Unit-III Drying

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

⇒ There are two ways to remove water by drying.

- Thermal Process
  - ↓ Heat required
- Non-thermal Process

Non-thermal Process-

It involves -

(i) Squizing :- Removal of water by squizing.

(ii) Adsorption :- Removal of water from the surface of object/wet substances.

(iii) By Extraction :- Removal of water by extraction method from wet substances.

Objectives of Drying :-

(1) To tranform the product in the acceptable form which will be useful for further processing.

(2) To reduce the transportion cost as drying reduces the weight of product.

(3) To improve some characteristics like flow of powder from hopper, compressibility and size reduction.

Applications of Drying :-

① **Preparation of bulk drugs :-** In the preparation of bulk drugs, drying is the final stage of processing. A few example are :

- dried aluminium hydroxide
- spray dried lactose
- powdered extracts

② **Preservation of drug products :-** Drying is necessary in the order to avoid deterioration.

Ex.

Crude drugs of animal & vegetable origin → chemical decomposition.

Blood product, skin, tissue → microbial growth.

Effervescent table (aspirin, penicillins) → chemical decomposition.

③ **Improved characteristics :-** Drying produces materials of spherical shape, uniform size, free flowing and enhanced solubility.

Some specific areas of importance are :

(a) Granules are dried to improve the fluidity and compression characteristics. These are essential for the production of tablets and capsules.

(b) Viscous and sticky materials are not free flowing. Drying modified these characteristics.

eg. male fern extract, malt extract and oleoresin.

④ Improved handling :-

Removal of moisture makes the materials light in weight and reduces the bulk. Thus the cost of transportation will be less and storage will be efficient. If moisture is present size reduction of drug is difficult. Drying reduces the moisture content.

Mechanisms of Drying Process

Heat tranfer

⇒ In this, heat is generated within the exterior surface

Mass tranfer

⇒ This involves the tranfer of moisture to the surface if solid subsequently vaporisation from the surface into the surrounding

Various theories are proposed to explain the movement of moisture -

1. Diffusion theory
2. Capillarity theory
3. Pressure gradient theory.

① Diffusion theory :- In diffusion theory the rate of flow of water is proportional to moisture gradient. According to this theory, moisture movement may be as follows.

⇒ Water diffuses through the solid to the surface and subsequently evaporates into the surrounding.

⇒ Evaporation of water occurs at an intermediate zone, much below the solid surface, then vapours diffuses through the solid into air.

② Capillarity theory :-

Capillary theory holds good only for free water in the bed. This type of movement of liquid takes places in the granules (pores) as well as in the spaces between the granules (void spaces). As the pore diameter is considerably smaller inside a granule than the surrounding granules, liquid surrounding the granules can be removed initially. Then pore liquid inside a granule is vaporised.

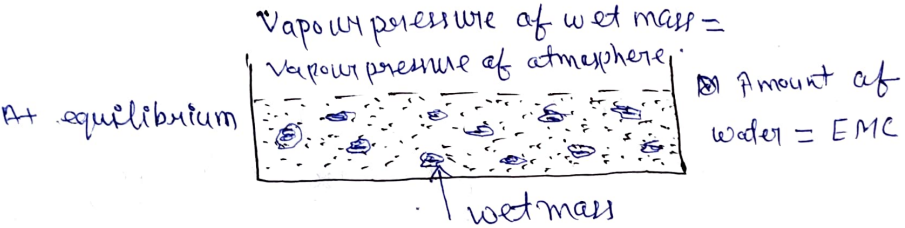
③ Pressure gradient theory :-

Pressure gradient theory is applicable to drying of solids by the application of radiation. In this process, it gives up random kinetic energy (or heat) to the inside surface of the solids ~~it~~ itself. Therefore, liquid inside

the solids is vaporised. As a result, vapour pressure gradient is developed which is the driving force for the movement of vapour to the surface.

Equilibrium Moisture Content (EMC)

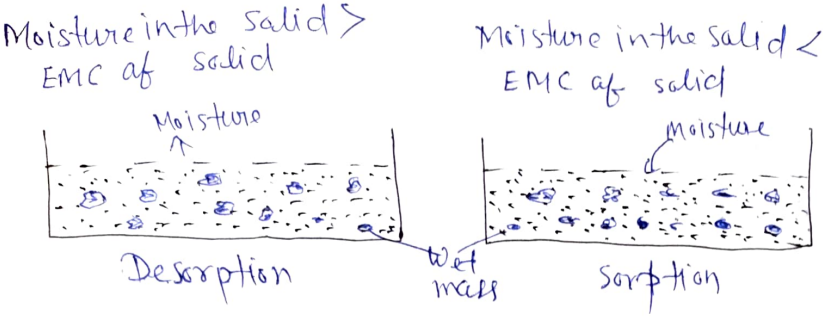
It is amount of water present in the solid which exerts a vapour pressure equal to the vapour pressure of the atmosphere surrounding it.



Depending on these conditions, the solids may absorb or lose moisture.

(a) When air is continuously passed over the solid containing moisture more than EMC, then solid loses water continuously till EMC is reached. This phenomenon is known as desorption.

(b) When air is continuously passed over the solid containing moisture less than EMC, then solid absorbs water continuously till EMC is reached. The phenomenon is known as sorption.



Measurement of EMC :-

The EMC of a material can be determined as follows-

⇒ The solid sample are placed in a series of closed chambers such as dessiccators. Each chamber consists of solution (desiccant), which maintains a fixed relative humidity in the enclosed air spaces.

⇒ In other words, the solid samples are exposed to several humidity conditions. The exposure is continued untill the material attains a constant weight (equilibrium conditions). The difference in the final and initial weights gives the moisture content.

Applications of EMC :-

⇒ EMC are useful in analysis of drying operation and particularly in predicting final moisture contents.

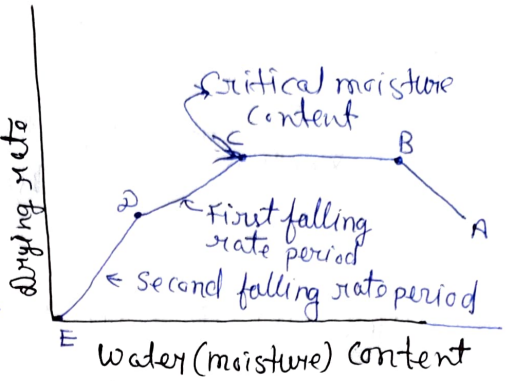
⇒ over drying can be prevented.

