Drying

Date __/__/__

→ It is removal of small amount of water or other liquid from a material by application of heat. to cause thermal vapourizatn.

→ It occurs when environ. is unsaturated with watr vapour.

Applications

→ Prepration of bulk drugs
  ex → dried $Al(OH)_3$, spray dried lactose, powdered extracts.
  • after crystallizatn & filteratn dryn is essential.

→ Preservation of drug products
dryn imp to avoid deterioration
• Crude drugs of animal & vitamin origin → chemical decomposition
• Blood product, skin, tissue → microbial growth
• Synthetic & semisynthetic drugs → chemical decomposition
• Effervescent tablets → chemical decomposition
(aspirin, penicillins)

→ For Improved characteristics
• Spherical shape, uniform size, free flowing & enhanced solubility
• Granules → dried → Improve fluidity ~~solubility~~ & compresn characteristic
  ↓
  essential for productn of tablet & capsules.

• Viscous & sticky materials are not free flowing, drying modifies these characteristics. (male fern extract, malt extract)

→ Improved handling → light in weight & reduces the bulk

Theory Of Drying

In ~~wet~~ solid mass → water → Bound H_2O / Unbound H_2O

Hygroscopic materials
Water in :-
- Fine Capillaries
- Cell & fibres walls
- Physical Interaction

Contains → **Bound water** → Condition → vapour press. of wet solid is less than the VP of pure water

Non-Hygroscopic materials
water in Void space

contains → **Unbound Water** → Condition → VP of wet solid is eq. to VP of pure water

* Bound water is the min water held by the material that exerts an eqb^m VP < VP of pure H_2O at same temp.

* Unbound water is amount of water held by the material that exerts an eqb^m VP = VP of pure H_2O at same temp

Air-dry :- durⁿ dryⁿ, water is easily lost, but resultⁿ solid is not completely free from water molecules.

Bone-dry :- After water is removed completely, c/d bone dry.

Mechan of Dryⁿ Process

Dryⁿ ⇒ Heat transfer + Mass transfer

Heat transfer ↓ Heatⁿ med → solid mat.

Mass transfer ↓ Transfer of moist. to surface of solid & subsequently vaporisatⁿ from surface to surroundng.

Theories to explain moisture movement :-

1. Diffusⁿ theory
2. Capillarity theory
3. Pressure gradient theory
4. Gravity flow theory
5. Vapourisatⁿ & condensatⁿ mechan

Diffusion theory

- Here capilarity, gravitational & frictional forces ⇒ Too small
- Rate of flow of water ∝ moisture gradient.
- Movement as follow –

→ water diffuses thru solid → surface → evaporate to surroundⁿ

→ Evaporatⁿ of H_2O occurs at an intermediate zone, much below solid surface, then vapour diffuses thru solid into air.

→ Applicable to hygroscopic materials.

limitations → • Dryⁿ rate can't be predicted over a range of moisture gradient.
  • diffusivity ↓ as moist. content & temp ↓ & Press↑

Capillarity theory

- Applicable to porous granular solids.
- Porous materials → inter-connected pores & channels (not circular or straight)
- as dryⁿ starts, a meniscus is formed in capillary & exerts a force, this is dryⁿ force for water movement thru pores towards the surface.
- Curvature of miniscus depends on pore diameter & determines strength of capillary force.
- Capillary force → small pores > large pores, ∴ small pores pull more water from larger pores & thus large pores get emptied first.
- Air enters emptied pores & moist. content relatively ↑ at surface.
- This theory only good for free water in bed
- This movement takes places in granules & voids.

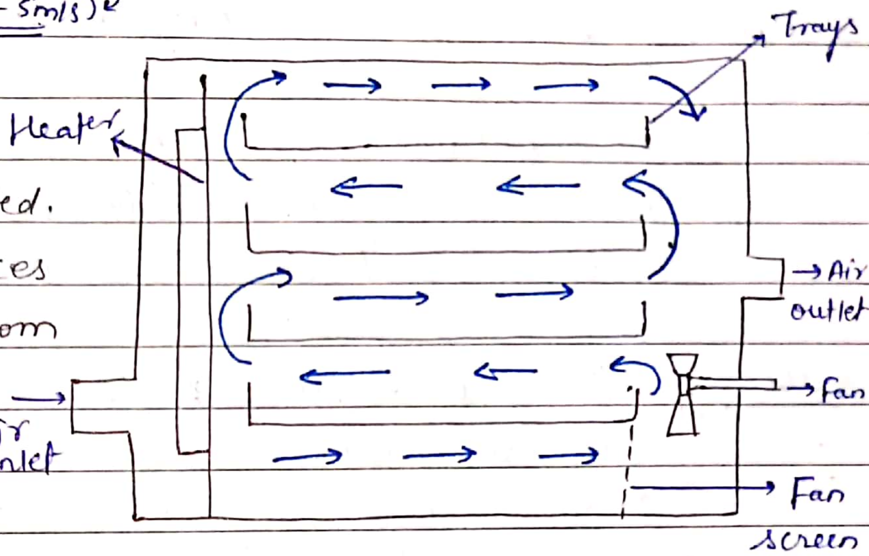
Pressure Gradient theory

- By applicatⁿ of Radiatⁿ, dryⁿ occurs.
- Radiation → a source → to generate internal heat
- Radiation interacts to polarized molecules & ions of material.
- This aligns molecules into order, which are otherwise

randomly oriented.

- when field reversed → molecules align to original orientation.
- Radⁿ gives random K.E. to inside surface of solid itself.
  ∴ liq inside solid vapourized.
  ∴ vapour pressure gradient is developed which is driving force for the movement of vapour to surface.

Tray Dryer (air speed 2–5 m/s)



Principle

→ Hot air is continously circulated.
→ Forced convection heating takes place to remove moisture from the solids placed in trays.
Simultaneously, moist air is removed partially.

Construction

- A rectangular chamber with insulated walls & has trays in it.
- for lab → min 3 tray
- for industry → more than 20 trays required.
- Tray = square = 1.2 to 2.4 m^2 area
  = loaded = 10.0 to 100.0 mm deep
  = dis b/w lower tray surface & loaded material = 40 mm
  = placed on wheels as can be rolled in & out of chamber
- fan fitted → to circulate air over trays & in corners directⁿ vanes are placed.

Working

- wet solid → Tray → chamber
- fresh air → inlet → heater & heated up → circulated by fans at 2 to 5 m/s
- Turbulent flow ↓ the partial VP in atm & also ↓ air thickness boundary layer.
- water picked up by air.

→ water evaporates from surface → water diffuses from int. of solid by capillary action

→ These events occur in single pass of air
→ Time of contact in single pass = short & amount of the picked = small
→ ∴ Discharged air to the tune of 80 – 90% is circulated back through fans.
→ Only 10 to 20 % of fresh air is introduced.
→ Moist air is discharged through outlet.
→ Thus const. temp. & uniform airflow over the material can be maintained for acheiving uniform drying.
→ Incase of wet granules (tablets & capsules) dryn continued until desired product is not obtained.

Uses — • Sticky materials, plastic subs., granular or crystal mass can be dried.
• Crude drugs, powders are also dried.

