Background and significance of gas monitoring research in coal mines

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Abstract. Based on the results of large data statistics of this year, this paper analyses the economy and personnel losses caused by coal mine gas disasters and gives examples of the status of the research and development of coal gas detection systems in several countries. Finally, the countermeasures are put forward in the light of China's national conditions.

Key words: Coal mine; gas monitoring; Background.

1. Research background

The main types of gas disasters are the gas explosion, coal and gas outburst, and gas poisoning. As a major coal producer in the world, China is one of the countries most threatened by the gas disaster. In the state-owned coal mines, the million tons mortality rate of high gas mines, coal and gas outburst mines is much higher than the other main producer countries of the world. Among all kinds of coal mine disasters (such as gas leak, roof fall, fire, water inrush, rock burst, dust and so on), the death toll of the major gas accidents accounts (more than one people dead each time) for more than 50% of the total death toll of all kinds of large accidents in coal mines.

2. Analysis Data

Since the twelve-word policy of gas management issued by the State Administration of Coal Mine Safety. The administrative departments of coal mines, production enterprises, and related scientific research institutes are strictly related to the ideas of "drain gas before mining coal, set coal production according to ventilation situation and monitoring and controlling" and deeply studied these relevant measures, methods, and techniques. Moreover, they carried out this research and got some remarkable success. As shown in this picture, the total number of gas accidents and the death toll in coal mines are prone to decline year by year from 2003 to 2011. However, the major (more than XX people dead each time) and particularly serious (more than XX people dead each time) gas accidents have not yet been effectively controlled. The statistical analysis of relevant data is shown in the figure.

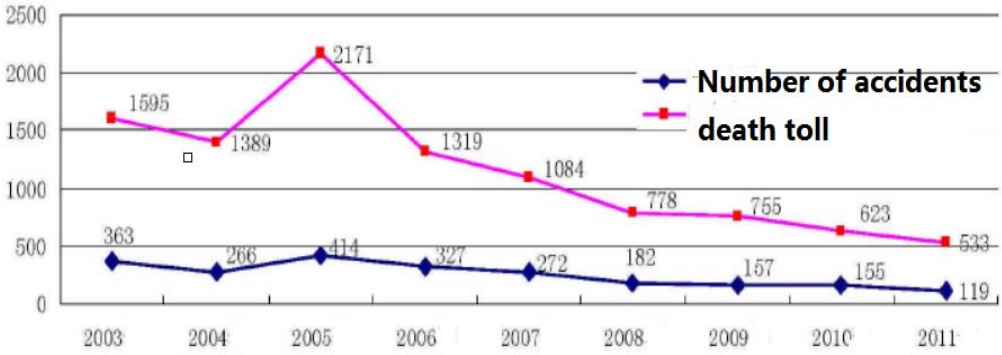

Fig 1. the gas accidents in china from 2003 to 2011

The above analysis shows that the prevention and control of coal mine gas disasters in China should be strengthened. Vigorously strengthening coal mine gas safety monitoring and disaster warning is of great significance for effective prevention and control of coal mine gas disasters and reduces casualties, and it has a long way to go. In the current, safety monitoring system of coal mines is widely installed and used, and gas disaster prevention and control have achieved initial accomplishment. We should soberly realize that the development, installation, and application of coal mines' gas safety monitoring and disaster warning system has entered a new platform stage. The gas safety monitoring network system based on the gas sensor has obtained a lot of real-time sensing data. However, because the comprehensive analysis of the system data and the ability of underground gas anomaly identification are still very weak, we still need professionals to judge the safety and development trend of the underground work environment based on the monitoring data obtained by the monitoring system. What is more, the status quo of sensor system reliability has not fundamentally changed. Therefore, some potential safety risks may deteriorate to significant accidents as technician failed to detect them in time and take appropriate preventive measures.

