

A calculation method of the optimal distance of the long-drawn short-pressure type local fan in mine based on the principle of the jet and Suction volume

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Abstract. In order to dilute the harmful smoke and dust of the working surface in the production of the roadway in the mine shaft, the combination of mine local ventilation is often considered when conditions permitting. However there is no definite method to determine the distance between fan and working surface. Considering the concentration of smoke, the size of working face, the ventilation time, the wind speed of the working face and the principle of suction volume, this paper analyzes the long - drawn short - pressure type of the ventilation scheme, and presents an optimal algorithm for the distance between the exhaust ventilator and the working face:

$$L_o = \frac{(v_{ft})^2 S_o^3 \beta}{3.398 S_w \bar{A}}$$
. Then this paper presents a reference distance for different wind speed requirements of a project.

1. Introduction

With the development of productivity and the advancement of science and technology, people have paid more attention to themselves. Coal resources as the main energy of our country, on the one hand, for our country's socialist modernization construction it provides a strong support, on the other hand, the environmental problems caused by coal production links caused people more and more attention. In the process of mine production and construction, dust becomes the main factor that restricts the physical and mental health of miners. The large amount of dust produced by tunnelling will seriously endanger the health of workers, which is the main cause of pneumoconiosis. Therefore, it is necessary to make effective ventilation in the construction of roadway.

2. Ventilation status of excavation face

The ventilation mode of the current mining work in our country is mostly ventilated by the local ventilation fan, as a supplement to the ventilation mode of the full mine ventilation. At present, the ventilation modes of local ventilation fans mainly include pressing, extraction and mixing.

Press ventilator and its electrical equipment layout in the fresh wind of roadway, and its power is often larger, which can provide far enough for roadway ventilation. Besides, its tunneling working face wind speed is bigger, so it can effectively discharge fume produced by tunneling blasting, speed up the driving speed, and improve work efficiency. At the same time, the pressure into the local fan can use flexible duct, so that we can guarantee with the heading face advancing on the premise of not mobile local ventilator, can deliver wind for long distances.



The exhaust ventilator and its electrical equipment are arranged in the wind in the driving roadway. If the driving face produces gas, the gas may cause an explosion by pulling out the ventilator. Therefore, in the mine with excessive gas content, if the exhaust ventilator is used, the explosion-proof device should be installed for the exhaust ventilator. The fresh air flow can enter the working face along the roadway and can provide a good working environment for the workers in the driving area.

Mixing ventilation is the ventilation method of pressure ventilation and extraction ventilation, which combines the advantages of the extraction and the pressure type. Generally speaking, the distance from the heading surface of the press ventilator is less than or equal to $(4-5)\sqrt{S}$, and the distance of the exhaust fan from the heading surface is less than or equal to $1.5\sqrt{S}$. While taking the long-drawn short-pressure type local fan, apparently the distance of the exhaust fan from the heading surface is greater than $1.5\sqrt{S}$, namely for exhaust ventilator in the calculation method of heading face distance is not clear.

