Design and Optimization of Roller Conveyor System

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Abstract: In this paper we studied existing conveyor system and optimized critical parts of roller conveyor system like Roller, C-channels for chassis and support, to minimize the overall weight of assembly and material & cost saving.

Paper contains geometrical modeling and finite element modeling of existing design and optimized design. Geometrical modeling is done using Catia V5R19 and finite modeling was done with the help of Ansys .Results shows safe design of optimized design. Optimization gives optimum design for same loading condition with huge amount of weight reduction. Using optimized procedure and using practical available structure 39.26% weight reduction is achieved

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

1.0 Introduction

1.1 Conveyors

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. 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. There are chain conveyors (floor and overhead) as well. Chain conveyors consist of enclosed tracks, I-Beam, towline, power & free, and hand pushed trolleys. Conveyor systems are used widespread across a range of industries due to the numerous benefits they provide. Conveyors are able to safely transport materials from one level to another, which when done by human labor would be strenuous and expensive.

- Conveyors can be installed almost anywhere, and are much safer than using a forklift or other machine to move materials.
- Also can move loads of all shapes, sizes and weights. Also, many have advanced safety features that help in preventing accidents.

Fig. 1.1 Conveyor Systems

There are a variety of options available for running conveying systems, including the hydraulic, mechanical and fully automated systems, which are equipped to fit individual needs.

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. 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.

In this paper the latest development of belt conveyor is done. It concentrates on energy efficiency, route optimization, distributed power, analysis and simulation (1). It is observed that the weight of the conveyor part increased due to the critical part of the system (2).The amount of processing that the device increase as the circuit design becomes more complex (3). ADAMS CAD system is used as simulation technique (4). Determination of the number of conveyors into the objective. To develops two staged method to optimized and maximum profit (5). Various types of cost estimation techniques are given for optimization of steel frames (6). The standard design where each roller is connected to line shaft, where the first roller in conveyor connected to line shaft and subsequent rollers are connected by sequential belts are studied(7).to identify the conveyor dynamic relationship, based on this formulate dynamic network model for the performance evaluation (8). In this paper deal with special kind of flow shop processing which quit different from the usual flow shop (9).

1.2 Types of Conveyor Systems,

1. Gravity Conveyor systems
2. Powered Belt Conveyor systems
3. Pneumatic conveyor systems
4. Vibrating conveyor systems
5. Flexible conveyor systems
6. -Vertical conveyor systems and spiral conveyors
7. Live Roller Conveyor systems

2.0 Scope of Present Study

1. Check design of existing conveyor system.
2. ANSYS APDL codes or Catia V5R19 for drawing of existing system.
3. ANSYS is used for linear static, modal, transient and optimization analysis.
4. Optimization of conveyor assembly for weight reduction.
5. Comparison between existing and optimized design.
6. By using the “STEEL TABLE” and “UNIVERSAL TESTING MACHINE” find out the maximum loading and maximum bending stress of the channel.

