# Lecture 09

# Types of dryers

**Drying & Storage Engineering**

**(PFE-304)**

# INTRODUCTION

Different types of dryers can be categorised as follow:

- Dryers in which products are kept in a bin and the heated or drying air is ventilated through them.
- Dryers in which products are kept moving. The movement of products is by gravity or by some mechanical means and the drying air is ventilated through them.
- Dryers with free falling bed due to gravity and the drying air is ventilated through the falling film of products.
- Dryers in which the products are dried in a state of fluidisation by strong blowing heated air.

# ➢ Deep bed dryers

- These batch-in-bin dryers are of large capacities to several hundred tonnes.
- The most common shapes are round or rectangular.

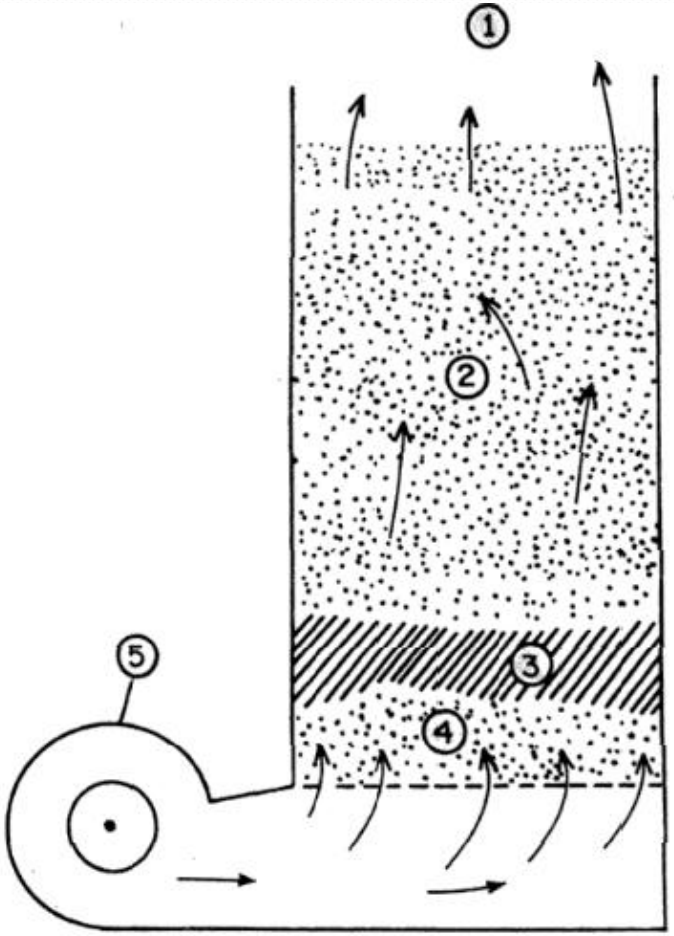


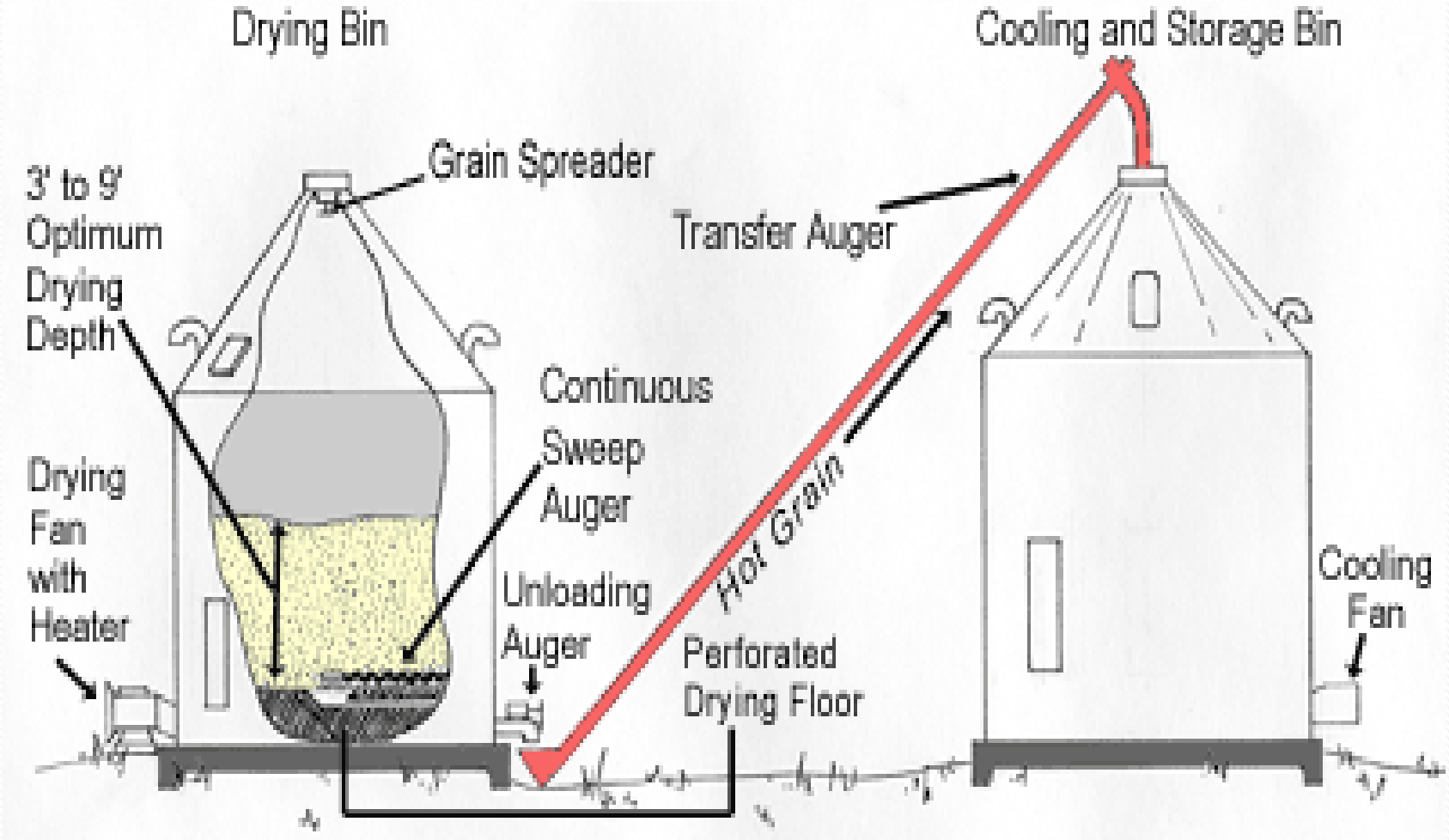

**Fig. 3.21 :** Deep bed dryer's schematic diagram
1. exit air 2. wet grain 3. drying zone 4. dry grain 5. blower

# ➢ Deep bed dryers

To operate deep bed dryers efficiently the following rules may be followed.

- An air flow rate of 2.94-3.92 $m^3$/min per tonne is recommended. The lower range of 2.94-3.43 $m^3$/min per tonne can be used safely in cooler and drier places, while the higher range of 3.43-3.92 $m^3$/min per tonne may be used in hot and humid climates. Rates above 3.92 $m^3$/min per tonne may result in uneven drying and is expensive in operation,
- If the moisture content of grains is upto 18%, the layer depth of grain should be limited to 3 m. For grains whose moisture content is above 18%, the maximum depth recommended is 2.5 m. Paddy with 2.5 m deep layer may take 20 days to dry during favourable weather and upto 40 days during bad weather. In tropics where sprouting occurs in 4-8 days, deep bed dryers are not very much successful.
- (iii) The net perforated area of the floor should be 15% of the total floor area. Air velocity of 300 m/min through the opening is preferable.

# Grain drying in bins



# Flat bed dryers

- The flat bed batch type dryer is similar to deep bed dryers except that the surface area of the dryer is more and the depth of the drying layer is less.
- These dryers are of usually 1-2 tonne capacity. These are designed for farm level operation.
- Grains are spread 0.6 to 1.2 m deep over the perforated floor and dried.

