Mixing

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

When food products are mixed there are a number of aspects that are different to other industrial mixing applications:

• mixing is often used primarily to develop desirable product characteristics, rather than simply ensure homogeneity

• it is often multi-component, involving ingredients of different physical properties and quantities

• it may often involve high viscosity or non-Newtonian liquids

• some components may be fragile and damaged by over-mixing

• there may be complex relationships between mixing patterns and product characteristics

Theory of solids mixing

In contrast with liquids and viscous pastes it is not possible to achieve a completely uniform mixture of dry powders or particulate solids. The degree of mixing that is achieved depends on:

• the relative particle size, shape and density of each component

• the moisture content, surface characteristics and flow characteristics of each component

• the tendency of the materials to aggregate

• the efficiency of a particular mixer for those components.

Theory of liquids mixing

The component velocities induced in low viscosity liquids by a mixer are as follows:

A. a longitudinal velocity (parallel to the mixer shaft)

B. a rotational velocity (tangential to the mixer shaft)

C. a radial velocity which acts in a direction perpendicular to the mixer shaft.

In high-viscosity liquids, pastes or doughs, a different action is needed. Here, mixing occurs by:

• kneading the material against the vessel wall or into other material

• folding unmixed food into the mixed part

• shearing to stretch the material.

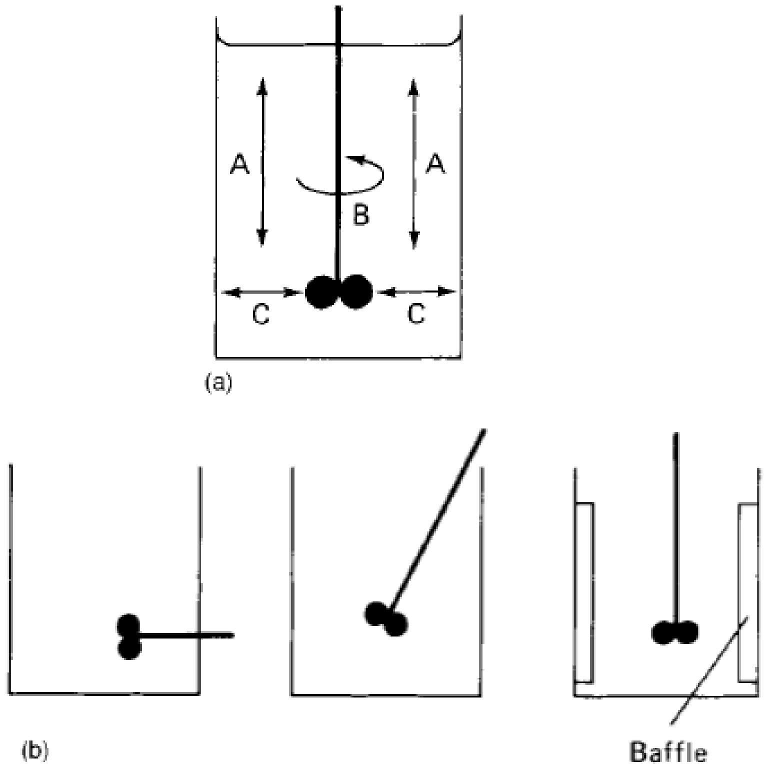


Fig. 5.1 (a) Component velocities in fluid mixing: A, longitudinal; B, rotational; C, radial; (b) Position of agitators for effective mixing of liquids.

Equipment

The selection of a correct type and size of mixer depends on the type and amount of food being mixed and the speed of operation needed to achieve the required degree of mixing with minimum energy consumption. There are a very large variety of mixers available, due to the large number of mixing applications and the empirical nature of mixer design and development.