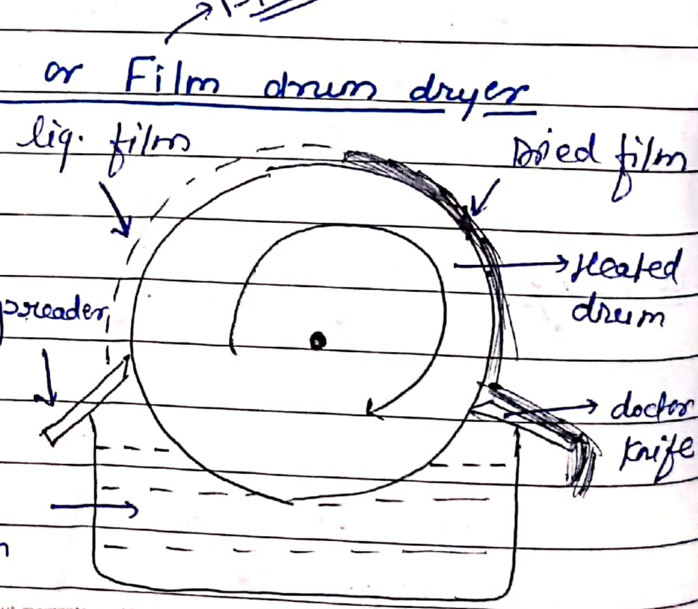
Adv → • Handling of material can be done w/o losses.
• Operated batch-wise :→ • each batch ~~so~~ handled as seprate unit.
• Valuable products handled efficiently.

Disad → • Tray dryer req. more labour to load & unload, hence cost increases
• Time consuming

Drum Dryer or Roller or Film drum dryer

Principle

→ A heated hallow metal drum rotates on its longitudinal axis, which is partially dipped in solⁿ to be dried.
→ Solⁿ carried as a film on surface of dryer & dried to form a layer.
→ A suitable knife scraps the dried material, while drum is rotating.



→ Construct^n

- Horizontally mounted hollow steel drum (0·6 − 3·0m = dia) (0·6 − 4·0 m = length) & external sur = smoothly polished.
- Below drum ⟶ feed pan placed such that drum dips partially into feed.
- Other side of drum = spreader & another side = doc. knife (scrap)
- Storage bin (or a conveyer) placed connect^n knife to collect material

Working

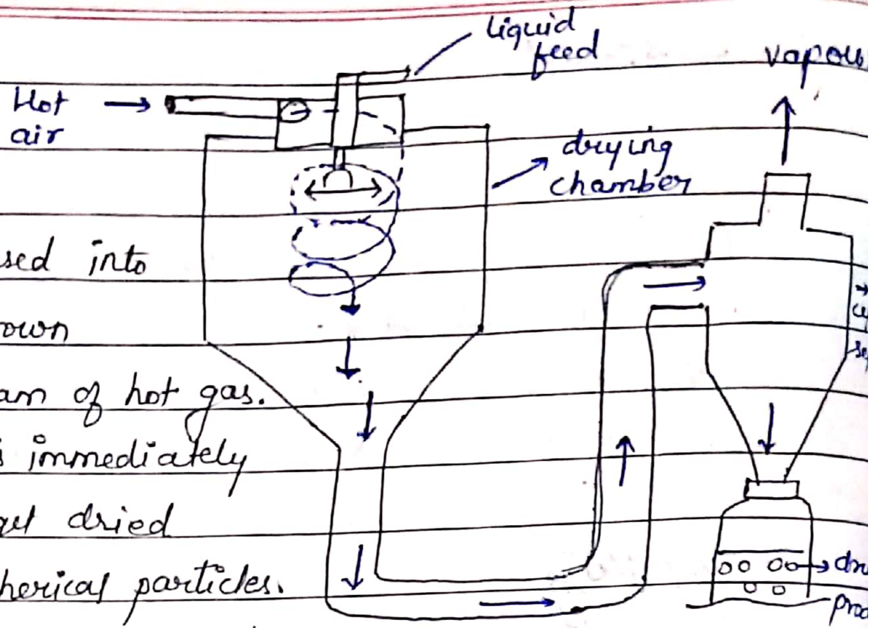
→ Steam ⟶ drum & heat transfer coefficent of drum metal ↑.
→ Dry^n capacity ∝ surface area of drum.
→ Heat transfer by conduct^n to material
→ Drum rotated at rate of 1 − 10 rev/min.
→ Liq. mat. tnt in feed adheres as thin layer to ext. surface of drum during its rotation.
→ Material dried dur^n its journey in less than 1 rotat^n.
→ Dried mat = scraped ⟶ doc. knife ⟶ storage
→ Time of contact of material with hot drum = 6 − 15 secs only.
∴ process^n cond^{ns} such as film thickness, steam temp are closely controlled.

• Uses — • Used for dry^n sol^n, slurries, suspensions, etc.
• Dried products are milk, starch, ferrous salts, suspens^n of ZO, kaolin, yeast, malt, etc.

• Adv — • Dry^n time less (few secs) = Beneficial for heat sensitive mat.
• Occupies less space as compared to spray dryer.
• Since thin film of mat. is formed rate of heat & mass trans. ↑.
• Product obtained is completely dried.

• Disadv — • Maintenance cost ↑
• Skilled operators needed to control feed rate, film thickness, etc.
• not suitable for salt sol^n with less solubility

Spray Dryers



Principle

- Fluid to be dried is atomised into fine droplets, which are thrown radially into a moving steam of hot gas.
- The temp. of the droplets is immediately increased & fine droplets get dried instantaneously in form of spherical particles.

→ This process completes in a few secs before droplet reach the wall of dryer.

Construction

- It has large cylindrical drying chamber with short conical bottom
  ↳ madeup of → stainless steel (dia = b/w 2.5 to 9m & height = 25m or more)
- Inlet of hot air provided at roof of chamber.
- Another Inlet carrying spray-disk atomizer is set in roof.
  (300 mm in dia) & 3000 to 50,000 rpm/min
- Bottom of dryer connected to cyclone seprator.

Working - In 3 stages :-

1) Atomization of the liquid / feed
2) Drying of liquid droplets / feed
3) Recovery of dried products

1) Atomizat^n of liq. to form liq. droplets

→ feed → atomizer either by gravity or suitable pump to form fine droplets.

→ final product ppts depend on droplet formed, hence select^n on atomizer type is imp., i.e., pneumatic atomizer, press. nozzle & spinning disc atomizer may be used.

→ Rate of feed adjusted such that droplets should be completely dried before reach^n the walls of dry^n chamber.

→ Product should not be over heated.

Drying of liq. droplets

- fine droplets dried here thru hot air inlet.
- surface of air droplet dried immediately to form a tough shell
- A liq. inside must escape by diffusⁿ thru the shell at a particular time.
- At same time heat transfer from outside to inside takes place at a rate greater than liquid diffusion rate. As a result, heat inside mounts up which allows the liq. to evaporate at a faster rate.
- This tendency of a liquid leads to rise in the internal press, which causes droplets to swell.
- Shell's thickness ↓ whereas permeability of vapour ↑.
- If shell is neither elastic nor permeable, it ruptures & int. press escapes.
- The air temp is adjusted in such a way that the droplet should be completely dried before reachⁿ walls of dryⁿ chamber.

(3) Recovery of dried products

- Centrifugal force of atomizer drives the droplets to follow helical path.
- Particles dried durⁿ their journey & finally fall at conical bottom.
- final product particle size → 2-500 mm.
- Particle size depends upon - solid content in feed
  - liq. viscosity
  - feed rate - disc speed.

