American Journal of Energy Engineering
2023; 11(3): 71-77
http://www.sciencepublishinggroup.com/j/ajee
doi: 10.11648/j.ajee.20231103.11
ISSN: 2329-1648 (Print); ISSN: 2329-163X (Online)

New Technologies for Preventing and Controlling Dust Hazards in Non Coal Mines in China

Zou Changfu

Chongqing Research Institute of China Coal Technology and Engineering Group Corporation, Chongqing, China

Email address:
3051617571@qq.com

To cite this article:
Zou Changfu. New Technologies for Preventing and Controlling Dust Hazards in Non Coal Mines in China. *American Journal of Energy Engineering*. Vol. 11, No. 3, 2023, pp. 71-77. doi: 10.11648/j.ajee.20231103.11

Received: June 14, 2023; **Accepted**: July 27, 2023; **Published**: July 31, 2023

Abstract: China has a large number of non-coal mines and a wide range of dust production points, making it difficult to supervise them. At the same time, the dust monitoring rate of non-coal mines in China's open-pit mining is low, and the continuous monitoring system of non-coal mines in underground mining is also lacking. In particular, the continuous monitoring technology of respiratory dust is still blank, and it is impossible to continuously monitor the respiratory dust pollution status of workers' workplaces in real time, and it is impossible to build an early warning system for pneumoconiosis in China, and it is impossible to achieve timely protection for operators. In order to further improve the progress of dust control technology in non-coal mine mountains in China, this paper analyzed the current status of dust hazards in China's non-coal mine mountains, comprehensively summarized the dust hazard control technology and dust detection technology in China's non-coal mine mountains, analyzed and studied the applicability and dust reduction effect of each dust control technology, and provided technical selection guidance for non-coal mine dust control. By analyzing the problems of dust hazard control in China's non-coal mine mountains, the development direction of dust hazard control technology in China's non-coal mine mountains is proposed, and the basic basis and development guide are provided for the dust control in China's non-coal mine mountains.

Keywords: China, Non Coal Mines, Dust Hazards, Current Situation, Development Direction

1. Introduction

There are many kinds of non-coal mines in China, mainly mining metal ores, radioactive ores and as petrochemical raw materials, building materials, auxiliary raw materials, refractory materials and other non-metallic mineral mines and tailings ponds. In recent years, after integration, the number of non-coal mines has gradually decreased, and the degree of mechanization has gradually increased. By the end of 2015, the number of non-coal mines has decreased to 37,879, and the mechanized shovel loading rate of open-pit mines has reached 92.7% [1, 2].

For a long time, due to the large number of non-coal mines, small scale, technical equipment and production technology is relatively backward, resulting in serious dust pollution in the production process. Dust not only endangers the safety of mine production, but also brings serious occupational hazards, causing pneumoconiosis, long-term inhalation will lead to lung tissue fibrosis, breathing difficulties, until suffocation death. In recent years, the total number of pneumoconiosis and silicosis caused by dust hazards in non-coal mines in China has shown an overall increasing trend year by year, and the age of onset has a shortening trend. According to statistics, 29,972 cases of occupational diseases were reported nationwide in 2014, including 26,873 cases of occupational pneumoconiosis, among which only 4,408 cases of occupational diseases were reported in the non-ferrous metal mining and selection industry. This accounted for 14.7% of the total number of people reported [3]. At the same time, the composition of non-coal mine rock is very complex, different mines have different ore raw materials, production technology and mining methods, and the dust damage degree is also different. According to the survey, the content of free SiO_2 in the dust produced in the mining process of non-coal mines is more than 10% [4]. Therefore, the dust produced in non-coal mines is extremely harmful to human body, and some metal mines are accompanied by a small amount of lead, chromium, cadmium and other metal dust in the mining process, causing heavy metal poisoning and other hazards.

In recent years, China has done a lot of work in preventing

dust hazards, protecting workers' health and preventing pneumoconiosis, and has made certain achievements, but the existing theory and technology cannot meet the needs of the rapid development of non-coal mine production, and the form of dust hazards is still severe, especially the mechanization of non-coal mine operations is strengthened, and the mining intensity is increased, which makes the dust hazards more serious. In dust control, on the one hand, the treatment technology and equipment are backward, the dust removal efficiency is low, especially the lack of effective means for respiratory dust control; On the other hand, the management system related to dust prevention and control is not perfect, and the non-coal mine mountain sites are multi-sided and complex, lack of effective supervision and control measures and technology, and supervision is difficult, resulting in the incidence of pneumoconiosis is still high.

