Design and Study on 100 thousand m^3/h Ventilation Air Methane Collecting System

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Keywords: Ventilation air methane, Translational collection device, Industrial application, Environmental protection utilization.

Abstract: In view of the large amount of gas emissions from coal mines, causing environmental pollution and waste of resources, the research on ventilation air methane(VAM) collection technology has been carried out. This paper developed a new type of coal mine VAM collection device, completed the construction of industrial test system, and conducted on-site industrial tests. The system can meet the requirements of the collection quality of the wind, reduce the impact on the main fan of the mine ventilation, and at the same time be more cost-effective. In the test, the device reached a design air volume of 100,000 Nm^3 / h and the operation is safe and reliable, and the switching is smooth.

1. Introduction

It is well known that in the coal mining process, a large amount of Coal Bed Methane in the coal seams is poured into the mining space. One of the basic means of gas control is to use ventilation to eliminate. In order to improve the safety of coal mine production, a large amount of gas is discharged into the atmosphere with the mine shaft well ventilator. Therefore, the concentration of methane in coal mines is very low (less than 1%), and it is unstable concentration and large amount [1-3]. The direct discharge of VAM is not only aggravating the greenhouse effect, but also a waste of energy. Therefore, collecting and utilizing VAM to reduce greenhouse gas emissions has become an urgent task for China's coal industry to achieve national emission reduction targets. The collection device is arranged above the coal mine ventilation diffusion tower. The front end is connected to the main fan of the coal mine, and the rear end is connected with the utilization device. The device needs to provide a stable airflow for the utilization system, playing an important role in the connection.

2. The research status

The existing domestic air collection methods mainly include side pipe air intake and top isolation air intake. The top isolation type is divided into several different ways according to the type of isolation. At present, there are mainly several methods such as top louver gas extraction, top collection device gas extraction, and top collection tube gas extraction.

The project constructed in Binchang Mine in Shaanxi adopts direct gas extraction from the side pipeline. This project has two vertical diffusion towers, the amount of ventilation gas in this project is 690,000 m^3/h. The proportion of ventilation gas collection is 43%. This method of collection is simple and effective, but the way to open holes directly in the diffusion tower is not acceptable to all mines.

  DOI: 10.25236/epcimms.2019.13

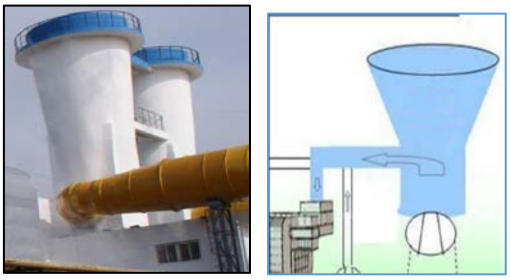


Fig.1 Shanxi Binchang ventilation gas collection method

The 12 sets of 90,000 m^3/h project in Shanxi Lu'an Gaohe Mine uses a wind-driven hood to collect ventilation air methane. This method is very efficient in collecting, but the investment is large and the implementation is difficult.

Fig.2 Shanxi lu'an Gaohe Mineventilation gas collection method

The top-isolated collection method is diverse in style and wide in applicability. It is more suitable for horizontal diffusion towers. Basically all horizontal diffusion towers use top-isolated collection methods. The main cases are as follows. Guizhou Jinqiao Coal Mine has built a 120,000 m3/h project, using the top-isolated blinds collection method. In this way, louver blades are used above the diffusion tower, and the wind collection is completed by pressure transformation inside the diffusion tower during operation.

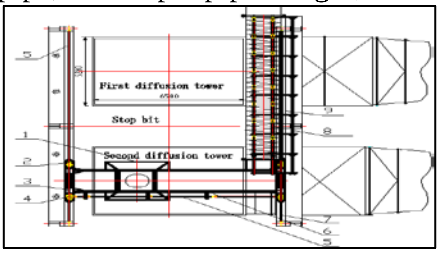
Fig.3 Guizhou Jinsha Mine ventilation gas collection method

According to the above research, the existing collection device structure has a large difference in collection efficiency. The existing devices are all fixed structures. When the subsequent combustion device is shut down, the collecting device is still installed above the air outlet of the diffusion tower and cannot be removed. This will not only have a resistance effect on the diffusion tower, but also leave a safety hazard. In order to solve this problem, this paper developed a parallel mobile collection system. Rely on the calculation to select a reasonable diameter and height of the hood to ensure stable design air volume during normal operation. When the ventilation fan is switched, the collecting device is completed in time to complete the switching. Flexible removal of the collecting cover when subsequent combustion units are not working. It is guaranteed that it does not affect the normal exhaust of the diffusion tower and is more economical.

