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Design and Analysis of Twin Screw Conveyor

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ABSTRACT

Screw (Auger) 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, salt and food processing. They are also used for metering (measuring the flow rate) from storage bins and adding small controlled amounts of trace materials such as pigments to granular materials or powders. Many studies on screw conveyors were conducted to examine performance and to develop new types [1]. Most of these studies were experimental in nature. Purpose of this paper is to explain design steps and to reduce the deflection of shaft by using hangers in twin screw conveyor according to CEMA standard(CONVEYOR EQUIPMENTS MANUFACTURER'S ASSOCIATION).

Keywords*: Screw Conveyor, Twin Screw Conveyor, CEMA Standard.*

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1. INTRODUCTION:

The screw conveyor is simplest and most efficient transport system for the bulk materials and is widely used in all fields of industry. A screw conveyor consists of a shaft mounted screw rotating in trough and a drive unit for running the shaft. The basic principle of material which is moved forward along the axis of trough is similar to the sliding motion of nut along a rotating screw when nut is allowed to rotate. The material is moved forward by the thrust of screw thread or flight [2]. Screw conveyors in modern industry are often used horizontally or at a slight incline as an efficient way to move semi-solid materials, including food waste, wood chips, aggregates, cereal grains, animal feed, boiler ash, meat and bone meal, municipal solid waste, and many others. The first type of screw conveyor was the Archimedes' screw, used since ancient times to pump irrigation water. Since the screw conveyor came into general use a little over a century ago for moving grains, fine coal and other bulk material of the times, it has come to occupy a unique place in a growing area of material handling processing. Today, modern technology has made the screw conveyor one of the most efficient and economical methods of moving bulk material. Screw conveyors can be operated with the flow of material inclined upward. When space allows, this is a very economical method of elevating and conveying. As the angle of inclination increases, the capacity of a given unit rapidly decreases.

1.1 Advantages of Twin Screw Conveyor:

Twin Screw Conveyors:
1.Are compact and easily adapted to congested locations.
2.Can transfer more material than single screw conveyor for same distance.
3.For bulky materials jamming of screws does not occur.
4. Can be used to control the flow of material in processing.
5.Are versatile and can be employed in horizontal, inclined and vertical installations
6. Can be sealed to prevent the escape of dust or fumes from inside of conveyor or keep does or moisture from entering into it.

2. 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.
7. Check deflection, thermal expansion and abrasion.

2.1 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.

2.2 Identify the material and the corresponding material code:

The type of material being moved can have a significant effect on the size and type of conveyor needed. The following charts will help you to classify your material and will help in selecting the proper conveyor components.

2.3 Determine capacity, conveyor size and speed:

$$N=\frac{\text{Required capacity }\left(\frac{ft^3}{hr}\right)}{\text{1 rpm capacity }\left(\frac{ft^3}{hr}\right)}$$

Equivalent Capacity (ft3/hr) = Required Capacity x CF1 x CF2 x CF3

$$N=\frac{\text{Equivalent capacity }\left(\frac{ft^3}{hr}\right)}{\text{1 rpm capacity }\left(\frac{ft^3}{hr}\right)}$$

Where,
CF1- Pitch Screw Capacity Factor.
CF2- Screw Flight Modification Capacity Factor.
CF3- Screw Mixing Paddle Capacity Factor.

2.4 Calculating Horsepower (Horizontal Conveying):

Frictional HP (HP_f)= $\frac{LNF_dF_b}{10^6}$

Material HP (HP_m) = $\frac{CLD\,F_fF_mF_p}{10^6}$

Total HP (HP_{total}) $=\frac{(HP_f+HP_m)F_o}{e}$

2.5 Determine 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. The following service tables are a guide to proper selection of the appropriate component group for the material being conveyed. Other components are then selected from the Components Section of this catalogue to suit the physical layout of the conveyor.

2.6 Check torsional ratings of components:

Screw conveyors are limited in overall length and size by the amount of torque that can be safely transmitted through the components selected. The shafts, bolts and pipe all need to be sized appropriately for the drive horsepower and rpm. Table Q combines the various torsional ratings of bolts, couplings and pipe so that it is easy to compare all stressed parts of standard conveyors. The table conforms to Conveyor Eng. & Mfg. design standards (often more conservative than CEMA standards).

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

2.7 Check screw deflection:

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.

