Design and Stress Analysis of Tail Cone Rotary Agitator in Horizontal Feeder

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Abstract- **The proposed work is to be carried out for validation and anti-deflection solution in design for cone hub agitation system in feeding process of pulp. This agitation process is different from conventional processes other processes carried out in vertical position it's a horizontal heavy work application is to be carried out for making pulp feeding and screening horizontally as to avoid inlet feeding from height. To give shape for this application end fitting tail cone agitator is designed to fulfill the application. In results will shows all the designed parameters are capable to withstand with boundary conditions provided. Boundary conditions to be evaluate for pulp capacity and vessel volume also rotary parameters involved. Pulp is the medium where this system will work ,pulp is simple wooded bleached coming from bleaching preheater in hot condition and to be feed to screw conveying system all these machineries are part of paper and pulping industry. Gusseting rings to be used for perfect stability and optimised cover sheet thickness. To minimise the weight of whole cone structure. So weldment big structure to be formed which will be cage formed inside the cone. Results will show the comparison in multiple designed tail cone agitator with its validation in stress analysis and deflection analysis also it proves the stability with modal analysis.**

Index Terms- **Agitators, ANSYS, CAE, CFD, Weldment**

1. INTRODUCTION

Agitation is the process of inducing motion of material in a specified way. In the chemical and other processing, industries, many operations are dependent to a great extent on effective agitation and mixing of fluids. Generally, agitation refers to forcing a fluid by agitator means to flow in a circulatory or other pattern inside a vessel. Agitation is a means mixing of phase can be accomplished and by which

mass and heat transfer can be enhanced between phases or with external surfaces. In paper making process different processes are takes place in which bleaching is also one of the important process. In bleaching process heating of raw material with water takes place and here is separations of fibers are takes place. After bleaching process the pulp is goes for agitation process, in agitation process mixing of additives with the pulp are takes place. So here this project gives brief conceptual idea about installation and working of agitator with its mechanical parameter. Previously this was used in separate vessel which was dismantled condition with the bleaching plants. Also agitator making technology was in casting as the agitator is a single device used here which is in non standardized dimension and shape so there is no scope to make it in casting process that's why we come to make within weldment.

Tail cone structure idea taken from aircraft building process if the same structure is used here to make mixing and stirring process in horizontal vessel, this tail cone is to be used as hub to hold blades outside .Agitator blades are to be fixed on this cone with dedicated fixtures provided with bolting or other feasible option.
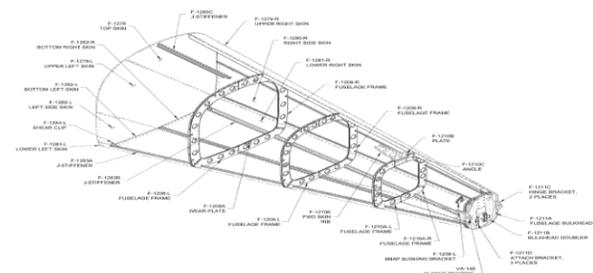

Fig1.1: General tail cone structure used in air craft design

In required application big tower around 10 meter high supplies pulp with bleaching processed this material need to be washed by dewatering process by big twin roll press before passing to dewatering twin roll press pulp must be mixed with some chemicals involves to make fibre soft and healthy ,it can be say the process to be designed here is to mixing and screening of material from flow condition .

