Analysis of Powered Roller Conveyor

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Abstract - *One of the major equipment in material handling is roller conveyor. As the roller conveyors are not generally subjected to complex state of stress they are designed by providing higher factor of safety .In this study failure of analysis of Powered roller conveyor is carried out for changing to loads. This work is under taken to do Analysis and optimization of Powered roller Conveyor using FEA for solving above Problem. Aim-In the present work, an attempt is made to reduction in weight of existing roller conveyor by optimizing the critical parts of (e.g. Inner & outer diameter of Roller, Thickness of Roller) conveyor without hampering its structural strength. Optimization gives optimum design for same loading condition with huge amount of weight reduction. Using this procedure and using practical available structure 29.82% weight reduction is achieved. Without affecting functional performance.*

Key Words:
Optimized design, Weight reduction, and material handling systems.

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. Conveyors are used when material is to be moved frequently between specific points over a fixed path and when there is a sufficient flow volume to justify the fixed conveyor investment.

Conveyor systems allow quick and efficient transportation for a wide variety of materials, which make them very popular in the material handling and packaging industries. Many kinds of conveying systems are available, and are used according to the various needs of different industries. Conveyor systems are commonly used in many industries, including the automotive, agricultural, computer, electronic, food processing, aerospace, pharmaceutical, chemical, bottling and canning, print finishing and packaging. Many factors are important in the accurate selection of a conveyor system. It is important to know how the conveyor system will be used beforehand. Some individual areas that are helpful to consider are the required conveyor operations, such as transportation, accumulation and sorting, the material sizes, weights and shapes and where the loading and pickup points need to be.

2. PROBLEM DEFINITION

In discussion with industry we came across problem, existing powered roller assembly fails in the running conditions when moving pallet wt on roller assembly is changed from & above 1000 Kg. Due to change in pallet wt above 1000 kg Failure of roller assembly is observed, which affects production. Total load is taken 2000kg. (Added factor of Safety)

3. DESIGN OF PRESENT SHAFT

3.1. Material – MS

E= 2.00×105 Mpa, ρ= 7800 Kg/m3, Syt = 1050 Mpa
Considering uniformly distributed load & FOS =2
Allowable Stress (σall) = Syt / Fs = 1050/2=525 Mpa
W=Pallet Weight x Factor of Safety
=1000 x 2 =2000 Kg

3.2. Maximum Stress Calculation for given condition-

W= 2000/4= 500 kg (Load act on 4 rollers at a time)
d = Outer diameter of Shaft = 20 mm
L = Length of Shaft = 666 mm
y = Distance from neutral axis = 20/2 = 10
a = Distance of Bearing from shaft end =45 mm
l= Distance between two bearing center =576 mm
Considering beam with uniformly distributed load,

Maximum Moment (Mmax) :-

Mmax =Wa
= 5000×45
Mmax = 225000 N-mm

Moment of Inertia (I) = π (d4) / 64
= π (204) /64
I = 7850 mm4

Maximum bending stress (σb)

(σb) = Mmax × y/ I
(σb) = Mmax × y/ I
= 225000 × 10/ 7850
(σb) = 286.62 Mpa

Checking Factor of Safety for design-

Fs = σall / σb
= 525/286.62
Fs = 1.8316
As Calculated Fs is smaller than assumed Fs, Selected Material & design can be considered as not safe.

3.3. Maximum Deflection (Ymax)

(Ymax) = wa2 (2a+3l)/6EI

= (5000×452) * (2×45 + 3×576)/ (6 x7850×2.00×105)

= 200000× (1818)/ (6×1.57× 109)

ymax = 1.9541 mm

3.4. Weight of Shafts = cross-section area*width * mass density* number of shafts

= π (0.010) 2 / 2*0.666*7800*18

= 29.3610 Kg

3.5 BEARING SELECTION:

3.5.1 Standard SKF deep groove ball Bearing,

SKF Bearing number 6204, ISI No.-20BC02, Weight =0.11 Kg

d= Bore diameter = 20 mm

D=Outer diameter = 47 mm

B= width = 14 mm

Bearing is suitable for High radial loads, economical.