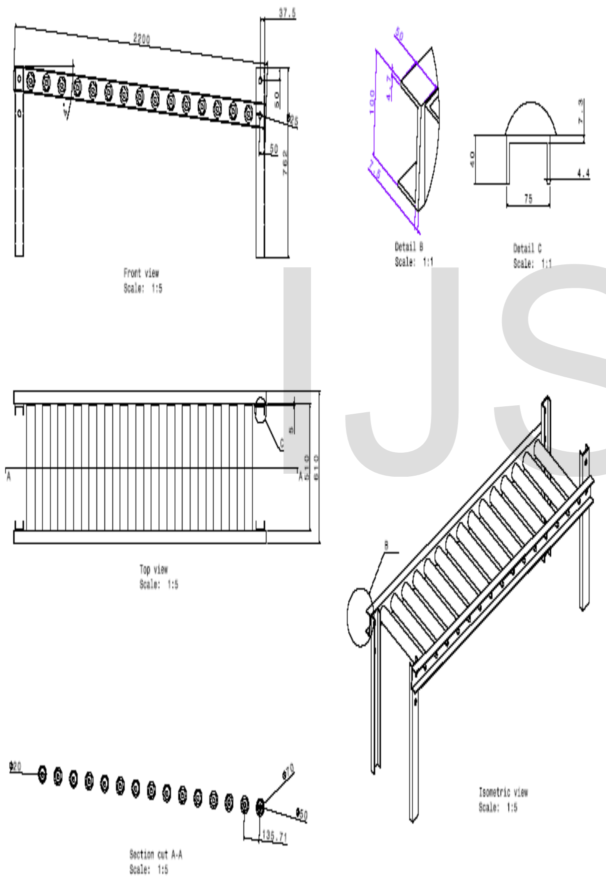

Fig. 2.1 Gravity Roller Conveyor Assembly

3.0 Design of the Existing Assembly of 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.

Gravity roller Conveyor has to convey 3500 N load, 30 inch above ground and inclined at 4 degree. Fig. 2.1 shows roller conveyor assembly.

Components of conveyor are as follows,

Table no 3.1 List of materials

Sr. No.	Component	Material	Qty.
1	C-Channels for Chassis	ISMC 100	2
2	Rollers	Mild Steel	15
3	Bearing	Std.	30
4	C-Channels for Stand	ISMC 75	4
5	Shaft	Mild Steel	15

Table 3.2 Total Weight of Existing Conveyor Assembly

sr. No.	Name of Component	Weight (Kg)
1	C- Channel for Chassis	39.066
2	Rollers	111.1181
3	Shafts	20.7421
4	Bearing	2.994
5	C- Channel for Supports	19.70
	Total Weight of assembly	**193.6121**

4.0 Geometric Modeling

Geometrical modeling done with the help of CATIA V5R17.

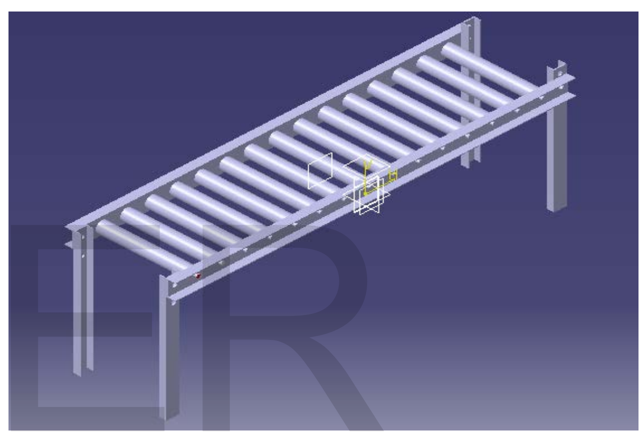

Fig. 4.1 Geometrical modeling using Catia

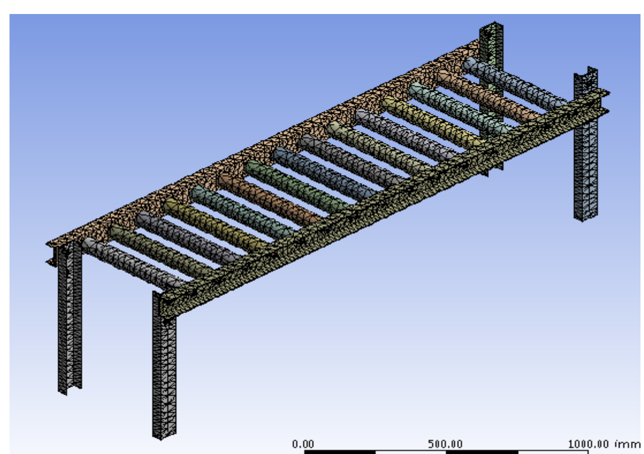

Fig. 4.2 Finite element mesh of the model

5. 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.

A static analysis can, however, include steady inertia load (such as gravity and rotational).

