Geometry and Architecture of Mixing Agitator – A Review

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Abstract- *Agitator is one of the important parts in the mixing process. Proper and uniform mixing gives improved quality of the product. In this paper, we have mainly focused on different types of agitator used in industries to increase the mixing performance in industry. Also includes the different parameters used for design of agitator. Mixing is one of the most fundamental operations in industries like paper, food, cosmetic, chemical, biochemical and pharmaceutical applications. The review drives us to design an error prone model for agitator which will increase the mixing percentage, ultimately increase the gain of industry to get place into market with price for product. The design of agitator affects on the mixing process as proper design can increase the mixing and uniform distributions of all additives, chemicals, raw material present in pulp.*

Keywords*-*Mixing Process, Agitator, Paper Industry, Design of Agitator

I. INTRODUCTION

Mechanical agitators can be divided into seven basic groups, namely 1. Paddles 2. Turbines, 3. Propellers, 4. Helical screws, 5. Cones, 6. Radial flow propellers and 7. High speed disc. Mixing by agitator take place due to momentum transfer. High velocity streams, produced by the impeller, entrain the slower mixing or stagnant liquid areas from all parts of the vessel and a uniform mixing occurs. As viscosity increase, frictional drag forces retard the high velocity stream and confine them to immediate vicinity of the impeller. Thus stagnant areas develop and uniform mixing is not achieved. Agitators having a small blade area which rotate at high speed, for instance, propellers, flat or curved blade turbine are used to mix liquids having low viscosities [3].

Various kinds of large impellers, such as FULLZONE (Kobelco Eco-Solutions Co., Ltd.), Super-Mix MR205 (Satake Chemical Equipment Mfg. Co., Ltd.), Hi-F mixer (Soken Technic Co., Ltd.) and MAXBLEND (Sumitomo Heavy Industries Co., Ltd.), have been developed in Japan. Since these Impellers have a high mixing performance over a wide range of viscosities, they are used in mixing, dispersion, reaction and polymerization processes. Recently, their use in the food and pharmaceutical industries is being considered. For agitation in the turbulent region, these large impellers are usually used with baffles to promote mixing. However, baffles often cause problems for washing and sterilization. Furthermore, in the laminar region, baffles are not effective for mixing, and in fact, they often obstruct mixing. Eccentric mixing is one of the traditional methods of promoting mixing in a vessel without baffles. An eccentrically located impeller generates a vertical flow, which contributes to mixing, without baffles. If a large impeller is used at an eccentric position, it is expected that the high performance of the large impeller can be combined with the advantages of eccentric mixer Separation damage and fracture rock movement reflect [2].

Agitation refers to force a fluid by agitating and to flow in a circulatory motion. Agitator has various purposes such as suspending solid particles, blending miscible liquids, dispersing a gas through a liquid in the form of small bubbles, and promoting heat transfer between the liquid and coil or jacket. There are some factor affecting the efficiency of agitating, some are related to the liquid characteristics such as viscosity and densities as well as some are related to geometry such as the container diameter (D), impeller length (Y), rotating speed (N), an height of impeller from bottom of the container (H), other Characteristics of mixing include the liquid the necessity of performing the process to make the liquid experience all kind of movement inside container. There is no universal system till now that is valid for all liquids and all tanks. Mixing is a very important unit operation in many industries like cosmetic, chemical, biochemical and pharmaceutical applications dairy and food process industry. For instance, all operations involving blending homogenization, emulsion preparation, extraction, dissolution, crystallization, liquid phase reactions, etc., need mixing in one form or the other [3].

