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Study on Mine Pouring Dust Purification Based on Wet Multiple Louvers Method

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In order to effectively control the dust content of wind source and improve the quality of ventilation in underground mines. In view of the mine actual situation, the wet multiple louvers method is applied to purify the dust content of wind source in the underground metal mine ventilation. The dust in the air is compared and measured between before and after purification. The results show that the dust in the air after purification is decreased obviously, and pouring quality is greatly improved. This method can effectively control air quality of wind source in the underground mine ventilation, it can also optimize the ventilation network, reduce the wind resistance and improve ventilation efficiency.

1. Introduction

Dust removal is an important method that it can effectively improve the underground work environment. This method has received application earlier in the other industrial department, however, dust control technology in the underground mine is developed in recent decades (Joseph et al., 2012; Ding et al., 2011; Kanaoka et al., 2000). The reason is that there is complicated production condition in the underground mines. Due to operation space is narrow and changeful, dust removal equipment is necessary to ensure higher safety and special requirement, such as small volume, light weight, large processing air volume, high dust removal efficiency, convenient in operation and maintenance, etc. These requirements are often contradictory, and it is difficult to balance that problem (Han et al., 2011; Kvasnak et al. 1993; Mi et al., 2012; Zarei et al., 2010). These problem increases the difficulty of the development the mine dust catcher, affecting the development of the mine dust removal technology (Li et al., 2011; Chen, 2006; Chao et al., 2000).
With the progress of industrial production and science and technology, the basic theory, the dust removal technology and equipment and various aspects have made great development in the mine dust prevention work. In recent decades, the status of the mine dust, related management technology and equipment research began to be taken seriously, and the scientific research work has made remarkable achievements (Li et al., 2011; Ali et al., 2013). In the production conditions of drainage system is convenient, saturated water ore-bearing rock and wettability condition in the underground mines, the wet type dust collector has shown the obvious superiority (Ansart et al., 2013). Therefore, the development of new type wet dust catcher work is great important to purify air in the underground mines. A large of researchers combines a variety of dust removal mechanism at a dust removal device, in order to strengthen the dust removal performance and better meet the mine requirements of dust removal.

2. Engineering background

2.1 Background

Two diagonal ventilation systems were adopted in a certain underground lead-zinc mine. The main shaft and auxiliary shaft is located on the central of diggings. The main shaft is used for ascending minerals, and the auxiliary shaft is used to enter fresh air. In the design, the main shaft is not come into the fresh wind, but using the throttle control fresh wind. However, after the ventilation system operation, it is difficult to manage the ventilation system due to large development system, multi working face, need to much air volume, ventilation

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wind road is long and large ventilation resistance. In this regard, the main shaft is often used to enter fresh air. According to the relevant provisions, the main shaft cannot be used to enter fresh air. It is difficult to develop new auxiliary shaft during short term. In this ventilation system, the main shaft must be used to enter fresh air in order to meet the needs of mine production. Under certain conditions allowing main shaft enter into the fresh air, supplement the requirement of the underground work on air volume. In the actual production process, due to the main shaft resistance is small, large section, intake air volume is larger and dustiness is much, so that the wind flow quality is polluted.

According to the recently measured wind condition for -280 m level of main shaft, under the condition of closed the air leakage of dust concentration in the air is approximately 3.29 mg/m3. The downhole slip system in -415 m level is main area that so much is produced, leading to air is polluted. Generally, based on the result measured dust, the air dust concentration is fluctuated from 0.64 to 0.64 mg/m3. This value is above standard that the dust concentration of air coming roadway and mining work face are should not be more than 0.5 mg/m3. Therefore, the main shaft above two levels can't be used to regard as air coming roadway. In order to ensure that incoming wind dust concentration to achieve safety and health standards, it is necessary to take effective measures for Purification the air in the -280 m and 415 m level. In this regard, it can be the dust concentration to suit the requirements of the safety rules and the air volume of mine's production (Yahya et al., 2017). This research proposes a novel ventilation way that can adapt to the production development. It is very meaningful to improve the underground work environment and to ensure workers' health of body and mind.

