A PROJECT REPORT

ON

"AUTOMATION OF MATERIAL HANDLING SYSTEM"

Submitted by

FAROOQUI SAAD (11ME21)

PACHAPURE ZAID (11ME40)

RAWOOT MUDASSIR (11ME46)

WANGDE NAWAZ (11ME61)

In partial fulfilment for the award of the Degree

Of

BACHELOR OF ENGINEERING

IN

MECHANICAL ENGINEERING

UNDER THE GUIDANCE

Of

Prof. ZAKIR ANSARI & Prof. ASIF GANDHI

DEPARTMENT OF MECHANICAL ENGINEERING

ANJUMAN-I-ISLAM

KALSEKAR TECHNICAL CAMPUS NEW PANVEL,

NAVI MUMBAI – 410206

UNIVERSITY OF MUMBAI

ACADEMIC YEAR 2014-2015

ANJUMAN-I-ISLAM

KALSEKAR TECHNICAL CAMPUS NEW PANVEL

(Approved by AICTE, recg. by Maharashtra Govt., DTE,

Affiliated to Mumbai University)

PLOT #2&3, SECTOR 16, NEAR THANA NAKA, KHANDAGAON, NEW PANVEL,NAVI MUMBAI-410206, Tel.: +91 22 27481247/48 * Website: www.aiktc.org

---

CERTIFICATE

This is to certify that the project entitled

"AUTOMATION OF MATERIAL HANDLING SYSTEM"

Submitted by

FAROOQUI SAAD (11ME21)

PACHAPURE ZAID (11ME40)

RAWOOT MUDASSIR (11ME46)

WANGDE NAWAZ (11ME61)

To the Kalsekar Technical Campus, New Panvel is a record of bonafide work carried out by them under our supervision and guidance, for partial fulfilment of the requirements for the award of the Degree of Bachelor of Engineering in Mechanical Engineering as prescribed by **University Of Mumbai**, is approved.

Project co-guide	Internal Examiner	External Examiner
(Prof. Asif Gandhi)	(Prof. Zakir Ansari)	

Head of Department	Principal
(Prof. Zakir Ansari)	(Dr. A.Razzak Honnutagi)

ANJUMAN-I-ISLAM

KALSEKAR TECHNICAL CAMPUS NEW PANVEL

(Approved by AICTE, recg. by Maharashtra Govt., DTE,

Affiliated to Mumbai University)

PLOT #2&3, SECTOR 16, NEAR THANA NAKA, KHANDAGAON, NEW PANVEL,NAVI MUMBAI-410206, Tel.: +91 22 27481247/48 * Website: www.aiktc.org

---

APPROVAL OF DISSERTATION

This is to certify that the thesis entitled

"AUTOMATION OF MATERIAL HANDLING SYSTEM"

Submitted by

FAROOQUI SAAD (11ME21)

PACHAPURE ZAID (11ME40)

RAWOOT MUDASSIR (11ME46)

WANGDE NAWAZ (11ME61)

In partial fulfilment of the requirements for the award of the Degree of Bachelor of Engineering in Mechanical Engineering, as prescribed by University of Mumbai approved.

(Internal Examiner) **(External Examiner)**

____________________ ____________________

Date: ___________

ACKNOWLEDGEMENT

After the completion of this work, we would like to give our sincere thanks to all those who helped us to reach our goal. It's a great pleasure and moment of immense satisfaction for us to express my profound gratitude to our guide **Prof. Zakir Ansari & Prof. Asif Gandhi** whose constant encouragement enabled us to work enthusiastically. His perpetual motivation, patience and excellent expertise in discussion during progress of the project work have benefited us to an extent, which is beyond expression.

We would also like to give our sincere thanks to **Prof. Zakir Ansari**, Head of Department, **Prof. Asif Gandhi**, and Project Co-Guide from Department of Mechanical Engineering, Kalsekar Technical Campus, New Panvel, for their guidance, encouragement and support during a project.

We would also like to give our sincere thanks to **Prof. Atul Meshram**, **Prof. Jawed Kazi**, **Prof. Nawaz Motiwala** and **Prof. Aslam Hirani** for their guidance, encouragement and support during a project. We also thank **Mr. Murtaza Najmi** and **Mr. Rajesh Gaonkar** for assisting us in our project.

I take this opportunity to give sincere thanks to **Mr. Sanjay Kanakiya**, Owner of *Pratap Re-Rollers Pvt.Ltd*, for all the help rendered during the course of this work and their support, motivation, guidance and appreciation.

I am thankful to **Dr. A.Razzak Honnutagi**, Director, Kalsekar Technical Campus New Panvel, for providing an outstanding academic environment, also for providing the adequate facilities.

Last but not the least I would also like to thank all the staffs of Kalsekar Technical Campus (Mechanical Engineering Department) for their valuable guidance with their interest and valuable suggestions brightened us.

FAROOQUI SAAD (11ME21) PACHAPURE ZAID (11ME40)
RAWOOT MUDASSIR (11ME46) WANGDE NAWAZ (11ME61)

ABSTRACT

In today's competitive era, every firm wants to automate their production line to improve and to stand in the global market. Manual material handling in re-rolling mills is a very risky process and hence to promote worker safety, firms are trying to achieve automation and eliminate manual handling. In this report, Material handling system of PRATAP RE-ROLLERS PVT LTD., a medium scale re-rolling industry has been investigated. A 5-Phase methodology by HK systems has been adopted to diagnose the problems in material handling at PRATAP RE-ROLLERS. Current report includes actual material handling system of the plant and three main areas that call for the improvement in material handling have been identified. Out of these three identified areas, this report focuses on one area and few feasible solutions in the form of semi-automated mechanisms have been proposed within the given constraints.

TABLE OF CONTENT

TABLE OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

Z_1= number of teeth on driver sprocket

Z_2= number of teeth on driven sprocket

D= Sprocket pitch diameter

P= Pitch

D_R = Roller Diameter

W= Width between plates

D_P = Pin Body Diameter

G = Plate Depth

w = Weight per meter of chain

Q = Breaking load minimum

L_n = Number of links

a = Centre distance

l = Total length of chain

$D_{a\ max}$= Top Diameter maximum

$D_{a\ min}$= Top Diameter minimum

$r_{i\ max}$=Roller Seating radius maximum

$r_{i\ min}$=Roller Seating radius minimum

$r_{e\ max}$= Tooth flank radius maximum

$r_{e\ min}$= Tooth flank radius minimum

α_{max}= Roller seating angle maximum

α_{min}= Roller seating angle minimum

$h_{a\ max}$= maximum tooth height above polygon pitch

$h_{a\ min}$= minimum tooth height above polygon pitch

$r_{x\ min}$= Tooth side radius

b_{f1}= Tooth width

b_a= Tooth side relief

K_1 = load factor

K_2 = correction factor for distance

K_3= correction factor centre distance

K_4 = correction factor for sprocket positioning

K_5 = correction factor for lubrication

K_6 =double shift work rating

K_s = Safety factor

N = Power rating

v = velocity of chain

n= factor of safety

T = tension while pulling of object

m_1= weight of the chain

m_2 = weight of the object to be conveyed

f_1 =friction factor between chain links

f_2 = friction factor between chain and sprocket

f_3= friction factor between object and the lower plate

g = acceleration due to gravity

C.G = Centre of Gravity

DECLARATION

I declare that this written submission represents my ideas in my own words and where others ideas or words have been included. I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

(NAME AND ROLL NO.)	**(SIGNATURE)**
FAROOQUI SAAD (11ME21)	________________________
PACHAPURE ZAID (11ME40)	________________________
RAWOOT MUDASSIR (11ME46)	________________________
WANGDE NAWAZ (11ME61)	________________________

Date:

Chapter 1 - Introduction

1.1 Company's Introduction

1.2 Aim and objective

1.3 Scope

1.4 Introduction of Automation of Material Handling

1.1 Company's Introduction

We are working at "PRATAP RE-ROLLERS PVT LTD" Mumbai's leading manufacturer, exporter & whole sellers of iron and steel hot re rolled & bright bar sections and 50 years in Trading & Supply of steel material.

Establishment: 6th February 1993

Product manufactured: Iron and Steel Products, Equal Angle, Flat Bars, H Beam, I Beam, Bright Steel Bars, Square Steel Bars and Steel Round Bars, Rectangular flat bars, Steel round bar, Squares steel bar, Hexagon, Beams, Angles, Channels.

(Mild Steel, Alloy Steel, Carbon Steel)

Applications of products:

- Automobile Industry
- Engine components
- Nuts, Bolts and Shafts
- All Heavy Engineering Industries
- Textile Machine Manufacturing
- Pumps / Electric Motor Industries
- Railways for manufacture of Engines as well as Coaches
- Defence Sector for making various Arms and Ammunitions
- Fan Industries
- For various fabrication jobs where accuracy is important
- For making shafts in Conveyors

1.2 Aim

The aim of the project is to study material handling system at PRATAP RE-ROLLERS PVT LTD and to identify those areas where semi-automated/automated mechanisms could be incorporated to enhance its material handling process, and to propose solutions to the problems given by the company's owner.

1.3 Objectives

1. To ease the material handling in the plant.
2. To promote safety and to improve working condition.
3. To eliminate manual handling as it involves health risks of the workers.

1.4 Scope

The scope of this project includes study of sre-rolling process and material handling system .At PRATAP RE-ROLLERS PVT LTD, and proposing suitable automated or semi-automated mechanism for the problem stated by the owner

1.5 Introduction to Automation of Material Handling

Material handling can be defined as: "art and science of conveying, elevating, positioning, transporting, packaging and storing of materials." Starting from the time, the raw material enters the mill gate and goes out of the mill gate in the form of finished products; it is handled at all stages within mill boundaries such as within and between raw material stores, various section of production department, machine to machine and finished product.[1]

Material handling involves the movement of materials, manually or mechanically in batches or one item at a time within the plant. The movement may be horizontal, vertical or the combination of these two. Material movement adds to the cost but not to the product value.[2]

There are two essential things needed to apply good materials handling:

- Expert material handlers: If you are manually handling materials and products for distribution, storage, etc. this refers to utilizing workers who will serve as material handlers. They are the ones who are going to store, distribute, etc. all the goods to their proper destinations. To ensure good material handling, you need effective material handlers who are really trained and excellent when it comes to the task they are to perform. This will ensure you that they are going to perform materials handling well for the safety of other workers and the products.
- Efficient material handling storage systems: If you also want to apply materials handling, efficient storage systems are also necessary. This refers to storage systems that are really functional and automated and can really handle materials well so your time, money and effort would be saved. Thus, the automation is necessary to ensure efficient material handling.

Objectives of Material Handling:

The primary objective of a material handling system is to reduce the unit cost of production. The other subordinate objectives are:

- Reduce manufacturing cycle time.
- Reduce delays, and damage.
- Promote safety and improve working conditions.

Function and Principle of Material Handling:

The main functions of material handling are:

- To choose most appropriate material handling equipment which is safe and can fulfil material handling requirements at the minimum possible overall cost.
- Minimize the movement involved in production operation.
- Minimize the distances moved, by adopting shortest routes.
- Employ mechanical aids in place of manual labour in order to speed up material movements.
- Safe, standard, efficient, effective, appropriate flexible and proper size material handling equipment should be selected.
- Utilize gravity for assisting material movements wherever possible.

Automation is the use of various control systems for operating equipment with minimal or reduced human intervention. A few advantages of automation include:

- Automated machine is performing tasks that are beyond human capabilities of size, weight, speed and endurance.
- Economy improvement of enterprises by reducing manufacturing cycle time, reducing wages, reducing the handling cost.
- Replacing human operators in tasks that involve hard physical or monotonous work.
- Promote safety and improve working conditions.

Limitations of automated material handling systems:

A good management practice is to weigh benefits against the limitations or disadvantages before contemplating any change. Material handling systems also have consequences that may be distinctly negative. These are:

1. Additional investment
2. Lack of flexibility
3. Vulnerability to downtime whenever there is breakdown
4. Additional maintenance staff and cost
5. Cost of auxiliary equipment.
6. Space and other requirements

It has been estimated that average material handling cost is roughly 10-30% of the total production cost depending upon product to process. By saving in the material handling cost, the cost of production can be reduced considerably.

In a typical manufacturing plant material handling accounts for 25% of all employees, 55% of all company space, 87% of the production time, and 15-75% of the total cost of a product.

1.5.1 Types of material handling

1. Industrial trucks
2. Cranes
3. Monorail
4. Hoists
5. Lifts
6. Tractors and trailers
7. Conveyors
8. Slides and chutes

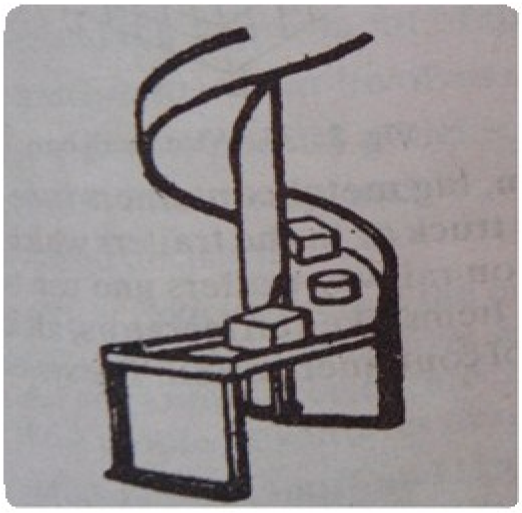


Figure 1 Spiral Chute

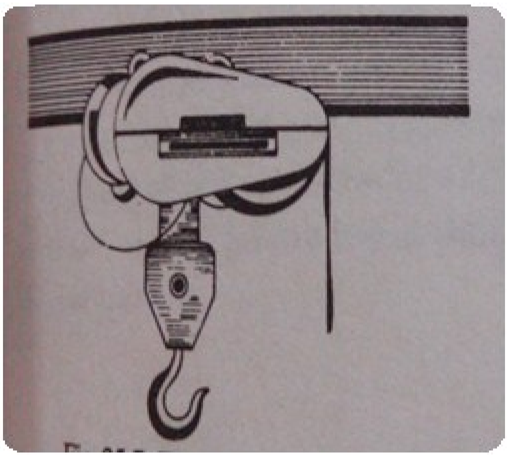


Figure 3 Electric Hoists

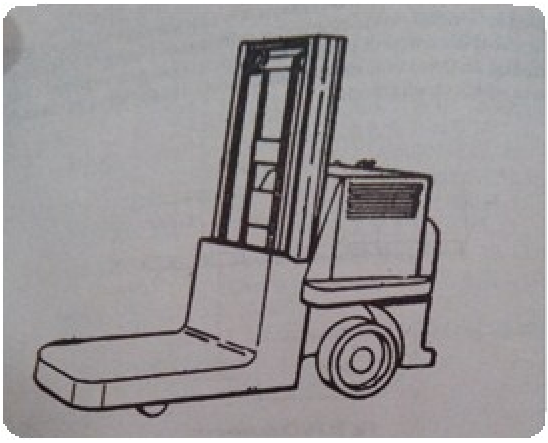


Figure 2 Platform Truck

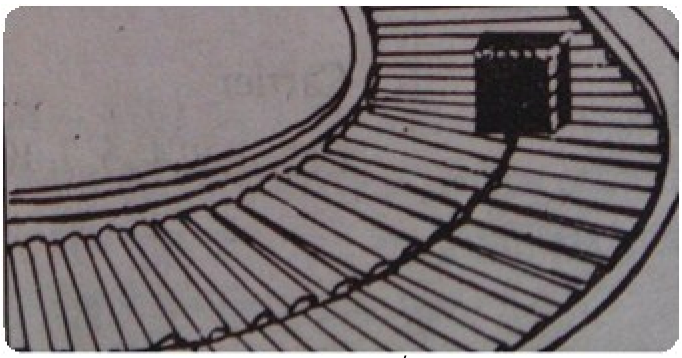


Figure 4 Roller Conveyor

Chapter 2 - Review of Literature

Literature review performed in order to put the theoretical background needed for this case study in context. It is necessary to find out literatures that exist and already is known within the area of the study. Moreover it is of interest to investigate methods and research strategies that already has been applied in order to avoid any replication of things that already exist. A literature review can also supply the researcher with theoretical backgrounds that is relevant of the specific area of interest.

(Bahale & Dr.S.S.Deshmukh, 2014) [2] Material handling involves the movement of materials, manually or mechanically in batches or one item at a time within the plant. The movement may be horizontal, vertical or the combination of these two. Material movement adds to the cost but not to the product value

(Yaman, 2001) [3] There is a necessity to describe the relationship between MHS design and facility layouts since these two problems are clearly related closely. Because one of the main objectives of facility layout is that of minimising the material handling system cost, the two design problems have to be solved together. The two alternatives for the solution sequence are shown in Figure 5.

