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DESIGN OF SPIRAL CHIP FEEDER USED IN PULPING PLUG SCREW UNIT

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***Abstract*— The objective of the present work is to prove the stability and strength of screw feeding mechanism made for outlet of pulping material screw conveyor. A screw reactor is a continuous reactor where the feed is transported and mixed by a screw (augur). The operating conditions have an influence on the process. In overall, work modeling comes into place, because it is faster and cheaper than experimenting. This work gives a list of possible modeling techniques, whether or not validated by experiments those are used for the different applications of the screw reactor. Work is done on sheet metal validation with welding and its methodology with proven material selection also bringing manufacturability of the same product. New product development shaped into conical screw feeding reactor with its shaft and flights design. Radial force effect on flight surface in spiral rotation is analysed and performed structural sustaining engineering work on it with validation results.**

***Index Terms*— Pulp Material, Radial force, Screw (Augur)**

I. INTRODUCTION

As we all know that screw conveyor is also known as auger conveyor. Screw conveyor is a mechanism that uses a rotating helical screw blade, called a "flighting", usually enclosed in a tube, to transport liquid or granular materials. They are used in mainly bulk handling industries. Nowadays, in industries screw conveyors are often used horizontally or at a slight incline as an efficient way to move semi-solid materials, including food waste, aggregates, wood chips, cereal grains, animal feed, boiler ash, meat and bone meal, municipal solid waste, and many others. First screw conveyor was invented by Archimedes (circa 287–212 B.C.).

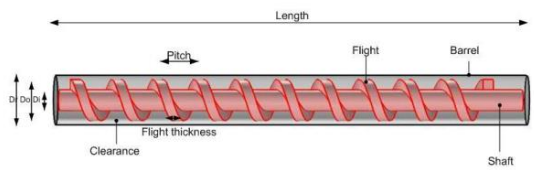

Fig.1 Standard pitch, single flight screw conveyor

When the screw shaft is rotating, due to the gravity of the material and the friction between the materials and the wall, it makes the material moving forward along the conveyor bottom under the push of the blade. It looks like an un-rotatable nut does translational movement along the rotating screw. The materials movement at the mid bearing is pushed by the moving-forward materials from back. Therefore, the materials delivery inside the conveyor is like a kind of slip movement. To have the screw shaft under better pulled state, normally have the motor and discharging port at same side of the screw conveyor. And have the outlet at the other end of screw. The screw blades push the materials to realize materials-delivery. Because of the materials gravity and also the friction between the materials and shell, the materials will not rotate together with the screw. The screw blade surface type according to the to-be-conveyed materials, it can be: entity type, belt type, and leaf surface type. The screw shaft of the Screw Conveyor is with thrust bearing at the end of the materials moving direction to give the screw shaft reverse force together with the materials. When it is comparatively long, then mid hanging bearing is required. Figure 2 shows the existing set up of screw conveyor which is currently used in paper industry.

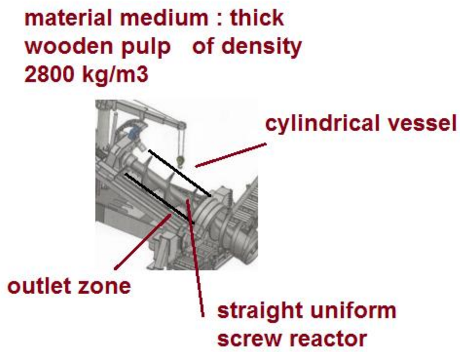

Fig. 2 Existing set up of straight screw feeder

II. LITERATURE SURVEY

A number of analytical, research and experimental studies along with various patented studies have been conducted to analyze the characteristics of the screw conveyor. They are used for carrying different material from one place to another place.

BORTOLAMASI, M., FOTTNER, J., (2001), "Design and sizing of screw feeders", Proc. Partec 2001, Int. Congress for Particle Technology, Nuremberg, Germany, 27-29 March 2001, Paper 69 [3] worked on the design criteria of screw feeders: a non proper design and selection of this device, which is present in large part of industrial processes, could mean poor performances, excessive power, severe wear of plant and degradation of the conveyed material. The design and sizing of a screw feeder is a highly complex procedure: for a correct and successful installation it's essential to have a proper understanding of the influence of all the system parameters. Because the relative phenomena cannot be described in a deterministic way, the standards procedures must be integrated with suitable lab. Tests which are the only way to predict and optimize the system behaviour.