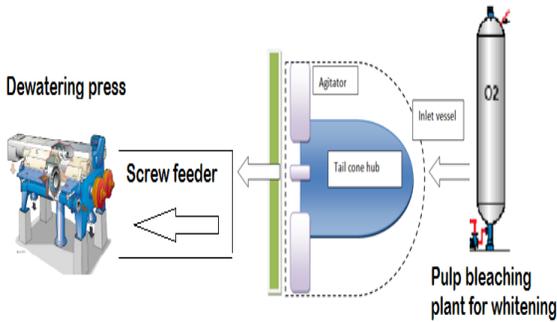## 2. PRODUCT WOKING STRUCTURAL SKETCH

Fig.2.1: Tail cone agitator hub assembly

Tail cone agitator hub assembly showing that our design is works in between pulp bleaching and Dewatering press.
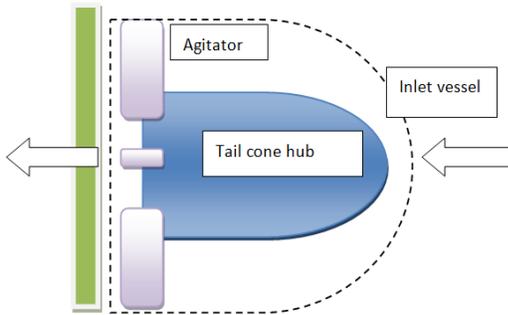
3. WORKING

Fig.3.1: Tail cone rotor assembly in application

Agitation: It refers to the induced motion of a "homogenous" material in a specified way.

"Agitation is the process of keeping a mixture that has been mixed state required for end product"

Agitators are devices that are used to stir or mix fluids, especially liquids, which is one of the basic mechanical process engineering operations. Essentially, agitators are used for the homogenization of liquids or liquid-solid mixtures by generating horizontal and vertical flows. These flows are generated by rotating agitator blades.

Fig.3.2 Agitation process

Mixing: It is the random distribution, into and through one another, of two or more initially separate phases. "Mixing refers to actual stirring of diff liquid or material to blend together into end product or mixture
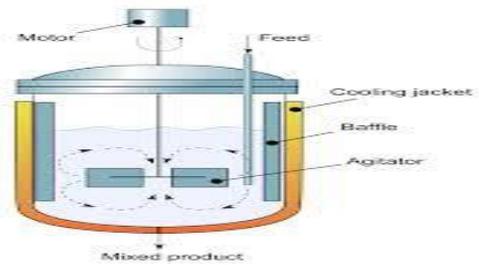

Fig. 3.3 Mixing process

4. LITERATURE REVIEW

Saeed Asiri (2012) design and implement a new kind of agitators called differential agitator. The Differential Agitator is an electro-mechanic set consists of two shafts. The first shaft is the bearing axis while the second shaft is the axis of the quartet upper bearing impellers group and the triple lower group which are called as agitating group. The differential agitator avoids the vortex forming in the liquid and gives a high homogeneous motion of the liquid due to transferring the vortex from the outer tank to internal container. The optimal shape of the internal container is the full open suction and discharge intakes.

Kazuhiko Nishi et al (2013) Mixing is one of the most fundamental operations in chemical engineering. Stirred tanks are widely used in the manufacture of such materials as chemicals, paints, inks, electronics materials, ceramics, foods, pharmaceuticals and cosmetics. Suitable mixing is indispensable to the purpose achievement of a process. The power consumption and mixing time for marbled, which is a type of large impeller, were investigated. The power consumption p, and mixing

time, θm, were measured under various eccentric conditions. The relation between the power number (np) and Reynolds number (re) and that between the dimensionless mixing time (nθm) and re were investigated. When eccentric mixing is used industrially, we should be concerned about the horizontal load to a agitating shaft. The large oscillating horizontal load causes serious problems, such as the falling off of the impeller or the breakage of the 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 have studied, the torque and horizontal load were measured in eccentric mixing under various eccentric conditions. The averages of both, the torque and the horizontal load, and their standard deviations, corresponding to the amplitude of fluctuation were shown

5. PROBLEM IDENTIFICATION

To transfer pulp towards dewatering press its essential to make chemical mixing and screening so to make feasible bigger diametric conical feeder needed to pass pulp from small diameter inlet to bigger diametric screw feeder entrance with its stirring and agitation process in vessel. Now a days agitators are used for screening and mixing which is positioned in vertical direction but it causes vortex motion so we need to used baffles to avoid vortex motion, again it causes bubbles which creates cavitation and pressure is formed which minimized the efficiency of agitator. So we are planning to design a tail cone agitatator to overcome this causes by positioning the rotary agitator in horizontal direction. The weight of existing agitator is maximum.

