DRYING

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Drying is defined as the process in which the removal of liquid from the material is done by the application of heat &is accomplished by transfer of liquid from the surface in to an unsaturated vapour phase.

OBJECTIVES:

- Drying is required during bulk manufacturing of granules, final stage compression as tablets or filling them in to capsule shells.
- Some of the products are obtained only by final stage drying process during their preparation. eg:Aluminum hydroxide, spray dried lactose, spray dried starch etc.,
- The bulkiness & weight of material can be reduced by drying.
- Certain drugs are to be dried for size reduction & also for extraction of active principles from them.
- Drying improves the stability of products.

FACTORS TO BE CONSIDERED IN SELECTING A DRYER FOR SUITABLE PURPOSE

- Whether the product is heat sensitive or not.
- The physical characters of the material to be dried.
- Nature of the solvent to be evaporated.
- Whether the process is to be carried out under aseptic conditions or not.
- The type & source of heat used.
- The quantity of material to be dried.
- The cost factor involved.

THEORY OF DRYING

- Drying involves both heat & mass transfer operations.

- Heat transfer involves application of heat to the material to be dried to undergo latent heat of vaporization of liquid present in it.

Heat transfer:- $dw / d\theta = q / \lambda$

Mass transfer:- Mass transfer depends upon rate of diffusion.

$$dw / d\theta = k^1 A (Hs - Hg)$$

$$k^1 = CGn$$

- The rate of heat transfer should be equal to rate of mass transfer.

$$dw / d\theta = q / \lambda = k^1 A (Hs - Hg)$$

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FACTORS INFLUENCING RATE OF DRYING

- Nature of material to be dried.
- Air flow
- Thickness of the solid bed & surface area
- Mode of heat transfer.

EQUILIBRIUM MOISTURE CONTENT

" EMC means vapour pressure exerted by the moisture present in the material is in equilibrium with that of vapour pressure exerted by moisture in the atmosphere".

- At EMC , the material is more stable & it does not absorb or loose moisture.

Significance of EMC :-

- It is advantageous to stop the drying process at EMC.
- Thermolabile materials can be saved from over drying.
- Length & time of drying can be saved.