Therefore, this paper discusses the status quo of dust control technology in China's non-coal mine mountains by combining technology and examples, and points out the development trend of dust control and supervision in China's non-coal mine mountains in the 145th and even longer period.

2. Status Quo of Dust Hazard Control Technology in Non-Coal Mines

2.1. Dust Control Technology of Non-Coal Mine Open-Pit Mining

Dust in the process of opencast mining is produced by drilling, blasting, shovelling, transportation, crushing, screening, soil discharge and other production processes, and each process is an unorganized discharge of dust. The dust concentration of non-coal mine in open pit mining is affected by many factors such as mining mode, mining progress, transportation mode and meteorological conditions, resulting in serious dust pollution in the process of non-coal mine open pit mining [5].

In particular, at the end of the 20th century, after some open pit mines in China entered deep pits, a deep pit like the bottom of a pot was formed in the stope with the decrease of the mining depth, the wind speed in the pit was sharply reduced, the ventilation was not smooth, and the temperature inversion was formed in the stope, which made it difficult for dust to escape and evacuation, and the pollution in the pit was intensified [6].

With the aggravation of the pollution of non-coal mine open-pit mining, the contribution of dust pollution to the deterioration of air quality has increased. In view of this situation, China's research on dust treatment in open-pit mining has gradually increased, and a certain dust-proof technology and equipment have been formed.

(1) Dry dust removal technology for drilling operations

In drilling operations, the impact, extrusion, cutting and stripping of the drill bit on the rock causes dust to fly, and the dust concentration reaches 450-1400mg/m^3 [7]. The dust particle size is small and the duration is long, which is one of the main sources of fine mine dust in the open pit mining area. Especially the drilling of crawler drill, its dust production intensity is greater, and it is more harmful to operators.

The domestic dust production control is mainly the use of wet drilling dust reduction, the use of central water supply drilling, in the process of drilling and slag discharge wet dust, reduce the amount of dust production. However, the drilling area of open pit is remote and the lack of water source restricts the popularization and use of wet drilling in open pit.

In recent years, the dry dust removal technology, which adopts dust collector for dust extraction and purification after the hole is closed, has been vigorously developed. Compressed air or induced draft fan is used as the power source to form negative pressure, so that the dust containing gas is sucked into the filter through the dust suction hood, and the dust is filtered and purified in the high-efficiency filter cartridge through the combination of wall settlement and high-efficiency micro-hole filtration, and the dust removal efficiency can reach 93% [8].

(2) Dust suppression technology of fog cannon in blasting operation

During blasting operation, the concentration of instantaneous dust production is as high as 2000~5000 mg/m^3 [9]. Due to the large blasting area, the number of blasting holes and the collapse degree, the dust production diffusion area is wide and far away, and the surface of blasting dust adsorb toxic and harmful gases generated by blasting, which is of great harm to human body.

Water cannon mud is used to suppress dust, and water is sprayed to the pre-explosion area before blasting to moisten the rock and reduce the amount of dust produced. Since the dust removal efficiency of ordinary water cannon mud is only 20%~30% [10], the workload of open-air blasting water sprinkling is large, and there is a lack of dust-proof water, which restricts the use of sprinkling pre-humidification measures.

In recent years, in view of the wide area of the open storage yard and blasting area, the long-range air-sent spray dust removal equipment (fog cannon) has been developed, and the fog cannon has the characteristics of long range (20~200m), wide coverage area (120~360° rotation), and good atomization effect (particle size 20~200μm) to spray dust removal in the blasting operation area. It can restrain and settle the dust produced by blasting well, and the application in the quarry such as Yuanlong in Guizhou Province shows that the dust removal efficiency can reach more than 75%.

(3) Dust extraction and purification technology for crushing and screening operations

High concentration of dust (1000 ~3000mg/m^3) is produced by friction impact in the crushing and vibrating screening process along the crushing and screening equipment. Since the crushing and screening equipment is easy to clog when spray dust removal measures are adopted, efficient closed dust extraction and purification measures are generally adopted to effectively seal the dust source point and control the non-diffusion of the generated dust. Dust extraction and purification are carried out by wet or bag dust collector (handling air volume 9000~36000m^3/h). The dust removal

efficiency can reach more than 99% [11].

