FIELD EXPERIMENTAL STUDY ON COMPREHENSIVE DUST CONTROL TECHNOLOGY IN FULLY MECHANIZED CAVING FACE OF EXTRA THICK COAL SEAM

by

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In order to solve the dust treatment problem of the coal Permian extra thick coal seam mined by Tashan Coal Mine, the comprehensive dust treatment technology research was carried out with the 8106 comprehensive discharge face and 8210 comprehensive discharge face of Tashan Coal Mine as the geological background, and the four aspects of coal seam water injection process, determination of water injection parameters, inspection of water injection and dust reduction effect and application promotion prospects were analyzed and studied.

Key words*: extra-thick coal seam, fully mechanized caving face, dust control, coal body water injection*

Introduction

As five main natural disasters in coal mines, dust has always affected the safe and efficient production of coal mines. Dust is also the main cause of pneumoconiosis in coal miners, many coal miners died of pneumoconiosis in previous years, due to the improvement of dust control level in recent years, the number of coal miners who died of pneumoconiosis was controlled, but coal dust still affected the safe production of coal mines and the working environment of coal miners. Therefore, dust control was still an urgent problem to be solved.

Therefore, the comprehensive dust control technology was studied in 8106 and 8210 fully mechanized caving face of Tashan Coal Mine. The establishment of effective dust comprehensive treatment system, on the one hand, can provide better working environment for mine workers, and reduce coal mining dust hazards, and also achieve safe and efficient mine production [1, 2], on the other hand, it also provides some technical support and experience for other similar mines to carry out comprehensive dust control research.

Engineering survey

The 3#-5# layer of Carboniferous Permian in Tashan Coal Mine has the characteristics of loose, easy to produce dust and poor wettability, so it is difficult to control dust [3-5].

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According to the measurement, the average total dust is 264 mg/m^3 and the average respirable dust is 138 mg/m^3 during the coal cutting period of the fully mechanized caving face in Tashan Coal Mine, the average total dust is 211 mg/m^3 and the average respirable dust is 132 mg/m^3 during the coal drawing period, the average total dust is 140.2 mg/m^3 and the average respirable dust is 85.7 mg/m^3 during the moving operation, the average total dust is 60.7 mg/m^3 and the average respirable dust is 32.3 mg/m^3. There is still a big gap with the national health standards and the industry standards of coal mine dust prevention and control [6, 7], it does not meet the national requirements for intrinsically safe mines in the dust prevention and control [8-10].

Water injection process

Arrangement and parameter of drilling wells

Firstly, the 8106 working face is alternately arranged with long and short drilling wells for uniaxial water injection. The length of the 8106 working face is 217.5 m, the recoverable length is 2490 m, the average coal thickness is 14.57 m, and the opening height of the drilling wells is 1.2 m from the floor, the final position of the drilling wells is the roof of the coal seam, the diameter of the drilling wells is 65 mm. Coal seam water injection drilling wells were carried out at the coal mining side of Lane 5106, the first drilling position is 100 m away from the cutting hole of the working face, the last borehole is 2.5 m away from the stop line, with a total length of 2387.5 m, uniformly arranged on one side, a total of 192 boreholes shall be arranged every 12.5 m. 8106 working face unidirectional water injection drilling layout parameters in tab. 1, and 8106 working face unidirectional water injection drilling layout diagram in fig. 1. The drilling angle and opening height of odd numbered holes were showed in fig. 2, and the even numbered holes were showed in fig. 3.

