Research on Key Technologies of Safety Production in Coal Enterprises

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Abstract. According to the production characteristics of coal enterprises in China, this paper analyzes the causes of production accidents, summarizes the key factors that should be considered in the process of safety production of coal enterprises, and then puts forward the key technology system of safety production of coal enterprises in China, which provides a basis for improving the production safety of coal enterprises in China, and also provides a reference for the production of foreign coal enterprises.

1. Introduction
Economic development, modern industry and people's daily life are inseparable from energy. However, due to the uneven distribution of energy in the world, all countries in the world are competing for energy. As an important energy source in China, coal plays an important role in the development of economy. Since 2005, coal has accounted for more than 70% of the primary energy consumption, so coal is the main source of energy for China's economic development. Because of the high accident rate of coal industry, safety production is the primary premise of coal mine development and an important embodiment of people-oriented. Only by realizing the safe production of coal mines can we ensure the sustainable development of coal mines and the continuous growth of economic benefits.

2. Accident-causing Theory

2.1 Representative viewpoints of Accident-causing Theory
Accident-causing theory is a theoretical reference for the prevention of similar accidents by analyzing and summarizing the causes and development process of these accidents after selecting a large number of typical accidents. With people's continuous research on various types of accidents, more than ten kinds of accident-causing theories have been put forward. The following are several mature accident-causing theories:

(1) Accident Proneness Theory
The theory holds that in the same operation process, some workers are more likely to cause accidents than others, and they are accident-prone people. It is found that this group of people is the main factor inducing accidents. Therefore, as long as these people are identified to avoid participating in relevant operations can prevent the accidents. However, it is difficult to distinguish people's accident prone personality, this theory was not accepted in the later stage.

(2) Causal Chain Theory of Heinrich accident
Heinrich, Bode, Adams and others have put forward the causal chain Theory of accidents. Among them, Adams causal chain theory is the earliest and most recognized. According to the theory, casualty accidents are caused by the interaction of multiple factors and occurred in sequence according to the causal relationship, which is a chain effect. Heinrich vividly describes the chain reaction of accidents through domino theory, in which the unsafe behavior of people and the unsafe state of objects are the basic causes of accidents, and the key to reduce casualties is to effectively avoid these two kinds of risk factors.

(3) Accidental Release Energy Theory
According to the theory, the accident is due to the release and transfer of abnormal energy. If this ability is transferred to the human body and exceeds the human capacity, it will cause personal injury. Therefore, it can be concluded that the casualty accidents can be avoided by controlling energy, changing the release path of energy and the forced person.

2.2 Application of Accident-causing Theory in safety production of coal enterprises
Accident-cause Theory can be applied to analyze coal mine safety accidents. According to the theory, after summarizing and analyzing the cases of coal mine accidents, the industry scholars put forward the coal mine accident-causing theory, and think that the causes of accidents mainly include three categories:

(1) Essential causes: There are problems in the internal and external management of the enterprise. The coal mine safety management system is incomplete and the external supervision and inspection measures are not in place.

(2) Indirect causes: The staff's own safety awareness and technical ability are not qualified. There are many risk factors in the coal mine production environment. There are potential safety hazards in the production equipment. Enterprises and managers make error decisions due to incomplete information.

(3) Direct causes: Unsafe behavior of people, unsafe state of mechanical equipment and other objects, unsafe factors of production environment.

3. Analysis on key factors of safety production in Coal Enterprises

3.1 Cause analysis of accidents in Coal Enterprises
The occurrence of coal mine accidents is the result of the combined action of multiple elements, and there is a specific connection between each factor. When these elements reach a certain amount of energy accumulation in the dynamic action, it will lead to the occurrence of accidents. If coal mine accidents want to be effectively prevented and controlled, the composition and mechanism of these elements must be clear.

