JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Design and Analysis of Overhead Automated Material Handling System

Abhijeet Kamble[1], Bhargav Kelkar[1], Aniket Jadhav[2]
1-UG student, 2- Assistant professor

Department of Mechanical Engineering, Smt. Kashibai Navale College of Engineering, Pune, India.

k.abhijeet99@gmail.com[1], bhargavdk01@gmail.com[1]
abjadhav@sinhgad.edu[2]

Abstract

There is always a need for a transporting mechanism in any industry. Traditionally, workers have been doing the hard labour job of lifting and further carrying heavy loads to a distance. This may be economically beneficial to the employer but certainly is counter-productive in a way, considering the time required for the displacement as well as the health risks associated due to prolonged work. This work focuses on the design and analysis of an overhead conveyor system. The optimum design was selected using Pugh controlled convergence method and further tested for its structural performance using finite element analysis. Finite element analysis has also been carried out with Solid Works to validate the structural integrity of the new concept design.

***Keywords*:** conveyor system; design; analysis; structural performance; Finite element analysis

I. INTRODUCTION

An overhead conveyor is an elevated system similar to a floor-level conveyor that is used to transport the materials throughout a facility. The main parts of the overhead conveyor are Rail, Carrier, Drive, Suspension attachments, Speed controller, Overhead tracks and structure. Overhead conveyors maximize conveyance by utilizing unused overhead space and do so via a revolving, endless loop of chain within a rigid track, or a straight run of trollies. Both the track and the carriers are simple enough to be designed into any desired shape, making them incredibly versatile in form and application. Overhead conveyors are easily implemented into most plants, as their modular design is meant to work around the complicated twists and turns of on-floor machines. In the present work, overhead conveyor structure including the track has to be designed for sandblasting application to carry a load of 50kg. For design and analysis, CAD software is used. For modelling Solid works and for analysis ANSYS software is used.

AA conveyor system is a common piece of mechanical handling equipment that moves materials from one location to another. Conveyor design and design optimization is the main definition of the problem. The main objectives include

1. Increase the efficiency of the plant.
2. Minimise the time required for handling.
3. Modelling through modelling software
4. Structural analysis through finite element software Ansys.

I. Literature Review

1) Garcia, et al. (2020). This Master's Thesis is based on design to look into the modelling and layout optimization of conveyor systems using an object-oriented modelling language. For the implementation of the methodology Open-Model free and open-source software has been used. There is research about conveyor systems analysis and currently available methodologies in the calculation of parameters such as throughput and technical availability. The required attributes for the calculation are analysed with the aim of preparing the methodology and a positioning calculation process is developed. That methodology could be implemented using another object-oriented modelling language than the selected one.

2) Patel et. al. (2014) proved that the first iteration of the project shows a load-carrying cage which is the main part that acts as a transportation unit was designed, analysed and fabricated with a high factor of safety. In the second iteration, the power transmission mechanism was designed with consideration of the load to be lifted. It is the main driving mechanism and made in such a manner that it could withstand the desired load and operate fully mechanically. All the major, as well as minor components, were selected and fabricated like a pulley, winch, Guide-way, base, shackle, fasteners etc. All the components and sub-assemblies were assembled together and installed at the proposed location. The test run was carried out to check the functionality and operation of the whole setup and it was found that the system operates properly with expected outcomes that the cage carried 50kgs weight up to a height of 14 feet in 98 seconds. Thus, a successful test run was conducted to raise the weight from the ground floor up to a certain height.

3) Umar et. al. (2018) conducted an experiment and concluded that a non-motorized trolley-lifter has been designed and developed in this study, based on the participatory inputs from end-users. The actual working operation of the high-field trolley-lifter proto-type has been successfully simulated in manual handling of sheet metals and has shown some early promises to improve work effi-science and occupational safety and health conditions. Through repeated simulated tasks, the use of the developed prototype reduced cycle time (up to 47%) and manpower utilization (from two to one). The prototype also improved the safety components of manual handling activity by ensuring minimal physical contact with sharp edges on the sheet metal. Finally, the developed trolley- lifter allows for a better working posture for transferring sheet metals and eliminates the need to provide manual contact/support to the heavy sheet metal throughout the transfer process.

