STRENGTH ANALYSIS AND WEIGHT OPTIMIZATION OF DOUBLE STRAND CHAIN CONVEYOR

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Abstract-*Double strand chain conveyor is a material handling system which is powered by a continuous chain and is primarily utilized to transport heavy loads. The material handling system is typically a double strand configuration with the load positioned on the chains, however multiple strand configurations are also available. This conveyor is generally very easy to install, requires minimal maintenance. They are sometimes referred to as a pallet conveyor due to their wide use in transporting wood or steel pallets. Multiple chain options allow for flexibility in applications as well as environments.*

The static analysis of the double strand chain conveyor is carried out. The 3D modelled in Catia was imported into hypermesh software and the analysis was done statically to find out the deflection and the stress. For validation, the critical parts was analysed separately in the software and the analytical calculations was carried out.

Later on weight optimisation was carried on for the critical parts. Different cross sections were used for weight optimisation.

Keywords: *Double strand chain conveyor, Pallet conveyor, Static analysis, Validation, Weight optimization.*

1. INTRODUCTION

Chain conveyor is a rugged and durable conveyor system that is used to transport a multitude of products that would not typically convey on a roller conveyor. Typical products that would be conveyed include pallets, racks, industrial containers and other products with a sturdy conveying surface.

Chain conveyor is powered by a continuous chain and is primarily utilized to transport heavy loads. The chain conveyor is typically a double strand configuration with the load positioned on the chains, however multiple strand configurations are available. This conveyor is generally very easy to install, requires minimal maintenance, and integrates easily in systems with CDLR and transfers. They are sometimes referred to as a pallet conveyor due to their wide use in transporting wood or steel pallets. Multiple chain options allow for flexibility in applications as well as environments.

Today's world is of automation and modernization in the manufacturing techniques. Material Handling is the part of this modern technique which are of importance in any of the industry. Material handling plays an important role in manufacturing and logistics. Almost every item of physical commerce is transported on a conveyor or lift truck or other type of material handling equipment in manufacturing plants, warehouses, and retail stores. The operators use material handling equipment to transport various goods in a variety of industrial settings including moving construction materials around building sites or moving goods onto ships. 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. In today's radically changing industrial markets, there is a need to implement a new manufacturing strategy, a new system operational concept and a new system control software and hardware development concept, that can be applied to the design of a new generation of open, flexible material handling systems.

Conveyors are used in many industries to transport goods and materials between stages of different processes. Use of conveyor systems is a very good way to decrease the risks of musculoskeletal injury in tasks or processes that involve manual handling, as they reduce the need for repetitive lifting and carrying. Conveyors are a powerful material handling tool. They offer the opportunity to boost productivity, reduce product handling and damage, and minimize labour required in a manufacturing or distribution facility. All lifting and conveying machines can be divided by their operating principles into two large groups:

(i)Intermittent motion, (ii) Continuous motion Intermittent motion includes all types of cranes, lifts; surface transport means (trucks, loaders, prime movers), aerial tramways and cable ways, scrappers and the like. Continuous motion includes conveyors, pneumatic and hydraulic transport means etc. which may generally called continuous transport machines or conveying machines. Continuous machines are characterized by non-stop motion of bulk or unit loads along a given path, without halts for loading and unloading. At the same time they can distribute loads among a number of destination points, deliver them to stores, and transfer products from one technological operation to another and ensure the desired pace of a production process.

1.1 OBJECTIVE OF PROJECT WORK

- The system is analysed statically for stress and deflection.

- The weight reduction is carried out.
- Stress and deflection analysis is done for each and every part of the system for the given loading conditions.
- Meshing and analysis is done in the hypermesh software.
- Validation is done by the theoretical calculations of individual part for the given load.

2. LITERATURE REVIEW

2.1 Design and Optimization of Roller in Belt Conveyor System for Weight Reduction

Pawar Jyotsna, D.D.Date, Pratik Satav (2014),The authors of the paper have studied the design and optimization of roller belt conveyor system for weight reduction. The main aim of this paper was to study the existing belt conveyor system and to optimize the critical parts of the roller belt conveyor system like roller, L channels, and support, to minimize the overall weight of the assembly. Mild steel material was used for design and analysis of roller conveyor system. The inner diameter of the roller was changed for the optimization of the roller for weight.