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3. Experimental Calculation:

Given data:

1. Material used – Limestone
2 .Required capacity- 30TPH
3. Trough length- 7.6m
4. Filling Factor- 33%
5. Screw speed – 50rpm
6. Screw outer diameter- 250mm
7. Screw centre pipe diameter- 114.3mm
8. Screw pitch- 250mm
9. Flight thickness- 5mm
10.Bulk density- 1000(kg/m^3)
11. Diameter factor(F_d)= 37
12. Bearing factor(F_b)= 1
13. Bearing to Bearing Centre distance(C) = 8600mm=338.58inch

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

$$=\frac{\pi}{4} * 50 * \frac{1000}{1000} * [250^2 - 114.3^2] * 250 * 0.33 * 60$$

=9.61 TPH

Frictional HP $= \frac{\text{conveyor length (ft)} * \text{speed} * \text{screw diameter factor } (F_d) * \text{bearing loading factor } (F_b)}{10^6}$

$$= \frac{24.934*50*37*1}{10^6}$$

= 0.043 HP

Material HP

$$= \frac{\text{conveyor capacity } \left(\frac{ft^3}{hr}\right) * \text{screw length (ft)} * \text{material wt.} \left(\frac{lbs}{ft^3}\right) * \text{flight factor } (F_f) * \text{material factor } (F_m) * \text{paddle factor } (F_p)}{\mathbf{10^6}}$$

$$= \frac{339.359*24.934*93.642*1*1.8*1}{10^6}$$

= 1.426 HP

Overload factor(F_O) =1.1

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

$$= \frac{(0.043+1.426)1.1}{0.87}$$

= 1.86 HP

Deflection $= \frac{\text{Flight thickness } * \text{screw wt (lbs)} * C^3}{384 * E * I}$

$$= \frac{5*1496*338.58^3}{384*29*10^6*161}$$

= 0.161 inch=4.11 mm

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

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4. Results:

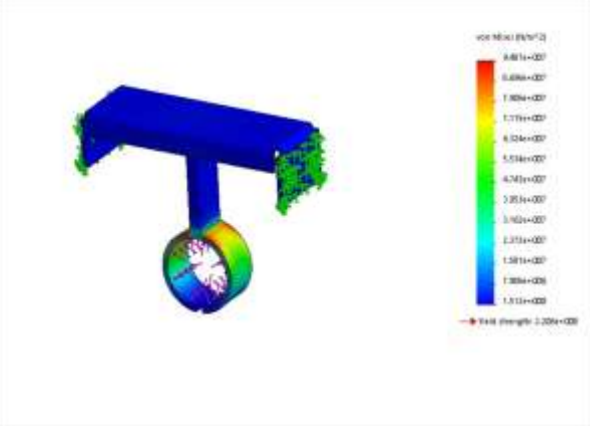

Fig. 1 Stresses in hanger

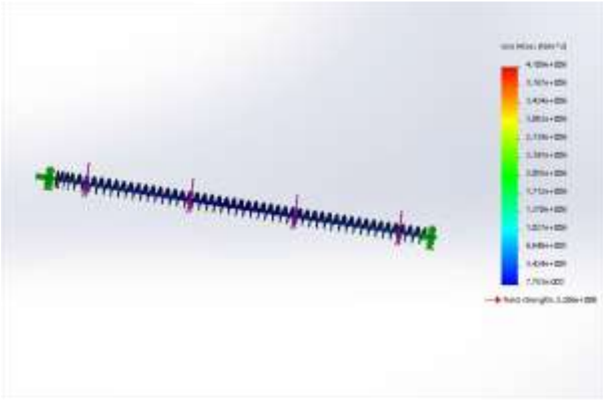

Fig. 3 Stresses on shaft & flights

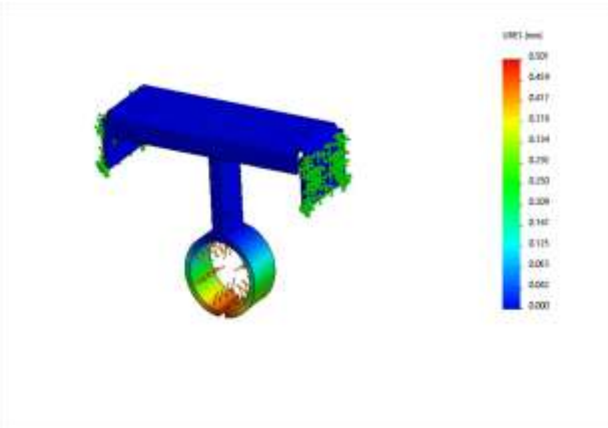

Fig. 2 Displacement of hanger

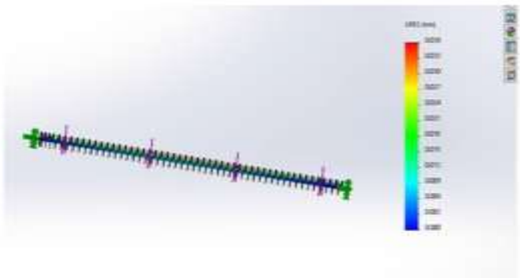

Fig. 4 Displacement of Shaft & flights

5. 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 it was found that the deflection of shaft(without hanger) is 4.11mm which is less than the allowable value i.e. 5mm.
3. But this deflection at the mid span can also be reduced by providing the hangers at the joints of the shaft. After doing FEA analysis by using the hangers , it was found that the deflection of shaft at the mid span is 0.036mm which is far less than the experimental value. Hence the design is more safe after using the hangers.

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