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Research Article

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Test and analysis of the influence radius of enhanced punching by hydraulic punching

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Abstract In order to study the reasonable hole layout parameters of Changping Coal Mine under hydraulic punching measures and improve the efficiency of gas drainage. The impact radius test of hydraulic punching enhanced extraction was carried out on 5302 bottom draw 2 lane 3 # coal seam in Changping coal mine, and the experimental effect was investigated. By comparing the gas concentration and flow rate of the survey hole around the punching hole before and after implementing hydraulic punching measures. The results show that the gas concentration of the boreholes within the influence range of water punching has increased to varying degrees; the effective impact radius of hydraulic punching extraction should be about 4.5m and the impact radius of about 7.5m using the flow method. The rational design of hole layout parameters laid the foundation.

Keywords Hydraulic flushing; Gas drainage; Pressure relief and permeability enhancement; Radius of influence

1. Introduction

Hydraulic punching can effectively relieve the pressure of the coal body, increase the coal permeability coefficient, and the layout process is simple, the punching time is shorter, compared with other hydraulic measures, the safety is higher, and it has become the most important to strengthen gas drainage The technical method has been widely used in the prevention and control of gas in soft and low permeability coal seams [1-4], and has achieved good results in eliminating the hidden dangers of gas disasters.

The No. 3 main coal seam in Changping Coal Mine has factors such as high gas pressure and complicated gas geological conditions, which lead to unsatisfactory gas drainage effect. Therefore, the mine intends to adopt hydraulic punching measures to improve the technology and equipment of gas extraction and solve the gas extraction problems that plague safety production. If, after implementing the hydraulic punching measures, the analysis of the influence radius of the extraction is not carried out, and the extraction pipeline is directly connected to the extraction, it will lead to unreasonable drilling parameters. Therefore, the accurate measurement of the influence radius of hydraulic punching along the bedding layer is of great significance for improving the efficiency of gas drainage and ensuring the safe production of coal mines. At present, the methods used to measure the influence radius of borehole drainage include pressure reduction method [5], computer simulation to determine the effective drainage radius of borehole [6-7], gas tracking method [8-9] and gas flow method [10-11] etc.

2. Hydraulic punching pressure relief mechanism and measures

2.1. Hydraulic punching pressure relief and permeability enhancement mechanism

Hydraulic punching refers to the use of bedding or penetration drilling to penetrate into the coal body and when drilling to a fixed point position, increase the water pressure to open the water jet of the hydraulic jet assembly. When the water injection jet pressure exceeds the strength of the coal body, the coal body Cracks occurred in the coal body, the coal body began to break, water flow entered the crack and infiltrated, and the static pressure transformed by the jet flow pressure was transmitted in the crack, and a water wedge force was formed to

further expand and extend the crack, causing the coal body to fracture and a large amount of cinder The discharge along the drill hole enables a certain pressure relief and gas discharge area to be formed in the coal body, and cooperates with the gas extraction measures to reduce the ground stress and gas pressure of the coal body, thereby eliminating the danger of coal body outburst [12-13].

2.2. Test equipment

The equipment used for hydraulic punching is shown in Figure 1. Mainly include: ZDY-3200S type hydraulic drilling rig for coal mine; Φ113mm punching drill bit and extraction hole drill Φ113mm; Φ73m × 100mm triangular drill pipe and high-pressure jet assembly, internal diameter 25mm high-pressure hose, 2BZ-40 / 12 high-pressure water pump, high The low-pressure water jet conversion device is composed of the hydraulic punching device shown in Figure 1.

