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Research on drawing and excavating gases with the big direction perforate in coal mine

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ABSTRACT

By describing the design and construction of directional drilling underground, and the effect of the gas extraction, the paper indicating that the process is stable and with low cost and it's convenient to control, by which the gas will be extracted after been relieved by the protective layer. Compared with the other processes being used on the ground, the advantages are more prominent, the process is valuable in promotion.

KEYWORDS

Directional long drill; Extraction; Relieved gas by the protective layer.



INTRODUCTION

Zhuxianzhuang mine is coal and gas outburst mine with the primary mineable coal seam of 8 and 10 seam. 8 coal seam has some good features such as stable quality, low sulfur, low phosphorus, high heat, and it is high-quality steam coal with an average thickness of 8.7m; 10 coal seam average coal thickness is 2.2m. There are 78m between 8 and 10 coal seam with recoverable reserves of 61.27 million tons. Both of the two seams have serious coal spontaneous combustion tendency with an average spontaneous combustion period of 2.5 months and coal dust explosive hazardous. Mine has been divided into three levels: air return level -275m, the first level -435m, the second level -680m and the third level -800m. 8 coal seam has more serious outburst disasters (It is outburst danger zone under -300m from the ground). 10 coal seam is also outburst coal^[1] (There has a relatively weak outburst danger at -680m level). With the increasing depth of mining, gas control needs to be studied and updated because coal and gas outburst danger increases accordingly.

Coal mine adjusted the mining sequence--mining 10 coal seam before 8 as the protective layer in 2009 according to the regional gas control requirements for example adhere to the comprehensive management of the area first and the part as supplement^[2]. Coal mine layout includes a gas drainage roadway throughout the whole coal face in sandstone seam floor under 8 coal seam 30 ~ 40m. Coal mine drill from the gas drainage roadway up to the 8 coal seam with the drilling diameter $\phi 94\text{mm}$, drilling spacing 30m. It has realized gas drainage by laying gas pipeline in the gas drainage roadway combined with drainage drilling.

When mining the coal face at the protective layer, the main roof above the goaf would collapse. Then, the pressure in protected area at 8 coal seam would be fully relief. Accordingly, gas drainage volume increased significantly. These measures decrease the danger of outburst in 8 coal seam. But the bottom drainage roadway deformed severely and produce a lot of fissures affected by mining the protective layer. The gas in 8 coal influx into the bottom drainage roadway from the fissure. The gas concentration is still more than 3% with air volume $1200\text{m}^3 / \text{min}$, so that is no use to increase the air volume. Finally, coal mine closed the gas drainage roadway, used roadway gas pumping mode drainage the gas in 8 coal seam^[3]. Coal mine solved the problems of pressure relief gas drainage, but a huge closed gas area remained, so there are a series of security risks in the following mining activities.

TECHNICAL CONDITIONS AND DRILLING DESIGN

Comb drilling technology is that by constructing long horizontal drillings in the relatively stable stratum beneath the target coal seam and perforating (or close to) coal like branches, realize long-term, and effective gas drainage in the soft coal seam.

Not only achieve drilling comb directional holes and horizontal directional holes, but also realize conventional rotary drilling process, coal mine chose ZDY6000LD (F) crawler hydraulic directional drilling rig produced by China Coal Technology & Engineering Group, Xi'an Research Institute to drill, equipped with a 1.25° , 1.5° screw motor and whipstock to deflect.

In order to achieve better gas drainage effect, Coal mine tries to ensure that the main drilling are activity drillings when design the gas pre-pumping drillings in 8 coal seam, avoid the impact of water accumulation to the gas drainage. According to mine geological features, arrange long drill in 8 coal bottom stratum. First, construct advancing branch drillings and the 600m long main drilling by using long horizontal directional drilling technology and equipped with $\Phi 96\text{mm}$ PDC drill in 8 coal seam bottom. When finish the main drilling, reaming the main drilling with $\Phi 113\text{mm}$ PDC reaming drill, and then down to open branch drillings in the main drilling with a retrievable whipstock.

1 # comb drillings opening azimuth 152° (the same as the strike of coal face), the opening angle 5° , respectively, in the 48m, 144m, 264m, 351m on the top right to open a branch drillings, in the 372m, 30m on the bottom left to open branch drillings. The main drilling's depth reaches 603m, the deepest branch drilling's depth reaches 147m. Please refer to the plane and profile distribution for the details.

The opening point of 2 # comb drillings at 1 # drillings' southwest horizontal spacing of 1.5m and the opening azimuth 160 °, opening angle 5 °. In the process of drilling, the azimuth should gradually reduce at 152 ° until drill to 60m. Respectively, in 60m, 150m, 251m on the top right to open branch drillings, in 351m, 300m, 216m, 120m, 42m on the bottom left to open branch drillings.

