DESIGN AND MANUFACTURING OF CHEMICAL AGITATOR

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ABSTRACT

Agitation field find its application along wide range of industries like food, cosmetics, chemical and pharmaceutics etc. Agitation is putting into motion by shaking or steering to achieve mixing. Certain processing operations, such as blending, dispersion gas absorption, crystallization etc., need agitation of liquids. In such operations agitator system has to be provided along with the basic equipment. The basic equipment may be a tank, a reaction vessel, a kettle or a crystallizer. Selection of an agitation system will depend on nature of liquid, operating condition and the intensity of circulation and shear. A variety of agitation systems are available, each one having a useful operating range. The aim of project is to design a slow speed agitator for a chemical mixing system. Agitation refers to the induced motion of homogeneous material in specified way. This project is based on design, manufacturing and testing of chemical agitator. The machine consist of two main group in which first one is power transmitting group and second one is agitating group. Power transmitting group consisting of electric motor, gear box, bearing etc, while agitating group consist of impeller shaft ,impeller blades and mixing chamber carrying chemicals as agitating group is continuously in contact with chemical. So it is design to operate in such environment. The electricity is supplied to electric motor which runs at 1440 rpm. The desired speed of impeller in mixing chamber is 50 rpm. So gearbox is used for speed reduction. Bearing holds gearbox and the impeller shaft is directly connected to the worm gear with help of rectangular key arrangement so that coupling is eliminated. Due to such type of arrangement, the cost of the unit is reduced up to 25% to 30% and the efficiency is also increased as compared to old type of agitators.

Keyword: - *Agitation , steering, mixing, blending, tank, chemical mixer, homogeneous mixing, motor, gear box, bearings, impeller shaft, impeller, efficiency.*

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1. INTRODUCTION

Agitation is putting into motion by shaking or steering to achieve mixing. Certain processing operations, such as blending, dispersion gas absorption, crystallization etc., need agitation of liquids. In such operations agitator system has to be provided along with the basic equipment. The basic equipment may be a tank, a reaction vessel, a kettle or a crystallizer. Selection of an agitation system will depend on nature of liquid, operating condition and the intensity of circulation and shear. A variety of agitation systems are available, each one having a useful operating range. Agitation field find its application along wide range of industries like food, cosmetics, chemical and pharmaceutics etc. The aim of project is to design a slow speed agitator for a chemical mixing system. Agitation refers to the induced motion of homogeneous material in specified way. This project is based on design, manufacturing and testing of chemical agitator. The machine consist of two main group in which first one is power transmitting group and second one is agitating group. Power transmitting group consisting of electric motor, gear box, bearing etc, while agitating group consist of impeller shaft ,impeller blades and mixing chamber carrying chemicals as agitating group is continuously in contact with chemical. So it is design to operate in such environment.

1.1 Purpose of Agitator

The mixing of fluids in agitated vessel is one of the most important unit operations for many industries including the chemical, bio-chemical, pharmaceutical, petrochemical, and food processing. Therefore determining the level of mixing and overall behavior and performance of the mixing tanks are crucial from the product quality and process economics point of views. One of the most fundamental needs for the analysis of these processes from both a theoretical and industrial perspective is the knowledge of the flow structure in such vessels.

1.2 Design Parameters

Depending on purpose of the operation carried out in a mixer, the best choice for the geometry of the tank and impeller type can vary widely. Different materials require different types of impellers and tank geometries in order to achieve the desired product quality. The flow field and mixing process even in a simple vessel are very complicated. The fluid around the rotating impeller blades interacts with the stationary baffles and generates a complex, three-dimensional turbulent flow. The other parameters like impeller clearance from the tank bottom, proximity of the vessel walls, baffle length also affect the generated flow. The presence of such a large number of design parameters often makes the task of optimization difficult.

1.3 Factors to be considered while designing

a. Type of agitator
b. Circulation pattern
c. Location of agitator in the basic equipment
d. Shape and size of tank
e. Diameter and width of agitator
f. Method of baffling
g. Power required for agitation
h. Shaft overhang
i. Types of stuffing box or seal, bearings, drive systems etc.

2. MIXING PHENOMENON

The objective of mixing is homogenization, manifesting itself in a reduction of concentration or temperature gradients or both simultaneously, within the agitated system. Mixing as the 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. Gases, confined in a container, mix rapidly by natural molecular diffusion. In liquids, however, natural diffusion is a slow process. To accelerate molecular diffusion within liquids, the mechanical energy from a rotating agitator is utilized. The rotation of an agitator in a confined liquid mass generates eddy currents. These are formed as a result of velocity gradients within the liquid. A rotating agitator produces high velocity liquid streams, which move through the vessel. When the high velocity streams come into contact with stagnant or slower mowing liquid, momentum transfer occurs. Low velocity liquid becomes entrained in faster moving streams, resulting in forced diffusion and liquid mixing. Kevin J. Myers [1] of University Of Dayton in February 2002 presents a research paper on “Optimize Mixing By the proper Baffles”. Baffles promote better flow in an agitated vessel but how to apply them and what kind to use takes some ingenuity. Joanna Karcz [2] of Department of chemical engineering Present research paper “An effect of impeller position on dispersion of floating particles in an agitated vessel". Key findings are, in order to avoid the floating of low density particles at the top of vessel and in order to achieve the proper mixing blade position should be 0.67*H.

