Gas Control Mode in Xinji Mining Area

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Abstract. With the increasing depth of coal mining in our country, the danger of coal mine outburst is becoming increasingly serious and complex. At the same time, the country's requirements for coal mine safety production are also increasing. In response to the current situation and needs of coal and gas outburst prevention and control in the new situation, it is urgent to establish a more suitable and comprehensive theoretical and technical system for coal and gas outburst prevention and control in the Xinji mining area. Based on this, the gas control mode of Xinji mining area was sorted out, the advanced technology and concept of gas control were summarized, the application of advanced gas outburst prevention and control technology and equipment was expounded, and the future development direction and research prospects of gas control were proposed, providing reference for comprehensively improving the gas disaster risk and hidden danger control ability and gas control level of Xinji mining area.

1 Introduction

With the depletion of shallow coal resources, the depth of coal mining is extending towards deeper areas at a rate of 10-25m/a[1-3]. After entering deep mining, the degree of ground pressure and gas disasters increases synchronously with the mining depth, and the probability of high ground pressure induced gas anomalies increases synchronously [4-7].

In order to standardize the prevention and control of coal and gas outbursts, the National Coal Mine Safety Supervision Bureau issued and implemented the "Detailed Rules for the Prevention and Control of Coal and Gas Outbursts" in 2019. Coal and gas outburst accidents have been effectively controlled, but it is still difficult to completely curb them. Statistics show that in the past 20 years (2021-2020), the number of outstanding accidents and deaths in China has shown a downward trend, but the proportion of outstanding deaths to the total number of deaths in coal mine accidents has shown a fluctuating growth trend, indicating that outstanding accidents are still at a relatively high level in coal mine accidents[8]. The frequent occurrence of accidents reflects the complexity of coal and gas outbursts in deep mining and the limitations of current anti outburst theories and technologies. Anti outburst work still has a long way to go in future coal mining. How to further improve the theory and technology of conflict prevention, as well as develop emerging technologies, while implementing the two "four in one" comprehensive conflict prevention measures, will directly affect the time span for China to achieve the goal of "zero protrusion".

2 Basic Overview of Xinji Mining Area

The mining area under the jurisdiction of middling coal Xinji Energy Co., Ltd. is located in Huainan, Fuyang and Bozhou. It has five pairs of production mines, all of which are underground mines, with an approved production capacity of 23.5 million t/a. Among the five pairs of mines, Xinji No.1 Mine, Xinji No.2 Mine, and Liuzhuang Coal Mine are coal and gas outburst mines, Kouzidong Mine is a high gas mine, and Banji Coal Mine is a low gas mine; Except for the moderate hydrogeological type in Xinji No.1 Mine, the other four pairs of mines are all complex hydrogeological types.

The geological structure of the mining area is complex, with multiple faults, developed fissures and folds, and complex gas geological conditions in the structural area; Xinji No.1 Mine and Xinji No.2 Mine are located under the overlying strata, covering the original coal seams and not utilizing them for gas dissipation. The original gas content and pressure of the coal seams are high, with the highest gas content of 14.22m^3/t and the highest gas pressure of 3.6MPa in each mined coal seam in the mining area; The close range mining of prominent coal seams poses difficulties in prevention and control; The coal seam is soft and has poor permeability, resulting in poor extraction efficiency. The hardness coefficient f of the coal seam is generally between 0.2 and 0.8, and the original permeability coefficient of the main coal seam is below 0.1m^2/($MPa^2 \cdot d$), with the lowest being only 0.00371m^2/(MPa^2·d). It belongs to a soft and difficult to extract coal seam, and the gas extraction efficiency of the coal seam in the non depressurized area is poor.

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More than 20 corresponding gas prevention and control techniques have been developed for different forms of gas geology and mining characteristics, forming a new set of standardized gas prevention and control technologies that are "applicable, replicable, and promotable". Especially in the areas of ground group hole extraction technology, protective layer extraction technology, comprehensive gas extraction technology, and low-permeability coal seam permeability enhancement, certain achievements have been made, effectively ensuring the safety production of mining areas.

3 Coal and gas outburst prevention and control technology

3.1 Key protective layer mining technology for close range coal seam group

The 4th, 5th, 6th, 7th, 8th, and 9th coal seams in the Xinji mining area are Group B coal seams. Through the key protective layer mining technology of the close range coal seam group, the permeability coefficient of the protected layer 8 coal seam is 520 times higher than before the technology was adopted. The pre extraction gas volume is 9.8 million m^3, and the pre extraction rate of the working face is 80%. The gas pressure of the 8th coal seam is reduced to below 0.4MPa, and the gas content is reduced to below 5.0m^3/t. During the mining period of the 8th coal seam working face, the gas emission rate is 4-7m^3/min, and the return air gas is 0.12%-0.3%, with an average of 0.16%; The permeability coefficient of the protected layer 6 coal seam is 460 times higher than before the use of this technology, with a pre extraction gas volume of 9.13 million m^3 and a pre extraction rate of 70% in the working face. The gas pressure of the 6 coal seam has dropped below 0.4MPa, and the gas content has dropped below 4.5m^3/t.