4) Jaiswal et. al. (2020) studied the elements that contribute to the design and analysis of the drum and chain link of EOT Crane. In this research work, the analytical and computational analysis is carried out for a load of 5000N. The drum and chain link of EOT are designed by using Pro-E software. The structural feasibility is analysed by the Finite Element Analysis method. Finite Element Analysis is used in this project. The finite Element Analysis method is used to obtain the maximum deformation and stress experienced by the drum and chain link with a loading of 5000N.

5) Malek et al. (2015) The study has proven a detailed explanation of how to improve the existing conveyor machine that is located in the industry. The author explained that the design of the conveyor machine used a timing belt that connected to the motor to move the shaft. Also, he explained improvements in sprockets and chains as drive mechanisms used in conveyor systems. From the discussion, further, improvements can still be done in this project to increase the success rate of the conveyor drive system. During this project, the author manages to make the conveyor belt move with the current equipment of the drive system to run normally but from his observation, the motor that runs the conveyor can still be improvised into a more powerful motor. Another improvement that still could be made for the conveyor drive system is to replace the chain system with a high-efficiency system. There are some advantages and some disadvantages to the same.

6) Rapid Design Guide for Overhead Conveyors, Rapid Industries, Inc. (2018). In this guidebook, the company has maintained the Utilise of the shelf tractor and hoist assemblies from proven manufacturers. This Code of Practice will be found to be a useful and authoritative source of information for all those people who are responsible for meeting legal obligations and indeed, for everyone concerned with safety at work. In particular, certain items covered by this code are supplied in the form of propriety designs for which the designer, manufacturer, etc. must accept full responsibility. Every effort has been made to achieve the highest degree of accuracy in the preparation of the data and advice supplied, but the ultimate responsibility for safety must continue to rest with the persons and organisations charged with specific duties in current legislation. Moreover, in this guide we can find the Utilise available plant space in the safest most efficient manner. It Provides multiple inspection and assembly stations, increases productivity and enhances product quality at the same time. It will reduce the downtime and maintenance problems and meet the most demanding customer requirements.

7) Code of Practice for the Safe Use of Lifting Equipment, Lifting Equipment Engineers Association, Edition 9, Lifting Equipment Engineers Association (2019). The code is a practical guide covering manual and power operated lifting machines and structures, such as overhead travelling cranes and runway structures, together with a wide range of below hook equipment, from general-purpose slings and lifting accessories, to the various types of vacuum and magnetic lifters. Its contents will be found useful in devising safe working practices for anyone using lifting equipment, as well as providing all the information necessary for safety training in this critical area of activity at work. This code is based on the ‘risk based’ philosophy of modern legislation that places duties on those involved in every aspect of the manufacture, supply and use of lifting equipment, which together, collectively and comprehensively address all health and safety issues. The terminology used in earlier editions of the code was that used in older legislation and standards. New legislation and standards often use different terms, and, over time, we have made necessary changes to keep them up to date. However, terminology varies globally, and the code is intended to apply to equipment commonly in use and that will include older equipment made to earlier standards and still serviceable. The reader is asked to bear this in mind if there is an apparent conflict in terms.

II. EXPERIMENTAL WORK

I. Design of Hanger

To identify the deformation, we have applied the force of 250N on the hanger and the result shows, the hanger will deformed up to 0.0305mm as shown in following figure no: I

