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Redesign of Gravity Roller Conveyor System for Weight Reduction through Optimisation

#1Mr.Sanket G.Pandit, #2Dr.A.G.Thakur

[1]sanketgp1@gmail.com
[2]ajay_raja34@yahoo.com

#1Student Mechanical Engineering Department,S.R.E.S.C.O.E,Kopargaon
#2Mechanical Engineering Department,S.R.E.S.C.O.E,Kopargaon.

ABSTRACT

Over the years a lot of work has been done and is still continuing with great effort to save weight and cost of applications. The current trend is to provide weight per cost effective and reliable products which meet the stringent requirements. Conveyors are used in many industries to transport goods and materials between stages of a manufacturing and material handling process. By reducing repetitive lifting and carrying of objects, conveyor reduces risk of injuries in tasks or process that involves in manual handling. Gravity roller conveyor uses principle of gravity to convey weight. The aim of this project is to study existing conveyor system and optimize the critical parts like roller, C-channels for chassis and support, to reduce the overall weight of assembly and material saving.

Keywords— **Factor of safety, Material handling system, Optimized design, Weight of assembly.**

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I. Introduction

Conveyor is used in many industries to transport goods and materials between stages of a process. Using conveyor systems is a good way to reduce the risks of musculoskeletal injury in tasks or processes that involve manual handling, as they minimize the need for repetitive lifting and carrying. Conveyors are a powerful material handling tool. They offer the opportunity to boost productivity, minimize product handling and damage and minimize labor content in a manufacturing or distribution facility. Conveyors are classified as either Unit Load Conveyors that are designed to handle specific uniform units such as pallets, and Process Conveyors that are designed to handle loose product such as sand, coffee, cookies, etc. which are fed to machinery for further operations or mixing. It is common for manufacturing plants to combine both Process and Unit Load conveyors in its operations. Roller conveyor is not subjected to complex state of loading still we found that it is designed with higher factor of safety .If we redesigned critical parts example. Roller, Shaft, Bearing& Frame etc. then it is possible to minimize the overall weight of the assembly.

II. II Problem Definition

The aim of the project is to Redesign existing gravity roller conveyor system by designing the critical parts (Roller, Shaft, Bearing), to minimize the overall weight of the assembly and to save considerable amount of material. Gravity roller Conveyor has to convey 200 kg load, 30 inch above ground. Fig. 1 shows roller conveyor assembly. Components of conveyor are as follows,

TABLE 1

COMPONENT USED DESCRIPTION

Sr. No.	Component	Material	Qty.
1	C-Channels for Chassis	ISMC 100	2
2	Rollers	Mild Steel	20
3	Bearing	Std.	40
4	C-Channels for Stand	ISMC 100	4
5	Shaft	Mild Steel	20

III. OBJECTIVES OF PRESENT STUDY

The following objectives of the study:

1. Study existing roller conveyor system and its design.
2. Geometric modeling of existing roller conveyor.
3. To carry out modal, linear static. Transient and optimization analysis of existing roller conveyor.
4. Modification of critical conveyor parts for weight optimization.
5. To carry out Analysis of Modified design for same loading condition.
6. Recommendation of new solution for weight optimization.

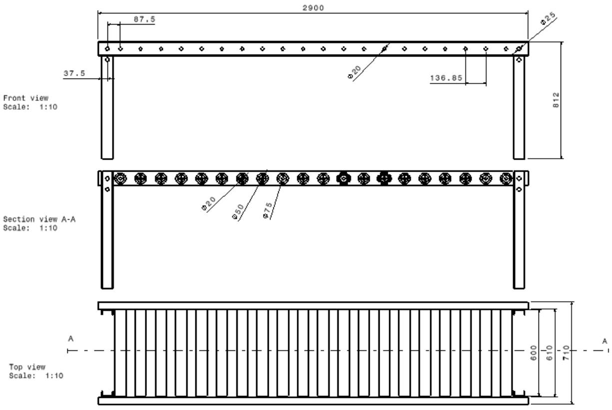

Fig.1 Gravity Roller Conveyor Assembly

IV . SCOPE OF PRESENT STUDY

1. Check design of existing conveyor system.
2. Simulation method applied to optimize parameters web thickness, flange thickness, web height, roller thickness and shaft diameter.
3. Simulations for linear static Analysis.
4. Simulations for Modal Analysis.
5. Optimization of conveyor assembly for weight reduction.
6. Comparison between existing and optimized design.

