Influence of Feeding Speed on Gas Flow Acceleration Classification and Drying for Filter Cake Treatment

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Abstract. As solid waste processing facilities deal with increasing amount in combination with enhanced environmental pressures, gas flow acceleration classification and drying is becoming one of the promising methods for filter cake treatment. The influence of feeding speed on gas flow acceleration classification and drying for filter cake treatment was investigated in terms of classification efficiency, purity and recovery proportion. The optimal feeding speed was 0.8 kg/h was the optimum feeding speed; at the same time, the diatomite recovery proportion was 41.7%. The present study could also provide an experimental basis for optimizing filter cake treatment process.

1. Introduction

Gas flow acceleration classification technology has been widely used in the fields of processing non-metallic minerals, recycling and utilizing electronic waste, sorting municipal waste and treating industrial waste [1-4]. In this paper, the gas flow acceleration classification and drying technology was used for filter aid recycling, which made the filter aid can be used many times and the amount of filter aid reduce; at the same time, the filter cake was dried, so that the collected sludge with low water content, which is convenient for subsequent treatment and provided a new idea for precoat filtration cake treatment environmental-friendly [5-6].

The filter cake obtained from diatomite precoat filtration for wastewater was selected as the classification object. The possibility of gas flow acceleration classification and drying technology applied to the precoat filter aid classification recovery and sludge drying was discussed [7-8]. The influence of gas flow temperature on moisture content, water removal efficiency, classification efficiency, and purity of export materials was investigated. The best feeding speed was found by these index.

2. Experimental

2.1. Methods

The precoat filtration and pulsating gas classification drying process studies were performed using the set up shown in Fig.1. Diatomite was used as filter aid. First, water and diatomite were added to the tank (4), then the compressed air was passed through the precoated liquor tank, a diatomite precoat
layer was formed in the precoat filtration machine (6). After the formation of coating layer, the wastewater was filtered through the prepared diatomite coating layer. The valve path of wastewater filtration was opened, the compressed air was passed through into the wastewater tank (3), and the wastewater was squeezed into the precoat filtration machine. The filter cakes (7) were collected in a filter cake collection tank (8), and the filter cake was composed diatomite precoat layer and sludge cake. These steps were repeated several times to prepare 3–4 kg filter cake for subsequent gas flow acceleration classification and drying experiment.

The diagram of gas flow acceleration classification and drying for precoat filtration cake experimental device is shown in Fig.2. With the fan and the pulsating airflow generator, the air produced a sinusoidal and cosine pulsating airflow. Then, the air was heated to the required experimental temperature in the gas heater. After the preparation of the filter cake, in order to facilitate the screw feeder feeding, the filter cake was manually chopped and was added to the screw feeder hopper; and the chopped filter cake was added by the screw feeder and was sent to gas stripping cyclone through the high temperature air. The gas stripping cyclone can increase the mass transfer between the high temperature gas and the diatomite, thereby achieving a better drying effect.

After deep dewatering by the cyclone, the dried diatomite and sludge slid into the gas flow acceleration classification device to classify the diatomite and sludge. The structure of gas stripping cyclone and the cyclone was basically the same, but the diameter of the bottom pipe of the gas stripping cyclone was much smaller to ensure that only diatomite and sludge can slide out of the underflow tube, and the air cannot influence the gas flow acceleration classification column to maintain the balance of the flow field.

The diatomite and sludge that entered the gas flow acceleration classification column were collected from the top and bottom outlets of the classification column due to the difference in density, respectively. The diatomite at the top outlet had bottom density, and entered the subsequent dust-removing cyclone together with air. The diatomite was collected at the bottom of the cyclone, and air escaped from the dust-removing cyclone outlet. The equipment had the advantages of small occupied area, continuous operation, good filter cake drying effect, high classification efficiency, integrated drying and classifying function, and diatomate recycling and filter cake amount reduction was realized.

Fig.1 Preparation of filter cake with diatomite precoat filtration for wastewater1-compressed air bottle; 2-valve; 3-Container with wastewater; 4-Container with diatomite solution; 5-Pressure gauge; 6-Precoat filter; 7-Permeate collection beaker; 8-Electronic balance; 9-Portable Raman spectrometer
2.2. Materials
The diatomite was supplied by Aladdin Reagent (Shanghai) Co., Ltd. Polyethersulfone membranes were purchased from Haining Zhengda Filter Equipment Co., Ltd. (China). Deionized water was obtained from Macklin Co., Ltd. (Shanghai). The wastewater was obtained from Shanghai Xinzhuang Wastewater Plant and stored at 4 °C to maintain the quality.

