DESIGN, ANALYSIS AND OPTIMIZATION OF ROLLER IN BELT CONVEYOR SYSTEM FOR WEIGHT REDUCTION

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Abstract: Belt conveyor systems play a very important role in material handling system. It moves the materials from one place to another place. The path for material transportation in conveyor system is large as compared to other material handling system. Design of conveyor system is simple and it has high load carrying capacity. Maintenance of belt conveyor system is also very easy and high reliability of operation. Design of material handling equipment is very ergonomics design. Material handling equipment are easy for facilitating easy, cheap, fast and safe loading and unloading. The main objective of conveyor systems is easy handling of materials of large weight and at large height which is very difficult to handle the human. The objective of this paper work is to design the idler for light weight materials which has less cost and high efficiency, which will increase the productivity at same time it should reducing dangers to workers operating that systems. In this paper study the existing Belt conveyor system and optimize roller to reduce the weight of assembly and to save the cost. Paper includes geometrical modeling by Catia V5R20 and Finite element analysis in ANSYS14.0. Results of different materials for idler in Finite Element Analysis stated.

KeyWords: Belt conveyor, Idler, Polythene roller, Aluminum Roller

1. Introduction:

Material handling system plays a very important role in industry. There are different methods for material handling such as crane, conveyor systems, fork lifting, bucket elevators, etc. plays a very important role for transporting and lifting materials or unit loads from one place to another. In different processing and manufacturing industries there is requirements of moving materials from one place to another hence conveyor system is used in such types of industries. For easily, fastly, safely and most efficiently transporting the materials from one place to another without manual handling belt conveyor system is very useful. According to the loads to be handled there are many types of conveyor systems like Chain conveyor, Belt conveyor, Screw Conveyor, Gravity and Bucket conveyor , Pneumatic and hydraulic conveyors etc. The selection of material handling equipments is mainly according to the nature of materials to be handled, size and weight of materials to be transported, distance of transportation and the volume to be transported, speed of transportation height etc. Manual to semiautomatic systems are the ranges for material handling equipments [1]. Idlers are used for supporting the materials to be transported and to protect the belt throughout its length. Belt conveyor is a non-stop motion of bulk loads or unit loads throughout the path for loading and unloading.

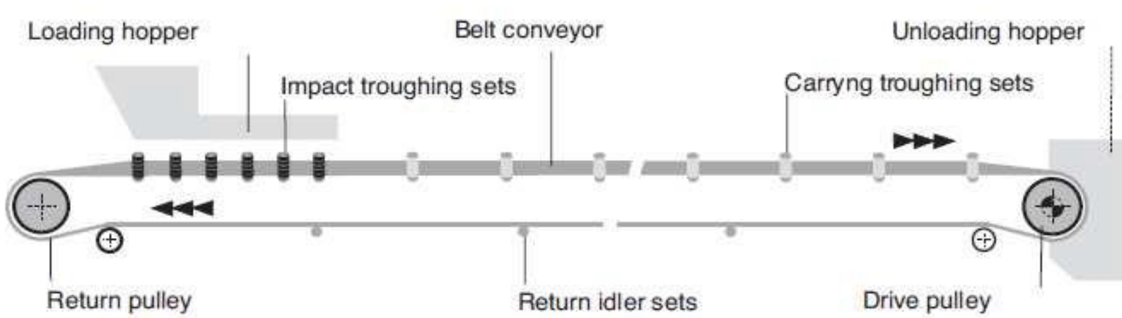

Fig.1. Belt Conveyor system

It has very easy and cheap maintenance also it has higher capacity for loading and unloading the dense materials it works with high efficiency over long distances. Belt conveyor is very useful for transporting the materials like sticky materials, abrasive materials wet and dry materials.

The belt, pulleys, idlers and drive system are the important components of drive for increasing the efficiency. Idlers are the important components of conveyor for energy saving. The operation efficiency increased by speed control of belt conveyor system. Conveyor systems are popular in the material handling and packaging industries because it allows immediate and efficient transportation for a variety of materials. Depending on the length of the conveyor the number of rollers is used in a conveyor system mostly it is in the hundreds up to thousands.

