Design and Manufacturing of Chemical Mixing Agitator

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Abstract— In this paper we have considered a project based on design, manufacturing and testing of a chemical mixing agitator. Agitation field find its application among a wide range of industries like food, cosmetic, chemical and pharmaceutical application. The aim of the project is to design a slow speed agitator for a chemical dosing system. Agitation refers to the induced motion of a "homogenous" material in a specified way. The machine consisting of two main group first one is power transmitting group and second one is agitating group. Power transmitting group consists of electric motor, bearing, gearbox and coupling while agitating group consists of impeller shaft, impeller blades and mixing chamber carrying chemicals. As the machine is made to work in a chemical environment specified by the company, during the testing it is found that the machine is able to work efficiently with the chemicals given by company. According to the requirement of dosing system plant and to reduce costing of design, this design of agitator is prepared; the performance of the system is checked by various testing methods. Thus it gives a better efficiency at a lesser cost, so it is advised to use this type of design for the agitator.

Key words: Agitation, Dosing, Speed reduction

I. Introduction

Agitation is putting into motion by shaking or steering to achieve mixing. 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. Selection of an agitation system will depend on nature of liquid, operating condition and the intensity of circulation and shear. This project is based on design, manufacturing and testing of a chemical mixer. The machine consisting of two main group first one is power transmitting group and second one is agitating group. Power transmitting group consists of electric motor, bearing, gearbox and coupling while agitating group consists of impeller shaft, impeller blades and mixing chamber carrying chemicals. As agitating group is continuously in contact with chemicals so it is designed 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 140 rpm so the gear box is used for speed reduction. Bearing holds gear box shaft it is then coupled to impeller shaft with help of rigid coupling. Impeller shaft carries three impeller blades these rotate at 140 rpm. The rotation of impeller in mixing chamber creates sufficient turbulence which is necessary for proper mixing of chemicals.

II. Construction

Electric motor of capacity 1/4 hp is fixed to the frame and it is coupled to the worm shaft of gear box. The shaft is mounted with the help of taper roller bearings. This worm is engaged with worm gear with speed reduction upto 140 rpm. This worm gear is coupled to the impeller shaft with the help of muff coupling. At the bottom of impeller shaft, the impeller hub is mounted on which three impeller blades are attached. These blades are inclined at 45˚ to horizontal plane. The circular tank of capacity 300 ltr.is used for carrying and mixing of fluids. This whole set up is shown in figure 1.

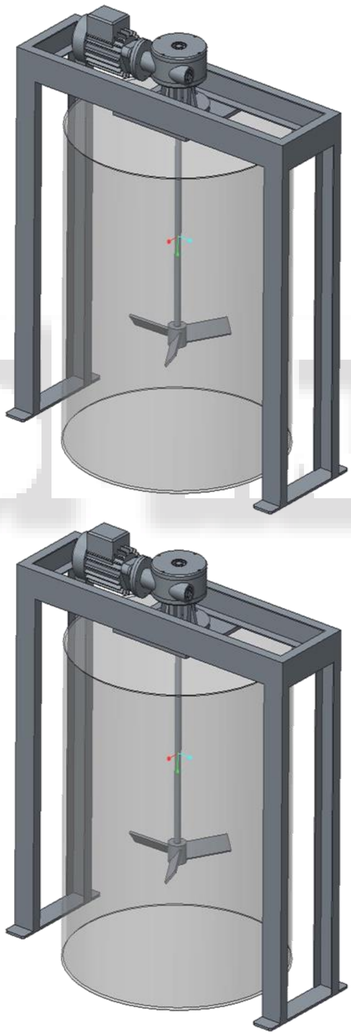

Fig. 1: Chemical Mixing Agitator Model.

III. Working

The main aim of this project is to proper mixing of chemicals and speed reduction upto 140 rpm. As speed reduction is more, we use worm and worm wheel gearbox.

When electric motor start rotating at 1440 rpm, the worm shaft of gearbox rotates at the same speed. As gear ratio is 10 the worm gear rotates at 140 rpm. This worm gear shaft is coupled to impeller shaft. Due to which the impeller starts rotating at 140 rpm. For given condition at this rpm the proper mixing is obtained.

A. Machine Specification:

1.shaft	
Material	SS306
Quantity	1 set
Dimension	Length-600mm,Dia.-22mm.
2. Impeller	
Material	SS306
Quantity	1 set
Type of impeller	Radial Flow Type
Dimension	Dia-360mm
No of blades	Three
3. Bearing Housing	
Dimension	CoreBore-15mm, Cup outside-42mm, Bearing Width-14.25mm.
Type of bearing	Taper Roller Bearing
Bearing no	30302
4. motor	
Type of Motor	Foot Cum Flange Mounted
Motor Hp	0.5 HP
Speed	1440 rpm.
Motor Phase	Three
5. Gear Box	
Type	worm and worm gear
Reduction Ratio	10:1

Table 1: (a) specifications of chemical mixing agitator

IV. 'STEADY' FORCES ON AN AGITATOR

An agitator is used, inter alia, to promote dispersion, suspension or mass transfer. It does this by renewing continually the interfaces between the constituents, by the production of turbulence or by the creation of mass circulation. Assume that the matching of agitator to purpose has already been undertaken and that the next steps are to consider the various mechanical aspects associated with supporting and driving the agitator. It is perhaps appropriate at this stage to review the types of agitator available and used throughout industry.

