Study on mining area of roof surrounding rock stability of mining fissure development

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Abstract. The "double end sealing device of drilling drilling water injection leakage" section, to the different depth of sealing hole drilling water injection test, observation in different directions and different drilling water Kong Shen missed development in mining fracture analysis at different depth of stratum loss, combined with different directions borehole sections of fissure, preliminary judgment the test site of mining roof surrounding rock fracture stability region boundary of mining; use of field test data, analysis of Yu Yang coal mine N21110 mining fissure development scope and the degree of fracture development in mining area of roof stability.

1. Introduction
With the advance of the working face, the overlying strata are affected by mining, and the stress failure produces the mining fracture zone with dynamic evolution distribution, which provides the main passage and space for the pressure-relief gas flow and storage in the coal and rock strata, it also provides the main passage for gas seepage to Goaf and working face\textsuperscript{[1-2]}. How to accurately determine the development height of overlying rock fracture zone after mining is of great significance to gas extraction\textsuperscript{[3-6]}. This research adopts "drilling Hole double-end plugging and leak detection device" to carry out the drilling step-by-step water injection method, that is, drilling holes to the roof of the coal seam under the well, and testing water injection into the holes at different depths, the development of mining fractures in rock layers of different depths is analyzed by observing boreholes in different directions and water leakage in different depths, so as to judge the development range of mining fractures in roof surrounding rock of mining stable area at the test site, as shown in Figure 1.
2. Overview of the test site

2.1. General Situation of test working face

The test was carried out at N21110 working face of Yuyang coal mine, Chongqing Songzao Coal Power Co., Ltd. The working face has a strike length of 177m, an inclined length of 1187m, an average inclined angle of 5.5° and an average thickness of 0.65 m, the working face roof is shown in Table 1.

Table 1. Table of roof condition of N21110 working face

| Name of roof | Lithology                        | Thickness /m | Lithology characteristics                      |
|--------------|----------------------------------|--------------|------------------------------------------------|
| Main roof    | Argillaceous limestone           | 1.5          | Gray, medium-thick, layered, hard               |
| Direct roof  | Mudstone 10 # coal bed arenaceous mudstone | 6.27         | Gray mudstone 10 # Coal Seam Light Gray Sandy mudstone |
| False top    | Mudstone                         | 0.6          | Black, with plant fossils                      |

2.2. Layout of laneway around test working face

The laneway of N21110 working face is about 4M wide and 2M high. The N21112 working face is being arranged to the north of the working face, and the N21112 return air lane has been excavated. The coal pillar width between the return Air Lane and the N21110 transport lane is about 8M, as shown in Figure 2.

2.3. Prediction of water flowing fracture zone in overburden rock

According to the mining parameters, geological mining conditions and roof lithology of N21110 working face in Yuyang Coal Mine, the failure height of overlying strata is calculated to be $9.27 \pm 4 \text{ m} \sim 14 \pm 5.6 \text{ m}$. Therefore, this test is to control the overburden failure in the range of 5 ~ 20m.
3. Step-by-step water injection test

3.1. Test plan

The test was carried out in N21112 return air roadway of Yuyang Coal Mine, and 75mm drill bit was used to drill the roof hole in the direction of N21110 transport roadway. The final hole was located above the roof of mining stable area of N21110 working face.

(1) Lateral test drilling of roof in mining stable area

In the N21110 mining stability area, three lateral test boreholes were constructed, the spacing of the holes was 0.5 m, the spacing of the holes was 0.2 m, and the boreholes were on the same horizontal line. Drilling parameters and layout are shown in Table 2 and Figure 3.

**Table 2** Parameter table of roof transverse test hole in mining stable area

| Hole number | Azimuth angle /° | Obliquity /° | Hole depth /m | Opening position |
|-------------|------------------|--------------|---------------|------------------|
| 4#          | 90               | 50           | 25            | Distance to base plate 1.5 m |
| 5#          | 80               | 50           | 25            | Top of the tunnel, away from the coal wall 800 mm |
| 6#          | 100              | 50           | 25            | Top of the tunnel, away from the coal wall 800 mm |
| 7#          | 90               | 60           | 25            | Distance to base plate 1.5 m |
| 8#          | 90               | 45           | 25            | Top of the tunnel, away from the coal wall 800 mm |

Remarks: The azimuth angle is the angle between drilling hole and N21112 return air lane

![Figure 3. Testing hole layout of roof in mining stable area](image)

The layout of roof test boreholes in mining stability area is shown in Figures 4 and 5.

