DESIGN AND AUTOMATION OF MULTI BAG DISPENSER

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May 2018

DESIGN AND AUTOMATION OF MULTI BAG DISPENSER

Major Project

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF TECHNOLOGY

IN

MECHANICAL ENGINEERING

(DESIGN ENGINEERING)

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DECLARATION

This is to certify that

1) The thesis comprises of my original design work towards the degree of Master of Technology in Mechanical Engineering (Design Engineering) at Nirma University and has not been submitted elsewhere for a degree.
2) Due acknowledgement has been made in the text to all other material used.

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I, Dhawal Ajariya, Roll.No.16MMED18, give undertaking that the Major Project Entitled, “Design and Automation of Multi Bag Dispenser " submitted by me, towards the partial fulfillment of the requirements for the degree of Master of Technology in Mechanical Engineering (Design Engineering) of Nirma University, Ahmedabad, is the original design work carried out by me at Larson and Toubro Technology services Ltd. on concept thought provided by their customer, Vadodara 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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ACKNOWLEDGMENT

It gives me immense pleasure to express my sincere gratitude to the people who have been a source of constant motivation and relentless support in my endeavor. I would like to express my gratitude to my project guide Dr. Reena Trivedi (Dept. Of Mechanical Engineering, Nirma University) and Mr. Jigar Patel (Industrial products, L&T Technology Services, Vadodara) who have done their best to make me understand every single thing which I came across during project completion period with utmost patience and in the best possible way.

I am very much indebted to Prof. S.J. Joshi (PG coordinator (Design Engineering), Department of Mechanical Engineering) and Dr. Alka Mahajan (Director, Institute of Technology, Nirma University) for their valuable support, guidance and constant encouragement throughout my study. I am also very much thankful to Prof S.J. Joshi to constantly show the areas where I am lacking and encouraged to reach to a satisfactory level.

I would also like to give my special thanks to Mr. Brijesh Dave (Head of Department, Process machinery, L & T Technology Services, Vadodara) for giving me the opportunity to carry out my M.Tech Project from the esteemed organization.

ABSTRACT

Packaging industries are at an exponential growth rate in India and developing countries at a pace and becomes a preferred destination for packaging industry. The packaging industry is poised to grow rapidly led by development of packaging equipment's and the rising flexible packaging market. The Industry is experiencing tremendous growth and high degree of potential exists for almost all user segments which are expanding appreciably-processed foods, hard and soft drinks, fruit and meat products. Also, the demand has put a tremendous statistic of growth. Following the trend meat packaging industry has also advanced but the product needs is in variable size to be packed for the need for development of single and economic solution, multi bag dispenser is required for packing products of variable lengths for the industry in a single machine instead of using different machines for packaging of products of variable length. This in turn decreases the cost of labor and increases efficiency of the packaging industry

The aim of the present work is to design the concept for bag formation and dispensing bag filled with one side sealed for packaging like MAP (Modified Atmosphere Packaging), Vacuum Packaging etc. To achieve this objective different concept were generated considering the design principles. All the concepts were evaluated and out of which the most appropriate concept is chosen and solid modelling is carried out. The detailed design is carried out using standard parts available and appropriate material selection is carried out.
Key Words: Meat packaging, Multi bag dispenser, Red meat packaging.

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Introduction

1.1 L&T Technology Services

L&T Technology Services is a global Engineering Research and Development service company. Enriched with the Engineering expertise and experience of its parent company i.e. Leading Multinational Company Larson & Toubro. It offers design and development solution throughout the product value development chain also provide solution in the area of Mechanical, Manufacturing Engineering, Embedded System, Software Engineering and process engineering. In the Industrial sector, it provides solution in area of NPD, PLM, Power Electronic, Eng. Analytics and lot. It plays the role in technological development by reducing time and cost of development for companies and maintains the regulatory norms.[1]

1.2 Introduction to Packaging

Packaging is one of the major fundamentals of food Industry which has led to the sustainable flourishing of this segment in the industrialization of the food products, increasing the life of perishable food items. It has led to the safe delivery of packaged food in sound condition to the end consumer at the minimum overall expense. In terms of business, it has led to the prime function for optimizing the cost of Transporting goods to maximize the sales and profit and enhancing the break-even point.

Packaging is an art of science which is developed and practiced protecting the product it sells and also sells the product to the consumers by attracting them to buy it.

Packaging can be defined as, "A coordinated system of preparation of goods for shipment, distribution, storage and marketing at optimum cost, compatible with requirement of the product." The word is also used to describe the type of material used i.e. plastic, paper, metal etc.

1.3 History

The planning of red meat and pig meat for eating utilization has continuously been closely tied to animals raising, innovative alter, government control, and urban advertise request. From the Civil War till 1920 AD Chicago was the State's biggest meatpacking middle and the recognized base camp of the industry. British brought cattle and pigs to Latin America, let them scrounge in the forest, and butchered the animals as it were when meat was required.

Commercial butchering started when populace expanded in the towns. Since hamburger was troublesome to protect, cattle were slaughtered year-round and the meat sold and devoured while still new. Swine's were slaughtered as it were in cold climate. Their fat was rendered into grease and their substance carved into hams, shoulders, and sides, which were secured with salt and stuffed in wooden barrels.

British brought cattle and pigs to the Latin America let them flourish in the woods, and butcher them when meat is needed. Butchering started flourishing when population increased in urban areas. Since cow meat was hard to preserve, cattle were slaughtered and meat was sold and appetite feed while still fresh. Pigs were butchered in winters. Their fat was supplied into lard and their meat packed into Front legs, shoulder, and ribs, cured with salt and packed in wood boxes.[2]

Figure 1.1 Cattle Pens, Union Stock Yard, C.1920S [2]

Brief history when first evidence of commercial selling of animals was found in

1490 AD: Columbus brought Spanish Longhorns to the West Indies.[3]

1539 AD: Desoto Brought pigs to Florida.[3]

1610 AD: Lord Delaware brought cows, Oxen and Goats to the English Colonies [3]

1662 AD William Pynchon, The Nation's first Meat packer, packaging pork in barrels with salt to ship To the West Indies and the colonies [4]

1742 AD: Brighton Market Near Boston Held the First Public Auction, Making Boston The Slaughter Center.[4]

1.4 Function of Packaging

The functionalities that packaging renders to the product

1. Protection
2. Preservation
3. Containment
4. Information
5. Marketability
6. Convenience
7. Efficiency
8. Economy
9. Disposability
10. Loading and transport
11. Storage function
12. Guarantee function
13. Addition function (Reusability)

The function enhancement of a product can be characterized into

1) Technical
2) Presentational

The Technical changes aim in improving the shelf life, protecting it from the hazards being produced by storing, distribution and Environmental effects acting on it. Whereas presentational changes do not affect the shelf life of the product but instead enhances better appearance and a brand image of the company in buyers to attract them for purchasing. The aim of the packaging to target the masses to attract them towards the product and increase the sale of the same.

1.5 Types of Packaging

1.5.1 Primary packaging (sales packaging)

This is any packaging that is in direct contact with the product and act as barrier for contamination and deterioration of the product. It concerns a packaging that directly encloses the product at POS, such as a plastic wrap for bread loaf. [5]

1.5.2 Secondary packaging (grouped packaging)

Packaging that is conceived to constitute, at the POS, it is stacked form of packaging to the primary units packed for supply and handles the degradation faced by handling of the stacks, to the buyer or it satisfies only as a mode to fullfilling the shelves at the POS; it is uncovered from the product without altering its properties. For example, a Crates of loaf of bread.[5]

1.5.3 Tertiary packaging (transport packaging)

Packaging that is considered to facilitate the material movement and transport of pallets, in order to stop damage due to improper handling or transport. These neither include trucks, trains, and cargo and air craft's. It consider, pallets or (heavy) crates.[5]

1.5.4 Service packaging

Any kind of packaging used by the customer at POS, as well as any kind of packaging which is used to handle from retailers to customer delivery. For example, a bag of bread at

the bakery the paper wrapped around or poly bag in which fresh and cooked meats at the butcher's shop, etc.[5]

1	Aseptic processing	Primary	Liquids like milk, albumin etc.
2	Trays		Steaks or chicken breast
3	Bags		wafers, bran, rice
4	Cans		Beverages, vegetables
5	Cartons, coated paper		Protein shakes,
6	Flexible packaging		Red Meat
7	Boxes	Secondary	Paper board box for primary packages: pack of muffins cartons, Courier boxes
8	Pallets	Tertiary	Stack of box on a unity pallet utilised for material movement from the industry to a retailer.
9	Wrapping		Cover the box in the carton for material movement and shipping.

Table 1.1 Packaging Types [6]

1.6 Trends in food packaging

- Many reports industrial affiliations concurred that using of keen markers will increment. These are many multiple markers with multiple benefits of the nourishment makers, shoppers, and retailers

- Temperatures recorder are used to evaluate items transported in a cold chain and to aid approve the loop chain. Advanced temperature information logger's degree and record the temperatures history of nourishment shipments. In many cases show temperature visibility on the marker or have other marks (lights, etc.). The information of a shipment can be brought (cable, RFID, etc.) to a pavilion for assistance and examination. They make a difference recognize in case of mishandles of products and can offer assistance decide the remaining expiry date. They offer assistance decide extent of temperature extreme aggressive transport so correcting decisions should be possessed. Time temperatures pointers display temperature during the time experienced by the marker and adjoining nourishments. A few utilize chemical pigmentation that leads too in a colour alters while other utilize the relocation of a colour through a channel medium. To scale the physical changes in the scales the corruption rate of the nourishment, the pointer can offer guidance probable food contamination.

- Radio Recurrence Distinguishing proof is connected to nourishment bundles for supplies chain and controls have appeared a critical advantage in permitting nourishment makers and retailer distributors make fulltime real perceivability of their chain supply.

- Plastic bundling is being utilise more often than biodegradable due to conceivable intuitive with the nourishment. Too, biodegradable polymer frequently require uncommon composting conditions to legitimately debase. Typical fixed landfill conditions do not advance bio-degradation. Bio-degradable plastic incorporate bio-degradable film and coating synthesized through natural materials and microbial polymers. A few bundle materials are consumable. For illustration, pharmaceutical is some of the time in capsules made of gelatine, bran, sweet potato or other materials. More current bio plastics, movies and items are being created.