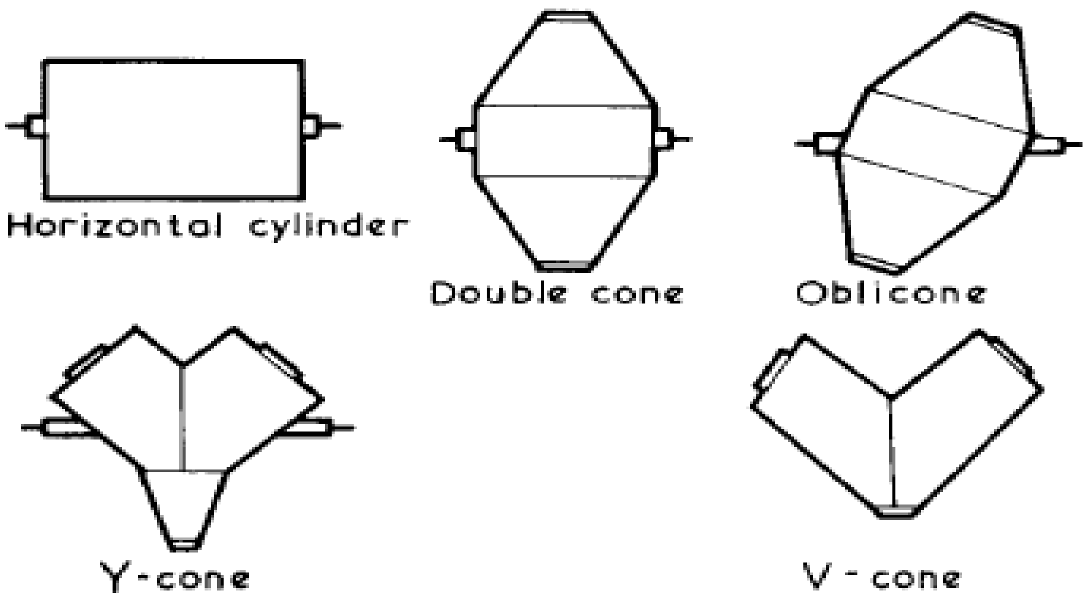
Mixers are classified into types that are suitable for:

1. dry powders or particulate solids
2. low- or medium-viscosity liquids
3. high-viscosity liquids and pastes
4. dispersion of powders in liquids.

1. **Mixers for dry powders and particulate solids**

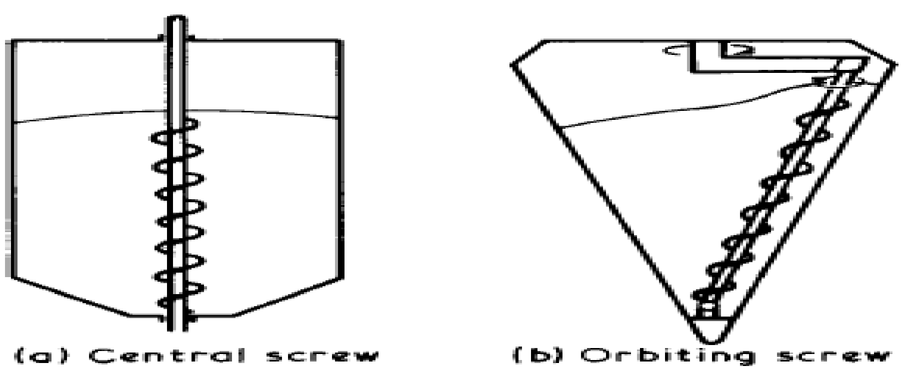
For mixing Dry, Particulate Solids usually tumbler mixer, horizontal screw and ribbon mixers, vertical screw mixers and fluidized bed mixers are used.

Tumbler mixer: These operate by tumbling the mass of solids inside a revolving vessel usually consist of hollow vessels, which rotate about horizontal axes. These vessels take various forms and some typical examples are-



Vertical screw mixer

These consist of tall, cylindrical or cone-shaped vessels containing a single rotating screw, which elevates and circulates the particles. The screw may be located vertically at the centre of the vessel. Alternatively, it may be set at an angle to the vertical and made to rotate, passing close to the wall of the vessel.



Ribbon mixers have two or more thin narrow metal blades (Fig. 5.5) formed into helices which counter-rotate in a closed hemispherical trough. The pitch of the ribbons is different so that one moves the material rapidly forwards through the trough, and the second moves the material slowly backwards, to produce a net forward movement of material. This type of mixer is used for dry ingredients and small-particulate foods.

