Present Situation and Development Trend of Coal Mine Gas Control in China

Dai Linchao[1, 2, a, *]

[1]Gas Research Branch, China Coal Technology Engineering Group Chongqing Research Institute, Chongqing 400037, China

[2]State Key Laboratory of the Gas Disaster Detecting Preventing and Emergency Controlling, Chongqing 400037, China

[a] dailinchao@126.com

Keywords: Coal mine, Gas control, Development trend, Key technology

Abstract: Based on the occurrence regularity of gas accidents in coal mines in China, the development history and current situation of coal mine gas control technology in China are summarized, and the severity of gas accidents in recent years is analyzed. And it is pointed out that the key technologies such as strengthening the control of key hazards of gas accidents, reducing workers in gas-prone sites, further strengthening the research and development of gas extraction technology, and strengthening gas utilization are the key points for future development of gas control in coal mines.

1. Introduction

China is the largest coal producer in the world. Its coal output has increased from 1.2 billion tons in 2000 to 3.52 billion tons in 2017, with an average annual growth rate of 6.5% (as shown in Fig.1). At the same time, China is also the country with the most serious coal mine disasters. The number of coal mine deaths decreased from 5798 in 2000 to 375 in 2017 (as shown in Fig.2), but the number of deaths in the same period is much higher than that in developed countries such as the United States [1]. With the increase of mining depth and intensity, the gas pressure, gas content and gas emission in coal seam increase significantly, and the harm of gas is becoming more and more serious. Therefore, gas control has become a major technical problem restricting the healthy development of coal mines in China [2].