Rate of Drying Curve :-

It follow two drying zones,

(i) Constant rate period

(ii) Falling rate period.



(i) Constant rate period

The amount of moisture vaporised per unit time per unit area of drying surface remains constant.

(ii) Falling rate period :-

The amount of moisture vaporised per unit time per unit area of drying surface decrease continuously.

Critical Moisture Content (CMC) :-

The break point of two zones where the moisture content at which the constant rate drying period ends and falling rate drying period starts.

⇒ Point A - Initial adjustment point where solid absorb heat and temperature increases.

⇒ Point B - represents equilibrium temperature condition.

⇒ Curve BC (Constant rate) :- It represent removal of unbound water from the product.

⇒ Curve CD (first falling rate) - It occurs when wetted ~~spo~~ stop in the surface continually

decline until the surface is dried.

- Curve DE (Second falling rate) – It begins at point D when the surface is completely dry.

$$\text{The rate of drying} = \frac{\text{weight of water in sample (kg)}}{\text{time (h)} \times \text{weight of dry solid (kg)}}$$

$$\%\ \text{Loss of drying (kg)} = \frac{\text{mass of water in sample (kg)}}{\text{Total mass of wet sample (kg)}} \times 100$$

$$\%\ \text{moisture content} = \frac{\text{mass of water in sample (kg)}}{\text{mass of dry sample (kg)}} \times 100$$

Tray Dryer

Principle:- In tray dryer, hot air is continuously circulated. Moisture is removed from the materials by forced convection. Simultaneously, the moist air is removed partially.

Construction:-

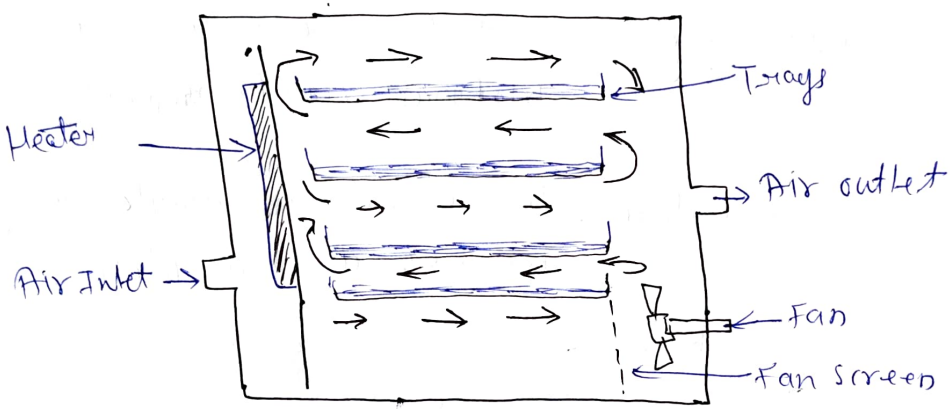


Fig. Tray dryer.

⇒ It consist of a rectangular chamber whose walls are insulated.
⇒ Trays are placed inside the heating chamber.
⇒ The number of trays may very with the size of dryer.
⇒ Dryer is fitted with a fan for circulating air over the trays.
⇒ There are also some direction vanes are placed in the corner of chamber to direct air in expected path (not shown in figure)

Working :-

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

⇒ Fresh air is introduced through inlet, which passes through the heaters and gets heated up.

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

⇒ Turbulent flow lowers the partial vapour pressure in the atmosphere.

⇒ The drying of the material occurs at its surface due to hot air circulation.

⇒ As the water on surface evaporated the remaining moisture of the material which was inside comes on the due to capillary action.

⇒ These events occur in a single pass of air.

⇒ The hot air cannot picked up a enough air at a single pass as the time of contact is less.

⇒ So it is recirculated along with 20% of the fresh air.

⇒ Moist air is discharged through outlet.

⇒ Thus constant temperature and uniform air flow over the materials can be maintained for achieving uniform drying.

Uses:-

⇒ Sticky materials, granular mass or crystalline materials, plastic substances, precipitates and pastes can be dried in a tray dryer.

⇒ Crude drugs, chemicals, powders, tablet granules or parts of equipment are dried.

Advantage:-

⇒ Handling of materials (loading and unloading) can be done without losses.

⇒ It is operated batch-wise.

⇒ Valuable products can be handled efficiently.

Disadvantage:-

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

⇒ The process is time consuming.

Drum Dryer (Roller Dryer, or Film Drum Dryer)

Principle:- In drum dryer, a heated hollow metal drum rotates on its longitudinal axis, which is partially dipped in the solution to be dried.

Mechanism is simple evaporation and no boiling is obtained.

Construction :-

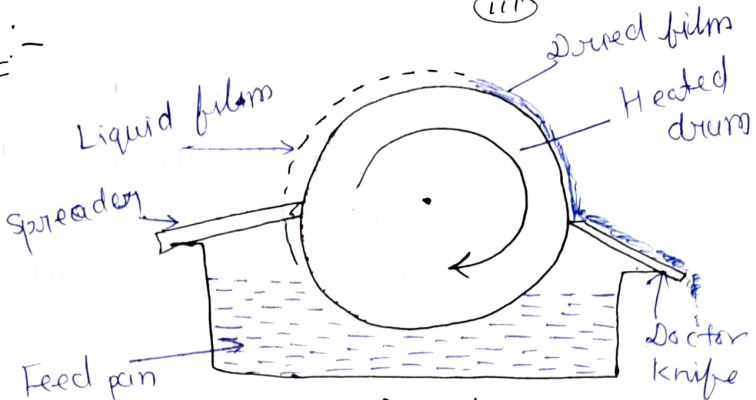


Fig - Drum dryer

⇒ It consist of a horizontally mounted hallow steel drum or chrome plated steel of 0.6 to 3.0 m. diameter and 0.6 to 4.0 m. length, whose external surface is smoothly polished. These reduce contamination.

⇒ Below the drum, feed pan is placed in such a way that the drum dips partially into the feed.

⇒ On one side of drum a speader is placed and on the other side a doctor's knife is placed to scrap the dried material.

⇒ A storage bin is placed connecting the knife to collect the material.

Working :-

⇒ Steam is passed inside the drum. Heat transfer coefficient of the drum metal is high.

⇒ Drum is rotated at 1-10 revolutions per minute.

⇒ The liquid material present in the feed pan adheres as a thin layer to the external surface of the drum during its rotation.

⇒ The material is completely dried during its journey in slightly less than one rotation.

⇒ The dried material is scrapped by the doctor's knife, which is then falls into a storage bin.