V. STUDY OF EXISTING SYSTEM FOR CONVEYOR ASSEMBLY

TABLE 2

A) Total Weight of Existing Conveyor Assembly

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**

B) GEOMETRIC MODELLING

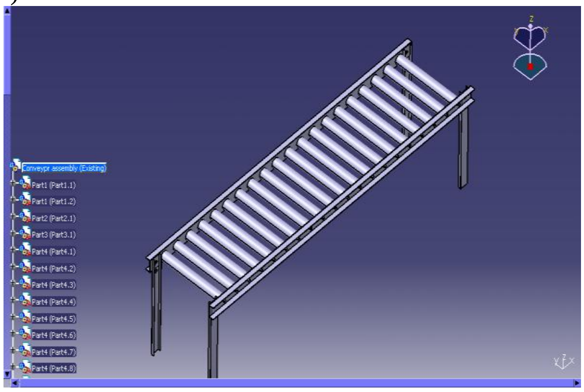

Fig.2 Geometrical modeling using Catia

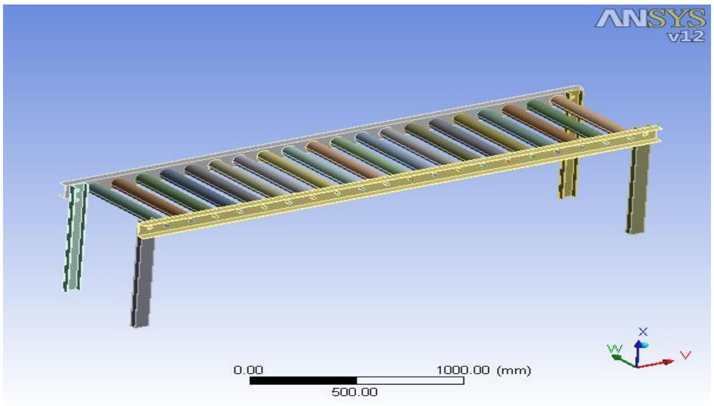

Fig. 3 Imported Model in ANSYS

C) FINITE ELEMENT MODELING

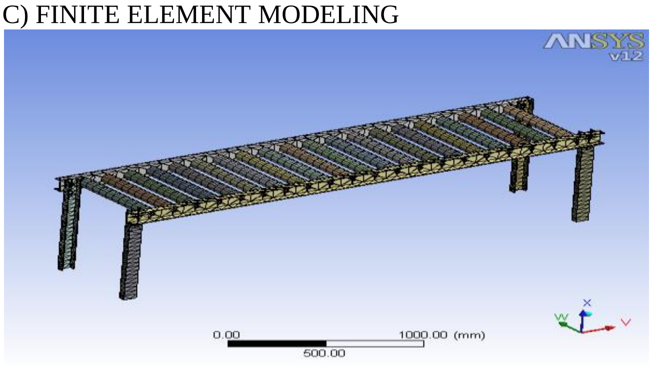

Fig. 4 Finite elemet mesh of the model (Isometric view)

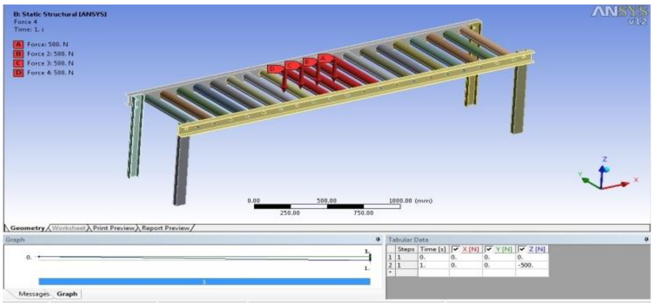

Fig. 5 a static load of 2000 N (approx 200 kg) is applied on the 4 rollers at the centre, as the deflection will be maximum, when the load is applied at the centre.

