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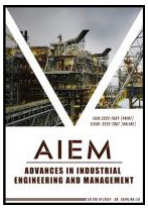

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RESEARCH ARTICLE

NEW THINKING ON PREDICTION TECHNOLOGY OF OUTBURST DANGER IN WORKING FACE

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ABSTRACT

Based on the hypothesis of comprehensive effect of gas outburst and the theory of three factors of outburst, through summarizing and analyzing the accident investigation reports of major outburst accidents in Guizhou, Yunnan, Shaanxi and other regions in recent years, it is concluded that the direct cause of outburst accidents is the lack or improper of outburst prevention measures, and the other is the most critical one Element is the change of geological structure. Based on the three factors theory of outburst, through the analysis of the traditional method, through analyzing traditional static prediction techniques such as comprehensive index method and drilling cuttings gas desorption index method for working faces, the existing traditional prediction technology index is lack of expression of geological structure, can not effectively reflect the geological situation of working face; combined with the current development status and application effect of borehole geophysical technology, in order to make up for the traditional working face The technical index of static prediction method of outburst danger is missing in the expression of geological structure. On the premise of fully discussing the importance of traditional prediction technology and the necessity and key of geological exploration for outburst prediction, the author puts forward a new idea of outburst danger prediction technology in "N + 1" working face, which provides an innovative direction for the development of outburst prediction technology in working face.

KEYWORDS

Outstanding prediction, borehole geophysical prospecting, critical index, prominent mechanism

1. INTRODUCTION

Gas outburst is a complex dynamic disaster. The mechanism of outburst is difficult to be unified because of the different coalfield conditions, stratigraphic characteristics and production conditions. Due to the mechanism of coal and gas outburst, four hypotheses or theories have been formed in general during the 1960s (Zhen, et al., 2023) : geostress theory, methane aerodynamics theory, geochemistry and multivariate factor theory. With the increasing mining depth and intensity and the diversification of coal and rock features, it is difficult for the single factor hypothesis to completely explain the causes of different outburst accidents. Therefore, more and more scholars are inclined to the comprehensive action hypothesis, which is the mechanism of outburst disaster. The core of the comprehensive effect hypothesis is that the outburst is mainly the outcome of the comprehensive effect of many factors such as mine pressure, gas pressure and stratigraphic structure. As for the key factors or leading factors that lead to the outburst, they are different in different coalfields, every type of mines and even all kinds of operating areas, which can be confirmed by the identification materials of outburst accidents in various mining areas and mines over the years.

The primary task of preventing and controlling gas outburst disaster is to indicate the risk of outburst, which includes the possibility of outburst occurrence and the degree of harm. In the field of gas disaster prevention and control research, after nearly 70 years of continuous research, China has already taken a leading position in the field of gas disaster prevention and control, and a relatively standardized and systematic forecasting technology system has been formed for the risk prediction of gas outburst, which may be summarized as contact forecasting technology and non-contact forecasting technology (Chen, 2024; Xu, 2021; Pu, 2021). According to the acquisition method of prediction indicators, contact prediction can also be called static prediction, and non-contact prediction is called dynamic prediction technology (Ning, 2019).

Contact prediction refers to sampling coal body or gas from the coal

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mining site of outburst coal seam, and taking a certain index of the state (static) of the sample as the basis for predicting the outburst risk of coal seam. Non-contact prediction is to determine the risk of mining layer near the working face through dynamic and continuous monitoring and comprehensive analysis of some indexes of the pressure state and failure stateof coal seam.