Table 1. The 8106 working face unidirectional water injection drilling layout parameters

Drilling parameters	Odd number drilling	Even number drilling
Number of boreholes [unit]	96	96
Drilling elevation angle [°]	5.3	10.7
Angle between borehole projection and roadway centreline [°]	90	90
Bore length [m]	145.6	73.7

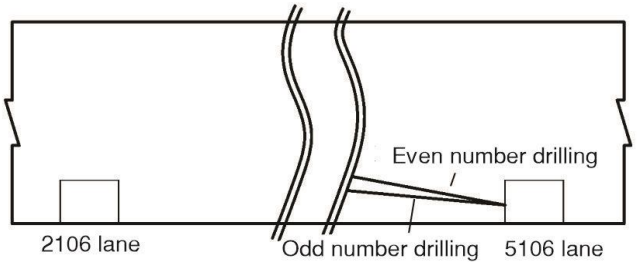

Figure 1. The 8106 working face unidirectional water injection drilling layout diagram

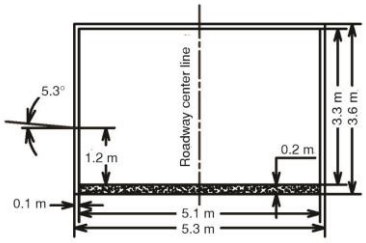

Figure 2. Drilling angle and opening height of odd numbered borehole

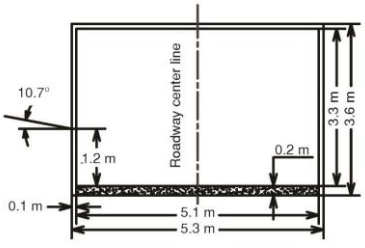

Figure 3. Drilling angle and opening height of even numbered borehole

During two-way water injection, the hole opening height is also 1.2 m away from the average floor, and the hole end point is located at the coal seam roof, with a diameter of 65 mm. The difference is that the coal seam water injection drilling is divided into three groups, the first group and the second group were constructed at the coal side of Lane 5106, and the third group is constructed at the coal side of Lane 2106, the construction of the second group of boreholes is stopped after the drilling of No. 24 borehole, the third group of boreholes were constructed in Lane 2106. The first drill in Lane 5106 is 100 m away from the cutting hole of the working face, and the first drilling position of Lane 2106 is 412.5 m away from the cutting hole of the working face, the last drilling position is 11 m away from the stop line. The drill holes are arranged in a two-way cross way, one drill hole is arranged every 25 m, a total of 192 drill holes are required to be arranged. 8106 working face bidirectional water injection drilling layout parameters in tab. 2, 8106 working face two-way water injection drilling layout diagram in fig. 4, the drilling angle and opening height diagram of the first group of boreholes in fig. 5, the drilling angle and opening height diagram of the second group of boreholes in fig. 6, and the drilling angle and opening height diagram of the third group of boreholes in fig. 7.

Table 2. The 8106 working face bidirectional water injection drilling layout parameters

Drilling parameters	First group of boreholes	Second group of boreholes	Third group of boreholes
Number of boreholes [unit]	96	12	84
Drilling elevation angle [°]	5.3	10.7	5.3
Angle between borehole projection and roadway center line [°]	90	90	90
Bore length [m]	145.6	70.0	145.6

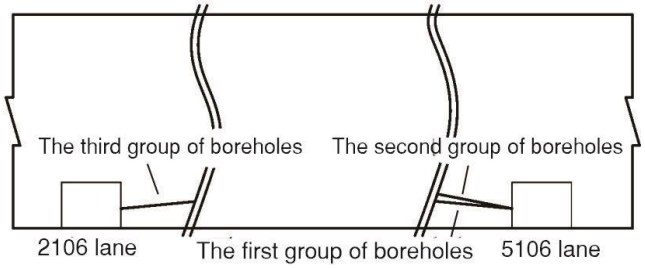

Figure 4. Layout diagram of bidirectional water injection borehole in 8106 working face

