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The Ventilation System of Khandiza Polymetallic Mine Through Minerals Deposits

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Abstract: *With the using of reliability-engineering and ergonomics theory, the various factors which can impact the reliability of a mine ventilation system have been approached in detail in this paper. It indicates that the main factors which will impact the reliability of the mine ventilation network are the mine ventilation system, the harmful diagonal structure of the network and changes in ventilation network. The main factors which will impact the normal operation of the fan are the types of the fan, its inherent quality, installation, use and maintenance management, the placement environment of equipment, equipment operators, and the method of operation of the main fan. The effectiveness of mine ventilation control equipment changes the resistance in the network branch roadway, which will have a major impact on the system's reliability; the main mining process underground will cause a serious disturbance of air-flow to the mine ventilation system. In addition, ventilation management has also a significant effect on the reliability of a mine ventilation system.*

Keywords: ventilation system, polymetallic mine, underground mine, Khandiza mine, ventilation management.

1. Introduction

A system is an interrelated collection of instruments, or a device, to perform certain required functions and achieve a certain goal. An underground mine ventilation system, is a large, complex and interrelated structure composed of a ventilation network, ventilation power and ventilation air control facilities (ventilation structures), which is interacting and mutually influencing. The system can continuously convey the fresh air flow from the ground point to the underground (the wind-needed point), dilute and discharge toxic and hazardous gases and dust, regulate the climatic conditions and create a safe and comfortable working environment for mining production. The ability of a mine ventilation system to accomplish this task is called reliability. In the Khandiza Mine, Blocks are prepared by precinct slopes, from which drilling and delivery drifts (orts) are passed. To ensure ventilation when working in the chamber, the drilling and delivery drifts of adjacent chambers are knocked down after 10 m by ventilation orts (ventilation failures). Ore extraction is carried out in layers with a width of 3-5 m by fans of drilling wells drilled from the drilling drift. Chipping occurs almost in a clamped environment, which improves the crushing of ore. The ore is released to the delivery drift, which passes through the contact of the ore body with the underlying rocks, through its end. The mining ventilation system is one of the eight traditional underground mining systems and is closely related to the safety situation. Currently, among mining evaluation, mining production capacity, or the standardization of construction, the mine ventilation system is an extremely important index. Almost all processes in mining produce dust. The major hazards of mine dust are pneumoconiosis and mineral dust explosion. In addition, the mine's high temperature, high humidity, the exhaust emissions of diesel equipment, radioactive radon and its daughters of mining are serious threats to the safety of employees and underground mines in normal production. Therefore, it is essential to set up a mining ventilation system which can meet the requirements of the daily production of air, guarantee the stability of air-flow direction and air quality, maintain the reliability and stability of the operation of the ventilation systems during disasters, and achieve rapid decision-making and relief. With the increasing of mining depth, mining intensity has increased leading to the growth of ventilation lines, the increase of ventilation resistance and the increase in temperature of the operating environment. A higher demand for the reliability of mine ventilation systems in metal mining is revealed.

In the Khandiziz Mine, the main ventilation fan of the WATER-ZOM type is used for ventilation of underground workings, which is installed on the surface near the mouth of unit No. 10 and works for injection.

However, with the growth of the service life of the mine ventilation system, ventilation equipment is aging, and ventilation practices and the structure of mine ventilation networks have changed, leading to changes in the ventilation system parameters, so that the intended functions of the ventilation system cannot be fully realized. Whether the mine ventilation is good or not depends on the reliability of the mine ventilation system. The reliability of a mine ventilation system can indicate the failure and accident risks of the system that may occur during normal operation, provide a scientific basis to the mine ventilation system design and management, find more comprehensive and rational indicators for the evaluation of the ventilation system or unit performance and also provide technical support to future deep mining ventilation. It is the key to prevent and reduce accidents in the ventilation

system and ensure their rational, economic and efficient operation, it is also an important task in optimizing ventilation design and promoting safety.

2. ANALYSIS OF THE RELIABILITY OF ERGONOMICS IN A MINE VENTILATION SYSTEM

The mine of Khandiza polymetallic mine In the case of stopping the main mine fan, ventilation disorder or detection in the current development of unacceptable toxic gases, in this formulation is immediately stopped, the people shown on fresh air or on a surface, internal combustion engines are muffled. Work is resumed only with the permission of the chief engineer of the mine after ventilation of the mine and reducing the concentration of toxic gases to an acceptable level.

