

Design and Modeling of Slat conveyor for Two Wheeler Assembly line

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Abstract - In this paper design calculation and modeling part of 2 wheeler assembly line slat conveyor is suggested for the company who is in the process of atomization of plant. Company needs dedicated conveyor system for 8 station 2 wheeler assembly line. Customer specifies functional requirement of conveyor i.e. working speed, width, weight. Input parameters are reference specification consider for design calculation. With the proposed conveyor System labor cost will be reduced also transportation of material handling cost will be reduced. On this conveyor system vehicle move from first station to last station and assembly operations are performed simultaneously with the help of control panel.

Key Words: Slat conveyor, Design calculation, Input parameter, moving weight, pull force, Modeling.

1. INTRODUCTION

A conveyor system is a common piece of mechanical handling equipment that moves materials from one location to another. Conveyors are especially useful in applications involving the transportation of heavy or bulky materials. Conveyor are mainly consisting of one or more endless chain on which slat, roller or belt are attached to form moving support of object being conveyed. They are driven by motor or gravitation energy. Many kind of conveying system are available and used according to various needs of different industries. Chain conveyor, roller conveyor, slat conveyor, gravity conveyor, belt conveyor, overhead conveyors commonly used in many industries including mining, automotive, agriculture, computer, processing, food, electronic, aerospace etc. for various purpose and application. Conveyors are used across the wide range in the industries due to numerous effects they provide.

The project is design and development of slat conveyor for the application of 2 wheeler assembly line. Conveyor mainly consists of component sprocket, chain, drive assembly, take up assembly, electric motor, torque convertor etc. Number of factors are including in the design and development of the conveyor like load calculation, conveyor chain selection, design of the various component, layout design, drafting, modelling, detail drawing etc.

The essential requirements of a good materials handling system may be summarized as:

- 1) Efficient and safe movement of materials to the desired place.
- 2) Timely movement of material when needed.
- 3) Supply of material at desired rate.
- 4) Storing of materials utilizing minimum space.

2. DESIGN METHODOLOGY

The parameters used for design of entire conveyor system are,

- Speed of conveyor
- Width of conveyor
- Number of station
- Total moving weight
- Chain pitch
- Number of sprocket teeth

The above parameters are considered during design of conveyor system. These parameters are reference specification specified by customers as their requirement. The design procedure used for conveyor system is as follows,

1. Calculate pull force and torque required for moving conveyor system with desired speed by calculating total moving load.
2. Select suitable conveyor chain.
3. Calculate power required to drive conveyor system select motor which gives desire power and speed with suitable speed reduction ratio.
4. Select torque limiter by considering motor output torque and require torque.
5. Select transmission chain
6. Shaft design
7. Bearing selection
8. Slat design
9. Take up screw design
10. Structure design

After completing entire design of conveyor system modeling conveyor by using software AUTOCAD and Solid EDGE.

3. INPUT PARAMETERS

Input parameters are reference specification such as number of station required, weight of the component, size of the component to be handled, required speed of the conveyor or any special requirement like auto lubrication, take up arrangement, overload protection arrangement etc. The specifications are specified by the customer as per their requirement.

The input parameter or specifications required for assembly line conveyor are described as follows,

1. Component to be handled : Scooter
2. Application of conveyor system : Assembly line
3. Number of station : 8
4. Conveyor length : 22m
5. Maximum total weight on conveyor : 1200kg
6. Component size (mm) L×W×H : 2000×500×1200 (Apprx.)
7. Chain pitch : 200mm
8. Speed of conveyor : 1 to 5mpm
9. Overload protection arrangement : Torque limiter

4. DESIGN CALCULATION FOR SLAT CONVEYOR

Slat Conveyor is design and developed for 8 station two wheeler assembly line. Conveyor length given in the specification is 22m from that distance between two stations i.e. station pitch is calculated.

Station pitch = 2.75m

4.1 Pull force calculation

Pull force is that force required for moving the chain, connected mechanical parts and object being conveyed. Chain pull force required for the conveyor system is dependent on the following factor,

1. Weight of object carried
 2. Conveyor chain weight
 3. Weight of support element
 4. Coefficient of friction
- Calculate total moving weight by calculating chain weight, vehicle total weight and slat weight multiplying total moving weight by coefficient of friction we can get pull force.
 - Over all coefficient of friction is due to bearing, rolling and flange friction so overall coefficient of friction is calculated by using the following formula,

$$\mu = (\mu' \times d + 2 \times k) / D \beta$$

Where, μ' = Bearing Friction=0.045
 d = Bearing average Diameter=3.5cm
 k = Friction Rolling / Sliding =0.045
 D = Roller Diameter =5.5cm
 β = Flange Friction =1.4

- Torque required at sprocket to drive the conveyor system is multiplication of pull force and sprocket radius. Before calculating pull force selection of sprocket teeth, pitch and calculation of PCD of sprocket is required.

