Design and Development of Cost Effective and Portable Blister Packing Machine

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Declaration

I certify that this research work titled "*Design and Development of Cost Effective and Portable Blister Packing Machine "* is my own work. The work has not been presented elsewhere for assessment. The material that has been used from other sources it has been properly acknowledged / referred.

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Abstract

Blister Packing is a packaging technique in which plastic (PVC Shell) covering the product to be packed is fused to the cardboard. This equipment is widely used in variety of sectors including pharmaceutical, electronic and hardware industries. Despite having huge applicability in packaging domain, these machines are not affordable for small business setup. The goal of this project is to create portable, cost effective and fundamental blister packing machine which meets local market requirements. Moreover, its manufacturing should be simple and purely based on local materials so that any fault during operations can be recovered by operator using local spares. The concept is based on reverse engineering to develop manual blister packing machine. Blister Packaging of any product by this machine involves several processes. Placing a wooden or metal mold under the heating element before adding the shell to the mold is the foremost step. The product to be packed is placed within the shell and shell is covered with laminated cardboard or boxboard placed on top of the mold. This machine uses heat to create a seal between the PVC shell and the cardboard backing. The thickness of PVC Sheet and its type is taken into consideration while adjusting heating element's temperature. The temperature is kept slightly higher than the point at which sheets softens. Transmission of heat starts upon manual pressing of hand lever. Lever is designed in such a way that it applies regular pressure for uniform distribution of heat with the use of an average person's hand power. In last, hand lever is depressed, and product is allowed to be cooled at room temperature for a short interval to finally pack the requisite product.

Key words: *Blister packing, PVC shells, Heating element, Cardboard, Wooden Mold*

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Chapter 1: Introduction

Blister packaging is type of packaging which uses heat to form seal between PVC shells and cardboard or aluminum backing. Vacuum formed molds completely cover the object and prevent it from minor damages as well as contamination. It is a cost effective and time saving packaging method.

1.1 Background

Few decades ago, pills were packed and stored in glass tubes, bottles, metal boxes and bags. Some medicines contain chemicals or elements which can react with air and pills get contaminated. Due to these reasons medicines was not readily available for patients as well as pills storage was also a big problem. keeping in mind these issues, scientists developed a way to store medicines for long time.

The original inventor of blister packaging machine cannot be verified but first patent of blister packing machine was registered by Enock Ancer on Feb 18,1947. Later, many scientists invented molds for specific applications.

Blister packaging was introduced in pharmaceutical industries back in 1960s.Purpose of blister packaging was to keep pills safe and secure and prevent them from contamination. Blister packaging made it easy for consumers or patients to take one pill out of blister pack and remaining pill remains safe and packed. Later, many types of advancements came, but in start there was single concept of joining PVC shells with aluminum foil. [1]

1.2 Types of blister packings

There are four major types of blister packaging

1.2.1 Face seal blister

In face seal blister cardboard is not completely covered with the shell. This is cheapest type of blister packaging. This type of packing is easy to open it does not provide much strength as compared to other types. This packing is also called as peel off blister. [2]

Figure 1 Face seal blister packing

1.2.2 Full face seal blister

In full face seal blister cardboard or aluminum foil is completely covered with PVC shells. It provides extra strength at edges as well as at top of shell. Mostly this type of packing is used in pharmaceutical industries while packing pills.it is also called push through blister. [2]

Figure 2Full face seal blister packing

1.2.3 Full card blister.

In full card blister PVC shells are made in such a way that it can slide over cardboard. No heat sealing is required in this process. Advantage of this packing is that it can be re-used. This is commonly used in tools packing. [2]

Figure 3 Full Card Blister Packing

1.2.4 Clamshell blister

In clamshell blister no cardboard is used only PVC is required. Two half shells are made with vacuum forming and they are joined together by using heat or by using low clearance sliding. This type of blister provides extra strength. Mostly electronics are packed in clamshells. [2]

Figure 4 Clamshell blister Packing

1.3 Blister packing Process [3]

1. Wooden mold of required shape
2. PVC shells of desired object
3. Place PVC shells in wooden mold
4. Fill product in the shells
5. Place cardboard or aluminum foil at the top of wooden or metal mold
6. Apply heat with pressure at top of cardboard

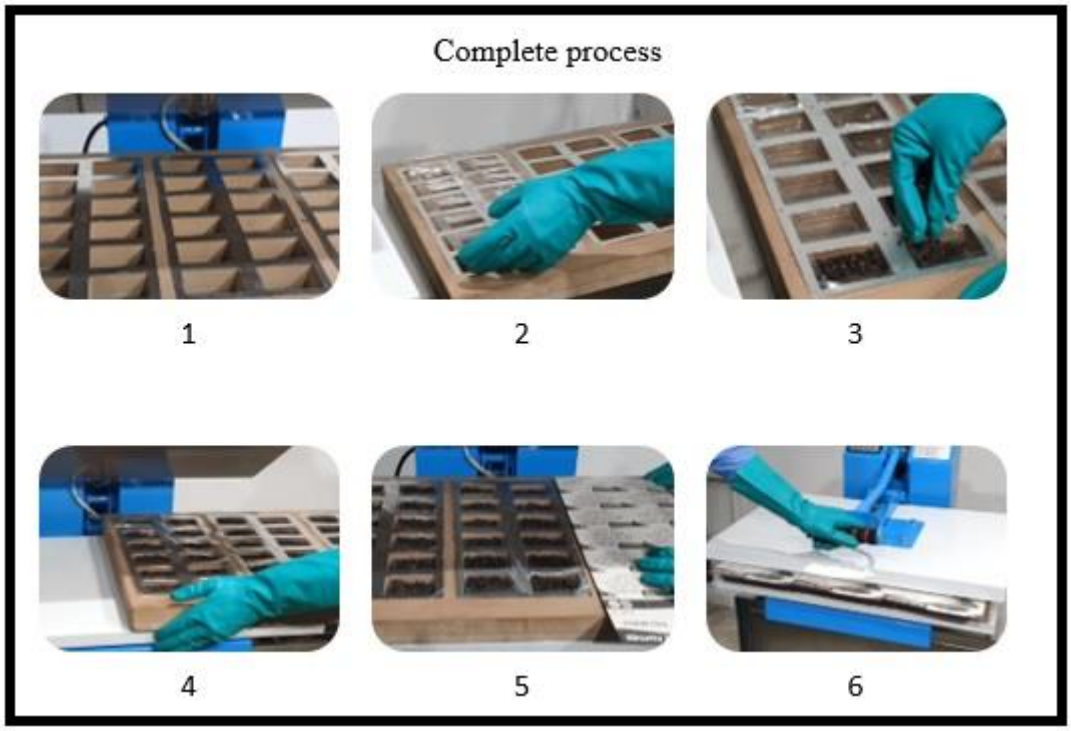

Figure 5 Steps involved in blister packing

1.4 Importance

Now a days blister packing is extensively used in almost every industry. Major contribution of blister pack is in pharmaceutical industry. It is a low-cost packing method as well as it has huge list of benefits in every field. [4]

1. It provides visibility to product
2. Cardboard has plenty of area advertisement as well as instructions
3. Cost effective
4. Resistant to tempering
5. Light weight
6. Improved shelf life

1.5 Applications

The use of blister packing is expanding rapidly across the board. Although we can't put everything in blister packing, it is a vital technique for handling a wide range of products. Blister packing equipment is utilized globally in several important industries, including: [5]

1. Hardware industry (Pliers ,Screw drivers)
2. Electronics (Mouse, USB drives)
3. Food industry (Butter, Candies)
4. Pharmaceutical industry (Tablets, Vaccines)
5. Automotive industry(LEDs)
6. Stationary (Colors, Thumb pins)
7. Toys industry (Hot wheels cars)

These are a few industries which are using blister packaging:

1. Camelion

2. Shield
3. Glaxo smith Kline
4. Dell
5. Phillips
6. Gillette

Figure 6 Blister packed Products

1.6 Motivation

Numerous technologies are available internationally but are not available in Pakistan. Despite the fact that numerous large enterprises in Pakistan import blister packing machines with numerous characteristics. Small businesses and industries cannot afford expensive products. Many parts are not readily available locally, the cost of local development of an identical machine is higher. Customized solution is significant because machine in international market has many functionalities and eventually gets expensive ,whereas our local market only need few functions. A machine will cost much less and be more efficiently customized if it is made to our specifications with the fewest necessary features. However, creating such a tailored solution requires thorough R&D of the currently in use machine and collaboration with local industry partners so that a solution may be made specifically for our local market.

After interacting with local packing machine manufacturers it was revealed that simple blister packing machines are not available in Pakistan however fully automated imported blister machine are available. This encouraged the machine's local and indigenous development.

1.7 Impact on local Industry

1.7.1 Utilization of local material and parts

All material and parts used in manufacturing this machine were purchased from local markets including bolts, Mild steel sheets, springs controller and heater.

1.7.2 Reduction in import bills

This machine, nevertheless, lacks many other capabilities, can still offer the vital function of heat sealing and is an alternative to expensive international machines. This machine is produced locally, which results in much lower manufacturing costs.

1.7.3 Small industries startup

Every sector, regardless of size, requires effective packaging for their products. In Pakistan, large number of individuals offer homemade goods like toys, handicrafts, food, etc. This machine gives them access to a quick and affordable local packaging solution, it enables them to both grow their existing businesses and establish new ones.

1.7.4 Employment creation

Manufacturing of machinery in local market provide several job opportunities. In the future, it will undoubtedly increase the number of jobs. Engineers and technical personnel were originally involved, then many more people with technical skills including welders, machinists, and painters performed their tasks.

1.8 Objective

Design and Development of portable Plate type Blister Packing Machine

1. Cost effective and user friendly
2. Indigenous solution

Chapter 2: Literature review

2.1 Basic configurations of blister packaging

There are two basic configurations of blister packaging. In one variety blister cavity is formed with the clear plastic sheet (PVC, PET, PVDC, etc.) and back side of shell is covered with either aluminum foil or cardboard backing this configuration is commonly used. Another configuration is to make blister cavities in aluminum foil by cold forming and lidding material is also aluminum this type is also called as alu-alu packing. [6]

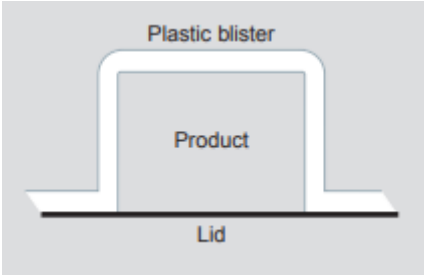

Figure 7 Configuration of Blister packing

2.2 Components of blister packing

There are four components involved in blister packaging

1. Forming film
2. Lidding material
3. Printing ink
4. Heat seal coat

Lidding material is first coated with primer ink (company name or product information) then heat seal coat is done. There are different materials used as heat seal coat, but PVDC is commonly used because it has significant resistance against moisture and vapors.

Table I: Comparison of forming films.

Type and Thickness of Forming Film (mil)	WVTR ($g/m^2/day$)*	Price per Unit Area**
PVC (10)	1.1	1
PVC/PVDC (10/1.2)	0.17	2.1
PVC/CTFE (8/0.76)	0.07	2.1
PP (12)	0.20	1.3
PET (10)	2.6	1.4
PS (12)	6	1.2
OPA/aluminum/PVC (1/1.8/2.4)	0	2.9

*As measured on the unformed film at an ambient temperature of 20 °C and 85% RH.
**Where 1 represents the price per unit area of 10-mil PVC.