D) Static Structural Analysis

A static analysis calculates the effect of steady loading condition on a structure, while neglecting inertia and damping effects, such as those caused by time changing loads. A static analysis can, include steady inertia load (such as gravity and rotational).

Design and analysis of roller conveyor for weight optimization & material saving , and time changing load that can be approximated as static equivalent loads (such as static equivalent wind and seismic loads commonly defined in many building codes). Select element and apply material properties shown in fig.5**.** Static analysis determines the displacements, stresses and forces in components caused by loads that do not induce significant inertia and damping effects. response conditions and Steady loading are assumed; that is, the loads and the structure's response are assumed to vary slowly with respect to time.

- Critical load condition

Load act on any 4 rollers hence by considering 200 kg load act on four rollers maximum deflection, maximum stress values are checked for existing design.

E) Procedure of Static analysis consists of these tasks:

- Build the Model
- Set Solution Controls
- Set Additional Solutions Options
- Apply the loads
- Solve the Analysis
- Review the result.

Results for static analysis,

1. Weight = the weight of the model is 342.46 kg.
2. Maximum deflection plot shown in fig 5
3. Maximum stress plot shown in fig 6

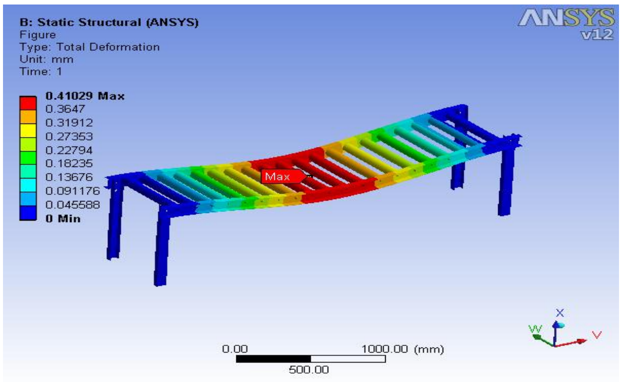

Figure 5 Deflection plot for existing design

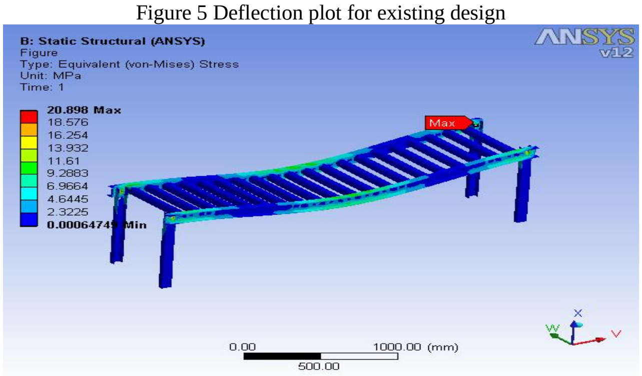

Figure 6 Stress plot for existing design

F) MODAL ANALYSIS

Modal analysis is used to determine the vibration characteristics (natural frequencies and mode shape) of a structure or a machine component while it is being designed. It also serves as a starting point for another, more detailed analysis, such as a transient dynamic analysis a harmonic response analysis, or a spectrum analysis. Modal analysis also used to determine the natural frequencies and mode shapes of a structure. The natural frequencies and mode shapes are important parameter in the design of a structure for dynamic loading condition. As the loading will be in upward direction (gravity) the mode shape which will show movement in vertical direction is important.

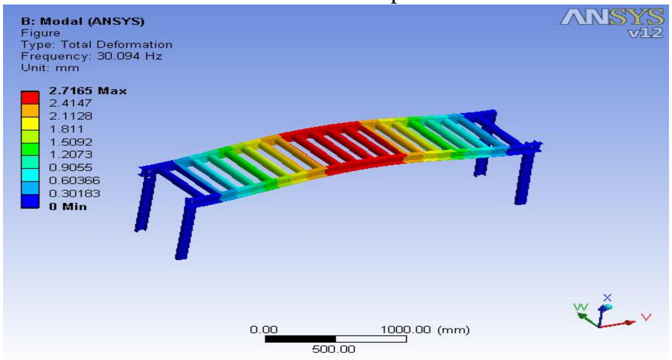

Figure 7 Critical Mode Shape

Result from Modal analysis :

1.From the results it is clear that the third mode shape will have maximum motion in vertical direction. So third natural frequency should be greater than the excitation frequency.