3.2 Remote protection layer mining technology

There are two main coal seams in the Shangshihe Formation of the Xinji mining area, namely the 13-1 coal seam and the 11-2 coal seam, with a spacing of about 70m. The 11-2 coal seam is selected as the protective layer for the 13-1 coal seam. At the same time, combined with the construction of the 13-1 coal seam floor roadway, through layer drilling is carried out to pre extract the pressure relief gas from the 13-1 coal seam. The 13-1 coal seam floor roadway is generally located at a depth of 20m to 30m from the bottom of the 13-1 coal seam. The interlayer drilling adopts non equidistant arrangement: the interlayer drilling spacing in the fully depressurized area is 30m × 30m, the interlayer drilling spacing in the insufficiently depressurized area is 30m × 10m, and the interlayer drilling spacing outside the depressurization range is 10m × 10m to ensure the control range of the top coal caving working face.

After the long-distance mining of the 11-2 coal seam protection layer in Xinji No.1 Mine, it was found that the pressure relief angle of the protected layer was 60°, and the pressure relief angles above and below the inclined direction were both 72°. The permeability coefficient of the 13-1 coal seam in the protected layer increased by 580 times, and the pre extraction gas volume was 11 million m^3. The pre extraction rate of the working face reached 80%. The gas pressure of the 13-1 coal seam decreased to 0.2MPa, and the gas content decreased to 3.8m^3/t. During the mining period of the 13-1 coal seam working face, the gas emission rate was 4-6m^3/min, and the return gas was 0.1% -0.2%, with an average of 0.12%, achieving good results.

3.3 Complete technology for controlling outburst coal seam gas without protective layer mining

The coal seam group 1 in the mining area is a prominent coal seam, consisting of coal seam 1 and coal seam 1. The average distance between coal seam 1 and coal seam 1 is 1 meter, and the thickness of coal seam group 1 is large. During the mining period of coal seam 1, a large amount of depressurized gas from the underlying coal seam 1 flooded into the working face of coal seam 1, greatly increasing the difficulty of gas control.

Gas control during excavation: In order to solve the problem of pressure relief gas from coal seam 1 flowing into the already excavated roadway during the machine roadway and cutting hole excavation of the upper coal seam working face, bottom plate drilling is used to pre extract coal roadway strip gas, reduce the amount of gas emission during excavation, and prevent gas exceeding the limit during excavation.

Gas control during mining: The gas emission in the working face mainly comes from this coal seam and adjacent coal seams. A comprehensive extraction method combining pre extraction and simultaneous extraction is adopted, with local coal seam extraction as the main source and goaf extraction as the auxiliary source. This coal seam mainly adopts the gas pre extraction and simultaneous mining and extraction methods combining the arrangement of parallel layer drilling and through layer drilling. The adjacent layers mainly adopt the gas pre extraction and simultaneous mining and extraction methods of arranging through layer drilling. And adopt high extraction roadway to release pressure gas in front of the mining face and extract gas while mining in the goaf behind the mining face. At the same time, adopt the method of burying pipes in the goaf to extract gas while mining in the upper corner.

During the excavation of the coal seam group working face, the gas concentration in the return air flow was 0.1% to 0.3%, and the gas emission rate of the excavation working face was 0.5 to 2.5m^3/min. The average excavation speed of the roadway was 10 m/d, achieving safe and efficient excavation of the coal roadway.

4 Advanced Technology for Gas Control in Xinji Mining Area

4.1 Comprehensive prevention and control technology for high stress, safe and efficient mining power disasters in kilometer deep wells

The horizontal elevation of Kouzidong Mine is -967m (mining depth 1000m), and the 13-1 coal seam is a non protruding coal seam. The measured maximum gas pressure is 0.48MPa, and the thick and hard rock layers of the 13-1 coal seam and its roof have a strong impact tendency. The first mining of the 111303 comprehensive mining face in the mine has a length of 1975m, a slope width of 328m, an average thickness of 4.1m, a daily output of 12000 to 15000 tons, and a high mining intensity. During the mining process of this working face, there is a risk of sudden coal extrusion or impact type dynamic hazards in geological structural zones or mining stress concentration areas. Kouzidong Mine conducted theoretical and technical research on the prevention of coal and gas dynamic disasters in the first mining layer of deep wells, and constructed a set of theoretical and technical systems for the prevention of coal and gas dynamic disasters dominated by high ground stress and complex gas occurrence in deep mines. The main regional measures adopted by the working face are: pre extraction of gas before mining to meet the standard, water injection to reduce the tendency of coal seam impact; Local measures include: prediction of drilling chip method indicators, online monitoring of advanced support pressure and support working resistance. The Kouzidong Mine was completed and put into operation one year ahead of schedule, and 5 working faces were safely and efficiently mined, creating a total of 289 million yuan in direct economic benefits and 1.08 billion yuan in indirect economic benefits.