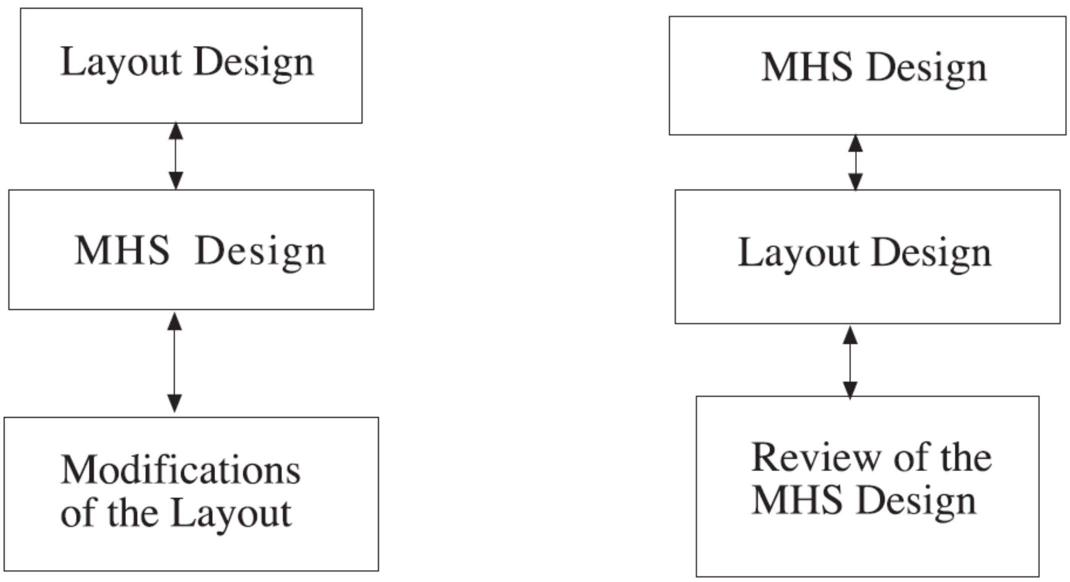


Figure 5 The Solution Sequence and Preferable Relations between MHS and Facility Layout Design

There are basically two functions of material handling section:

1. To select production machinery and assist in plant layout so as to eliminate as far as possible the need of material handling.
2. To choose most appropriate material handling equipment which is safe and can fulfill material handling requirements at the minimum possible overall cost.

(Bahale & Dr.S.S.Deshmukh, 2014) [2] Inefficient Material Handling Symptoms are Aisles are cluttered, over handling of products, dock confusion in loading/unloading, too much manual labour, lack of gravity flow movement, poor use of skilled labour, stock out on parts and supplies, lack of standardization, high loss and damage, excess scrap, flow inefficiencies, confusing products storage, too much walking, excessive indirect and labour cost, idle cube storage, excessive long hauls, dirty facilities and excess amounts of employees.

(Yaman, 2001)[3] Detail consideration of the specific equipment starts with a consideration of the specific parts to be handled, whereas strategic design focuses on more general aspects which comprise the following:

- The characteristics of the material to be moved.
- The attributes of the method.
- The physical facility constraints under which the task is to be done.

(Yaman, 2001)[3] As with most design problems, MHS design involves trade-offs between the performances of the system based on multiple criteria. For instance, it is generally not possible to implement a system which minimises cost and maximises reliability. Hence, the MHS designer must either explicitly or implicitly consider multiple, conflicting and non-commensurate objectives. These objectives may be well defined in the design specifications.

(Yaman, 2001) [3] The choice of MHS equipment depends on the product and process requirements. For this reason, MHS equipment can be selected according to the product and process specifications.

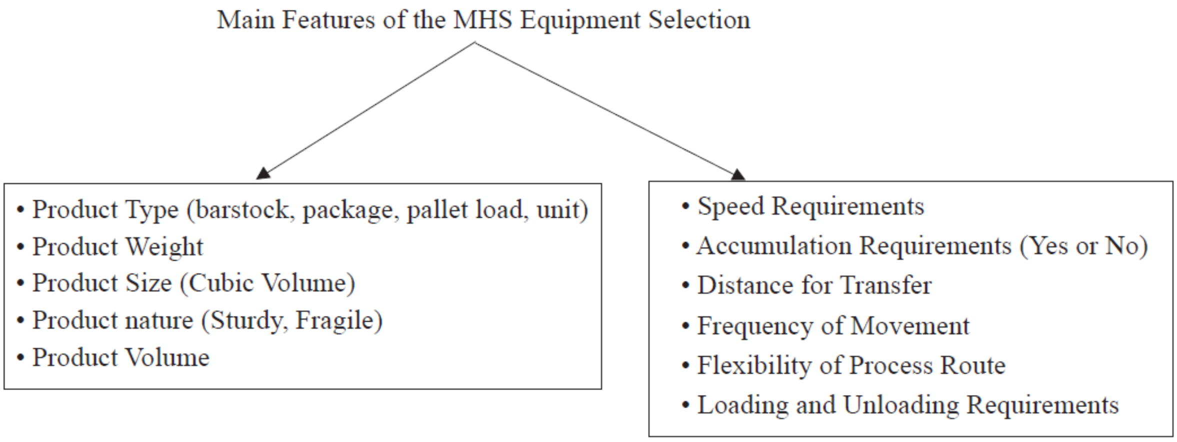


Figure 3. Product and Process Features for MHS Equipment Selection

(Management, 2011)[1] According to Gurgel (1996), the equipment should be selected based on some preliminary considerations: take into account the utilization of the factory floor and its load capacity; examine the dimensions of doors and corridors; pay close attention to ceiling height, identify the environmental conditions and their nature, avoid the use of combustion engines traction equipment's in storage of food products, meet all safety standards to protect humans and to eliminate the possibility of incurring criminal and civil liabilities arising from accidents, and examine all kinds of available energy options and their capacity to supply required movements.

(Management, 2011) [1] With regard to the attributes to be considered in a material handling system, according to Kulak (2005), effective use of labor, providing system flexibility, increasing productivity, decreasing lead times and costs are some of the most important factors influencing selection of material handling equipment.

(Yaman, 2001)[3] Material handling equipment selection is a complex task and there is usually more than one good solution for any particular situation.

Chapter 3 - Methodology

The simple and effective 5 phase program developed by HK Systems, Inc. that takes a motivated client from concept to ownership has been adopted in our project at "PRATAP RE-ROLLERS PVT LTD. The process has been created with the following attributes:

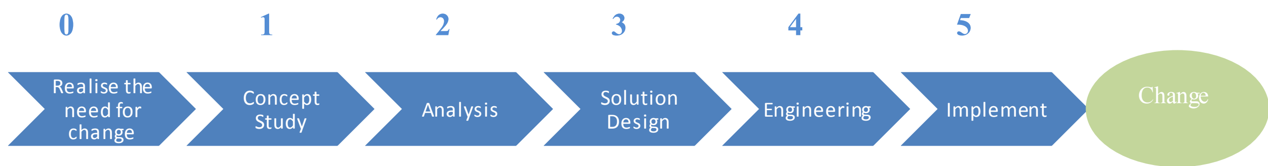
Scalable: The project may include adding 25 feet of conveyor to an existing warehouse or it may be the development of a 2 million square foot automated e-fulfillment DC. This process can be scaled for a broad continuum of size and complexity.

Practical: There is no single right answer when conducting design. The levels of fit depend on the company culture, customers, and economy. This process flexes to accommodate those variables.

Recyclable: This process has a beginning but no end. It is intended to be an ongoing, dynamic part of the company operation. It will continue to serve the company as, company later refine the cost of ownership, consider modernizations, and remission of the assets for changes in business.

Phases:

The following graphic illustrates the phases involved in the overall project process, the activities in each phase, and the deliverables that can be expected from each phase.



Phase activities:

Phase 0:

- Desire to improve productivity?
- Planning for growth?
- Need to reduce costs?
- Accommodate structural change or acquisition?
- Overcome labour quality/availability challenges?

Phase 1:

- Listening to customer objectives & constraints
- Data analysis

Phase 2:

- Applying experience
- Interactive, iterative design & layout
- Touring relevant installed technologies
- Together refining the best fit solution

Phase 3:

- Simulation engineering & analysis.
- Innovation
- Identify products and subsystems required
- Apply lessons learned

Phase 4:

- Specifications of materials and components
- System Engineering
- Manufacturing Engineering

Phase 5:

- Manufacturing
- Procurement
- Installation
- General construction
- Factory and field integration testing

Chapter 4 - Report on Present Investigation

4.1 Material handling and Process Study

4.1.1 Coal handling:

PRATAP RE-ROLLING mill uses pulverised coal for heating of raw materials (ingots, billets, etc.) in furnace.

Coal handling in plant is done in 3 stages:

i. Receiving the coal (coal unit area)
ii. Pulverization of the coal (coal unit area)
iii. Transporting the coal (furnace area)

- ***Receiving the coal:***

  - ✓ The coal is received in large lumps ranging from 2mm to 50mm size at the coal unit in the plant.
  - ✓ The coal is brought by truck, directly at the coal unit area .Once the coal is unloaded from the truck; it is stored at the coal unit area for pulverization.

Figure 6 Coal Storage

- ***Pulverization of the coal:***

  - ✓ Pulverizing is the process of reducing the coal into fine particles for efficient combustion of coal in the furnace.
  - ✓ The coal unit of the plant also consist of a pulveriser mill; it is a mechanical device for grinding of coal into small particles.
  - ✓ Once the coal is pulverized into fine particles they are stored in coal sacks
  - ✓ Now these coal sacks are carried to the blower, installed near the furnace.

Figure 7 Pulverization Unit

- ***Transporting the coal:***

  - ✓ The pulverized coal is transferred to the blower using construction trolleys that are manually handled.
  - ✓ Blower helps in injecting pulverized coal into the furnace with high velocity.
  - ✓ These coal sacks are placed near the blower so that the coal can be transferred from the coal sack into the blower as when required.

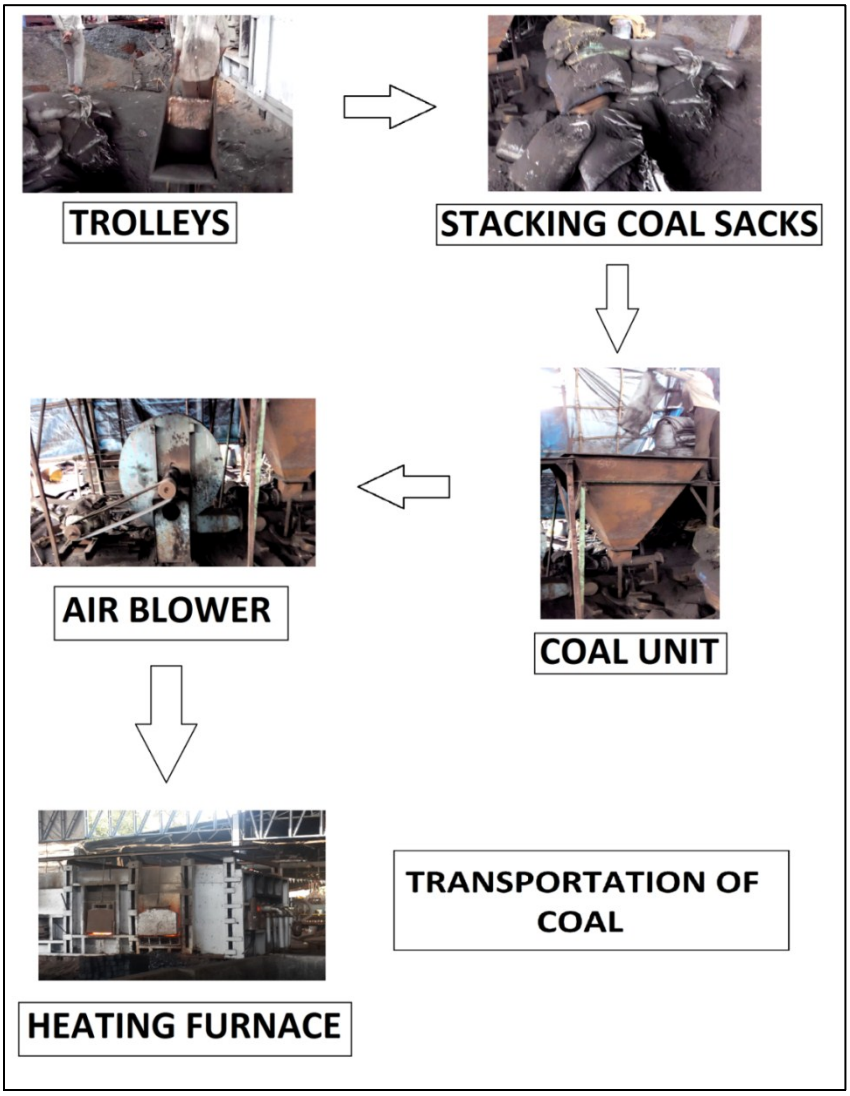


Figure 8 Transportation of Coal to Furnace

4.1.2 Product handling

Raw materials are received at the raw material storage area which is situated at the leftmost part of the plant these raw materials are delivered by truck into the plant and are carried to the raw material storage site using a crane. The crane stacks the raw material one above the other. These raw materials are kept at storage site unless required for subsequent processing.

Figure 9 Storage of Raw Material

➢ ***Cutting of raw material:***

Figure 10 Cutting into billets or blooms using gas cutting

- ✓ The 1st step in processing, is cutting the large raw material into small sized billets or blooms.
- ✓ These billets have the dimensions required for the final product i.e. considering correct length, height and thickness of final product.
- ✓ Large Ingots are cut into the small billets using gas cutting techniques also called as oxy-fuel cutting.
- ✓ In oxy-fuel cutting, a torch is used to heat metal to its kindling temperature.

- ✓ A stream of oxygen is trained on the metal burning it into a metal oxide that flows out as slag, hence cutting the material into 2 pieces.
- ✓ The entire process of gas cutting is manually handled. The use of fuel gases together with oxygen can give rise to dangerous situation hence user must have adequate knowledge of how to handle gases equipment's and the necessary protective equipment's must be used.
- ✓ These cut billets are then placed at the work table of furnace using a crane and when it is in excess they are stacked near the furnace for future use.

➢ ***Heating of billets in furnace:***

Figure 11 Electric Pusher

- ✓ The billets to be heated are placed on furnace worktable using a crane and then they are manually aligned in one single horizontal line; placed one beside the other forming a continuous line of material.
- ✓ This aligning is very important as the furnace used is of pusher-type.

  In pusher type furnaces the work pieces being heated are moved across the hearth under the action of electric or hydraulic pusher positioned behind the charge.
- ✓ In furnaces billets are heated until they become red hot. Heating is very important as it affects the property of the material and also metals offers less resistance to deformation when heated.
- ✓ At PRATAP RE-ROLLERS PVT LTD, the pusher is of electric type. The billets to be heated are charged form one end of the furnace and moved through the furnace by pushing the last piece with a pusher at the charging end. As each cold piece is pushed into the furnace against the continuous line of material a heated piece is removed.
- ✓ The heated piece is ejected through a side door to the mill table by manual means.
- ✓ The red hot material is manually pushed out of the side door using a long rod and carried to the mill table using a roller and chain conveyer.

- ***Movement of billets across roll mill stand for rolling:***

  - ✓ Once the billets are heated in the furnace and transported to the roll mill area, they are then rolled through several mill stands so as to undergo deformation at each pass and to acquire the dimensions of final product.

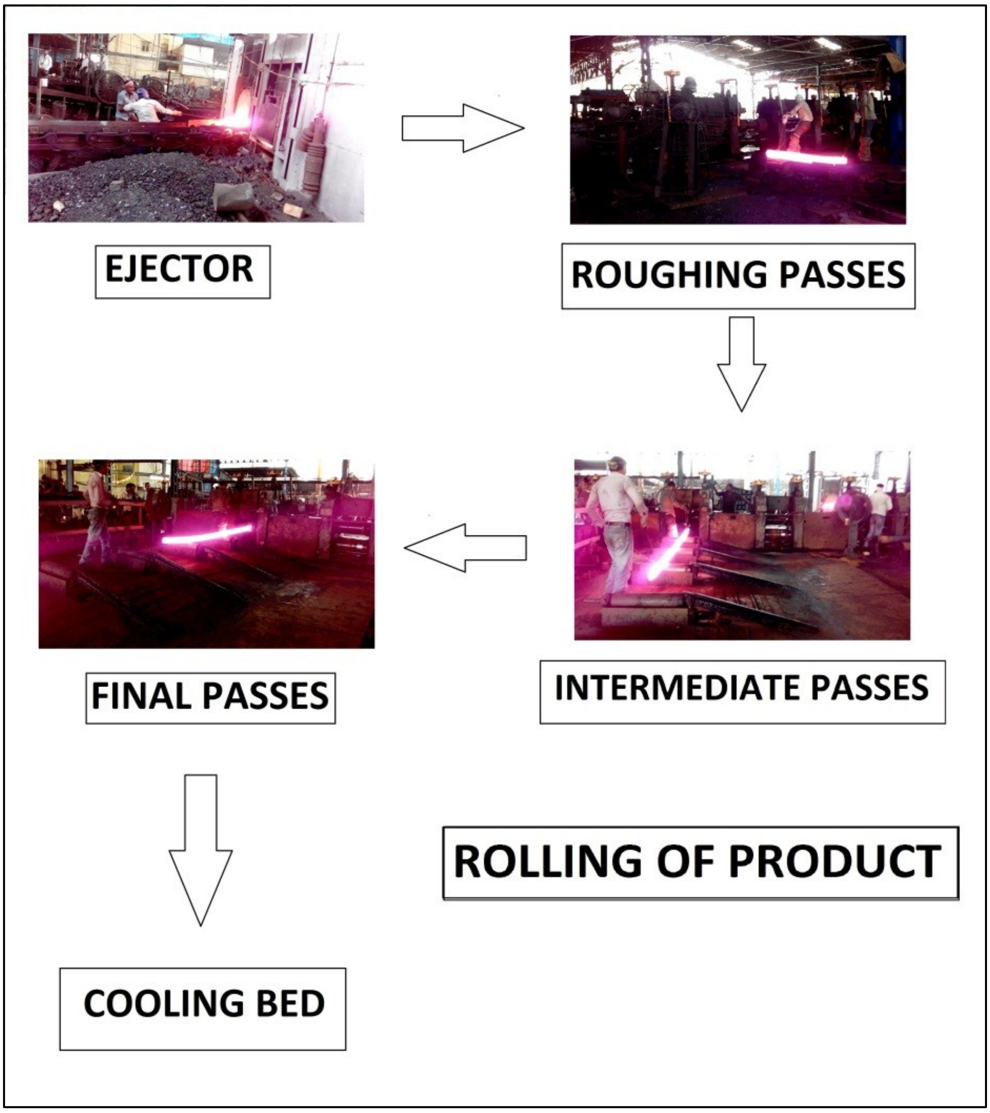


Figure 12 Movement of billets across rolling mill stands

  - ✓ At Pratap Re-rollers, they have 6 rolling mill stands for each furnace. These mill stands are horizontally placed in a single line, one besides the other comprising of 1 roughing stand, 3 intermediate stands, and 2 finishing stands. Each stand consists of 3 high rolling mills.

