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Analysis on the Research Progress and Development Direction of Coal Mine Gas Prevention and Control Technology in China

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Abstract The coal plays a dominant role in the primary energy consumption in China gas is the associated production in the process of coal mining which is one of the main disasters to threaten the safety of coal mining the gas prevention difficulty increases constantly with the changes of the coal mining conditions and the coal mining process This paper introduces the gas prevention technology in recent years from the aspects of the gas prediction technology gas extraction and utilization technology and gas warning and monitoring technology The existing problems of the existing gas prevention technology are analyzed and the development assumption of the gas prevention technology is proposed.

Keywords Gas prediction technology; Gas extraction and utilization technology; Gas warning and monitoring technology

Introduction

The gas disaster accident is the most serious disaster in the five major disasters of coal mines. After years of technical research, system and management innovation, the coal mine safety situation has gradually improved. In 2015, there were 352 accidents in coal mines in China, 598 deaths and millions of tons of deaths. The rate was 0.159, of which 45 coal mine gas accidents and 171 deaths. Despite this progress over the past, the death rate of millions of tons of coal mines in China is still high, and there is still a big gap compared with developed countries in the West. As the mining depth increases, the difficulty in controlling disasters such as gas and coal-rock power is increasing. Therefore, strengthening the research on coal mine gas prevention and control technology and effectively curbing the occurrence of gas accidents in deep mines are the urgent tasks of coal mine gas prevention and control in China [1].

1. Research Progress in Gas Control Technology

Gas threats to mine safety mainly include explosions, coal and gas outbursts and suffocation. Therefore, the prevention and control of gas disasters mainly focuses on the prevention and control of gas accumulation, prevention and control of gas explosions, and prevention of coal and gas outbursts. Gas prediction technology, gas extraction technology and gas monitoring and monitoring technology [2].

1.1. Gas Prediction Technology

The prediction of mine gas emission is the basis for mine and mining area ventilation design, gas drainage design, gas management and coalbed methane resource assessment. At present, there are mainly mine statistical

methods and point source prediction methods. The mine statistical method is based on the actual gas emission data of the mine or adjacent mines. After statistical analysis, the law of mine gas emission with the depth of mining is obtained to predict the gas emission of new mining area or new mine. The method is based on a large amount of statistical data and has high prediction accuracy. The source-source prediction method is proposed and established during the "7th Five-Year Plan" and "Eighth Five-Year Plan" period along with the progress of China's gas content measurement technology and gas occurrence law. The essence is based on the coal seam gas content, according to the coal seam gas occurrence law, coal seam mining method, geological conditions, mining and mining, and the law of gas desorption and migration under the influence of mining, according to the gushing law of the gas source of the mine. Calculate the gas volume of each source, and finally calculate the gas inflow of the mining face, mining area and mine according to the source and sink relationship. After more than 20 years of research on the mine gas emission quantity source prediction method, the prediction accuracy rate can reach more than 85%, and it has been widely used in the country [3].

Coal bed gas content is one of the main parameters of coal seam gas occurrence, and it is an important basis for mine gas emission and coal seam outburst risk prediction. According to the scope of application, the determination method can be divided into the coal seam gas content determination method in the geological exploration period and the coal seam gas content determination method applied in the underground field. Both methods require a coal sample to be placed in a sealed container and the amount of desorption, loss, and residual amount are measured. In recent years, the gas content measurement technology has made great progress, and developed a closed sampling device for underground coal seams and a rapid measurement technology for coal seam gas content. It solves the problem of hard coal pressure wind sampling, temperature rise, accelerated gas desorption, loose coal seams, or long sampling time. The problem of large error in estimation of loss amount, such as long-point drilling sampling, and rapid determination of gas content

1.2. Gas Extraction and Utilization Technology

China's coal mine gas drainage technology has experienced four development stages: one is the high gas permeability coal seam gas drainage stage; the other is the adjacent layer pressure relief gas extraction stage; the third is the low permeability coal seam enhanced extraction gas stage; Comprehensive extraction of gas stage [4].

1.2.1. Gas Drainage Technology in This Coal Seam

The gas drainage in this coal seam is mainly for the gas drainage of the mining coal seam or the danger of eliminating the coal and gas outburst of the mining layer, mainly including the gas drainage technology of the bedding borehole, the gas drainage technology of the through-hole drilling, the gas drainage of the cross-drilling. Enhanced extraction techniques such as mining techniques, hydraulic measures or controlled explosions, and gas extraction techniques combined with bedding and through-hole drilling. Enhanced extraction technology is the main research direction in recent years, mainly including hydraulic reaming, hydraulic slitting, hydraulic fracturing, high-pressure air blasting cracking, carbon dioxide cracking and deep hole controlled explosion [5].

1) The bedding layer is mainly used for coal roadway mining working face and Shimen see coal. It can realize edge mining and pressure relief in the mining process.