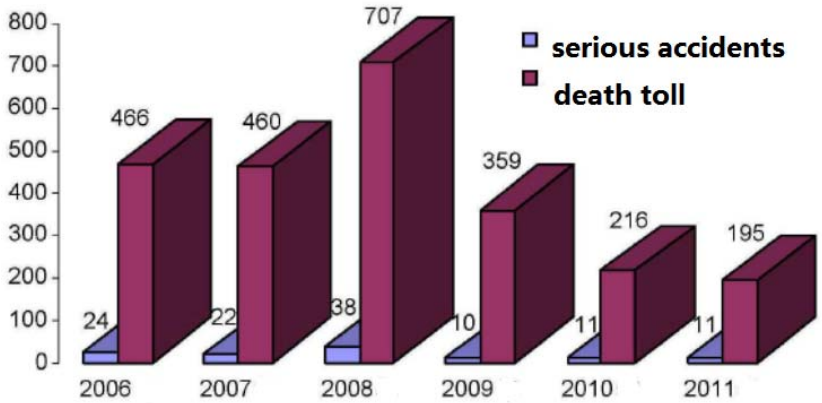

Fig 2. the number of serious gas accidents in China form 2005 to 2011

Therefore, we must fundamentally promote the current safety monitoring system in coal mines. Let the gas safety monitoring and warning capabilities improve to a new level. On the one hand, we must study the gas safety monitoring and early warning system based on the theory and method of multi-sensor information fusion. On the other hand, we should find out the natural knowledge and fusion model that can be used to identify underground gas anomalies through data mining methods in extensive historical data. Then use these natural knowledge and fusion model to monitor gas in coal

mines. Therefore, we can continuously enhance the reliability and intelligence level of gas safety monitoring and disaster warning system in coal mines.

3. The present situation of gas monitoring and warning system in coal mines

The primary task of gas monitoring and the gas warning in coal mines is to use all kinds of sensing equipment to monitor and report the level of gas concentration in the underground tunnel space in an all-around, real-time, continuous and accurate way. At the same time, evaluate and predict the danger state of gas outburst in each working face. Technicians need to get the abnormal change of underground gas monitoring data, especially the causes and trend of concentration overrun. Moreover, they also need to control the gas concentration within the safety range. What is more, they have to prevent and suppress gas outburst, gas accumulation, gas explosion, and other accidents. They also need to forecast and warning the gas hazard.

4. Gas monitoring and sensing technology

Compared with the developed countries in the world, the research and application of gas sensing and monitoring instruments in China started late. But the development is fast, and gas sensors based on various principles are available. In the early XX century XX, China began to develop carrier catalytic components. With the improvement of the manufacturing level of sensitive components and the development of electronic technology, especially the broad application of large-scale integrated circuits and microcomputers, the gas sensing monitoring technology has been flourishing.

5. Gas concentration sensor

The main component of mine gas is methane, or CH4, which accounts for about XX. At present, the detection methods of gas concentration include catalytic combustion method, infrared spectroscopy method, semiconductor gas sensing method, optical fiber method, gas chromatography method and so on. They all have different advantages and disadvantages. The carrier catalytic combustion gas sensor has the benefit of high accuracy and low price. It currently widely used in China's coal mines. But its components are unstable and short in life.

According to statistics, when the relative humidity reaches XX, and the temperature reaches 96 degrees Celsius, the sensitivity will decrease by 20% after ten days and drop to 50% after 40 days. However, after trying to improve the performance of some components, the tuning period of the sensor can be extended to XX weeks, with a lifespan of more than XX months. In this regard, we can refer to the series of high and low concentration gas sensors developed and manufactured by Chongqing Academy of Coal Science and Technology. The principal technical indicators are as follows:

Detection range:
0%~4% CH4
Detection error:
<=0.1%(0%~1% CH4)
<=0.15%(1%~2% CH4)
<=0.2%(2%~4% CH4)

6. Acoustic emission sensor

Acoustic emission is a phenomenon that the elastic strain energy propagates in the medium in the form of stress waves during the deformation process of solid materials. A great deal of experience shows that most of the solid materials will produce acoustic emission when they deformed by force. For that coal gunfire in common knowledge, is caused by the elastic strain which released by coal rock. Due to the influence of mining activities, the coal body in front of the working face will produce three zones, namely the pressure relief zone, the stress concentration zone and the initial stress zone. In the stress concentration zone, a significant amount of elastic deformation energy accumulated in the coal and rock mass. When elastic deformation reaches the limit of coal and rock mass, it will undergo a

qualitative change. At the same time, some elastic energy can transform into other forms of energy, such as sound and electromagnetic radiation. Moreover, these energy forms are propagated and released in coal and rock mass, and even enter into the mining space.