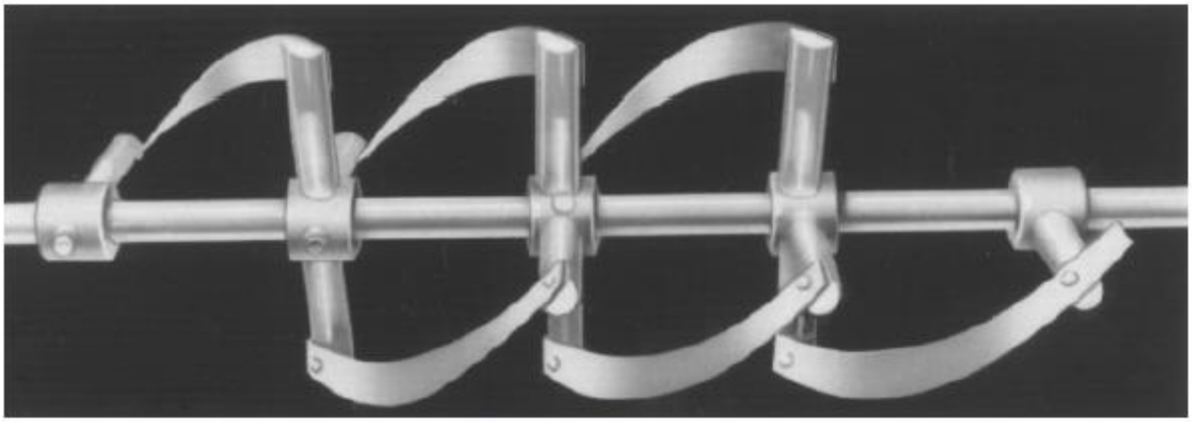


Fig. 5.5 Ribbon mixer.

Applications for screw, ribbon and tumbler mixer:

Applications for screw, ribbon and tumbler mixer include- preparing cake and soup mixes, blending of grains prior to milling, blending of flours and incorporation of additives into them.

2. **Mixers for low- or medium-viscosity liquids**

A large number of designs of agitator are used to mix liquids in unbaffled or baffled vessels. The advantages and limitations of each vary according to the particular application but are summarised in Table:

Table: Advantages and limitations of selected liquid mixers

Type of mixer	Advantages	Limitations
Paddle agitator	Good radial and rotational flow, cheap	Poor perpendicular flow, high vortex risk at higher speeds
Multiple-paddle agitator	Good flow in all three directions	More expensive, higher energy requirements
Propeller impeller	Good flow in all three directions	More expensive than paddle agitator
Turbine agitator	Very good mixing	Expensive and risk of blockage

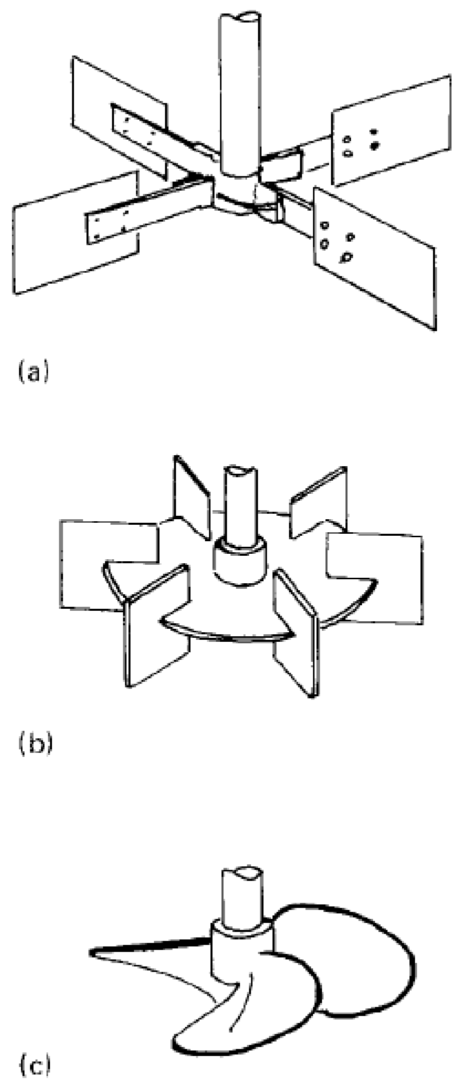


Fig. 5.6 Agitators: (a) flat blade agitator; (b) vaned disc impellor; (c) propeller agitator. (After Smith (1985).)