The value of both the deformation and the stress was high as compared to the existing design, but was under the permissible limits. They also showed that the calculated factor of safety is much greater than the assumed and hence the material is safe and provision for weight optimisation is possible.

2.2 Analysis and optimization of gravity roller conveyor using ansys

Mr.AmolB.Kharage, Prof. Balaji Nelge, Prof. Dhumal Ketan

The authors analysed the Gravity roller conveyor in ANSYS software. The main focus was to study the gravity roller conveyor and to analyse it. Also the optimisation of the critical parts was done using composite material for the overall weight reduction without hampering its structural strength.Static, modal and transient analysis wasdone. Also the existing and the optimised design results were compared.

In this paper, the weight reduction is done on the main assembly unlike others where the roller weight optimisation is concentrated. The weight optimisation of the conveyor was done using carbon fibre material for roller and C-channel frame.

2.3 Design and weight optimization of gravity roller conveyor

Mr. Sunil Krishna Nalgeshi (2016) The author studied about the design and weight optimization of roller conveyor without deviating its structural strength. In this work, each component is designed analytically and the total weight of the conveyor is calculated by adding weights of individual components. Here in order to optimise the model, the material is changed from mild steel to polycarbonate material.

Different parts of the conveyor module were designed and analysed for optimal weight and the weight reduced was around 100 kg.

3. PROJECT METHODOLOGY

3.1 Process Methodology

Initially, the conveyor model is imported into hyper mesh which is basically designed and sent from the customer end in CATIA software. There are various ways to import the model in the software. For ex IGES, STEP etc. are the ways by which we can import the geometry in the hyper mesh software. Once the CAD model is imported, the geometry cleanup is done in the software. Geometry cleanup includes the deletion or removal of the unwanted lines or the surfaces in the model. After the geometry cleanup is done, the next thing is the starting of the meshing. Here each and individual components are meshed first using a suitable element size and then the 2D mesh is converted into 3D mesh either by solid mapping or by doing tetra mesh. Once all the parts are meshed, we start giving the connections by selecting the type RBE2 connector. RBE2 is a rigid body connector. Once the meshing and connections is done, we get into the analysis part.

The first step in analysis part is to create the materials and their properties. In our case the material used is mild steel. The next step is creation of load collector card. Two cards are assigned in load collector, one is single point constraint (SPC) and the other one is the force card. In spc, we specify the fixed constraint and in the force card, we apply the load. The load step is created and the values are assigned. Once the values are assigned, the next step is to get the results from the software. In Hyper view solver, we get the values for stress and the deflection.

The above process is the methodology which details about the insights the software. The stress and the deflection is obtained for the complete assembly. In order to validate the results, the critical components are analyzed separately for maximum load in the software and the analytical calculations are done separately and the results are validated.

Here, the critical components selected are I cross section Beams and I cross section Columns. The bending moment and the deflection are obtained for I beam by both software method and the analytical method. For columns, the buckling load is calculated and the stress is obtained at this buckling load.

Finally, the cross sections are modified for the weight optimization. Three cross sections i.e. I beam with varying c/s area, C channels and the Square tubes are used for the analysis of weight optimization. Same load is applied on all the three cross sections and the stress and deflection is calculated and if they are in the permissible limits, the new optimized cross sections are considered for the weight optimization.

The material used is Mild Steel. The values are given below

TABLE 1- MILD STEEL PROPERTIES

Physical Properties	Values
Density	7700 kg/m^3
Young's modulus	210 GPa
Poisson's ratio	0.3
Tensile yield strength	250 M Pa

3.2 Analysis Inputs- Conveyor

Basically, the inputs which are required for the analysis of the component is explained in this part. Initially, the loading and boundary conditions of the conveyor module is explained and then the I beam inputs and the Column inputs are given.