Because the vibrating screen is moving up and down in the process of vibration screening, the ordinary sealing method is difficult to seal, and there is a problem of dust escape in the process of dust extraction and purification, which reduces the purification efficiency. In recent years, the magnetic soft seal sealing technology is used between the vibrating screen plate, and the soft seal can be telescoped with the reciprocating movement of the vibrating screen, ensuring the tightness of the vibrating screen during the movement, increasing the efficiency of dust extraction and purification, and achieving the best dust extraction effect.

(4) chemical dust suppression technology for shovel loading transportation

During shoveling and transportation operations, the secondary dust pollution is serious under the action of wind flow, and the dust concentration can reach 50~150mg/m^3. The traditional treatment method for secondary dust is sprinkling dust, but sprinkling dust is greatly affected by the weather, and the water evaporates too fast in summer, requiring frequent sprinkling, which consumes a lot of industrial water, and the temperature in northern winter is too low, and sprinkling water is easy to lead to ice and slippery road surface, resulting in safety risks.

In recent years, a highly efficient chemical dust suppressant has been developed, which is suitable for secondary dust removal in material pile shoveling and road transportation. After spraying dust suppressant in material pile and road, a flexible and dense continuous polymer micro-film is formed on the surface of mineral rock, which inhibits secondary dust removal. At the same time, it has the properties of hygroscopic, moisturizing and condensing, so that the road surface is always moist and the road dust solidifies into a group. Particles with larger particle size and not easy to fly are generated again, and the dust removal efficiency reaches more than 95% [12]. The amount of dust suppressor is 2.0kg/m^2 ~ 3.0kg/m^2 at a time, and the dustproof validity period can reach 7~15 days, which becomes a simple and efficient dust removal method in the process of shovel loading and transportation.

2.2. Non-Coal Mining Dust Control Technology

The main mining method of underground non-coal mine is blasting mining, and some large mines have introduced rock roadheader for mining. Dust is produced in each production process of mine, which is divided into the main dust production process by drilling, blasting, anchoring, shoveling, unloading, crushing and screening, and each production process affects the other.

The dust control of underground non-coal mines in China is mainly based on wind and water comprehensive dust prevention technical measures, that is, on the one hand, water will capture the dust wetting; On the other hand, the dust is expelled from the well by means of air flow.

(1) Air flow purification technology

Mine ventilation is the most fundamental measure of dust removal. Due to the complex ventilation system of non-coal mine, the phenomenon of air leakage and short circuit in the system is prominent, and the clean air flow and dirty air are connected in series, resulting in dust pollution in other working places of the mine. Aiming at the problem of air flow pollution in mine, in terms of dust treatment in air inlet lane, optical control automatic spray dust removal technology and timing automatic spray dust removal technology have been researched [13]. In terms of dust control in return air lane, automatic spray dust removal technology exceeding the limit of dust concentration was developed during the "11th Five-Year Plan" period, which can determine the start and stop of dust removal devices according to the dust concentration of return air lane and play a role in purifying air flow [14].

(2) Blasting high-pressure spray dust removal technology

The concentration of dust produced by blasting mining in non-coal mine ranges from 400 to 800mg/m^3, and water cannon mud is mainly used for dust removal, which is about 20% lower than that of earth cannon mud alone [15]. Under the condition of spray pressure of 8MPa and spray flow rate of 20L/min, the water mist of the sprayer is used to close the entire roadway section of more than 5 meters, so that dust, smoke and other harmful substances are intercepted at the head of the roadway and are moistened by the water mist to clean the dust-containing air flow. The dust concentration in the blasting face is reduced to less than 7mg/m^3 within 7min after blasting, while in the case of low-pressure spraying (spray flow rate 50L/min), it takes 30min to drop to less than 10mg/m^3 [16].

In view of the characteristic of dust with charge, water mist is pre-charged on the basis of spray dust removal to accelerate the adhesion and condensation of dust particles and droplets and improve the dust removal efficiency, especially the dust removal efficiency of respirable dust. The application shows that under the conditions of spray pressure of 2MPa and water mist charge of 35kV, the dust removal efficiency of cement and fluorite dust can be increased by 30%, and that of talc by 40% [17].