- ✓ The hot billets are manually guided into the roll zone i.e. the area over which the rolls act on the material, and its plastic deformation occurs.
- ✓ The billets are rolled through mill stands one at a time, and often they are passed forward and backward through a single stand. Each pass gradually changes the shape and dimension of the billets closer to that of the required finished product.
- ✓ After passing the billets through the finishing stand achieving the final dimensions, the hot billets are transported to cooling bed area through a roller and chain conveyor system.

➢ ***Cooling of hot billets:***

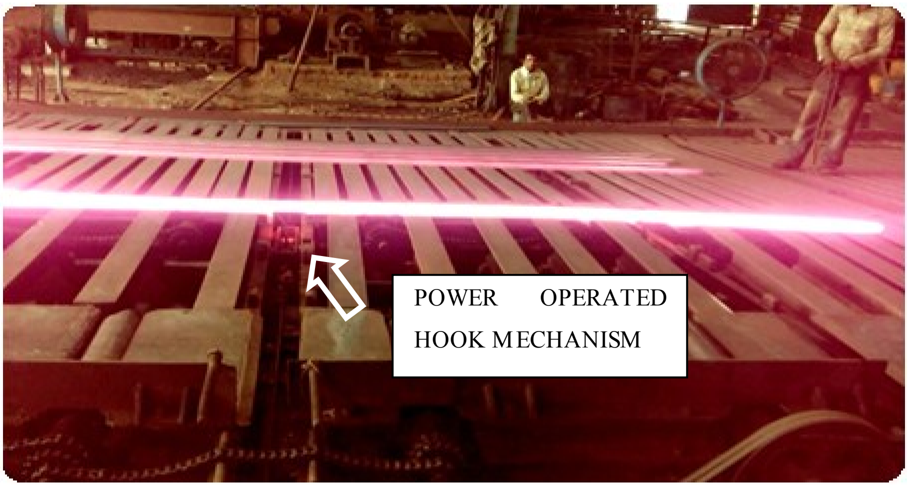


Figure 13 Cooling Bed

As the hot billets approaches the cooling bed area through the roller and chain conveyor, these billets are pushed onto the cooling bed using a mechanized electric system. Cooling medium adopted is natural cooling i.e. air cooling. The hot billets are placed on the cooling bed and allowed to cool under the atmospheric air. This process is completely automated and the process is controlled by an operator sitting behind the cooling bed.

- ***Transportation of cooled billets to shearing machine:***

  - ✓ Once the hot billets are cooled, they are then manually placed on the conveyor, using a hollow-bit tong.
  - ✓ The conveyor is situated at the end of cooling bed. This roller conveyor transports cold billets up to the shearing machine, located at the right side of cooling bed.
  - ✓ At shearing machine, the ends of the billets are cut without the formation of chips. Shearing machine is of power shear type i.e. electrically powered and lever operated. An operator sitting in-front of the shearing machine controls the entire shearing process.
  - ✓ After shearing these edges cut billets are ready for packing.

Figure 14 Shearing Machine

➢ ***Packing (bundling and strapping):***

- ✓ The edge cut billets are then manually flipped onto the bundling and strapping table using two long rods.
- ✓ After billets are placed on the packing table they are properly aligned using tongs and a bundle of 6-8 billets are formed.
- ✓ Once they are properly aligned and a bundle is formed, each bundle is strapped using a strapping machine.
- ✓ After the billets are bundled and strapped a crane carries the finished product from packing area to the storage area.

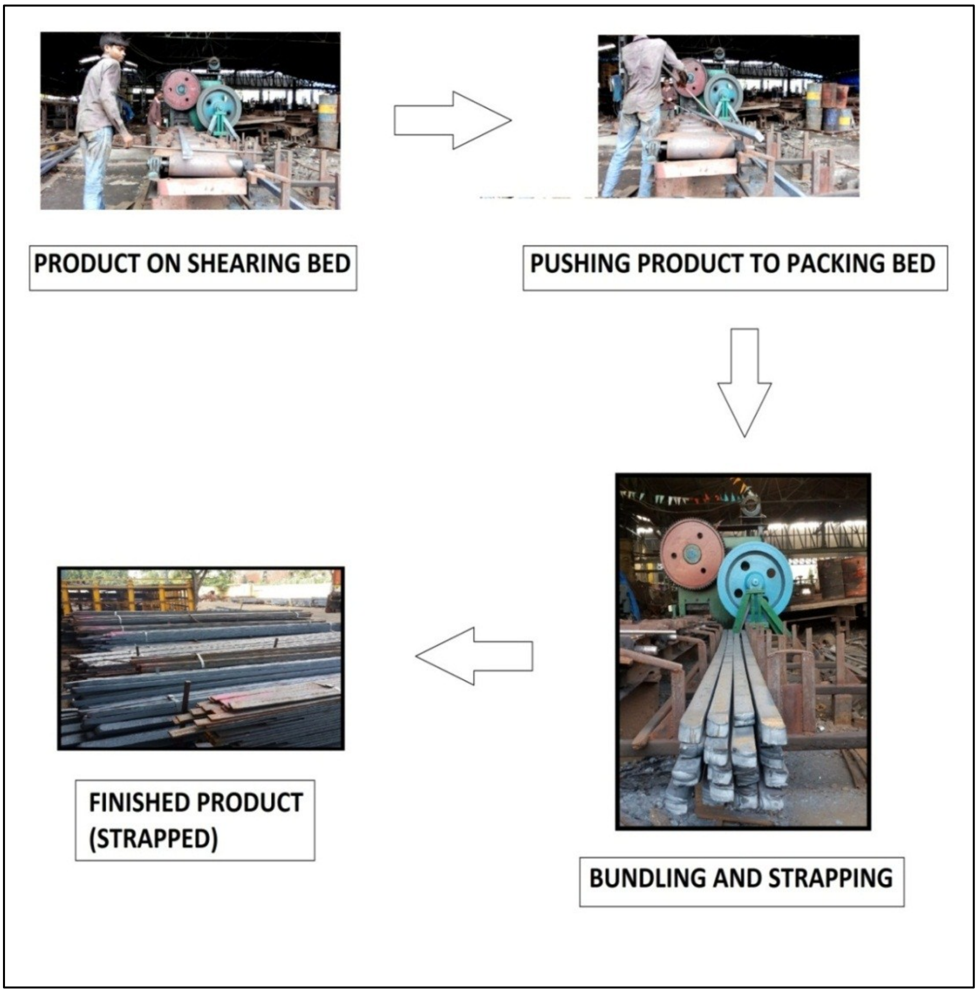


Figure 15 Packing of Product

4.1.3 Areas of automated/manual material handling in product process

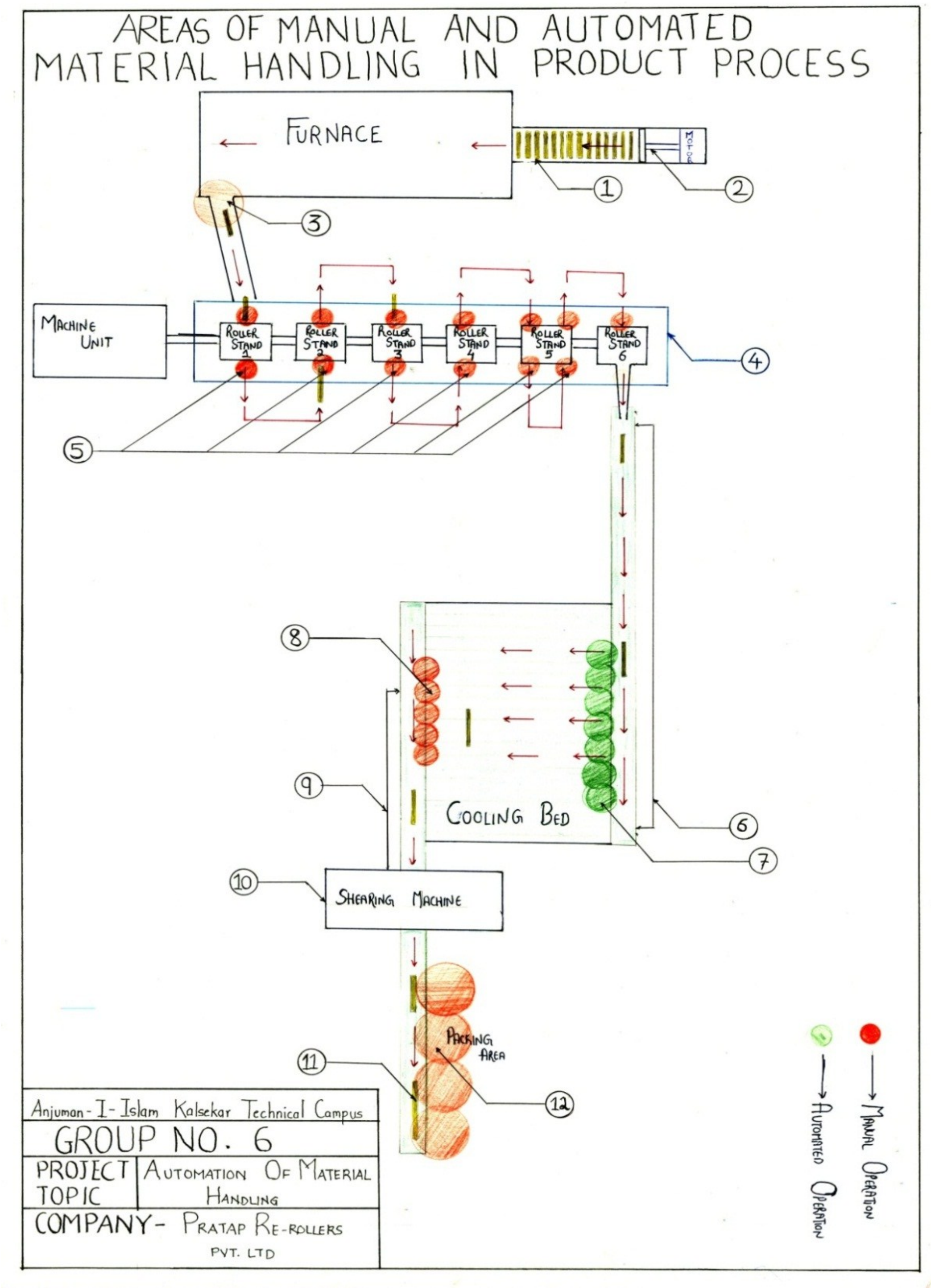


Figure 16 Areas of Material Handling

Table 1 Description of Automatic, Semi-Automatic and Manual operations in plant

NO	DESCRIPTION	AUTO/ MANUAL SEMI AUTO
1	Manually aligning the billets on the furnace worktable to form a continuous line of material using tongs.	MANUAL
2	Pushing of the aligned billets into the furnace using electric pusher.	AUTO
3	Ejecting of red hot billets from the side door manually using long rods.	MANUAL
4	Passing red hot billets across series of rolling mill stand so as to acquire final product dimensions.	MANUAL
5	Manually guiding the billets into the rolls and after each pass carrying the billets to the next stand for another pass	MANUAL
6	Transferring of billets from finishing stand to the cooling bed using roller chain conveyor.	AUTO
7	Transferring of billets onto the cooling bed using power operated hook.	AUTO
8	Manual transferring a billet at a time from cooling bed onto roller chain conveyor.	MANUAL
9	Using roller chain conveyor transporting billets to shearing machine.	AUTO
10	Cutting the billets edges using shearing machine.	AUTO
11	Manually flipping of the edge cut billets onto the packing bed using long rods.	MANUAL
12	Manually aligning the billets on the packing area to form a bundle of 9-12 billets and then strapping them.	MANUAL

4.2 Problem Definitions

Problems identified in material handling are:

1. Coal transportation to furnace
2. Ejection of heated billets from furnace
3. Product handling after shearing process

4.2.1 Coal transportation to furnace:

After pulverization of coal in coal plant, the powder is manually carried with the help of trolleys by workers to the hopper.To tackle this problem the team decided to make use of **screw conveyors**.

Figure 17 Trolleys

Figure 18 Screw Conveyor

A screw conveyor or auger conveyor is a mechanism that uses a rotating helical screw blade, called a "flighting", usually within a tube, to move liquid or granular materials.

We proposed an underground screw conveyor line from the coal storage unit to both the furnaces. After keeping this suggestion in-front of the owner we were informed about the practical difficulties in its maintenance and if any granular particle slightly larger in size gets stuck in between the blades, it gets very difficult to trouble shoot this problem as it involves complete dismantling of the whole assembly to locate where the particle has been blocked.

Simultaneously the other team was also working on this problem and understanding the need of the owner we decided to focus on providing probable solution to product handling after shearing

4.2.2 Ejection of heated billets from furnace

This process involved a high safety risk as working in the vicinity of the furnace meant workers had to work at a very high temperature. The team than thought of a pusher or ejector mechanism and when we started to search some data online, we discovered that there was many manufacturers' supplying furnace-ejector as a separate part. This was brought in notice of the owner.

The owner then asked the team to address product handling after shearing problem on first preference. So the team started working on product handling after shearing problem before pondering on ejector mechanism.

Figure 19 Billet Ejection from furnace

Figure 20 Ejector Furnace

4.2.3 Product Handling after Shearing Process

After shearing process, the finished product is manually handled by workers and dispatched into packing area. We observed that three workers are employed at this station.The finished products were packed and stacked only on the right side of the bed as seen in the adjacent figure.

The owner wanted to eliminate the labour force that was required in pushing finished products onto the packing bed and wanted an automated or semi-automated mechanism that could replace worker and also do the same function as done by the workers i.e. pushing finished products onto packing bed.

Figure 21 Workers manually lifting the product

4.3 Green Zone of Shearing Bed

Position of equipment plays an important role in material handling. The first step was to find the correct pposition of equipment's to be placed so as to have optimum working position.

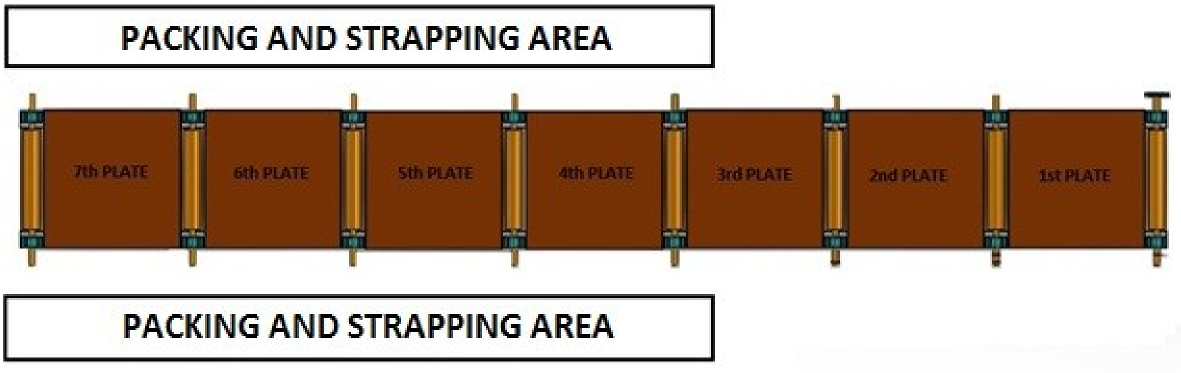


Figure 22 Packing and Strapping area of Shearing Bed

As shown in the figure 22, stacking and packing area lies in front of the 3rd to 7th plate. The finished products need to be pushed onto the packing area. Hence, the region between 3rd-7th plates becomes the potential area for placement of equipment.The team decided to call this region between 3rd-7th plates as GREEN ZONE region; therefore logically equipment should be placed in the green zone of the bed.