II. LITERATURE REVIEW

D.Chitra and L.Muruganandam (2013) Solid – liquid mixing is important in chemical engineering operations such as adsorption, crystallization, dissolution, leaching, ion exchange, precipitation and catalytic reactions. Several studies on solid-liquid mixing system have been done for characterizing just suspended condition. Other parameters such as solid concentration distribution, cloud height, power consumption and scale up have not been studied extensively. Solid concentration distribution is one of the important features of solid-liquid stirred tank. Proper design of solid-liquid stirred tank requires sound knowledge of solid concentration profile in an agitated tank. Solid distribution in agitated vessels depends on different parameters, namely impeller type, impeller clearance, impeller speed, solid loading and physical properties of solid and liquid. Many methods are available for predicting solid distribution in agitated tank. These include optical method, sample withdrawal method, iso-kinetic sampling, two electrode conductivity probe method, four electrode conductivity probe method [8],

Electrical resistance tomography method and optical fiber an attempt has been made to study the effect of particle size and density on solid concentration distribution. In this, variation of solid volume fraction both in radial and axial direction in a stirred vessel driven by a Rushton turbine for different sizes and density were simulated by CFD using frozen rotor steady state approach. Radial Solid concentration profile is similar for different sizes except near the wall. The axial solid concentration profile is observed to be a similar pattern for different density particles and different sizes within this closer range. At a speed of 300 rpm non homogeneity was observed in both axial and radial direction and it was also found that solid volume fraction profile in the radial direction was similar for different sizes except near the wall as the range of variables(particle size and density) selected for the present study is of closer range. It was observed that the solid volume fraction decreased with the increase in solid density and solid size at all heights for all radial positions and it is more significant at higher heights. Using Rushton turbine in a flat bottom agitated vessel. The model developed was validated with the experimental results from literature review, and then the model was used to simulate the solid concentration distribution. In this study uses a Computational Fluid Dynamics (CFD) package, CFX 12, to simulate the solid concentration distribution in an agitated tank [7].

Weetman and Howk (1988) developed a new type of mixer to provides axial flow in a non-uniformly flow field. Such as may be established by gas and provides a large axial flow volume without flooding and withstands variable loads on the blades. There by providing for a reliable operation. The mixer impeller is made up of paddle shaped blades, which near their tips (e.g., at 90% of the radius of the impeller from its axis of rotation) and which are of a width at least 40% of the impeller's diameter. The blades also have camber and twist. They are formed by establishing bending moments which form the blades into sections which are curved and flat, with the flat section being at least in the central area of the base of the blades. The hub for attaching the blades to the shaft of the mixer has radically extending arms with flat surfaces. The bases of the blades are spaced from the shaft to define areas there between. These areas are reduced in size, thereby limiting the passage of sparing gas between the blades and the shaft. The strength of the coupling between the blades and the shaft are enhanced by backing plates of the width greater than the width of arms. These backing plates are fastened between arms and the flat sections of blades. Bolts extending through aligned holes in the arms, backing plates and blades provide stronger and secure attachment of impeller blades to the shaft. The impeller will operate reliably in the environment which provides variable loads on the blades [4].

Kazuhiko Nishi, Naoki Enya (2013) eccentric mixing is used in industry; it should be concerned about the horizontal load to an agitating shaft. It is expected that the average torque and horizontal load on agitating shaft are larger than in the concentric mixing without baffles. Since these values fluctuate with the rotation of the impeller, the instantaneous maximum value is still larger. The large, fluctuating torque and horizontal load can cause serious problems, such as the falling off of the impeller or the breakage of the shaft, motor, mechanical seal or gearbox. It is, therefore, important to understand the relation between these values and the impeller rotational speed when designing the mixing equipment and determining the operating conditions. They states the torque and horizontal load were measured in eccentric mixing using a MAXBLEND impeller, this is an example of a large impeller, at various impeller rotational speeds and under various eccentric conditions in a turbulent state. The average torque and standard deviation, corresponding to the amplitude of fluctuation were calculated, and the cause of the fluctuation was investigated by FFT (fast Fourier transform) analysis [2].