Torque = force * radius

$$PCD = \frac{\text{pitch}}{\sin \frac{180}{Z}}$$

Calculations

1. Total chain weight = 4200kg = 4.2 ton
2. Total vehicle weight on conveyor = 1200kg
3. Total weight of all slats = 1824 kg.
4. Total Number of slats = 228
5. Number of ideal slats = 182
6. Number of load slats = 46
7. Total moving weight = 7224 kg
8. Pull force = 500kgf = 4905 N
9. Coefficient of friction = 0.06
10. Torque required at sprocket = 1600Nm

For this conveyor system 500 kgf. i.e. 4905 N pull force and 1600Nm Torque is required to drive the conveyor with 7224kg moving weight.

4.2 Conveyor chain selection

A conveyor chain is chain that has been designed specifically for chain conveyor systems. It consists of a series of journal bearings that are held together by constraining link plates. Each bearing consists of a pin and a bush on which the chain roller revolves. Chain gives motion to the slats attached on it and convey the object. It is subjected by tensile stress due to the pull force so selection of chain is depend on pull force applied by the motor and strength of chain.

- Required strength of chain is obtained by multiplying pull force by service factor. Select the chain for that strength from the manufacture catalogue.
- For this conveyor system,

Required strength of chain = 4000 kgf

Where, service factor $C_s = 8$

4.3 Power calculation and motor selection

The parameters required to calculate the required power are,

- Speed at motor output shaft
- Output motor torque
- Speed reduction ratio
- Drive shaft and motor is connected by the transmission chain so Speed and torque changes from motor to drive shaft. It is necessary to consider appropriate transmission ratio.
- Drive shaft speed is calculated from required conveyor speed select appropriate speed reduction ratio and calculate required speed and torque at motor output shaft.
- Calculate require motor power by using the formula,

$$\text{Required motor power} = \frac{2\pi NT \times Cs}{60 \times E}$$

Where, Service factor $C_s = 1.3$

Transmission efficiency $E = 0.90$

For this conveyor system,

Speed reduction ratio = 3

Speed at drive shaft = 3.04

Torque at drive shaft = 1600Nm

Speed at motor output shaft = 9.12

Torque at drive shaft = 533.33 Nm

Required motor power = 0.75 Kw

From the catalogue 0.75 Kw with 9.2 rpm output speed geared motor is selected which gives required torque and speed at drive shaft with transmission ratio 3.12

4.3 Drive shaft design

Drive shaft is subjected by bending and torsional moment. It is made up of ductile material hence maximum shear stress theory is used to design shaft

40Cr4 material is used for drive shaft

Yield strength $S_{yt} = 550\text{MPa}$

According to maximum shear stress theory and ASME code,

$S_{sy} = 0.30S_{yt} = 165\text{MPa}$

Permissible shear stress (τ) for 40Cr4 is 100MPa

\therefore Factor of safety, $f_s = S_{sy}/\tau = 1.65$

F.B.D. and B.M.D. of shaft and is shown in fig. Length of shaft is considered as per working condition and space available

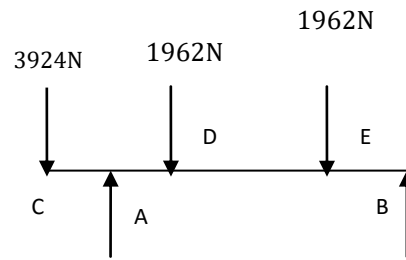


Fig.no.4.1 F.B.D. of drive shaft

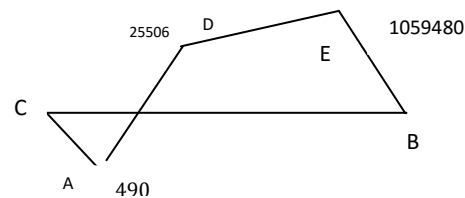


Fig.no.4.2 B.M.D. of drive shaft

Maximum bending and torsional moment is at C & E.

$$M_{bmax} = 1059480 \text{ Nmm}$$

$$M_{tmax} = 968050.8 \text{ Nmm}$$

According to maximum shear stress theory and ASME code,

$$\tau = \frac{16}{\pi d^3} \sqrt{K_b M b^2 + K_t M t^2}$$

$$d = 37.15\text{mm} \approx 40\text{mm}$$

Designed value of shaft diameter is 40mm according to maximum shear stress theory. 40 mm shaft diameter is required for drive shaft of conveyor.

