

Spray driers are mainly classified according to

A) Method of atomization

- a) Pressure atomization
- b) Centrifugal atomization
- c) Pneumatic atomization

B) Method of heating air

- a) Steam
- b) Fuel oil
- c) Electricity

C) Position of drying chamber

- a) Vertical
- b) Horizontal

D) Direction of air flow in relation to product flow

- a) Counter current
- b) Co-current
- c) Mixed current

E) Pressure in dryer

- a) Atmospheric
- b) Vacuum

F) Shape of drying chamber

- a) Flat bottom
- b) Conical bottom

Air Supply

a) Air filtration

- i. Efficient air filters for the air used for drying and cooling are essential to avoid contamination of the powder from the air.
- ii. Fabric filters are commonly used at the end of the dryer to collect the fine material escaping from the cyclones.

b) Air heating

- i. Inlet air temperature 215 – 220 °C is achieved by boosting another heating system alongwith steam heater.
- ii. Saturated steam of 10-12 bar gives an air temperature of 170 – 180 °C , as the heating surface is normally rated to give an air temp of 8 – 10 °C below the temp. of the steam.
- iii. Air is heated to about 150 to 250 °C for drying milk products. The relative humidity of hot air is quite low, normally below 3%.

Atomization

- ✓ The word atomization covers the process of liquid bulk break up into millions of individual droplets forming a spray. A cubic meter of liquid forms approximately 2×10^{12} uniform 100 μm droplets which offer a total surface area of over 60,000 m^2 . Thus the evaporation rate is rapid, due to vast surface area of droplets.
- ✓ In addition the atomizer acts as a metering device to control the flow rate of the product into the dryer.
- ✓ The particle size generally ranges from 50 to 150 μm in dia.
- ✓ The atomization also affects the product properties such as air content , bulk density, particle size, color and dispersibility.
- ✓ The three methods of atomization are pressure nozzle, centrifugal or rotating disc, and Pneumatic atomizer.

Spray – air contact

Much of the moisture is removed at constant rate from the droplets by the air in the course of its movement.

The main drying zone is within 0.6 m of the atomizer.

The relative direction of spray and air may determine the particle size, granularity and bulk density.

The direction of air flow in relation to product flow may be counter-current, co-current or mixed current.

Drying chamber

Drying chambers are designed to discharge the majority of the product at the base or to convey all the products with exhaust air to a product separation and recovery unit.

Types

- i) Flat bottom
- ii) Conical bottom
 - i) Vertical
 - ii) Horizontal

- ✓ The conical bottom is particularly suitable for products with a fat content such as milk. When this type of chamber is used, the whole amount of powder is conveyed to cyclones. This chamber is particularly suitable for free flowing powder with no tendency to settle on the tapering walls.
- ✓ The lower cone height = upper cylinder
- ✓ Whatever the design of drying chamber, the powder must be removed as rapidly as possible, because exposure of dried milk to a hot air stream reduces its solubility.
- ✓ The drying chamber is the most space demanding part of the dryer and requires heavy investment to house a large drying chamber.
- ✓ The air residence time in the drying chamber is 25 – 30 seconds.
- ✓ The active evaporation in a dryer occurs in 4 – 5 seconds.
- ✓ The droplets and resulting dry particles is in the spray dryer from 10 to 30s. The time may be much greater if droplets is not immediately removed from the dryer.
- ✓ Air moves into and through the dryer at a velocity from 360 to 600 m/min.

For making preliminary calculations, the following equations may be used

$$w \cdot c(t_1 - t_2) = q = U_a(\Delta t_m)V_d$$

w = mass flow rate of air, kg/h

c = sp. Heat of air kcal/kg^oC

t_1, t_2 = inlet and outlet air temperature in the dryer, ^oC

q = total rate of heat transfer in kcal/h

U_a = volumetric heat transfer coefficient with values of 150 to 270 kcal/hm² ^oC

Δt_m = mean temperature difference throughout the dryer, ^oC

V_d = volume of dryer, m³

Dryer efficiency

$$\text{Thermal efficiency} = \left(\frac{1 - R}{100} \right) \left(\frac{t_1 - t_2}{t_1 - t_0} \right)$$

R = Radiation loss, % of total temp. Drop in dryer

t_0 = atmospheric air temp, °C

t_1 = temperature to which the air is heated, °C

t_2 = temperature of air leaving the dryer, °C

The overall thermal efficiency of spray dryer is 50 – 60%

The thermal efficiency of air utilization in the dryer is enhanced by

- (a) High inlet air temp
- (b) Low outlet air temp.
- (c) High thermal efficiency of heat exchanger for heating air
- (d) Use of outgoing exhaust air to heat incoming air
- (e) Reducing heat losses and air leakage from dryer body.

