Agitation and mixing

Agitation is a means whereby mixing of phases can be accomplished and by which mass and heat transfer can be enhanced between phases or with external surfaces.

Mixing is concerned with all combinations of phases of which the most frequently occurring ones are

- Gases with gases
- Gases into liquids: dispersion.
- Gases with granular solids: fluidization, pneumatic conveying; drying.
- Liquids into gases: spraying.
- Liquids with liquids: dissolution, emulsification, dispersion
- Liquids with granular solids: suspension.
- Pastes with each other and with solids.
- Solids with solids: mixing of powders.

Purpose of Agitation

- Suspending solid particles in a liquid
- Blending miscible liquids e.g. methanol-water
- Dispersing a gas through a liquid in the form of small bubbles
- Dispersing a second liquid, immiscible with first to form an emulsion or suspension of fine drops
- Promoting heat transfer between liquid and a coil or jacket.

Agitated Vessels

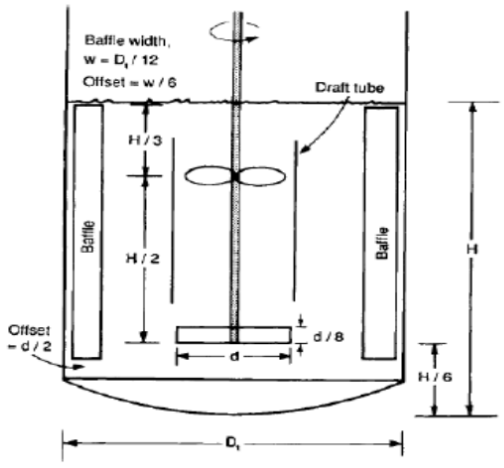


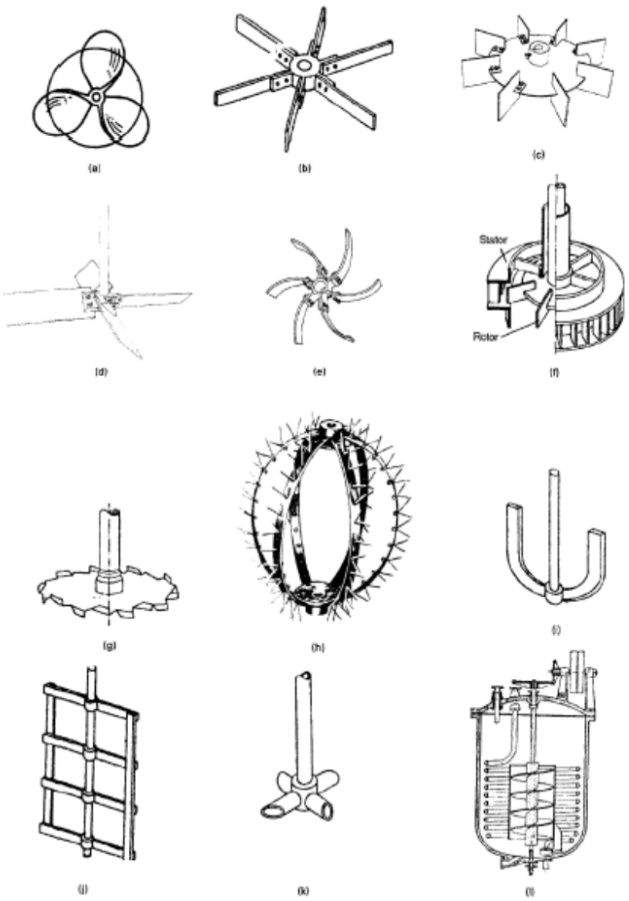
Figure shows stirred tank design, not to scale, showing a lower radial impeller and an upper axial impeller housed in a draft tube. Four equally spaced baffles are standard. H = height of liquid level, D,=tank diameter, d =impeller diameter.

- Round bottom to eliminate corners where fluid cannot penetrate.
- Impeller is mounted on a shaft.
- Shaft driven by a motor.
- Baffles to reduce tangential motion of fluid.

Types of Impellers

A rotating impeller in a fluid imparts flow and shear to it, the shear resulting from the flow of one portion of the fluid past another. Flow is in the axial or radial directions so that impellers are classified conveniently according to which of these flows is dominant.