* evaporatⁿ capacity = 2000 kg / hr.

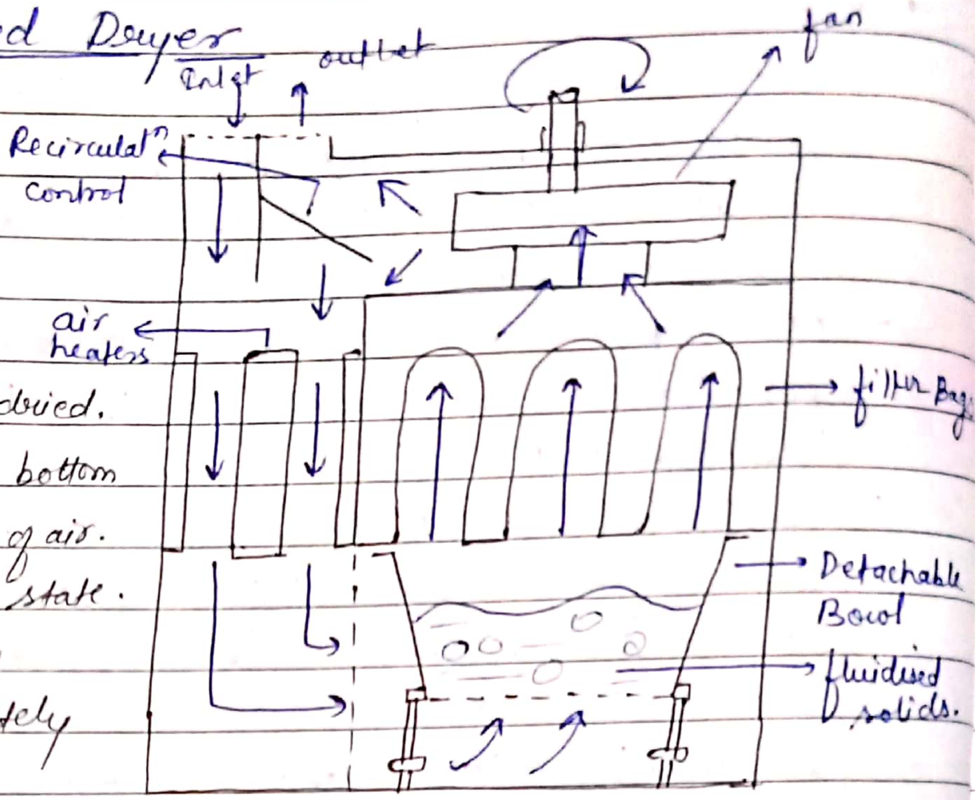
uses — quantity of mat. to be dried is large, product is thermolabile, hygroscopic or undergoes chemical decompostⁿ.
(milk, lactose, blood, hormones)

Adv → Dryⁿ rapid (3-30secs), labour cost ↓, uniform product, Product shows excellent solubility, Sterile products dried.

Disad → very Exp. Equipment bulky, not always easy to operate, thermal efficiency ↓

Drugs are used → Acacia, Blood product, Chloramphenicol, Concentrated penicillin And Vitamin

Fluidised Bed Dryer



Principle

→ Hot gas is passed at ↑ pressure thru perforated bottom of container containing granules to be dried.
→ Granules are lifted from bottom & suspended in the stream of air. This condtⁿ c/d fluidised state.
→ Hot air is surrounding every granule to completely dry them.
Thus materials uniformly dried

Construction → vertical fluid bed dryer
→ Horizontal fluid bed dryer

→ Dryer = stainless steel or plastic
→ detachable bowl at bottom of dryer is placed, used for charging & discharing.
– Bowl has perforated bottom with a wire mesh support for placn materials to be dried.
– fan mounted in upper part of/for circulating hot air.
– fresh air inlet, prefilter & heat exchanger are connected serially to heat the air to the required temp.
– Temp of hot air & exit air are monitored
– Bag filters are placed above the drying bowl for recovery of fines.

Working

→ wet granules → detachable bowls → bowl to dryers
→ fresh air → prefilter (it gets heated by passing thru heat exchanger)
→ Hot air flows through bowl bottom & fan rotates (air velocity ↑

→ Velocity of air > Settling velocity → Granules remains partially suspended in gas stream

→ after some time, pressure point is reached at which frictional drag on particle = force of gravity.

→ Granules rise in the container cz of ↑ velo. gas (1.5-7.5 m/s) & later fall back in a random boiling motion. This condtn c/d as fluidised state.

→ Gas surrounds every granule to completely dry them.

→ Air leaves dryer by passing thru the bag filter.

→ Entrained particles remain adhered to inside surface of bag & periodically bags shaken to remove entrained particles.

→ Intense mixing b/w granules & hot gas provides uniform condtn of temp, compostn & particle size distribution.

→ Dryn is achieved at const. rate & falling rate is very short. Any attempt to ↑ the air velocity may result in entrainment.

→ Residence time for dryn = 40 mins

→ material left for some time in dryer for reachn ambient temp.

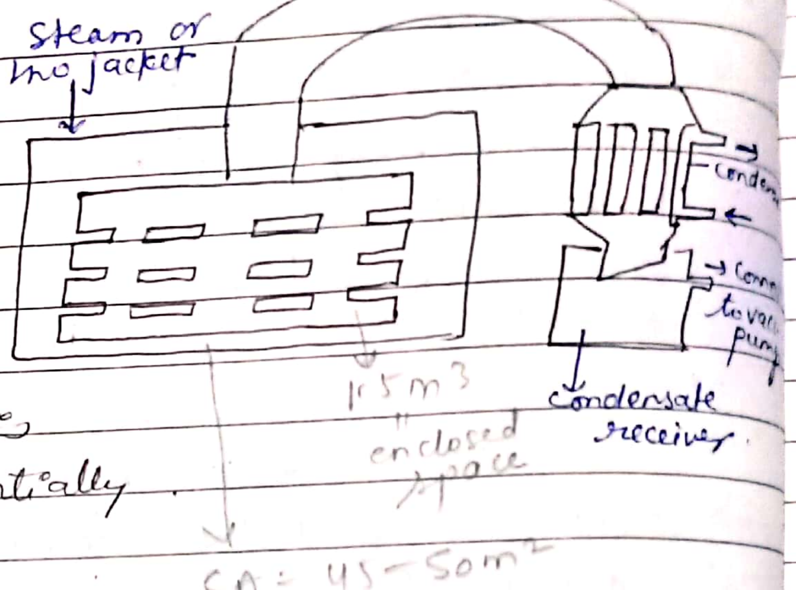
→ Bowl taken out for dischargn & end product is free flown

Uses →
- To dry granules in productn of tablets.
- Used for 3 operatn → mixing, granulatn & dryn.
- Used for coatn of granules.

adv → time less used, available in diff size, dryn containers are mobile & labour cost ↓, thermal efficiency is 2 to 6 time than tray dryer, ↑ output from a small floor space, used either as batch or continous type.

disad → Attrition occurs (avoided by binding agents)
Organic powders causes electrostatic charges.

Vaccum Dryer



Principle

- Materials dried by vaccum applicatⁿ.
- When vaccum created, pressure ↓ so that water boils at ↓ temp hence, water evaporates faster.
- → Heat transfer becomes efficent, i.e., rate of dryⁿ enhances substantially.