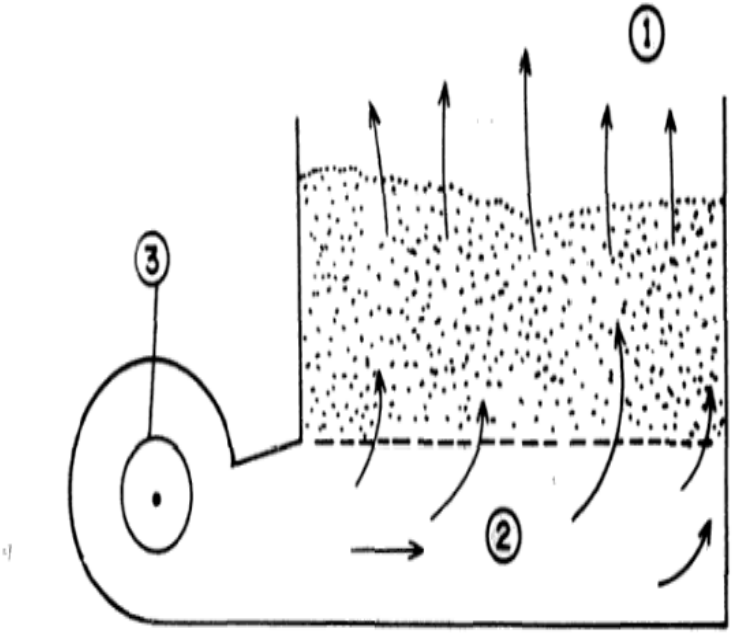



Fig. 3.31 : Flat bed dryer
1. exit air 2. plenum chamber 3. blower

# Continuous flow dryer

**These dryers are columnar type in which wet grains flow from the top to the bottom of the dryers.**

**The rate of flow of grains through columns can be regulated by conveyors.**

**Drying is accomplished by forcing heated air across the falling layers of grains.**

**These dryers are of two types-**

1. **Mixing - If the grains are diverted in the dryer, it is called a mixing type dryer.**
2. **Non-mixing - If the grains flow in a straight path, the dryer is called a non-mixing type**

# Mixing dryer

- **The baffles are provided to cause the grains to mix during their downward flow.**
- **These dryers use low air flow rates of 50-95 $m^3$/min-tonne and high drying temperature of 65°C.**
- **Zig-Zag columns enclosed by screens on both sides are used primarily to achieve mixing action during drying process.**

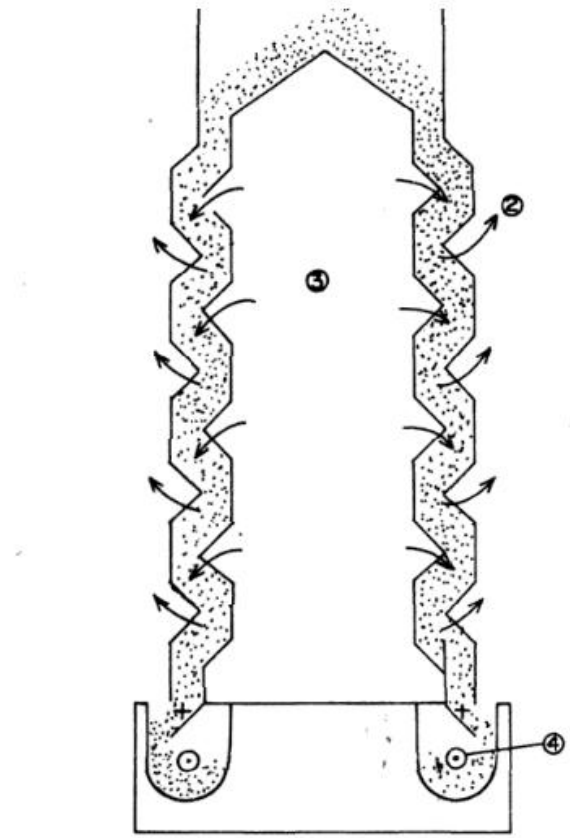



**Fig. 3.32 :** Continuous flow dryer (mixing type)
1. feed hopper 2. exit air 3. plenum chamber 4. dry material outlet

# Non - mixing dryer

- **The baffles are not provided in the columns and drying takes place between two parallel screens, 15-25 cm apart.**
- **In these dryers high air flow rates of 125-250 $m^3$/min-tonne can be used.**
- **It permits a faster movement of grains in columns. Drying air temperature of 54°C is used in non-mixing dryers.**

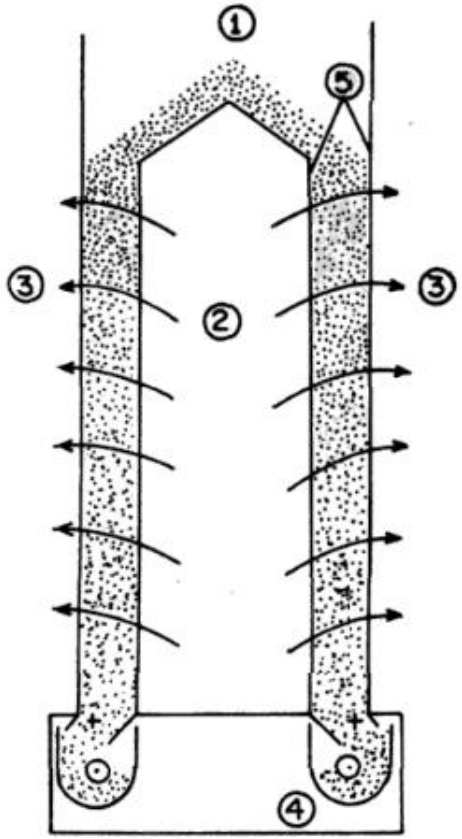



**Fig. 3.33 :** Continuous flow dryer (non-mixing)
1. feed hopper 2. plenum chamber 3. exit air
4. dry grain out let 5. screened grain column

# Recirculating dryers

- In continuous flow dryers, a multipass procedure is used to avoid excessive drying stress.
- During each pass, the grains are exposed to the heated air for a short time (15-30 min) and about 1-3% of the moisture content is removed.
- In such dryers, drying air temperature of 60-80°C is used.
- Drying is faster and effective because of the continuous movement of grains during the short drying times.
- Between drying passes, the grain is stored in a tempering bin for 4 to 24 hours to allow the moisture content at the centre and the surface of the grain to equalise.

