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Experimental Study and Analysis on Performance and Dedusting Efficiency of Frothing Generator

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Abstract: By simulating test and study in laboratory, the structure and performance of frothing generator were determined. The relative curves between the frothing volume and gas velocity of foaming net, supplying liquid volume and the content of foaming agent were obtained respectively. There were an optimum gas-velocity of foaming net, an optimum supplying liquid volume and an optimum content of foaming agent under the condition of the given material quality and shape of foaming net and spraying form. The spraying froth is of a great assistance in collecting respirable dust.

Key words: frothing generator; dedusting efficiency; gas velocity; frothing volume; liquid volume.

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1 Introductin

Froth dedusting utilizes the characteristic of surface-active agent. Foam dedusting agent is mixed with water for a certain proportion, a great quantity of high-multiple froth is produced by frothing generator [1]. Dust is collected by making use of no-porous froth cover and keeping from the dust resource. It relies on the action of interception, adhesive collision, wetting and so on. This method is more efficient for respirable dust particularly. Since froth dedusting has the characteristic of constructional simplicity, lower cost and lower loss of water, high efficiency for respirable dust and so on, it has been widely applied to dust control at present [2]. The main factors of affecting froth dedusting efficiency are the prescription of foaming agents, the structure of frothing generator and the methods of spraying froth. This paper aims to study the structure and performance of frothing generator, and to determine the characteristic parameters of frothing generator by experiment.

2 Structure and Operating Principles of Frothing Generator

The frothing equipment of water-force fluidics type and gas jets type is generally adopted by frothing generators for dust suppression. The frothing equipment developed by the authors and used in this test mainly consists of fan, foaming-net, spray-nozzle, pressure pump and supplying liquid flexible tube. The structure of frothing generator is shown in **figure 1**.

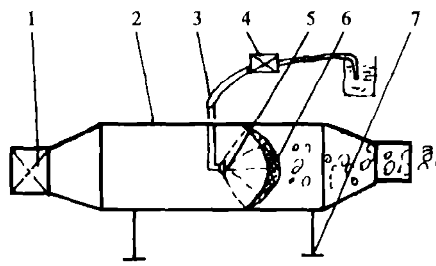

Figure 1 Structure of frothing generator, 1—fan; 2—frothing generator cover; 3—flexible tube; 4—pressure pump; 5—spray nozzle; 6—foaming net; 7—supporter.

2.1 Operating principles

The fan is taken as the gas resource. The water solution of foaming agent is well distributed and sprayed on the foaming net in a specially made frothing generator. A great quantity of high-multiple froth is successively produced by the action of forced gas-flow [3]. It is directly or through a pipe sprayed to the dust resource, and the purpose of dust suppression is achieved.

2.2 Structure of equipment

Fan: The gas volume and pressure of the fan is selected on the basis of the required frothing volume.

Liquid supply system: It is the main units of supplying foam solution in the frothing equipment that consists of pressure pump, flexible tube of liquid supply, liquid manometer, governor valve, foam solution case and so on. The prepared foam solution is exhausted

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from the solution case to the spray nozzle of the frothing generator.

Foaming net: It is an important unit to produce froth with the foam solution. The frothing volume is affected by the numbers of foaming net layer, the size of net hole and the net material properties. The test of frothing performance was carried out with five different kinds of net-materials at the same conditions. The test results show that the double-banked paraboloid or spherical surface cotton fabrics net is the best to produce good quality and large volume of froth.

3 Experimental Study of the Performance of Frothing Generator

3.1 Design of the experimental equipment and measurement of various parameters

The experimental equipment was designed to satisfy the experimental requirements as shown in **figure 2**.

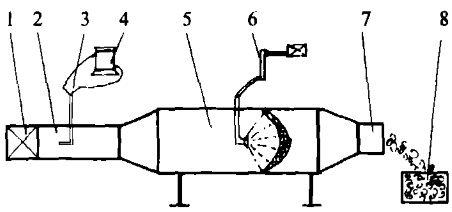

Figure 2 Experimental equipment, 1—fan; 2—measured duct; 3—Pitot tube; 4—micromanometer; 5—frothing generator; 6—flow meter; 7—froth outlet; 8—froth case.

(1) Measurement of gas quantity and gas velocity.

The gas pressure P_d (Pa) in the test duct is measured with a Pitot tube and micromanometer. Due to small diameter test duct, the gas velocity is measured at the centre-point [4]. The gas velocity V_1 in the test duct is

$$V_1 = k\sqrt{\frac{2gP_d}{\rho_g}} \quad \text{(m/s)},$$

where k is the correlating coefficient of the Pitot tube; g the gravitational constant, m/s^2; ρ_g the gas density, kg/m^3.