4.2 Complete set of comprehensive gas treatment technology for 20000 tons of ultra long working face per day

The 13-1 coal seam of Liuzhuang Coal Mine is an outburst coal seam. Currently, the development and mining areas of the 13-1 coal seam in Liuzhuang Coal Mine are all non outburst danger areas. The average thickness of the 151306 working face is 5.56m, and the original gas content of the coal seam is 4.9m^3/t. The mining method is full height mining at once, with a working face length of 320m and a daily output of 15000 to 22000 tons. The gas emission rate of the mining working face is 25-35m^3/min. The production of the working face is high, and the amount of coal and gas desorption is large. In addition, during the mining process, gas from the adjacent layers of Group C coal is emitted towards this face, making gas control difficult.

By using high extraction roadway to extract gas from goaf and pressure relief, pre extraction of gas from mining area through layer drilling, extraction of gas from goaf through buried pipes at the upper corner, and exhaust gas, the average gas emission during the mining period of the working face is 28m^3/min, and the gas extraction rate of the working face can reach 22m^3/min. The extraction rate is 78%, and the average gas concentration in the return air is generally 0.2% to 0.3%, achieving safe and efficient production of the working face. This gas control technology has been widely applied in working faces with a daily output of over 20000 tons in the 13-1 coal seam of Liuzhuang Coal Mine and the 13-1 coal seam of Kouzidong Coal Mine.

4.3 Drilling and gas extraction technology for high-level drilling site roof direction

For working faces with gas emission rates between 10 and 15m^3/min and without high extraction tunnels, the Xinji mining area will construct a high-level drilling site in the wind tunnel and drill holes in the roof direction of the drilling site to extract gas from the goaf of the working face, in order to prevent gas exceeding the limit in the upper corner; Each group of boreholes should be pressed for at least 30m to ensure that there are always high-level boreholes for gas extraction during the advancing process of the working face.

The gas emission rate in the Xinji mining area is less than 10-15 m^3/min, and the working face adopts a high-level drilling site to construct a high-level roof drilling direction, which can effectively eliminate the accumulation of gas in the upper corner. The extraction purity is generally 4-8 m^3/min, and the return air gas of the working face is generally 0.08% -0.3%.

5 The Problems and Prospects of Gas Outburst Prevention and Control in Xinji Mining Area

5.1 There are problems in the prevention and control of gas outbursts in the current Xinji mining area

The main problems in the current gas control process in the Xinji mining area are:

(1) The occurrence of gas is irregular and uneven. As the mine expands deeper, the gas content in the coal seam further increases. At the same time, the combined effect of increased geostress will further increase the difficulty of gas control.

(2) Coal seams are generally soft and have poor permeability, and the difficulty of gas extraction remains a challenge for gas control.

(3) There is a gap between gas treatment equipment and technology and the needs of gas treatment. Hard rock drilling equipment cannot meet the drilling needs of hard rocks, which affects the progress of gas control drilling construction. Directional long drilling has high geological requirements and is prone to collapse when passing through fault structures, resulting in a low porosity rate. Currently, it is only used to replace high

pumping tunnels and has poor adaptability in complex structural areas and coal seams.

5.2 Development Trends and Research Prospects of Gas Outburst Prevention and Control

(1) Considering the difficulties and technical issues in preventing and controlling gas outbursts in the Xinji mining area, it is necessary to vigorously carry out research on the three-dimensional joint area gas control technology of above and below the well, and explore new models for surface area gas control under the conditions of large mining depth in the Xinji mining area.

(2) Drawing on the experience of oil and shale gas extraction, research and implement surface drilling coal seam permeability enhancement technology, fully utilizing the good construction conditions and equipment characteristics of surface drilling, and implementing surface coal seam permeability enhancement technology to increase gas extraction volume.

(3) In the direction of intelligence and automation, we will accelerate the upgrading of advanced equipment such as directional drilling machines, fully automatic drilling machines, and remotely controlled automated drilling machines, further improving their geological adaptability and drilling positioning accuracy.

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