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Redesign and Analysis of Roller Conveyor for Weight Reduction

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ABSTRACT

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. Although a wide variety of materials can be conveyed, some of the most common include food items such as beans and nuts, bottles and cans, automotive components, scrap metal, pills and powders, wood and furniture and grain and animal feed. Many factors are important in the accurate selection of a conveyor system. The aim of this project 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.As the roller conveyors are not generally subjected to complex state of stress they can be designed by providing higher factor of safety it leads to unnecessarily increase in material cost. This can be reduced effectively by separately designing conveyor part and testing whole assembly for mode shape analysis for critical parts. Gravity roller conveyor has to convey 200 kg load, 812 mm above ground.

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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 reduce the need for repetitive lifting and carrying.

Fig. 1 Roller Conveyor

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 eg. Roller, Shaft, Bearing& Frame etc. then it is possible to minimize the overall weight of the assembly. Powered belt conveyors are considerable long (9000 meter to 10000 meter) as compared to roller conveyor. So we can achieve considerable amount of material saving if we apply above study related to roller conveyor to this belt conveyor.

II. LITERATURE REVIEW

.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, strength criterion, 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.

Chun-HsiungLan [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.

John Usher et al. [7] provides an analysis of the reliability and availability of two common designs of the line-shaft roller conveyor. The first is a standard design in which each roller is belted directly to a spinning line shaft under the conveyor. The second is a new design in which only one top roller is belted to the line shaft and all other rollers are belted to the one powered roller in a series arrangement. The main reason for this design is that the upper belts are faster to replace than belts connected to the line shaft, thus increasing system availability. However, the latter design is less reliable in that the failure of a single belt may lead to multiple roller failures.

III.OBJECTIVES OF THE STUDY

The following are the objectives of the study:

1. Study existing roller conveyor system and its design.
2. Geometric modeling of existing roller conveyor.
3. To carry out linear static, modal, 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

IV.SCOPE OF THE STUDY

aFollowing are the scope of the 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.METHODOLOGY

A. Working Of FEA

FEA uses a complex system of points called nodes which make a grid called a mesh. This mesh is programmed to contain the material and structural properties which define how the structure will react to certain loading conditions. Nodes are assigned at a certain density throughout the material depending on the anticipated stress levels of a particular area. Regions which will receive large amounts of stress usually have a higher node density than those which experience little or no stress. Points of interest may consist of: fracture point of previously tested material, fillets, corners, complex detail, and high stress areas. The mesh acts like a spider web in that from each node, there extends a mesh element to each of the adjacent nodes. This web of vectors is what carries the material properties to the object, creating many elements.

B. Modal Analysis (ANSYS 14.0)

Modal analysis is used to determine the vibration characteristics (natural frequencies and mode shapes) 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.

C. Static Structural Analysis.

A static analysis calculates the effect of steady loading condition on a structure, while ignoring inertia and damping effects, such as those caused by time varying loads.Design and analysis of roller conveyor for weight optimization & material saving (velocity), and time varying load that can be approximated as static equivalent loadsStatic analysis determines the displacements, stresses, strains, and forces in structures or components caused by loads that do not induce significant inertia and damping effects. Steady loading and response conditions are assumed; that is, the loads and the structure's response are assumed to vary slowly with respect to time.

