Design and Development of Tyre Transfer Unit

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Declaration

This is to certify that

I). The thesis comprises my original work towards the degree of Master of Technology in Mechanical Engineering(Computer Integrated Manufacturing) at Nirma University and has not been submitted else where for Degree.

II). Due acknowledgment has been made in the text to all other material used.

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Undertaking for Originality of the Work

I, **Dhaval Anadkat.**, Roll. No.**10MMCM01** , give undertaking that the Major Project entitled "**Design and Development of Tyre Transfer Unit**" submitted by me, towards the partial fulfillment of the requirements for the degree of Master of Technology in **Mechanical Engineering(Computer Integrated Manufacturing)** of Nirma University, Ahmedabad, is the original work carried out by me and I give assurance that no attempt of plagiarism has been made. I understand that in the event of any similarity found subsequently with any published work or any dissertation work elsewhere; it will result in severe disciplinary action.

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This is to certify that Major Project Report entitled "Design and Development of Tyre Transfer Unit" submitted by Mr. Dhaval Anadkat (10MMCM01), towards the partial fulfillment of the requirements for the award of degree in Master of Technology in Mechanical Engineering in the field of Computer Integrated Manufacturing of Nirma University is the record of the work carried out by him under our supervision and guidance.

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Abstract

Automation is often employed as a riser for production rate and quality in industries. Automation is the application of mechanical, electronic, and computer-based systems to operate and to control manufacturing. Automation implies that human labor, both cognitively and physically, is replaced by electronic or mechanical devices. In automated manufacturing systems, the operations are performed with a reduced degree of human participation. The dissertation is dealing with structural design and analysis for tyre transfer, such as deformation, stress and hindrances in existing industrial structure. The integrated problem of manual transfer of the tyres from storage to assembly line describes the importance of development of new system.

A particular path is selected for the proposed system, an unit structure is designed for manufacturing whole structure of path. Trolley is designed such a way that, it carries 6 tyres to assembly point at a time. The computation approach employs the finite element technique to solve the three dimensional structural problem and structural analysis. An experimental solution is carried out. Simulation as well as three dimensional geometry is developed and modeled by using software program SOLID EDGE ST3. Whereas computational analysis is carried out with the help of ANSYS WORKBENCH, to determine deformation, stress and to decide the safety of the structure. Material selected for manufacturing the proposed system, is structural steel. The guide-rail structure is analyzed for the loading conditions, which results as a safe structure and, column-beam structure (main frame) is also analyzed by applying loads, which has the safe results too.

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Chapter 1

Introduction

1.1 Background

The efficient, reliable, and economical design of automation system has been a standard demand for industry people and engineers since the very beginning of automation in mechanical engineering. Automation systems are today widely employed in the industrial environment for easier, accurate and faster processing. The main advantages of these systems are reduced operation time and work handling time significantly, and replacing human operators in tasks that involve hard physical or monotonous work. They may be used in a variety of configurations ranging from automated manufacturing, transfer system, or simply for the movement of any small thing. Several manufacturers in the market propose automation system to allow the system to work in simplest to very robust or complex conditions.

In any industry, some manual work has to be carried out, which increases the errors and time consumption is more, so implementing an automation system in the possible area, time is saved and errors occurring due to humans, can be decreased. Designing for low loss, needs more capital but leads to a improved system and lowered errors, more reliable operation, "After all the cost of lifetime losses is far greater than the cost of first installation, lower lifetime costs". Implementing an automation system increases the cost at initial stage, but gives better results for lifetime. The increasing number of industries in modern-day, and increasing demand of highly accurate quality goods, automation system proves better to fulfill the requirements. In the last few years, new behavior performances have indicated the need for new and more accurate modeling approaches. In particular, reduction in human errors and slower production rate are goals that require the solution for achieving new heights in field of production. So an automation system named as Electric Monorail System is proposed for the transfer of tyres.

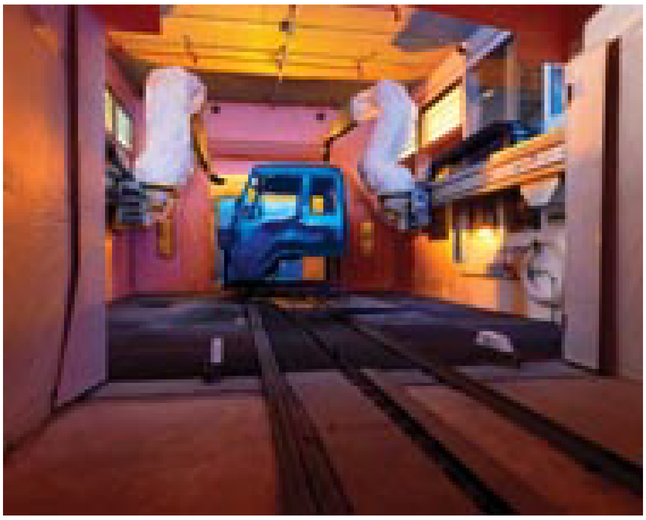


Figure 1.1: Automation in industry in current days

1.2 Motivation

In today's fast growing and developing world, daily new challenges and demands arise. Same things goes for the industrial development. In industries, automation plays a key role in its production rate. More automation systems used in the main system, more production rate will be achieved with improved quality, which further helps to satisfy customers requirement.
Asia Motor Works (AMW) a truck manufacturing company, established in Bhuj, has the same problem. They are highly desperate to change some of the manual works to be automated. Bottleneck among many possibilities was transfer unit for tyre. In current situation they are using fork lift to transfer tyre, which leads many problems, so a new system had to be developed for transfer of tyre, which I found suitable for my dissertation.

1.3 Problem Identification

With the regular increasing demand of the company's product trucks, company is unable to reach the required demand due to some manual work, among many of them, one major problem is of tyre supply at a proper time. So changing the system for supply of tyre in a company, a major problem can be resolved. And for the same, analysis of existing structure has to be carried out. In the current position company is using a fork lift for this purpose, which is not the permanent solution for the transfer of tyres. And as per planned production rate of company, due to the increase in requirement of trucks, trucks have to be produced at a rate of 7.5 Job per hour(JPH), whereas current production rate is 4 Jph.

Company is producing 50 trucks a day, in current situation at 4 Jph, which leads to the requirement of tyres at 500 tyres a day. But looking towards growth, company is planning to produce nearly 90 trucks a day or planning to work at 7.5 Jph. This will generate requirement of more number of tyres, almost double.

According to the company's requirement, the new system has to be designed which can reach the requirement of supply of tyre to the assembly line.

1.4 Objective of Dissertation

- To carry out a structural study of existing structure to decide the path.
- To analyze the suitable path for the transfer system.
- To carry out design of the structure of path within given conditions.
- To analyze the structure for the deformation and stress acting on it.

1.5 Methodology

- To full fill the objectives of the study the following are used:
  - Literature review: Survey of books, journal articles, research papers, standards and other relevant literature has been carried out.
  - Process study: Conceptual design is carried out, path and system used, factors affecting it.
  - Analytical method: Structural analysis is carried out, selection of material, dimension, loading condition and force calculation.
  - Modeling: 3D model preparation using Solid Edge ST3
  - Material selection for the components.
  - FE Analysis: Static stress analysis using ANSYS 11.0 to find stress and deformation pattern.
  - Results: Considering the details of proposed structure results are compared with the existing system.
  - Conclusions and scope of future work.

Chapter 2

Literature Survey

2.1 Introduction

[1] This paper describes the conversion of an existing full-scale 5-ton payload crane into a semi-automatic Handling Robot. By its size, degrees of freedom, and mode of operation this crane resembles typical construction cranes, which can be enhanced in the same manner. The new control system allows operation of the crane in either a manual or a semi-automatic mode, and it can be taught to memorize up to 50 different benchmarks, i.e. particular points at the construction site, as well as safe routes among them.

The major components of the system include: a programmable controller, three speed regulators, three encoders, several limit switches, a wireless remote control set, and a user-friendly M.M.I. (Man-Machine-Interface). Most of the components can be installed externally in the vicinity of the cranes joints and inside the cabin, with minimal intervention in the original wiring. Following the physical retrofitting of the crane, a series of tests examined performance, accuracy, repeatability, and safety aspects. They demonstrated a L-50 percent shortening of typical work cycles, high accuracy and repeatability, and a generally safer operation due to pre-tested paths and smoother movements with less sway and swing of the load.

[2]In the automobile industry, mixed-model assembly lines are used to produce many different vehicles without carrying large inventory. For achieving high productivity, it is required to keep a constant rate of usage of parts used by the assembly line. They have developed a new dynamic sequencing method for level production of assembly line and built up an automated sequence-control system which had been operated manually. In this paper, they presented i) the nature of sequence control problems, ii) a dynamic sequence control algorithm, and iii) the experience of automating a buffer control system.

In this publication [3] improvement of the manufacturing strategy theory is suggested, mainly based on employment of human factors engineering. Moreover, to fully utilize the advantages from automation, the manufacturing strategy content and process needs refinement has investigated.
In this paper [4] the methodology presented, contains five sub-processes where the chosen level of automation is aligned with the manufacturing strategy. Together they form an automation strategy, which secures a desired direction of the firm and also supports robustness and reliability of the manufacturing system due to the holistic approach chosen.

This [5] research analyzes selected attributes of 85 existing construction automation and robotics technologies to examine certain trends in the development of construction technologies and the attributes of the technologies which can influence their use by construction companies. In general, previously identified priorities for automation are close to being fulfilled, and correspond with opportunities for adoption. Most of the technologies concentrate on areas of identified benefits, and attempt to reduce the complexity associated with adoption through only minims changes in tasks. In the same way, complement changes required to use the technologies are kept at a minimum overall. This analysis is used to identify further opportunities for the development and implementation of construction automation and robotics technologies.

[6]This paper describes an engineering solution for automatic transportation of au-

tomobile transmission sub-assembly to testing stand station. The SYT (synchronous) type motor-driven conveyor system is used to realize the automatic transportation. Due to the space limitation, according to the requirement of customer, an overhead conveyor system is designed and manufactured.

[7]In this paper ergonomics studies, on the machine control and the resultant movements of the cabins and the hooks in 51 electric overhead traveling cranes in a heavy engineering factory, showed that control-movement compatibility is absent in most of the cranes. Also, the layout of the groups of controls and the orientations of each of the individual controls with respect to the operators' seats varied from one crane to another. As the operators were shifted from one crane to another every week, there can be high chances of making mistakes during moving the controls, which might have resulted in severe accidents, especially during periods of high workload. A number of low-cost ergonomics solutions have been recommended to minimize these problems.

[8]This paper aims to develop a finite element model for a scale crane rig in the laboratory such that the dynamic characteristics of the scale crane rig can be predicted from the relevant features of the developed finite element model. First of all, the finite element modeling and experimental modal testing for the scale crane rig are carried out. Two kinds of coupling connecting the load cell and the tested structure for achieving the better experimental outcome are proposed. Then, the finite element model is modified, according to the experimental results, using various techniques. The presented results reveal that the new modified finite element model, by replacing the conventional infinite rigidity for the ground-fixed nodes with the appropriate stiffness for the translational and rotational springs, can predict the vibration characteristics of the experimental crane rig with satisfactory accuracy.

2.2 Introduction to finite element analysis

The finite element method is a numerical analysis technique for obtaining approximate solutions to a wide variety of engineering problems. Although originally developed to study stresses in complex airframe structures, it has since been extended and applied to the broad field of continuum mechanics. Because of its diversity and flexibility as an analysis tool, it is receiving much attention in engineering schools and in industry. In more and more engineering situations today,it is necessary to obtain approximate numerical solutions to problems rather than exact closed-form solutions. For example, we may want to find the load capacity of a plate that has several stiffeners and odd-shaped holes, the concentration of pollutants during nonuniform atmospheric conditions, or the rate of fluid flow through a passage of arbitrary shape. Without too much effort, we can write down the governing equations and boundary conditions for these problems, but we see immediately that no simple analytical solution can be found. The difficulty in these three examples lies in the fact that either the geometry or some other feature of the problem is irregular or arbitrary. Analytical solutions to problems of this type seldom exist; yet these are the kinds of problems that engineers are called upon to solve.

2.3 Automation

It can be defined as a process which follows defined operations according to define time limit in a sequential manner with less or no human labor, with specialized equipments.

Automation is the application of mechanical, electronic, and computer-based systems to operate and to control manufacturing. In automated manufacturing systems, the operations are performed with a reduced degree of human participation. The level of automation is often described in discrete steps, i.e. manual, semi-automated, or automated, depending on the task allocation between operators and equipment.

2.3.1 Advantages and disadvantages of automation

Advantages

- Replacing human operators in tasks that involve hard physical or monotonous work.

- Replacing humans in tasks done in dangerous environments (i.e. fire, space, volcanoes, nuclear facilities, underwater, etc.)
- Performing tasks that are beyond human capabilities of size, weight, speed, endurance, etc.
- Automation may improve in economy of enterprizes, society or most of Reduces operation time and work handling time significantly.

Disadvantages

- Unemployment rate increases due to machines replacing humans and putting those humans out of their jobs.
- Technical Limitation: Current technology is unable to automate all the desired tasks.
- Security Threats/Vulnerability: An automated system may have limited level of intelligence, hence it is most likely susceptible to commit error.
- High initial cost: The automation of a new product or plant requires a huge initial investment in comparison with the unit cost of the product.