3.5.2 Total weight of Bearing

= 36×0.11 = 3.96 kg

4. DESIGN OF PROPOSED SHAFT

4.1. Material – MS

E= 2.00×10^5 Mpa, ρ= 7800 Kg/m3, Syt = 1050 Mpa

Considering uniformly distributed load & FOS =2

Allowable Stress (σall) = Syt / Fs = 1050/2=525 Mpa

4.2. Maximum Stress Calculation for given condition-

W= 2000/4= 500 kg (Load act on 4 rollers at a time)

d = Outer diameter of Shaft = 20 mm

L = Length of Shaft = 666 mm

y = Distance from neutral axis = 20/2 = 10

a = Distance of Bearing from shaft end =20 mm

l= Distance between two bearing center =626 mm

Considering beam with uniformly distributed load,

Maximum Moment (Mmax):-

Mmax =W× a

= 5000 × 20

Mmax = 100000 N-mm

Moment of Inertia (I) = π (d^4) / 64

= π (20^4) /64

I = 7850 mm4

Maximum bending stress (σb)

(σb) = Mmax × y/ I

(σb) = Mmax × y/ I

= 100000 * 10/ 7850

(σb) = 127.39 Mpa

4.3. Checking Factor of Safety for design-

Fs = σall / σb

= 525/127.39

Fs = 4.1213

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

4.4. Maximum Deflection (Ymax)

(Ymax) = wa2 (2a+3l)/6EI

= $(5000\times20^2) * (2\times20 + 3\times626)/(6x\ 7850\times2.00\times10^5)$

= $200000\times (1918)/ (6\times1.57\times 10^{9})$

ymax = 0.4072 mm

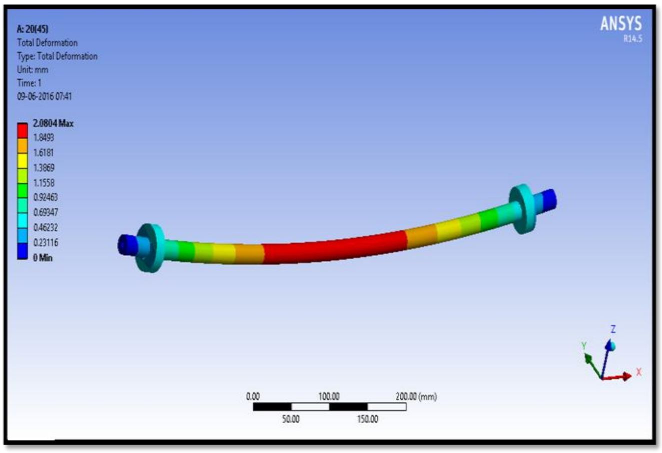
As compared to length 626 mm deflection of 0.4072 mm is very small. Hence selected design can be considered as safe.

Table No. 05- Comparison of Analytical Result of Present Shaft and Proposed Shaft

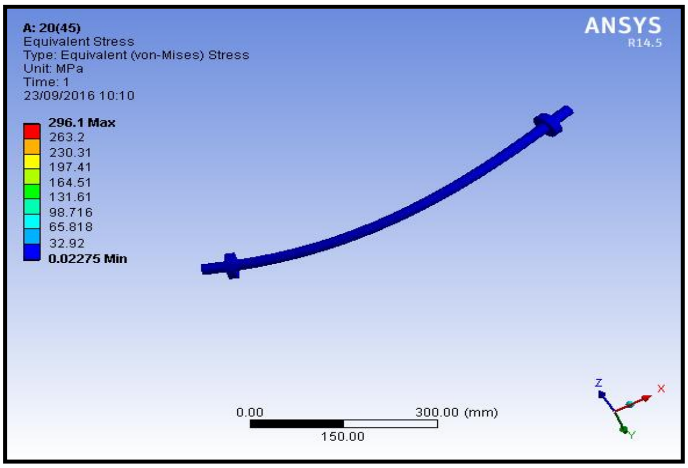
description	Present Shaft	Proposed Shaft	Unit
Maximum Bending Stress	286.62	127.39	Mpa
Checking factor of safety for design	1.8316	4.1213	
Deflection	1.9541	0.4072	mm

