Research and practice of scientific management innovation methods for safe, efficient and rapid tunneling in coal mining

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Abstract. Coal mining management is a crucial means of ensuring the safety and efficient extraction of coal. Currently, mining accidents occur annually due to management loopholes. Continuous enhancement of scientific management and innovation in coal mining is paramount for achieving sustainable development in the coal industry. The introduction of efficient tunneling technology has emerged as a significant innovation in coal development. This paper adopts a research methodology that combines theory with on-site application. It proposes a management approach grounded in safety and quality management, with market-oriented operations as a focal point, and incentives through value-added assessment in the operational process. Through practical application at China Energy Xinjiang Company, the implementation of the "Four Steps Six Rings" comprehensive safety and quality management strategy is highlighted in the management system, covering all aspects from personnel management to equipment operation. The objective is to enhance the operational efficiency of coal mining enterprises, achieving rapid and safe excavation in mining operations. This approach aims to address the challenges associated with management deficiencies, contributing to a safer and more efficient coal mining industry.

Keywords: Scientific management; Efficient tunneling technology; Safety and quality management; Market-oriented operation mechanism; Job process value-added assessment.

1 Introduction

Coal, as China's most crucial primary energy source, is expected to maintain its predominant position in the energy mix for the next 20 years. The healthy development of the coal industry is intricately linked to the overall sustainable development of the national economy. Strengthening scientific management and innovation in coal mining, particularly focusing on the proactive management of mining technology, is vital. Ensuring a robust foundation in the initial stages of mining technology management is crucial for achieving the sustainable development of the coal industry [1]. Currently, there are several challenges in coal mining and management, including[16]:(1) Safety Hazards and Accidents: The coal mining sector consistently faces challenges related to

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safety hazards and accidents, stemming from factors such as equipment malfunctions, improper personnel operations, poor management, or non-compliance. Improving safety standards and training is crucial to minimizing accidents .(2) Management Deficiencies: Management shortcomings in coal mining can result in inefficiency, increased costs, and heightened safety risks. Strengthening scientific and innovative management methods to elevate overall management levels is a necessary step for improving operational efficiency.

As a leading nation in advanced coal mining technology, China has witnessed the continuous emergence and widespread application of new, highly efficient excavation technologies and their scientific management methods in recent years. Through the efforts of technical professionals, these innovations have demonstrated significant success in coal mining operations. With the impetus of the technological revolution, the application and management of high-efficiency coal mining technologies show a clear development trend [2][3].

This study contributes to the development and progress of efficient mining management, effectively enhancing the operational efficiency of coal mining enterprises and achieving high production efficiency in mining operations [7].

2 Establish an intrinsic safety management system

Guoneng Xinjiang Company puts production safety in the first place in all work, and highlights the implementation of the "four steps and six rings" integrated safety and quality management strategy. These four steps include people, machines, systems, and systems, covering a full range of safety management measures from personnel management to equipment operation [10]. The six closed-loop include work procedures, target responsibility, quality management, hidden danger management, three-violation personnel help and education, and safety accident management, forming a complete circular closed-loop system [4]. Through continuous strengthening of safety management, the company comprehensively improves the intrinsic safety assurance capability of the mine[5].

2.1 Promote intrinsic safety management and build a mine safety system with strong safety awareness

Shaping intrinsically safe people is the key to achieving intrinsic safety in mines, and has a preemptive and guiding role. Guoneng Xinjiang Company has highlighted the three key points of cultural guidance, skill training and behavior cultivation to cultivate a high-quality workforce, so that they have a strong sense of safety, a high level of skill quality and standardized behavior[11].