Powder recovery systems

Conical bottom: the powder may be removed by a rotating discharge valve or a suction blower.

Flat bottom: mechanical sweepers, conveyors or vacuum collectors are used.

Bag Filters

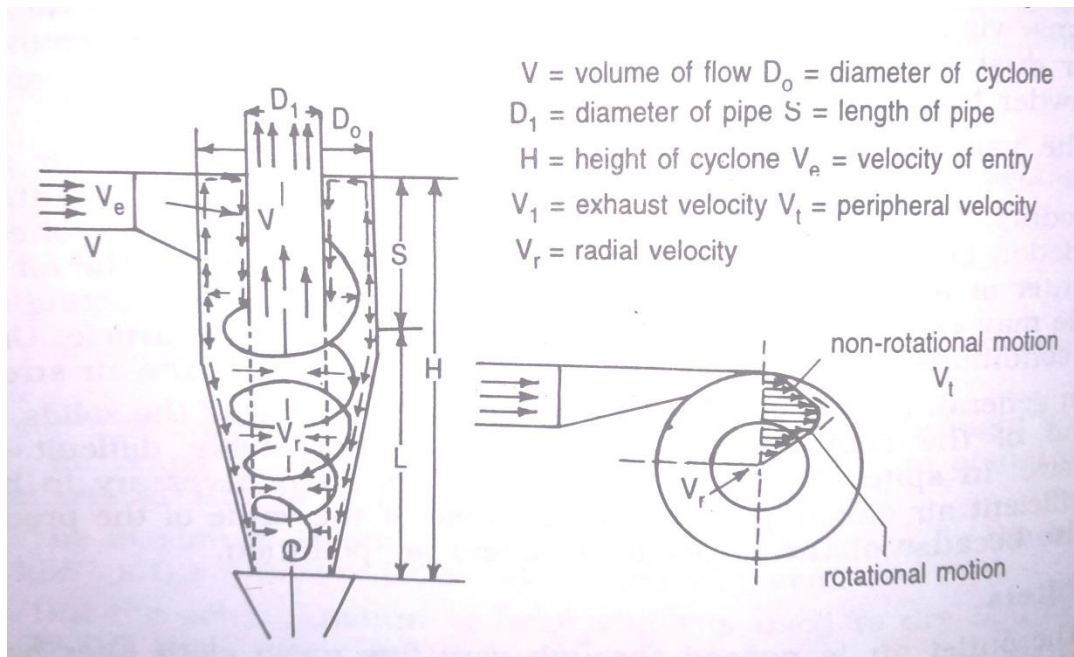
Bag filters are used where 100% collection efficiency is required from a one stage separation unit.

The material: cotton, wool, plastic.

Losses 0.2 to 0.5 %.

Cyclone separators

- ✓ Cyclones are centrifugal particle separator.
- ✓ It employs centrifugal rather than gravitational force to remove the particles.
- ✓ In the cyclone separator, air with particles at a high velocity is introduced tangentially into a cylindrical vessel which has a much larger cross-section than the entering duct. The velocity is decreased in the cylinder, thus permitting the settling of the solids. The velocity of the air decreases near the wall of the cyclone and the product falls by gravity and is removed from the bottom.



The limiting particle diameter d_1 is found by the following equation

$$d_1 = \sqrt{\left(18 \times \mu \times \frac{V}{v_t^2} \times \Delta\rho \cdot 2\pi L\right)}$$

The above equation shows that it is possible to separate even every small particles if

- (a) The entry velocity is high
- (b) The cyclone is long
- (c) It is possible to distribute the flow of air over a number of smaller cyclones.

Thank

you