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Study on High efficiency pre-cracking Technology of Coal seam

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Abstract. More than 90% of coal seams in our country are low permeability coal seams, which seriously affects the safety of mine production. Therefore, a kind of solid pre-splitting agent is studied in this project, and the effect of coal seam pre-splitting test is studied in Nantun coal mine. This paper introduces the action principle of the solid pre-splitting agent, and then tests and studies the fracture pore characteristics of the coal in Nantun coal mine, selects the reasonable pre-crack drilling arrangement scheme, carries on the coal seam pre-cracking experiment and collects the results. Through the comparison of the pre-splitting effect of coal seam, it is concluded that the pre-cracking radius of this technology can reach 25 meters, which makes the primary and secondary fractures in the coal body expand, the coal body joints, and the fracture penetration network, thus increasing the permeability of the coal seam. At the same time, a large number of uniform cracks were produced because of the pre-splitting, which improved the lump coal rate. The pre-splitting reduces the coal dust concentration and the strength of the coal body, and reduces the energy consumption of cutting ratio, thus realizing the energy-saving and clean mining of coal mine.

1. Introduction

With the increase of coal mining depth, rock pressure increases, the production of dust in coal face is large, the period of spontaneous combustion of coal is shorter, and the rate of block coal is low, the problems of coal spontaneous combustion are more and more serious. In order to solve this problem, a series of research and practice work have been carried out on coal seam pre-cracking in our country. At present, the pre-cracking methods mainly include high-pressure water injection, carbon dioxide, blasting vibration and so on. The main problems of coal seam pre-cracking by high pressure water injection are uncontrollable and unable to achieve more uniform crack expansion. Water injection pressure is small, so it can not fracture coal body to produce cracks. The use of carbon dioxide pre-splitting to enhance penetration, on the one hand, the construction is complex, on the other hand, the pre-cracking force is not enough, and is difficult to achieve pre-cracking effect. Blasting with explosives, explosives are characterized by strong ignition, instant detonation (several subtle), the influence range is limited (generally affecting 3 m~5 m). In this paper, the original crack and pore



distribution of the coal in Nantun Coal Mine are measured by mercury pressure method, and the corresponding solid pre-splitting agent is studied and selected, and the coal seam is fully pre-splitting by reasonable drilling arrangement. High efficiency pre-cracking technology of coal seam is different from the existing pre-splitting blasting methods, and the effect is much better than the current pre-splitting technology.

2. Theoretical analysis of high efficiency pre-cracking technology in coal seam

2.1. Principle introduction

The new gas-producing device developed by this technique is ignited by ignition powder, and the high-pressure gas is quickly wedged into the primary fracture of coal and rock after combustion, and the shear stress is produced in the coal and rock to cause the crack to expand. At the same time, the gas wedge is formed by high pressure gas and the pressure continues to rise. After reaching the set pressure, the gas generating device will explode, which will further develop the fracture, and divide the interlaced coal and rock mass into network fracturing. The technical mechanism of solid pre-splitting agent is shown in Figure 1. presplitting .

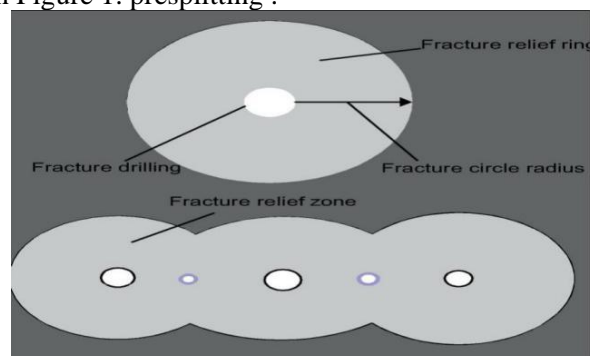


Figure 1. Diagram of the pressure relief of the slit.

2.2. Feature analysis

The pre-splitting characteristics of solid gas-producing pre-splitting agent are as follows:

(1) After ignition, the detonation is not reached immediately, but a large amount of high-pressure gas (in drilling hole) is produced by rapid combustion. When the pressure reaches 200kg/cm^2 (designed according to the mechanical properties of different coal seams), a large amount of gas is produced instantly, which has the function of blasting as well as presplitting. And according to different borehole diameter, coal seam condition, site construction condition, gas production pre-splitting agent, it can be designed into different diameter, different length and different characteristics.