(3) Drilling hole dust removal technology

Wet drilling is mainly used in short boreholes in non-coal mines. For long boreholes, dry pneumatic slagging (dust concentration greater than 1000mg/m^3) is used in wet boreholes due to problems such as difficulty in slagging and stuck drilling, and a new type of dust removal technology is developed. This technology is powered by a ring-gap air ejector (the ejector can reach 25m^3/min and 4000MPa in the case of compressed air pressure of 0.5MPa and air consumption of 0.75m^3/min), and adopts the principle of efficient wet filtration and dust removal for dust removal. When the spray flow rate of the dust collector is 20 L/min and the air volume is 12.8 m^3/min, the dust removal efficiency of the dust collector reaches 98%.

(4) Automatic shotcrete dust removal technology for anchoring and shotcrete support

Dust control by anchoring and spraying has always been the focus and difficulty of dust control in China. In non-coal mines, dust control by anchoring and spraying is mainly applied by wet or damp spraying, but dust pollution (dust concentration 150~1000mg/m^3) at feeding port, exhaust port

and spray port has still not been effectively solved. During the "Twelfth Five-Year Plan" period, Chongqing Coal Research Institute developed an automatic shotcrete equipment integrating shotcrete and dust control in the shotcrete area according to the characteristics of dust production in the shotcrete operation. The dust generated in the shotcrete process is extracted by the dust control device arranged on the equipment. After the use of the equipment, the total dust concentration of the operator can be reduced to less than 6mg/m^3. The concentration of respirable dust is reduced to less than 3mg/m^3, and the dust produced at the feeding port is controlled by using a closed cover, which can reduce the total dust concentration of operators to less than 8mg/m^3 and the respirable dust concentration to less than 3mg/m^3 during the anchoring and spraying operation.

(5) Efficient closed dust extraction and purification technology of ore pass

The concentration of ore dust from ore chute unloading reaches 30~200mg/m^3, and the impact air flow is too large and the cross-pollution of ore chute groups is serious, which is the difficulty in dust control of ore chute unloading at present. In view of the dust-producing characteristics of ore ore discharge in chute, the use of parallel chute mutual buffer space can reduce the impact air volume of the upper ore drawing to 26.7%, which greatly reduces the impact effect of air flow. At the same time, all ore ore discharge ports maintain air inlet to chute to prevent dust leakage, and strengthen the closure of ore ore discharge ports to maintain good air tight, and adopt efficient dust collector for dust extraction and purification. The comprehensive treatment technology of "pressure relief", "plugging", "pumping" and "dust removal and purification" has been formed, and the dust removal efficiency can reach more than 90%.

(6) Ultrasonic atomization dust removal technology for crushing and screening

For the fine dust produced by crushing and screening (concentration up to 1000~3000mg/m^3), the compressed air is used to impact the resonator to produce ultrasonic waves, and the ultrasonic waves will mist the water into fine droplets with a particle size less than 20μm. With the high-speed air flow, the atomized water rapidly diffuses within 0.2~1s in the closed cover to catch and condense the fine dust. The dust quickly settles down to achieve local dust suppression, and the dust removal efficiency for respirable dust is more than 97%.

(7) Integrated dust prevention technology of rock roadheader

Part of the introduction of roadheader for rock excavation can refer to the advanced dust comprehensive treatment technology of coal mine integrated excavation face, the use of high-pressure external spray dust removal technology, under the spray pressure of 8MPa, spray flow of 30L/min, the dust removal efficiency of the roadheader driver can reach 80% ~ 90%. Combined with the dust control technology of wall attached air duct and the comprehensive dust prevention measures of dust extraction and purification by efficient dust collector, the total dust of the TBM driver can be reduced to less than 8mg/m^3 and the respirable dust can be reduced to less than 4mg/m^3 when the extraction air volume is 75% ~ 80% of the compressed air volume. At the same time, for the long single-head roadway or stope in deep Wells, the recycling purification and dust removal technology can be adopted to send the air after dust removal to the working surface to realize the recycling of air flow. It is an extremely economical and effective measure in the area where the ventilation system is difficult to control or the area where fresh air flow is difficult to effectively supply in remote areas of the underground.

(8) Individual protection technology

The personal protective equipment to prevent dust hazards has developed from the traditional cotton mask to the chemical fiber filter material self-priming dust mask with air valve and the newly developed filter air supply dust mask. The core component of the developed filter air supply dust mask adopts a folding structure, and its air supply can be arbitrarily adjusted in the range of 70L/min ~ 120L/min, respiratory resistance ≤196Pa, dust resistance ≥ 99.9%, continuous working time >6h. These personal protective devices play a role in protecting operators in some local areas where it is inconvenient to use large dust removal equipment, and are especially suitable for high-intensity operators, greatly reducing the risk of pneumoconiosis.

