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Performance Improvement of Flow Rate of Spiral Chip Feeder in Pulping Screw Unit

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Abstract **- Work proves the stability and strength of screw feeding mechanism made for outlet of pulping material augur. A screw reactor is a continuous reactor where the feed is transported and mixed by a screw (augur). The operational 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.**

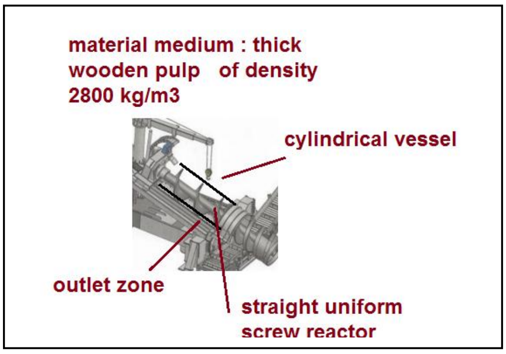
New product development shaped into conical screw feeding reactor with its shaft and flights design. Radial force effect on flight surface in spiral rotation is analysed and performed structural sustaining engineering work on it with validation results.

Keywords— Screw; Radial Force; Pulping material

I. INTRODUCTION

A screw conveyor is also known as auger conveyor. It 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.

Existing Machine Components



Fig, 1 Straight screw feeding

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.

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 [4] 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. Not enough flow output

Augur screw flights, required to make outing of pulp material are not providing enough flow output.

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.

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IV. PROPOSED SOLUTION

Here I am developing 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 shape of flights are also change. The shape of flights are varies as per diametrically referring to outer casing which is now conical in shape.

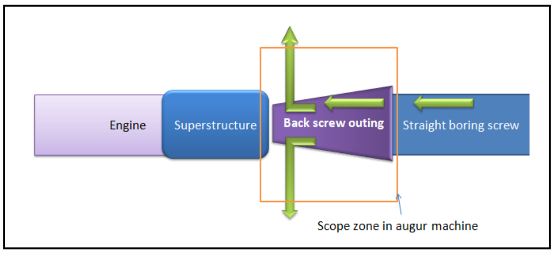

Fig.2 Work Plan Layout

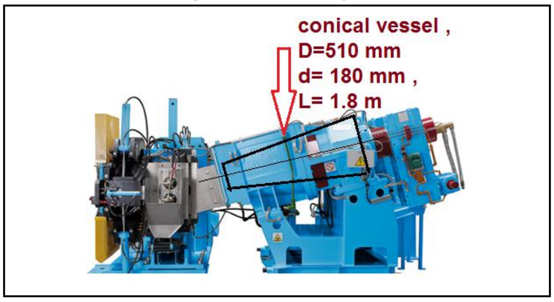

Fig.3 Structure of new Proposed solution

V. DESIGN STRATEGY

Design:

1. *Spool (shaft) Design:*

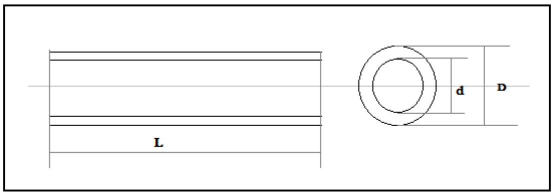

Fig. 4 Spool Nomenclature

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

$$\sigma = 0.6\sigma_{el} \text{ or } 0.36\sigma_{ut}$$

Take whichever is less value
From design data book,
$\sigma_{el} = 190$ MPa
$\sigma_{ut} = 510$ MPa
Hence $\sigma = 0.6 \times 190 = 114$ MPa
Or
$\sigma = 0.36 \times 510 = 183.6$ MPa whichever is small
hence $\sigma = 114$ MPa
we have from 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],

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

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],

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

$J = 1.0 \times 10^6$ 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] ,

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

where,

$$T_e = \sqrt{(M^2+T^2)} \text{.................. (vi)}$$

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

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According to Macaulay's Method, Maximum Deflection is given by [5],

