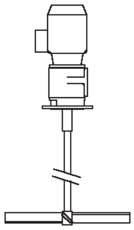


Mixing : What is it ?

- Definition and principles
- Mechanics of mixing

Mixing, an industrial problem

There is not a chemical or petro-chemical process, water treatment, pharmaceutical, food or mineral treatment industry where a mixing operation is not included at some stage or another.
According to compatability and the physiochemical characteristics of the different constituents, as well as the volumes to be mixed, it is more or less easy to satisfy the mixing criteria.

Definition and principles of mixing in the liquid state

• Physical mixing

For mixing to take place, there has to be interpenetration of particles in the different zones of the volume to be mixed. The differences in properties recorded in various localised samples, statistically analysed, give a measure of the mixing homogeneity. The volume or scale of each sample equally gives a measure of the efficiency of mixing.

• Mixing with a chemical reaction or change of state

The contact between particles can give rise to a chemical reaction whose progression is governed by several criteria.

Most often the mixing action criterion is the concentration of one or several constituents in a given sample, but this is far from being the only one.

When a chemical reaction or a change of state occurs in the mixing volume, the decision criteria are more complex and a "process" mixing is said to occur.

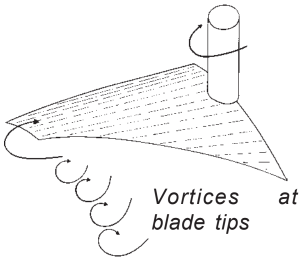
The mechanics of mixing

• Turbulences

In a liquid medium the hydrodynamic phenomenon giving an interpenetration of particles is turbulence. Turbulence is said to be occuring when, to the average velocity of a particle, are added transversal and longitudinal variations in time, direction and intensity.
It is understood that these transversal and longitudinal velocities assure an efficient mixing as they carry the fluid particles from one zone to another.

• Vortices

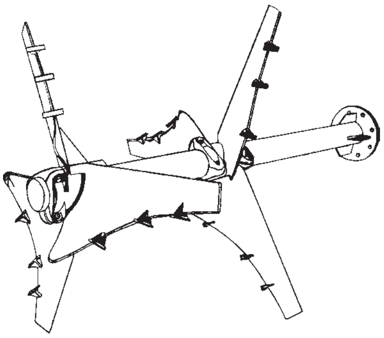
The rotational movements of particles, compared to those around, are called vortices. Vortices begin in the slipstream of obstacles and end due to the friction between the particles.
They create high velocity gradients in the fluid and are thus very efficient mixing factors.
However their lifespan and efficiency are very much linked to the viscosity of the medium to be mixed.



The degree of mixing

Mixing is at an optimum if, whatever the sample size considered, interpenetration of particles can be seen; that is interpenetration exists between all neighbouring zones and in volumes of 1 dm^3, $1cm^3$, $1mm^3$ etc.

Straight away it can be seen that "medium" (pump flow rate) flows favour product convection (transport) movements (large scale mixing), and that velocity variations favour diffusion phenomena (small scale mixing or micro mixing). For certain applications the moving mixing element can be fitted with turbulence generating attachments.



Propeller with turbulence teeth

Mixing mechanics and viscosity

Dynamic viscosity m is expressed in Pascal seconds (Pa.s) or sometimes in poises (CGS units). 1 Pa.s = 10 poises.

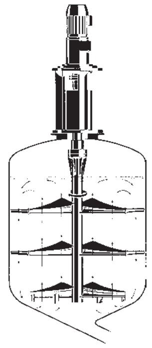
The influence of viscosity is generally expressed by a Reynolds number. The Reynolds number is dimensionless, that is, independant of the system of units used and of the relative size of the reference dimension.

$$\boxed{Re = \frac{\rho \times V \times d}{\mu}}$$

"r" and "V" are respectively density and speed of rotation of the mixing element of diameter "d".

The appearance of turbulent motion corresponds to a Reynolds number of about 8000. Turbulence increases with this number and is accompanied by a change in the mixing operation appearance. This becomes completely turbulent for a Reynolds number above 30000.

In a pasty or concentrated solid medium, when the movement is badly transmitted from one particle to another, it is necessary for all regions of the mixing volume including those beside the walls to be in direct contact with the mixing element of the mixer (large diameter and SABRE® double flow propellers).



SABRE® propeller for viscous fluids

Viscosity measures internal friction of the liquid. It was defined by Newton as the ratio of shear tension to velocity gradient.

$$\boxed{T = \mu \frac{dv}{dr}}$$

T = shear tension

μ = proportional coefficient (dynamic viscosity)

$\frac{dv}{dr}$ = velocity gradient

When the viscosity is constant in all directions, continuously and for a given temperature, the fluid is said to be Newtonian. A certain number of fluids do not conform to the proportionality law established by Newton. They are said to be non-Newtonian.

For example:

- Amongst the fluids whose viscosity is independant of time:
  - pseudo-plastic fluids whose viscosity reduces when the velocity gradient increases,
  - dilatant fluids whose viscosity increases when the velocity gradient increases.

- Amongst the fluids whose viscosity is dependant on time :
  - thixotropic fluids for which, at a constant shear tension, viscosity reduces with time.
  - rheopect fluids for which, at a constant shear tension, viscosity increases with time.

MILTON ROY
Mixing

FRANCE - ROBIN INDUSTRIES S.A.
10, Rue du Bois Gasseau
BP 94 - Samoreau
77212 Avon Cedex - France
Tél. : +33.(0)1.60.74.95.20 - Fax : +33.(0)1.64.23.74.02
www.miltonroymixing.com - Email : contact@miltonroymixing.com

A division of
DOSAPRO MILTON ROY

FRANCE - DOSAPRO MILTON ROY S.A.
10, Grande Rue - 27360 Pont Saint Pierre
Tél. : +33 (0)2 32 68 30 00 - Fax : +33 (0)2 32 68 30 93
www.dosapro.com - Email : contact@dosapro.com