Through the analysis of typical cases of coal mine accidents, the causes of coal mine accidents can be attributed to the lack of technology and management. Due to the backward technology and inadequate management, people (low personal quality, weak safety awareness, fluke psychology in the production process, unqualified production skills, etc.), material (equipment aging, long-term equipment disrepair, insufficient safety protection, etc.) , environment (insufficient ventilation, poor lighting conditions, complicated geological conditions, etc.), information (downhole staff cannot obtain information timely, inaccurate information transmission, etc.) are the indirect causes of safety accidents in coal mines. Then, the unsafe behaviors of people, the unsafe factors of environment and the unsafe state of objects are caused. The combination of the above factors leads to the occurrence of flood, gas, roof, fire and other accidents, resulting in casualties and economic losses.
3.2 Main factors for safety production

According to the mechanism of coal mine accidents, after a comprehensive analysis of the main factors affecting of coal mine safety production, it can be found that the production environment of coal mine is complex, and there are many factors threatening the safety of coal mine and inducing accidents. In addition to the constraints of water, fire, gas, dust, roof and floor and other geological conditions, there are much higher accident rates in all aspects of mining machines transportation during the production process. Furthermore, underground operators need to have higher security skills and high safety awareness, and also need to improve safety management regulations to ensure coal mine safety production. In the construction process of the world-class coal mine system safety dimension, for the five natural disasters of coal mine (i.e. gas disaster, coal dust, flood, fire and roof accident), the following factors will be considered:

(1) Unsafe factors of environment

Unsafe factors of environmental mainly refers to the five natural disasters in coal mines. One ventilation and three preventions (i.e. mine ventilation, gas prevention, fire prevention and dust prevention) are the main measures for underground disaster prevention. Mine ventilation is an effective measure to reduce the concentration of gas and dust, and avoid gas explosion and dust explosion, while optimizing the working environment and improving the working efficiency. Coal mining often leads to spontaneous combustion, so fire prevention technology is one of the important methods of coal mine disaster prevention. Mine dust is the main cause of silicosis in underground workers. Coal mine flood and roof collapse are also the key content of geological disaster prevention.

(2) Reasonable allocation of employees

Personnel arrangement should be fully considered in coal mine production. The safety of coal mine production is improved by the reasonable allocation and scheduling during coal mine production, the improvement of personal skills, the training of safety common sense, and the improvement of staff quality. And then control the occurrence of accidents from reducing people's unsafe behavior.

(3) Security measures

Due to the particularity of coal mine operation, it is difficult to ensure the safe production only by the prevention and control of disasters and the self-management of operators. The corresponding rules and regulations and control mechanism can comprehensively investigate the safety level of coal mines. The safety guarantee measures mainly consider the coal mine safety rules and regulations, safety culture, capital investment, organization and other contents, aiming to guarantee the safe production and effective management of the coal mine.

Figure 1. Interaction model of coal mine safety accident.
4. Key technology system for safety production of coal enterprises in China

By analyzing the accident-causing theory and the key factors of safety production, the safety production of coal enterprises should start from two aspects of technology and management. That is, according to the five major disaster elements of coal mines, namely gas, dust, fire, water and roof, corresponding advanced technical measures should be adopted. In terms of safety management, coal enterprises should focus on prevention, take good care of hidden dangers, and prevent them before it happens. We should have the ability to pre-control security risks, and establish a comprehensive safety management system, have a clear safety production responsibility system, and constantly eliminate the unsafe behaviors of employees and the unsafe state in the enterprise. We should build enterprise risk pre-control management, employee unsafe behavior management, production system element management, comprehensive management and safeguard management.

Figure 2 shows the key technical system for safe production of coal enterprises.

Figure 2. The key techniques for the safety production of coal mine.
5. Conclusion
By analyzing the cases of coal mine production accidents and combining with the field investigation, this study summarizes the advanced technical methods of coal enterprise safety production, and establishes the key technology system of coal mine safety production. From the two aspects of technology and management, it puts forward the key technology of safety production for the five major disasters of coal mine. And at the same time, with the help of safety production pre-control management, safety system element management and other safety technologies, it can fully guarantee the safety production of coal enterprises, aiming to escort the safety production of domestic and foreign coal enterprises.

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