MEE 510

PRODUCT DESIGN

15/ENG/06/020

1) PRODUCT DESIGN

The product to be designed and fabricated is a material handling system(vertical conveyor) which is to be used to transfer work materials from their ground point to the work stations.

2) MATERIAL SELECTION

1. Mild Steel Rod
2. Angle Iron
3. Mild Steel (H Channel)
4. Conveyor Rope Hook
5. Release Plate
6. Conveyor Plate

3) FACTORS CONSIDERED IN CHOOSING MATERIALS

1. Tensile Strength
2. Modulus
3. Creep
4. Compressive Strength
5. Impact Strength

4) DESIGN SPECIFICATIONS

Design Specifications are all shown in file attached to document

5) DESIGN DRAWINGS

Design drawings are shown in file attached to the document

6) BEME

The bill of materials is shown in the image attached to the document

7) DESIGN CALCULATIONS

**Bending control**

The bending stress “σb” of the shaft was calculated using Equation (1) for hollow shaft:

b= 32BMdo(do4-di4) (1)

where b = bending stress (N m-2);

BM = bending moment (N m);

do = outside shaft diameter (mm);

di = inside shaft diameter (mm);

π =3.142 (constant).

To obtain bending moment “BM”

q = 2.14 kg m-1 = 21.0 N m-1

l = 2440 mm

For uniformly distributed load (UDL)

If reaction at A=Ra and at B=Rb

Ra + Rb = ql (2)

where, q = weight of the material;

l = length of the shaft.

ql = 21.0× 2.44 = 51.24 N/m

But Ra = Rb

And Ra = ql12and Rb = ql12b

Ra= 51.242=25.62

But 2.44 m Ra = Rb

Since the system is an UDL

Rb = 25.62 N

To obtain bending moment “BM” for Equation (3)

Hibler (2002)

BM= ql28

q = 21.0 N m-1

l = 2.44 m

BM= 21.0⨯(2.442)8=15.63Nm

BM = 15.6282 N m

From Equation (1)

b= 32BMdo(do4-di4)

do = 33 mm = 0.033 m

di = 24.5 mm = 0.00245 m

π = 3.142

b= 32⨯15.63⨯0.3303.142(0.3304-0.2454)=6.36210-6N/m2

**Torsional control**

Angle of twist = T×LG×J (4)

where, T = Torque or torsional moment (N m);

L =Length of the shaft (m);

G = Modulus of rigidity of the shaft (N m-2)

J = Polar moment of inertia of the cross section area about the axis of rotation (Nm-2)

Torsional moment, T= 2T×JD (5)

J = Polar moment of inertia of the cross section area about the axis of rotation (Nm-2)

But

𝐽= (do4-di4)32 (for holllow shaft)

T= π×J×(do4-di4)σ×D

where, J = maximum shear stress (according to ASME code is 53 × 106 N m-2);

π = 3.142;

D = Diameter of the shaft (m);

do = outside diameter of the shaft (m);

di = inside diameter of the shaft (m)

3.142 53 106 0.03444- 0.02454 160.085= 1010.9353 Nm

T = 1010.9353 N m

Diameter control dL=3 32Ttπt

where,

BM = bending moment = 15.6282 N m;

T = torsional moment = 1010.9353 N m;

J = allowance

shear = 53×106 (N m-2);

T=(15.6282)2+ (1010.9353)2= 1011.0561 N m-2

3 32 1011.0560923.14253××106=5.79cm

dL= 5.7912cm

dḺ = 5.7912,

π = 3.142

D = diameter of the auger (m)

S = pitch of the auger = 31 mm = 0.031 m

**Driving power of the motor “P”**

P = Q g (Lv.Ki H)k (9)

where, Q = capacity of the auger (kg s-1);

Ki = coefficient of friction for grains and chopped hags (ki ranges between 2.2-2.7);

Ki = overloading coefficient (k = 1.05-1.2);

Lv = length of the conveyor = 2.44 m,

H = perpendicular height = 1.840 m;

g = acceleration due to gravity =9.81 m s-2

From Equation (9)

P = 0.8333× 9.81(2.44× 2.7 +1.840)×1.2 = 82.68 W

Therefore for safety factor the driving power “P” is taken to be 90 watt.

**Driving force of the conveyor**

If the conveyor must function, the angular moment is expected to be directly proportional to the angular force which should be greater than the required driving force.

Actual angular force

Fw=2Mwditan⁡(a+B)

where, Mw = Angular moment;

di = Diameter of screw where the bulk of the materials moves (m);

Q = Pitch angle, R = 23°;

B = Frictional angle for the whole screw(°)

From F = tan B (11)

F = Coefficient of friction (F = 0.32-0.58)

B = tan−1 F (12)

Therefore

B = tan-1 0.38= 20.81°

Angular momentum for the shaft was calculated using the Equation (13)

Mw=qm2πn(Nm)

where, qm = weight of the materials to be transported (kg m-1) and is given as Equation (14)

qm= QsV

n = number of screw rotation and is taken according to the conveyor materials for dense (Coarse) material.

where, n = 0.8-1.5.

V = Velocity of the auger (m s-1) and is given as Equation (15)

V = S ×π (15)

where, S = Pitch of the auger = 0.031 m s-1;

V = 0.031 × 3.142 = 0.09740 m s-1

From Equation (14)

qm=0.83330.09740=8.56 kg/m

Therefore

Actual qm = 8.56 × 2.44 = 20.88 kg

From Equation (13)

Mw=20.8823.1421.5= 2.2151 Nm

Fw=22.2151110tan⁡(23°+20.81°)=0.04198N°

Magnitude of the driving force “F0” was determined using the Equation (16)

Fo'=qmLvHf.g(N)

where, Lv = length of the conveyor (m

H = vertical height (m);

f = coefficient of friction;

g = acceleration due to gravity (m s-2).

therefore

Fo' = 8.56(2.44 +1.84)0.38 9.81 =136.57 N

The driving force F′0 must be greater than the Angular force. i. e. F′0>F0

i.e. 136.57 > 0.04198

8) DESIGN PROCESS

**Fabrication of Lifting Structure**

The fabrication of the lifting structure began with assembling the two main posts. The Two-Posts were assembled using horizontal braces that were evenly spaced along its length. The top horizontal brace of the lifting structure was the most important of all of the horizontal braces because it housed the electric chain hoist mounts. These braces were attached to the two main posts using screws. The installation of the braces give room for the added weight of the load the hoist would be lifting to be fully supported by the lifting structure.

After this was achieved, the material cart fabrication began with cutting the aluminum into the necessary lengths.

The safety cage was the last piece of the conveyor to be installed. The safety cage was designed to fit around the base of the conveyor with a safety space between it and the conveyor. This space between the safety cage and the conveyor was to restrict a person from placing a finger through the holes in the cage panels and becoming caught in the moving parts of the conveyor.

Finally, the electric chain hoist was added to the conveyor so that testing could begin. The hoist was hung from the eye bolt that was installed into the top horizontal brace of the lifting structure, and the hoist was then simply plugged into a 110 volt outlet to supply power for the hoist's operation. The hoist chain was then attached to the mounting hole on the plate on the back of the material cart.