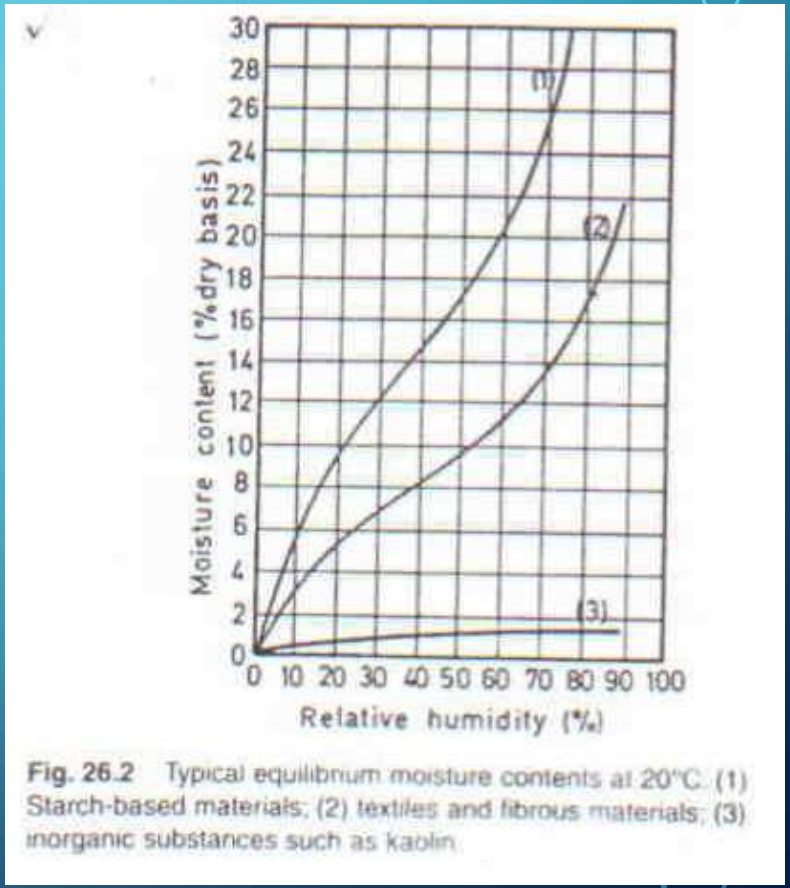


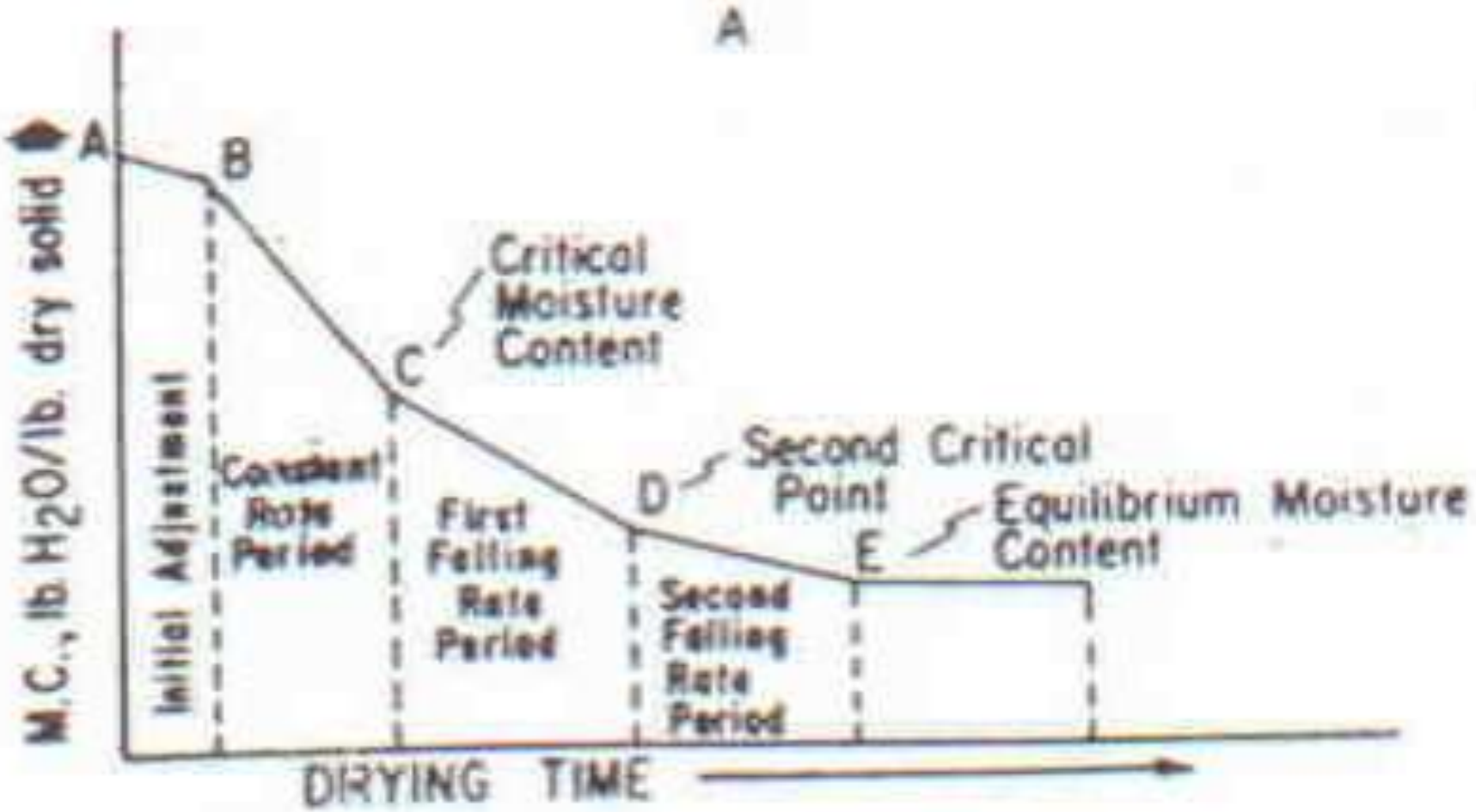
Fig. 26.2 Typical equilibrium moisture contents at 20°C. (1) Starch-based materials; (2) textiles and fibrous materials; (3) inorganic substances such as kaolin

EFFECT OF SHRINKAGE ON DRYING PROCESS

There are 3 different types of shrinkage.

1. Change in the surface of material per unit weight
2. Formation of hardened layer upon the surface
3. Warping or checking of material

DRYING RATE CURVES



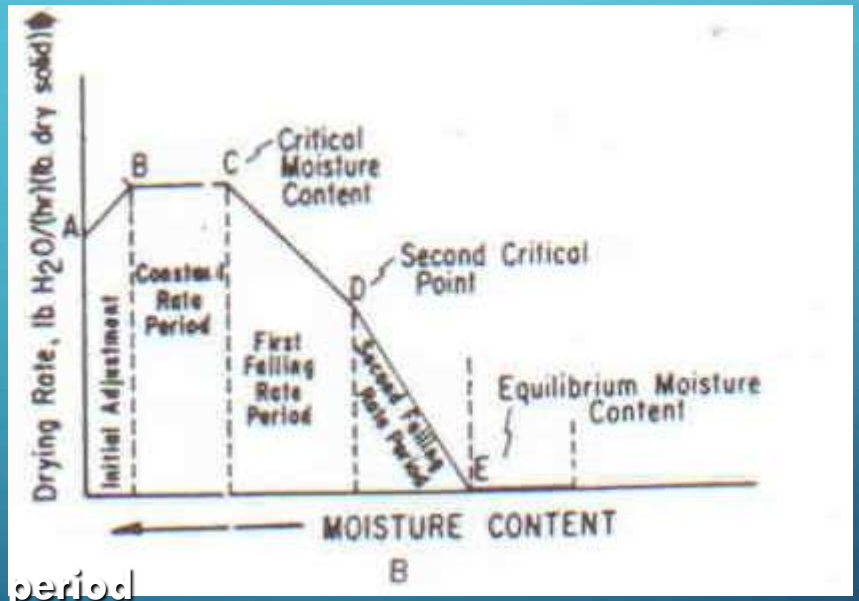
A-B : Initial adjustment period

B-C : Constant rate period

C-E : Falling rate period

C-D : First falling rate period

D-E : Second falling rate period



A-B : Initial adjustment period
B-C : Constant rate period
C-E : Falling rate period
C-D : First falling rate period
D-E : Second falling rate period

CLASSIFICATION OF DRYERS

Based upon nature of material subjected to drying :

1. Dryers for drying of solutions, suspensions and emulsions. Eg: spray dryer, drum dryer
2. Dryers for drying of semi solid or sticky masses. Eg: pan dryer, agitated batch dryer.
3. Dryers for drying of damp solid masses. Eg: tray dryer, tray and truck dryer, tunnel and conveyer dryer, turbo tray dryer, rotary dryer, vacuum oven, freeze dryer, fluid bed dryer.