Figure 8 Sheet Types and Properties

This figure shows the comparison of different types of material, their thicknesses as well as cost and WVTR.

WVTR is water vapor transmission rate, the rate at which water vapor permeates through solid over specific period.

Thicknesses are given in mil where mil is known as thousand of an inch. To understand, ,10 mil PVC has thickness of 0.254 millimeter. [6]

2.3 Thermoplastic material types and properties

Blister shells can be made from a variety of materials. Each substance has unique characteristics and uses.

Figure 9 Thermoplastic Sheets

2.3.1 PVC (Polyvinyl Chloride)

PVC is a versatile, inexpensive plastic that is ideal for use in blister packaging. It has the following properties

1. Molding temperature 40-60 C
2. Melting temperature 89 C
3. Density 1.4 g/cm3
4. Water absorption 24 hours (0.1 to 0.4 percent)
5. Provide medium to high strength

PVC is simple to form and pack since the melting and molding temperatures are both lower. Another advantage is that packing uses less heating power, which saves money. [7]

2.3.2 PVDC (Polyvinylidene chloride)

Polyvinylidene chloride is made by polymerization of vinylidene and chloride. It has great properties aesthetically as well as technically.it can change color at different temperatures.it is mostly used in food packaging because of its low permeability to gases and vapors. Following are the properties

1. Moisture regain is less than 0.1%
2. High elastic recovery
3. Excellent gloss
4. Density 1.7 g/cm3
5. Softening point 145 to 165 C
6. Flame redundant
7. High strength

Due to its high cost and limited supply, PVDC is only utilized in blister packaging for a few specific applications, such as protecting food products from moisture and gases and some components that need to look good. [8]

2.3.3 PP (polypropylene)

PP is a polymer with great chemical resistance that is sanitary and versatile. PP that cannot crystallize has a low melting point, despite some grades having a high melting point and high density. It has a variety of characteristics and uses, including the following.

1. Thermally bondable
2. Strong
3. Lightweight
4. Moisture regain 0.1%
5. Melting point 180 C (crystallizable grade)

Due to its limited availability, PP is only used in a very limited number of applications. [7]

2.3.4 PETG (Co Polyester)

Combining polyester and diols produces PETG (polyethylene terephthalate glycol). They have many different applications. This packaging material is used mostly for medical accessories. It has a range of colors and is easily molded into complicated shapes. Here are a few characteristics of PETG. [9]

1. Melting temp 81-91 C
2. High impact strength
3. Good chemical resistance
4. Easy to form
5. Density 1.26 g/cm3

2.4 How to choose the right material for blister

This choice is entirely dependent on the application. Packaging made of PVC and aluminum is used in the pharmaceutical industry. Tools are typically packaged in full card blister packaging, and since heat sealing is not necessary, any form of thermoplastic can be used.

Due to its low cost and widespread availability, PVC is traditionally the thermoplastic most employed in the packaging sector.

Heater temperature is kept a little higher than PVC melting point since PVC can be packed at temperatures between 85 and 95 C. [10]

2.5 Types of blister packing machines

Based on operating process fully automated blister machines are divided into three types [11]

1. Roller type blister packaging machine
2. Plate type blister packaging machine
3. Roller plate type blister packaging machine

2.5.1 Roller type blister packaging machine

In a roller-type machine, the heating cylinder meets the mold cylinder, creating a line contact that allows for instant heat sealing. This machine is mostly used in the pharmaceutical industry. This type has the restriction that it cannot pack stiffer or larger products.

The feed rate of the rollers determines how quickly a product is produced; however, this has restrictions because the heating process needs a certain amount of time to pack products properly. [12]

Figure 10 Roller type Blister Packing machine

2.5.2 Plate type blister packaging machine

In this type, the heating element is a flat plate, and the molds that contain the product-filled shells are similarly flat. Heater and mold come into contact on the surface. The heating area affects operation speed. The ability to pack stiff products like toys or large items is a major benefit of flat type machines. More height is provided for the products. Depending on the size of the machine, cavities can be made bigger. [12]

Figure 11 Plate Type Blister Packing Machine

2.5.3 Roller Plate type blister packing machine

This kind of blister machine combines both flat and roller types. In a roller plate type machine, the mold is flat while the heating element is a roller type. Between the roller and the plate, there is a line contact. Due to the complexity of the structure, only little adjustments are permitted. These devices are intended for certain uses. [12]

Figure 12 Roller Plate type Blister packing Machine

2.6 Further classification of plate type blister packing machines

Depending on operation scale and applications plate type blister packing machines can be divided further [11]

1. Fully automated blister machine
2. Semi-automated blister packing machine
3. Hand operated blister packing machine

Figure 13 Automated vs manual Blister Packing Machine

2.7 Components of Hand operated plate type blister packing machine

1. Flat plate cast-in aluminum heater
2. Temperature Controller
3. Temperature sensor
4. Molds for packaging [13]

2.8 Heating elements

Flat plate type aluminum heaters can be made by using various types of heating elements [14]

1. Cartridge heater
2. Single pass tubular heater
3. Bendable tubular heating element

All these heaters can be used or plate heating. These elements have various temperature ranges and properties.

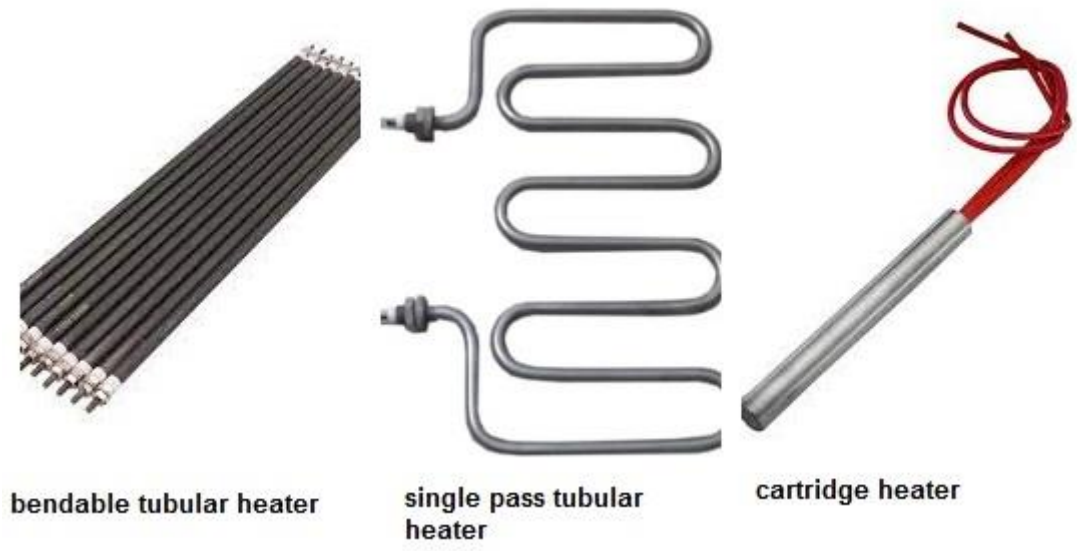

Figure 14 Heating Elements

2.8.1 Cartridge heater

There are three types of cartridge heaters [15]

1. Low density
2. High density
3. Medium density

Table 1 Cartridge heater Properties

Temperature range	Up to 800 C
density	Up to 50 watt /cm2
Operating voltage	12v DC, 220- or 440-volt AC

2.8.2 Single pass tubular heater

These heaters are wet type, and they can be molded into almost any shape. Tubular heaters provide uniform heating, and these are most commonly used in cast in aluminum plates. [15]

Table 2 Single Pass Tubular heater Properties

Temperature range	Up to 650 C
density	12 watt/in2
Operating voltage	220 V, 440V

2.8.3 Bendable tubular heater

These heater can be molded into any shape before first time use once they are heated they become rigid. [15]

Table 3 Bendable tubular heater Properties

Temperature range	Up to 1000 C
density	15 to 75 watt/in2
Operating voltage	220 V, 440V

2.9 Controller

In process control more than 95% of the control loops are of PID or PI controller. They are used to maintain the working temperature of any system. PID controller uses relay to turn on or off the heating element by taking feedback from temperature sensor usually thermocouples.

Proportional, Integral, and Derivate refer to PID. Few systems require PID Control, as some processes just employ proportional gain, while others use proportional and integral. [16]

Figure 15 Rex C-100 PID Controller

2.9.1 Characteristics of P,I and D controller

Proportional gain Kp reduces rise time, but never eliminates the steady state error. Integral gain Ki eliminates the steady state error, but it makes the transient response worse. Derivate gain Kd improves the stability of system by reducing the overshoot and improving the transient response. All these effects are summarized in the table 4. [17]

Table 4 P,I and D Characteristics

CL RESPONSE	RISE TIME	OVERSHOOT	SETTLING TIME	S-S ERROR

Kp	Decrease	Increase	Small Change	Decrease
Ki	Decrease	Increase	Increase	Eliminate
Kd	Small Change	Decrease	Decrease	Small Change

2.10 Temperature Sensors

We can use two type of temperature sensor with PID controller

1. Thermocouple
2. RTD

Both thermocouples and resistance temperature detectors RTDs are used to monitor temperature. These sensors are chosen over other types because they simplify measurement taking and prevent laborious conversion processes. Table 5 explains their main distinctions. [18]

Table 5 RTD vs Thermocouple Properties

	RTD	**Thermocouple**
Temperature Range	-200°C to 500 °C.	−180 °C to 2,320 °C.
Stability	Highly stable	Poor stability
Accuracy	More accurate	Less accuracy
Sensitivity	Highly sensitive	Less sensitive
Response time	Less than thermocouple	More than RTD
Output	Linear	Non-Linear
Cost	Expensive	Cheaper than RTD

2.11 Molds

To create the desired blister shells, molds are needed. Molds can be made of metal or wood, but the simpler method is to build a wooden mold with a metal lining on top. Maintaining a precise level mold surface is crucial. Accurate heat sealing is provided by an even surface.

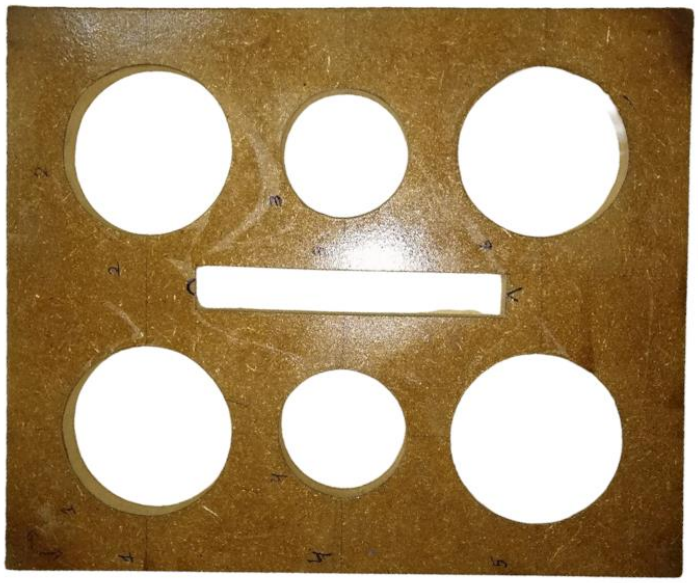

Figure 16 Round Wooden Mold for Thermoforming

Figure 17 Square Wooden Mold for Thermoforming

A wooden mold with a metal lining was created for packing purposes. The role of the metal lining is to deliver accurate heating and pressure.

