Discussion on Deviation Correction Technology of Long Borehole in Gas Drainage

Zunyu Xu 1, 2,*

1 National Key Laboratory of Gas Disaster Detecting, Preventing and Emergency Controlling, Chongqing 400037, China
2 Gas Research Institute, Chongqing Research Institute Co., Ltd., China Coal Technology Engineering Group, Chongqing 400037, China

*Corresponding author e-mail: xcheng@aust.edu.cn

Abstract. To solve the drilling layer (especially small inclination to wear long borehole) deviation cause gas control drilling control range is not up to standard, large quantities and the problem of poor drainage effect in Xinji coal mine based on the analysis of borehole construction result in deviation in a variety of reasons, targeted in technology, management, system, equipment, and adopted a series of effective measures on the scene to "rectify", puts borehole deflection can be controlled within the scope of reduced the drilling quantity, raise the drilling control ability, increase the gas control working time, realized the "technical economic integration".

Key words: Drilling through layer, Small Angle, Measurement of slope, Deviation, Deviation correction.

1. Preface
With the mining activities of the mine gradually turn to the deep level, the gas occurrence, in-situ stress, structural complexity and outburst risk of coal seams are increasing, and most coal seams do not have the conditions for protective layer mining. Borehole pre drainage is still an indispensable important means of gas control work [1-3]. The "effectiveness" of pre drainage drilling construction is the prerequisite to solve the target coal seam gas.

How to effectively improve the drilling rate and accurately control the pre pumping area, effective measures can be taken based on the factors of coal and rock occurrence and structural development, in the process of design and construction [4 ~ 7]. However, in the process of drilling (especially the long drilling hole with small inclination angle), due to the weight of drill pipe, the swing of drill bit and the difference of resistance to crushing between soft and hard rock, the problem of drilling deviation can not be solved with the current equipment and technology. Domestic gas drainage borehole trajectory measurement and directional correction, ultra long distance and high precision structural belt advanced detection technology research are just started, far from meeting the requirements of efficient and safe production.
2. Causes of borehole deflection

2.1. Geological factors
(1) Anisotropy of rock
   The drilling efficiency is higher than that in the direction perpendicular to the bedding, and it is not easy to be inclined in the direction of drilling.
(2) Soft hard rock interbedding
   When the borehole passes through the intersection of soft rock and hard rock at an acute angle, especially at a small angle, the deviation of drilling hole is caused by the different resistance to crushing of soft and hard rock.
(3) Coal rock interface
   When the borehole passes through the coal and rock interface, the smaller the angle between the borehole and the interface is, the drilling hole will "run" with coal due to the rock crossing resistance.

2.2. Construction factors
(1) The foundation of the drilling rig is uneven and instable. During drilling construction, the drill pipe shakes and causes deflection.
   (2) In the process of drilling, the pressure of the drilling rig is too high, the drilling is blocked, and the drill pipe is forced to bend, resulting in the deviation of drilling direction.
   (3) The drill pipe has elastic deformation in the hole due to its self weight, which disturbs the drilling direction of the bit.

3. Analysis of borehole migration law
Due to the superposition of multiple factors, the deviation of borehole is inevitable (as shown in Fig. 1). In engineering practice, it is concluded that the smaller the inclination angle and the longer the hole depth, the greater the probability and amplitude of deflection.

![Fig. 1 Comparison of actual and designed drilling trajectory (inclinometer drilling)](image)

Drilling deviation is the "bottleneck" restricting the drilling engineering of gas control. It is necessary to systematically study how to "accurately" drill under the objective condition of "Deviation".
4. Research on drilling deviation correction technology

4.1. Technical scheme of rectifying deviation

(1) In the stage of roadway design, several schemes are compared to discuss the relationship between floor roadway layout and drilling quantity and construction difficulty, so as to avoid a large number of small angle long boreholes.

(2) When the pre drainage boreholes are used as the regional outburst prevention measures, the boreholes are arranged according to 0.8 times of the effective extraction radius of the coal seam, and the boreholes are densified within the fault structural zone (drop ≥ 1.0m) and its front and rear 20m. It can reduce the possibility of the existence of drainage blank zone due to borehole deflection.

(3) Standardize the design process of gas control boreholes and strengthen process control. The drilling design unit, construction unit and geological survey department closely cooperate, constantly revise the geological data, invert the drilling control situation, adjust the drilling design parameters pertinently, and timely make up holes in the areas not controlled by the drilling. The drilling design process is shown in the following figure 2:

Fig. 2 Technical process of deviation correction

(4) According to the geological occurrence conditions, the maximum drilling pressure and average drilling speed when drilling to the coal and rock layers are determined.

(5) Carry out the drilling verification system, verify the difference between the actual coal seam elevation and borehole inversion coal seam occurrence, find out the cause of deviation, and continuously improve the details of drilling design. Through drilling is carried out in two excavated roadways, and the accuracy of inclinometer is verified according to the actual penetration position of borehole and the expected through position of inclinometer.

