

Application of KCG Series Dry Dust Collectors in Achieving Dust-Free Conditions in Underground Mine Construction

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Keywords: Dust-free mine; KCG series; Dry dust collection; Dust control

Abstract: With the continuous improvement of coal mine safety standardization, the growing awareness of occupational health among employees, and the increasing requirements from regulatory authorities, the construction of dust-free mines is bound to become an important development direction. The KCG series mining dry dust collectors have become key equipment for effectively controlling underground dust due to their high dust removal efficiency, safe and reliable performance, and environmentally friendly characteristics. They are widely applicable to mining and tunneling faces, transfer points, crushing points in powder bins, shotcrete operation sites, and other locations.

1. Introduction

Recent international research shows that in the field of mine dust control, foreign countries are actively exploring the integrated application of new dust suppression materials and intelligent monitoring control technologies, striving to achieve more efficient and precise dust control [1]. Domestically, the hazard of underground coal mine dust has long been a major factor affecting the underground environment and the physical and mental health of miners [2]. With coal mines widely distributed and mining methods varying across China, dust issues have become particularly prominent over years of extraction. As the level of mechanized and intelligent production improves, the dust generation intensity in coal mining, tunneling, transportation, and other processes has significantly increased, making the constraints of dust pollution increasingly evident. A large amount of dust not only reduces visibility at work sites and affects normal equipment operation but also leads to occupational health problems such as pneumoconiosis among miners, posing a serious threat to their safety [3, 4].

At the same time, the state is placing greater emphasis on environmental protection and occupational health, with increasingly stringent policies and continuously rising safety standards for coal mines. Against this backdrop, the construction of dust-free mines has become an inevitable trend in the development of modern large and medium-sized coal mines. The KCG series of mine dry dust collectors, as advanced dust control equipment, play a vital role in promoting the construction of dust-free mines by virtue of their high dust removal efficiency, energy savings, and environmental benefits, providing strong support for improving the underground working

environment and safeguarding the health of miners [5].

2. Current Status and Pathways for Dust-Free Mine Governance

2.1. Industry Policy Orientation

Documents such as the *14th Five-Year Plan for Mine Safety Production*, *Green Mine Construction Specifications*, and *Coal Mine Safety Regulations* have clearly mandated dust control, incorporating dust-free conditions into the core assessment indicators for green mines and intelligent mines. Currently, standardized regulations for the coal, metal, and non-metal mining industries have separately issued dust concentration limits, dust prevention facility configurations, and monitoring and operation maintenance specifications, promoting the upgrade from "dust reduction" to "dust-free" [6].

2.2. Technical Pathways and Equipment

The technical pathway for governance is generally: source – process – end-of-pipe full-chain governance. The main governance methods include: spray dust suppression, dry fog dust suppression, foam dust suppression, wet dust collection equipment, dry dust collection equipment, local sealing, ventilation dust removal, and local sealing, etc. Combined with dust monitoring systems, it has initially realized a governance pathway of dust identification, early warning, and intelligent linked dust control [7].

2.3. Overview of Various Equipment Conditions

Governance technical pathways such as dry fog dust suppression, spray dust suppression, foam dust suppression, and wet dust collection equipment have shortcomings including limited application scope and poor effectiveness. The wastewater generated by spray dust suppression and dry fog dust suppression requires secondary treatment, increasing the operational costs of enterprises. For roadways with soft floors, contact with water easily forms muddy water accumulation, affecting normal production operations. Foam dust suppression has high costs, generators are prone to blockage during use, and maintenance workload is large. Meanwhile, chemical foaming agents will affect coal quality and underground water sources, making them difficult to promote. Local sealing and ventilation dust removal belong to dust transfer and do not fundamentally solve the dust pollution problem. Dry dust collection adopts a process of physical filtration and centralized treatment of collected dust particles. Without generating secondary pollution, it can achieve effective filtration and dust collection, with a dust removal efficiency as high as 99% [8]. Overall, the construction of dust-free mining areas has currently advanced from single-point governance to a comprehensive stage of systematic, intelligent, and standardized promotion, with policy guidance, technological breakthroughs, and management upgrades working in synergy.