(2) The site construction is very convenient. And there is no explosive-like martyrdom distance, once ignited will burn. After combustion, the main components are: water, nitrogen, carbon dioxide and other non-toxic and non-corrosive harmless gases. The pre-cracking agent is intrinsically safe, normal pressure, no point at room temperature, and combustion temperature is always below 500°C . In addition, when the pressure is less than 30kg/cm^2 in the drilling hole, it will be extinguished automatically.

3. Experimental research

3.1. Fracture pore property test

The traditional mercury pressure instrument was used to test the mercury pressure of the tested coal samples in 93 lower 09 working face of Nantun Mine. The porosity and pore distribution of the coal were tested.

3.1.1. Interpretation of result. The mercury pressure curve of the coal sample is shown in Figure 2. The mercury and mercury removal curves of the raw coal samples before pre-cracking are not obvious, and the mercury removal efficiency is 49%. It can be seen from the mercury curve that the porosity of coal samples before pre-cracking is small, the connectivity of pores is poor, and the pore distribution is not uniform. It shows that the pores of Nantun coal are mostly closed or semi-sealed, and the permeability is poor. The porosity is 2.78%, which is low permeability coal.

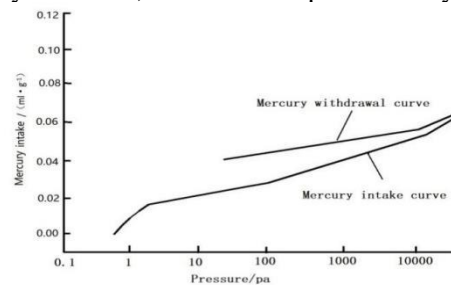


Figure2. Pre-cracking mercury curve.

3.2. Locale pre-splitting experiment

3.2.1. General situation of working face. 93 lower 09 working face is located in the middle of Nine Mining area 2. The west and south are adjacent to the 3 lower coal-wind oxidation zones, the east is the south Jianxing village protection pillar, the north is 93 lower 07 working face goaf, and the south 93 lower 09 face 1. In the process of working face roadway mining, the tunnel will be connected with the original 93 upper 09 and 9309 down passageway respectively. The face elevation is -328.7m ~ -387.1m, the average is -357.9m, the south is high and the north is low. The coal thickness is 3.35m ~ 0.80m, the average is 2.89m. The coal seam inclination is 3° ~ 10° , with an average of 7° . The inclined long wall comprehensive mechanization is adopted in the method of mining full height and all caving coal at one time.

3.2.2. Pre-splitting scheme. The pre-splitting step of gas-producing tool is mainly divided into the following five steps: preparation of early stage, shot hole, charge, hole sealing, and shot blasting.

(1) The drilling arrangement is shown in Figure 3.

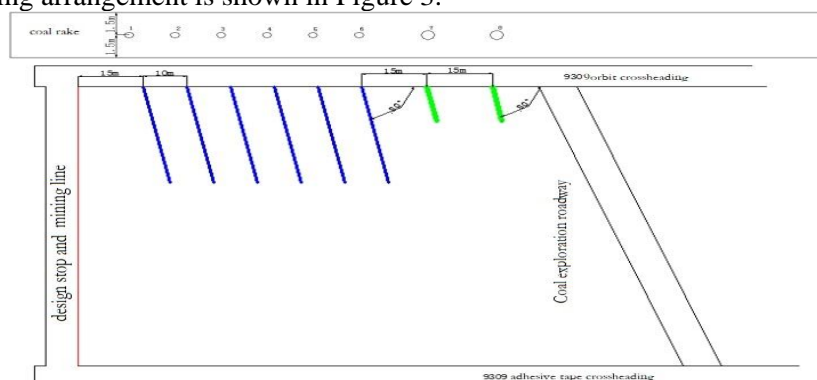


Figure 3. Drilling scheme.

(2) Construction charge

All charge construction is strictly designed and carried out in accordance with the standard construction design. Before loading the solid pre-cracking agent, it is necessary to go through a probe operation to ensure that the borehole passage is unblocked. Only one charge is loaded for the first time, and then the opening of the hole channel is verified again. It can meet the requirements of non-residual cannon.