2.3.2 Automation strategies

Two different perspectives on automation strategies have been identified. The first perspective is when the overall manufacturing strategy is equal to an automation strategy, i.e. the strategy is automation. With this perspective automation is a functional strategy on its own. The other perspective, which has proven to be the most successful, is when decisions concerning automation are treated as one of several decisions in a manufacturing strategy, this is the perspective mainly communicated in the operations management literature. Among other decisions during the manufacturing strategy formulation, one question is to what degree different tasks should be automated. When automation is one of several aspects considered in the manufacturing strategy, the decisions concerning automation is a consequence of the manufacturing capabilities (such as cost, quality etc.) that the company wants to achieve.

2.3.3 Needs for successful automation

The quality management system should be supportive to the technology level that we choose, including self-adjusting Statistical Process Control, SPC, and adaptive control. The skill level of the personnel needs to be in congruence with the technology level for managing the system, doing programming tasks etc. Some of the work tasks involved in a highly automated manufacturing system may be simple routine tasks, but it is also likely that new and very advanced tasks are created.

2.4 Possible solutions for the installation of tyre transfer unit

For implementation of any system, there are always number of options to consider for the selection of any new thing. Among which the best one has to be found out and should be implemented after a study and serious discussion. For the selection of tyre transfer system, there were many options available. A study on relevant system was carried out and a most applicable system was chosen for the transfer unit. Among the relevant one's, few systems are discussed below to decide which one makes it better to be implemented.

2.4.1 An belt conveyor path can be made to transfer tyres

With the help of belt conveyor, tyres can be easily transferred to the required place, but it can have a bit problem in transferring it to the height. Generally belt conveyors are the easier mode of transportation for the transfer of heavy things in the company, but they require large floor space, so where enough floor space is available belt conveyors are easy to use. They can also be used for transporting material at

Figure 2.1: Belt Conveyor used for transfer System

vertical heights, but they do require slop for up and down movement, which can consume more space and if that slope lies within some working area, it can cause safety problems.

2.4.2 An Electric Monorail System can be used.

Nowadays overhead cranes are mostly used in companies as it doesn't block any floor space and gives the accurate transfer or movements to the parts. It is easier to use or operate with the help of a chain hoist.

2.4.3 An under ground path can be used to transfer the tyres

An underground path can be made but it requires the pit in ground, its safety measures are also higher. For this system conveyor system is used. are used.

Figure 2.2: Use of EMS for transfer System

2.5 Automation systems

2.5.1 Conveyor system

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. The basic function of a conveyor is to carry or transport cases and totes to different parts of the warehouse. How fast the item travels, if it can be accumulated on the conveyor, and how much it costs to power the conveyor are all key differences used to decide which conveyor type should be used. Automation has conveyor class types, each unique in its features and capabilities. Whether you need the energy efficiency of the Auto Roll motor driven roller conveyor or the simplicity of a gravity conveyor.
There are different types of conveyor systems, among which few are as described below.

- Auto Roll Conveyor
- Live Roller Conveyor
- Line Shaft Conveyor

- Belt Conveyor
- Vertical Conveyor
- Chain Conveyor
- Gravity Roller Conveyor
- Extendible Flexible Roller Conveyor
- Skate Wheel Conveyor

2.5.2 Electric Monorail System (EMS)

The electric monorail conveyor, an overhead conveying is a well-tried, indispensable means of transport for a flexible and rationalized flow of materials. An electric monorail conveying system consists of a networked track system that is adapted to the desired transport route and the required transport capacity. Running on these tracks are individual powered load carriers.

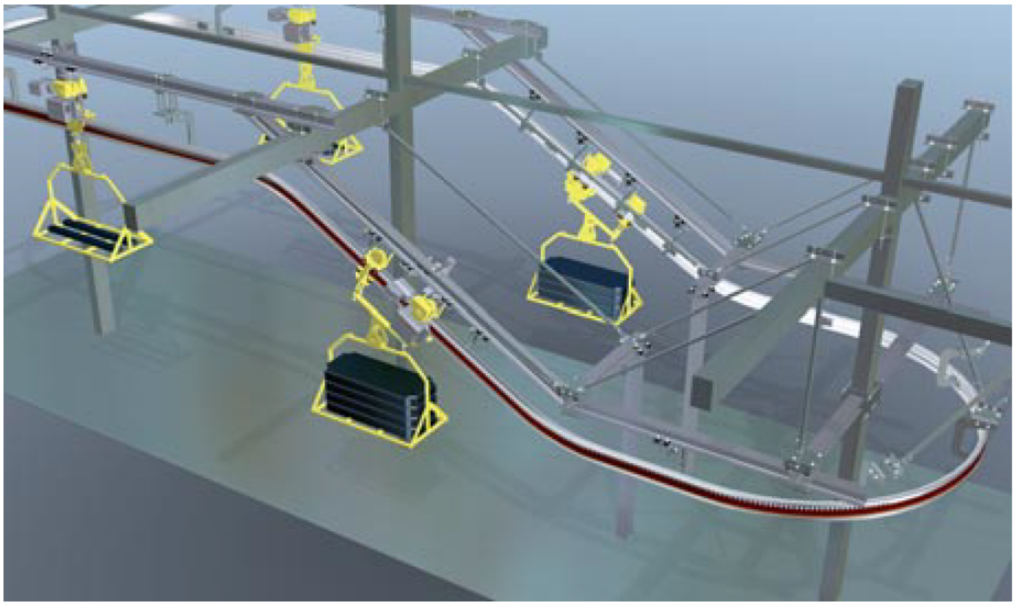


Figure 2.3: Single Load carrier Electric Monorail system

- Advantages of EMS
  - Fast and Gentle transport with higher flexibility
  - Automation may improve in economy of enterprizes,Reduces operation work handling time significantly.
  - Energy Efficient transport
  - Silent transport
  - May give better results in dangerous conditions compared to human beings.
  - The individual drive unit for each carrier permits carriers to travel at different speeds and even to change these in rapid succession.

Types of EMS. EMS can be divided in two types according to the type of load carrier used.

Single load carrier

It is a type of EMS, in this load carrier is single which means the system or our carriage will be moving on a single girder with a single attachment with the beam. This can carry lesser load as compared to the double load carrier with the same specification.

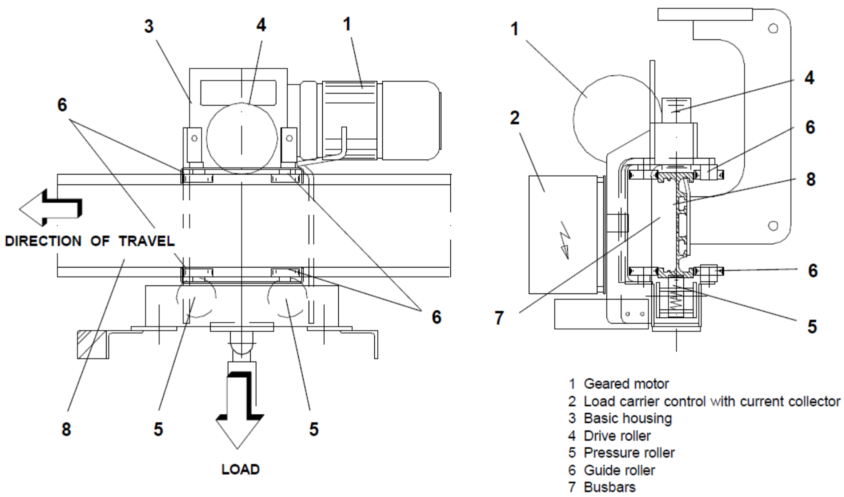


Figure 2.4: Single Load carrier

Double Load Carrier

In this type of load carrier trolley or hanging element will be connected with two supports increasing its load carrying capacity. Double load carrier type of EMS is used in our case as its capacity to carry load is higher than single load carrier.

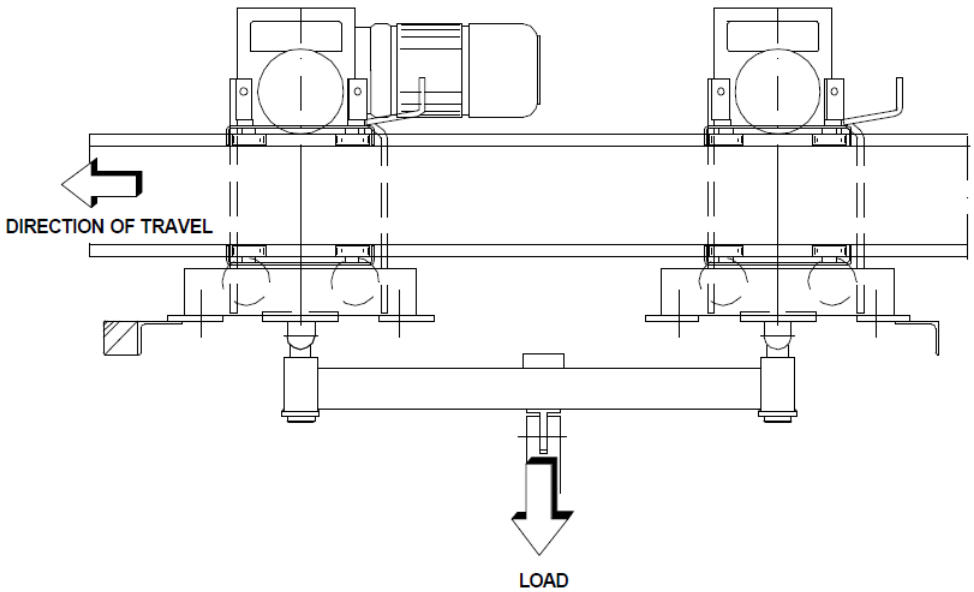


Figure 2.5: Double Load Carrier

- Major components of EMS
  - A Central Processing Unit (CPU) with adequate memory and computational capacity.
  - A Controller with multiple input/output connections, to govern the motors of the joints and handle fit back and signals.
  - Keypad and several lines of alphanumeric display (this can later be enhanced to a color graphic display)
  - Encoders or pulse generators - to be mounted on each joint of the crane in order to monitor their movements. Sensors, limit switches, and other devices for either routine calibration of the encoders or safety purposes.

– Speed regulators attached to the motors of each joint, to ensure smooth acceleration and deceleration of the hook.

2.6 Tyre lifting systems

Now as discussed above, there will be a system to move the trolley on the designed path, there must be a system for lifting the trolley to the desired height.

2.6.1 Geared Chain Drive

If whole path is planned a fully automatic system, geared chain drive can be used, which works with the help of controllers, and will help with the up-down movement of trolley, where trolley will be lifted with the help of clamps. When trolley reaches the lifting or dropping place, sensors will sense the trolley and it will work accordingly, and when it reaches the ground surface, another pair of sensor will sense trolley and work according to the programme. Further carriage moves upward and follows the path same way.

Figure 2.6: Geared chain drive

2.6.2 Hydraulic Lift

Another system can be implemented is that a lift can be fixed at the place of up and down movement of trolley, where, with the help of sensors, its movement can be controlled and work can be executed. When trolley with the tyres arrives on the lift, sensor senses the carriage which helps in opening the clamp. This opened clamp carriage reaches the pick up stand and clamps another trolley, and same path and system is followed by empty trolley carrier. This way things continue their way. In this system there will be requirement of total 14 trolleys as there are different carriages for empty trolleys and for the trolley with the tyres.

In figure 2.7, "A" indicates moving plate, which is supposed to be lift the trolley. Whereas "B" indicates the hydraulic cylinder needed to lift the trolley.