Philip J. OWEN (2009), "Screw conveyor performance: comparison of discrete element modeling with laboratory experiments" CSIRO, Melbourne, Australia 9-11 December 2009 [4] worked on the predicted mass flow rate was inexcellent agreement with experimentally measured values for the horizontal and vertical configurations across the full range of screw rotation rates. Although the throughput predictions for the screw conveyor inclined at 30° and 60° followed the same qualitative trend, there were moderate differences between the DEM and experimental results.

Jigar N. Patel (2013), "Productivity Improvement of Screw Conveyor by Modified Design" (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 3, Issue 1, January 2013 [5] worked on to represent the modification of screw conveyor for get same output from modified design with reduced size and less power consumption. Screw conveyors are widely used for transporting and/or elevating particulates at controlled and steady rates. They are used in many bulk material applications in industries ranging from industrial minerals, agriculture, chemicals, pigments, plastics, cement, sand. They are also used for measuring the flow rate from storage bins and adding small controlled amounts of trace materials such as pigments to granular materials or powders.

III. PROBLEM IDENTIFICATION

A. Flow output is not enough

Existing design output is not enough. By changing the design of screw flights, will increase the flow rate.

B. Bending of flights

The flights on current machine tend to bend while in operation. There is a possibility that thicker sheets for flights may solve the problem.

C. Welding of spiral flights

Flights are spiral in shape and are welded on the main shaft. Thus, the weld, if not properly designed, takes the load and failure occurs.

IV. PROPOSED SOLUTION

The proposed solution consists the change in existing system to increase the flow rate. Here we are going to develop the shape of outer casing of screw conveyor with existing cylindrical shape into new conical shape to increase the flow rate of pulp in paper industry. Due to this change, the internal structure of screw feeder will also change. To use this new change structure we need to develop some internal components as per new required design. The shape of flights are varies as per diametrically referring to outer casing which is now conical in shape.

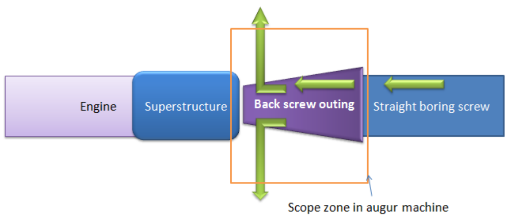

Fig.3 Work Plan Layout

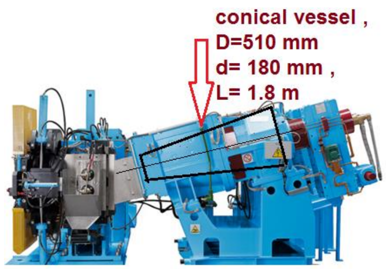

Fig.4 Structure of new proposed solution

Because of proposed conical shape, the flights design will also get change as per cone. Here we design new anti-bending beam to support the flights in working condition.

V. DESIGN STRATEGY

Design:

1. Spool (shaft) Design:

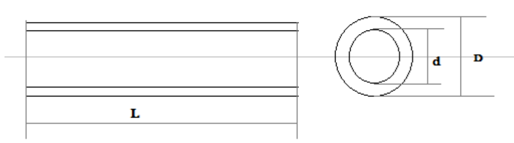

Fig. 5 Spool Nomenclature

When the shaft is subjected to bending and twisting moment simultaneously, it is designed on the basis of two moments.

According to American Society of Mechanical Engineers (ASME) code for the design of transmission shaft the maximum permissible bending stress (σ) may be taken as

$\sigma = 0.6\sigma_{el}$ and $0.36\sigma_{ut}$

Take smaller value.

From design data book,

$\sigma_{el} = 190$ MPa

$\sigma_{ut} = 510$ MPa

Hence $\sigma = 0.6 \times 190 = 114$ MPa

and

$\sigma = 0.36 \times 510 = 183.6$ MPa

Take whichever is small

hence $\sigma = 114$ MPa

we have flexure formula [7],

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

Where,

M = bending moment

w = 1.5 N/mm (as in input standard)

$M = wL^2 / 2 = 1.4 \times 10^6$ N-mm

I = moment of inertia [7]

$$I = \frac{\pi}{64}(D_0{}^4 - D_i{}^4) \text{............ (ii)}$$

We have,

$D_o = 80$ mm

L = 1350mm

$Y = D_o / 2 = 40$mm

So we have,

$\sigma = 114$ N/mm^2

By putting above values in equation (i), we get

$D_i = 74.5$ mm ≈ 75 mm

Now, according to American Society of Mechanical Engineers (ASME) code for the design of transmission shaft the maximum permissible shear stress (τ) may be taken as 18% of ultimate tensile strength (σ_{ut}).