Safety culture is the heart and soul of safety management. The company continues to deepen and promote the management of 365 safety culture and continuously enrich the connotation of safety management culture [6]. Through safety education, creditworthiness education, family education and other means, create a strong safety atmosphere,

cultivate rigorous work style and humanistic care. The company advocates the implementation of intrinsic safety, encourages everyone, every department and every link to start from themselves, assume safety responsibilities, and gradually realize the transformation of safety management from "conscious" to "self-acting" [8]. In addition, the company has improved the system of supporting the safety culture, and promoted the culture through the system, so as to ultimately achieve the safety management goal without too much intervention[12].

Starting from strengthening the safety awareness of employees, the company has carried out a series of safety education activities. These include the "Speech Exhibition and Remembrance and Education" activity with the participation of all employees, which enhances the deterrent power of employees' awareness and education on safety through safety discussions, accident case exhibitions and safety memories[13]. In addition, the company has increased training efforts, carried out full-staff rotation training and independent training of district team teams through the education and training center, and improved the safety skill level of employees. At the same time, the company actively carries out on-the-job training, technical competition and golden blue-collar training to improve employees' risk factor identification ability, safety skill operation ability and emergency response ability [14].

The company adheres to the principle of "five self-management" (personal self-discipline, team autonomy, regional team autonomy, professional department consciousness, and management spontaneousness) to promote the cultivation of behavior. The foundation of safe behavior is established through self-discipline, autonomy, autonomy, consciousness and spontaneity [15]. At the same time, the company improves the standard of behavior through innovative concepts, considers each process and link from the perspective of safety management, and achieves no loss, no omission, no error. In addition, the company implements the operation of post standard process, deepens the safety confirmation and post standard process operation tips through pre-knowledge and prevention preparatory activities, cultivates the professional habit of employees to predict and confirm safety before operation, and realizes the intrinsic safety of people.

2.2 Promote intrinsic safety management and build a safe and reliable mine safety system

Investing in intrinsically safe equipment is an effective means to achieve intrinsic safety, which plays a fundamental and promoting role in the construction of intrinsically safe mines [2]. In terms of investment in intrinsic safety equipment, the company follows the principle of advanced technology, strong guarantee and remarkable results, and gives full play to the role of scientific and technological security.

The company deepens the implementation of the personnel limit requirements of the mining group company, and actively implements the personnel limit listing system in the mining area. The company also adopts advanced equipment and technology, such as integrated tunneling and anchor boring machine, excavation integrated coal shovel and rake, loading, rock loading integrated machine, etc., to realize automatic and continuous operation and improve the modernization level of mine equipment. In addition,

the company is committed to the development of unattended posts, formulates corresponding schedules and measures, and strictly controls the number of underground workers.

The company uses the funds of Angtso to update the pipelines and equipment at the construction site to improve the safety and reliability of the system. The company actively grasps the integrated management of technological innovation and supporting equipment to solve the key technical problems that restrict the development of safety. In addition, in view of water damage and drilling problems, the company comprehensively uses audio perspective technology to advance control and measurement, and formulates detailed water detection and release measures to eliminate hidden dangers.

The company is committed to comprehensively building an informationized mine, optimizing the underground positioning system, promoting the application of office automation system, and realizing paperless office. The company also improves the monitoring and monitoring system of gas, high temperature point monitoring and personnel positioning to improve the level of mine safety monitoring and monitoring. In addition, the company uses automation technology to transform coal mining, transportation, power supply, drainage, ventilation, lifting and coal preparation to promote automation construction.

2.3 Promote intrinsic safety management and build a standardized mine safety system

The construction of an intrinsically safe environment is an important foundation for achieving intrinsic safety, which has a guarantee and promoting role in the construction of intrinsically safe mines[3]. The company pays attention to the requirements of connotation, practicality, simplicity and dynamic compliance, strengthens standardized operations and prevents hidden dangers in the operation process from the source, and promotes the formation of an intrinsically safe environment.

The company formulates implementation rules, establishes safety and quality standards higher than industry standards, strictly controls the process of positions and types of work, and improves the on-site dynamic evaluation system. The company carries out the selection of "high-quality projects" every month, advocating civilized on-site management, standardized placement of utensils, refined process operation, and high-quality project quality. The company takes the construction of safety and quality standardization as the basis of intrinsic safety management and promotes the long-term mechanism of quality standardization construction.