![Figure 4. 4#，5#，6# Borehole profile](image)
3.2. Experimental data observation
There are 3 lateral test boreholes and 2 Longitudinal Test Boreholes in the roof of the mining stable area. Some information about water injection and leakage in the test borehole is shown in Table 3~7.

(1) Lateral test drilling of roof in mining stable area

Table 3 4# borehole water injection and leakage information record sheet

| Water injection depth /m | Drop Height /m | Sealing pressure /MPa | Injectionpressure /MPa | Leakage/L | Water injection time/min |
|-------------------------|----------------|-----------------------|------------------------|-----------|-------------------------|
| 3.75                    | 2.9            | 0.4                   | 0.15                   | 4.2       | 1                       |
| 5.25                    | 4              | 0.4                   | 0.16                   | 2.1       | 1                       |
| 6.75                    | 5.2            | 0.4                   | 0.17                   | 5.6       | 1                       |
| 8.25                    | 6.3            | 0.4                   | 0.18                   | 5.1       | 1                       |
| 9.75                    | 7.5            | 0.4                   | 0.19                   | 6.1       | 1                       |
| 14.25                   | 10.9           | 0.4                   | 0.23                   | 4.85      | 1                       |
| 17.25                   | 13.2           | 0.4                   | 0.25                   | 1.7       | 1                       |
| 18.75                   | 14.4           | 0.4                   | 0.26                   | 1.2       | 1                       |
| 20.25                   | 15.5           | 0.4                   | 0.27                   | 0.9       | 1                       |

Table 4 5# borehole water injection and leakage information record sheet

| Water injection depth /m | Drop Height /m | Sealing pressure /MPa | Injectionpressure /MPa | Leakage/L | Water injection time/min |
|-------------------------|----------------|-----------------------|------------------------|-----------|-------------------------|
| 3.75                    | 2.9            | 0.4                   | 0.15                   | 2.2       | 1                       |
| 5.25                    | 4              | 0.4                   | 0.16                   | 2.1       | 1                       |
| 6.75                    | 5.2            | 0.4                   | 0.17                   | 5.3       | 1                       |
| 8.25                    | 6.3            | 0.4                   | 0.18                   | 4.8       | 1                       |
| 9.75                    | 7.5            | 0.4                   | 0.19                   | 6.1       | 1                       |
| 14.25                   | 10.9           | 0.4                   | 0.23                   | 5.8       | 1                       |
| 17.25                   | 13.2           | 0.4                   | 0.25                   | 1.6       | 1                       |
| 18.75                   | 14.4           | 0.4                   | 0.26                   | 0.9       | 1                       |
| 20.25                   | 15.5           | 0.4                   | 0.27                   | 1.2       | 1                       |
3.3. Analysis of test drilling data

Based on the observed data, the quantitative and qualitative analysis of the water injection loss of each observation hole is carried out.

(1) Lateral test drilling of roof in mining stable area
According to the data, the variation curve of drilling leakage in lateral test in mining stability area is obtained, as shown in Figures 6~8.

![Figure 6. 4#~6# variation curve of hole leakage with hole](image)

![Figure 7. 4#~6# variation curve of borehole leakage with vertical](image)

![Figure 8. 4#~6# variation curve of hole leakage with horizontal distance](image)