2.2 In-situ measurement

In order to further grasp the detailed information and specific parameters determination of research plan, the second survey and measurement data is carried out in the field by research group. Some parameters is measured in the -280 m and -415 m level, such that wind speed, wind direction, air capacity, dust concentration, size of roadway, temperature and humidity environment. The testing process is shown in Figure 1. Left and right is show different testing location in the Figure 1. In the testing process, restricted by various conditions, leading to some data have not been collected effectively. The main test data and the results are shown in Table 1.

(1) -280 m level (2) -415 m level

Figure 1: The second field investigation and test pattern

Table 1: The measured data in the -280 m and -415 m level

Location	Dust concentration		Temperature (°C)	Humidity (%)	Velocity (m/s)	The size of roadway(m)			Remark
	All	Breathe				Roof	Bottom	Side	
-280 m Roof	1.25	0.476 0.449	25.6	82.3	0.41	3.115	4.214	3.130 2.372	
-280 m Bottom	3.25	0.942	26.4	81.6	0.94	2.810	4.531	1.627 2.030	
415 m Level	1.75	0.639	27.8	83.4	10.47	1.806	0.777	-	
415 m Level	1.73	1.020 0.820	28.1	81.5	10.46	1.990	1.981		
415 m Level	4.80	2.833	28.3	84.7	-	3.042	3.330	2.235 2.887	
415 m Level	4.50	2.700 2.070	28.2	85.2	0.5	-	-	-	

3. Purification scheme

3.1 Scheme choosing

Air dust removal technology is the use of two phase flow of gas-solid or liquid-solid separation principle trap in the gas solid or liquid particulate matter. The commonly used dust removal device include mechanical filter, wet dust collector, electrostatic precipitator, filter separator and bag filter. According to the actual environment in mines, the wet precipitator is used to purify mine air. The wet precipitator is separation unit between air dust and air using of liquid droplets or liquid membrane washing dust settlement. It is made up of water film dust catcher, spray tower, venturi scrubber tower separator and cyclone plate form.
Considering the environment and the actual situation, the dust cleaning system of main shaft should meet the following requirements in the present study.
1. To purify the air volume. 20 m3/s;
2. After purification dust concentration is lower than the relevant safety rules. <0.5 mg/m3;
3. To keep the dry air, the water mist must be avoided into auxiliary shaft during purification treatment.
4. Purification facilities cannot affect the normal production operation.
5. As far as possible use of the existing tunnel engineering and facilities.

3.2 Scheme designing

According to the result of dust removal scheme in the section 3.2, the main dust removal method and dust removal technology is adopted. The basic structure is shown in Figure 2.

