

Research Article

Research on the Factors of Fatigue of Coal Mine Workers and Its Control Measures

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Abstract: China is the largest coal producer in the world, it play a important role in the international field of coal production, but due to the frequent occurrence of coal mining accidents, it cause a enormous damage to the state's manpower and material resources. This article on research of the cause of the coal mining accident, it describes the fatigue of the coal mine workers assignment is the main cause of the accident and the threat to the safety of workers, and points out the important factors in ergonomics. MMEC theory is introduced and using for reference MMEC theory, finding out influence the cause of the coal mine worker fatigue, and combined with the relevant laws and regulations system to control and reduce the proposed method of coal mine worker fatigue to reduce and prevent the occurrence of coal mine accidents have some guidance Significance.

Keywords: Coal mine workers, control safety, fatigue, MMEC theory, rest time

INTRODUCTION

China is the largest coal producer and consumer in the world, has about 500 million coal miners, shares one-third of the total coal output of the world. However, its accident frequency and death toll have accounted for 80% of the world. For many years China's coal production has been plagued by safety condition. Industrial accident frequency has declined these years, but it is still in a higher level. Of all the reasons, fatigue is probably the one of most important factors that leads to mine accident.

Fatigue due to physical overload is an important factor that causes accidents. To make it clear, we investigated Yang Tuo Mine of Beijing Mining Bureau. In this survey, we measured the labor load and fatigue index of different posts miners, compared the 14 years work accident record from 1981 to 1994, and then analyzed their relations (Hattori *et al.*, 1987; Mou and Quansheng, 1991).

According to the labor load determination and main load fatigue standard questionnaire survey, subjects' total labor load degree and fatigue level slightly go beyond boundaries, and the load degrees are quite different, for example, rock excavation work load is the largest, coal digger load slightly lower than rock excavation work of these two kinds of posts' fatigue are relatively serious, while underground electromechanical work and transport work are relatively light (Wu, *et al.*,

2007; Wang and Feng, 2005). Correspondingly, the annual mortality and wounded rates for every thousand person of different posts are: rock excavation worker 1.76 and 60.74%; coal digger 1.44 and 34.18%; electromechanical workers 0.56 and 20.73%; transportation workers 0.19 and 9.04%. These data show that the higher the fatigue degree of a work is, the easier to cause accident, conversely low.

The statistics also shows the probabilities of accidents occurred in the different time (morning (8:00-15:00) 31%, t noon (16:00-23:00) 31%, and night (0:00-7:00) 39%). At night is the highest; the reason may be miners are sleepy and easily fatigue under the high strength work load. Fatigue is one of the most important reasons that cause night accidents.

Through analyses we can draw this conclusion: accident occurs frequently when people are fatigue. The higher the fatigue degree is, the higher the probability of an accident is. So in order to control coal mining accidents, we should alleviate coal worker's body load to prevent accidents and guarantee their safety.

WHY MINERS' FATIGUE SO IMPORTANT

Fatigue: Coal workers' fatigue belongs to occupational tiredness which is a physiological and psychological phenomenon reacted to work load and living environment's comprehensive effect. It will appears when man's body function and working ability falls to a

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certain extent. The cell, tissue or organs functioning or reaction capability weakens when human body exercising too hard or stimulate overpowered. Fatigue can protect the body against strain, but as for the accuracy operation, excessive fatigue often induces accident, so we shall take effective countermeasures.

Mine workers' fatigue can be divided into physiology, psychological and pathological fatigue. Physiological fatigue loads from the manual operations; psychological fatigue, also known as mental fatigue, is caused by the sprite, poor working environment, monotonous work, mental and emotional burdens; pathological fatigue is the fatigue due to disease. Therefore, the coal miners suffer from both physiology and psychological fatigue. Fatigue produced by daily work can be eliminated through the necessary sleep; and accumulated fatigue through the essential break and rest. Long-term accumulation of fatigue will develop into pathological fatigue, which becomes hidden accidents.