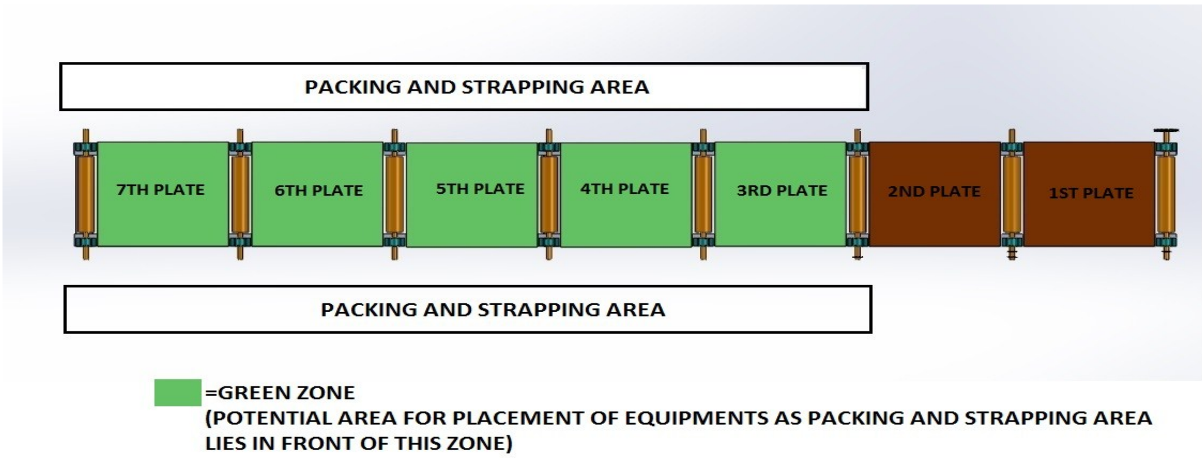


Figure 23 Green Zone of Shearing Bed

4.4 Motorising Initial Three Rollers

After shearing process, a worker is employed near the bed, to pull the finished products in the green zone of the bed, so that the finished products could be pushed onto the packing area situated in front of the green zone of the bed

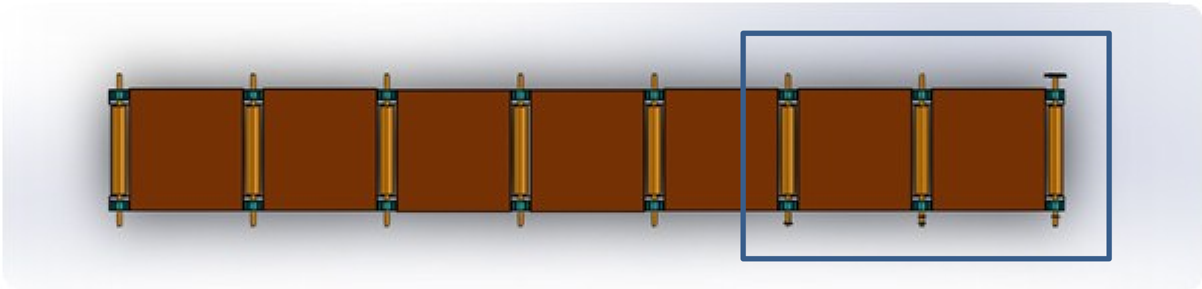


Figure 24 Square indicating motorisation of 3 rollers

Also sometimes, when the ends of the finished products are not cut properly, a worker using tongs pushes the finished products again into the shearing machine to give finished products, a proper cut.

Hence, the first hurdle in automating the given problem was to make sure that the finished products after shearing process automatically reach at the green zone without human intervention and at the same time if required the finished products could be easily retracted back into the shearing machine, to give a proper cut, if missed in the first chance.

In light of these issues, one of the probable solutions that the team concluded was to automate the rollers of the bed using a motor and a chain drive.

Sr. no	Problem	Solution
1	To make the finished products reach the green zone of the bed,	Logically the rollers prior to the green zone should to be motorized.
2	Retraction of finished product if it is deprived of a proper cut.	The motor so selected should operate in both clockwise and anticlockwise direction.

- **Design of belt drive for three rollers:**

Assuming 16 hour's duty of the mechanism

Correction factor (f_a)

Taking, fa= 1.3

Diameter of Motor Shaft =125 mm

Speed of Motor = 1440 rpm

Selecting belt cross section:

Selecting Type A cross section of the belt so as to have higher life.

Cross section	Load on drive (kW)	PCD (mm)	Top Width (W) (mm)	Thickness (T) (mm)	Weight /Metre (kgf)
A	0.49 kW	125	13	8	0.106

Standard belt selection from PSG. 7.58

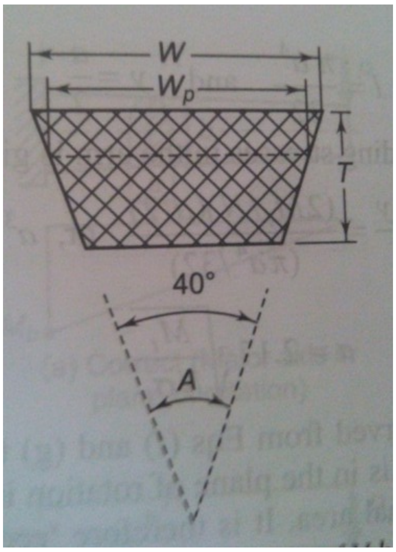


Figure 25 Pulley Cross Section

Belt Speed

Required linear velocity for mechanism is 2.82 m/s

$$\omega = \frac{2\pi N}{60}$$

n = 532 rpm

Taking n = 540 rpm

Selecting pulley size

$$D = d\left(\frac{n}{n1}\right)$$

D = 330 mm

Selecting standard pulley size from PSG 7.54

Length of Belt

C =0.762m D=0.330m d=0.125m

L=$2C + \left(\frac{D+d}{2}\right) + \left(\frac{(D-d)^2}{4C}\right)$

L= 2.25m

Selecting standard length (Bhandari T 13.14 Pg. 524)

L= 2300 mm

Arc of contact (α)

$$\alpha = 180 - \sin^{-1}\left(\frac{D-d}{2C}\right)$$

α = 166°

Speed Ratio = *2.66*

Number of belts

$$No\ of\ Belts = \frac{Transmitted\ power\ x\ fa}{Power\ rating\ x\ fc\ x\ fd}$$

Number of belts = 2 belts

Power Required

$$P = \frac{2\pi NT}{60}$$

Power Required = 2.26 kW

Selecting **3 Hp** Standard Motor

4.5 Design and Analysis

4.5.1 Gas Spring Operated Flap

➢ **Introduction**

A gas spring operated flap is basically a system consisting of gas spring to lift the flap for lifting the product. The energy for the spring is provided by gas at high pressure and the whole system is self-contained and sealed against loss. gas spring uses a compressed gas, contained in a cylinder and compressed by a piston, to exert a force.

➢ **Components**

The components of the mechanism are:

1. Shearing Bed
2. Cast Steel Flap
3. Gas Spring
4. Push button

1. *Shearing bed:*

The shearing bed is cast steel working table. The finished material rolls over the pairs of rollers. The product is manually lifted and pushed to next strapping section.

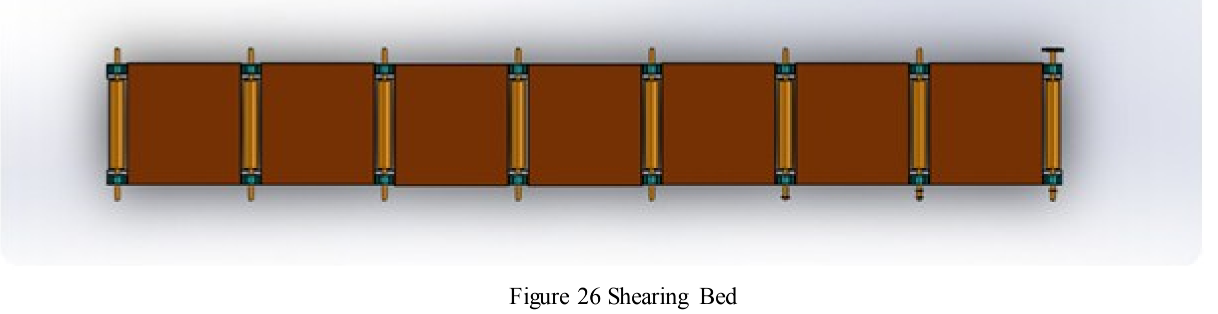


Figure 26 Shearing Bed

2. *Flap:*

It is rectangular welded structure designed to carry the product to next section of strapping in production line, of cross-section 4.7m x 1m.It is pivoted by the means of continuous hinges and operated by gas springs.

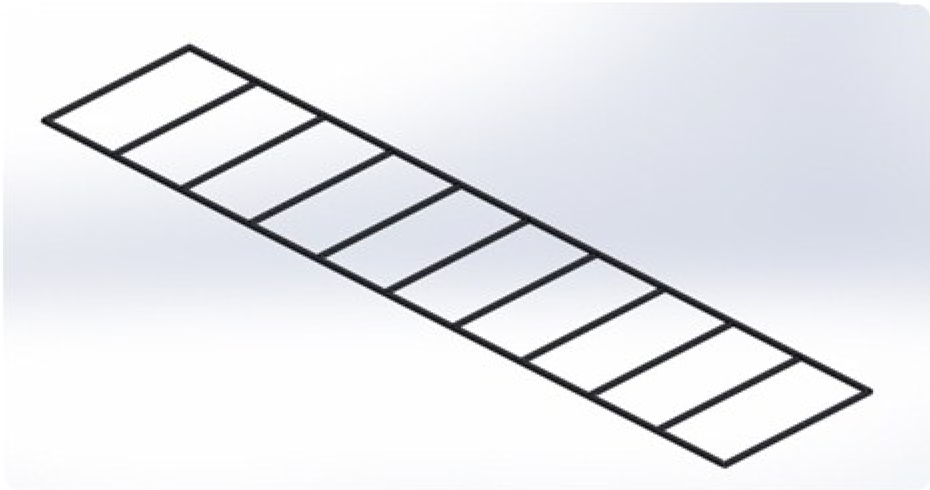


Figure 27 Flap

3. *Gas spring:*

A gas spring is a type of spring that uses a compressed gas, contained in a cylinder and compressed by a piston, to exert a force. It can take force of 20-2500N.

It has following components:

1. Cylinder
2. Piston and piston assembly
3. Sealing system
4. Nitrogen gas charge

Figure 28 Gas Spring

4. *Push Button:*

Pre-assembled bowden cables connect push-buttons that can be ideally positioned for easy actuation and down lifting of gas springs. These ergonomic push-buttons are easily actuated due to specially designed head. Bowden industrial push buttons can take load up to 1000N actuating force for Gas Springs.

Figure 29 Push Button

➢ Working of Gas Spring:

The compression of the rod/piston into tube/cylinder reduces the volume of the tube as it compresses. When the cylinder is filled with gas, this constitutes the spring like force or action associated with gas springs.

An air cylinder creates the force by the air pressure inside the cylinder pushing on one side of the piston to the higher pressure than from opposite side of the piston. This creates net force difference which is exerted back through the air cylinder shaft.

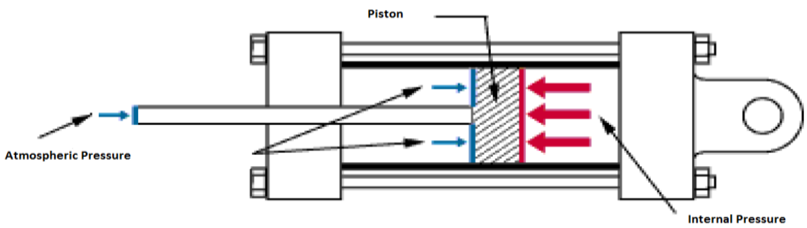


Figure 30 Spring action of Gas Spring

The gas pressure on both of the piston is equal. However, there is small area of the shaft where the internal gas pressure does not exert any pressure. Therefore, the internal pressure times shaft cross-sectional area equal the output force exerted by the shaft.

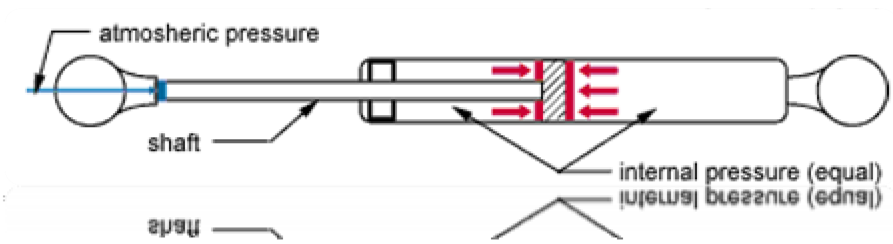


Figure 31 Gas Pressure

- **Design and Selection:**

  - *Design Considerations:*

    - Weight of the product: 200 kg
    - Operating temperature: 100°C

  - *Shearing Bed Dimensions:*

Length: 6.45 m	Breath: 0.8m	Height: 0.762 m

  - *Flap Dimensions:*

No	Type	Dimensions	Weight
12	Square rod	0.75” x1m	34 kg
2	Side bars	0.75”x4.7m	26.76 kg
Total weight:80Kg			

- **Analysis of flap:**

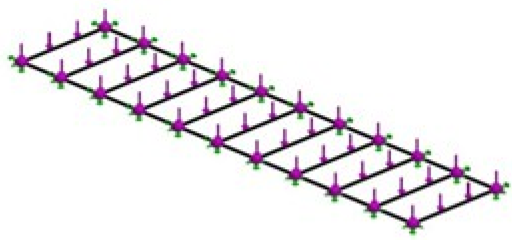


Figure 32 Analysis of Flap

For analysis of flap,

1. Force was applied on upper face.
2. Hinge effect was applied on the back side of the flap and constrain of 60^{o} was applied for hinge effect
3. Temperature effect was also considered

- *Resultant Forces:*

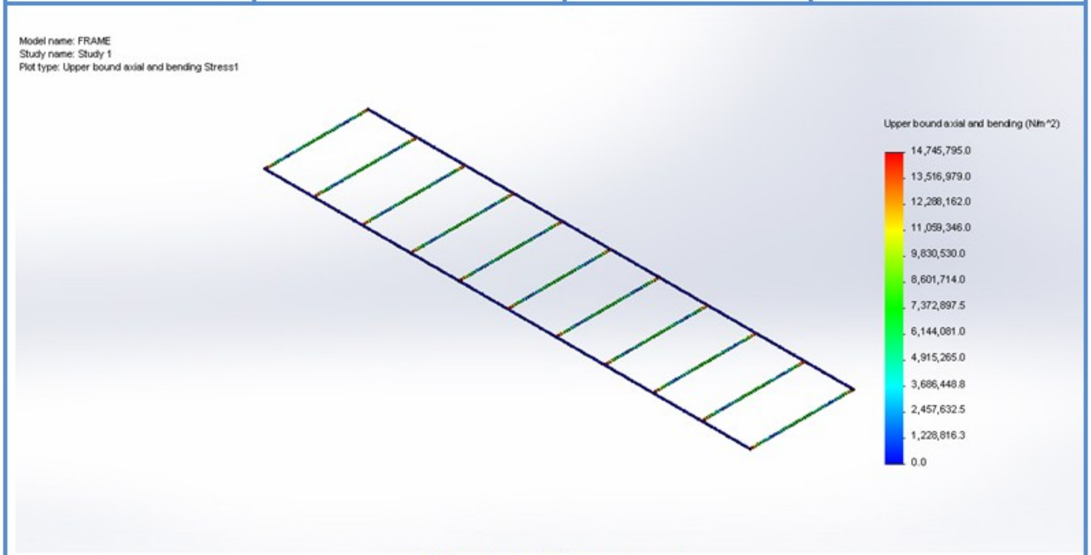
Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N	0	2234.96	0	2234.96

- *Resultant Moments:*

Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N·m	0	0	1.57982e-005	1.57982e-005

Stress Analysis:

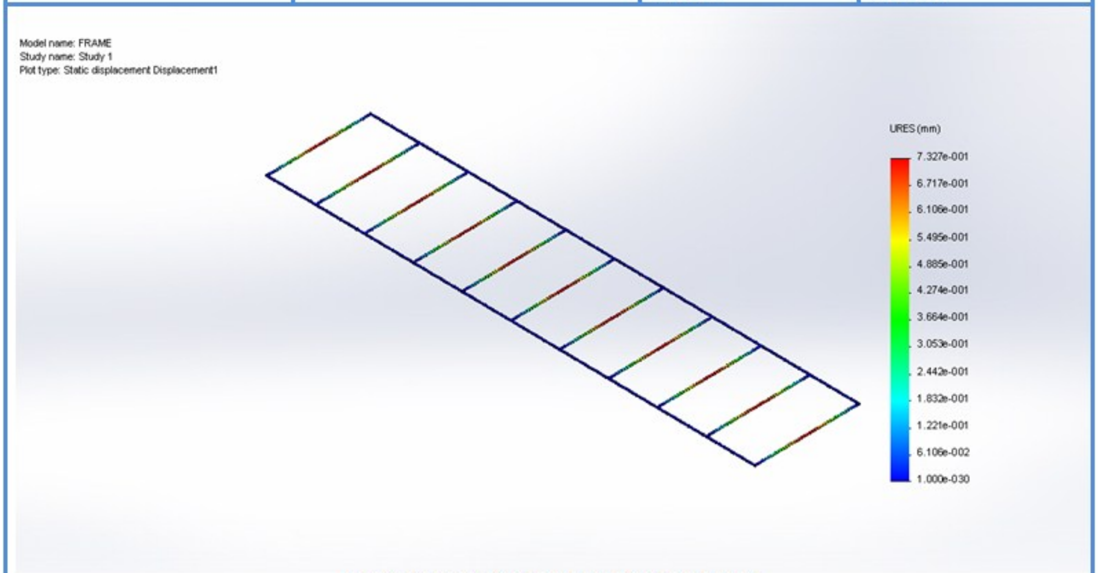
Name	Type	Min	Max
Stress1	TXY: Shear in Y Dir. on YZ Plane	0 N/m^2 Element: 121	1.47458e+007 N/m^2 Element: 1



FRAME-Study 1-Stress-Stress1

Displacement Analysis:

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0 mm Node: 1	0.732721 mm Node: 21



FRAME-Study 1-Displacement-Displacement1

- **Selection of gas springs:**

The selection of gas springs was carried out with help of bansbach software considering following aspects:

1. Weight of product : 250 Kg
2. Weight of flap : 80 kg
3. Maximum angle of lift : 60^{o}
4. Mounting co ordinates

- *Input parameters :*

Handle length	1000 mm
Start angle	0 deg
Rotate for	60 deg
Weight of flap + Product	2500 N

Co-ordinates	X	Y
Centre of gravity	500 mm	0mm
Flap mount	500mm	0mm
Frame mount	200mm	170mm
Number of springs	3	

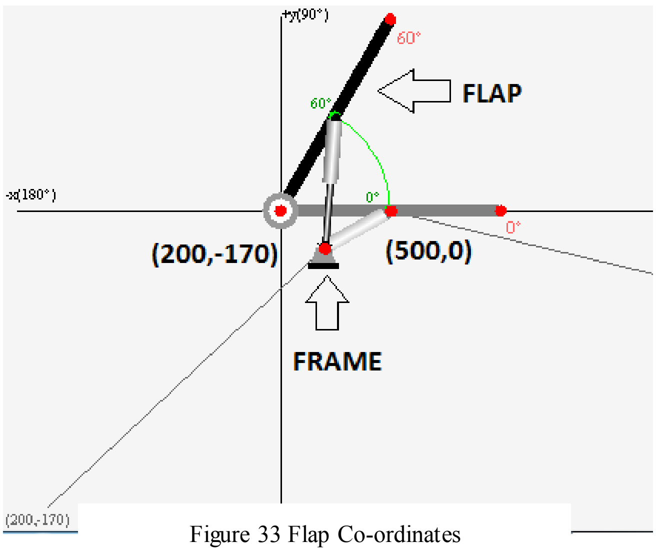


Figure 33 Flap Co-ordinates

- **Analysis and working of mechanism:**

After the final material is sheared over the shearing machine, it proceeds to the shearing bed. Over here, the product gets rolled over the automated rollers and finally reaches the green zone of the shearing bed, the operator of shearing machine press the push-button so as to actuate the gas spring .So as to lift the flap and the product to the next strapping section.

