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Structural Behaviour Analysis of Vertical V Shaped Soil Crusher and Agitation.

B.U.Gaderao[1], S.M. Jadhav[2], Dr.S.Y.Gajjal[3]
[1]PG Scholar, NBN Sinhgad school of Engineering pune,[2]Assistant professor NBN Sinhgad school of Engineering pune, [3]Professor, NBN Sinhgad school of Engineering pune.

***Abstract*- This work gives approach for performing stress analysis of an agitator of a large mixing vessel used in soil earthen process plant. The analysis is carried out to estimate stress strain and deflection in agitator body. The agitator is subjected to vibration due to multi-pointed forces resulting from bending and pushing force imported by the Agitation operation. The approach followed in this work involves in step wise (1) Stress analysis of agitator shaft for unit displacement using FE method (2) Estimation of stress outcomes variation using loading data obtained. The work also discusses an alternative approach for estimating stress quantity variation through static stress analysis. Research work gives solution for developing the mixture agitator with v shaped Weldment which is made by using weldment techniques standard material plates, Agitator looks v- shaped from front view and circular hub is designed to hold the structure of agitator. Project gives result and validation on the basis of software tool as well as mathematical tool. This proves the strength in designed agitator. Along with agitation process of pulping stirrer is also considered which is mounted on top of the agitator hub.**

***Index Terms*– Agitator, Impeller, Mixing, Materials, vessel, FEM, ANSYS11**

I. INTRODUCTION

Agitation is a very important processing operation in any material forming process industry. For instance, all operations involving blending, emulsion preparation, dissolution, crystallization, extraction, liquid phase reactions, etc., important in need mixing in one form or the other. Broadly speaking two types of agitating or mixing devices are available, namely,

- Static loaded
- Dynamic loaded

Static mixtures are becoming important in low range among processes, and hence among plant executers for they are very simple to installing processes, and required minimum maintenance. The static agitator devices are usually used as a chemical reactor to formulate reaction between two fluids and solid paste. The static agitator is available for conducting highly reaction pertaining solid-liquid operations.

The dynamic agitation consists of the fundamental equipments, which can be a vessel, a reaction vessel or impact tank having an agitation baffles system. Design of an agitator system will depend on the nature of the material medium, the detailed design of a Dynamic agitator system, operation conditions and the intensity of circulation and shear strength. The process of inducing process in mixing of materials in a particular way depends on effective press and mixing paste form solid and liquid to a great value effect.

Generally, agitation refers to missing force a fluid on solid by agitating and to flow in a circulatory motion inside the vessel. Agitator has various uses like suspending solid particles, blending mixing liquids, dispersing a material through water in the characteristics as particles, and promoting heat losing and gaining between the liquid and vessel cover. There are some parameters affecting performing efficiency of agitating, some are related to the liquid properties such as viciousness and high density. And some are related to geometry such as the vessel diameter, blade beam length , rotational speed , and height of jaw rotor from bottom of the vessel, other characteristics of mixing include the liquid the necessity of reacting the process to form the material agitate all part of load actions inside vessel. There is no standard system till now that is valid for all liquids and all vessels. In our project was using soil as a raw material which is having a property becoming thick wet when we apply uniform heat and agitation. For this requirement we used to design agitation in this project. Work is to make conceptual model & design technological concept for crushing & refining of clay medium for automated earthen pot making process .this work gives perfect solution to crushing the hard dry soil coming directly from container into its bigger opening hopper. Crushing component is the weldment designed with multiple flanges inside the vessel with spiral shaped arrangement to make collection of material in centre while rotating in crushing process. Work gives boundary conditions calculated with considering force behavior in the system. Theoretical &analytical validation is to be compared with experimentations. Since prototype to be made with designed dimensions.

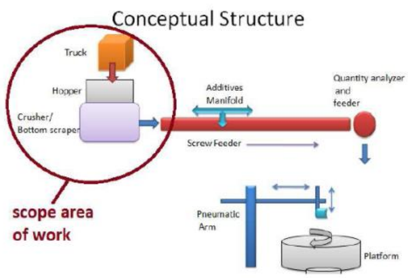


Fig.No.1 .conceptual structure

A. *Problem Definition*

The problem found in Separate outlet with feeder, Weight of existing mechanism is very high, the cost of mechanism is so high, Dismantling of mechanical components are not possible.