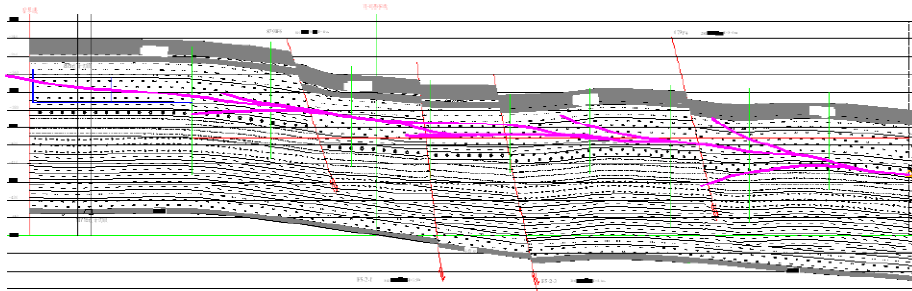


Figure 1: Boreholes distribution in rock

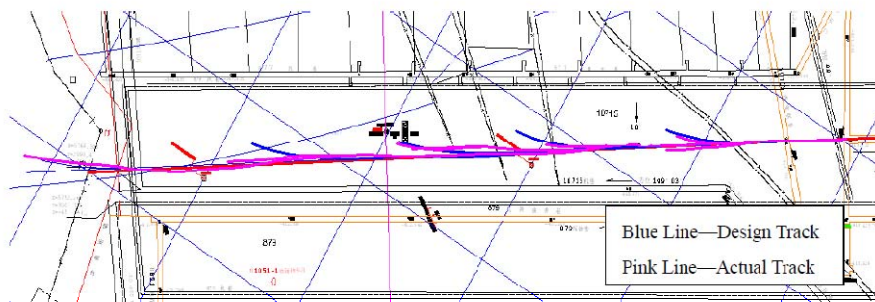


Figure 2: Boreholes distribution on working face

CONSTRUCTION TECHNOLOGY

Construction sequence

There are two kinds of sequences to construct the branch drillings—advancing and retreating processes. It must face to the problem of opening the branch drillings from the main drilling and involve the re-entry technology regardless any sequences chosen.

According to the drilling design and geological conditions, coal mine used advancing drilling process to construct the branch drillings on the top right, then used retreating drilling process to construct the bottom left branch drillings, when drilled to the depth of design 603m.

Advancing branch drilling process, also known as opening branch drillings from the outside to inside. That is to say drill the main drilling, at the same time drill the branch drillings. This branch drilling process is always used to detect the coal occurrence and goaf geological structures, as the preparation of the next period.

Retreating branch drilling process, also known as opening branch drillings from the inside to outside. That means when finish the main drilling, reaming the main drilling with $\Phi 113\text{mm}$ PDC reaming drill, and then down to open branch drillings in the main drilling with a retrievable whipstock.

Directional drilling technology and drilling parameters

According to the design of opening drilling parameters (inclination and azimuth) place the rig, drill the 12m opening drilling with rotary drilling process. BHA: $\Phi 96\text{mm}$ PDC flat drill bit and $\Phi 73\text{mm}$ drill pipe.

Then reaming 3m, BHA: $\Phi 153\text{mm}$ reaming drill + $\Phi 73\text{mm}$ drill pipe. Installation orifice tube, the orifice coupled to the gas-liquid separator.

Both the main and branch drilling section used directional drilling technology, that means control the drilling track by adjusting the roll on the screw motor tool with the MWD technology.

Advancing and retreating branch drillings, main drilling's BHA: $\Phi 96$ mmPDC flat drill bit + $\Phi 73$ mm non-magnetic screw motor ($1.25^\circ / 1.5^\circ$) + $\Phi 73$ mm non-magnetic drill pipe + $\Phi 73$ mm cable drill pipe.

Reaming BHA: $\Phi 113$ mmPDC reaming drill + $\Phi 73$ mm non-magnetic screw motor ($1.25^\circ / 1.5^\circ$) + $\Phi 73$ mm non-magnetic drill + $\Phi 73$ mm cable drill pipe.

Drilling parameters: Mud pump displacement of 200 L / min; pump pressure for 2 ~ 4.5 MPa, drilling fluids: water.

Retrievable whipstock open branch drilling process

The object of *Mine Small Curvature Comb Drilling Technology and Equipment* is that to by constructing long horizontal drillings in the relatively stable stratum beneath the target coal seam and perforating (or close to) coal like brunches, realize long-term, and effective gas drainage in the soft coal seam. The branch point of the comb drillings is in the stratum, that is difficult to drill lateral branch drillings only using the screw drill, if the rock has high hardness. So put the retrievable whipstock into the drillings, as the help of screw drill deflecting the branch drillings.

DRILLING CONSTRUCTION AND EFFECTS

Coal mine constructed 2 comb drillings in all, 8 and 9 branch drillings contained in 1# and 2# comb drillings respectively. The depth of the main drilling reaches 603m, and the branch drillings' depth reaches 147m maximally, total footage 2639m. The drillings are perforated directly in the bottom stratum floor 8 coal seam, through 4 faults whose maximum gap reaches 8m. The maximum footage is 75m in single shift (8 hours), the net perforate prescription reaches more than 15m/h in sandstone. The drilling construction is from the rig reaching the coal mine to finish the whole project, Since 2010 October 18 to November 20, 34 days in all.

