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REVIEW OF FINITE ELEMENT ANALYSIS OF ROLLER CONVEYOR FOR MATERIAL HANDLING SYSTEM

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ABSTRACT

Material handling plays an important role in the modern industries now a days. Almost every item of physical commerce is transported on a conveyor or lift truck or other type of material handling equipment in manufacturing plants, warehouses, and retail stores. The current work focuses on the weight reduction of the gravity roller by redesigning and save considerable amount of material. In this paper the comparison of the design calculation for the gravity roller before and after optimization are detailed.

Keywords: Gravity Roller, Conveyor, Optimisation

I INTRODUCTION

Today's world is of automation and modernization in the manufacturing techniques. Material Handling is the part of this modern technique which are of importance in any of the industry. Material handling plays an important role in manufacturing and logistics. Almost every item of physical commerce is transported on a conveyor or lift truck or other type of material handling equipment in manufacturing plants, warehouses, and retail stores. The operators use material handling equipment to transport various goods in a variety of industrial settings including moving construction materials around building sites or moving goods onto ships. 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. In today's radically changing industrial markets, there is a need to implement a new manufacturing strategy, a new system operational concept and a new system control software and hardware development concept, that can be applied to the design of a new generation of open, flexible material handling systems.

II PROBLEM DEFINITION

The aim of this work is to redesign existing gravity roller conveyor system by designing the critical parts (Roller, Shaft, Bearing & Frame), to minimize the overall weight of the assembly and to save considerable amount of material. Also system needs to be examined for 'load case' of sudden release of the component over the conveyor system. The existing conveyor system is shown in the figure below.

Figure. 1.2 Roller Conveyor System (Existing Case)

Gravity roller Conveyor has to convey 350 kg load, 30 inch above ground and inclined at 4 degree. Figure. 1.3 shows roller conveyor assembly.

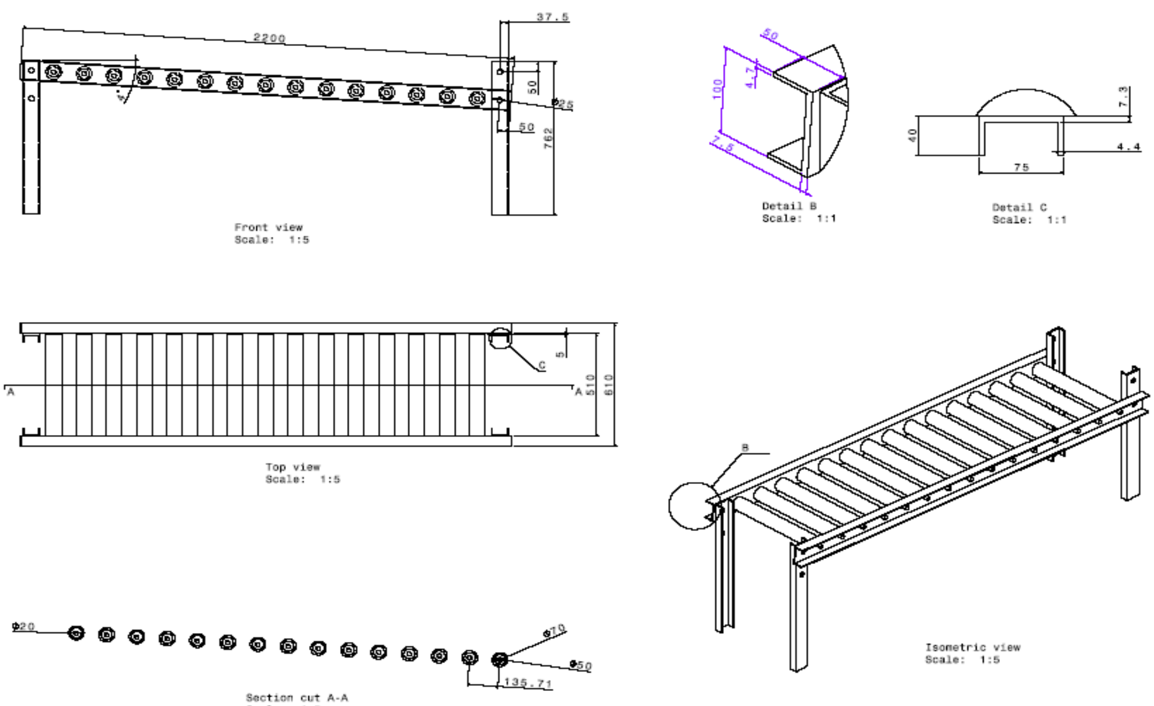

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Table 1.1 Components of the Conveyor system