(3) Hole sealing

The hole sealing method for the drilling hole of the working surface is mainly to perform hole sealing by using the cement slurry, and the sealing tool material of the cement slurry is mainly provided with a steel pipe and a cement mortar for sealing. The sealing structure of the cement and water is 1/ 0.4 by using the silicate cement (425).The sealing structure of the specific drilling hole is shown in Figure 4.

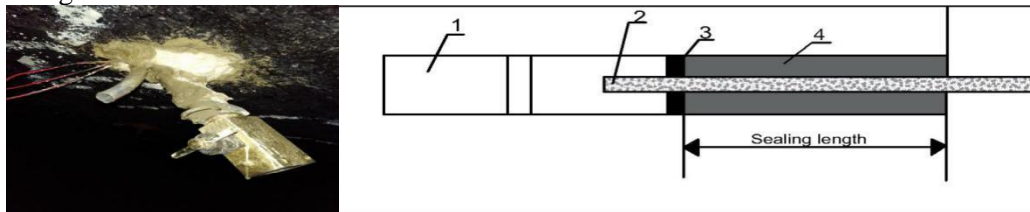


Figure 4. 1. drilling 2. steel tube 3. baffle 4. cement slurry

(4) Blasting

Detonation: ignition of the production apparatus with a 200-release gun, not immediately after detonation, rapid combustion of the solid pre-splitting agent produces a large amount of high-pressure gas (in the hole), the high-pressure gas rapidly expands along the crack gap semi-enclosed pore. Create a large number of new cracks. When the pressure is less than 30kg/cm^2 in the drilling hole, it will turn off automatically.

4. Presplitting effect test

4.1. The comparative effect of the slit pores before and after presplitting

By analyzing the mercury curve of coal samples after pre-cracking (Figure5), it can be seen that there are obvious differences between the mercury input curve and the mercury reduction curve under different pressures, and the mercury removal efficiency is up to 60%.

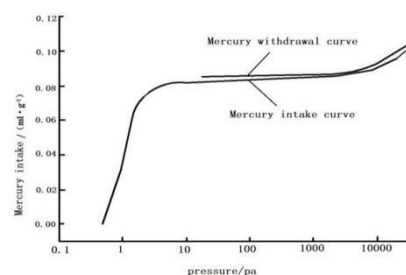


Figure 5. Mercury pressure curve after pre-splitting.

It can be seen from the mercury-feed curve that the pre-cracked coal has a more obvious hysteresis ring, which reflects that the coal body porosity becomes larger, pore connectivity is better, pore distribution is more uniform, and most of the pores become open after pre-cracking. From small holes to large holes connectivity has become better, cracks through the network.

4.2. Coal dust prevention

According to the actual monitoring values, before pre-cracking, 150 meters away from the drilling site, 300 mg / m^3 of total dust, 40 meters from the location of the hole, and 360 mg / m^3 of total dust. Coal seam water injection after pre-cracking, water injection standard: no re-injection or hole leakage stop water injection. Water injection condition: 2# Drilling water injection 2m^3 , 4# Drilling water injection 1.5m^3 , 7# Drilling water injection 3m^3 , all other boreholes are about 1m^3 , after pre-cracking, the coal seam is in the position of 4# holes after water injection, monitored all dust 310mg/m^3 .

The coal cutting test was carried out after pre-cracking. By comparing with the concentration of coal dust produced by coal cutting before pre-cracking, the dust reduction effect of pre-cracking was obtained. See Figure 6.

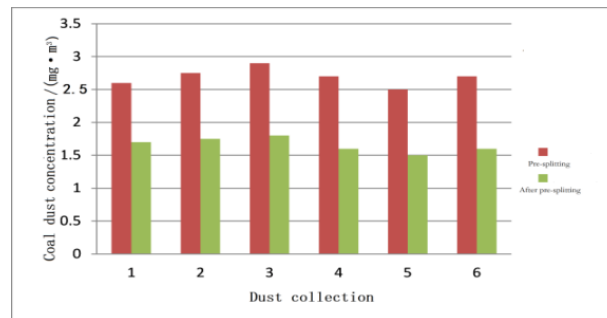


Figure 6. Concentration of cut-off coal dust before and after pre-cracking in working face.

According to the measured results, the coal dust concentration decreases obviously after pre-cracking with high efficiency pre-splitting technology. At the same time, during the coal cutting period, it is obvious that no coal dust flying around the coal seam can be found, and the clean mining of coal seam can be realized effectively.