2) Cross-drilling is applied to the mining face, and its drainage effect is better than parallel parallel drilling. Through-drilling is generally arranged in the floor rock gas drainage roadway, adjacent coal seam roadway or roof rock mining roadway, drilling from the drilling field to the mining layer, and the whole coal seam is thick. The final hole point of the hole is arranged in a mesh format, and the spacing is determined according to the pre-extraction time and the permeability of the coal seam. The effect of gas drainage through the layer drilling hole is obvious and has been widely used.

3) Cross-drilling gas extraction technology. The technology utilizes the floor rock roadway to drill the pre-extracted coal seam gas into the coal seam of the mining layer to ensure the elimination of the protruding danger during the coal roadway excavation. Then, after the coal roadway is excavated, the gas in the range of the mining face is drilled to the surface of the mining face to ensure the elimination of the danger of the mining face. It is mainly suitable for the prominent dangerous coal seams without protective layer [6].

4) Hydraulic reaming, hydraulic slitting and hydraulic fracturing are all hydraulic enhanced mining measures. Hydraulic reaming and hydraulic cutting are punching coal seams with high-pressure water jets, causing partial pressure relief of the coal seams, extending and expanding the fractures, increasing the permeability of the coal seams, thereby increasing the gas drainage volume of the coal seams. Hydraulic fracturing is the use of a high-pressure pump to press water into a coal rock layer under a certain pressure, causing cracks in the coal rock layer and increasing the permeability of the coal rock layer.

5) The high-pressure air blasting cracking technology uses the high-pressure air shock wave as the power source to instantaneously impact the coal body in the borehole along the coal seam through the nozzle of the blasting device, so that the coal body vibration between the impact drilling and the controlled drilling hole generates displacement or Cracks increase the permeability of coal seams [7].

6) The carbon dioxide cracking technology is characterized by rapid gasification when the temperature of carbon dioxide exceeds 31 °C or the pressure is greater than 7.35 MPa. The liquid carbon dioxide is filled in the main pipe of the cracker, and the heating device is quickly excited by the detonator, and the liquid carbon dioxide is instantaneously vaporized. When the pressure reaches the ultimate strength of the shearing piece, the constant pressure shearing piece breaks and the high pressure gas is released from the venting device, thereby causing the coal body to crack [8].

1.2.2. Gas Drainage Technology in Adjacent Layers

At present, the adjacent layer gas drainage mainly adopts the top and bottom floor gas drainage roadway extraction and drilling extraction or a combination of the two. The basic principle of roof gas drainage roadway layout is to arrange the final hole point of the pumping roadway or the pumping hole in the "O" ring of the overburden mining fissure. The gas drainage roadway is divided into high-drainage roadway and high-drainage roadway according to different layout modes. Going to the high pumping lane is divided into two types: the inner fault type and the high pumping lane and the outer fault type high pumping lane [9].

1.2.3. Gas Extraction Technology in Goaf

According to the state of the goaf, it can be divided into semi-enclosed goaf extraction and fully enclosed goaf extraction. Semi-enclosed goaf extraction mainly includes intubation and borehole extraction (including ground drilling, top and bottom drilling). Fully enclosed goaf extraction mainly includes closed intubation and surface drilling [10].

In recent years, the surface drilling gas drainage technology has been greatly developed. The surface drilling is used to extract the pressure-removing gas in the mining area, or the fracturing technology is used to expand the crack to increase the gas permeability, so as to eliminate the risk of coal and gas outburst and reduce the coal seam mining. The amount of gas emission in the process realizes green mining of coal and gas resources. The technology has been almost successful in applications such as Huainan, Huaibei and Jincheng [11].

1.2.4. Coal Mine Gas Utilization Technology

Since the "Twelfth Five-Year Plan", China's coal mine gas utilization technology has made important progress: Developed a complete set of low-concentration coalbed methane pressure swing adsorption deoxidation and concentration technology equipment, which can achieve one-time compression multi-stage concentration, and increase the concentration of coalbed methane with a concentration above 10%. More than 90%, the overall recovery rate of methane reaches more than 85%. The self-developed carbon molecular sieve methane recovery rate has increased by 3% - 5%, and energy consumption has been reduced by 20%. The intrinsically safe process technology for cryogenic liquefaction of oxygen-bearing coalbed methane has been developed, so that the methane recovery rate is not less than 98% [12].

1.3. Gas Warning and Monitoring and Monitoring Technology

In the early 1980s, China began to introduce safety monitoring systems from abroad and used them in some coal mines. By absorbing and digesting the advanced technology imported from abroad, and combining with the actual situation of China's coal mines, the coal mine safety monitoring and control system has developed rapidly in China, and various coal mine monitoring systems and their supporting products have emerged. The

monitoring and monitoring system has also evolved from early ground single-microcomputer monitoring and monitoring to networked monitoring and monitoring and network monitoring of different monitoring and monitoring systems.