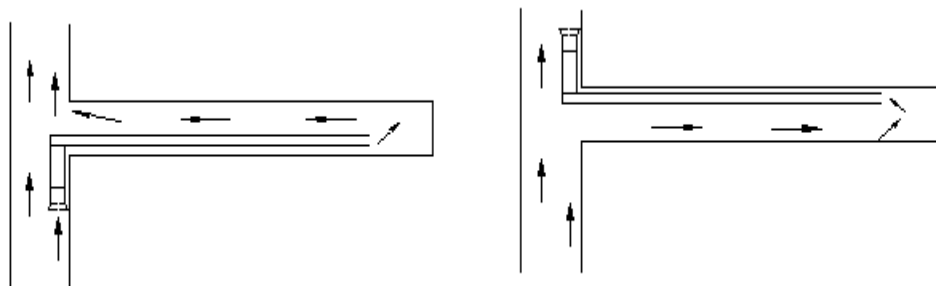


Figure 1. Press ventilation and extract ventilation schematic

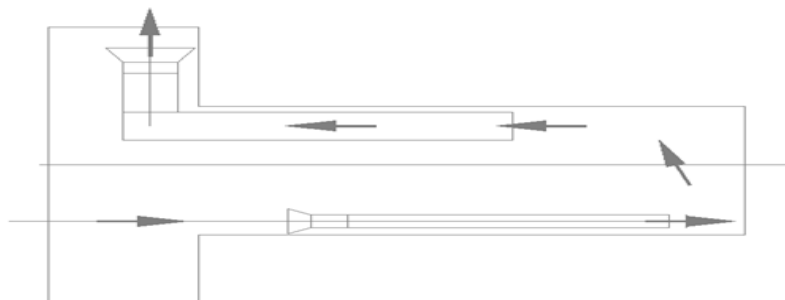


Figure 2. The long-drawn short-pressure diagram of mixed ventilation

3. Calculation method

For long-drawn short-pressure ventilation, the air pollution from the working surface is diluted by the pressure blower and discharged from the exhaust ventilator. First, the cylinder of the pressure ventilator is arranged, due to the requirement that the distance between the working face and the air outlet of the press ventilation fan should be within the effective range of the airflow, the airflow in the air outlet of the air blower is analyzed.

According to the principle of suction volume and jet, as shown in FIG(3), there are:

Wind line: $y = x \tan \alpha$;

The center line of the wind speed: $v = 2.28 v_1 \left(\frac{r}{x} \right)^{\frac{1}{2}}$;

Edge wind speed: $V_{\text{edge}} = \frac{2.28}{e} v$;

Among them, v_1 is the outlet wind speed, r is the wind tunnel radius, and α is the Angle of the wind line, usually $\tan \alpha$ takes 0.154.

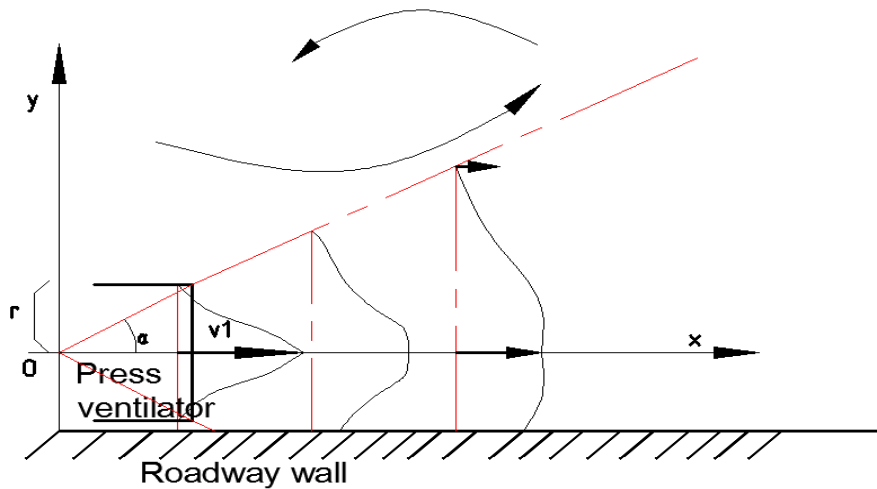


Figure 3. The drawing of the airflow in the air outlet

According to the provisions of the coal mine safety regulations, the minimum wind speed of the rock roadway must not be lower than 0.15m/s, and the minimum wind speed of the coal roadway and semi coal and rock roadways shall not be less than 0.25 m/s. As the wind speed increases, the dust in the working surface will gradually decrease. However, when the wind speed continues to increase, the dust concentration will be raised, so that the dust concentration will rise again, so in general, the optimal wind speed of the work surface v_f is in the range of 0.25-0.45.