B. *Aim of the project*

1. To design compact and vertical mount in flat conical cabinet *agitating* device.
2. To analyze a v shaped mixing unit agitator model component for effective working condition.

C. *Objective of project*

1. To perform the design and validation for stirrer mechanism which can be withstand with the boundary conditions coming with the working system.
2. To increase the Mixing Percentage of material To reduce the processing cycle time,
3. To increase the production rate and to decrease the labor cost.

D. *Scope of project*

Agitator is the mechanism, which can be used in many industries. The different industries where agitator may work is like sugar industry, paint industry, food processing, can crushing, paper industry, etc

E. *Process*

Soil Crushing Metal chips separation by magnetic chip separator Clay Feeder with mixer screw conveyor Additives (Water, Color) mixing by spray manifolds applied on screw conveyor

• Big Hopper (1500-2000 Kg capacity)

Hopper receives raw material from trolley /truck and directly send to starts making fine powder of soil.

• Rotary crusher and metal chips separate or vertical mounted rotating unit makes fine powder of coming hard soil. Also makes Metal chips separate by magnetic pads attached on inner wall of the scraper vessel.

• Screw Feeder and mixture Vertical mounted rotating unit makes fine powder of coming hard soil. Also makes metal chips separate by magnetic pads attached on inner wall of the scraper vessel.

• Pot shaper to make proper standard shape from clay additional mold type guider to be fixed on upper Arm which will guide the clay to turn in guiding curves.

• Actuator /Arm Pneumatically operating Arm with "Festo" / SMC Germany make Pneumatic linear Actuators will perform the automatic cyclic operations as per the Programmed in PLC (Programmable logic Control) Proper fixture will hold the Mold unit which is designed to perform standard shaping and guiding operation.

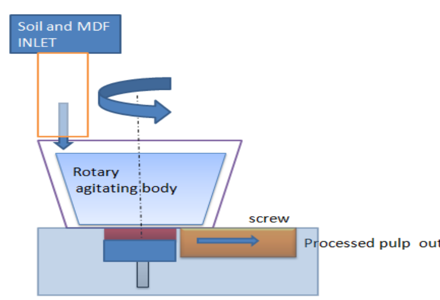


Fig. No. 2. Conceptual layout.

F. *Main design features*

Versatile, reliable, high-efficiency mixing hydraulics and material options Compact Reliable operation and reduced costs Reliable, simplified and heavy-duty bearing unit hub with a variety of different lubrication options Modular design minimizes the spare part inventory costs Validation with mathematical and CAE analysis.

II. BACKGROUND

"Design and sustaining of virtual Agitators to improve Agitating Performance." Represented design and implement a new kind of mixing agitator called differential agitator. The Differential Agitator is an mechanic and electromech set consists of two axles. The first shaft is the bearing axis and the second axle is the axis of the quartet upper antifriction bearing blade mount group and the triple lower group which are called as agitating impeller group. The agitating group is installed inside a cylindrical vessel equipped especially to contain four sided axis for the liquid entrance and square directors called fixing group for the liquid output. The fixing group is installed containing the agitating group inside any tank whether from upper or lower position. The agitating process occurs through the agitating group bearing causing a lower force over the upper group leading to outing the liquid from the square directors of the liquid entering and exactly the liquid moves to the denser place under the selected upper group. Then, the liquid moves to the so high pressure area under the agitating pack causing the liquid to exit from the square directors in the lower surface get the optimum design of the geometrical parameters of the S shaped agitator elements and to validate the advantages of the differential agitators to give a high agitation performance. of the vessel. For improving efficiency, relative study and shape design and optimization has been carried out. Mathematical validation, manufacturing and laboratory tests were conducted to formulate and implement the differential vertical agitator.

Joelle Aubin & Catherine Xuere, has investigated the effect of multiple Internal impeller parameters on hydrodynamics and mixing performance in a stirred tanks using computational fluid dynamics. They assessed the connection between impeller stages and compartment Lagrangian particle tracking. They showed that by a rotating internal impeller by 45° respect to its be sided thing, instead of a 90° rotation as recommended by producers, enables a larger range of operating conditions, and lower Reynolds number flows, to be handled. Again by slightly reducing the distance between the lower two impellers, fluid exchange between the impellers is obtained up to Re = 27.