⇒ The time of contact of the material with hot metal is 6 to 15 seconds only.

⇒ Therefore, processing conditions such as film thickness, steam temperature are closely controlled.

Uses:

⇒ Used for drying solutions, slurries, suspensions, etc.

⇒ The products dried are milk product, starch product, ferrous salt, suspension of zinc oxide, suspension of kaolin, yeast, antibiotics, DDT, insecticides,.

Advantages:

⇒ Drying time is less, only a few seconds. Therefore, heat sensitive materials can be dried.

⇒ Occupies less space.

⇒ The product obtained is completely dried.

Disadvantages:

⇒ Maintainance cost of drum dryer is higher than other dryers.

⇒ Skilled operation are essential to control feed rate, film thickness, speed of rotation and temperature.

Spray Dryer

Principle :-

⇒ In spray dryer, the fluid to be dried is atomized in to fine droplets.
⇒ The droplets thrown in moving steam of hot gas.
⇒ Temperature of droplets immediatly increased and get dried in the form of spherical particles.

Construction :-

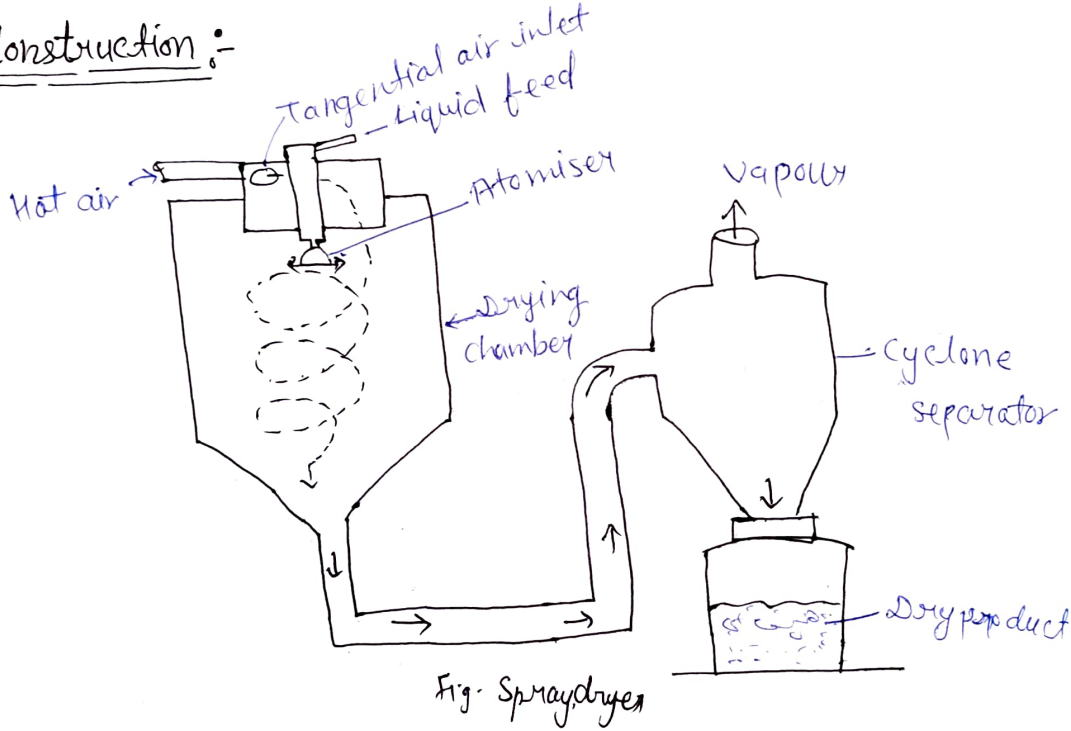


Fig. Spray dryer

⇒ It consist 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 set in the roof.

⇒ The spray disk atomizer is about 300 m in diameter and rotates at a speed of 3,000 to 50,000 RPM.

⇒ Bottom of the dryer is connected to a cyclone separator.

Working :- Drying of the 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 the liquid droplets :-** Fine droplets are dried in the drying chamber by supplying hot air through the inlet.

③ **Recovery of the dried product :** Centifugal 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 ~~sec~~ second. Particle size obtained is ranging from 2 to 500 ~~mm~~ μm..

⇒ Maximum size of spray dryer has capacity of 2000 kg per hour.

Uses :-

⇒ The quantity of the material to be dried is large

⇒ It is used for drying of all types of material and mostly the thermolabile, hygroscopic drugs or the materials that undergoes chemical decomposition

Advantages:

⇒ Spray drying is a continuous process and drying is very rapid (3-30 sec).

⇒ Labour costs are low as it combines function of an evaporator, crystillizer, dryer, a size reduction and a classifier.

⇒ Disadvantage :-

⇒ It is very bulky and expensive.

⇒ not always easy to operate.

Fluidised Bed Dryer (FBD)

Principle :-

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

⇒ The granules are lifted from the bottom and suspended in the stream of air. This condition is called fluidized state.

⇒ Hot gas is surrounding every granules to completely dry them.

Construction:-

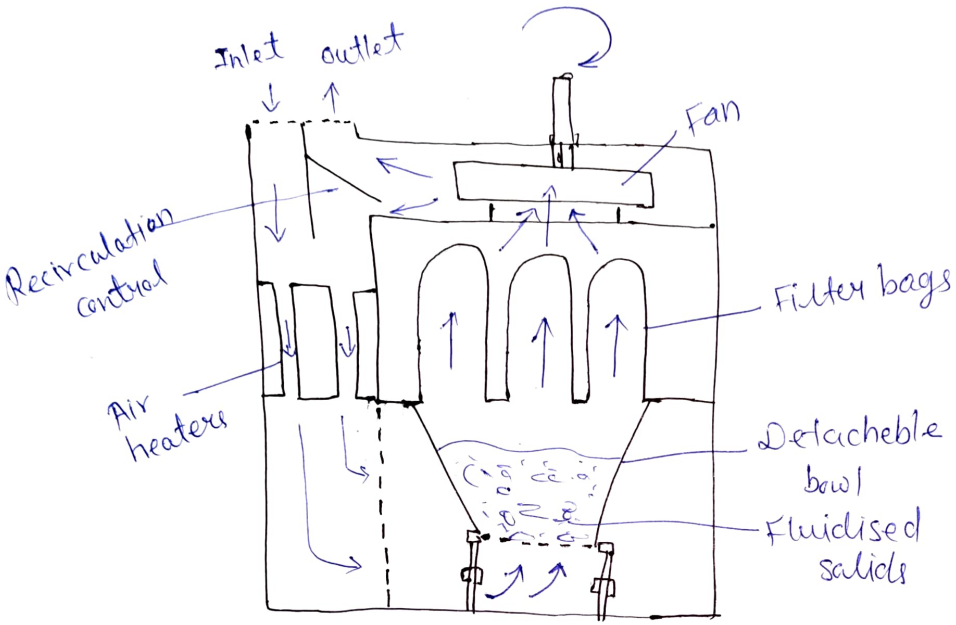


Fig. Fluidised bed dryer

⇒ The dryer is made up of stainless steel or plastic.
⇒ A detachable bowl is placed at the bottom of the dryer.
⇒ The bowl has a perforated bottom with a wire mesh support for placing materials to be dried.
⇒ A fan is mounted in the upper part for circulating hot air.
⇒ Heat exchanger are connected to heat the air to the required temperature.
⇒ Bag filters are placed above the drying bowl for recovery of fines.