Construction

- → Made up of cast iron heavy jacketed vessel.
- → So strong that can withstand ↑ ~~pressure~~ vaccum within the oven & steam pressure in jacket.
- Enclosed space (approx 1.5m3) is divided into no. of portions by means of 20 hollow shelves, which are part of jacket.
- These shelves provide large surface area (45-50 m²) for heat conductⁿ.
- Over shelves, metal trays are placed for keepⁿ material.
- Oven door can be locked tightly to give air tight seal.
- Oven connected to vacuum pump by placing condenser in b/w.

Working

- Material → spread on trays → placed on shelves ↓ doors closed firmly
- Pressure ↓ upto 30 to 60 kilopascals by means of vaccum pump & door closed firmly
- Steam / hot air supplied to hollow space of jacket & shelves. & heat transfer by conduction takes place.
- At this vaccum, evaporatⁿ of water from material takes place at 25-30°C on account of ↓ of BP.
- Water vapour passes to condenser where condensatⁿ occurs.
- at end vaccum disconnected & material collected from tray.

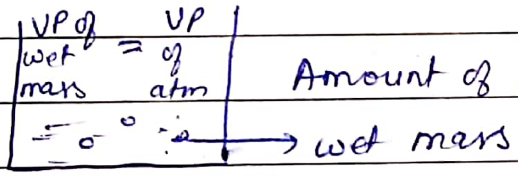
Uses → Heat sensitive material, dusty & hygroscopic materials, drugs with toxic solvents, feed with valuable solvent, etc.

adv → Large surface area for heat transfer, Handling easy, Hot water of desired temp can be supplied.

disad Heat transfer coefficients ↓, limited capacity, more expensive & sometimes danger of over heating.

Equilibrium Relationship

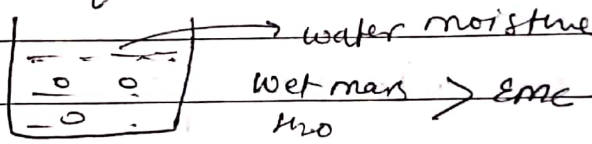
When the amount of water present in the solid exerts VP equal to VP of atm. surroundⁿ, is c/d eqbᵐ moisture content.



VP = VP of atm
⇓
EMC

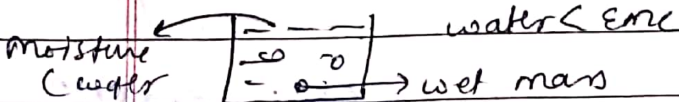
Case I –

When hot air passed through wet mass having const. mass & const. humidity & amount of H_2O > EMC, this is c/d desorption

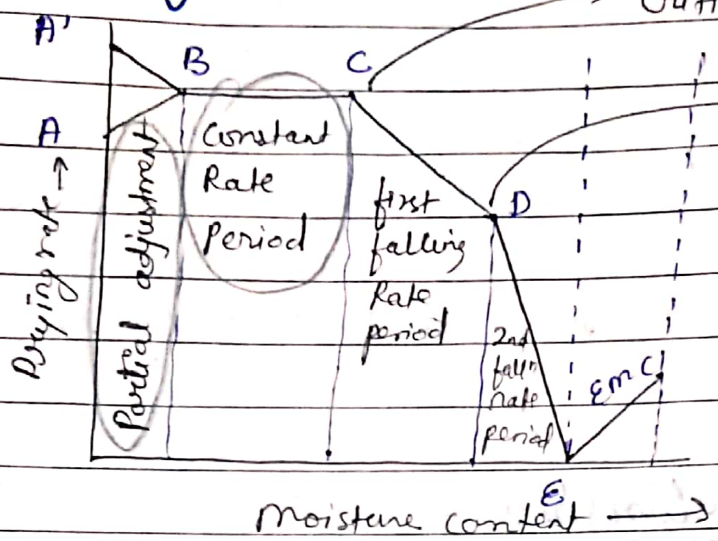


Case II

At const temp & humidity amount of water < EMC, drug retains its moisture & c/d as Sorption

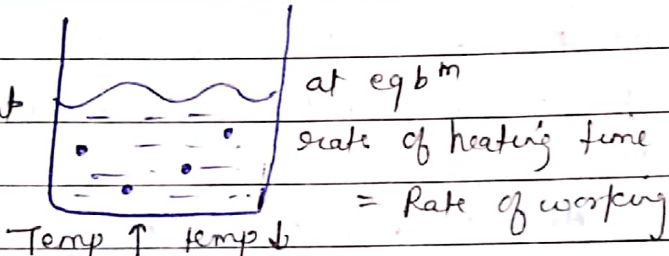


Drying Rate Curve



① A–B

Initial adjustment

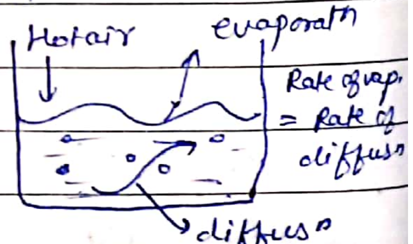


When heat is supplied, heat is absorbed & moisture content is lost. Cooling also takes place. Surface tension gets removed

Rate of cool^n = Rate of heat^n.

② [B – C]

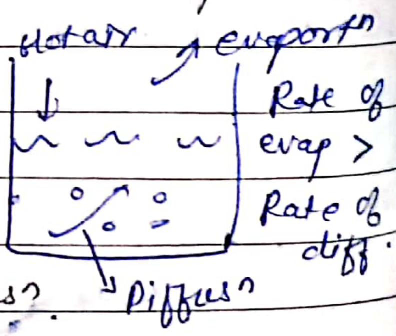
Constant Rate period



- Temp & dry^n rate becomes const.
- moisture from inside gets on surface due to diffus^n to maintain eqb^m.
- After const. rate period the moisture left is slurry c/d critical moist. content.

③ (C–D)

1st fall^n rate

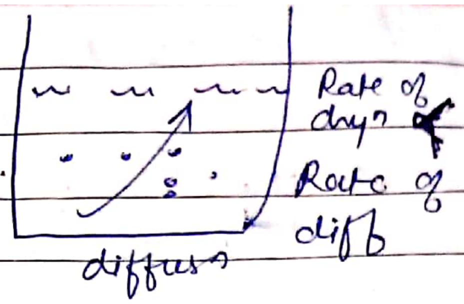


- The moisture on the surface gets removed as the rate of eva. > rate of diffus^n.
- Dry patches occur on the surface.
- The moisture left after is c/d 2nd critical point

(4) D–E

2nd falln Rate

Dryn rate ↓ & evaporatn gets finished.



EMC (Eqbm mois. content)

Last temp after which dry can't occur cz VP = VP of atm.

