Research on Outburst Prevention Method in Deep Coal Road Strip Area

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Abstract: Aiming at the prevention of outburst in the strip area of deep coal roadways with high geostress, it proposed a method for prevention of outburst in the strip area of coal roadways in which the pressure relief floor roadway is pre-excavated, and it is applied in Fengcheng mining area. The application shows that the method has obvious anti-outburst effects, technical and economic benefits, and broad application prospects.

1. Introduction
With the increase of coal mining depth, the in-situ stress increases in deep mines, it becomes more complicated the mechanism of outburst accidents in deep coal roadways, and it becomes more diverse of the types occurrence.¹⁻³ The dynamic disaster accident caused high ground stress in coal roadway.⁴ The in-situ stress induced by disturbances such as anchoring operations is the main power source for the coal roadway driving in high ground stress and high gas pressure coal seam, and the coal and gas sudden pressure out accidents involving gas. With complex geological structure, high in-situ stress, and soft coal seams, the excavation of coal and gas is delayed due to stress concentration⁵. Even the coal and gas outbursts caused by drilling through the strata gas drainage and high-pressure hydraulic fracturing to increase permeability have occurred in the floor roadway In view of ‘the complexity and variety of deep coal roadway outbursts’, it is necessary to analyze the characteristics of deep coal and gas dynamic disasters and propose reasonable coal roadway strips to prevent outbursts.

2. Outburst prevention methods in coal roadways
Aiming at the outburst of deep in-situ stress-dominant coal roadway, the floor rock roadway is pre-arranged at a certain distance directly below the coal roadway to be excavated to relieve the pressure of the in-situ stress of the coal and rock mass above the roadway, and at the same time cooperate with the cross-layer drilling for gas drainage. It achieve the role of simultaneously eliminating ground stress and gas hazards. The method is introduced as follows:

(1) According to the mining requirements, it formed a ventilation system and a gas drainage system for the pre-excavated floor pressure relief rock roadway in advance.

(2) The floor rock roadway is arranged directly below the coal roadway to be excavated along the coal seam direction. It is determined as the geological data and the lithology of the coal seam floor, the reasonable space position of the floor rock roadway from the coal seam (usually 8~12m, the lithological hardness is relatively large using a small value, otherwise take a large value). The rock roadway should
adopt a wide section to strengthen the pressure relief effect. As shown in Figure 1.

![Figure 1. Outburst prevention method in the borehole area of the roadway through the pressure relief floor](image)

(3) Gas drainage design of pre-drainage boreholes in floor pressure relief rock tunnels is included drilling site design, drilling design, sealing design and drainage parameter design. The drill site is arranged in the pre-excavated floor pressure relief rock tunnel, and the drill site spacing is designed according to the investigated extraction radius. According to the decompression effect of the roadway, the boreholes are arranged in a fan shape in the roadway, with a large hole spacing in the middle and a small spacing between the two sides. The coal roadway is controlled in the range of 15m above and below. The borehole diameter is 75–90mm. Holes is made in the roof of the roadway and penetrate 0.5m into the roof of the coal seam. The hole should be sealed immediately after the drilling is completed. The sealing material is cement and polyurethane. It is 8~10m of the sealing length of the drainage hole above the pressure relief floor roadway.

(4) Gas drainage construction of pre-drainage boreholes in pressure relief rock tunnels is included construction drilling, hole sealing and installation of drainage pipelines. According to the drilling design and drainage requirements, the pressure relief gas drainage boreholes will be constructed in advance to ensure sufficient pre-drainage time for the drainage boreholes. After the drilling is completed, the hole should be sealed immediately. After the hole is sealed, the drainage pipe of the drainage hole is connected to the gas collecting and draining device, and then connected to the main pipe through the connecting pipe for gas drainage.

(5) Gas drainage through pre-drainage boreholes in pressure relief rock roadways. It is sure that the negative pressure of gas drainage is not lower than 13kPa, and the drainage time is determined according to the effective influence radius of different drainage to realize the effective drainage of coal seam gas.

(6) Inspection and verification of highlighting hazardous effects. In accordance with the "Outburst Prevention Regulations", the effect is tested of regional measures for pre-drainage of gas before coal tunnel excavation, and the regional outburst prevention effect is verified during the tunneling process.

(7) Safe excavation of coal roads. Enough anti-outburst measures should be reserved when driving in a coal roadway without outburst danger. Tunneling operations can only be carried out after taking safety protection measures. When driving in areas with prominent dangers, the two-level "four-in-one" anti-outburst measures should be strictly implemented.

