

# Analysis and Optimization of Spray Structure for Mine Wet Dust Remover

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**Abstract:** Through the analysis of the relationship among spray and flow and performance of dust remover, it gets a better spray structure, and realizes the precipitator of low internal resistance and low water consumption combined with application environment. It proves by application in Jia-Yang mine of Sichuan Coal Group that the wet dust collector can effectively suck the dust air flow in the field, and the working environment of the working surface is obviously improved because the dust removal efficiency of the working face is 96.64%.

**Keywords:** Dust Remover; Spray; Resistance; Dust Removal Efficiency.

## 1. Introduction

A large amount of dust will be produced in the process of driving in the mine. In order to reduce the dust concentration in the working face, it is necessary to open the dust collector frequently, and the performance of the dust collector is very important. The mine wet dust collector is widely equipped with a single fan as the power, but the biggest problem of the single-stage wind type dust collector is that the static pressure is generally about 2100Pa, and its load capacity is low. Therefore, the improvement of low water consumption and low internal resistance of mine wet dust collector is of great significance to improve the performance of the dust collector. In this paper, by improving the dust removal effect of the dust collector and reducing the resistance Angle of the spray section, the spray structure of the dust collector is optimized.

## 2. Research on Optimization of Wet Dust Collector for Mine

### 2.1. Nozzle Selection

A large number of experiments and studies by scholars at home and abroad show that the smaller the particle size of the spray droplets in the wet dust collector, the higher the dust collection efficiency. Through the dust collection experiment on the solid cone nozzles and hollow cone nozzles developed by Chongqing Coal Research Institute, it is concluded that the solid cone nozzles participate in dust collection more droplets than the hollow cone nozzles in the same time, and the dust collection effect is good, which has been verified in the experiment. The experimental data are shown in Table 1.

**Table 1.** Comparative experimental data of dust removal efficiency of two nozzles

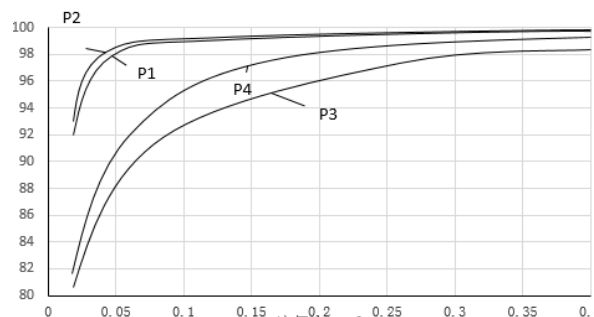
Nozzle pattern (Particle size 100um)	Air volume m <sup>3</sup> /min	Spray pressure Mpa	Spray flow L/min	Dust removal efficiency
Solid cone	249	2	13.2	98.8%
Hollow cone	254	2	12.6	93.6%

From the test results, the spray performance of the solid nozzle is better than that of the hollow cone spray, so the solid cone nozzle is selected. Under the condition of 2Mpa and

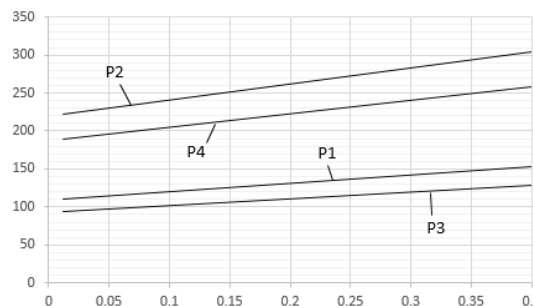
spray pressure, the spray flow rate is 2.2L/min, the atomization Angle is 35°, and the particle size is 101um.

### 2.2. Spray Method

In order to investigate the relationship between the spray flow rate and spray method and the internal resistance and dust removal efficiency of the experimental system under the same air volume and spray pressure, the dust removal efficiency and resistance under the conditions of forward spray (P1), reverse spray (P2), forward spray (P3) and reverse spray (P4) at the front end of the fan were tested. The test results are shown in FIG. 1 and FIG. 2.