VI. EXISTING MODEL AND PARAMETERS

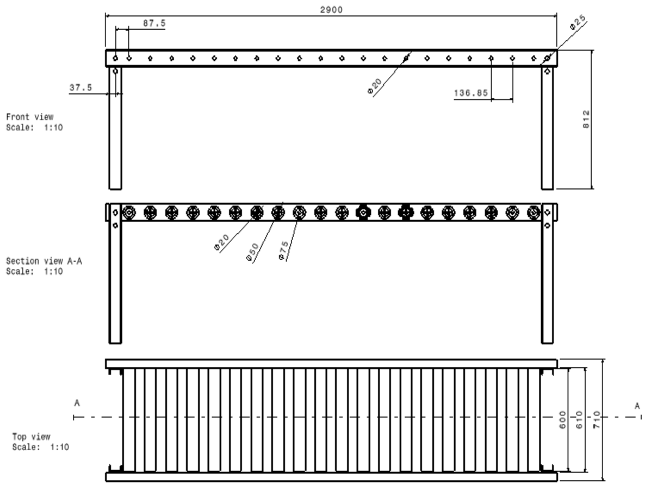

Fig. 2 Existing Gravity roller conveyor system

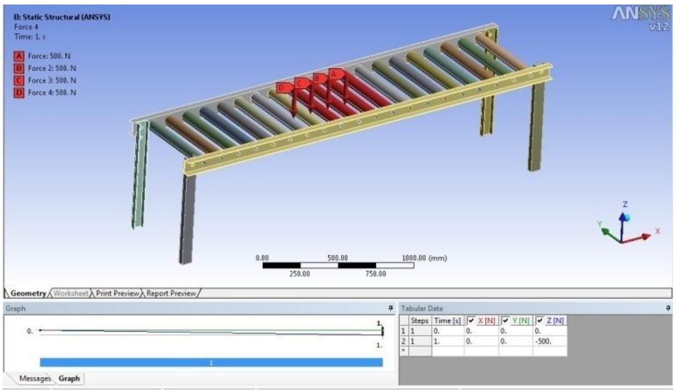

Fig. 3 FEA Model

TABLE I

CriticalParameters for existing design

Excitation Frequency	50 Hz
Maximum deflection	1.8mm
Maximum stress	35 MPa

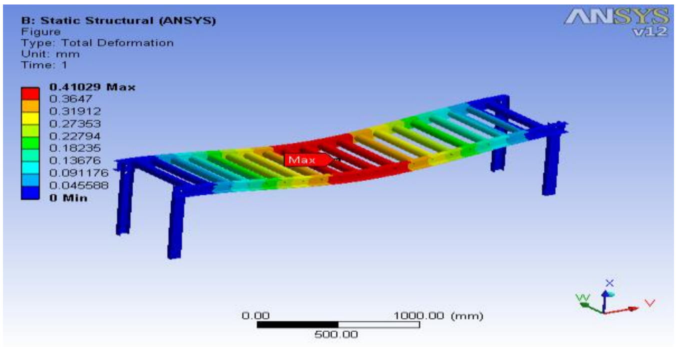

Fig.4 Deflection plot for existing design

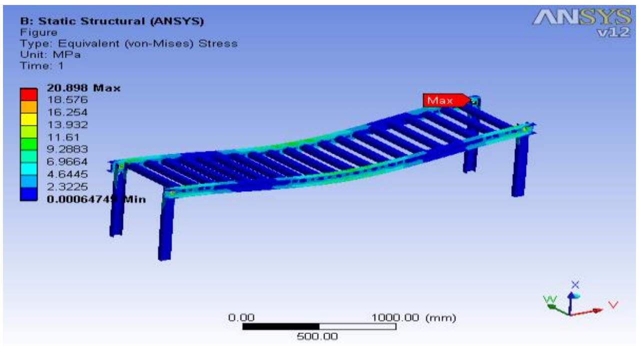

Fig. 5 Stress plot for existing Design

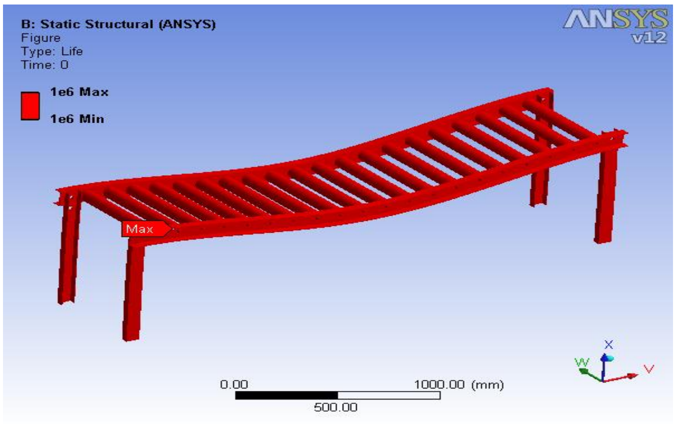

Fig. 6 Life for Existing Design

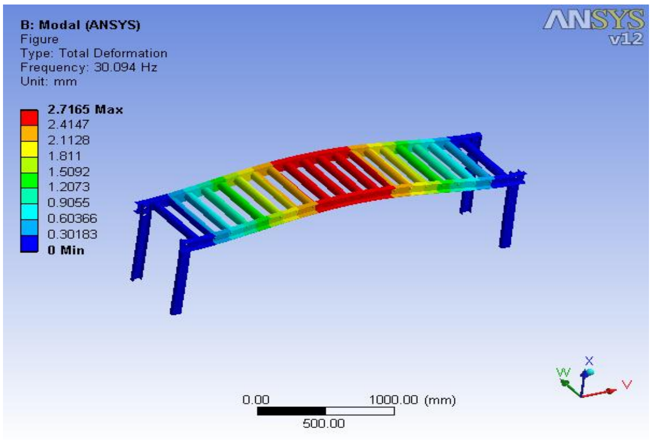

Fig. 7 Critical Mode shape

As we can see from the results obtained that the factor of safety is higher and there is scope of optimization by reducing the factor of safety used in design, we can redesign the system which will give us comparatively less weight, further material and cost saving. So optimization is to be done and