A review paper on Redesign of Gravity Roller Conveyor System for Weight Reduction through optimization

Mr. Sanket Pandit, Dr. A.G.Thakur

Abstract— This work presents an application of concept of concurrent engineering and the principles of design for manufacturing and design for assembly, several critical conveyor parts were investigated for their functionality cost and ease of assembly in the overall conveyor system. The critical parts were modified and redesigned with new shape and geometry and some with new materials. The improved design methods and the functionality of new conveyor parts were verified and tested on a new test conveyor system designed, manufactured and assembled using the new improved parts.The improved methodology for design and production of conveyor components is based on the minimization of material, parts using the rules of design for manufacture and design for assembly.The semi finished material has to be transported from one station in the assembly to another at a distance of upto 50 meters or more. The method of manual transport by fork-lift is time consuming. A mechanism for continuous and uninterrupted transport is desired. This is carried out with reference to roller conveyor system (Existing system). The existing system will be redesign and optimize for weight, resulting into material saving by modifying and analyzingthe critical conveyor parts.

Index Terms— weight,factor of safety.

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1 Introduction

Conveyor is used in many industries to transport goods and materials between stages of a process. Conveyors are a powerful material handling tool. They offer the opportunity to boost productivity, reduce product handling and damage and minimize labor content in a manufacturing or distribution facility. Conveyors are generally classified as either Unit Load Conveyors that are designed to handle specific uniform units such as cartons or pallets, and Process Conveyors that are designed to handle loose product such as sand, gravel, coffee, cookies, etc. which are fed to machinery for further operations or mixing. It is quite common for manufacturing plants to combine both Process and Unit Load conveyors in its operations.Gravity Roller conveyor is not subjected to complex state of loading still we found that it is designed with higher factor of safety. There is definitely an economic need not only to control the conveyor speed and the number of parallel machines, but also to find the optimum solution in reaching the maximum profit of a deterministic production quantity. Through this study, the control of the conveyor speed in optimizing the production of the machines and conveyors becomes concretely solvable.

2 Literature Review

Alspaugh M. A. [1] presents latest development in belt conveyor technology & the application of traditional components in non-traditional applications requiring horizontal curves and intermediate drives have changed and expanded belt conveyor possibility. For Examples of complex conveying applications along with the numerical tools required to insure reliability and availability will be reviewed.This paper referenced Henderson PC2 which is one of the longest single flight conventional conveyors in the world at 16.2611 km. But a 19.123 km conveyor is under construction in the USA now, and a 23.52 km flight is being designed in Australia. Other conveyors 30-50 km are being discussed in other parts of the world.

S.H. Masoodet. al. [2] presents an application of concept of concurrent engineering and the principles of design for manufacturing and design for assembly, several critical conveyor parts were investigated for their functionality, material suitability,cost or ease of assembly in the overall conveyor system. The critical parts were modified and redesigned with new shape and geometry and some with new materials. The improved design methods and the functionality of new conveyor parts were verified and tested on a new test conveyor system designed, manufactured and assembled using the new improved parts.

The improved methodology for design and production of conveyor components is based on the minimization of material, part and cost are using the rules of design for manufactured and designs are assembly. Results obtained on a test conveyor system verify the benefits of using the improves tacts. The overall material cost was reduced by 19% and the overall assembly cost was reduced by 20% compared to conventional methods.

Dima Nazzalet. al. [3] discusses literature related to models of conveyor systems in semiconductors. Acomprehensive overviews of simulation-oriented models are provided. We also identify and discuss specific research problems and needs in the design with control of closed-loop conveyor. It is concluded that new analytical and simulation models of conveyor systems need to be developed to understand the behavior of such systems and bridge the gap between theoretical research and industry problems.