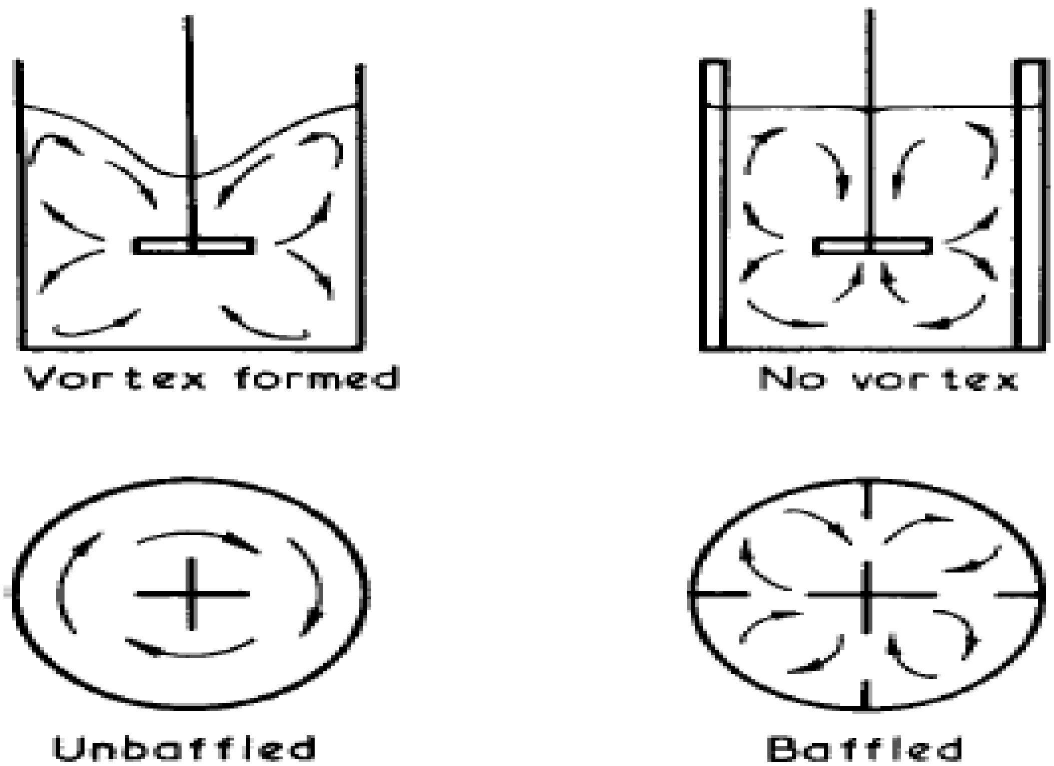
Applications for impeller mixers:

For preparing brines and syrups, preparing liquid sugar mixtures for sweet manufacture, making up fruit squashes, blending oils in the manufacture of margarines and spreads, premixing emulsion ingredients

Vortex and How it can be reduced

If an impeller agitator is mounted on a vertical shaft located centrally in a mixing vessel, the liquid will flow in a circular path around the shaft. If laminar conditions prevail, then layers of liquid may form the contents of the vessel rotate and mixing will be inefficient. Under these conditions a vortex may form at the surface of the liquid. As the speed of rotation of the impeller increases this vortex deepens. When the vortex gets close to the impeller, the power imparted to the liquid drops and air is sucked into the liquid. This will greatly impair the mixing capability of the mixer. Rotational flow may cause any suspended particles in the liquid to separate out under the influence of centrifugal force.