Design and analysis of roller conveyor for weight optimization & material saving and time varying load that can be approximated as static equivalent loads (such as static equivalent wind and seismic loads commonly defined in many building codes). Required properties of

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material are selected**.** Static analysis determines the displacements, stresses, strains, and forces in structures or components caused by lodes that do not induce significant inertia and damping effects. Steady loading and response conditions are like that is, the loads and the structure's response are assumed to vary slowly with respect to time.

Critical load condition-

Load is acting on any four rollers hence by considering 3500 N load acting on four rollers maximum deflection, maximum stress values are checked for existing design.

5.1 Results for static analysis.

-Weight of the model is 193 kg
- Maximum deflection plot shown in fig. 5.1
- Maximum stress plot shown in fig. 5.2

Load of 3500 N is applied on 4 rollers which located at the centre of the conveyor system. We get the maximum deflection and maximum stress.

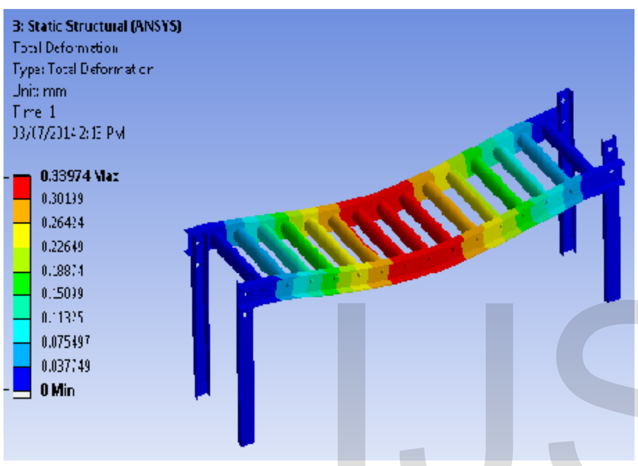

Fig. 5.1 Deflection plot

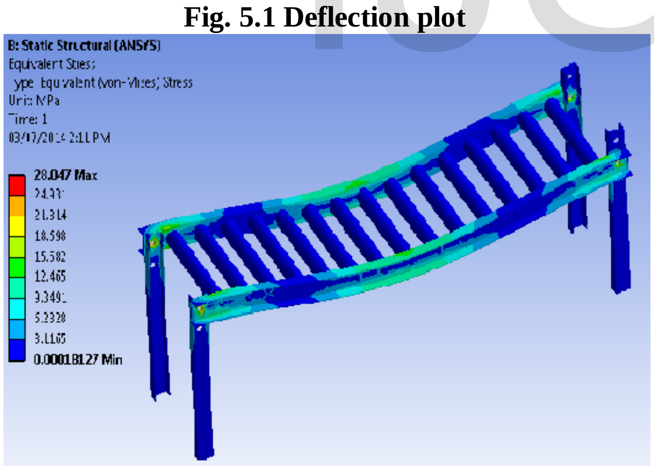

Fig. 5.2 Stress Plot

5.2 Modal analysis

- Modal analysis is carried out to find natural frequency and mode shapes.
- As the loading will be in vertical direction (gravity) the mode shape which will show movement in vertical direction is important.

There are different types of critical mode shapes occur in the conveyor system. We selected the transverse mode shape which require for the analysis purpose.

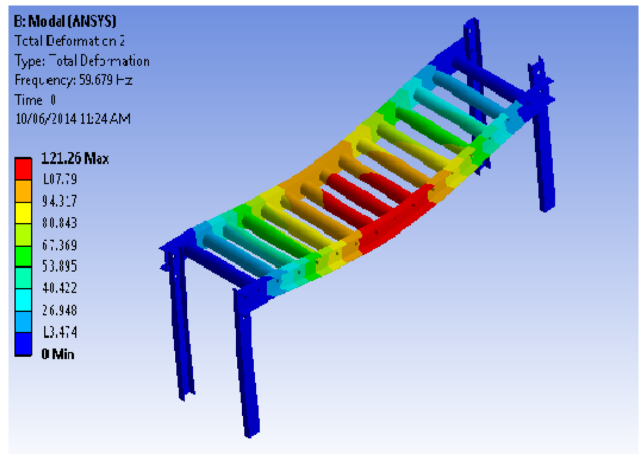

Fig. 5.3 Critical Mode Shape

Result from Modal analysis-

- From the results it is clear that mode shape in fig will have maximum motion in vertical direction. So natural frequency should be greater than the excitation frequency.
- Natural frequency is 59.679 Hz.