suitable channels are to be selected from available channels. As we can have higher deflections and stresses than present values, we will redesign the system for those values which are safer as well as will reduce weight of the system.Again the values should match the standard channel values so that the channels would be easily available in market, so redesigning the system for available channels.

Optional Channels available are:

ISMC 75 x 40

ISMC 100 x 50 ISJC 100 x 45

ISMC 125 x 65 ISJC 125 x 50

VI. DESIGN ANALYSIS AFTER WIEGHT REDUCTION

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

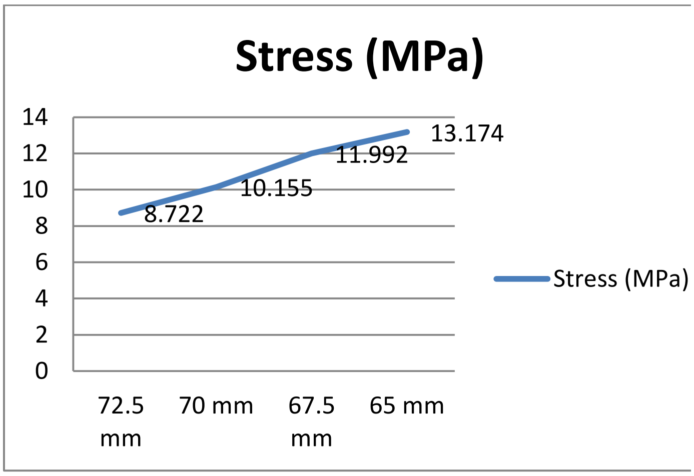

Fig. 8 Roller OD Vs Induced Stress

TABLE II
Parameters Of Optimized Design

Sr. No.	Name of Component	Weight (kg)
1	C- Channel for Chassis	33.650
2	Rollers	115.007
3	Shafts	10.340
4	Bearing	3.5928
5	C- Channel for Supports	22.1765
	Total Weight of the assembly	**184.766**