6. OBJECTIVES

1. Design of cone shaped hub for agitator assembly to make pulp screening.
2. To design fixture arrangement for agitator blade mounting.
3. Optimised design to make compact drive unit and rotary mount.
4. Rotation of cone supporting components to be considered.

5. Validation by stress behaviour and deflection analysis.
6. Modal analysis to perform and to know behaviour in different frequency conditions.

7. SCOPE OF WORK

1. Cost effective design
2. Manufacturability of cone hub as well as agitator.
3. Assembly CAD model.
4. Calculations
5. ansys results With approved reports.

8. FORMULATION

1. Concept modelling, (3D model complte assembly)
2. Weldment structure using standard ISO raw material and filler material.
3. Multiple options to make optimised selection and best solution.
4. Joints/coupling design.
5. Dedicated Fixture development for agitator holding and its fitment.
6. Ansys results with stress values and affecting component.

8. RESEARCH METHODOLOGY

The tail cone shape agitator is modified design of old flat agitator. It is made up from the weldment method. This agitator consists of three parts that is stirrer, central hub and blade. This agitator gives more efficiency. The mixing vessel contain agitator, opening for screw feeder conveyor, motor, motor shaft. The motor is located at the bottom of vessel and agitator rotate in mixing vessel in horizontal position. All the agitation group have to locate at the bottom of bleaching plant, pulp is come from this is now direct comes in agitation group and mixed the additives in pulp.

8.1 MATERIAL FOR AXEL HUB
Stainless steel types 1.4301 and 1.4307 are also known as grades 316 and 316L respectively. Type 316 is the most versatile and widely used stainless steel. It is still sometimes referred to by its old name 18/8 which is derived from the nominal composition of type 316 being 18% chromium and 8% nickel.

Type 316 stainless steel is an austenitic grade that can be severely deep drawn. This property has resulted in 316 being the dominant grade used in applications like sinks and saucepans. Type 316L is the low carbon version of 316. It is used in heavy gauge components for improved weld ability. Some products such as plate and pipe may be available as "dual certified" material that meets the criteria for both 316 and 316L. 316H, a high carbon content variant, is also available for use at high temperatures.

8.2 AGITATOR SHAPE SELECTION

I] Depends on the viscosity of the liquid

As the viscosity if consider the system require more surface to pass the pulp forward hence 60 mm width plate is welded to collect and spread towards the screw feeder. In our design shape of agitator more stability and more area to collect also very less chances to get failed ,as there are no more bolting and casting joints involved only proper weldment are considered into the current new design which gives more flexibility to repair if any wear tear occurs in future .

II] Depends on the time of mixing

For specific time of mixing, the best mixer is the one that mixes in the required time with the smallest amount of power. As the weldment parts are very small and light weighted. Hub centrally mounted with holding the horizontal agitator to rotate along with axial rotation gives perfect balance with the system. That is the benefit we got to make fitting of stirrer bracket on top of the hub to rotate along with agitator.

8.3 CAE Tool:

ANSYS, Inc. is an engineering simulation software (computer-aided engineering, or CAE) developer headquartered south of Pittsburgh in the Southpointe business park in Cecil Township, Pennsylvania, United States. One of its most significant products is Ansys CFD, a proprietary computational fluid dynamics (CFD) program.

8.4 ANSYS workbench platform:

The ANSYS Workbench platform is the framework unifying our industry-leading suite of advanced engineering simulation technology. An innovative project schematic makes it possible to build even complex metaphysics analyses with drag-and-drop simplicity. With bidirectional parametric CAD connectivity, powerful highly automated meshing, an automated project-level update mechanism, pervasive parameter management and integrated optimization tools, the ANSYS Workbench platform delivers unprecedented productivity, enabling process capture and Simulation-Driven Product Development.