Working :-

⇒ The wet granules to be dried are replaced in the detachable bowl.
⇒ The air is allowed to pass, which subsequently gets heated by passing through a heat exchanger.
⇒ The hot air flows through the bottom with velocity of greater than settling velocity of granules.
⇒ The granules rise and then fall back in a random boiling motion.
⇒ This condition is said fluidised state.
⇒ The gas surrounds every granule to completely dry them.
⇒ The air leaves dryer by passing through the bag filter.
⇒

Uses.

⇒ Used for the drying of granules in the production of tablets.
⇒ Used ~~in~~ for coating of granules.

Advantages.

⇒ 15 times faster than a tray dryer.
⇒ Available in different size (5 to 200kg/h)
⇒ The drying is uniform.

Disadvantages.

⇒ Many organic powders develop electrostatic charges during drying.
⇒ Chances of attrition of same material resulting in the production of fines.

Vacuum Dryer

Principle :-

⇒ In vacuum dryer, material is dried by application of vacuum.

⇒ Due to application of vacuum the liquid boils at a low temperature than the boiling point. So evaporation of liquid takes place faster and at low temperature.

Construction :-

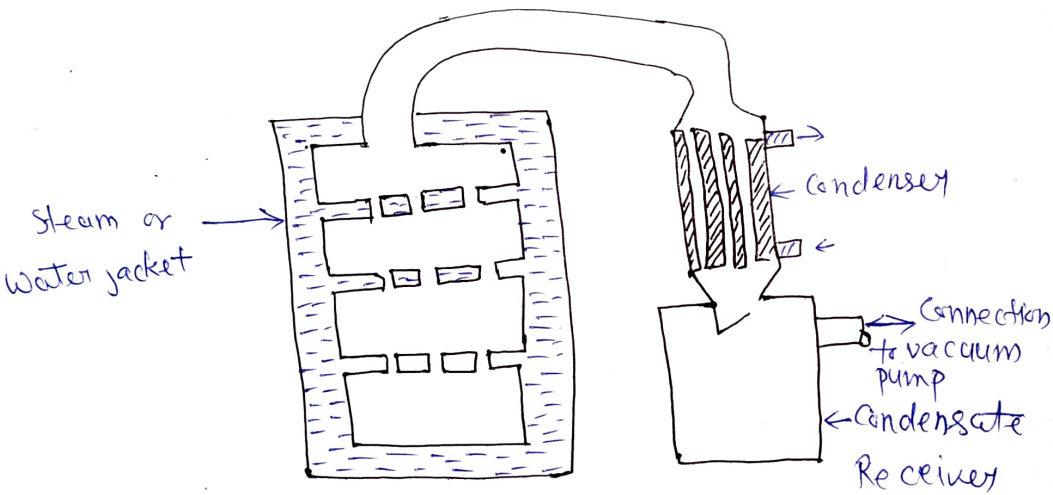


Fig. Vacuum dryer.

⇒ It is made of a cast iron heavy jacketed vessel, which can withstand high vacuum within the oven and steam pressure in the jacket.

⇒ The enclosed space is divided into a number of portions by means of no hollow shelves, which are part of the jacket.

⇒ These shelves provides larger surface area for conduction of heat.
⇒ over the shelves, metal trays are placed @ for keeping the material.
⇒ The oven door can be locked tightly to give an air tight seal.
⇒ The oven is connected to a vacuum pump.

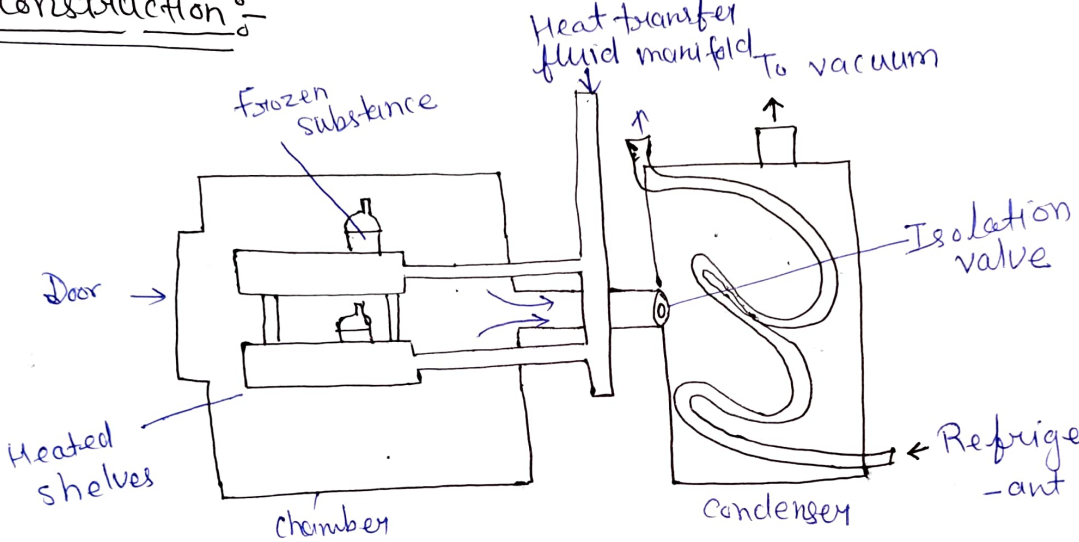
Working :-

⇒ The material to be dried is spread on trays,
⇒ The trays are placed on the shelves.
⇒ Door is closed firmly.
⇒ Pressure is decreased upto 30 to 60 kPa by means of a vacuum pump.
⇒ Steam or hot air is supplied into the hollow space of jacket and shelves.
⇒ Heat transfer by conduction takes places.
⇒ At this vacuum, evaporation of water from the material takes place at 25-30°C, on account of lowering of boiling point.
⇒ Wapour of water passes into the condenser where condensation takes place.
⇒ At the end of drying, vacuum line is disconnected. The material is collected from the trays.