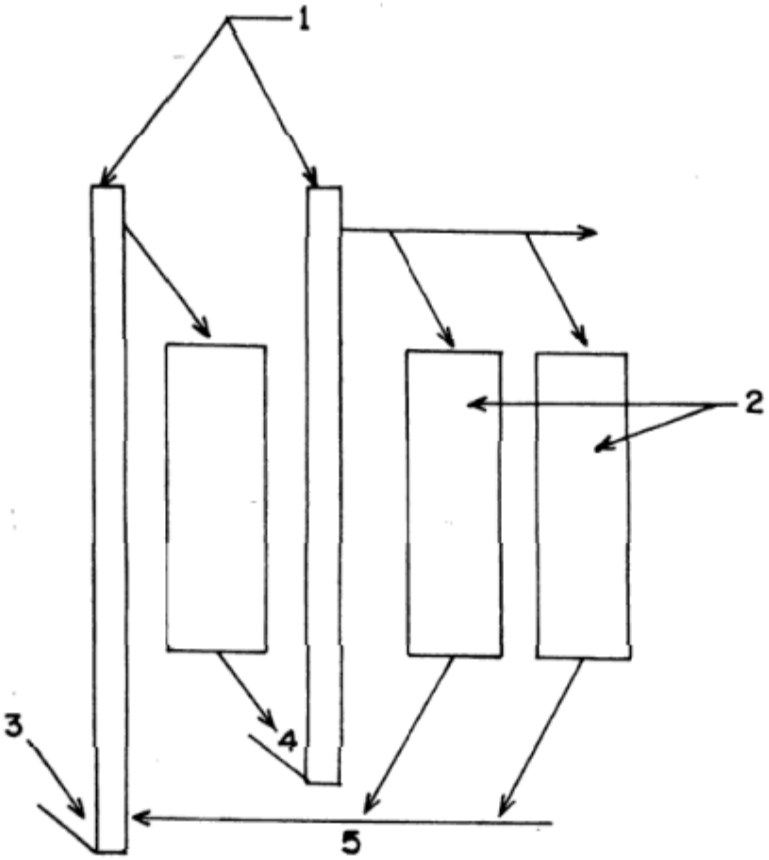
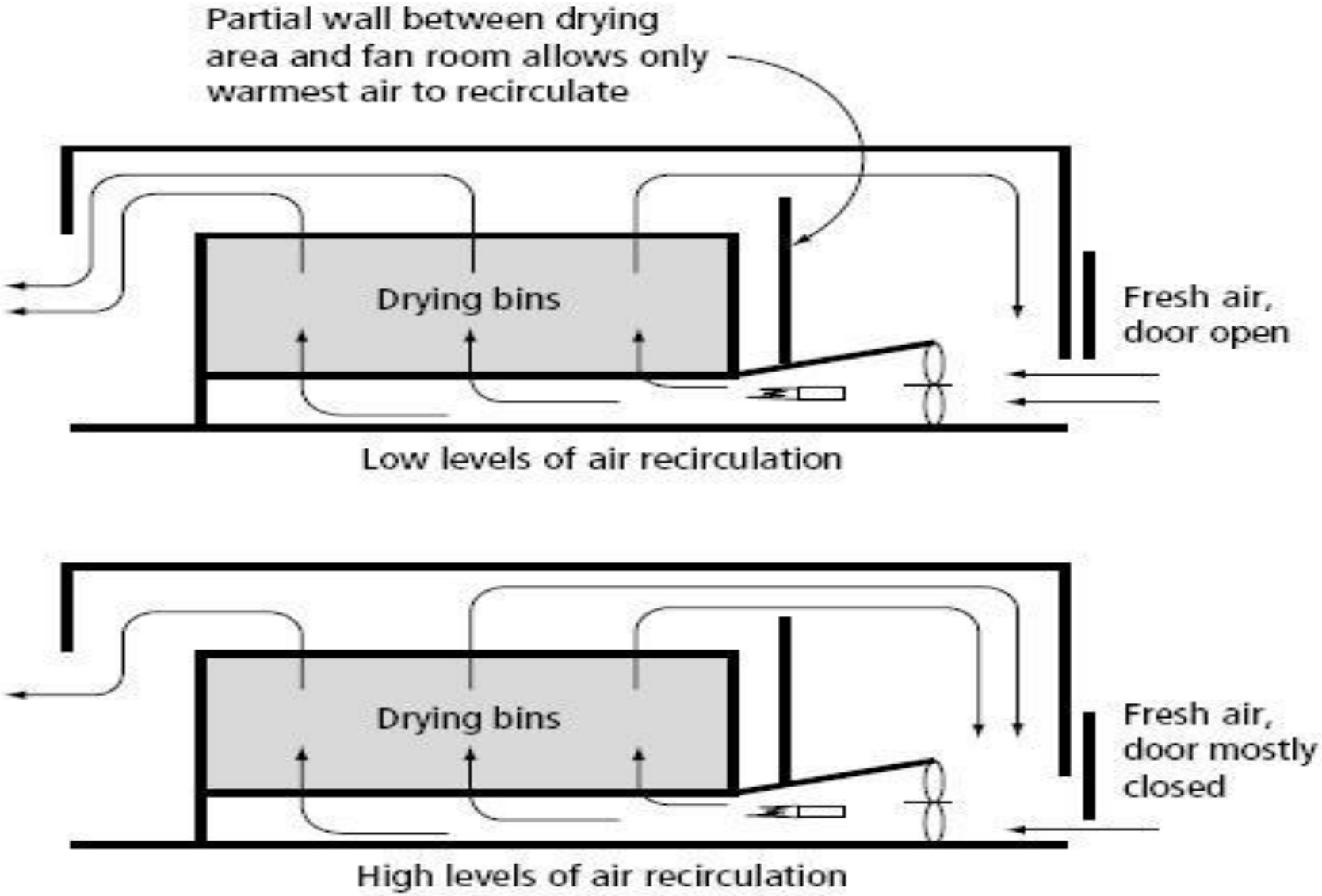
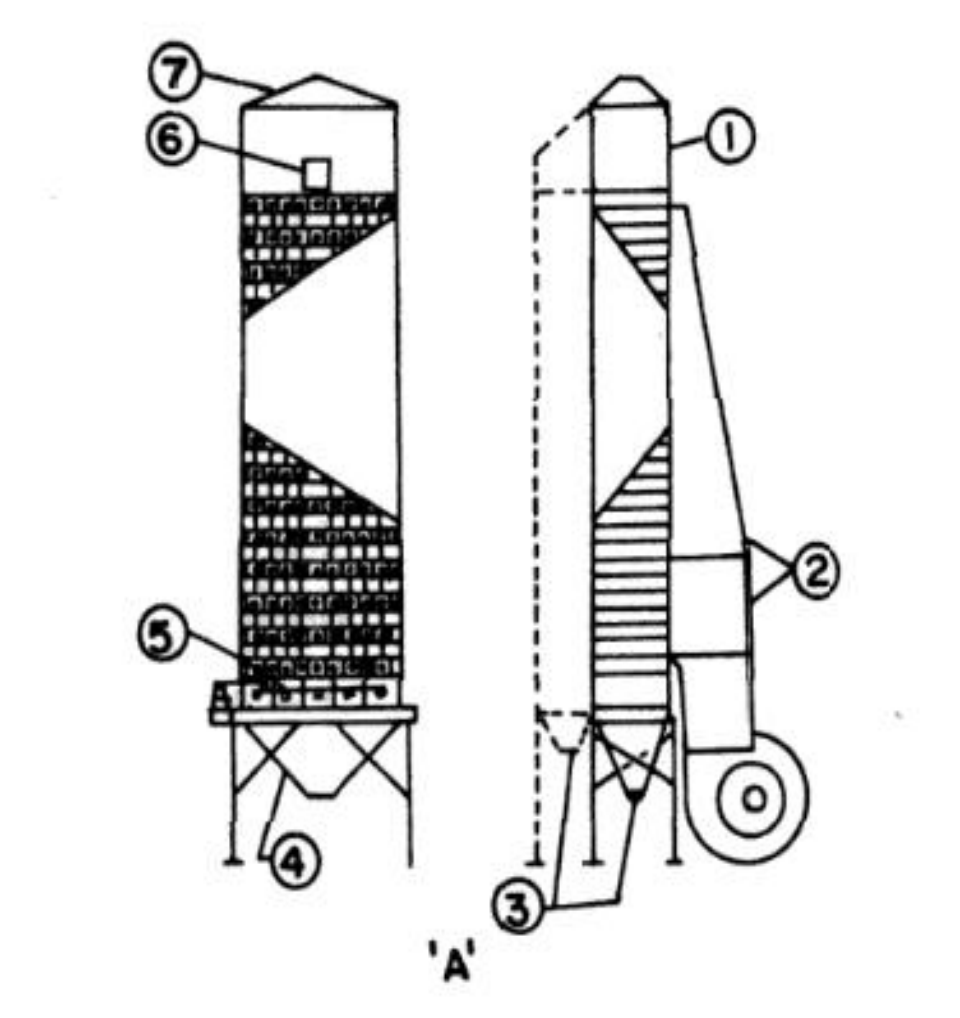



**Fig. 3.26 :** Recirculatory dryer's schematic diagram
1. elevator 2. tempering bins 3. wet material
4. semidried material 5. conveyor


Partial wall between drying area and fan room allows only warmest air to recirculate
Drying bins
Fresh air, door open
Low levels of air recirculation
Drying bins
Fresh air, door mostly closed
High levels of air recirculation

# LSU dryers

- The design of this continuous dryer was developed at the Lousiana State University in the mid 1950, called the LSU dryer.
- This design was developed specifically for rice, to ensure gentle treatment, good grain mixing and good air- to-grain contact.