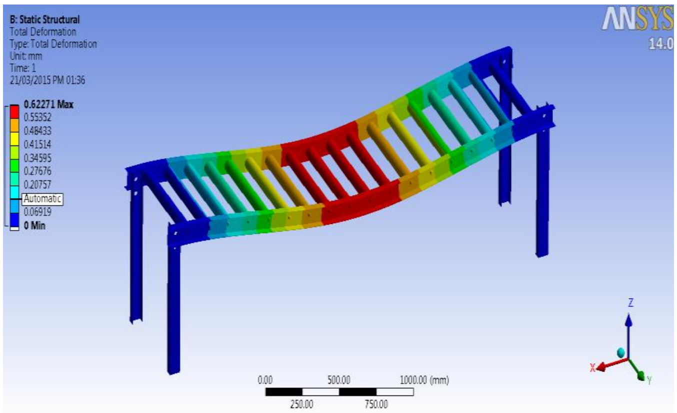

Fig. 9 Deflection plot for optimized Design

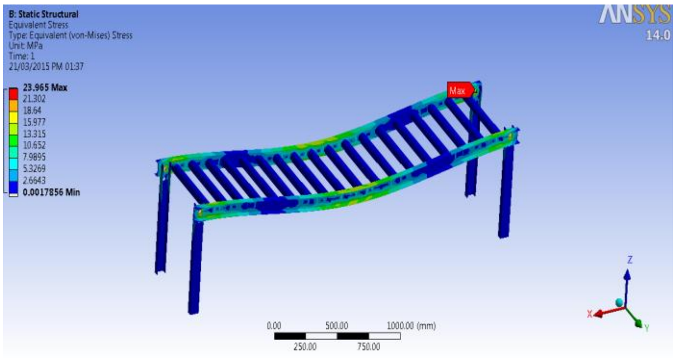

Fig. 10 Stress plot for optimized Design

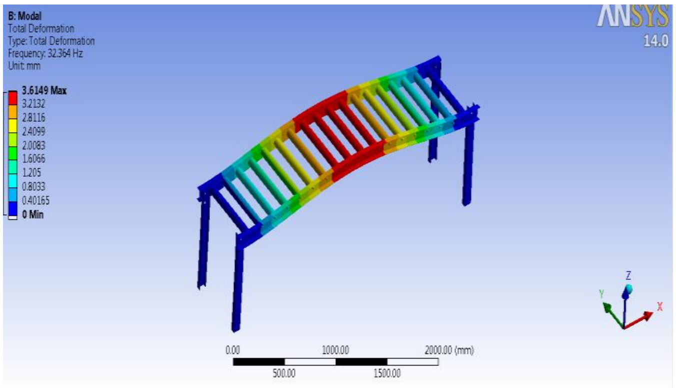

Fig. 11 Natural frequency of optimized design

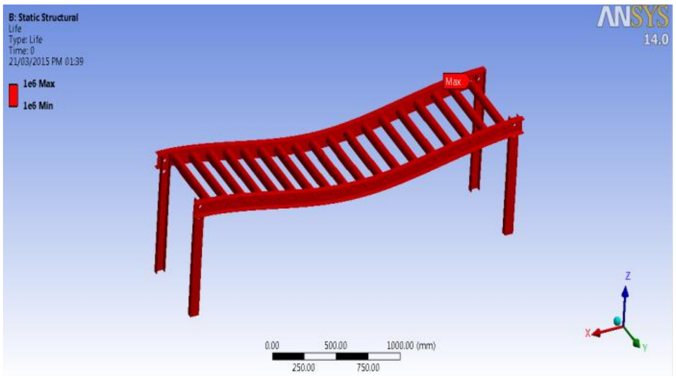

Fig. 12 Life of optimized design

VII. VALIDATION

Numerical solution is done for optimized model and the results are compared with the experimental results.Actual physical model is done for validation using optimized design parameters and it is found that the design is working safely.Compare to existing design the changes are made in three parts viz. C-channel for chassis, C-channel for support and roller.As the parts in which changes are made in existing design are standard so made easily available in market and are assembled for testing on which 200 kg load is applied and safety is checked. The weight of the physical model is slightly less than the optimized model values, shown in below table.

