Technology of High-Pressure Water Jet Apply in Rock Cross-Cut Fast Uncovering Coal in Serious Outburst Coal Seam

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Abstract. Coal and gas power risk was increased under the condition of high stress, high gas and low permeability of coal seam in deep mine, low permeability coal seam gas pre pumping was very difficult. Drilling enlarging by high-pressure water jet used high pressure water as the driving force to wash and peel the coal body in the drilling, it aimed to discharge the coal and release the gas in the coal seam quickly, the gas pumping efficiency was improved, the stress of coal seam was declined, and the goal of rapid pressure relief and permeability was achieved. It applied in some serious outburst rock cross-cut coal uncovering area, with drilling enlarging by high-pressure water jet technology, drilling equivalent get to 500~800mm after drilling enlarging, about 3~9 times of the original diameter, gas extraction concentration was 1~2 times higher than before, coal uncovering time was shortened by 1/3~1/2, the effect of field application was obvious.

General Situation

Special research on high pressure water jet through the state "10th Five-Year” and "11th Five-Year”, high-pressure water jet technology has achieved the results of the stage¹²³. In the practice of coal bed methane extraction through drilling construction, on the one hand, some research institutes used the technology of controlled pre splitting blasting, hydraulic fracturing and hydraulic cutting, it has achieved the goal of coal seam pressure relief and enhanced pumping which had certain effect under the condition that the coal seam was relatively hard and brittle, the permeability was better, and the outburst danger is small; However, it was limited to the coal seam with low permeability and outburst risk by controlling the pre splitting blasting. The practice showed that high-pressure water jet technology drilling holes under the condition of low permeability and soft coal seam was also prone to occur the problems that slag was not smooth and the rate of drilling hole was not high. On the other hand, in the early stage of high pressure water jet drilling technology research, this technology had significant effect in the application of layer-through drilling and rock cross-cut coal uncovering unloading pressure to strengthen the extraction of gas. Because in these drilling without drill seam hole long, by adopting the technology of slag was relatively easy and the drilling diameter was large which can significantly improve the permeability of coal seams around the borehole. Therefore, it was an important way to promote coal mine safety and production efficiency through research and development of low permeability coal seam of high-pressure water jet drilling, reaming technology and equipment.

Rock cross-cut coal uncovering was usually in the place of a new mine, a new level or new mining area had not yet revealed the coal seam, On the one hand, the gas pressure and in-situ stress were in the original state, the outburst danger was not known or not fully understood; When exposing coal seam, the working face by the more hard rock burst into the soft coal seam, the concentrated stress in front of the working face was easy to abrupt, and it was more likely to occur coal and gas outburst.
"The key technology of rock cross-cut rapid extraction and uncovering outburst coal seam" was on the basis of hydraulic increasing permeability and strengthening of gas extraction in coal seam, with high pressure water jet cutting coal and increased permeability of coal, further expansion of coal seam gap to increase permeability of coal body, to achieve the rapid extraction of gas and pumping standards, so as to shorten the time of rock cross-cut coal uncovering to ensure the safety of uncovering coal construction.

Technical Principle

Drilling enlarging by high-pressure water jet was rely on high-pressure water shock ability, it can make force of coal broken gradually, the large scale movement in the direction of the drilling has caused the expansion deformation and displacement of the coal body, this promoted the coal body to be released in a certain range around the pore. At the same time, the fracture of the coal body which was fully discharged pressure around the drilling was increased obviously, thus it can greatly improving the permeability of coal seam, promoting gas desorption and emissions and greatly reduce the gas content in coal seam, and the plastic and humidity of coal seam increased, which not only eliminated the outstanding power, but also changed the nature of the outburst coal seam, thus play a role of prevent outburst in the mining operation. Also by high-pressure water immersion making large areas of coal body overall hardness decreased, weakening the bedding property difference of soft and hard layered in coal seam, adjust the gas pressure distribution, reducing the gas pressure gradient, further avoiding the danger of outburst. Drilling enlarging by high-pressure water jet increased coal plasticity reduced the coal body internal stress concentrated, improved the permeability of coal seam, promoted the release of gas, increased the ability to prevent coal and gas outburst, played a role of comprehensive outburst control and rapid elimination of outburst.

[1] The first technical feature of pressure cut fast pumping gas and coal covering technology in rock cross-cut was that coal seam or coal seam group which needs to be uncovered in the vicinity of coal uncovering control pumping area to carry through the layer combined with the hydraulic high pressure cutting. One of the purposes is to put water into the coal, increasing the permeability of coal seams, a substantial increase in the permeability of the coal seam; The purpose of the two is to change the stress and strain of the surrounding rock in rock cross-cut, further to the coal body extrusion, increase the permeability.

[2] The second technical feature of pressure cut fast pumping gas and coal covering technology in rock cross-cut was that 50% drilling coal for high pressure water jet cutting, hard coal body cutting fracture was created by the dynamic effect of high pressure water jet, and flushing the soft coal body, further increasing permeability and pumping space.

