UNIT-3

Drying: It is the process of removal of small amount of liquid (water, moisture) by application of heat to obtain dry solid or solid product.

eg- Drying of clothes.

Applications

⇒ Drying is necessary to make material light weight.

⇒ It increase stability → Removal of moisture, significant decrease rate of chemical reaction, chances of microbial attack or enzymatic action and thus improve stability.

⇒ During production of tablets, granules are dried to improve flow property as well as

⇒ Helps in production of bulk drug and also help in preservation of drug product.

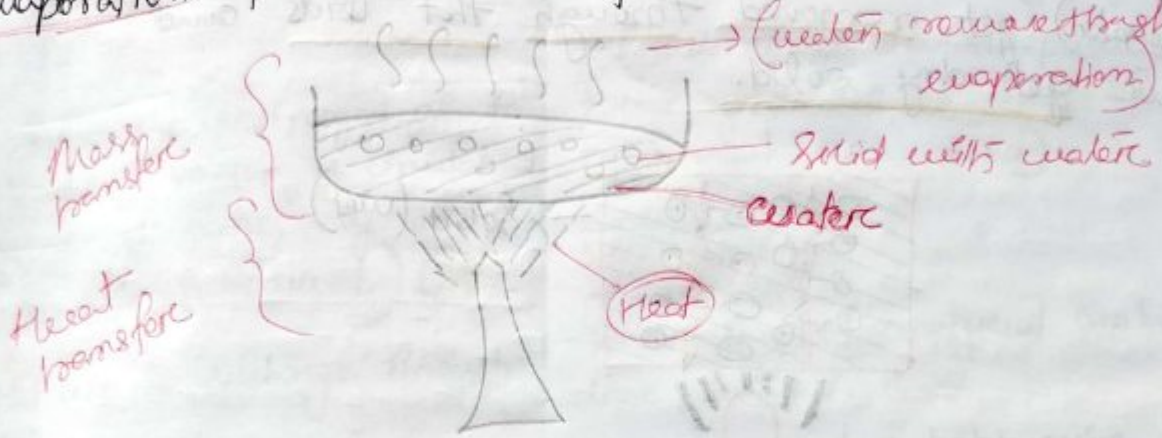
Mechanism of drying process

On thermal process of drying involve two process —

(i) Heat transfer
(ii) Mass transfer

(i) **Heat transfer:** In this, heat is generated within the solid and flow to the exterior surface.

(4) Mass transfer: It involves movement of the moisture to the surface of the solid and its subsequent evaporation from the surface.



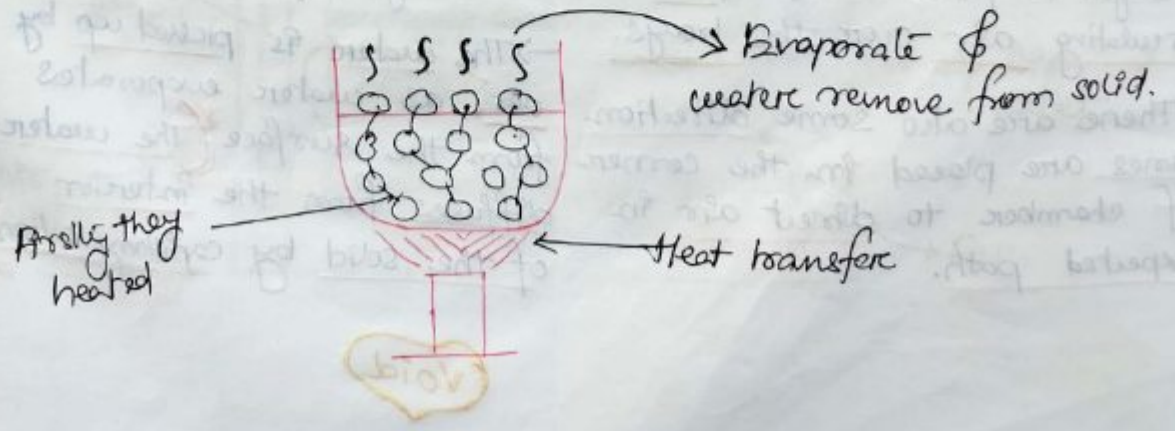
⇒ There are also some theories of drying :—

(1) Diffusion theory: Acc. to diffusion law, heat transfer (move) from high concentration to low concentration.

→ So, when heat apply on wet solid, the bottom particles of liquid get heated, then they transfer their heat to another one (next)

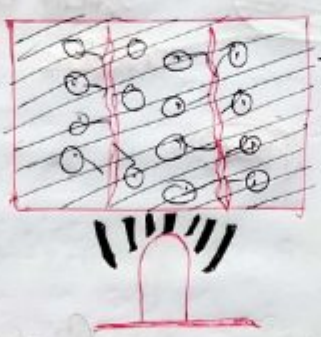
→ Then it transfer to next and the last final particle of liquid (on top) gets evaporated.

→ And finally dry solid obtained, all water (liquid) remove from wet solid.



(11) Capillary theory: There are some capillary like voids present in wet solid.

→ So when we provide heat on that solid, liquid (water) get removed through that voids and we get dry solid.



Tray Dryer

Principle: In tray dryer, hot air is continuously circulated.

→ Forced convection heating takes place to remove moisture from the solids placed in trays.

→ Simultaneously, the moist air is removed partially.

Construction:

→ It consists of rectangular chamber whose walls are insulated.

→ Trays are placed in the heating chambers.

→ Dryer is fitted with a fan for circulating air over the trays.

→ There are also some direction vanes are placed in the corners of chamber to direct air in expected path.

Working:

→ Firstly, wet solid is loaded into tray, then trays are placed in the chamber.

→ Now, fresh air is introduced through inlet, which passes through the heaters and get heated up.

→ The hot air is circulated by means of fans at 2-5 m/s.

→ Turbulent flow lowers the partial vapour pressure in the atmosphere and also reduce the thickness of the air boundary layer.

→ The water is picked up by air, as water evaporates from the surface. The water diffuses from the interior of the solid by capillary action.