Takes coal miner's fatigue question: When one is fatigue, the body changes from the alert state to sleep state, and the shallow dormant state as physical strength decline, is difficult to concentrate attention and react and so on. Fatigue will reduce their work efficiency and quality, prevent their sense of danger and judgments, and impede the ability to remove danger, produce unsafe behavior unconsciously, and finally endanger the safety of coal mines and their health.

The current international coal industry environment is easy to make coal miners fatigue to a certain degree. If not effectively controlled, the situation will deteriorate further. Such a wide range of coal miners' fatigue, making the in-service workers generally decline to sub-competency, and not at any state, which would seriously jeopardize the coal enterprise operation and their operation safety. The widespread fatigue is bound to make the world's coal industry trapped in danger. The society will not accept the fact that the task of protect the life, property and underground facilities is entrusted to the workers who can't control themselves effectively because of fatigue. Therefore, we must pay attention to coal.

Miners' fatigue, use some kind of theory or practice to find the causes of fatigue and take some appropriate measures.

FINDS OUT FATIGUE REASONS AND PROPOSES MEASURES BY USING MMEC THEORY

MMEC theory: The MMEC theory produces in Man-Machine-Environment (MME) theory which is the basic theory of ergonomics in the field of industrial safety. Ergonomics is the combination of the Greek root word ergo (work) and nomos (law or custom). Ergonomics officially born in 1950 in the United Kingdom, the

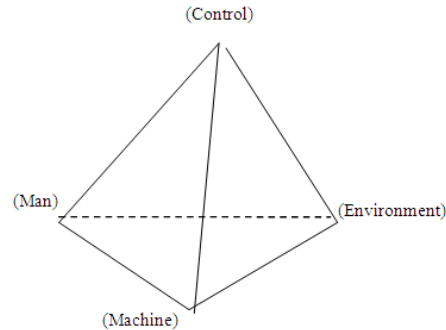


Fig. 1: Tetrahedral structure

International Ergonomics Association was founded in 1960; Chinese Ergonomics Association was founded in 1989. The official definition of ergonomics is: To study the anatomical, physiological and psychological factors in a certain working environment, study the interaction between humans and machines and the environment, study how to balance work efficiency, health, safety and comfort issues at work or after work. MME theory studies the human technically, machine, the environment and their relations, this has decided the ergonomics study is engaged in the humanist machinery and the environment design and the relational research. MME theory since being published, has been widely utilized in the industrial safety, and achieves a lot in technical analysis and evaluation, but ergonomics and MME theory are difficult to become effective guidance to conduct extensive security industry. So we must find a new theoretical method.

Many facts show that the accident is an unexpected and devastating event which happens when the relationship between the three elements (MME) discorded. To avoid or reduce accidents, we must control man, machine, environmental factors and their relationship to foresee and limit the occurrence of accidents in the industrial safety area, "control" is also an indispensable basic elements. These four elements form a tetrahedral structure (Fig. 1) and it states clearly their relationship, indicates the internal relations or more elements of the overall relationship between research and treatment. Generalized "control" is used to call "management", just as Fig. 1 shows.

In fact, in the field of industrial safety, in addition to the safety of mechanical design, facilities and environment, the staff is more of a relatively fixed time period in mechanical and environmental conditions. They are easy to make mistakes because inertia, forgetfulness, lack of knowledge and ability, fatigue, agitation can arise artificial faults, therefore, we need appropriate management measures to keep people of any state and the coordination of man, machine and environment. Human, machine, environment and their relationships have a close contact with management. Thus, MMEC theory has a broad application prospects in this field.

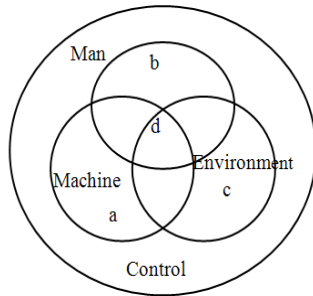


Fig. 2: Geometric relations

As a graphic map of Fig. 1, 2 reflects the MMEC theory geometric relationship between the four elements; all elements are closely linked with each other. In Fig. 2: a area represents the performance of the machine on the impact of human safety, human should adapt to machine, control the machine; b area represents the performance impact of environment on human safety, people should respect and appropriate adjust to environment, including man-made environment and the natural environment; c area is the machine-environment interaction area, displays for the influence environment to machine, machine should adapt to and protect the environment; d area displays the comprehensive relations of these four elements, it is an accident-prone area, we should pay more attention to this area. Through the management element of planning, organizing, leading and monitoring the safety management system, it can achieve its own control and the use the system to control man, machine and environment.