Rotational flow, and hence vortexing, may be reduced by locating the mixer off centre in the mixing vessel and/or by the use of baffles which located at the inner wall of the mixing vessel



3. Mixers for high-viscosity liquids and pastes

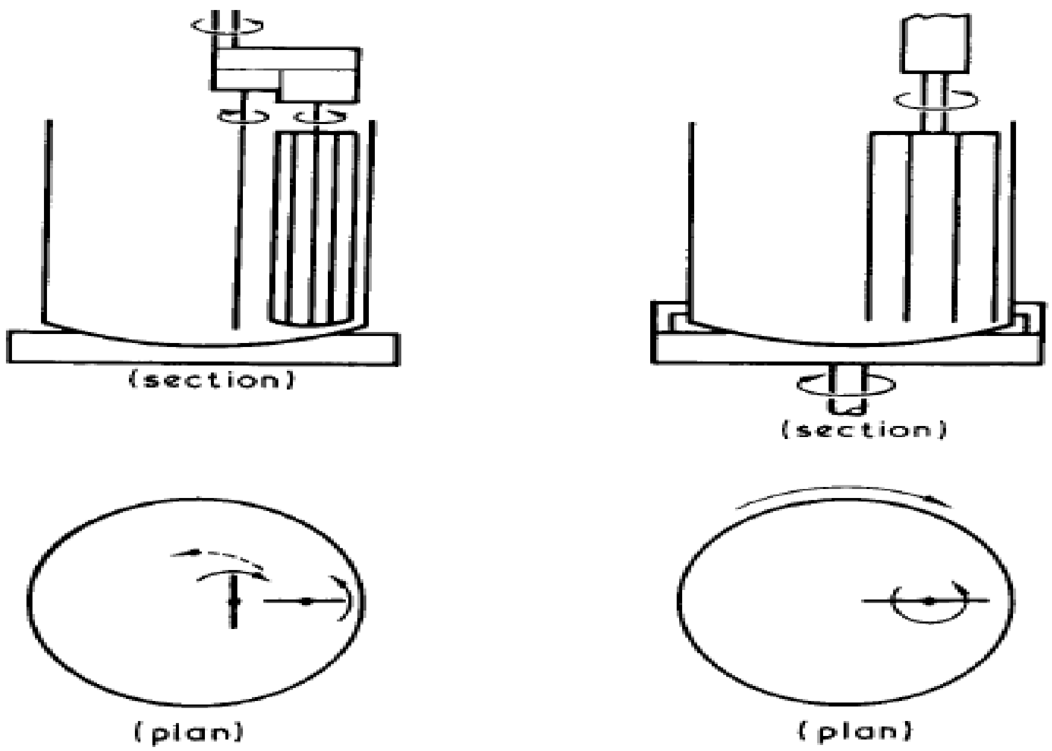
During mixing of high viscosity liquids and pastes, the performance of mixer depends on direct contact between the mixing elements and the materials of the mix. This is because when the equipment mixing highly viscous and paste like materials, it is not possible to create currents which will travel to all parts of the mixing vessel, as happens when mixing low viscosity liquids.

Thus, the material must be brought to the mixing elements or the elements must travel to all parts of the mixing vessel.

For mixing high viscosity liquids and pastes usually paddle mixer, pan mixer and kneaders are used.