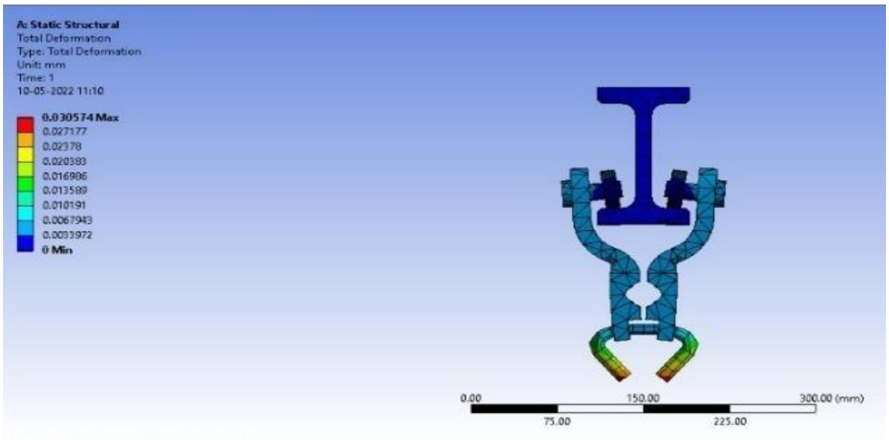

Figure No. I: Deformation of Hanger After Applying Load of 250N

Now finding elastic strain deformation at the hole where hook and hanger get in contact, we applying force of 250N only on hook side and the strain deformation will induced up to 0.0002mm as shown in following figure no. II

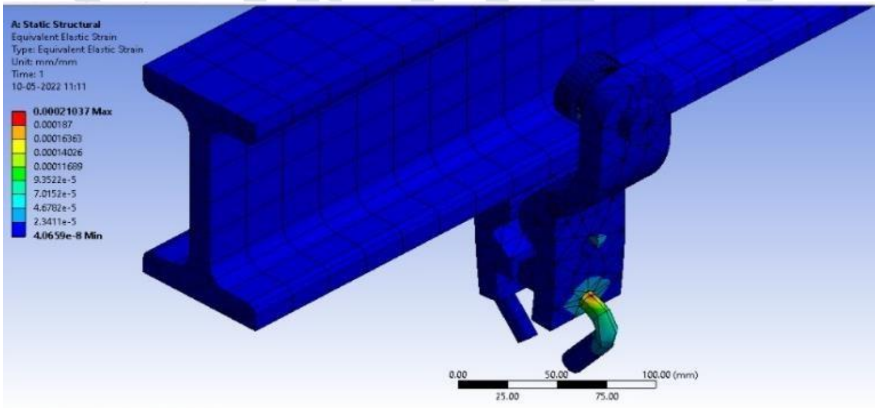

Figure No. II: Equivalent Elastic Strain Between Hanger and Hook

II. Design of conveyor hook

For this project, we studied a conveyor hook compatible with the eye type chain produced by the forging method. Material standard AISI 4340 or DIN 34CrNiMo6 as it has high carbon steel and property of corrosion resistance. The chemical composition and mechanical properties according to standard as J. D. Costa, 2001: 70 Finite element analysis of an approximation model for hook from Solid Works 2013 by creating a 3D standard workpiece. The analysis scope is allowed by hooks material as AISI 4340, Fixed Geometry grip design for locking the position that cannot move. Define 300 N (almost 30kg) force applied to the hook at the centre of the curved surface. From investigated results of the finite element method. To find the actual sizes according to ISO 7597: 2013 (Forged Steel Lifting Hooks with latch, grade 8). The purpose is to improve the hooking efficiency of strength by SolidWorks 2013 with the same weight or less. The design variables to create the optimised hook design process is mentioned below.

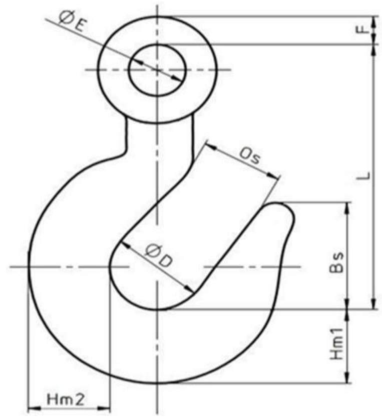

Figure No. III *Nomenclature of Hook*

From a SolidWorks 2013, software results show a yield point occurs at 640 MPa then maximum stress at 352.08 MPa from the analysis result and safety factor at 3. From investigated results of the finite element method and design for 300 N complies with ISO7597 standard and define to be the largest size.