Sr. No	Component	Material	Qty.
1	C-Channels for Chassis	C 10	2
2	Rollers	Mild steel	14
3	Bearing	Std.	28
4	C-Channels for Support	C 10	4
5	Shaft	Mild Steel	14

3.1 DESIGN CALCULATIONS FOR EXISTING CONVEYOR

The design calculations for the existing system was carried out as follows

3.1.1 Design of Roller

Roller is made of MS.

Material properties of MS are as follows,

Young's modulus of elasticity $E = 2.0\times10^5$ MPa,

Material density ρ= 7850 Kg/m^3,

Yield stress = 250 MPa

Considering uniformly distributed load & factor of safety $F_S = 1.5$

Allowable Stress (σ_{all}) = S_{yt} / Fs =250/1.5=166.67 MPa

- **For 40 mm Diameter**

Maximum Stress Calculation for given condition -

W= 12 kg (Load act on 4 rollers at a time)

D_1= Outer diameter of roller = 40 mm

D_2 = Inner diameter of roller = 40-(2x2) =36 mm

w = Width of roller = 500 mm

y = Distance from neutral axis = 30/2 = 15mm

Considering uniformly distributed load**,** fixed at both ends.

Maximum Moment (M_{max}) = $\frac{WXL}{4}$ = 14715Nmm

Moment of Inertia (I) =Π (D_1^4 - D_2^4)/64 = 43193.84mm^4

Maximum bending stress σ_b = $\frac{Mmax\ x\ y}{I}$=5.1101N/mm^2

Checking Factor of Safety for design-

$$F_s = \frac{\sigma all}{\sigma b} = 32.61$$

As Calculated Fs is greater than assumed Fs, Selected Material can be considered as safe.

Maximum Deflection (y_{max}) = $\frac{W x L^3}{384 x E x I}$= 4.4358x10^{-9}mm

As compared to length 500 mm deflection of = 4.4358x10^{-9}mm is very negligible. Hence selected roller can be considered as safe.

Similar5 calculations were carried out for the 35 mm diameter and 30 mm diameter where the factor of safety obtained are 16.38 and 11.73 respectively

As compared to length 500 mm deflection of 1.2325X10^{-8} mm is very negligible. Hence selected roller can be considered as safe.

Weight of Rollers - = cross-section area×width × mass density× number of rollers=103.57 Kg

3.1.2 Design of Shaft

Shaft is made of MS.

Material properties of MS are as follows,

Young's modulus of elasticity E = 2.0×10^5 MPa,

Material density ρ= 7850 Kg/m^3,

Yield stress = 250 MPa

Considering uniformly distributed load & factor of safety F_S = 1.5

Allowable Stress (σ_{all}) = S_{yt} / Fs =250/1.5=166.67 MPa

Maximum Stress Calculation for given condition-

Maximum Moment (M_{max}) = 13.96 Nm

Moment of Inertia I = Π (D^4)/64 =7.8540×10^{-9} m^4

Maximum bending stress σ_b = $\frac{Mmax\ x\ y}{I}$ = 17.78 MPa

Checking Factor of Safety for design-

$$Fs = \frac{\sigma all}{\sigma b} = 9.374$$

As Calculated Fs is greater than assumed Fs, Selected Material can be considered as safe.