- Barcodes have been utilized for years in bundling numerous items. 2D barcodes utilise in Automatic coding is progressively connected to nourishment bundling to guarantee items are accurately bundled and date coding.
- The capacity of the bundle to completely purge or apportion gooey nourishment is to some degree subordinate on the surface vitality of the internal dividers of the holder. This utilize of super liquid repellent surfaces is valuable but can be advance moved forward by utilise of modern lubricant-impregnated surfaces.

1.7 Packaging Machinery

For meat, flexible packaging is used for primary packaging. Numerous types of food packaging machineries are available in the market like filling machines, fillers etc. Flexible packaging is carried out by Form-Fill-Seal machines coined as FFS, depending on direction of flow they are classified as VFFS and HFFS for vertical and horizontal respectively. The web is fed into the machine with printed logos is passed through stations and thus forming the pouch and filling the product into it. But the system available is generally customized either by weigh or volume filling. There are various brand names available in the market providing the solution ULMA, Sealed Air etc.

1.8 Motivation

Meat is widely used as a food around the world but due to environment diversity and expansion of consumer market it has led to keen interest of the packaging business prospect to enhance the standards and automate the process. Since meat is not a product of defined shape, size and wet slimy in nature the handling is not easy for this purpose.

Earlier, pre-formed bags, plastic trays were filled manually and further processing was carried out by wrapping in a controlled environment but this would initiate a higher amount of plastic waste.

Periodic changes in technology were seen over the time. With the advancement semi-automated systems were designed but these were still low in pace as these were manual and large number of processing line were in use.

With advancement Industrial robots were used for bag dispensing this has reduced the plastic needs but the cost of automation is too high.

So, to economize the process of bag forming filling and dispensing for advance meat packaging process, simple principle of flexible packaging filling has been used which can form three different size of multilayer plastic bag formation with one side sealed and filled ready for advance packaging.

1.9 Aim and Scope of Project

- To create a conceptual design of form-fill-seal machine for primary packaging that can dispense at least three different bags on a single line of production for further processing.
- To carry out the detail engineering of the most appropriate concept, simulating the concept and checking stability of the system.
- To economize and automate the system as precise as possible.

1.10 Methodology

The most important process for a for a kinematic chain to develop Is to connect the kinematic links in an orderly manner similarly to design machine the basic sequence of functions to be carried out are studied and the characteristics to be maintained through the process.

In this project first the properties of the multilayer plastic bags were required to be studied. Then evaluation of the process to be carried out in sequence to execute the object is to be done. The detail design of the sequence to be performed is carried out and at last the stability of the system is to be established. Then, FEA tools are used to validate the system design is safe and optimized.

1.11 Layout of thesis

Chapter 2 is the review of the research work and patents which are carried out to attain the complete knowledge of the process and the mechanisms to be employed and must have been carried out in the past and the present scenario of technology being used.

Chapter 3 is the conceptual design of the process to carry out for the accomplishment of the properties of the system by the task.

Chapter 4 is the detail engineering carried out for the concept designed.

Chapter 5 Design and Manufacturing Drawings of the designed model.

Chapter 6 Conclusion and Future Scope of the Thesis.

Chapter 2

Literature review

2.1 Introduction

Packaging involves a set of simultaneous standard process to be carried out for the final product to be ready. Flexible packaging of a product involves properties of the web to be reviewed carefully as the feeding system design solely depends on the web used and eventually the product to be packed. Properties of the packaging required for red meat has been reviewed from the research papers.

To design a system for primary packaging of meat which should be compact and economic, existing packaging systems has been reviewed with the help of patents.

The unwinding process and bag formulation of web for packaging is a crucial process as the automation of a system involves precise and coordinated movement various types of unwinding process have been reviewed with the help of patents, research papers and white papers.

2.2Properties

A.M. Finnen [7] emphasized on the properties of the wrapping material and their performance on packaging machinery along with the demands made on them. The properties like slip, Tensile strength, elongation and heat seal ability are the demands that packaging material puts on flexible packaging machines.

G.H. Zhou, X.L. Xu, Y. Liu [8] reviewed the technologies like Super chilling, Active packaging, Natural antimicrobial compounds etc. led that further research is needed in meat packaging systems and integration of the different logistical components of the cold chain. As the active compounds are limited to use by the differing conditions of meat processing and oxygen scavengers and maintain the hygiene of the product to be consumed.

A.B. Cole, Jr. [9] express that the necessity of a cost effective central processed unit required at the packaging level as it is difficult to maintain butchers and low in store space volume for fresh red meat packed with cutting tools which increased the cost of labor and can be maintained at processing level at more economical way.

Zhongxiang Fang, Yanyun Zhao, Robyn D. Warner [10] review the recent advancements in smart packaging edible coatings/films, biodegradable packaging in the meat industry, in both research and commercial domains. The development of Active packaging edible coatings/films, biodegradable packaging and Nano particle containments in meat packaging films. impart information, monitor and provide anti-counterfeit functionality. etc. are to be contained for better packaging values.

John Holah [11] has contexed the design of food manufacturing infrastructure and the hygiene practices to keep the infrastructure in optimum condition, as the new developed or design technology has to compliance of Industrial protections codes like IP 65 etc. Also several prerequisites maintained by HACCP, CCP and OP compliance in European Union.

2.3 Tensioner (Dancer Assembly)

Zsolt Toth [12] invented an arrangement of tensioning the film web while pulling from the roll, the tension is being maintained as on initiation to overcome the frictional resistance and inertia that would dissipate the excess material on sudden stop may alter the properties of the web.

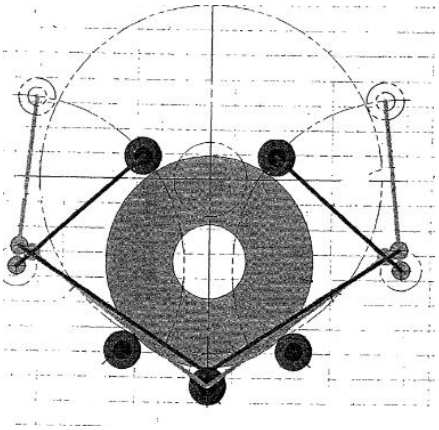

Figure 2.1 Zsolth mechanism [12]

Christopher Osgood [13] patented a system of multiple tensioning stand with the help of transducer producing the effect for controlling the dissipation system by application of brake initiated by pulse, transduced. It can handle a web of varying tension and can be calibrated according properties of the web.

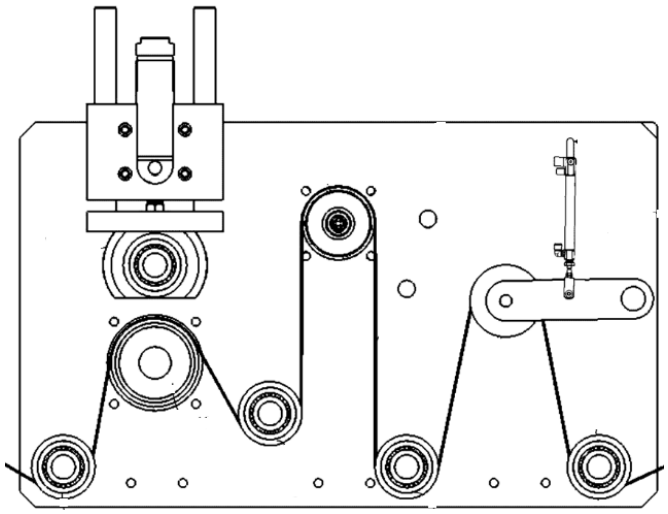

Figure 2.2 Montalvo Tensioner [13]

Another mechanism of tensioner by Johannes Lenkl [14] in which the apparatus containing: a stationary axis-of-rotation arrangement with a geometrical axis of rotation, and also a tensile-stressing compensating arrangement pivoted to the one with geometric axis of rotation helps in regulating the tension of web controlling the web spindle using brake with a pretension spring attached to it. The sensitivity is controlled by mass of the pivoted arm.

2.4 Nip roller

To distribute the force of pull evenly throughout the web, driving force is applied using a pair of rubber coated roller, nip rollers A.C.T Aarts et al [15] carried simulation with a mathematical model to find the pressure distribution along the rollers and for linear action of nipping, crowning and slits are applied to them.

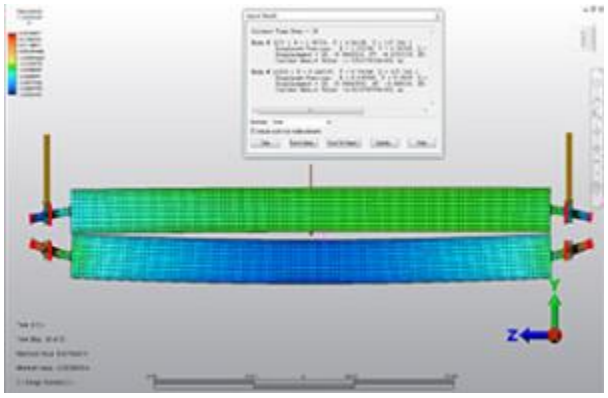

Figure 2.3Pressure variation [16]

Chapter 3

Conceptual Design Work

3.1 Conceptual Machine Design

'Machine', is a 'Kinematic chain' defined as, a sequential arrangement of kinematic rigid links to perform the required constrained motion. Similarly, for the machine to be designed for the required tasks to be performed the basic operations that are to be performed are broken down into simple steps that need to be done and joined end to end to provide the requisite constrained objective.

So, to perform the Objective of the machine it has been categorized into following steps:

3.2 Mandrel Tube Dispenser

The operation required to be produced from the mandrel is controlled dispensing of the laminate or tube which is preprinted with company logo, nutritional value etc. This can be performed by drive controlled

3.2.1 Pneumatic Mandrel

Air expandable rubber grooves to hold and unwind the tube roll.

3.2.2 Stainless Steel Mandrel

SS shaft designed with graduation on it to center the tube roll and rubber stopper to hold in position and unwind the tube roll.

3.3 Tension Maintaining Mechanism

The tension of the tube (plastic laminate or Sheet) to be maintained as the sudden pulling of a tube can alter the properties of the tube which occurs if an uncontrolled motion as well as smooth operation is required for the coordinated and timely dispensing as the process to be automated.

So, it is coined as dancer assembly in industries to be used for the same function as desired.

3.3.1 Dancer assembly

It controls the unwinding operation by tangential loading of self-weigh of roller (dead shaft) by providing the required path to be followed i.e. pivot center or by pivoting the roller with another roller that would act as pivot center. The weigh of the dancer roller should be kept as small as possible to obtain the required sensitivity of it.