2. OVERVIEW OF THE CURRENT SITUATION OF GAS OUTBURST PREDICTION TECHNOLOGY

China began to study the prediction of outburst risk from the late 1970s, and in the late 1980s, many kinds of outburst prediction methods have been basically formed, and have been promoted and used nationwide. In order to adapt to different coalfields, different mines and all types of geological conditions and further improve the accuracy of prominent prediction, Wang et al proposed the prediction technology of sensitive indicators in 1991 (Xu, 2021). Since 1990, with the improvement of science and technology level, the prediction technology and equipment based on mechanization, information technology and intelligent technology have been developing continuously. Coal and gas outburst basically realizes non-contact dynamic prediction based on multi-factor synthesis. However, due to the particularity of coal mine production environment and the complexity of outburst occurrence mechanism, non-contact dynamic prediction technology is not mature enough at present, especially the determination of the critical value of multi-parameter fusion quantitative evaluation index is particularly lacking. Therefore, it cannot be directly used to guide mine outburst prevention work. It is only used as an auxiliary method or verification means of static prediction technology in all mining areas.

By studying the traditional static prediction technology of outburst risk, it can be seen that the Comprehensive indicator method and some other methods commonly used in the industry, but can not effectively reflect the geological structure, which is the key factor leading to outburst. Although later, based on the principle of sound, magnetic and wave detection technology, some research institutions proposed acoustic emission prediction technology and electromagnetic radiation prediction technology, aiming to supplement the technical gap of geological detection in the projection prediction, in order to improve the projection system, but due to the technology is not mature enough or the use of limited conditions, so far, In the prediction of gas outburst, the blank of geological structure prediction has not been well filled, and the geological structure, a key factor affecting gas outburst, has not been optimized.

By carefully combing and studying two outburst prediction technologies, contact static prediction and non-contact dynamic prediction, and analyzing the basic principles, key indicators and applicability of each prediction method, the author has obtained Table 1 of technical characteristics of outburst prediction methods.

3. CAUSE ANALYSIS OF COAL AND GAS OUTBURST ACCIDENTS

By summarizing and analyzing the identification materials of gas outburst accidents in several mining areas in Shaanxi, Yunnan, Guizhou and other places in recent years, there are generally the following common characteristics in coal mines where outburst accidents occur: (1) There are kinds of subjective factors in the direct causes of outburst accidents, which can be summarized as imperfect outburst measures and incomplete implementation of outburst measures; (2) The most critical

Table 1: Technical characteristics of gas outburst prediction methods

Prediction technique	Basic characteristics	Forecasting method	Key indicator [Corresponding expression]	Basic principle
static forecast technology	Discontinuous, touch	Borehole gas emission Initial velocity method	q	Comprehensive indicator method
		Cuttings gas desorption Index method	$\triangle h_2$	Reflecting the degree of coal damage and gas content
		Cuttings measurement	S	The amount of drilling cuttings is an effective index to reflect the magnitude of ground stress
		Cuttings rate method	n	Cuttings ratio n can be used as a prediction index of outburst, and when n is greater than 4, outburst risk occurs
		D、K Comprehensive index method	D、K	Reflecting the physical and mechanical properties of gas and coal rock
		Drilling cuttings Comprehensive index method	S_{max}、K_1、C、$\triangle h_2$	Reflect the situation of gas emission spread
		R Index method	R [$R_1=(S_{max}-1.8)(q_{max}-4)$、$R_2=S_{max}+4.5q_{max}$]	Comprehensive indicators reflecting the physical and mechanical properties of coal, coal seam gas, and coal seam state
Dynamic state forecast technology	Continuous, non-contact	Acoustic emission technology	/	Assess the risk of coal bed outburst at the edge
		Gas emission Dynamic index	V_{30}、K_V	Reflect the amplitude of the increase in gas emission per unit coal fall and the amplitude of the change in gas emission
		Electromagnetic radiation technology	Electromagnetic radiation intensity, pulse number	Monitoring of rock deformation electrical signals

indirect causes of outburst accidents are the development of structural coal, soft coal seam, coal body stress concentration in the outburst area, and significant changes in coal seam occurrence near the outburst point.