The gas volume of the frothing generator Q_g is

$$Q_g = V_1 S_1 \quad (\text{m}^3/\text{s}),$$

where S_1 is the cross-sectional area of the test duct, m^2.

The gas velocity of the foaming net, V is

$$V = \frac{Q_g}{S} \quad \text{(m/s)},$$

where S is the cross-sectional area of the foaming net, m^2.

(2) The measurement of flow volume of foam solution.

A flow meter is equipped between the pressure pump and the spray nozzle, and the liquid supply volume of foam solution Q_l is directly measured in the flow meter [5].

(3) The measurement of frothing volume.

A large froth case is laid at the outlet of the frothing generator. The frothing time in which the case is full of froth is measured. Then the frothing volume per unit time is calculated which is marked as Q_f [6].

3.2 Experimental results and analysis

(1) The relationship between the frothing volume Q_f and liquid supply volume Q_l.

For different gas velocities of foaming net, the relative curves between Q_f and Q_l, are given in **figure 3.** In the test, the volume fraction of foaming agent is 0.5%. The curves in figure 3 show that Q_f increases with increasing Q_l as the gas velocity or volume is constant. It increases rapidly at first, and then is gradually getting slower. It is showed that Q_f increases no more after Q_l reached a certain value.

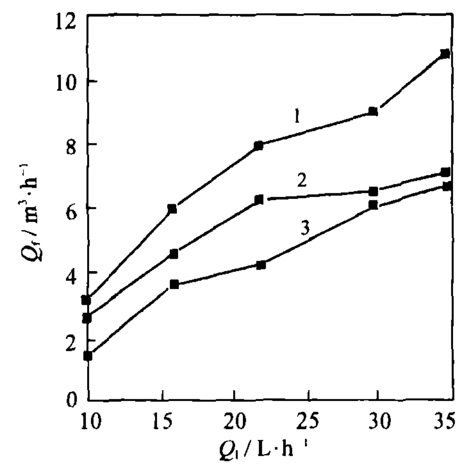

Figure 3 The relationship between the frothing volume (Q_f) and liquid supply volume (Q_l), 1—V=2.21 m/s; 2—V=2.85 m/s; 3—V=3.31 m/s.

(2) The relationship between the frothing volume and the gas velocity of foaming net.

For different liquid supply volume, the relative curves between frothing volume (Q_f) and gas velocity of foaming net (V) are obtained from the laboratory test as shown in **figure 4**. In the test, the volume fraction of foaming agent is 0.5%. The curves in figure 4 show that Q_f increases with the increasing V within a certain range, but it will decrease with the increasing V exceeding the certain range as the liquid supply volume is constant. Moreover, it is also found that the flying froth and spraying droplets at the outlet of frothing generator are produced at higher V. In consequence, there is an optimum V value under the condition of the given structure

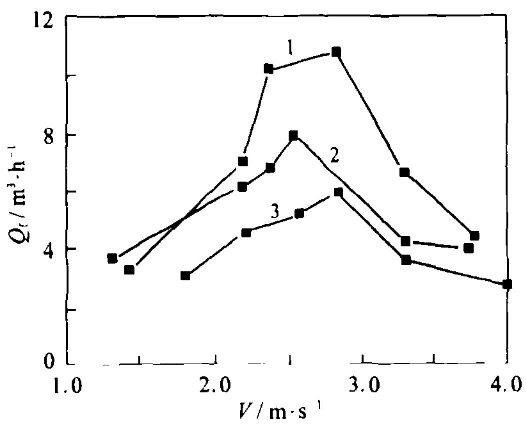

Figure 4 The relationship between the frothing volume (Q_f) and the gas velocity of foaming net, 1—35 L/h; 2—32 L/h; 3—16 L/h.

of frothing generator and the given material quality and shape of foaming net. The optimum V value in this test is 2.4–3.0 m/s.

(3) The relationship between the frothing volume Q_f and the volume fraction of foaming agent φ.