Finding reasons based on MMEC theory: There are many causes can induce fatigue of coal miners, and they should be controlled systematically. In order to ensure the measures to be systematically and concise, reduce gaps and overlaps, according to Fig. 2, the control measures of fatigue are as follows:

- **Man element area:** coal miners are not comprehensive and suitability trained, lack of work experience, professional ability and professional quality; the working arrangement is unreasonable, the responsibility is overweight, the work intensity is oversized, the age oversized or works in spite of one's illness; sleep or relaxation time is insufficient; leisure activity excessively causes work low-spirited; intense relationship, family discord or family trouble, emotional negative; in the circadian rhythm trough.
- **Machine element area:** underground equipment not maturity or poor reliability; unreasonable mine or equipment design.
- **Environmental element area:** temperature too high or too low, noise, poor working conditions; poor lighting.
- **Related areas:** worker not suited to the work environment and local conditions; difficult to grasp

mine device operating characteristics, machine obsolete, huge maintenance work, equipment not work well under the conditions; long time work in poor surroundings, work overload; work monotonous and lose interest.

- **Management element area:** the working hours and rest time are unreasonable, manning levels below the job requirements, work organization and distribution are unreasonable; lack of underground and aboveground contact, lack contact with commanders, working routine's standardized degree is low, development work or mining plan is unreasonable; shift method is unreasonable, unreasonable management strategies, administrative deficit.

Propose countermeasures based on MMEC theory:

- **Management element area:** To ensure run a simple and efficient management system; take full account of tasks and people, machines, environmental conditions, to ensure manning levels or even higher than the government's manning requirements; distribute proper work time and break or rest time for workers; improve management skills, make reasonable arrangements of personnel and work intervals; develop and implement appropriate procedures to ensure and maintain miners competence; ensure the normal operation of the implementation of maintenance procedures for underground machinery; to guarantee the underground command staff have the rights to make their own decision under special circumstances in written assurance; provide clear, concise written documents to ensure that underground coal miners are familiar with operating procedures, working hours, communication methods and procedures of their mines. Pay close attention to fatigue-related international regulations and domestic legislation and follow them; ensure miners get appropriate rest before on duty.
- **Man element area:** To ensure that coal miners have been fully trained, including how to prevent fatigue; ensure that workers are physical qualified, have appropriate working experience, qualifications and quality; to take measures to guarantee some factors such as language barriers, social and cultural differences, and religious issues will not lead to mental fatigue and safety issues; to provide workers appropriate stimulation to prevent boredom and its resulting fatigue; the coal miners should understand how to work effectively, have moderate entertainment, get enough meals and the nutrition, get full sleep and rest, have a good relationship, good at adjusting mood, good at adapting the mine work; guarantee the workers' essential work break and their contact with family members.
- **Machine element area:** Make sure the design and construction of the mine meet interrelated

requirements, and maximize the use of ergonomics methods to prevent the fatigue of such factors.

- **Environmental element area:** To ensure underground environment suitable for living and working; properly arrange the personnel work time to avoid fatigue.
- **Related area:** Ensure management sustained and effective; make a harmonious relationship between these four factors, coal miners will not fatigue under the conditions.

Management measures: According to MMEC theory analysis, reasonable arrangements of working hours and rest time for mine workers is an important factor in reducing mining accidents. In china, "Labor Law" and "Labor Contract Law" have set some rules on coal miners' rest time:

- Eight (8) working hours per day, 40 working hours per week, two days off per week.
- Cannot lengthen work hours at will, if really necessary, the decision should be supervised by work union and the worker himself, usually not more than 1 hour a day, 3 hours to the maximize, shall not exceed 36 h per month.
- Properly arrange workers' furlough such as New Year and Spring Festival, May Day, National Day and other holidays that laws and regulations prescribed.