Taking Bailongshan Coal Mine in Dongdian Mining area of Yunnan Province as an example, outburst occurred for 18 times from 2005 to 2009. According to the accident investigation data, all the gas dynamic phenomena or outburst accidents occurred in the area of geological structure development or the area of coal seam. In 2019, there were three major gas outburst accidents in Zimuga Coal mine, Sanjia Coal Mine and Guanglong Coal Mine in Guizhou Province, and two gas outburst accidents in Liaoyuan Coal Mine and Qiaoziliang Coal mine in Shaanxi Province in 2020. According to the investigation report of the above five major outburst accidents released by the network network of the State Administration of Mine Safety, without exception, the direct cause of the accident was that the mine did not take effective measures to prevent outburst or the measures were not implemented in place. One of the key common factors in the indirect cause was that the geological exploration work was not implemented in place, and the prominent site was in the abnormal area of geological structure (Qi, et al., 2021).

4. NEW TECHNOLOGY OF OUTBURST PREDICTION

In view of the above accidents investigation causes unanimously pointed out that the causes of gas outburst accident in addition to the physical and mechanical characteristics of rock and gas occurrence, coal structure is one of the key factors leading to outburst, and the current industry generally adopted comprehensive indicator method and other methods, All of them reflect the physical and mechanical properties of coal and the gas occurrence characteristics of coal, all of them can not reflect the tectonic structure, which is the key factor leading to the outburst. Therefore, based on the development status of transparent geological technology in recent years, based on the three major disaster factors of outburst, the paper's author fully affirmed the necessity of comprehensive indicator method in the prediction of outburst, and should attach great importance to local geological advance detection. The author carefully studied and analyzed the principles, advantages, disadvantages and applicability of various structural detection technologies. Among them, borehole radar, borehole transient electromagnetic and other borehole geophysical exploration technologies based on geological radar technology have great advantages in detecting local geological structures. Although the detection range of borehole geophysical exploration is small (generally 15-20m around the hole), the detection range of borehole geophysical exploration is relatively small. However, its accuracy is high, it can clearly identify the stratified interface of coal and rock, and distinguish the structural development area by the degree of coal and rock fragmentation. It has great advantages for advance detection of coal roadway driving face and prediction of coal face uncovered by Shimen, and its detection range fully meets the needs of local outburst prediction of working face. The author believes that while fully implementing the existing N kinds of working face prediction technology in outburst mine, it is very necessary to add the local geophysical prospecting technology to form a new method or new idea of working face outburst prediction based on the combination of outburst index prediction and borehole geophysical prospecting. The author calls this method a new idea of working face "N+1" outburst risk prediction.

5. "N+1" HIGHLIGHTS THE APPLICATION AND EFFECT ANALYSIS OF PREDICTION TECHNOLOGY

Through investigation and investigation, Shu Longyong et al. from the General Institute of Coal Science Research implemented the "N+1" working face outburst prediction method in the relevant outburst mines under Yangmay Group and Zheng Coal Group, and carried out in-hole geophysical exploration in the advanced detection borehole (or advanced pressure measurement borehole), and realized the accurate prediction of the working face outburst risk without increasing any drilling quantity. It not only improves the safety of outburst prevention work to a large extent, but also realizes the high efficiency of outburst prediction, and realizes the rapid and accurate prediction of the outburst.

6. CONCLUSIONS

1) By summarizing and analyzing the investigation data of major gas outburst accidents this year, it is reached that the most critical factor of indirect causes of the outburst accidents is that the sites are located in geological anomaly zone;

2) Stem from the theory of three factors that cause outburst disaster, through analyzing the traditional prediction techniques, the existing prediction techniques lack effective expression of geological structure;

3) A new idea of "N+1" outburst prediction of working face is proposed, which provides an innovative direction for the development of gas outburst prediction technology in the future;

4) At present, the borehole geophysical exploration technology can not be effectively integrated with the traditional methods, but the integration and application of multi-parameter and multi-channel prediction technology is the inevitable trend of the development of prominent prediction technology in the future, and relevant technical equipment should be continuously improved and integrated in this direction to improve its field applicability.

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