4.3. Gas extraction effect

All drilling holes in 93 lower 09 working face after pre-cracking are connected into pumping branch pipe on a confluence pipe, and hole plate flowmeter is installed on the confluence pipe to monitor the overall extraction situation of drilling holes in driving face. Comparison of pre-cracking data before and after pre-cracking in coal face. After 20 days, the average gas volume fraction was 51%, the average mixed discharge was $1.43 \text{ m}^3 / \text{min}$, the average net drainage was $0.73 \text{ m}^3 / \text{min}$, and the average 100 m hole drainage was $0.1321 \text{ m}^3 / (\text{min} \cdot \text{hm})$. Comparing the extraction data of 93 lower 09 working face with the data before pre-cracking, see Table 1.

Table 1. Comparison of gas drainage data.

Extraction parameter	Pre-splitting blasting	After pre-splitting blasting	amplification/%
Mean mash gas volume fraction/%	20.2	51	152
Average pumping mixed flow/ $(\text{m}^3 \cdot \text{min}^{-1})$	0.52	1.43	175
Average net pumping flow/ $(\text{m}^3 \cdot \text{min}^{-1})$	0.12	0.73	508
Average net discharge of 100 m borehole extraction/ $(\text{m}^3 \cdot \text{min}^{-1} \cdot \text{hm}^{-1})$	0.0071	0.1321	1760

It can be seen from the table that the extraction concentration, the mixed flow rate and the pure gas flow rate of the drilling holes are significantly increased after the solid pre-splitting agent pre-cracking and penetration enhancement are carried out in the working face.

4.4. Analysis of lump Coal rate before and after pre-cracking

Table 2. Comparison of lump coal rate before and after pre-cracking.

Sequence number	Pre-splitting blasting		After pre-splitting blasting	
	Total 4/t	lump coal	Total 4/t	lump coal
1	25.5	9.75	19.4	9.62
2	35.3	11.35	31.7	20.52
Total	60.8	21.1	51.1	30.14
percentage/%	33		59	

The analysis of Table 2 shows that the lump coal rate before and after pre-cracking is 33% and 59%, with an average increase of 26%. It can be seen that the solid pre-splitting agent pre-cracking technology is beneficial to the increase of coal mass coal yield and the effect is remarkable.

4.5. Energy consumption analysis of coal cutting

The research shows that the implementation of high-efficiency pre-cracking technology makes the primary and secondary cracks in the coal body expand, the coal mass joint, the crack through network, reduces the strength of the hard coal body, thus reduces the cutting impedance of the drum, and reduces the energy consumption of the cutting ratio of the coal seam. It leads to the change of the cutting process parameters of the working face.

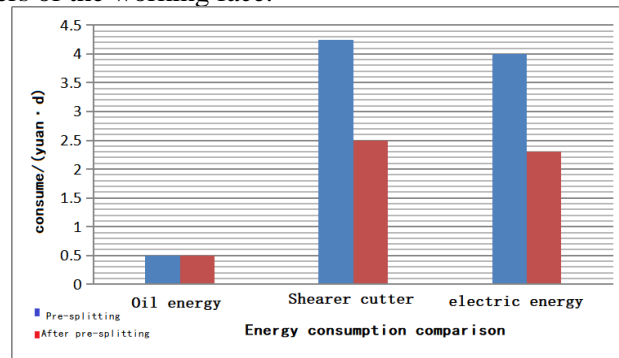


Figure 7. Working face cutting technical parameters before and after pre-cracking.

As can be seen from the comparison of Figure 7, the cut-off ratio of the coal seam after pre-splitting is reduced by about 35% than the energy consumption, so that the effective cracking of the coal body is realized, and the energy-saving and mining of the coal seam is realized.

5. Conclusion

The high efficiency pre-splitting technology of coal dust makes the primary and secondary cracks in the coal body expand, the joint of coal body, the crack through network, and then increases the rate of coal production by 26%, reduces the strength of hard coal body, and thus reduces the cutting resistance of the drum. The specific energy consumption of coal seam cut down by 35%; After pre-cracking, the coal seam water injection effect is better, the coal dust concentration is reduced, and the clean mining is realized.

Through the successful experiment of coal dust high-efficiency pre-splitting technology in Nantun Coal Mine, the technical parameters and experience of pre-splitting blasting are accumulated for the mining of other mining areas in the future.

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