# LSU dryers

- It is a mixing type continuous flow dryer, in which layers of inverted V-shaped channels are installed.
- The layers alternate between hot air intake and exhaust air outlets and are staggered to provide mixing.
- The LSU dryer is of high capacity and being used in big commercial rice mills.

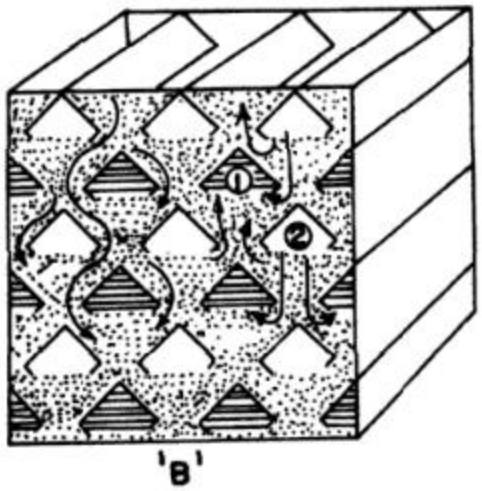


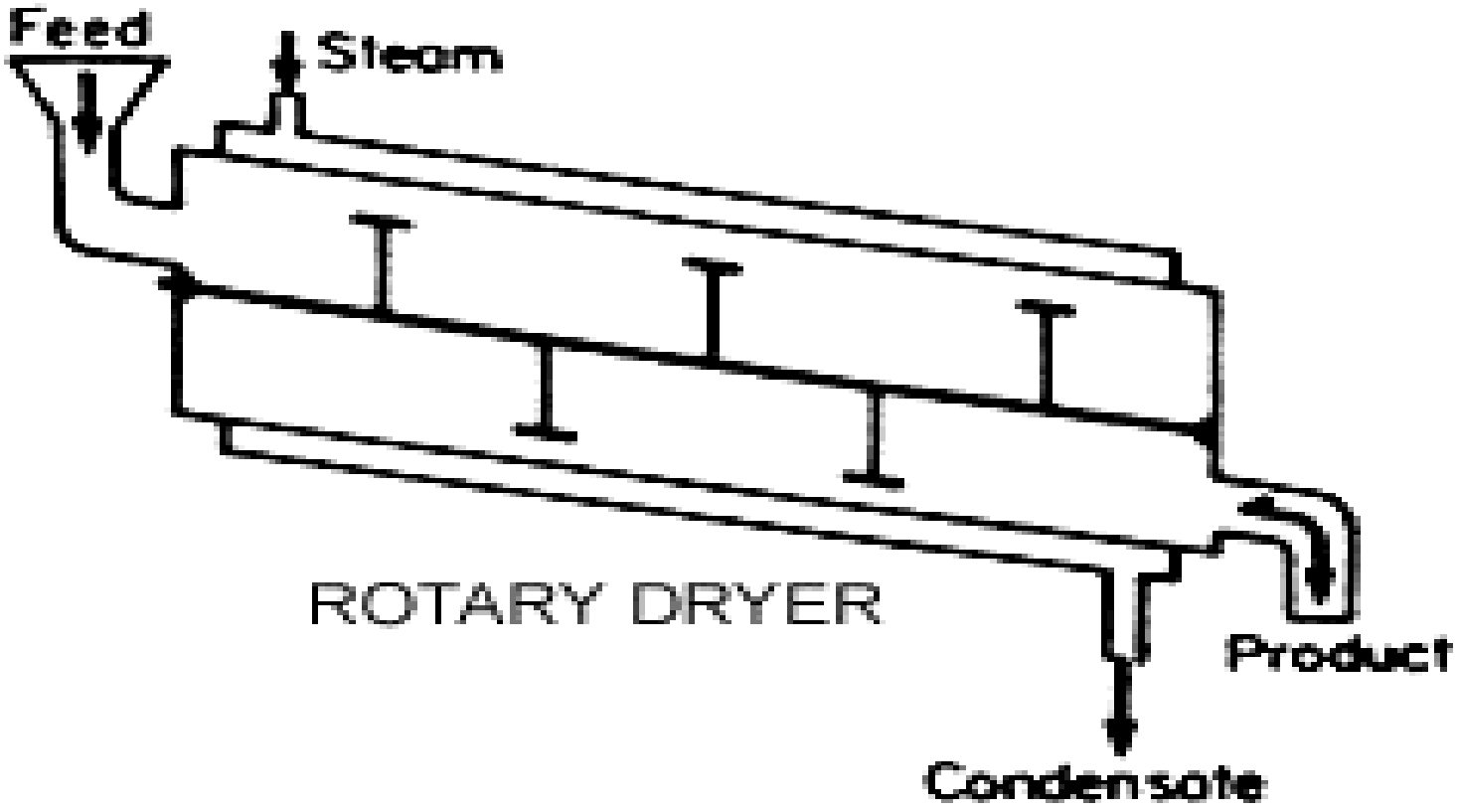

**Fig. 3.34 :** LSU dryer
A' 1. garner 2. duct 3. dry material outlet
4. hopper 5. continuous flow 6. door 7. roof
'B' cross-section of drying chamber
1. air exhaust 2. air intake

# Fluidised bed dryers

- **The fluidised bed drying technique holds an important position among modern drying methods.**
- **It is used mainly for granular materials, nevertheless, it is also applicable in the drying of solutions, pastes and liquids sprayed onto the fluidised inert bed.**
- **The principle of operation of fluidised bed dryer is to provide sufficient air pressure to fluidise a thin bed of grain/ product, giving excellent air/ grain contact.**
- **Above a certain pressure, related to the weight per unit area of the grain bed, the pressure drop across the bed becomes constant with volume flow rate, so that fast drying can occur.**

# Rotary dryers

- **In commercial rotary dryers the diameter of drum is between 1 to 3 m and the length is from 3 to 6 m.**
- **It is operated at slight inclination.**
- **The drum rotates on its axis. The grain flows downward through the rotating drum and is periodically lifted by inclined flights, then dropped, ensuring good air/ grain con tact.**
- **However, in commercial practice the main method of drying is convective heating by drying air whereas, in the small scale designs heating is by conduction through the walls of the drum.**


Feed
Steam
ROTARY DRYER
Product
Condensate

# Rotary Dryer

# Rotary dryers

- **Tamil Nadu Agricultural University a continuous type rotary dryer has been developed. The grains are dried by direct contact with heated sand. The dryer is used for drying of parboiled paddy as well as for dry roasting of Bengalgram and other grains.**