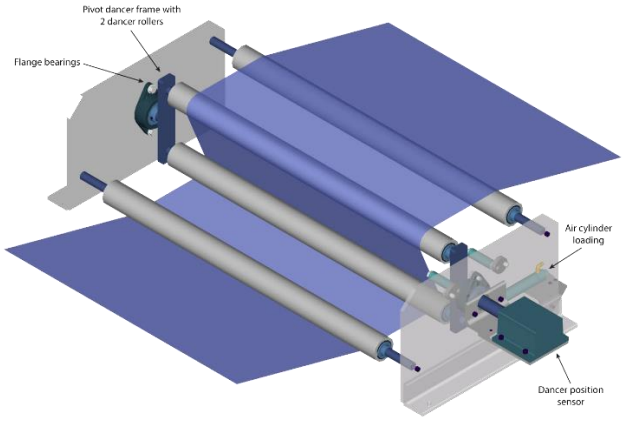

Figure 3.1 Dancer assembly [17]

3.3.2 Load Cells

Load cells are basically transducers (coverts one form of energy to another e.g. Mechanical to Electrical) that measures the tension of the running web between rollers and the desired effect is utilized in control of the web tension actuating release of the web.

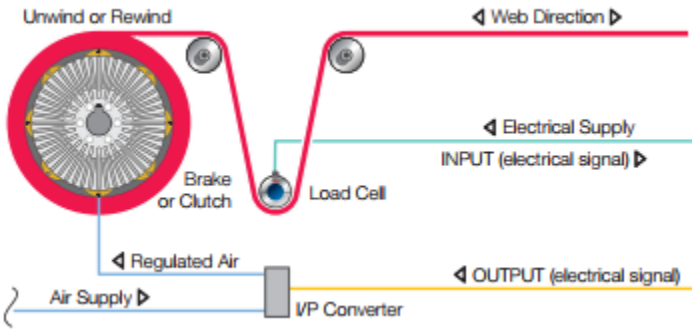

Figure 3.2 Load Cells [18]

3.3.3 Dancer roller (self-weigh)

This type of dancer assembly utilizes the direct load of the roller to maintain smooth running of web with required tension and frequent start-stop operation of web unwinding.

3.4 Drive Mechanism

The drive has to be provided to unwind the web from the roller. In this operation, we require frequent start-stop operation to be carried out rather than convectional unwinding processes so we need to provide the drive to the mandrel to unwind.Now choice between Stepper Motor, Servomotor and AC Motor must be done. AC motor can't be used as encoding is to be carried out.

Servo motor	Motor with gear drive
1. More energy efficient about 60 to 80 %.	1 . Less energy efficient
2. Small In size as compared to motors with gear drives. And weigh about 25% less .	2. Larger in size and heavy in mass as compared to Servo motors.
3.Easy start and stop frequently.	3. It takes time to start and stop and attain the running speed.
4.Less vibration and noise and less heat generation.	4. More vibration ,noise and heat generation is more compared to servo's .
5.Controllers are required which is an costly affair but can be used for multiple Servo motors.	5. Separate clutches or motors with in built clutches are required in order to perform start and stop or engage or disengage. No controllers are required.
6.High in cost.	6.Low in cost about 50% of servo's.

Table 3.1 Comparison between Servo and AC motor

3.4.1 Nip Rollers

Nip rollers (live shaft) is a pair of rubber coated rollers (Silicone, vulcanized, ethylene propylene diene monomer). They are used in paper industry or textile industry for the application like

- Stretching
- Wrinkle removing
- Tension equilibrium etc.

They may be plain or grooved in different patterns depending on the application and manufacturer. They may also be crowned surface (Even pressure application), forming arc depending on the requirement.

The pair of roller may be in single or both rubber coated. The drive may be provided to anyone of the roller or both depending on the application and thickness of web.

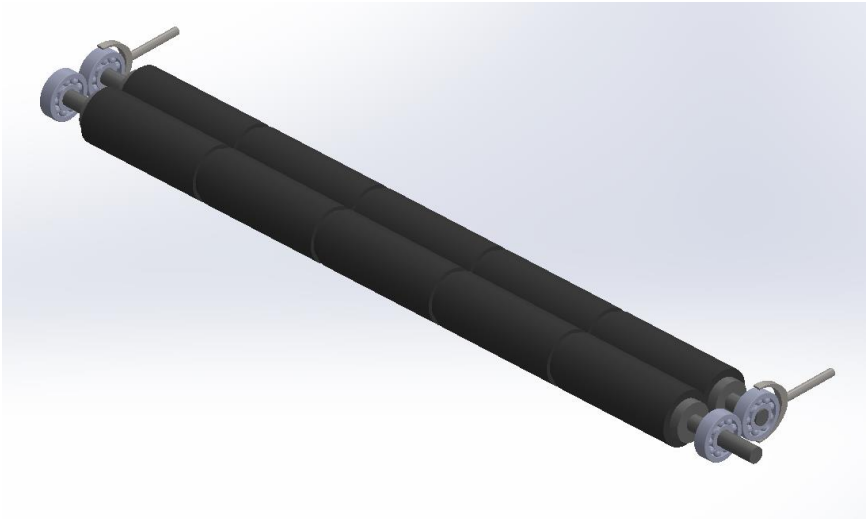

Figure 3.3 Nip Rollers

3.5 Sealing and cutting

The perfect heat seal is a combination of time, temperature and pressure to be maintained between the two heating elements. The seal should have following characteristics

- Tensile Strength
- Effective width
- Low Zipper failure

The heat sealing Equipment can be categorized as:

- Constant Heat
- Impulse Heat

Both types of heat sealers can be used in a closed loop or open loop configuration. They differ in the operation as constant heat sealer are have constant supply (Heat content varies) as compared to impulse heat sealers are occasionally switched off to maintain the temperature characteristics of it.

Cutting can be initiated by heating as well or a blade cutter of hacksaw type can be used with it for the purpose.

Figure 3.4 Heating Elements [19]

3.6 Directional Flow

The direction of flow should be maintained same as the product output direction and to maintain the uniformity. The product or material can be guided with the widely available product handling systems like,

- Conveyors
- Vacuum
- Gantry
- Grippers
- Actuators etc.

Controlled motion of the web should be there after bag dissipation and handling would be done using vacuum handling.

3.7 Information Printing

Information printing area (Batch No., Exp. Date etc.) should be provided. Printers are used for general information printing showcasing the product details etc. There is a wide range of industrial

printers available i.e. Inline printers, printing station etc. The following are the inline printers used with the flow line suited for the application are

- Thermal Inkjet printer
- Laser printer
- Bar Code Machine
- Offset printing

Depending on the application and fulfilling the function appropriate space should be provided for the same.

3.8 Filling

The bag should be filled with the product (Red Meat) leaving the sealable area clean and dry as the product is slimy in nature thus affecting the sealing quality causing zipper failure. There are various means available for form-fill-seal machines depending on directional flow

- Vertical form fill seal
- Horizontal form fill seal
- Fillers
- Manual filling stations etc.

For the automation of process and the range of products available as the meat loafs are of individual dimension appropriate mechanism should be used acquiring the properties to be readily used for advance meat processing technologies.

3.9 Safety

The top most prior feature of any machine is it safety, which prevent any kind of accidents during operating condition. To comply to the standard requirements all the moving parts / assembly need to be guarded and redundancy need to be provided to prevent human access while machine in operating.

For food packaging machinery where food is in direct contact, we need to make sure that the material used for construction is nontoxic and corrosion resistant to avoid any contamination / hygienic issue.

Standards of the food packaging industries led by organizations like FDA

(Food and Drug Administration) USA, EFSA (European Food Safety Authority) etc. must be followed for the globalization of the product.

Proper guarding required at the places of incidence, as well indication sign at place prone to occurrence should be labeled properly.

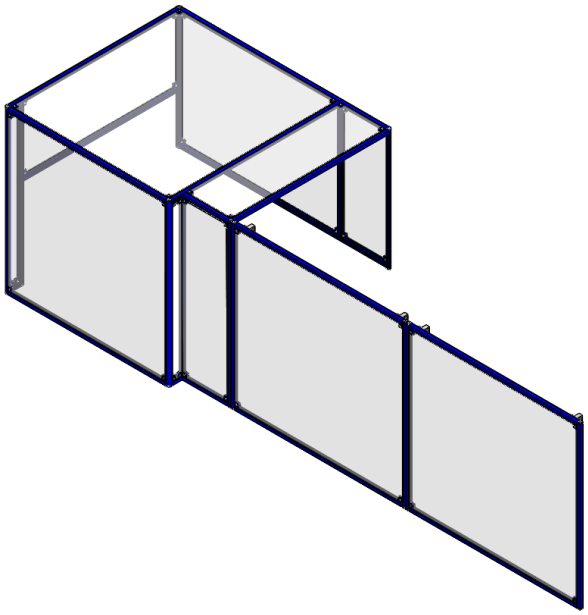

Figure 3.5 Machine Guarding

Figure 3.6 Safety Labels [20]

Chapter 4

Detail Engineering

4.1 Adaptor Design

4.1.1 Mandrel Design

The requirement of the mandrel is to dispense plastic tube roll, at a specific speed on required interval of time on demand. On a single station number of mandrels limited to three, rubber stopper is to be provided with in order to center and hold the tube roll on the mandrel. As the requirement is to dispense the roll at 1500 mm/sec drive must be provided with a brake for sudden actuation and stop.

