Design of bag filter for micro pulverizer

Mingming Liu¹, Ning Wang¹, Ying Shan¹, Peiyuan Zhao¹
¹Mechanical and Electronic Engineering College, Shandong Agriculture And Engineering University, Jinan, Shandong Province, P.R. China 250100
lmmjx@126.com

Abstract. In feed industry, a lot of dust will be produced in the process of raw material commination, which will cause environmental pollution and be harmful to the health of workers and so on. In this paper, a kind of bag filter for micro pulverizer in feed industry is designed. The bag filter was firstly carried out, including the design of the overall scheme, the calculation of filtering wind speed, the filter bag parameters, the blowing component system, and the specific structure design of the dust collector according to the dust processing capacity and dust characteristics. The test proves that this bag filter has an average dust removal efficiency of more than 96%, which can effectively deal with the dust generated by the micro pulverizer, and provide an application reference for solving this type of dust pollution treatment.

1. Introduction
The crushing of feed raw materials is one of the most important processes in feed processing, which is an important factor affecting feed quality, yield and processing cost. A large amount of dust is produced in the crushing process of feed raw materials, which not only causes some difficulties to the actual operation, but also pollutes the air and affects the health of the workers[1]. In this paper, a bag filter is designed for the dust characteristics generated by the micro pulverizer, the required air volume required by the crushing system, and the operating conditions of the surrounding equipment. It is used to collect the dust generated around the micro pulverizer, so that the dust concentration at each operation point can be reduced to 2mg/m³, and the overall dust removal efficiency is above 96%.

2. Application site and technical parameters of a micro pulverizer dust collector

2.1 Application place
The schematic diagram of the application site of the bag filter for the micro pulverizer is shown in Figure 1. The feeder receives the materials waiting to be crushed and evenly delivers them to the micro pulverizer. The micro pulverizer is responsible for the granular material grinding into powder material (finished powder products). The powder materials are deposited into the material below the screw conveyor. The screw conveyor delivers the powder materials to the next process or directly packs them. A large amount of dust suspended in the air will be generated in the above process. For the dust suspended in the air, an air suction hood is adopted to suck the dust into the air inlet at the bottom of the bag filter. The dust is filtered through the bag filter to prevent the dust from flying in the air.
Figure 1. Schematic diagram of application site of bag filter for micro pulverizer
1. Feeder 2. Micro pulverizer 3. Bag filter 4. Screw conveyor

2.2 Technical parameters of micro pulverizer

| Power (Kw) | Speed (r/min) | Size of input granules (mm) | Crushing fineness (meshes) | Disposing air quantity (m³/h) |
|------------|---------------|-----------------------------|---------------------------|-----------------------------|
| 0.75       | 1400          | 200                         | 60~120                    | 475                         |

3. Overall scheme design of bag filter

3.1 Overall structure of bag filter
The overall structure design of the bag filter is composed of fan, purification room, injection system components, dust-containing gas room and other parts, as shown in figure 2.

Figure 2. General structure diagram of the bag filter
1. Fan 2. Injection system components 3. Purification room 4. Dust-containing gas room

3.2 Working principle
The dust-containing gas enters the dust-containing gas chamber from the bottom of the box, and the dust with a larger particle size settles first. The dust with a smaller particle size becomes purified air after filtering through the filter bag, which enters the clean air chamber and is discharged from the outlet. The dust is blocked on the outer surface of the filter bag. When the dust on the surface of the filter bag reaches a certain amount, the dust must be removed. During ash cleaning, the high-pressure airflow triggers the solenoid valve jets in sequence according to the set requirements by the pulse
controller, enters the filter bag through the nozzle, and the filter bag expands sharply, so that the dust accumulated on the surface of the filter bag is shaken off. Such periodic pulse blowing will make the filter bag in an effective filtering state and ensure the normal operation of the dust removal system.

4. Parameters and structure design of bag filter

4.1 Determination of filtering wind speed

Generally, the filter wind speed of the pulsed bag filter is between 0.8 to 1.5m/min. Through analyzing the particle size and characteristics of dust in the field, and combining with the adsorption experiment effect in the field, the design was determined to take 1m/min. According to the technical parameters of the micro pulverizer mentioned above, the required treatment air volume is 475m³/h. Considering the air resistance of the bag filter, the type of fan of the bag filter is selected as 9-19-4.2C. According to the formulas:

\[ V = \frac{Q}{60V} \]

In the formulas: S is the total filtering area of the filter bag, Q is the processing air volume required by the pulverizer, and V is the filtering air speed.