Hook design loading by the optimization method with weighted factors rating method can increase the strength but can reduce material then the effect of this result was reduced material costs. The manufacturing process can be forged from ISO 7597 standard because shape and size are not different. The optimised size of the hook. There are 8 variables factors to effective for all sizes and can be compared as shown in Table No: I

Table No. I: *The comparison between the standard hook with the new design of hook*

Parameter	**Standard hooks (mm.)**	**Optimise size (mm.)** (comparison between the standard hook with new design of hook)
Bs	50	45
D	40	12.2
E	24	12.2
F	13	12.2
H (m1)	34.4	30.7
H (m 2)	34.4	27
L	124	100
Os	35	30.5

III. Overhead conveyor I beam track

I. Features of the I-Beam monorail conveyor:

1. Available in 3″, 4″ and 6″ conveyor track heights
2. Heavy duty forged linked chain and trolleys.
3. Welded design for rugged, long-term use.
4. Drop forged, rivet less chain is highly flexible and requires no tools for assembly.
5. Open track and chain design, all components are exposed and visible.

II. Additional components to improve versatility:

1. Wheel turns from 18″ to 30″ radius
2. Roller turns of 18″ to 60″ radius
3. In-line drives or sprocket turn drives capable of pulling long chains of feet with variable speeds.
4. 3″, 4″ and 6″ I-Beam monorail conveyors are amongst the most commonly used overhead conveyors in the industry.

III. Height of conveyor system

1. As the material travels overhead, one needs to consider the height from the ground as loading and unloading of the trolleys are done manually.

2. The average height of labour, as well as the length of the arm, is to be considered as one of the secondary objectives is to provide ease or comfort in working conditions.

3. According to many sources, the average height of Indian men is between 163 cm and 177 cm. Let us consider 170 cm height for the conveyor system.

4. Reducing the height of the carriers, **160 cm** height from the ground is considered.

IV. Design of Overhead conveyor track

We are applying unit force of 250N including wight of hanger and trolley on 1 metre of I-Beam Section and find the stress concentration for the same. Normally the trolley capacity will determine the size of the conveyor. In some cases, the maximum allowable chain pull may be exceeded even though the trolley loads may be within the capacity of the rail and trolleys. In these cases, either specify the next larger system or go to multiple drives.

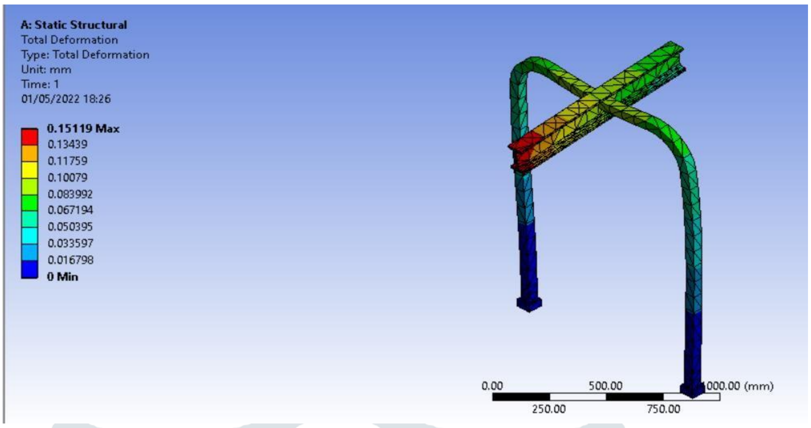

Figure No. V: Analysis of deformation on 1 metre of I-Beam after applying force

Now we have added the force of 250N on the I section including the weight of the trolley and hanger. As per result shown by Ansys, the I section beam is acting as a simply supported beam and under impression of deformation of 0.0004mm. The stress strain analysis for a 1 metre sample beam has shown in the following figure no: VI