- *During lifting:*

The following two graphs shows relation between two parameters lifting angle (X-axis) and Force or weight (y-axis).

The 30N of force to lift the flap from the starting position or 0° when pulling at the previously defined grip (HAP) i.e. the flap at the closed position. When the flap reaches approx. 33° the gas spring is strong enough to lift it and hold it without any other external force.

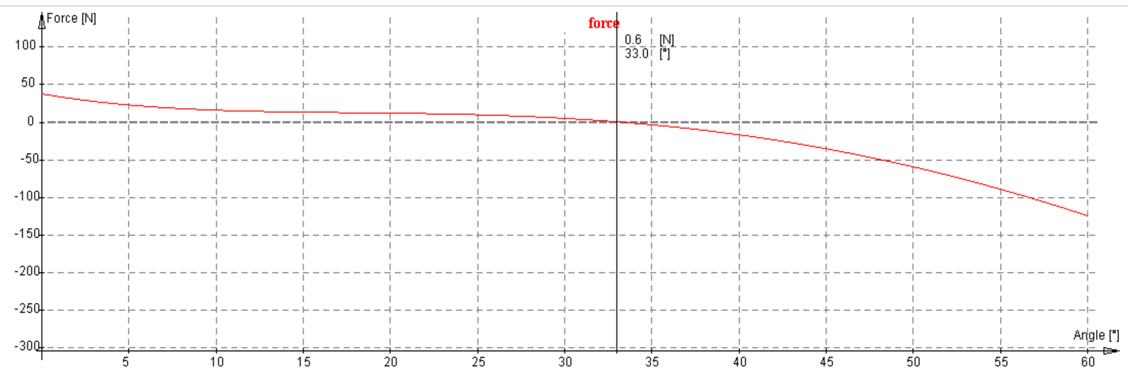


Figure 34 Force for Uplift

- *During Closing:*

To close the flap the flap from the open position (60°) with 10N force until approx. 46°.At this point the weight of the flap is greater than the extension force of the gas spring and the flap will close without any force.

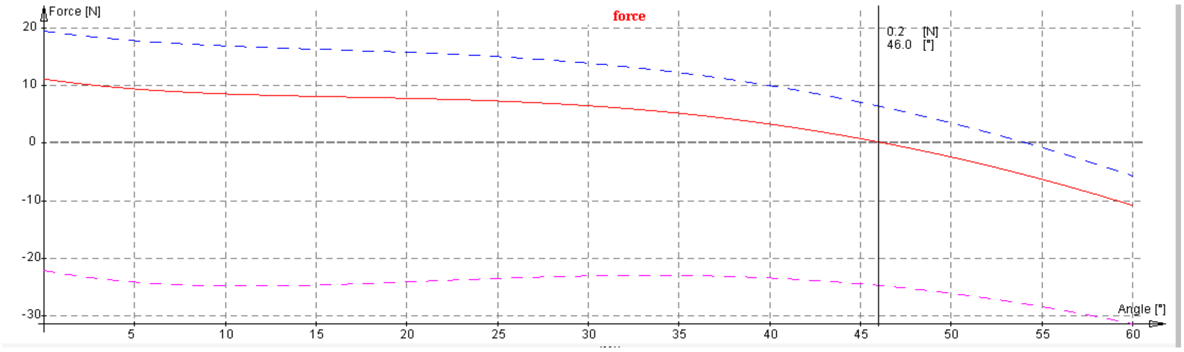


Figure 35 Force for Downlift

➢ Bansbach Spring Configuration

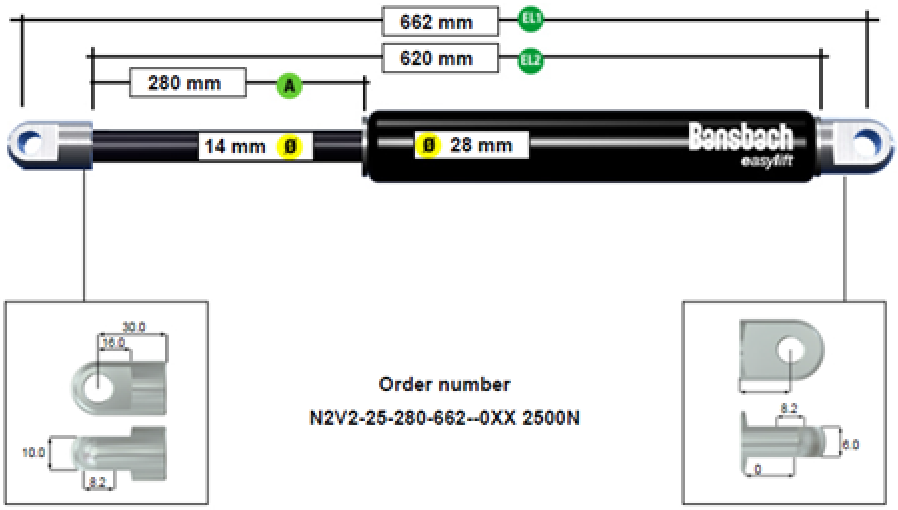


Figure 36 Spring Configurations

- **Service and Maintenance:**

Gas springs are manufactured based on a simple structure, which requires no repair throughout their lifetime. Gas springs that are damaged during operations after use can be easily repaired by simply replacing the damaged parts.

In addition, adequate load can be specified by directly adjusting the pressure on site.

- **Life:**

Gas spring are generally permitted to have a maximum force loss of 10% after 40000 cycles at a max of five cycles per minute at room temperature and in ideal fitting circumstances. Here are several factors that affect gas spring lifespan in an application.

- ✓ External factors such as temperature changes and other physical environmental influences can affect seal aging and wear and thereby speed up the process of force loss.
- ✓ A gas spring will also last longer if it is fitted free from vibrations and in such a way that no lateral forces can be produced.
- ✓ A good rule for a designer is to always choose a gas spring with the largest possible cylinder volume for the amount of force required.

- **Costing:**

FLAP		GAS SPRINGS	
Material	¾" Square CI class 40 hot finished	No. of gas springs	3
Weight	80 Kg	Cost/gas springs	Rs. 3000
Price/Kg	Rs. 64	Total Price	Rs. 9000
Total Price	Rs. 5120		
Welding Cost Rs. 1000			
Total Price : Rs. 14120			

Table 2 Costing of Gas Spring Operated Flap Mechanism

- **Modification in Problem Definition of Product Handling After Shearing**

In the month of January, when we were done with gas-spring flap mechanism, we were informed by the owner that he now wanted to drop finished products on both side of the bed. Therefore our suggestion of gas-spring operated flap was rejected as it drops the products only on one side.

Hence, now our problem definition of finished product handling after shearing was modified and system was needed to be designed considering packing area on both side of the bed.

4.5.2 Push Mechanism Using Pneumatically Operated Rodless Cylinders

➢ **Introduction:**

A Rodless pneumatic air cylinder can guide and support a load throughout the entire stroke length of the cylinder making them a great choice over rod-style air cylinders where saving space is of great concern.

Rodless cylinders are well suited for applications with long strokes or high moment loads. They save space because the stroke is contained within the cylinder's overall envelope.

Figure 37 Rodless Cylinder

➢ **Working of Rodless Cylinders:**

Air cylinders are devices that use air pressure to put piston into linear motion, such as in an air compressor. A typical air cylinder has a rod and piston that operates the air cylinder. A rodless air cylinder has no rod outside of the cylinder but rather a piston connected to a carriage inside the cylinder.

- **Benefits of rodless air cylinders with respect to our application:**

  - Equal Force and Speed
    Rodless cylinders have equal force and speed on both forward and backward stroke.
  - Any Length of Stroke
    Infinitely variable strokes are available.
  - Space saving
    The lack of a piston rod allows for nearly half the space requirement of a "rod type" pneumatic cylinder.

- **Selection Criteria for Rodless Cylinders:**

For proper selection of Rodless cylinder following data were taken into considerations. This data refers to one single Rodless cylinder only.

1. Length of actual working stroke = 1000 mm
2. Magnitude of load = 100 kg (Fz = 1000 N)
3. Orientation of load (location relative to cylinder carrier) = horizontal above the carrier
4. Final velocity of mass attached to carrier = 0.3 m/s
5. Cycle rate = 25 cycles per minute
6. Cycle time= 3 seconds
7. Centre of gravity of load in relation to the cylinder's load carrying device=
8. Orientation of the actuator= horizontal
9. Available air pressure = 08- 10 bar

➢ Moment Consideration:

Even if a load is located on and directly over the centre of the load carrying device, it will still be subjected to bending moments on acceleration. For off centre or side loads, the resulting moment is calculated by determining the distance from the centre of mass of the load being carried to the centre of the cylinder's load carrying device.

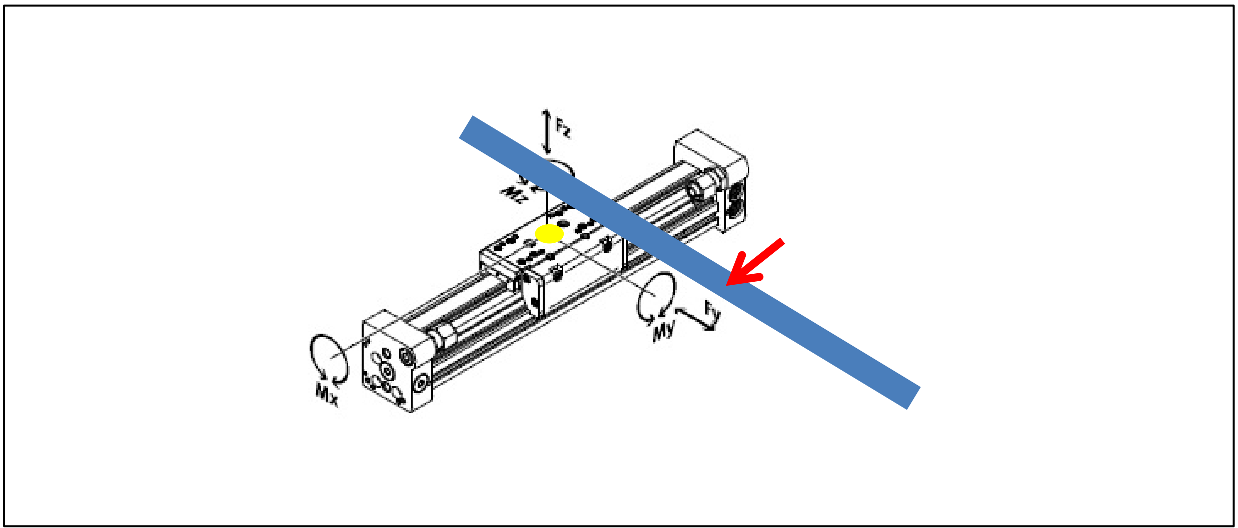


Figure 38 Moments on attachment

As shown in above fig 37. Yellow dot represents C.G of load carrying device (slider).Red arrow represents the direction of force on attachment at the C.G of finished product represented by blue line.

Force = 100kg = 1000N

Distance between C.G of load carrying device and C.G of finished product = 1.079 m

Moment (Mz) = 1000*1.079 = 1079 N. m

- **Effects of Dynamic Loading:**

Unlike rod style cylinders, many rodless cylinders must support the load during acceleration and deceleration at each end of stroke. When there are side or overhung loads the dynamic moments must be calculated to determine which rodless cylinder is best equipped to handle the resulting forces.

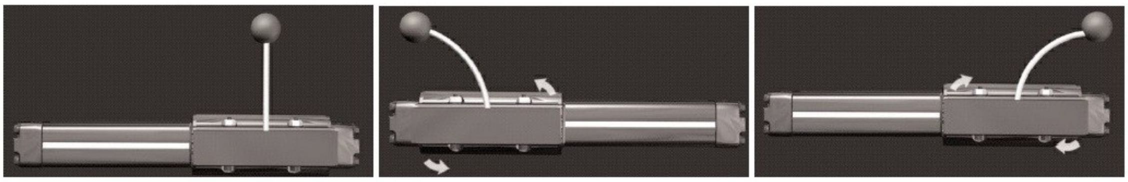


Figure 39 Effect of acceleration and deceleration on attachment.

Shock absorbers (mounted on the cylinder) are normally used in such applications to help compensate for the inertial effects of dynamic loading. In addition, it is recommended that a stopping device be placed nearest to the centre of gravity of the moving load.

- **Selection of rodless cylinders:**

Based on the above data, various rodless cylinders were searched that could withstand the necessary force and moments. The below table is taken from festo's catalogue for rodless cylinders. It is evident from table that a cylinder of piston diameter 63mm will be sufficient for handling force and moment generated in pushing the finished product line.

Permissible forces								
Piston	8	12	18	25	32	40	50	63
Fy max	300	650	1850	3050	3310	6890	6890	15200
Fz max	300	650	1850	3050	3310	6890	6890	15200
Permissible torque								
Mx max	1.7	3.5	16	36	54	144	144	529
My max	4.5	10	51	97	150	380	634	1157
Mz max	4.5	10	51	97	150	380	634	1157

Table 3 Various Rodless Cylinders

- **Position of rodless cylinder:**

Now, the team decided on the number of Rodless cylinders to be placed. Using one cylinder meant more force and more moment on a single Rodless cylinder and hence less life of equipment. Moreover one cylinder would not have been sufficient for pushing of long rods of around 5-6 feet. Using two cylinders meant the force and moments would have been divided into two and there were many placement options available to effectively push long rods. Using more than two cylinders meant less force and moments on each cylinder but the cost would increase significantly as Rodless cylinders are quite expensive.

Hence, the team decided to go with TWO CYLINDERS taking into account the force and money considerations

The team tried to place the Rodless cylinders in such a way that the C.G. of the finished products would lie in between these two Rodless cylinders.

The team had many placement options for two cylinder combination such as:
One cylinder on 3rd plate and other on 7th plate
One cylinder on 4th plate and other on 6th plate
One cylinder on 4th plate and other on 5th plate
One cylinder on 5th plate and other on 6th plate

Adjacent placement options like 4th- 5th plate and 5th -6th plate were rejected, as placing too close meant C.G. of finished product should be within the gap between the two closely placed Rodless cylinders and placing this close would lessen the gap. Moreover, these combinations are not symmetric considering the green zone of the bed.

3rd and 7th plate placement option, though being symmetric was too far and hence was rejected

Therefore, 4th and 6th plate option was selected for placement of rodless cylinders.

