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Experimental Study of Pre-splitting Blasting Enhancing Pre-drainage Rate of Low Permeability Heading Face

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Abstract

Taking the heading face of a coal mine as an example, the test of deep-hole pre-splitting blasting was processed. The amount of gas draining after pre-splitting was compared to the amount of direct drainage, and the effective radius of drainage was surveyed. The test results showed that the drainage rate of K_1 coal seam reached 37.13%, which reduced the drainage time by 60%, 10 days after pre-splitting, and the gas desorption index exceed the standards until the fifth blasting. The drainage rate of K_4 needed 12 days to reach 34.28%, which reduced the drainage time by 60%, and the gas desorption index exceed the standards when the third blasting processed. Obviously, the effect of gas drainage was improved by pre-splitting blasting. The effective drainage radius of K_1 and K_4 were 4.5 m and 5.2 m respectively after pre-splitting blasting.

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Keywords: heading face; pre-splitting blasting; drainage radius; coal mine

1. Introduction

Coal and gas outburst is an extremely violent dynamic phenomenon of mines, which seriously affected the normal production and safety of staff. It is one of the worst disasters in coal mine. However, most of the domestic coal and gas outburst mines have characteristic of low penetrability. When driving the coal roadway and draining the gas directly, the draining rate could not meet requirement in a short time. So the

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risk of coal and gas outburst in heading face could not sufficiently reduce which affected the driving speed and succeed of exploitation and driving. As a new technology of looseness and antireflection to the coal seam, pre-splitting blasting was widespread used in high gas mine. It could increase the length and breadth of the stratum several times in range around the blasting drill, and improve the penetrability for the coal seam in the influence range of pre-splitting blasting (Gong, 2008). So the gas drainage level increased, and the drainage time reduced (Liu, 2007). At the same time, the stress concentration ribbon was moved forward, and the risk of coal and gas outburst was weakened. Consequently, the driving speed and security of coal roadway was improved (Cai, 2007).

2. Coal Seam and Gas Conservation Condition in Test Region

There were two workable coal seam in test region of the coal mine executing pre-splitting blasting, which was K_1 and K_4. The thickness of K_1 was 1.03～5.86 m, and averaged 2.92 m which was all workable. The thickness of K_4 was 0.09～1.22 m, and averaged 0.61 m which was partial workable. The layer distance between K_1 and K_4 was 30.8 m. The inclination of coal measure stratum was 14～16° .The absolute gas emission rate of coal mine was 54.8 m^3/min, and the relative gas emission rate was 44.6 m^3/t. The primitive gas pressure of coal seam in test region was 2.75 MPa by field measuring, and the permeability coefficient of coal seam was 1.01×10^{-4}～4.96×10^{-3} m^2/Mpa^2.d, which belonged to coal seam of harder gas drainage.

3. Arrangements of Drainage and Blasting Drills

The gas drainage and blasting drills were arranged along the direction of coal roadway driving. Out of the contour line of the coal roadway, the controlling scope was 5 m in up-incline and 3 m in down-incline, and amount to 450 m^2. There were 14 drills to construction, which combined deep and shallow drills. The depth of drills was about 4.6~45.2 m, and the aperture was 75 mm. In order to increasing the permeability of coal seam, one or two drills out of the 14 drills were chosen to be blasting drills in each round of driving. The disposal of drills was shown in Fig.1.

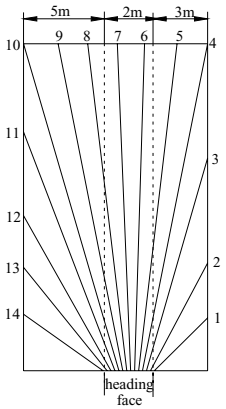

Fig.1. arrangement of drainage and blasting drills

4. Observation of blasting effect

4.1. Observation of blasting effect in K_1 coal seam

4.1.1 The choose of blasting and observation method

In order to review the effect of pre-splitting blasting to gas drainage, as shown in Fig.1, one of the 14 drills was selected to be blasting hole. The other 13 were draining drills. The amount of gas drainage, the time of drainage and the cuttings desorption index after pre-splitting was compared to analysis. The blasting hole selected was the 7# drill in contour of the front of coal roadway driving. The depth of the drill was 45m. The length of charge was 30.4m.