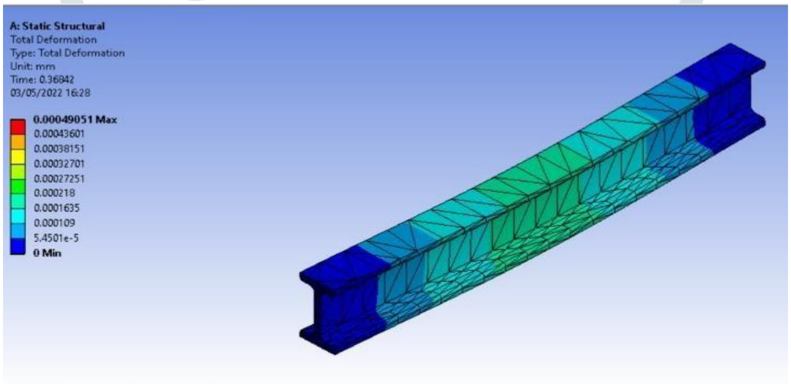

Figure No. VI: Analysis of Deformation on Simply Supported Beam

Here we have designed a route for the conveyor and applied the force of 10200N on the I section. This includes all the forces acting on the beam as e.g., weight of hanger, weight of bearing, weight of chain and the weight of trolley. After the analysis on Ansys software, we got the result as the beam is bending at the U curve with 0.4912mm. The result has shown in Figure No: VII

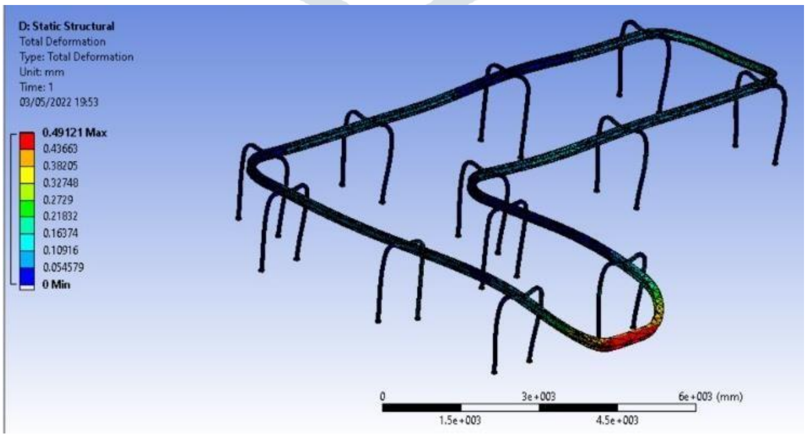

Figure No. VII: Deformation of I beam at U Curve.

After the modification of adding two support frames at both the U curves which was a weak paper as per previous results from Ansys. With the new supports, the structure looks safe with maximum deformation of 0.00015mm with applied load of 10200N. The detailed analysis has shown in following figure no: VIII

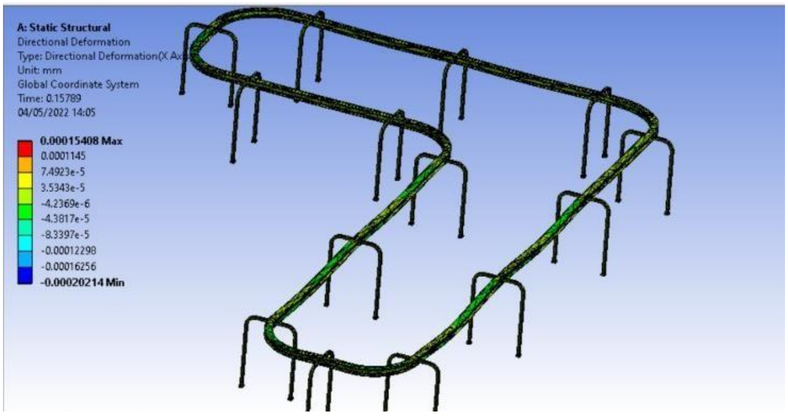

Figure No. VIII: Analysis of Deformation of Beam with Extra Two Supports

By adding ribs on both sides of the corner of the supporting frame, the structure's strength has been improved by 3.3802MPa. Additionally, the strain analysis on the rib has shown a value of 1.7052e. The illustration is shown in figure no. IX