The company has high standard positioning, high level improvement, and comprehensively improves the level of safety and quality management. The company promotes the solution and rectification of quality problems by tracing the chain of responsibility. In addition, the company strictly implements the safety and quality responsibility system to promote safety and quality management to strive for excellence. The company also grasps the improvement of clean production, strictly grasps the prevention and control of pollution and comprehensive utilization of resources, and builds green mines.

A sound system is an important guarantee for achieving intrinsic safety, and has a normative and binding role in the construction of intrinsically safe mines[4]. The company strengthens the construction of the system and implements standardized, standardized and normalized intrinsic safety governance. The company has improved the safety and quality management system, safety culture construction system, safety production responsibility system and hidden danger investigation and management system, etc., and formed a complete set of intrinsic safety governance system system. The company focuses on strengthening the responsibility system for safe production, clarifying the responsible person and the scope of responsibility, and implementing the main responsibility for safe production. At the same time, the company has established a hidden danger investigation and management system, strengthened hidden danger investigation and rectification, and ensured that hidden dangers are eliminated in time. The company has established an intrinsic safety monitoring and early warning system to timely grasp the safe operation of mines, warn in advance and take corresponding measures. At the same time, the company strengthens security risk assessment and control to ensure that security risks are within controllable range. The company has also established a comprehensive safety production management platform to realize centralized management and unified scheduling of information, and improve the efficiency and level of intrinsic safety management.

By highlighting the "four-step and six-ring integration" safety and quality management strategy, Guoneng Xinjiang Company pays attention to personnel training, scientific and technological investment, system construction and system improvement, and comprehensively promotes the construction of intrinsic safety in mines. Through these measures, the company has improved the intrinsic safety assurance capability of the mine and ensured the continuous stability of safe production.

3 Implement market-oriented operation mechanism

3.1 Clear tasks and strengthened evaluation

Relying on the market-oriented platform within Guoneng Xinjiang Company, each work area is committed to achieving refined management and dividing evaluation units. Material consumption is incorporated into the market-oriented mechanism, and an evaluation system of "region to team, team to individual" is established, forming a management model in which everyone has clear performance indicators. In the use of accessories, equipment and tools are clearly assigned to individuals and managed by number, and an evaluation ledger is established. The consumption of repair parts is evaluated, the regional team evaluates, and the team evaluates the individual.

3.2 Strict on-site supervision and strengthen management

Cost control at the regional level is critical to workplace efficiency [9]. In order to strictly monitor costs, TNB Xinjiang Company has achieved strict cost control by controlling tunnel lighting and anchor top spacing. Starting from the source of construction technology, the use of materials is strictly controlled in each area and strives to reduce

production costs. By paying attention to management details, each area ensures refined management, which improves work efficiency.

3.3 Emphasize process and strengthen supervision

Guoneng Xinjiang Company prioritizes the process management of excavation surfaces from design, construction to acceptance, and realizes dynamic supervision and process optimization. A quality early warning mechanism for engineering projects has been established. Safety and quality problems arising during the construction process will be dealt with in a timely manner through early warning notices, and specific rectification time limits will be set and follow-up reviews will be conducted. This forms a closed-loop management cycle of engineering hidden dangers and prevents the generation of defective products. The company has also implemented a long-term inspection system called "Three Highlights", which is inspected every Friday and followed up on Monday. In addition, they have established quality files for engineering projects, implemented a "lifelong responsibility system" for engineering quality, and traced defective projects indefinitely, effectively improving the quality awareness of employees and leaders.

4 Carry out value-added assessment of job processes

4.1 Eliminate loss and waste

(1) Prevent loss

Clarify the responsible entity of each position, clearly attribute the enterprise items, and ensure that the loss caused by any reason is borne by the responsible entity. Carry out anti-theft activities and crack down on theft.