"Agitator and Wiper Design Modification for Milk Machine." Studied that mixing is a very important unit operation in any dairy processing food process industry. All operations involving blending, extraction, emulsion preparation, crystallization, dissolution, liquid phase reactions, etc., need mixing in one or other form. The work includes the dynamic mixing various processes of a food processing industry particularly about Milk product making process. To attain uniform agitation and the optimized product preparation time for getting desired quality, a newly developed concept of automated agitator is being suggested. The existing agitator is not suitable to for the comfortable working loads hence creates problems in output of the various parameters affecting organization efficiency viz., quantity, quality, delivery time and work force capacity. By studying three different models, one will be selected for the final fabrication. To select the best design, simulation method will be used to conduct required experiment. Desired inputs have been selected from various literatures and the discussion with the field experts. Real time study has been conducted to satisfy the requirement of the customer. Tomas Jirout, Frantisek Rieger in their "Impeller design for mixing of suspensions "has stated the effect of impeller type on off-bottom particle suspension. The correlations were proposed for calculation for suspended impeller speed of eleven impeller types and geometries in the range of concentrations and diameters of particle On the basis of numerous suspension measurements. The suspension efficiency of tested impellers was studied with the help of the power consumption required for off-bottom suspension of solid particles.

Daniel Geiyer studied a side entry agitator test stand and developed side entry agitator test stand at RIT in conjunction with Light Mixers, SPX Corporation. The test stand requires the ability to measure torque, RPM, axial force, also perform vertical translational motion and angular movements. It is required to fill a void in the industry by the system, and the system will be made up of steel, using bolted and welded connections. A variable frequency drive and a Lab View interface with the appropriate data acquisition devices are used. Also the Load cells are used for sensing,

Ronald J. Weetman & Bernd Bigas, in his "Mixer Mechanical Design – Fluid Forces" has suggested the mechanical design of mixer with the emphasis on the fluid forces that are opposed on the impellers by the fluid continuum in the mixing vessel. From the study it is observed that the forces are due to transient fluid flow acting on the mixing impeller. These loads are dynamic and are transmitted from impeller blades to the mixer shaft and gear reducer. A general result for the form of the fluid force equation can be obtained. The importance of the mechanical interaction of the mixing process with the mixing vessel and impeller is focused.

III. MATH

A. Design Methodology

1) Knowing the material properties and the loading conditions, the FEM using ANSYS11 will used to

2) The study will ended up with conclusions to maximize agitator performance and minimize the geometrical parameters to be used for manufacturing the differential agitator.

B. Agitator geometry

1) The main parts can be considered to design the agitator. Following Equation shows the standard relations between geometry of type and distance of impeller, proportions of vessel and number of impeller blades.

$$\frac{D_a}{D_t} = \frac{1}{3}, \quad \frac{W}{D_a} = \frac{1}{5}, \quad \frac{L}{D_a} = \frac{1}{4} \qquad (7)$$

Where D_a is Impeller diameter, D_t is tank diameter, W is width of impeller blade and L is length of impeller blade.

C.Impeller Design

From the power of motor and speed of impeller, the external force which effect in impeller blade as tip force in the end will be calculated. Blade thicknesses will an obvious mechanical design consideration. The blades of impeller must be thick so as to handle fluctuating loads without failure. The following equation ensures blade strength. The minimum Blade thickness is determined as follows:

$$t = 0.981 \sqrt[2]{\frac{P\, f_L \left(\frac{D}{2}\right) - \left(\frac{D_z}{2}\right)}{N\, n_b \sin\alpha \left[f_L \left(\frac{D}{2}\right)\right] W\, \sigma_b}}$$

Where, f_L is the location fraction for PBT and is equal to 0.8, W is the blade width [m], b is Number of blades, σ_b is the allowable stress in blade, α is the blade angle (assumed 45^0).

IV. DESIGN AND DEVELOPMENT

A. Spool design

The ferrous, non-ferrous materials and non metals are used as shaft material depending on the application. Most commonly used ferrous materials for the shaft is Hot-rolled plain carbon steel. This material is least expensive. Extra machining operation is required to make the surface smooth as scaling is always present on the surface due to hot rolling.