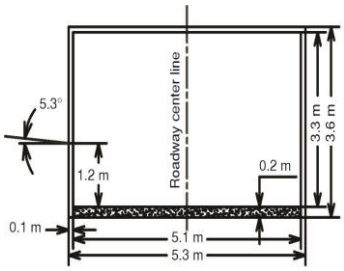

Figure 5. The first group of drilling angle and opening position diagram

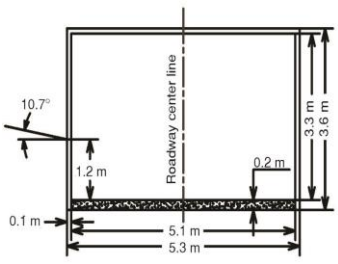

Figure 6. The second group of drilling angle and opening position diagram

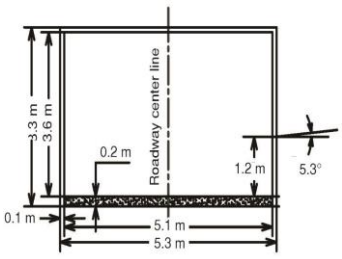

Figure 7. The third group of drilling angle and opening position diagram

Sealing method

At the beginning of this test, the hole was sealed with a hole sealer. However, after a period of use, the pressure of the hole packer on the hole wall increased, and the hole wall was fractured. When the working face was pressed, the hole packer cannot be reused. In the later test, polyurethane was used for sealing, 5 m seamless steel pipes was used to inject water into the hole, and the 2 m seamless steel pipes were wrapped with gunny bags, finally, the wrapped area was filled with polyurethane. The polyurethane was sent into the water injection hole, and the hole was sealed after expansion and solidification, the test showed that the polyurethane sealing effect was good, and the water injection amount in the coal increased.

Water injection and water supply system

Dynamic pressure water pump for water injection was adopted in this test. The water source for coal body water injection was supplied by two static pressure pools with a volume of 500 m^3 on the ground of the main adit, the water source was from the main adit to the 1070 belt roadway and then to the 5106 roadway, after reaching the 5106 roadway, it was connected to the water injection tank through a hose, lastly, it is connected to a high-pressure injection pump to reach a single water injection borehole. The relevant parameters of the water injection pump used in this test are shown in tab. 3.

Table 3. Water injection pump related parameters

Interrelating parameter	Specification
Model	3BZ-135/17
Power	45 kW
Rated pressure	17 MP
Working pressure	8 MP
Flow rate	135 Lpm

Determination of water injection parameters

Determination of coal seam water injection parameters

Through the observation and analysis after replacing and increasing the instrument, when using the sealing device to seal the hole, the pump body pressure is 7 MPa, the resistance is large, the water flow back to the water tank is more, the surface temperature of the water tank is higher, and the pump is often operated under high temperature and high pressure, which shortens the life of the water injection pump and causes more accidents. After changing the sealing process, the instrument data were analyzed. When the total pressure of the pump body was 6 MPa, the pressure of the sub-meter was 5 MPa, and the pressure of the water injection orifice was 3 MPa. After stopping the pump to close the gate at the water injection orifice, the orifice pressure gauge returns to zero, indicating that there is no pressure in the coal wall hole.

Statistics of total water injection

Through the above measures, effectively guarantee the 8106 working face of coal water injection, in September 8106 working face water injection is 5161 m^3, 511 m^3 more than in August, 1012 m^3 more than in July and September water injection. The water injection volume of 8210 working face is 2790 m^3 in August and 2738 m^3 in September. The details are shown in tab. 4.

Table 4. Statistics of coal water injection in working face from July to September

Working surface	July	August	September
8106 working face	4109	4610	5161
8210 working face	3982	2790	2738

Through the optimization of working face drilling layout and parameters, effectively increase the coal water injection, 8106 working face in April 27 began two-way water injection. After adopting the double-lane porous coal body method in the working face, the average daily water injection volume increased by 80 m^3, which effectively increased the water injection volume of the coal body. The details are shown in fig. 8.