Figure 18 Round Wooden Mold with Metal Lining for blister packing

Chapter 3: Design

Any product's design adheres to a standard hierarchy. Once a problem has been discovered, design challenges that begin with considering a solution to the situation. The typical design process is shown in Figure 19.

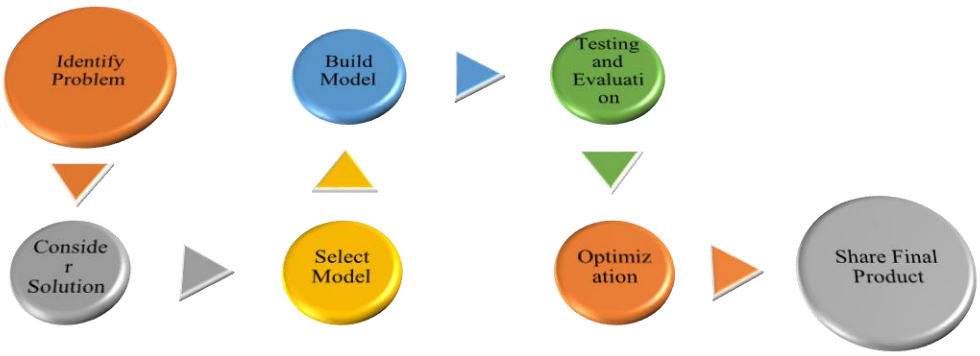

Figure 19 Design Process Steps

3.1 Engineering Materials

Although there are many different types of materials, metals are typically employed in the manufacturing of machines. There are many different types of metal, each with unique qualities and uses. [19]

3.1.1 Selection of Material

The crucial step in design is material selection. Each material has a unique strength and set of qualities. Finding the material that best meets design requirements is the goal of material selection. A good material is one that accomplishes the machine's primary goal for the least amount of money.

Either evolution or revolution govern material selection. Old materials or those that have been somewhat modified by evolution are selected. To minimize risks, evolutionary selection is frequently used. Revolutionary selection is beneficial, but it may also be hazardous and expensive because it requires more research to introduce and test new material properties.

It's important to take note of the material's machinability since cheap material that is difficult to manufacture is useless.

The lack of readily available materials in Pakistan is another issue because importing materials will raise machine costs. [20]

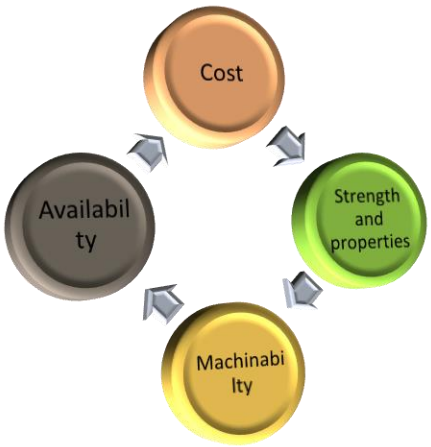

Figure 20 Material Selection Characteristics

Carbon Steel Materials Table

The table below provides representative mechanical properties for several common carbon steels.

Material	Condition	Yield Strength [ksi]	Ultimate Strength [ksi]	Elongation %	Elastic Modulus [psi]	Density [lb/in^3]	Poisson's Ratio
AISI 1020	Hot Rolled	32	50	25	29e6	0.283	0.32
	Cold Worked	60	70	5			
	Stress Relieved	50	65	10			
	Annealed	28	48	30			
	Normalized	34	55	22			
AISI 1045	Hot Rolled	45	75	15	29e6	0.283	0.32
	Cold Worked	80	90	5			
	Stress Relieved	70	80	8			
	Annealed	35	65	20			
	Normalized	48	75	15			
ASTM A36		36	58	21	29e6	0.283	0.3
ASTM A516	Grade 70	38	70	17	29e6	0.283	0.3

Figure 21 Carbon Steel Properties

3.1.2 Mild Steel

A form of carbon steel with a lower carbon percentage is called mild steel. It is additionally known as low steel carbon. Less than 0.30 percent of it is carbon. It is highly ductile but has little strength. Mild steel is a cheap and weldable type of steel. Mild steel is frequently used to make wires, sheet metal, and machine parts. This material is perfect for ordinary machine use because it is simple to machine and weld. This material is suitable for manual blister packing machine It has several advantages mentioned below. [21]

1. Low cost
2. Wide range of sheet sizes
3. Readily available
4. Easy to weld
5. Easy to machine
6. Recyclable

3.2 Design

Every design process includes some problem-driven points that define the design and working structures. Based on the heating element that was readily accessible in the local market, the initial design kept the heating area at 12" x 15" in size. Additionally, everything was planned around the heating area. [22]

3.3 CAD Model

The remaining machine elements were created in SOLIDWORKS while taking the aspect ratios of the heating plate into consideration.

3.3.1 Base Plate

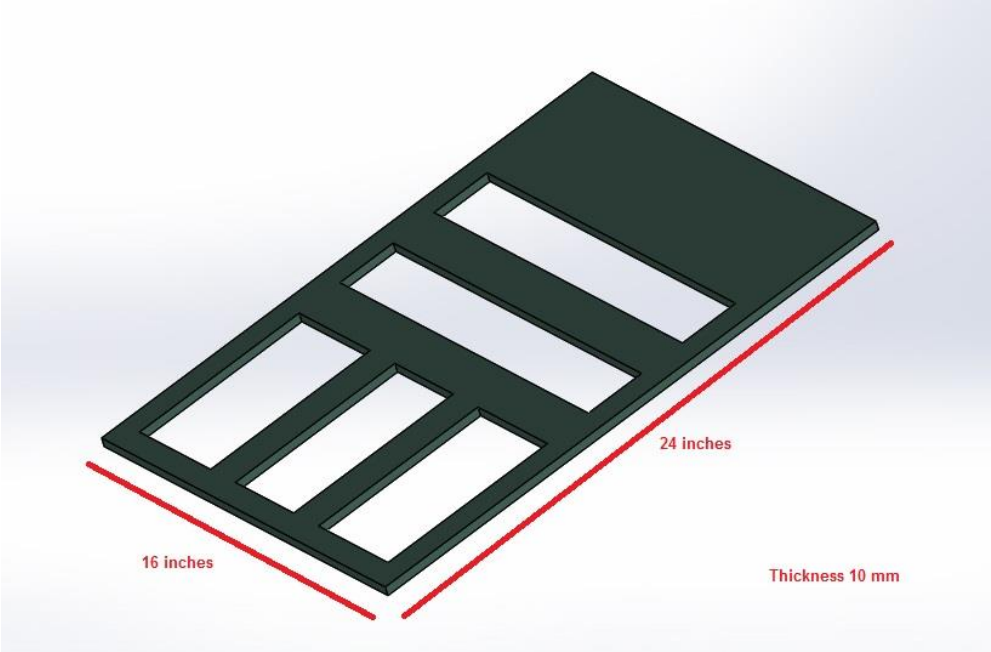

Figure 22 CAD Model Base Plate Design

The base plate is a crucial component since it serves as the foundation for all other components. Because vertical adjustment and lever movement will cover this area, the back end is kept stronger. The center of the back side will hold the entire load of heaters and levers. To reduce weight, slots are constructed at the front.

Dimensions of base plate are L 600mm * W 400mm * H 10mm.

3.3.2 Vertical column

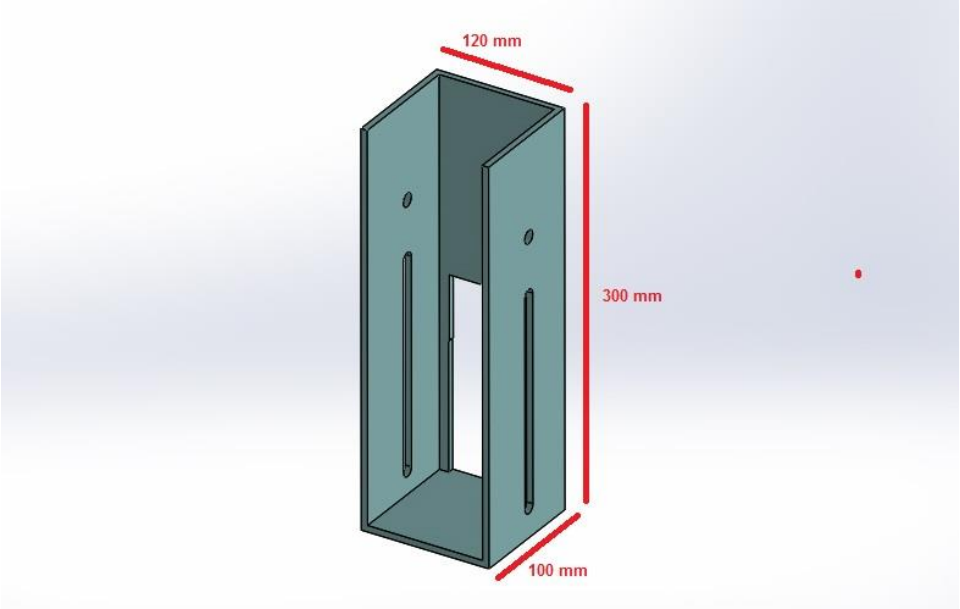

Figure 23CAD Model Vertical Column Design

This column will be fastened to the base plate's back end. Slots are made to change the heater's height in accordance with the height of the mold, while upper holes are made to attach the heater lifting lever. These holes are made to accommodate pins.

3.3.3 Lever for Lifting heater.

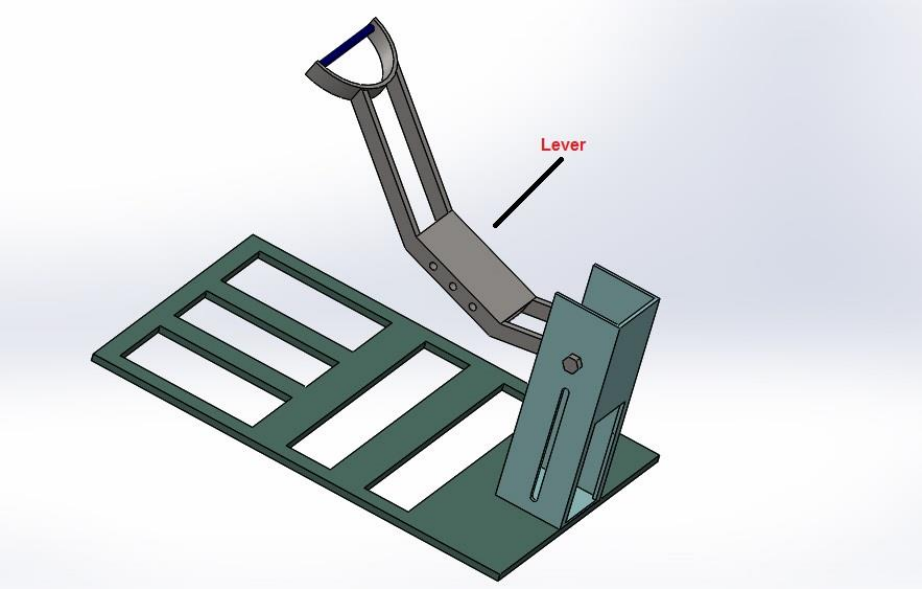

Figure 24 CAD Model Hand Lever Design

At the upper holes of the vertical column, a lever is attached. To modify the height of the lever, multiple holes are drilled in the center.