Alloy steel as one can understand is a mixture of various elements with the base steel to improve its physical properties. To get the total advantage of alloying materials it is required the heat treatment of the machined components after its manufacturing. Some of the common alloying materials are Nickel, chromium and vanadium. However, alloy steel is more costly. This material is used for relatively severe service conditions. The alloy steels are used where more strength is required. These alloy materials have fewer tendencies to crack, warp or distort while heat treatment. Residual stresses are also low as compared to carbon steel. In some cases the shaft needs to have resistance to wear, then attention is given to make the shaft surface to be wear resistant. Since height of the vessel is fixed and of vessel is also decide as per the volume requirement.

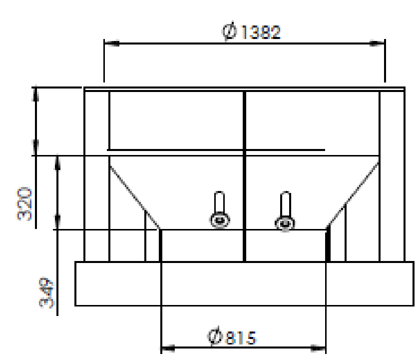


Fig.No.6.Crushing vessel in ANSYS model

Vessel consideration :
Cylindrical shape + fruxtum
Cylindrical shape : Dia 1322 x 320
Volume is
V1=πr2 h
424914285.7142854 mm3 =425 litres

Now volume of frustum =
Volume = □/3 [h (R ^{2} + r R + r ^{2}]
r= 407 mm
R =650 mm
H =350 mm
V2 = 312530506.6 mm3 = 312 litres
Total vessel volume = V1 +V2= 737 litres

Total load inside the vessel when material medium comes in contact of the rotary system and medium filled in vessel for processing Since density of the material medium is 2200 kg/m3Now , mass inside the vessel available = vxd= 1621 kg So total load coming inside parts is
1621x 9.81= **16210 N**

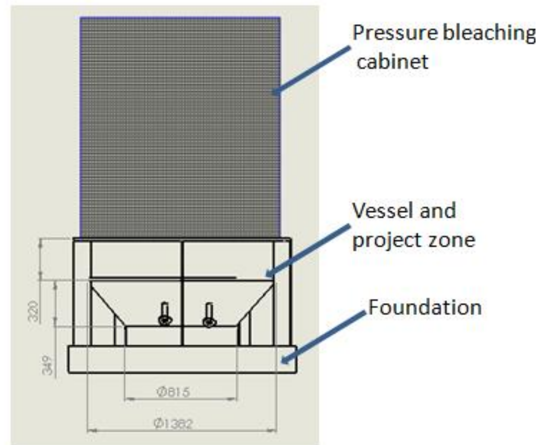


Fig.No.7.Arrangement of crushing vessel

Vertical Shaft for rotating the load inside vessel will be active in one pack of conveying .We will consider 500 kg for safer side , thought the total load 1621 kg is coming here flow will be of only 400 kg so we can now consider 500 kg max is coming inside the vessel and force would be 5000 N = 5KN. The free body diagram of the shaft is as shown in the figure.

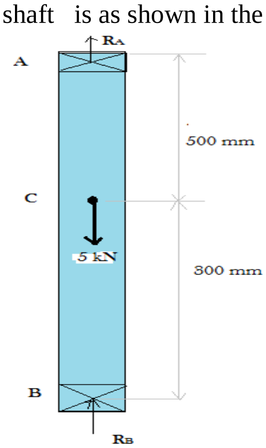


Fig.No.8.Vertical shaft

The load of 5 kN is acting at C
Let R_A and R_B be the reaction at A and B respectively equation of equilibrium

$\Sigma Fy = 0$
$R_A - P + R_B = 0$
Or
$R_A + R_B = P$

$R_A + R_B = 5000$........(i)

one equation for two unknowns [statically

indeterminate]
∵ both ends A and B are fixed,
thus
$\delta_{AB} = \delta_{AC} + \delta_{CB} = 0$ where,

$$\delta_{AC} = \frac{R_A l_1}{EA}$$

$$\delta_{CB} = -\frac{R_B l_2}{EA}$$

$$\frac{R_A l_1}{EA} - \frac{R_B l_2}{EA} = 0 \text{ .... (ii)}$$

Let
D_o be the external diameter of Shaft = 30 mm
And D_i be the internal diameter of Shaft = 22 mm
Therefore, Area = $(\pi / 4)(D_o^2 - D_i^2) = 326.72\ mm^2$
E = Modulus of Elasticity = 200GPa
By putting the values in equation (i) and (ii) and solving, we get
$R_A = 1877.55$ N
$R_B = 3122.45$ N