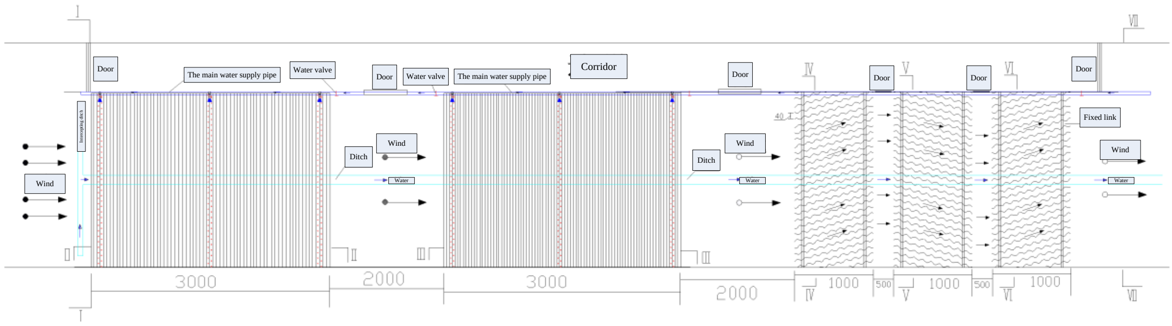

Figure 2: Dust removal scheme structure

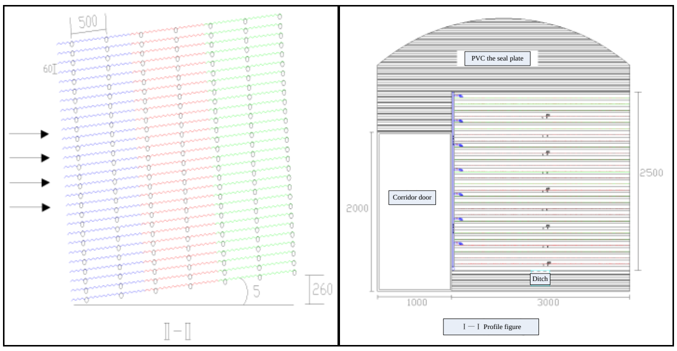

Figure 3: The left view (Left) and front view (Right) of first module

The first module is shown in Figure 3(Left). It is of 3 m in length, height of 2.5 m, each layer of 60 mm plate spacing and a total of 42 layer corrugated plate. Dust air will enter into the dust catcher from the left, plank forward inclination for 5°. The pipe bracket is designed a total of 7 row and 0.5 m per row spacing. Three-dimensional scaffold diagram is shown in Figure 4(Left). Three sides are sealed by using plastic plate in the first module. The spray water pipes are supplied through the external water pipes.
The entrance of the first module purification cross-sectional is shown in Figure 3(Right). A side is pedestrian passage and air-tight door, and intermediate entry is inertial filter of corrugated plate construction. The other part is closed by using corrugated plate and concrete. The drain is located in the middle of roadway, the section size is 0.3 m×0.3 m.

Water supply and sealing structure of spray system is shown in Figure 4(Right). The Spray water is supplied through the water valve. It is composed of 24 adjustable valves, and divided into 3 vertical rows. The external water supply structure of the first and second module water supply system is shown in Figure 5. The local water supply system structure is shown in Figure 6.

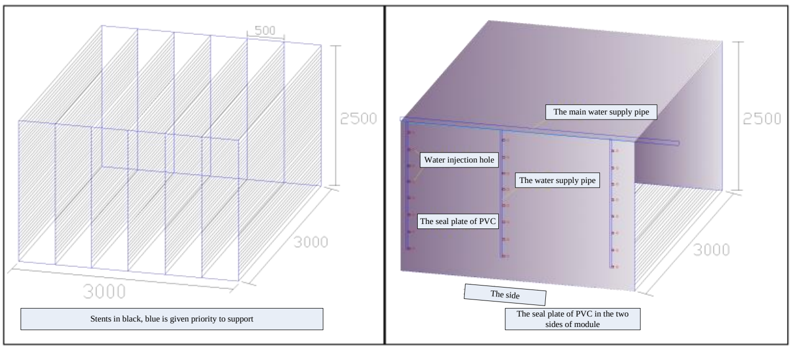

Figure 4: Three dimensional frame diagram and water supply pipe sealing structure