4.5.RESULT FROM ANSYS 14.5 FOR PRESENT SHAFT

Deformation in Present Shaft

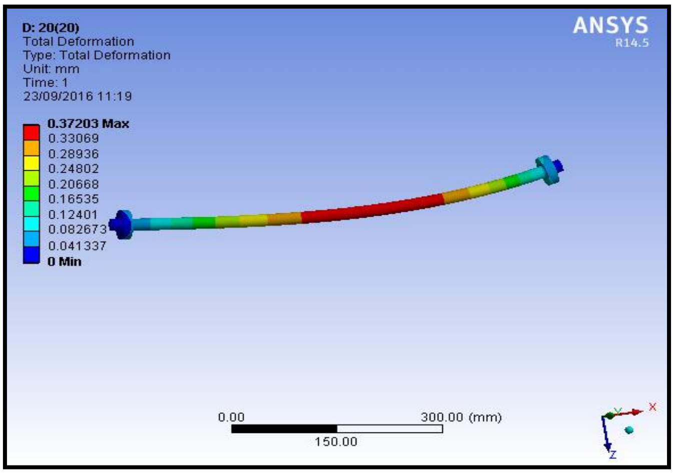


Stress in Present Shaft

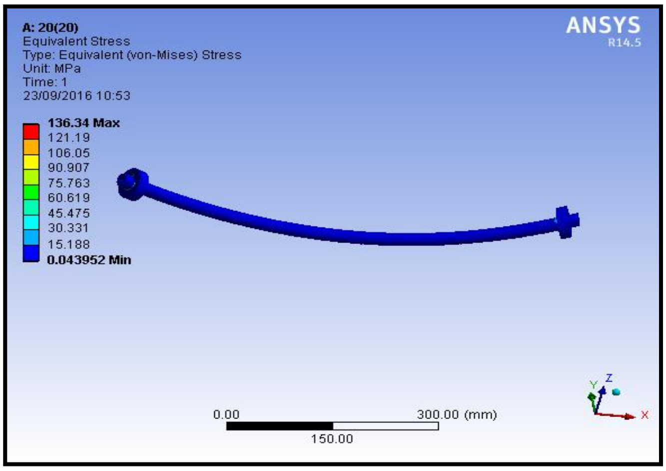


RESULT FROM ANSYS 14.5 FOR PRPPOSED SHAFT

Deformation in Proposed Shaft



Stresses in Proposed Shaft



description	Existing Shaft		Redesign Shaft		Unit
	Analytical	Ansys	Analytical	Ansys	
Maximum Bending Stress	286.62	296.1	127.39	136.34	Mpa
Deflection	1.9541	2.080	0.4072	0.3720	mm

5. DESIGN OF PRESENT ROLLER

5.1. Material – MS

E= 2.00×105 Mpa, ρ= 7860 Kg/m3, Syt = 520 Mpa
Considering uniformly distributed load & FOS =2
Allowable Stress (σall) = Syt / Fs = 520/2=260 Mpa

5.2. Maximum Stress Calculation for given condition

W= 2000/4= 500kg (Load act on 4 rollers at a time)
D1= Outer diameter of roller = 60 mm
D2 = Inner diameter of roller = 44 mm
w = Width of roller = 560 mm
y = Distance from neutral axis = 60/2= 30
Considering beam with uniformly distributed load,