At present, the transmission methods of domestic safety monitoring and control systems are basically based on the "fiber ring network + signal cable" method. The fiber ring network is mainly Gigabit. Among them, some of Shenhua's mines are the first to adopt 10 Gigabit bandwidth; The system mainly has 485 bus, CAN bus, FSK, DPSK and time-division baseband. In addition to conventional catalytic combustion, thermal conductivity, electrochemical and infrared, optical fiber sensing and laser sensing technologies are rapidly evolving and are gradually entering mass applications.

In recent years, China has paid more and more attention to the outstanding forecasting and early warning technology for coal and gas outburst mines. This technology is a comprehensive analysis and calculation of the safety information monitored and mastered by coal mines, and comprehensively evaluates the dangerous state and development trend of each working face. Techniques for issuing early warning signals and corresponding countermeasures based on the evaluation results [13-14].

2. Gas Research and Development Technology Research and Development Direction

2.1. Gas Prediction Technology

1) Further improve the source prediction method. The source-source prediction method is the preferred method for predicting mine gas emission in particular for new mines. However, with the development of coal mining technology and technology in China, it is necessary to carry out research on the prediction of gas emission from the fully mechanized caving face and the prediction of stratified mining gushing, in order to further improve the prediction formula of gas emission.

2) Conduct research on dynamic prediction technology of gas emission. The dynamic prediction of mines can truly reflect the actual situation of gas emission in the production process of mining face with dynamic behavior, making the prediction more targeted, time-sensitive and reliable, in order to meet the needs of modern mines for high-yield and high-efficiency construction.

2.2. Gas Extraction and Utilization Technology

1) Strengthen research on soft coal anti-penetration and enhanced drainage technology in coal mines. In view of the unsatisfactory effect of deep coal soft coal, lack of effective monitoring and evaluation methods for anti-reflection effect, research and development of in-depth gas and liquid enhanced anti-reflection technology, and anti-reflection effect stereo monitoring technology, greatly improve underground soft coal seam gas pumping Mining effect.

2) In-depth study of directional drilling technology and equipment for coal seams. Increase the promotion of the soft and protruding coal seam drilling and hole-forming equipment developed during the “Eleventh Five-Year Plan” and “Twelfth Five-Year Plan” period. Continue to carry out research on directional drilling technology and equipment for soft coal seams, research on large-aperture high-position long-distance directional drilling rigs, and geotechnical drilling technology and equipment for underground coal mines, and improve the hole-forming rate of extraction drilling to adapt to gas drainage technology. Development needs.

3) High-efficiency gathering and utilization technology of low-concentration coalbed methane. In view of the low concentration of gas in coal mines, unstable gas sources, low concentration, and poor economy, research and development of low-concentration gas power generation technology, low-concentration coal-bed gas heat-cooling technology, and low-concentration gas scale quality utilization technology. Improve the gas utilization rate in coal mines, and achieve various concentrations of coalbed methane gathering and transportation, utilization and zero gas emissions.

2.3. Gas Warning and Monitoring Aspects

l) Intelligent system. Coal and gas outburst warning and monitoring and control systems should be integrated with next-generation information technologies such as the Internet of Things, the Internet, and cloud computing, combined with gas emission forecasting method, transient electromagnetic method, acoustic emission method,

and coal rock deformation and pressure. Mutations, etc., comprehensive warning and warning, so that coal and gas outburst comprehensive early warning technology to achieve full coverage, high precision prediction of gas disasters.

2) Development of new sensors. Vigorously develop intrinsically safe, low-power wireless sensors, develop long-distance, non-contact harmful gas measurement, especially to overcome the application difficulties of laser CO and other harmful gas sensors. Combined with the new sensor technology, with the continuous advancement of digital and intelligent sensors, the anti-interference ability of the integrated warning system for coal and gas outburst is improved, the wireless transmission intelligent network is realized, and the reliability of the early warning system is improved.

3) The system should address the path of compatibility. In view of the non-standard communication protocol and the non-standardization of the physical layer protocol of the transmission equipment, it is necessary to find a way to solve the system compatibility or formulate corresponding professional technical standards as soon as possible, which is very important for promoting the development of mine monitoring technology and the promotion and application of the system.

3. Conclusion

Through the continuous efforts of the majority of science and technology workers and coal mine workers over the years, the research on the existing coal mine gas prevention and control technology in China is gradually maturing, and has achieved a series of fruitful results, making great contributions to the safety production of coal mines in China. However, with the advancement of China's social science and technology, the mining methods and mining processes applied to coal mines have been constantly changing, coupled with the increasing requirements for safe production of coal mines in China, new requirements for new technologies, new equipment, and improved management. . Therefore, we must continue to increase the research and development of technology and equipment, continuously improve the science and technology innovation system, expand the scope of application of new results, improve the scientific management level, adhere to the people-oriented, firmly establish the concept of "safety is the primary productive force", and comprehensively upgrade the coal mine. Safety technology and management level are important guarantees for promoting the healthy and sustainable development of the coal industry.

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