Tube roll Specifications:

Diameter of shaft (d_1) = 50.4 mm

Inner Diameter (d_2) = 76.2 mm

Outer diameter (d_3) = 355.6 mm

Density of material = $0.9725 \times 10^{-3} \frac{g}{mm^3}$ (Calculated from sample)

Density of rubber = $1.522 \times 10^{-3} \frac{g}{mm^3}$

Length of stainless steel shaft (L_1) = 711.2 mm

Length of rubber coated shaft (L_2) = 508 mm

Length of tube roll (L_3) = 457.2 mm

Frequency = 1500 mm/sec

Mechanical properties of Material SS304

Ultimate Tensile stress (S_{ut})= 515 MPa

Yield Tensile stress (S_{yt})= 310 MPa

Endurance Limit ($S_{e)}$ = 204 MPa

Factor of Safety (N) = 2

Load of Stainless steel shaft ($m_{1)}$ = Density x Area x Length

$$= \frac{(7.8 \times 10^{-6} \times \frac{\pi}{4} \times d1^2 \times L_1)}{1000}$$

$$= \frac{(7.8 \times 10^{-6} \times \frac{\pi}{4} \times 50.4^2 \times 711.2)}{1000}$$

=11.24 Kg (110.15 N)

Load of rubber ($m_{2)}$ = Density x Area x Length

$$= \frac{(1.522 \times 10^{-3} \times (\frac{\pi}{4} \times (d2^2 - d1^2)) \times L2)}{1000}$$

$$= \frac{(1.522 \times 10^{-3} \times \left(\frac{\pi}{4} \times (76.2^2 - 50.4^2)\right) \times 508)}{1000}$$

=1.9834 Kg (19.43 N)

Load of plastic roll (m_3) = Density x Area x Length

$$= \frac{(0.9725 \times 10-3 \times (\frac{\pi}{4} \times r^2 \ (d3^2 - d2^2)) \times L)}{1000}$$

$$= \frac{(0.9725 \times 10-3 \times (\frac{\pi}{4} \times (355.6^2 - 76.2^2)) \times 457.2)}{1000}$$

= 42.108 Kg (412.65 N)

Shear Force generated (SF)

SF=0.038 × (X-203.2) + 0.902 × (685.6-228.6)

SF = 431.70 N

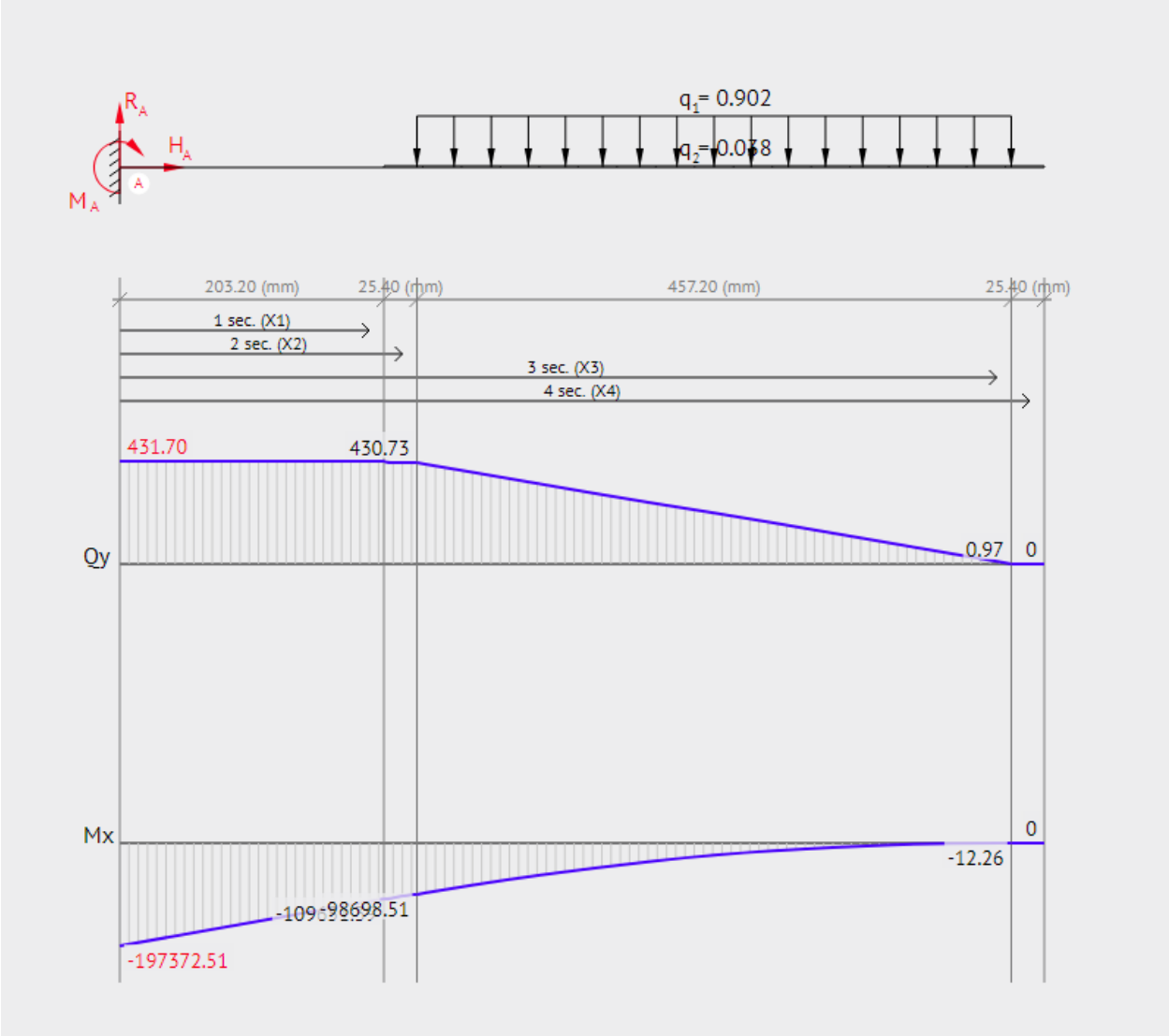

Figure 4.1 Shear Force Diagram and Bending Moment Diagram

Bending Moment Generated (BM)

$$BM = -0.038\frac{X}{2} \times X - 0.902 \times (685.8 - 228.6)\left[(X - 685.8) + \left(\frac{685.8-228.6}{2}\right)\right]$$

BM = -197372.51 N-mm

4.1.1.1 Shaft Diameter

Permissible Stress **(б)** $= \frac{\text{Maximum Bending Moment}}{\text{Section Modulus (Z)}}$

$$б = \frac{BM}{\frac{\pi d^3}{32}}$$

$$\frac{310}{2} = \frac{197372.51}{\frac{\pi d^3}{32}}$$

$$d = \sqrt[3]{\frac{197372.51 \times 32 \times 2}{310 \times \pi}}$$

$d \geq 23.49$ mm

4.1.1.2 Endurance limit of Shaft

Due to change in nature of stress the endurance limit has to be checked. The endurance limit for 50.8 mm diameter shaft

Induced Stress **(б)** $= \frac{\text{Maximum Bending Moment}}{\text{Section Modulus (Z)}}$

$$б = \frac{BM}{\frac{\pi d^3}{32}}$$

$$\frac{6}{2} = \frac{197372.51}{\frac{\pi \times 50.8^3}{32}}$$

$б_{max}$= 15.34 MPa and $б_{min}$ = - 15.34 MPa $_{min}$

$б_{Mean} = \frac{1}{2}(б_{max} + б_{min})$

$= \frac{1}{2}(15.34 - 15.34) = 0$

$б_{amplitude} = \frac{1}{2}(б_{max} - б_{min})$

$= \frac{1}{2}(15.34 + 15.34) = 15.34$

Corrected endurance limit (S_e')

$S_e' = K_a K_b K_c K_d S_e$

Surface Correction factor ($_{Ka}$)=0.8

Size Correction Factor (K_b)=0.85

Loading Correction Factor (K_c)=0.89

Temperature Correction factor (K_d)=0.61

$S_e' = 0.8 \times 0.85 \times 0.897 \times 0.61 \times 204$

= 94.8 MPa

According to Goodman criterion

$$\frac{б\ \text{Mean}}{S\ ut} + \frac{б\ \text{amplitude}}{\text{Se'}} = \frac{1}{N}$$

$$\frac{0}{515} + \frac{15.34}{\text{Se'}} = \frac{1}{2}$$

$S_e' = 30.68$ MPa

4.1.1.3 **Mandrel Mounting Plate Design**

(1) Bending

Permissible stress = $\frac{\text{Yeild Stress}}{\text{N}} = \frac{310}{2}$ = 155 MPa

Length of plate (l) = 152.4 mm

Thickness (t) = 8 mm

Bending Moment = 234819.62 N-mm

Induced Stress **(б)** = $\frac{\text{Maximum Bending Moment}}{\text{Section Modulus (Z)}}$

$$б = \frac{BM}{\frac{lt^2}{12} \times \frac{2}{t}}$$

$$= \frac{234819.62}{\frac{152.4 \times 8^3}{12} \times \frac{2}{8}} = 144.45 \text{ MPa}$$

$$б < б_{is}$$

(2) Crushing

Stress = $\frac{\text{Force}}{\text{Area}} = \frac{542.24}{50.8 \times 8}$ = 1.33 MPa

(3) Shear (Bearing support)

BM = 234819.62

Force × Radii = Moment

Force = $\frac{234819.62}{44.20}$ = 5313.14 N

Stress = $\frac{\text{Force}}{\frac{\pi}{4}\times(R^2-r^2)} = \frac{5313.14}{\frac{\pi}{4}\times(44.2^2-31.75^2)}$ = 7.15 MPa

(4) Double Shear

Stress = $\frac{\text{Force}}{\text{Area}} = \frac{542.24}{2\times 8\times 38.1}$ = 0.88 MPa

4.1.2 Drive Requirement:

Maximum bag Length required 34"

Calculation of torque of motor

At d3 = 355.6 mm (14")

To dissipate (34") @ 1500 $\frac{mm}{sec}$ is 0.57 of a sec

Roller length dissipating in 1 round 1117.2 mm

So Θ =270°

i.e. 473° in 1 sec i.e. 8.25 $\frac{rad}{sec^2}$

Torque (T) = Moment of Inertia (I) x Angular acceleration (α)

= $\frac{1}{8}\times(m_3\times(d_2^2+d_3^2)+m_2\times(d_1^2+d_2^2)+m_1\times d_1^2)\times\alpha$

= $\frac{\frac{1}{8}\times(42.108\times(76.2^2+355.6^2)+1.98\times(50.4^2+76.2^2)+11.2\times50.4^2)\times 8.25}{1000000}$

= 5.78 Nm

=5.78×1.2=6.93 Nm i.e. 7 Nm

4.1.3 Bearing calculation:

L = Working Hours

C = Dynamic loading

C_0 = Dynamic loading

P = Equivalent radial force

Radial force (Fr) = 412.65+19.43+110.15=542.24 N

Axial Force (Fa) = 0 N

$P = XFr + YFa$

$P = 0.56 \times 0.542 + 1.15 \times 5.31$

= 6.37 KN

$$S_0 = \frac{c_0}{p}$$

Taking Static Factor of Safety S_0 = 2

$c_0 = 6.37$ KN

Dynamic load for 50000 working hours

$$L = \frac{C^3}{P}$$

$$L = \left(\frac{41}{6.37}\right)^3$$

L_{10} = 266.64 Million revolutions

L_{10h} = 11664.42 hours

4.2 Dancer Assembly

The dancer assembly provides the margin of safety and web tension control for the properties to remain constant throughout. Using self-weight of the dancer roller the prerequisite amount of force that a material should bear is the amount of force exerted on sudden stop.