Maximum Moment (Mmax) :-

(Mmax) = $W \times L^2/8$
= (5000×560 x 560) /8
Mmax = 196000 Nmm

Moment of Inertia (I) =

$\pi\,(D1^4 - D2^4)/64$
$= \pi\,(60^4 - 44^4)/64$
I = 451959 mm4

Maximum bending stress (σb)

(σb) = Mmax × y/ I
(σb) = Mmax × y/ I
= 196000 × 30/ 451959
(σb) = 13.01 Mpa

5.3. Checking Factor of Safety for design-

Fs = σall / σb
= 260/13.01
Fs = 19.9838

As Calculated Fs is greater than assumed Fs, Selected Material & design can be considered as safe. Hence wt reduction can be possible.

5.4. Maximum Deflection (ymax) = $5\times W\times L^3/384EI$

(ymax) = $5\times W\times L^3/384EI$

$= (5\times5000*560^3) / (384*2.00*10^{5}* 451959)$

ymax = 0.126 mm

As compared to length 560 mm deflection of 0.126 mm is very negligible. Hence selected Roller can be considered as safe.

5. 5.Weight of Rollers -

= cross-section area× width ×mass density× number of rollers
$= \pi\,(60^2 - 44^2) \times 560 \times 7860 \times 18/4$
=103.4918 Kg

6.0 Need of Optimization

As factor of safety Rollers is very high there is scope of weight reduction in this component.

Selection of Critical Parameter

Roller Outer diameter

Roller Inner diameter

Roller thickness

7. DESIGN OF PROPOSED ROLLER

7.1. Material – MS

E= 2.00×105 Mpa, ρ= 7860 Kg/m3, Syt = 520 Mpa
Considering uniformly distributed load & FOS =2
Allowable Stress (σall) = Syt / Fs = 520/2=260 Mpa

7.2. Maximum Stress Calculation for given condition

W= 2000/4= 500kg (Load act on 4 rollers at a time)
D_1= Outer diameter of roller = 60 mm
D_2 = Inner diameter of roller = 50 mm
w = Width of roller = 603 mm
y = Distance from neutral axis = 60/2 = 30
Considering beam with uniformly distributed load,

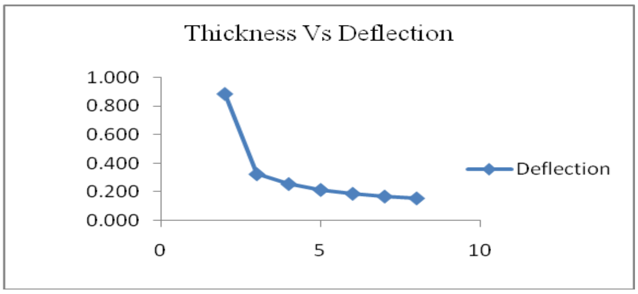
Maximum Moment (Mmax):-
$((Mmax) = W \times L^2/8$
$= (5000 \times 603 * 603)/8$
Mmax = 227255 Nmm
Moment of Inertia (I) = π ($D1^4$ - $D2^4$)/64
$= \pi (60^4 - 50^4)/64$
I = 329209 mm4
Maximum bending stress (σb)
(σb) = Mmax × y/ I
(σb) = Mmax × y/ I
= 227255 × 30/ 329209
(σb) = 20.709 Mpa
Checking Factor of Safety for design-
Fs = σall / σb
= 260/20.709
Fs = 12.555
As Calculated Fs is greater than assumed Fs, Selected Material & design can be considered as safe.