3.3.4 Vertical Adjustment Mechanism

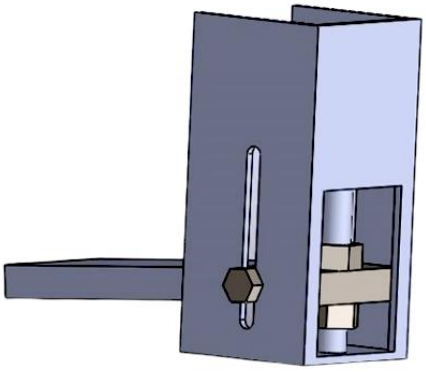

Figure 25 CAD Model Height adjustment mechanism Design

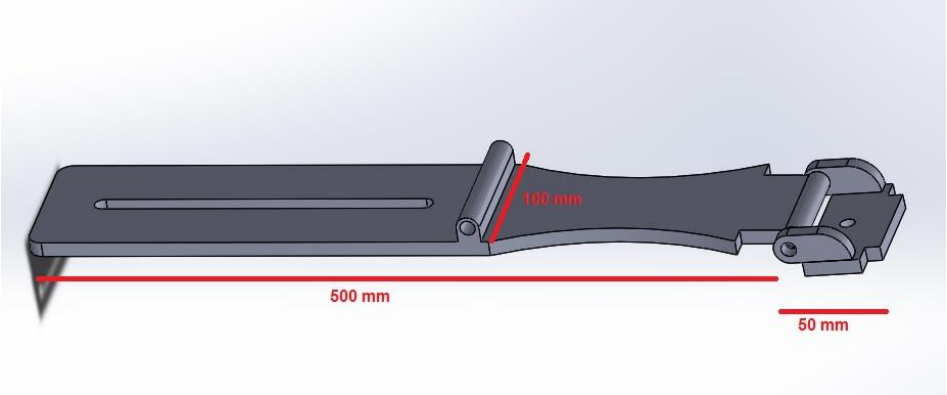

Figure 26 CAD Model heater plate lever Design

Lever, a pivot, and a plate with a hole in the middle make up the height adjustment mechanism. All of these are attached with pins, and a plate is fed through a vertical column. By twisting the nut up and down, we can alter height after the bolt has passed through the hole.

The heater plate can be adjusted horizontally via a slot in the lever plate. Figure 27 can be used to gain a thorough understanding.

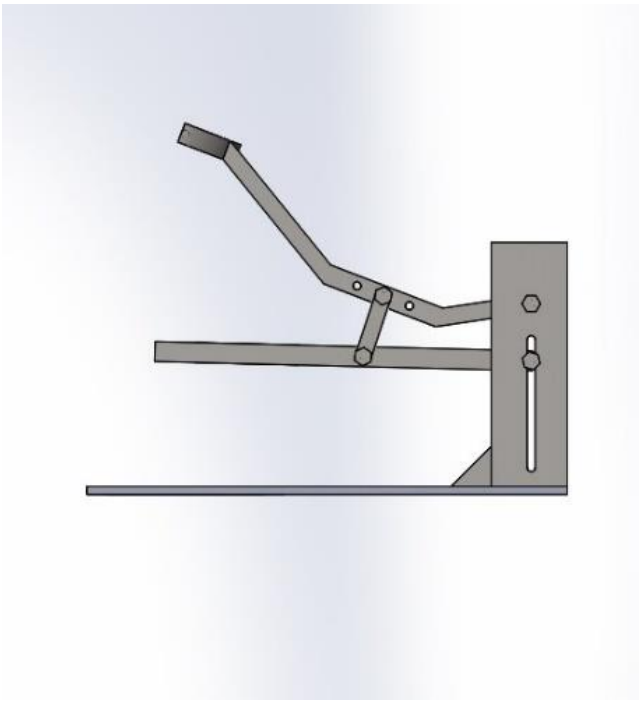

Figure 27 CAD Model levers and column assembly

3.3.5 Connecting Rods

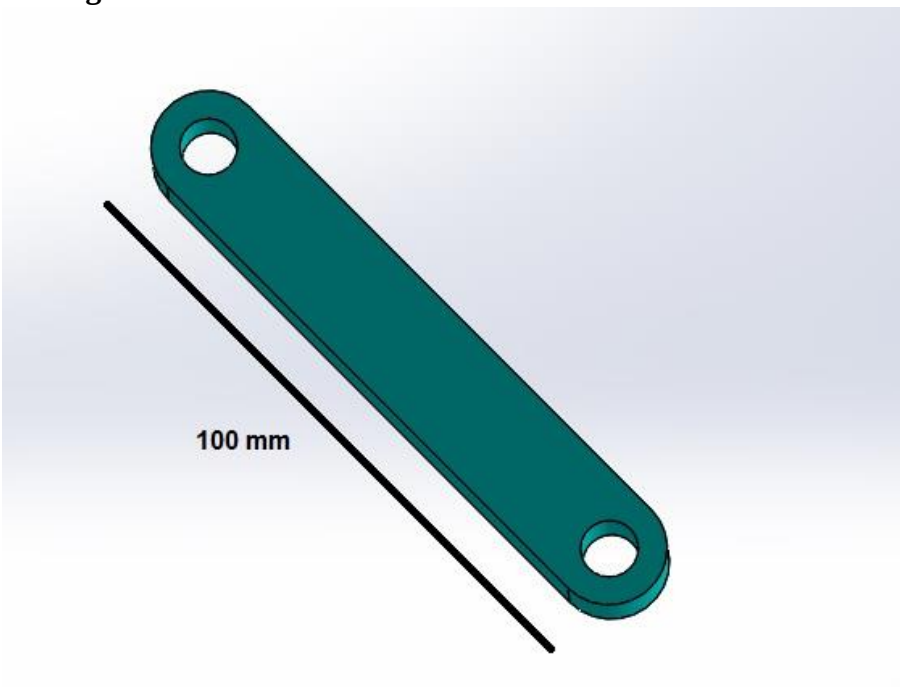

Figure 28 CAD Model Connecting rod Design

To connect the upper lever to the height adjustment lever, connecting rods measuring 10 mm in thickness and 100 mm in length are made.

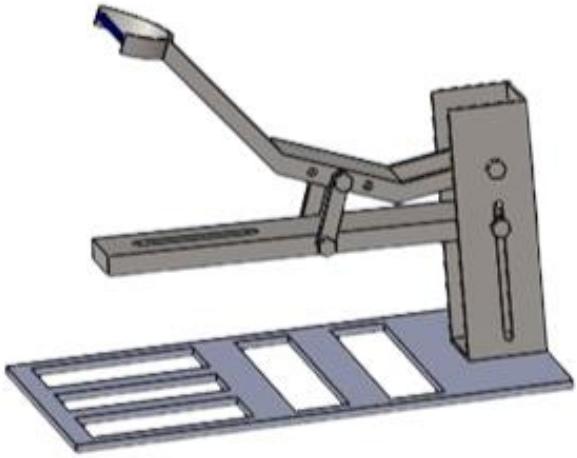

Figure 29 CAD Model connecting rod view in assembly

3.3.6 Ribs

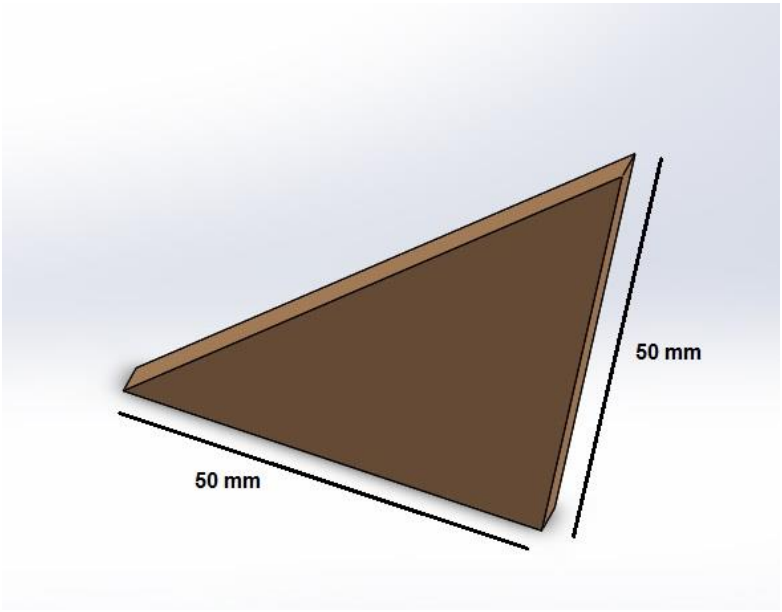

Figure 30 CAD Model Ribs Design

Ribs are made to provide extra strength and support between vertical column and base plate.

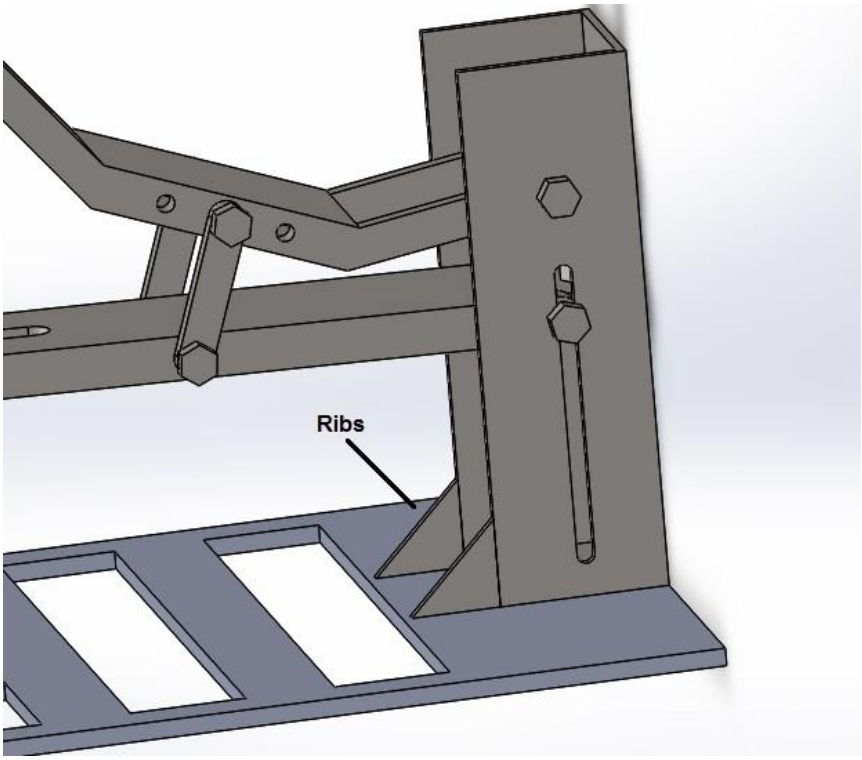

Figure 31 CAD Model ribs Supporting vertical column

3.3.7 Pins

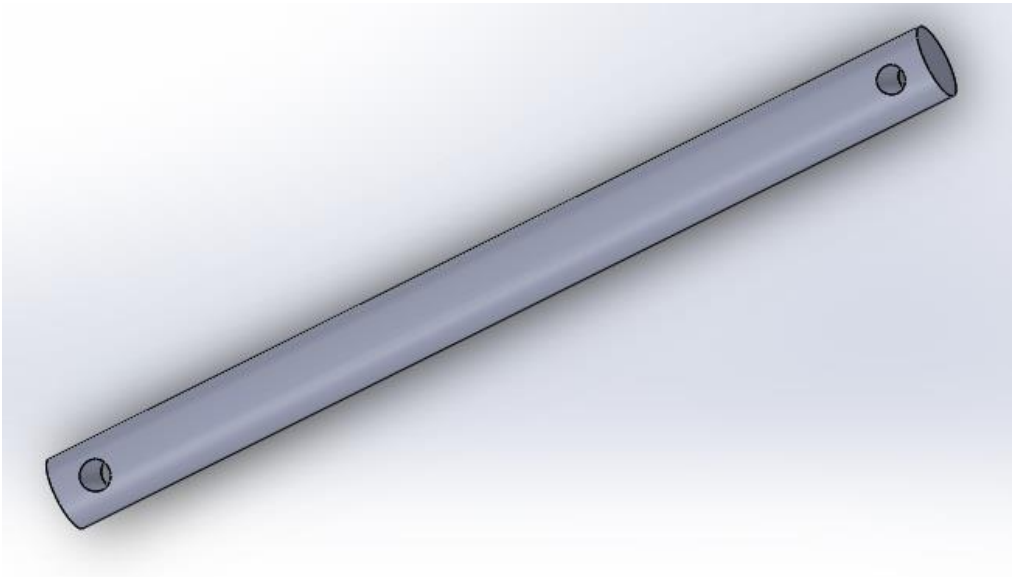

Figure 32 CAD Model Pins Design

Pins are used to connect different machine parts. Pins are 130 mm long and 9.5 mm in diameter. Cotter pins can fit through the tiny holes in both ends to provide locking.