(2) Prevent waste

Directly link cost consumption to income distribution and cultivate good saving habits. Implement on-site fine management, accurately manage equipment and materials, and standardize the working environment. An organized job site makes workflows smoother and more efficient.

4.2 Recycling, reuse and recycling

(1) Recycling, reuse, recycling

Develop recycling principles, including the principles of safety, economy, coordination and reasonable remuneration. Analyze the items of each position one by one, determine the materials that can be recycled and reused, and formulate specific recycling measures and methods.

(2) Repair and recycle waste

Formulate principles for recycling, including safety, economy, coordination, rewards, standardization and specialization. Repair items that are slightly worn, rusted, or damaged. For waste items, explore their potential functions and transform them.

4.3 Low-cost substitution and high-function substitution

(1) Low-cost substitution

Ensure that there is no loss of cost, integrity of quality, and no loss of value before it is put into work and converted into new value. By replacing recycled and reused items, we can make use of the advantages of human resources and materials, especially the spare time of employees and the idle time of equipment, so that we can manufacture the required items in-house. In addition, reducing the amount of original items used is a low-cost alternative, often combined with process reform and delicate work.

(2) High-function substitution

Through the renewal of the whole machine, the overall function of the post operation is improved, the working conditions are improved, the labor intensity is reduced, and the economic benefits are brought about. Job operators need to actively learn and master new equipment, solve various problems after new equipment is put into use, 4.3 Job process value-added activities: dual strategies to promote performance improvement

4.4 Discover human potential and material potential

(1) Explore human potential

Pay attention to the multi-functional development of employees, learn and master the skills of various positions, and be able to work in a variety of positions. Improve your skills by learning, learning from each other and learning from each other's strengths.

(2) Discover the potential of things

Purchase items in a timely manner, and do not purchase items that are not used temporarily, dispose of items that are no longer needed in a timely manner, and accelerate the use of items. Discover and realize the potential functions of items to make the most of their many uses. Ensure that the protection of facilities, equipment and tools is properly maintained.

4.5 Equipment improvement and process improvement

(1) Equipment improvement

The basic principle of equipment improvement is to carefully analyze and demonstrate, avoid blind improvement and risky actions, so as not to affect the function of the original equipment.

(2) Process improvement

Any process technology has the possibility of improvement, even if the overall process technology is difficult to break through, there are still many local links and details that can be improved. For example, there are still many local aspects that can be improved in the mature overall process technology.

4.6 Develop labor organization efficiency and job operation functions

(1) Develop the efficiency of labor organization

The role of labor organization is not only to simply gather individual workers, but to optimally combine the individual values of job operators, and maximize the overall benefits in each of them according to their ability and harmonious configuration. Labor organizations need to strictly restrain the constraints of individual responsibilities and rights, fully release the energy of individuals, and realize the fulfillment of their respective responsibilities and full play of their strengths.

(2) Develop job operation functions

From the perspective of job value, efficiency is life, and time is money. Make full use of every minute and second of the job to ensure that time is not wasted in the operation process, so as to realize the development of the job function.

4.7 Meticulous operation and meticulous maintenance

(1) Careful operation

Gradually accumulate job value through careful operation. Any position can achieve increased value through careful operation. Conversely, operator errors, improprieties or roughness can lead to loss of job value.

(2) Meticulous maintenance and overhaul

Meticulous operation mainly solves the operation problems of people, while careful maintenance and overhaul solve the problems of facilities, equipment and tools. Take care of your facilities, equipment and tools as you would and make sure they are meticulously maintained.

4.8 Pursuit of quality excellence and service excellence

(1) Pursuit of excellent quality

Quality is the life of the post and the basis of the value of the post. The quality of the post operation can be directly reflected in the quality of the finished product, and can also be reflected in the operation process. Quality determines the price and value of products, and the quality of the operation process determines the value of job operations.