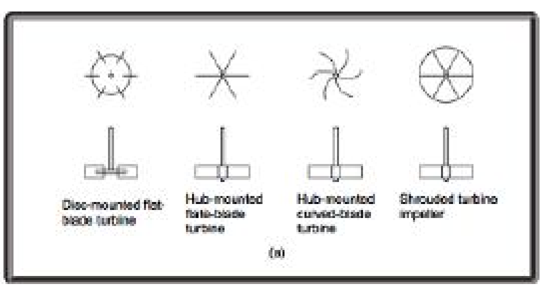
III. TYPES OF AGITATOR

There are different agitators are available in the industry. Some of the impellers are as follows [5, 6]

1. Helical Agitator

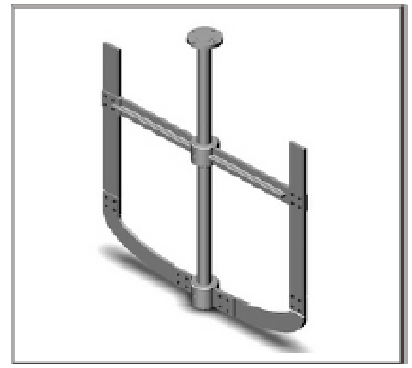
These agitators have blades with a twisted mechanism, just like the threads of a screw. The curves result in a vigorous motion of the fluids to be agitated. Helical agitators are most useful for mixing viscous liquids. Helical impellers or agitator are used primarily in applications involving very viscous materials. They operate with minimal clearance at the vessel wall and provide axial flow at low speed. Their construction can be single or double outer flight with or without an inner flight. The outer flight provides upward pumping action while the inner flight pumps in the down-ward direction. (The inner flight does not add to impeller performance in the case of Newtonian fluids.) These impellers, like the Anchor, provide improved heat transfer in a viscous fluid system.

2. Turbine Agitator



It is type of process agitator is the turbine agitator. Turbine agitators can create a turbulent movement of the fluids due to the combination of centrifugal and rotational motion. Turbine type impeller is well suited for gas/liquid reactions. It provides radial flow, while drawing gas down a hollow shaft and disperses through the impeller for effective high speed stirring. This is generally for low viscosity appliances. Standard sizes available: 3/4”, 1-1/4”, 2” and 4” diameter.

3. Anchor Agitators

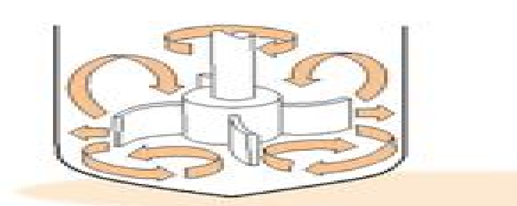


This simple agitator consists of a shaft and an anchor type propeller and can be mounted centrally or at an angle. It is mainly used in reactors. This type of impeller is best suited for high viscosity fluids (5,000-50,000 cp). This impeller provides radial flow and improved heat transfer at relatively low speeds. It generally provides minimal radial clearance between it and the vessel wall. Anchor impellers can be provided with wipers and/or cross arm support.

4. Radial Propeller agitator

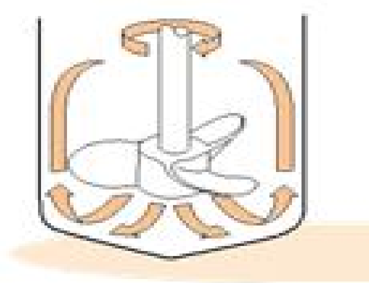
This impeller provides a combination of axial upward and radial fluid flow. It, like the Anchor and Helical Impellers, operates in close proximity to the vessel wall.Radial agitators consist of propellers that are similar to marine propellers. They consist of two to four blades that move in a screw like motion, propelling the material to be agitated parallel to the shaft.

5. Curved blade turbine



It is often referred to as a “backs wept turbine”; this impeller can be used in very viscous mixtures where power consumption can be of concern or in liquid/friable solid applications. It provides reduced shear and a radial flow pattern. Vessel baffling is required for optimum performance.