3.3.8 Heater plate Assembly

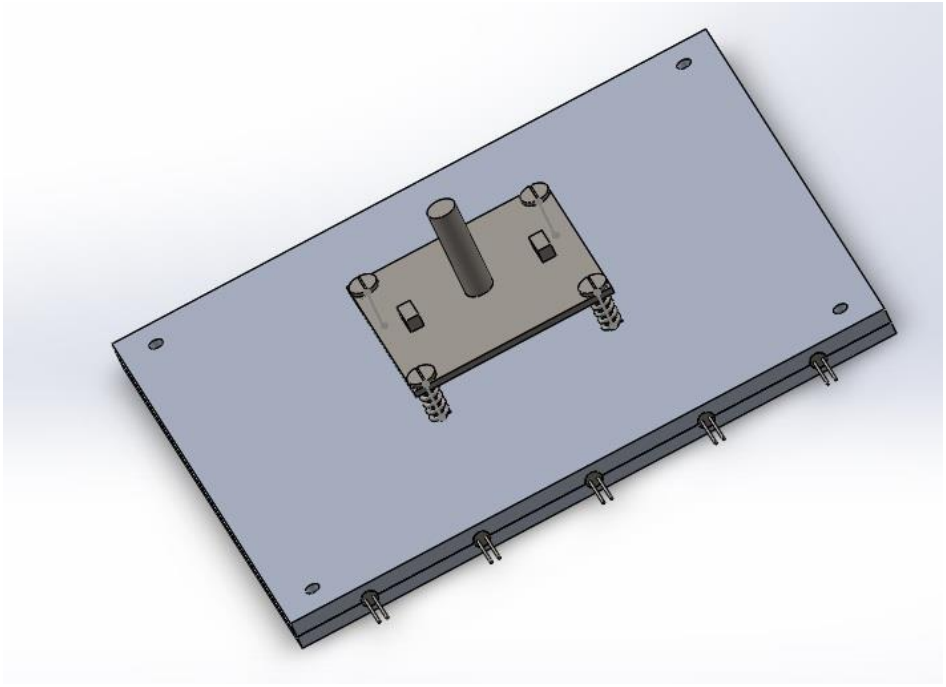

Figure 33 CAD Model heating plate assembly Design

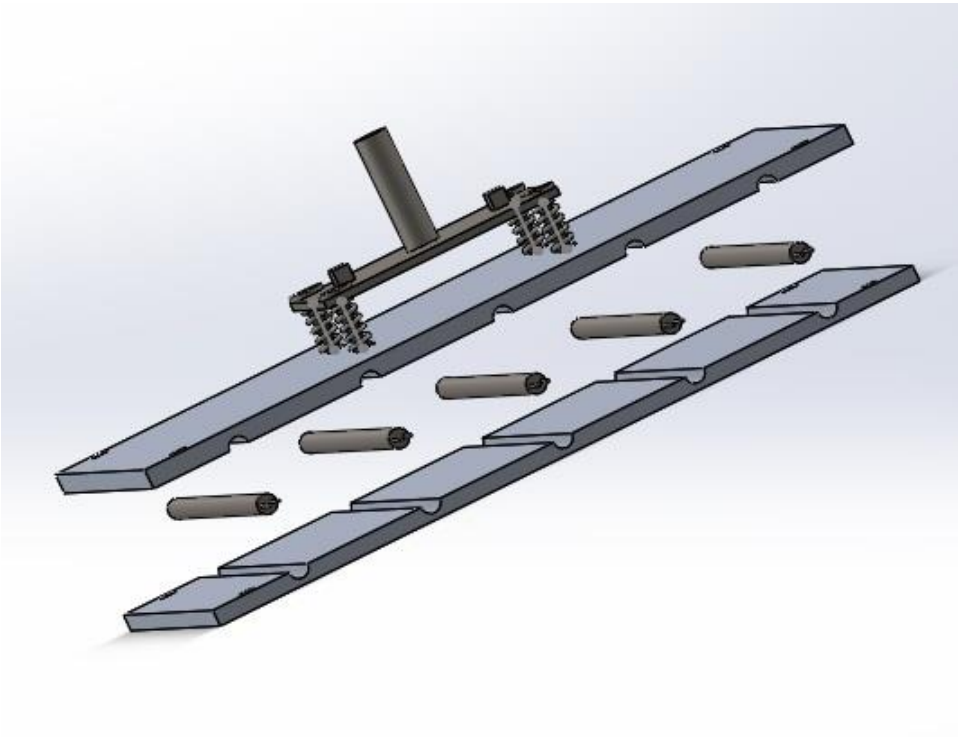

Figure 34 CAD Model heater plate exploded view

The heating element or conveniently available heater plate is part of the heater plate assembly, which also includes four springs for stability while pressing the heater.

3.4 Complete CAD Assembly

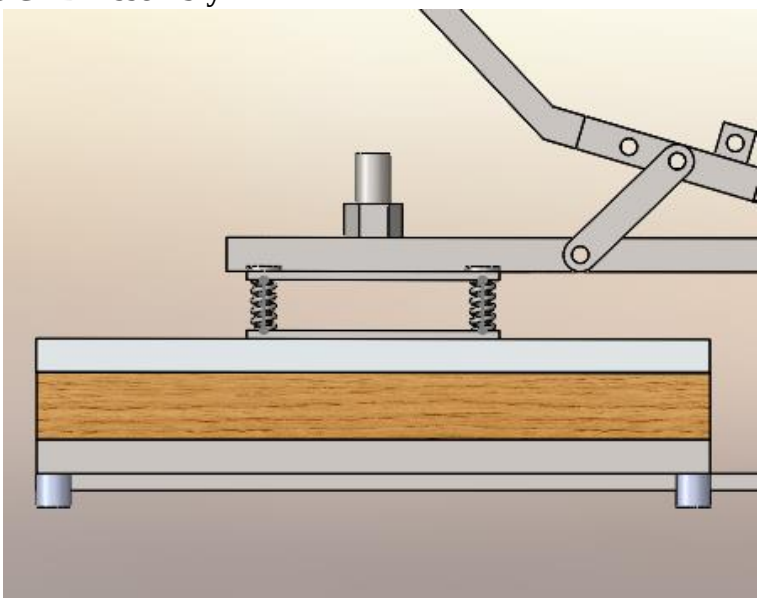

Figure 35 CAD Model Complete machine design Assembly

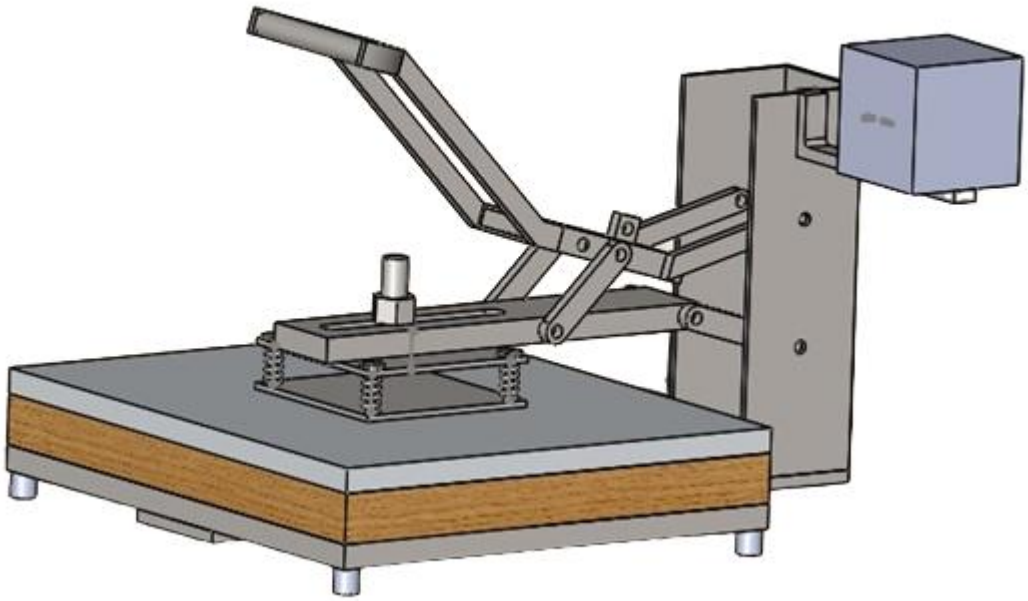

Figure 36 CAD Model 3D assembly view

Chapter 4: Manufacturing and Fabrication

The initial stage after CAD modelling is to get all the pieces made with the aid of local or University resources.

4.1 Gas Cutting by MRC NUST

Mild steel metal sheet was initially cut by MRC NUST to the desired size. [23]

Figure 37 MRC Gas cutting setup

Figure 38 MRC GAS cutting

4.2 CNC Laser Cutting

It was possible to use a CNC laser cutting facility from a nearby shop. All CAD parts' drawings were created and sent to a laser cutting facility. To minimize metal sheet waste, drawing optimization was carried out.

Laser cutting uses DXF file format. The sheet's original dimensions were 2 feet by 3 feet.

sketch with parts for a frame and a lifting mechanism is shown in Figure 39 and 40 .