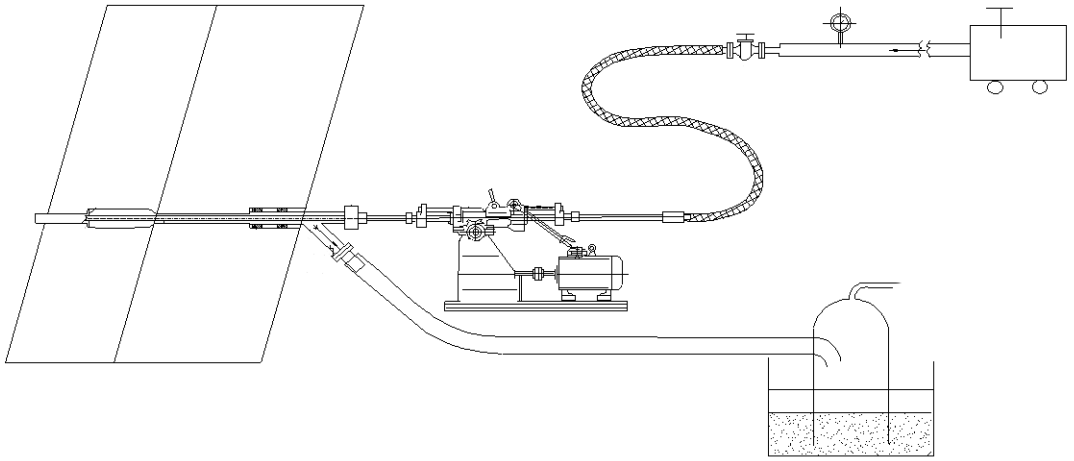


Figure 1: Diagram of hydraulic punching device

2.3. Test method

Commonly used inspection methods for effective radius of drilling include flow method and pressure method. Considering the long construction time of the roadway in the 2202 bottom drainage roadway, most of the surrounding rock in the borehole is in the state of loose pressure relief, and it is difficult to re-close the hole to measure the pressure. Therefore, the flow method is used as the effective extraction radius of hydraulic punching and the method of investigating the radius of influence.

Generally, the flow-radius influence radius investigation steps are as follows: firstly, the drainage borehole is constructed as a survey hole at a different radius from the intended punching hole. Investigate the hole grouping, combine the drainage pipes and install the orifice flowmeter, measure the gas concentration and gas flow in the hole, and check the construction of the hydraulic punching hole (measure hole) and penetration after the gas concentration and flow in the hole are stable Withdraw the drill pipe after the coal seam, and then replace it with a hydraulic punching nozzle for hydraulic punching. During the hydraulic punching process, the gas concentration and gas flow in each group of survey holes are recorded in detail. The change of gas flow determines the effective radius of hydraulic punching.

3. Hydraulic Punching Parameter Design

3.1. Overview of the test site

Shanxi Jincheng Anthracite Coal Mining Group Changping Coal Mine was founded in April 1993 with a designed production capacity of 0.30 Mt / a. Changping Coal Mine has undergone many changes, renovations and expansions since its establishment, and its current production capacity has been upgraded to 5.00 Mt / a. Changping Coal Mine mainly adopts No. 3 coal seam, which is non-spontaneous and stable. The permeability coefficient of coal body is 0.0116 ～ 0.0520 m^2 / (MPa2 · d), which belongs to the more difficult coal seam.

According to the comprehensive statistical analysis of the whole mine, the extraction concentration of bedding holes is 18 ~ 23%, and the average flow rate of bedding holes per 100 meters is 0.0068m³ / min.

The 5302 bottom pumping 2 roadway with hydraulic punching measures is located in the K6 limestone layer of the 3 # coal seam floor. The roof of the roadway is sandy mudstone with a thickness of 9.31m, the floor is fine-grained sandstone with a thickness of 1.87m, and the distance from the 3 # coal bed is not less than 6m. The roadway has a net height of 2.9m, a net width of 4.4m, and a net cross section of 12.76m^2. It is supported by high-strength anchors, metal nets, anchor cables and reinforced joists. 3 # coal seam, thickness 5.79m, black, powder and lump, strip structure, stepped fracture, semi-bright coal, with glass luster. The roadway layout of the implemented hydraulic punching measures is shown in Figure 2.

