Lesson-30

Mixing and Agitation

30.1 INTRODUCTION

In most of the processing operations in dairy plant, the process fluid may have to be heated or cooled. It would need some kind of agitation. Similarly, mixing various ingredients like that for ice cream mix, is also common. They form very important unit operations in the processing industry. The aim is to achieve the objective with minimum of energy input, and wear and tear.

30.2 AGITATION

It is the induced motion of a material in a specified way usually in a circulatory pattern inside some sort of container. **e.g.**Agitation of milk in a storage tank.

30.3 MIXING

It is random distribution, into and through one another, of two or more initially separate phases. **e.g..** Mixing of Ice cream ingredients before freezing.

30.4 AGITATION and MIXING OF LIQUIDS

The purpose of agitation and mixing can be many, depending on the process objective.

1. To distribute solid particles more uniformly. **e.g.** Ingredients in ice cream mix
2. Blending miscible liquids **e.g.** In Gerber test shaking different fluids before putting butyrometer in the Centrifuge
3. Dispersing gas through the liquid. **e.g.** Agitation in silos by compressed air
4. Dispersing immiscible liquids to form emulsion or suspensions of fine drops
   e.g. Butter oil in RCM
5. Assisting in heat transfer e.g. agitation in multipurpose vat for batch pasteurization

30.4.1 Agitation equipment

1. Vessel: i) Usually cylindrical, slightly round bottom to avoid pockets of stagnant liquid
   ii) Top of vessel may be closed or open
   iii) Height of liquid approximately equal to diameter of the vessel.

2. Motor with shaft of sufficient length, directly connected or through reduction gear. Shaft has an impeller and may have support

30.4.2 Types of agitators

There are different types of agitators, to suit to the varied process operations. Below are some of them. The types a) and b) are of turbine types, while the c) and d) type are propeller type.

i) Paddle	ii) Propeller	iii) Turbine
Open Straight Blade	Bladed Disk	Vertical Curved blade

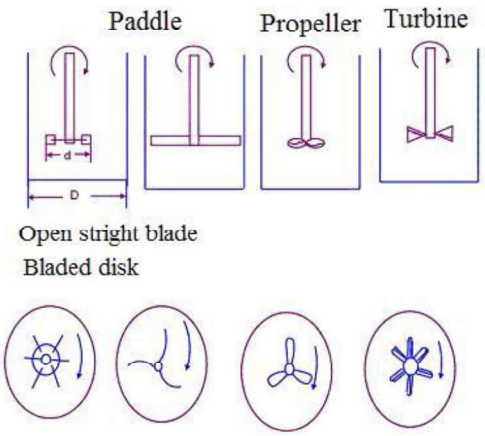

Fig. 30.1 Agitators

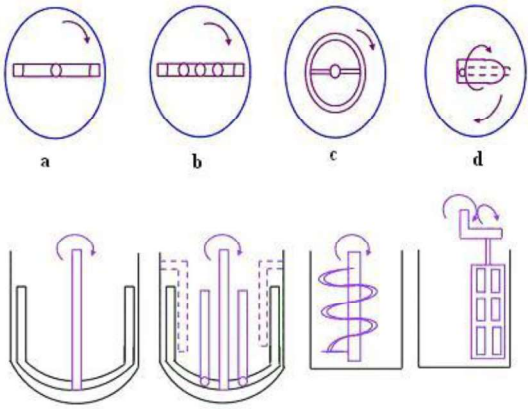

Fig.30.2 Agitator (Scraping type)