In order to minimize the product development time and improve the product quality, 3 dimensions at CAD/CAE system is essential. It is necessary to develop a system which utilizes the concept design data at the early stage for the whole process of the product development. The purpose of this paper is to improve the

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product quality by the sufficient design study iteration at the early stage of design. A CAD system which can be used for the concept ofdesign and an appropriate CAD environment should be developed and another purpose is to shorten the product development time at the late stage of design, this is proposed byC. Sekimoto [4] in his paper.

[5] discusses multi conveyor systems in supporting machine loading and unloading. The study in this paper not only meditates the concept of balancing the number of parallel machines, the conveyor speed for adjacent pallets, the overall relevant costs and the determination of the number of conveyors into the objective, but also develops a two-staged method to optimize the combined problem to reach a maximum profit.

Moreover, the computerized sensitivity analyses are discussed in this study. This paper contributes an applicable scheme for production design in manufacturing and provides a valuable tool to conclusively obtain the optimal profit of a given production quantity for operations research engineers in today's manufacturing with profound insight. It is concluded that this study definitely provides an adaptable and efficient tool for production design to optimize the profit ofa given order quantity.

3 PROBLEM DEFINATION

The semi finished material of weight 200 kg has to be transported from one station in the assembly to another at a distance of upto 50 meters or more. The method of manual transport by fork-lift is time consuming. A mechanism for continuous and uninterrupted transport is desired. This is carried out with reference to roller conveyor system (Existing system).The existing system will be redesign and optimize for weight, resulting into material saving by modifying and analyzingthe critical conveyor parts.

3 DESIGN CALCULATION FOR EXISTING DESIGN

3.1 Design of C Channel for chasis

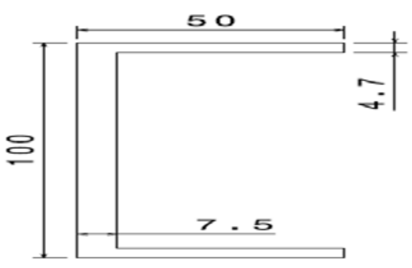

Fig1.C-Channel

Fig1.Material-Rolled steel C-10

$E = 2.10*10^5$ Mpa, $\varrho = 7830$ Kg/m^3, $S_{yt} = 490$ Mpa

Calculation of given dimension

Considering load act at a center & Factor of Safety =2

Allowable Stress (σ_{all}) = $S_{yt}/F_s = 490/2 = 245$ Mpa

Load acting = (Load capacity +Weight of C- frame + Weight of Roller + Weight of Shaft + Weight of Bearing)/4

Load acting = (200+52.20 +231.496 +32.5946 +3.992) / 4

= 130.07 kg

L= 812 mm, W= 135 kg on each channel,

Maximum bending moment (M_{max})

$M_{max} = WL/4$

$= 135 *9.81* .812/4$

$M_{max} = 268.84$ Nm

Given C- Channel, ISMC 75

h= Depth of section, t_f = thickness of flange,t_w = thickness of web,

A= Sectional area I_{xx}= Moment of Inertia along x-axis

h= 75 mm

b= 40 mm

$t_f = 7.3$ mm

$t_w = 4.4$mm

A = 8.72cm^2

y = 37.5 mm

I_{xx}= 67.865 cm^2

Maximum bending stress $\sigma_b = M_{max}*y/I$

$=268.84 *(37.5*10^{-3})/ (67.865 *10^{-8})$

σ_b =14.86MPa

3) Checking Factor of Safety for design

$F_s = \sigma_{all}/ \sigma_b$

$= 245/ 14.86$

$F_s = 16.49$

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

4) Maximum Deflection (y_{max}) =

$y_{max} = WL^3/48EI$

$= (135 *9.81*0.812^3) / (48*2.10*10^{11}* 67.865 *10^{-8})$

$y_{max} = 1.036*10^{-4}$m

y_{max}=0.1036 mm

As compared to length 812 mm deflection of 0.1036 mm is very negligible. Hence selected channel can be considered as safe.