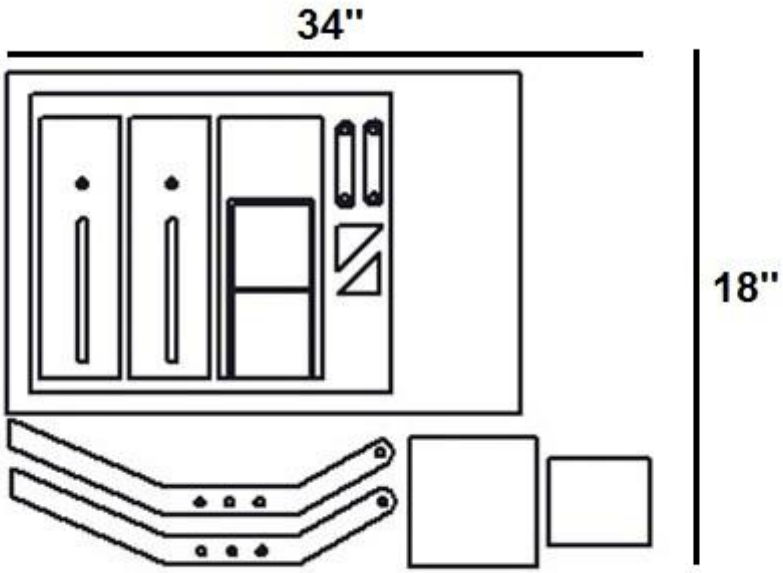

Figure 39 2D drawing for laser cutting of machine parts

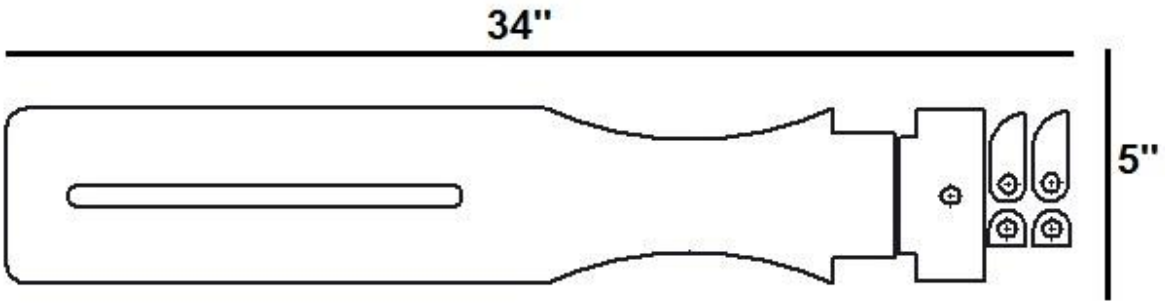

Figure 40 2D drawing For laser Cutting of lever

These drawings were fed into the laser machine's computer, and a reference point was established. The laser then moves along the lines of the sketch.

Figure 41 Laser Cutting

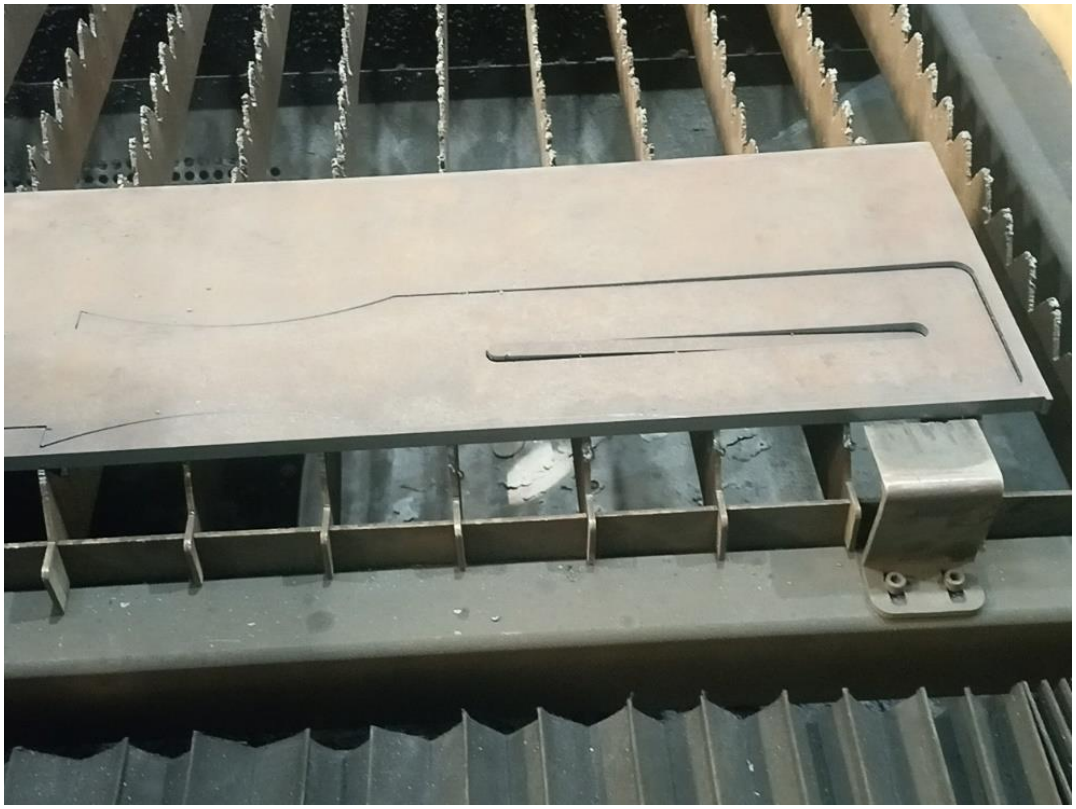

Figure 42 Parts after Laser cutting

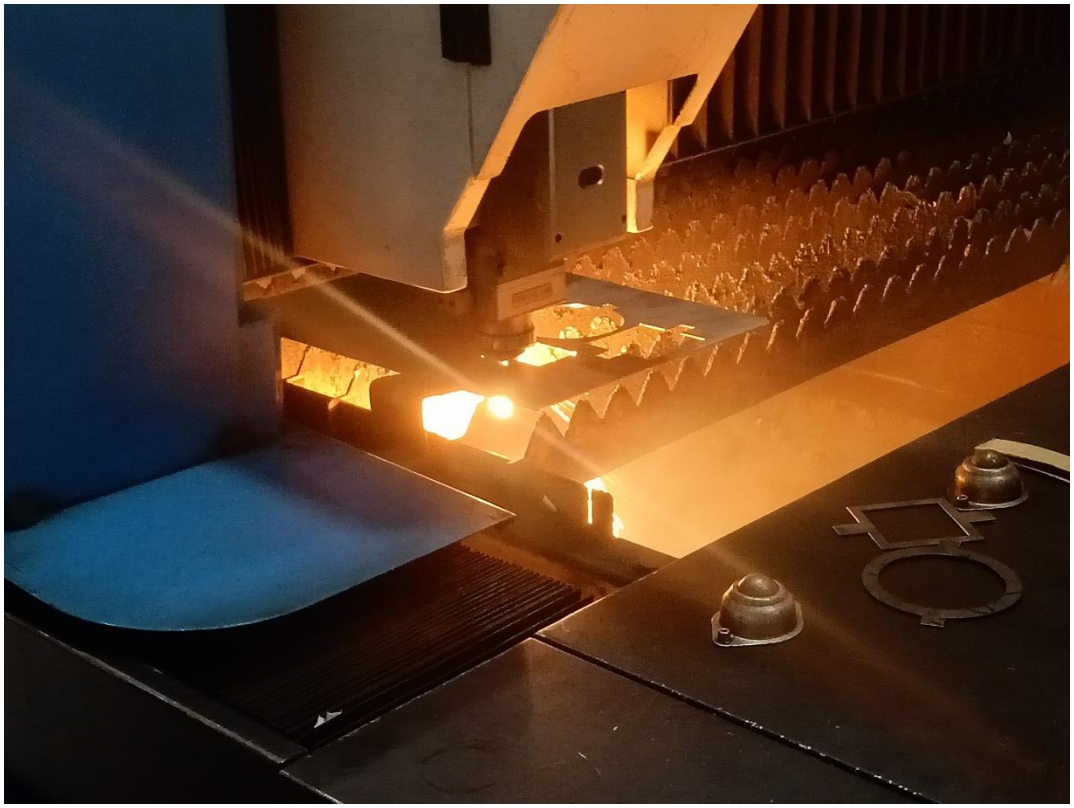

Figure 43 Mold Lining Laser Cutting

4.3 Welding

Accurate welding was used to assemble all frame components created by laser cutting. Local market provided welding services. Maintaining correct angles was important while welding. Any error could result in a pin insertion issue.

Figure 44 Welding setup

Figure 45 Welding of machine parts

4.4 Paint job

The university facility was used for painting. The entire painting procedure is divided into three parts. Red oxide was first applied to the parts in order to prevent rust and serve as a base coat for subsequent paint. Second, three layers of paint were applied, with a period of time passing

between each application. For an additional glossy appearance, a varnish coating was applied after painting.

Figure 46 Spray Painting setup

4.5 Heater and controller

Cast in aluminum heating plate can be produced using a single pass tube heater or a cartridge heater, however the issue is that there is a chance that the elements could be damaged during the casting process.

Cost analyses for producing heaters and for ready-made heaters were done. The analysis's findings indicated that manufacturing heaters involves risk even when ready-made heaters are offered at less price.

The inability to change the heating range and size problems while utilizing ready-made heaters is a problem.

Combo heat press machine heater was determined to be practical for our application following extensive research.

4.5.1 Combo heat Press Machine heater

There are two sizes of this heater: 12" x 15" and 24" x 17". These heaters' intended use is to print t-shirt thermal stickers. Teflon film is fastened to the heater to prevent damage to clothing.

A heater measuring 12" by 15" was chosen for the prototype. [24]

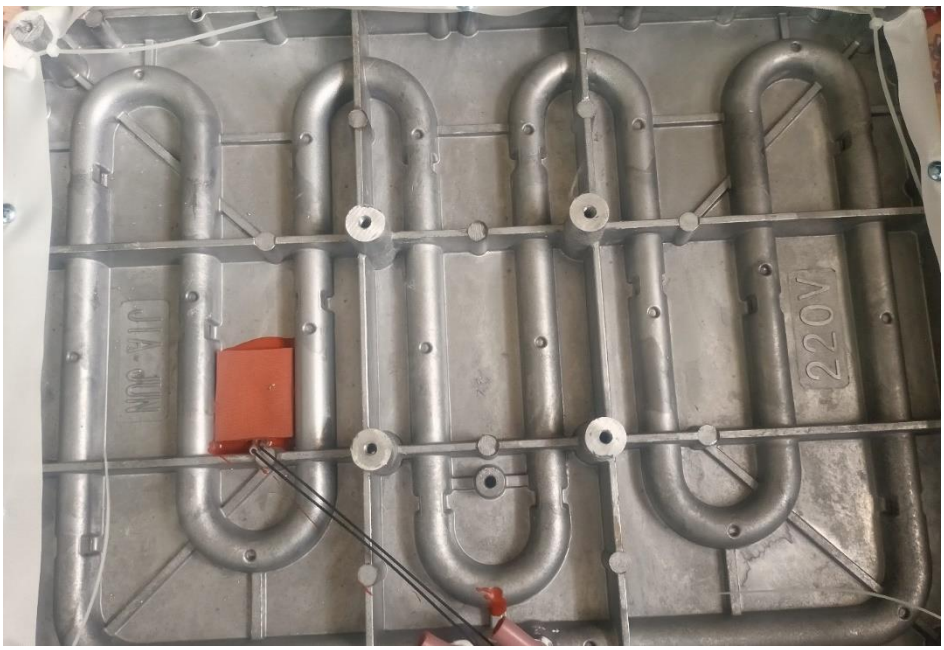

Figure 47 Combo Heat press Heater Plate

Figure 48 Combo heat press heater Front side

Figure 49 Combo heat press heater with safety cover

4.6 Assembling

After completing all manufacturing steps, machine pieces were put together using pins, nuts, and bolts.