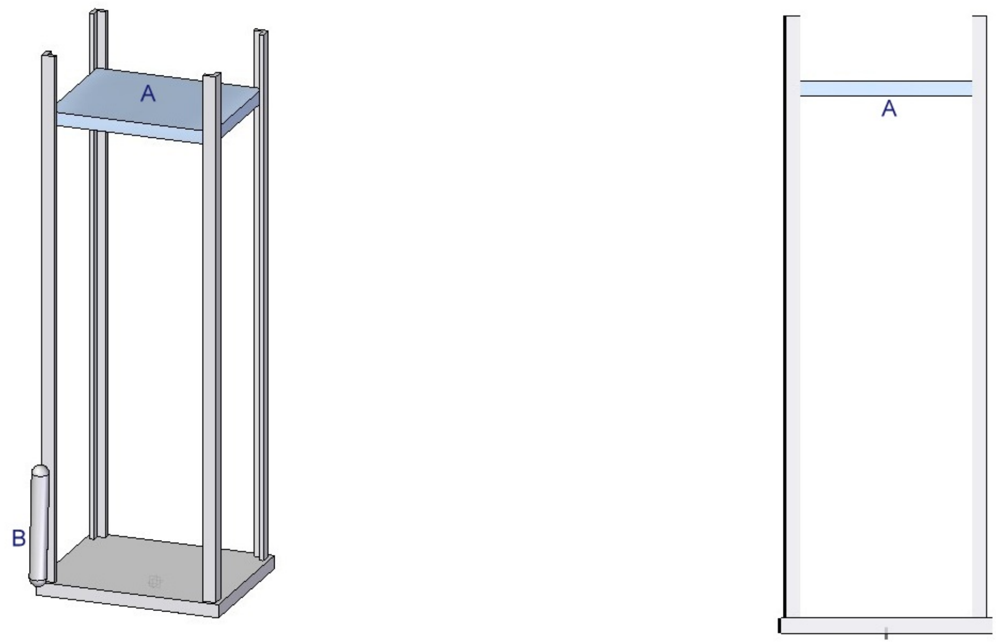


Figure 2.7: Hydraulic lift

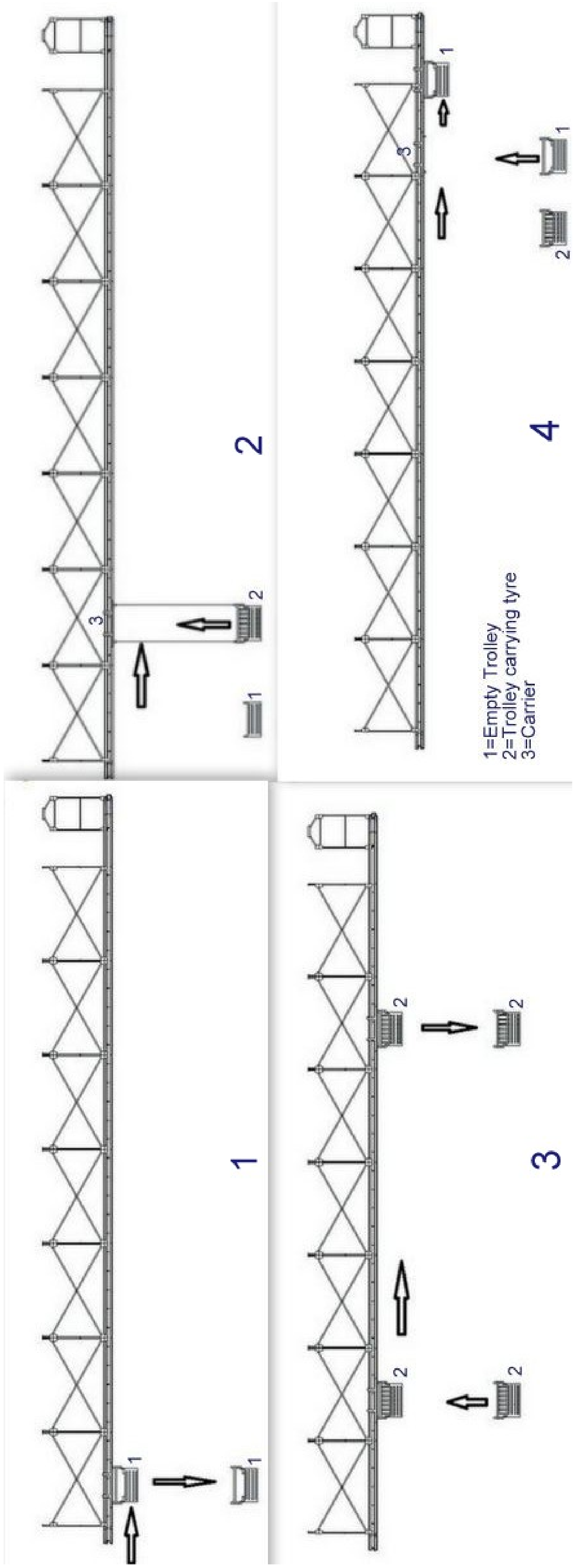
Figure 2.8 shows the working of tyre transfer system. Figure is described in four stages to understand it clearly.

1^{st} stage indicates the initial position of the trolley. It shows that after completing its path, empty trolley returns to its initial position, on its carriage and due to sensors, it stops there. Then trolley moves in downward direction and carriage drops trolley there.

In the 2^{nd} stage, it is shown that, carrier moves to next position, where a trolley loaded with tyres is already placed, and carrier picks-up the trolley, which guides, vertical movement of the trolley.

3^{rd} stage describes the vertical movement of the carrier and then, trolley is guided to assembly point of tyres on guide-rail, where trolley gets its downward movement, and after reaching ground floor, gets un-clamped from carrier.

Stage 4 indicates the same thing as stage one, the only difference is in the condition of trolley, i.e. empty or loaded. In this stage, it is shown that, carrier un-clamps the trolley and travels in transverse direction to pick up empty trolley, and then moves vertically upward to follow the same route.


1=Empty Trolley
2=Trolley carrying tyre
3=Carrier

2.7 Summary

The systems discussed above were having different advantages for the different types of systems and conditions. According to our requirement and our convenience, EMS will be a better option to implement for our tyre transfer system due to some of its advantages and its working. Advantages of implementing EM System.
Automatic tyre transfer system should be thought of to harness following advantages

- It would be difficult to install belt conveyor in middle of company's structure.
- Installation of belt conveyor would require more area on the floor as 120 and 160 meters of close path has to be developed.
- EM system will require floor space for trolley to move up and down only when it is loaded or unloaded.

Chapter 3

Conceptual Design

3.1 Problem Description

This chapter includes the details of existing system for tyre transfer, its drawbacks and conceptual design of proposed tyre transfer system. It is also shown that, on which basis a system is selected and why. Among all the possible ways and systems, the chosen one is the simple and economical for the implementation for the transfer of tyre in the company.

It has many advantages over the existing system, and the drawbacks of the existing systems can be easily eliminated with the help of proposed system.

3.1.1 Existing tyre transfer system

The existing tyre transfer system of company includes a fork-lift to transfer the tyres from storage to tyre assembly point. This fork lift transfers four tyres per turn(i.e. circular route from storage to assembly point), on a dedicated path of 160 Mtrs.

3.1.2 Drawbacks of existing transfer system

- As tyres are transfers via forklift, it takes a long to travel, and its path lies within the assembly line, so it consumes more time.

- This transfer with the help of forklift is manual, so safety is not there.
- Supply rate of the tyre is quite low at the desired position, and many hindrances are there in the path, at the same time it will also disturb other forklifts running for other purposes and humans as they to need to be alert all the time.
- Allowing a forklift also creates noise as well as environmental pollution in the company which leads to the disturbances and loosing of workers concentration.

The company is working with current production rate of 4 Job Per Hour (JPH), which is projected to be 7.5 JPH in near future, so as production of truck increases, requirement of tyre will increase at the assembly point. Now supplying the tyres with the help of fork-lift is not safer and convenient at the same time, as more number of fork lifts are to be deployed for that, or a special fork-lift should be there for transfer of tyres only for whole day, which is not economical. So for that a new system should be developed to transfer the tyres from storage to assembly point, and if we still continue the existing system to transfer the more number of tyres to meet projected production rate, it will become quite expensive, calculation of which is shown in table 3.1

SR	Assembly Line	Ideal	Target
1	Job Per Hour (JPH)	4 JPH	7.5 JPH
2	Assets Involved	Forklift, Operator	Dedicated Path
4	Production Of Trucks	40 Trucks/Day	75 Trucks/Day
5	Tyres to be transferred	400/Day	750/Day
6	Path To Be covered	16 kms/Day	30 kms/Day
7	Tyres Carried/ Forklift	4	4
8	Time Consumed To Transfer tyres/Day	2.5 Hrs	4.5 Hrs
9	Cost/Month	43250Rs	81600Rs

Table 3.1: Comparison Between current and projected production rate for existing system

Table 3.1 describes the details and comparison between current production rate and projected production rate, from which we can clearly see that if same system will continue transferring tyres how costly it can be, where a new transfer system will help in reducing the cost.

3.1.3 Comparing existing system with proposed system

In this section, existing tyre transfer system and simulated system based on material safety as well as cost is compared. Table shows the comparison between proposed system and present Tyre transfer system.

In table 3.2, a comparison and analysis of current and proposed situations, which helps to analyze and visualize the results. It also shows how the proposed system can be cost efficient than the current system and where the money is saved. Tariff of power consumption is calculated as 7.4 Rs/unit. In the existing system, to drive a forklift, a trained person has to be deployed, whereas in proposed system, practically, no specific person is required, as, the workers working in tyre subassembly plant, can place the trolley at its specific place.

		Existing System		Proposed System		
Sr No		Target Conditions	Guide Rail Motor (3.5 KW)	Carriage Motor (3.5 KW)	Clamp Motor (0.5 KW)	
1	Job Per Hour (JPH)	7.5 JPH	7.5 JPH	7.5 JPH	7.5 JPH	Job Per Hour (JPH)
2	Production Of Trucks	75 Trucks/Day	75 Trucks/Day	75 Trucks/Day	75 Trucks/Day	Production Of Trucks
3	Tyres to be transferred	750/Day	750/Day	750/Day	750/Day	Tyres to be transferred
4	Path To Be covered	30 kms/Day				
5	Tyres Carried/ Forklift	4	120 Mtrs	120 Mtrs	120 Mtrs	Path Length
6	Speed of forklift	7 Km/Hr	22 mins	2.4 mins	0.5 Mins	Activate Duration of Motor
7	Load/Unload time	2 mins	23	23	23	No Of Paths Covered/Day
8	Time Consumed To Transfer tyres/Day	4.5 Hrs	8.43 Hrs (506 Min)	0.92 Hrs (55.2 Min)	0.2 Hrs (12 Min)	Path Covered/Day
9	Rent Of Fork Lift	30000/Month Approx	29.855 Units	3.2 Units	0.5	Units Power Consumed/Day/Mot
10	Diesel Consumption (Transferring the tyres)	20.5	4	4	4	No. Of Motors Used
11	Diesel Consumption (Loading/Unloading tyres)	35 Litre	88.515 Units	9.6 Units	1.5 Units	Power Consumption (Units)
12			663.86	71.04	11.1	Power Consumption (Rs)
13	Total Expense/Month	81600				51235.56

Table 3.2: Cost comparison of existing system and proposed System

3.2 Selection of path

A proper path must be selected for the implementation of tyre transfer system. Path selected should have some of the initial criteria for easier installation. Path selected for transfer of system is a result of a deep study carried on it. There were possibilities for other path also, but that were neither convenient nor possible because of few limitations from the company, like, its existing structure, fixed rigid obstacles, which can't be shifted, safety factor or path may be crossing working area.

Symbol	Indication
A	Tyre Storage
B	Tyre Assembly Point
C	Assembly line
1	path of length 120 M
2	Path of length 160M

Table 3.3: Symbol and indications for figure 3.1

- Factors considered for selection of path
  - Fewer hindrances to be removed.
  - Easier installation of the system in the structure.
  - Easier path to follow.
  - Minimum movement and turns.

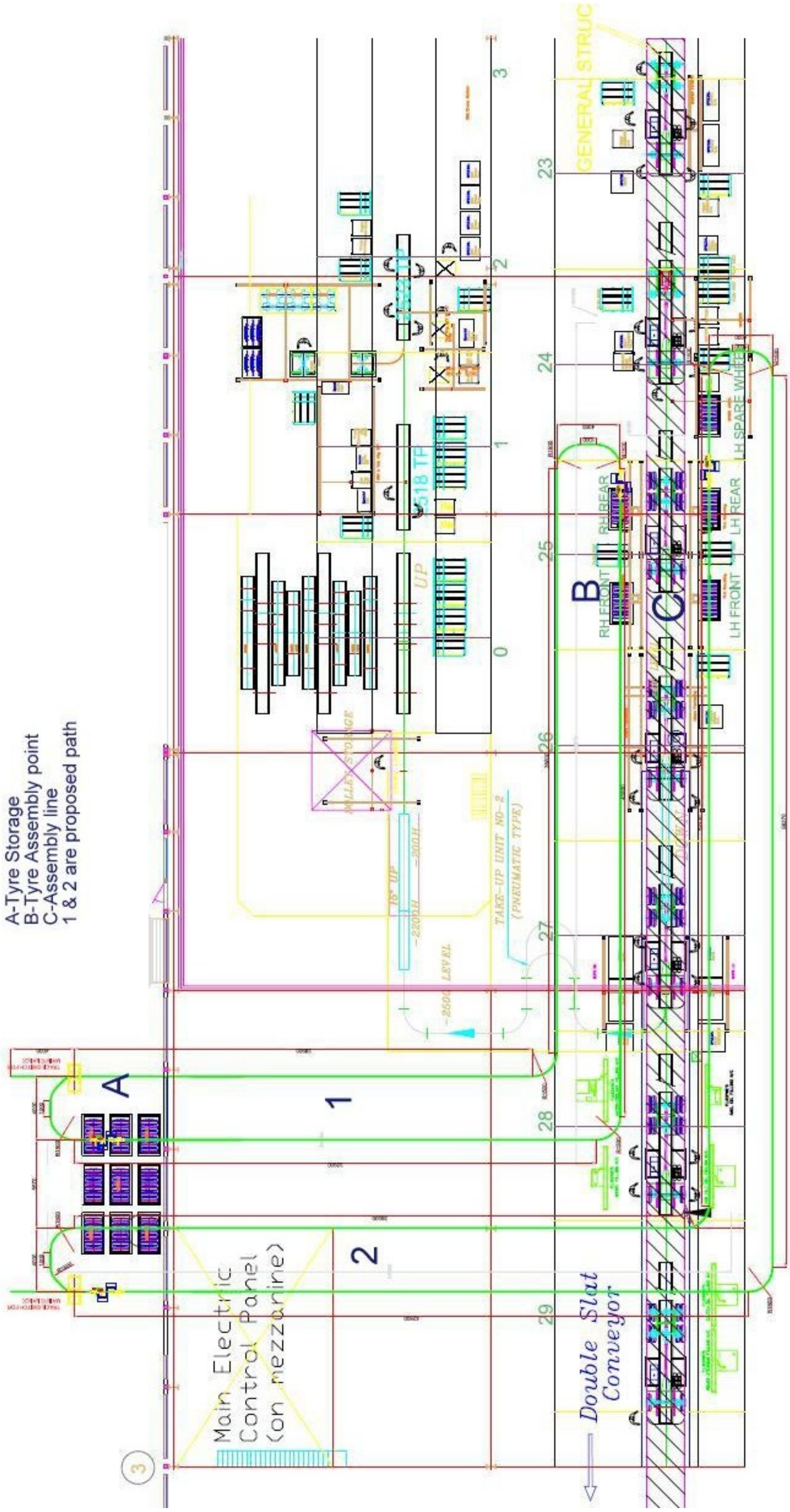


Figure 3.1: Present layout of shop floor

Figure 3.1 is of present shop floor of the company, in which tyres are transferred from storage to assembly point.
In figure, "A" indicates the place of tyre storage, where tyre sub-assembly takes place.
"B" indicates the tyre assembly points, where tyres have to be transferred, and assembled to the trucks on production line.
"C" indicates the assembly line on which all operations are carried out.
"1" and "2" indicates the proposed paths which are having length of 120M and 160M respectively.
Proposed path is highlighted with the green colored lines.