[3] The third technical feature of pressure cut fast pumping gas and coal covering technology in rock cross-cut was that the technology innovation of hole sealing was carried out, and at the two ends of the hole drilling rock section pre sealing with mine synthetic resin, the expansion material was used to press the sealing hole, the tightness of the drill hole was enhanced, the concentration of pumping was increased.

Application Effect

Basic Situation of Test Area

In Huainan, Shanxi, Liaoning mining area carried out drilling enlarging by high-pressure water jet down hole, horizontal hole and upward hole expanding test of serious outburst coal seam rock cross-cut coal uncovering. Drilling enlarging by high-pressure water jet test was carried out in Liaoning Daxing Mine North Wing concentrated belt conveyer dip to expose 12 coal seam. Coal seam average dip angle was 4°, the thickness of coal seam was about 2.4m, the gas pressure and content of coal seam were $P_{12}=5.6\text{MPa}$, $X_{12}=10.4\text{m}^3/\text{t}$, and the firmness coefficient was $f=0.22$. 
Drilling enlarging by high-pressure water jet test was carried out in Shanxi Wangfeng Mine main incline shaft to expose 3 coal seam. The average thickness of 3 coal seam was 5.0m, coal seam dip angle was 4~9°, the gas pressure and content of coal seam were $P_3=3.0\text{MPa}$, $X_3=13.74\text{m}^3/\text{t}$, and the firmness coefficient was $f=0.3$.

When the central pedestrian subinclined shaft of Huainan Xinji Mine exposed 6 coal seam, in view of the fact that coal seam permeability was poor, it carried out drilling enlarging by high-pressure water jet to increase coal seam permeability test. 6 coal seam contained 6-1, 6-2 coal seam, the average dip angle of coal seam was 33°, the average thickness of the two coal seam was 3.36m, 0.87m. The gas pressure and content of coal seam were $P_6=0.82\text{MPa}$, $X_6=5.81\text{m}^3/\text{t}$, and the firmness coefficient was $f=0.34$.

**Analysis on the Effect of High-Pressure Water Jet Drilling and Enlarging**

A total of 178 measure drilling have been construct ed in the test area of Daxing mine, drilling diameter was 114mm, design of 2m at the bottom of the drilling, it have 47 drilling using drilling enlarging by high-pressure water jet technology. Statistical distribution of equivalent borehole diameter Using drilling enlarging by high-pressure water jet equipment enlarging drilling, the equivalent hole diameter distribution as shown in figure 1.

![Figure 1. Statistical distribution of the equivalent drilling diameter after the expansion of down drilling enlarging by high-pressure water jet.](image1)

After drilling constructed, using high-pressure to enlarge drilling, the drilling diameter were above 400mm, among them, the diameter of 500~600mm was the most, the proportion was 36%. According to the statistical results of hydraulic enlarging drilling, drilling enlarging by high-pressure water jet had good application effect, single hole coal output was 0.5~8.0t, the drilling enlarging efficiency was high, and pressure relief was obvious, the success rate of 100%, the success rate drilling enlarging was 100%.

When -700m central pedestrian subinclined shaft exposed 6 coal seam, using drilling enlarging by high-pressure water jet equipment enlarging drilling, the equivalent hole diameter distribution as shown in figure 2.

![Figure 2. Statistical distribution of the equivalent drilling diameter after the expansion of horizontal 6 coal seam drilling enlarging by high-pressure water jet.](image2)

After drilling constructed, using high-pressure water jet to enlarge drilling, the drilling diameter were above 650mm, among them, the diameter of 650~700mm was the most, the proportion was
57%. Single drilling coal output was 2.5~3.5m$^3$, the average value was 2.9m$^3$, the effect was very significant. According to statistical data analysis, 6 coal drilling equivalent diameter up to 656~790mm after drilling enlarging, this was 8.7~10.5 times before drilling enlarging, the average equivalent diameter of 720mm, for 9.6 times before drilling enlarging.

**Main Conclusion**

[1] Drilling enlarging by high-pressure water jet can make the coal rapid pressure relief and increase permeability, and change the stress state of the coal, increase of coal plasticity, which was beneficial to the gas drainage, improve coal seam permeability, reduce coal stress concentration, it played a role of comprehensive outburst control and rapid elimination of outburst.

[2] Taking the technology of drilling enlarging by high-pressure water jet in rock cross-cut coal uncovering area, coal seam permeability increased significantly, drilling equivalent diameter to 500~800mm after drilling enlarging, equivalent diameter increased by 3~9 times, gas extraction concentration was 1~2 times higher than before, pumping rate in the area of rock cross-cut coal uncovering was up to 65%~86%, rock cross-cut coal uncovering time was shortened by 1/3~1/2.

[3] This technology has been applied in the serious outburst mine, safety uncovering coal seam of nearly 50, to protect the safety and fast uncovering coal seam, the coal bed methane extraction rate of low permeability coal seam was improved, and the goal of pressure relief and permeability of soft low permeability coal seam was achieved, which has important application value.

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