Pan mixer

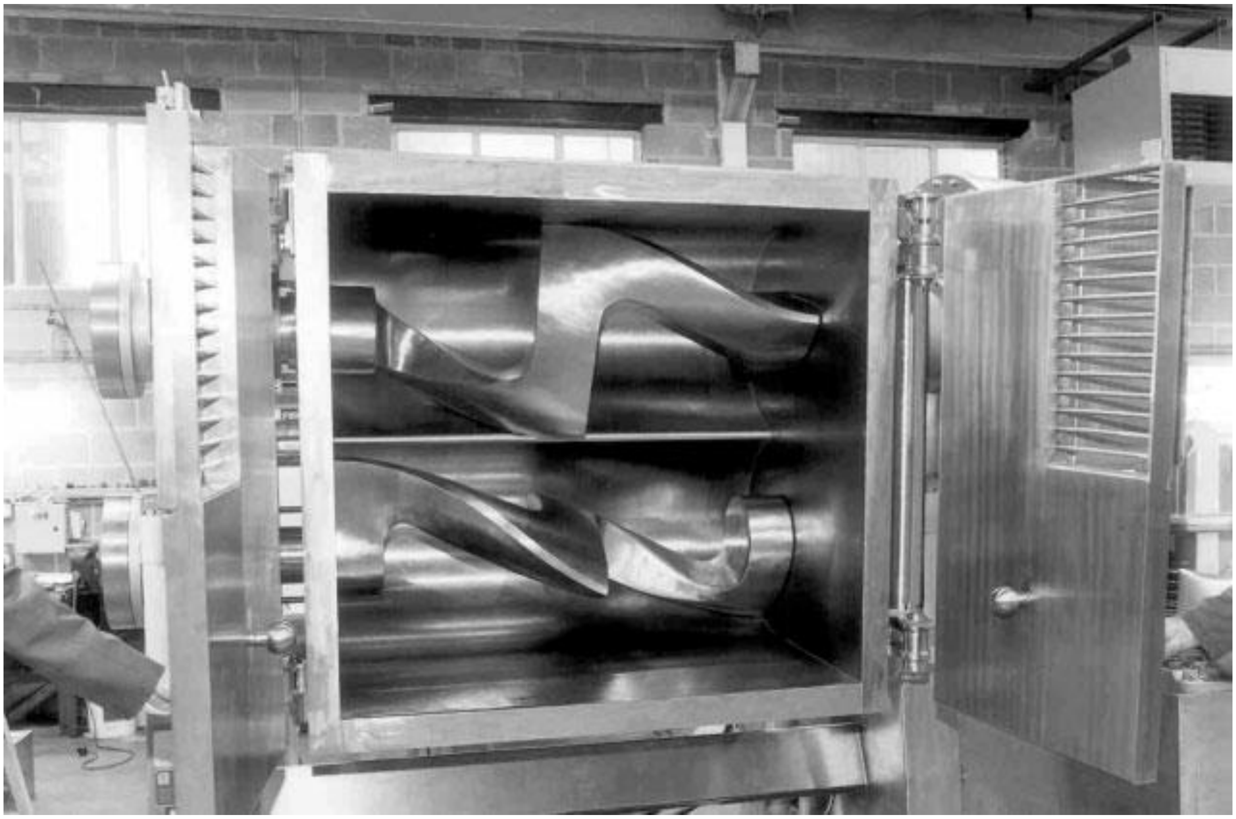
These are of two general types. In the stationary pan mixer the mixing elements move in a planetary path, visiting all parts of the stationary mixing pan. In the rotating pan type, the mixing vessel is mounted on a rotating turntable. The mixing elements also rotate, but in one position, and are located near the pan wall.



(a) Stationary pan mixer (b) Rotating pan mixer

Kneader

A common design of kneader consists of a horizontal trough with a saddle shaped bottom. Two heavy blades mounted on parallel, horizontal shafts rotate towards each other at the top of their cycle. The blades draw the mass of material down over the point of the saddle and then shear it between the blades and the wall and bottom of the trough. Mixing times are generally in the range 2–20 min.



Applications for pan mixers and kneaders:

Application for pan and kneader include- dough and batter mixing in bread, cake and biscuit making, blending of butters, margarines and cooking fats, preparation of processed cheeses and cheese spreads, manufacture of meat and fish pastes.

Effect on foods:

The action of a mixer has no direct effect on either the nutritional quality or the shelf life of a food but may have an indirect effect by allowing components of the mixture to react together. The nature and extent of the reaction depend on the components involved but may be accelerated if significant heat is generated in the mixer. In general, mixing has a substantial effect on sensory qualities and functional properties of foods. For example, gluten development is promoted during dough making by the stretching and folding action which aligns, uncoils and extends protein molecules and develops the strength of the gluten structure to produce the desired texture in the bread. The main effects are to increase the uniformity of products by evenly distributing ingredients throughout the bulk.