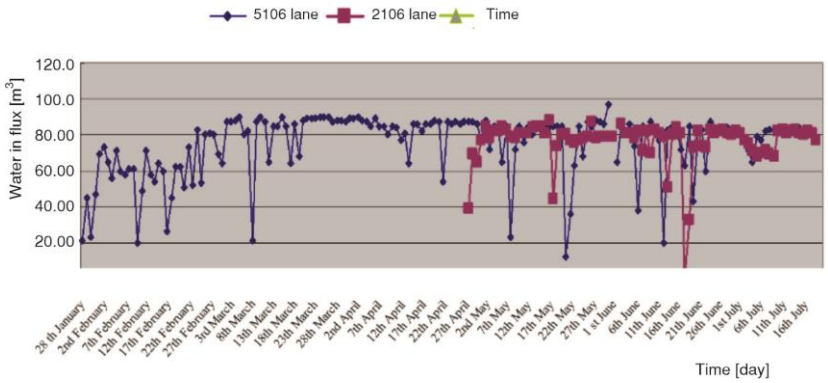

Figure 8. Change of water injection in 8106 working face

Statistics of single hole water injection

In the previous stage, only one total flow meter was installed when the double-hole rotation injection was adopted on the working face. In the previous stage, the water injection system of the working face was optimized. On the basis of the original flow meter, an anti-seismic pressure meter and a high-pressure flow meter were installed on each branch pipe to statistically observe the single-hole flow and pressure data. The specific data are shown in tab. 5.

Table 5. Statistics of single hole water injection in 8106 working face

Drilling number	49#	50#	51#	52#	53#	54#	55#	56#	57#	58#	59#	60#
Water influx [m^3]	321	328	296	315	308	316	304	296	314	1245	323	325

According to the tab. 5, the average single-hole water injection volume of coal water injection in the working face is 314 m^3.

Statistics of water injection per ton of coal

The water injection per ton of coal is given by:

$$Q_t = \frac{Q_s}{L+r}\pi\left(\frac{r}{2}\right)^2\rho \tag{1}$$

where Q_t is the ton coal water injection, Q_s – the single hole water injection, L – the bore length, r – the wetting radius, and ρ – the coal density. The generalized density of coal is also considered in [11-15].

Substitute into the formula, the calculated water injection per ton of coal is 0.012 m^3/t.

On-site water injection dust reduction effect

Dust concentration of working face

Through coal water injection, the dust concentration of each process operation in fully mechanized mining face is detected [16]. Total dust concentration of 8106 working face in July, August, and September in tab. 6, trend change diagram of total dust concentration of 8106 working face in three months in fig. 9. We present the respiration dust concentration of 8106 working face in July, August and September in tab. 7. Trend diagram of respirable dust concentration of 8106 working face in three months is showed in fig. 10.

Table 6. The 8106 working face total dust concentration detection data table

Process	July	August	September
During coal cutting	487.1	164.3	149.9
During coal drawing period	208.1	112.4	96.3
During the moving period	198.6	109.8	100.1
During the return wind	186.4	91.1	78.8

Table 7. The 8106 working face breathing dust concentration detection data table

Process	July	August	September
During coal cutting	222.2	84.5	62.3
During coal drawing period	108.4	36.1	46.4
During the moving period	116.4	41.2	48.2
During the return wind	117.8	41.6	35.8

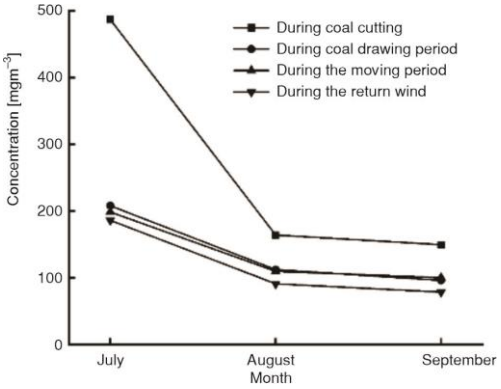

Figure 9. Trend change diagram of total dust concentration of 8106 working face in three months