→ These event occurs in a single pass of air, so the time of contact is short and the amount of water picked up in a single pass is small.

→ (Therefore, the discharged air to the tune of 80-90% is circulated back through fans, only 10-20% of fresh air introduced.) (NO)

→ Moist air is discharge through outlet.

→ Thus, constant temp° and uniform airflow over the material can be maintained for achieving uniform drying.

→ At the end of drying, trays are pulled out of the chamber and taking to a tray dumping station.

*(In case of wet granules (tablets, capsules etc) drying is continued until the desired moisture content is obtained)

Uses:

→ Sticky material, plastic substance, granules, precipitates and pastes can be dried in a tray dryer.

→ (Crude drugs, chemicals, powders, tablet, granules or parts of equipment are dried)

Advantages:

→ Handling of material can be done without losses.

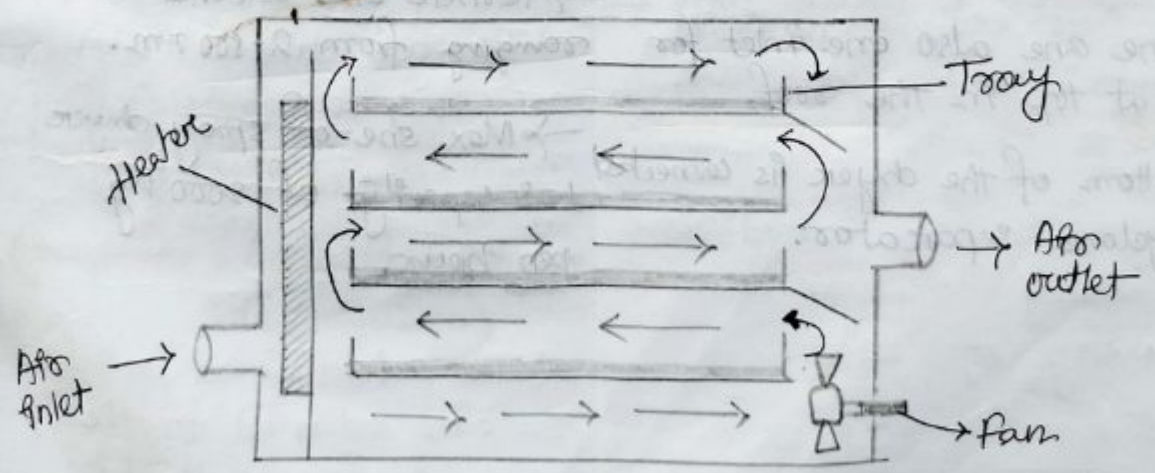
→ It is operated batch wise.

→ Valuable products can be handled efficiently.

Disadvantages:

→ Tray dryer requires more labour to load and unload. Hence, cost increases.

→ Process is time-consuming.



Spray Dryer

Principle: In spray dryer, the fluid to be dried is atomised into fine droplets, which are thrown radially into a moving stream of hot gas.

→ The temperature of the droplets is immediately increased and fine droplets get dried instantaneously in the form of spherical particles.

→ This process completes in a few seconds before the droplets reach the wall of the dryer.

Construction:

→ It consists of a large cylindrical drying chamber with a short conical bottom, made up of stainless steel.

→ An inlet for hot air is placed in the roof of the chamber, another inlet carrying spray-disk atomizer is also set in the roof.

→ There are also one inlet for food at top in the roof.

→ Bottom of the dryer is connected to cyclone separator.

Working:

Drying of material in spray dryer involves 3 stages —

① **Atomization of the liquid**

The feed is introduced through the atomizer either by gravity or by using suitable pump to form fine droplets.

② **Drying of the liquid droplets**

Fine droplets are dried in the drying chamber by supplying hot air through the inlet.

③ **Recovery of the dried product**

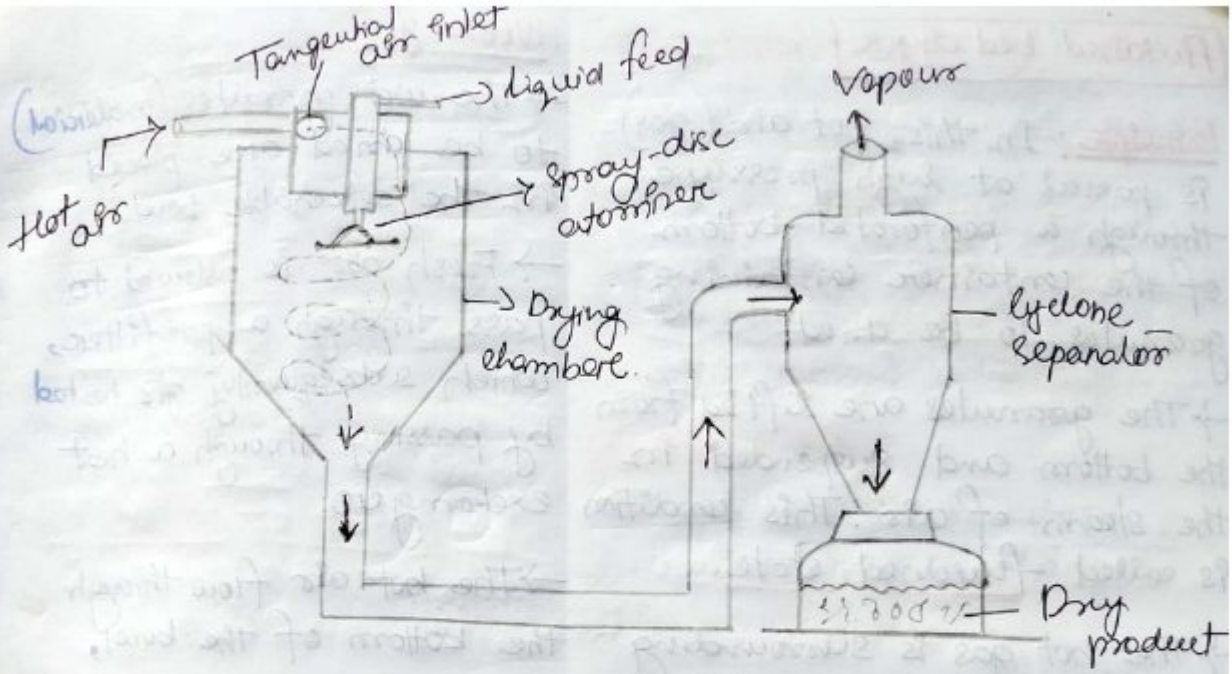
Centrifugal force of atomizer drives the droplets to follow helical path.