Path selected for the installation of system is as shown in figure 3.1. This contains the fewer hindrances to be removed and convenient according to the structure of the company. At the same time this route has the smallest path to follow, without more turns. The original structure of the company is shown in figure 3.2, with the hindrance, which has to be removed. This structure is for the maintenance of trolley, which reaches there, from the pit, after completing the route of assembly line. This structure can be shifted to the successive beam, as establishing our structure there is not possible due to entry gate for supply of other inventories.

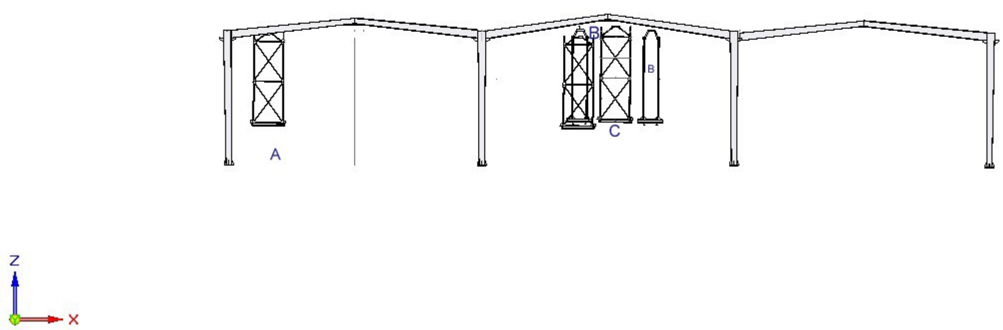


Figure 3.2: Elevation of the original structure of the plant assembly line

Symbol	Indication
A	Hindrances in structure
B	Tyre Assembly Strcuture
C	Central frame of company

Table 3.4: Symbol and indications of figure 3.2

From figure 3.2 or table 3.4, we can see that, there is a hindrance "A"in the existing system, which has to be shifted, to a new position which should not come in our way. whereas "B" indicates the structure used for the assembling tyres to the truck, it is not for transferring, but only for assembling the tyres.
"C" indicates general central structure of the plant, which is hung in the center all the way.
Figure 3.3 shows the isometric view of the existing system of the company.

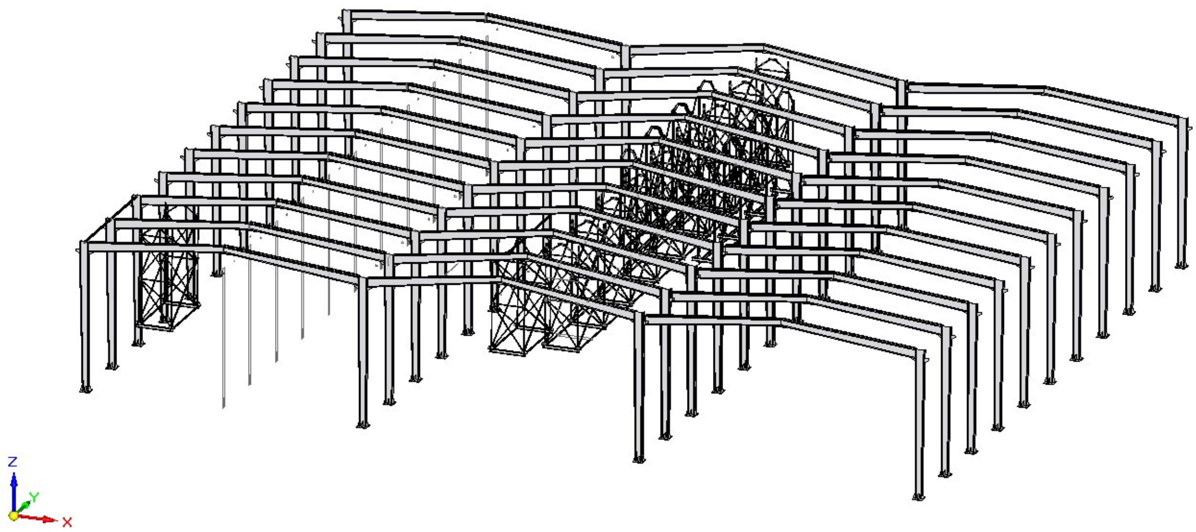


Figure 3.3: Isometric view of the existing assembly line with the hindrance

3.3 EM System design

A EMS can be used to transfer material or parts from one place to another over the head. To use EMS, requirements should be clear and, according to that, it can be designed. Depending on the use and requirement, EMS may very in types and properties. new proposed system will have the specifications as described in following discussion. Now to meet the requirements, path is designed, details of which is as described here.

3.3.1 Specifications of EMS

In table 3.5, specifications of EM system are defined. The specifications are decided on the basic requirement of company, some basic data available, as well as based on calculations for the defined path of transfer unit.

Path no	Track Length	Speed Of Trolley	Time To complete Path(Min)	No. Of Tyre Delivere/Hr	No. of Trolley	Height of trolley
1	120	5 (M/min)	26	42	3	6M
2	160	5 (M/min)	36	42	4	6M

Table 3.5: Details of proposed system

Here, in this figure 3.4, four stages of the trolley movement are shown, which describes how trolley will move on the path.

In the 1^{st} part, initial position of clamp and trolley are shown, where trolley is at downward position and clamp is open.

2^{nd} position shows that as trolley moves upward and reaches at position where it is clamped, the clamp gets closed and picks up the trolley.

In the 3^{rd} part it is shown that, trolley moves on the path with the help of motor, and reaches its decided position, it stops there, clamp opens and trolley will get placed on the lift structure.

In the 4^{th} part it shows that trolley moves downward from where it can be picked up by the workers.

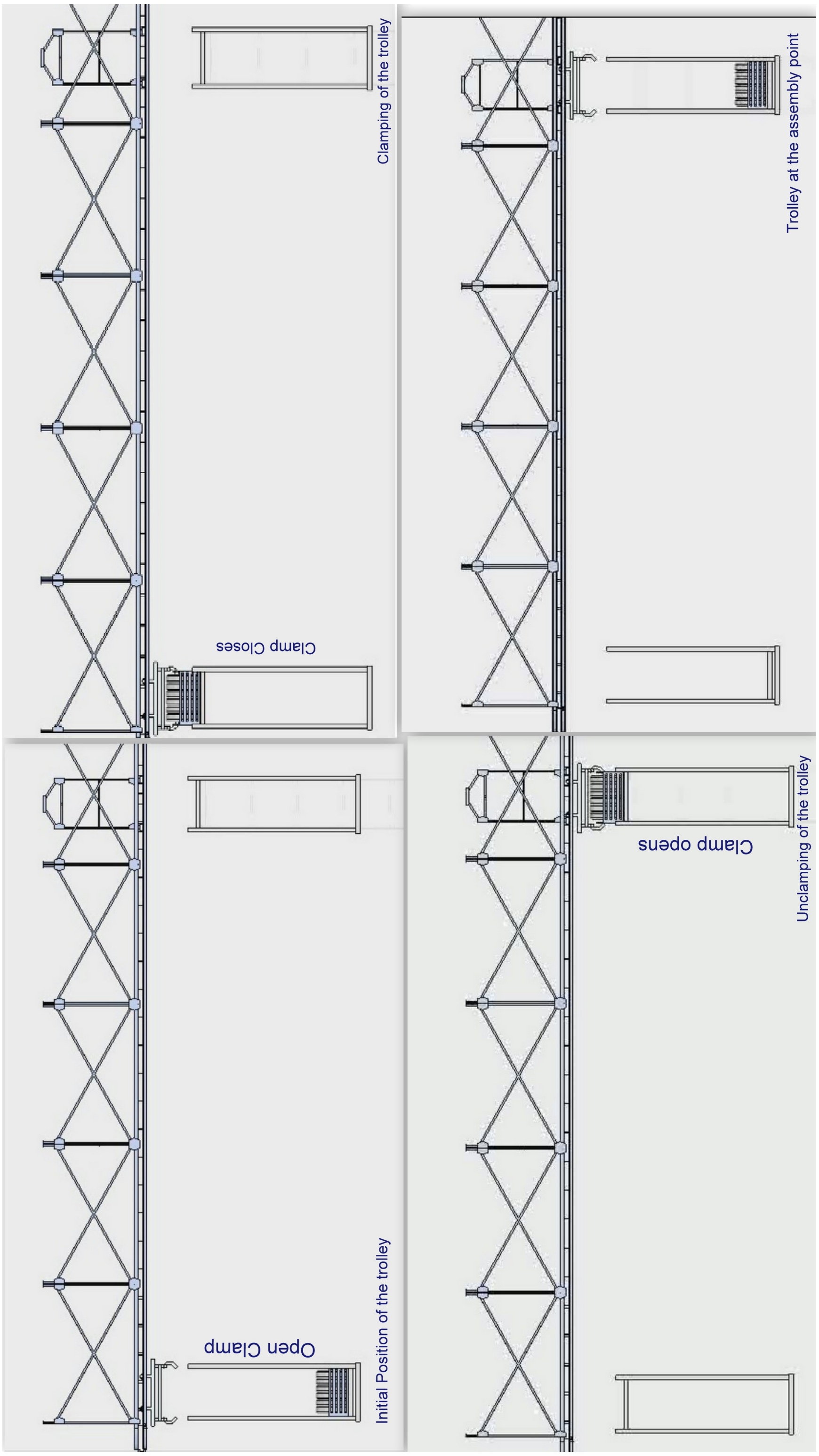


Figure 3.4: Hydraulic lift Structure

3.3.2 Design of Guide-rail

In the proposed structure of the transfer system, a general structure is to be designed first, on which trolley will hang and rotate in that path. A structure for that should be designed carefully to withstand or allow hanging load of 15KN. 15KN is the load of trolley and its carriage in the loaded condition. An analytical study was carried out for that, to decide which sections will be used as column and which one as a beam, so failure should not take place. The structure has to be designed by considering the requirement of trolley to be attached. This analysis is done for a individual part of path of 5 meter length, which is a common (Repeating) structure.
According to proposed design, payload on whole path of the structure will be 6 trolleys i.e. 60KN. After calculations, the sections selected for construction of structure, as angle section for column and I section for beam are used. Figure 3.5 shows the frame structure designed to carry the trolley. This structure has a length of 5M and it is used repeatedly to make a complete path.

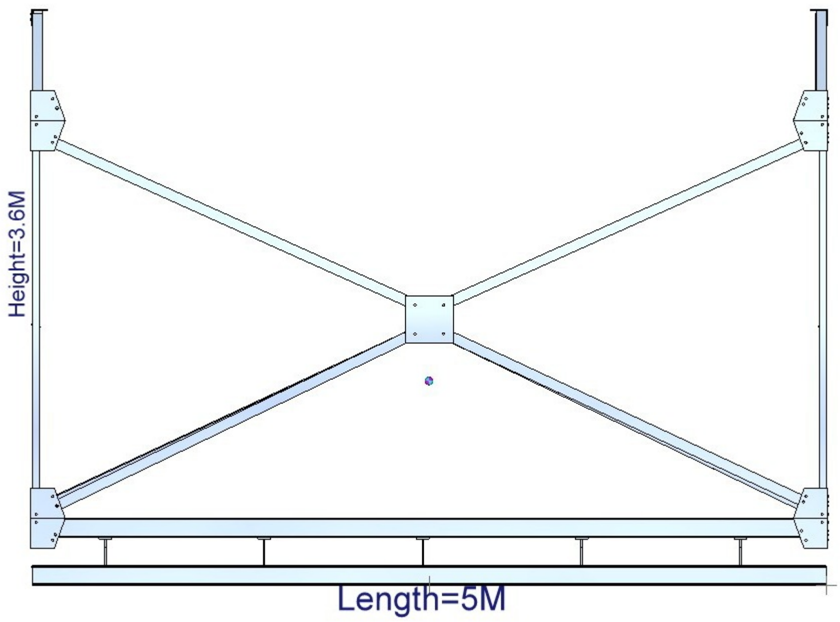


Figure 3.5: Structure of frame designed for trolley movement

- Angle section (column)

As mentioned above, angle sections will be used as column. Below is the calculation for the same, calculation will give the idea that which sections can be used and which one can be more convenient, economical and strong enough to withstand applied load. Calculating for the sections to be used in structure:

$T_{dg} = \frac{A_g \times F_y}{\gamma_{mo}}$

T_{dg}=Partial safety factor for failure in tension by yielding

f_y = yield stress of the material A_g=Gross area of cross section

γ_{mo} = 1.1 (IS 800:2007)

$A_g = \frac{15 \times 10^3 \times 1.1}{250}$

$A_g = 66mm^2$

So from the value of area of cross section A_g we can decide the size of angle and it is $60 \times 60 \times 6$ (IS Steel Table). According to the design, section used will be of size, $60 \times 60 \times 6$ which will be safe to carry the load applied on it.