2. Problem Definition:

To design a prototype for belt conveyor system by optimizing the Idler to minimize the failure of idler and to save the materials and cost.

3. Objective of the Study

- Study the belt conveyor system.
- Design and analysis of Conveyor system.
- 3 D modeling of conveyor assembly.
- Optimization of Idler of existing belt conveyor system.
- To do the modifications in design of idler for system optimization.
- To do the analysis of modified design for different loading conditions.

4. Scope of Study

1. Study the of actual design of belt conveyor system.
2. Model Analysis of belt conveyor system
3. Optimization of Idler for reduction of weight and cost saving.
4. Comparison between different materials idlers.

5. Design of Conveyor System

5.1. Introduction of Design of Conveyor System

In the design of belt conveyor system for getting optimum efficiency and optimum design determination of the right dimensions of the belt conveyor equipments and other critical parameter values is important during loading and unloading conditions. Different parts of conveyor systems are idlers, pulleys, belt, motor, pneumatic cylinder, rollers, etc.

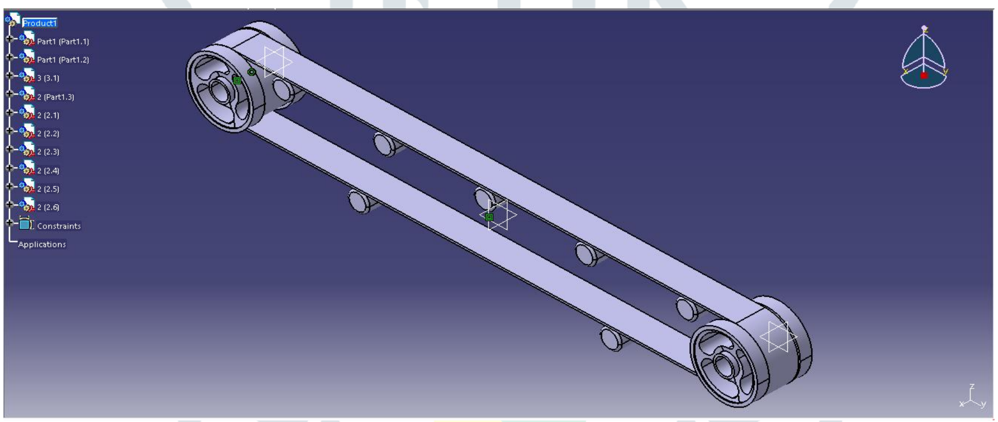

Fig. 2 CATIA Design of Belt Conveyor

5.2. Part Design

Material:- Leather

$\rho = 1000$ kg/m^3

L = 1.2 m

w = 10 kg

V = 0.3 m/sec

$\mu = 0.26$

C = 0.165 (surcharge factor)

- **Determination of belt width.**

$M = \rho * Q$ --------------1

Where, $Q = Cb^{2*}V$

$M = \rho * C\,(0.9B - 0.05)^2 * V * 3600$ ---2

B = 70 mm

Q = Capacity of conveyor, m^3/s

ρ = Mass density of material, Kg/m^3

- **Determination of pulley diameters.**

$D_{min} = K_1 * K_2 * Z$ -----------------3

D_{min} = 160 mm

D_{tail} = 160 mm

Assuming snub pulley to drive pulley diameter ratio as 0.5,

$0.5 = D_{snub} / D_{drive}$

D_{snub} = 80 mm

Assuming idler pulley to drive pulley diameter ratio as 0.25,

$0.25 = D_{idler} / D_{drive}$

$\mathbf{D_{idler} = 45, 50\ mm}$

- **Width of pulley,**

$= B + 2*S$ ----------------------4

= 130 mm.

- **Design of Idlers:-**

l_1 = centre to centre distance between snubs & pulley.

l_2 = centre to centre distance between drive & tail pulley.

No. of return idlers.

$t_r = l_1 / (Z_r + 1)$ ----------------5 $\mathbf{Z_r = 2}$

No. of carrying idlers,

$t_k = l_2 / (Z_k + 1)$ ---------------6

$\mathbf{Z_k = 5}$

- **Design of shaft:-**

A shaft is for transmitting torque and power from one element to other.