Freeze Dryer → (Lyophilization)

Principle :- In freeze drying, 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 :-



∋ It consist of -
- → Drying chamber in which trays are loaded.
- → Heat supply in the form of radiation source, heating & coils.
- → Vapour condensing or adsorption system.
- → Vacuum pump or ~~system~~ steam ejector or both.

Working :- It involves 5 stages -

① Preparation and pretreatment
② Prefreezing to solidify water

③ Primary drying (Sublimation of ice under vacuum)
④ Secondary drying (removal of residual moisture under high vacuum)
⑤ Packing.

① Preparation and pretreatment :- It is essential process, which reduces the actual drying by 0-10 times. The final product becomes more porous.
→ Liquid or solid desiccants are also used for this purpose.

② Prefreezing to solidify water :- Vials, ampoules or bottles in which the aqueous solution is packed are frozen in cold shelves (about -50°C). During this stage, ~~com~~ cabinet is maintained at low temperature and atmospheric pressure.

③ Primary drying :- 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. 0.0090°C and 0.533 kPa, (4.50 mmHg) for the sublimation when water alone is present.
→ Vacuum is applied to the tune of about 3 mmHg on the frozen sample. The temp. is linearly increased to about 30°C in a span of 2h.
⇒ As the drying proceeds, thickness of the frozen layer decrease and the thickness of partially dried solids increases.

→ Primary drying stage removes easily removable moisture (98 to 99% water is removed).
→ Still traces of moisture is present in the sample.

④ Secondary drying :- During this stages, traces of moisture is removed. The temp. of the solid is raised to as high as 50 to 60°C, but pressure is lowered below that is used in primary drying. The rate of drying is very low and it takes about 10 to 20 h.

⑤ Packing :- After vacuum is replaced by inert gas, the bottles and vials are closed.

Uses:
It is most commonly used in the production of dosage forms, such as injections, solution and suspensions.

Advantages -
→ Heat sensitive materials can be dried.
→ Sterility can be maintained.
→ Loss of volatile material is less.

Disadvantages -
→ Equipment and running costs are high.
→ The period of drying is high.
→

Mixing

Mixing (blending) is a unit operation in which a uniform mixture is obtained from two or more component by dispersing one within the other.

Types of Mixing

- Homogenous
  - Liquid - liquid
  - Solid - solid
  - Gas - Gas
- Metrogeneous
  - Solid - Liquid
  - Gas - liquid
  - solid - gas.

Applications :-

1. It invalves in preparation of different types of formulation. Ex- Tablet, Capsule, Syrup etc.
2. Dry mixing of several ingredient ready for direct compression as in tablet formulation.
3. Wet mixing in the granulation step in the production of tablet & Capsule.
4. It also helps in preparation of injectable formulation.

⇒ Factors Affecting Mixing :-

1. **Nature of Product :-** Same nature of particle increases the rate of mixing.

Same nature of particle ∝ Rate of mixing

② Particle Size :- It is easy to mix two powders having approximately the same particle size. As the particle size increases, flow properties also increase due to the influence of gravitational force on the size. So particle size is directly proportional to rate of mixing.

size of Particle ∝ rate of mixing.

③ Particle shape :-

The same shape of particles increase mixing of these components.

⇒ The irregular shapes can become interlocked and decrease rate of mixing

Same particle shape ∝ Rate of mixing.

④ Particle charge :-

⇒ Same charge particles mixing may be decrease the mixing because (+ve, +ve) or (-ve, -ve) charge are ~~repul~~ non-attracted.

⇒ Different charge particles mixing may be increases the mixing.

So, Neutral charge particle mixing increase the rate of mixing.

Neutral charge particle ∝ Rate of mixing↑

⑤ Density of the Particle :-

If material density is high, then decreases the rate of mixing due to the fact that dense material always moves downward and settles at the bottom.

Difference between Solid and Liquid Mixing

Solid Mixing	Liquid Mixing
1. Product often consists of two or more easily identified phases.	→ Truly homogeneous liquid phase can be observed.
2. Large sample size is required.	→ Small sample size is sufficient to study degree of mixing.
3. Solid mixing equipment are commonly referred to as mixers and blenders	→ Fluid mixing equipment are termed as liquid agitators.
4. mixing requires high power.	⇒ mixing requires low power.

Mechanism of Solid mixing :-

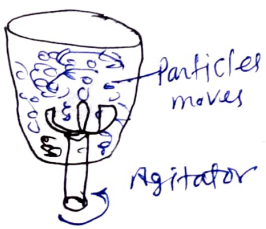
The mechanisms in solid-solid mixing are :-

(i) Convective mixing
(ii) Diffusive mixing.
(iii) Shear mixing.

① Convective mixing :-

Convective mixing is achieved by the inversion of the powder bed using blades or paddles or screw element.

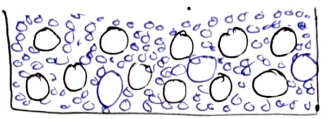
A large mass of material moves from one part to another. This mixing is referred to as macro-mixing.



(ii) **Diffusive Mixing :-**

It involves the random motion of particles within the powder bed and particles change their positions relative to one another.

- It occurs at the interfaces of dissimilar regions.
- It referred to as micro mixing.



(iii) **Shear Mixing :-** In this type, the force of attraction are broken down by applying shear on it. So particles can easily move between regions of different composition and mix easily.

Mechanisms of Liquid Mixing :-

Two types liquid -

i) miscible liquid → two liquid mixed easily

ii) Immiscible liquid → not easily mix (mix by using agents)

Mechanisms :

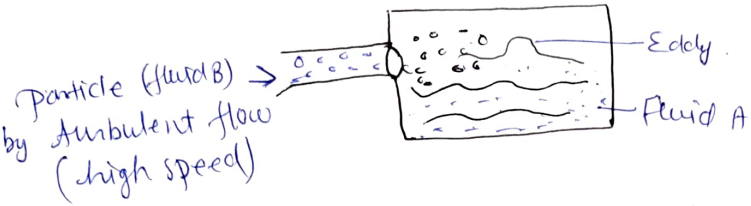
1. Bulk transport mixing
2. Turbulent Mixing
3. Laminar Mixing
4. Molecular diffusion mixing.