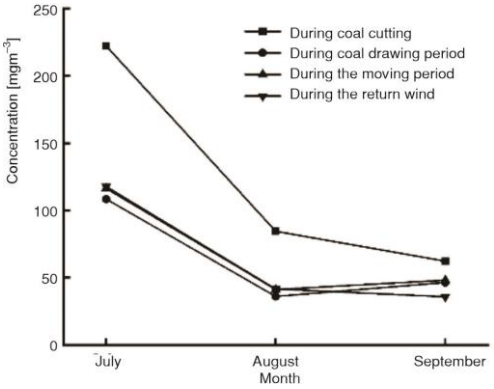

Figure 10. Trend diagram of respirable dust concentration of 8106 working face in three months

It can be seen from the chart. After the coal body water injection, the total dust concentration and respiratory dust concentration detected by each process operation of 8106 working face are significantly reduced. It shows that the research of this comprehensive dust control technology has been verified, which effectively solves the problem of dust reduction in the working face, but the concentration during the coal caving period and the moving period increases, indicating that this control technology needs to be further improved.

Water injection wetting radius

The wetting influence range of coal injection in the early stage of fully mechanized mining face is determined based on previous experience. According to this situation, it is necessary to test the wetting influence range, so as to reasonably determine the borehole spacing. Therefore, in September, three boreholes were tested in 8106 working face, 58#, 59#,

and 60#. When the working face advances 6 m from the 58 # borehole, the dust concentration of the working face is measured daily. Details are shown in fig. 11.

When the working face is within 1-4 m from the 58# borehole from the early shift on the 21st to the night shift on the 22nd, the dust concentration during coal cutting is obviously increasing, indicating that the wetting influence range of each borehole is 4 m, as is showed in fig. 11.

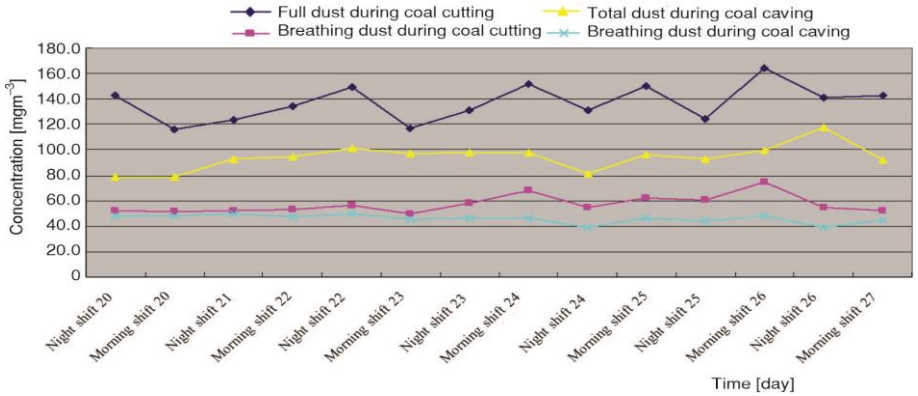

Figure 11. Change of dust concentration at different boreholes in 8106 working face

Conclusion

In this study, Tashan coal mine 8106 and 8210 fully mechanized caving face as the geological background, the conventional water injection work and optimized coal water injection process after the dust data comparison. The dust concentration of each operation stage during the production of fully mechanized caving face is lower than that of the original, which effectively suppresses the large amount of dust generated during the caving, cutting, moving and returning of the working face, improves the working environment of coal miners, effectively improves the production and mining environment of the mine, and lays a good foundation for the construction of intrinsically safe mine. Through the comprehensive dust control based on coal water injection in fully mechanized mining face, the coal water injection in fully mechanized caving face is formed as a breakthrough point. A lot of process improvement and parameter test work have been carried out, and the wetting influence range of each borehole after optimizing the coal water injection process is determined to be 4 m. The important parameters obtained from these tests have certain technical support and method reference for the study of comprehensive dust control technology in fully mechanized caving face of Permo-Carboniferous extra-thick coal seam.

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