Classificatn of dryers

(1) Static Bed dryer → Tray dryer, → freeze dryer

adv → No size red.

disad → only upper surface in direct heat contact

(2) Movn Bed dryer – drum dryer

(3) fluidised Bed dryer – drug particle suspended in air stream

adv – Every particle get req. amnt of heat

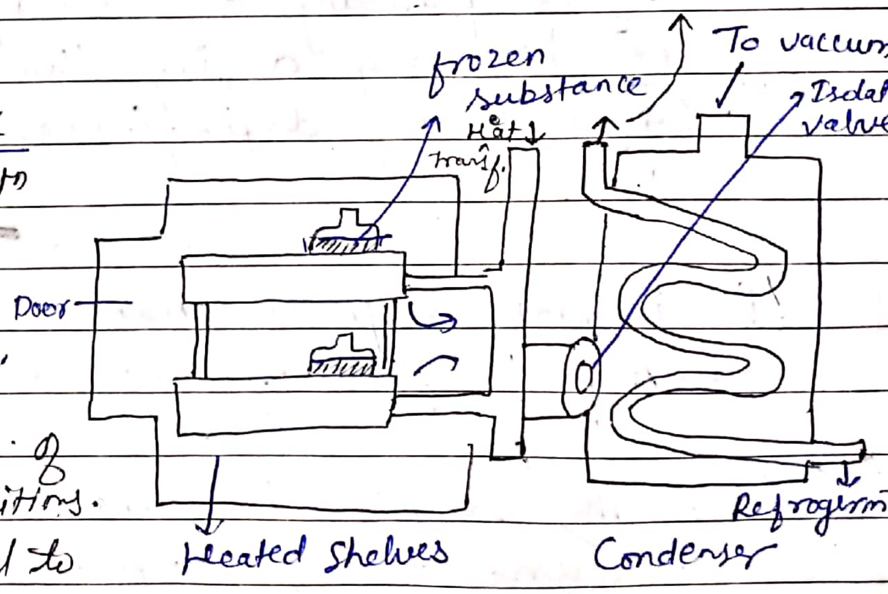
(4) Pneumatic dryer – Spray dryer

adv → fast drying.

freeze dryer

freeze dryn c/d = lyophilizatn

Principle



- water is removed from frozen state by sublimatn.
- solid-liq-vap eqbm phase dia. of tho is useful to decide exp. conditions.
- Dryn achvd by subjectn material to temp & press below triple point (↓ eutectic temp).
- Under these condtn, any heat transfered is used as latent heat & ice sublimes directly into vapour state. The water vapour is removed from system by condensatn in a cold trap maintained at a temp lower tho frozen materi'l.

Constructn

1. drying chamber in which trays are loaded
2. Heat supply in form of radiation source, heating coils.
3. Vapour condensing or adsorption system.
4. Vacuum pump or steam ejector or both.

- Dry chamber designed for batch process & has shelves for keepg materials.
- Dist b/w subliming surface & condenser must be less than the mean path of molecules. It ↑ rate of dryn.
- Condenser consists of a relatively large surface cooled by solid CO_2 slurred with acetone or ethanol.
- Temp of condensor << evaporated surface of frozen substance.
- To maintain condtn, condenser surface cleaned repeatedly.

Working

It has following steps:–

1. Prepration & pretreatment
2. Prefreezing to solidify water
3. Primary drying (Sublimatn of ice under vacuum)
4. Secondary drying (removal of residue moisture under ↑↓ vacum)
5. Packing

① Prepratn & pretreatment

→ Any sample is inserted in a limited amount in the container

→ The sample has moisture content which is removed by keeping it normally by the help of tray drying, it incs 8–10 times drying.

② freezing – with help of freezer at –50°C the substances freezed & moisture in it is also freezed

Disad → ① Oxidatⁿ of product psbl.
② Equipment & running cost ↑
Date ___/___/___ ③ time consuming Page No.: ____

Rate of coolⁿ (temp drop) is 1-3 Kelvin /min.

③ Primary drying
Moisture in frozen state has to be removed that is done by sublimation at eutectic point.
→ for water ~~eutectic~~ triple point is at 0.0098°C temp & 0.533 Kg Pascalⁿ pressure.
→ Eutectic point = press & temp at which solid changes to vapour
→ Sublimation def.
→ Sub. placed at heating slabs (heated by radiatⁿ) & sublimation occurs at -10 to 30°C & is gradually obtained (this temp.) within 2 hrs. pressure is 3 mm of Hg, this temp & press is eutectic point.
As vapour forms it has to be removed immediately so as to maintain temp. diff & 98-99% H_2O removed with period of 2 hrs.

④ secondary drying
Residual mois. (1-2%) removed by ↑ temp & press i.e, 50-60°C & ~~500 m~~ 50 mm Hg & time taken here is 10-20 hrs to completely remove moisture.

⑤ Packing - Product obtained is porous & crystalline. Container removed from heating, slab & cooled.

Uses → ① for drying of no. of products like blood plasma, bacterial cultures, antibiotics, vitamins & enzymes.
(ii) used for several food items like mushrooms, meat, coffee concentrates, citrus fruit juice.

Adv → Heat sensitive materials can be dried.
Denaturation of proteins doesnot occur.
Loss of volatile material is less.
Material can be dried in final container.

Mixing

Date __/__/__ Page No.

→ Mixing is defined as a process that tends to result in randomization of dissimilar particles within a system.
→ mix = To put together
→ Blending = to mix smoothly & inseprably together.

Mixing Applications

→ wet mixing in the granulation step is the production of tablets & capsules.
→ Dry mixing of several ingredients ready for direct compression as in tablets.
→ Dry blending of powders in capsules, dry syrups & compound (insufflations) powders
→ Production of pellets for capsules.

Diff b/w liquid mixing & Solid mixing

Liquid mixing	Solid mixing
→ flow currents are responsible for transporting unmixed material to the mixing zone adjacent to impeller.	→ Flow currents are not possible.
→ Truly homogeneous liquid phase can be observed.	→ Product often consists of two or more easily identifiable phases.
→ Small sample size is sufficient to study degree of mixing.	→ Large sample size is required.
→ Mixing requires low power	→ Mixing requires high power

Mechanisms of mixing In Solids

→ convective mixing
→ shear mixing
→ Diffusive mixing

Convective mixing

- achieved by inversion of powder bed using blades or paddles or screw elements.
- Large mass of material moves from one part to another.
- Also c/d Macromixing.

Shear mixing

FOA = Broken

- forces of attractⁿ are broken down so that each particle moves on its own b/w regions of diff. composition & parallel to their surfaces.
- In particulate mass → force of attractⁿ are predominating, it makes the layers slip over one another.
- These types ~~are~~ of forces are predominant among some types of particles.
- Shear forces reduce these attractions & reduce scale of segregation.

Diffusive mixing

- Includes random motion of particles within the powder bed, thereby particles change their positions relative to one another.
- Occurs at Interfaces of dissimilar regions.
- Reffered as Micro mixing
- flow characteristics of powders largely determines the ease with which the primary particles can be mixed.

Factors Influencing Mixing

① Nature of surface

- Rough surface of one of components does not induce satisfactory mixing as active substance enters into the pore of other subst.
- Addⁿ a substance which will be adsorbed on surface, can ↓ aggregation. Ex – (Aerosil Colloidal Silicon dioxide) to Zinc oxide)

(2) Density of the particles (↓ density = small particles)

- Of Minor Importance.
- Demixing ↑ when density of smaller particle is higher.
- This happens due to fact that dense material moves downwards & settles at bottom.

(3) Particle size

→ Easy when both powders have approximately same particle size.

- Variation of particle size leads to sepration as small particles moves downwards thru spaces b/w large p
- As particle size ↓, flow ppts ↑ due to gravitational force.

Particle size less than 100 μm are free flowing & it facilitates mixing

(4) Particle shape

- Ideal shape → spherical → uniform mixing
- Irregular shapes become interlocked & less chances of se

(5) Particle charge

Particles → attractive forces → electrostatic charges ↓ can lead to sepration or segregat

(6) Proportion of materials

→ Best result → 2 powders mixed in equal proportion by w & by volume.