Calculation of air demand in working face: $Q = \frac{19}{t} \sqrt{AL_0 S_w}$;

The effective distance of pressure fan: $x = \beta \sqrt{S_w}$; $\beta \in [4, 5]$

In this equation, L_0 is the distance between the exhaust ventilator and the working face, S_w is the area of work surface, and t is the time required for ventilation, A is the explosive consumption of the blasting. In the farthest edge of wind speed calculation,

$v_f = v_{edge} \cdot \tan \alpha$. Since the distance from the intersection of the wind boundary to the air duct is much smaller than the distance from the air duct to the working surface, x is approximately considered as the distance from the air duct to the working face, there are:

$$V_f = \frac{2.28 (\tan \alpha)}{e} \frac{\frac{19}{t} \sqrt{AL_0 S_w}}{S_0} \left(\frac{d}{x} \right)^{\frac{1}{2}}$$

The optimal distance of the distance of the exhaust fan from the heading surface:

$$L_0 = \frac{(v_{ft})^2 S_0^{\frac{3}{2}} \beta}{3.398 S_w^{\frac{1}{2}} A}$$

From the derived formula, it can be seen from the derivation formula that the optimal distance is related to heading face area, fan duct selected area, working face distance to press fan duct, required explosive quantity and dust removal time. When working face has a big area and explosive dosage is large, or the ventilator duct diameter is small and the required ventilation time is very short, we should reduce the distance of the exhaust ventilator; Since the exhaust ventilator has a certain counteracting effect on the airflow of the press ventilator, the distance from the exhaust ventilator to the working face should be increased when the required wind speed is higher. It should be noted that the distance between the suction vents of the exhaust fan and the press fan should be greater than 10m.

4. Verification analysis

A single heading of a mine is known, as shown in the figure, uses mixed ventilation. The model of the press ventilator is JF-42-2GS, the power is 4KW, the wind pressure is 1500Pa, the diameter of the ventilator is 300mm, and the total length is 59m; the model of the exhaust ventilator is JF-52-2, the power is 11KW, the wind pressure is 1700Pa, the diameter of the ventilator is 500mm, and the total length is 843m. The driving face area is 5.6m^2 , a blasting explosive quantity is 24.5 kg, ventilation time for 20 min. As shown in figure (4):

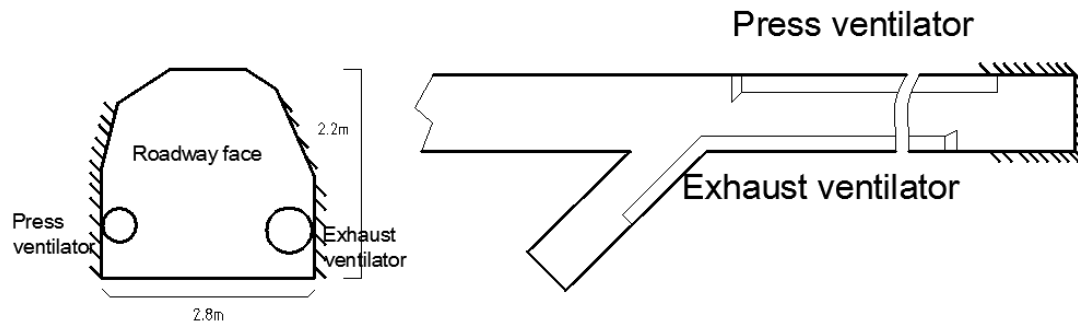
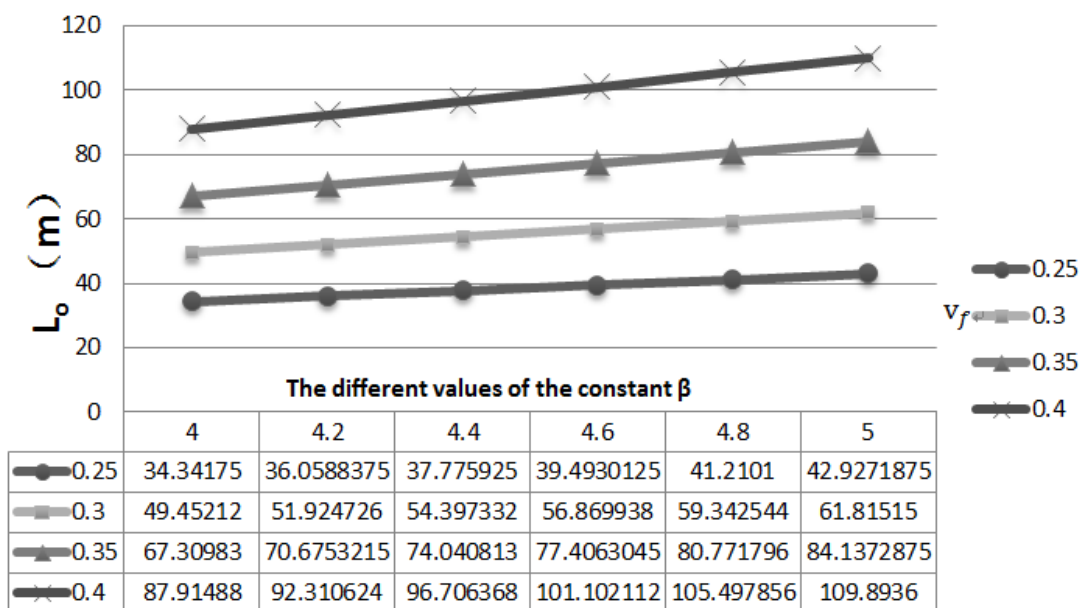