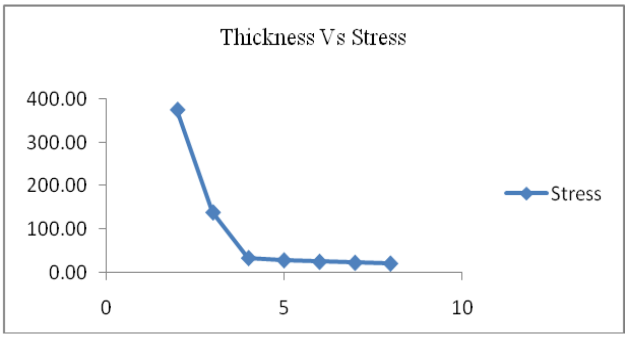
7.3. Maximum Deflection (ymax) = $5 \times W \times L^3/384EI$
(ymax) = $5 \times W \times L^3/384EI$
$= (5 \times 5000 \times 603^3) / (384 \times 2.00 \times 10^5 \times 329209)$
ymax = 0.217 mm
As compared to length 560 mm deflection of 0.158 mm is very negligible. Hence selected Roller can be considered as safe.

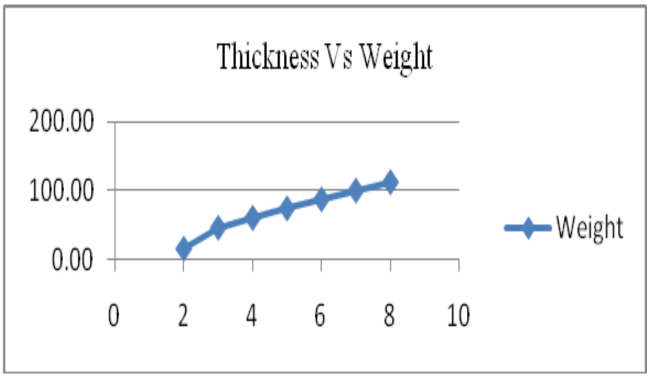
7.4. Weight of Rollers -
= cross-section area ×width ×mass density× number of Rollers
$= \pi (60^2 - 50^2) \times 603 \times 7860 \times 18/4$
=73.67 Kg

8. DESIGN ANALYSIS AFTER WEIGHT REDUCTION

After studying number of iteration for various Parts of roller conveyor a optimized design can be selected on the basis of following parameter.