4.1.2. Comparative analysis of blasting effect before and after blasting

When did pre-splitting blasting in transport lane of K_1 coal seam, the gas flow of blasting processed and drainage directly was shown in Fig.2.

When driving without pre-splitting blasting but just pre-draining, the draining rate got to 30% needed 25 days. But after taking pre-splitting blasting, through 10 days draining, the gas rate decayed from beginning draining 42％ to demolishing 5％. The instantaneous gas flow decayed from beginning draining 1.53m^3/min to demolishing 0.33m^3/min.The total amount of gas draining was 1.8312 Million m^3. The pre-draining rate got to 37.13％. The time of draining was cut down 60%. The draining rate was improved 7.13%.

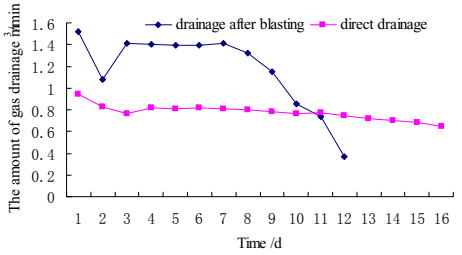

Fig. 2 The amount of gas draining comparison of blasting and direct drainage in K_1 coal seam

4.1.3. The cuttings desorption index contrastive analysis

Before the driving of coal roadway, studied on cuttings desorption index, the results showed that without pre-splitting blasting, the gas desorption index exceed the standards when constructed to the third blasting. The maximum value could get to1.223ml/min.$g^{1/2}$.

After practicing deep hole pre-splitting blasting draining, this could drive 5 small blasting. The efficacy of indicators is 0.643ml/g.$min^{1/2}$ appeared that the gas desorption index exceed the standards at the fifth small blasting (total driving is 32m).

4.2. Observation of blasting effect in K_4 coal seam

4.2.1. The selection of blasting drills

Taking into account the penetrability of K_4 coal seam was very low, and the difficulty of gas drainage was large relatively. There were 2 drills selected as the pre-splitting blasting holes. They were 5，7# in Fig.1, respectively. The depth of the holes was 45m and 45.2m respectively. The length of charge was all 30m. The other 12 were as draining holes.

4.2.2. Comparative analysis of blasting effect after pre-splitting

When did pre-splitting blasting in transport lane of K_4 coal seam, the gas flow of blasting cycles and draining directly was shown in Fig.3.

After pre-splitting blasting, the total draining time was 12 days. The gas rate decayed from beginning draining 31％ to demolishing 4％. The instantaneous gas flow decayed from beginning draining 1.21m^3/min to demolishing 0.24m3/min. The pre-draining rate got to 34.28％. When driving without pre-splitting blasting but just pre-draining, in order to get to the same pre-draining rate, it needed more than 30 days. It reduced 18 days by carrying out pre-splitting blasting.

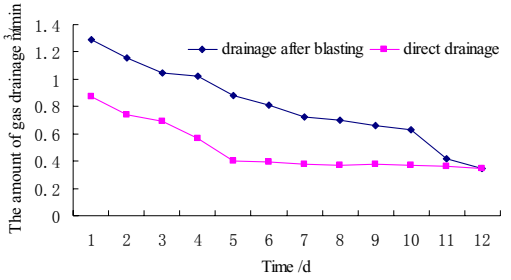

Fig.3 The amount of drainage comparison of blasting and direction in K_4 coal seam

4.2.3. The cuttings desorption index contrastive analysis

If taking the traditional emission outburst technology, the gas in driving process sometimes was at the critical value. This made it difficult to drive and construct.

After practicing deep hole pre-splitting blasting draining, this could drive 3 small blasting cycles. The efficacy of indicators is 0.768ml/g.$min^{1/2}$ appeared that the gas desorption index exceed the standards at the third small blasting cycle.

Thus, reliable protection was provided by pre-splitting blasting for the safety of driving in the coal. Prominent sign did not occur in driving process. The gas rate was generally between 0.1 and 0.6.