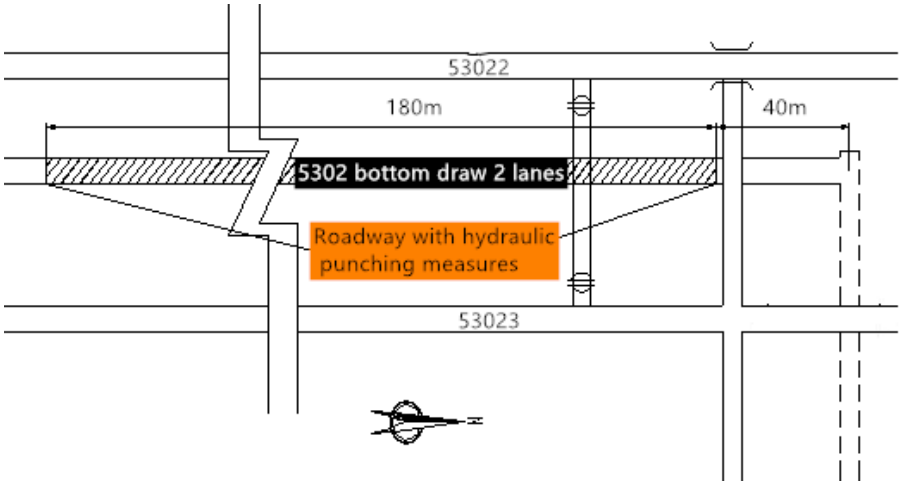


Figure 2: Roadway schematic diagram of hydraulic punching measure section of 5302 bottom pumping 2 roadway

3.2. Field test

The measured gas content of the third unit of the 2nd lane of 5302 bottom pumping, the maximum gas content value is 15.0874m³ / t. During the hydraulic punching of the bottom pumping tunnel, the tunnel is driven by a local fan. The fan model is FBD No. 7.5 / 2 × 55KW press-in fan. The air volume of the working face is about 850m^3 / min. The length of the tunnel in the test area of the hydraulic punching inspection of the floor tunnel is 180m. The tunnel in the survey area avoids the structure and the crack development area to the maximum extent. The specific arrangement of the drilling holes in the hydraulic punching measure section is shown in Figure 3.

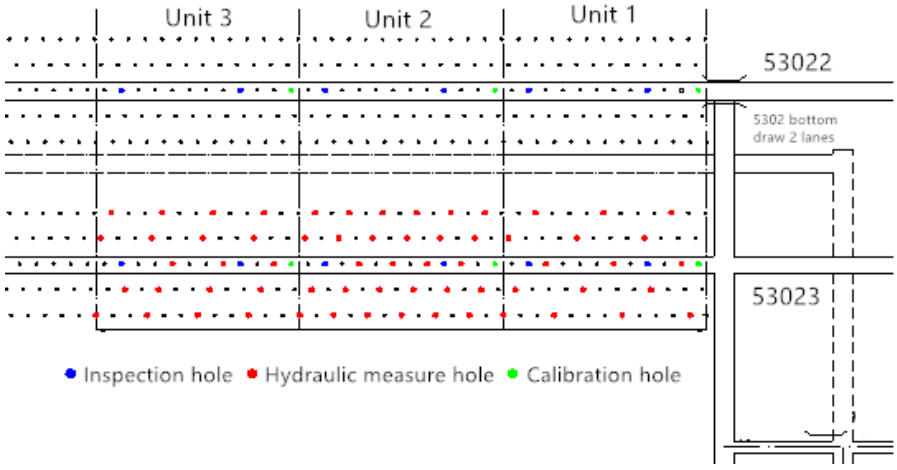


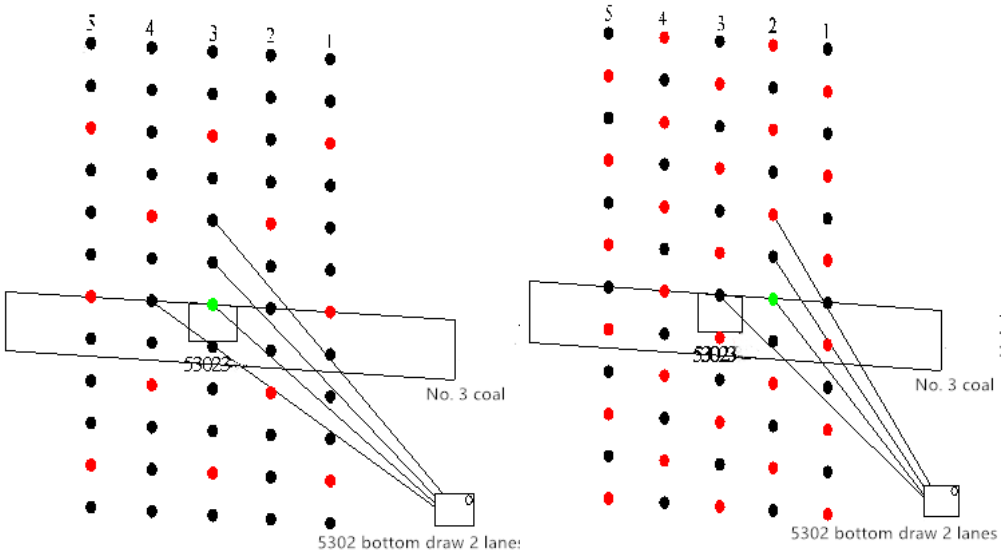
Figure 3: Drilling layout of hydraulic punching measure section