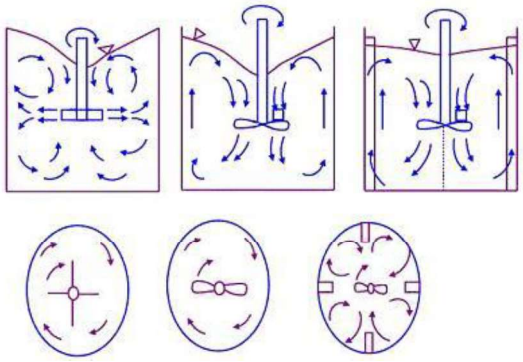

Fig.30.3 Vortex formation

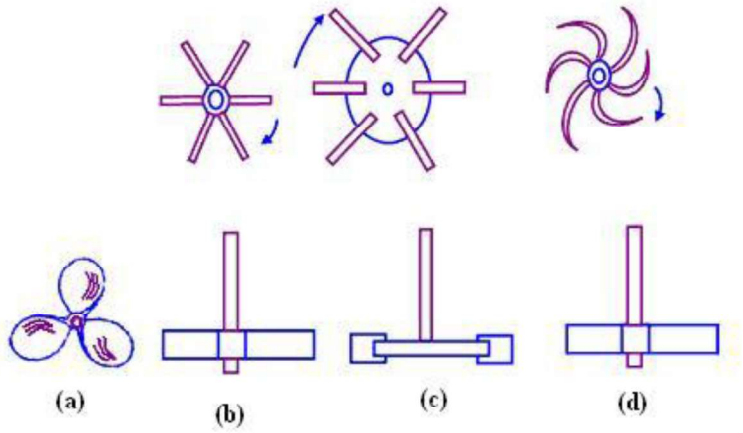

Fig.30.4 Turbine

(a). Three blade marine propeller (b). Open straight blade turbine

(c). Blade disk turbine (d). Vertical curved blade turbine

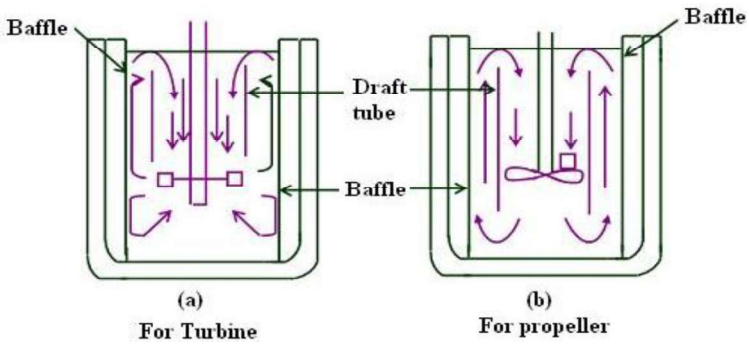

Fig.30.5 Baffle

30.4.2.1 Methods to avoid formation of vortex:

Action of agitation sometimes leads to formation of vortex, which can suck air into the fluid being agitated. Methods by which this objective is achieved are:

i) Tilted impeller shaft

ii) Mounted on side (eccentrically) of tank

iii) Baffles

* Vertical strip perpendicular to the wall of tank
* Four baffles sufficient
* For turbines type of agitators the width of baffle is < 1/12 D_t

For propeller width the same is <1/18 D_t

* Side entering, inclined or off-center propellers do not need baffles

30.5 DRAFT TUBES

Draft tubes are used when direction and velocity of flow to the suction of the impeller to be controlled. They are useful when high shear at impeller itself desired. **e.g.**: emulsions. Also they are used when solid particles tend to float on surface