- I section (beam)

As mentioned above, I sections will be used as beam. Below is the calculation for the same, calculation will give the idea that which sections can be used and which one can be more convenient, economical and strong enough to withstand applied load. As trolley has to travel on beam structure, calculations is carried out for maximum point load, which can give better safety and reliable structure.

Calculating the load applied on the beam, bending Moment at beam must be calculated to know which type of sections to be used. Now we have, where,

M=bending Moment

W=weight

l=length = 5 m

weight to be taken with safety factor 1.2

$W = max, possible 12500(N) \times 1.2 Safetyfactor = 12000N, M = 18KN/M$

Section modulus $Zp = \frac{M}{f}$
where,
f=yield stress of the material = 250
so,
From the calculation shown above, we have chosen I-Beam (ISMB 150) for our structure design.[9] (IS 800:2007). According to the calculation we should have section modulus $72cm^3$
but
we have taken Z=110.4 cm3.
So this will provide us with a safe and reliable structure. ISMB 150 have
$Z = 110.4cm^3$
After selecting the section, calculate the stress produced in it. So, for calculation of stress, we have Where, I= Moment of Inertia.
Now

$I = \frac{bh^3 \pm 2 \times (\frac{b-t_w}{2})}{12} \times (h_1^3)$

Putting the standard values, in the above formula, Stress can be calculated. Here we have
b=80mm.
h=150mm.
tw=4.8mm.
h1=134mm.
By putting the above values in formula and calculating,
we get I=742.1 mm^4
Now putting value of I in Eq. 5.8,
we get
I=225.372 N/mm_2,
where
M=22.5KN and Y=75.

With the help of above both calculation, I beam and angle sections are chosen for the structure design.

3.3.3 Design of trolley

Trolley used to carry the tyres from floor to a height of 6M and to the assembly point should be capable enough to carry the load, so trolley used here is made of structural steel and its height and width are such, that it can carry 6 tyres a time. It is provided with a gate on one of the sides to place tyres in it. The width of the trolley is 1800MM, which is slightly more than the width of 6 tyres, as six tyres are to be carried in it. Height of the trolley is taken as 700MM, which is less than diameter of tyre, it is taken such because if a part of tyre remains out from a trolley it will not create any problem, as a sufficient height is given.
Tyres will be placed inside the trolley from the gate given at one side which opens in manner as shown in figure 3.6, it will be easier to place the tyres. The carrier used will be as shown in figure 3.7, on which motors and sensors are also carried along with the trolley.

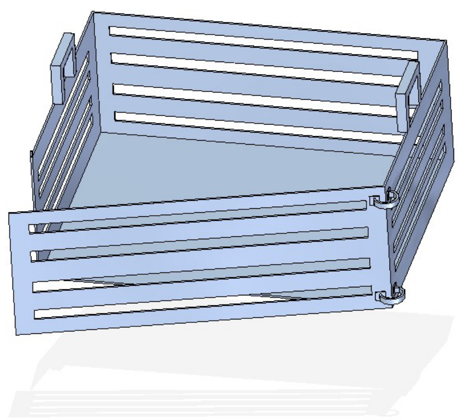


Figure 3.6: Structure of trolley

Table 3.6 shows Bill Of Material(BOM) of major electronic components. No. of motors required per carriage are three.
1. For the rotation of carriage on path of 120 or 160M. We call this motor as Guide-Rail motor as it will be used cover the path on guide-rail. This motor will be of

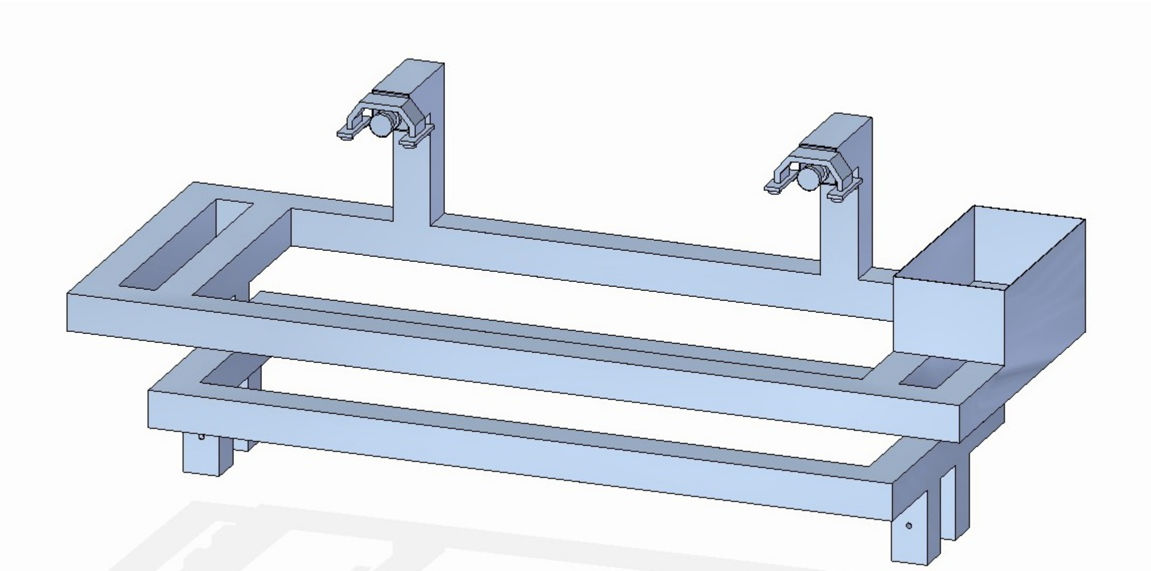


Figure 3.7: Structure of carriage

3.5KW, as it has to transfer trolley weighing 1500kg.

2. For the vertical movement of trolley, a motor is required which will be of capacity 3.5KW as it has to carry load of 1500kg of trolley containing tyres. We call this motor as carriage motor as it will help up-lower the carriage.

3. 3^{rd} motor will be used to open the clamps of the carriage, which helps in pick-up or dropping of trolley, so higher torque is not required there, and a motor of 0.5KW will serve our purpose.

A set of three motors is required per carriage, so according to the number of carriages used, thrice the number of motors used, in which two motors are same i.e.3.5KW, where 3^{rd} one is of 0.5KW.

So for total of 7 carriages which includes 3 carriages on path of 120M, and 4 carriages on path of 160M, 21 motors are required among which 14 motors of 3.5KW and 7 motors of 0.5KW are required.

Sensors required for the system is described as follows.

Four pairs of sensors are required per carriage.

1. One part of a pair is attached at the carriage and its other part is fixed at a point

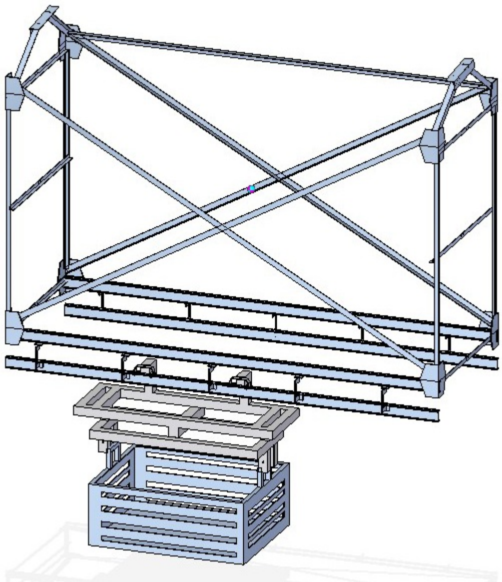


Figure 3.8: Structure of guide-rail with trolley

where carriage has to lower down, so as and when carriage reaches near, other part of sensor will sense the carriage, and will command the guide-rail motor to stop and carriage motor to activate, which takes the trolley to ground position.

2. In the 2^{nd} sensor, one part is attached near the floor, which will sense the carriage lowering down and, send a message to deactivate the carriage motor and activate the clamp motor at the same time. Then a delay of 5sec is given so that trolley gets placed correctly, and then again it will activate the guide-rail motor, which moves the carriage in horizontal direction at the ground level.

3. One part of this sensor is attached near clamp and other to the pick up stand of trolley, as carriage reaches there, it will sense the carriage and will send a command to open clamp, which will pick -up the trolley, and moves upward to the main structure, on the guide-rail.

4. We require 4^{th} pair of sensor to sense the upward position of trolley, when it returns to upper position after picking the empty trolley up, it gets connected to the guide-rail path. Now we have different carriages, but single parts of the pair of sensors, refer as a male part, are fixed at their respective places. As we have two different positions to lift and drop the tyres, we need 4 complete pairs for 1 path, which means, we need total of 6 pairs for both the paths.

Sr No.	Component name	Specification	Quantity
1	Motors	3.5 KW (Induction)	14
2		0.5 Kw (Induction)	7
3	PL Circuit	Allen Bradley Micrologix	1
4	Sensors	Laser Sensors	6 Pairs+ 10 female Port Extra

Table 3.6: BOM of Electronic Parts

After attaching all 8 pairs, we will require other 12 female parts.

3.3.4 Lifting System

Now, there will be need of a system to move the trolley on the designed path, there must be a system for lifting the trolley to the desired height. Now as we are going for a fully automatic system, geared chain drive is used, which works with the help of controllers, and will help with the up-down movement of trolley, which will be requiring a 3.5 kw motor for the very movement, where trolley will be lifted with the help of clamps. When trolley reaches the lifting or dropping place, sensors will sense the trolley and will stop the guide-rail motor and activates the carriage motor for the downward movement of trolley, and when it reaches the ground surface, another pair of sensor will sense trolley and deactivates carriage motor, opens the clamp and then guide-rail motor moves the system ahead and picks up the empty trolley from there, which is already placed over there. Further carriage moves upward and follows the path same way.

3.3.5 Proposed structure

Company Structure after installation of system will be like in the figure 3.10,3.11,3.12. Two L-Shaped structure to the both side of center structure is the proposed structure for the installation system, where hindrance is shifted. At the left side in structure,

Figure 3.9: Geared Chain Hoist

tyre sub assembly unit is there so, tyres loaded from that side and will be unloaded just before it takes turn at the tyre assembly point. The controlling used for this will have a programming accordingly so that it lowers down at the defined place, where a loaded trolley is exchanged with an empty one.
Figure 3.9 shows the proposed structure layout on which trolley will travel the path, guided by carriage.
It is also shown that there will be two paths and total length of it will be 120M and 160M. Figure 3.10 shows how the structure of shop floor will be after installation of our proposed structure. Figure 3.12 shows the isometric view of structure of shop floor will be after installation of our proposed structure.