According to the borehole layout design of 5302 bottom pumping and 2 roadway drainage design, 5302 bottom pumping and 2 roadway were constructed with strip pre-drainage holes to cover the west road 53022 and east road 53023, respectively. The distance between the final holes of each hole in a single row of drilling holes is

11m, and the covering range is 53m and the projection range of both roadways of 15023 is 15m. In this hydraulic punching measure, drill holes were selected on the east side of the first to third extraction units of the 5302 bottom draw 2 lanes to implement hydraulic penetration, and the layout of the hydraulic measure holes of each unit is different. Unit 1 is hydraulically punched according to the "diamond" arrangement of ①③⑤—0—②④—0—①③⑤in each row along the roadway. Unit 1 consists of 15 sets of hydraulic punching measure holes. Unit 2 runs along the roadway in each row ①③⑤—②④—①③⑤ in a "triangle" arrangement, and unit 2 has a total of 30 sets of hydraulic punching measure holes. Unit 3 is drained along the row of the roadway in an alternate arrangement of ①③—②④—⑤. Unit 2 has 22 sets of hydraulic punching measure holes. Three drainage units are arranged with 67 sets of hydraulic punching holes.

4. Analysis of experimental results

In order to investigate the effective influence radius of hydraulic punching in 5302 bottom pumping and 2 lanes, hydraulic punching tests were conducted on the 6th group 3 # borehole in the first extraction unit and the 6th group 2 # borehole in the second extraction unit. During the investigation period, in order to avoid the disturbance effect of adjacent punching holes and effective influence radius, during the investigation period, the three groups of drill holes along the strike no longer perform hydraulic punching operations. At the same time, a single-hole investigation and measurement device was installed for each inspection hole, using the flow method to comprehensive. The effective influence radius of the two measures holes was examined, as shown by the green drilled holes in Figure 4. The effective impact radius of these two hydraulic punchings will now be recorded and analyzed separately.



(A) Unit 1 group 6 group 3 # hydraulic punching measures hole layout *(B)Unit 2 group 6 group 2 # hydraulic punching measures hole layout*

Figure 4: Layout of the holes for the effective measurement of hydraulic punching of Unit 1 and Unit 2

(1) Investigation on the punching radius and effective radius of the 3rd hole in the 6th group of the first extraction unit

The plan view of the 3rd drilling hole in the 6th group of the first extraction unit is shown in Fig. 4 (a). The green dots in the picture are the positions of hydraulic punching holes.

3 # The length of the coal section of the punching hole is 13m. When the punching water pressure is 4-12MPa and it is basically stable at 8MPa, the punching time per meter is controlled to 30min according to the general time period from the start of slag discharge to the return of clean water. Seeing that the coal section has a total coal output of 3.5 tons, the coal density is 1.4t / m3, and the hole diameter is 113mm. According to this calculation, it is equivalent to expanding the hole with a diameter of 113mm to a hole of 360mm through hydraulic punching. The three groups of drill holes around the punching holes: 7-3 # (normal distance 5m), 6-4

(normal distance 8.9m), 8-3 # (normal distance 10m) are hydraulic punching investigation holes, in parentheses The normal distance range between each inspection hole and measure hole is marked, which will not be repeated below. Figure 2 shows the detailed record and investigation of the quantification of the contaminated gas every 2 hours before and after hydraulic punching.

