Statistical analysis and countermeasures of gas explosion accident in coal mines

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Abstract

Accident statistical analysis is an important means of studying accident rule. In this paper, gas explosions that happened during 2001–2013 are analyzed statistically, and a comparative analysis of the number of gas explosions and the number of corresponding deaths during these 13 years is performed. The data of gas explosion is analyzed statistically from the regional, moment and month of gas explosion, some of statistical rules of gas explosion between 2001 and 2013 are summarized, and these laws are analyzed and studied. The countermeasures that could prevent and control gas explosion are proposed by combining with these laws. The results contribute to the more effective prevention and control of gas explosion accidents and also promote safe production.

1. Introduction

Gas explosion is one of the major coal mine disasters, and is one of the major coal mine accidents that often makes dies in groups the group wound. It often leads to the destruction of the ventilation system, the disorders of air flow, the spread of toxic gases, or even successive disasters and bring great difficulties and dangers to the rescue work. The number of gas explosion in China's coal mine is relatively frequent, in recent years as China put more emphasis on mine safety, the safety issues mine have been greatly improved, the number of gas explosion accidents...
have also reduced to a certain extent.

In this paper, the gas explosions accidents that happen during the 2001−2013 in China are analyzed by the method of accident statistics. Accident statistics use statistical theory to do statistics, analysis and research on the number of production safety various aspects, and the production safety situation is reflected from the aspect of quantity. Mine safety situation in each period can be learned through the statistical analysis of our coal mine gas explosion accident data, so the major safety problems that should be solved in the future are found, and provide the basis for making the wide measures that prevent accidents. In this paper, some statistical regularities of coal mine gas explosion are summarized through analyzing the data of gas explosion in recent years, and this is much more helpful to the effective prevention and control of gas explosion hazards.

2. Gas explosion statistical analysis

This statistical data of gas explosion that happen during the 2001−2013 is gotten from the safety administration of work safety web address, some of the relevant literature and the news that published by the safety administration of work safety [1−4].

2.1. Gas explosion deaths and accidents analysis

The annual death toll in gas explosion and the number of accidents from 2001 to 2013 are shown in Fig. 1 and Fig. 2, and the overall downward trend of the annual death toll in gas explosion and the number of accidents can be seen from the figure. The deadliest year in gas explosion accident is 2005, followed by 2002 and 2001; the year when there are the most number of accidents gas explosion is 2002, followed by 2001 and 2003. The annual death toll in gas explosion and the number of gas explosion accidents have declined sharply since 2005, and the year when there are the fewest death toll in gas explosion and the fewest number of gas explosion accidents is 2012. That the security situation take a great turn for the better after 2005 can be seen from the data, and the reasons are that mine safety is attached great attention by China in recent years, a series of law and regulations, rules and regulations, technology regulation are promulgated by China, the coal mines that do not have safety production conditions and illegal coal mines are rectified and closed [1]. The safety basic management of small coal mine and state owned coal mine are strengthened, and gas control and safety supervision are strengthened, the extract and use of security costs is cleared. The upper limit of original standard is regarded as the lower limit of new standard, and that the companies can appropriately and independently improve extracting standard basing on the upper limit of standard is allowed. The evaluation agency management and safety training management are strengthened, and these measures impel coal mine gas explosion to significantly decline after 2005.

Fig. 3 is the number of gas explosions which cause more than 30 people died, and what can be seen from the figure is that the number of gas explosions which cause more than 30 people died is reduce in its totality, the year when there are the most number of gas explosion accidents which cause more than 30 people died is 2005, there are 7 especially severe gas explosion accidents, in total, which cause more than 30 people died.