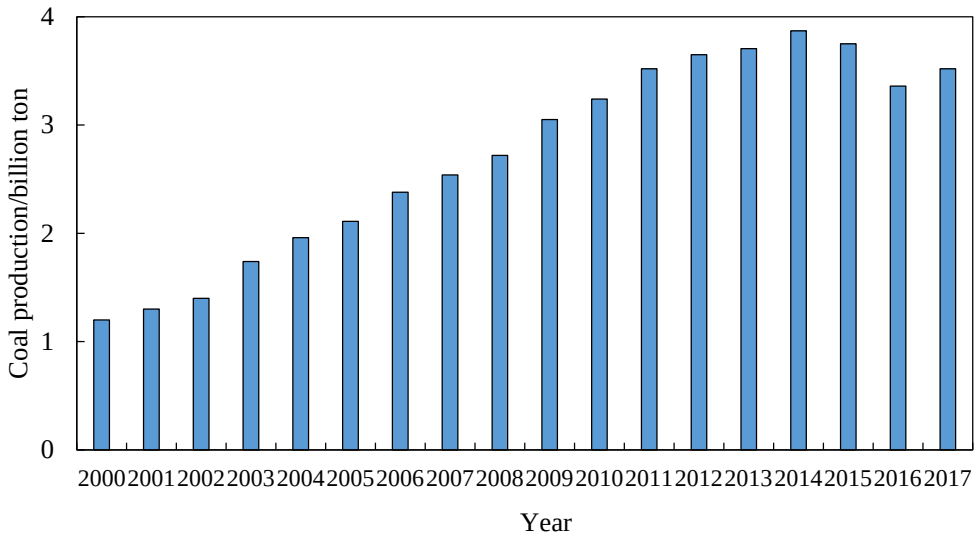

Fig.1 Coal production in China from 2000 to 2017

  DOI: 10.25236/epcimms.2019.11

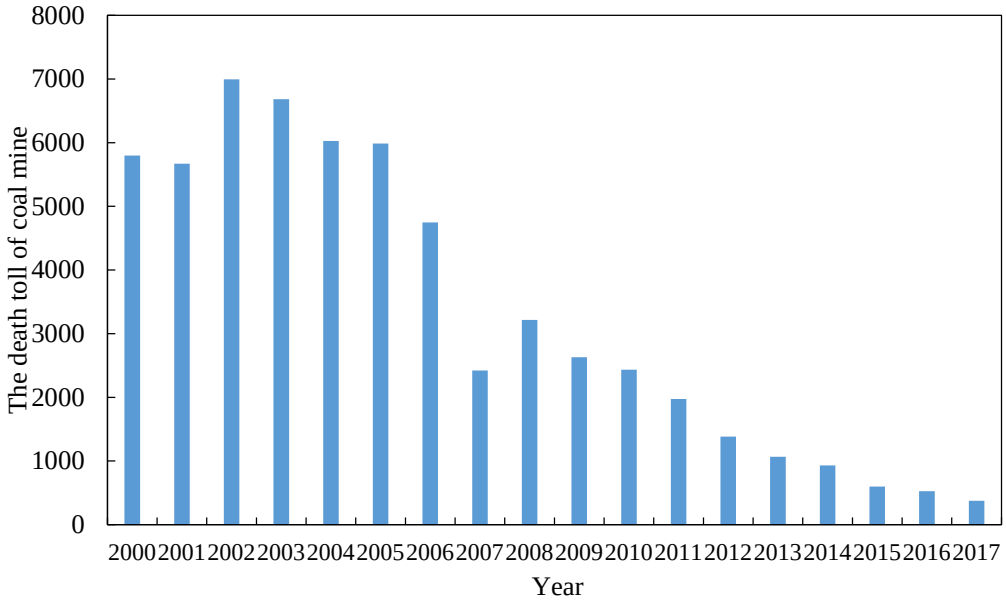

Fig.2 Deaths in coal mines in China from 2000 to 2017

2. Development of Coal Mine Gas Prevention and Control Technology in China

The development of coal and gas outburst prevention technology in China has experienced three stages [3-5].

(1) From the early days of the founding of New China to the 1980s, the technology of preventing and controlling coal and gas outburst in our country is mainly based on learning foreign experience, testing and applying some single or partial measures of preventing and controlling coal and gas outburst, such as mining protective layer, pre-drainage of gas, large diameter advance drilling, vibration blasting, etc. The research and practice of outburst prevention technology is still in the primary exploratory stage, and coal mine outburst accidents occur frequently. The number and intensity of outbursts rose rapidly, with hundreds of outbursts per year, up to nearly a thousand.

(2) From the late 1980s to the early 21st century, on the basis of a comprehensive summary of the development of outburst prevention technology, especially outburst prediction technology and safety protection technology, China Coal Technology Engineering Group Chongqing Research Institute and Shenyang Research Institute assisted the Ministry of Coal Industry in formulating the first "Detailed Rules for the Prevention and Control of Coal and Gas Outburst" in 1988 (revised in 1995), and put forward the "four in one" comprehensive outburst prevention measure system for the first time, which includes outburst risk prediction, outburst prevention technical measures, outburst prevention measures effect inspection and safety protection measures. In this period, Chongqing Research Institute and Shenyang Research Institute developed forecasting technology (comprehensive prediction indicators of outburst risk (D, K), drilling cuttings gas desorption indicators (K_1, h_2), initial velocity of gas emission from boreholes and so on), outburst prevention technology (hydraulic punching, deep hole loose blasting and so on) and safety protection technology (pressure air self-rescue system, reverse air door and so on). These technologies have brought our country's overall outburst prevention technology into a new stage, which has produced remarkable results in reducing and suppressing outburst accidents in coal mines.

(3) Since 2005, in order to adapt to the rapid development of high-yield and high-efficiency production technology of coal mining mechanization in China, Chongqing Research Institute has put forward the theory of "mechanical mechanism of coal and gas outburst" on the basis of the outstanding "comprehensive function hypothesis", which provides a new theoretical basis for the prevention and control of outburst. At the same time, they have developed direct gas content determination technology, electromagnetic wave geological anomaly advanced detection technology, along the coal seam long borehole pre-drainage coal seam gas technology, soft coal

hydraulic fracturing technology, etc., which provide technical means for the prevention and control of outburst areas. On this basis, relying on the "Detailed Rules for the Prevention and Control of Coal and Gas Outbursts", China formulated and promulgated the "Regulations for the Prevention and Control of Coal and Gas Outbursts" in 2009, and put forward the "four in one" regional comprehensive outburst prevention measures, which include regional outburst risk prediction, regional outburst prevention measures, regional measures effectiveness test and regional verification. And together with the local "four in one" comprehensive outburst prevention measures, it constitutes two "four in one" comprehensive outburst prevention measures system, and clarifies the principle of "regional outburst prevention measures first, local outburst prevention measures supplement".