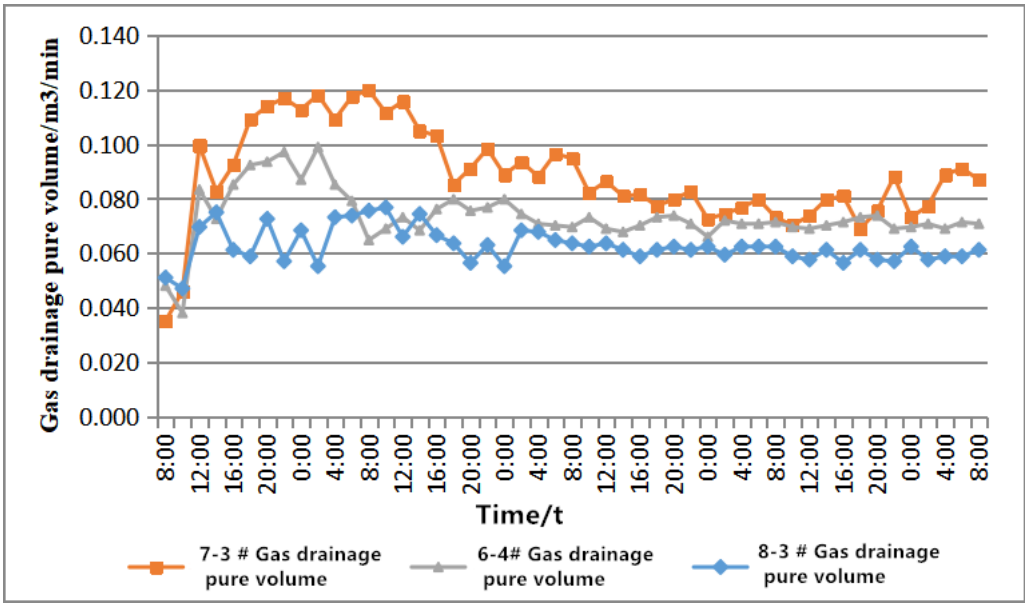


Figure 5: Variation trend of gas scalar quantity of unit 1 hydraulic punching

It can be seen from Figure 5 that the implementation effect of the above hydraulic punching parameters on site varies slightly according to the distance of the survey hole, but overall the gas flow changes of the three groups of survey holes before and after hydraulic punching are not obvious, only there are 7-3 # inspection holes. At the initial stage of the implementation of hydraulic punching measures, the gas drainage pure volume has increased to a certain extent. Specifically, the 7-3 # survey hole (normal distance 5m) gas drainage pure volume increased from 0.035m^3/min before the punching operation, the maximum value increased to 0.12m^3/min after the punching measure, and the average was 0.089m^3/min The gas concentration of the drainage is generally 3% before punching and expanding, and the maximum value increases to about 6% after punching, with an average of 8%. Compared with the 7-3 # inspection hole, the gas drainage pure volume of the 6-4 # inspection hole (normal distance 8.9m) has decreased, and the gas drainage concentration has also decreased to a certain extent. It is 0.074m^3/min and 4%. But the 8-3 # inspection hole (normal distance 10m) has almost no influence on the hydraulic drainage and expansion measures. The average drainage pure volume and drainage concentration are 0.063m^3/min and 4%.

Judging from the changes in the extraction volume, the inspection holes 7-3 # and 6-4 # were affected by the disturbance of hydraulic punching to varying degrees, but the extraction purity of the 8-3 # hole with a distance of 10m from the measurement hole did not change much. The 6-4 # hole extraction pure quantity separated from the measure hole by 8.9m has undergone the process of pure quantity promotion and attenuation within 18h after the implementation of the hydraulic punching measures. Therefore, the effective radius of hydraulic punching should be 4 ~ 5m The influence radius is about 5 ~ 8m, but the gas flow of the three groups of inspection holes gradually stabilizes about 48h after the completion of the punching operation, and the inspection holes of 7-3 # and 6-4 # are all lowered before the punching The extraction pure quantity level shows that after a period of stress balance, the disturbance effect caused by hydraulic punching is gradually eliminated, and the cracks are closed again, and the purity of 8-3 # inspection hole is even lower than the level before punching. The inspection hole is in a region with a high degree of stress concentration. Therefore, the investigation of the effect of the first unit shows that the effective radius of hydraulic punching should be about 4.5m, and the impact radius is about 7.5m. After the punching operation is completed, the stress will recover again and the flow rate will decay faster.

(2) Inspection of the 2nd drilling unit sixth group 2 # drilling punching radius and effective influence radius
The plan view of the 2nd drilling unit sixth group 2 # borehole is shown in Figure 4 (b) respectively. The green dots in the picture are the positions of hydraulic punching holes.
The punching situation at this punching location is similar to the first unit. The coal section of the 3 # punching hole is 10.8m long. When the punching water pressure is 4 to 12MPa and it is basically stable at 8MPa, the slag is returned to the general time period of clear water, the punching time per meter is controlled to 30min, and the total coal output in the coal section is 2.92 tons. The density of coal is 1.4t / m^3 and the hole diameter is 113mm. Hydraulic punching expands the 113mm hole to a 361mm hole. The three groups of drill holes around the punching holes: 7-2 # (normal distance 5m), 6-3 # (normal distance 8.5m), and 8-2 # (normal distance 10m) are hydraulic punching investigation holes, in parentheses The normal distance range between each inspection hole and measure hole is marked. Figure 2 shows the detailed record and inspection of the gas scalar change every 2 hours before and after hydraulic punching.