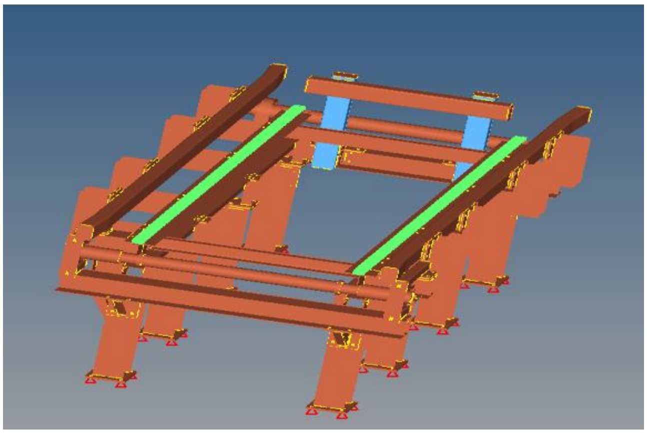

Fig -1: Loading and Boundary Conditions on the Conveyor

As shown above, the green colored section shows the Loading conditions and the Red colored Triangles at the bottom shows the Fixed or the Boundary conditions.

3.3 Analysis Inputs- I Beam

Once, the analysis is done for the conveyor, preparation is done for the simulation of the I beam. Similar way to the conveyor, the loading and boundary conditions are applied to the I beam.

The chosen I beam acts as a Simply supported beam and a UDL of 4 ton is applied to the cross section. Also the dimensions of the I cross section is shown below

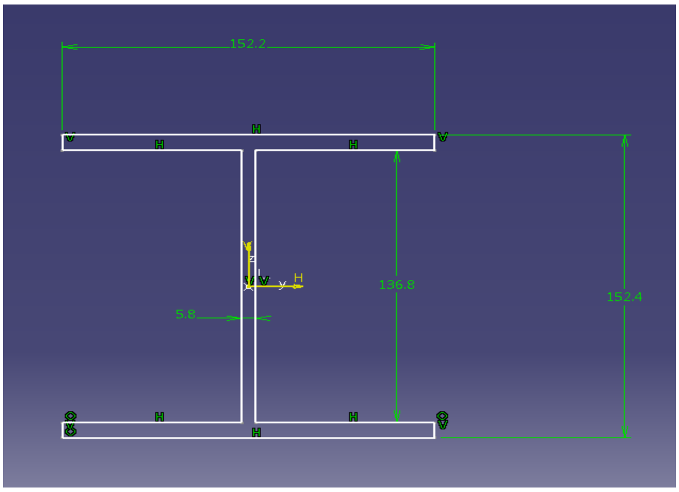

Fig-2: Dimensions of I cross section

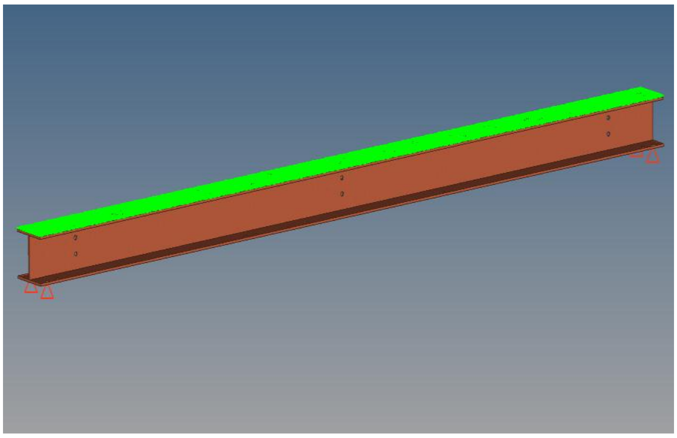

Fig-3: Loading and Boundary conditions

3.4 Analysis Inputs- Column

Columns are made ready for analysis similar to that of I beams. Loading and boundary conditions are applied to the columns as shown.