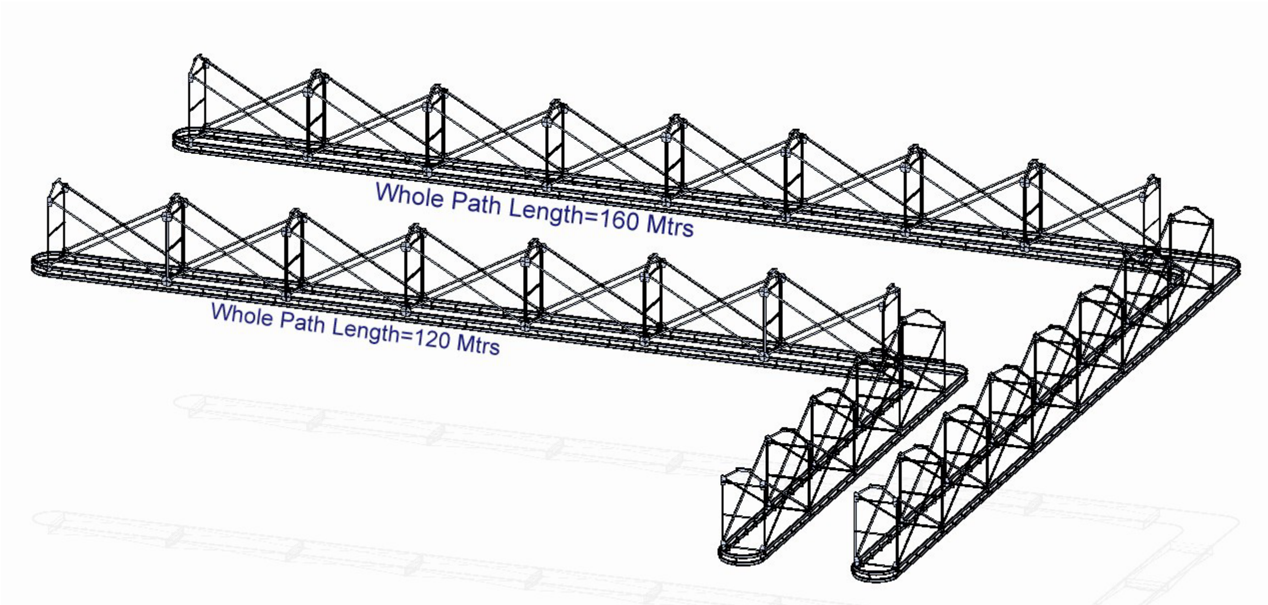


Figure 3.10: Isometric view proposed Structure

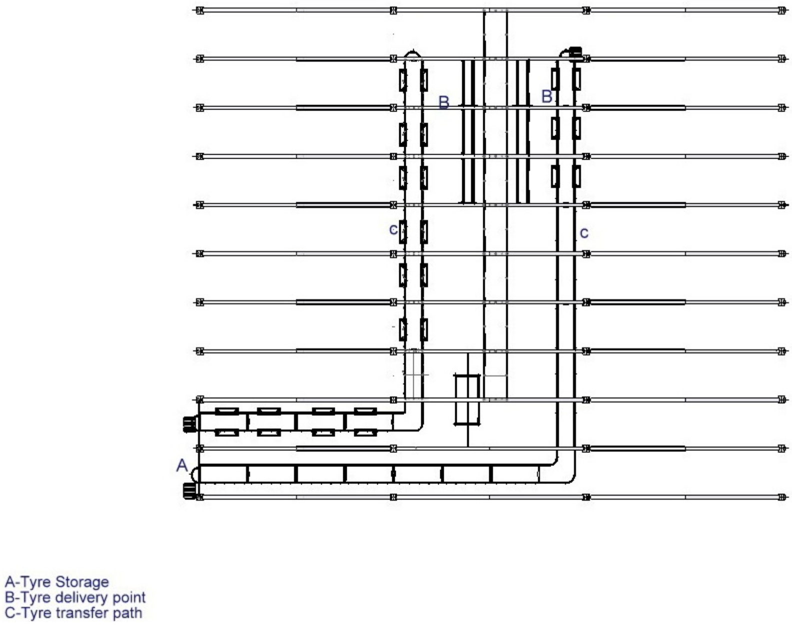


Figure 3.11: Top View of proposed Structure

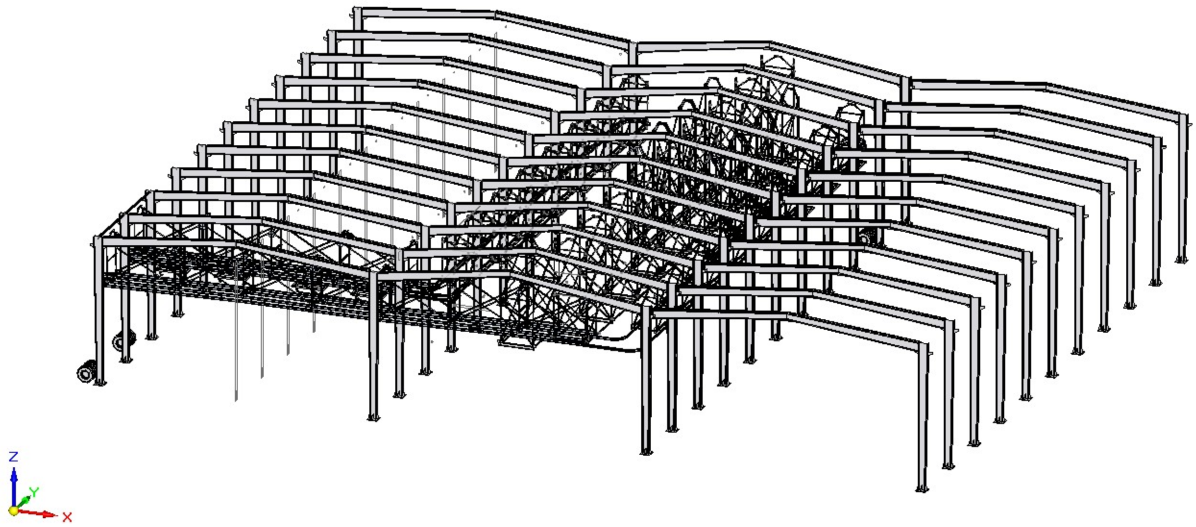


Figure 3.12: Isometric view of company with proposed Structure

3.4 Cost Analysis

3.4.1 Definition

"The accumulation, examination, and manipulation of cost data for comparisons and projections".
"Cost analysis is a systematic process for calculating and comparing benefits and costs of a project, decision or government policy".

3.4.2 BOM of proposed structure

Table 3.6 shows the BOM of the parts used in the proposed structure. The details shown in table, contains details for a unit structure, which gets repeated to make desired structure of the transfer unit.

Sr No.	Component name	Dimension	Material	Quantity
1	I beam	ISMB 150	Structural steel	4
2	Angle Section	$60 \times 20 \times 2500$	Structural steel	4
3	Angle Section	$60 \times 20 \times 2600$	Structural steel	4
4	Angle Section	$60 \times 20 \times 1800$	Structural steel	6
5	Angle Section	$60 \times 20 \times 850$	Structural steel	4
6	Angle Section	$60 \times 20 \times 730$	Structural steel	2
7	Angle Section	$60 \times 20 \times 600$	Structural steel	2
8	Angle	$218 \times 218 \times 188$	Structural steel	16
9	Plate	$400 \times 400 \times 20$	Structural steel	2

Table 3.7: BOM of sections used

Chapter 4

Finite element analysis of tyre transfer system

4.1 Introduction

It is always a difficult task to analyze the things based on the previous data available and than compare the things required or used for project work. In this chapter a detailed study on simulation is shown. Which shows how and where simulations are carried out and the data is compared with available ones.

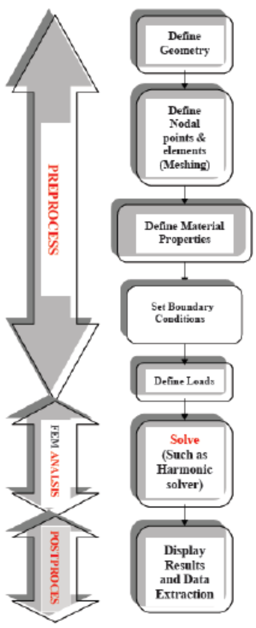


Figure 4.1: Flow chart of FEM analysis using ANSYS

Now, we come to the simulation of path using Finite Element Method with the simulation tool ANSYS. As shown in figure 4.1, the task sequence in an ANSYS simulation has some main parts which are essentially the same no matter how your simulation project looks like:

a. Geometry Modeling

b. Setting up material properties(such as permeability,resistivity,conductivity etc)

c. Meshing

d. Application of loads and degrees of freedom. Deciding what boundary conditions have to be fulfilled.

e. Numerical solving: This gives us the solution for every nodes or elements(discrete!)

f. Postprocessing: Visualization of element solution and data export

4.1.1 Geometry and Material properties

- Geometry of the Guide-Rail Structure

Figure 4.2 shows the geometry of guide rail structure, on which trolley is about to run.
The structure of the path has to carry load of 1500 kg (of tyres and carriage), so the material used to construct it, must be strong enough to carry the load of trolley including its self weight, among some of the safe materials, the most reliable and economic material should be chosen. Here results with some of the materials are shown in the figure, among which we will be choosing structural steel.

- Geometry of the Column-Beam Structure

The following figure, Figure 4.3 shows the geometry of Column-Beam Structure , on which the guide structure will be fixed.

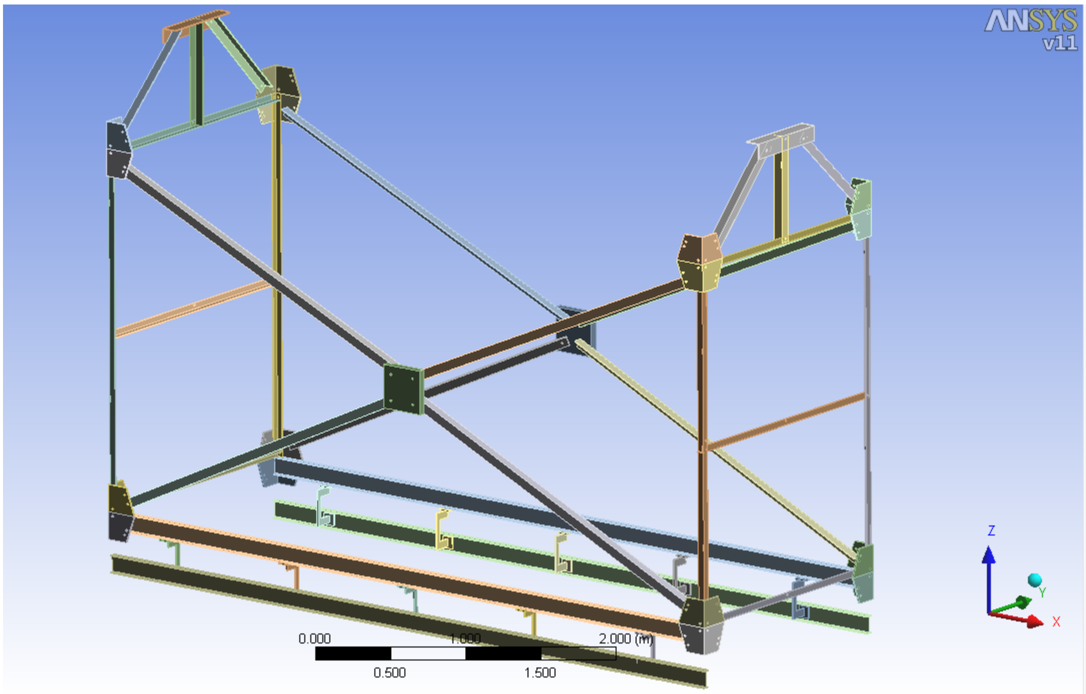


Figure 4.2: Geometry

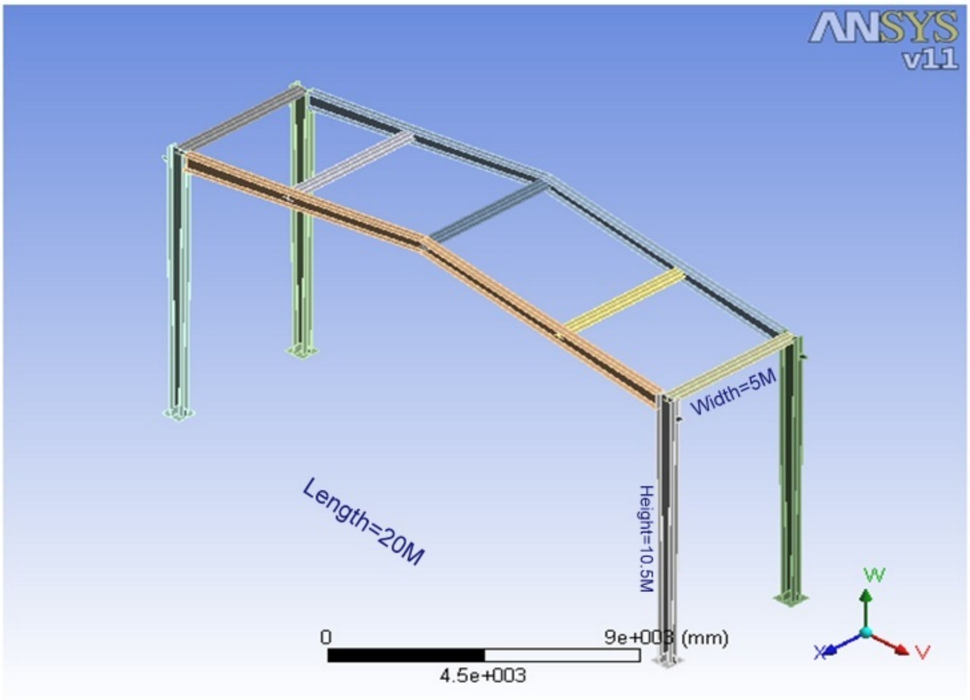


Figure 4.3: Geometry

4.1.2 Meshing and Element types

Meshing is the process in which geometry is spatially discredited into elements and nodes. This mesh along with material properties is used to mathematically represent the stiffness and mass distribution of structure.

- Meshing Of Guide-Rail Structure

Figure 4.4, as follow, shows the way with which structure is meshed. Meshing of structure is a mesh of 0.5mm size, and element type defined is tetrasolid 87.

