Basic knowledge

Mixing

Mixing is the opposite of separating. The materials being mixed may be gaseous, liquid or solid.

During the **mixing of solids**, the processed substances are powderous or granular. The objective is usually to create mixtures as homogeneous as possible. This is illustrated particularly clearly by the example of the manufacture of tablets: inadequate mixing of the starting substances would result in differing agent compositions in the tablets.

During **stirring**, the continuous phase is liquid. A liquid, gas or solid is mixed into a liquid.

Key applications of stirring are:

- **Mixing of miscible liquids**

The purpose is to balance out differences in concentration and temperature. Moreover, the course of the reaction in the mixture can also be controlled, as the reaction speed is dependent on the mix quality of the reaction partners.

- **Mixing of immiscible liquids (emulsifying)**

The liquid phase to be dispersed is in droplet form in the other liquid phase. This is true in the case of cosmetic creams and lotions for example.

- **Dispersion of soluble solids in liquids**

The solid is dispersed in the liquid, and in the process is disintegrated into atoms, molecules or ions. The solid is no longer identifiable as such after being dissolved. Stirring accelerates the dissolution process.

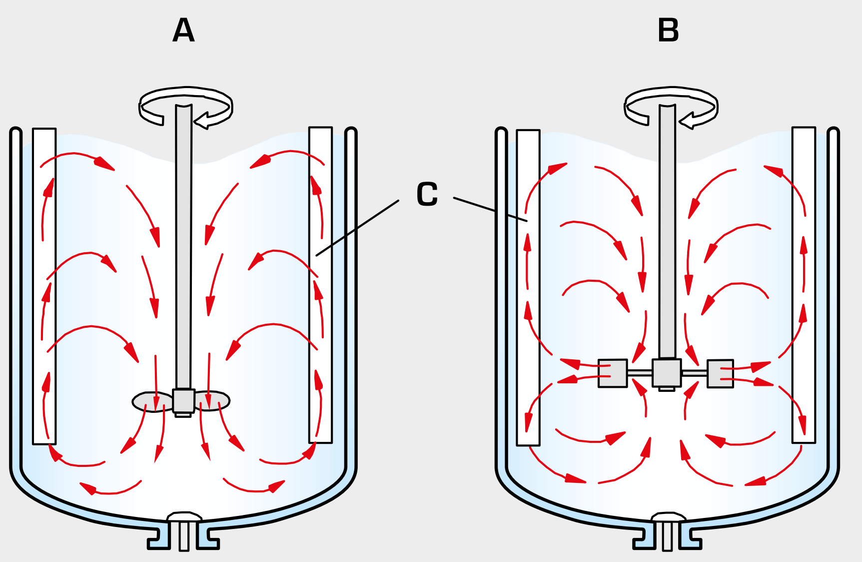
- **Dispersion of an insoluble solid in a liquid (suspension)**

The resultant suspensions tend to segregate, meaning that over time the solid particles would sink. Stable suspensions are created only at particle sizes below 1µm. An example is to be found in the case of paints, in which colour pigment particles are suspended in resins.

- **Gasification of liquids**

Gas bubbles in the liquid are finely distributed by means of a perforated plate or other forms of injectors. One application is the precipitation of iron oxides by injection of air in waste water treatment

Stirrers of a wide variety of forms are used, depending on the application. They can be roughly differentiated according to the flow field they create. Accordingly, there are axial, radial and tangential conveying stirrers. Flow impeders or buffers are employed to prevent the entire vessel contents rotating along with the stirrer.



Typical flow fields in stirred tanks

A axial-conveying propeller mixer
B radial-conveying plate mixer
C flow impeder

Basic knowledge

Agglomeration

Agglomeration is the opposite of comminution. The terms agglomeration, granulation and pelletisation designate the process of particle size enlargement of solids. Powderous fine material is joined together to form larger particle bodies. The particle bodies can be designated as flock, granulate, agglomerate, pellets, briquettes or tablets. The reason for employing an agglomeration process may be to improve the flow behaviour, to enhance mixability, to reduce dust creation, or to alter shape, size, porosity, strength, etc.

A rough distinction can be made between the following agglomeration methods:

- **Constructive agglomeration**

Individual, free-moving particles are agglomerated together to form larger bodies, or are agglomerated onto existing particle bodies. Often liquids are used as the binding agent. Constructive agglomeration may occur in fluidised beds.

In rolling agglomeration, large particle bodies are formed by snowballing. The technical application is implemented by way of dish or drum granulators or mixers.

- **Compression agglomeration**

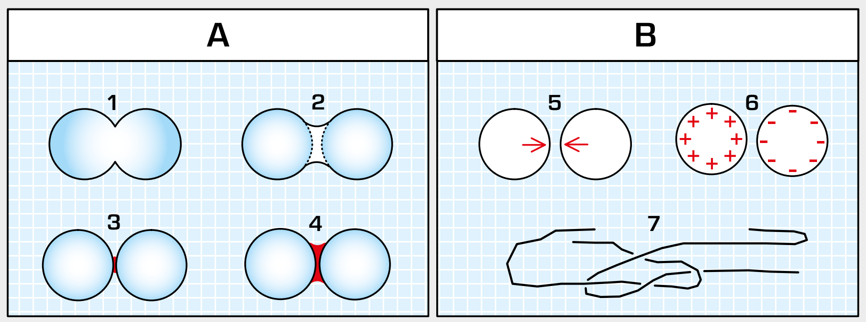
An agglomeration is formed from a powderous solid by the action of external compression forces. In tablet production, the powder is compressed in a die with a stamp. Another application is roller pressing, using two smooth rollers (resulting in uneven agglomerations) or rollers with trough-like recesses (resulting in mouldings such as briquettes).

- Other processes: **flocculation** to separate suspensions from liquids; **sintering**.

Different binding mechanisms, with differing adhesive forces, take effect depending on the process (see illustration). A fundamental distinction can be made between mechanisms which involve material binding and those which do not. The most stable are solid archs created by sintering. Solid archs may also be created by other processes if thermo-setting or crystallising binding agents are used.

In constructive agglomeration, adhesion by liquid bridges is of primary importance. Depending on the ratio of liquid to solid, the type of liquid and the pore shape and size, adsorption layers permanently bonded to the surface or free-moving liquid bridges are produced.

In the case of van der Waals' forces and electrostatic forces, there is no material binding. Van der Waals' forces play a major role in compression agglomeration. Positive bonds occur in fibrous materials such as paper and felt.



Binding mechanisms in agglomerates:

A mechanisms involving material binding, **B** mechanisms without material binding;
1 solid bridge by sintering, **2** solid bridge made of thermo-setting or crystallising binding agent,
3 solid bridge with permanently bonded adsorption layer, **4** free-moving liquid bridge, **5** attraction by van der Waals' forces,
6 electrostatic attraction, **7** positive bond