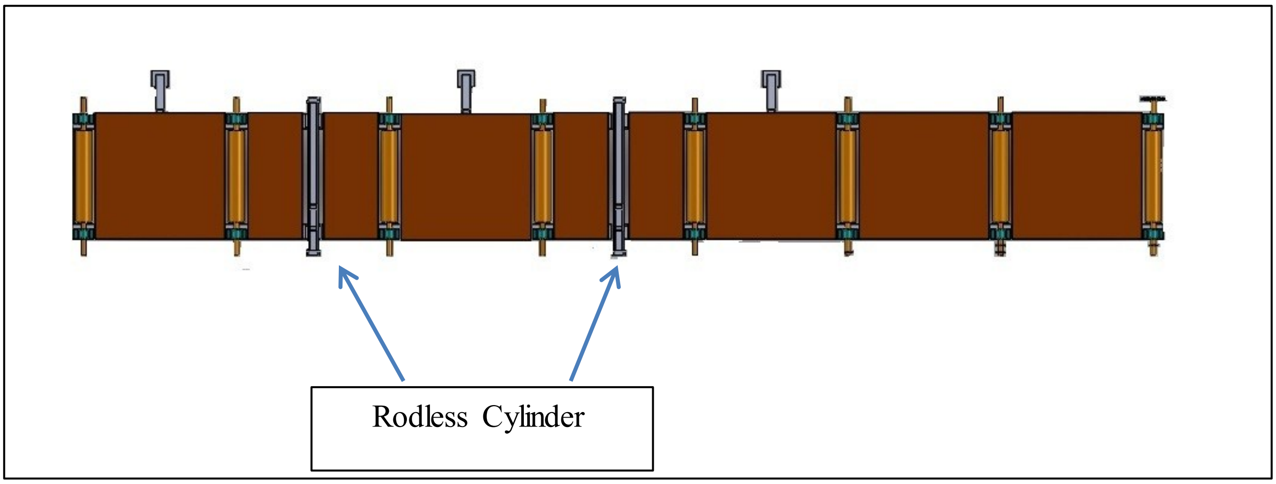


Figure 40 Rodless Cylinders Position

These cylinders would be placed beneath the bed in the middle of the plate and a cut of 6cm along the length of the plate would be made to accommodate the protruding attachment.

- **Attachment**:

An attachment here means the device that will be used to push the finish products onto the packing bed or rather that part of the rodless cylinder that will touch the finished product and push them.

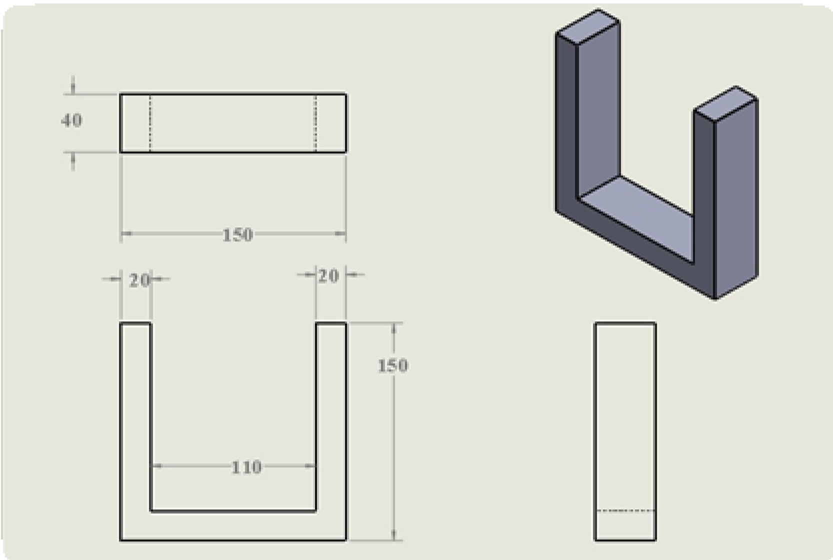


Figure 41 Rodless Attachment

Attachment here could be of various designs, various materials and various dimensions. Attachment needs to be fabricated separately depending upon the application it has to serve and this attachment will be attached to the slider of the rodless cylinder using bolts.

Since, we could not get the detail specifications of a slider. The team decided to make an attachment based on a few assumptions of the slider, as in the placement of bolts.

- **Analysis result of rodless attachment:**

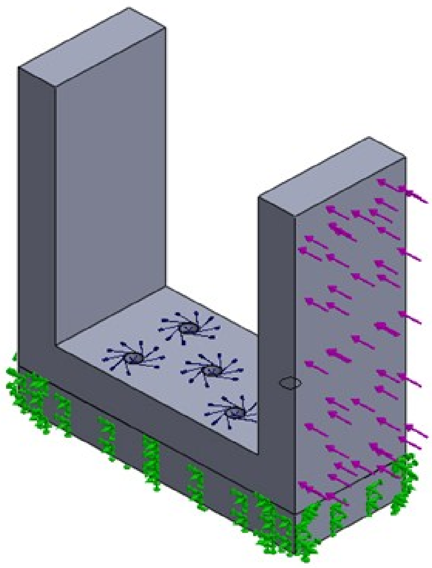


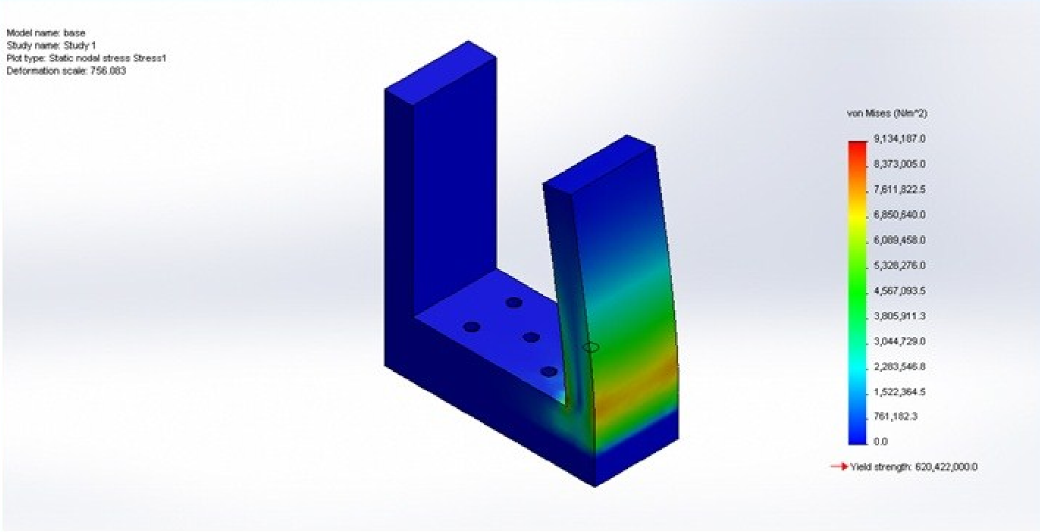
Figure 42 Analysis of Attachment

For analysis of rodless attachment,

- ✓ Force was applied on the face that has pink arrows.
- ✓ Green arrows represents fixed constrains between attachment and slider.
- ✓ Blue arrows represents bolt constrain.

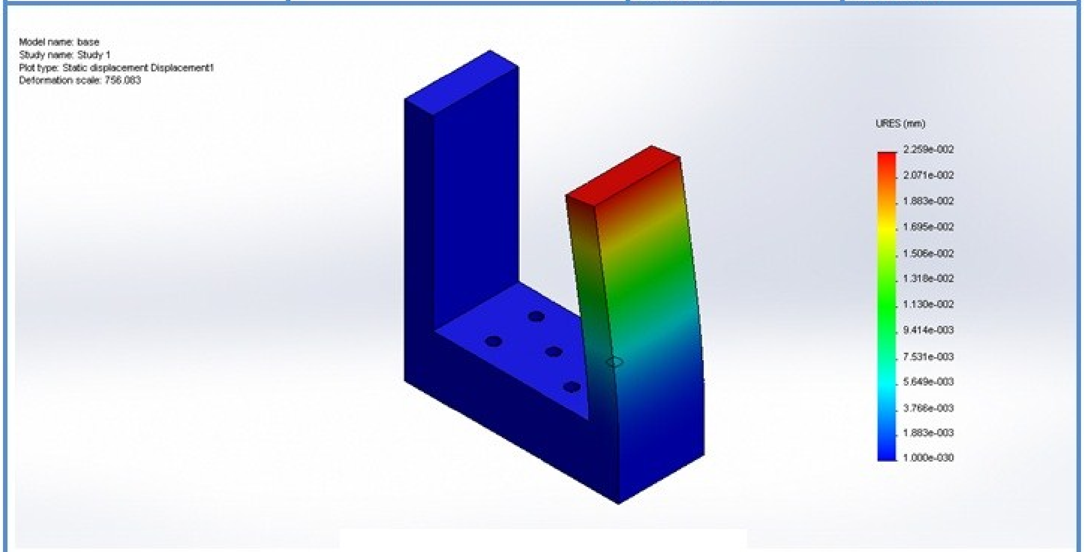
Stress Analysis:

Name	Type	Min	Max
Stress1	VON: von Mises Stress	3.67236e-008 N/m^2 Node: 20485	9.13419e+006 N/m^2 Node: 8993



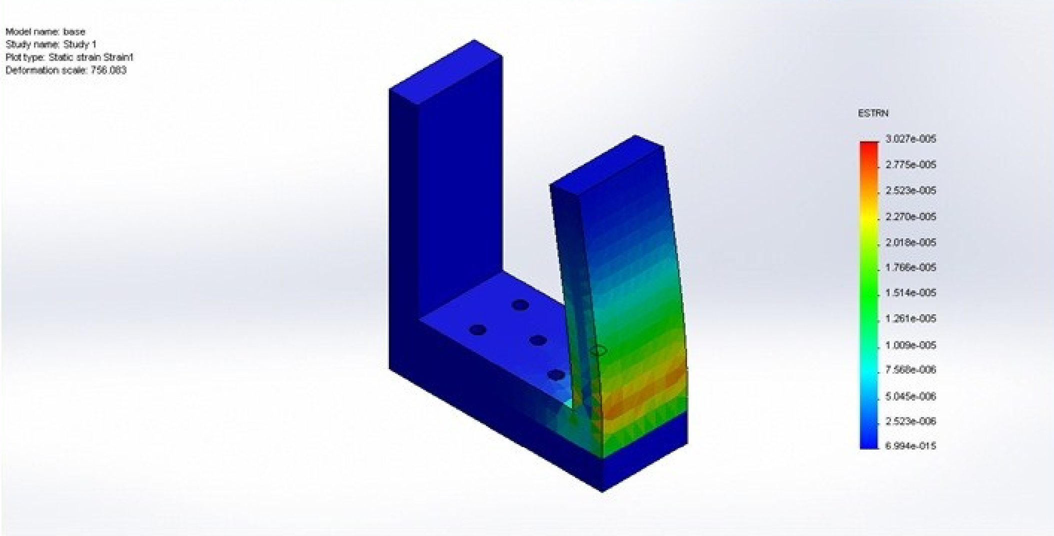
Displacement Analysis:

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0 mm Node: 86	0.0225945 mm Node: 231



Strain Analysis

Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	6.99378e-015 Element: 4437	3.0273e-005 Element: 2783



- **Working:**

The initial three rollers of the bed being automated, finished products would automatically reach at the green region of the bed.

Once the finished product reaches the green region of the bed, the operator working at the shearing machine would initiate the rodless cylinders using a foot pedal placed beside and beneath the shearing machine.

The attachment along with the slider will strike the finished product and push them along the width of the bed and then drop them onto the packing bed in the forward stroke.

Now, if the next product needs to be pushed on the same side, the operator will hit the foot pedal and retract the attachment to its initial position but, if the next product needs to be pushed on the opposite side, then the operator will keep the attachment at the forward stroke end position and will wait till the finished product reaches the green region. After the product has reached green region the operator will hit the foot pedal and this will cause the attachment to move in the backward direction and now finished product will be pushed onto the opposite side in backward stroke this will solve the problem of dropping the products on both side of the bed.

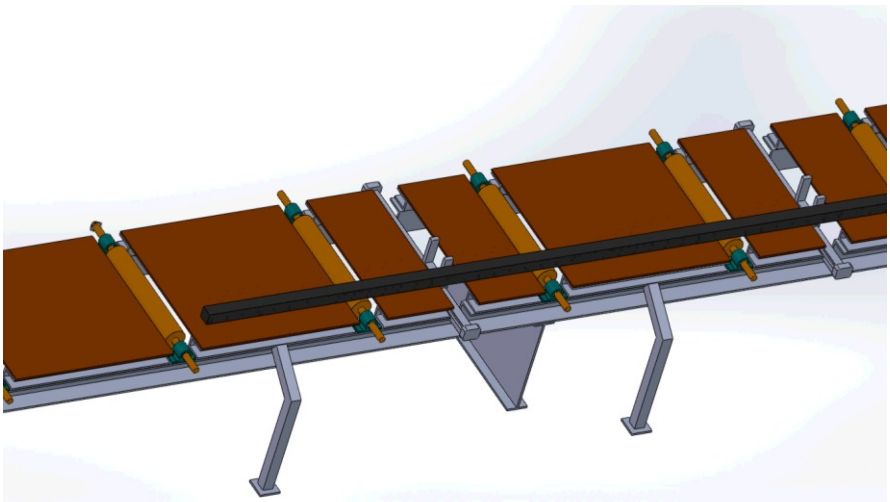


Figure 43 Working of Rodless Cylinders in Pushing Finish Product

➢ **Pneumatic Circuit of Rodless Cylinders**

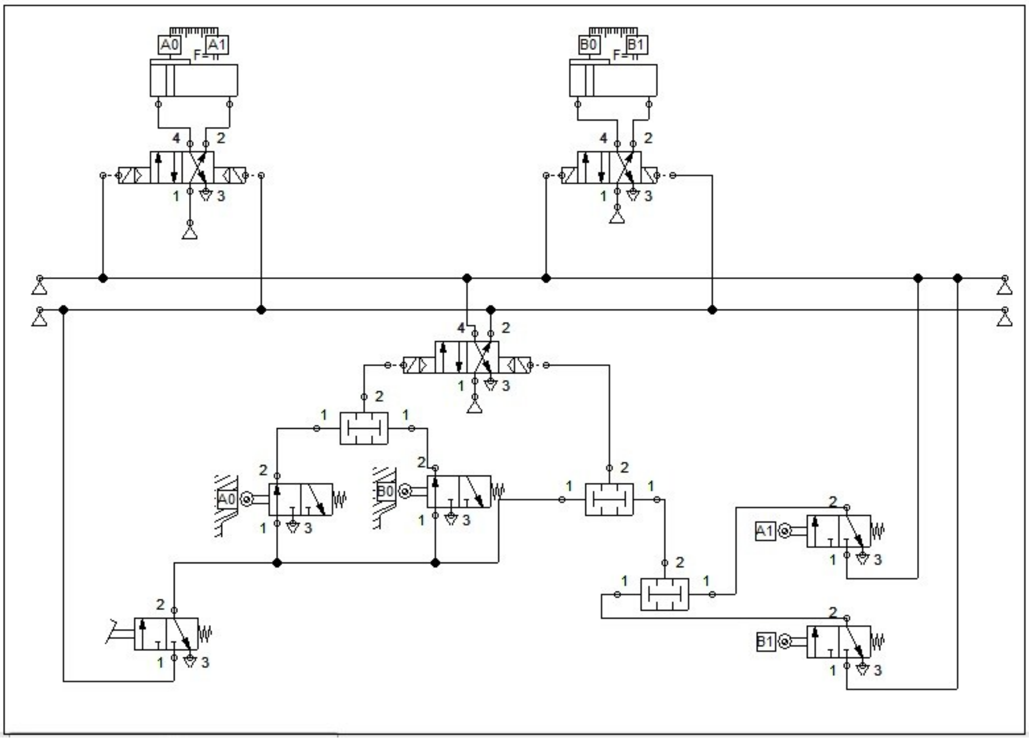


Figure 44 Pneumatic Circuit Connection of Rodless Cylinder without Actuation

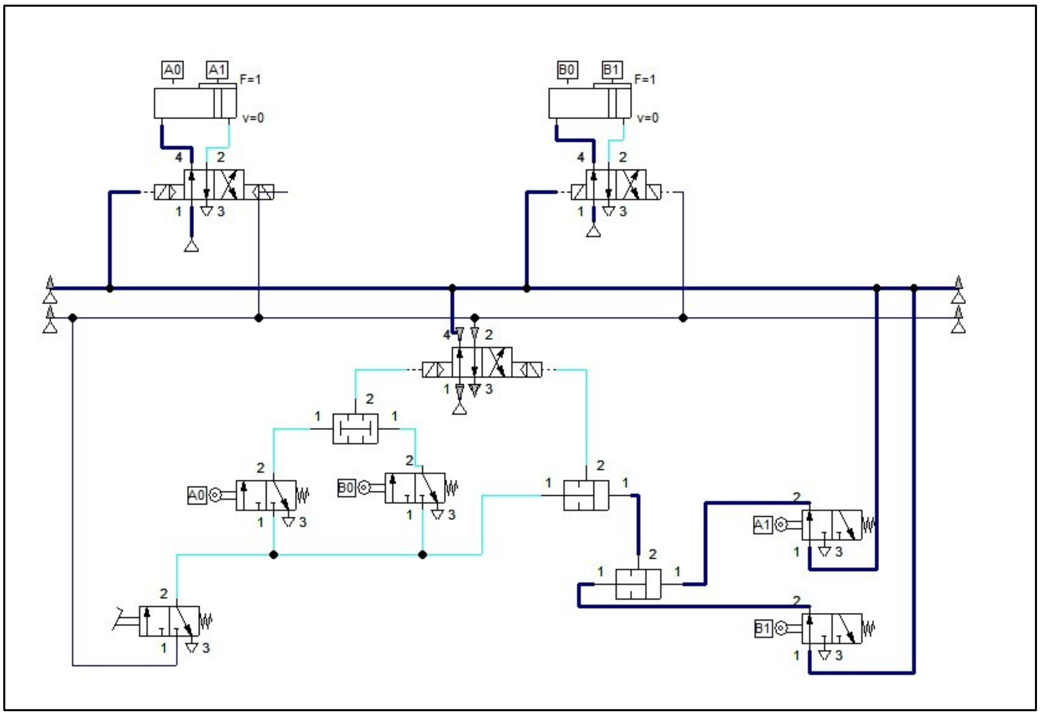


Figure 45 Actuation of Cylinders

- **Maintenance**

Cylinders are designed to give a very long life expectancy. However, packing's and seals might need periodical replacement, to which the frequency will depend on the operating conditions and cycling.