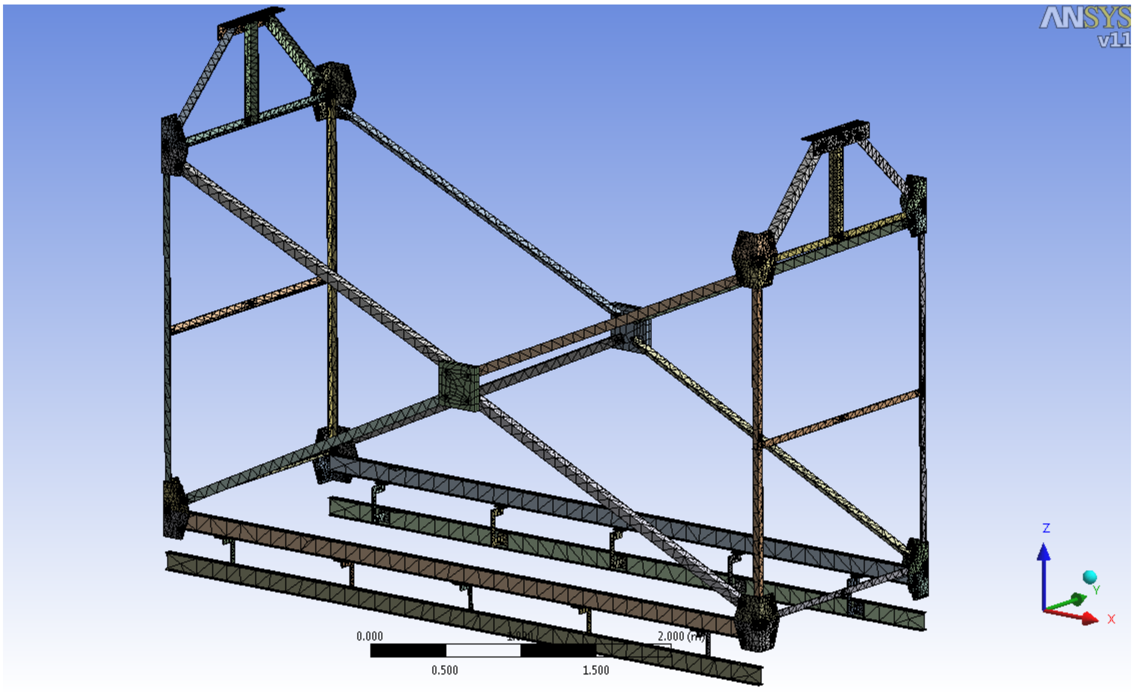


Figure 4.4: Meshing

4.1.3 The load

After having defined the simulation geometry along with the material properties and having defined the finite element mesh along with the boundary conditions, we have to define the loads.

- Load applied on the guide-rail Structure

A static structural point load of 15000 Newton (Load of trolley containing tyres) is applied on bottom surface of I Section. To carry out the analysis fixed supports have to be given, which is given to the upper surface of the horizontal part at the top, which will be bolted to the beam of the structure.

In this, figure 4.5 shows the fixed supports given to the structure and the load positions, i.e. where the load is applied and the amount of load applied is also shown.

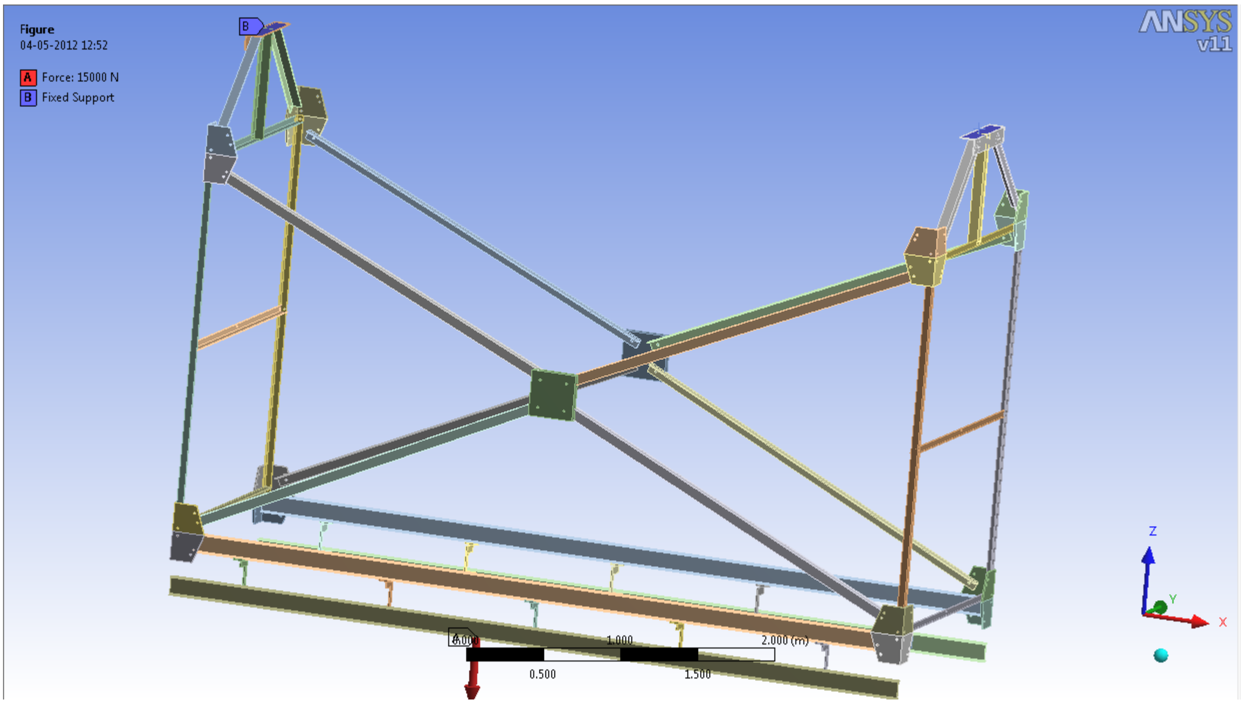


Figure 4.5: Load Applied

- Load applied on the Structure

In this, figure 4.6 shows the fixed supports given to the structure and the load positions, i.e. where the load is applied and the amount of load applied is also shown. Load applied on the structure is 15 and 45 KN for different loading conditions.

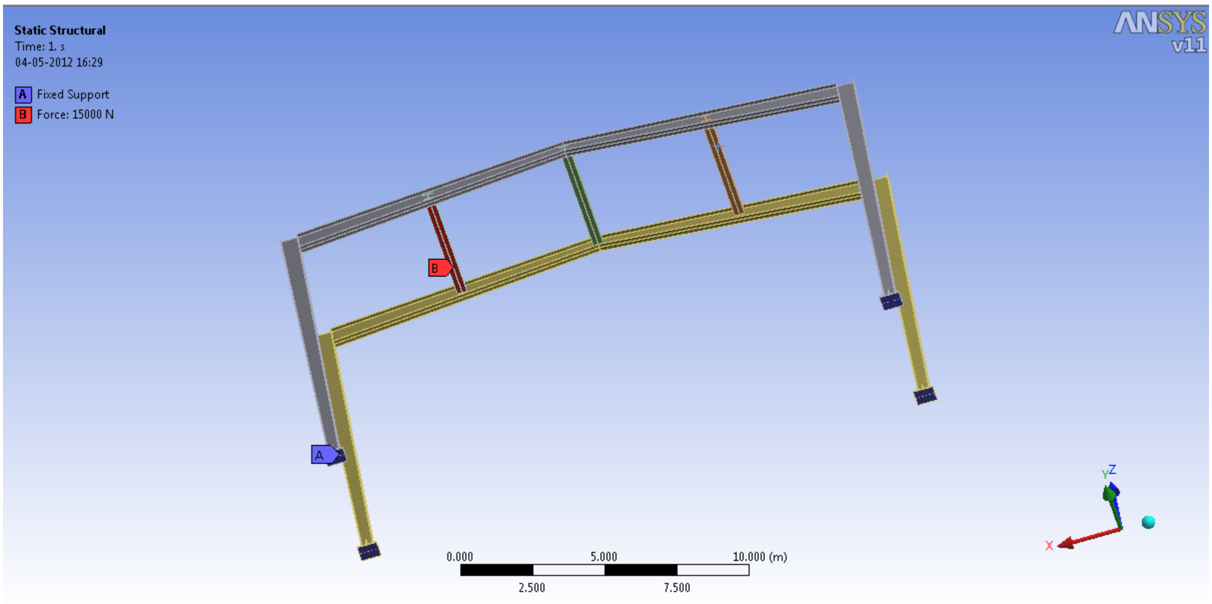


Figure 4.6: Load Applied

4.1.4 Post Processing

After building the model and obtaining the solution, it is need to show solution which defined before solving. To show it, we should perform post processing. Post processing means reviewing the results of an analysis. It is probably the most important step in the analysis, because one is trying to understand how the applied loads affect the design, how good the finite element mesh is, and so on. Via the post processor of ANSYS, it is possible to plot or visualize the results at Nodal as well as element based solution.

Chapter 5

Results And Discussion

5.1 Introduction

In this chapter, the simulation results of given tyre transfer system and existing system has been introduced. The results of both system has been discussed. Results of column-beam structure for two-different loads and results of guide-rail structure is also discussed.

5.1.1 Results for Guide-rail structure

Guide-rail structure has been modeled as per the methodology discussed in previous section. A load of 15KN has been applied on the rail section. Simulation has been carried out and a stress of 8.861e7 Pa i.e. (88.6 Mpa) is observed in the structure.

From results of analysis shown in the figures 5.1 and 5.2, it is seen that, load acting on the structure, has total deformation of 1.8mm, which is very less and is allowed on the structural span of 20M, whereas von-mises equivalent stress value is 88.6Mpa for the load of 1KN, this stress is well below the safe limit i.e. 210Mpa, yield stress of structural steel, which is used to fabricate the guide-rail. So proposed structure is safe, and will not deflect or fail for calculated load.

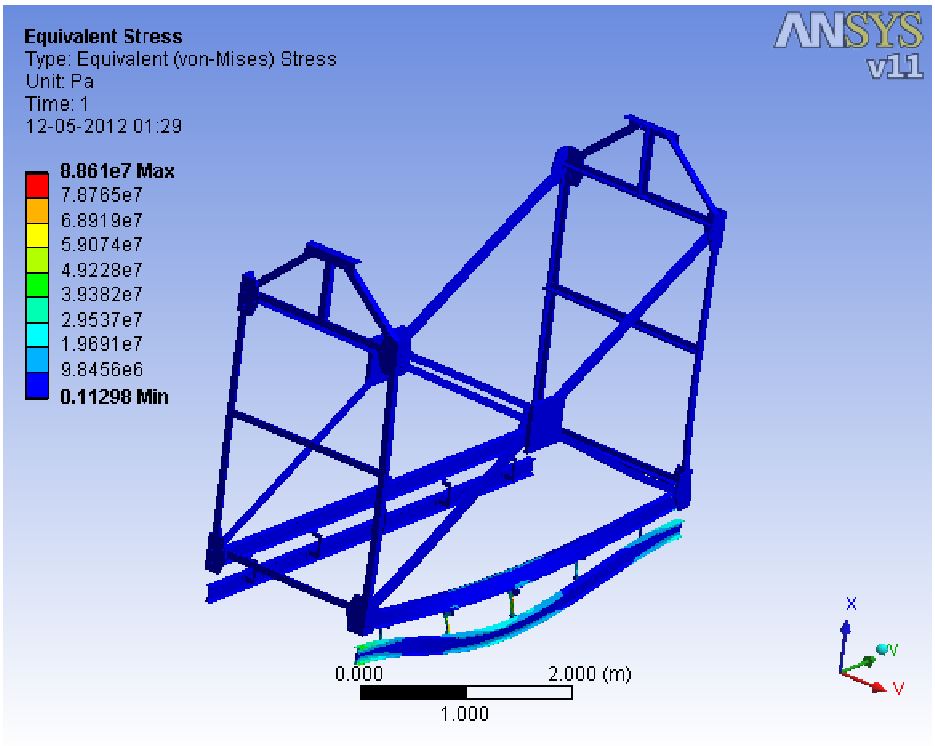


Figure 5.1: Result of equivalent stress

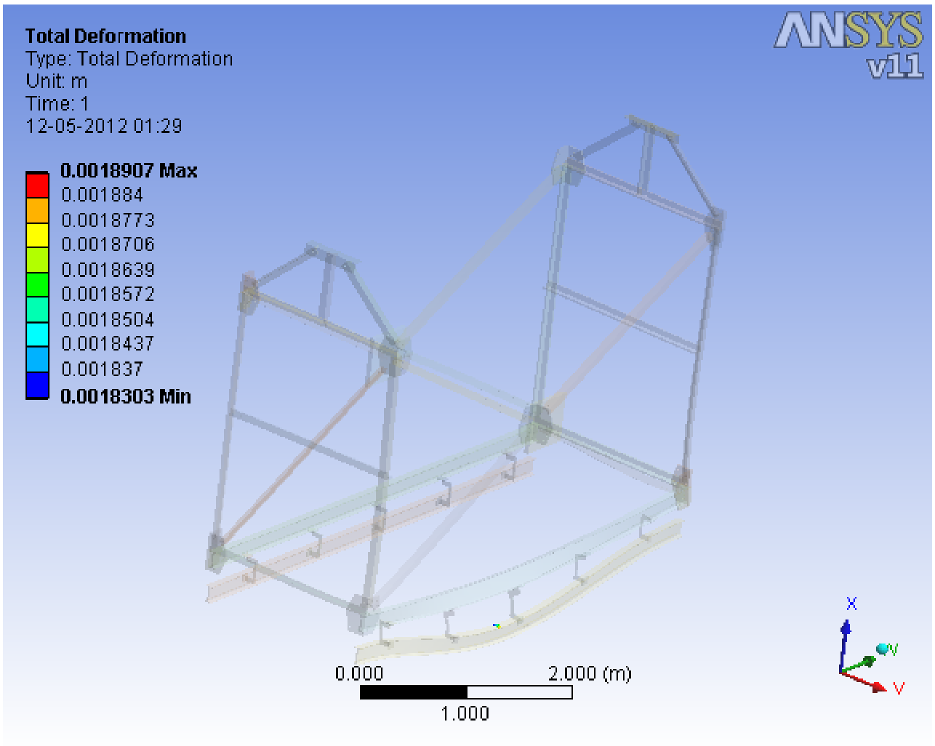


Figure 5.2: Result of total Deformation

Sr No.	Type	Total Deformation	Equivalent (von-Mises) Stress
1	Minimum	0. mm	8.861e7 Pa (88.6 Mpa)
2	Maximum	1.8907 mm	0.11298 Pa ($0.13 \times 10^{-3} Mpa$)

Table 5.1: Results for load on guide-rail structure

5.1.2 Results for column-beam structure

Results for 15KN load

For the load of 15KN, analysis of column-beam structure have been carried, and following results are achieved. From the results it can be seen that, deformation value achieved is slightly higher, but stress acting on structure is very less, so our structure is safe.