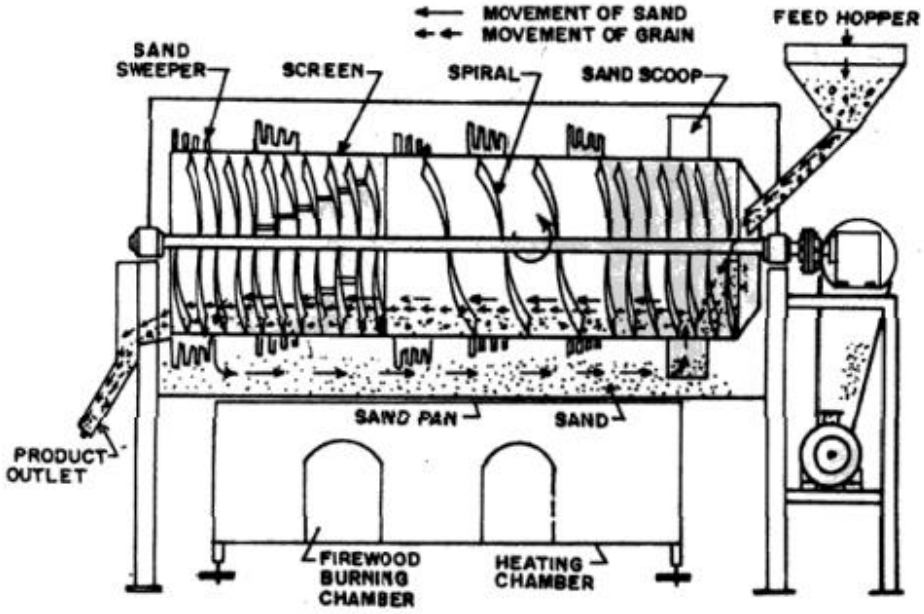
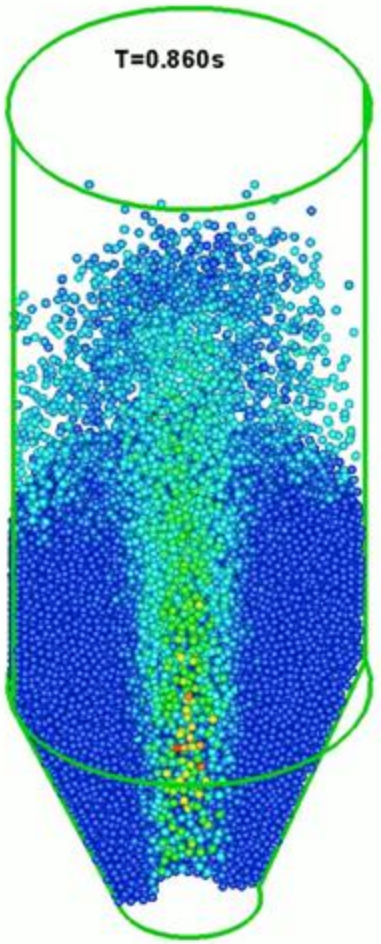



Fig. 3.35 : Continuous flow heated sand medium rotary dryer

# Spouted bed dryers

- The spouted bed drying principle is similar to that of fluidised bed drying, but it is less developed.
- Instead of fluidising the whole bed, a jet of air is spouted upwards through a section of the bed, the grain being entrained in the jet and falling out of the spout in a fountain onto the annular region of grain surrounding the spout.
- The whole bed of grain is continually being heated and dried.
- Thus the process is energy efficient and uniform in treatment..



# Tray dryers

- **In a tray dryer, many shallow trays are kept one above the other with a gap in between, in the drying chamber.**
- **Tray dryer is generally used for drying of vegetables and similar semi-perishables.**

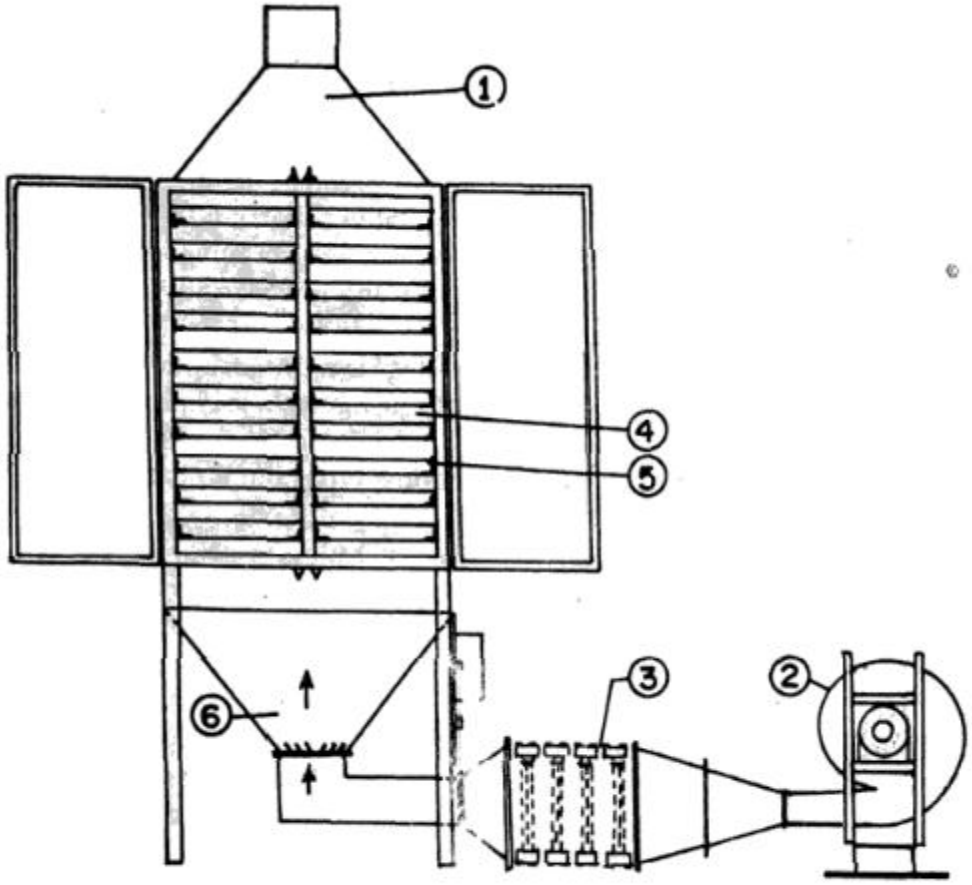
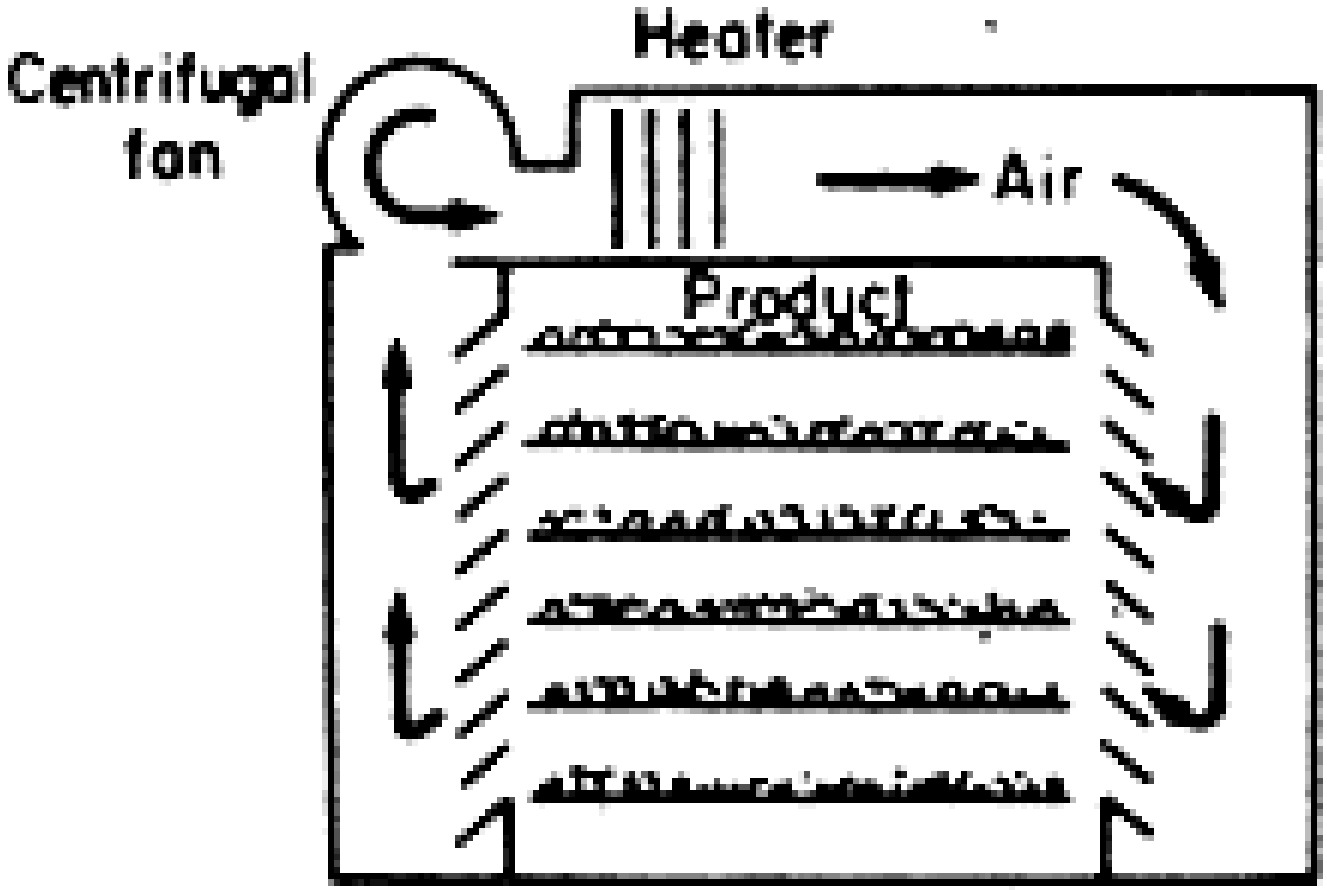