- **Service**

  - ✓ Rodless / Linear cylinders have a life expectancy of about 8000km.
  - ✓ After calculation of the travel per day we find, about 0.5 km is travelled per day.

- **Costing**

SR. NO	COMPONENTS	QUANTITY	PRICE (INR)
1	RODLESS CYLINDER	2	420000/-
2	COMPRESSOR (40W,7.5HP,180LTR,780RPM)	1	60000/-
3	FOOT VALVE	1	1000/-
4	ATTACHMENT FABRICATION	1	3000/-
5	ACCESORY CHARGES	-	2000/-
TOTAL			**486000/-**

The total cost of installing rodless cylinders is approximately Rs 5, 00,000.

4.5.3 Chain Sprocket Pusher

➢ **Introduction**

Chain drive is a way of transmitting mechanical power from one place to another. It is often used to convey power to the wheels of a vehicle, particularly bicycles and motorcycles. It is also used in a wide variety of machines besides vehicles.

Sometimes the power is used by simply rotating the chain, which can be used to lift or drag objects. In other situations, a second gear is placed and the power is recovered by attaching shafts or hubs to this gear.

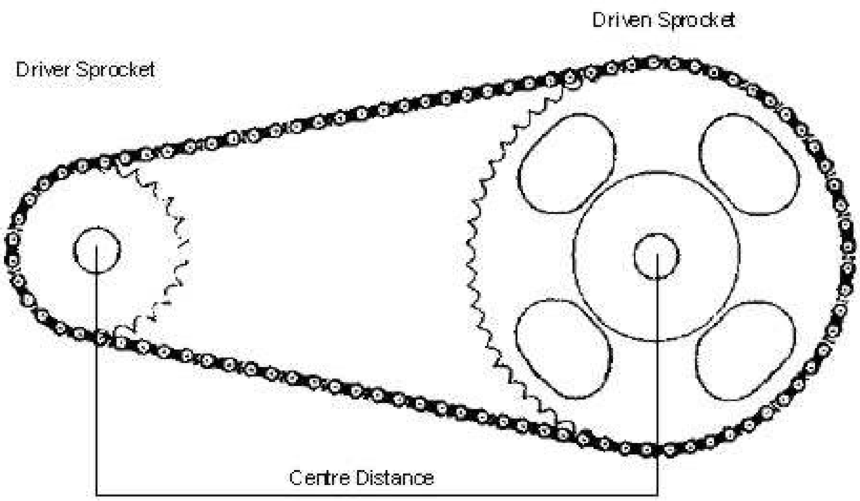


Figure 46 Chain Drive

- **Components**

The following are the components of Chain Sprocket Pusher:

1. Chain
2. Sprocket
3. Attachment
4. Motor
5. Shaft
6. Bearing

1. Chain

A chain is a series of linked metal rings used for fastening or securing something, or for pulling loads. A Roller chain or bush roller chain is most commonly used for transmission of mechanical power on many kinds of domestic, industrial and agricultural machinery, including conveyors as well.

Figure 47 Roller Chain

2. Sprocket

A sprocket or sprocket-wheel is a profiled wheel with teeth that mesh with a chain, track or other perforated or indented material. The name sprocket applies generally to any wheel upon which radial projections engage a chain passing over it.

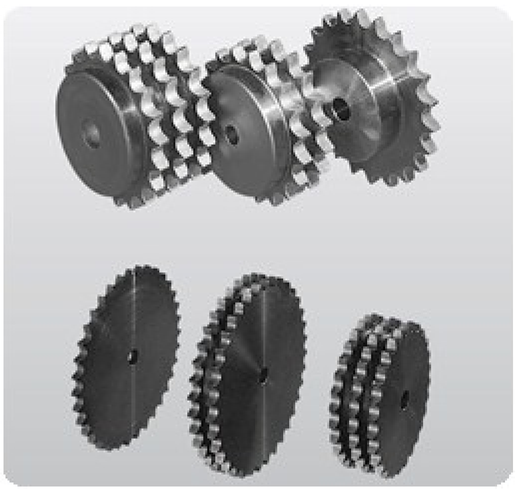


Figure 48 Sprockets

3. Attachment

Moving of objects, transporting or lifting of articles, roller chains with attachment are used as a possible solution to fulfil the operational requirements. These attachments are readily available or may be designed to meet the required specifications.

4. Motor

A motor is used to provide the power for driving the sprockets.

5. Shaft

The sprockets are mounted on the shaft which is supported over bearings.

6. Bearing

It is used to support the rotating shafts.

Figure 49 Plumber Block

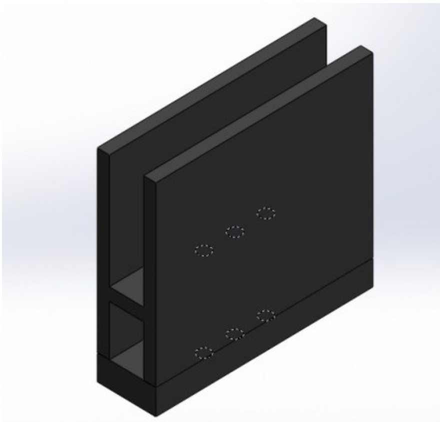


Figure 50 Designed Attachment

Figure 51 Shaft with Bearing and Sprocket

➢ Working

Generally, chain drive is used to transmit power. It can also be used as a conveyor for lifting, pulling or pushing of load. Here the system is powered with the help of motor. The motor drives the shaft with the help of belt drive. The sprockets that are mounted over the shaft rotate.

As the sprockets rotate, the chain moves as it is in a mesh. The attachments are attached to the chain and move along the length of the chain. The attachment over the chain carries the material (in this case rolled bars) along the direction in which the chain moves and pushes it into the pit.

➢ Positioning of Sprocket and chain

As the material handling equipment was to be placed between the 'Green zone' regions. A single chain drive was not ideal due to large moments and loads there by increasing the diameter of the sprockets and chain. So the team agreed on placing 2 parallel lanes of sprockets. The ideal way was to place it in between 4^{th} and 6^{th} plate so as to keep the C.G. of the material within it. Although it was a possible solution but this will increase the shaft length increasing the bending moment of the shaft. So the team decided to place it in between 5^{th} and 6^{th} plate. This was one of the most optimal solution for positioning of the chain drive.

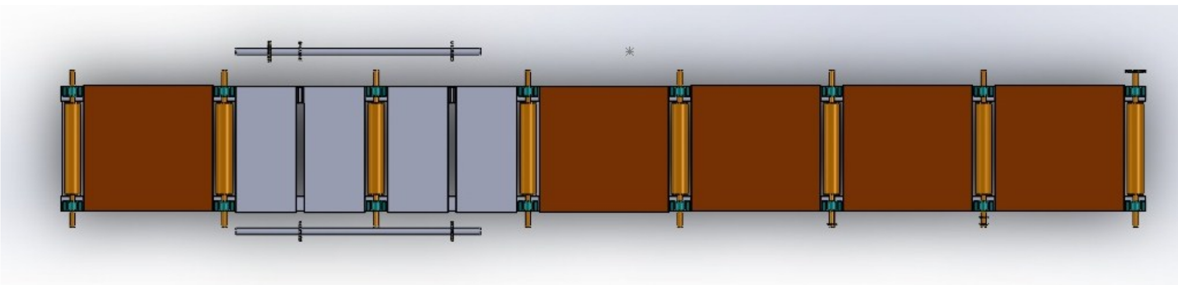


Figure 52 Attachment Position on Shearing Bed

➢ Design of Chain Sprocket Pusher :

The design of Chain Sprocket pusher includes:

1. Design of Chain
2. Design of Sprocket
3. Design of Belt Drive
4. Design of Shaft
5. Selection of Bearing
6. Selection of Motor

❖ *Chain Selection:*

There are two important rules in the design of a chain drive. They are as follows:

1. The number of pitches or links the chain should be even.
2. The no of teeth on the driving sprocket should be always odd.

The odd no of teeth on sprocket and even no of links facilitates uniform wear.
So, assuming minimum no of teeth on sprockets be 17.
$Z_1 = Z_2 = 17$
Assuming the diameter of the sprockets to be 120 mm (less than 150 mm due to space constrains)

The engagement of the chain and sprocket wheel is on the pitch circle diameter (D). Pitch circle diameter of the sprocket is defined as the diameter of an imaginary circle that passes through the centre of link pins as the chain is wrapped on the sprocket.

From PSG; we have

$$D = \frac{P}{\sin(180/z)}$$

Where,

Z is the no of teeth on sprocket.

So we get;

P = 22.049mm

We have nominal pitch size from PSG according to ANSI standards

Assuming P = 25.40 mm

Calculation of new diameters of sprockets

$$D = \frac{P}{\sin(180/z)}$$

$$D = 138.23\ mm$$

Selected Chain: <u>16-B R2517</u>

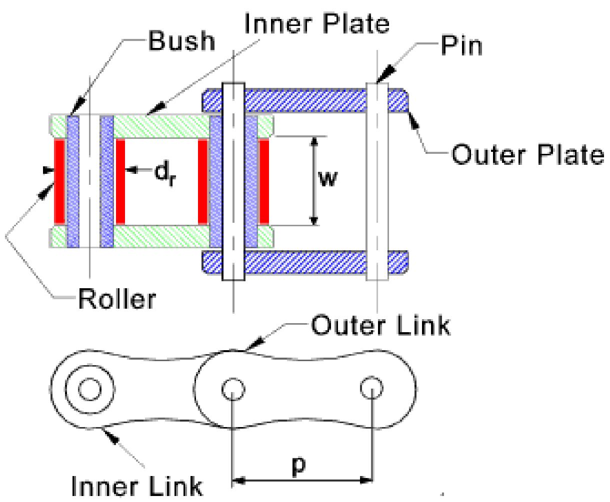


Figure 53 Chain Link Nomenclature

Specifications:

Feature	Symbol	Dimension
Roller Diameter	D_r	15.88 mm
Width between plates	W	15.90 mm
Pin Body Diameter	D_p	8.27 mm
Plate Depth	G	21.00
Overall joint max	A_1 A_2 A_3	40.40 mm
Bearing Area		2.10cm^2
Weight/ m	W	2.70 kgf
Breaking Load min	Q	6500 kgf

Table 4 Chain Specifications

- *Centre Distance:*

The length of chain is always expressed in terms of number of links.

The formula for no of links on chain is given by

$$Ln = 2\left(\frac{a}{P}\right) + \left(\frac{Z1 + Z2}{2}\right) + \left(\frac{Z1 - Z2}{2\pi}\right) \times \frac{P}{a}$$

Assuming the centre distance between the sprockets about 1 m. (Due to constrains)

We get;

$Ln = 103.6$ Links

Assuming

$Ln = 104$ Links

The above formula is in analogy with the length of the belt. The first two represent the number of links when ($Z_1 = Z_2$) and the sides of the chain are parallel. The third term takes into consideration the inclination of the sides. It is obvious that the chain should have even no of links since the chain consists of alternate pairs of inner and outer plates.

❖ *Corrected Centre distance:*

After selecting the exact number of links the centre distance between axes of the two sprockets is calculated by the formula:

$$a = \frac{P}{4}\left\{\left[Ln - \left(\frac{Z1+Z2}{2}\right)\right] + \sqrt[2]{\left[Ln - \left(\frac{Z1+Z2}{2}\right)\right]^\wedge 2 - \left[8\frac{Z1-Z2}{2\pi}\right]^\wedge 2}\right\}$$

$a = 1104.9\ mm$

For allowance of small sag

$a = 0.998 \times 1104.9$

$a = 1102.69\ mm$

The length of chain is calculated by the formula

$l = Ln \times P$

So we get;

$l = 2641.6\ mm$

➢ **Design of Sprocket:**

❖ *Sprocket Material:*

- ✓ Small sprockets (up to 100 mm diameters) are generally machined from low carbon steel bars.
- ✓ Larger sprockets (more than 100 mm diameter) are generally machined with low carbon or medium carbon steel bars.
- ✓ For velocity of less than 180 m/min (3 m/s) the sprockets are heat treated to obtain BHN of 180 or more.

❖ *Sprocket Geometry:*

	Feature	Formula	Dimensions
Top Diameter	$D_{a\ max}$	$D + 1.25P - D_r$	154.1 mm
	$D_{a\ min}$	$D + P(1 - 0.941) - D_r$	145.35 mm
Roller Seating radius	$r_{i\ max}$	$0.505\ D_r + 0.069\ \sqrt[3]{Dr}$	8.19 mm
	$r_{i\ min}$	$0.505\ D_r$	8.01 mm
Tooth flank radius	$r_{e\ max}$	$0.008\ D_r\ (Z^2 + 180)$	59.58 mm
	$r_{e\ min}$	$0.12\ D_r\ (Z + 2)$	36.2 mm
Roller seating angle	α_{max}	$120 - (90/Z)$	114.70^o
	α_{min}	$140 - (90/Z)$	134.70^o
Tooth height above polygon pitch	$h_{a\ max}$	$0.625P - 0.5Dr + 0.8(P/Z)$	9.13 mm
	$h_{a\ min}$	$0.5\ (P - D_r)$	4.76 mm
Tooth side radius	$r_{x\ min}$		25.4 mm
Tooth width	b_{f1}	$0.95\ W$	15.105 mm
Tooth side relief	b_a	$0.15\ P$	3.18 mm

Table 5 Sprocket Specifications

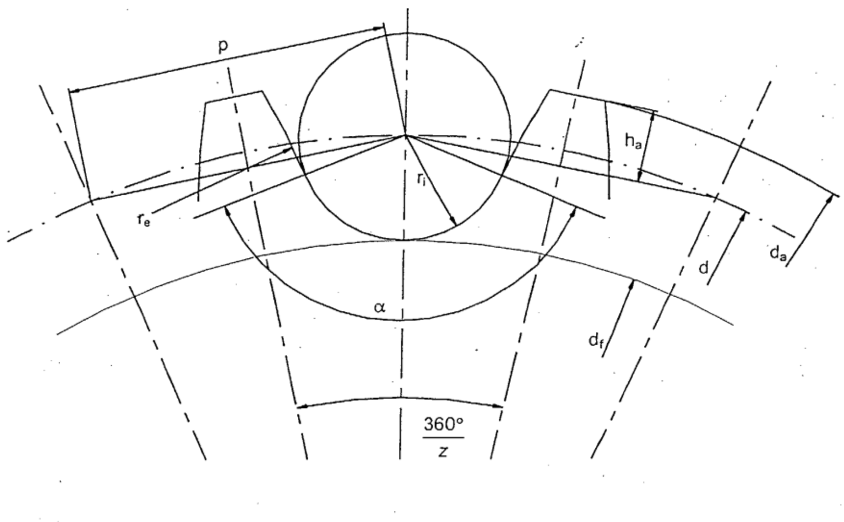


Figure 54 Sprocket Geometry

- ***Checking Safety of chain:***

Safety factor

$K_s = K_1 \times K_2 \times K_3 \times K_4 \times K_5 \times K_6$

K_1 = load factor = 1.25

K_2 = correction factor for distance = 1.25

K_3= correction factor centre distance = 0.8

K_4 = sprocket positioning = 1

K_5 = lubrication (periodic) = 1.5

K_6 =double shift work rating = 1.25

K_s= 2.34

Power transmitted based on allowable breaking stress

$$N = \frac{Q\ v}{102\ n\ Ks}$$

Assuming;

v = 0.33m/s; n =4; N = 0.33 kW

We get;

Q = 1050.192 kgf

Hence the chain is safe.

❖ *Total chain tension while pulling of object:*

The formula is given by;

$$T = m_1 g f_1 \times 1.1 + m_1 g f_2 + m_2 g f_3$$

Where;

m_1= weight of the chain = 7.132kgf

m_2 = weight of the object to be conveyed = 100 kgf

f_1 =friction factor between chain links

f_2 = friction factor between chain and sprocket

f_3= friction factor between object and the lower plate

Assuming friction factors = $f_1 = f_2 = f_3$= 0.35 (from B.V. Bhandari)

We get;

T= 394.76 kgf < Q (6500kgf)

Hence the chain will be safe in pulling of object

➢ **Design of belt drive:**

Power calculation:

Design power [N] = 0.33 Kw

Correction factor (f_a)

Assuming 16 hour's duty of the mechanism

Taking, fa= 1.3

Power = 0.429 Kw

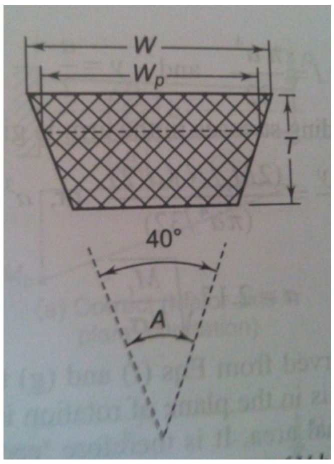
But selecting power = 0.49 Kw for A type belt

Selecting belt cross section:

Selecting Type A cross section of the belt so as to have higher life.