3. Safety guarantee for slab tunneling

3.1. Ventilation gas
All fans in the floor rock tunnel must realize "dual fans, dual power supplies" and be able to switch automatically. The air door facilities must be built in strict accordance with the requirements of the anti-outburst door to ensure that the ventilation system is independent and unblocked. During the tunneling
process, gas management must be strengthened to prevent gas from exceeding or accumulating. Full-time safety supervisors and gas crews must be arranged for on-site inspection and supervision. It is must to implement strictly the gas inspection and hidden danger investigation system.

3.2. Geological exploration
It must be strictly implemented the measures of "exploring before digging". Drilling is used to detect the distance between the roadway and the coal seam and the structure in front of the driving. Before the roadway is constructed, it constructed generally at least 3 front holes penetrating the coal seam. In special circumstances, it is necessary to intensively explore the holes, accurately grasp the construction dynamics and surrounding rock changes, and prevent the coal seam from being uncovered by mistake. At the same time, it insist roof detection on daily. The anchor cable must be constructed at least once a day to detect the occurrence of coal and rock on the roof of the roadway. When it is predicted that there is a geological structure in front of the roadway, the exploration hole must be constructed 20m before the geological structure to accurately grasp the occurrence of the geological structure. The tunneling operation can only be continued under the conditions of strict implementation of the corresponding safety technical measures.

3.3. Roof management
Under normal conditions, it take the following measures, such as strengthen roof management, strictly prohibit empty roof operations, and strictly implement the knocking and asking roof system. Under special circumstances, it must punch more eyes and less charge before opening the door, and fire the shots in stages. It should to reinforce the support of the roadway within 10m before and after the opening and penetration point. It should be strengthened support when the roadway passes through cracks, fault structures and other broken period of surrounding rock.

3.4. Drainage and spontaneous combustion of coal seams
In order to avoid mutual interference, it should be at least 120m away from the coal roadway when the floor roadway and coal roadway excavation face under construction at the same time. In order to avoid the drainage of other boreholes and the natural fire of the coal seam, after the tunnel driving face is tunneled, the through-bed drill holes behind the tunneling direction should be disconnected and sealed in time.

After drilling through the floor of the floor rock roadway, the holes shall be sealed and continuously pumped in time to prevent the discharge of a large amount of drilling gas, which may cause excessive gas and coal seam fire.

4. Field application

4.1. Anti-outburst effect
The single B4 coal seam is mined in Fengcheng Mining Bureau, which is a gently inclined medium-thick coal seam with low air permeability ($\lambda=1.7\times10^{-5}$–$0.74\text{m}^2/\text{MPa} \cdot \text{d}$), high gas pressure $P_{\text{max}}=9.2\text{MPa}$, high content $W=13.5$–$25.3\text{m}^3/\text{t}$, the coal seam is soft (firmness coefficient $f=0.3$–$0.8$). It the hardest-hit area where gas disasters frequently occur, which is the total of 186 outstanding accidents occurred in history.

Table 1 is shown that the coal roadway outburst prevention effect is significant after using this outburst prevention method.

| Mine  | Roadway (article) | Total footage (m) | Aperture (mm) | Drill cuttings desorption index $K_1$ (mL/g·min$^{1/2}$) | Drilling cuttings $S$ (kg/m) |
|-------|--------------------|-------------------|--------------|----------------------------------------------------------|----------------------------|
| Qujiang | 4                 | 1770              | 75           | 0.07–0.49                                                 | 6–14                       |
It can be seen that the 3 pairs of mines in the Fengcheng mining area, have dug 23 coal lanes with a total footage of 13,408m. The predictive index K1 value and S value basically have no over-standard phenomenon, and it has been realized the safe and rapid excavation of coal roads.

4.2. Technical and economic benefits
This method reduces the amount of drilling of 301698m, greatly reduces the cost of mining and excavation, and generates direct economic benefits of 350,670,000 yuan (see Table 2). The speed of coal road excavation has been increased from 40m/month to 100m/month, resulting in an indirect economic benefit of 1211.4925 million yuan.

| Local ventilation fee | Drainage fee | Maintenance fee | Tunneling construction fee | Drilling construction fee |
|-----------------------|--------------|-----------------|---------------------------|--------------------------|
| 58.90                 | 16.73        | 1128.86         | 322.73                    | 796.86                   |
| 221.50                | 62.93        | 15963.22        | 1213.60                   | 2996.55                  |
| 165.62                | 47.05        | 8924.56         | 907.42                    | 2240.55                  |

5. Conclusion
It is proposed a method for preventing outburst in strip areas of coal roadways, which is to arrange floor rock roadways directly under the roadways to be excavated to relieve the in-situ stress of the overlying coal and rock masses of the roadways, and cooperated with through-bed drilling for gas drainage at the same time.

Practice has proved that the outburst prevention method has a significant anti-outburst effect, resulting in a direct economic benefit of 350.67 million yuan and an indirect economic benefit of 1211.4925 million yuan, which has important reference significance for the outburst prevention of similar mines.

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