Unit | Numerical value   |
|------------------------------------|------|------------------|
| Height of coal seam                | m    | 1.3 ~ 2.3        |
| Dip angle of coal seam             | °    | 15 ~ 21          |
| Coefficient of robustness          |      | 0.23             |
| Damage type                        | type | III ~ IV         |
| Gas pressure                       | MPa  | 0.57 ~ 1.13      |
| Gas content                        | m³/t | 7.7 ~ 13.1       |
| Attenuation coefficient            | d⁻¹  | 0.32 ~ 1.2       |
| Permeability coefficient           | m²/MPa·d | 0.47 ~ 1.71 |
| Initial velocity of dispersion     | mmHg | 27               |

3. Analysis of the technical concept of Hydroplation

3.1. Hydroplation technology

High-pressure water jet drilling integration is a technology to improve the efficiency of drilling gas extraction, that is, in the construction of perforated drilling, the use of drilling rigs to drive high-pressure drill pipe and expansion drill bit rotation, water tank high-pressure water through high-pressure hose, high-pressure rotating water tail, high-pressure drill pipe and drilling high-low-pressure converter on the nozzle to drill the drill coal wall to strike, cut or peel. Through the high-pressure expansion drill pipe along the drilling axial direction of the formation of the entire drilling radial continuous expansion of the hole, to expand the drilling diameter, increase the exposed area of the coal seam and drilling radial discharge range purposes, thereby improving the breathability of the coal seam and gas extraction effect, and further reduce the coal seam gas pressure. At the same time, after wetting the coal seam, the elasticity of the coal body is reduced, the initial speed of coal body discharge pressure and gas dispersion is reduced, which is conducive to the prevention and control of coal and gas prominent[5-9].
3.2. High-pressure water jets combine drill teeth to break coal

The destructive effect of the current on the material of the coal rock body is mainly embodied in: (1) the impact force of the laser; (2) Water wedge action; (3) the stress wave effect produced by the flow; (4) Air erosion damage. The impact force of the air current and the resulting stress wave play a major role, running through the whole process of opening the hole. Water wedges and cavitation play a role in promoting the expansion of accelerated damage. When the jets and impact surfaces are orthoexciton, the jets shock the plane and then turn downstream, and the degree of deflection varies with the shape of the rock body destroying into depressions, as shown in Figure 1.

![Impinging jet and its different reflection directions on rock](image)

When the compressed waves of the impact rock body are transmitted to the free surface of the rock body, the stress on the rock body is reduced from the compression stress at the time of infraction to the stretch stress at full reflection. When the stretch stress exceeds the extrusion strength of some low-intensity rock bodies, the stretch breaks there, creating a fissure[9-13]. The crushing structure of water jets in non-homogeneity materials is shown in Figure 2.

![Crushing mechanism of water jet in heterogeneous material](image)

4. Drilling expansion integrated construction design

4.1. Drilling expansion integrated equipment and technology

High-pressure water jets drilling expansion integration equipment mainly includes: special drill bit, high-pressure drill pipe, high-low-pressure converter, high-pressure rotating water tail, high-pressure hose, high-pressure water pump, water tank, high-pressure gate valve, filtration device, drilling rig, supporting tools.

4.2. Drilling design

According to the mining deployment needs of the trench head coal mine, the test was selected to be carried out at the bottom of 1151 pumping lanes. This test designed two sets of drilling, the first group for the original drilling group, a total of four columns, each column of 10 drilling holes, hole bottom spacing 4m. The second drill is a drilling group with four columns, each with 10 boreholes and a hole bottom spacing of 4m. In accordance with the requirements of the Prominent Rules for the Prevention and Control of Coal and Vavae (2019 edition), Each group of drilling control coal seam transport lane contour line 16m, lower 16m, to meet the drilling control lane contours outside the requirements of more
than 15m. The drilling layout plan is shown in Figure 3, and the drilling layout profile is shown in Figure 4.

4.3. drilling construction
The first group of drilling for ordinary drilling, do not expand the hole, drilling diameter of 89mm, the purpose of which is mainly to examine the C5 coal seam in the case of unexplode various parameters.

The second group of drilling holes is the expansion drilling, in the construction process, the design of the drilling holes for cross-expansion, that is, the first column and the third column 1, 3, 5, 7, 9 and the second column, the fourth column 2, 4, 6, 8, 10 drilling holes respectively. In the first two expansion drilling construction process, we must control the drilling progress, the purpose is to investigate the coal rate, the amount of coal and the relationship between time, analysis of the size of the expansion and the amount of coal.