→ Particles are dried during their journey and finally fall at the conical bottom, which further move into cyclone separator.

→ All these process are completed in few seconds.

→ Particle size obtained is ranging from 2-500 nm.

→ Max. size of spray dryer has capacity of 2000 kg per hour.



[Spray Dryer]

Uses:

→ The product is a better form than that obtained by any other dryer.

→ The quantity of the material to be dried is large.

→ Also used in drying of thermolabile, hygroscopic material and those material which undergoes chemical decomposition.

Advantages:

→ It is continuous process and very rapid.

→ Labour costs are low for its combine function.
(evaporator + crystallizer + dryer + size reduction)

Disadvantages:

→ Very bulky & expensive.

→ Not always easy to operate.

Fluidised bed dryer

Principle: In this, hot air (gas) is passed at high pressure through a perforated bottom of the container containing granules to be dried.

→ The granules are lifted from the bottom and suspended in the steam of air. This condition is called fluidised state.

→ The hot gas is surrounding every granule to completely dry them, thus material or granules are uniformly dried.

Construction:

→ It is made up of stainless steel.

→ A detachable bowl is placed at the bottom of the dryer (used for load material)

→ A fan is mounted in the upper part for circulating hot air.

→ Fresh air inlet, prefilter and heat exchanger are connected serially to heat, air & to the required temp°.

→ Bag filters are placed above the drying bowl for the recovery of fines.

Working:

→ The wet granules (material) to be dried are placed in the detachable bowl.

→ Fresh air is allowed to pass through a prefilter, which subsequently gets heated by passing through a heat exchanger.

→ The hot air flow through the bottom of the bowl,

→ Simultaneously, fan is allowed to rotate. The air velocity is gradually increased.

→ When the velocity of the air is greater than settling velocity of granules, the granules remain partially suspended in the gas stream.

→ After some time, granules rise in the container because of high velocity. Later, fall back in the random boiling motion (fluidised state)

→ The gas surrounds every granules to completely dry them, the air leaves the dryer by passing through the bag filter.

→ The entertained particles remain adhered to the inside surface of the bags, the bags are shaken to remove the entertained particles.

→ The residence time for drying is about 40 minutes.

→ The material is left for some time in the dryer for reaching ambient temp.

→ The bowl is taken out for discharging.

→ The end product is free flowing.

Uses:

→ Used for drying of granules in the production of tablets.

→ It can be used for three operation —— mixing, granulation & drying.

Advantages:

→ It requires less time to complete drying.

→ Available in different sizes with drying capacity from 5-200 kg per hour.

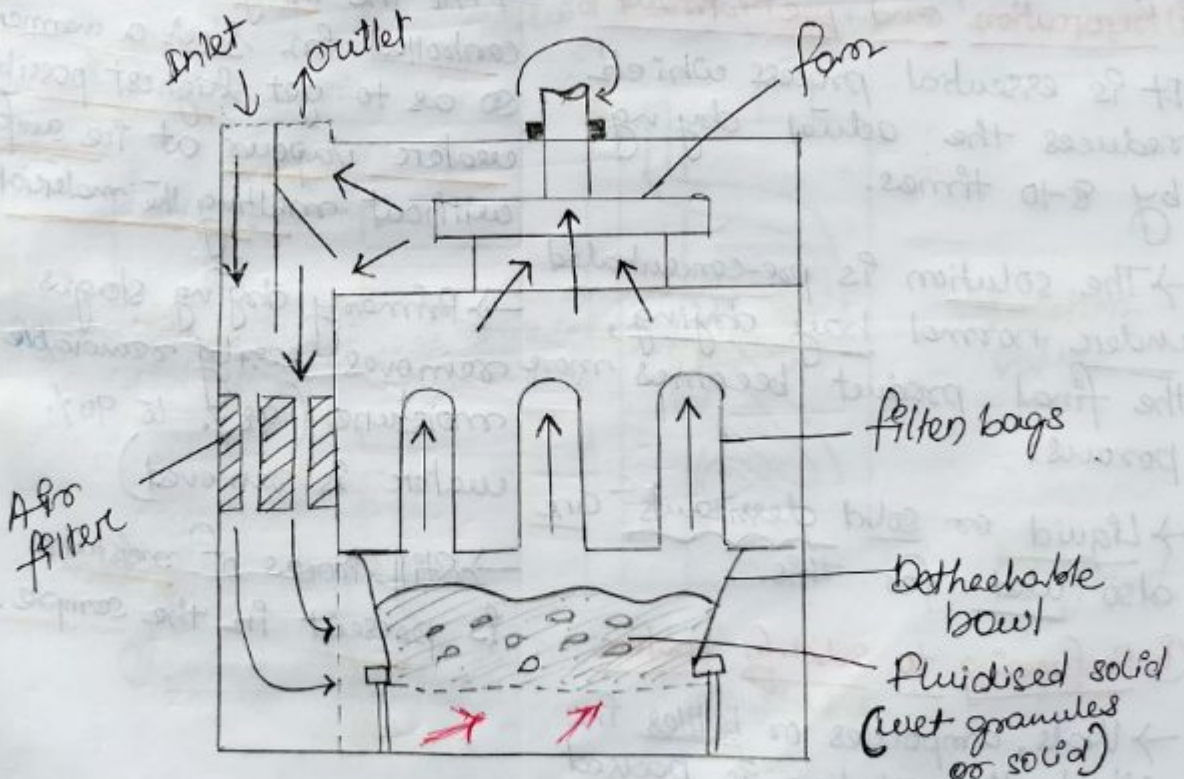
→ Also used in making.