6.0 Need of Optimization

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

6.1 Optimized design.

Optimized design on the basis of following criteria.

6.2 Selection of Critical Parameter

- Flange Width
- Flange thickness
- Web height
- Web thickness
- Roller Outer diameter
- Roller thickness

- Selecting available components which are similar to optimized design.
- Select ISJC 100 and ISJC 75 C-channels for chassis and supports respectively
- Roller Outer diameter is 60 mm and roller thickness 5 mm

6.1 Total Weight of Conveyor Assembly (Optimized Design)-

Sr. No	Name of Component	Weight (Kg)
1	C- Channel for Chassis	25.62
2	Rollers	50.92
3	Shafts	20.7421
4	Bearing	2.994
5	C- Channel for Supports	17.32
	Total Weight	**117.5961**

6.2 Analysis of Optimized Design:

Static structural analysis is done with the help of ANSYS workbench.

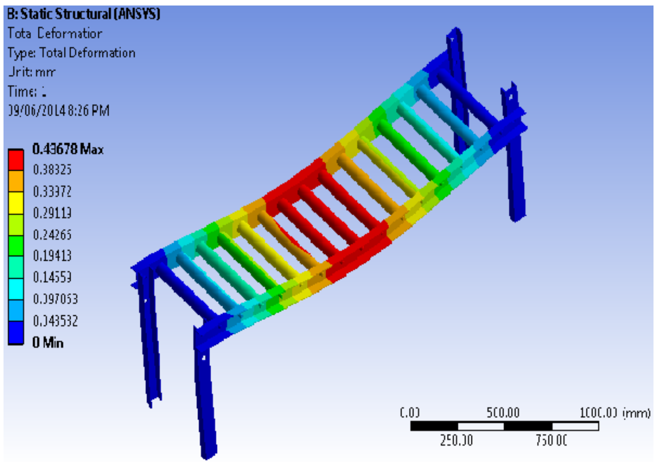

Fig 6.1 Linear Static Analysis of Optimized design: Deflection plot

Static structural analysis is done with the help of ANSYS workbench.

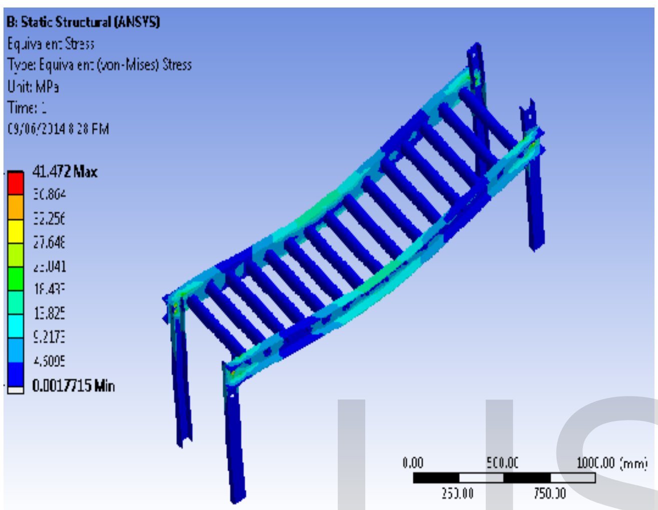

Fig 6.2 Stress Plot – Optimized design

Model analysis is done with the help of ANSYS workbench.