In other words,

$\tau = 0.18\ \sigma_{ut}$

Maximum permissible shear stress,

$\tau = 0.18\ \sigma_{ut}$

$= 0.18 \times 510$

$= 91.8$ MPa

From torsional equation we have [7],

$\frac{T}{J} = \frac{\tau}{R}$……………………. (iii)

Where,

T = torque acting on the shaft

j = polar moment of inertia

τ = torsional shear stress

R = Distance from neutral axis to outermost fibre

$= D_0/2$.... where D is diameter of the shaft

= 40 mm

We know that, for solid circular shaft, polar moment inertia (J) is given by [7],

$J = \frac{\pi}{32}\left(D_0{}^4 - D_i{}^4\right)$ …..... (iv)

$J = 1.0 \times 10^6\ mm^4$

Now, the Shear stress is

$\tau = 0.3\ \sigma_{el}$

$= 0.3 \times 190$

= 57 MPa

Hence,

Torque acting on shaft

$T = 1.425 \times 10^6$ N-mm

Twisting moment,

According to maximum shear stress theory,

Maximum shear stress [5] ,

$\tau_{max} = \frac{16 D_0}{\pi(D_0{}^4 - D_i{}^4)} T_e$…… (v)

where,

$T_e = \sqrt{(M^2+T^2)}$………………. (vi)

By putting values of M and T in eq^n (vi), we get

$T_e = 1.713 \times 10^3\ N/mm^2$

Hence Maximum shear stress,

$\tau_{max} = 68.7\ N/m^2$

According to Macaulay's Method, Maximum Deflection

is given by [5],

$y = \frac{wL^4}{8EI}$…………………….. (vii)

Hence, Maximum Deflection is

y = 6 mm

2. Flight Design:

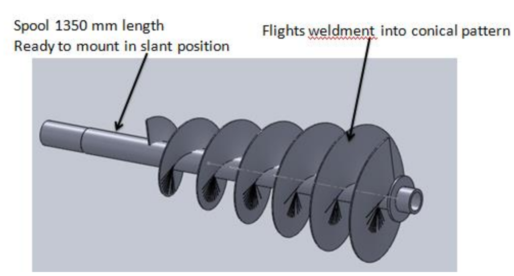

Fig.6 Flights welded on shaft

Flight diameter is taken 420mm means at least 60% of pitch must be considered to give easy spiral bend to the sheet metal flight bending.

Hence maximum possible pitch considering i.e. 250mm. Pitch we will take 150 mm for each flight. We get total 6 flights over the length of spool.

3. Design of Anti bending beam for flight

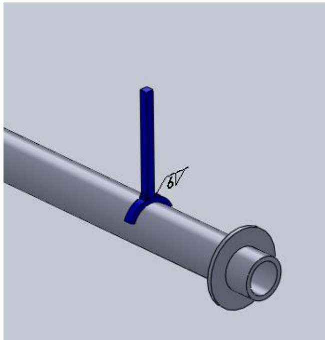

Fig. 7 Anti-bending beam on shaft

T shaped bracket designed for circular mounting and flights are welded with this structure.

This bracket holds all the radial loads coming on flights and sustaining all the bending stresses which may affect flight shape and size with failures. For preventing the bending of flights I designed the this new beam.

Applying loads to see behavior of this beam

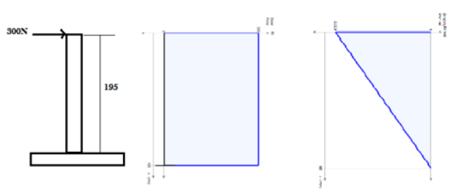

Fig. 8 Load on anti-bending beam

Maximum Shear load = V = 300N

Maximum Bending Moment = M = 58500N-mm

We have from flexure formula [7],

From eq^n (i)

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

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 is given by [7]

$$y = \frac{wL^3}{3EI} \quad \text{(viii)}$$

Hence,

$$y = 0.8\ mm$$

VI. VALIDATION

1. Spool validation

Details of "Moment"	
Scope	
Scoping Method	Geometry Selection
Geometry	1 Face
Definition	
Type	Moment
Define By	Vector
Magnitude	2.7488e+006 N·mm (ramped)
Direction	Click to Change
Suppressed	No
Behavior	Deformable
Advanced	