30.5.1 Disadvantage

1. Draft tubes add to the fluid friction.
2. For a given power input, reduce flow rate.

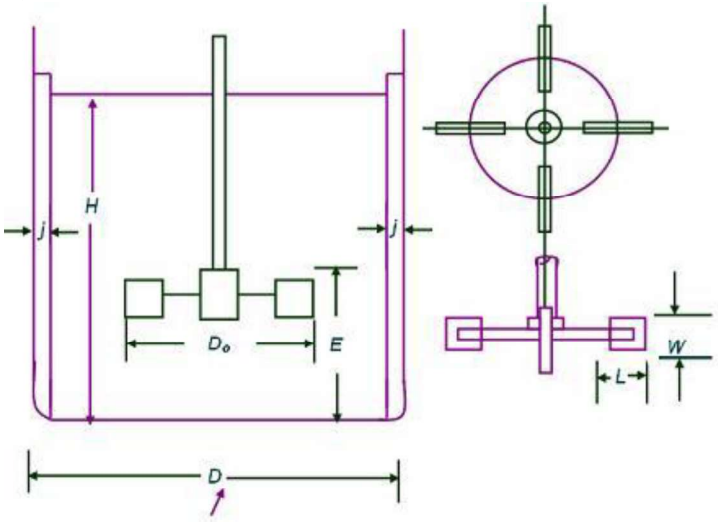

Fig.30.6 Standard turbine

30.5.2 Typical proportions

With regard to the dimensions mentioned in the above figure 30.4, the general proportions of the dimensions are given below:

$$\frac{Da}{Dt}=\frac{1}{3} \qquad \frac{H}{Dt}=1 \qquad \frac{J}{Dt}=\frac{1}{12}$$

$$\frac{E}{Dt}=\frac{1}{3} \qquad \frac{W}{Da}=1 \qquad \frac{J}{Da}=\frac{1}{4}$$

Number of baffles usually is 4. The number of impeller blades are of the range 4 to 16, but usually 6 or 8. If greater depth of the process fluid is desired, then two or more impellers are mounted on the same shaft. Bottom impeller, either of the turbine or propeller type, is mounted about one impeller diameter above the bottom of the tank.

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Lesson-31

Power Consumption of Mixer-Impeller, Selection of Mixing Equipment in Dairy Industry, Mixing Pumps

31.1. INTRODUCTION

The operation of agitation has to be effective in achieving the objective, at a minimum cost as well as in short time. With increasing cost of electricity, the energy consumption of agitation and mixing has to be carefully audited for energy savings. In the analysis electrical energy consumption, the techniques of optimization, dimensional analysis are done to minimize the cost of installation and operation.

31.2. CIRCULATION, VELOCITIES AND POWER CONSUMPTION IN AGITATED VESSELS

Volume circulated by impeller must be sufficient to sweep out the entire vessel in reasonable time. Velocity of the stream leaving the impeller must be sufficient to carry the currents to the remotest points. Turbulence in moving stream often governs the effectiveness of the operation. It is caused by large velocity gradients.

Volumetric flow rate, q is proportional to the speed and the cube diameter of impeller. Another important parameter is the Flow Number, a dimensionless number.

Flow Number, $N_{Q1} = N_{Q1} = q\ n\times (Da)^3$

Flow number is constant for each type of impeller

For standard flat–blade turbine, in a baffled vessel, $N_Q \approx 1.3$

For Flat – blade turbines, the total flow, estimated from the average circulation time for particles is

$qT=0.92\times n\times (Da)^3 \times (Dt/Da)$

For a Dt/ Da =3 the $q_T = 2.76\,nD_a^3$ or 2.1 times the value at the impeller (N_Q=1.3). The above equation should be used only for Dt / Da ratio between 2 and 4

31.3. POWER CONSUMPTION

When the flow in the tank is turbulent, the power requirement can be estimated from the product of the flow 'q' produced by the impeller and the kinetic energy, per unit volume of the fluid.

$Q=n\times (Da)^3 \times N_Q$

$E_K = \rho \times (V_2{}_1)^2 / 2{\cdot}gc$

Where V_2^1 = Actual velocity of the particle at the impeller blade tip, which is slightly smaller than the tip speed μ^2

Power requirement, that is $n \times (Da)^3 \times N_Q = \rho\, 2 \cdot gc \times \alpha \cdot \pi \cdot n\, (Da)^2$

$= \rho \times n^3 \times (Da)^5 (\alpha)^2 \times (\pi)^2 \times N\, q / 2g_c$

Where $\alpha = (V_1)^2 (\mu)^2$

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