5) Weight of Channels = cross-section area*length * mass density* number of Channels

$= (8.72*10^{-4}*.812*7830*4)$

= 22.1765 Kg

3.2 Design of roller

Fig2.Roller

Material – MS
$E = 2.10 * 10^5$ Mpa, ρ= 7860 Kg/m^3, S_{yt} = 590 Mpa
Considering uniformly distributed load & Factor of Safety =2
Allowable Stress (σ_{all}) = S_{yt} / F_s = 590/2= 295 Mpa

2) Calculation by considering given roller dimension
W= 200/4= 50 kg (Load act on 4 rollers at a time ------- Given)
D_1= Outer diameter of roller = 75 mm
D_2= Inner diameter of roller = 50 mm
w = Width of roller = 600 mm
y = Distance from neutral axis = 0.075/2 = 0.0375

3) Maximum Moment (M_{max}) =
$$M_{max} = W*L^2/8$$
$$= (50*9.81*.6^2)/8$$
$$M_{max} = 22.0725 \text{ Nm}$$

4) Moment of Inertia (I) =
$$I = \Pi (D_1^4 - D_2^4)/64$$
$$= \Pi (0.075^4 - 0.05^4)/64$$
$I = 1.24635*10^{-6}$ m^4

5) Maximum bending stress $\sigma_b = M_{max} * y/ I$
$= 22.0725 * 0.0375 / 1.24635*10^{-6}$
σ_b = 0.66 Mpa

6) Checking Factor of Safety for design
$F_s = \sigma_{all} / \sigma_b$
= 295/0.66
F_s =446.96
As Calculated F_s is greater than assumed F_s, Selected Material can be considered as safe.

7) Maximum Deflection (y_{max}) =
$$y_{max} = 5*W*L^3/384EI$$
$= (5*50*9.81*.6^3) / (384*2.10*10^{11}* 1.24635*10^{-6})$
$y_{max} = 5.27 *10^{-3}$ mm
As compared to length 600 mm deflection of $5.27 *10^{-3}$ mm is very negligible. Hence selected channel can be considered as safe.

8) Weight of Rollers = Cross-section area*width * Mass density* number of rollers
$= \Pi (0.075^2 - 0.05^2) *0.6*7860*20/4$
= 231.496 Kg

3.3 Design of Shaft

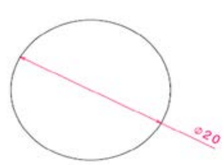

Fig3.Shaft

Material – MS
E= 2.10*105 Mpa, ρ= 7860 Kg/m3, Syt = 560 Mpa
Considering uniformly distributed load & Factor of Safety =2
Allowable Stress (σall) = Syt / Fs = 560/2=280 Mpa

2) Calculation by considering given Shaft dimension
W= 200/4= 50 kg (Load act on 4 rollers at a time)
D = Outer diameter of shaft = 20 mm
w = Width of shaft = 660 mm
y = Distance from neutral axis = 0.02/2 = 0.01

3) Maximum Moment (Mmax) =
Mmax = W*L2/8
= (50*9.81*.662)/8
Mmax = 26.7077 Nm

4) Moment of Inertia I = Π (D4)/64
= Π (0.024)/64
I = 7.8540*10-9 m4

5) Maximum bending stress σb = Mmax * y/ I
= 26.7077 * 0.01/ 7.8540*10-9
= 34.005 Mpa

6) Checking Factor of Safety for design
Fs = σall / σb
= 280/34.005
Fs = 8.234
As Calculated Fs is greater than assumed Fs, Selected Material can be considered as safe.