Based upon the mode of heat transfer:

1. Conductive dryers: Eg: Pan dryer, Batch dryer, vacuum oven, freeze dryer.

2. Convective dryers. Eg: tray dryer, tray and truck dryer, turbo and tray dryer, rotary dryer, FBD, spray dryer.

3. Radiant dryers. Eg: vacuum oven, tunnel and conveyor dryer.

Based upon the movement of material to be dried:

1. **Static bed dryers :**

   Eg: drum dryer, tray dryer, tray and truck dryer, tunnel and conveyor dryer, freeze dryer, vacuum oven.

2. **Moving bed dryers :**

   Eg: spray dryer, pan dryer agitated bed dryer, turbo and tray dryer, rotary dryer, FBD.

TRAY & TRUCK DRYER

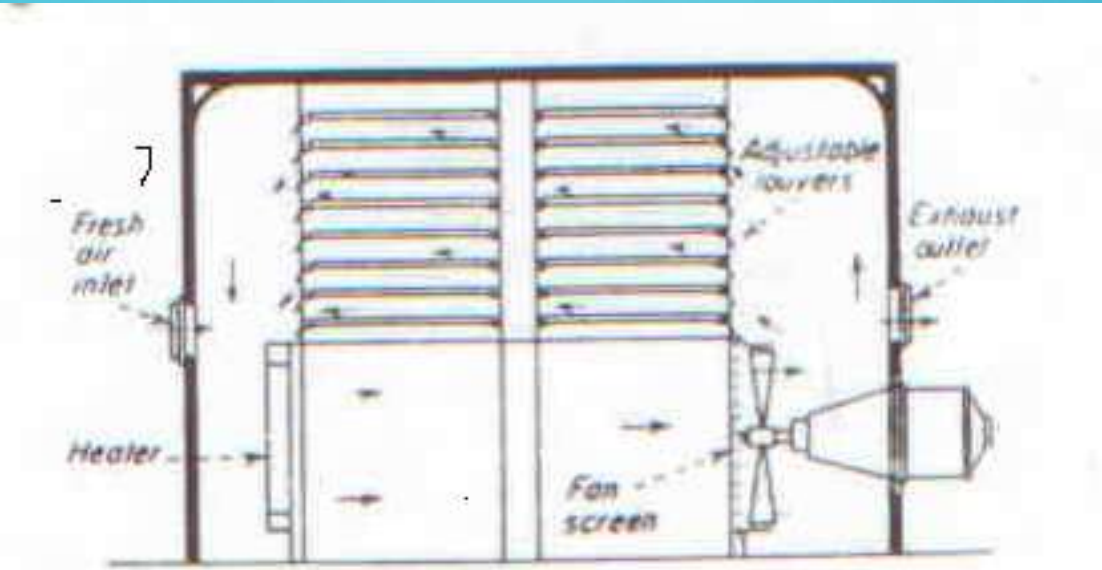


FIG. 3-6. *Tray dryer. (Courtesy of the Proctor and Schwartz Company.)*

ADVANTAGES:

- These are batch operated dryers.
- In pharmaceutical processes the maximum lot of material subjected may be up to 100-200 pounds which does not require continuous operations.
- Different kinds of materials can be dried in a batch wise process.