Control measures on man: It is well known that many coal mining accidents occur because of coal miners' negligence and irresponsibility. According to the MMEC theory analysis results, the person factor is very important. So here are some measures:

Innovations and improvements: Safety education and training is an important component to the enterprise safety management. Innovative safety training method has a positive meaning to ensure safety production. Through safety training, miners can realize high labor intensity can lead to fatigue, and fatigue is a hidden threat to safety, miners should understand how to prevent fatigue, make a reasonable rest schedule; psychological guidance also should be strengthened. Through psychological counseling workers can ease mental fatigue, enhance communication between them then prevent fatigue disgust and boredom.

Enhances the miner quality, avoids mining accident: The employees' safety quality level is an important factor to the safe production. As technology advances, the coal mine mechanized degree will certainly to enhance, the labor intensity will accordingly to reduce, the safety coefficient will certainly to increase, but the mechanized degree's enhancement set a higher request to worker's quality. But at present, there still are many

peasant labors in the mining front line; their quality is relatively low, lack of safety common senses, sometimes blindly taking risks when working, lack of adaptability and self-protection capabilities. Mine is a high-risk industry, a small mistake could spark an accident, capture the lives of dozens of people. Therefore, only by improving the quality of workers, making the safety idea strike root in the hearts of the people can fundamentally reduce the mining accident's occurrence.

To attract high quality, educated, competent people, national policies should be introduced to provide front-line workers 3 to 5 times higher wage than the other sectors. The through can attract high-quality personnel to engage in this work, then change the poor quality of the status fundamentally, and finally improve the present safety condition of our country. Furthermore, it should increase the number of high physical quality, experienced, qualified workers, from the grassroots to achieve the overall objective of improving the quality of coal miners, essentially eliminate the human factor in hidden dangers, and minimize the risk, even come to no accident.

Safety culture construction: Safety is the top priority in all works, is an eternal theme in coal production. In order to improve and consolidate the safety situation in underground production constantly, the coal enterprises should focus on creating a safety culture. The content of safety culture is the material, ideas, knowledge and skills about safety. Through education and advocacy, motivation, practice, and other ways to force acting on the man, machine and environment, management factors, and gradually form a good safety management of the environment, safety concept, safety habits; The key is to create good security values, then react to human, machine, environment, management consciously continue to improve mine safety management, including the control of staff fatigue.

Safety culture is the core of mine management culture, and its fundamental purpose is to cast the good behavior of each employee and safety habits. Specifically, it may require employees to work by the chapter operation in every detail of every process. Only in this way, the promotion of safety culture cannot be ups and downs on the surface and become a mere formality. Further to avoid the accidents occurrence in essence. At the same time, it is benefit to set up a harmonious environment.

The civilization of coal mine safety culture embody in the following two aspects:

- **Individual civilization.** Through the cultural leading, continuously improve the cultural quality, professional civilization and professional ethics of coal staff in order to model the new age miners who possess the character of modern industrial civilization.

- Group civilization. Through the cultivation to individual, form the idea of a civilization held commonly by group within the enterprise and gradually form a healthy group cultural atmosphere.

CONCLUSION

To control coal miners' fatigue, it's not only operating coal mine safety and the guarantee of the security operations of coal miners, but also a higher quality of life and the pursuit of coal worker successors team needs.

- Through to the miners' labor load and fatigue index analysis that led to accident, miners fatigue is the main reason, given the concept of fatigue and fatigue of the classification.
- Based on the MMEC theory, finding out the reasons for fatigue coal miners, that man-machine-environment-management and associated areas of fatigue leading to the root causes of the miners, and miners were given control of the specific measures of fatigue.

- Expounded the relevant domestic laws and regulations, and puts forward the "forty-six" operating system superiority, advocating the use innovation safety training and improve training quality method to improve the quality of safety culture in employees, reducing safety accidents.

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