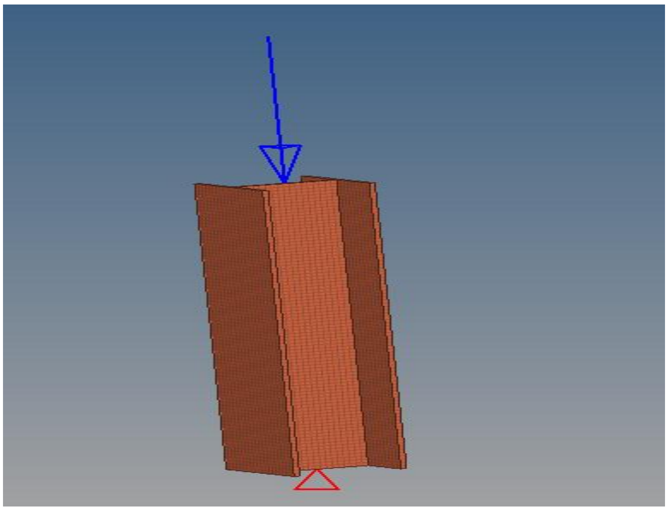

Fig-4: Loading and Boundary conditions on Column

4. Results and discussions

4.1 Stress and Deflection in the conveyor

The following figures show the results of stress and deflection acting on the conveyor system. The maximum stress acting on the conveyor is 105 Mpa and the Maximum deflection is 0.15 mm.

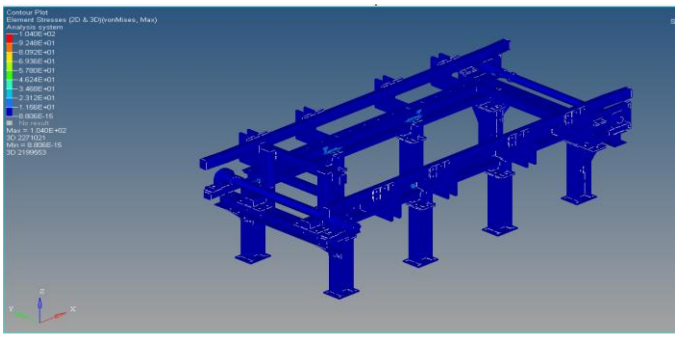

Fig-5: Stress in the conveyor system

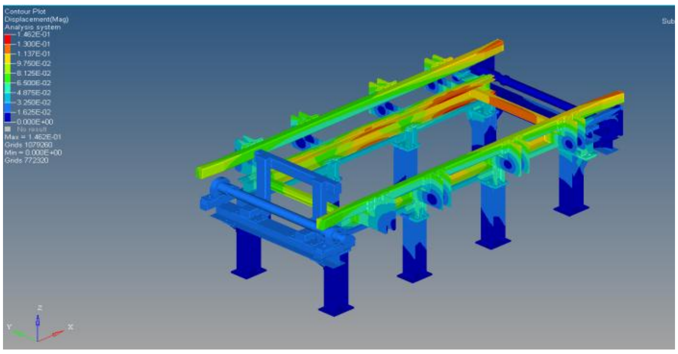

Fig-6: Deflection in the conveyor system

4.2 I Beam simulation

I beam simulation is done by two ways. One is numerical analysis and the other way is analytical calculation.

4.2.1 Numerical Results

The Numerical results obtained from the software are shown below. The Bending moment and deflection comes around to be 130*10^5 Nmm and 5.2 mm respectively.