TUNNEL & CONVEYOR DRYER

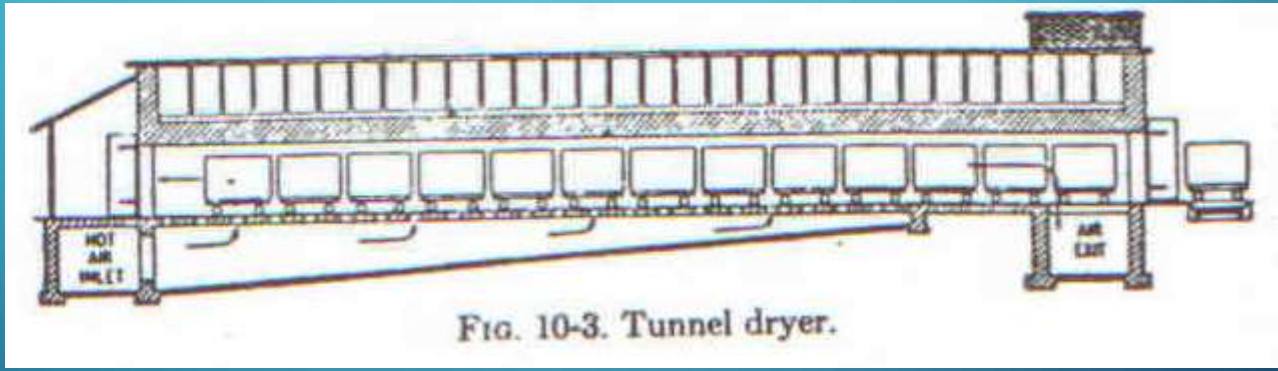
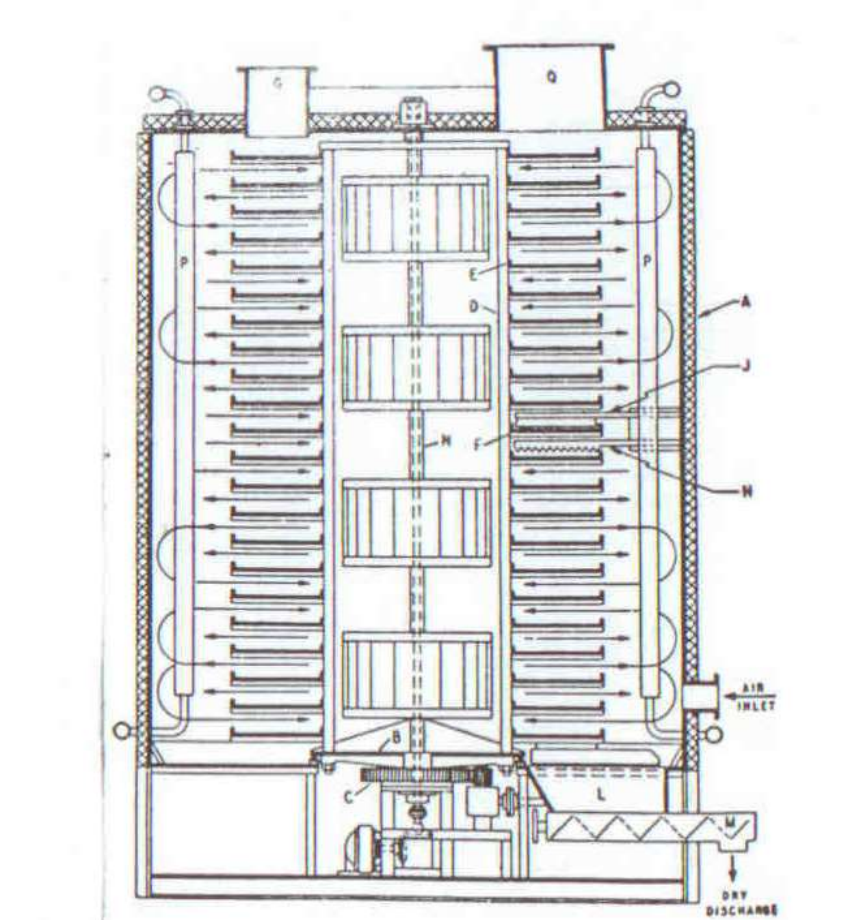
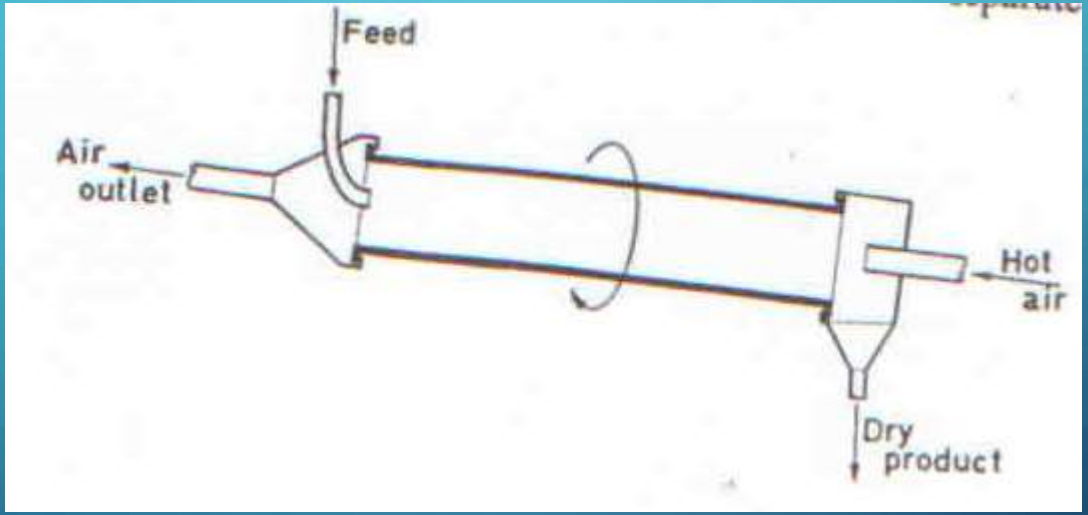


Fig. 10-3. Tunnel dryer.