Figures 50 illustrates the entire assembly.

Figure 50 Manual Blister Packing Machine

Tension Springs are fastened to the heater plate from a vertical column. When in standby mode, these springs offer lift.

Figure 51 Springs for Lifting Purpose

Pins are secured using cotter pins at the edges and spacing washers.

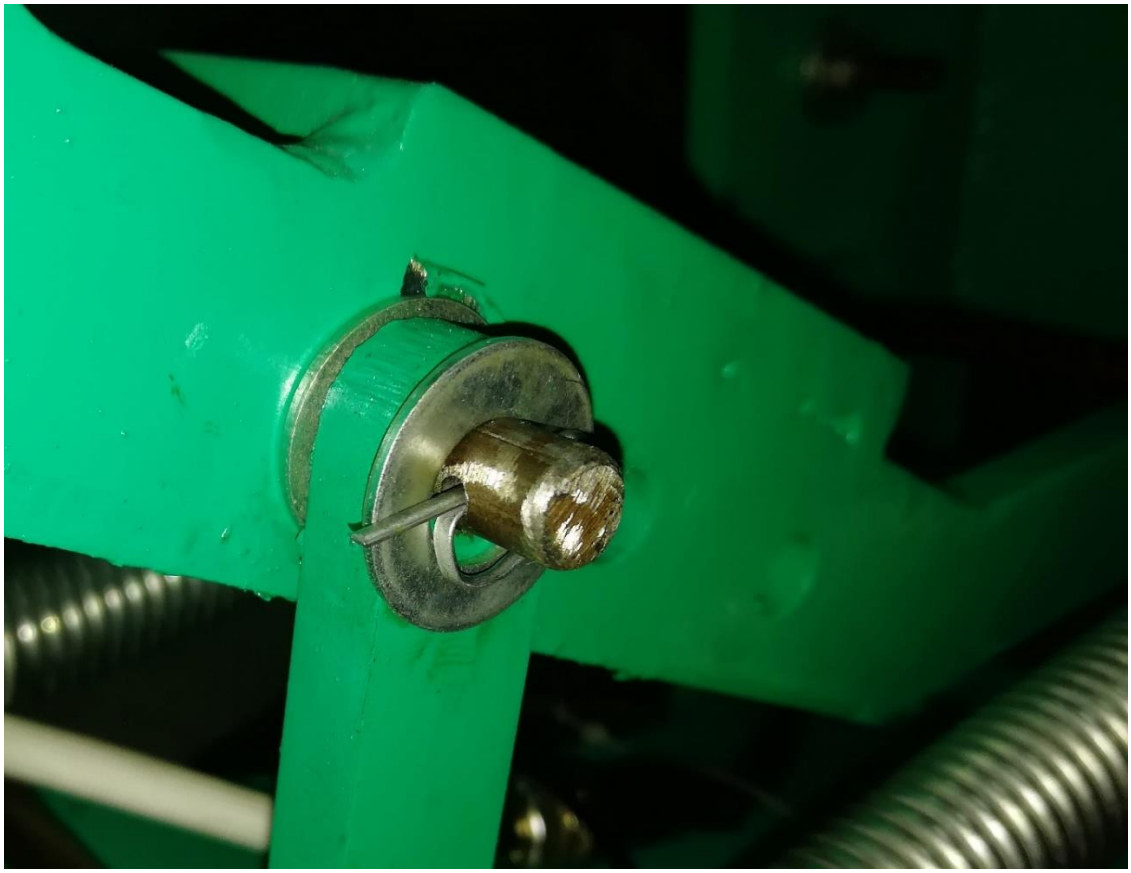

Figure 52 Pins Locking by using cotter pins

The heater's height is adjustable with an M12 bolt. It can be locked after adjustment by tightening the upper and lower bolt.

Figure 53 shows how the height adjustment mechanism works.

Figure 53 Height Adjustment

Chapter 5: Testing and Results

5.1 Cartridge heater test

Simple tests were conducted in order to understand how the PID controller and heater worked.

5.1.1 Components required for testing

1. PID controller
2. Magnetic contactor / SSR (solid state relay)
3. Thermocouple
4. Cartridge heater
5. Metal work piece

5.1.1.1 PID controller

RKC REX C- 100 controller is used here for testing cartridge heater.

Specifications of rex c100 are as follow

Table 6 REX C- 100 properties

Range	0-1200 C
Output	Relay
Input	220 V AC ,50/60 HZ

Figure 54 REX C 100 thermocouple

5.1.1.2 Magnetic contactor /SSR

Magnetic contactors, which use a magnetic coil to function, are also known as magnetic switches. SSR makes no noise while switching because it has no moving parts. These two are utilized to drive big loads.

SSR requires a DC voltage supply to operate, whereas magnetic contactors operate at 220 volts AC. Although contactors are simple to use, they make noise when switching. [25]

Figure 56 Magnetic Contactor

Figure 55 Solid state relay

5.1.1.3 Thermocouple

Here, the temperature is measured using a K-type thermocouple. Thermocouples come in a variety of styles and dimensions.

- Grounded
- Ungrounded
- Exposed

We employed two types: exposed k type thermocouples and grounded stud type thermocouples. Due to the shell case, the response time of stud type thermocouples is quite slow, whereas exposed type thermocouples perform significantly better. It responds promptly.

5.1.1.4 Cartridge Heater

Cartridge heaters came in Huge range of sizes (Dia and Length) and Power rating .

Cartridge heater used here is

Figure 57 Cartridge heater used in testing

Table 7 Cartridge heater properties

Dia	12.5mm
Length	80 mm
Wattage	300 watts

5.1.1.5 Work Piece

Mild steel cylindrical piece is used here for testing

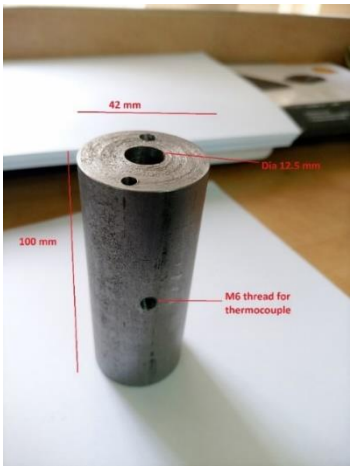

Figure 58 Work Piece for testing

Table 8 work piece characteristics

Dia	42 mm
Length	100 mm
Center hole for cartridge heater	Dia 12.6 mm Depth 75 mm

5.1.2 Cartridge heater test results

Our desired temperature is between 130 and 140 C, and SV is set to that value, I, and D gains are modified for the heater to operate at its best. Our required temperature was attained, and a temperature gun was used to verify it.

Figure 59 Cartridge heater testing

5.2 Blister packing machine testing

The blister packaging machine's heater was set to 130°C for the identical test we conducted earlier, and the results using two different sheet thicknesses are shown in Table 9.

Table 9 Results (PVC Sheets Thickness VS Temp and Time)

	Sheet Thickness	**Backing type**	**Pressing Time**	**Temperature**
Sheet 1	0.4mm	Box board laminated	8 sec	130
Sheet 2	0.15mm	Box Board laminated	5 sec	130
Sheet 1	0.4 mm	Card Board Laminated	7	120
Sheet 2	0.15mm	Card Board Laminated	5	120

5.3 Products

Results are better than anticipated. Future study needs to address a few minor concerns even though the machine is functioning properly. These products were made using a blister packing machine as samples.

Figure 60 Blister packed product 1

Figure 61 Blister packed product 2

Figure 62 Blister packed product 3

5.4 Tear Test

Figure 63 shows that the seal remained unbroken while the box board began to tear down. This tear test was used to evaluate the quality of the seal created by heat sealing.

Figure 63 Tear Test of blister packed Product

5.5 Conclusion

The cost-effective and reliable manual blister packing machine is the research's output. It offers packing space up to 12 x 15 inches. Simple controls make it easy for laypersons to use. Although no company in Pakistan manufactures manual blister packing machines, various businesses replicate imported models. Many burdensome characteristics were reduced because they could be obtained locally for a fair price, such as Trimming, Printing, and Vacuum shaping. Our focus was on developing a heat-sealing technique because the main issue was packing, which was provided by imported machines at a significant cost. In the market, shells are easily accessible. However, we created shells in the shape we wanted using a vacuum forming equipment that was previously made by NUST. All components are local, making it simple to obtain after-market services. The figures above illustrate some samples of products. it offers high-quality sealing. Our claim was that we could help industries that couldn't afford pricey machinery. This Machine proves to be more efficient than we anticipated.

With more research, it might be fully or partially automated. Even though they make operations simpler, these upgrades are pricey.