2.3. Status Quo of Non-Coal Mine Dust Detection Technology

There are three main contents of non-coal mine dust detection: dust concentration, dust particle size distribution and free SiO_2 content in dust, of which dust concentration includes total dust concentration and respirable dust concentration.

Dust concentration detection equipment mainly includes dust sampler, direct reading dust meter and dust concentration sensor. Among them, the sampler can be used for short-time large flow sampling or for breathing dust workshop sampling; The direct reading dust meter can quickly test and read the readings directly. Dust sensor for online monitoring of dust concentration, there are light scattering type and electrostatic induction type, light scattering type is suitable for low concentration dust environment, electrostatic induction type is suitable for high concentration dust environment. In addition, for the explosive dust environment, the dust concentration sensor and power supply developed by Chongqing Research Institute meet the explosion-proof requirements of explosive dust, achieving further breakthroughs in dust concentration sensors.

In the continuous on-line monitoring of dust concentration, there are few applications of non-coal mine monitoring equipment and technology. For underground mining mines, complete sets of technology and equipment for remote online real-time monitoring of coal mine dust prevention equipment can be used to monitor the operating status parameters of dust prevention facilities through pressure sensors, flow sensors, power sensors, dust concentration sensors, etc., to judge the operating status through the state parameters, and to monitor the dust concentration sensor to judge the use effect. The

system is connected to the monitoring and monitoring system of the six major systems in the mines under the non-coal mine mountains, and the use of all dust prevention equipment under the mine can be timely and accurately understood through the computer screen in the monitoring room. The monitoring data is transmitted to the user terminal of relevant supervisors through the cloud computing center and Beidou satellite, and the supervisors can also timely understand the real situation of dust under the mine.

In view of the characteristics of unorganized emissions in open-pit mines, the atmospheric dust monitoring system can be used for monitoring, and the laser atmospheric dust precision detection technology, dust particle whirlwind separation and cutting technology and the Internet of Things, cloud computing and big data analysis and processing technologies can be integrated to achieve real-time monitoring of the total dust concentration and PM10 and PM2.5 pollution index of unorganized emissions in mines. At the same time, the dynamic record and filing of dust pollution sources and over-limit early warning are implemented to achieve all-round monitoring and supervision.

3. Development Trend of Dust Hazard Control in Non-Coal Mines

The level of non-coal mine dust hazard prevention technology and equipment has been continuously improved after several years of research, and has a high level. However, there are many kinds of non-coal mine mining in China, the difference in mining conditions is huge, and the dust source points are many and wide, and the adaptability of technology is very strong, and some key technical bottlenecks need further breakthrough.

There are three main reasons for the serious harm of dust in non-coal mines in China:

3.1. The Concept of Occupational Hazards Is Poor

China's non-coal mine workers do not have a deep understanding of occupational hazards, especially the harm and prevention of pneumoconiosis has not attracted enough attention. In terms of dust treatment facilities, there are also many shortcomings, such as some non-coal mine mountains in addition to the basic sprinkling dust removal equipment has not installed other dust removal equipment, and other parts of the installation of dust removal equipment enterprises, due to neglect of maintenance, the dust control system is basically aging or stopped unused, in addition, some mines only purchase equipment. There is no comprehensive treatment from the aspects of dust nature, source, pollution degree, system support, etc., and the dust removal effect is very limited.

3.2. Poor Adaptability of Dust Control Technology

3.2.1. Problems in Dust Treatment of Non-Coal Mines in Open-Pit Mining

Open-pit mining operations have a wide range of dust production points and serious dust generation without organization. The current technology can not fully meet the needs of China's open-pit mining, and efficient dust prevention and reduction technology needs to be developed and promoted. For example, in deep concave open-pit mining environment, the existing technology is difficult to achieve better dust reduction effect. The mobile crushing bin is not fixed, the area of the mouth is large, the blanking and crushing both produce a lot of dust, and the general atomization dust suppression effect is poor. There is a serious shortage of water in the north of China, and blasting sprinkler pre-wetting or air-sent spraying technology consumes a lot of water, while ordinary water cannon mud dust removal efficiency is low, and there is a lack of effective treatment means.