TURBO & TRAY DRYER



ROTARY DRYER



AGITATED BATCH DRYER

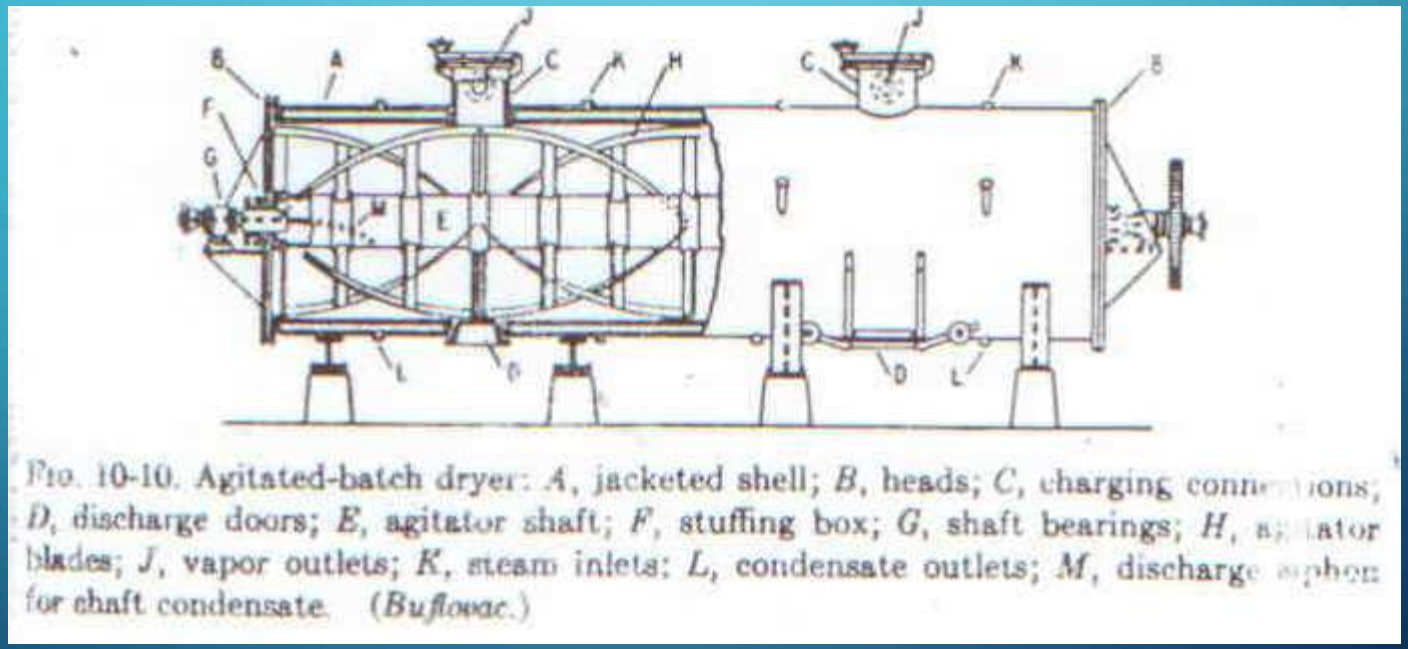
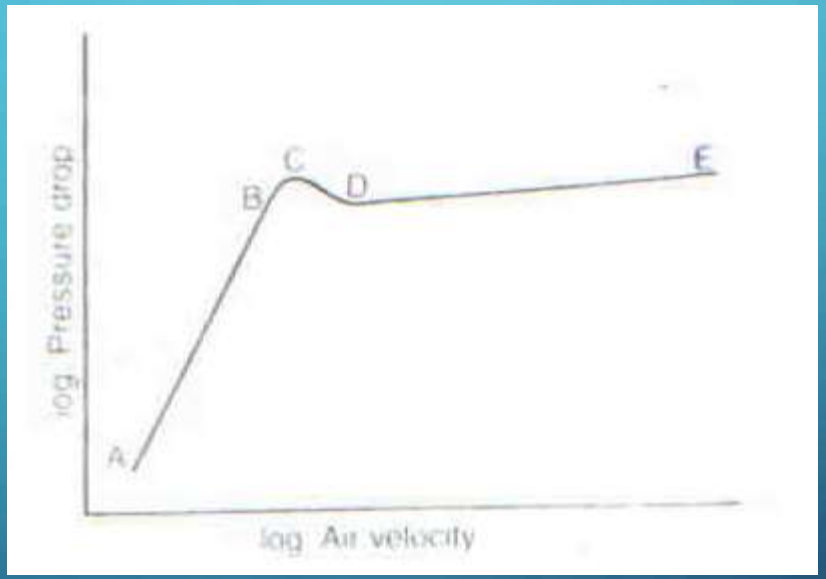
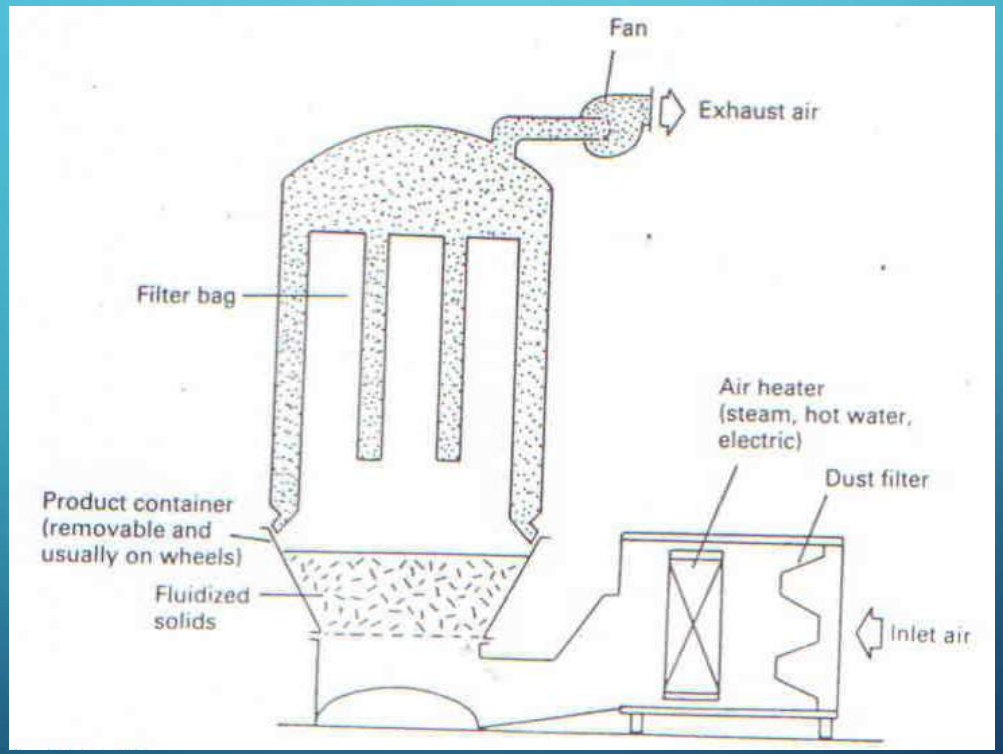


FIG. 10-10. Agitated-batch dryer: *A*, jacketed shell; *B*, heads; *C*, charging connections; *D*, discharge doors; *E*, agitator shaft; *F*, stuffing box; *G*, shaft bearings; *H*, agitator blades; *J*, vapor outlets; *K*, steam inlets; *L*, condensate outlets; *M*, discharge siphon for shaft condensate. (*Buflovac.*)

FLUID BED DRYER




Fan
Exhaust air
Filter bag
Air heater
(steam, hot water,
electric)
Dust filter
Product container
(removable and
usually on wheels)
Fluidized
solids
Inlet air

ADVANTAGES :

- The temperature of FBD is constant and drying time is very short.
- The fluidized state produces a free flowing product.
- The free flowing of individual particles eliminates the risk of soluble material migration.
- The containers are mobile, making handling simple & reducing the labor costs.

