First International Symposium on Mine Safety Science and Engineering

Study on PCPR Security System Construction in Coal Mine

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Abstract

Based on the accident-causing theory, the basic causes of accidents and casualties to control and effectively curb accidents is analyzed, the theory of essential safety in mine construction and its connotations are introduced, which proposes prevention, control, protection and rescue in the whole process of mine production that is PCPR security system. Taking Changcun coal mine as an example, PCPR security system must be carried out into different links of mine production. Moreover, the paper expounds new mine safety protection and rescue system, improves system construction, as well as demonstrates its practicability and feasibility. The research provides theoretical support system and technical security mechanism to promote the essential safety in mine construction.

Keywords: Accident causing; PCPR; security system; essential safety; emergency rescue

1. Introduction

In recent years, China's coal mine accidents, causing heavy casualties and economic losses, and had a negative impact on international public opinion. To raise the safety level and to lower the prevalence of accidents, then finally to realize essential safety is the target of security system construction in coal mine enterprises [1-3]. By now, steps have been taken to ensure safety with certain success, but the measures haven’t worked out satisfactorily [4]. The principle of safety first, precaution crucial and treatment comprehensive should be observed in the process of mine production, meanwhile, the construction of safety quality system, safety culture system, safety supervising system and security protection system should be strengthened. Every coal mine enterprise must keep the concept of safety first firmly in mind [5-7]. SUN Ji-ping pointed out that important guarantee for safe production are correct concept, logical

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plan, reliable equipment, practical technology, qualified workers, scientific standard, strict system, refined management, effective rescue and so on [8]. Based on interconnections between man-machine-environment and management, the author analyzed the causes of coal mine accidents according to the conditions of coal mine and put forward the “PCPR” safety system in the whole process of mine production. Safety management can be improved to control accidents in safety system engineering methodology.

2. Essential safety mine construction theory

2.1. Accident-causing Theory

Accident-causing theory discusses the occurrence mechanism and coal mine accident causation model based on a large number of the typical accidents, and derives regulation of the accidents [9]. The quantitative and qualitative analysis is applied to avoid the accidents and improve safety management, so it provides sufficient theory evidence. With the development of science and technology, as well as, the deepening of cognition, the changing of coal mine accident essence, man's understanding of accident cause is developing all the time. The typical accident-causing theory includes the accident causation sequence theory, the track-cross theory and so forth [10]. Based on the accident-causing theory, the cause of coal mine accident consists of the following four aspects [11]: human unsafe behaviors, unsafe condition of things, unsafe working environment, defects in management. Combining with production practice of coal mine, the application of process and factors in analysis on accident-causing theory of coal mine, theoretical chart of coal mine accident-causing theory is put forward as shown in Fig.1.

![Fig.1 Coal mine accident causing theory diagram](image)

2.2. Essential safety coal mine construction

Originated from the explosion-proof electrical equipment, the essential safety means that the electrical equipment, based on its own structure, prevents the fire or explosion of hazardous gases caused by overheating, arching or cremation through limiting the circuit voltage and current. Essential safety is
expansion of connotation intrinsic safety, corporations’ safety management system in normal operation, and safety is always in controllable state without any mechanical, physical, equipment, and safety accidents; production remains safe, orderly, healthy, stable state, the formation of effective safety management system and guarantee the implementation and ensure the company's long-term safety [12].

Essential safety of coal mine construction is a new concept with the development of coal mine management, and its essence is building a long-term security mechanism to reduce the frequency of accidents to minimum level or even zero, through advanced protection and rescue measures, reducing losses of casualties and equipment to improve the controllability of the accidents[13]. Through initiative prediction and prevention risk factors during production process, taking measures to control the risks which will cause accidents, transformed from post-processing to pre-control, so that secure long-term mechanism is obtained [14]. Essential safety is human, material, environment, technology, management and other elements of the optimal matching, through the realization of personnel operating without errors, no hidden environmental design, equipment trouble-free operation, scientific management with no loopholes, and knowledge of mine safety management process. Combined with all elements in mine accident causing theory, structure diagram of essential safety of coal mine construction is shown in Fig.2.