(1) Bulk transport Mixing :-

The movement of a large portion of a material from one location to another location in a given system, with the help of rotating blades or paddles etc.

② Turbulent Mixing :-

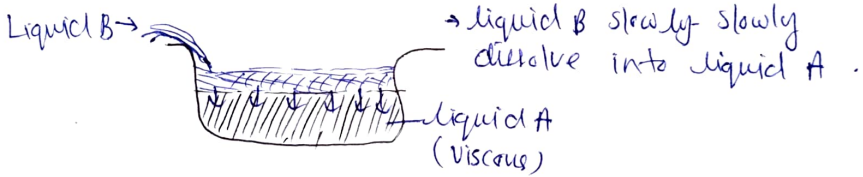
In which mixing takes place due to turbulent flow,
due to turbulent flow, velocity and speed of particles increase and they move faster.
Due to move faster, they also create Eddy.
(portion of particle moving as a unit in a direction)



⇒ Turbulent flow is highly effective mechanism for mixing.

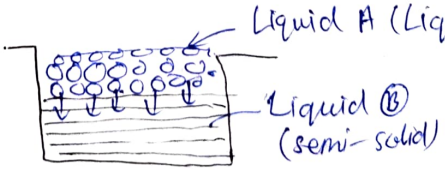
③ Laminar Mixing :-

Laminar mixing is the mixing of two dissimilar liquids through laminar flow. i.e. the applied shear stretches the interface between them.



④ Molecular diffusion Mixing :-

It is the mixing at molecular level in which molecules diffuse due to thermal motion.
⇒ mixing takes place due to concentration gradient.
⇒ It take place for semi-solid like ointment, gel etc.



Mechanism of Semi-Solid Mixing :-

- Semi-solid dosage forms includes ointments, pastes, cream, jellies etc.

Mechanism -

⇒ For mixing of such dosage form, we use agitator. The agitator must move the material throughout the mixer.

⇒ The mixing action include combination of low speed shear, smearing, wiping, folding, ~~stretching~~ stretching and compressing.

Equipments use in Mixing :-

⇒ Double Cone blender
⇒ Twin shell blender
⇒ Ribbon blender
⇒ Sigma blade mixer
⇒ Planetary mixer
⇒ Propellers
⇒ Turbines
⇒ Paddles
⇒ Silverson Emulsifier.

Double Cone Blender

Principle :- The mixing of powder in double cone blender due to tumbling motion of blender as well as shearing action with blade.

Construction :-

⇒ All parts of equipment are made up of stainless steel.
⇒ It consist of two cones which are attached and rotated.

⇒ One horizontal shaft drive which are attached with motor for rotating.

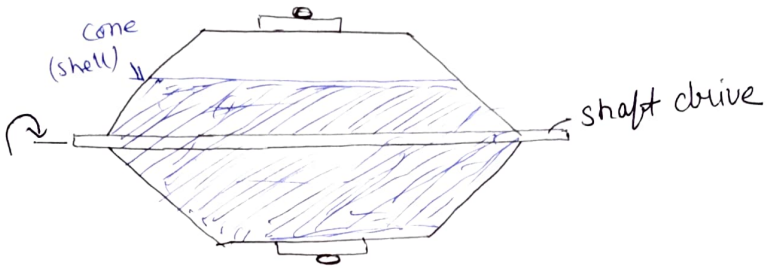


Fig. Double cone blender

Working :-

→ The material which is to be mixed is loaded in the blender. Generally it is filled ~~between~~ up to 50-70% of its total volume.

→ As the blender rotates (30RPM) the material undergoes tumbling motion and mixes the material thoroughly.

→ Agitator blade can also be fixed in order to produce shearing action.

Advantages:

⇒ Operation is easy.
⇒ Easy to load, unload & clean.
⇒ Available in various sizes.

Disadvantages:

→ Required high head space for installation.
⇒ Less shear is applied.

Use: It can used for pharmaceutical preparations, powders etc.

⇒ Homogenous mixing of dry powder & granules.

Twin Shell Blender (V-cone blender)

Principle:- This mixing occurs due to tumbling motion.

Construction-

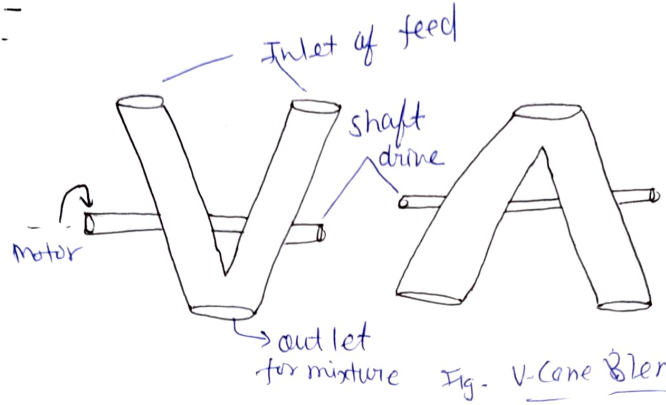


Fig. V-Cone Blender

- It is made of stainless steel or transparent plastic.
- Smaller models take a charge of 20 kg and rotate at 35 RPM. while larger ones take a charge of about 1 tonne and 15 RPM.
- It is connected with horizontal shaft which connect with motor.

Working:-

- The material to be mixed is loaded approx. 50-60% of its total volume.
- As the blender rotates, the materials undergoes tumbling motion.
- When the V is inverted, the material ~~slip~~ split and the recombine, this process yield to mixing.

⇒ After mixing, mixed material is collected in the bottom of V.

⇒ Blender speed is need to maintain for prevent shear.

Uses:

- Used in dry blending of free flowing solids.

Advantages:

- They handle large capacities.
- Easy to load, unload and clean.
- This equipment requires minimum maintaince.

