Empirical Study on Dust Distribution and Prevention in Thermal Power Plant Based on Big Data and Cloud Computing

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Abstract. In order to reduce the dust concentration in front of the boiler room in thermal power plants, a dust distribution monitoring system for thermal power plants based on cloud computing and big data technology was proposed. With real-time dust distribution data monitoring as the core, the system realizes the unified management of information collection and information receiving, storage, analysis and processing on a system platform, avoiding the independent operation of each system; The system can monitor the dust distribution status in a timely and effective manner, and realize the information interaction among the monitoring plan, monitoring implementation, monitoring summary, monitoring report and project management module, thus forming the information integrated management of the collection work. After analyzing and testing the generation process, concentration value and free silica content of dust in thermal power plants, the results show that the dust concentration value increases with the increase of boiler height. The average dust concentration value detected at the top of the boiler is 7.42 mg/m3, which is higher than the average dust concentration value of 4.21 mg/m3 in the middle of the boiler and 3.85 mg/m3 at the bottom. Therefore, the effective prevention and control of dust hazards in thermal power plants should be carried out in strict accordance with relevant national regulations.

Keywords: thermal power plant; Dust distribution; Prevention and control strategy.

1 Introduction

In recent years, with the rapid development of the national economy, the incidence of occupational pneumoconiosis has been increasing, but with the increasingly sound and perfect national laws and regulations related to occupational health, since the establishment of the occupational disease reporting system in the 1950s, more than 600000 cases of pneumoconiosis have been detected in the mainland of China, with a cumulative death rate of 140000 cases and a case fatality rate of 24%. The direct economic losses caused by occupational diseases and industrial accidents each year reach 100 billion yuan, and the indirect economic losses reach 200 billion yuan. In addition, in international trade, it is more difficult to estimate the export trade losses caused by anti-dumping of labor standards (workers' wages+labor protection). Therefore, the prevention and treatment of pneumoconiosis

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has a long way to go. The increasingly tense power supply situation across the country has led to the rapid rise in the construction of power plants around the country, with coal-fired power plants accounting for more than 90%. Since the new (expanded) coal-fired power plants are all construction projects that may cause occupational disease hazards, the assessment of occupational disease hazards needs to be carried out in accordance with the Law of the People's Republic of China on the Prevention and Control of Occupational Diseases and other laws and regulations.

Productive dust is a major occupational harmful factor in coal-fired power plants. Dust is produced in the whole process from raw coal into the plant to boiler combustion and emission. With the continuous improvement of the national requirements for environmental protection and occupational health of workers, and the improvement of dust removal technology and equipment, dust control in thermal power plants has become the most important thing. Productive dust can be suspended in the air of the working environment of thermal power plants for a long time, and this tiny solid particle is produced during the operation of thermal power plants. Boiler operation, electric welding operation, coal conveying system, dry dust removal and coal pulverizing and pulping system of desulfurization technology are the main links in the operation of thermal power plants, and productive dust is gradually produced in these working links, which are very harmful to human health [1]. Therefore, thermal power plants should minimize the dust hazards in the working environment and effectively control these dusts, so as to improve the life safety of employees in thermal power plants and avoid pneumoconiosis.

Coal dust. Coal dust is highly dispersible, and it contains no more than 10% of free silica (the highest emission concentration required by relevant state departments is 10mg/m3), and the particle diameter of coal dust usually does not exceed 5μm[2].Boiler dust. Boiler dust is highly dispersible, and contains 10%-40% of free silica (the highest emission concentration required by relevant national departments is 2mg/m3), and the particle diameter of boiler dust usually does not exceed 5μm[3].

2 Monitoring system of dust distribution law in thermal power plant based on cloud computing and big data technology

In coal-fired power generation enterprises, there are many kinds of dust. There are coal dust and limestone dust during the transportation, storage and treatment of raw materials; Silica dust and gypsum dust may exist during thermal operation and power generation production; There may be welding fume, silica dust, limestone dust, gypsum dust, asbestos dust, silicate dust and other dust during the maintenance operation. Due to the production process characteristics of thermal power generation enterprises, the dust existing in the operation posts and production links are relatively concentrated, mainly distributed in the raw and auxiliary material storage and transportation system, the combustion power generation system around the boiler body, and the ash removal system. In addition, there may be a large amount of mixed dust in the process of boiler and other pipeline equipment maintenance.