5. Investigation of test results
5.1. Analysis of the correlation between hydro pressure, coal rate and amount of coal produced
Through the controlled construction of drilling holes 1-1 and 1-3 of hydraulic reaming group, the following conclusions can be drawn.

(1) When the hydro pressure is below 7MPa, the slag in the borehole is not discharged well. After the pressure reaches more than 12MPa, the slag discharge is more stable. The rate of coal production increases when more than 16MPa is exceeded.

(2) When the pressure is stable at 12 to 15MPa, the normal coal yield is 18.9 to 29.3 kg/min, and the average coal-out rate is 24.1 kg/min.
(3) The amount of coal produced per meter per hole is 0.73 to 1.21t, and the average amount of coal produced is 0.97t/m.

Therefore, according to the characteristics of the C5 coal seam of the trench head coal mine, it is determined that the pressure control is 12 to 15MPa, the amount of coal per meter is controlled at 0.8 to 1.0t, and the opening time is about 80min.

5.2. Analysis of gas extraction effect

(1) Single-drilling gas concentration

After drilling construction is completed, the "two blocks and one injection" sealing process is used to seal holes, even pumping, and each group of drilling holes for individual metering. After extraction of a class, the starting pumping concentration determination, and every 3 days for 1 determination, selected the two groups of the largest concentration of drilling for comparison. With data comparison analysis, you can see:

a. The concentration of drilling start pumping is generally higher than that of ordinary drilling, about 2.3 to 4.1 times that of ordinary drilling.

b. The attenuation of the drilling concentration is relatively small, and the continuity of the extraction concentration is obviously better than that of ordinary drilling.

![Figure 5 The change of the pumping drilling of the maximum gas concentration of the expansion group and the ordinary group](image)

(2) Gas extraction

In the course of this test, two sets of metering devices were installed at the ordinary group drilling and expansion group drilling sink pipe, which measured the mixed flow and mixed gas concentration of two sets of drilling in two months, and finally came to the change of their pumping volume (see Figure 6 for specific changes), and analyzed the field data to know:

a. In two months time, the pumping volume of ordinary drilling unit dropped from 0.42m³/min to 0.16m³/min, with an average pumping volume of 0.285m³/min; The drilling of the expansion hole dropped from 0.91m³/min to 0.51m³/min, with an average pumping volume of 0.7025m³/min.

b. using the same time, the drilling volume of the expansion hole is 2.5 times that of the ordinary drilling (statistical average).

c. The pumping attenuation of ordinary drilling gas is greater than that of drilling gas after widening.
Figure 6 A comparison of the amount of gas extracted from the expansion drilling and ordinary drilling

5.3. Residual gas content and extraction time inspection
(1) Before drilling construction each group drilling construction, each group took two coal samples to determine the coal seam gas content, in the ordinary drilling area measured coal seam gas content of 12.3 m³/t, in the expansion area measured gas content 12.5 m³/t. After two months of pumping, the maximum residual gas content was measured at 10.1 m³/t in the ordinary drilling area, and the maximum residual gas content was 9.2 m³/t in the expansion area, with a decrease rate of 17.8% and 26.5%, respectively.

(2) In the same extraction cycle, the gas content drop rate, the expansion drilling can reach 1.51 times the ordinary drilling. Only from the content drop rate analysis, after the expansion of the region's extraction time can be shortened by nearly one-third of the time.

6. Conclusion
The following conclusions can be drawn by carrying out the research on the technical measures of drilling expansion integration and permeable in the 1151 bottom pumping lane of the trench head coal mine:

(1) Through the investigation of the integrated hydro-expansion of C5 coal seam drilling in the trench head coal mine, it is suggested that the hydro-expansion hole of this soft coal seam similar to the trench-head coal mine is that the hydro-pressure is generally 12 to 15 Mpa, and the expansion time is 80 minutes.

(2) The integrated process of high-pressure water-injection drilling has obvious effects in improving pumping concentration, increasing extraction volume and shortening extraction time, which can greatly improve the effect and progress of mine gas treatment.

(3) The method of spacing hydroplification can not only solve the problem of increasing the permeation of soft coal seams, but also save the amount of engineering, and the coal mine with similar conditions of C5 coal seam deposit in the trench head coal mine can be popularized and applied.

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