(2) Pursuit of service excellence

A superior quality strategy naturally includes quality of service. Enhancing job value through excellent service quality has its own particularity. The value generation and evaluation of services are more humane than products, so specific strategies and efforts are required to increase the value of services.

4.9 Ensure that responsibility assessment and reward and punishment incentives are in place

(1) Ensure that the responsibility assessment is in place

Responsibility assessment is the basic element to ensure that the value of the position increases. Through the implementation of responsibility assessment, promoting the increase of job value is the basic strategy.

(2) Ensure that rewards and punishments are in place

Economic rewards and punishments and profit drive are the basic means of fine management of job value. The realization of job value is first reflected in the financial value generated by use value. The lack of rewards and punishments will affect the basis of job value management.

4.10 Job Value-Added Claims and Job Loss Claims

(1) Job value-added remuneration

The realization of job value depends on the remuneration payment of the position customer. There are connections between orders or normal jobs, and each position has to undertake specific job tasks. After completing the assignment, a market settlement is carried out, and the remuneration is the market purchase of the value of the position.

(2) Claims for loss of posts

If the quality of the product or service does not meet the standards or regulations agreed by both parties, there are defects, and a claim can be made according to the quality indicators. For quantitative errors, a relevant basis can be provided for making a claim.

5 Implement positive incentive management to improve safe and efficient excavation

In order to give full play to the role of positive incentives, TNC Xinjiang actively makes use of the advantages of regional team management, encourages each district team to innovate management methods, and implements independent management to achieve the goal of creating standards and meeting standards. Guoneng Xinjiang Company has innovatively introduced a level target reward system in the first comprehensive mining area. At the beginning of each month, the monthly plan of each district team is formulated, and when the district team completes the monthly plan, the district team will be rewarded for exceeding the standard according to the scale of every 15 meters of rock lane promotion, coal lane advancement of every more than 20 meters, and comprehensive mining promotion of every more than 30 meters. For each step raised, each of the "role model pioneers" of the district team will be rewarded with 500 yuan, and the deputy of the district team will be awarded 1,000 yuan; On the basis of the original reward, the "role model pioneer" of the district team will be awarded another 600 yuan each, the deputy of the district team will be awarded 1200 yuan, and so on. At the same time, a record-breaking reward scheme was developed and implemented, and for a single monthly boring size that exceeded the record of the group company, the unit will receive a reward of 50,000 yuan, and the "role model pioneer" will receive a reward of 5,000 yuan; For a single monthly boring size that exceeds the company's record, the unit will be rewarded with 60,000 yuan, and the "Role Model Team" will be rewarded with 8,000 yuan. Through these positive incentives, the enthusiasm of the district team and employees to achieve safe and efficient excavation has been improved, and the realization of the company's goal of safe and efficient excavation has been promoted.

6 Conclusion

Through the continuous innovation of management methods, the enhancement of the production organization's effectiveness is assured by establishing a safety-quality management system rooted in a people-oriented approach, scientific and technological security, and a comprehensive and robust framework. This solid foundation is pivotal for the safe, efficient, and rapid excavation of coal mines.

(1) A safety-quality management system has been proposed, prioritizing a people-oriented approach, scientific and technological security, and a well-established framework. This system lays a robust foundation for ensuring the safe, efficient, and rapid excavation of coal mines.

(2) The implementation of a market-oriented operation mechanism has been realized through a multi-dimensional operation system that includes detailed responsibilities, active site supervision, and meticulous attention to the process. This approach serves as a robust starting point for ensuring the safe, efficient, and rapid excavation of coal mines.

(3) Value-added assessment of post-process activities has been executed, with a focus on source control, stringent adherence to on-site operator protocols, and the establishment of effective incentives. These measures contribute significantly to ensuring the safe, efficient, and rapid excavation of coal mines.

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