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

Hence, Maximum Deflection is **y** = 6 mm

2. Flight Design:

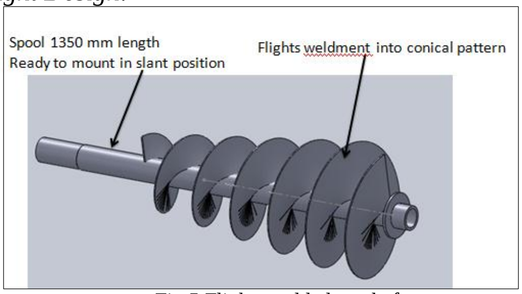

Fig.5 Flights welded on shaft

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

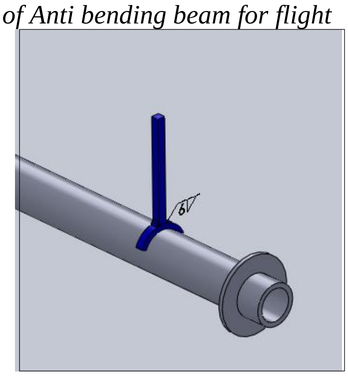

Fig. 6 Anti-bending beam on shaft

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

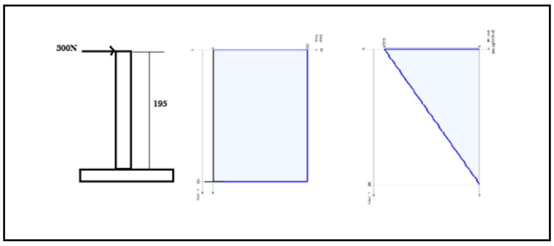

Fig. 7 Load on anti-bending beam

Maximum Shear load = V = 300N
Maximum Bending Moment = M = 58500N-mm
We have from flexure formula [7],
From eq^n (i)

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

Where,
M = bending moment = 58500 N-mm
I = Moment of Inertia = $bd^3 / 12 = 15 \times 15^3 / 12 = 833.33$ mm^4
y = d/2 = 7.5 mm
Hence bending stress
$\sigma = 104$ N/mm^2

Deflection is given by [5]

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

Hence,

$$y = 0.8\ mm$$

4. Flow rate calculation

By referring Fig. 1
Cylindrical vessel volume is given by following formula
Volume of Cylinder = $\pi r^2 h$
V=368 Litres with water content
There was no dewatering in this vessel due to gravity possibilities in cylindrical vessel.

By referring Fig. 3
Volume of Conical vessel is given by following formula-

$$V = \frac{\pi h}{3}\{R^2 + Rr + r^2\}$$

V= 181 Litres

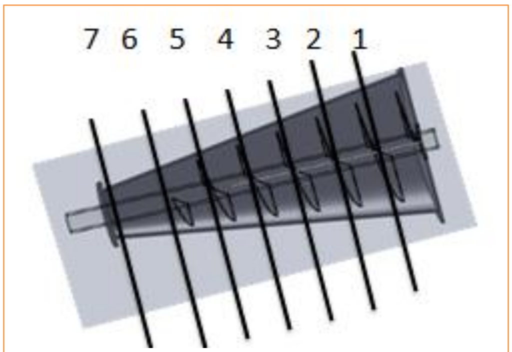

Fig. 8 Compartments formed on new proposed structure

There are total 7 buckets (compartments) with all different in volume.

From CAD data, derived volume of buckets (compartments) 36, 35, 31, 23.5, 19, 18, 18 litres as considered frustum zones and derived diameters from CAD model to get volume of buckets.

Since 50 % water is removed from perforated vessel sheet by squeezing the pulp in screw feeding system. So from starting bucket to end bucket we are getting 36 to direct 18 litre volume.

So from starting bucket to end bucket we are getting 36 to direct 18 liter volume.

Output in 7 rotations = 20/7=2.85
Since speed of this plug screw is rotating at 20 rpm.
Therefore 18x2.85 = 51.3 litre volume output is delivered per minute.

14 rpm condition was delivering 52 litres in one rotation.
For one minute (for 7 buckets) 14/7=2, 2x52 =104 litre
Almost 104 litres was the feed rate per minute.
After this dewatering roll press have cycle time of 6 minutes for per 100 litres volume.
So, 100 litres / 7 min was the production rate of pulping feeder with dewatering.
Existing model = 100 lit/7 Min = 14.2 lit/min
New model = 51.3 lit/ min

VI. RESULTS AND ANALYSIS

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

	Existing Model	New Developed Model
Flow Rate	14.2 Lit/min	51.3 Lit/min

VII. APPLICATIONS

A screw reactor is used for different applications-

It is used for transport of material, drying, thermo chemical reactions and extrusion.

Screw or auger conveyor use in snowblowers, to move snow towards an impeller, where it is thrown into the discharge chute.

An auger is used in some rubbish compactors to push the rubbish into a lowered plate at one end for compaction.

Screw conveyors can also be found in waste water treatment plants to evacuate solid waste from the treatment process.

VIII. CONCLUSION

Load sustaining parameters are found safe in design. As all the stresses found under yield strength value. Screw in conical shape feeding vessel can work. New system is almost 37% more efficient than existing system. We are getting flow benefits because of conical shape. Bigger diameter is for inlet and smaller diameter is for outlet which give outcomes to make gravity flow. As compare to old design there was a simple cylindrical vessel was abstraction to fall material and was coming only by screw rotation. Now it is coming by screw forces and gravity loads of material also.

IX. ACKNOWLEDGMENT

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