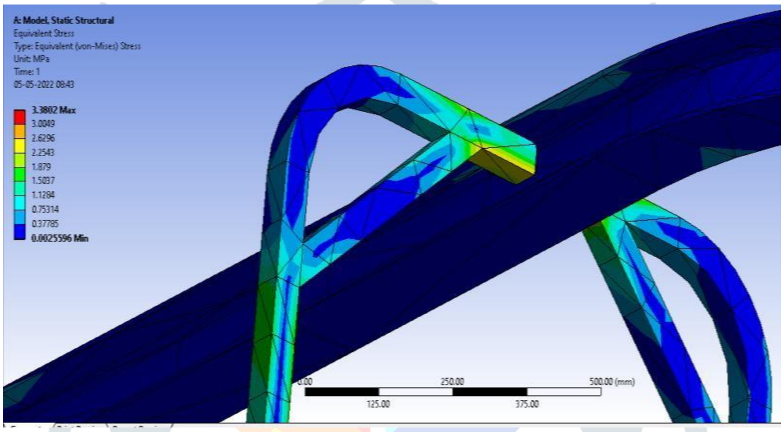

Figure No. IX: Stress Analysis of Rib

III. RESULT AND CONCLUSION

The first test was regarding all the Design Elements. The CAD model has been tested in ANSYS software and in this test, we checked every design aspect of the system. All the components have optimum design according to the requirement. In this test, problems including static/dynamic, structural analysis, heat transfer, and fluid problems, as well as acoustic and electromagnetic, in the structure we found that the bending at U curve is much larger of0.7125mm while applied on full load.

The second test is carried out on the same structure with addition of two support frames at the curve points and the analysis shows the bending of 0.00015mm. Now the structure is fully safe. After the further analysis on Ansys software, we got the result as the beam is bending at the U curve with 0.4912mm. After the modification of adding two support frames at both the U curves which was a weak paper as per previous results from Ansys. With the new supports, the structure looks safe with maximum bending of 0.00015mm with applied load of 10200N.

To improve the strength of structure, we added ribs on both sides on the corner of supporting frame. The results of stress experienced by the rib has shown about 3.3802MPa and the strain analysis on the rib is 1.7052e. Now the design is fully safe and ready to manufacture.

REFERANCE

1) Inigo Moraza Garcia, Layout planning of Continuous Conveyor Systems Using Modelica, Master’s thesis to achieve the academic degree of Master of Science Production Science and Management, Graz University of Technology, Year 2020.
2) Biren. N. Patel, Urmila. S. Munagekar, Onkar. R. Chaubal, Prajakta. S. Meshram, Patil Aniket K., Design, Fabrication and Installation of Mechanically Operated Lift for Floor wise Transportation, International Journal of Engineering Research & Technology, Volume 07, Issue 06, ISSN 2351-9781, Year 2017
3) Radin Zaid Radin Umar, Nadiah Ahmad, Isa Halim, Poh Yan Lee, Malek Hamid, Design and Development of an Ergonomic Trolley-Lifter for Sheet Metal Handling Task, International Journal of Engineering Research & Technology, Volume 10, Issue 3, Pages 327-335, ISSN 2093-7911, Year 2018
4) Mr Ankit P. Jaiswal, Prof. Kishor R. Sontakke, Design and Analysis of Chain Block System for Evaluation of Brake Load, International Journal of Trend in Science Research and Development, Volume-01, Issue-6, ISSN: 2456-6470, Year 2020.
5) Abdol Malek, Farid, Design and Development to Improve Mechanism of Conveyor System Part 1, International Journal of Engineering Research & Technology, Volume 2, Issue 3, ISSN 9366-3947, Year 2015.

6) Rapid Design Guide for Overhead Conveyors, Rapid Industries, Inc. Year 2018
7) Code of Practice for the Safe Use of Lifting Equipment, Lifting Equipment Engineers Association, Edition 9, Lifting Equipment Engineers Association Year 2019.