Disadvantages:

→ Many organic powders develop electrostatic charges during drying.

→ To avoid this, efficient electrical earthing of the dryer is essential.

→ May cause some attrition, resulting in the production of fines.



Freeze Dryer (Lyophilization)

Principle: In freeze dryer, water is removed from the frozen state by sublimation i.e direct change of water from solid into vapour without conversion to a liquid phase.

Construction:

→ Consists of drying chambers in which tray are loaded.

→ Heat supply in the form of radiation.

→ Vapour condensing or adsorption system.

→ Vaccum pump or steam ejector.

Working

Involves 5 stages :—

① Preparation and pretreatment

It is essential process which reduces the actual drying by 8-10 times.

→ The solution is pre-concentrated under normal tray drying, the final product becomes more porous.

→ Liquid or solid dessicants are also used for this.

② Prefreezing to solidify content

→ Vials, ampoules or bottles in which the solution is packed are frozen in cold shelves (about −50°C)

→ During this stage, cabinet is maintained at low temp & atm. pressure.

③ Primary drying (Sublimation of ice)

→ In this step, the material to be dried is spread as much large surface as possible for sublimation.

→ The temp. and pressure should be below the triple point of water i.e 0.0098°C and 0.533 Kilopascals for the sublimation.

→ Vaccum is applied to the tune of about 3mmHg on the frozen sample.

→ The temp is linearly increased to about 20°C in a span of 2hrs.

→ All the things has to be controlled in such a manner so as to get highest possible water vapour at ice surface without melting the material.

→ Primary drying stages removes easily removable moisture (98% to 90% water is removed)

→ Still traces of moisture is present in the sample.

(iv) Secondary drying:

→ During this stage, traces of moisture is removed.

→ In this, the rate of drying is very low and it takes about 10-20 hours.

(v) Packing:

→ After vaccum is replaced by inert gas, the bottles & vials are closed.

Uses

→ Most commonly used in the production of dosage forms such as injections, solutions and suspensions.

Advantages:

→ Thermolabile material (heat sensitive) can be dried.

→ Loss of volatile material is less.

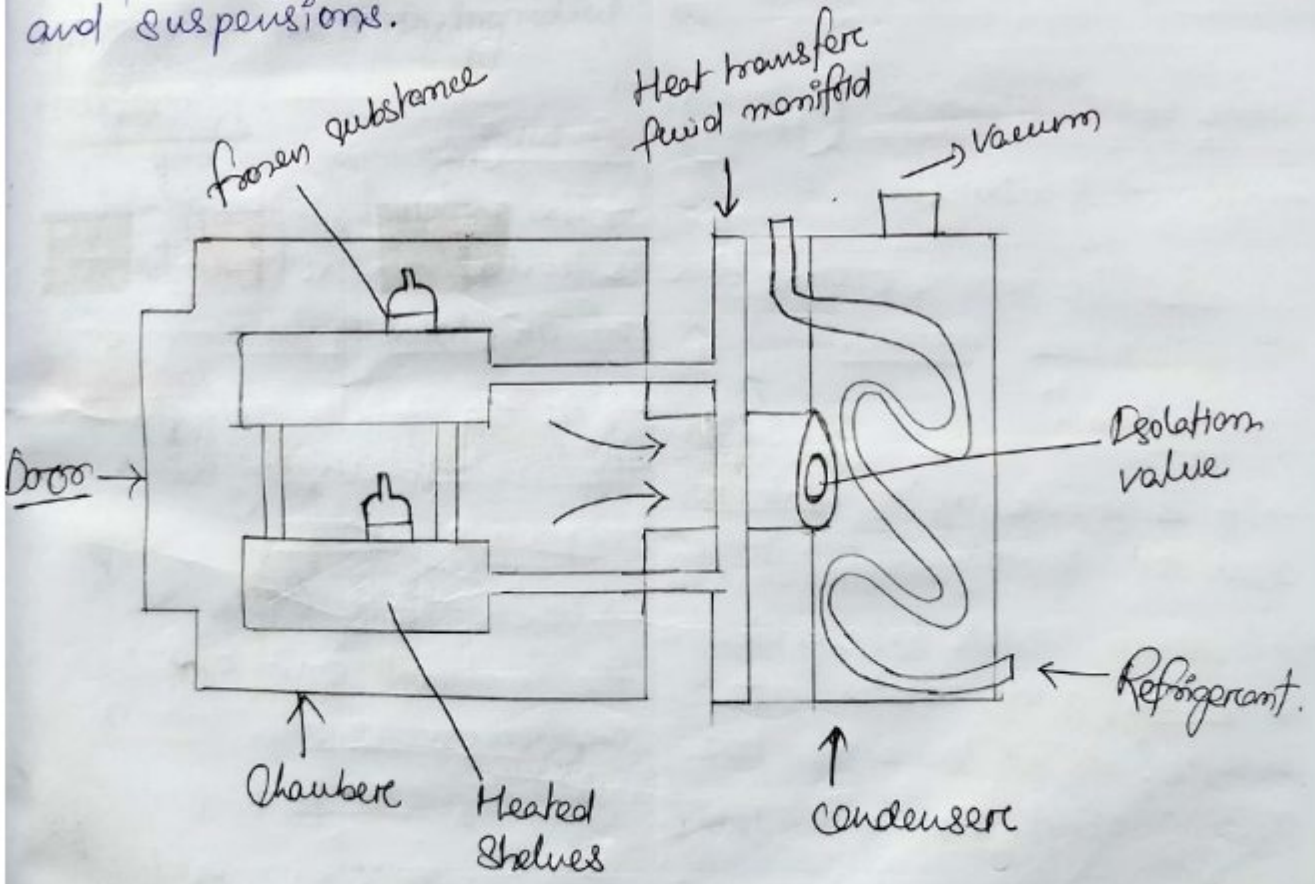
→ Sterility can be maintained.

Disadvantages:

→ Equipment and running costs are high.