4.2 Filter bag design

The dust produced by the micro pulverizer has the characteristics of larger particle size and lower density and works at normal temperature, so this design selects the polyester needle felt filter bag. According to the market supply, the size of filter bag is 120mm in diameter and 1500mm in height. The filter area of bag filter is 7.92m². According to the formulas:

\[ S = \pi DL-S_1 \]

\[ S_{\text{total}} = nS \]

In the formulas: S is the filtering area of a single filter bag, D is the diameter of the filter bag, L is the height of the filter bag, S₁ is the filtering area (5% - 10%), S_{total} is the total filtering area, and n is the number of filter bags.

According to the formula (4-3):

\[ S = \pi DL-S_1 = 3.14 \times 0.12 \times 1.5 - 3.14 \times 0.12 \times 1.5 \times 0.08 = 0.508 (m^2) \]

According to the formula (4-4), the number of filter bags required is:

\[ n = \frac{S_{\text{total}}}{S} = \frac{7.92}{0.508} = 16 \]

Considering the symmetry of the filter bag structure and the convenience of maintenance and cleaning in the later stage, the layout design of the filter bag is 4 square rows and 4 columns, and the center distance between the two holes is 160mm, as shown in figure 3.
4.3 Design of injection component system

The function of the injection component system is to shake off the dust on the surface of the filter bag and ensure that the filter bag has the ability to filter normally and efficiently. The injection component is mainly composed of the air receiver, solenoid valve, injection pipe, injection nozzle, pulse controller, etc. The design of specific structure is shown in Figure 4.

The blowing pipe is welded with DN40 seamless steel pipe to form the blowing pipe circuit. The solenoid valve selects GOYEN Ø40mm solenoid valve. The discharge flow of the magnetic valve is calculated according to the formula:

\[
Q = \frac{198.3 \times Cv \times P_1}{\sqrt{G}} = 71.1/0.15s
\]

The air receiver can store a certain amount of compressed air to meet the needs of soot blowing. The compressed air enters the air receiver after being filtered the dust, water and oil through the air source processor, and then enters the injection device under the control of the solenoid valve to realize the dust cleaning. The necessary volume of the pressure vessel can discharge 71 / 0.15sec of flow air storage volume:

\[
V = \frac{Q}{P_1 - P_2} \frac{71100}{1.4} = 50.78 \text{ (L)}
\]

In the formula, V is the flow, P_1 is the pressure before ash cleaning, and P_2 is the pressure after ash cleaning.
The nozzle is the end device to realize the ash removal by compressed air. The nozzle is provided with a row of jet holes arranged according to a certain rule, which are aligned with the filter bag mouth. The diameter of the nozzle is determined by the formula:

$$\phi_p = \sqrt{\frac{C d^2}{n} \sqrt{\frac{0.55 \times 40^2}{16}}} = 7.4 \text{ (mm)}$$

In the formula: $\phi_p$ is the average diameter of the nozzle, C is coefficient (50%-65%), n is the number of injection holes, and d is the outlet diameter of the pulse valve.

Pulse controller is the main control equipment of the dust remover blowing and cleaning system. Among them, the correct setting of pulse width and pulse interval is the key to the normal operation of the ash cleaning system. The model of the pulse controller is YM-ZC-6-16D, which the range of pulse width adjustment is 0.03 to 0.3 seconds, the range of pulse interval adjustment is 3 to 60 seconds, the input voltage is AC220V, the output voltage is DC24V, and 16 output circuits.

4.4 Structural design of the bag filter

The frame structure of the bag filter is the framework of the whole bag filter, and the other parts of the bag filter are fixed on it. The bag filter frame is mainly composed of two parts: a clean room and a dust-containing gas room. The bag filter purification room is a closed chamber formed by the wall panels formed by bending steel plate and connected by bolts. The gas in the purification room is the clean gas formed after filtering by the bag. The purification room is mainly used for installing the spray pipe, nozzle and other parts. The dust-containing air chamber is a closed chamber connected by the wall plate bending and forming through bolts, which provides space for the filter bag to filter the dust. The dust-containing air room is mainly used to install the bag frame, filter bag and other components. An inspection door is designed on the dust-containing air room. Opening the inspection door can facilitate the installation and maintenance of the filter bag. The structure design of the bag filter is shown in Figure 5.

Figure 5. Structure of bag filter
1. Clean room 2. Dust-containing gas room 3. Inspection door

5. Conclusion

In this paper, a kind of bag filter is designed for the micro feed pulverizer. The overall scheme is designed and the key parameters of the filter are calculated. The field test shows that the average dust removal efficiency of the bag filter designed by this method is more than 96%, which can effectively deal with the dust produced by the micro pulverizer and provide an application reference for solving this kind of dust pollution.
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