This system takes the real-time dust distribution data monitoring as the core, realizes the unified management of information collection, information reception, storage, analysis and processing on a system platform, and avoids the independent operation of each system. The system can timely and effectively monitor the dust distribution state, realize the information interaction of monitoring plan, monitoring execution, monitoring summary, monitoring report and project management module, and then form the information comprehensive management of collection work [4]. The structure block diagram of this system is shown in Figure 1.

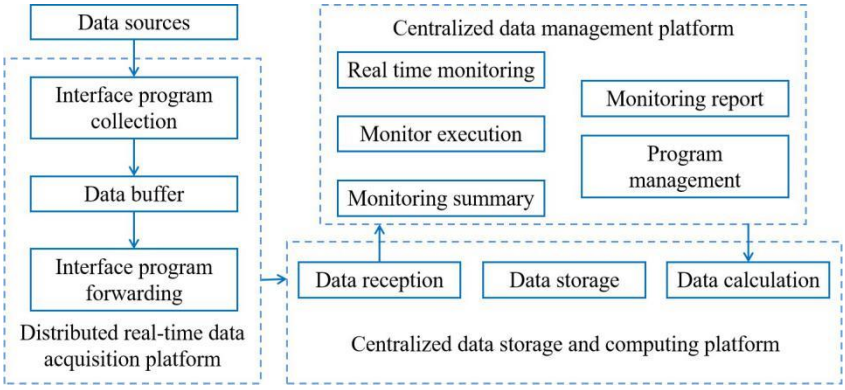

Fig.1. Dust distribution monitoring system of thermal power plant based on cloud computing and big data technology

2.1 Test situation

(1)Layout of measuring points

The measuring points shall be arranged according to Appendix B of Measurement Method of Dust in Workplace Air. The monitoring of dust concentration in the workplace shall comply with the national standard, and the testing contents include dust concentration and dispersion in the workplace [5]. The measuring points are mainly arranged in the coal conveying system of thermal power plant, the boiler body of thermal power plant and the boiler maintenance place. In order to study the variation law of dust in different height layers of boilers in different thermal power plants, combined with the structural characteristics of boilers themselves, several sections were determined according to different heights. These sections include the top of the boiler, the combustion tail of the boiler, and the operation room. The coal conveying system focuses on the middle part of the coal conveying belt and the local area near the dust collector; The production equipment mainly includes drum, superheater, dust collector and main steam pipeline, as well as the combustion part of pulverized coal such as coal feeding, powder conveying and burner. The measuring points of the boiler overhaul site are mainly arranged at the operating points of the on-site staff and the places where they often stay or pass by.

(2)Testing instruments

The main technical index of FN-K ii dust concentration meter: the weight concentration detection range: 0 ~ 100 mg/m3.

Weight detection error: < 15%.

Dispersion detection is divided into four grades: < 2,2 ~ 5,5 ~ 10 and > 10μm.

Time range: 5, 10, 20, 30, 60 s.

(3)Content of free silica in dust of each workplace

The content of free silica in workplace dust is one of the important indicators to measure its harm to human body. The higher the content, the greater the harm to human body [6]. Through systematic sampling and analysis, it is found that the content of free silica in dust in different workplaces varies greatly, as shown in Table (1).

Table 1. Content of free silica in dust of each workplace (%)

Coal conveying system	boiler body	Wait for turbine
4.34±2.3	19.66±8.8	3.42±2.1

2.2 Dust detection results and analysis

After systematic analysis and calculation, the detection and analysis results of dust distribution in each workplace of thermal power plant are shown in Table (2).

Table 2. Test results of dust distribution in each system of thermal power plant

Workplace of thermal power plant	Dust monitoring points (one)	Qualified points of dust concentration (one)	Average dust concentration (mg/m3)
Coal conveying system	82	73	10.71
Boiler operation place	220	185	5.16
Boiler maintenance site	42	8	9.06

The main dust concentration exceeding the standard of the coal conveying system is at the head and tail of the coal conveying belt and the pulverizing and conveying system. The highest dust concentration is 13.71 mg/m3, and the content of free silica in the dust is less than 10%. The main reason for exceeding the standard is that the dust-proof management of the coal handling system in individual thermal power plants can't keep up, and the facilities are neglected to maintain; The existing dust-proof equipment can't work normally, and there are no corresponding rules and regulations, so that it can't work well [7]. In addition, the decline of coal quality and the increase of coal consumption in small pits also aggravate the dust pollution of coal conveying system.