8.5 ANSYS Meshing:

Mesh generation is one of the most critical aspects of engineering simulation. Too many cells may result in long solver runs, and too few may lead to inaccurate results. ANSYS Meshing technology provides a means to balance these requirements and obtain the right mesh for each simulation in the most automated way possible. ANSYS Meshing technology has been built on the strengths of stand-alone, class-leading meshing tools. The strongest aspects of these separate tools have been brought together in a single environment to produce some of the most powerful meshing available. Highly automated meshing environment makes it simple to generate the following mesh types: Tetrahedral, Hexahedral, Hexahedral Core, body fitted Cartesian, prismatic inflation layer. Cut cell Cartesian, tetrahedral inflation layer. Consistent user controls make switching methods very straight forward and multiple methods can be used within the same model. Mesh connectivity is maintained automatically. Different physics requires different meshing approaches. Fluid dynamics simulations require very high-quality meshes in both element shape and smoothness of sizes changes. Structural mechanics simulations need to use the mesh efficiently as run times can be impaired with high element counts. ANSYS Meshing has a physics preference setting ensuring the right mesh for each simulation

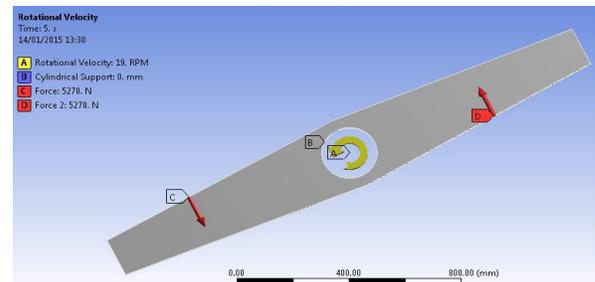### 9. NUMERICAL ANALYSIS OF EXISTING FLAT AGITATOR

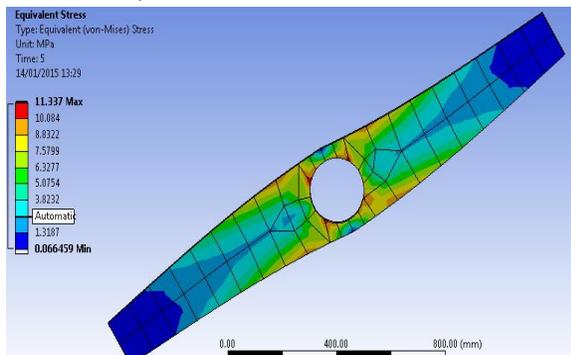Fig.9.1 Boundary conditions on flat agitator

9.1 Boundary condition

Fig.9.2 Equivalent stress on flat agitator

This gives boundary conditions on flat agitator which gives different required results. In this force applied in both side but in opposite direction. This agitator given rotational velocity is 19 rpm. Boundary conditions are same environment as that of its working condition. So this gives same result as same as that of working condition. Applied boundary conditions are specified above. After solving this we will get result of stress produced on it, deformation of flat agitator.

This figure shows equivalent stress on flat agitator. After application of boundary conditions we solve this for calculating stress on flat agitator. The Ansys has given results as maximum stress on flat agitator is 11.337 Mpa. This maximum stress is at central part of agitator. The red colour shows maximum stress on agitator. The here stress is very less because the weight and dimensions of flat agitator is so high.