Along with the observance of optimal working conditions (temperature, humidity, air cleanliness, lighting, industrial noise, vibration, etc.), one of the requirements for the protection and working conditions of employees is to provide them with workwear, shoes, gloves; in winter, when working in cold rooms, insulated workwear and felt boots. A mine ventilation system is a complex, random, "fuzzy" and unstable man - machine – environment system affected by many factors. It is also a system of dynamic development with spatial and temporal changes, which has its own characteristics. There are many factors affecting the reliability of a mine ventilation system: the ventilation route, method, network, mine-face forward and transfer, whether it is tunnel-through or closed, deformation (roof-fall, slabbing, kick drum, etc.); the role of natural wind, the operating fan, wear and corrosion; the condition of ventilation structures; roadway pedestrians, vehicles, and deposits and other natural factors; and ventilation safety management (administration, personnel, systems and measures, monitoring equipment, etc.). It is difficult to bring the effectiveness of any reasonably designed and well-equipped ventilation system into full play without a good ventilation management team. Therefore, the analysis of the reliability of a mine ventilation system should include four aspects: the ventilation network, the ventilation power, the ventilation control facilities and the ventilation management team.

2.1. THE VENTILATION NETWORK

Khandiza polymetallic mine The ventilation network is an interrelated, complex aggregate composed of all the roadways the airflow goes by, consisting of the mine ventilation (the arrangement of the relative location of the air shaft into-the-mine and back-from-the-mine), and the mid-ventilation and stoop ventilation networks. Mine ventilation includes three types: the central type, the diagonal, and the central-diagonal hybrid. The choice of ventilation system directly affects the length of the line and the resistance of ventilation in the underground mine. Different ventilation systems have different resilience. The ventilation tunnel in the ventilation network can be divided into a parallel roadway, a roadway in series and a diagonal roadway according to their mutual relations in the network. This research on the reliability of a mine ventilation system is to focus on a diagonal network (harmful and harmless diagonal). With the continuous advance and succession of the mine face, the preparation, production, ending and taking-over of the mining area, the extension of the mine, and the consequent implementation of the construction and removal of ventilation structures, the network structure of a mine ventilation system changes over time, causing changes in ventilation parameters, such as wind volume distribution. Whether the direction of flow and air volume in the ventilation network can sustainably meet the demand of the wind points or not, plays a decisive role in the reliability of a mine ventilation system. In the study of the reliability of a given wind direction in a mine ventilation network, the main factors to be taken into consideration are: wind speed, dust concentration, temperature, and the concentration of toxic and harmful gases. We must analyze whether these indicators are within reasonable limits of the requirements of the statutes. There are many reasons for the failure of the flow in the wind road, such as natural wind, wind pressure in fires and changes in the status of the mechanics of the fan; or changes in wind resistance in the tunnel, caused by falls, rib spalling, floor heave, accumulation of debris inside the tunnel, vehicle operation, pedestrians, and destruction of ventilation structures or combinations of the various reasons mentioned above.

2.2. AIR PRESSURE

Ventilation power is the power of the system architecture, composed of the energy source such as the main fans, auxiliary fans, local fans and natural power, which provide energy for the main air flow. The main fan may include the centrifugal and axial types, which provides the power for the mine ventilation mechanically. In the Khandiziz Mine, the main ventilation fan of the WATER-ZOM type is used for ventilation of underground workings, which is installed on the surface near the mouth of unit No. 10 and works for injection.

For ventilation of tunneling and mining operations, local ventilation fans of the VM-12 and SVM-6 types are used.The main fan is charged with a wing of the mine or total mine ventilation and has been in long-term continuous operation. The operation stability refers to whether the operating point of the fan is within a reasonable range and whether the fans will mutually interfere. The main fan has the largest and most direct effect on the mine ventilation system, the operation stability has a decisive role in the security of

the mine ventilation system and it is also an important indicator of the reliability of the mine ventilation system. The following factors should be taken into account when considering the reliability of the fan: the fan selected; the inherent quality of mechanical and electrical equipment; equipment installation quality; equipment use and maintenance management; the equipment placement environment and the users of the fans. The methods in which the main fan works mainly include: unconventional, pressure, and the pressure pumping-in hybrid. On the one hand different ways of working produce mine air at different pressure states. On the other hand, different forms of distribution in the whole air line result in different ventilation from the perspective of air quantity, quality and extent of disturbance by natural air flow.