Consider a flat plate such as a single blade on an agitator, with a fluid passing about it at a relative velocity *v*. The dynamic pressure exerted on the plate is theoretically $\frac{1}{2} \times \rho \times v^2$And the theoretical force, is this pressure multiplied by the plate area,

$$F_t = \frac{1}{2} \times \rho \times v^2 \qquad \text{..............................} (1)$$

The actual force on the plate F_a is related to the theoretical force by a drag coefficient C_D

Where $C_D = \frac{F_a}{F_t}$, Thus $F_a = C_D \times \frac{1}{2} \times \rho \times v^2$ ……… (2)

Power (P) is (force x velocity) (i.e. force x distance/time), so

$$P = F_a \times v \text{ and } P = C_D \times \frac{1}{2} \times \rho \times v^3 \times A \qquad \text{.........} (3)$$

For a flat paddle agitator, the frontal area A is a combination of the length of the Blade and its width, both of which are functions of D; thus, A∝ D^2Velocity is a functionof impeller diameter and speed of rotation, thus v ∝ND.

Combining these gives: $P \propto N^3 D^5$ ……………….. (4)

The 'propeller law', an experimentally proven law derived from dimensional analysis, states that the theoretical power requirement $P_t$of the agitator is given by$P_t = \rho N^3 D^5$and the actual power P transmitted by the agitator is related to this through a coefficient, P_0i.e.

$$P = P_0 P_t$$

$$P = P_0 \rho N^3 D^5 \qquad \text{..............................} (5)$$

In the mixing literature, $P_0$the power coefficient is generally termed the Power Number.Like the drag coefficient, it varies with such things as Reynolds number

$$R_e = \frac{\rho N d^2}{\mu} \qquad \text{..........} (6)$$

A typical curve of against Reynolds number for turbine impellers is given in Figure 2. and similar curves are obtained for all impellers. The foregoing description of the production of forces and of the subsequent power requirements is centered on a single flat blade impeller. If more blades were added, it may at first sight seem that the power would increase in proportion, but this is not so, because the blades are subjected to a diminishing local normal velocity.

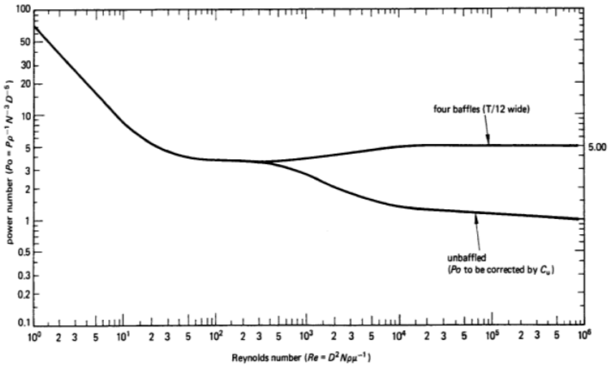

Fig. 2: Graph of Power no.Vs Reynolds no.

The wake influence of 'upstream' blades is similar to a sheltering effect and the power increases in proportion to the numbers of blades raised to a power in the range 0.5-0.8. Having determined the power requirement of the agitator, the next problem is that of designing a suitable method of transmitting this power from the electric or hydraulic motor.

V. NUMERICAL RESULT

A. Impeller Assembly:

FEM of impeller assembly using ANSYS 14 as a logical solution of static and parametric optimization to obtain the optimal volume of impeller for a maximum performance and high agitation process index.

The output as shown in Figure 3 was the von misses strain which was 2.5704e-007 mm/mm as maximum value. The maximum von misses strain was in the shaft of impeller and minimum at the mixing tank as shown in Figure 3. The strain and the deformation were safe.

The maximum value of von misses stress was 5.1363e-002 MPa. which was at top of the shaft as shown in figure 4.

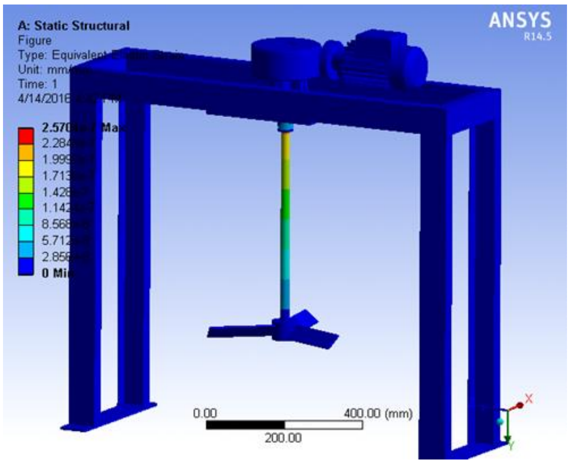

Fig. 3: Von misses strain in impeller assembly.