3.2.2. The Problems of Dust Management in Underground Mining Non-Coal Mines

The mining depth of non-coal underground mines continues to increase, the production equipment tends to be mechanized and large-scale, and the dust production concentration is further increasing. The original technology is difficult to match the existing technology, such as the influence of ventilation system organization on the prevention and control of unorganized dust in single-head stope, discharge ore pass and roadway; It is difficult for dry dust removal equipment to improve dust removal performance and body lightening under high humidity and high concentration dust environment in coarse crushing chamber. The air circulation efficiency is low in areas where ventilation system is difficult to control or where fresh air flow is difficult to supply effectively. The dustproof technology of shotcrete operation still needs to be perfected in combination with the technological process.

3.2.3. Self-Priming Filter Personal Protection Technology Is Difficult to Meet the Needs

At present, the dust concentration in foreign non-coal mine workplaces is mostly controlled below 8mg/m^3, and the use of self-priming filter dust masks can meet the needs. The dust concentration in non-coal mine workplaces in China is large, most of them use wet dust removal measures, and the moisture content in the air is large, requiring that the filter of the individual respiratory protection device must have a higher dust capacity and stronger moisture resistance, which greatly limits the promotion of individual protection technology.

3.3. Supervision Is Difficult

China has a large number of non-coal mines and a wide range of dust production points, making it difficult to supervise them. At the same time, the dust monitoring rate of non-coal mines in China's open-pit mining is low, and the continuous monitoring system of non-coal mines in underground mining is also lacking. In particular, the continuous monitoring technology of respiratory dust is still blank, and it is impossible to continuously monitor the respiratory dust pollution status of workers' workplaces in real time, and it is impossible to build an early warning system for pneumoconiosis in China, and it is impossible to achieve timely protection for operators.

In view of the above problems, the development direction of China's non-coal mine dust hazard control technology can be summarized as follows:

1. In view of the dust prevention problem in deep pit open-pit mining, research on comprehensive dust prevention technology and equipment in deep pit open-pit mining process is carried out. By studying the distribution law of air flow and the strength of dust source in deep pit open-pit mining, research on dust distribution and diffusion law, targeted research and development of mobile, portable and efficient dust removal equipment, and comprehensive treatment technology combining various dust prevention measures are adopted for treatment.
2. For the dust prevention problem of the mobile crushing bin, research on the key technologies and equipment of mobile dust source control and dust removal integration is carried out. On the basis of studying the law of dust production and dispersion of moving dust source, the flow field control technology of air curtain dust control and the integrated dust removal technology of automatic spray and dust extraction purification are studied, and the supporting optimization research is carried out in combination with the production process.
3. In order to prevent dust from blasting in open pit, a new type of water cannon mud is developed to improve the dust removal effect. Compared with the traditional water cannon mud, the dust removal efficiency is increased by 30-50%, and the dust removal efficiency is more than 70%, thus greatly reducing the problem of the damage of explosive dust and solving the problem of water shortage in the blasting area.

Aiming at roadway type stope blasting, on the basis of studying the dust generation characteristics and distribution laws of respirable dust, a cloud and fog dust suppression system is established in the stope. Through high-pressure spray ejection and ultrasonic atomization technology, a high-efficiency cloud and fog dust suppression wall is formed to capture and aggregate dust, so as to achieve efficient treatment of respirable dust in the stope and prevent the diffusion of dust-bearing air to other workplaces.