Figure 4. Section of roadway and local mixed ventilation diagram of roadway

It can be seen from above that the distance of the exhaust ventilator is determined by the distance of the pressure fan duct to the working surface. The distance $x = \beta \sqrt{S_w}$ is the empirical formula, and β often takes from 4 to 5, so the value of β is studied as the independent variable. In addition, according to the difference of wind speed required by the ventilation surface, the following results can be obtained from the different wind speed v_f required on the work surface, as shown in the figure below:

The optimal distance distribution of the exhaust ventilator from working face



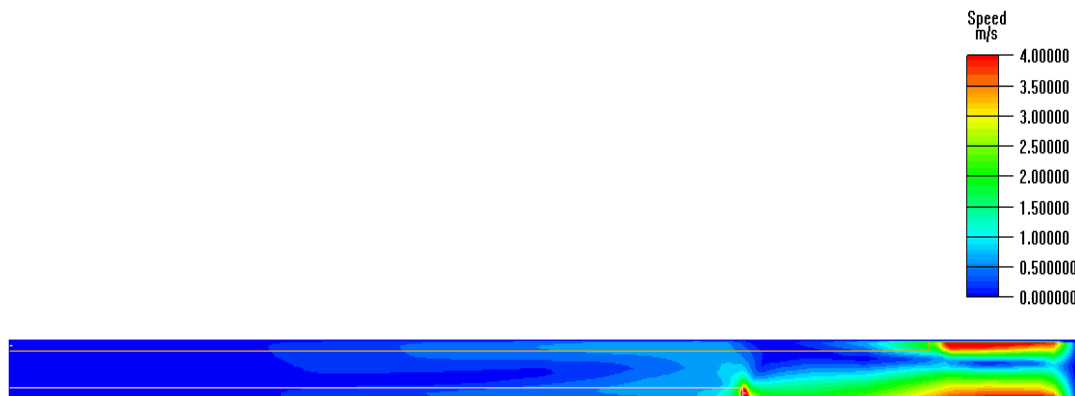


Figure 5. When β takes 0.4, v_f takes 0.3, 1.5 m high of the wind speed distribution
(Created by Fluent AirpakVer 3.0)

5. Conclusion

Under the condition of partial ventilation, the optimal distance calculation formula for blasting soot is calculated based on the operation process of various kinds of dust, considering the requirement of working face and the time of dust removal. Therefore, this equation can be applied to determine the optimal distance of the exhaust ventilator to the work surface according to the conventional parameters and the different values of the selected β and v_f , and no longer based on the experience to make the general inference, which is of great practical significance.

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