For different liquid supply volume, the relative curves between frothing volume Q_f and volume fraction of foaming agent (φ) are obtained as shown in **figure 5**. In the test the gas velocity of frothing net is 2.85 m/s. The curves in figure 5 show that Q_f increases rapidly with increasing V at first, and then decreases with increasing V after φ reaches 0.8%. This illustrates that there is an optimum φ value for a maximum Q_f. The optimum φ value in this test is approximately 0.5%–0.8%. In addition, from the experiment it is discovered that the more the number of the foaming net layer is, the less the frothing volume and the higher the stable time of froth are. As the outlet area of the frothing generator becomes smaller, the frothing volume and the frothing diameter are accordingly getting smaller. Therefore, the number of foaming net layer and the outlet area of frothing generator are determined in accordance with practical requirements.

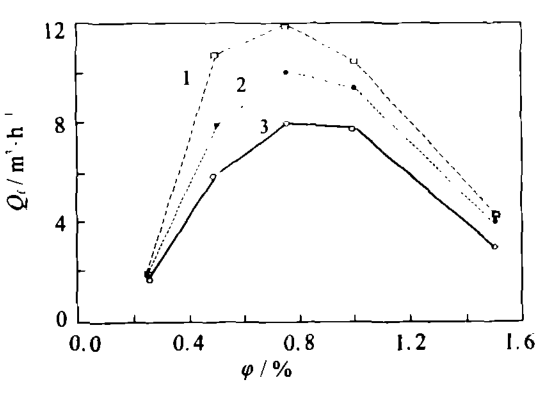

Figure 5 The relationship between the frothing volume (Q_f) and the volume fraction of foaming agent (φ), 1—35 L/h; 2—22 L/h; 3—16 L/h.

(4) The determination of the performance of frothing generator.

For satisfying different dedusting conditions, the different constructive sizes of frothing generators are determined in accordance with the experimental size of the frothing generator and the analysis of test results in laboratory. If the frothing volume is about 1 m³/min, the outside size of the frothing generator and its frothing performance are as follows.

Frothing volume: 0.8–1.2 m³/min;

Foaming multiple: 200–400;

Stable time: 15–30 min;

Content of foaming agent: 0.5%–0.8%;

Liquid supply pressure: 0.2–0.4 MPa;

Liquid supply volume: 2.5–5 L/min;

Gas velocity of foaming net: 2.4–3 m/s;

Outside diameter of frothing generator: 200 mm; length: 1000 mm.

4 Measurement of Froth Dedusting Efficiency

For determining the effect of froth dedusting, the dedusting apparatus of the fixed-point dusting resource is experimentally simulated. In which talcum powder is adopted as the test dust and the dust concentration are measured by filter-paper-strain method. The dust size distribution is measured by optical stage micrometer. The dedusting efficiency is respectively measured in spraying water and froth. The relative curves between the dedusting efficiency η and dust particulate diameter d_p are drawn from the experimental results as shown in **figure 6**. The curves in figure 6 show that η increases with increasing d_p, the respirable dust η is more than 85% in spraying froth,and only 10%–32% in spraying

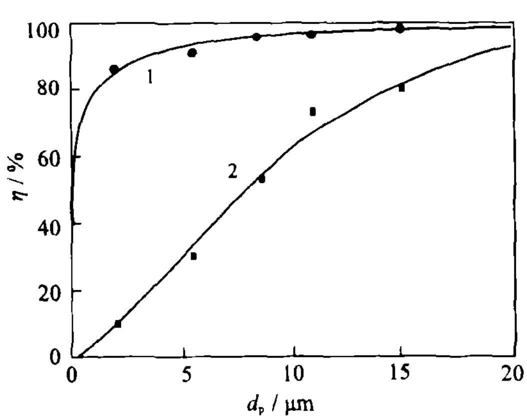

Figure 6 The relationship between the dedusting efficiency (η) and dust particulate diameter (d_p).

water.

5 Conclusions

(1) The volume of frothing performance depends mainly on the structure and form of frothing generator. There is an optimum velocity of foaming net under the condition of the given structure of frothing generator and the given material quality and shape of foaming net. In this test, the gas velocity of foaming net is about 2.4–3 m/s.

(2) The key factors of frothing generator are the material quality and shape of foaming net, and spraying form. The double-sphere surface cotton net and centrifugal spray nozzle are adopted in this test.

(3) The stable time of froth is related with the volume fraction of foaming agent and the number of foaming net layer besides adding the stable agent in the prescription of foaming agent. It is general that the larger the volume fraction of foaming agent, the more the number of the foaming net layer, the smaller the froth diameter, the longer the stable time, and the lower the frothing multiple.

(4) The froth dedusting efficiency may reach more than 90%, and the collection efficiency of respirable dust is more than 85%. The dedusting efficiency of spraying froth is much higher than that of spraying water, while its consumption of water quantity is only 1/4–1/5 of spraying water.

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