5. Observation of pre-splitting blasting drainage radius

The gas drainage radius was an important parameter which influenced the effect of drilling gas drainage. Generally speaking, the longer the drainage time, the larger the drainage radius(Chen, Guo,2008, Clarson, Karacan,2001). But in order not to affect the efficiency of the driving face and ease mining to succeed, we must draw out more gas in a limited time.

The above analysis showed that after pre-splitting blasting, drainage results had improved markedly in driving face. Drainage radius was related with the permeability of coal seam (Wang,2008), gas content and pressure(Liu,2009), and many other factors(Liu,2007), and therefore if needed to design reasonable drainage radius of the drainage to ensure the best results, it must be put investigation after the pre-splitting blasting.

5.1. Observation of drainage radius in K_1 coal seam

At the time of the driving of coal roadway in K_1 coal seam, that conducted on the impact of drainage area study which pre-splitting blasting effected on the drainage. There were 3 cycles for deep hole pre-

splitting blasting were conducted. Each cycle was layout a blast hole and a inspection hole, hole label was showed Figure 1. The Settings of the blast hole and inspection hole and the gas flow before and after blasting were showed in table 1.

Table 1 Amount of gas drainage before and after pre-splitting blasting of K_1 coal seam

cycles	blast hole		inspection hole		charge investigation department and hole spacing (m)	gas flow of study hole (m^3/min)		incremental increase of blasting
	No.	depth (m)	No	depth(m)		before blasting	After blasting	
1	5	30.4	7	45	3.2	0.016	0.036	125%
2	7	38	3	33	4.5	0.018	0.041	128%
3	8	38	3	33	5.1	0.018	0.025	39%

As could be seen from Table 1, after the first two pre-splitting blasting cycles, gas drainage at inspection holes increased significantly by 125% and 128% respectively and got to more than double. After the third pre-splitting blasting, the gas flow at inspection holes while had increased; the increase in volume compared to the previous two circles was little. Department under the charge blasting holes and the inspection holes could determine the effective radius was 4.5m at the pre-splitting blasting of K_1 coal seam.

5.2 Observation of drainage radius in K4 coal seam

The Observation of pre-splitting blasting drainage radius in K_4 coal seam was conducted in one driving working face. There were 3 deep holes pre-splitting blasting were conducted. Each test were layout a blast holes and a inspection holes, hole label was showed Figure 1.

The Settings of the blast hole and inspection hole and the gas flow before and after blasting were showed in table 2.

Table 2 Amount of gas drainage before and after pre-splitting blasting of K_4 coal seam

cycles	blast hole		inspection hole		charge investigation department and the hole spacing(m)	gas flow of study hole (m^3/min)		incremental Increase of blasting
	No.	depth (m)	No.	Depth (m)		Before blasting	After blasting	
1	8	38.2	10	45.1	2	0.026	0.058	123%
2	7	38	4	45	5.2	0.029	0.062	114%
3	9	38.3	4	45	5.6	0.036	0.054	50%

As could be seen from Table 2, the antireflection effect at the first and second blasting was more obvious. Gas drainage at inspection holes increased by 123% and 114% respectively, while the third does not increase significantly compared to first two, a 50% increase. Department under the charge blasting holes and the inspection holes could determine the effective radius was 5.2m at the pre-splitting blasting of K_4 coal seam.

6. Conclusions

- Pre-splitting blasting could make a range of coal around the blasting hole produce a large number of fissures, and increased gas permeability, thereby enhancing the gas drainage volume. And it was conducive to reduce the conspicuous risk at the front of driving face.
- The draining rate of K_1 coal seam after pre-splitting blasting reached 37.13% in just 10 days, which reduced the draining time by 60%, and the gas desorption index exceed the standards until the fifth blasting cycle. The draining rate of K_4 needed 12 days to reach 34.28%, which reduced

the draining time by 60%. And the gas desorption index exceed the standards when the third blasting cycle processed. Obviously, the effect of gas draining was improved by pre-splitting blasting.

- Field test study showed that pre-splitting blasting was only within a certain range to improve gas drainage volume. The effective draining radius of K_1 and K_4 coal seams were 4.5 m and 5.2 m respectively.

Acknowledgements

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