The stress on flat agitator is less than yield point of its material and it can sustain load produced by pulp but the weight of this agitator is so high.
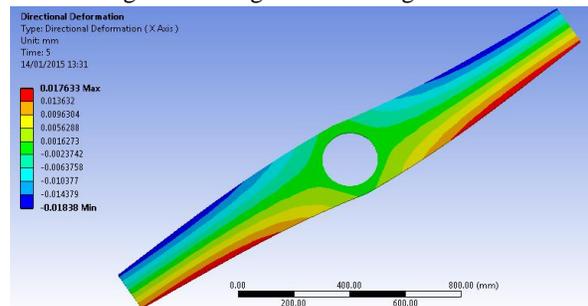

Fig.9.3 Directional Deformation on of flat agitator

This figure gives the total directional deformation on flat agitator. This gives very less deformation i.e. Maximum 0.0176 mm. The red colour indicates maximum deformation portion. It gives that in flat agitator deformation occurs at maximum portion.

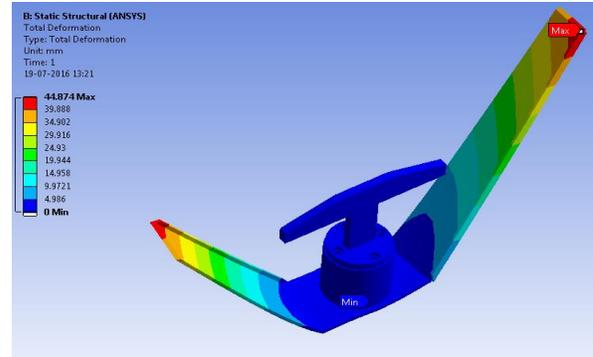9.2 Total Deformation on tail cone rotary Agitator

Fig.9.4 Total Deformation on tail cone rotary Agitator

The above figure shows the total deformation on V shape agitator. This gives the deformation occurs in V shape agitator after application of boundary condition. Total deformation on V agitator is 44.874 mm. The red colour shows maximum deformation occurs on agitator. This shows that, maximum deformation occurs at the tip of the agitator and less deformation is at the central hub of agitator. As this deformation is very less and negligible at the central hub of agitator so our design is safe. Different colour shows the deformation in agitator at that region. Blue colour shows the safe condition. This shows we can safely use the agitator.

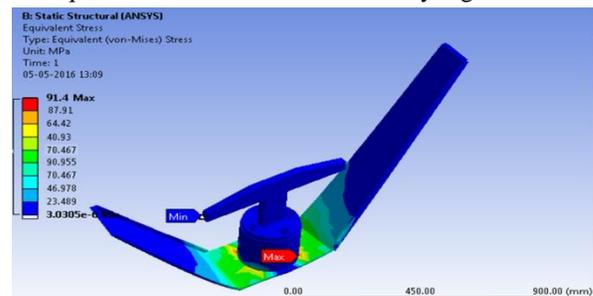9.3 Equivalent Stress on tail cone rotary Agitator

Fig.9.5 Equivalent stress on tail cone rotary Agitator

The above figure shows the equivalent stress on the agitator body. The figure shows all details about maximum stress produced on agitator. The red colour show maximum stress produced on agitator. The blue colour show the minimum stress on agitator blade.

Maximum equivalent stress =91.4 N/mm2

Minimum equivalent stress = 3.030 x 10-6 N/mm2

By applying boundary condition on agitator, we have calculated stress on agitator. Maximum stress is indicated by red in colour. The material used for this agitator is AISI 316 and it is having yield stress 205

Mpa.So it shows that our design is safe and it will not fail in working condition. We have validated our stress by numerical analysis and by analytical analysis. So both analysis give nearly equal results.

Sr. No.		
01	Maximum Stress on tail cone rotary agitator	83.32 Mpa
02	Bending stress on tail cone rotary agitator	114 Mpa
03	Deflection Stress on tail cone rotary agitator	44.874 mm
04	Weight Of tail cone rotary agitator	205 kg

10. RESULT AND DISCUSSION

We have modified the design of agitator. For safe design of agitator we have calculated different stresses produced on this agitator and some other parameter which are important.
The above table will give all values of this stresses.

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