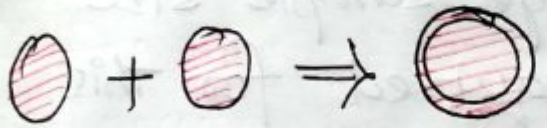
→ The period of drying is high.

→ The product should be only packed for vaccum or using inert gas or in containers impervious to gases for prevent oxidation.



Mixing

Mixing is defined as a process in which two or more component are mix together and converted into one form (component)

eg- 

⇒ Mixing is an operation in which two or more component in a separate or roughly mixed condition are treated, so that each particles lies as nearly as possible in contact with a particle of each of the other ingredient uniformly.

Applications

Difference between Solid and Liquid Mixing

Solid mixing	Liquid mixing
→ Truly homogeneous liquid phase can be observed.	→ Product often consist of two or more easily identified phases.
→ Small sample size is sufficient to study degree of mixing.	→ Large sample size is required for this.
→ Mixing requires low power.	→ Requires high power.

Twin Shell Blender (V cone blender)

→ For solid mixing

Principle: The mixing occurs due to tumbling motion.

Construction:

→ It is made up of stainless steel or transparent plastic.

→ Smaller Models take a charge of 20 kg and rotates at 35 rpm, while large one has capacity about 1 ton and 15 rpm.

→ It is connected with horizontal shaft, which connect with motor.

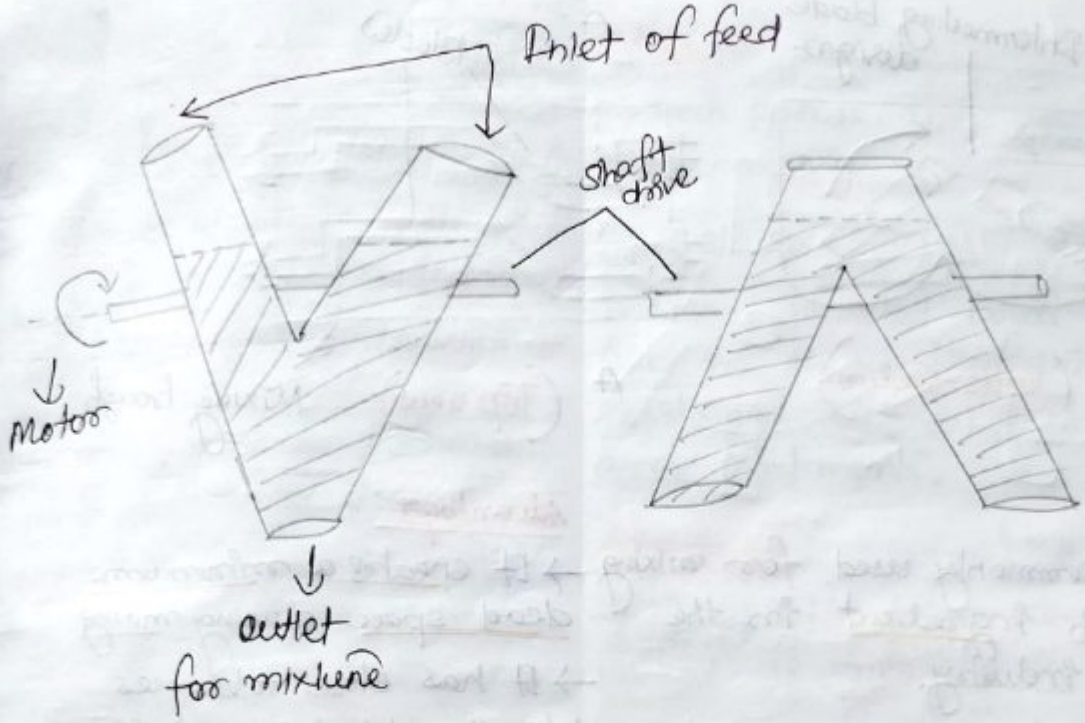
Working:

→ The material (to be blended) is loaded approx. 50–60% of its total volume.

→ As the blender rotates, the material undergoes tumbling motion.

→ When the V is inverted, the material split and the recombine, this process yield to mixing.

→ After mixing, mixed material is collected from the bottom of V.



Uses: → Used in solid mixing.
→ Mixing of orders.

Sigma blade mixer

Principle: The mechanism of mixing is shear.

→ Also convective mixing is achieved by cascading the material.

Construction:

→ It consists of double trough shaped stationary bowl.

→ Two sigma shaped blades are fitted horizontally in each trough of the bowl.

→ They are connected to a fixed speed drive.

→ The mixer is loaded from top and unloaded by tilting the entire bowl.

Working:

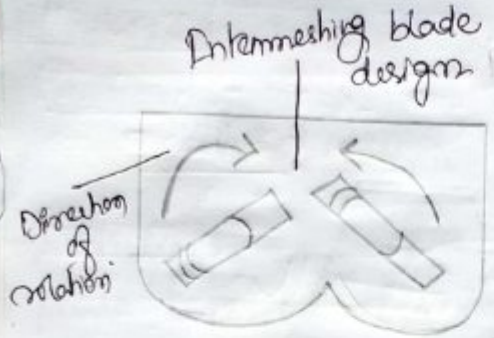
→ Material (powders) are introduced from the top of the trough and then covered it.

→ Now, allowed the sigma blades to rotate through the fixed speed drive.

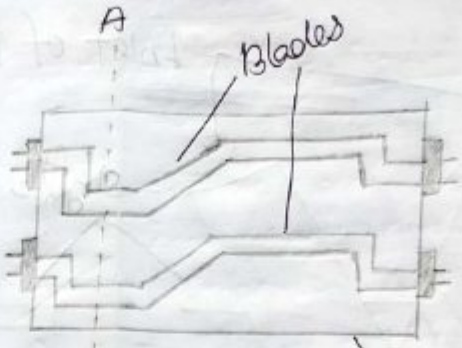
→ The blades move at different speeds, one usually about twice the speed of other, resulting in lateral pulling of the material.