7) Maximum Deflection (ymax) =
ymax = 5*W*L3/384EI
= (5*50*9.81*.663) / (384*2.10*1011* 7.8540*10-9)
ymax = 1.113 mm
As compared to length 660 mm deflection of 1.113 mm is very negligible. Hence selected channel can be considered as safe

8) Weight of Shafts = cross-section area*width * mass density* number of shafts
= Π (0.012) *0.66*7860*20
= 32.5946 Kg

3.4 Design of Bearing

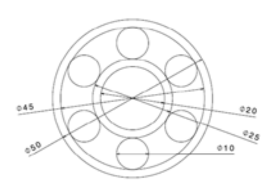

Fig4.Bearing

Standard MRC Bearing,

MRC Bearing number CONV-4 SF, Weight =0.0998 Kg

d= Bore diameter = 20 mm

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D=Outer diameter = 50 mm

B= width = 25.4 mm

Bearing is suitable for High radial loads, economical.

Total bearing used = 40

2) Total weight of Bearing = 40*0.0998

= 3.992 kg

3.4 Design of C-Channel for support

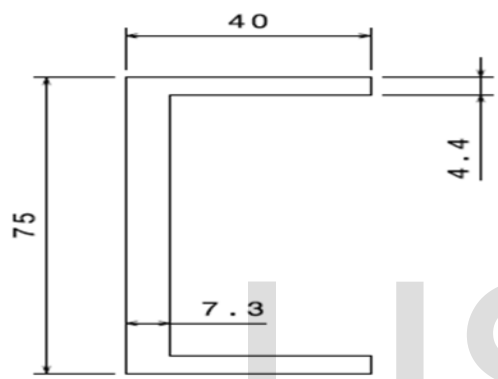

Fig.3.4 Design of C-Channel for support
Fig3.4 shows made up of Material- Rolled steel C-10
E= 2.10*105 Mpa, ρ= 7830 Kg/m3, Syt = 490 Mpa

2) Calculation of given dimension
Considering load act at a center & Factor of Safety =2
Allowable Stress (σall) = Syt / Fs = 490/2= 245 Mpa
Load acting = (Load capacity +Weight of C- frame + Weight of Roller + Weight of Shaft + Weight of Bearing) /4
Load acting = (200+52.20 +231.496 +32.5946 +3.992) / 4 = 130.07 kg
L= 812 mm, W= 135 kg on each channel,

Maximum bending moment (Mmax)
Mmax = WL/4
= 135 *9.81* .812/4
Mmax = 268.84 Nm
Given C- Channel, ISMC 75
h= Depth of section, tf = thickness of flange, tw = thickness of web,
A= Sectional area Ixx = Moment of Inertia along x-axis
h= 75 mm
b= 40 mm
tf = 7.3 mm
tw = 4.4mm
A = 8.72cm2
y = 37.5 mm
Ixx = 67.865 cm2
Maximum bending stress σb = Mmax *y/I
= 268.84 *(37.5*10-3)/ (67.865 *10-8)
σb = 14.86 MPa

3) Checking Factor of Safety for design
Fs = σall / σb
= 245/ 14.86
Fs = 16.49
As Calculated Fs is greater than assumed Fs, Selected Material can be considered as safe.

4) Maximum Deflection (ymax) =
ymax = WL3/48EI
= (135 *9.81*0.8123) / (48*2.10*1011* 67.865 *10-8)
ymax = 1.036*10-4 m
ymax =0.1036 mm
As compared to length 812 mm deflection of 0.1036 mm is very negligible. Hence selected channel can be considered as safe.

5) Weight of Channels = cross-section area*length * mass density* number of Channels
= (8.72*10-4*.812*7830*4)
= 22.1765 Kg

4 TOTAL WEIGHT OF CONVEYOR ASSEMBLY

TABLE 1

Sr. No.	Name of Component	Weight (Kg)
1	C- Channel for Chassis	52.20
2	Rollers	231.496
3	Shafts	32.594
4	Bearing	3.992
5	C- Channel for Supports	22.1765
	Total	**342.4585**

Scope of study-

The mechanical elements of the Roller Conveyor need to be designed individually and tested in the assembly environment. The structure need to be tested for external forces acting on the entire assembly.

7.2 Acknowledgments

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