TABLE III
Weight of the assembly

Sr. No.	Name of Component	Weight(kg) Existing Design	Weight(kg) Optimized Design
1	C-Channels for Chassis	52.20	33.650
2	Rollers	231.496	115.007
3	Shafts	32.594	10.340
4	Bearings	3.992	3.5928
5	C-channels for Supports	22.1765	22.1765
	Total Weight of Conveyor Assembly	**342.4585**	**184.766**

VIII. CONCLUSION

1) Result of linear static analysis shows the difference between maximum deflection and stress in existing and optimized design is negligible.
2) Result of transient analysis shows there is negligible difference between maximum deflection and stress in existing and optimized design.
3) Even there is some difference in deflection and stresses of existing and optimized design, but it is in permissible limit.

TABLE IV
Effect of Optimized design on maximum deflection, stresses and natural frequency

Design	Max. Def(mm)	NaturalFreq. (Hz)	Max. Stress(N/mm^2)
Existing	0.41029	30.094	20.898
Optimized	0.62271	32.364	23.965

TABLE V
Weight reduction and material saving due to

Optimized Design

Design	Weight(kg)	%Material required compared to Existing design	%Material save compared to Existing design
Existing	342.4585	100	--------------
Optimized	184.766	53.9528	46.0472

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REFERENCES

[1]. M. A. Alspaugh, “Latest Developments in Belt Conveyor Technology”MINExpo 2004, Las Vegas, NV, USA. September 27, 2004.

[2].S.H. Masood · B. Abbas · E. Shayan · A. Kara “An investigation into design and manufacturing of mechanical conveyors Systems for food processing”, Springer-Verlag London Limited 2004.

[3]. DimaNazzal , Ahmed El-Nashar“Survey Of Research In Modeling Conveyor-Based Automated Material Handling Systems In wafer fabs” Proceedings of the 2007 Winter Simulation Conference.

[4]. Chun-HsiungLan, “The design of a multi-conveyor system for profit maximization” International Journal AdvManufTechnol (2003) 22: 510–521.

[5]. John Usher, John R , G. Don Taylor “Availability modeling of powered roller conveyors”**.**

[6].Espelage W, WankeE.“Movement minimization for unit distances in conveyor flow shop processing”.

[7].C.Sekimoto “Development of Concept Design CAD System”, Energy and Mechanical Research Laboratories, Research and Development Center, Toshiba Corporation.

[8]. Ying WANG, Chen ZHOU “A Model and an analytical method for conveyor system in distribution centers”, J SystSciSystEng (Dec 2010) 19(4): 408-429.

[9]. R. Long, T. Rom, W. H¨ansel, T.W. H¨ansch, J. Reichel “Long distance magnetic conveyor for precise positioning of ultra cold atoms” Eur. Phys. J. D 35, 125–133 (2005).

[10] R. Pascual, V. Meruane, “Analysis of transient loads on cable-reinforced conveyor belts with damping consideration”, Proceedings of the XXVI Iberian Latin-American congress on computational methods in engineering CILAMCE 2005 Brazilian Assoc. for comp mechanics & Latin American assoc of comp methods in engineering, Guarapari, Espirito Santo, Brazil, 19th -21st October 2005. Paper CIL0620.

[11] A. Harrison, “non-linear belt transient analysis by numerical simulation”, Bulk Solids Handling International journal, Nr. 3, 2008, Page no 1-7.

[12] ChetanKothalkar, T. Wankar, R.S. Wankar, “Analysis of the short distance gravity actuated oscillatory trolley conveyor”, 14th National Conference on machines and mechanisms (NaCoMM09), NIT, Durgapur, India, December 17-18, 2009, NacoMM2009-ASMCK24. Page no 84-90.

[13] AshishDevikar, KarthikVasudevan, Nikhil garge, Edward Williams, Rajesh welekar, “Evaluating the performance of a complex power and free conveyor system in a flexible manufacturing environment”, proceedings of the 2010 winter simulation conference, 978-1-4244-9864 @ 2010 IEEE. Page no 1574-1583.