Mixing

Introduction

- Mixing : intermingling of two or more dissimilar portions of a material, resulting in the attainment of a desired level of uniformity, either physical or chemical, in the final product .
- Agitation : the creation of a state of activity such as flow or turbulence, apart from any mixing accomplished .

Mixing is applied to achieve specified results in the following situations :

1- Creating a suspension of solid particles ,
2- Blending miscible liquids ,
3- Dispersing gases through liquids ,
4- Blending or dispersing immiscible liq. in each other ,
5- Promoting heat transfer between fluid (liq.) and the coi or jacket of a heat exchanging device .

In general, agitators can be classified into the following two groups.

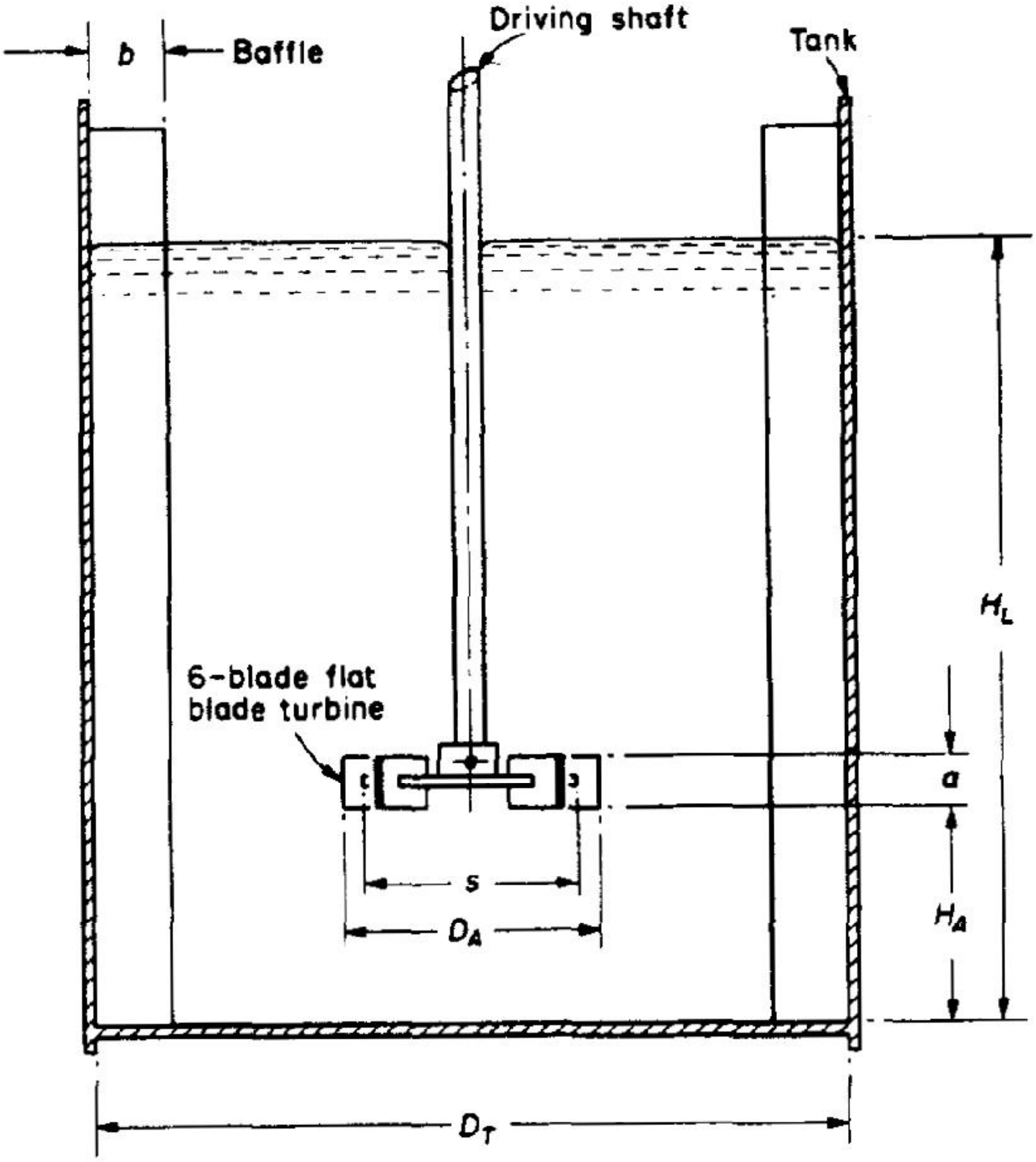
1 Agitators with a small blade area which rotate at high speeds. These include turbines and marine type propellers.

2 Agitators with a large blade area which rotate at low speeds. These include anchors, paddles and helical screws.

The second group is more effective than the first in the mixing of high viscosity liquids.

Standard tank configuration

A typical turbine mixing system is the standard configuration defined by the following geometrical relationships:



1- a six-blade flat blade turbine agitator
2- $D_A = D_T/3$
3- $H_A = D_T/3$
4- $a = D_T/5$
5- $r = D_T/4$
6- $H_L = D_T$
7- *4* symmetrical baffles
8- $b = D_T/10$

Processing considerations sometimes necessitate deviations from the standard configuration .
Agitator tip speeds T_s given by the following equation are commonly **used** as a measure of the degree of agitation in a liquid mixing system .

$T_s = \pi D_A N$

Tip speed ranges for turbine agitator are recommended as follows :

2.5 to **3.3 m/s** for **low** agitation
3.3 to **4.1** ***m/s*** for medium agitation
and
4.1 to 5.6 m/s for high agitation

Dimensionless groups for mixing

In the design of liquid mixing systems the following dimensionless groups are of importance :

The power number

$$P_0 = \frac{P_A}{\rho N^3 D_A^5} \qquad \text{---1}$$

The Reynolds number :

$$(Re)_m = \frac{\rho N D_A^2}{\mu} \qquad \text{---2}$$

The Froude number :

$$(Fr)_m = \frac{N^2 D_A}{g} \qquad \text{---3}$$

The Weber number :

$$(We)_m = \frac{\rho N^2 D_A^3}{\sigma} \qquad \text{---4}$$

In the above equations, ρ, μ and σ are the density, dynamic viscosity and surface tension respectively of the liquid; P_A , N and D_A are the power consumption, rotational speed and diameter respectively of the agitator. The terms in equations 1 to 4 must be in consistent units. In the SI system ρ is in kg/m^3,

μ in Pa s and σ in N/m; P_A is in W, N in rev/s and D_A in m .

By dimensional analysis, the power number P_o can be related to the Reynolds number for mixing $(Re)_m$, and the Froude number for mixing$(Fr)_m$, by the equation

$$P_0 = C(Re)_m^x.(Fr)_m^y \qquad ---5$$

Where :

C : is an overall dimensionless shape factor which represents the geometry of the system .

Eq. (5) can also be written in the form

$$\emptyset = \frac{P_0}{Fr_m^y} = C(Re)_m^x \qquad ---6$$

Where :

∅ : is defined as the dimensionless power function

In liquid mixing systems, baffles are used to suppress vortexing . Since vortexing is a gravitational effect, the Froude number is not required to describe baffled liquid mixing systems. In this case the exponent y in equations 5 and 6 is zero and F& = 1.

Thus for non-vortexing systems equation 6 can be written either as

$$\emptyset = P_0 = C(Re)_m^x \qquad ---7$$

Or as log P_0

$$\log P_0 = \log C + X \log(Re)_m \qquad ---8$$

The Weber number for mixing We, is only of importance when separate physical phases are present in the liquid mixing system as in liquid-liquid extraction .