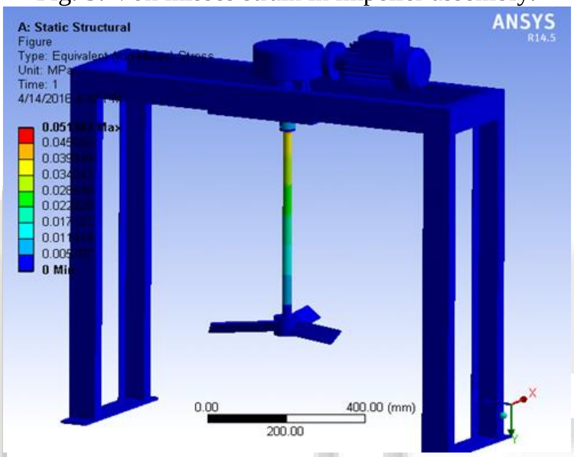

Fig. 4: Von misses stresses in impeller assembly.

B. Impeller:

FEM of impeller using ANSYS 14 as a logical solution of static and parametric optimization to obtain the optimal volume of impeller for a maximum performance and high agitation process index.

The output as shown in Figure 5. was the von misses stress which was 1.843e5 Mpa as maximum value.

The maximum value of von misses strain was1.0274e-6 m/m as shown in figure 6.

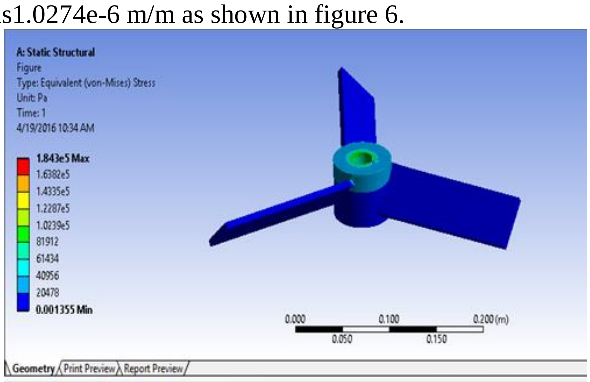

Fig. 5: von misses stresses in impeller

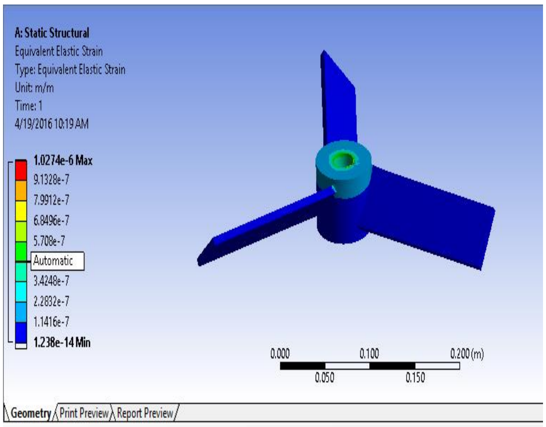

Fig. 6: Von misses strain in impeller.

VI. TEST RESULTS

1) Run Out Test:-
   This test is carried out to check the eccentricity of the shaft.
   Instrument used:- Dial Gauge.
   Observation:-
   The shaft was 0.06 mm out, while the permissible limit was 1 mm for 1 m shaft.
2) Current Test:-
   This test was carried out to check the current passing through motor.
   Instrument used:- Digital Clamp Meter
   Observation:-
   The current passing through Red, Yellow and Blue phase wire was 0.3 Amp.
3) Speed Test-
   This test was carried out to check speed in rpm of the shaft.
   Instrument used:- Digital Tachometer
   Observation:-
   The speed of the shaft was around 140 rpm.

VII. COST ESTIMATION

Sr No	Component	Cost
1	Gearbox	6500
2	Motor	3800
3	Bearing housing	1300
4	Bearings	1200
5	Driven shaft with machining	2200
6	Shaft impeller with machining	3500
7	Tank	6500
8	Frame	5200
	Total	30200

Table 2: cost estimation

VIII. ADVANTAGES, LIMITATIONS AND APPLICATIONS

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.

Limitations-

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

Applications-

- Water treatment plant.
- Blending chemical stocks.
- Sugar industries, food processing industries.
- In ice plant to make the brine solution.
- Pharmaceutical industries.
- Paper mill.

IX. Conclusion

Thus the machine is prepared by designing and manufacturing the components, and assemble 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 is our main objective. 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.

X. Future Scope

1) Baffle plates- for impeller speed up to 180 rpm turbulence created in the mixing chamber is sufficient. For large sized tanks we can provide baffle plates to increase turbulence by suppressing vortex motion.
2) Concept of double impeller- In order to ovoid floating of low density particles at the top of tank and to avoid segregation of high density particles at the bottom.
3) Sensors- To check impeller speed. To observe mixing process. To monitor temperature in the mixing chamber.
4) Square tank- If we use square tank for mixing chamber instead of circular tank with baffle plates it will give same mixing efficiency.

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