Fig.2 Essential safety coal mine construction structure diagram

3. PCPR security system construction

Changcun coal mine in China firstly using the World Bank's loan to build a modern mine commissioned in 1995, after sixteen years of development and growth, and has developed from the initial designed 400 million tons of capacity to 800 million tons. Initial mine construction designed by German engineers, with a large number of imported equipment and facilities, mine safety management levels are higher. A new concept of PCPR security system is put forward on the basis of the existing management level. The concrete construction content is shown in Fig.3.
3.1. Source Prevention

Combined with the actual five major disasters, source control management is improved. Coal gas control: mine ventilation system transformed the power supply; increasing gas extraction strength; vigorously promotes the gas monitoring; set up perfect gas warning control regulation of any responsibility for the management mechanism. Coal-dust governance: working face coal seam water injection; wet work; ventilation and dust control; the fully mechanized working face a closed between dust control device; install the water curtain heading face dust electromotor catching dust nets every critical water type water quality filters recoil; the spray system installation time; all fixed point installing the automatic spray and reprinted achieve closed dust control. Fire prevention underground: all of the use of flame retardant belt, flame retardant wind tube, flame retardant cable; flame retardant support material, flame retardant vigorously promotes the prevention and management of all kinds of exogenous fire; key sites equipped with enough fire extinguishing equipment in good performance; perfects fire piping system. Flood control: insisting on first probe; establishing and perfecting three-dimensional seismic exploration, transient electromagnetic exploration, advance prospecting, geophysical advanced drilling four advance guard; grey water installation confined water real-time automatic control system and hydraulic pressure; all face dual drainage area are regularly switching. Roof management: perfecting online monitoring system network; heading face put temporary support force development for device to support system with high pressure; strengthen the heading face of the support design, material and equipment, support quality management; put the fully-mechanized face small vice frame support device, the emulsion concentration ratio. It also strengthens other auxiliary facilities construction such as lifting,
transportation, power supply: mine hoist system and the hydraulic control system are digitally upgraded; rail modification is completed; auxiliary haulage system up and down the well is realized closed management.

3.2. Process Control

When an accident happens, process control restrains the development of accident with technical means and appropriate management measures. For major hazards, such as coal and dust explosion, exogenous fire and spontaneous fire in intake airflow roadway of mining area, although the source of prevention, but there are still uncontrollable factors, once the disaster happen, strong technology to control the development of the accident must be operated to reduce casualties and accident losses.

Changcun coal mine disaster in process control has been walking in the forefront of the nation, in addition to inhibiting gas explosion with explosion-proof water bag, also configuring the road barrier coal mine gas explosion suppression systems for gas detection and suppression explosions and fires. Using ZR1000 carbon dioxide generator, the fire and explosion suppression is particularly significant for coal mine gas explosion prevention and the prevention of fire and other rescue and relief work. Establishment of a new type of troubleshooting, implementation of risk management investigation and corrective grading closed, building security management mechanism for continuous improvement and safety technical measures.

In the exogenous fire control and cooperation with China University of Mining and Technology, in the mining area is established a belt fire remote emergency rescue monitoring system. N3 mining area exogenous fire emergency rescue system schematic diagram is shown in Fig.4. normally open FM1 and FM2 of remote control are arranged at the connection between two intake airflow roadway, FM3 of remotely control locking throttle is set at the connection between belt roadway and return airflow roadway, and smoke sensor is respectively set at the head and machine tail, which are monitored by central station to monitor smoke and switch state of air doors on ground. System using optical fiber communication, and the use of standby power system automatically switched, micro-power design techniques and on the condition that power off during disaster does not affect the control system, and the high pressure gas bottle and cylinder pressure of the trachea double insurance to ensure the system power source. If the belt roadway catches fire, smoke signal transmission to the smoke sensors to monitor and verify information on the ground to start remote emergency rescue system; normally open air doors FM1, FM2 closed to prevent smoke flow along the rail into working face; blocking air door FM3 opened, effectively resulting airflow into return airflow roadway; accompanied by a small amount of fresh air flow from track roadway into the working face, leave for staff to provide safe passage to eliminate toxic and harmful gases injury on the working face. Large number of fire accidents cases showed that: from ground received report of fire until lot of smoke polluting, it needed 30 minutes or so, the ground deploy plan to control smoke and by rescue workers to control switch the air doors needs at least 1 hour. Therefore, we must use the air doors remote control to compose emergency rescue system to control smoke flow on the conditions of disaster.