Cross section	Load on drive (kW)	PCD (mm)	Top Width (W) (mm)	Thickness (T) (mm)	Weight /Metre (kgf)
A	0.49 kW	125	13	8	0.106

Standard belt selection from PSG. 7.58



Belt Speed

Required linear velocity for mechanism is 0.32 m/s

Selecting pulley size

$$D = d\left(\frac{n}{n1}\right)$$

D = 0.125mm

Selecting standard pulley size from PSG 7.54

d = 125 mm

Length of Belt

C =0.5m D=0.125m d=0.125m

L=$2C+\left(\frac{D+d}{2}\right)+\left(\frac{(D-d)^2}{4C}\right)$

L= 1.39m

Selecting standard length

L=1.430m = 1430 mm

Arc of contact (α)

$\alpha = 180 - \sin^{-1}\left(\frac{D-d}{2C}\right)$

α = 180°

Number of belts

$$No\ of\ Belts = \frac{Transmitted\ power\ x\ fa}{Power\ rating\ x\ fc\ x\ fd}$$

Number of belts = 2 belts

- **Design procedure for shaft:**

Locations of mounting on the shaft are:

- ✓ Pulley Location: 200 mm from first end
- ✓ Sprocket Location: 400 mm from first end and 200mm from other end
- ✓ And Length of shaft= 2879mm

The forces on the shaft will be:

- ✓ Single point loads:
- ✓ Point loads are due to sprocket chain weight and pulley weight.
- ✓ Force by each sprocket
- ✓ Force by pulley

❖ <u>**Design of shaft**</u>**:**

Shafts are designed based on:

- ✓ Strength
- ✓ Rigidity

Design of shaft based on strength with both twisting and bending moments:

1. The shaft must be designed on the basis of two moments simultaneously.
2. Materials are subjected to elastic failure when subjected to multiple forces.

<u>Shafts under multiple forces are analyzed by two types of theories.</u>

1. **Maximum shear stress theory** (Guests theory) – Used for ductile materials
2. **Maximum normal stress theory** (Rankine's theory) – Used for brittle materials

Using Maximum shear stress theory:

We have, for a solid shaft, the max. Shear stress (τmax) is given by

$$\tau max. = \frac{16}{\pi D^3} \sqrt{(M^2 + T^2)} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(\mathbf{2})$$

σ = Bending stress – MN mm $^{-2}$

τ = Shear stress MN mm $^{-2}$

D = Diameter of the shaft.

If Maximum Shear stress is equal to allowable shear stress then τ max. = τ

Material selection:

We have chosen the material C55 Mn75 according to the Indian Standards (IS) and EN 9 in British Standards (BS).

Properties of the material C55Mn75:

MATERIAL	C55 Mn75
% C	0.50 - 0.60
%Mn	0.60- 0.90
Tensile Strength	700 - 850 N/mm^2
Yield Strength	460 N/mm^2
Brinell Hardness Number(HB)	255 - 311

Permissible Shear Stress

[τ]=σ/FOS =750/3=250 N-mm $^{-2}$

Twisting Moment

$$M = \frac{60x10^6(KW)}{2\pi N} = 63025.35 \text{ N-mm}$$

Calculation of Bending Moment of pulley:

$M = (T1 - T2)\ x\ [(D1 + D2)/2]\ldots\ldots\ldots\ldots(1)$

$T1 - T2 = M/D$

$T1 - T2 = 504.20\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$

On solving (1) and (2) we get

T_1= 1083.74 N

T_2= 579.54 N

Weight of pulley (W) = 5x 9.81=48.1 N

Total weight = 50 N

Total Downward force on pulley ($P_1 + P_2$ + W) = 1713.28 N

$\sum(Y) = Ra + Rb - 1713.28 - 1500 - 1500$

$Ra + Rb = 4713.28\ N$

Moment at A

$\sum (M\ Ra) = 0$

$0 = (-1713.28x0.2) + (1500x0.2) + (1500x2.079) - (Rbx2.279)$

On solving above equations we get;

R_a=1349.64 N

R_b=3363.63 N

Maximum Bending Moment = 342650 N-mm

Shaft Diameter on strength basis

$\tau max = \frac{16\sqrt{M^2 + T^2}}{\pi D3}$ ……………………………(**2**)

$250 = \frac{16\sqrt{(342650)2 + (63025.35)2}}{\pi D3}$ ……………………………(**2**)

D_s = 24 mm

Assuming D_s= 25mm

❖ *Bearing Selection:*

Diameter	SKF No.	Co (kgf)	C (kgf)
25	6005	520	780
25	6205	710	1100
25	6305	1040	1660
25	6405	2000	2825
25	205	1140	1500

Selecting SKF 6405 Bearing

➢ **Motor selection**

We require maximum torque of 63 N.mm from above calculation we have selected a motor of 1 HP. using the formula below,

$$T = Power * 9.554/n$$

- **Analysis of attachment:**

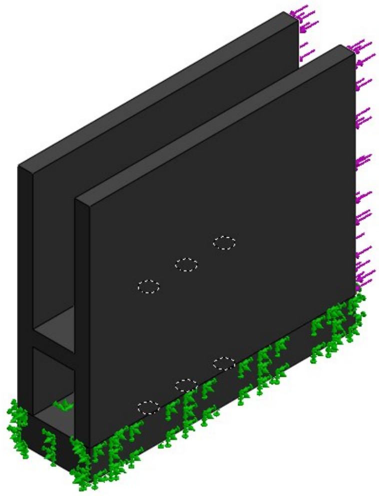
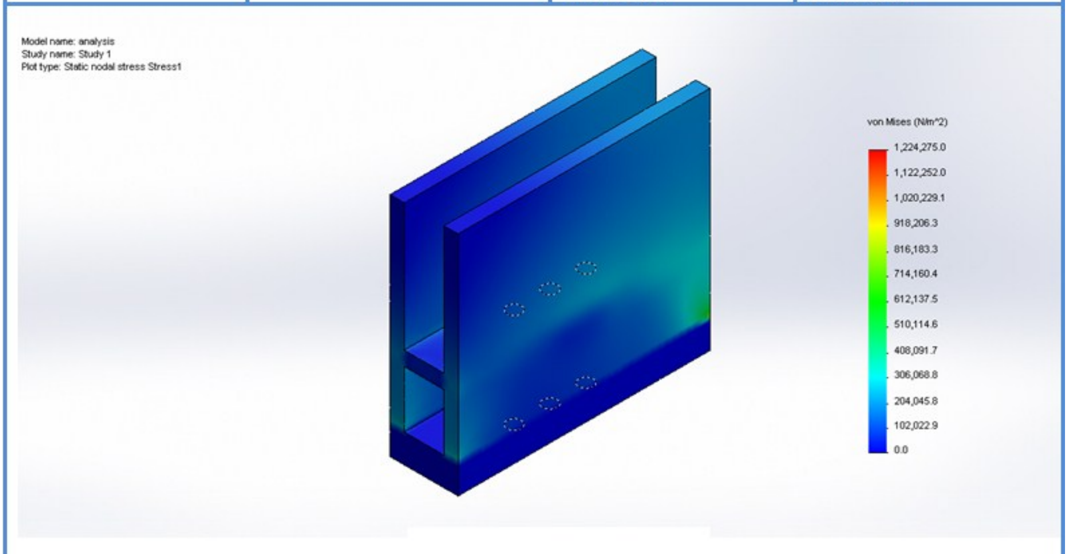


Figure 55 Designed Attachment

For analysis of chain attachment, we fixed the lower face of the attachment as shown by green arrows and applied force on the side face as shown by the pink arrows in fig 48.Temperture effect was also considered in this analysis.

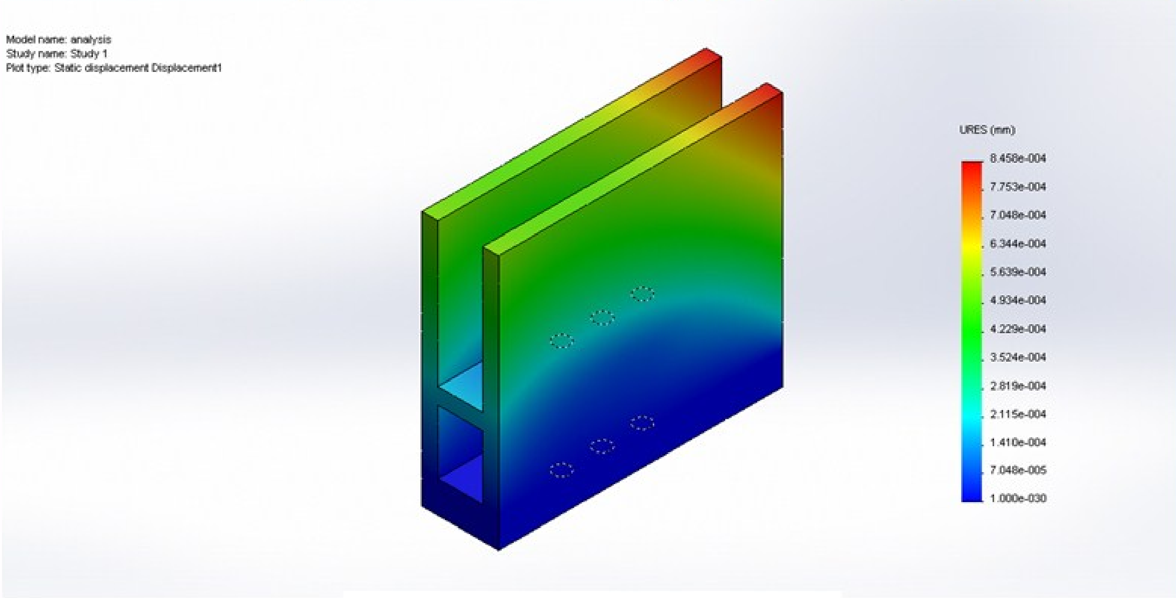
Stress Analysis:

Name	Type	Min	Max
Stress1	VON: von Mises Stress	7.30622e-008 N/m^2 Node: 55957	1.22428e+006 N/m^2 Node: 44610



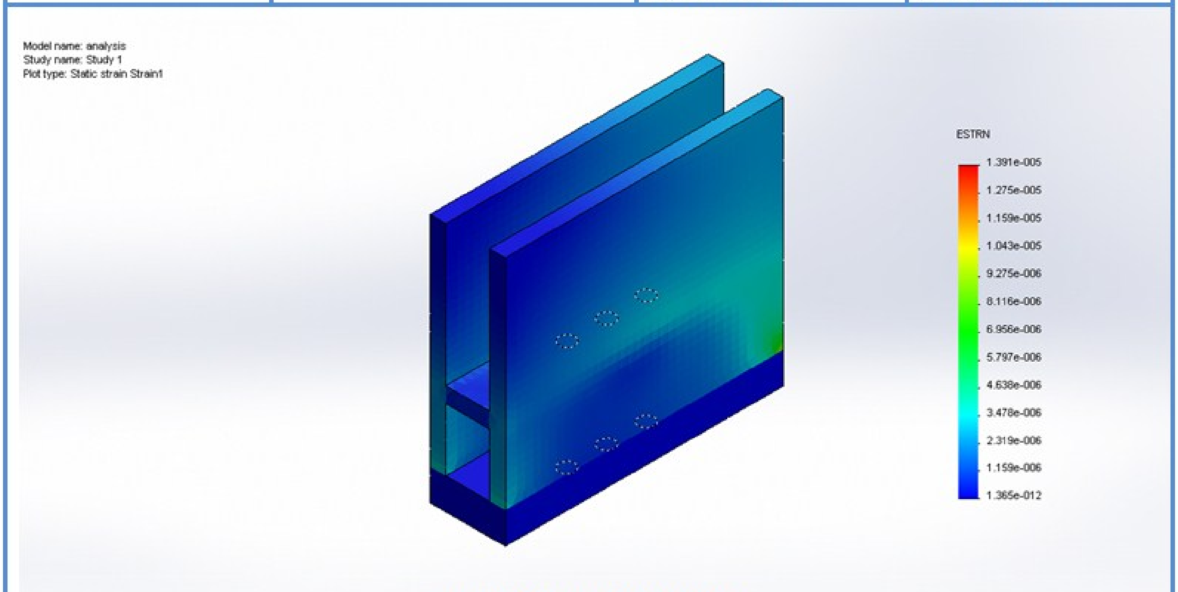
Displacement Analysis:

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0 mm Node: 312	0.000845811 mm Node: 2193



Strain Analysis:

Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	1.36536e-012 Element: 31324	1.39126e-005 Element: 8564



analysis-Study 1-Strain-Strain1

Maintenance

Regular chain maintenance is important to obtain maximum life. In a correctly sized and installed drive, chain can be expected to last for approximately 15,000 hours. The following maintenance schedule is suggested.

After every month:

- ✓ Check chain adjustment and rectify if necessary.
- ✓ Change oil, oil filter, and clear the sump.

Annually:

- ✓ Carry out the above checks.
- ✓ Check for wear on side-plates.
- ✓ Check for chain elongation.
- ✓ Check cleanliness of components: - Remove any accumulation of dirt or foreign materials.
- ✓ Check for shaft and sprocket alignment.
- ✓ Check for wear on sprockets.
- ✓ Check the condition of the lubricant.
- ✓ Check the lubrication system.

- **Costing of Chain Sprocket Pusher**

Part	Cost per part	Quantity	Cost
Motor	Rs. 4000	1 No	Rs. 4000
Chain	Rs. 4400	5 meter	Rs. 4400
Sprocket	Rs. 1200	4	Rs. 4800
Shaft	Rs. 500	2	Rs. 1000
Bearings	Rs. 430	4	Rs. 1720
Welding and installation			Rs. 2000
TOTAL : Rs. 17920			

4.6 Payback Period

- **Payback Period**

The time required to recover the cost of investment is known as payback period. It is very important for an organization to know the payback period before deciding on giving a final nod to any project.

Time required for payback period is given by:

$$\text{Time required} = \frac{\text{installation charges}}{\frac{Total\ money\ saved\ on\ worker\ salery}{year\ or\ month\ or\ day}}$$

- ***Payback for Gas Operated Flap:***

Total installation charges = Rs. 14120

Salary of one worker/month = Rs. 12,000

Number of workers eliminated: 2

Total money saved/month: 2*12000 = Rs. 24,000

Total money saved/year: 24,000*12 = Rs. 2, 88,000

Number of days for payback = 14120/2, 88,000*12*30 = 17.65 days

Therefore, the payback period for rodless cylinders is approximately **18 days.**

- ***Payback period of Rodless Cylinder:***

Total installation charges = Rs.4, 86,000

Salary of one worker/month = Rs. 12,000

Number of workers eliminated: 2

Total money saved on worker salary/month: 2*12000 = Rs. 24,000

Total money saved on worker salary/year: 24,000*12= Rs.2, 88,000

Number of days for payback = 1.6875 year = 616 days

Therefore, the payback period for rodless cylinders is approximately **19-20 months.**

- ***Payback period of Chain Drive Pusher:***

Total installation charges = Rs. 17920

Salary of one worker/month = Rs 12,000

Number of workers eliminated: 2

Total money saved/month: 2*12000 = Rs. 24,000.

Total money saved/year: 24,000*12 = Rs. 2, 88,000

Number of days for payback = 17920/2, 88,000*12*30 = 22.4 days

Therefore, the payback period for chain drive is approximately **23 days.**

Chapter 5 - Results and Discussions

Sr. no.	Parameters	Rodless Cylinders	Chain Sprocket Pusher
1	Speed Of Operation	The speed of pneumatic cylinders can be varied using flow control valve. Moreover a maximum speed of 3 m/s can be achieved.	The speed remains fixed and cannot be varied. Maximum speed is 0.33 m/s
2.	Maintenance	Rodless cylinders require minimum maintenance as it does not make use of mechanical linkages. A minimal Quarterly maintenance is required.	Chain drive makes use of links and it requires more maintenance in comparison with Rodless cylinders. It requires monthly maintenance.
3.	Life of equipment	Life expectancy of rodless cylinders is 8 years with regular use.	Due to more wear and tear of parts, the life expectancy of chain drive is less and is around 3-4 years. Then it needs to be replaced.
4.	Cost	Rs. 486000/-	Rs. 17920/-
5.	Payback period	19 months	23 days

Table 6 Results and Discussions

Chapter 6 - Conclusions

6.1 Conclusion

In achieving the solution for problem of pushing finished products onto packing and strapping area, both rodless cylinders and chain drive are competent enough. Though the cost and payback period of Rodless Cylinder is more when compared with chain drive but on a long term basis, considering the service life and maintenance of rodless cylinders, the team concluded that rodless cylinders will be best suited for the above stated problem.

6.2 Future Scope

The system for product handling after shearing is automated by the solution provided by us. So, all the processes after strapping to bundling can be AUTOMATED further.

Chapter 7 - Bibliography

[1] Material Handling Mangement, Vol 4 (July-Dec 2011).

[2] Bahale, A. P., & Dr.S.S.Deshmukh. (2014, March). Improving Material Handling Efficiency in a Ginning Machine Manufacturing Company. *International Journal of Innovative Research in Science,Engineering and Technology, Vol.3*(Issue. 3), 10180.

[3] Yaman, R. (2001). A Knowledge-Based Approach for Selection of Material Handling Equipment and Material Handling System Pre-design. *Turk J Engin Environ Sci*, 267-278.

[4] Bansbach. Retrieved from bansbach.com.

[5] Khanna, O.. *Industrial Engineering* (Vols. ISBN- 818992835X). Dhanpai Rai.

[6] Rudenko. *Material Handling Equipment*. Mir Publisher Moscow.

[7] Systems, S.. Retrieved from stablius.com.