5. MODELLING:

Generate the model of the component of conveyor as per the design by using the CAD software like AutoCAD, SOLID EDGE. 2D models are generated by using the software AUCAD 2014 and 3D models are created on SOLID EDGE ST3.

There are different component of conveyor listed as,

- i. Drive shaft
- ii. Take up shaft
- iii. Slat
- iv. Conveyor chain
- v. intermediate structure

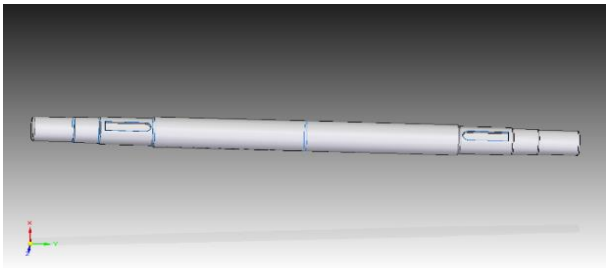


Fig 5.1 Take up shaft

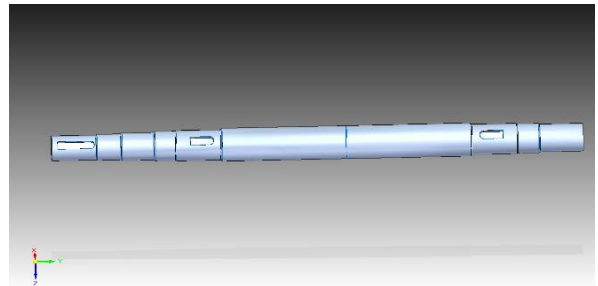


Fig.5.2 Drive shaft

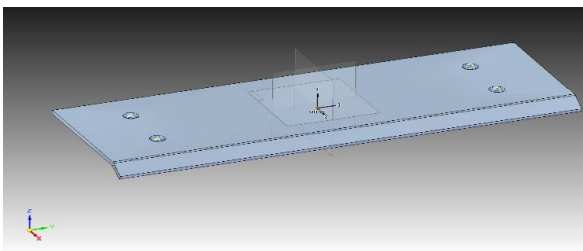


Fig 5.3 Idle slat

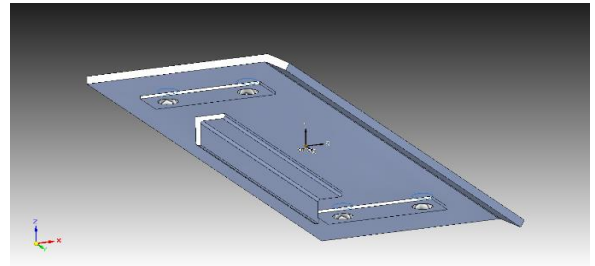


Fig. 5.4 Load slat

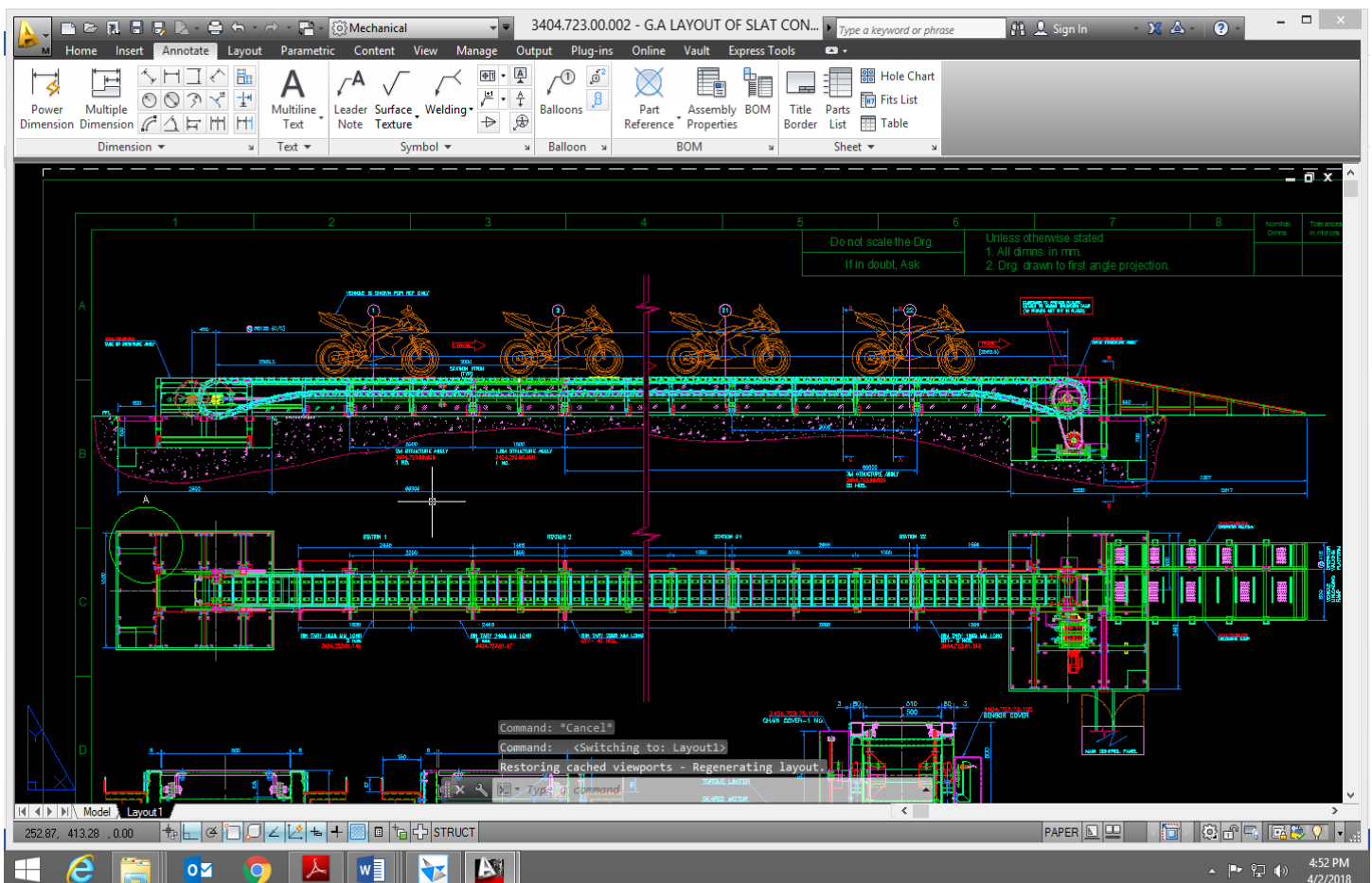


Fig.5.5 G A Layout of slat conveyor

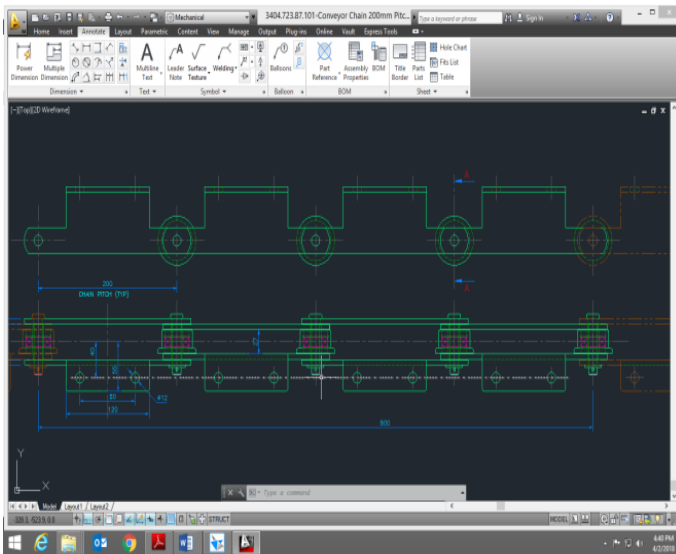


Fig.5.6 Conveyor chain

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3. CONCLUSIONS

1. Design calculation and modeling part of project design and development of 2 wheeler assembly line slat conveyor is completed here. This project is for company who is in the process of atomization and need slat conveyor for assembly line of two wheeler.
2. The pull force required to move conveyor chain in this conveyor system is 4905N for total moving load 7224Kg.
3. To drive the conveyor required speed and load 0.98hp motor with 9.8rpm output speed geared motor is selected and secondary speed reduction ratio is 3:1
4. The component gets modelled by using solid edge software and final assembly of conveyor system is completed. AUTOCAD software is used to create 2D drawings.

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