Appendix A

2D Drawing (side view) of blister packing machine

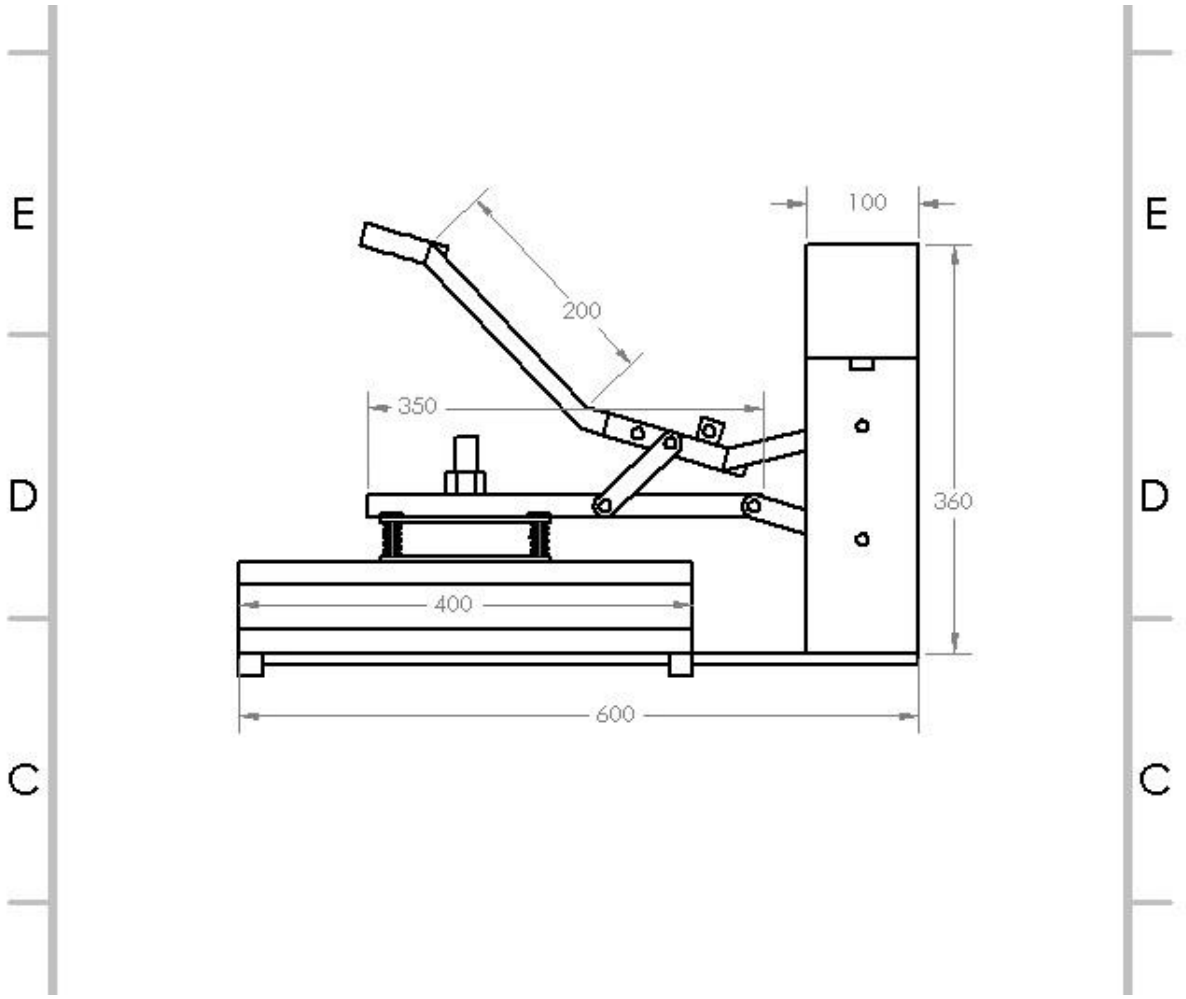

Figure 64 2D drawing side view

2D Drawing (front view) of blister packing machine

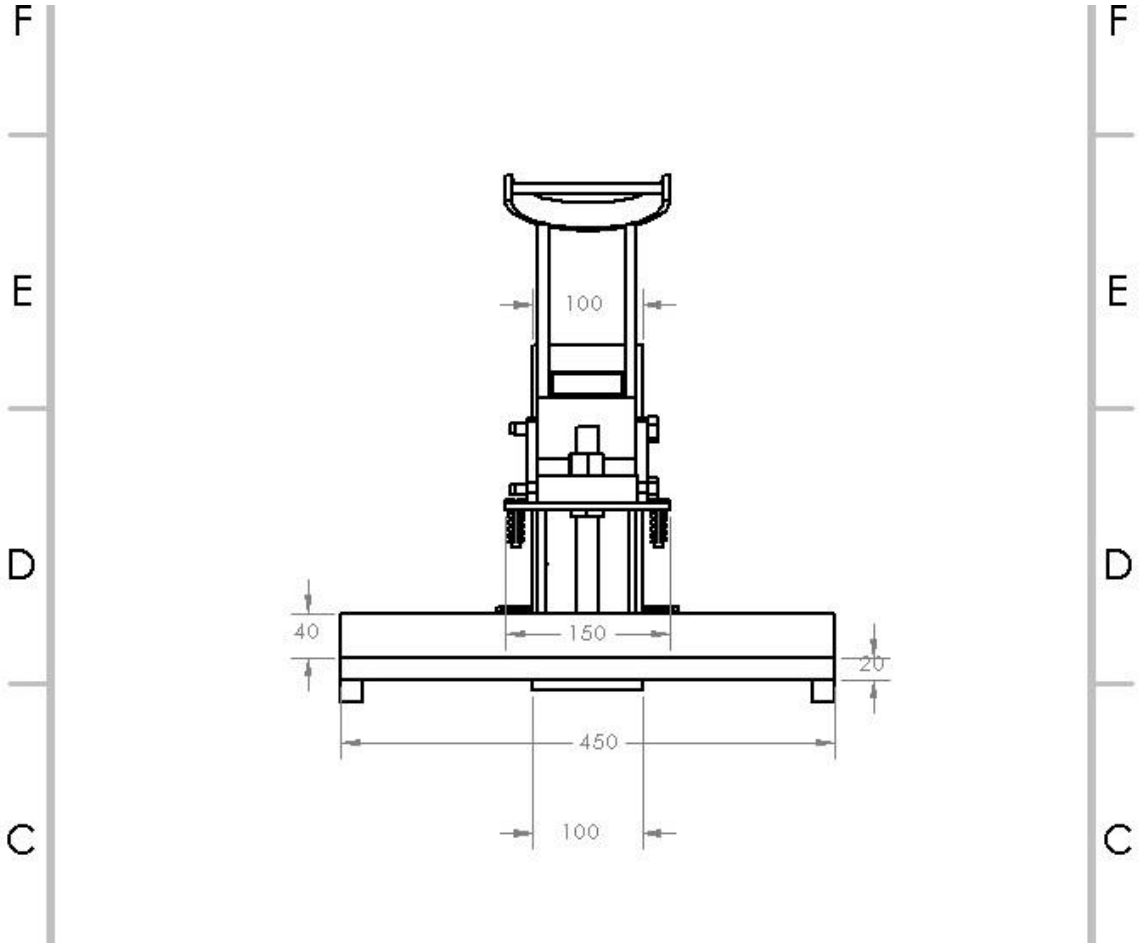

Figure 65 2D drawing Front view

2D Drawing (Top view) of blister packing machine

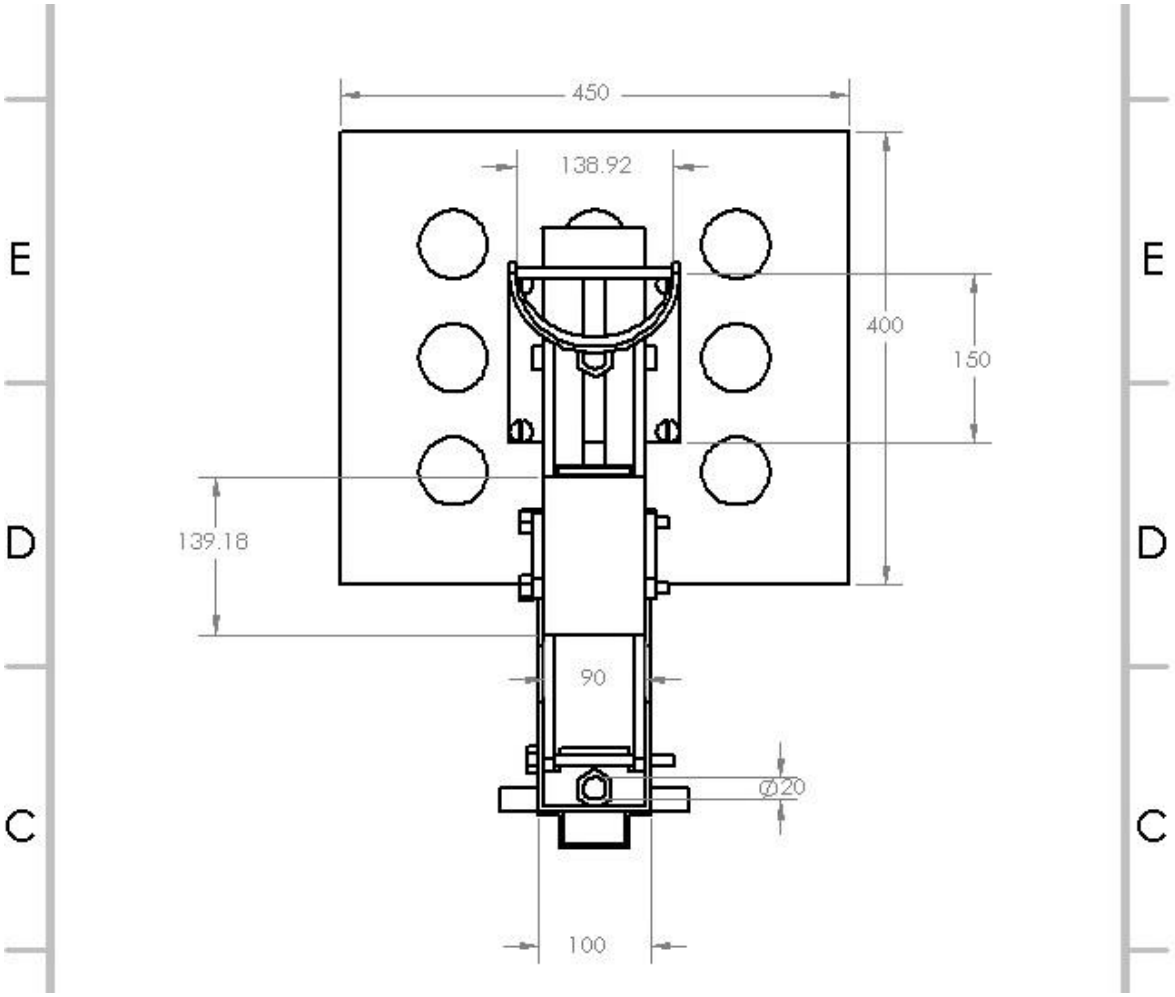

Figure 66 2D drawing top view

References

[1] "ipharmachine," [Online]. Available: https://www.ipharmachine.com/who-invented-blister-packaging-the-beginning-of-blister-packaging.

[2] [Online]. Available: https://www.howtobuypackaging.com/types-of-packaging-the-blister-pack/.

[3] "Pharmaceutical-tech," [Online]. Available: https://www.pharmaceutical-tech.com/articles/a-complete-guide-on-blister-packaging-machine.

[4] "nichrome," [Online]. Available: https://www.nichrome.com/blog/importance-of-blister-packaging-in-the-pharma-industry/.

[5] "Tianhui," [Online]. Available: https://tianhuipackingmachine.com/wide-range-of-applications-of-blister-packaging-machine/.

[6] R. Pilchik, "Basic configuration of blister," *pharmaceutical technology*, 2000.

[7] "Swicofil," [Online]. Available: https://www.swicofil.com/commerce/products.

[8] "polymerdatabase," [Online]. Available: https://polymerdatabase.com/Polymer%20Brands/PVDC.html.

[9] "Dielectric Manufacturing," [Online]. Available: https://dielectricmfg.com/knowledge-base/petg/.

[10] M. L. Biljana Pavicevic, "Choosing the right blister packaging film," *Macedonian pharmaceutical bulletin*, 2016.

[11] "SENIEER," [Online]. Available: https://www.senieer.com/blister-packaging-machine/.

[12] "HUALIAN Pharmaceutical Machinery," [Online]. Available: https://www.hlyj.net/News/N-196.html.

[13] "nextpackaging," [Online]. Available: https://www.nextpackaging.co.in/blister-sealing-machine.html.

[14] "perana caladon trading," [Online]. Available: http://peranacaladon.com/heating-elements/.

[15] "Madina Electric Heaters," [Online]. Available: http://madinaheater.com/index.htm.

[16] "Electronics hub," [Online]. Available: https://www.electronicshub.org/pid-controller-working-and-tuning-methods/#Trial_and_Error_Method.

[17] I. S. I. O. Dzmitry Hryniuk, "Non-linear PID Controller and Methods of Its Setting," *IEEE*, 2017.

[18] "BYJUS," [Online]. Available: https://byjus.com/physics/difference-between-rtd-and-thermocouple/.

[19] R. CHESTER, in *MATERIALS SELECTION AND ENGINEERING*, Elsevier Science Ltd..

[20] D. C. M. Ashby, "Materials selection in mechanical design," *JOURNAL DE PHYSIQUE IV,* vol. 3, 1993.

[21] "AZO Materials," [Online]. Available: https://www.azom.com/article.aspx?ArticleID=6115.

[22] "Extrudesign," [Online]. Available: https://extrudesign.com/machine-design-mechanical-engineering/.

[23] "Manufacturing resource center," [Online]. Available: https://smme.nust.edu.pk/about-us/resources-offices/smme-mrc/.

[24] "Diyprinting," [Online]. Available: https://diyprinting.com.ph/product/6-in-1-combo-heat-press-machine/.

[25] "Electgo," [Online]. Available: https://electgo.com/resources/difference-between-ssr-and-relay.