$M_t = [(60*10^6) *(kw)] / (2\pi N)$ -----------7

$M_t = 893.92$ N.mm

For Pulley 1:-

$F_t = 18.105$ N

$F_s = 8.004$ N

W = 10*9.81 = 98.1 N

$(F_t + F_s + W) = 3055.1$ N -----------------8

Bending moment at 1st pulley,

$\mathbf{M_b = 6472.53\ N.mm}$

Diameter of shaft (d) :-

$\tau_{max} = [16/\pi d^3] * \sqrt{(Mb)2 + (Mt)2}$ -----9

∴ d = 20 mm

5.3. Resisting forces on Belt Conveyor

- **Load resistance due to lifting of material (F_m) :-**

$F_m = m_m * g*h$ -------------------------10

$\mathbf{[F_m = 9.81\ N]}$

Where, m_m = conveyor capacity (kg/m)

h = height through which the material is lifted (m)

- **Frictional resistance due to idlers (F_r):-**

i) Frictional resistance due to carrying run idlers (F_{cr}):-

$F_{cr} = F_c \{m_m+m_b+ [(m_i*Z_c)/l_2]*g*l_2$ -------11

$\mathbf{[F_{cr} = 3.15\ ]}$

F_c = Friction factor = 0.018

m_b=weight of belt per unit length = (11.5*B)=(11.5*0.06783)=0.734 kg/m

m_i =mass of each idler = 1kg assume.

Z_c = No. of carrying idlers =5.

l_2 = centre to centre distance between drive & tail pulley.

ii) Frictional resistance due to return run idlers (F_{rr}):-

$F_{rr} = F_c \{m_b+[(m_b*Z_r)/l_1]*g*l_1\}$-------------12

$\mathbf{[F_{rr} = 0.4309\ N]}$

- **Resistance at loading station (F_L):-**

$F_L = M (V - V_i)$ -----------------------------13

$\mathbf{[F_L = 0.000277\ N]}$

M = mass flow rate (kg/sec)

V_i = component of incoming material velocity along the belt line(m/sec)=0.2

- **Frictional resistance at unloading (F_u):-**

$F_u = (3.1 \text{ to } 3.6)*m_m*g*B$ -----------------14

$\mathbf{[F_u = 20.05\ N]}$

- **Frictional resistance at cleaning station (F_{cl}):-**

$F_{cl} = k_{cl} *g*B$ ---------------------------------15

$\mathbf{[F_{cl} = 0.9398\ N]}$

- **Power requirement of belt conveyors :-**

$\frac{\text{Ftight}}{\text{Fslack}} = e^{\mu\theta}$ ----------------------------------16

$\frac{\boldsymbol{Ftight}}{\boldsymbol{Fslack}} = \boldsymbol{e^{0.25*3.141}}$ **= 2.192**

$F_1 = F_{slack} + 0.939$

F_{tight} = 18.105 N

F_{slack} = 8.004 N

- **Power required to drive the pulley :-**

  $P_o = \frac{(Ftight - Fslack)*V}{1000}$ --------------17

  [P_o = 3.033 w]

- **Maximum tension ($F_{t\,max}$) :-**

  $F_{t\,max} = F_{tight} + F_c$ ------------------------18

  [$F_{t\,max}$ = 18.177 N]

- **Braking strength of belt (F_{bs}):-**

  $F_{bs} = N_f * F_{t\,max}$ --------------------19

  [F_{bs} = 54.53 N]

- **No. of plies (Z_p):-**

  $F_{bs} = S_{ut} * B * Z_p$ ------------------20

  [Z_p = 2 plies]

6. Parameters:

Table 1:- Design values for Belt conveyor system.