Moreover, the choice of working methods of the main fan directly affects the air leakage rate in the ventilation system. Natural air pressure is a natural phenomenon objectively existing in a mine. It is an energy difference of air flow along the roadway caused by a variety of natural factors on the mine surface and underground. This energy difference exists in all the roadways, including mine lanes. The main factors that affect the natural pressure in a mine include temperature, air condition, elevation, the work state of fans, air volume, the number of mine workers, system layout and so on. Under the action of natural wind pressure a mine will produce natural ventilation. Its role is sometimes beneficial for mine ventilation, sometimes the opposite. When the direction of natural pressure is in the opposite direction to the airflow caused by the main fan, the pressure of the fan unit will not only overcome the resistance of mine ventilation, but also overcome the natural wind, which is obviously not conducive to normal mine ventilation. In some mines opened up in China's mountainous areas, the role of natural ventilation in winter can replace some of the basic work of the main fan. Visibly, natural air pressure is an important driving force in mine ventilation that cannot be ignored. In addition, the natural wind pressure may cause some local counter-wind or no wind in some tunnels, resulting in accidents when the mine ventilation system reliability decreases.

2.3. VENTILATION CONTROL FACILITIES

Ventilation control facilities are a series of moderating and controlling facilities used to control hazardous air leakage and distribute fresh air flowing into the underground according to production needs, such as a throttle (permanent and temporary), a window, wind walls, a wind bridge, auxiliary fans , air curtains, a wind deflector and so on. Among them, the auxiliary fan has a dual function acting as power and regulator as well. The fundamental effect of ventilation control facilities on the reliability of the mine ventilation system is to be achieved by changing the branch wind resistance. Underground ventilation control facilities are the basic measures adopted to guide the air flow to achieve the objective of the allocation of the intended air volume. Generally, the ventilation control facilities determine the scale of influence according to their opening on both sides of the wind pressure. Therefore, the management of underground ventilation control facilities must be strengthened to improve its reliability. The greater wind pressure gap on both sides tends to be linked with the major air-supply zone and the return air zone. Damage or improper use may lead to air flow short circuit of the major-air supply and return air zones. Even worse, it may result in changes in air volume distribution and even reversed airflow in large areas. Ventilation control facilities can be classified into three categories according to their different roles: The first is used to cut off air flow facilities, such as the wellhead closed doors, dampers, air walls, wind screens, etc. Its main function is to cut off airflow and prevent air flow from passing, the greater the amount of air leakage, the worse reliability it has. For instance, some serious air leakage, not cutting off the air flow, seriously affects the stability of air flow and may even result in static or reverse air flow. These facilities require to be highly structured and rigid with less air leakage. The second type is used to pass the air flow, such as a wind bridge, the main reverse-air unit fan, the fan tunnel and so on. Its function is to make air flow smoothly through. The greater the amount of wind damage, the worse the reliability of ventilation. For example, for the air bridge, the design should not only consider minimizing air leakage, but also consider possible measures for reducing local resistance. Such facilities require weaker wind resistance and less air leakage. In addition, the mine's main fan reverse-air device directly affects the reliability of the entire ventilation system. A mine reverse-air system is a generic term for all types of facilities which are used to reverse the air flow underground. In order to prevent the noxious and poisonous gases generated by fire from the air intake system (shaft bottom) encroaching into the work place, the whole mine or a local tunnel needs to be reverse-aired, and sometimes reverse-aired in order to meet the need for rescue work. The reverse-air system is the major technical measure which is used to prevent the expansion of disasters. Most mines use the main fan to achieve reverse-air effects on the normal flow. The reverse-air performance of the main mine fan directly reflects the resistance to disaster of the mine ventilation system. The third category, such as a regulation windscreen, is used to regulate and control the through air flow. Its main function is to make air flow through the windscreen and it is designed to ensure the flow is consistent. The greater difference between the two sides, the less reliable the facility.

2.4. VENTILATION MANAGEMENT

Khandiza polymetallic mine a mine ventilation system is actually a complex "man-machine" engineering system. "Man" is the main body of the system, mainly referring to the operator and manager. "Machine" refers to all the objects under human control, mainly referring to the ventilation network, power and ventilation air control facilities. The reliability of any man-machine

engineering system will depend on the reliability of "man" and the reliability of "machine." From a managerial point of view both normal production, on the one hand, and the management of disaster, on the other, should be taken into account. The mine's ventilation safety management should be considered, that is, the establishment of ventilation management agencies, financial investment, management, and the formulation and implementation of operational rules and regulations.