Stresses in each section AC and BC

$$\sigma = \frac{P}{A}$$

Hence Stress in AC

$$\sigma_{AC} = \frac{R_A}{A} = \frac{1877.55}{326.72} = 5.75\ N/mm^2$$

Similarly Stress in BC

$$\sigma_{BC} = \frac{R_B}{A} = \frac{3122.45}{326.72} = 9.56\ N/mm^2$$

According to American Society of Mechanical Engineers (ASME) code for the design of shaft the maximum permissible stress (σ) may be taken as 36% of the ultimate tensile strength (σ_{ut}) or 60% of yield strength, whichever is less
In other words,
$\sigma = 0.36\ \sigma_{ut}$
For Steel,
$\sigma_{ut} = 515$ MPa
Therefore, Maximum Permissible stress,
σ = 0.36 x 515 = 185.4 MPa
Or Maximum Permissible stress,
σ = 0.6 x 205 = 123 MPa
Hence Maximum Permissible stress, σ = 123 MPa

As the stresses developed in the shaft are less than the maximum permissible stresses,
Outside diameter of Shaft = 30 mm
Inside Diameter of the shaft = 22 mm

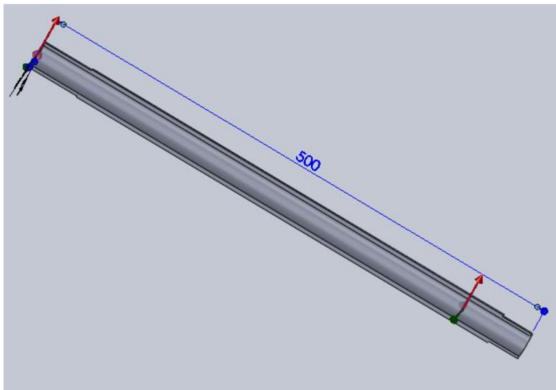


Fig.No.9. Hollow Shaft of 30 mm OD and 22 mm ID Length will be 500 mm.

B. Crusher body formulation

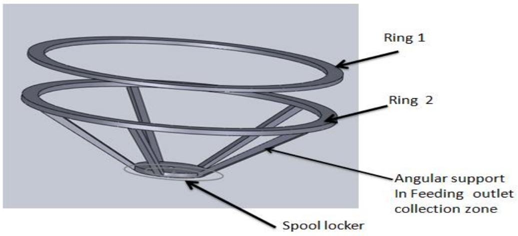


Fig.No.10.Weldment structure for agitating body

Now weldment structure for making agitating body stands in the good position for stability, for making crushing and pressing operation with soil medium main active vertical beams are to be developed as shown.

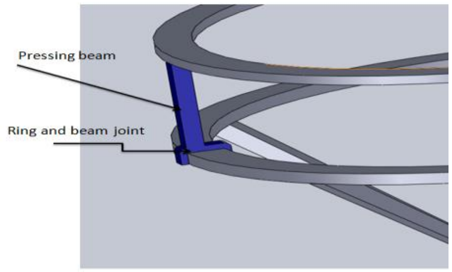


Fig.No.11. Crushing beam assembly between ring1 and ring 2

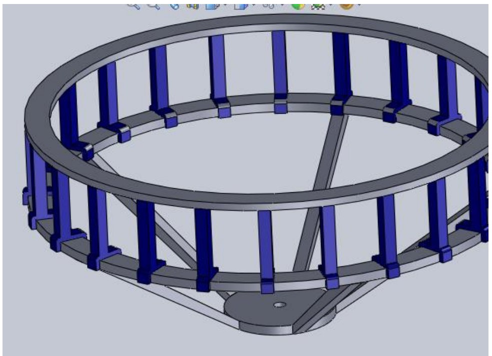


Fig.No.12. Crushing beam assembly

24 units of vertical beams are loaded since the gap we are getting between two beams is 125 mm , our medium blocks are above 170 mm so to make agitation its possible be we should not tale less than 24 unit since the gap to be maintained.,