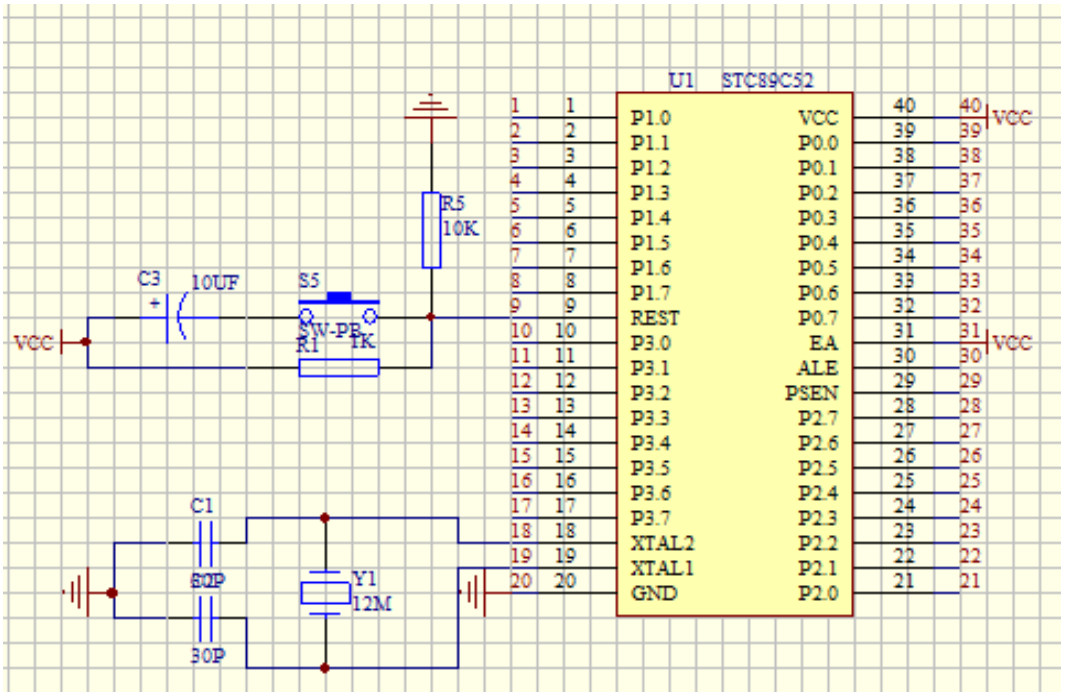

Fig 3. the sample of sensor circuits

Our country has also researched in this field. We found that the acoustic wave during coal rock failure is closely related to mine pressure activity. What is more, the magnitude of acoustic intensity can reflect the quantity of mine pressure. Although our country started late, and behind the United States, Britain, Japan, Russia, Germany and other countries, we have developed and produced a variety of practical application of acoustic emission monitoring equipment in mines. These instruments are mainly used to judge the damage and development trend of coal and rock mass, especially to predict the risk of coal and gas outburst. Zou Yinhui and others introduced the acoustic emission monitoring equipment, which designed with embedded structure. The equipment can collect full waveform data and monitor in real time. Moreover, it can be operated independently and also can link to an environmental monitoring system for continuous dynamic monitoring.

7. Electromagnetic radiation sensor

In the last century, He Xueqiu and Wang Enyuan of China University of Mining and Technology proposed the prediction of coal and gas outburst by electromagnetic radiation. They principally base on two indexes of electromagnetic pulse and electromagnetic radiation intensity. The fundamental principle of this method is the gas containing coal and rock rheological failure mechanism, along with the physical detection method about the theory of the electromagnetic effect of coal and rock destruction. This method can continue running dynamic prediction and remote monitoring of the coal and rock mass in front of mining and excavation faces. It has the characteristics of small workload, short test time and no influence on the efficient production of mining and excavation faces.

Fig 4. coal disasters AE sensor and software

Fig 5. the KBD5 coal disaster EME sensor and software

8. The gas safety monitoring system

The development and equipment of gas safety monitoring system in coal mines are relatively early in foreigner countries, which including the United States, Britain, Germany, France, Poland and so on. The research and application of this aspect in China started relatively late. From the initial stage of new China to the XX of the last century, the underground miners mainly used the portable optical gas calibrator and the anemobarometer to detect environmental parameters. Therefore, it is almost impossible for the ground to monitor the underground environment in real time.

9. Summary

Through months of continuous learning and practice, the research was finally completed. Among them, a lot of problems area encountered, such as the failure of motor rotation, which was, as later found out in repeated inspection, due to the short circuit caused by false welding in the original welding.

Acknowledgements

This work is supported the following fund:

2017 The student work subject program of Hezhou university: “college students' network addiction of the student work service research” (No, hzxysz201707).

2016 The higher education research subject project project of Hezhou university: “between collaborative innovation research of entrepreneurial talent cultivation system”.

2016 Guangxi university scientific research project:” Study on image processing based on digital compression sensing theory of intelligent robot” (No, KY2016YB454).

2017 college students' innovative entrepreneurial project: “The agricultural robot autonomous operations research based on machine vision”(No,201711838096) && “Multi-functional autonomous agriculture robot development”(No,201711838121) &&”Research and development of navigation system for agricultural robot”(No,201711838008) &&”Research and development of data acquisition system and servo control system for mobile platform of agricultural robot” (No,201711838075) &&”Research and development of visual navigation system for agricultural robot test platform”(No,201711838076).

2017 Guangxi education science 'ten-three-five' planning project: “Based on zte's ICT education platform of fusion, work-integrated learning education training mode research” (No,2017B107).

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