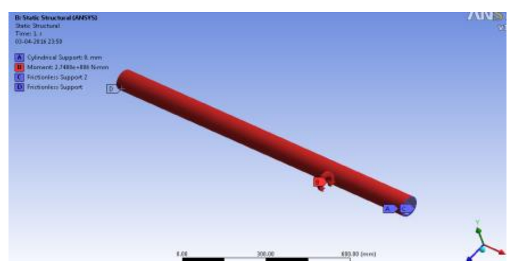

Fig. 10 Spool model in Ansys workbench

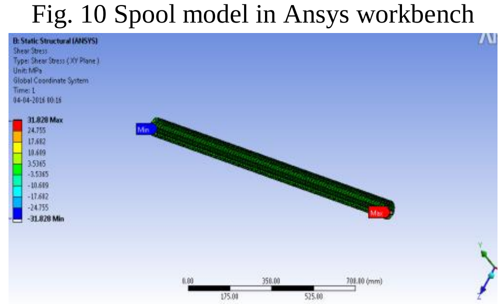

Fig. 11 Stresses on Spool model

Shear stress = 31.82 MPa

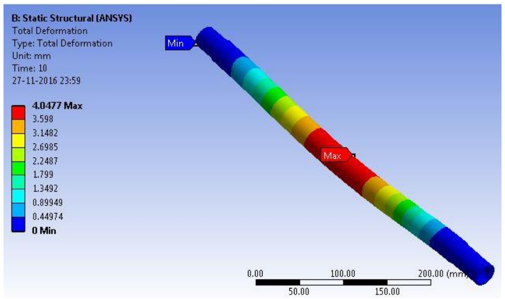

Fig. 12 Deflection of Spool

Deflection = 4.07 mm = 4 mm

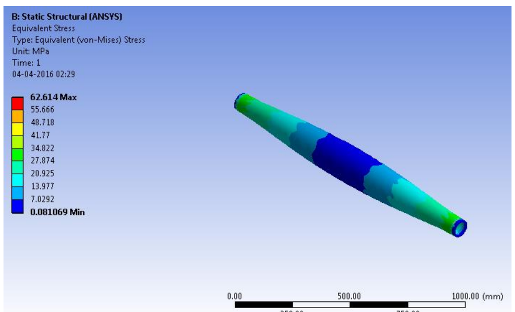

Fig. 13 Von-Mises stress on Spool

62.61 MPa stress found.

2. Anti-Bending Beam

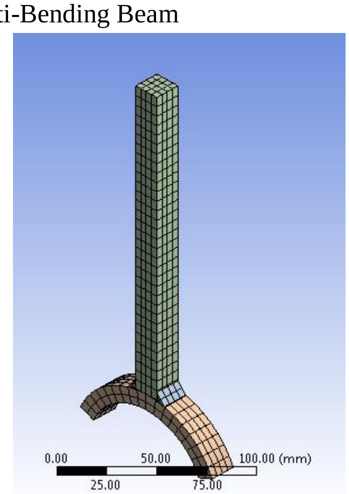

Fig. 14 Mesh generation on Anti-bending beam

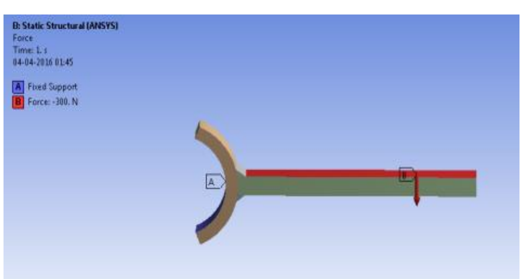

Fig. 15 Forces on Anti-bending beam

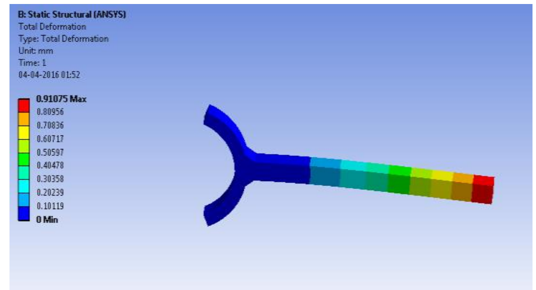

Fig. 16 Deformation on Anti-bending beam

0.9 mm deflection observed.

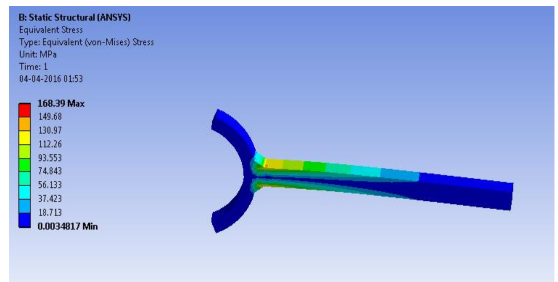

Fig.17 Von-Mises stress on Anti-bending beam

168.39 MPa Von Mises stress observed.

3. Assembly flight deflection

Assembly simulation on CAE

- Applying all boundary condition on all flights simultaneously,
- Analysis on stress and deformation results to validate design ,
- If deflection found positive (beyond zero value) structure of flights joints will get changed.
- Again analysis on rework will be included.