3.3. Safety Protection

Safety protection is technical measure to reduce casualties and economic losses after accidents occurred. In China’s coal mines, safety protection consciousness is too indifferent; theory distempered, facilities imperfect, leading to plenty of casualties when accidents occur. Based on establishing personnel position system, pressure wind self-rescue system, water supply rescue system, monitoring and supervision system, communication connection system, combined with the establishment experience and achievement of evacuee shelter underground in South Africa, Europe and America. Changcun coal mine first proposed the new security protection system as the main body of refuge chamber and lifesaving
cabin combining with safety production conditions, and in line with the principle of human-oriented, safe and reliable, advanced practice.

The key of coal mine safety is the front-prevention of hidden trouble and process control, however, the accidents tell us that casualties directly caused by underground disaster only account for 10% in the whole, mostly because after the accident toxic and harmful gases produced by the spread of invasive and cause poisoning or suffocation. In order to enhance the ability of avoiding and resisting disasters, and to reduce losses to minimum degree, Changcun coal mine gradually establishes and perfects accidents safety protection facilities and personnel security guarantee system.

New safety protection system construction in Changcun coal mine is a gradual perfection process. At present, N3 as demonstration base, perfect construction project of S3、S5、S6 mining area protection system by stages, and gradually establish safety protection net system covering the whole coal mine. Refuge chamber and lifesaving cabin aims to provide spatial guaranteeing workers’ life and health, and at least accommodating 96h survival material in the condition of isolated supply. Permanent refuge chamber is able to maintain workers survival long time. New safety protection system is very important to cope with disasters and guarantee workers’ life safe.

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3.4. Emergency rescue

Through careful plan and detail demonstrated, and fully using various facilities and equipment in coal mine, emergency rescue is that making various disaster emergency rescue preparedness, establishing detailed catastrophe control plan and staff escape route, and regular exercise. After accidents occurred, starting emergency rescue preparedness is able to quickly control its development and eliminate accidents as far as possible, and protects workers’ life safety so that reduces the losses for workers, property and environment to minimum level.

Based on establishing safety protection system, Changcun coal mine further perfects and improves fast emergency rescue rapid response mechanism in the whole coal mine. According to the principle of open information, rapid reaction, effective action, and combined with the establishment of avoidance facilities, such as lifesaving cabin, adjusts and perfects the original emergency rescue response preparedness. Especially, after establishing safety protection system, N3 mining area is carried out the catastrophic exercise, and provides evidence for emergency preparedness.

The establishment of safety protection system and emergency rescue system is the last ditch to ensure the workers’ life safe, however, after systems established, perfecting management and maintenance and training skills are necessary. On the condition that equipment operates safety and reliably and workers operate proficiently, it can play its role and effectiveness in the critical moment.

4. Conclusions

Using of accident-causing theory to analyze causes of mine accidents and the connotation of the essential safety. Furthermore, connecting with the elements of accident-causing theory, basic method to construct essential safety of coal mines is obtained.
With coal mine production conditions, new idea (PCPR) to establish security system is proposed. Through the guidance to carry out the PCPR safety construction, it provides theoretical and technical support for construction essential safety of coal mines.

In the process of disaster control, the construction of belt fire emergency rescue system is firstly proposed and analysis of its working principle feasibility, furthermore, the new safety protection system is put forward, which could be the foundation of domestic emergency system construction and theoretical development.

PCPR security system covers the entire production of coal mine, collection management system and technology in one, which strongly guarantees the mine safety production and be of high popularization value and significance.

References