**Fig. 3.36 :** Diagram of a tray dryer
1. exit air 2. blower 3. heater 4. inter space between trays
5. trays 6. plenum chamber

# Tray dryers




TRAY DRYER

# Tray dryers

- **The trays may or may not have perforated bottom. Perforated trays are used when the plenum chamber is at the bottom of drying chamber.**
- **If the heated air is coming from the sides of drying chamber, the trays may not have perforated bottom**
- **The gap in between the group of trays permits air ventilation.**
- **Products are kept in thin layers in the trays.**

# Tunnel dryers

- It is similar to tray dryer. When the group of trays is stationary, the system is called a tray dryer but when the group of trays is moving in a tunnel, the system becomes a tunnel dryer
- The flow of heated air in a tunnel dryer may be concurrent or counter current.

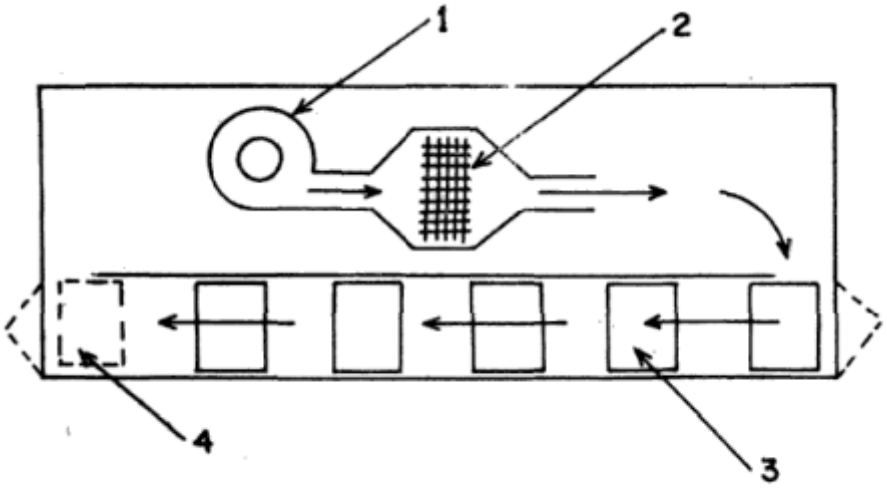
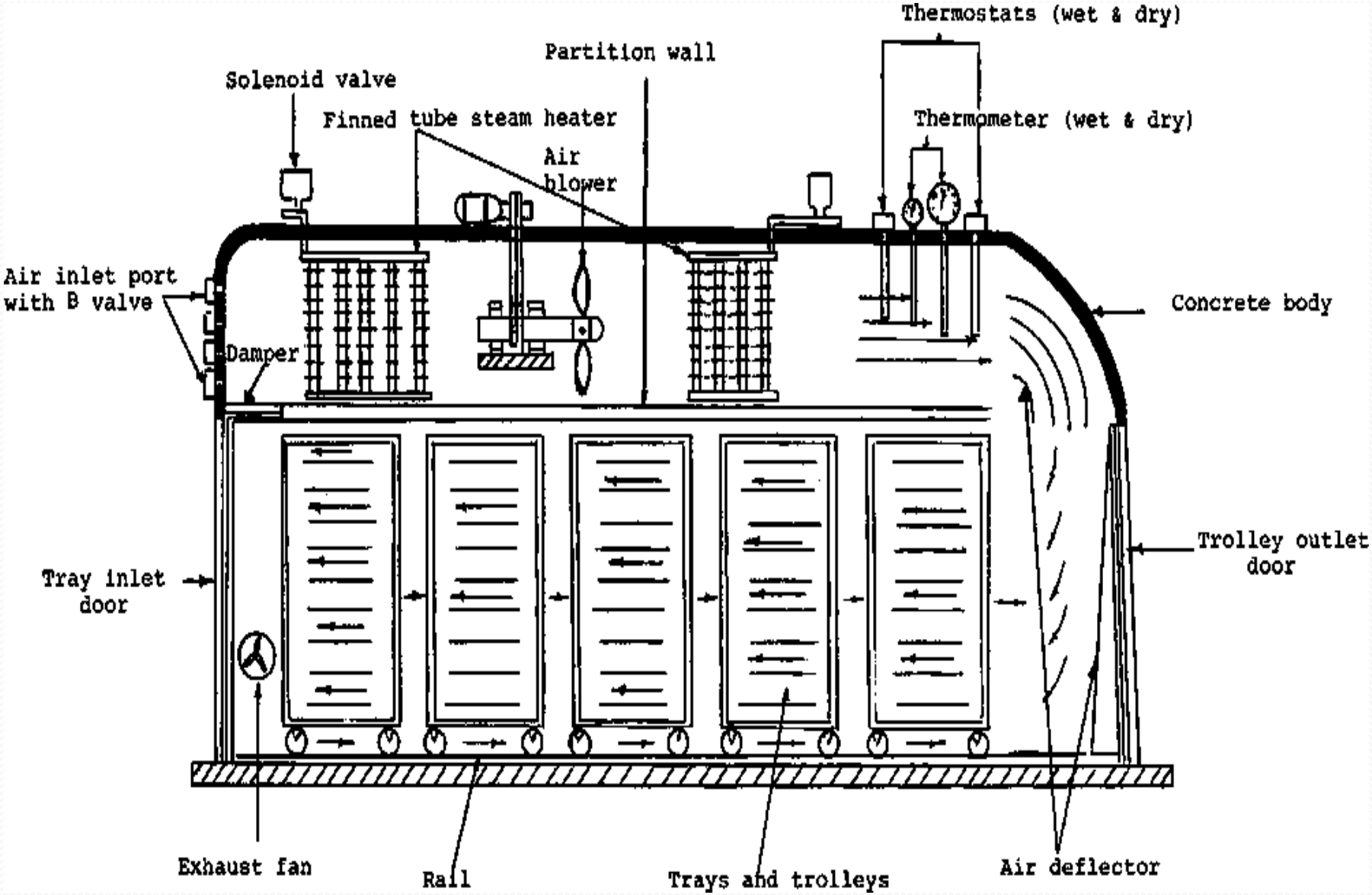
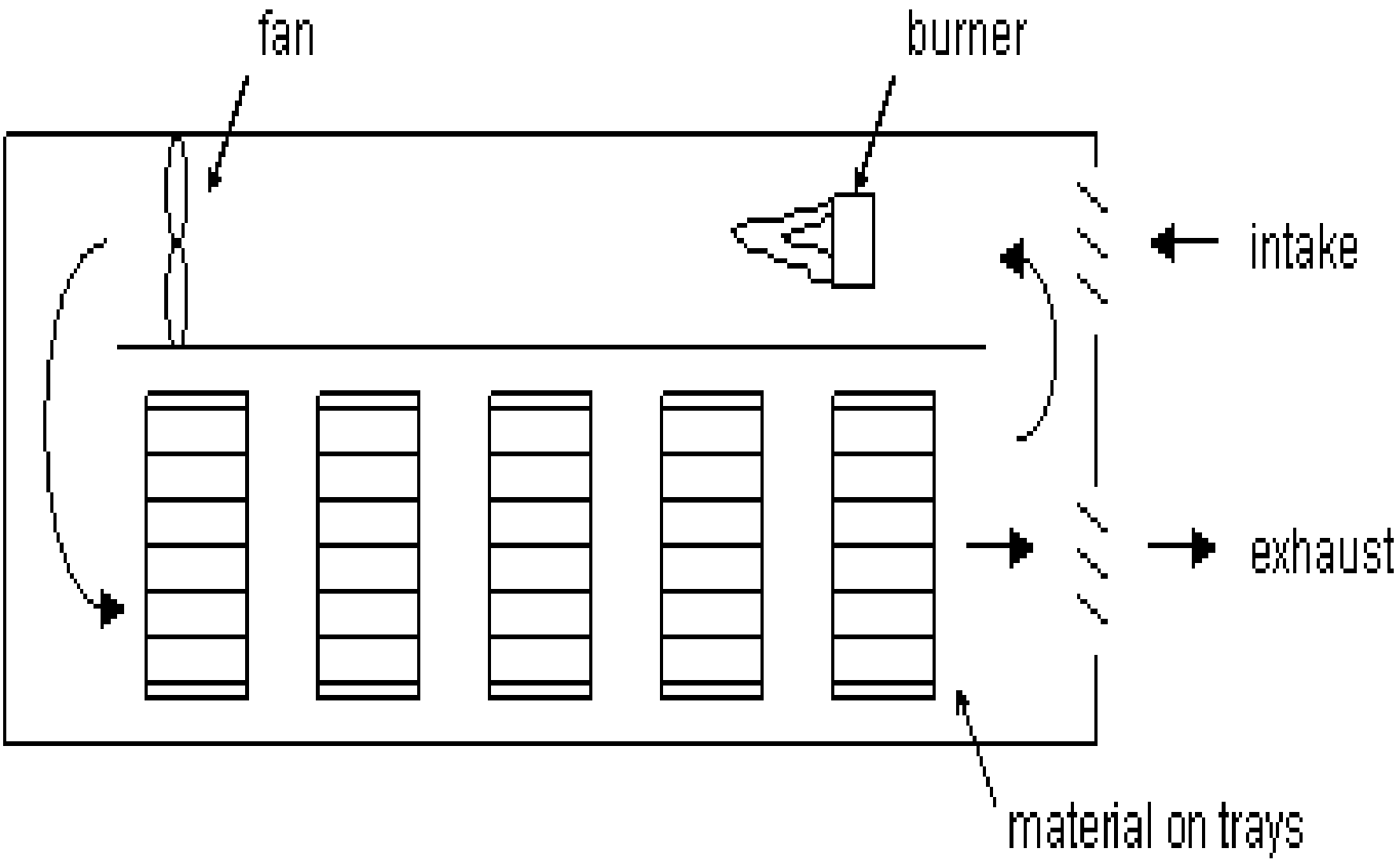