Disadvantage:

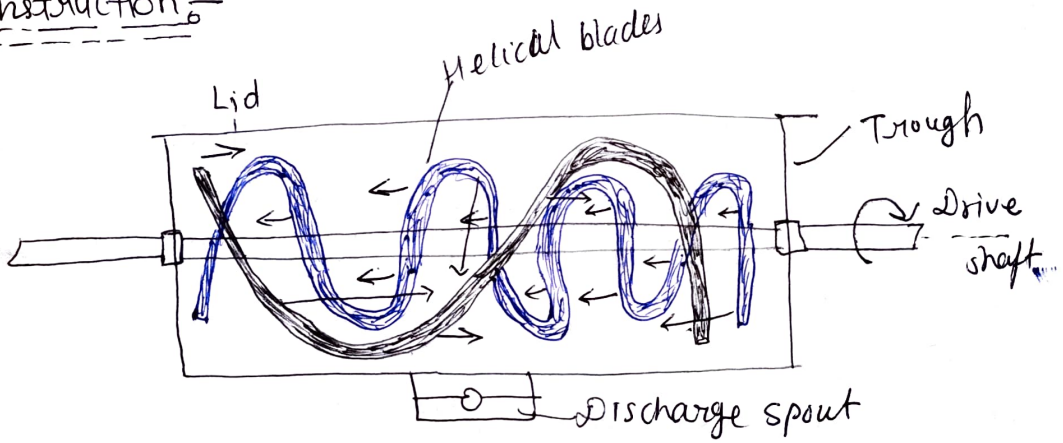
- Need high head space for installation.
- Not enough shear.

Ribbon Blender

Principle:- The mechanism of mixing is shear. Shear is transferred to the powder bed by moving blade in a fixed shell.

- Convecting mixing also occurs as the powder bed is lifted and allowed to fall to the bottom of the container.

Construction:-



- It consists of a non-movable horizontal cylindrical shell usually open at the top.
- It is fitted with two helical blades, mounted on same shaft.
- Blades have both right and left hand twist.
- Blades are connected to a fixed speed drive.
- Load from top and discharge from bottom.

Working :-

⇒ Material are introduced from the top and then closed with a lid.

⇒ Ribbon are allowed to rotate, one blade moves the solids slowly in one direction and others move them quickly in opposite direction.

⇒ Convecting mixing also occurs by tumbling action.

⇒ The counteracting blades set up high shear and are effective in breaking up lumps or aggregates.

⇒ Helical blades moves powders from one end to another and mixing take place.

⇒ Now, the blend (mixture) discharge from the bottom opening.

Use: It is used to mix finely divided solids, wet solid mass, sticky and plastic solid.

⇒ It is also used for liquid-solid and solid-solid mixing.

Advantages -

⇒ High shear can be applied using perforated baffles which bring about rubbing and breaking of aggregates.

⇒ Head space requirement is less.

Disadvantages:

⇒ Dead spots (area that remain unmixed) are observed.

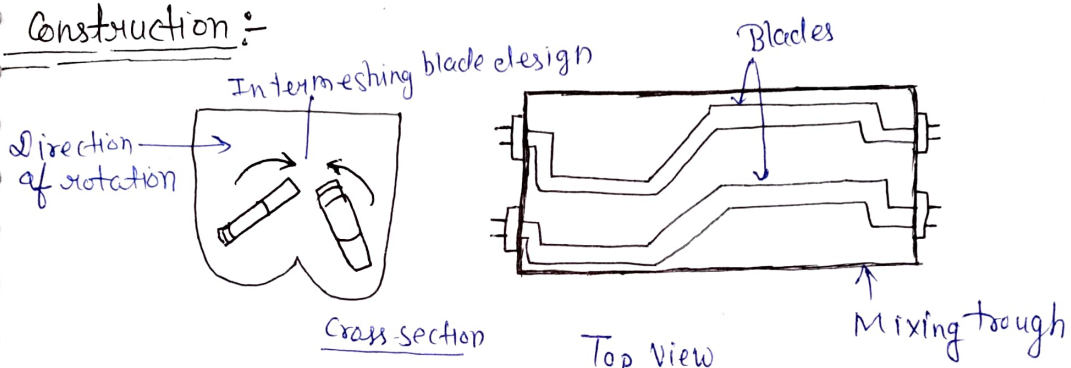
⇒ It is having fixed speed drive.

Sigma blade Mixer

Principle :- The mechanism of mixing is shearing.

- Convetive mixing is also achieved by cascading the material.

Construction :-



- It consist 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 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 this, mixing take place and final mixture discharge through tilting the entire bowl.

Use :- It is primarily used for liquid-solid mixing, although it can be used for solid-solid mixing.

⇒ Used in wet granulation process in the manufacture of tablets and ointments.

Advantages -

- It has minimum dead space during mixing.
- It has close tolerances between the blade and the side-walls as well as bottom of the mixer shell.

Disadvantages:

⇒ Sigma blade mixer works at a fixed speed.

Planetary Mixer

Principle :- In the 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 (convective motion) obtained.

Construction :-

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

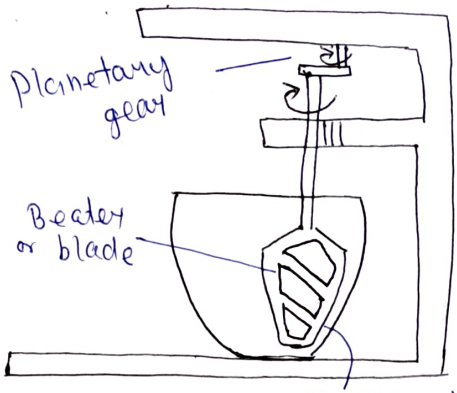


Fig. Planetary Mixer

- Mixing blade is mounted from the top of bowl.
- The mixing shaft is driven by a planetary gear train.
- It rotates around the ring gear, which further rotates round 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 part of the vessels.

⇒ 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 is introduced through top in the bowl.

⇒ By moving powder through blades shear is applied on material and also powders makes an upward movement.

⇒ So, tumbling motion is also obtained.

⇒ Intially 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.

Use:

- Low speed are used for dry mixing.
- Fast ~~mi~~ speed in wet granulation.
- Steam jacketed bowls are used in the manufacture of sustained release product and ointments.

Advantages:-

⇒ Speed of rotation can be varied as needed.
⇒ More useful for o wet granulation.
⇒ No dead space obtained.

Disadvantages:

- It required high power.
- It has limited size and is useful for batch work only.

Impellers:- These are those device which are mainly used for liquid mixing.

- These are classified into three types on the basis of the shape and pitch of the blades that are attached to the central shaft.

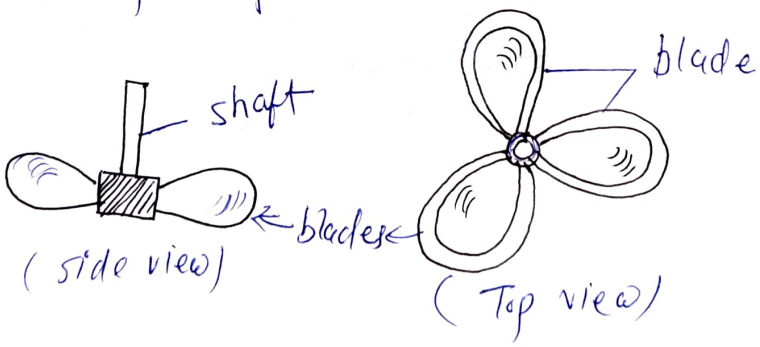
Impellers → Propellers
→ Turbines
→ Paddles.