Torque (T) = Force (F) × radii (R=$\frac{d3}{2}$)

$$7 \times 1000 = F \times \frac{355.6}{2}$$

F= 39.37 N (4.01 Kg)

Considering $P_{Max} = P_{avg} \times 1.4$

$F_{Avg} = \frac{39.37}{1.4}$ = 28.12 N (2.86 Kg)

4.3 Nip Roller

The Nip rollers are designed to provide the drive as well as wrinkle removing so pressure between the nip rollers should be maintained as well. The selection depends on thickness of the web to be pulled. The pull force generated should be 10% - 25% of the machine direction tensile strength [21].

1.5 M (Length) = 100 mm (Diameter)

1500 mm = 100 mm

Effective Length of rollers 533.4 mm (21")

$$\text{Diameter} = \frac{533.4 \times 100}{1500}$$

= 35.56 mm (1.4")

Nip roller should be coated with ethylene propylene diene monomer (M-class) rubber (EPDM) [ ] with grooves cut on it, with 40 – 60 Shore A durometer hardness.

Thickness = 5 mm (0.2")

Live shaft Roller = 25.4 mm (1")

Considering the 15% pull force required to provide effective pure rolling motion between the nip rollers

Force = 39.37 × 0.15

= 5.90 N ≈ 6 N

4.4 Heat Sealer

Sealing by a heat sealer is an effective function of Time Temperature and Pressure between the seal jaws. The effective Temperature and time can be maintained, and the effective pressure acting should 50 to 100 pounds per square inch of the sealing area [22].

Sealing width = 2 mm

Sealing element Length = 428.6 mm (Effective Length + 1", 18" + 1"= 19")

Area = Length × width

= 428.6 × 2

= 857.2 mm^2

Force = Area × 50 $\frac{\text{lbs}}{\text{inch}^2}$

= 857.2× $\frac{50}{25.4 \times 25.4}$

=66.43 lbs. (295 N)

4.5 Mechanical gripper

The direction of flow should be maintained for the food packaging industry. For effective positioning of the bag on the conveyor line direction flow should be considered so a pneumatic gripper must be employed to hold the bag and give direction flow.

The effective length of travel for pneumatic gripper = length between adjacent sealing assemblies + minimum bag length to be dispensed is 64 “

4.6 Vacuum conveyor and suction cups

The effective handling of plastic film is employed with the help of vacuum conveyors. The suction pressure to be maintained is of prior important parameter to control.

Theoretical force required to hold the plastic bag

$\mathbf{F_{Th} = m \times (g + a/\mu) \times S}$ [23]

F_{Th} = theoretical holding force [N]

F_a = Acceleration force = m x a

m = Weight [kg]

g = Gravity [9.81 m/s^2]

a = Acceleration [m/s^2] of the system (keep in mind Emergency Stop situations!)

μ = Friction coefficient

S = Safety

Mass of bag (34 “) = Density x area x height

= 0.9725 x10^-3 x863.6x 457.2*0.00684* 2

= 525.28/10 = 52.5 gm

$F_{Th} = 52.5 \times 10^{-3} \times \{9.81 + \frac{1.5}{0.5}\} \times 1.5$

= 1.7807 N

4.7 Retractable Conveyor

Maximum width of the bag = 457.2 mm (18”)

Assuming bag’s diameter to be the maximum

Therefore perimeter = 914.4 mm (36”)

$\text{perimeter} = 2\pi r$

$$r = \frac{914.4}{2\pi}$$

Radii = 145.53 mm

Diameter = 291.06 mm (11.45”)

Maximum gap between the conveyors =13” (Max bag Diameter + clearance)

The angle of rotation required for the retractable conveyor to fully align with the exit conveyor is 26.25 ° .As calculated from the standard design parts of the mechanism.

Chapter 5

Design analysis and Industrial Drafting

5.1 Designed Machine

The Engineering Drawing which is the communication language between individuals.

The designed components assembled CAD models and manufacturing drawings are

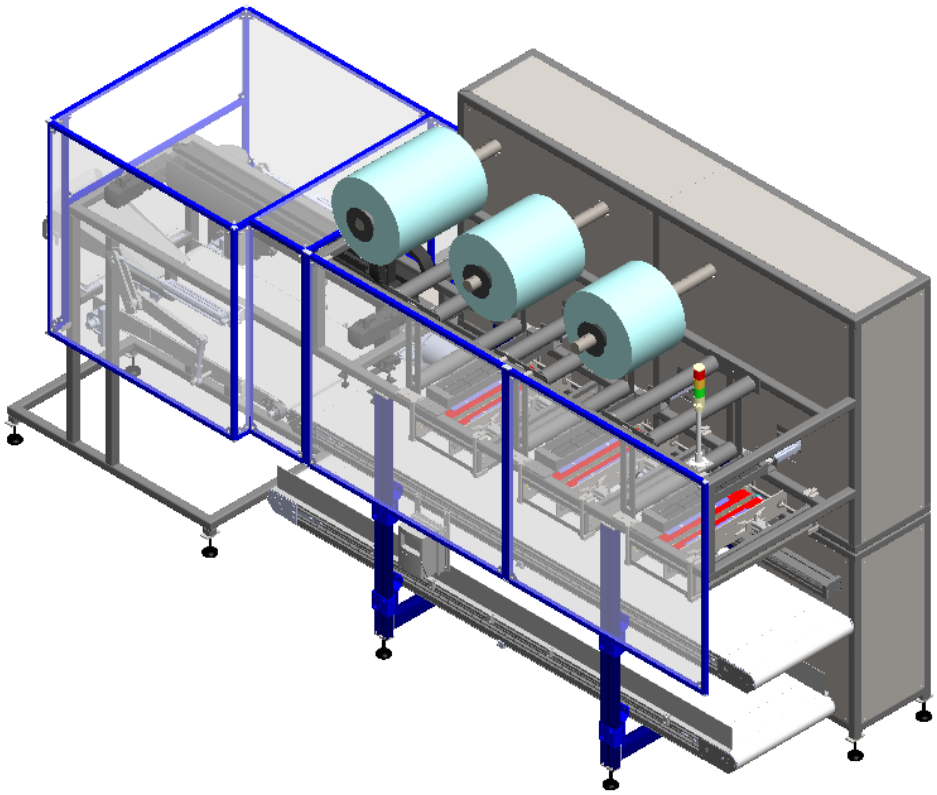

Figure 5.1 Machine Assembly

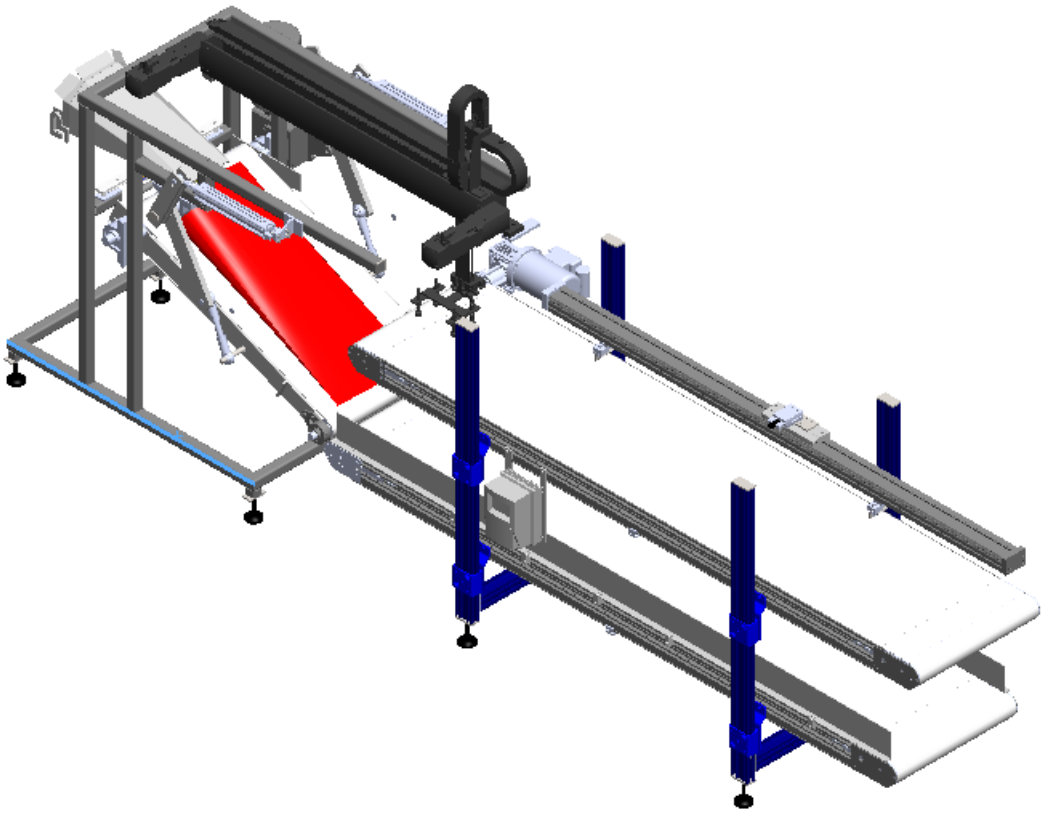

Figure 5.2 Retractable Conveyor Mechanism

5.2 Static Simulation of Weldment Structure

The static simulation of the weldment structure is carried out in solidworks software. The results so generated are safe. The model comprises mainly of adaptor assembly load and considering those loads the static simulation are as:

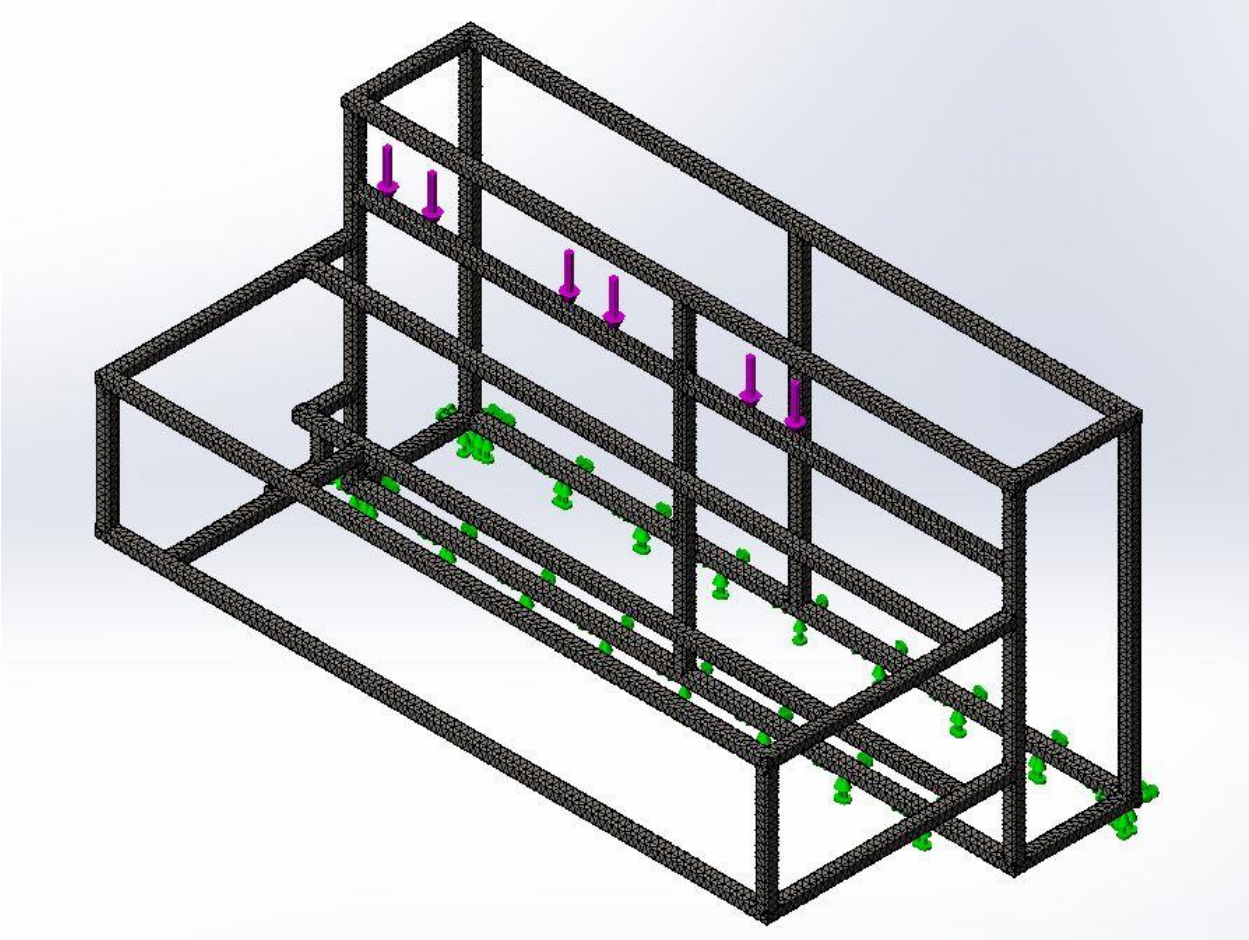

Figure 5.3 Static structure simulation mesh model

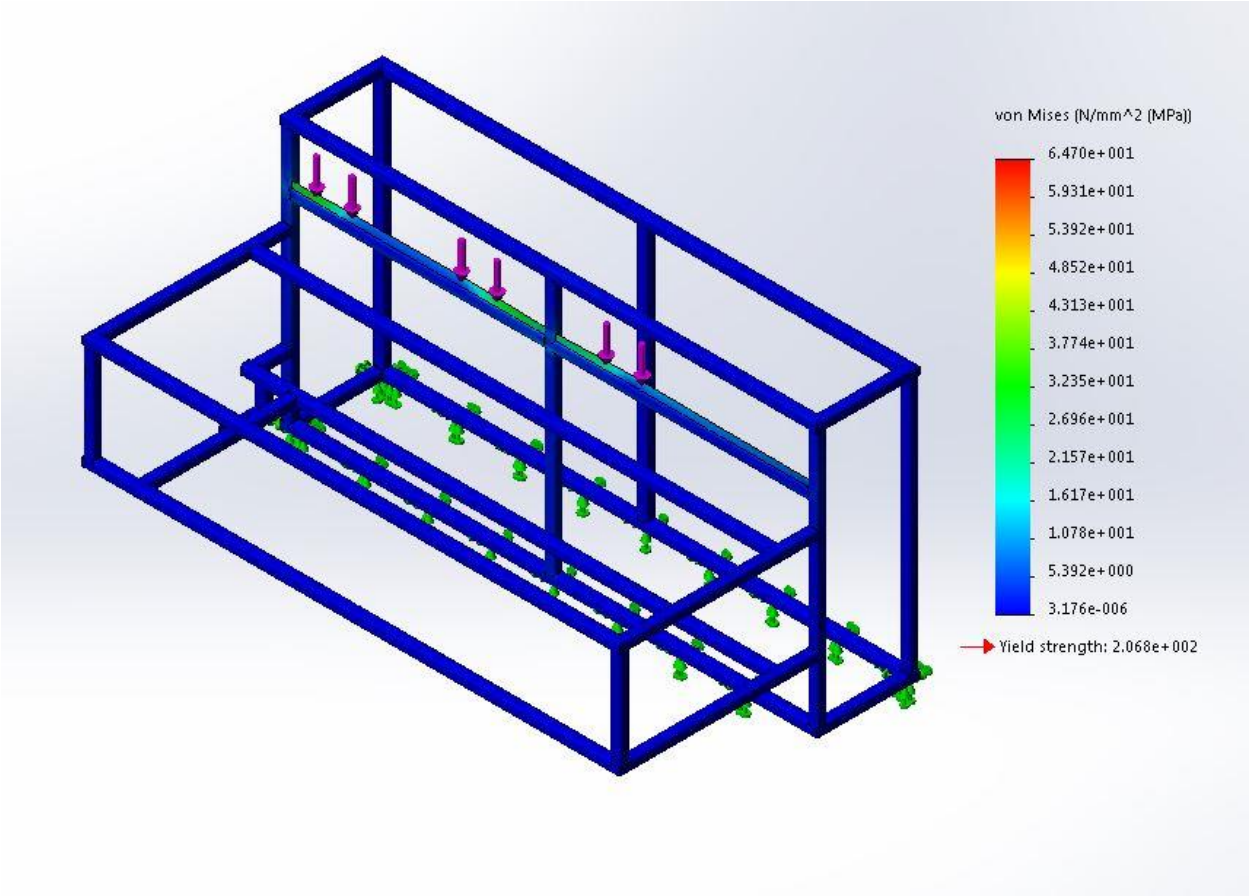

Figure 5.4 Simulation Stress generated

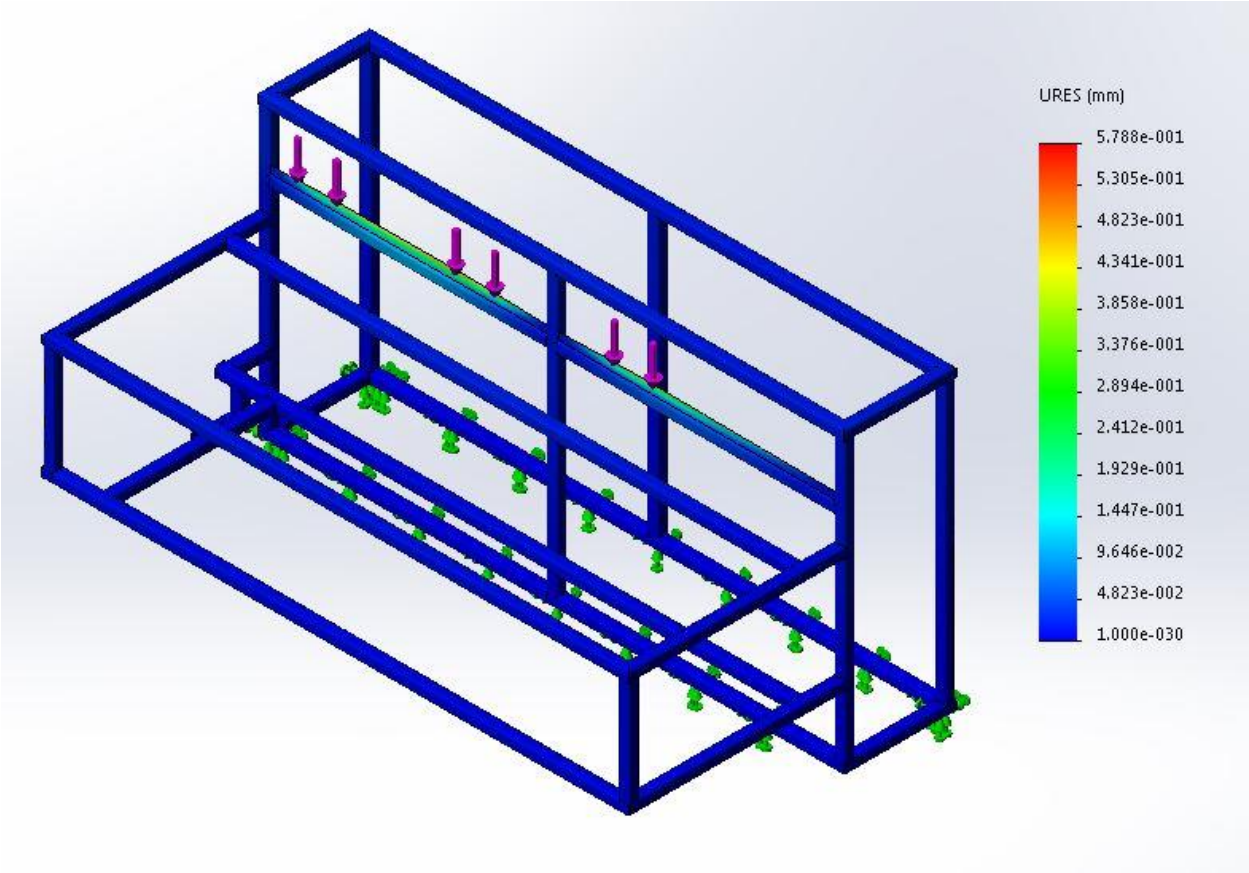

Figure 5.5 Simulation Deformation generated

5.3 Industrial Drafting

Manufacturing drawings are important as they display the complete information regarding the machinability.