From the test results of boiler dust, the dust concentration increases with the increase of boiler height, and the average dust concentration at the top of the boiler is 7.42 mg/m3, which is higher than the average dust concentration in the middle of the boiler of 4.21 mg/m3 and the average dust concentration at the bottom of 3.85 mg/m3. The particle size of dust below 5 μm is the most harmful to human body, and its dispersion increases with the height. The reason is that the dust produced by various factors in the boiler operation flutters upward with the hot air around the boiler, resulting in the dust concentration and dispersion increasing with the height [8].

The qualified rate of maintenance dust is less than 20%, and the content of free silica in the dust is high. Among them, 81% of the monitoring sites have free silica content greater than 10%. Dust diffuses due to heat preservation during overhaul and dust accumulation during cleaning. At the same time, the dust concentration increases and decreases with the progress of the project, on-site disassembly and assembly, the walking direction of tools, equipment and personnel, and the changing wind source, and the over-standard rate is high [9].

3 Prevention and control countermeasures and suggestions

3.1 Improve the intact rate of equipment

Improve the management level of boiler and equipment, formulate dust-proof measures for boiler operation, strengthen daily monitoring and management of boiler operation, put an end

to positive pressure combustion and prevent leakage of furnace powder. Arrange the major, medium and minor repairs and equipment maintenance of the boiler, strengthen the daily monitoring of the boiler and equipment, improve the maintenance process of the boiler equipment, and treat the defective equipment in time to prevent the dust from escaping, escaping and leaking.

3.2 Reduce secondary dust sources

Before overhaul, clean water and vacuum adsorption should be used as much as possible, and dry cleaning should be used less to prevent dust and boiler dust from spreading. Dust on the ground, walls, building components and boiler body, and dust accumulated after equipment maintenance and major repairs should be cleaned regularly to avoid the formation of secondary dust sources. In addition to dust suppression, dust prevention, dust catching, dust discharging and dust blocking measures, auxiliary air supply and exhaust equipment should be reasonably installed on the boiler operating platform to reduce the dust concentration of the boiler operating platform by increasing ventilation.

3.3 Prevention and control of coal dust in coal conveying system

To give full play to the role of existing dust-proof facilities, it is necessary to strengthen maintenance and formulate corresponding rules and regulations. At the same time, effective dustproof methods are adopted, such as water washing, water spraying, water film dust removal, negative pressure cleaning, etc. Local ventilation can be used in the conversion part of coal feeding and powder conveying system to reduce the escape of dust. Strengthen the sealing of the coal hopper and the coal conveying belt, and set sprinklers at the coal unloading points, around the coal piles, and at the transfer station of the belly belt conveyor, so as to increase the coal humidity and reduce the amount of dust.

3.4 Establish regular inspection system

A regular inspection system should be established for dust workplaces in thermal power plants, and the operation and integrity of dust removal equipment and the implementation of various dust prevention measures should be checked in time. Strengthen the monitoring of free silica content in incoming coal, and restrict the coal with free silica content greater than 10% from entering the factory. Regularly classify the hazards of productive dust, evaluate the application effect of various dust-proof measures, and further play the role of dust-proof measures [10].

3.5 Use personal protective equipment

Personal protection is an important auxiliary measure in dustproof technical measures. Especially in the process of overhaul and maintenance, operators on duty and boiler overhaul and maintenance staff must wear dust-proof appliances in line with national standards before they can enter local areas with extremely high dust concentration such as boilers, coal mills, electric precipitators, etc., and work in dust dead corners.

4 Conclusion

In the process of effective prevention and control of dust hazards in thermal power plants, we should strictly follow the relevant regulations formulated by the state, rationally optimize dust-proof equipment and technology, realize automatic operation, cultivate employees' self-

protection awareness, and closely monitor the dust-proof work in the production process. Only in this way can we effectively prevent the harm caused by dust in thermal power plants to human bodies and greatly guarantee the life safety of employees.

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