The comparative analysis between the number of gas explosion accidents, the annual death toll in gas explosion accidents and the annual death toll in coal mine accidents, the annual death toll in coal mine accidents [2−4] during the 2001−2013 is shown in Fig. 4, that the ratio of the number of annual gas explosion to the annual death toll in coal mine accidents is 1%−5% can be seen from Fig. 4 and Fig. 5, but the ratio of the annual death toll in gas explosion accidents to the annual death toll in coal mine accidents is 7%−20%, that gas explosion accident is one of the major accidents that causing mass casualties can be seen. Effective control of the gas explosion accident frequency can significantly reduce the total number of deaths in coal mine.

The especially severe accidents (30 and above), major accidents (10 to 29), larger accidents (3 to 9) and general accident (2 or less) four levels which divided by the number of deaths are analysed, the statistics on the number of gas explosion accident that happen during the 2001−2013 are according to the four grades, the results are shown in Fig. 6. Thus that the number of larger accidents account for more than half of the total accidents, followed by major accidents and general accidents, the number of the especially severe accidents is least can be seen from the figure.
2.2. The geographical Analysis of gas explosion accident

The provinces of gas explosion that happen during the 2001–2013 were analyzed statistically, also the annual death toll in gas explosion accidents and the number of gas explosion accidents of different provinces are shown in Fig. 7 and 8. What can be seen from Fig. 7 is that almost all provinces of mainland China have gas explosion accidents in addition to Fujian, Tibet, Hainan provinces. The province where there are the most number of accidents gas explosion is Guizhou, followed by Hunan, Sichuan, Shanxi, Yunnan, Chongqing and other provinces. The gas explosion accidents of six provinces account for 62.5% of the national total gas explosion accidents, and Guizhou account for 21.4% of the national total gas explosion accidents. The big difference of the number of gas explosion accidents that happen in different provinces
can be gotten by analysis, the main reason is that different regions have different geological conditions, technique conditions and management conditions, and lead to relatively large difference level of coal mine safety production. The main causes of Guizhou frequent coal mine gas explosion accidents are the complex conditions of coal seam hosting in Guizhou, large quantity of mines, small scale of coal mines, the highly gassy mine and coal gas outburst mine in Guizhou account for nearly 70% of total coal mines, leading to coal mine accident of Guizhou more frequent.

What can be seen from Fig. 8 is that the province where the most number of deaths in gas explosion accidents is Shanxi, followed by Guizhou, Heilongjiang, Henan, Hunan. Every statistics of accidents which lead to more than 10 deaths are shown in Fig. 9, the province where the most number of accidents which lead to more than 10 deaths is Shanxi, followed by Guizhou, Heilongjiang and Henan. The accidents which lead to more than 10 deaths of Shanxi account for 60.3% of the total number of gas explosion accidents, Guizhou account for 16.2%, Henan account for 44.8%, Heilongjiang account for 26.4%, so the big accidents are most easily occurs in Shanxi and Henan, the main reasons is that Shanxi and Henan are both major coal production provinces, there are many large state-owned coal mines, and the scale and production of the mine are large, there are many workers who work underground, so when the accident happen, the toll death is greater.

What can be seen from above figures is that the key areas of coal mine safety production are Guizhou, Hunan, Sichuan, Shanxi, Chongqing, Yunnan and other provinces; the coal mine production safety situation of small provinces Zhejiang Province, Hubei, Guangdong and other provinces are noteworthy; and the coal mine production safety situation of provinces where especially severe accidents happen frequently Hunan, Henan, Guizhou and other provinces should be highly valued.
2.3. Time Analysis of gas explosion accident

Fig. 10 is distribution curve of the number of gas explosions according to time, the peak time of gas explosion occur is around 11:00, and began to decrease after 11 o’clock; afterwards there is another peak at 16 o'clock. This rule also reflected by annual data of 2011, 2012, 2013. This is consistent with the rule of coal mine accidents statistical analysis according to time in the literature [5]. The research results in the literature [5] also indicate that 11 o’clock, 16 o'clock are the peak time of coal mine accidents by the method of statistical analysis. So supervision and management should be strengthened at the two moments in the process of coal production.