6. Marine Impeller



This an axial flow impeller generally pitched for downward pumping action, however, upward pumping is also available. This impeller provides a high, uniform discharge and therefore is best suited for low viscosity liquid blending applications. Vessel baffling is required for optimum performance

IV. PROBLEMS WITH AGITATOR

1. Most agitator cause vortex in the center of the liquid the matter that enforces the Manufacturers to put Baffles inside the agitating tanks.
2. Most agitator lead to bubbles inside the gas causing dribble which is prohibited in liquids of low flash points.
3. These agitators cause bubbles in the liquid of the liquid vapor which causes cavitation. This cavitation's lead to lowering the agitating efficiency due to storing a great amount of energy in the form of pressure.
4. To design the agitators, there is a need to calculate the electric power of the motor according to the tank size and liquid type.
5. When calculating the electric power of a motor, we are urged suppose that the tank is cylindrical.
6. There is no a universal system till now that is valid for all liquids and all tanks except the differential agitator.
7. No uniform mixing of pulp takes place, due to improper design
8. Different stresses produce on agitator and it may bend
9. Efficiency of mixing process decreases due to high Weight of agitator

V. MATERIALS FOR AGITATOR

Stainless steels are widely used in food and beverage manufacturing and processing industries for manufacture, bulk storage and transportation, preparation and presentation applications. Depending on the grade of stainless steel selected, they are suitable for most classes of food and beverage products. 'Stainless' is a term coined early in the development of these steels for cutlery applications. It was adopted as a generic name for these steels and now covers a wide range of steel types and grades for corrosion or oxidation resistant applications. The main requirement for stainless steels is that they should be corrosion resistant for a specified application or environment. The selection of a particular "type" and "grade" of stainless steel must initially meet the corrosion resistance requirements. Additional mechanical or physical properties may also need to be considered to achieve the overall service performance requirement.

Properties of Stainless Steel plate

Sr.No	Properties	Specification
1	Min /Tensile Strength	515 Mpa
2	Yield strength	205 Mpa
3	Max allowable Stress	130 Mpa
4	Modulus of elasticity	193 Gpa
5	Max Temp Limit	816^0 c

VI. DESIGN PARAMETERS

Design parameters of agitators are

1. Standard relation for agitator geometry.

Following Equation shows the standard relations in geometry of type and location of impeller, proportions of vessel and number of impeller blades.

$$\frac{Da}{Dt}=\frac{1}{3},\frac{W}{Da}=\frac{1}{5},\frac{L}{Da}=\frac{1}{4},\text{-------}(1)$$

Where
Da Impeller diameter,
D_t is tank diameter, W impeller blade width and L is impeller blade length

2. Power Calculations

Now the power can be consumed in mixing and agitation the power is a function of power number and Reynolds number which are depending on dimensions selected $P=N_pD_a^5N^3\rho$---------(2)

Where Np represents power number. Da represents impeller diameter (m), N represents Impeller Speed. (s-1) and ρ represents Fluid Density. (Kg/m^3). In agitation process Power number is Depending on Reynolds number.

3. Impeller thickness

From the power of motor and speed of impeller, the external force which effect in impeller blade as tip force in the end has been calculated. Blade thickness was an obvious mechanical design consideration. The blades must be thick enough to handle fluctuating loads without bending or breaking. The following calculation takes into account the blade strength. The minimum Blade thickness can be calculated as follows:

$$t=0.981*2\sqrt{\frac{p.Fl\left(\frac{D}{2}\right)-(Da/2)}{Nnsin\alpha\left(Fl\left(\frac{D}{2}\right)\right)W\sigma}}\text{--------------(3)}$$

Where, fL is the location fraction for PBT equal to 0.8, W is the width of the blade [m], is Number of blades , σb is the blade allowable stress and α is the blade angle.

Torque calculation

Computing shaft size for both allowable shear and tensile stress depends on the rotational speed of the mixer, p lus the style, diameter, power, location, and service of each impeller. For Shaft the maximum torque will occur above the uppermost impeller. The maximum torque is: [1].

$T = (P/\omega)$--------------(4)

VII. CONCLUSION

The review finds that, there are different types of agitator areavailable. In the different industry mixing process of pulp is not uniform and proper. Different stresses are produced in the agitator like bending stress, deformation stress.The parametric study can give the new design which can increase the mixing percentage. Also weight of agitator is high due to different joining methods present to join arms and hub together. We can reduce the weight of agitator so power consumption of agitator can decrease and efficiency and mixing percentage increases with reducing of its weight.

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