Maximum Deflection (y_{max}):

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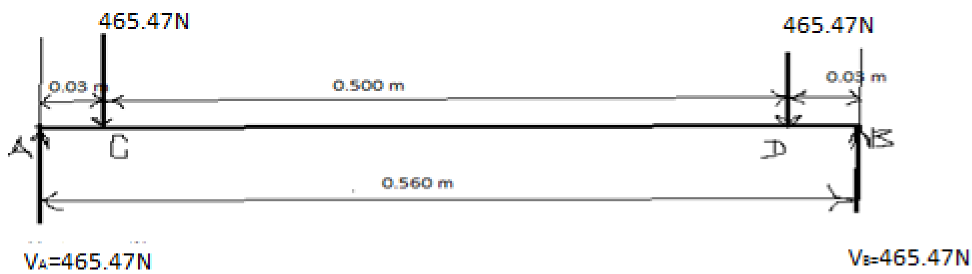

The B.M.at any section distance ‘x’ from pt.A is given by,

$EI\times \frac{d^2y}{dx^2} = 465.47\times x|-465.47(x-0.03)|-465.47(x-0.53)$

Integrating the above eq.^{n} we get,

$EI\times\frac{dy}{dx} = 465.47\times x^2/2+C_1|-465.47(x-0.03)^2/2|-465.47(x-0.53)^2/2$

$= 232.73\times x^2+C_1 |-232.73 (x-0.03)^2|-232.73 (x-0.53)^2$

$EI\times y = 77.57\times x^3-3.696\times x + |-77.57 (x-0.03)^3|-77.57 (x-0.53)^3$………(2)

To find deflection at point ‘D’,put x=0.53m in eq.^{n} 2,

Take $E=2.1\times10^5$ MPa & $I=7.8540\times10^{-9}$ m^4

Y_D= -0.65 mm. (downward)

Deflection is remains same in between point C & D because there is no any other load acted.

Hence Maximum Deflection (y_{max}):0.65 mm

As compared to length 560 mm deflection of 0.65mm is very negligible. Hence selected shaft can be considered as safe.

Weight of Shafts = cross-section area× width × mass density× number of shafts = 19.33 Kg

3.1.3 Design of c-channel for Chassis

C-channel for chassis is made of rolled steel C-10.

Young’s modulus of elasticity $E = 2.0\times10^5$ MPa,

Material density ρ= 7850 Kg/m^3,

Yield stress = 275 MPa

Maximum Stress Calculation for given condition -

Maximum bending moment (M_{max}) = $\frac{WXL}{4}$1319.63 Nm

Maximum bending stress σ_b = $\frac{Mmax \times y}{I}$=35.34 MPa

Checking Factor of Safety for design-

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$$F_s = \frac{\sigma all}{\sigma b} = 5.18$$

As Calculated Fs is greater than assumed Fs, Selected Material can be considered as safe.

Maximum Deflection (y_{max})-

$$y_{max} = \frac{WxL^3}{48EI} = 1.357\times10^{-3} \text{ m}$$

As compared to length 2200 mm deflection of 1.37mm is very negligible. Hence selected channel can be considered as safe.

Weight of C-frame -

= cross-section area×length of frame× mass density = 2×20.15 = 40.30kg

3.1.4 Design of C- Channel for Supports

Maximum bending moment (M_{max}) = $\frac{WXL}{4}$= 247.03 Nm

Maximum bending stress,

$$\sigma_b = \frac{\text{Mmax x y}}{I} \text{-} 73.53 \text{ MPa}$$

Checking Factor of Safety for design

$$Fs = \frac{\sigma all}{\sigma b} = 2.49$$

As Calculated Fs is greater than assumed Fs, Selected Material can be considered as safe.

Maximum Deflection (y_{max}) = $\frac{WxL^3}{48EI}$ =0.445 mm

As compared to length 762 mm deflection of 0.445mm is very negligible. Hence selected channel can be considered as safe.

Table Weight of Optimized Conveyor

Sr. No.	**Name of Component**	**Weight (Kg) (Approx)**
1	C- Channel for Chassis	
2	Rollers	47.47
3	Shafts	19.33
4	Bearing	6.982
5	C- Channel for Supports	19.93
6	**Total Weight of assembly**	**134.012**

IV RESULTS BEFORE OPTIMIZATION

From static analysis of existing roller conveyor it is clear that when a static load of 875 N (approx 87.5 Kg = 350 Kg/4) is applied on the roller at the centre. We found that the maximum deflection is 0.0089 mm and maximum stress is 4.56 MPa.

From analytical design calculation of existing roller conveyor it is clear that when a static load of 875 N (approx 87.5 Kg = 350 Kg/4) is applied on the roller at the centre. We found that the maximum deflection is 0.0016 mm and maximum stress is 0.717 MPa.