C. Material assign

Steel (AISI304)

Table No.1.AISI304 steel grade best for anti corrosion

Property	Value	Units
Elastic Modulus	1.9e+011	N/m^2
Poisson's Ratio	0.29	N/A
Shear Modulus	7.5e+010	N/m^2
Density	8000	Kg/m^3
Tensile Strength	517017000	N/m^2
Yield Strength	206807000	N/m^2
Thermal expansion Coefficient	1.8e-005	/K
Thermal Conductivity	16	W/(m-K)
Specific Heat	500	J/(Kg-K)

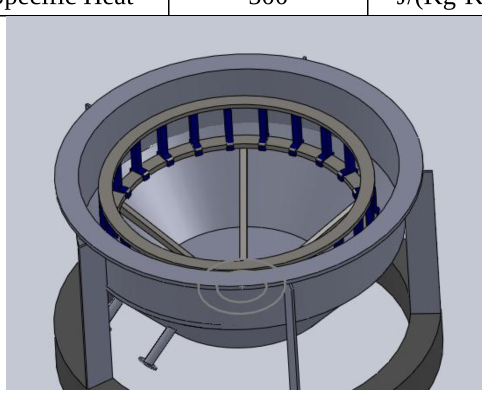
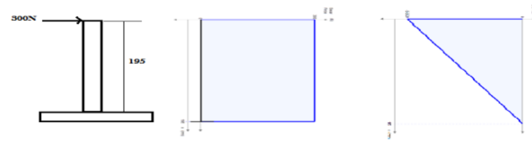


Fig.No.13.Press body agitator Installation Bracket for pressing material between vessel