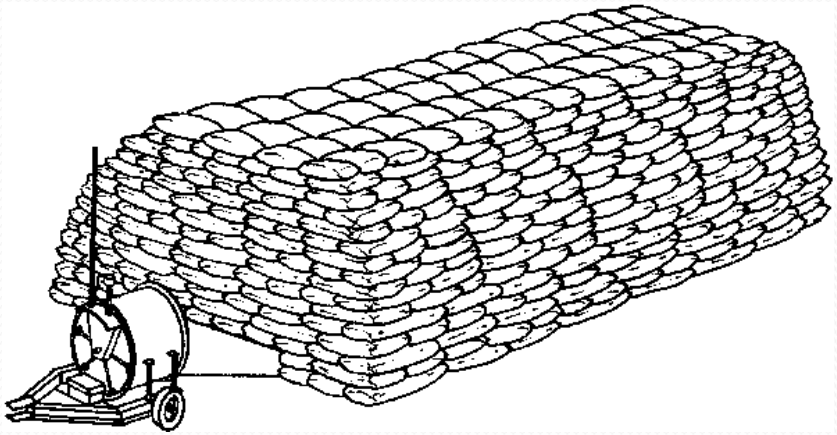

Fig. 3.37 : Schematic diagram of funnel dryer
1. blower 2. heater 3. trays 4. exit air chimney


Thermostats (wet & dry)
Partition wall
Solenoid valve
Finned tube steam heater
Thermometer (wet & dry)
Air blower
Air inlet port with B valve
Concrete body
Damper
Trolley outlet door
Tray inlet door
Exhaust fan
Rail
Trays and trolleys
Air deflector


fan
burner
intake
exhaust
material on trays

# Grain drying in bags

- **This method is useful to dry grains in small quantities. The method requires large number of unskilled labourers. More space is needed because bags of grain are put on perforated racks.**
- **The heated air is forced through the racks and bags. The drying air temperature is kept at 45°C and the air flow rate at 4 $m^3$/min. During drying, the bags are inverted at least once to accomplish drying on both sides of the bags.**



# Solar dryer

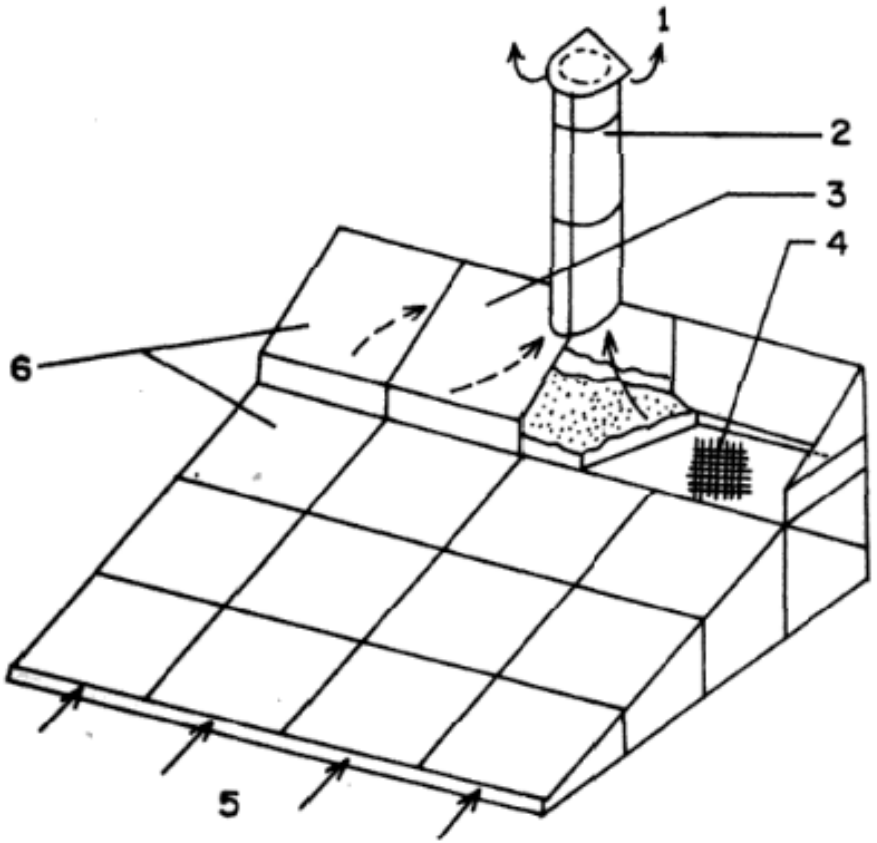



**Fig. 3.38 :** Direct dryer (natural convection)
with separate collector and drying chamber
1. exit air 2. chimney 3. transferable panel 4. bamboo/nylon mesh
5. air intake 6. clear plastic sheet

