Design and Analysis of Twin Screw Conveyor

[1]Akshay Dipak Shivpuje, [2]Assist.Prof.V.S.Mahajan

[1]*Research Scholar, Dept. of Mechanical Engineering, JSPM's Rajarshi Shahu College of Engg, Maharashtra, India*

[2]*Assistant Professor, Dept. of Mechanical Engineering, JSPM's Rajarshi Shahu College of Engg. Maharashtra, India*

Abstract : Screw (Auger) conveyors are widely used in many bulk material applications in industries ranging from industrial minerals, agriculture, chemicals, pigments, plastics, cement, sand, salt, and food processing for transporting and elevating particulates at controlled rates. The purpose of this paper is to explain design steps and to reduce the deflection of the shaft by using hangers in a twin-screw conveyor according to CEMA standards.

IndexTerms – Twin Screw Conveyor, CEMA

I. INTRODUCTION

The screw conveyor traditional method of conveying materials known to mankind it is the simplest and most efficient transport system for bulk materials. With the help of modern technology, the screw conveyor has become one of the efficient and economical methods of moving bulk material. In modern industries screw conveyors are often used horizontally or at a slightly inclined angle as an efficient way to move semi-solid materials. The material is moved forward by the thrust of the screw thread or flight. In modern industries horizontal screw conveyors are often used or at a slight inclined angle as an efficient way to move semi-solid materials. As the angle of inclination increases, the capacity of a given unit rapidly decreases.

II. *DESIGN STEPS*

1) Establish conveying requirements
2) Identify the material and the corresponding material code
3) Determine conveying capacity, conveyor size, and speed
4) Calculate required horsepower - select motor size
5) Determine the recommended size of components
6) Check the torsional ratings of components and deflection

II. I.

A] *Establish conveying requirements*

a) Type of material to be conveyed.
b) Required flow (lbs per hour or cubic feet per hour).
c) Distance material will be conveyed.

B] *Identify the material and the corresponding material code*

When designing a screw conveyor, special considerations must be given to the selection of components if the material conveyed has unusual characteristics

C] *Determine Capacity, Conveyor Size & Speed*

For screws with standard, full pitch flights the conveyor's speed is:

$$N = \frac{Required\ Capacity\ (ft^3/hr)}{1\ Rpm\ capacity\ \ (ft^3/hr)}$$

Equivalent Capacity (ft^3/hr) = Required Capacity x CF_1 x CF_2 x CF_3

$$N = \frac{Required\ Capacity\ (ft^3/hr)}{1\ Rpm\ capacity\ \ (ft^3/hr)}$$

D] *Calculating Horsepower (Horizontal Conveying)*

Frictional HP =

$$\frac{Conveyor\ length\ (F_l) * Speed * Screw\ Diameter\ Factor\ (F_d) + Bearing\ loading\ factor (F_b)}{10^6}$$

Material HP =

$$\frac{Conveyor\ Capacity\left(\frac{ft^3}{hr}\right) * Screw\ length(ft) * material\ wt\ \left(\frac{lbs}{ft^3}\right) * flight\ factor\ (F_m) * paddle\ factor(F_b)}{10^6}$$

Total HP $= \frac{(HP_m+HP_f)*F_o}{drive\ efficiency}$

E] ***Determine the recommended size of components***

To properly select the screw conveyor components for a particular duty, they are broken down into three components groups that relate to both the material classification code and to the screw size, pipe size, type of bearings and trough thickness.

F] ***Check the torsional ratings of components& deflection***

Screw conveyors are limited in overall length and size by the amount of torque that can be safely transmitted through the components selected as per engineering & manufacturing design standards (CEMA standards).All the components are needed to be sized appropriately for the drive horsepower and rpm.

$$\text{Torque (TQ)} = \frac{63025*HP}{RPM}$$

The amount of deflection the screw pipe experiences due to the screw weight is directly proportional to its useful life. Deflection of a standard length screw is rarely a problem. However, if longer than standard screw sections are to be used without intermediate hanger bearings, care should be taken to prevent the screw flights from contacting the trough. Deflection should be held to a minimum to increase the useful life of the screw.

$$D = \frac{wl^3}{384EI}$$

D = Deflection at mid-span in inches (horizontal screw)
W = Total screw weight in pounds
L = Screw length in inches
E = Modulus of Elasticity (2.9 x 107 psi for carbon & stainless)
I = Moment of Inertia of pipe.

II. Experimental Calculation:

Given data:

1. Material used- Limestone
2. Required capacity- 30TPH
3. Trough length- 7.6m
4. Filling Factor- 33%
5. Bearing factor (F) = 1
6. Screw speed- 55rpm
7. Screw outer diameter- 249.783mm
8. Diameter factor (Fa) -37
9. Screw center pipe diameter- 113.4mm
10. Screw pitch-250.83mm
11. Flight thickness- 5mm
12. Bulk density- 1000(kg/m)
13. Diameter factor (Fa) -37 mm
14. Bearing to Bearing Centre distance(C) - 8500mm 334.6457inch

Design Capacity = $\frac{\pi}{4}$ * Screw Speed * $\frac{bulk\ density\frac{kg}{m^3}}{1000}$ * [$OD^2 - CD^2$] * pitch * filling factor * 60