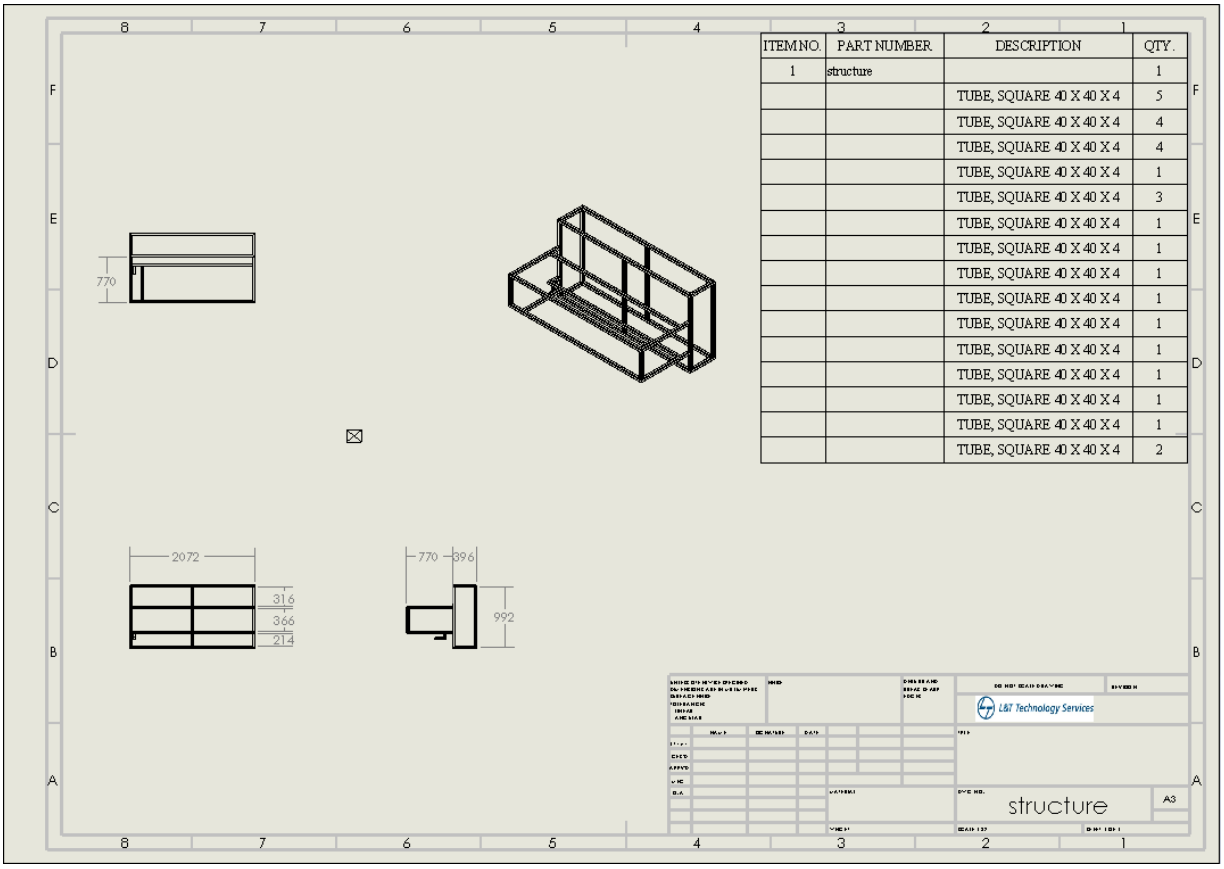

Figure 5.6 Structure

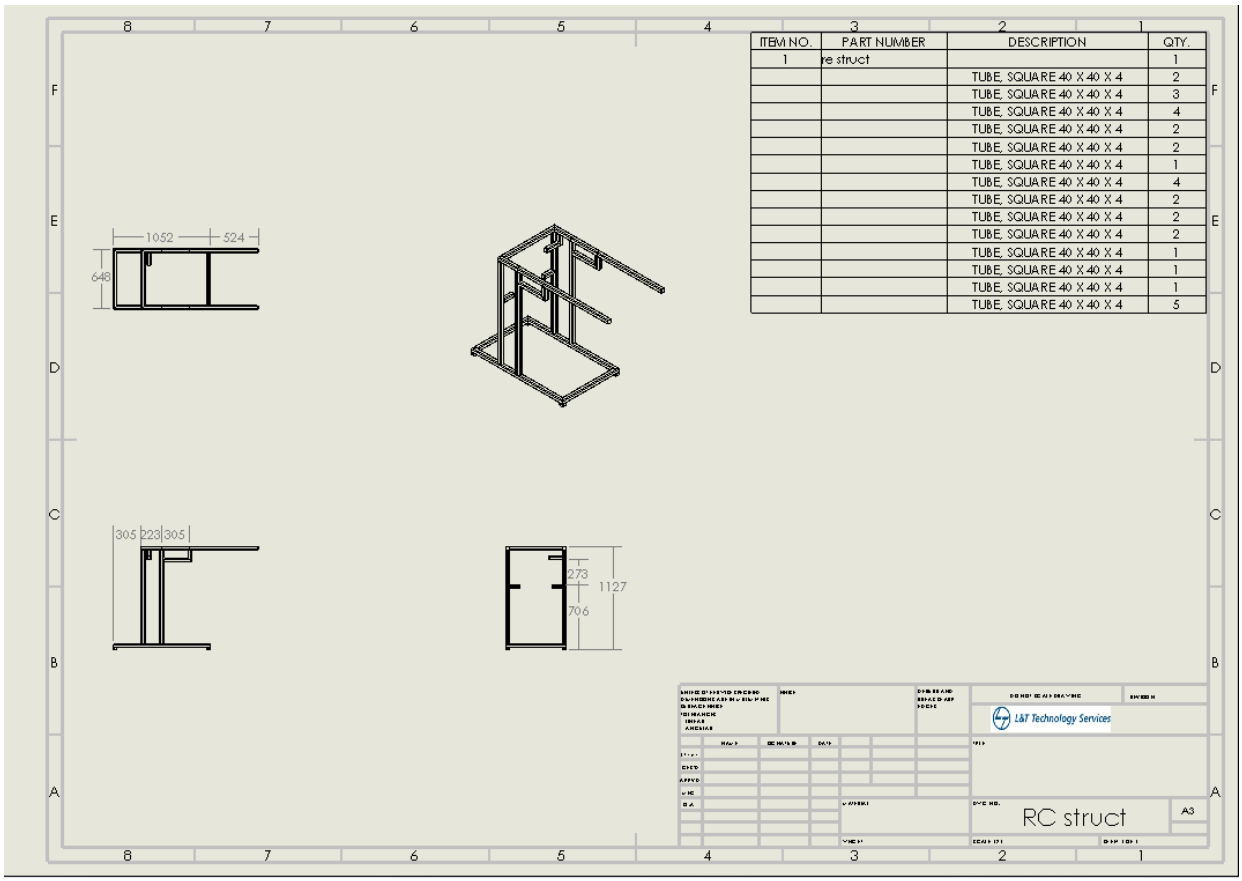

Figure 5.7 Retractable Conveyor Structure

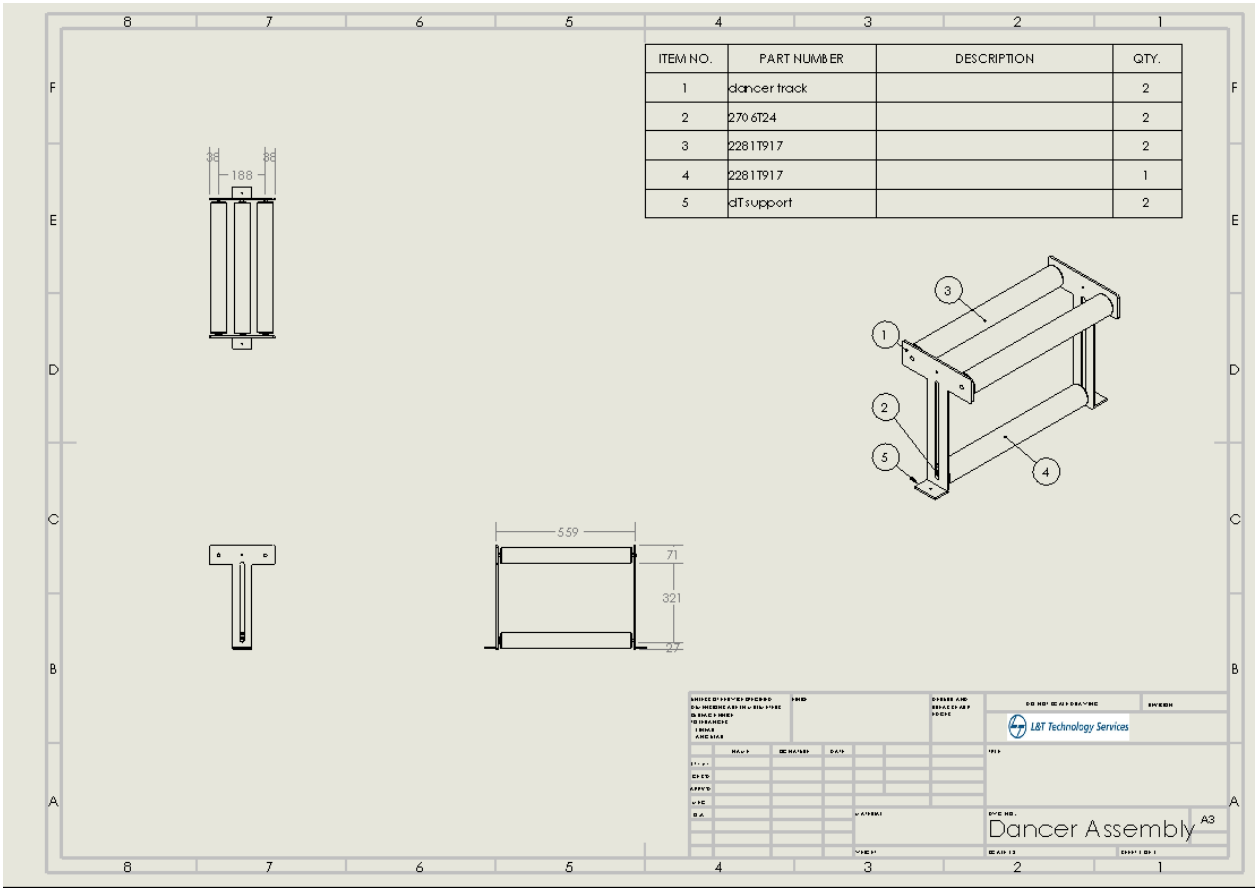

Figure 5.8 Dancer Assembly

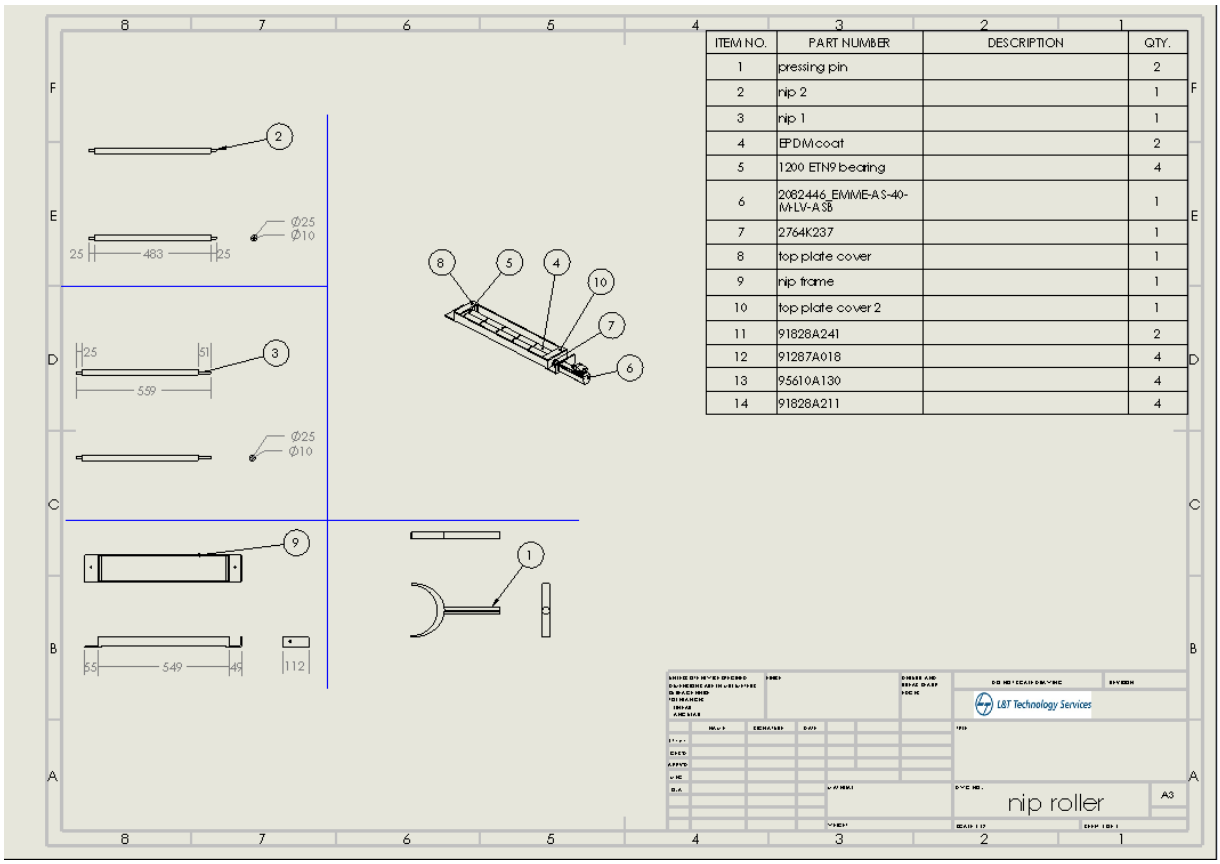

Figure 5.9 Nip Roller Assembly

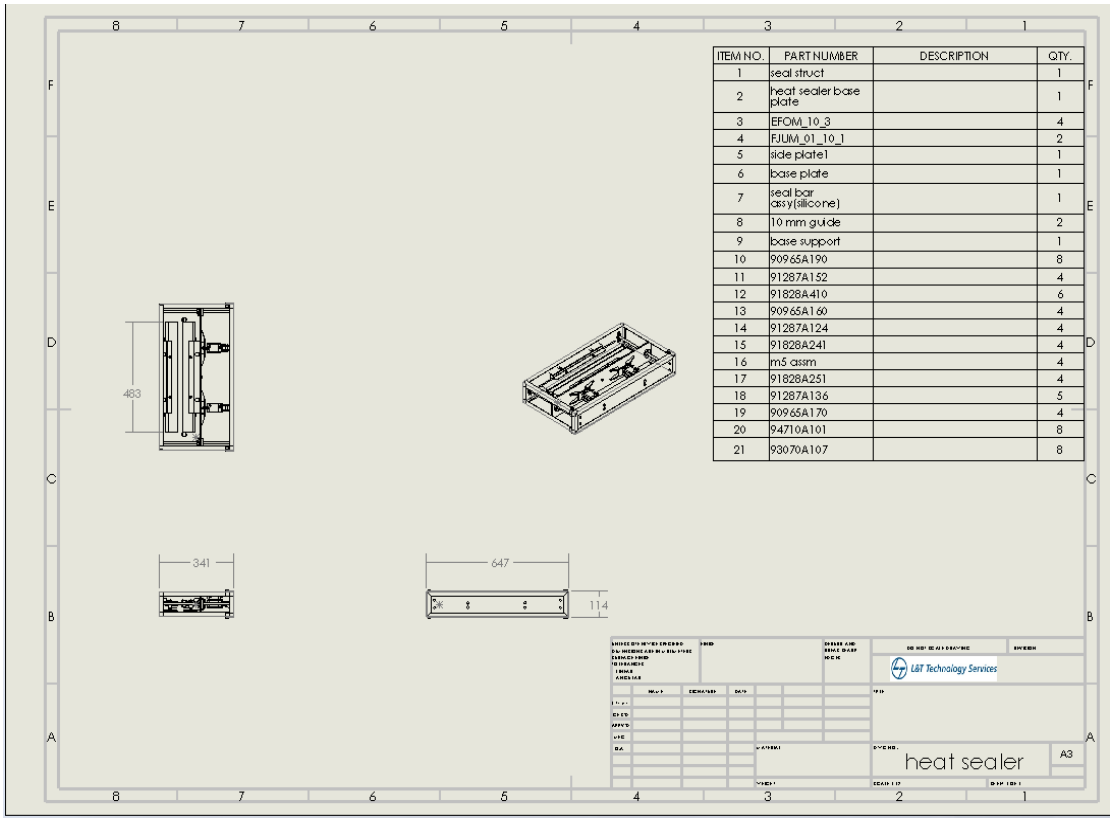

Figure 5.10 Heat Sealer

Chapter 6

Conclusion and Future Scope

6.1 Conclusion

The aim of the work is to automate the primary meat packaging process at the slaughter house. Meat is a delicate and perishable food item so to pack the variable sizes multi bag dispensing machine is conceptualized and design using the first principle is carried out. To achieve the objective three different concepts were conceptualize considering the functions, flexibility and productivity and cost requirements a concept is chosen and designed.

The design is carried out up to the level of mechanical design of the system and manufacturing requirements of the machine. Material selection has been done considering the needs of food Industry standards most of the automation components have been selected from the standard automation components available.

The 3D CAD model, Industrial drafting and manufacturing drawings are solid modeled in software.

6.2 Future Scope

The Proof of Concept (POC) to be carried and validating the designed concept can be carried out. It can be done using alternatives instead of standard automation components at the first stage. Once the concept is validated the machine can be developed using the BOM (bill of material) and manufacturing drawings.

In future, the concept can be allied with the new advances in technology of meat processing. Also, can be in line with the sealing machines like Modified Atmosphere Packaging, Vacuum Packaging etc. Also, the packaging on machine can be commercialized in global market as it has been designed considering the European and American standards of FDA

References

[1] http://www.lnttechservices.com/about-us/company-profile.

[2] http://www.encyclopedia.chicagohistory.org/pages/804.html.