In addition, the research and popularization of AE monitoring devices, electromagnetic radiation meters and other mining face outburst risk monitoring technologies, especially the research and development and popularization of outburst warning technology and equipment, provide a means for automatic monitoring of the change of outburst risk comprehensive influencing factors before, during and after mining production and making hidden danger warning. It has taken a great step towards informationization, automation and intellectualization of prevention and control.

3. Current Situation of Coal Mine Gas Prevention and Control Technology in China

From the above developments, the current situation of gas control are as follows:

(1) As far as coal mine safety is concerned, due to the improvement of coal mine safety policy and gas control technology, great progress has been made in coal mine gas control over the past ten years. The number of deaths from coal mine safety accidents and gas accidents has dropped to the level closest to the industrial injury mortality rate of the national industrial and mining enterprises, although this level is not stable.

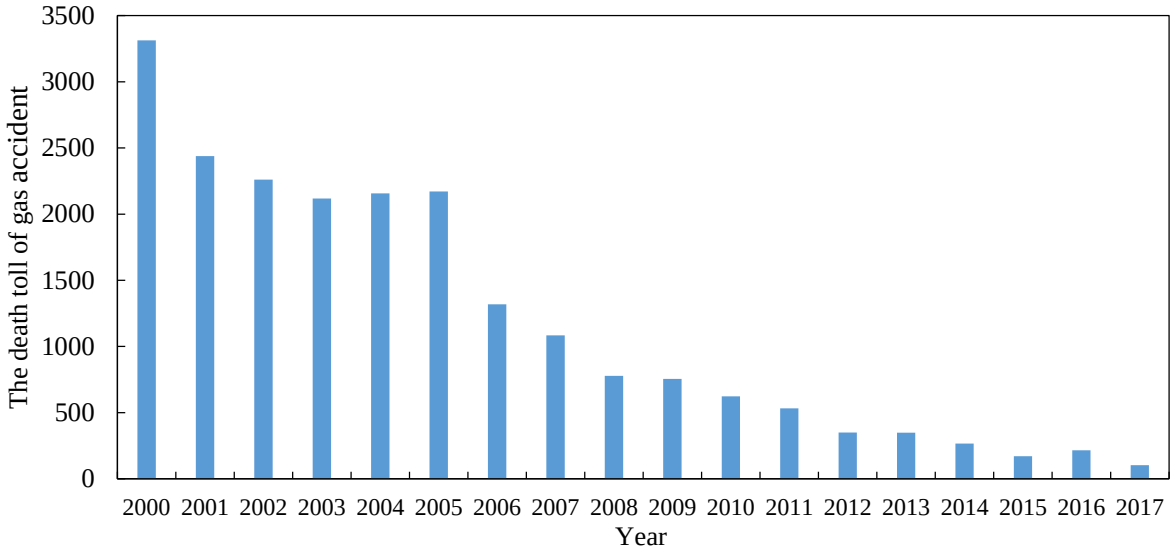

Fig.3 Deaths in gas accidents in China from 2000 to 2017

Similarly, Fig.3 also shows that there has been a significant decline since 2006 when the whole country paid attention to gas control, and a four-year decline since the introduction of a series of new technologies and regulations in 2009. However, since 2012, the number of deaths from coal mine gas accidents has declined slowly and fluctuated. This shows that the coal mine gas disaster prevention and control has entered a difficult period, and the period that only one policy or a set of technologies can be expected to achieve significant results is coming to an end.