→ By moving powders through blades, cascading action (convective) as well as shear action can be achieved.

→ By this, mixing take place and final mixture discharge through tilting the entire bowl.



(Cross-section)



(Top view)

Mixing trough

Uses:

→ It is commonly used for mixing of dough ingredient in the baking industry.

→ Used for liquid-solid mixing and mostly used in solid-solid mixing.

Advantages

→ It creates a minimum dead space during mixing.

→ It has close tolerances b/w the blades and the side-walls as well as bottom of the mixer shell.

Disadvantage: It works at a fixed speed.

Planetary mixers

Principle: In a planetary mixer, the blade tears the mass apart and shear is applied between a moving blade and a stationary wall.

→ Mechanism of mixing is Shear and also tumbling (corrective motion) obtained.

Construction

→ It consists of a vertical cylindrical shell, which can be removed either by lowering it beneath the blade or raising the blade above the bowl.

→ The mixing blade is mounted from the top of the bowl.

→ The mixing shaft is driven by a planetary gear train.

→ It rotates around the ring gear, which further rotates around the mixer blade.

→ It is normally built with a variable speed drive.

Working

→ In the planetary mixer, the agitator has a planetary motion.

→ It rotates on its own and around the central axis so that it reaches all parts of the vessel.

→ The beater is shaped to pass with close clearance over the side and bottom of the mixing bowl. (No dead space in the mixing bowl)

→ Material (powders) is introduced through top in the bowl.

→ By moving powders through blades, shear is applied on material and also powders make an upward movement.

→ So, tumbling motion is also obtained.

→ Initially the blade moves slowly for premixing and finally at increased speed for active mixing. (High shear can be applied for mixing)

→ Emptying the bowl may be done by hand (scooping) or by dumping mechanism.

Uses

→ Low speeds are used for dry mixing.

→ Fast speed in wet granulation.

→ Steam jacketed bowls are used in the manufacture of sustained release products and ointments.

Advantages

→ Speed of rotation can be varied as needed.

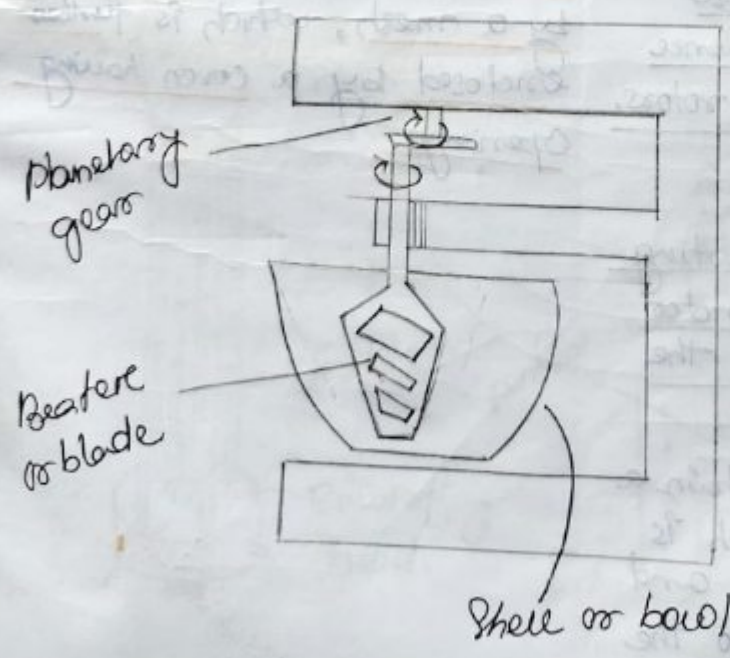
→ More useful for wet granulation.

→ No dead space (unmixing space)

Disadvantages

→ It requires high power.

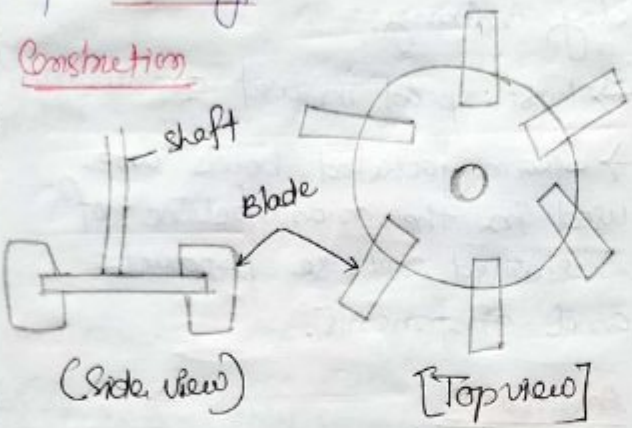
→ It has a limited use and is useful for ~~both~~ batch work only.



Turbines

Principle: It works on the principle of shearing.

Construction



⇒ A turbine consists of a circular disc to which a number of short blades are attached.

⇒ The diameter of the turbine ranges from 30-50% of the diameter of the vessel.

⇒ It rotates at a low speed than propellers. (50-200 rotations per minute)

Working

⇒ Take a liquid, which we have to mix in a vessels.

⇒ Then placed the turbine into vessels and start the rotation.

⇒ Blades of turbine produces flow in liquid and also produces shear, which yield to mixing.

⇒ After certain period when liquid mixed, turbine removed from the vessels.

Uses

⇒ Effective for high viscous solution upto 7000 pascal.second
eg- Syrups, glycerin

Advantange: Gives greater shearing forces than propellers. So, they are suitable for emulsification.

Silverson mixer emulsifier

Principle: It produce intense shearing force and turbulence by the use of high speed rotors.

Construction

⇒ It consists of long supporting columns connected to a motor which gives support to the head.

⇒ The central position contain a shaft, one end of which is connected to the motor and other end is connected to the head.

⇒ The head carries turbine blades, which are surrounded by a mesh, which is further enclosed by a coven having openings.