3. The Role of KCG Series Mining Dry Dust Collectors in Dust-Free Mine Construction

Dry dust collection, due to its adoption of physical filtration technology and absence of secondary pollution, plays a pivotal role in the construction of dust-free mines. Since Yancheng Lanfeng Environmental Engineering Technology Co., Ltd. obtained the first domestic invention patent for mining dry dust collectors in 2010, the product has undergone 5 iterations, achieving upgrades in miniaturization, lightweight design, modularization, serialization, and intelligence [5].

It is widely applied in various major dust-generating links underground such as mining, tunneling, crushing, and transportation. The equipment mainly consists of the dust collector body, matching axial fan, cleaning system, dust collection and discharge system, ash discharge device, and intelligent control system.

3.1. Intelligent Control

The intelligent control system realizes functions such as pressure monitoring, fault audible and visual alarms, timed/fixed-pressure cleaning, automatic cleaning upon shutdown, and local/remote control [9]. (1) Timed automatic cleaning function: Set automatic cleaning, performing 4 cleaning cycles per cycle period, with an interval of 10s between each cleaning; the cycle interval time is adjustable, with an adjustment range of 2 min~60 min, allowing an error of ± 3 s per minute, and can also be independently adjusted according to working conditions. (2) Fixed-pressure automatic cleaning function: During equipment operation, when the system detects that the equipment resistance is greater than the set value (the set value is adjustable), the system automatically performs the cleaning action, while the audible and visual alarm emits a sound alarm and the red light flashes, until the equipment resistance drops below the set value, at which point cleaning stops. (3) Automatic cleaning upon shutdown function: After the system receives the power-off signal from the fan control switch, it automatically starts cleaning. (4) Local and remote control function: The cleaning system has two modes: "local control" and "remote control". If "local mode" is adopted: personnel can operate the equipment at the mine flameproof and intrinsically safe programmable control box. When switched to "remote control" mode, personnel can operate the equipment from the control center.

3.2. Safety Monitoring and Automatic Adjustment Function

Through air volume and wind speed sensors, the on-site airflow speed is monitored in real time [10]. Through optimization algorithms, the power supply frequency is adjusted, realizing automatic adjustment of the suction air volume of the dust collection equipment, ensuring that the ratio between roadway air supply and suction remains within the safe required range[11].

Through harmful gas sensors, the on-site harmful gas content is monitored in real time, and gas values are displayed in real time. When harmful gases exceed the set limit, the signal is transmitted to the control system, which immediately interlocks the equipment to ensure safe production.

3.3. Cloud Display and Centralized Control

Leveraging communication means such as wired networks and 5G transmission, various data on the equipment's operating status are uploaded in real time to the surface centralized control center to realize control [12].

4. Further Optimization and Development Direction of KCG Series Mining Dry Dust Collector

Despite its numerous advantages, the KCG series mining dry dust collector possesses inherent limitations that require attention.

4.1. Optimal Matching Between Dust Collector Body Size and Air Handling Capacity

The air handling capacity of a dry dust collector is closely related to the total area of its internal

filter elements and the rated air volume of the matched fan [13]. While fan selection addresses rated airflow, a smaller collector body restricts the space available for arranging filter elements, thereby limiting the total filtration area. A reduced filtration area leads to higher filtration velocity and increased equipment resistance, consequently decreasing the overall air handling capacity [14].

The conflict between body size and air volume essentially concerns the relationship between filtration velocity and resistance of the filter elements. Future significant improvements hinge on the development of filter media capable of high filtration velocities with low resistance [15].

4.2. Issue of Dust Blinding on Filter Bags in High Humidity and Water Spray Environments

When moist dust contacts the surface of filter elements, the negative pressure adsorption process often results in the formation of a mud cake adhering to the filter surface [16]. As this mud cake accumulates, it rapidly leads to filter element failure. Future solutions may involve technological developments focusing on raw material properties and pre-drying methods [17].

4.3. Further Advancement of Intelligence

Future development includes deeper integration and interlocking between the dust collection equipment and other primary mine systems, such as main ventilation fans, gas detection devices, and transport equipment [18]. Additionally, enhancing interconnectivity with managers' mobile devices will make the system smarter and more convenient.

5. Conclusions

Although the KCG series of dry dust collectors for mining have played a significant role in the construction of dust-free mines, achieving intelligent control, automatic adjustment of safety monitoring, cloud display, and centralized control, there are issues in their application process, such as the contradiction between the size of the dust collector body and the processing air volume, the tendency of dust to clog the bag when it comes into contact with water, and the need for further intelligent upgrades. Solutions need to be actively sought to enable their wider application.

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