In the name of God

Manual

Spray dryer

Datis Energy Industrial

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Datis Energy

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Learning objectives

Separating detergent powder from saturated solution and calculating the amount of dry powder in spray dryer.

Introduction

Drying is one of the multipurpose industrial functions.

Spray dryers can dry a product very quickly compared to other methods of drying. They also turn a solution (or slurry) into a dried powder in a single step, which simplifies the process and improves profit margins.

In pharmaceutical manufacturing, spray drying is employed to manufacture Amorphous Solid Dispensation, by uniformly dispersing Active Pharmaceutical Ingredients into a polymer matrix. This state will put the active compounds (drug) in a higher state of energy which in turn facilitates diffusion of drug spices in patient body.

The function of laboratorial spray dryer has some differences with the industrial one. Actually the drying in the laboratory devices, only omits the external moisture of the sample, so the weight of sample does not change considerably. The fast process of spray drying makes it suitable to dry temperature sensitive solids. Instead of advantages which spray dryer has, it has some defects

1. The sample must be liquid.

2. The durability of solid particles is high.

3. The efficiency of the apparatus is low.

In order to avoid exiting of solid particle with exhaust air, a cyclone is located besides the main chamber. Using centrifugal force, the cyclone gathers the particles and prevents their exhaust.

Theory

According to drying definition, drying is a thermal process. Although this process is done by penetration in solid or by using a gas, many substances dry in a temperature higher than boiling point or maybe much higher than boiling temperature. In order to dry remained wet particles. The role of heat in spray dryer is heating the feed until it reaches the evaporation temperature, liquid evaporation temperature, heating solid and reaching to final temperature and heating vapor and getting to final temperature. The most critical part is heating liquid. If MS is considered as the mass of total solid particles which is dried rate in unit of time and X_a, X_b are primitive and ultimate moisture of dried solid, then the transferred heat in mass unit is calculated as below:

$$q/m's = Cps\ (Tv - T\ sa) + Xa\ Cpl\ (Tv - Tsa) + (Xa - Xb)\lambda + Xb\ CPL(Tsb - Tv) + Cps(Tsb - Tv) + (Xa - Xb)Cpv * (Tva - Tv)$$

In this equation T_{sa} is feed temperature, T_v evaporation temperature, T_{sb} is final solid temperature, T_{va} final mid vapor temperature and, λ is evaporation heat, C_{ps} specific heat of solid, C_{pl} specific heat of liquid and C_{ps} specific heat of vapor.

Mass transfer in dryers

In all dryers which a gas passes over or in solid particles, mass is transferred from solid's surface to gas, or using solids inside channel. The resistance in heat transfer process is the controller of dryer's speed, not heat transfer rate, because the moisture should reach to the surface and then evaporate fast.

A spray dryer takes a liquid stream and separates the solute or suspension as a solid and the solvent into a vapor. The solid is usually collected in a drum or cyclone. The liquid input stream is sprayed through a nozzle into a hot vapor stream and vaporized. Solids form as moisture quickly leaves the droplets. A nozzle is usually used to make the droplets as small as possible, maximizing heat transfer and the rate of water vaporization. Droplet sizes can range from 20 to 180 µm depending on the nozzle type. Drying is a relative process, it means in most solids, moisture of the particles is partially remained. The average diameter of exhausted particle is obtained from experimental equation bellow:

$$D_s = 12.2 * 10000r\,[T/(pl\ n\ r^2)]^{0.6} * (\mu/L)\text{^}0.2 * [\sigma\ PI\ Lp/T^2]^{0.1}$$

Device's efficiency

$$\%Ra = (m_{s,p}/m_{s,f}) * 100$$

$m_{s,p}$ is product mass, $m_{s,f}$ is feed weight.

Co-current dryer

In a co-current dryer, the spray is directed into the hot air entering the dryer and both pass through the chamber in the same direction. Co-current dryers are the preferred design for heat-sensitive products because the hottest drying air contacts the droplets at their maximum moisture content. Spray evaporation is rapid, and the temperature of the drying air is quickly reduced by the vaporization of water. The product does not suffer from heat degradation because the droplet temperature is low during most of the evaporation time. Once the moisture content reaches the target level, the temperature of the particle does not increase greatly because the surrounding air is now much cooler. Dairy and other heat-sensitive food products are usually dried in co-current dryers.