**Fig 1.** Spray and dust removal efficiency characteristic curve



**Fig 2.** Spray and resistance characteristic curves

As can be seen from FIG. 1, under the conditions of various spray methods, the dust removal efficiency increases with the increase of spray flow rate. The dust removal efficiency of nozzle upwind jet is better than that of downwind jet. The dust removal efficiency of spray at the front end of the fan is better than that of spray at the back end of the fan. When P3 or P4 spray method is used, the liquid-gas ratio should be above

0.2L/m<sup>3</sup> to meet the 97% requirement. The adoption of P3 or P4 spray method, liquid gas ratio of 0.03L/m<sup>3</sup> or more dust collector can reach 97% of the requirements. Therefore, P2/P1 method can effectively reduce the spray flow of dust collector.

As can be seen from Figure 2, spray resistance increases with the increase of spray flow rate. The resistance of the nozzle in reverse injection is greater than that in forward injection. Both P1 and P2 spray methods can ensure the dust removal efficiency, but the resistance generated by P2 spray method is 100Pa larger than P1 at the liquid-gas ratio of 0.03L/m<sup>3</sup>, so the nozzle of the mine wet dust collector adopts P1 spray method.

### 2.3. Spray Structure

The air flow enters the fan, the air flow section becomes smaller and the air flow converges. The traditional spraying method is spraying the fan fairing, and the kinetic energy of the water droplets is large. A large amount of water mist hits the fan fairing to form water droplets, and the water flow forms the bottom of the dust collector with the convergence of the air flow.

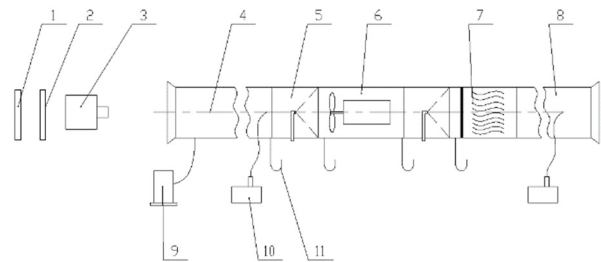
In order to reduce the waste of spray dust droplets, a new spray structure is designed. Spray on the perimeter of the fan, and the kinetic energy of the droplet at the edge of the spray is reduced, and it converges with the wind flow. This ensures that more than 95% of the spray particles flow to the fan channel to ensure the best dust collection capacity.

## 3. Comparison Test of Dust Collector Performance before and after Optimization

In order to investigate the performance improvement of the improved precipitator, the improved KCS-250D-I mine wet precipitator and KCS-250D mine wet precipitator are selected to test the performance parameters.

### 3.1. Test System

The arrangement of the experimental system is shown in 3. Firstly, dust is generated by the dust generator, and the dust-containing gas is sucked into the experimental system by an axial flow fan. The spray dust removal is started, and U-shaped tubes are arranged before and after the spray device to test the resistance of the spray section.



1- Thermometer; 2- barometer; 3- Dust generator; 4- Test the air duct; 5- Spray device; 6- Axial fan; 7- Dehydrator; 8- Test ventilator; 9- compensated micro pressure gauge; 10- Sampler; 11- U-shaped tube;

Fig 3. Layout of the experimental system

Table 2. Test of fractional dust removal efficiency of spray-improved dust collector

Size (um)	≥60	60~50	50~40	40~30	30~20	20~10	10~8	8	7	6	5	4	3	2
efficiency %	100	100	100	100	99.7	98.1	97.6	95.96	94.6	94.69	92.8	92.14	89.59	87.14

Table 3. Performance test results of two kinds of dust collectors

Dust collector	Air volume (m <sup>3</sup> /min)	resistance (Pa)	Load (Pa)	efficiency (%)	Liquid-gas ratio (L/m <sup>3</sup> )	Water pressure (MPa)
KCS-250D-I	250	880	660	98.6	0.05	2
KCS-250D	250	1100	410	97.3	0.18	2

### 3.2. Improved Classification Dust Removal Efficiency of Dust Collector

The fractional dust removal efficiency test was carried out on the spray improved dust collector, and the test data are shown in Table 2. From the classification dust removal table, it can be seen that the efficiency of spray improvement respirable dust removal can reach 92%, which is particularly beneficial to the prevention and treatment of pneumoconiosis.