3. The device structure and working principle

3.1 Parallel moving collecting device structure

The device adopts a parallel moving structure, and collects different air volumes by collecting cover at different locations. At the same time, the resistance to the main exhaust fan is effectively reduced. It is mainly used for ventilation and gas collection in the process of exhaust gas combustion, providing stable gas for subsequent utilization systems. The device mainly includes gas collecting cover, driven wheel, driving wheel, chain, connecting bridge, transmission shaft, track, collecting pipe, telescopic pipe, telescopic pipe hanger, column and so on.



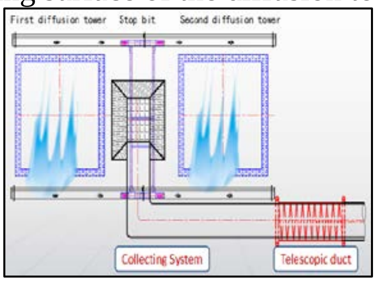
1-Collection cover 2-Driven wheel 3-Connecting bridge 4-Drive wheel 5-Drive shaft 6-Collection air duct 7- Rail 8-Telescopic air duct 9-Telescopic air duct hanger

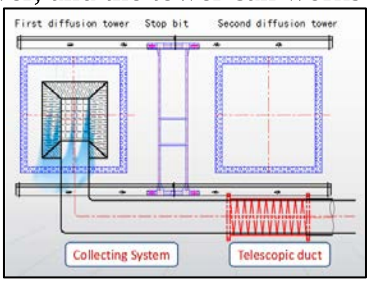
Fig.4 Parallel moving collecting device structure

The collecting cover is the main part of the collection system responsible for collecting the ventilation gas. Collecting pipeline links collecting cover and subsequent wind-utilizing devices. The parallel moving system including the driven wheel, the drive wheel, the chain, the connecting bridge, the drive shaft, the track, the telescopic tube and the like realize parallel movement of the collecting device, and the column provides support for the device. The parallel moving mechanism including the driven wheel, the active wheel, the chain, the bridge, the transmission shaft, the track, the telescopic tube realize parallel movement of the collecting device, and the column provides support for the device. The system does not affect the working state of the main exhaust fan of the coal mine, and it is more safe, economical and flexible.

3.2 Working principle

The collecting cover stops between the two diffusion towers before starting up, and the collecting hood starts synchronously when the back-end combustion equipment is started, as shown in Fig.5. As soon as the diffusion tower one is in operation, the collecting cover moves parallel under the traction of the power mechanism such that the center of the collecting cover is in a vertical line with the center of the diffusion tower. The gas enters the collecting cover under the action of the main exhaust fan and the combustion system induced draft fan. Then the gas passes through the collection line for operation of the thermal storage oxidation unit, as shown in Fig.6. If the exhaust vents switch, the second diffusion tower works, and the collecting cover is moved to the diffusion tower to collect. It is also can provide VAM for subsequent devices, as shown in Fig.7. When the combustion system is suspended, the collecting cover is completely removed from the working surface of the diffusion tower, and the tower can works normally without safety hazards.





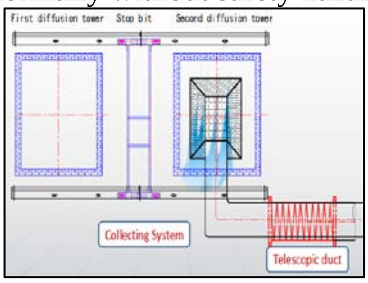


Fig.5 Stop bit Fig.6 No.1 diffusion tower Fig.7 No.2 diffusion tower

4. Design and calculation

The coal mine has two diffusion towers, one for standby. The distance between the two diffusion towers is 8.4m, the size of the air outlet is 5.3m×6.5m, and the air volume is about 790,000m^3/h. The back-end thermal oxidizer has a wind treatment capacity of 100,000 m^3/h. In order to reduce the impact of the collection system on the wind shaft ventilation, and save the control equipment such as large dampers at the same time, a parallel mobile collection system is used.