# Solar dryer

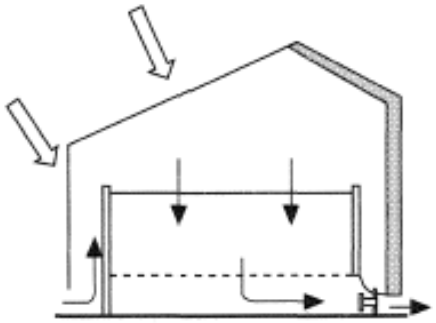
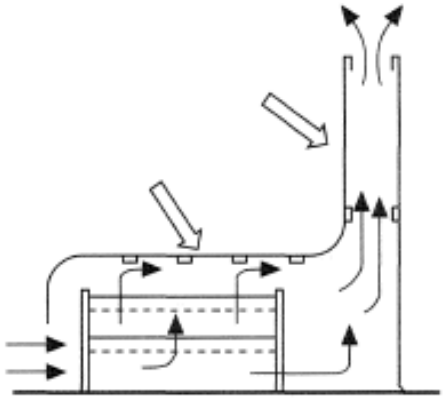
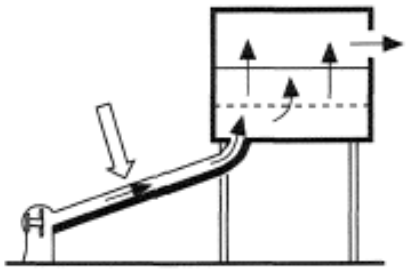
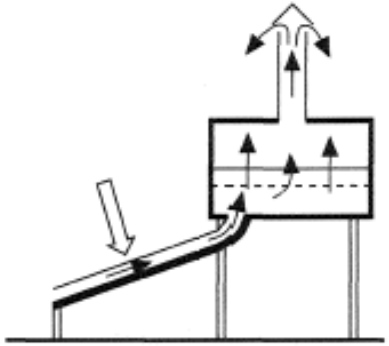
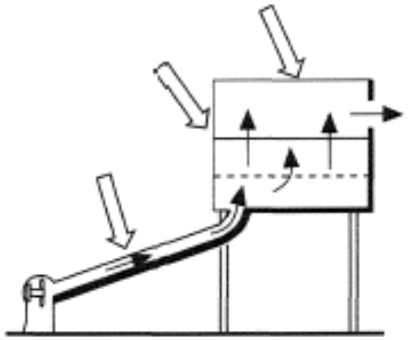
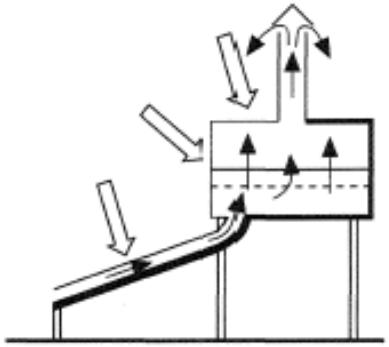
- **Solar drying of agricultural products can be advantageous alternative to sun drying for the farmers of developing nations.**
- **It can be a means of supplementing or replacing artificial dryers with consequential savings in fuels and costs.**
- **Solar drying provides higher air temperatures and lower relative humidities than simple sun drying.**

# Solar dryer

- **It enhances the drying rates and lower final moisture content of dried products.**
- **As a result the risk of spoilage is reduced, both during the actual drying process and in subsequent storage.**
- **In many cases, solar drying can be feasible alternative wholy or partially to artificial drying.**

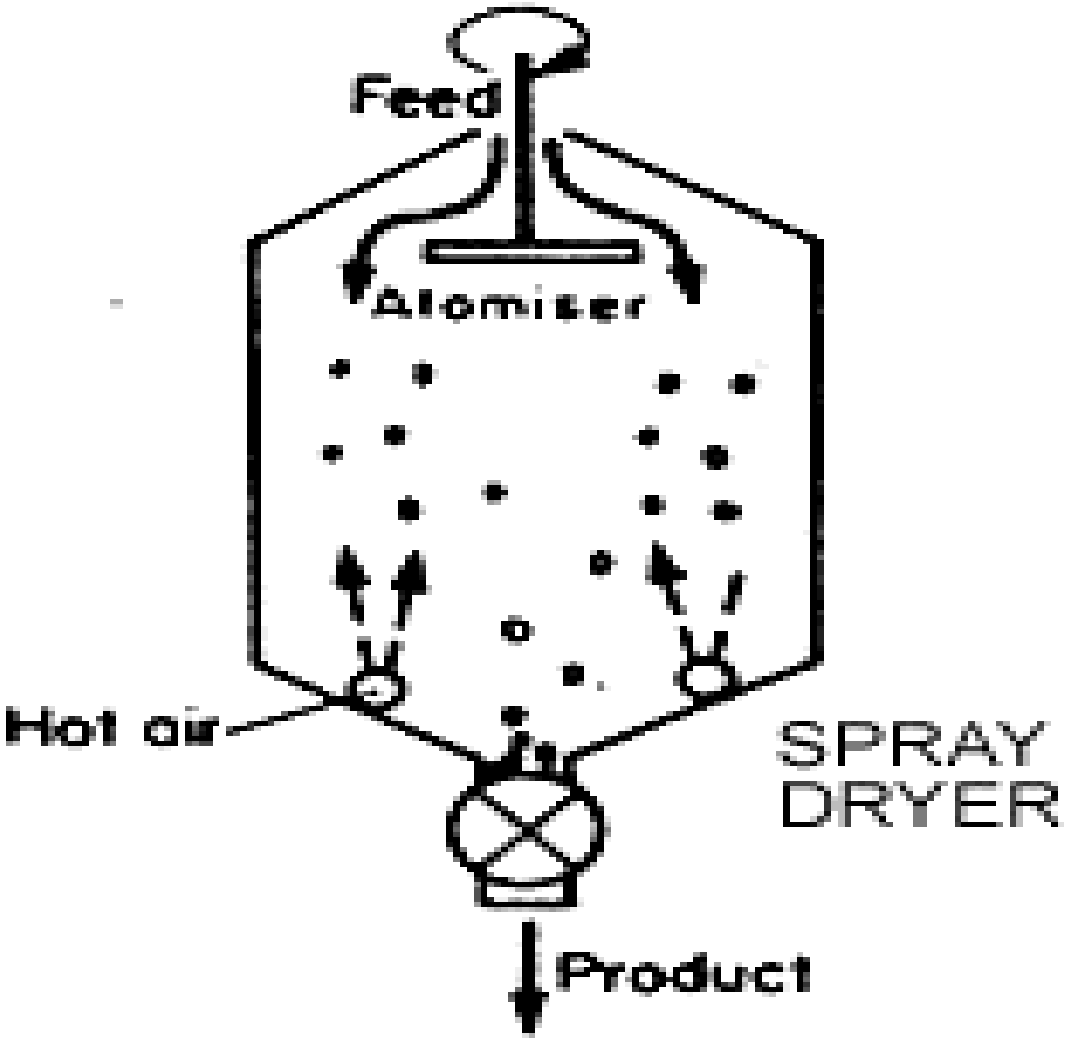
# Types of solar dryer

1. **Direct dryer with natural convection and with combined collector and drying chamber.**
2. **Direct dryer with natural convection and with separate collector and drying chamber.**
3. **Indirect dryer with forced convection and with separate collector and drying chamber.**

| | Active Dryer | Passive Dryer |
|---|---|---|
| Integral (Direct) Type |  |  |
| Distributed (Indirect) Type |  |  |
| Mixed Mode |  |  |

# SPRAY DRYER

- In a spray dryer, liquid or fine solid material in a slurry is sprayed in the form of a fine droplet dispersion into a current of heated air.
- Drying occurs very rapidly, so that this process is very useful for materials that are damaged by exposure to heat for any appreciable length of time.
- The dryer body is large so that the particles can settle, as they dry, without touching the walls on which they might otherwise stick.
- Commercial dryers can be very large of the order of 10 m diameter and 20 m high.


Feed
Atomiser
Hot air
SPRAY
DRYER
Product

# THANK YOU