= $\frac{\pi}{4}$ * 55 * $\frac{1000}{1000}$ * [$249.783^2 - 113.4^2$] * 250.83 * 0.33 *60

= 9.66 TPH

Frictional HP = $\frac{Conveyor\ length\ (F_l) * Speed * Screw\ Diameter\ Factor\ (F_d) + Bearing\ loading\ factor (F_b)}{10^6}$

$= \frac{24.936*55*37*1}{10^6}$

= 0.050HP

Material HP = $\frac{Conveyor\ Capacity\left(\frac{ft^3}{hr}\right)*Screw\ length(ft)*material\ wt\ \left(\frac{lbs}{ft^3}\right)*flight\ factor\ (F_m)*paddle\ factor(F_b)}{10^6}$

$= \frac{339.359 * 22.965 * 93.642*1*1.8*1}{10^6}$

= 1.316 HP

Overload Factor (F_o) = 1.1

Total HP = $\frac{(HP_m + HP_f)*F_o}{drive\ efficiency}$

$= \frac{(0.050+1.316)1.1}{0.87}$

= 1.727 HP

Deflection $= \frac{Flight\ thickness * screw\ wt(lbs) * c^3}{384 * E * 1}$

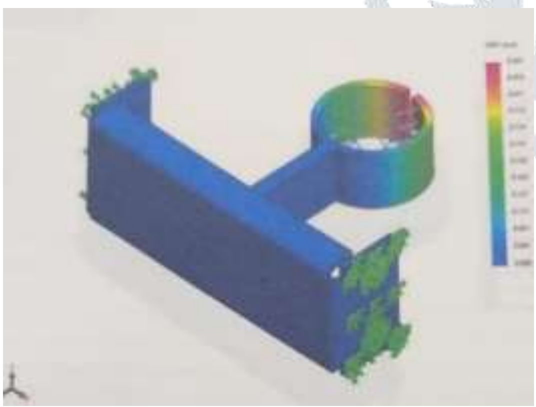
$= \frac{5*1496*334.6457^3}{384*29*10^6*161}$

= 0.156 inch = 3.962 mm

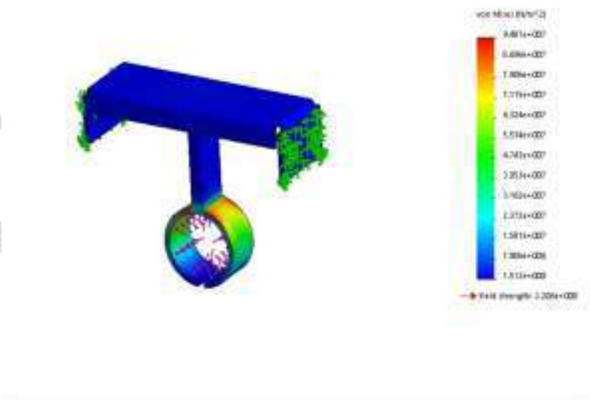
(Value of constants and factors like filling factor , F_f, F_d, F_p, F_o, F_b bulk density, moment of inertia are taken from CEMA standard Catalogue)

III. Results

Displacement of hanger

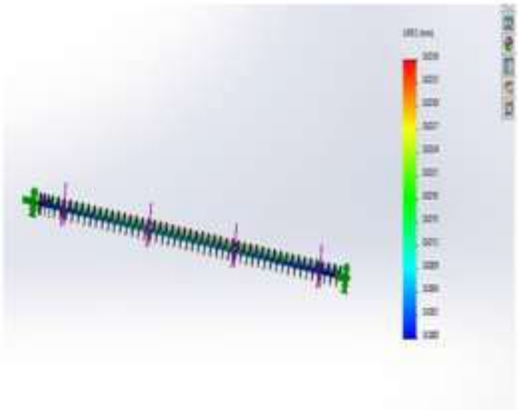


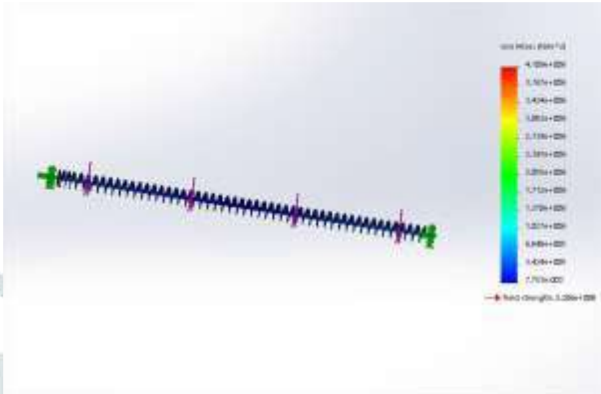
Stresses in hanger



Displacement of Shaft & flights

Stresses in Shaft & flights





V. Conclusion

1. The total shaft length used in the screw conveyor was 7.6 m which was comparatively long, due to which there will be large amount of deflection at the mid span. So shaft is cut into appropriate length and are joined by using bushes, so that there will be reduction in deflection.
2. Experimentally deflection value of shaft is 3.96 mm which is less than the allowable value 5mm.
3. We can reduced the deflection by using hanger at the joints. After an FEA analysis by using hangers, it was found that the deflection of mid span of shaft is 0.044 mm which is far less than the experimental value. So we can conclude that design is much safer with hangers.

VI. REFERENCES

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