A few common types are illustrated in figure and are described as follows:



a. The three-bladed mixing propeller is modeled on the marine propeller but has a pitch selected for maximum turbulence. They are used at relatively high speeds (up to 1800rpm) with low viscosity fluids, up to about 4000cP. Many versions are available: with cutout or perforated blades for shredding and breaking up lumps, with saw tooth edges as in Figure (g) for cutting and tearing action and with other than three blades. The stabilizing ring shown in the illustration sometimes is included to minimize shaft flutter and vibration particularly at low liquid levels.

b. The turbine with flat vertical blades extending to the shaft is suited to the vast majority of mixing duties up to 100,000CP or so at high pumping capacity. The simple geometry of this design and of the turbines of Figures (c) and (d) has inspired extensive testing so that prediction of their performance is on a more rational basis than that of any other kind of impeller.

c. The horizontal plate to which the impeller blades of this turbine are attached has a stabilizing effect. Backward curved blades may be used for the same reason as for type (e).

d. Turbine with blades is inclined 45^{o} (usually). Constructions with two to eight blades are used, six being most common. Combined axial and radial flows are achieved. Especially effective for heat exchange with vessel walls or internal coils.

e. Curved blade turbines effectively disperse fibrous materials without fouling. The swept back blades have a lower starting torque than straight ones, which is important when starting up settled slurries.

f. Shrouded turbines consisting of a rotor and a stator ensure a high degree of radial flow and shearing action, and are well adapted to emulsification and dispersion.

g. Flat plate impellers with saw tooth edges are suited to emulsification and dispersion. Since the shearing action is localized, baffles are not required. Propellers and turbines also are sometimes provided with saw tooth edges to improve shear.

h. Cage beaters impart a cutting and beating action. Usually they are mounted on the same shaft with a standard propeller. More violent action may be obtained with spinned blades.

i. Anchor paddles fit the contour of the container, prevent sticking of pasty materials, and promote good heat transfer with the wall.

j. Gate paddles are used in wide, shallow tanks and for materials of high viscosity when low shear is adequate. Shaft speeds are low. Some designs include hinged scrapers to clean the sides and bottom of the tank.

Flow patterns in Agitated Vessels

Depends upon

- Type of impeller
- Characteristics of the liquid (viscosity)
- Size and proportions of the tank, baffles and the impeller

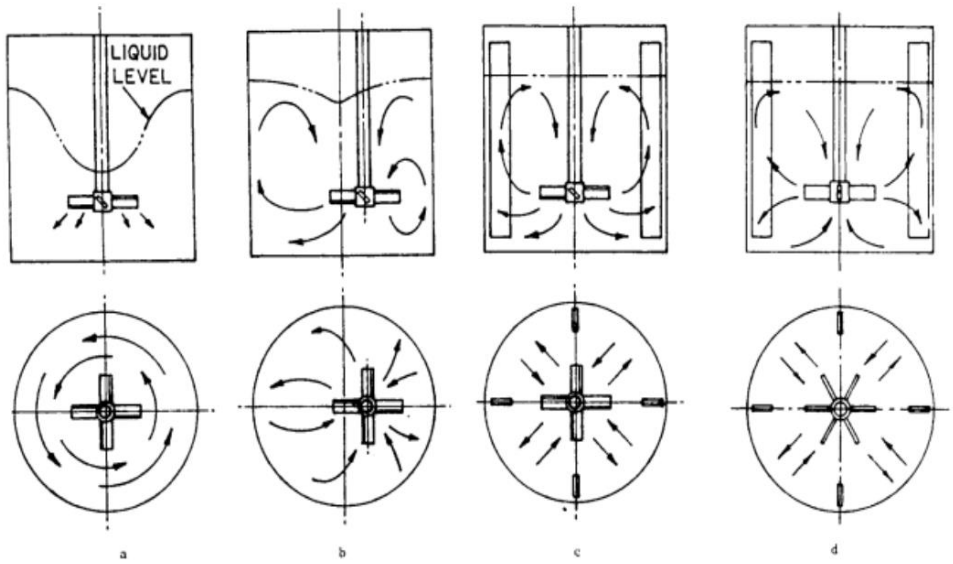


Figure above: Agitator flow patterns. a) axial or radial impellers without baffles produce vortexes. b) off-center location reduces the vortex. c) Axial impeller with baffles. d) radial impeller with baffles

- In unbaffled tank there are strong tangential flows and vortex formation at moderate stirrer speeds
- With baffles, vertical flows are increased and rapid mixing of liquid.
- Two or more impellers can be mounted on single shaft for a long vertical cylindrical tank
- Lowest impeller is usually a radial flow impeller (straight blade turbine); the upper is axial flow
- Lowest impeller is about one impeller diameter above the bottom of the tank.

Paddle type agitator

- Speed range 5-300rpm.
- Used for large size vessels.
- Agitator size almost touching vessel wall.

- Normally used for reaction vessel having jacket by providing good heat transfer area.
- Doesn't allow solid buildup at the wall.