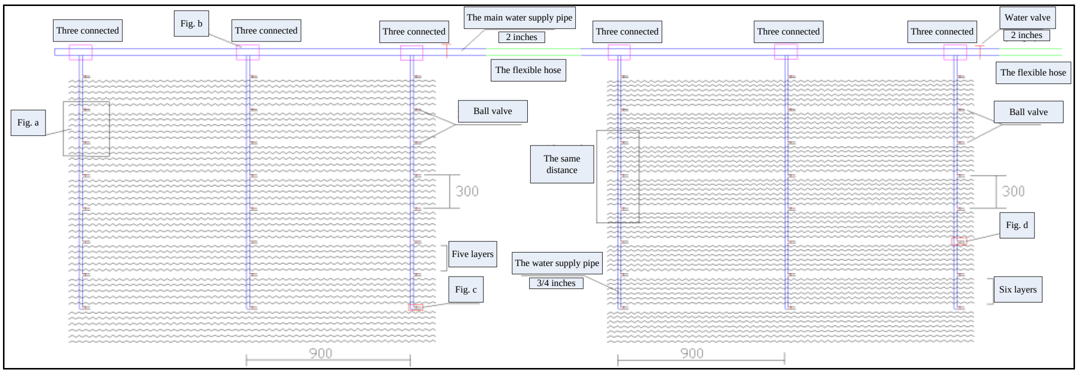

Figure 5: The water supply system structure of the first and second module

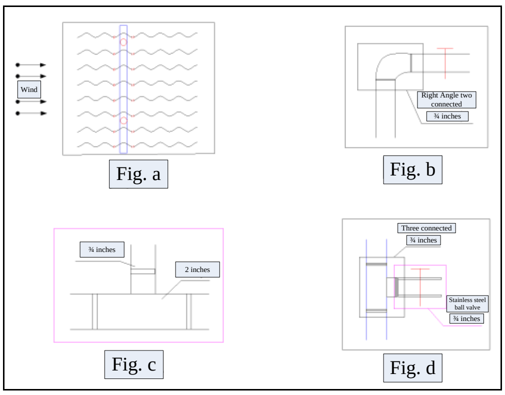

Figure 6: The section schematic structure of water supply system

The second module left view is shown in Figure 7(Left), it is basically the same to the first module structure. It is of 2.5 m in height, width of 3 m, each layer of 50 mm plate spacing and a total of 50 layer corrugated plate. The pipe bracket will be adjusted and other basic parameters unchanged. The third module left view is shown in Figure 7(Right). There is a total of three parts and have the same direction (15°). The efficiency of mist and dust removal will be improved by repeating the function of three parts.

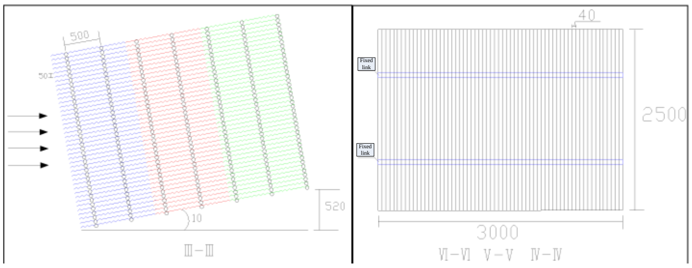

Figure 7: The left view of the second and third module

4. Purification scheme

According to the scheme design of section 3 and in-situ conditions, dust removal equipment was installed and debugged in the 280 m and 415 m level of main shaft. After a period of trial working, the purification of the main shaft air can meet quality requirements. Purification system working and purification affection have been tested by research group for the 280 m and 415 m level. In order to match the dust concentration of between before and after purification, a lot of parameters are tested in the field. The field test is shown in Figure 8. The tested result is listed in Table 2.

Table 2: The measured data in the -280 m and -415 m level after purification

Name		Entrance (Before)	Exit (After)	Remark
-280 m level	Temperature	22-23°C	20-21°C	
	Humidity	50-70%	60-85%	
	Wind velocity	2-3 m/s	2-3 m/s	
	Wind volume	15-20 m3/s	15-20 m3/s	
	Dust concentration	4-10 mg/m3	0.5-1.5 mg/m3	All
		1-3 mg/m3	0.15-0.45 mg/m3	Breathe
-415 m level	Temperature	22-24°C	19-20°C	
	Humidity	50-75%	90-95%	
	Wind velocity	1-1.5 m/s	1-2 m/s	
	Wind volume	10-12 m3/s	10-12 m3/s	
	Dust concentration	4-10 mg/m3	1-1.5 mg/m3	All
		1-3 mg/m3	0.3-0.48 mg/m3	Breathe

a) 280 m entrance

b) 280 m exit

c) 415 m entrance

d) 415 m exit

Figure 8: The device debugging in- situ

5. Purification scheme

According to the in-situ test and analysis in this article, the method of wet dust is used to purify air in the underground mine. It is shown that this method can effectively remove the dust in the air. Through the study of above all, the following conclusions were obtained.

1. This method meets the demand for fresh wind in the underground mines. The working environment of underground mines is improved strongly.
2. This research shown that optimization of ventilation quality by reducing the dust concentration can effectively reduce wind resistance and improve the work efficiency.
3. By the development for intake air purification project in the -280 m and -415 m level, a new way of ventilation using main shaft is proposed, and it has widely applied value.
4. By the purification engineering for main shaft ventilation in the -280 m and -415 m levels, providing about 30~40 m3/s of fresh wind for underground mines, effectively alleviate the ventilation pressure of underground mines.

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