Propellers

Principle:- It based on the mechanism of shearing.

Construction:-

- A propeller normally contains a number of blades (three blade design most common).
- It may be either or left handed depending on the direction of slant of their blades.
- the size of the Propellers is small (sufficient for low viscous liquid).
- General speed up to 8000 RPM.



Working :-

⇒ Take a liquids which we have to mix in a container.
⇒ Then dip the propeller in that container with the help of stand etc.
⇒ Now, start the motor and allower to rotate propeller.
⇒ The propeller produce axial movement of liquid, which yield to mixing.
⇒ After completed mixing, remove the propeller from container.
⇒ ~~Wet~~ We get mixed liquid in cantainer.

Use :-

⇒ Used when high mixing capacity is needed.
⇒ Multivitamines, elixir, disinfectant solution are manufactured using propellers.

Advantages :-

⇒ For high ~~ca~~ mixing capacity.
⇒ Effective gas-liquid dispersion is possible at the laboratory ~~sta~~ scale.
⇒ All sides of mixing is possible.

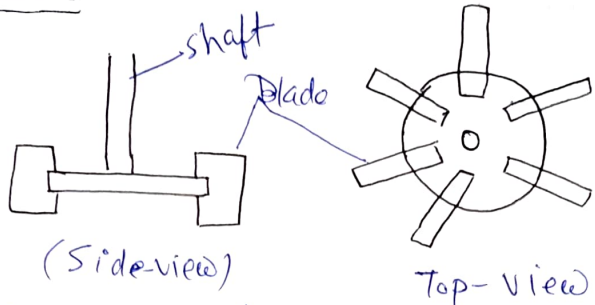
Disadvantages :

⇒ No effective with liquid of viscasity greater than 5 pascal second. eg. glycerin & castor oil.
⇒ not used for rapid settling suspension.

Turbines

Principle :- It work on the principle of shearing.

Construction :-



- A turbines consist 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 vessels.
- It rotates at a lower speed than propeller (50-200 RPM)

Working :-

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

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

⇒ Blades of turbines produces flow in liquid and also produce 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.

e.g- Syrup, liquid paraffin & glycerin etc.

⇒ Mainly used for semi-solid mixing.

Advantages :-

It gives greater shearing force than propellers, so these are suitable for emulsification.

Disadvantage -

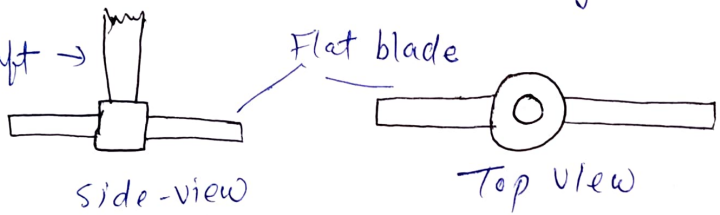
⇒ High cost.

Paddles

Principle :- It work on the principle of shearing force.

Construction :-

⇒ A paddle consist of a hub centrally with two long flat blades attached vertically.



⇒ Paddles with two blades or four blades are common.

⇒ It consist a shaft that are connected to motor.

Working :-

- Take a sample (liquid) which we have to mixed in a tank.
- Then placed the paddles into tank and start the rotation.

- A shaft carrying hub-blades rotates at a low speed (150 RPM), they push the liquid radially and tangentially.
- After mixing paddles are removed from liquid tank.

Use: Used in manufacturing of antacid suspension. (aluminium hydroxide gel, magnesium hydroxide).

Advantages:-

⇒ Avoid dead spot in mixing.

⇒ Vertex formation is not possible due to low speed.

Disadvantages:-

⇒ ~~Not~~ Mixing of the suspension is poor, therefore, ~~baffl~~ baffled tanks are required.

Silverson Emulsifier

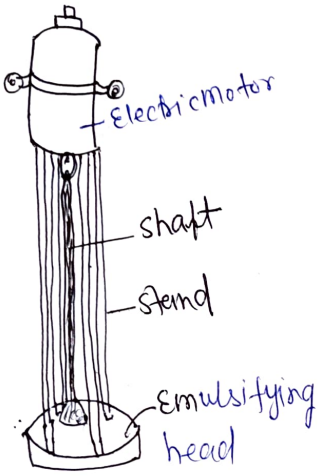
Principle:- It produce intense shearing force and turbulence by the use of high speed rotation.

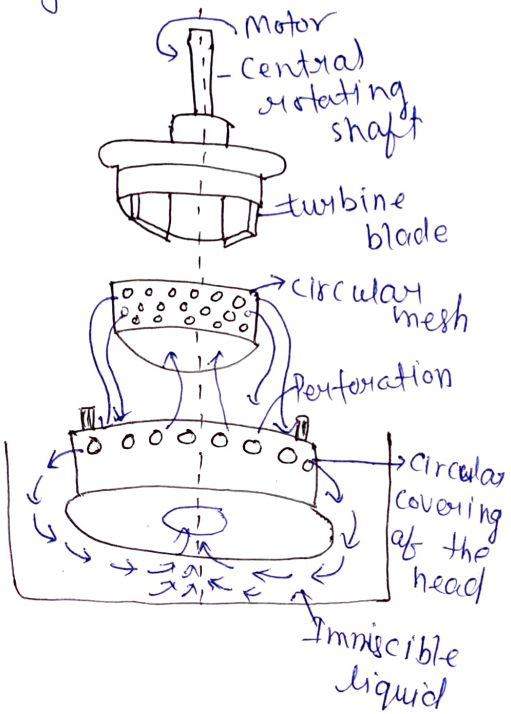
Construction:-

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

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

- The head carries turbine blades, which are surrounded by a mesh, which is further enclosed by a cover 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 is turn rotates turbines blades at a very high speed.
- This creates a pressure difference. As a result, liquid are sucked into the head from the center of the base and subjected to intense mixing action.
- Then liquid exped from the mesh through centrifugal forces.

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

Use: Used for the preparation of emulsions and creams of fine particles size.

Advantages:

- It is available in different sizes.
- It can be used for batch operations.

Disadvantage -

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