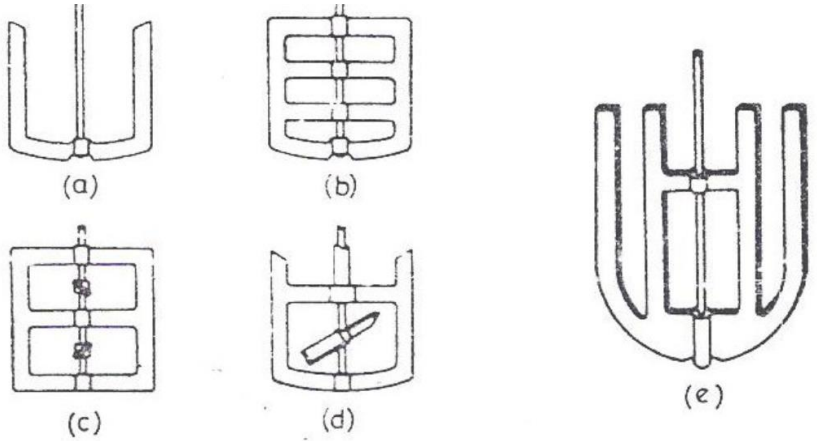


Figure: Paddle agitators: (a) Anchor, (b) Gate, (c) Gate with pitched cross arms, (d) Anchor with pitched cross arms, (e) Combined anchor and gate

Propeller type agitator

Axial flow impellers

- Maximum flow is achieved at axis of agitator
- Maximum vessel size is 1m3
- Maximum speed is 415 r/minute
- Diameter of propeller is 15-30% of vessel diameter

Turbine type agitator

- Motion is achieved due to rotary action of impeller
- Two types are available
  - Axial flow turbine
  - Radial flow turbine
- flat bladed
- pitched bladed
- curved bladed

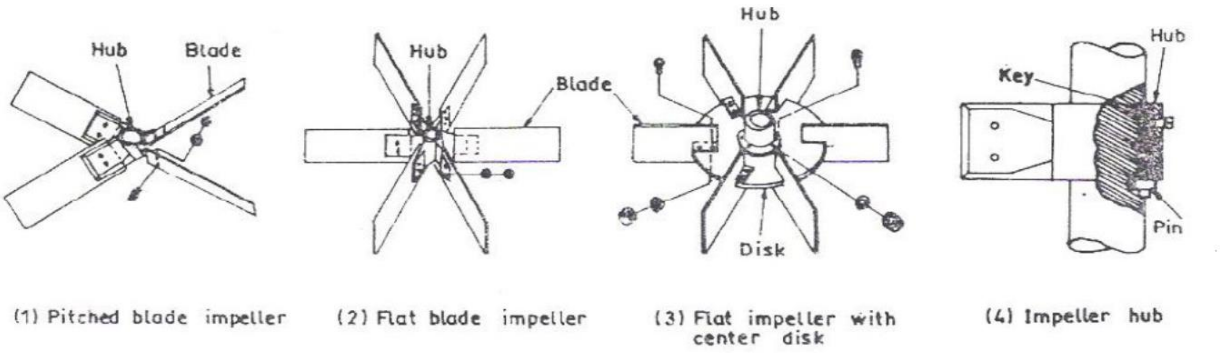


Figure: Types of turbine impeller

Helical or ribbon type agitator

Four types are available in market

- Single helical
- Double helical
- Helical screw
- Ribbon type

- Good for top to bottom liquid circulation
- Used for blending for pseudo plastic materials
- High power requirement

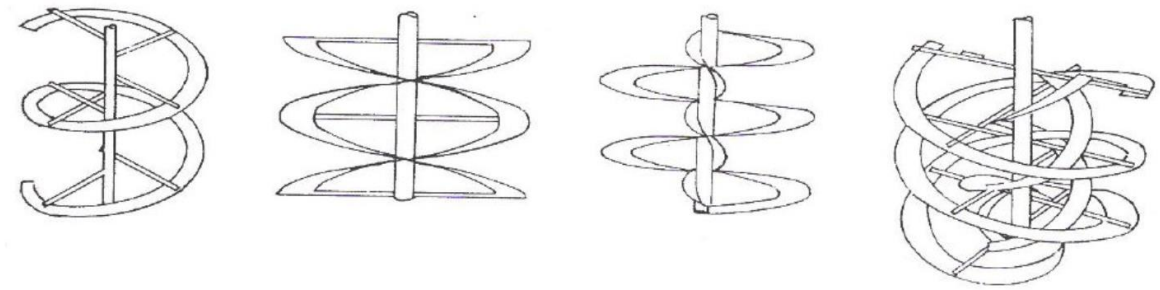


Figure: Types of helical ribbon agitator

MIXING OF POWDERS AND PASTES

Industries such as foods, cosmetics, pharmaceuticals, plastics, rubbers, and also some others have to do with mixing of high viscosity liquids or pastes, of powders together and of powders with pastes. Much of this kind of work is in batch mode. The processes are so diverse and the criteria for uniformity of the final product are so imprecise that the non-specialist can do little in the way of equipment design, or in checking on the recommendations of equipment manufacturers.

