Research and Design of a New Rotary Blast Dryer

He Bo, Cui Shuai, Li Hao, Shuning Liu
Guang’an Vocational and Technical College, Intelligent Manufacturing and Energy Engineering, Guang’an, Sichuan, 638000, China

Abstract. The vertical shock screening and drying machine is mainly composed of a drying box located at the upper part and a screening box body located at the lower part for drying and sieving wet materials. The device designs a superheated steam recovery device to collect the superheated steam during the drying process. There are two main applications for collecting collected hot water vapor. The first is that passing it into the heating box to heat the filling chamber in the drying box. And the second is preheating cold air to reduce the amount of heating energy. An LC shocking device is arranged in the drying box to make the wet material uniformly distributed on the material plate. And at the same time, it can promote the heat transfer area between the wet material and the hot air, thereby improving the energy utilization efficiency of the system. Using a porous grading sieve, the lower screening device can screen materials of different particle sizes at one time. The vertical shock screening and drying machine can effectively improve the utilization rate of energy and the emission of pollutants in the drying process. Thereby, it can achieve the energy saving and the emission reducing.

Key words: Vertical shock; Screening; drying; energy saving; environmental protection.

1. Introduction
With the improvement of modern scientific research level, people made more and more attention on the energy conservation, environmental protection, efficient use of atoms and the higher work[1,3]. Most of the experimental reactions in the laboratory were about solid-liquid phase extraction or liquid-liquid phase extraction. There were a large amount of wet materials would be generated during the process. We need to dry the wet material and screen it for further processing. However, there was no integrated device for drying and screening, which seriously affected production and work efficiency, currently.

Therefore, we have designed a vertical screening and drying machine. The device integrated the drying box and the screening box, which could improve the work efficiency, effectively. The research played a positive role in saving conventional energy and avoiding pollution. It also made a great significance for building an energy-saving society and promoting the development of green and healthy industries [4-6].

2. Main functions
The vertical vibration screening and drying integrated machine mainly contained two parts. The one part of it was a drying box with several material boards from the top down on the upper side. And the other part was the screening box on the lower side. The heating method of the drying box was mainly hot air.
The dried material gained heat energy by convective heat exchange of hot air. The heat passed through the surface of the material and inside the material, and conducted heat and mass transfer between materials and between materials and air. The generating superheated steam was collected and passed into the drying box for heating materials, insulating the drying cabinet and preheating raw cold air during the drying of materials. The design could achieve the heat recovery and recycling and solve the problems such as waste of energy caused by direct discharge of superheated steam during the drying process of traditional air dryer. Set the LC oscillation device in the drying box through the vertical vibration method. Wet material was evenly distributed on the material plate, and at the same time, the heat transfer area between the wet material and the hot air was increased, which improved the energy efficiency of the system.

The lower part of the screening box also adopted the vertical shaking method. The purpose of sieving materials with different particle sizes at one time was achieved through porous classification and sieving. The vertical vibration screening and drying integrated machine could improve the energy utilization rate compared with the traditional drying box, effectively. The superheated air was used as a heat source to replace the traditional gas heating method, which could reduce exhaust gas emissions during the drying process, reduce environmental pollution, achieve energy saving and emission reduction.

3. Overall design plan

![Overall structure diagram](image)

1-Drying box; 2-Screening box; 3-LC Oscillator; 4-Blower; 5-exhaust pipe; 6-Superheated steam recovery device; 7-Material board; 8-Bulkhead; 9-Screening board; 10-Chassis; 11-Base; 12-Heating furnace; 13-Water absorption device

Fig. 1 Overall structure diagram

The device was mainly composed of two parts: drying box and screening box. The drying box contained six parts: drying box, an air-conditioning air pump, a superheated steam recovery device, an LC oscillator, an air exhaust pipe, and a porous material board. Valves, pressure gauges and flow meters were connected to each device to control and monitor the flow of hot air and ensure the safety of the drying box operation. Screening box consisted two parts: porous screen and LC oscillator. The diameter of the drying box and the number of material plates could be designed according to the capacity of the wet material. The number of sieving plates in the sieving box was designed according to the amount of wet material and the number of holes. Now, took the 5 layers of material plates and the 3 layers of screening plates as the examples. The drying box and the screening box were separated by a partition. The design structure diagram of the overall device was shown in Figure 1.
3.1. Drying box

The gas heating method was too wasteful of fuel and easily caused environmental pollution used in traditional tumble dryers. Therefore, the drying box adopt the hot air heating method in this vertical screening and drying integrated machine. The hot air heated the material, so that the material got heat and the moisture removed. The purpose of drying was achieved. Since the density of the superheated water vapor generated was lower than that of the air during the drying process, a blower and an exhaust pipe were arranged on the upper material plate of the two material plates in the drying box. The superheated steam entered the superheated steam recovery device through the exhaust pipe under the suction of the blower. The superheated steam passed into the interlayer wall of the drying box, and played a role of heating and holding the drying box. The design could assist drying materials, realize energy recycling and save energy.