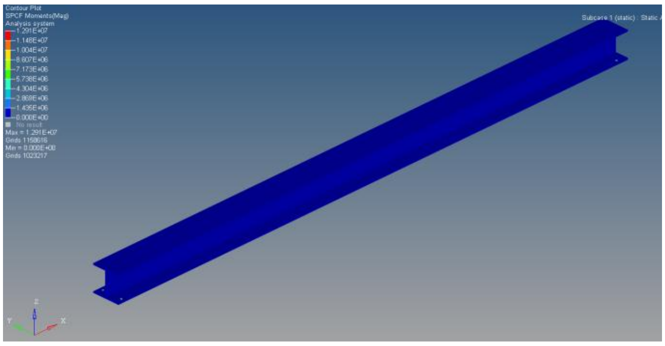

Fig-7: Bending Moment in I beam

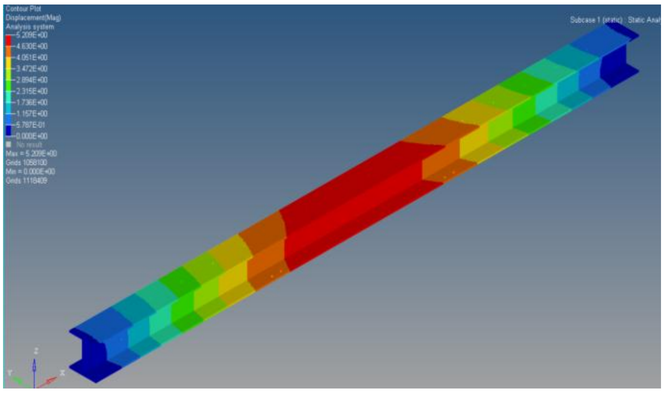

Fig- 8: Deflection in I beam

4.2.2 Analytical results

Calculation of Maximum bending moment (M_{max}):

$$M_{max} = \frac{WL^2}{8}$$

$$= 4 * 1000 * 9.81 * \frac{3093^2}{8}$$

M_{max} = 150* 10^5 N mm (1)

Calculation of Maximum Deflection (δ_{max}):

$$\delta_{max} = \frac{5WL^3}{384EI}$$

$$= \frac{5 * 40000 * 3093^3}{384 * 210000 * 13660682.54}$$

δ_{max} = 4.8 mm (2)

As seen above, the numerical and analytical results are almost nearer with an error percentage of about 10%.

4.3 Column Simulation

4.3.1 Numerical Results

The numerical results obtained from the software are shown below.

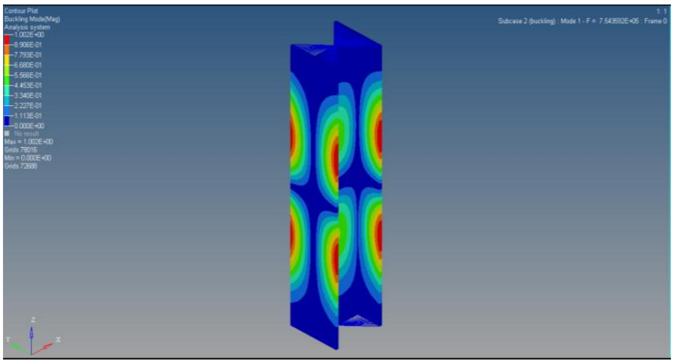

Fig-9: Buckling load in the column

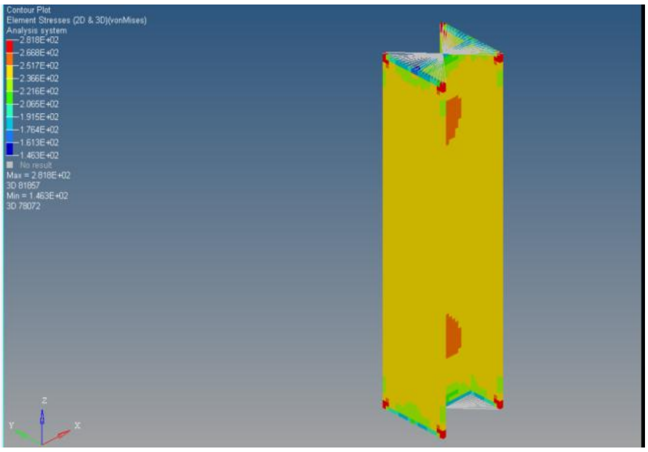

Fig-10: Stresses in the column

The Buckling load is around 7.54*10^5 N and the stress acting on the column in around 282 MPa

4.3.2 Analytical results

Calculation of Euler Critical Load (P_e):

$$P_e = \frac{4\pi^2 EI}{L^2}$$

$$= \frac{4 * 3.142^2 * 210000 * 13660682.54}{700^2}$$

P_e = 231.13* 10^6 N (3)

Calculation of maximum compressive load (P_c):

$$P_c = \sigma A$$

P_c = 791.91 kN (4)