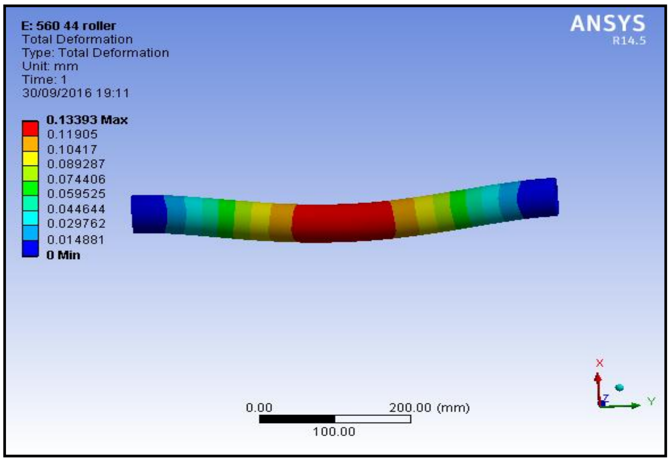




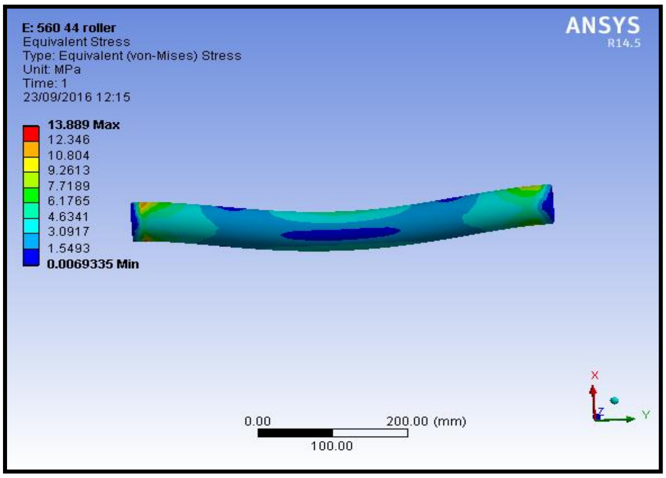


9. RESULT FROM ANSYS 14.5 FOR PRESENT ROLLER

Deformation in Present Roller

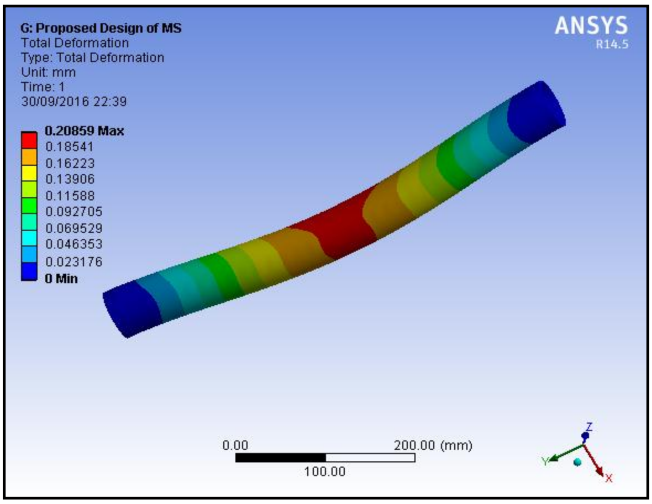


Stress in Present Roller

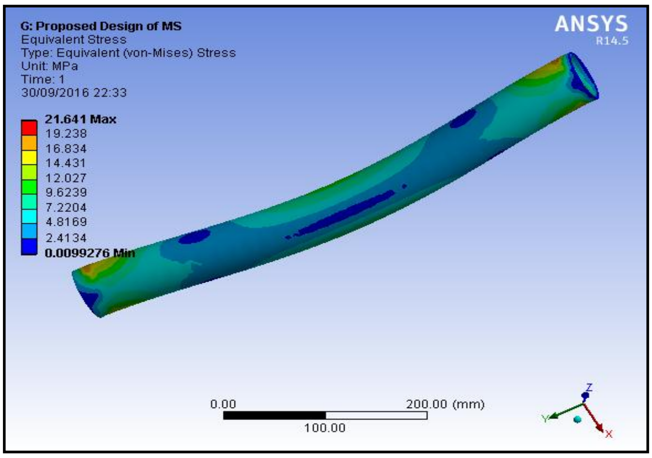


RESULT FROM ANSYS 14.5 FOR PROPOSED ROLLER

Deformation in Proposed Roller



Stress in Proposed Roller



Results- Compared Effect of Present Design of Roller with Proposed design

Sr. No.	Name of Component	Weight (Kg)	
		Existing Design	Optimized Design
1	Rollers	103.49	73.67
2	Shafts	29.36	29.36
3	Bearing	03.90	03.90
	Total Weight	136.75	106.93

9.1 Observation from Ansys Results- Effect of Proposed Design compared with Present design-

Design	Analytical Calculation		Ansys Result	
	Max. Def. mm	Max. Stress N /mm2)	Max. Def. mm	Max. Stress. N/mm2)
Present	0.126	13.01	0.1339	13.889
Proposed	0.217	20.709	0.2083	21.641

10. Weight reduction due to Optimization

Design	Weight (Kg)	% Material required compared To Existing design	% Material save compared To Existing design
Present	136.75	100	-
Proposed	106.93	70.18	29.82

3. CONCLUSIONS

Existing design calculation shows the factor of safety is very greater than requirement and there is a scope for weight reduction.

- Critical parameter which reduces the weight is roller outer diameter, roller Inner outer and roller thickness.
- Though value of deflection, stress is more in case of Optimized design, but it is allowable.
- 29.82 % of weight reduction is achieved due to Optimized design.
- 29.82 Kg. weight reduction achieved by optimized design than existing design.

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