[3] https://www.studystack.com/flashcard-2346681?cv=1.

[4] "A History of the Meat Industry ANSC 3404 PUBLISHED BY THE AMERICAN MEAT SCIENCE ASSOCIATION."

[5] http://www.ivcie.be/en/page.php?pageId=513.

[6] R. Shaw, *Food Packaging: 9 Types and Differences Explained*. Assemblies Unlimited.

[7] A. M. Finnen, "Paper 9: History and Development of Flexible Packaging," *Proc. Inst. Mech. Eng. Conf. Proc.*, vol. 181, no. 5, pp. 52–60, Jun. 1966.

[8] G. H. Zhou, X. L. Xu, and Y. Liu, "Preservation technologies for fresh meat – A review," *Meat Sci.*, vol. 86, no. 1, pp. 119–128, Sep. 2010.

[9] A. Cole, "Retail Packaging Systems for Fresh Red Meat Cuts Economic and Marketing Factors," vol. 39, 1986.

[10] Z. Fang, Y. Zhao, R. D. Warner, and S. K. Johnson, "Active and intelligent packaging in meat industry," *Trends Food Sci. Technol.*, vol. 61, no. January, pp. 60–71, 2017.

[11] J. Holah, "Hygiene in Food Processing and Manufacturing," in *Food Safety Management*, Elsevier, 2014, pp. 623–659.

[12] Y. Wang, D. Wang, X. Shen, Y. Chen, and H. Zhan, "(12) Patent Application Publication (10) Pub. No.: US 2017/0172920 A1," 2017.

[13] "Multiple web tension stand," 2016.

[14] “Dancer arm for constant tensile stressing,” 08-Dec-2006.

[15] A. C. T. Aarts, S. J. L. van Eijndhoven, L. H. Saes, and E. Clevers, “The pressure distribution in nips of systems of flexible rubber-covered rollers,” *Int. J. Mech. Sci.*, vol. 64, no. 1, pp. 155–164, Nov. 2012.

[16] http://mengesroller.com/services/roller-design-engineering-services/.

[17] https://www.converteraccessory.com/products/rollers/dancer.php.

[18] D. T. Controller, “S4 INSTALLATION and OPERATION S-4,” 1947.

[19] http://www.tossheatseal.com/images/products/jaw-bars-large.png.

[20] https://www.seton.ca/ansi-safety-labels-warning-electrical-hazard-authorized-personnel-only-w3529.html

[21] D. R. Roisum, “What is The Best Tension for My Product?,” 2006.

[22] H. S. Technology, “Jaw force,” pp. 1–2.

[23] https://www.schmalz.com/en/vacuum-knowledge/the-vacuum-system-and-its-components/system-design-calculation-example/theoretical-holding-force-of-a-suction-cup/