The following figures 5.3 and 5.4, shows that equivalent stress acting on structure is 28.0777 Mpa, which is below yield stress, and deformation is 4.5mm, which is very small for a 20M span, so structure of column-beam analyzed is also safe for load of 15KN, where 15KN is the weight of carriage containing trolley and tyres.

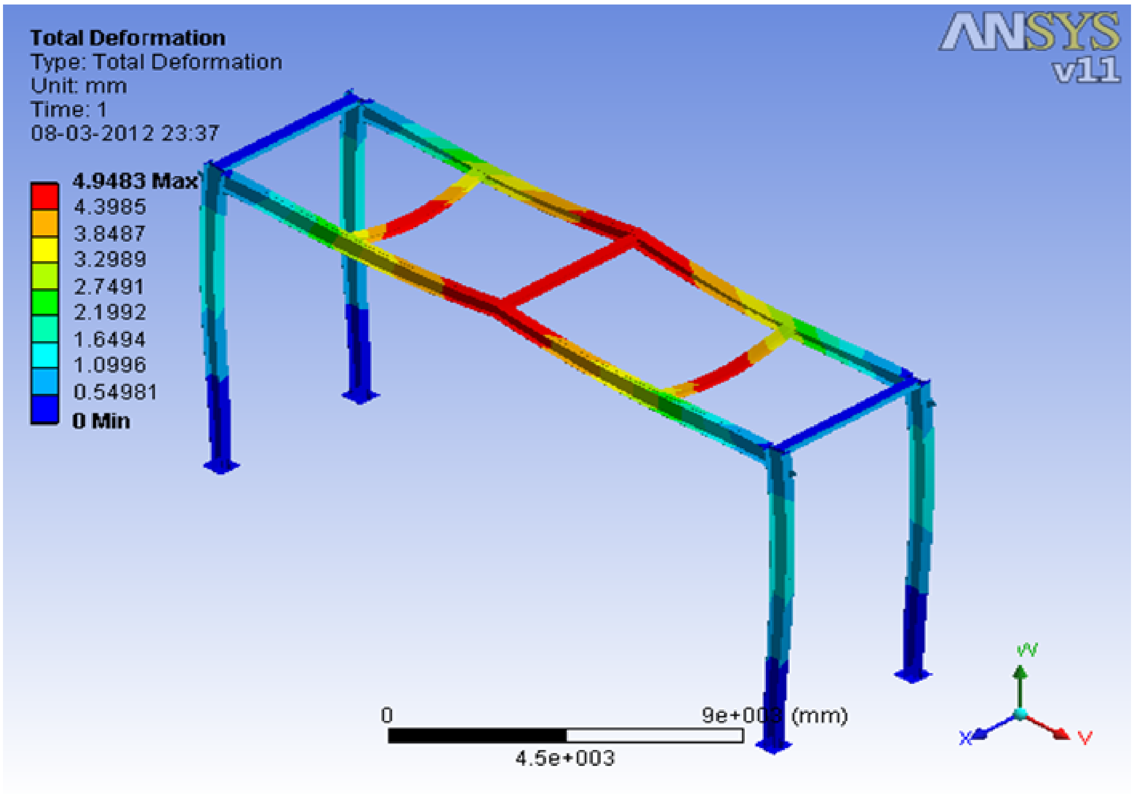


Figure 5.3: Total deformation for 15KN Load

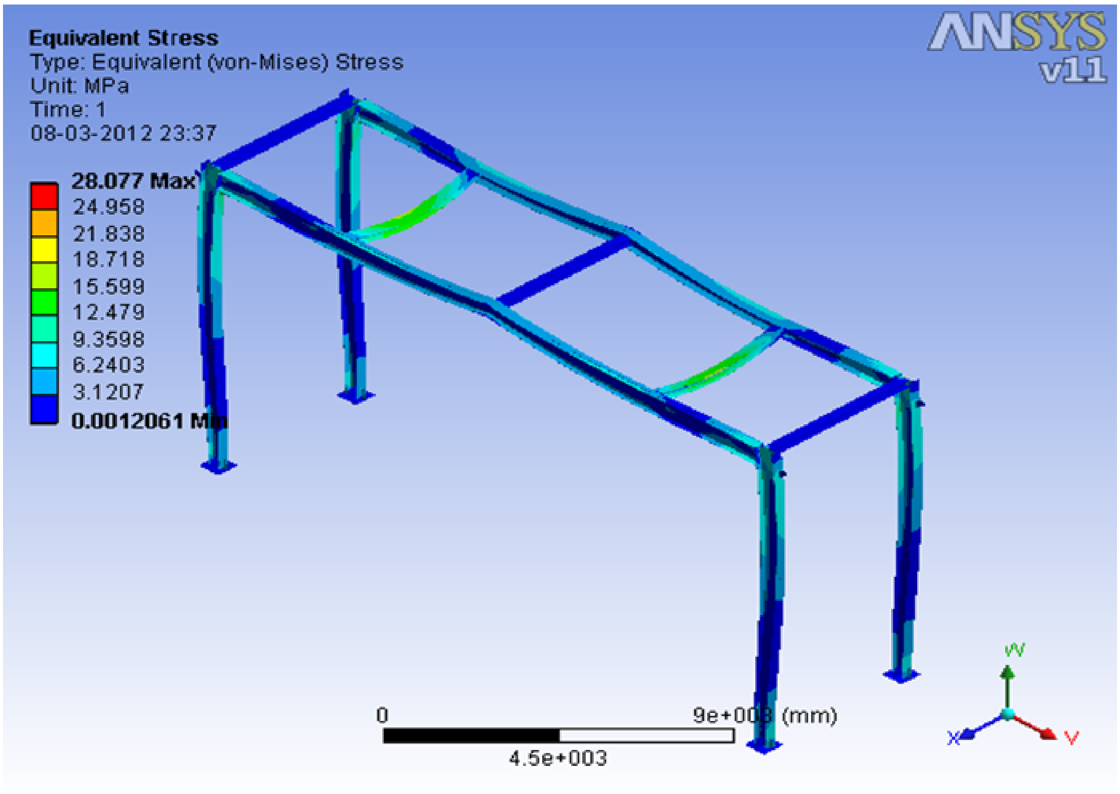


Figure 5.4: Equivalent stress for 15KN Load

Sr No.	Type	Total Deformation	Equivalent (von-Mises) Stress
1	Minimum	0. mm	1.2061e-003 MPa
2	Maximum	4.943 mm	28.077 MPa

Table 5.2: Results for load of 15KN

Finite Element Results of the structure for the applied load of 15KN is shown here, where details of fixed supports, deformation and equivalent stress is shown.

Results for 45KN load

The following figures, 5.5 and 5.6, shows the results of equivalent stress and total deformation of the structure for 45000N Load, where 45000N is the total load on the structure i.e. load of existing structure and load of the proposed structure.
From the results it is found that stress acting on the structure is 84.231 Mpa, which is below yield stress, and deformation is 14.5mm, which is very higher than permissible value, so adding trusses to the structure would be preferable to minimize the deflection.

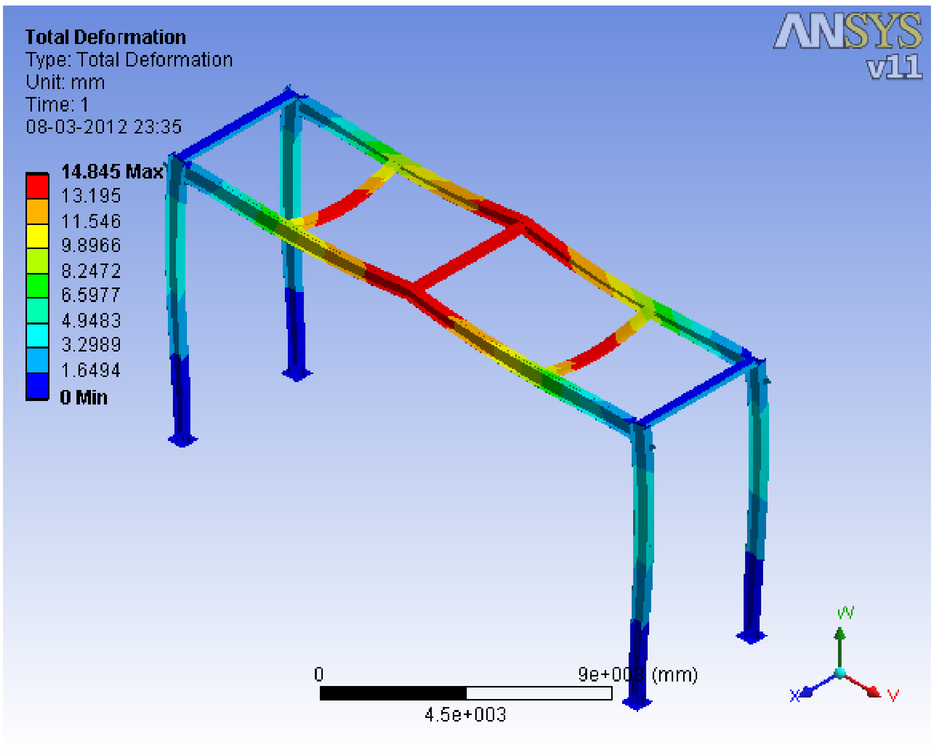


Figure 5.5: Total Deformation for 45KN Load

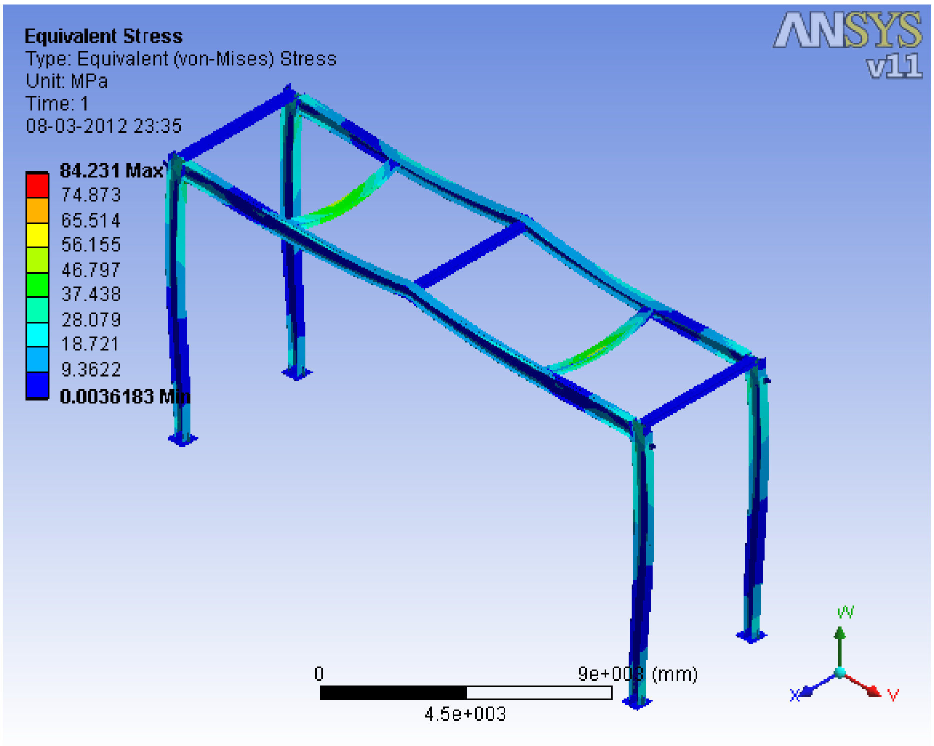


Figure 5.6: Equivalent Stress for 45KN Load

Sr No.	Type	Total Deformation	Equivalent (von-Mises) Stress
1	Minimum	0. mm	3.6183e-003 MPa
2	Maximum	14.845 mm	84.231 MPa

Table 5.3: Results for load of 45KN

Chapter 6

Summary and Future Work

6.1 Summary

After carrying out a detailed study, we come to know that there are number of systems available around us for the automation of tyre transfer system, among which Electric Monorail System (EMS) is chosen as a transferring system. Path selected for the system also had many options as well as many hindrances, but chosen path is the best suitable to the requirement.

The methodology presented above consists of a structured process divided into the sub-processes Design and selection of path, modeling of path, and selection of transfer system to be installed, measurement of levels of automation, linking level of automation and strategy, and documentation. By embedding measurement and analysis of levels of automation in the process of manufacturing strategy, appropriate levels of automation can be found. These appropriate levels of automation are aligned with the manufacturing strategy and, thus, form together the automation strategy, which secures a desired direction of the firm and also supports robustness and reliability of the manufacturing system due to the chosen holistic approach.

Analysis of the structure is also carried out which shows that structure is safe with the applied load it can sustain the load of new structure to be implemented.

6.2 Future Work

- Fabrication of the proposed structure can be carried out, which will be helpful for increased production rate.
- Installation of complete system.
- Testing and synchronization with other existing systems.

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