It can be seen from the diagram that the variation regularity of the test boreholes in different azimuth angles is quite consistent, indicating that the fracture height is relatively consistent in the horizontal direction. On the whole, the testing hole leakage shows the changing trend of size and size. In the shallow part (3.7 ~ 4m) of the test drilling hole, the leakage is slightly larger (2 ~ 4L/min), this is because the shallow part of the test drilling hole is located in the loose zone of the roadway and the protective coal pillar, and the protective coal pillar is affected by the mining of the working face, and the fractures are relatively developed; In the interval of 4 ~ 6 m, the loss of borehole is reduced, which shows that the borehole enters the area above the coal pillar which is less affected by mining, and the degree of fracture development is low in this area; When the vertical height of the Borehole Exceeds 6M, the leakage of the Borehole survey points remains at a high level within the range of 6 ~ 14.1m, which is more than 4L/min, indicating that the survey points of the borehole are in the area where the fractures are well developed in the N21110 working face, this area is affected by the mining of this working face, and the longitudinal fracture is highly developed. When the vertical height of the Borehole exceeds 14.1 m, the
leakage of the measured point decreases to less than 2 L/min, which indicates that the degree of fracture development in this area is low and that the borehole has passed through the fracture zone.

(2) Longitudinal test drilling of roof in mining stable area

According to the data in Table 3-2,3-5,3-6, the change curves of drilling leakage in vertical test in mining stable area are obtained, as shown in Figures 9~11.

As can be seen from FIG., the variation law of borehole leakage is consistent with that of lateral test borehole. With the increasing of the drilling angle, the length of the drilling hole in the fracture zone becomes smaller, which accords with the existing Distribution Law of the fracture zone.

4 #,7 # and 8 # boreholes (corresponding dip angles of 50 °, 60 ° and 45 °) enter the relatively developed fracture region near the vertical heights of 5.9 m, 6.1 m and 5 m respectively, and the corresponding horizontal distances are 7 m, 6.2 m and 5.1 m, it shows that the development range of the mined-out area is not vertical, but arc-shaped, and the whole shape is semi-saddle shape, the development scope of mining fracture in Goaf is shown in Figure 12.
4. Conclusion

Based on the analysis of the geological conditions and mining technical conditions of N21110 working face in Yuyang coal mine, the reliable underground observation method is selected on the basis of reasonable prediction of the development range of fractures, in-situ tests and data analysis on the leakage of sectional water injection have been carried out in 5 mining stable zones, and the main conclusions are as follows:

(1) The variation law of Borehole leakage measured in mining stable area is generally consistent, and the variation trend of the magnitude is generally presented. In the shallow part of the test hole (3.7~4m), the leakage is slightly larger (2 ~ 4L/min), and then the leakage decreases in the interval of 4~6m, which shows that the test hole enters the area above the coal pillar which is less affected by mining, the degree of fracture development is low in this area; In the range of 6 ~ 14.1 m, the leakage rate of Borehole survey points is higher than 4 L/min, which shows that the survey points of Borehole survey are located in the area where the roof rock fractures are relatively developed, and this area is affected by mining in this working face, it is located in the range of fracture zone; When the vertical height of the Borehole exceeds 14.1 m, the leakage of the Borehole survey point decreases to less than 2 L/min, which indicates that the degree of fracture development in this area is low and that the borehole survey point has passed through the fracture zone.

(2) With the increase of the testing hole angle, the boundary coordinates of the fractured zone in the roof of the working face decrease transversely and increase vertically, and the upper limit of the fractured zone is about 14.1m. The development range of mined-out fracture in Goafr is not vertical distribution, but arc distribution, and the whole shape is semi-saddle shape.

(3) In the case of intact rock strata, the soft rock is more plastic, can withstand greater bending deformation, is easy to lose crack energy, and is not easy to produce cracks; moreover, most soft rock expands when exposed to water, is easy to plug cracks, and has a restraining effect on mining cracks, hard Rock can stop the crack from spreading more than soft rock. Therefore, the best combination of rock layers to prevent the development of roof fractures is hard rock first, then soft rock, then hard rock, hard and soft rock superimposed accordingly.

(4) Due to the perfection of the current testing methods and the accuracy of the parameter-value trade-off, it may affect the accuracy of the results of the study area. Especially when there is a small fault in the working face, it may cause the High Anomaly of the overlying rock fracture near the fault.

Acknowledgements

Technology of optimum selection of mining area, optimum well location and formation level for CBM well pumping in Goafr (20201101001-2).
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