2.4.1. NORMAL PRODUCTION MANAGEMENT AND MINE DISASTER

Mine production is inseparable from transportation and improvement, while people often ignore the impact when they are analyzing the ventilation system. The mine entrance is usually regarded as the main entrance of the airflow ventilation system. Enhancing the stability of equipment operation has a global impact on mine air. The size of equipment depends on the wind speed and direction of the piston wind. The presence of piston wind produces a disturbance of the systematic air-flow. The disturbance is dynamic and nonlinear. Underground blasting plays an important part in mine production. It has regular, periodic and transient characteristics. The main effects of blasting on the mine ventilation system are as follows: an enormous blast wave disturbs ventilation airflow during the process of blasting; a large amount of toxic and harmful gases and dust diminish the mine air quality; vibration from blasting will deform roadways and cause collapses and piles after blasting, affecting the wind resistance of branch networks. Because the ore stays in a loose state in the course of chute and ore-drawing operations this provides a roadway to air leakage, and the induced draft produced in the falling of high-speed air flow and the shear airflow scatter caused by the head resistance together disturb the air flow within the system. Underground catastrophes in metal mines mainly refer to fire disaster, water inrush, large areas of collapse and roof-fall of the main roadway. These major mine accidents not only affect the reliability of the mine ventilation system but may cause the system's overall paralysis. For example, fire pressure generated by an underground fire will cause a tremendous negative impact on the operation of main fans.

2.4.2. MINE VENTILATION AND SAFETY MANAGEMENT

The institutional establishment of ventilation management is an important requirement for safe mine production. The management level is reflected by whether management practices are established, whether they are sound, and whether this sound practice is required. Management practices exert a direct impact on mine safety. Mine ventilation and safety management practices generally use a beeline functional system in which management principles follow a management hierarchy, unified command, unified power and responsibility, division of labor, unity and collaboration. Dynamic organization using these five principles ensures that the ventilation management system can perform with high efficiency. Adequate funding for investment in and improvement of the reliability of mine ventilation systems must be ensured. For example, the training of safety personnel, the use of ventilation test instruments (such as pressure measurement, dust measurement, temperature measurement, humidity measurement, etc.) and the improvement of ventilation systems and timely maintenance require investment. Management practices must be perfected and put in place to ensure the implementation of measures to protect underground personnel, equipment and facilities, the working environment, and to maintain ventilation systems in a safe condition. For example; the mine emergency rescue plan, a variety of disaster prevention and mitigation measures, mine measured wind, dust, and fan condition test measures. A reliable ventilation system needs to maintain daily inspection, maintenance and management. Strict regulations and rules are to be established for employees to follow; such as the use of dust detection systems, underground ventilation and dust workers' codes of practice, rewards and penalties for dust levels in the ventilation system and so on. Starting from human reliability, the focus is to consider people's unsafe behavior. Unsafe behavior affects the operation or the safe operation of work, resulting in lower system reliability, and even the complete failure of the system and safe behavior. Many reasons contribute to people's unsafe behavior, such as the professional quality of employees, safety awareness, sense of responsibility, physical and psychological factors, age, education and so on.

3. CONCLUSIONS

Khandiza polymetallic mine the underground ventilation system of a metal mine is a complex of random, open, non-stable and dynamic characteristics. Although a mine ventilation system consists of the ventilation network, ventilation power and air control facilities, the system reliability should not be limited to these. The main conclusions are as follows:

• Main effecting factors on the reliability of a mine ventilation system can be listed out as follows according to their importance: ventilation network, ventilation power, ventilation control facilities and ventilation management.

• Analyze the reliability of the underground ventilation network, focusing on several factors such as the mine ventilation pattern, the hazards of angle-connected networks, and underground ventilation network changes over time, and so on.

• The main factors affecting reliable fan operation are the selection of the type of fan, the inherent quality of mechanical and electrical equipment, the installation quality of equipment, equipment use and maintenance management, the equipment placement environment, and blower equipment operator and operating style of main fan.

• The fundamental impact of ventilation control facilities on the reliability of a mine ventilation system is to be achieved by changing the branch wind resistance.

• With the increasing depth of mining, underground mining processes such as improved transportation, ore chutes, underground blasting and so on must be evaluated as to their effects on the reliability of the mine ventilation system.

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