Working

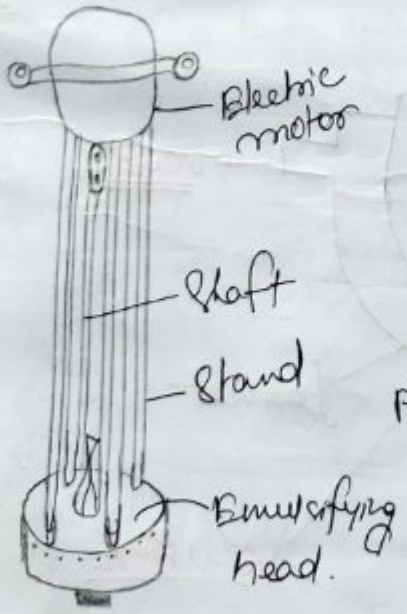
⇒ The head is placed in the vessels containing immiscible liquid (completely dipped)

⇒ Then, start the motor, rotating shaft rotates the head, which in turn rotates turbine blades at a very high speed.

⇒ This creates a pressure difference. As a result, liquids are sucked into the head from the center of the base and subjected to intense mixing action.

⇒ Then liquid expel from the mesh through centrifugal force.

⇒ The intake and expulsion of the mixture ensures the rapid breakdown of particles and help to mix them.



Uses

⇒ Used for the preparation of emulsions and creams of fine particle size.

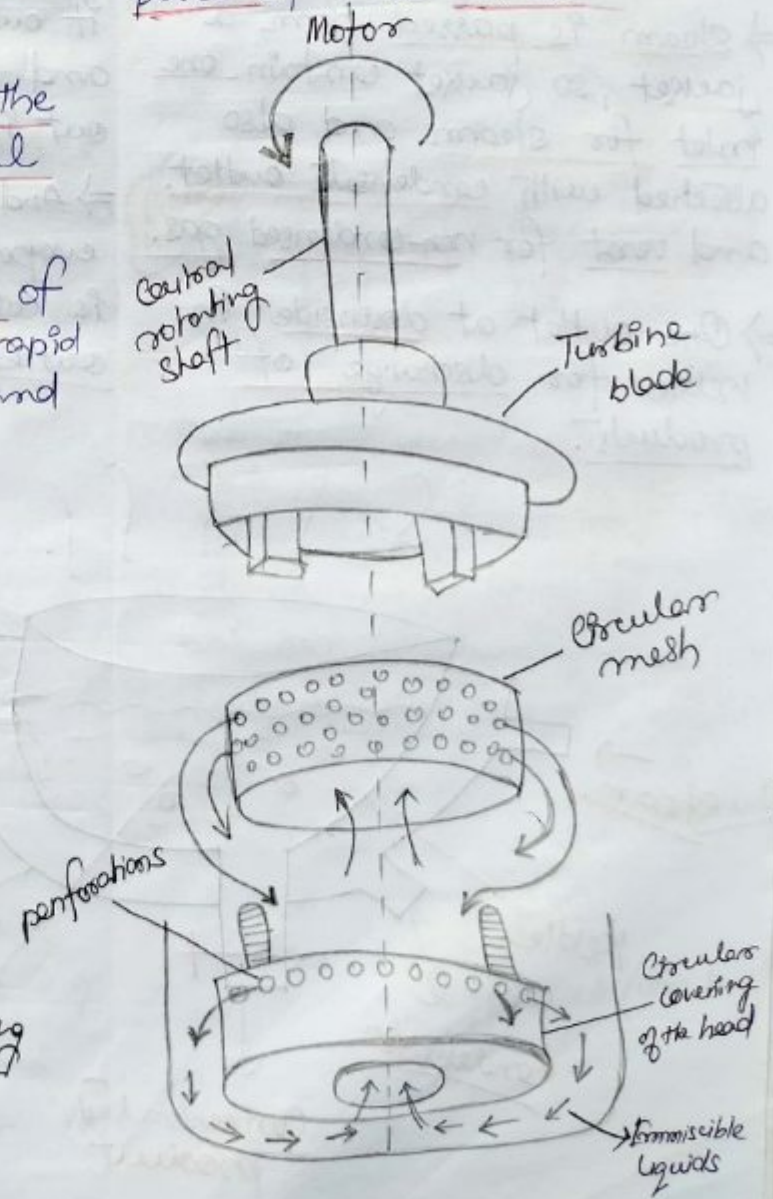
Advantages

⇒ It is available in different sizes.

⇒ It can be used for batch operations.

Disadvantages

⇒ Sometimes, there is a chance of blocking of pores of the mesh.



Steam Jacketed Kettle [Evaporating Pan]

Principle: The principle used in this evaporator is evaporation, in which (hot) steam passed and by absorbing heat (liquid) get evaporate.

Construction

⇒ It consists of a hemisphere pan which is made up of a copper or a stainless steel.

⇒ And this pan is covered at downside by a tube, which is made up of copper & it is called jacket.

⇒ Steam is passed from a jacket, so jacket contain one inlet for steam and also attached with condensate outlet and vent for non-condensed gas.

⇒ One outlet at downside in kettle for discharge of products.

Working

⇒ Mostly solution (aqueous extract) is placed in kettle.