D. Vertical beam calculation



SFD BMD

Fig.No.14. SFD & BMD Vertical beam calculation

Maximum Shear load = V = 300N

Maximum Bending Moment = M = 58500N-mm

We have from flexure formula,

$$\frac{M}{I} = \frac{\sigma}{y} \quad \text{.........(i)}$$

Where,

M = bending moment = 58500 N-mm

I = Moment of Inertia = bd^3 / 12 = 15 x 15^3 / 12 = 833.33 mm^4

y = d/2 = 7.5 mm

Hence bending stress

σ = 104 N/mm^2

Deflection

$$y = \frac{wL^3}{3EI}$$

Hence,

$$\boldsymbol{y = 0.8\ mm}$$

V. RESULT

A. Spool in vertical position

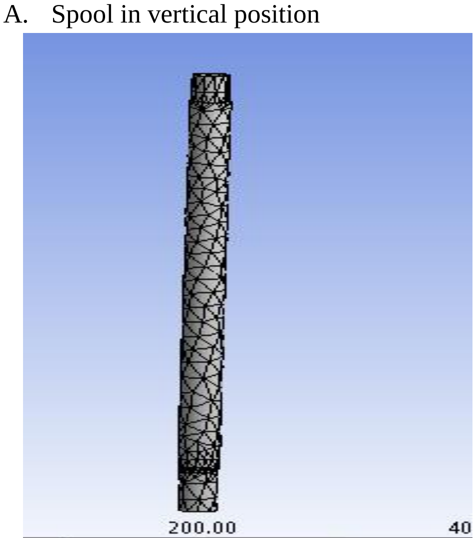


Fig.no.15. vertical beam in ANSYS

B. Meshed body

Fig.No.16. force applied on vertical beam 5000N

C. Boundary conditions applied

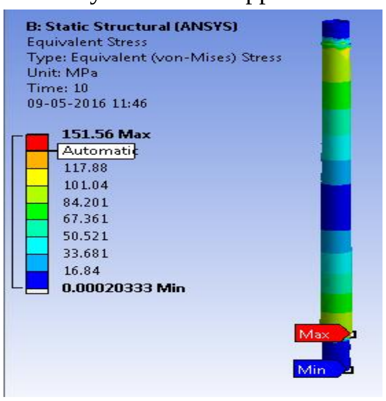


Fig.No.17. Equivalent max stress =151.56 mpa

D. Total Deformation

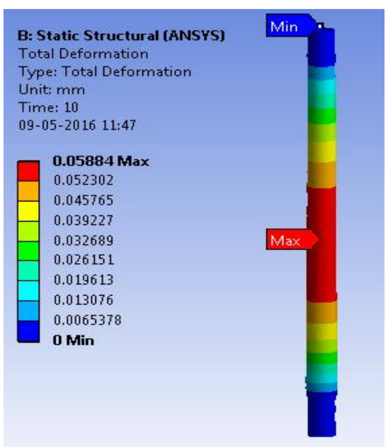


Fig.No.18. Total Deformation 0.05 mm

E. Static Structure Analysis

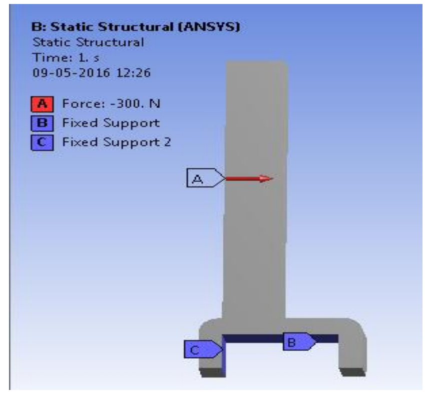


Fig.No.19. Static structure analysis

F. Von Mises Stresses Applied

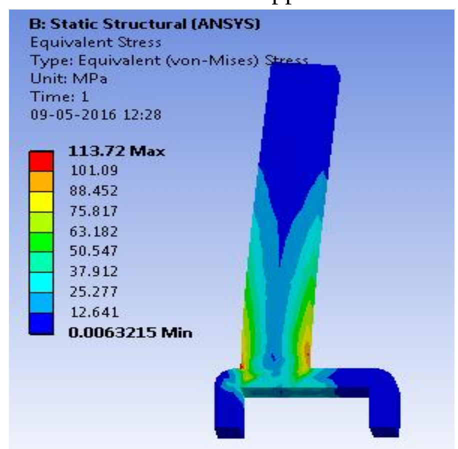


Fig.No.20.Von-Mises stress Analysis 113 .7 mpa

G. Total deformation

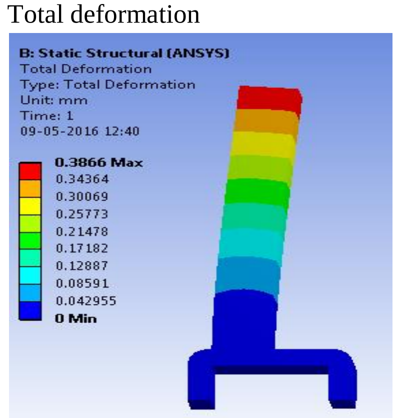


Fig.No.21. Total deformation 0.4 mm deflection found

H. Stress Intensity

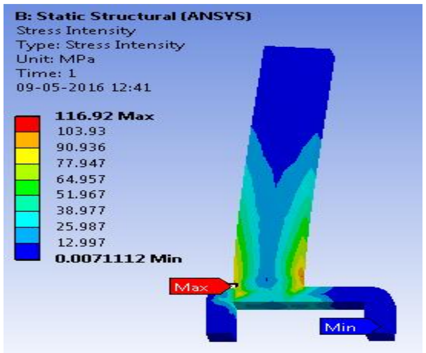


Fig.No.22. Stress intensity range

Interpretation Result

Design	Parameter	Load (N)	Analytical Result	ANSYS result
shaft	Maximum bending Stress(N/mm^2)	5000	123	151.56
	Deflection (mm)		0.10	0.05
Beam	Maximum Bending Stress(N/mm^2)	300	104	113.72
	Deflection (mm)		0.8	0.4

VI. CONCLUSION

From work this can be concluded that the structural requirement as per the input can be executed for soil crushing and agitation the medium of said density also it's feasible to make it in conical shaped body mounting vessel, only the thing is having uncertainty is vessel body need to be evaluated as the forces will come. The Stress induced in various components of the agitator vessel is computed using ANSYS and are found to be below the maximum allowable stress values as per ASME. The changes in the dimensions of the vessel confirm to the shape of the vessel. Since the vessel do not fail for the operating conditions, the integrity of the vessel is intact and is safe to operate. Since the shaft does not vibrate with resonance, the vibration of shaft is not responsible for the excessive vibration of the upper dish end.

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