Fig. 11 is distribution curve of the number of gas explosions according to month, what can be seen from the month distribution curve of gas explosions is that the occurrence of coal mine accidents not concentrate in any particular month, the main reason is that the influence that change of climate act on the coal mine operations is not obvious.

3. The Countermeasures of gas explosion

In recent years, the situation of China's coal mine safety is relatively stable overall, the annual death toll decreased. Especially since 2006, coal mine accidents have been decreasing significantly year by year. But in China gas explosions is frequent compared with other countries. Therefore, there are the following suggestions.

1) Increasing the gas explosion prevention control equipment and safety supervision
   The majority of China's coal mine is small coal mine, the level of overall production technology is low, equipment is poor, mining methods is backward, and the adequate safety guarantee is lack. Mines’ super powers and super strength production is serious. States should reduce the number of small coal mines which not have the safety conditions by the way of close, transformation, integration. Meanwhile the safety investment of enterprises should be supervised, the gas explosion prevention control technology equipment of coal mine should increase. Enterprises should be urged to raise the security cost according to law and that security cost are used in safe production should be ensure.

2) Improving the level of coal mine safety management
   The level of coal mine safety management is general low, the site management is chaotic, the safe production responsibility system is not perfect, and the phenomenon of creating intrinsically safe working conditions and improving the overall safety performance is ignored, so that the safety technical measures are not made full use of. The mine gas monitoring systems should be established, and the abnormal state of gas accumulation overrun should be detected and dealt with timely [6]. The control and management of detonate fire source should be strengthened, and the explosion of electrical equipment should be banned, and the gas that ignited by blasting should be prevented, and the sources of fire which can detonate gas should be eliminated.

3) Strengthening worker training
   The majority of China's front-line coal mine workers are farmers who don’t have high level of educational, and the mobility of worker is relatively large, the training of workers gas explosion knowledge need to be strengthened[6]. The phenomenon of low quality and lack of the necessary safety education and training become
even more serious in small mines. According to the mine workers quality is poor, mine managers should actively promote the implementation of mine safety training and education to promote safety knowledge, the workers awareness of the current grim safety production situation can be improved, the sense of urgency, crisis and responsibility at work can be strengthened. The training system should be perfected in the process of training, the high-quality teaching staff should be equipped, and the safety training materials should continuing tend to become standard. According to the principle of full participation, counterpart training, implement step by step, so the improving of worker safety skills should be focused, also the effective should be focused, the workers who are participating in safety skills training should be arranged in batches reasonably and periodically, the check work of safety skills training should be constantly strengthened.

4) Strengthening gas explosion prevention and control technology research

The study of gas explosion mechanism should further deepened, the research on gas explosion warning technology should be strengthened, the emergency signal should be sent to the relevant departments and dangerous situations should be reported according to the law which summarized before or the possibility of precursor which obtained by observing before the gas explosion accident happen. Meanwhile the research on the new technology of barrier explosion should be strengthened, so the propagation of gas explosion can be effectively obstructed, strengthening the barrier explosion of new technology research, gas explosion propagation can be effective obstructed, the scope of the disaster can be reduced.

4. Conclusions

Through the statistical analysis of China's coal mine explosion accident from 2001, conclusions are drawn as follows:

(1) China's coal mine safety situation presents an improving trend year by year, the number of accidents and the death toll present downtrend. Since 2006 the death toll and the number of gas explosion have already declined dramatically.

(2) From the view of regions, Guizhou is the province where accidents easily happen, followed by Hunan, Sichuan, Shanxi, Yunnan and Chongqing etc. Shanxi is the province where major accidents easily happen. These provinces should make efforts to strengthen mine safety management.

(3) From the view of time trend, the accident probably happen at any time of any month, but the two peak of gas explosion are around 11:00 and 14:00. So the safety work should be strengthened every moment, the mine safety supervision should be strengthened especially at around 11:00 and 14:00.

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