Julian fasano [3], Eric E. Janz, Kevin Myers in 2012 present a research article on "Design Mixers To Minimize Effects of Erosion and Corrosion Erosion". The research paper focused on various static and dynamic factors that affect the rate of erosion. Suggestions made by them are, equal tip speed to minimize the rate of erosion and coating of hard material like ceramic, carbide etc. to high velocity areas of blade. D. Chitra[4] of VIT India in April-June 2014. Present a research article on "Effect of Impeller Clearance and Multiple Impeller Combinations on solid Suspension in a Standard Flat Bottom Agitated Vessel". It includes determination of critical impeller speed. According to them critical impeller speed is minimum speed to achieve of bottom suspension. Dense particle segregate at the bottom so to avoid this impeller height should be 0.33*H from bottom.

2.1 Characterization of Mixing Quality

Agitation and mixing may be performed with several objectives:

a. Blending of miscible liquids.
b. Dispersion of immiscible liquids.
c. Dispersion of gases in liquids.
d. Suspension of solid particles in slurry.
e. Enhancement of heat exchange between the fluid and
f. The enhancement of mass transfer between dispersed phases.

When the ultimate objective of these operations is the carrying out of a chemical reaction, the achieved specific rate is a suitable measure of the quality of the mixing. Similarly the achieved heat transfer or mass transfer coefficients are measures of their respective operations. These aspects of the subject are covered in other appropriate sections of this hook. Here other criteria will be considered. The uniformity of a multiphase mixture can be measured by sampling of several regions in the agitated mixture. The time to bring composition or some property within a specified range (say within 95 or 99% of uniformity) or spread in values-which is the blend time-may, be taken as a measure of mixing performance.

2.2 Mixing Operations

The main applications of the mixing can be classified in terms of the following five operations:

A. Homogenization:

Homogenization can be described as the equalization of concentration and temperature differences, which is the most important and the most frequently carried out mixing operation

B. Enhancing heat transfer between a liquid and heat transfer surface:

Mixing reduces the thickness of the liquid boundary layer hence the thermal resistance on the heat transfer surface and convective motion of the tank contents ensure that the temperature gradients within the tank content are reduced.

C. Suspension of solid in a liquid:

In continuous process homogenous distribution of the solid in the bulk of the liquid is required. By mixing the suspension, settling of the particles as a result of gravity is prevented.

D. Dispersion of two immiscible liquids:

Dispersion in liquid/liquid systems is associated with the enlargement of the interface area between two immiscible liquids. This accomplished by the lowest impeller speed at which one phase is completely mixed into the other.

E. Dispersion of a gas in a liquid:

The aim of this operation is to increase the interfacial area between the gas phase and liquid phase. Increasing the gas liquid interfacial area is obtained by gas sparing by means of stirrers.

2.3 Flow Patterns in Stirred Vessel

According to the main directions of the streamlines in the vessel, there are three principal types of flow. These are tangential flow, radial flow and axial flow.

Tangential flow

Where the liquid flows parallel to the path is shown in Figure 1. When the flow is predominantly tangential, discharge of liquid from the impeller to the surroundings is small. Tangential flow takes place in a paddle type impeller running at a speed, which is not sufficient to produce a noticeable action of the centrifugal force.

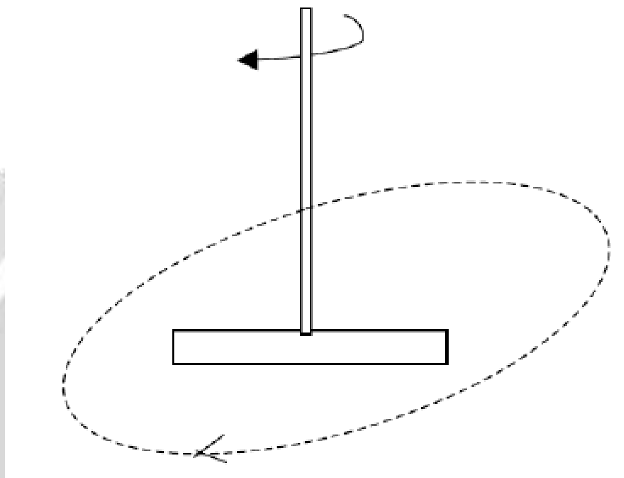


Fig -1: **Tangential flow**

Radial flow

The liquid discharges from the impeller at right angles to its axis and along a radius. Figure 2 shows the flow pattern of a impeller with its axis coinciding with that of the vessel and producing radial flow. In this case it is apparent that the impeller produces two flow sections; one is in the bottom part of the vessel it entrains the liquid in the upward direction and displaces it at right angles to the axis of the impeller; the other is in the upper part of the vessel, the impeller entrains the liquid downwards, displacing it like perpendicular to the impeller axis.