### 3.3. Comparative Test of Dust Collector Performance Before and After Improvement

The comparison of the performance parameters of the spray optimized filter KCS-250D-i and the original filter KCS-250D is shown in Table 3.

It can be seen from Table 3 that after optimizing and improving the spray structure, the internal resistance of the dust collector is reduced by 220Pa, and the load capacity of

the single-stage fan can be increased by 10%. The spray flow rate is reduced from 45L/min to 12.5L/min, and the discharge of 15.6 tons of water can be reduced in one shift of coal mine. The dust removal efficiency is 1.3% higher than before.

## 4. Field Application

### 4.1. Current Status of the Working Face

The net section of the excavation face of Jiayang Coal Mine of Sichuan Coal Group is 8.9m<sup>2</sup>. The working face adopts the spray dust removal measures inside and outside the TBM. However, due to the low spray pressure, the spray nozzle atomization effect is poor. Coupled with the lack of effective filtration measures, the nozzle blockage phenomenon is more serious, which affects the dust removal effect of spray on the working face. After testing, the original dust concentration of the working face is 1183mg/m<sup>3</sup> when no dust prevention measures are taken.

## 4.2. Dust Removal System Layout

In order to effectively control the dust concentration of the working face, the working face adopts long pressure short suction ventilation dust removal technology. The system layout is shown in Figure 5. The dust collector KCS-250D-I dust collector is installed on the roadheader, and the dust collector cover is arranged on the turntable of the roadheader. At the same time, the dust collector is connected with the dust collector by using a skeleton air duct, and the skeleton air duct is arranged in the outlet of the dust collector to discharge the clean air treated by the dust collector to the tail of the runway of the second transport. Considering the large ventilation volume of the working face and the high wind speed of the working face, in order to avoid the large amount of dust caused by the direct impact of the pressure wind on the head, a wall attached wind duct is installed at the tail of the pressure

wind duct to convert the pressure air into a spiral air flow and form a barrier to prevent the diffusion of dusty air from the head.

## 4.3. Test Results

In order to investigate the dust control effect of the dust removal system on the working face, dust concentration tests were carried out on the working face before and after the measures, and the test results are shown in Table 4. It can be seen from Table 4 that the dust removal efficiency of the dust removal system reaches 96.64, effectively reducing the dust concentration of the working face and improving the working environment of the working face. At the same time, from the point of view of the dust removal efficiency of the dust collector, the dust removal efficiency is 98.88%, which is basically consistent with the laboratory test results.

**Table 4.** In-situ dust removal efficiency test of dust collector in coal mine

Driver's original dust concentration mg/m <sup>3</sup>	Existing dust concentration at the driver's location mg/m <sup>3</sup>	Dust concentration in the front section of the vacuum hood mg/m <sup>3</sup>	Tail dust concentration of dust collector mg/m <sup>3</sup>	Efficiency of dust %	The driver in the dust efficiency %
853	28.6	1183	13.3	98.88	96.64

## 5. Conclusion

(1) After optimized design, the final spray parameters of the wet dust collector are as follows: spray at the front end of the fan supporting the dust collector, forward spray, ring spray, liquid-gas ratio 0.05L/m<sup>3</sup>, and rinse spray at the back end.

(2) Through the field application, it is found that the dust collector can effectively suction the dust bearing air flow on the working face, and its dust removal efficiency is 96.64, which effectively reduces the dust concentration on the working face.

## References

- [1] XIE Yao-she. New respirable dust suppression systems for coal mines [J]. China Univ Mining & Technol, 2007, 17 (3): 321-325.
- [2] Ma Suping. Study on mechanism of dust removal by spraying [J]. Journal of China Coal Society, 2005, 30 (3):297-300.
- [3] Ma Suping, Kou Ziming. Research and Analysis of spray dust removal efficiency [J]. Journal of Taiyuan University of Technology. 2006, 37(3):327-330.
- [4] Cheng Weimin. Experimental study on the Relationship between nozzle spray pressure and atomization particle size [J]. Journal of China Coal Society, 2010(8):1308-1311.