S.NO.	Parameter	Values
1.	Belt width (B)	70 mm
2.	Pulley Diameter ($D_{min} = D_{drive} = D_{tail}$)	160 mm
3.	Snub Pulley Diameter (D_{snub})	80 mm
4.	Idler Diameter (D_{idler})	45, 50 mm
5.	Width of pulley	130 mm
6.	Speed of motor (N)	1440 rpm
7.	Speed of pulley (N_p)	36rpm
8.	No. of carrying Idlers (Z_k)	5
9.	No. of return idlers (Z_r)	2
10.	Thickness of belt	5 mm

7. Result and Analysis

- Aluminum Materials:

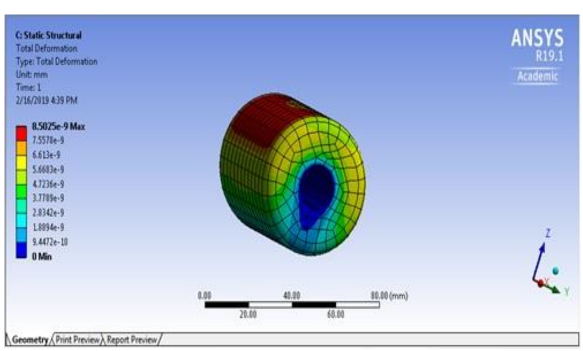

Fig. 3 Deformation of Idler for Aluminum materials

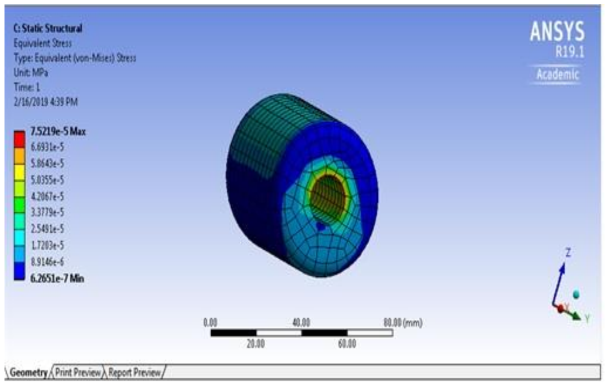

Fig. 4 Stresses of Idlers for Aluminum Materials

- Polythene Materials :

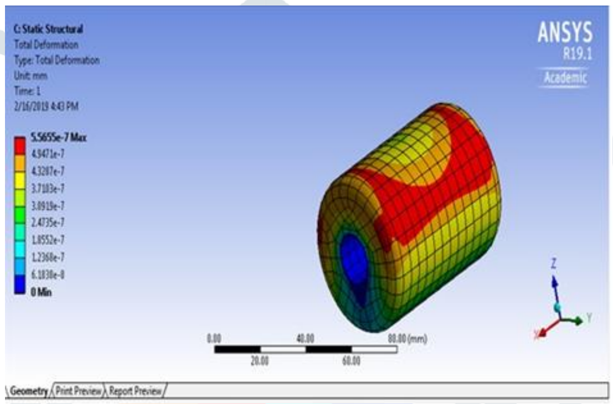

Fig. 5 Deformation of Idler for Polythene Material

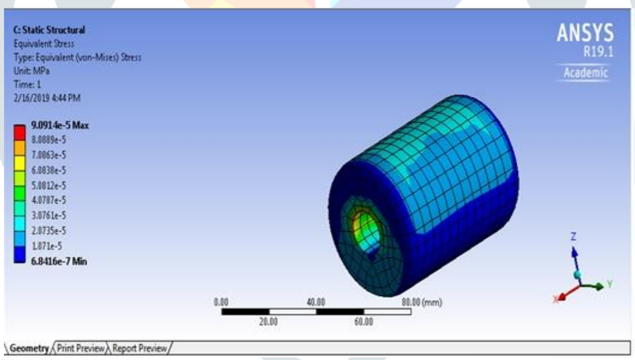

Fig. 6 Stresses of Idlers for Polythene Materials

8. Result Table:

Sr. No.	Parameter	Aluminum	Polythene
1.	Deformation (Max)	$8.50e^{-9}$	$5.56e^{-7}$
2.	Stress (Max)	$7.52e^{-5}$	$9.09e^{-5}$

8. **Conclusion:** The aluminum and polythene material used for roller has very less deformations and stresses it can sustain the load of materials hence there is a scope for cost saving and weight reduction.

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