→ If large diff in prop → mixing done in ascending order of their weights (Geometric mixi

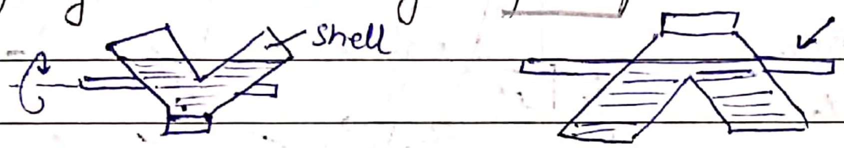
Classification of Equipments for Solids mixing

free flowing Solids – V cone blender
Double cone blender

Cohesive Solids – Planetary mixer
Sigma blender

Twin Shell Blender or V cone blender

- Made up of stainless steel or transparent plastic.
- Small models capacity = 20 kg & rotate = 35 RPM.
- larger models capacity = 1 tonnes & rotate = 15 RPM.
- Material is loaded thru either of shell hatches.
- Emptying done through apex part.



→ Material to be blended is loaded app. 50 – 60% of its total volume.

→ As blenders rotate, material undergoes tumbling motion.

→ when V = inverted → material splits into 2 portions.

→ Process of dividing & recombining continously yeilds ordered mixing by mechanical means.

→ Powder mass is converted shock wise, so that demixing density differences will occur.

→ Rotated, so that material alternatively collected in bottom of V.

→ Blender speed is the key for mixing efficency.

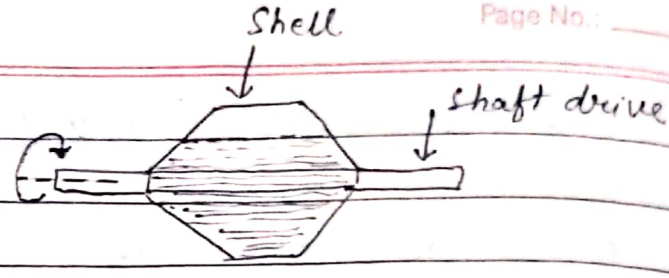
→ At ↑ speeds = more dusting or segregation of fines is possible

→ At ↓ speeds = not enough shear may be applied.

Adv → Suitable for fragile granules.
Handle large capacities
Easy to clean, load & unload
Req. min. maintenance.

Disad – ↑ headspace for installatn
• Not suitable for ↑ particle size diff.
• If powders are free flowⁿ, serial dilution req. for addⁿ of low dose active ingredients.

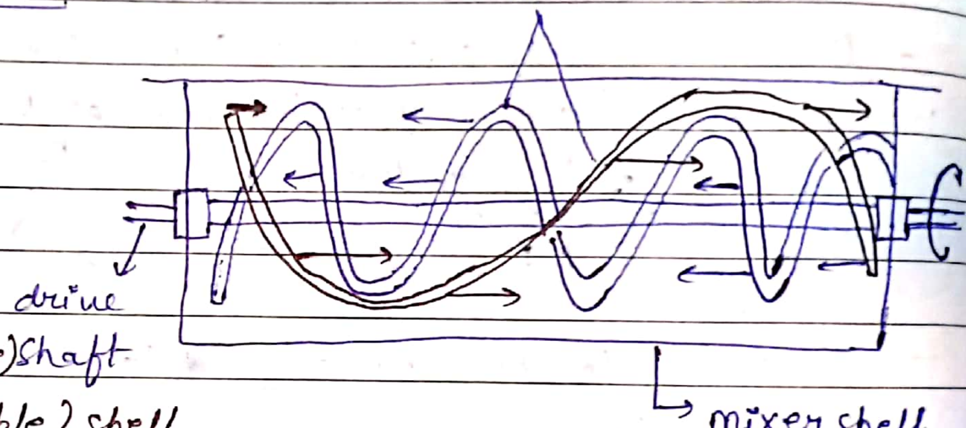
Double Cone blender



- It is charged & discharged through same port.
- Efficent for mixing particles of diff. densities.
- Rate of rotation should be optimum depending upon size & shape of tumbler, nature of material to be mixed.
- Range :- 30 to 100 RPM.
- Method :- same as that of V cone blender.

Ad & dis = " " " " " " ".

Ribbon Blender



Principle

→ Mechanism is shear.
→ Shear transffered to powder bed by moving blades (ribbon shape) shaft in a fixed (non-movable) shell.

- Convective mixing also occurs as the powder bed is lifted & allowed to cascade to the bottom of the container.
- An eqbm state of mixing can be achieved.

Construction

- It has non-movable horizontal cylinder tough shell; open at
- It has 2 helical blades, mounted on same shaft through long axis of trough.
- The blades have both right & left hand twists.
- The blades are connected to a fixed speed drive.
- It has a bottom discharge spout.
- Through closed with a lid.

Working

- Through fixed speed drive, ribbons allowed to rotate.
- One blade moves solid slowly in one direction & another blade moves them quickly in another direction.
- Diff. powders introduced → from top of trough.
- Body → covered → due to dust evolved during dry blending & granulat^n sol^n may evaporate durn wet granulation.
- Powders lifted by → centrally located vertical screw ↓ cascaded to the bottom of container. (Tumbling Action)
- Counteract^n blades → set up ↑ shear & are effective in breakup^n up lumps or aggregates.
- Helical blade → move powder from one end to another.
- final stage represents eqb^m stage.
- Operat^n cond^n of a given mixer → effects steady state & quality of mixing.
- Blend → discharged from bottom.

Uses – It is used to mix :- (finely divided –)
- solids – wet solid mass – sticky solid – Plastic solid

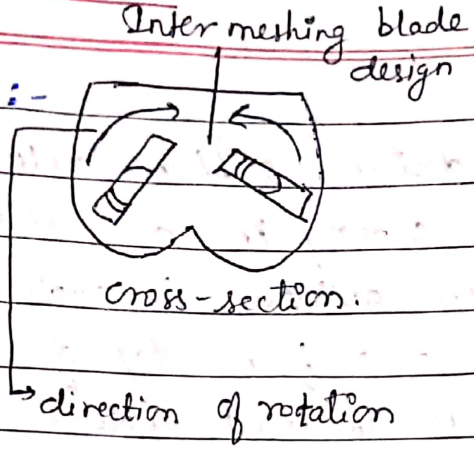
Advantages – ↑ shear applied → perforated baffles ↓ rubb^n & breaking of aggregrates.
- Headroom requirement is less.

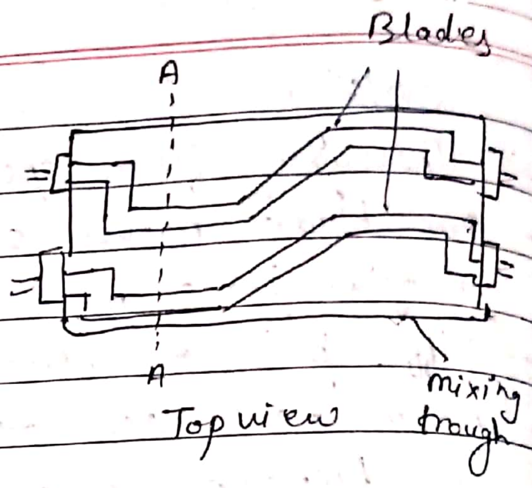
Disadv – poor mixer as movement of particles is 2-D
- shearing action is less as in planetary mixer
- Has fixed speed drive.