An outlet valve, pressure gauge and temperature gauge were designed at the bottom of the drying box to detect the temperature and pressure of the sandwich wall. When the temperature of the sandwich wall was too low or the internal pressure was too high, opened the valve to discharge liquid water and cooler air to ensure the safety of operation and the temperature of the drying box. We could use the temperature of superheated steam to pre-heat cold air raw materials to reduce the energy consumed by the heating furnace for raw cold air. A cold air blower is designed at the entrance of the superheated steam recovery device to make the cold air blow into the superheated steam recovery device, As shown in figure 2. The superheated steam exchanges heat with cold air to preheat cold air. A moisture absorption device was designed at the outlet of the superheated steam recovery device, and the moisture in the preheated air was absorbed to obtain dry preheated air. The preheated air was inputed into the heating furnace to obtain hot air, thereby reduced the energy consumed of heating raw material and making full use of energy.

The material board adopted a mesh structure inside the drying box, as shown in figure 3. The mesh size could be adjusted according to the size of the wet material, and the vertical oscillation drying method is adopted. Flow way of drying hot air was bottom up to make a full contact of wet materials with hot
dry air during drying. The design could increase the heat and mass transfer area between wet materials and hot air in order to dry the material more uniformly and efficiently and avoid damaging the wet materials by traditional drying methods.

3.2. **Superheated steam recovery and moisture adsorption device**

Due to the large temperature difference between the inside and outside of the superheated steam recovery device, it was easy to cause the liquefaction of the superheated steam and generate condensate on the inner and outer walls of the device. Therefore, the heat recovery device was provided with a heat insulation layer. The heat-insulating layer was filled with a heat-insulating material, which was used to heat the superheated steam.

The alkaline solid adsorbent was used in the moisture adsorption device to adsorb moisture, such as a mixture of sodium hydroxide and calcium oxide. Superheated steam was input from the top of the moisture adsorption device and output from the bottom to ensure full contact between the superheated steam and the desiccant and to improve the moisture absorption rate, and then obtain hot air.

3.3. **Specific operation**

In actual operation, selected the material plate model and the screening plate model according to the size of the wet material and the size of the screening particle size, firstly. After selection, installed the material board in the drying box. The screening plate was installed in the screening box. Placed wet material on the material plate and made sure all valves are closed.

The valve 1 was opened, and cold air was introduced into the air heating furnace to heat the cold air through the blower 1. The temperature of the air in the furnace was monitored by the heating furnace thermometer. Opened the inlet and outlet of the drying cabinet 2-5, when the hot air in the heating furnace reached the set temperature. The obtained hot air was discharged into the exhaust pipe through the blower 2-3, and then entered the drying box to preheat the drying box. Checked the barometer, flow meter and temperature meter to make sure that they can work normally. After a period of time, the hot air flow was adjusted based on the moisture content of the wet material. Turned on the LC oscillator and adjusted the oscillation frequency to make the wet material oscillate evenly on the material plate. Monitored the temperature gauge and pressure gauge, and adjusted the flow of hot air inlet and outlet in time during the drying process. After ventilating for a period of time, the hot air blower could be properly turned off, so that the drying box was performed at a constant temperature and pressure. Reduced the amount of hot air and avoided waste of energy on the premise of ensuring normal drying.

The wet materials continuously emit superheated steam with the progress of the drying process. After a period of time, opened the valve 6-7 and the blower 4-5 at the water vapor outlet of the cabinet. Under the action of the blower, superheated steam entered the superheated steam collection device through the exhaust pipe. After collecting for a period of time, observed the pressure gauge and opened the superheated steam outlet valve 8-10. The superheated steam was passed into the interlayer of the drying box, which was used for heating and holding the drying box, and played a role of assisting the heating of wet materials. The temperature in the interlayer of the cabinet and the degree of water vapor liquefaction were detected by observing the thermometer and level gauge of the drying cabinet. The amount of input superheated steam was controlled and the cooler air and water in the interlayer were discharged by adjusting valves 8-12. Thereby, the temperature of the interlayer of the drying cabinet was controlled.

When the temperature of the interlayer of the drying box was in a dynamic equilibrium, closed the valve 11, opened the blower 6 and the valves 13-15. Passed the cold air into the superheated steam recovery device to preheat the cold air. After a period of time, opened the valve and made the preheated air input into the moisture absorption device. Preheated air was input into the moisture absorption device. The mixture of preheated air and superheated steam were converted into dry hot air after the water absorption treatment. The preheated dry air was discharged into a preheated air storage tank, or directly into an air heating furnace to heat the preheated air. This design could save energy and improve energy efficiency. Turned off the hot air blower completely, and evacuated the material plate, so that the dried
material could fall on the isolation plate for screening when the wet material drying operation was completed. Valves 17-19 were safety valves.

Opened the isolation plate, adjusted the size of the opening of the isolation plate, so that the dry material flowed to the first layer of screening plate continuously and evenly. Turned on the LC oscillator, adjusted the frequency of the oscillator, and carried out particle size screening on the sieve plate. Took out the sieved materials on each layer of sieving plate regularly to prevent the stagnation of materials on the sieving plate, which affected the screening efficiency. After the screening was completed, closed the valve. Organized and cleaned the machine for subsequent use.

4. Conclusion
The main innovation of the design was to chelate the drying process and the screening process. A superheated water recovery device was added to the drying process to recycle energy. An LC oscillator was designed on the screening device to improve the screening efficiency. The vertical shock screening and drying machine can effectively improve the utilization rate of energy and the emission of pollutants in the drying process. Thereby, it can achieve the energy saving and the emission reducing.

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