2.Third natural frequency is 30.094 Hz.

VI NEED OF OPTIMIZATION

PARAMETERS TO BE OPTIMIZED IN GIVEN ASSEMBLY

1) Effect of Flange Thickness
2) Effect of Web Thickness
3) Effect of Flange Width
4) Effect of Web Height
5) Effect of Roller Thickness
6) Effect of Roller Diameter

VII OPTIMISED STUDY

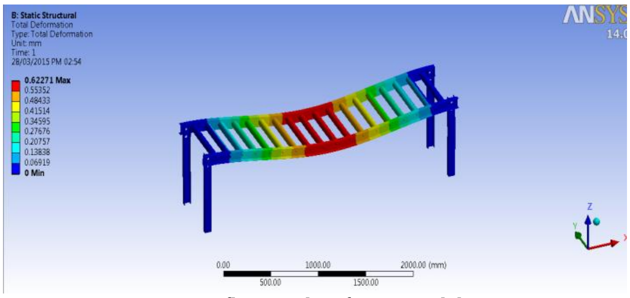

Figure 8 Deflection plot of Optimized design

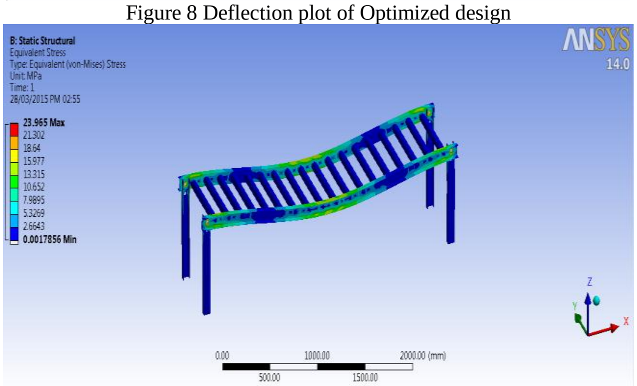

Figure 9 Stress plot of Optimized design

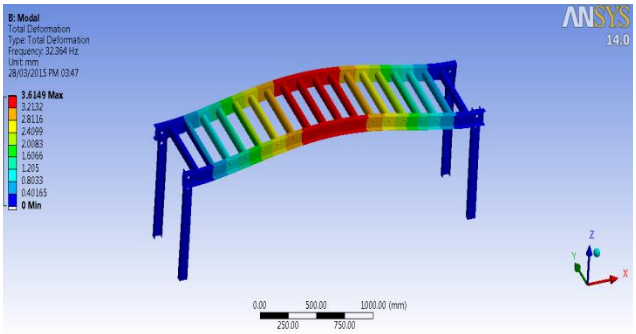

Figure 10 Natural Frequency of optimized design

8) RESULT

TABLE 3

Effect of optimized design

Sr.no	Name of Component	Weight (Kg)
1	C-Channels for Chassis	33.650
2	Rollers	208.3464
3	Shafts	10.340
4	Bearings	3.5928
5	C-channels for Supports	22.17
	Total Weight of Conveyor	**278.1057**

TABLE 4

Comparison between Existing And Optimized Assembly

Design	Max def, mm	Nat freq,Hz	Max stress,N/mm^2
Existing	0.41029	30.094	20.898
optimized	0.62271	32.64	23.965

TABLE 5

Weight Reduction through optimization

Design	Reduction Weight, (Kg)	%Material Required compared to existing design	% Material saving compared to existing design
Existing	342.4585	100	---------
optimized	278.1057	81.20	18.80

9) CONCLUSION

Detail comparison of Optimized design Analytical and Working physical model:-

- The overall change in analytical values and physical values are 18.79 %.
- The difference in the weight is due to the case of manufacturing the components at lower limit values compare to the software where real values are used.
- The values of deflection and stress of the optimized design is more than existing design, but it is allowable.

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