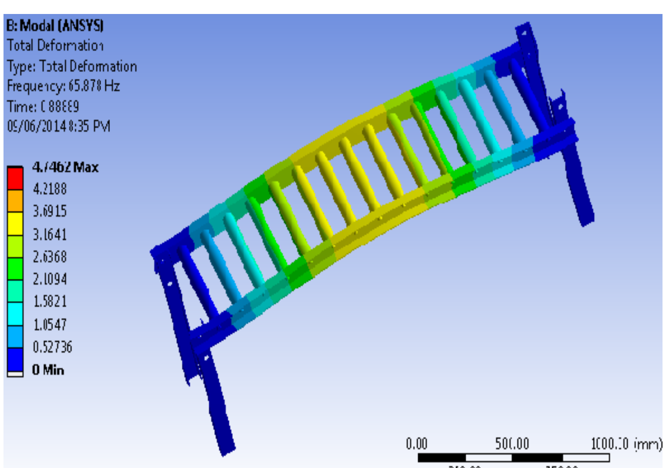

Fig. 6.3 Critical Mode Shape of Optimized design

Transient structural analysis is done with the help of ANSYS workbench.

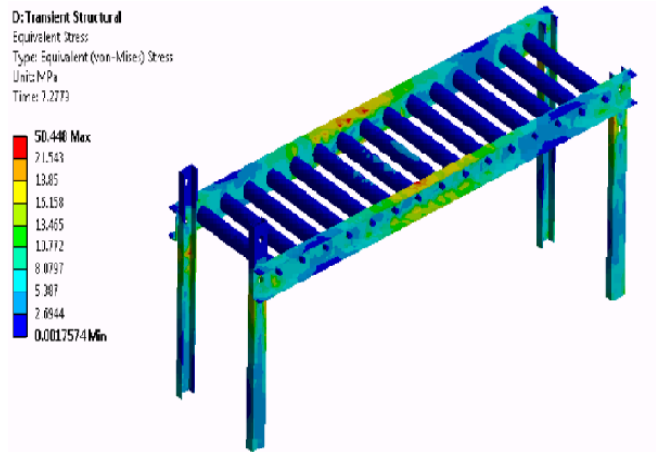

Fig 6.4 Transient Structural

7.0 Results and discussion

Sr. No	Name of Component	Weight (Kg) Optimized Design	Weight (Kg) Existing Design
1	C-Channels for Chassis	25.62	36.066
2	Rollers	50.92	111.1181
3	Shafts	20.7421	20.7421
4	Bearings	2.994	2.994
5	C-channels for Supports	17.32	19.70
	Total Weight of Conveyor	**117.5961**	**193.6121**

7.1 Observation from Results- Effect of Optimized Design Compared with existing design-

1) From above chart we can find the great change in weight of optimized design and existing design. (60 Kg. weight reduction)

2) Here we can observe changes in 3 main components, i.e. C-channels for Chassis, C- Channels for Supports and Rollers due to optimization.

Design	Max. Def (mm)	Natural Freq. (Hz)	Max. Stress (N/mm^2)
Existing	0.3397	59.67	28.047
Optimized	0.4367	65.87	41.47

7.2 Weight reduction due to Optimization

Design	Weight (Kg)	% Material required compared To Existing design	% Material save compared To Existing design
Existing	**193.6121**	100	--
Optimized	**117.5961**	60.73	39.26

8 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 of C-channels, roller outer diameter and roller thickness.
- Though value of deflection, stress is more in case of Optimized design, but it is allowable.
- Transient analysis also gives the permissible stress limit i.e. 50.40 Mpa.
- 39.26% of weight reduction is achieved due to Optimized design.
- 60.73 Kg. weight reduction achieved by optimized design than existing design.

9 Future Scopes

1) Fatigue analysis for life calculation.
   Fatigue analysis can be done by obtaining the SN curve. ANSYS predicts the number of cycles of different regions.
2) Buckling analysis.
   Buckling analysis of support channels can be done to find maximum load.
3) Non-linear analysis.
   Material non-linearity can be considered to find more accurate results.
4) Selection of appropriate material.
   By selecting inferior quality of material further weight reduction of conveyor is possible.
5) Thermal Analysis can be considered for further study.

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