Calculation of total buckling load (P_{max}):

$$\frac{1}{P_{max}} = \frac{1}{P_e} + \frac{1}{P_c}$$

P_{max} = 7.89* 10^5 N (5)

Calculation of stress at buckling loads (σ_{max}):

$$\sigma_{max} = \frac{P_{max}}{A}$$

$$= 7.89 * \frac{10^5}{3167.76}$$

σ_{max} = 250 MPa (6)

Calculation of Bending stress (σ_b):

$$\sigma_b = \frac{My}{I}$$

$$= \frac{\left(\frac{WL^2}{8}\right)y}{I}$$

$$= \frac{20000 * 700^2 * 75}{8 * 13660682.54}$$

σ_b=9.67 Mpa (7)

Calculation of Von Mises stresses (σ_v):

$$\sigma_v = \sigma_b + \sigma_{max}$$

σ_v=259.67MPa (8)

4.4 Weight Optimization

4.4.1 Need for Optimization

Calculated Factor of Safety is higher than the assumed Factor of Safety, and hence we can come to a conclusion that there is a scope of Weight reduction.

In order to reduce the weight, we can choose the various cross sections like Square tubes, c channels etc.

Various cross sections like I beam with changed cross section, C channel and Square tube is considered for weight optimization.

4.4.2 Use of I Beam

The I cross section Beam is used with a varied cross section. Standard I cross of dimensions 85*175*5.8 mm is used where the width of the flange is 85 mm, the height of the web is 175 mm and the thickness is 5.8 mm.The displacement comes around 7 mm which is well under permissible limit of 8.59 mm.

4.4.3 Use of C channel

Another alternative was the use of C channel. The standard C channel was taken from the Steel Authority of India Pvt Limited (SAIL). This a standard C channel of dimensions 200*75*6.2 mm where the length of C channel is 200 mm, width of the channel is 75 mm and the thickness of the channel is 6.2 mm. This C channel is manufactured in the Durgapur Steel Plant.

The displacement obtained is 5.3 mm.

4.4.3 Use of Rectangular Hollow Section

Another alternative was the use of Rectangular Hollow section. The standard rectangular hollow section channel was taken from the VIZAG Steels. This a standard cross section of dimensions 200*100*4 mm where the width of cross section is 100 mm, height of the cross section is 200 mm and the thickness of the cross section is 4 mm.

The displacement obtained is 6.2 mm.

5. Conclusions

Initially, the complete model was selected for the analysis for the static strength. Later on for validation purpose, the critical parts like, I cross section Beam and Columns were considered. Bending Moment, deflection and the stresses were obtained for the I cross section beam. The assumed Factor of Safety was 1.5 and the Factor of Safety obtained here was 2.45. As the values were well within the range, the cross section was considered as safe and there was a scope for weight optimisation.

The next analysis was conducted on the columns. Here the safety was considered by taking into account of the load applied. The load applied to thecolumns was 40000 N and the Total Buckling Load was around 7.89*105 N. This proves that the column can bear the load of 19.75 times the applied load.

The next aspect in the analysis was about the weight optimisation. For weight optimisation, the critical part chosen was I beam where directly the load was acting. Three different cross sections were chosen of same material. One is I beam withdifferent dimensions, second one is the C channel and the third one is the rectangular tube. The comparison between all the three cross sections is listed in the table below.

Table- 2: Weight optimisation Comparison

Cross section	Optimised Weight (kg)	Total weight reduced (kg)	Percentage of reduction
I beam	60	15	20
C Channel	66	9	12
Rectangular Tube	50	25	33.34

6. FUTURE SCOPE

- ❖ The present work is limited to only static analysis. It can be further simulated and analysed for Non linear or Transient Dynamic Analysis as the loads will be varying with respect to time.
- ❖ This present work can be taken forward and can be used for simulation in the real time application or real life situation.
- ❖ Since there are vibrations acting on the conveyor, the model can be worked out on the Modal or NVH (Noise Vibration and Harshness) analysis.
- ❖ Fatigue life analysis can be done by obtaining SN curves.

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