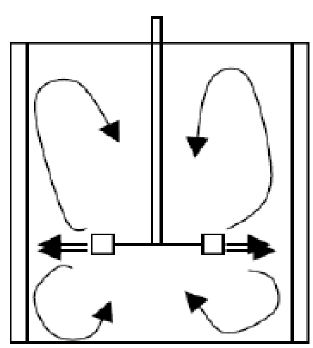


Fig -2: **Radial flow pattern**

Axial flow

Axial flow, in which the liquid enters the impeller and discharges from it parallel to it axis as shown in Figure 3

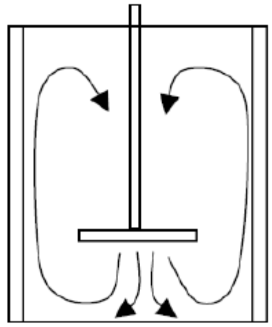
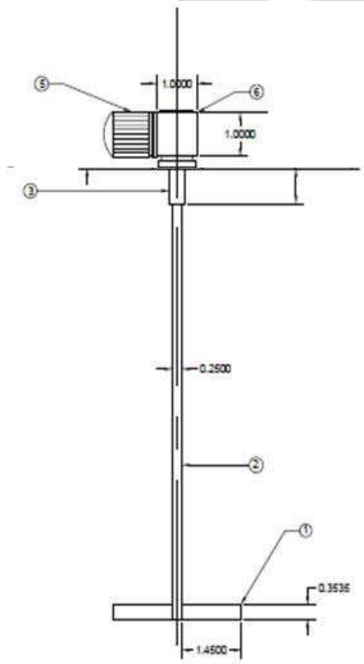


Fig -3: **Axial flow pattern**

3. CONSTRUCTION AND WORKING



Sr. No.	Description	Material Of Component
1	Pitched Blade Impeller	SS316
2	Agitator Shaft	SS316
3	Bearing Housing	CI
4	Motor	
5	Gear Box	
6	Bottom Clearance- 215mm	
7	Shaft Length- 1045mm	

Fig -3: **Conceptual diagram Chemical agitator For low speed application**

It consists of motor (1440rpm, 0.5HP, 3Ø), worm and worm wheel gear box, bearings (deep grooved ball bearing), impeller shaft with keyway, rectangular key, impeller and chemical mixing vessel or tank. In order to reduce the speed from 1440 rpm to low speed i.e.50 rpm worm and worm wheel gearbox is used. In this motor shaft is connected to worm shaft. The impeller shaft is directly coupled to the worm wheel with the help of rectangular key. The impeller is connected to the impeller shaft with the help of lock nut. When motor is started by providing 3phase AC supply, it rotate at 1440rpm. This speed is reduced to low speed (50rpm) with help of reduction gearbox unit. This speed is transmitted to impeller through impeller shaft. Because of this Impeller rotate at designed speed, so that proper mixing of chemical is carried out. Due to such type of speed reduction from motor speed to low speed, so that homogeneous mixing is achieved and vibration problems are eliminated completely.

4. ADVANTAGES AND LIMITATIONS

4.1 ADVANTAGES

- As sufficient turbulence is achieved in the mixing chamber, hence homogeneous mixing is obtained.
- Low noise and vibration so no need of vibration isolator.
- Required less maintenance.
- No need to provide baffles.
- Low cost due to less number of accessories
- It achieves various chemical properties and dilute solution is obtained.
- It is energy efficient.

4.1 LIMITATIONS

- Able to work in particular range of viscosity.
- Limited capacity.
- Designed for particular application.

5. CONCLUSIONS

Thus the machine is prepared by designing and manufacturing the components, and assembled these components with standard available parts. The machine setup is then tested to ensure its satisfactory performance. During the testing it is found that, the machine is able to work with specified rpm and sufficient turbulence is created inside the mixing chamber. The vibrations created during running condition are much less. These all results in homogenous mixing of contents in the mixing chamber, which are our main objectives. The problem is that the machine is able to work in particular range of viscosity and it is able to handle the limited capacity for which it is previously designed. For given conditions the performance of machine is found to be satisfactory. In future for large capacity tanks concept of baffling, sensors and concept of square vessel are also suggested.

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