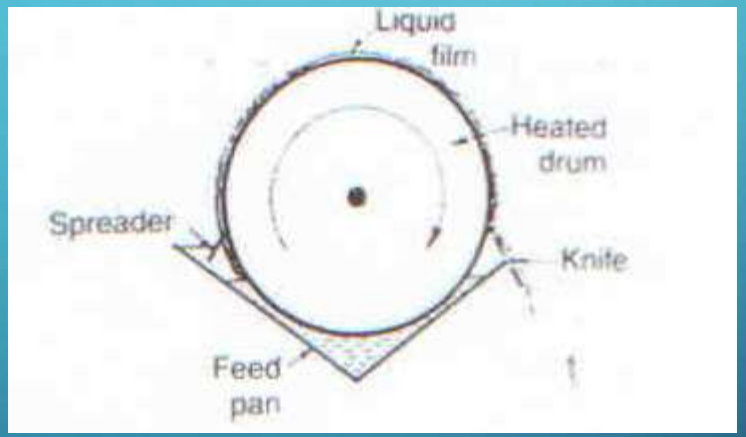
DISADVANTAGES :

- The turbulence of fluid state may lead to production of fines.
- Fine particles may become entrained and must be collected by bag filters.
- The vigorous movement of particles can lead to generation of static charges.

APPLICATIONS :

- It is mainly used for drying of solid powder material & tablet granules.
- It is used for production of spansules or beads for micro encapsulation of products. Egg: ferrous sulphate beads.
- It is used for production of pelletization of drugs which undergo degradation. Eg: omeprazole pellets.
- It is used for the coating of granules or small tablets for their enteric or film coating.

DRUM DRYER



ADVANTAGES:

- It is versatile piece of equipment.
- It offers rapid drying in few seconds.
- It produces a flaky mass of solid material.
- It can also be used for thermolabile materials under vacuum.
- It can be continuously operated for one type of material.

DISADVANTAGES:

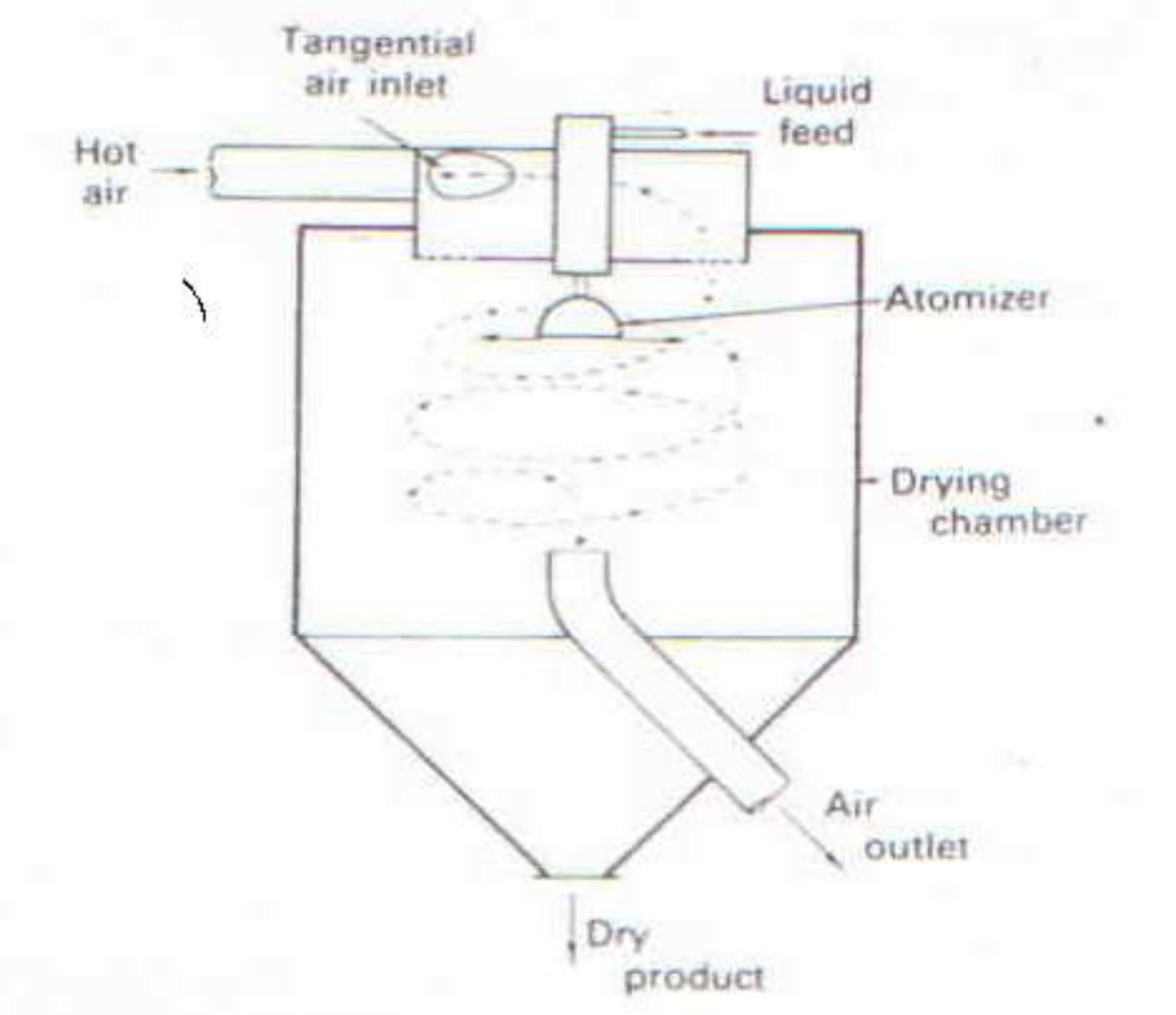
- The drying rate is highly critical.
- Not suitable for salt solutions containing insoluble or poorly soluble substances.