Sigma Blade mixer

Principle :– → Mechanism based on shearing.
→ Inter-meshing of sigma shaped blades create high shear & kneading actions.
→ Convective mixing 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.
→ These are connected to a fixed speed drive.
→ Mixer → loaded from top
→ unloaded = tilting the entire bowl by means of a rack & pinion drive.

Working :-

• diff. powders introduced from top of trough.
→ Body covered as considerable amount of dust may be evolved during dry blending & granulatⁿ solⁿ may evaporate during wet granulation.
→ Through fixed speed drive, sigma blades allowed to rotat
→ Blades move at different speeds, one usually about twice the speed of other, resulting in lateral pulling of the material.
→ They turn towards each other so that the powders move from the sides to centre of the bowl.
→ material further moves downwards over the point & the sheared b/w the blades & wall of the trough.
→ Thus cascading action (convective) as well as shear actⁿ can be achieved.
→ Perforated blades help in breaking lumps & aggregate
→ Thus high shear forces are set up.
→ The final stage of mix represents an eqbᵐ state.
→ The operating conditions of a given mixer can

markedly affect the steady state & thus quality of the mixing.

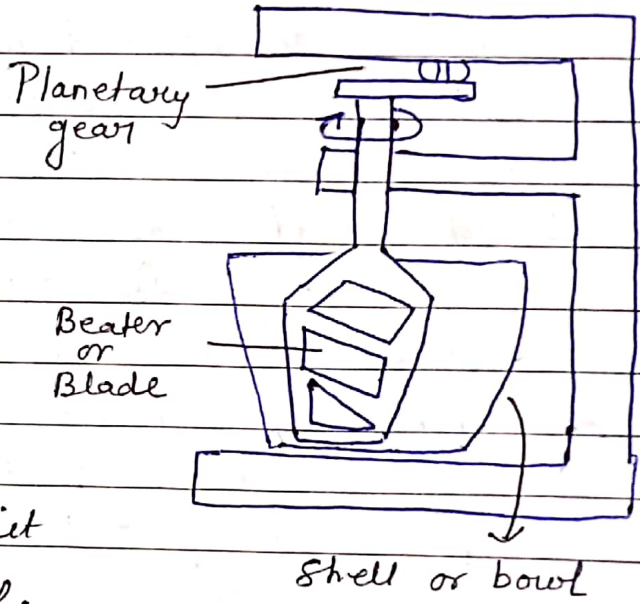
→ By means of a rack & pinion drive the bowl is tilted to empty the blend.

Uses → • mixing of dough ingredients in baking industry.
• Used in wet granulation process. (tablets, pills)
• Used for liq- solid mixing.

Adv → • Creates min. dead space durn mixing.
• It has close tolerances b/w the blades & the side-walls as well as bottom of the mixer shell.

Disad → works at fixed speed.

Planetary mixer



Principle :- In this, the blade tears the mass apart & shear is applied b/w a moving blade & a stationary wall.

→ The mixing arm moves in two ways ; around its own axis & around the central axis, so that it reaches every spot of the vessel.

→ The plates in the blade are sloped so that the powder makes an upward movement.

→ ∴ tumbling (convective) motion also obtained

Construction

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

- mixing blade is mounted from the top of the bowl.

- Mixing shaft is driven by a planetary gear train, as indicated in fig.
- It rotates around the ring gear, which further rotates around the mixer blade.
- It is normally built with a variable speed drive.

Working :- - Agitator has planetary motion.
- It rotates on its own & around the central axis so that it reaches all parts of the vessel.
- Beater is shaped to pass with close clearance over the side & bottom of mixing bowls.
- Blade tears the mass apart & shear is applied b/w the moving blade & the stationary wall.
- Plates in blade are sloped so that the powder makes an upward movement.
- Therefore, tumbling (convective) motion is also obtained.
- Since it is a variable speed driven, initially the blade moves slowly for premixing & finally at ↑d speed for active mixing.
Thus ↑ shear applied for mixing.
- Emptying bowl may be done by hand (scooping) or by dumping mechanism.

Uses :- - Precise mixing by breaking agglomerates rapidly.
- ↓ speed for dry blending
- ↑ speed for kneading action.

Adv :- - Speed of rotation can be varied.
- Useful in wet granulation.

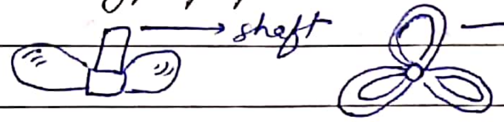
Disad :- Mechanical heat is built up.
Requires high power
Limited size & useful only for batch work.

Liq. mixing → Impellers → Prop, Turb, Paddles

Date ___/___/______

Propellers

- It contains no. of blades.
- 3 bladed design = most common one for liquids.
- Marine type propeller similar to blade of table or ceiling fan.



- It may either left or right handed, depend^n upon direct^n of slants of their blade.
- four bladed or toothed = used for special purposes.
- In deep tank, push-pull propeller is used. ~~for special purpose~~
- These work in opp. direction to create a zone of high turbulence.
- Propeller size = small (Ratio of diameter b/w propeller & container is 20) = suff. for ↓ viscous liquids.
- For large tanks, max^m size = 0.5 m propeller is used.
- Small propellers → full flow of motor speed turn at up to 8000 rev/min.
- Propeller reduces axial (longitudinar) movement of liq.
- The flow currents leave the propeller continue through the liq in a given direct^n until deflected by the floor or wall of the tank.

uses → used when ↑ mixing capacity is needed.

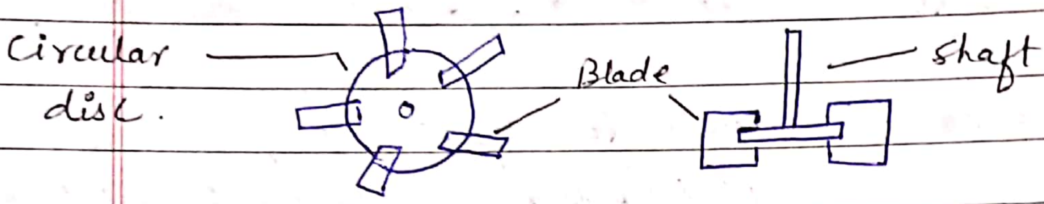
→ useful to handle max. viscosity of liq i.e., 2.0 pascal-sec & slurries upto 10% solids of fine mesh size.

- multivitamin elixir, disinfectant soln are manufactured using propellers.

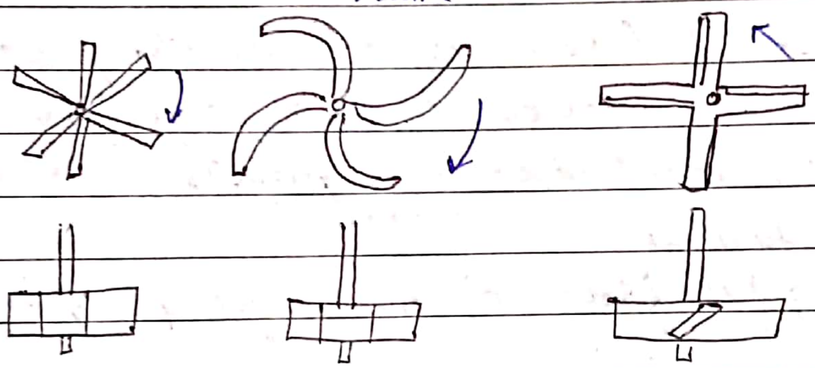
Disad – Not normally effective for liquids of viscosity greater than 5 pascal-second (glycerin, castor oil)

Turbines

- It has a circular disc to which no. of short blades are attached.
- Diameter ranges from 30-50 %. of dia. of vessel.
- Rotates at ↓ speed than propeller (50 – 200 RPM)
- Blades may be straight, curved, pitched or verticle.