Table 5.1 Total Weight of Existing Conveyor

Sr. No.	Name of Component	Weight (Kg) (Approx)
1	C- Channel for Chassis	40.30
2	Rollers	103.57
3	Shafts	19.33
4	Bearing	6.982
5	C- Channel for Supports	19.93
6	**Total Weight of assembly**	**190.192**

V RESULTS AFTER OPTIMIZATION

From static analysis of optimized roller conveyor it is clear that when a static load of 875 N (approx 87.5 Kg = 350 Kg/4) is applied on the roller at the centre. We found that the maximum deflection is 0.0022 mm and maximum stress is 8.08 MPa.

From analytical design calculation of existing roller conveyor it is clear that when a static load of 875 N (approx 87.5 Kg = 350 Kg/4) is applied on the roller at the centre. We found that the maximum deflection is 0.0042 mm and maximum stress is 1.63 MPa.

Table Total Weight of Optimized Conveyor

Sr. No.	Name of Component	Weight (Kg) (Approx)
1	C- Channel for Chassis	40.30
2	Rollers	47.47
3	Shafts	19.33

4	Bearing	6.982
5	C- Channel for Supports	19.93
6	**Total Weight of assembly**	**134.012**

5.1 EFFECT OF OPTIMIZED DESIGN COMPARED WITH EXISTING DESIGN-

Table Effect Optimized Design

Sr. No.	Name of Component	Weight (Kg) Existing Design	Weight (Kg) Optimized Design
1	C- Channel for Chassis	40.30	40.30
2	Rollers	103.57	47.47
3	Shafts	19.33	19.33
4	Bearing	6.982	6.982
5	C- Channel for Supports	19.93	19.93
6	**Total Weight of assembly**	**190.192**	**134.012**

1) From above table we can observe that there is great change in weight of optimized design as compared to existing design (56.18 Kg weight reduction).
2) Here we can say that change in dimension of Rollers optimizes the weight of entire conveyor system.

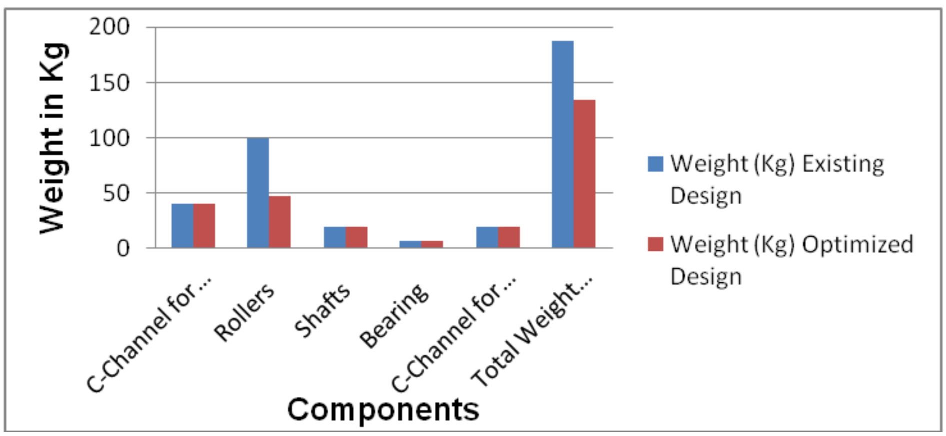

Figure Plot for Effect of Optimized Design

Weight Reduction Due to Optimization:-

Table Weight Reductions Due to Optimization

Design	Weight (Kg)	% Material required compared to existing design	% Material save compared to existing design
Existing	190.192	100	-----
Optimized	134.012	70.46	29.54

As per the standards of Conveyor manufacturing companies' permissible deformation is 8 mm.

VI CONCLUSION

- Existing design calculation shows the factor of safety is very greater than requirement and there is a scope for weight reduction.
- The critical parameter for weight reduction is Outside Diameter of Roller. Though the values of deflection and stress are more in case of optimized but it is allowable.
- 29.54 % of weight reduction is achieved due to optimized design.
- 56.18 Kg of weight reduction is achieved due to optimized design as compared to existing design.

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