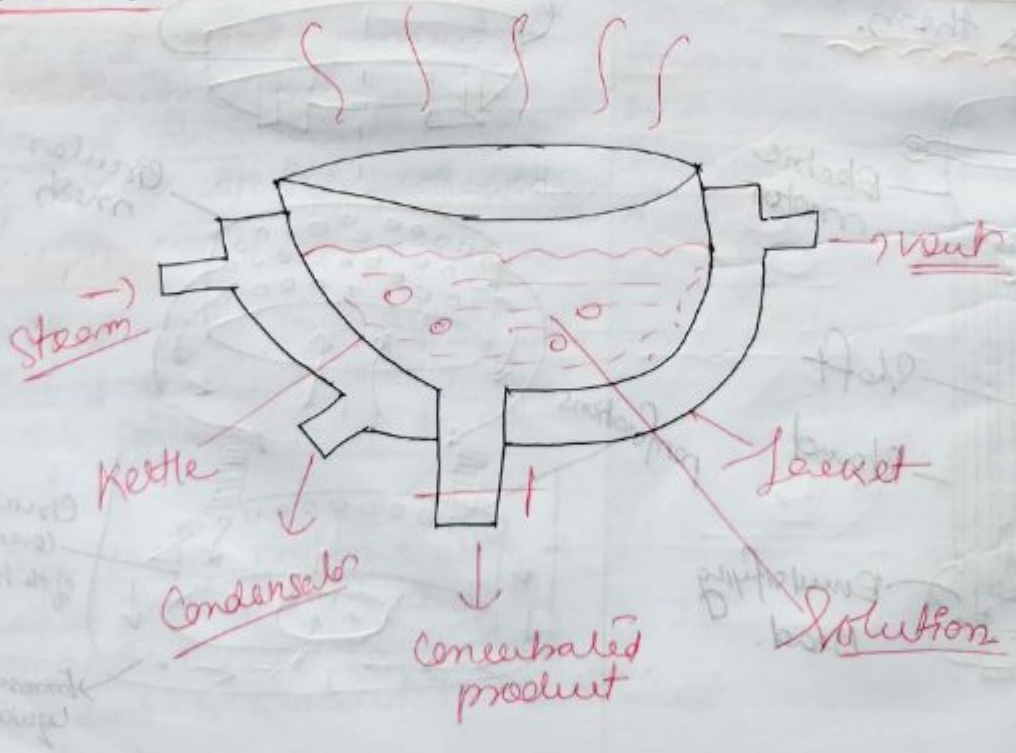
⇒ Then hot steam is supplied in jacket.

⇒ Now, if we do this in small scale then we stirred it manually & if we do it on large scale, then use machines for stirring.

⇒ Solution absorb heat from jacket and start converting into vapours.

⇒ That steam which condensed, it out from condensate outlet and remaining steam is out in the form of vent.

⇒ And, there in kettle, after evaporation final product is collected from the product outlet.



Use

→ Used for concentrating aqueous extracts and thermostable liquors.

Merits

→ It is used on both small or large scale.

→ Easy in use, cleaning & also its maintainence.

→ Not very expensive.

Demerits

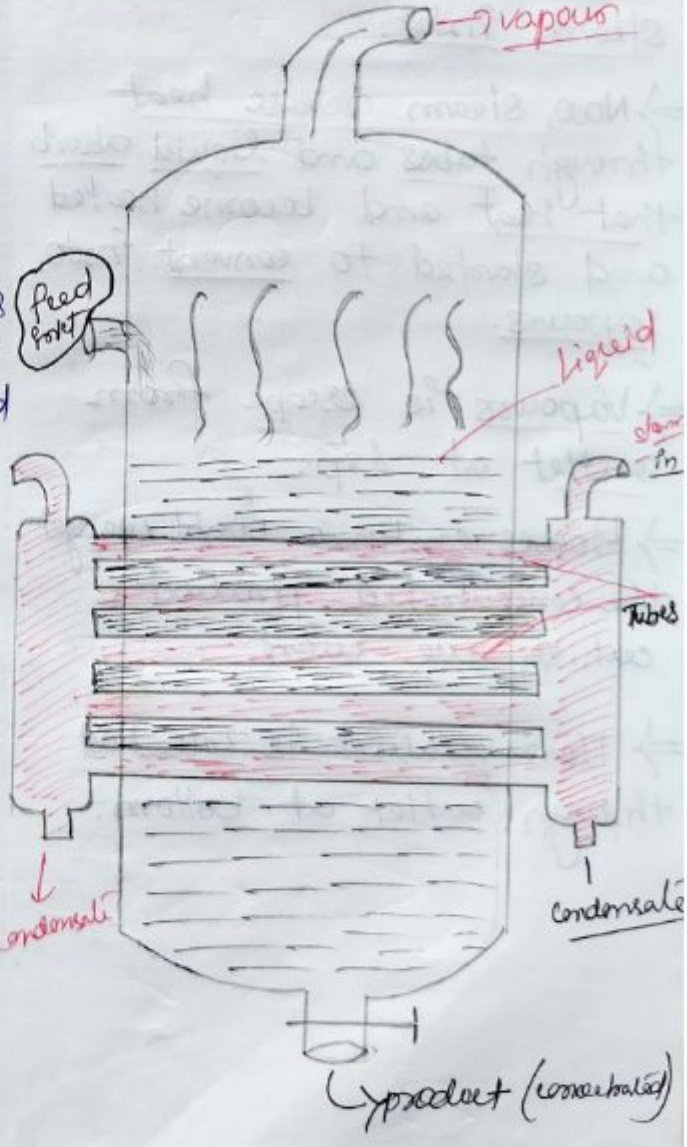
⇒ Not suitable for heat sensitive material.

⇒ Heat economy is less. Hence, cost per unit material production is more.

Horizontal Tube Evaporator

Principle: In this, evaporation takes place through tubes which are horizontally fitted.

⇒ Steam passed through tubes and liquid outside the tubes get heated by absorbing heat and convert into vapours and pass out from top.



Construction

⇒ It consists of a large cylinder body in which, some tubes are fit in b/w cylinders horizontally.

⇒ Made up with cast iron or plated steel.

⇒ It is about 1.8–2.4 m wide and 2.4–3.6 meter long.

⇒ One inlet for feed and outlet at downside for concentrated product.

=> Steam Inlet form which steam enter also condensate for steam and outlet for steam.

=> One outlet at top for discharge vapours.

=> There are steam compartment in which 6-8 tubes placed horizontally and steam passed through it.

Working

=> Firstly, feed enter through inlet and steam enter from steam inlet.

=> Now, steam release heat through tubes and liquid absorb that heat and become heated and started to convert into vapours.

=> Vapours is escape from outlet at top.

=> Process continue until we get the concentrated product, which we want.

=> Then product is collected through outlet at bottom.

Uses

Used for non-viscous solutions

Merits

- Easy to install and operate
- Cheap (Not expensive)
- Suitable for non-viscous liquids.

Demerits

=> Not suitable for viscous liquid.

=> Heat sensitive material (not suitable)