(a) General assembly of blade disk turbine or flat bladed turbine



(b) various types of blades

→ Flat bladed turbine ⟶ produces radial & tangential flow but as speed ↑, radial flow dominates.

→ Pitched blade turbine ⟶ produces axial flow.

→ Near impeller, the zone of rapid currents, high turbulence & intense shear is observed.

→ Shear produced by turbines can be further enhanced using a diffuser ring.

→ A diffuser ring is a stationary perforated or slotted ring, which surrounds the turbine, it increases the shear forces.

→ Liquid passes through the perforations reducing rotational

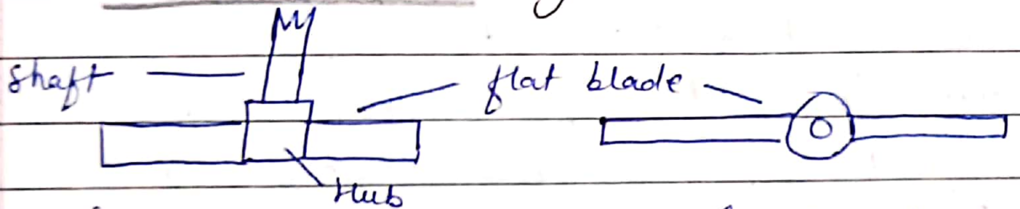
Swirling & vortexing

Uses → Effective for ↑ viscous solⁿ with wide range of viscosities upto 7,000 pascal-seconds (syrups, liq paraffin, glycerine)
- They can handle slurries with 60% solids.
- These are suitable for liquids or large vol. & ↑ viscosity, if tank is baffled.

Adv → It gives greater shearing forces than propellers, though the pumping rate is less, ∴ suitable for emulsification

Paddles

- It consists of a hub centrally with two long flat blades attached to it vertically.



(a) Side view (b) Top view

- Two or four bladed paddles are common.
- Sometimes, the blades are pitched.
- In few paddles, blades are dished or hemispherical in shape & have a large surface area in relation to the tank in which they are used.
- Bcs of this shape, paddles pass close to the tank walls & effectively mix viscous liquids, avoidⁿ dead spots & deposited solids.
- A shaft carrying 6 hub-blades rotate at low speed of order of 100 RPM.
- They push liq radially & tangentially with almost no axial motion unless the blades are pitched.
- In deep tanks, several paddles are attached one above the another at same shaft.
- At very low speed it gives very mild agitation

in an unbaffled tank, where as for ↑ speeds baffles are necessary. or else the liq is swirled around the vessel with little mixing.

Uses :- Antacid manufacturing ($Al(OH)_3$ gel & $Mg(OH)_2$), agar & pectin related purgatives, antidiarrhoeal mixtures.

Adv → Vortex formation not possible with paddle impellers bcz of low speed mixing.

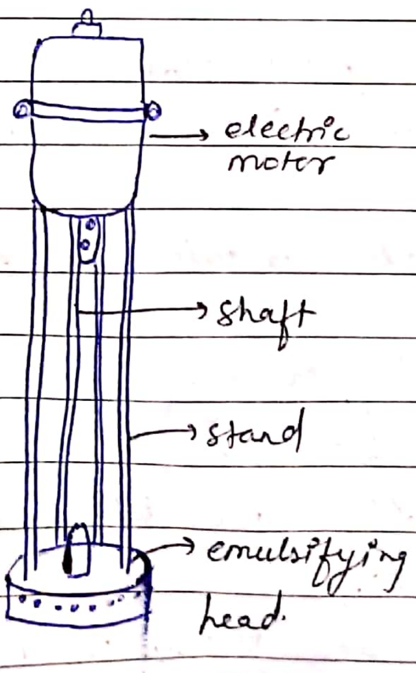
Disad → Suspension mixing poor, ∴ baffled tanks Req.

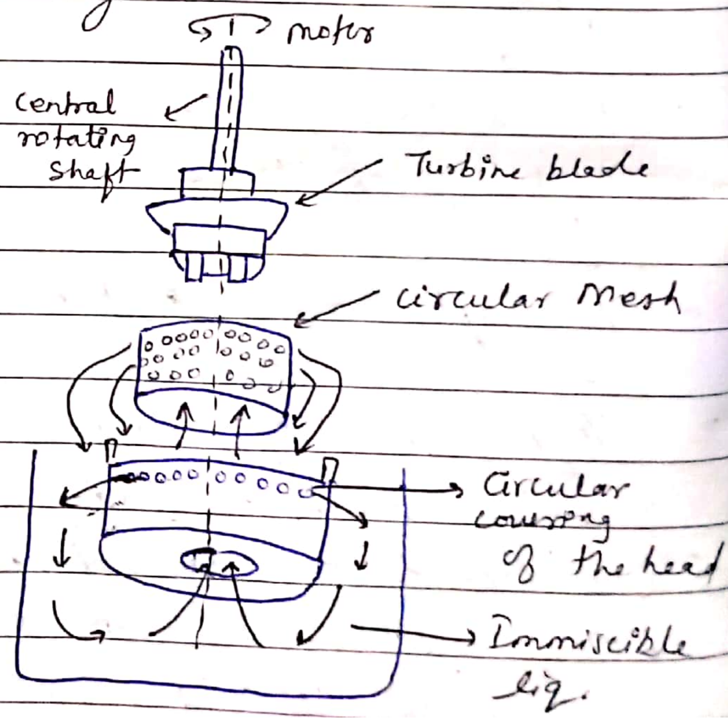
Silverson Mixer – Emulsifier

Principle :- It produces an intense shearing force & turbulence By the use of high speed rotors.

- This turbulence causes the liq to pass through fine interstices formed by closely placed perforated metal sheets.
- Circulation of materials takes place thru the head by the suction produced in the inlet at the bottom of the head.
- Circulatn of material ensures rapid breakdown of the dispersed liq. into smaller globules.

Construction





- It has long support^n columns connected to motor & other end connected to head.
- The head carries turbine blades.
- Blades are ~~so~~ surrounded by a mesh, which is further enclosed by a cover having openings.

Working - Emulsifier head placed in → vessel (coarse sol^n or immiscible liquids)
completely dipped →

- motor started → central rotat^n shaft rotates head
↓
rotates turbine blades at a very ↑ speed. ← a press. diff is created. ← thus liq. are sucked into head from centre of base ← liq. subjected to ↑ mixing action.
↓
centrifugal forces expel head contents with great force thru mesh → onto the cover → as a result fine emuls^n emerges thru openings of outer cover.

- Intake & expulsion of the mixer set ups a pattern of circulation to ensure rapid breakdown of the bigger globules into smaller globules.

Uses - Emulsions & creams of fine particle size.

Adv - Diff. sizes available.
Used for batch operations.

Disad - Ocassionally chance of mesh clogging.

Pg - 96, 97 & 103

Mech of liq mixing → Bulk
Turbulent
Laminar
Molecular diffus^n.