4.2. Site rectification measures

(1) The standardized drilling site construction requirements shall be formulated, and the specification, floor and lithology of the drilling site shall be determined, and grouting shall be carried out in the drilling field with poor lithologic conditions. The drilling opening position shall be calibrated based on the center line of the drilling field, and the control deviation shall not be greater than 100 mm.

(2) Carry out the acceptance before drilling, and confirm the construction conditions of the drilling site, the stability of the rig substructure installation, and the integrity of the drill pipe and its joints.

(3) Increase the distance between boreholes and reduce the disturbance of surrounding rock caused by drilling construction. The distance between holes for crossing layer drilling shall not be less than 0.5m, and that for bedding hole shall not be less than 0.8m.
4.3. Other corrective measures
Set up a gas control drilling leading group with the chief engineer of the mine as the group leader to balance all kinds of problems in the drilling construction. Establish a "six in one" management system for gas control boreholes, and define the procedures and responsibilities of relevant personnel for drilling design, construction, acceptance, evaluation, improvement and scrapping.

Video acceptance shall be carried out in the area where drilling is concentrated, and the process monitoring of drilling construction, tripping out and sealing shall be strengthened to eliminate the fluke mentality of construction personnel on site. The inclinometer is replaced by a lightweight and easy to operate inclinometer to improve the efficiency and accuracy of inclinometer. The inclination measurement management shall be strictly carried out. The slope measurement of through layer pre pumping borehole shall not be less than 20%, and the inclinometer depth shall not be less than 70% of the hole depth. The borehole located in the geological structural zone or the deviation between the actual construction and the predicted coal depth is more than 10 m.

The drilling design unit shall strengthen the supervision of the drilling construction and acceptance, randomly check the parameters of the drilling hole, and take timely measures when problems are found. The construction unit shall strengthen the self-management, regularly carry out self-examination and self-correction activities of drilling construction, plug system loopholes and eliminate management defects, so as to ensure that the gas control boreholes are constructed in place according to the design requirements, and the drilling parameters are true and reliable. Establish a ground video acceptance team, strictly implement the video acceptance fine management process, strengthen the monitoring of the drilling process from opening to sealing, and strive to achieve the archives management of "one hole, one video".

5. Engineering application
The 220108 working face of Xinji No.2 coal mine is located in no.2201 mining area of No.1 coal seam group. Floor roadway is arranged on the floor of working face, which is about 16m away from 1 coal seam floor.

A total of 24 strip extraction boreholes were designed in the 14# upper drilling field of floor roadway, and the final hole points were arranged as 10 * 15m, as shown in Figure 3. After drilling construction, it is found that there are still uncontrollable areas in the construction area, as shown in Figure 4.

![Fig. 3 Borehole design drawing](image)

![Fig. 4 Borehole inversion analysis (deviation) diagram](image)
During the construction, the deviation between some parts and the design expectation is large, and the results of the deviation are analyzed and summarized to guide the hole filling design. The hole supplement design is shown in Figure 5.

In order to achieve the purpose of "rectifying deviation", the design inclination angle and azimuth of the supplementary drilling hole are "compensated" according to the average deviation of the drilling hole in the construction area. The control situation after completion of drilling is shown in Figure 6.

According to the final drilling completion drawing, the distance between the final hole points is within 10 * 15m, which is controlled to 15m outside the contour line on both sides of the roadway, and there is no dynamic phenomenon such as spray hole and drill clamping during the construction process, which meets the needs of gas control in air tunnel.

6. Conclusion
The deviation is inevitable in the construction of drilling hole (especially the long drilling hole with small inclination angle). In this paper, the reasons of drilling deviation are analyzed in detail, and a series of measures are taken in technology, field, system, equipment and management to correct the deviation. The drilling rate is effectively improved, and the drilling deviation is placed in the controllable range, which reduces the drilling engineering quantity and improves the drilling control ability To increase the time guarantee of gas control work.

Acknowledgments
This work was financially supported by the national key research and development program of China (2017YFC0804206).

References
[1] Li Yaohui. Practical research on comprehensive gas control technology in mine complex geological structure area [J]. Coal mine modernization, 2020 (03): 71-73.
[2] Su Guoqiang. Study on regional outburst prevention technology of seam gas in pre drainage section of bedding borehole [J]. Mining equipment, 2020 (01): 126-127.
[3] Wang Wenwei. Study on gas migration law of pre drainage coal seam by borehole [J]. Energy and environmental protection, 2019, 41 (09): 25-27 + 31.
[4] Wang Weinan. Error analysis of dip angle positioning of coal mine water exploration and drainage holes [J]. Coal science and technology, 2019, 40 (04): 37-39.

[5] Zhao Tingyan. Analysis of the causes of borehole bending and preventive measures [J]. China coal geology, 2009, 21 (S1): 62-63 + 73.

[6] Zhao zhenqu, Ma Shifeng, Ma Shijie. Fine gas drainage and system construction in coal mine [J]. Energy and environmental protection, 2018, 40 (06): 82-86 + 138.

[7] Ding Zhiwei, Zhou Kan. Analysis of borehole deflection law for underground gas drainage [J]. Coal mine modernization, 2014 (06): 89-91.