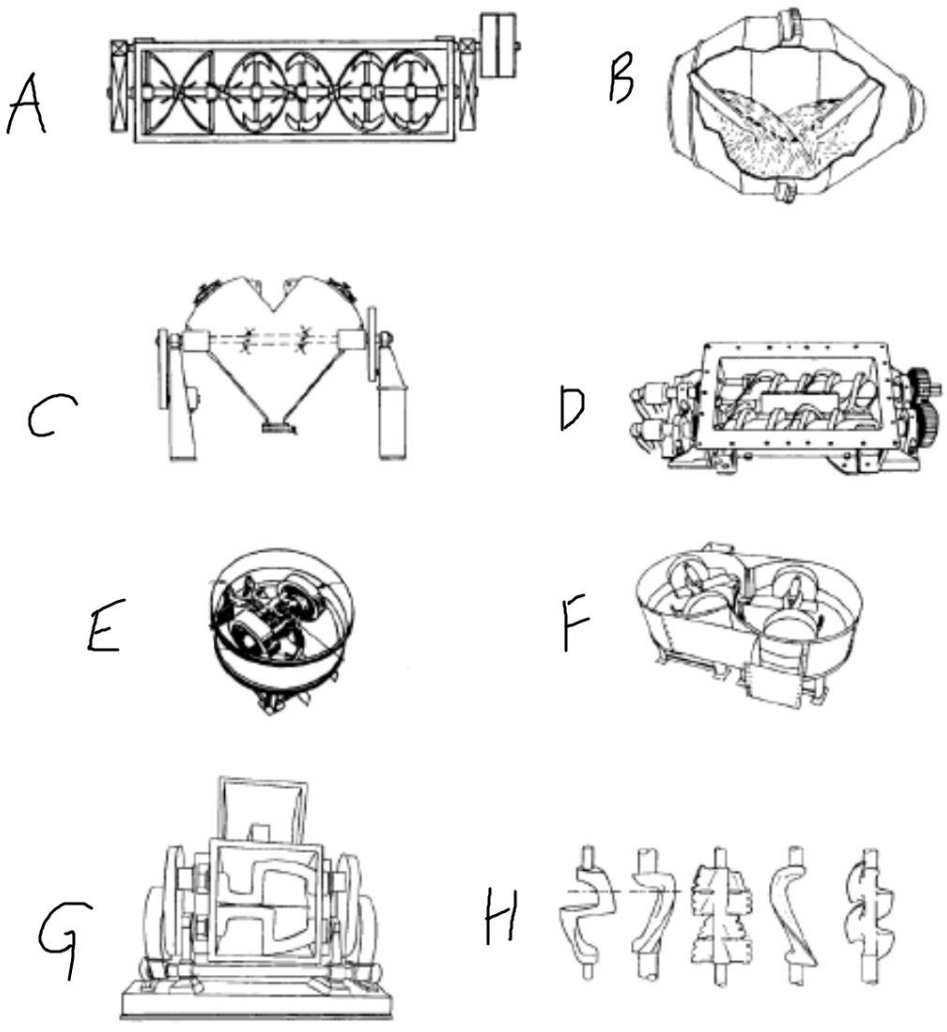


Figure. Some mixers and blenders for powders and pastes. (a) Ribbon blender for powders. (b) Flow pattern in a double cone blender rotating on a horizontal axis. (c) Twin shell (Vee-type); agglomerate breaking and liquid injection are shown on the broken line. (d) Twin rotor; available with jacket and hollow screws for heat transfer. (e) Batch Muller. (f) Twin mullers operated continuously. Double-arm mixer and kneader. (h) Some types of blades for the double-arm kneader.

POWER REQUIREMENT

For an effective mixing, the volume of fluid circulated in a vessel via an impeller must be sufficient to sweep out the entire vessel in a reasonable time.

FACTORS AFFECTING THE POWER REQUIREMENT:

- Properties of fluid to be agitated
- Height of the liquid
- Tank size and dimensions

- Agitator type and size
- Speed of agitator

In the next lecture, we will talk about Terminologies in Power Calculation