APPLICATIONS:

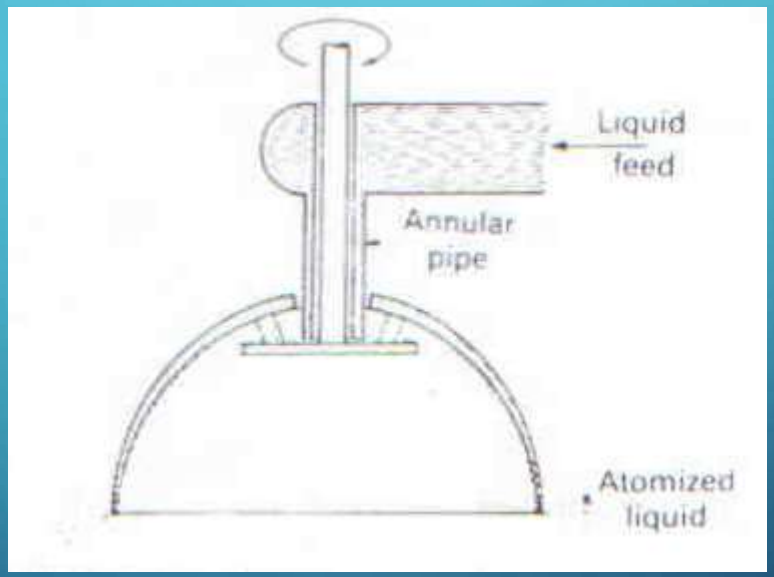
- It is mainly used for drying of solutions or suspensions.

- Used for drying of materials such as milk products, starch products, ferrous containing solutions, suspension of kaolin, ZnO, yeast suspension, pigment solution, malt extract, antibiotics, calcium carbonate, barium carbonate etc.

SPRAY DRYER


Tangential
air inlet
Liquid
feed
Hot
air
Atomizer
Drying
chamber
Air
outlet
Dry
product

ROTARY AUTOMIZER



ADVANTAGES:

- The products obtained has low density , improved solubility & bulky in nature.
- Rate of drying is very rapid.
- Spherical shaped granular products are produced which are directly compressible.

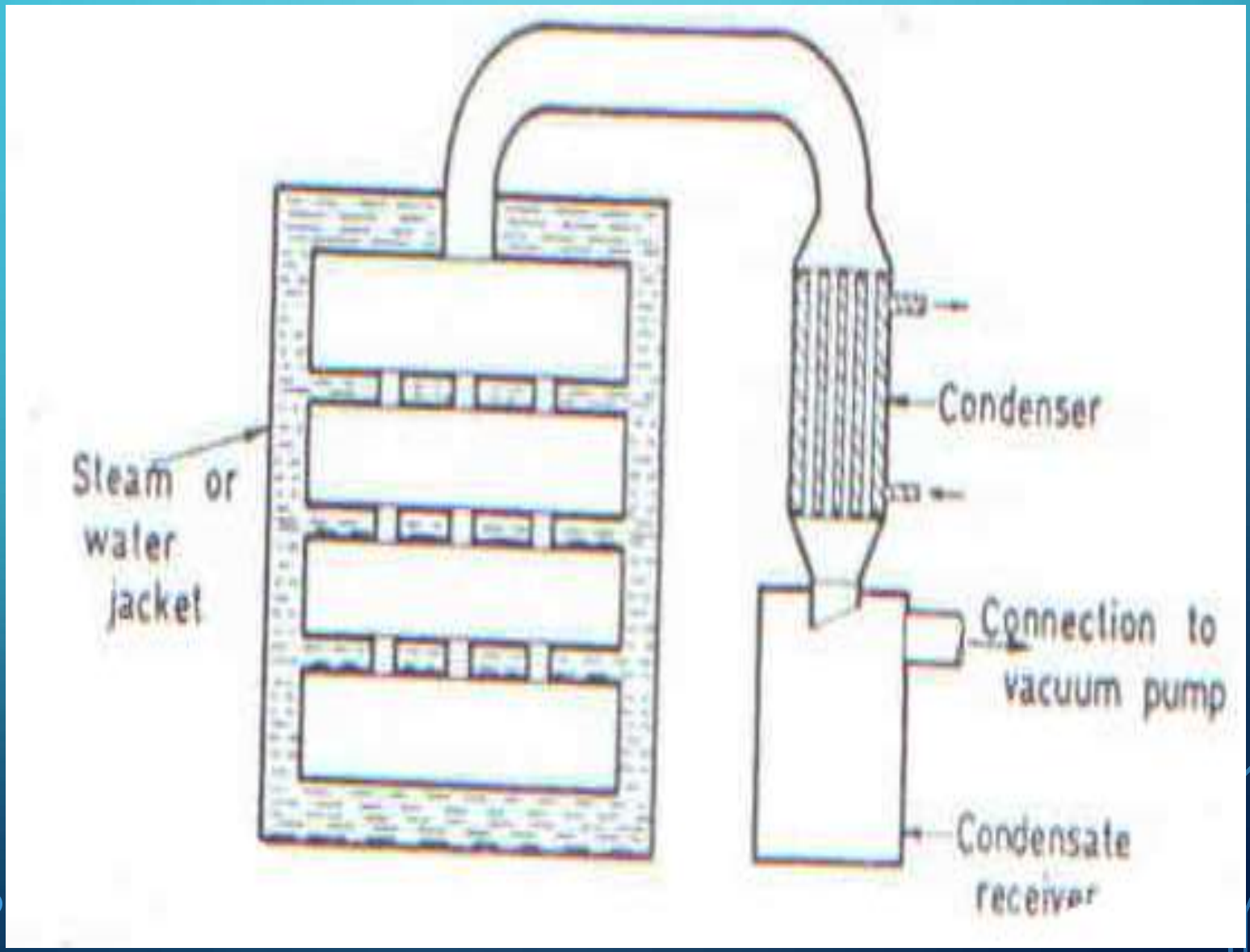
DISADVANTAGES:

- A typical spray dryer occupies 15m height& 6m diameter.
- The thermal efficiency is rather low.

APPLICATIONS :

- It is highly suitable for drying of thermolabile materials, suspensions and emulsions.
- For micro encapsulation of oily substances like vitamin-A, D by using polymer.
- For producing reconstitutable products.
- Masking bitter taste by incorporation of organic polymer to coat the dry products.
- Drying of materials aseptically .Eg:serum hydrolysate.
- Widely used for drying of milk products, milk etc .
- The spray dried products are borax, barium sulphate, calcium phosphate, soaps & detergents.
- It is also used for drying of serum hydrolysate, coffee & tea extracts, vitamins, hormones, plasma products, yeast products ,bacitracin, methyl cellulose, vaccines, chloramphenicol, pancreatin, penicillin etc.

VACUUM OVEN


Steam or
water
jacket
Condenser
Connection to
vacuum pump
Condensate
receiver

ADVANTAGES :

- Thermolabile substances can be dried at low temperatures.
- A porous & friable products can be obtained during drying, suitable for tablet manufacturing.
- Costlier solvents can be recovered by using condenser.

DISADVANTAGES :

- Heat transfer may be low & non uniform.
- The capacity is limited.
- The labour & running costs are very high
- There is a danger of entrainment of fines.

APPLICATIONS :

- It is used for heat sensitive materials which undergo decomposition under high temperatures.eg: Alkaloids,glycosidal extracts.

- It is used for drying of hygroscopic & dusty materials.

- Used for the purpose of producing drugs in porous form.

FREEZE DRYER

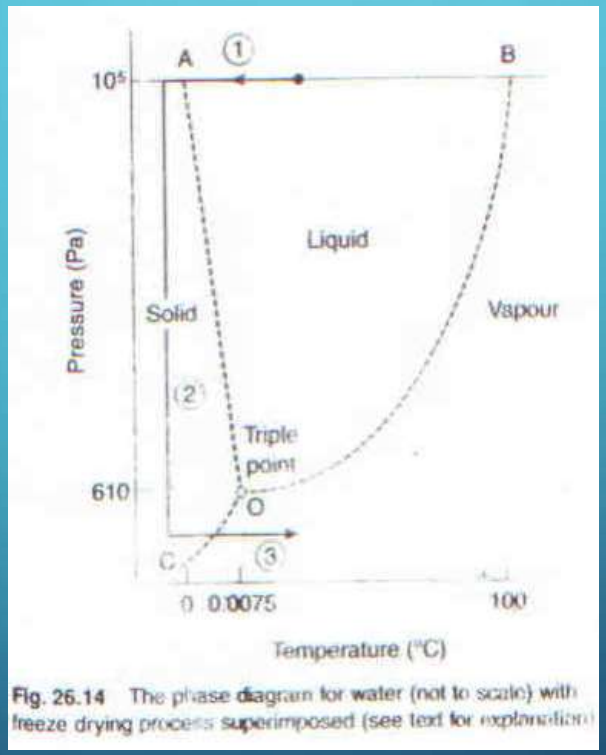


Fig. 26.14 The phase diagram for water (not to scale) with freeze drying process superimposed (see text for explanation)

PRECAUTIONS :

- The material to be dried should be maintained below the triple point conditions ie.-10 to -30c
- The surface area provided should be increased.
- The vapours raised should be removed as quickly as possible.
- The packing of the product should be done at the similar vacuum conditions.

STEPS INVOLVED IN FREEZE DRYING:

- Freezing :

  1.shell freezing.

  2.Vertical spin freezing.

  3.Centrifugal evaporative freezing
- Vacuum application or primary drying
- Heat supply
- Vapor removal
- Secondary drying
- Packing

ADVANTAGES:

- Thermo labile products can be freeze dried without undergoing oxidation or hydrolysis.
- The product obtained is light, porous & improves the solubility.
- There is no concentration of solutions prior to drying.
- Under high vacuum the drying process can be carried out in a highly aseptic conditions.

DISADVANTAGES:

- The product obtained by freeze drying is highly hygroscopic in nature.
- The process is very slow and requires a very complicated plant which is highly expensive.
- It is difficult to dry solutions containing hot aqueous solvents.

APLLICATIONS:

1. Freeze drying is mainly used for drying of biological products such as vaccines, seras, enzymes, blood products, antibiotics, etc.
2. It is used in maintenance and preservation of microbial cultures.
3. Fibrinogen dissolved in sodium chloride injection and then clotted by addition of human thrombin is freeze dried.
4. A solution of gelatin containing formaldehyde is freeze dried and is used for surgical dressing.
5. Freeze dried hemoglobin formulated with sucrose is widely used to prevent dehydration of hemoglobin.
6. Vaccines produced by freeze drying are BCG, yellow fever, small pox, chicken pox, tetanus, hepatitis B vaccines etc.


THANK YOU