Validation on spool less flighting will evaluated which will help to get conclusion.

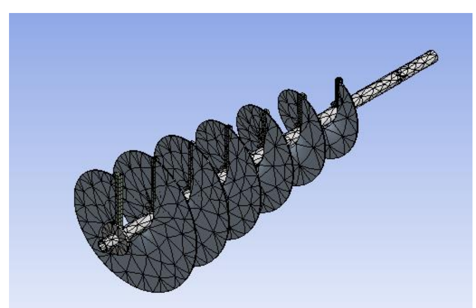

Fig. 18 Meshed model of assembly

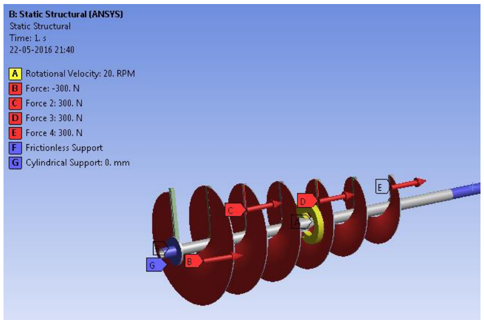

Fig. 19 Boundary conditions applied on assembly

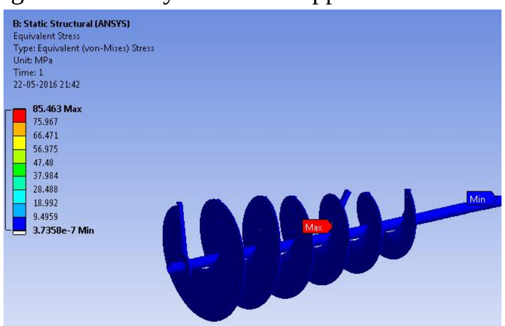

Fig. 20 Von-Mises stress on assembly

Von-Mises Stress = 85.46 MPa

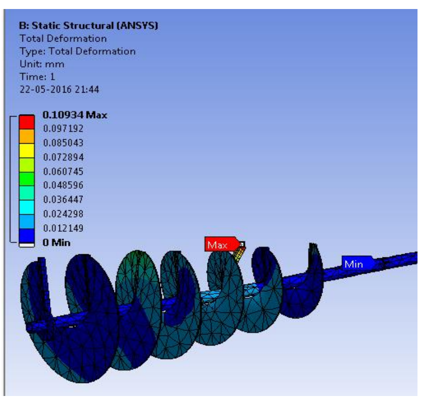

Fig. 21 Deflection on assembly

Deflection is 0.109 max and is negligible

VII. CONCLUSION

Load sustaining parameters are found safe in design. As all the stresses found under yield strength value.

Table I. Comparison of flow rate of Existing and New developed model

Spool	Theoretical value	FEA value
Deflection	6mm	4mm

Anti-bending beam	Theoretical value	FEA value
Deflection	0.8mm	0.9mm

Screw in conical shape feeding vessel can work but welding and joint preparation areas need to be engineered with some specific standard then only manufacturing can be easily take into feasibility.

ACKNOWLEDGMENT

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REFERENCES

[1] Coperin Ktron Industry for process equipment.
[2] Manufacturing of micropellets using Rayleigh Disturbances Polymer Engineering Center 1513 University Ave, Madison, WI 53706
[3] BORTOLAMASI, M., FOTTNER, J., (2001), “Design and sizing of screw feeders”, Proc. Partec 2001, Int. Congress for Particle Technology, Nuremberg, Germany, 27-29 March 2001, Paper 69
[4] Philip J. OWEN (2009), “Screw conveyor performance: comparison of discrete element modeling with laboratory experiments” CSIRO, Melbourne, Australia 9-11 December 2009
[5] Jigar N. Patel (2013), “Productivity Improvement of Screw Conveyor by Modified Design” (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 3, Issue 1, January 2013
[6] Roberts: Aspects of Attrition and Wear in Enclosed Screw Conveyors, Powders & Bulk Solids Conference and Exhibition Proceedings, 1993.
[7] V.B. Bhandari, Design of Machine Elements
[8] CEMC Screw conveyor manual version 2.20 - 2012, by Conveyor Eng. And Mfg. Co.

[9] Stevens, G. N., “Performance Tests on Experimental Auger Conveyors” , Journal of Agricultural Engineering Research, Vol.7, No. 1, 1962, pp. 47-60

[10] Yu, Y., Arnold, P.C., “Theoretical Modelling of Torque Requirements for Single Screw Feeders”