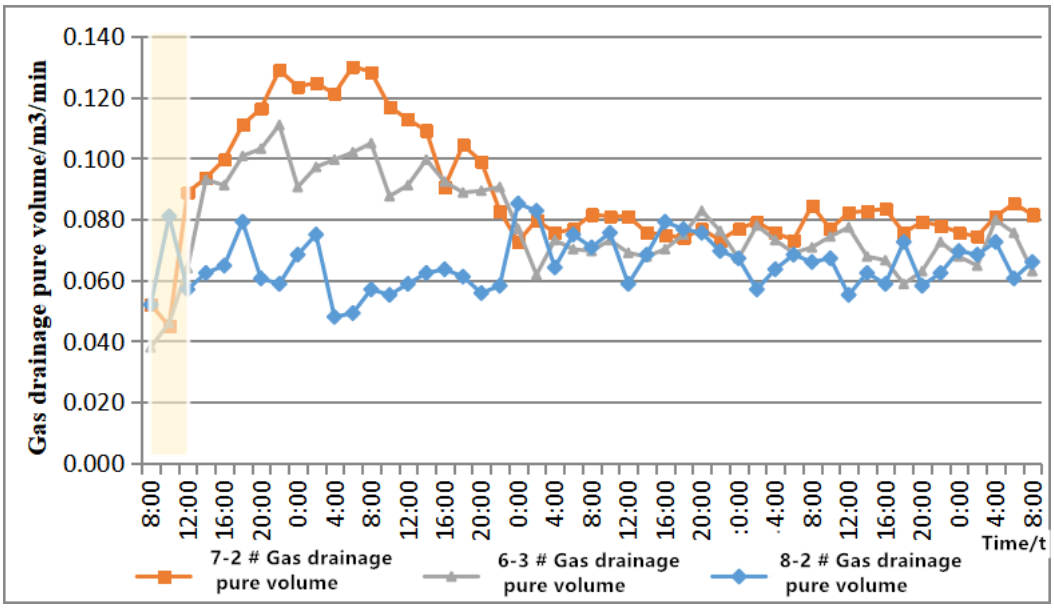


Figure 6: Variation trend of gas scalar quantity extracted by unit 2 hydraulic punching

The inspection results in Figure 6 verify the inspection conclusion of the first unit. The implementation effect of the above hydraulic punching is also different due to the distance from the inspection hole. Specifically, the inspection hole 7-2 # (normal distance 5m). The pure extraction volume is increased from 0.045m^3/min before the expansion and expansion operation, and the maximum value is increased to 0.129m^3/min after the expansion and expansion measures, with an average of 0.089m^3/min. About 11% after the expansion and expansion measures, an average of 7%. Compared with the 7-2 # inspection hole, the gas drainage pure volume of the 6-3 # inspection hole (normal distance 8.5m) has decreased, and the gas drainage concentration has also decreased to a certain extent. It is 0.078m^3/min and 5%. However, the gas drainage pure volume and gas drainage concentration of the 8-2 # inspection hole (normal distance 10m) have not been affected by hydraulic impact expansion measures. The average drainage purity and drainage concentration are 0.065m^3/min and 4.8, respectively %.
Judging from the change in the extraction volume, the inspection holes 7-2 # and 6-3 # were affected by the disturbance of hydraulic punching to varying degrees, but the extraction purity of the 8-2 # hole with a distance of 10m from the measurement hole did not change much. Among them, the extraction pure quantity of 6-3 # hole separated from the measure hole by 8.5m has undergone the process of pure quantity promotion and decay within 40h after the hydraulic punching measures are carried out. The influence radius is about 7.5m, but after 48 hours after the punching operation is completed, the gas flow of the three groups of inspection holes has gradually stabilized. The 7-2 # inspection hole and 6-3 # inspection hole are all reduced to the pre-punching pumping Purity level indicates that after a period of stress balance, the disturbance effect caused by hydraulic punching is gradually eliminated, and the crack is closed again, and the purity of the 8-2 # survey hole is even

lower than the level before punching, indicating that the survey The hole is in an area with a high degree of stress concentration. Therefore, the investigation of the effect of the second unit shows that the effective radius of hydraulic punching should be about 4.5m, and the impact radius is about 7.5m. After the punching operation is completed, the stress will recover again and the flow rate will decay faster.