2.3. Classification effect evaluation index
After being classified by integrated gas flow acceleration classification and drying equipment, the samples were collected at the top and bottom outlets. The sample collected from the top outlet, that is the bottom outlet of the cyclone, was sieved to obtain the mass was \( m_t \); the top diatomite, the top sludge mass was recorded \( m_{w1} \), and the total mass of the top export \( m_v \). The sample collected from the bottom outlet of gas flow acceleration classification column was sieved to obtain the sludge mass \( m_{w2} \), the bottom outlet diatomite mass was \( m_{gt} \), and the total mass of bottom outlet \( m_x \). According to the above data, the diatomite classification efficiency \( \eta_g \), sludge classification efficiency \( \eta_w \), total classification efficiency \( \eta_t \), the diatomite purity of the top outlet \( p_{gt} \), and the sludge purity of bottom outlet \( p_{w2} \) can be calculated [11-12]. \( c_1 \) reflected the top outlet recovery, \( c_2 \) reflected the bottom outlet recovery. The classification efficiency was calculated from Eqs. (1) to (3), and the purity were calculated from Eqs. (4) and (5), respectively. \( c_1 \) and \( c_2 \) were calculated from Eqs. (6) and (7).

\[
\eta_g = \frac{m_{gt}}{m_d} \times 100\% \quad (1)
\]

\[
\eta_w = \frac{m_{w2}}{m_d} \times 100\% \quad (2)
\]
\[ \eta_i = \left( \eta_g \times \eta_w \right)^{\frac{1}{2}} \times 100\% \]  

(3)

\[ p_{g1} = \frac{m_{g1}}{m_i} \times 100\% \]  

(4)

\[ p_{w2} = \frac{m_{w2}}{m_i} \times 100\% \]  

(5)

\[ c_1 = \frac{m_i}{m_i} \times 100\% \]  

(6)

\[ c_2 = \frac{m_i}{m_i} \times 100\% \]  

(7)

Where \( \eta_g \) is diatomite classification efficiency, the top outlet diatomite mass is \( m_{g1} \), the total diatomite mass is \( m_{g} \); sludge classification efficiency is \( \eta_w \), the bottom outlet sludge mass is \( m_{w2} \), the total sludge mass is \( m_{w} \); total classification efficiency is \( \eta_t \); the diatomite purity of the top outlet is \( p_{g1} \), the total mass of the top outlet is \( m_{i} \); the sludge purity of bottom outlet is \( p_{w2} \), the total mass of the bottom outlet is \( m_{i} \); \( c_1 \) is the percentage of top outlet recovery mass, \( c_2 \) is the percentage of bottom outlet recovery mass.

3. Results and discussion

The classification efficiency at different feed speed is shown in Fig.3. It can be seen from Fig.3, the diatomite classification efficiency decreased with feed speed increasing. This is due to the feed amount was too much to exceed the treatment volume of the gas flow acceleration classification column, some diatomite fell into the bottom outlet of the gas flow acceleration classification column, so that the diatomite classification efficiency decreased. The trend of sludge classification efficiency was exactly opposite to diatomite [14-15]. This is because with the feed speed increasing, too much sample exceeded the maximum amount that can be carried by certain gas flow speed, and the sample fell into the bottom outlet, so the sludge classification efficiency increased with the feed speed largeting.

![Fig.3 Influence of feeding speed on the separation efficiency of export materials](image-url)
The influence of feeding speed on the purity of export material is shown in Fig. 4. When the feeding speed changed from 0.4 kg/h to 1 kg/h, the diatomite purity of the top outlet increased from 71.1% to 85.1%, and the diatomite purity of the top outlet increased slowly, which was due to the increasing feeding speed, and the material at the top outlet was diatomite, and the sludge entered the bottom outlet. The sludge purity change of the bottom outlet was shown in Fig.4, when the feeding speed changed from 0.4 kg/h to 1 kg/h, the sludge purity of the bottom outlet decreased from 82.6% to 46.9%, and the sludge purity of the bottom outlet decreased, because the feeding speed exceeded the processing threshold of the gas flow acceleration classification column, and some diatomite cannot be treated in time, and entered into the bottom outlet, which resulted in the sludge purity of the bottom outlet decreased.

![Fig.4 Influence of feeding speed on the purity of export materials](image)

The recovery proportion of different export material with different feed speeds is shown in Fig.5. When the feeding speed changed from 0.4 kg/h to 1 kg/h, the recovery proportion of the top outlet material reduced from 63.2% to 22.8%. This was because the feeding speed was too high and exceeded the maximum treatment of the gas flow acceleration classification column; some material fell into the bottom outlet, so the recovery proportion of top outlet reduced. As more material entered the bottom outlet, the material recovery proportion of the bottom outlet increased.

![Fig.5 Influence of airflow velocity on recovery proportion of different export material](image)
4. Conclusion
Considering the classification efficiency, purity and recovery proportion at different feeding speed, 0.8 kg/h was the optimum feeding speed. At this time, the diatomite recovery proportion was 41.7%.

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