Technical information

Figure

Specification

1. Nozzle
2. Heat generation
3. Heat diffusing with vortex maker
4. Blower
5. Glass made Main chamber
6. Separating cyclone
7. Glass made collecting vessle
8. Controlling system
9. Peristaltic pump

Nozzle

The Feed solute which is liquid by using nozzle should change into small droplets and be dispersed in main chamber in order to add the surface of mass transfer. The spray nozzle sprays the feed as liquid droplets inside chamber.

This nozzle has the ability to regulate spraying time and it can set closing time of the nozzle.

Heat generation, distributer and blower system

Regulatable Heating element, heats the air and controls the temperature. The air is prepared by blower in a way that blower's round is controlable and it could be set. Exiting air from blower, heated by heater, by crossing the helical channel in vortex form, enters the main chamber and sprays there.

Main chamber, cyclone and product collecting vessel

The critical point of this device is the main chamber. The nozzle and disperse system is located above this chamber. The air which contains solid

particles, exits the main chamber and enters cyclone. Solid particles using centrifugal force are dispersed around the chamber and the air is in center. Under the cyclone there is a collecting vessel which gathers the final product.

Under the apparatus there is a nut which is located for cleaning the device.

Beside the collector there is a process which could be used for cleaning or adding accessories.

Controlling system

The controlling system

Entrance temperature

Controlling blower rotation speed

Controlling heater's power

Setting spray duration

Experiment description

Follow these steps

1. Provide the feed fluid and place it in its place. The feed fluid must contain under 20% dry material.
2. The feed fluid must be dissolved in the solvent.
3. Connect the compressor.
4. Connect the nozzle's pipes. It has 3 places for 3 tubes; one is shown by the letter "A" which is connected to an 8 mm tube, and is exited from the dryer. The other is shown by the letter "F" which is connected to a 6

mm tube, and is exited from the Peristaltic Pump. The third one is located on the top of the nozzle and is connected to the Pneumatic Jack to move the needle.

5 Connect the system to the electrical power.

6 Turn on the system.

7 Set the fan on its maximum speed.

8 Turn on the heater.

9 Set the desired temperature for drying using the Air Inlet Temperature displayer as described before (for salt- water 120℃). This temperature changes according to feed fluid specification.

10 Set the Needle Timer according to digital displayer part at the end of this instruction.

11 Place the nozzle at the top of main tower.(NOTICE : Before placing the nozzle at its place, you should make sure of the proper spraying of the needle; to do so, turn on the Peristaltic Pump ,and in order to have the best quality of the product , set the flow rate on a low amount. Then test the function of the nozzle and make sure of the nozzle not to be leaky. When the testing is done, turn off the peristaltic pump then put the nozzle at its place.)

12 Wait until the Chamber's temperature reaches the set temperature, then turn on the peristaltic pump.

13 The final products will be collected in the vessel.

- **Attention**: Pay enough attention in regulating pump's flow rate, if the pump has low flow rate, the pump would stop working, in this situation enhance pump's flow rate, if you do not increase the pump flow, the pump would break down.
- To prevent the feed from being clotted, the pumps' flow rate should be reduced.

Apparatus turn off Command

First, turn off the pump then let the blower continue blowing in main chamber and cyclone for 5 minute to lower the over-all temperature and preventing thermal stress in chamber, then turn off the blower.

Fault resources:

If the device didn't work check these options:

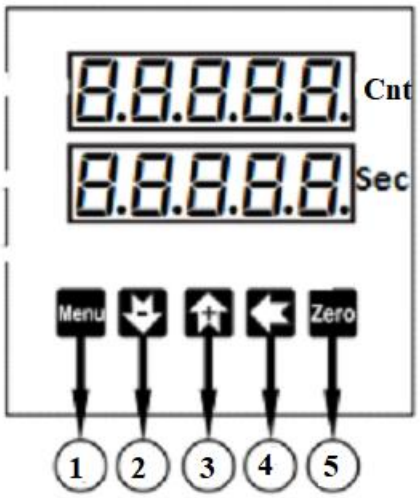
Sticking of solid on chamber's wall

Particles or air escape

Sticking of feed particles to feed channel

The pump has a gate, open the gate and check the lamp to be on then check its switch to be down.

Digital displayer



To set the digital displayer, press menu, “off” displays on the screen, using up and down buttons set desired off time, press “menu” again the digital displayer shows on, using 2 and 3 buttons set your desired on timing, press “menu” your time setting will be saved.

The higher segment of displayer is shown by “Cnt”

If you press “zero” then the counter which illustrates the number of ups and downs of the needle of nozzle, turns to zero and reset.