Collecting cover size calculation:

$$S_J / S_k = Q_J / Q_k \quad (1)$$

Where S_J is the area of the cover, S_K is diffusion tower air outlet area, Q_J is collecting air volume, Q_K is the gas amount of the tower.

In order to make the wind speed in the cover as uniform as possible and to improve the absorption efficiency, the diffusion angle of the cover should be no more than 60°. (Derived from the description of the external exhaust hood in the 08K106 industrial ventilation hood).

$$\partial = ATAN((\frac{L_C - L_P}{2}) / H) \quad (2)$$

Where ∂ is the diffusion angle, L_C is Collecting cover length, L_P is Collecting pipe diameter, H is the collection cover height.

Through calculation, the size parameters of the 100,000 m^3/h VAM collecting system were obtained.

Table 1 Main technical parameters

No.	Technical indicators	Parameter
1	Collecting cover size (m)	2.9×2.7-1.5×1.5
2	Collecting cover height (m)	1.5
3	Collecting cover wall thickness (mm)	6
4	weight (t)	4.02
5	span(m)	9
6	large wheel base(m)	2.5
7	Maximum wheel pressure	Fmax≈25kN

5. Collecting system industrialization test

5.1 Collecting air volume and concentration experiments

In order to investigate the collected air volume and concentration of the device, a flow sensor and a concentration sensor are provided. During the test, the rated condition of the combustion unit continued to work for about 35 hours, and the main fan frequency was maintained at 50 Hz. The switching valve works normally throughout the test. The average air volume during the experiment was 101,000 m^3/h. Since the gas concentration and pressure is fluctuate, the concentration of the mixture after blending fluctuates between 0.9% and 1.1%. The average concentration during the test was 0.95%. The collecting device achieves the expected design air volume and concentration, and meets the normal working requirements of the thermal storage oxidizing device.

5.2 Resistance test of the collecting device on the main fan

In order to detect the influence of the collecting hood on the main fan the working current, power and negative pressure of the fan in different states are recorded. First, record the working current, power, front end negative pressure and other data under normal working conditions. Then, move the collecting hood to the working position and open the main fan of the thermal storage oxidation system. After the unit is in stable operation, the operating current, power, front end negative pressure and other data of the axial flow exhaust fan are recorded again. The test data is shown in Table2. The results show that the collecting system can meet the demand of collecting air volume during work. The influence on the main fan current, power and other parameters of the system is less than 1%. The overall impact on the main exhaust fan is small enough to be acceptable.

Table 2 Ventilation main fan operating parameters

No.	Time interval	Working status	No.1motor current/A	No.2motor current/A	Power /kw	Pressure /mmH_2O
1	0:00 to 17:00	not collect	42.7	39.2	404.0	170.2
2	18:00 to 17:00 on the second day	not collect	42.8	39.1	401.6	168.3
3	18:00 to 8:00 on the third day	collect	42.8	39.1	398.6	165.4
4	9:00 to 17:00 on the fourth day	collect	42.9	39.1	400.0	165.8
5	Full-time data deviation	(L3 - L1) / L1	0.24%	-0.28%	-1.34%	-2.82%
6	Simultaneous data deviation	(L4 - L2) / L2	0.23%	0.00%	-0.40%	-1.49%

6. Conclusion

(1) Completed the design of the 100000m^3/h parallel mobile VAM collection device, including collecting cover, bridge, drive wheel, drive shaft, collection duct, track, telescopic duct, telescopic duct hanger and other components. The industrial system was completed in the coal mine.

(2) The test proved that the device can effectively collect VAM. It can meet the air volume and concentration requirements of the VAM for the thermal storage oxidizer. At the same time, the resistance to the diffusion tower is less than 1%, which does not affect the normal operation of the diffusion tower and the main fan of the wind row.

(3) Parallel mobile collection device can well meet the processing requirements of VAM for thermal storage oxidizer. It can effectively reduce methane emissions and has the dual benefits of energy saving and environmental protection.

Acknowledgements

This study was financially supported by the National Science and Technology Major Project of China (N0.2016ZX05045-006).

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