(2) But coal mine gas accident is still the most critical and volatile content in coal mine safety work. In recent years, gas accidents account for about one third of the deaths in coal mines, of which more than 80% of the major accidents in 2016 are gas accidents. From Fig.4 and Fig.5, we can see that the number of fatalities in gas accidents is higher than that in larger accidents, and the

number of fatalities in major accidents obviously fluctuates. Therefore, the impact of major and extraordinarily serious accidents on society is more serious, which shows that major and more serious gas accidents are not only the focus of prevention and control of coal mine gas disasters, but also the difficulty. In recent years, although the total number of serious and extraordinarily serious accidents has decreased, the fluctuation itself shows that there is no reliable means to prevent and control the occurrence of heavy and extraordinarily large gas accidents.

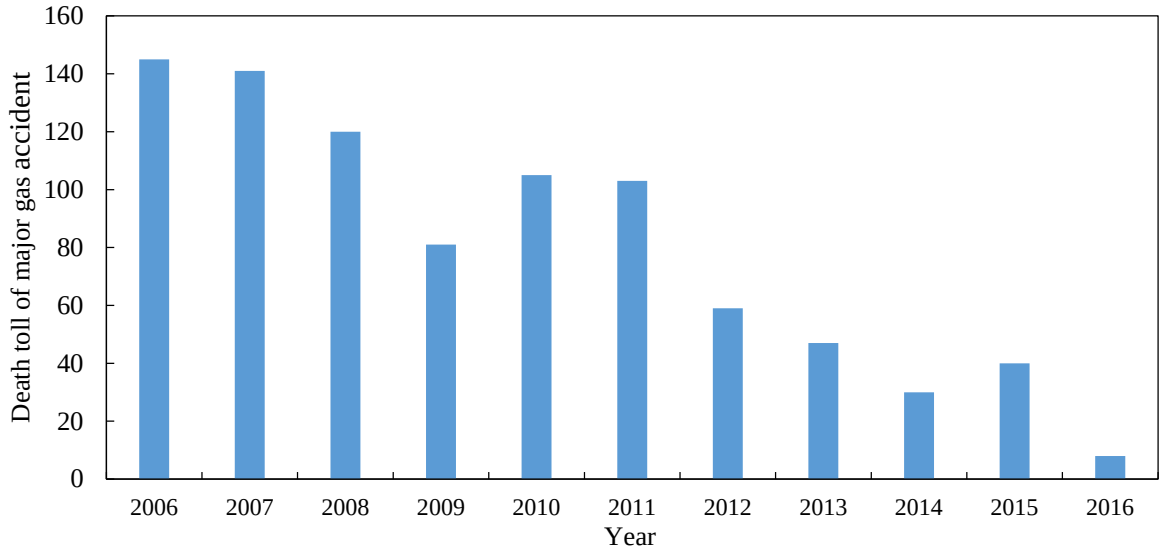

Fig.4 Death toll of major gas accidents

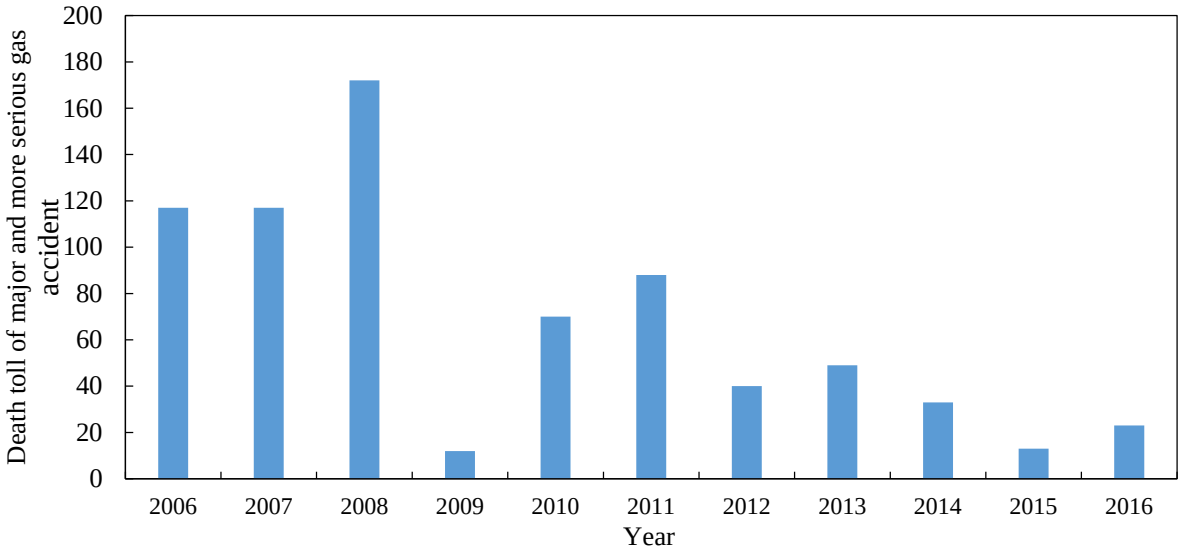

Fig.5 Death toll of major and more serious gas accidents

4. Main Thought and Work Direction of Gas Control

The fluctuation of gas accidents shows that the existing means do not meet the requirements of reliable control of heavy and super-heavy gas accidents, with greater randomness of components. Therefore, exploring effective management and technical means to prevent and control heavy and super-heavy gas accidents and reducing the uncertainty of occurrence of heavy and super-heavy gas accidents is a key work in a period of time.

At the same time, serious and extraordinary accidents are regular, such as the high risk of occurrence, the high probability of occurrence of accidents, and the concentration of personnel in the place, so it is easy to occur serious and extraordinary accidents.

To this end, the following suggestions are made:

(1) Strengthen the prediction and investigation of key hazard sources of gas accidents in an all-round way, strengthen the implementation of disaster prevention and control measures for key hazard points and regions of prediction and investigation, so as to make the measures targeted, focused and strong enough, and improve the reliability of accident prevention;