5. Conclusion

1) After implementing hydraulic punching in the 2302 bottom pumping lane of Changping Coal Mine, the gas concentration of the boreholes in the affected area has been increased to varying degrees. To a certain extent, it has effectively alleviated the current situation of excavation succession caused by the low extraction efficiency of the low permeability coal seam and the difficulty of coal gas extraction.
2) Using the flow method, it was determined that the effective radius of the hydraulic punching in No. 2 bottom 3 # coal seam of Changping Coal Mine 5302 should be about 4.5m, and the impact radius is about 7.5m, which provides a reasonable reason for the mine to implement hydraulic punching measures. Drilling parameters. It can be extended to other production face of the mine, and has certain guiding significance for determining the effective extraction influence radius.
3) Based on the substantial increase in gas extraction volume, it has shortened the time for the mine gas extraction to meet the standards, improved the production efficiency, and provided technical support for the safe and efficient production of the mine.

References

[1]. Yuan Liang, Lin Baiquan, Yang Wei. Research progress and development direction of coal mine hydraulic technology gas control research in China [J]. Coal Science and Technology, 2015, 43 (01): 45-49.
[2]. Chen Xiangjun, Du Yunfei, Li Liyang. Research on comprehensive anti-outburst effect of coal hydraulic measures [J]. Coal Science and Technology, 2017,45 (06): 43-49.
[3]. Liu Yanwei, Ren Peiliang, Xia Shibai, et al. Investigation and analysis of pressure relief and permeability enhancement effect of hydraulic punching measures [J]. Journal of Henan Polytechnic University, 2009, 28 (6): 695-699.
[4]. Li Bo, Zhang Lulu, Sun Donghui, et al. Research progress and analysis of existing problems in hydraulic punching measures [J]. Journal of Henan Polytechnic University (Natural Science Edition), 2016, 35 (1): 16-22
[5]. Wei Jianping, Li Bo, Liu Mingju, et al. Determination of effective influence radius of hydraulic punching outburst elimination and optimization of drilling parameters [J]. Coal Science and Technology, 2010, 38 (05): 39-42.
[6]. Wang Zhaofeng, Zhou Shaohua, Li Zhiqiang. Numerical calculation method of effective drainage radius of gas drainage boreholes [J]. Coal Engineering, 2011 (06): 82-84.
[7]. Wei Jianping, Liu Yingzhen, Wang Dengke, et al. Numerical simulation of effective radius of hydraulic punching [J]. Coal Mine Safety, 2012, 43 (11): 9-12.
[8]. Chen Hui, Niu Jianchun, Li Zhilei, et al. Research on SF_6 tracer method combined with numerical simulation to determine the effective radius of borehole drainage [J]. Mining Safety and Environmental Protection, 2016,43 (04): 14-18.
[9]. Hao Tianxuan, Song Chao. Numerical simulation combined with SF_6 tracer method to determine the effective gas drainage radius of coal seam boreholes [J]. Chinese Journal of Safety Science, 2013, 23 (01): 22-27.
[10]. Yang Hongmin, Xia Huihui, Chen Liwei. Research on the measurement of the influence radius of bedding drilling along the coal seam in this coal seam [J]. Coal, 2011, 20 (03): 1-2.
[11]. Ma Xiangpan, Wang Zhaofeng. Research on determination of gas drainage influence radius based on flow method: 2017 National Annual Conference of Gas Geology, Tengchong, Yunnan, China, 2017 [C].

[12]. Wang Zhaofeng, Fan Yingchun, Li Shisheng. Application of hydraulic punching technology in soft and low permeability outburst coal seam [J]. Coal Science and Technology, 2012, 40 (02): 52-55.
[13]. Liu Mingju, Ren Peiliang, Liu Yanwei, et al. Coal breaking theory analysis of hydraulic punching and outburst prevention measures [J]. Journal of Henan Polytechnic University (Natural Science Edition), 2009, 28 (02): 142-145.