4. To study the technology and equipment of unorganized dust control in ore ore chute, single head stope and roadway, and develop multi-mechanism compound dust removal and purification device on the basis of reasonable organization of ventilation system, expand the use surface, further improve the performance of dust collector, make it efficient, light and easy to use on site, and solve the problem of unorganized dust pollution control in ore ore chute, single head stope and roadway.
5. Further carry out research on key technologies and equipment for mine shotcrete dust treatment. On the basis of in-depth study of jet jet theory, rebound dust production mechanism and injection process, develop intelligent autonomous injection technology and equipment, study the integrated technology of continuous mixing and pumped wet concrete injection and high-pressure atomized water-assisted spray dust suppression technology. Improve the wet spray dust removal technology and process supporting technology, especially for the new system of anchor thin spray support dust control and process supporting technology.
6. In terms of dust monitoring, the construction of mine occupational hazard warning information big data center and third-party monitoring and supervision platform, and based on the characteristics of light scattering and electrostatic induction dust concentration sensors, the development of high-precision dust detection instruments and portable monitors suitable for various dust concentration conditions. Based on the respirable dust cyclone that meets the separation efficiency curve of "BMRC" developed by Chongqing Coal Research Institute, the respirable dust concentration sensor and wireless real-time tracking and monitoring instrument are developed to realize continuous online monitoring and real-time tracking and monitoring of respirable dust concentration, and develop in the direction of high-precision, long-distance and large-area continuous monitoring.
7. In terms of pneumoconiosis prevention and control, through the study of the complete set of dust monitoring technologies in non-coal mines, the concentration, toxicity and other parameters of respiratory dust that cause pneumoconiosis are collected, and combined with the accumulated dust exposure time of dust exposure personnel, the physical and chemical characteristics of dust and other indicators, the existing research results on pneumoconiosis are applied to establish the early warning index system and discrimination model of pneumoconiosis. On this basis, the dust hazard warning system of non-coal mine mountains was established by using the pneumoconiosis hazard ring theory and the method of excessive risk classification of pneumoconiosis, and the dust hazard warning system was realized, and the dust prevention and control measures were optimized to scientifically guide the dust prevention and control and the monitoring and management of pneumoconiosis.

Funding

China Coal Technology & Engineering Group major project (2021-2-TD-ZD009).

References

[1] State Administration of Work Safety. Non-coal mine safety Production "Twelfth Five-Year Plan" [Z]. Beijing: State Administration of Work Safety, 2011.

[2] State Administration of Work Safety. Letter on soliciting opinions on the "13th Five-Year Plan for Safety Production in non-Coal Mines (Draft for Comment)" [Z]. Beijing: State Administration of Work Safety, 2016.

[3] Yu Xiankun, Yang Hong. Investigation and discussion on occupational hazards in metal mines [J]. Modern Mining, 2016, (5): 173~175.

[4] National Health and Family Planning Commission, People's Republic of China. Bulletin on the Prevention and Control of occupational Diseases from 2010 to 2014 [Z]. Beijing: Bureau of Disease Prevention and Control, National Health and Family Planning Commission, 2011 to 2015.

[5] PAN Bin. Discussion on dust control measures in large open-pit mines [J]. Copper Engineering, 2007, (4): 1~3.

[6] Yang Yuxin. Analysis of dust pollution and diffusion law in deep concave open pit mine [J]. Mining Engineering, 2003, 1 (5): 48~51.

[7] Zhang Zhenyu. Dust pollution and its control in open Pit Mining [J]. Metal Mine, 2006 (2): 85~87.

[8] Tan Jianwen, Yang Chengjin, Zhu Fengling, et al. Development and application of negative pressure dry borehole dust collector [J]. Jiangxi Coal Science and Technology, 2012 (3): 77~78.

[9] Zhu Jinhua, Xia Jun, Liang Qianfu, et al. Blasting dust control of buildings [J]. Mining Technology, 2009, 9 (5): 125~126.

[10] Zhao Yifang. Theory and Technology of mine dust prevention [M]. Beijing: Coal Industry Press, 1995.

[11] Guo Liwen. Dust removal design of limestone crushing and screening workshop in Hangang [J]. Industrial Safety and Dust Prevention. 1997, (6): 26~27.

[12] Liu Shaoyu, Zhu Xiulin, Yang Jing, et al. Research progress of port dust suppression technology [J]. Port Loading and Unloading. 2013, (2): 44~47.

[13] Ouyang Guangbin, Qian Gaofeng. Application research of comprehensive dust removal technology and equipment in coal mining face [J]. Mining Safety and Environmental Protection. 2008, (6): 51~56.

[14] Wu Baijian, Chen Yingxing, Liu Qinggong, et al. Dust control and continuous monitoring technology of fully mechanized mining face in Kaiyuan Company [J]. Mining Safety and Environmental Protection, 2008, (4): 30~32.

[15] Li Dewen, Ma Jun, Liu Heqing. Coal Mine dust and Occupational disease prevention technology [M]. Jiangsu: China University of Mining and Technology Press, 2007.

[16] Zhang Binggui. Discussion on comprehensive treatment technology of dust in local small coal mines [J]. Mining Safety and Environmental Protection. 2007, (2): 67~69.

[17] WANG Yingmin. Mine ventilation and dust prevention [M]. Beijing: Metallurgical Industry Press, 1993.