(2) Reduce the number of workers in gas accident-prone places and reduce the number of deaths from gas disaster accidents. By means of studying new technologies and optimizing management, we try to reduce the number and concentration of personnel in gas accident hazard sites.

(3) Further strengthen the role and status of gas extraction in coal mine gas control work, gradually abandon the way of excessive reliance on ventilation to discharge gas. And measures such as policy guidance, management strengthening and technical support should be taken to further enhance the role of regional pre-drainage in coal mine gas extraction, and gradually eliminate or substantially reduce the risk of gas disasters before regional coal seam mining. In recent years, the technologies of hydraulic fracturing and ultra-high pressure hydraulic cutting in soft coal seam, which have achieved remarkable results, also provide conditions for the application of pre-drainage gas technology.

(4) Actively support the utilization of coal mine gas, in order to promote gas extraction, mobilize the enthusiasm of coal mine gas extraction, and achieve triple benefits of safety, economy and environmental protection.

Through the implementation of the above gas control measures, the goal of gas control in coal mines in the next 10 years should be as follows: (1) The number of deaths from coal mine gas accidents decreased by 40~50%. (2) The number of deaths caused by heavy and heavy gas accidents has been reduced to less than 40% of the total number of deaths caused by gas accidents.

Acknowledgments

The study was supported by the National Natural Science Foundation of China (No.51874348, No.51774319, No.51574280), and National Key Research and Development Program (No.2016YFC0801402).

References

[1] Liang Guodong, Guo Jian. Statistical analysis of the causes of coal mine gas accidents in China[J]. China Energy and Environmental Protection, 2018,11:75-78.

[2] Xu Longcang. Study on improving the sealing effect of CMM drainage boreholes and its application[J]. China Coalbed Methane, 2008,5(1):23-24.

[3] Wang Youan. Four-in-one comprehensive outburst prevention measures-New stage of preventing coal and gas outburst[J]. Coal Mine Safety, 1990, 12:10-15.

[4] SHI H, WU X, WANG L, et al. Design of Real-time Detection System for Hemodialysis Machine Operating Parameters[J]. Journal of Applied Science and Engineering Innovation, 2018, 5(4): 113-116.

[5] Wen Guangcai. Coal mine safety technology[M]. Beijing: Science Press, 2017