When finish the long drillings in the bottom floor, drainage the gas with gas drainage pump on the ground, install pipeline V cone automatic metering device. Measured orifice negative for -13kPa, the average gas concentration 31%, pure gas flow $1.3\text{m}^3 / \text{min}$. Continued drainage 6 months, $11,200\text{m}^3$ of gas extraction. At the same time, control the gas on the coal face with bottom borehole, well drilling on the ground, high level borehole in the air roadway, laying pipeline in the gob and increasing the air volume. The project extraction volume accounts for nearly 50% of the total volume because of the great amount drainage pipeline in the bottom floor. Therefore, they will not be considered when comparing. Initial gas drainage flow $2.38\text{m}^3 / \text{min}$ on the ground drainage well, but the amount decay to 8% just in 3 months. The total drainage volume is $1.1\text{m}^3 / \text{min}$ by high level borehole in the air roadway and laying pipeline in the gob, $2.3\text{m}^3 / \text{min}$ by air roadway. Coal face gas pumping rate is 63.5%, among them, the single long drilling's drainage volume account for 15% in the total volume. The effect is obvious.

TABLE 1: Drainage statistics of comb type boreholes on 10715 face of Zhuxianzhang coal mine

Time	1#Long Drilling (m^3)	Ventilation (m^3)	Ground (m^3)	High level drilling field (m^3)	Embedded pipe of gob (m^3)	Bed Plate Tunnel (m^3)	Accounts for the proportion of total gas drainage (%)	Accounts for the proportion of total gas emission (%)
December 2010	0	27072				50835	0	0
January 2011	127	108319	4514	7723	7775	107514	0.1	0.054
February 2011	23575	118503	96289	22611	25075	76702	10.68	6.951
March 2011	16324	129960	108572	10225	26758	77603	7.315	4.623
April 2011	23083	122610	26229	9078	39666	59703	17.14	8.972
May 2011	13805	70413	6842	9750	12747	86964	11.87	7.394

CONCLUSIONS

The directional long drillings mainly drainage the pressure relief gas in the protected seam, 2# drillings constructed in the goaf of the protected seam, so there is no gas drainage volume. However, the gas drainage effect of the 1# drillings constructed in the non-mining protected seam is obvious, and the pure gas flow is stable.

Compared with the ground drilling well, the directional long drillings in the mine have following advantages:

Avoid the affection of construction environment. This work face design 2 drilling wells, but only construct 1 well, because lack of the ground environment.

Solve the problem that the drillings was blocked on the affection of mining activities. Because the drilling was constructed from the finishing line to the open-off cut, the air outlet leads to the coal face, and the horizon is in the curve subsidence zone, the drillings is hard to be destroyed. Realize the continuous gas drainage.

Low cost of the drilling construction. The ground drilling wells often are constructed in the wild, the problem of preparation works is hard to be solved. Every well's cost is about 1 million yuan. Construction in the mine often could choose the existing roadway, the power and water supply would be convenient. The average cost of every drilling is about 300 ~ 400 thousands yuan.

High drill success rate. The directional drilling rigin mine doesn't need to perforate the topsoil, the layer's lithology could be chosen, so the main drilling is always constructed in the stable stratum, improve the stability of the drillings.

The drillings could pump a long time, the drilling well's drainage time is generally about 200m after finishing the work face. Suppose that the promoting speed of the work face is 3m, the time of drainage is less than 3 months; so the drillings could drainage gas for 4 months after finishing the work face, and the pure gas flow could stably reach more than $0.8\text{m}^3 / \text{min}$.

Compared with the bottom gas drainage roadway, the directional long drillings in mine have the following advantages:

Reduce the gas drainage roadway construction amount. For example, it can reduce 7.5 million yuan cost, if the work face's strike length is 500m.

Mining the protective seam can make the gas be controllable, needn't increase the air volume, won't create the closed gas area.

Easy to choose the horizons' location. Since the drillings' direction could be artificial controlled, it is easier to choose the horizon than roadway's variable slope. Once the lithology is inappropriate, can return to restart, will not cause a huge waste.

At the same time, the directional long drillings in mine contains the following disadvantages:

Screw motor use imported expensive materials, oncesticking or losing, will increase the cost.

In the drill pipe is signal transmission lines, it may appear contacting problem, make the signal interrupted.

Zhuxianzhuang Coal Mine, between the 8# and 10# coal seam, the sandstone has a high abrasive coefficient, the screw motor bend outer tube is easy to wear and need to be replaced. Increase the cost, and affect the efficiency.

In summary, the directional drillings technology in mine has superiority on the problem of the pressure-off gas drainage, can meet the pressure-off gas' need in mine. Currently, the problem of drill process, equipment and material will be solved with the improvement in technology and equipment material. In the long term, the process of drainage gas inprotected seam with directional drillings has a big promotional value.

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