Palestine Polytechnic University

College of Engineering

Developing of Vacuum Forming Machine

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جامعة بوليتكنك فلسطين

كلية الهندسة

دائرة الهندسة الكهربائية

اسم المشروع

Developing of Vacuum Forming Machine

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بناء على توجيهات المشرف على المشروع وبموافقة جميع أعضاء اللجنة الممتحنة، تم تقديم هذا المشروع إلى دائرة الهندسة الكهربائية للوفاء بمتطلبات الدائرة لدرجة البكالوريوس.

توقيع المشرف

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توقيع رئيس الدائرة

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إهداء

إلى معلمنا وقائدنا وحبيبنا وشفيعنا و قدوتنا محمد صلى الله عليه وسلم.

إلى من رسموا بدمائهم خارطة الوطن وطريق المستقبل وهندسوا بأجسادهم معاقل العزة والكرامة وإلى من هم أكرم منا جميعا شهداء الوطن الحبيب.

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الملخص

"تطوير آلة صنع قوالب بلاستيكية"

المشروع أحد أنواع التشكيل الحراري وهو التشكيل بالشفط، يهدف المشروع الى تطوير ماكنة تشكيل البلاستيك المستخدمة لإنتاج قوالب عن الحجر الطبيعي، بهدف تحويل عملية الانتاج الى الوضع الآلي و تحسين عملية الانتاج، وللتخلص من بعض المشاكل الموجودة، مثل:عدم كفاءة المنتج، عدم القدرة على التحكم بالحرارة، الحاجة لوقت لانتاج القالب، حيث تم إضافة إضافة بعض الأجزاء الضرورية للتشغيل الآلي والتحكم في الماكنة، وتشمل: PLC للتحكم، HMI للتحكم والمراقبة و نظام هوائي للحركة. وفي نهاية المشروع تم تطوير الماكنة وإضافة الأجزاء الجديدة، وتم اختبار الماكنة وقد أعطت نتائج ملحوظة في تحسن جودة القالب المنتج، تقليل الوقت والجهد اللازمين للإنتاج والتحكم والمراقبة لعملية الإنتاج كاملاً.

Abstract

"Developing of Vacuum Forming Machine"

The project is one of the types of thermoforming which is the formation of vacuum, the project aims to develop the plastic forming machine that used to produce molds for natural stone, in order to transform the production process into automatic mode, improve the production process, and to eliminate some of the existing problems such as: Product inefficiency, inability to control the heat and the need for time to produce the mold, where addition of some parts necessary for automation and control of the machine, including: PLC to control, HMI to monitoring and control system and pneumatic system to movement. At the end of the project the machine has developed and addition of new parts, the machine was tested and gave noticeable improvement in quality of the product, reducing the time and effort required for production, control and monitoring of the production process.

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Chapter One

Introduction

1.1 Overview

1.1.1 Thermoforming

Thermoforming is a process in which a flat thermoplastic sheet is heated and deformed into the desired shape. The process is widely used in packaging of consumer products and to fabricate large items such as bathtubs, contoured skylights, and internal door liners for refrigerators. Thermoforming consists of two main steps: heating and forming. Heating is usually accomplished by radiant electric heaters, located on one or both sides of the starting plastic sheet at a distance of roughly 125 mm (5in).Duration of the heating cycle needed to sufficiently soften the sheet depends on the polymer, its thickness and color .

The methods by which the forming step is accomplished can be classified into three basic categories:

- Vacuum thermoforming
- Pressure thermoforming
- Mechanical thermoforming

1.1.2 Vacuum Forming

Vacuum forming, commonly known as vacuum forming, is a simplified version of thermoforming, whereby a sheet of plastic is heated to a forming temperature, stretched onto or into a single-surface mould, and held against the mould by applying vacuum between the mould surface and the sheet. The vacuum forming process can be used to make most product packaging, speaker casings, and even car dashboards. (**Figure 1.1**)

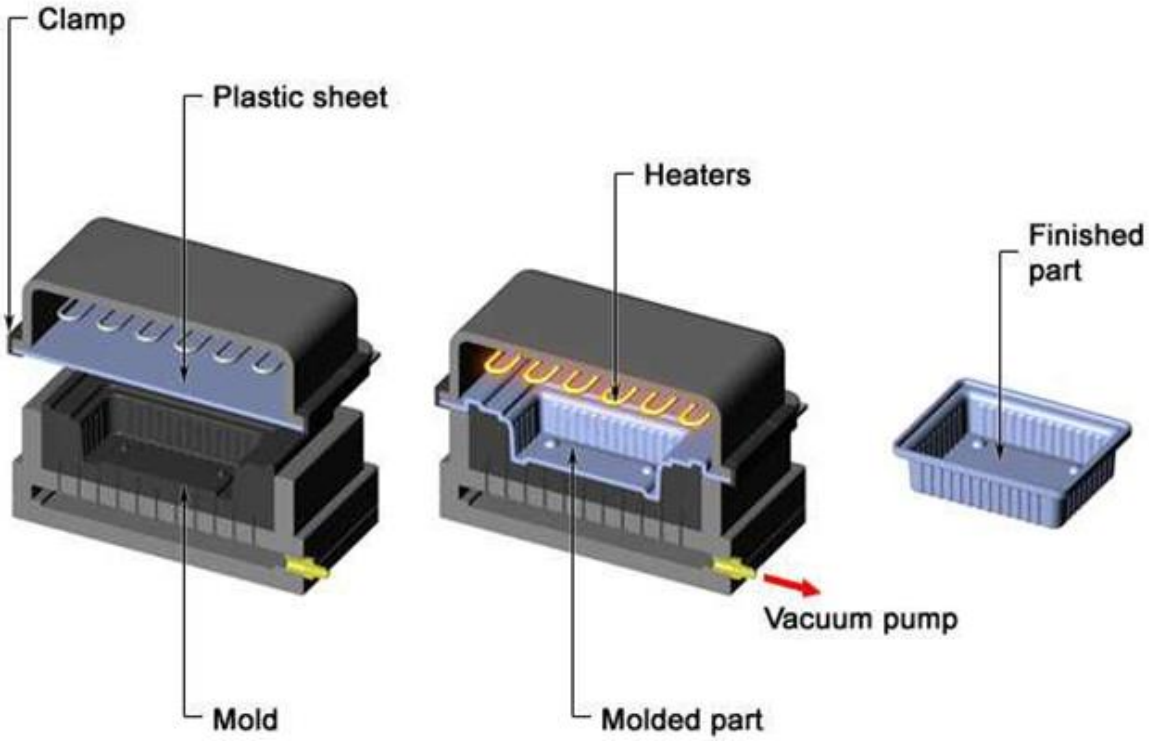


Figure 1.1:vacuum forming

1.1.3 Pressure Thermoforming

At this point it is useful to distinguish between negative and positive moulds. The moulds having concave cavities are known as negative moulds. A positive mould has a convex shape. Both types are used in thermoforming. In the case of the positive mould, the heated sheet is draped over the convex form and negative or positive pressure is used to force the plastic against the mould surface. The difference between positive and negative moulds may seem unimportant, since the part shapes are virtually identical.(**Figure 1.2**)

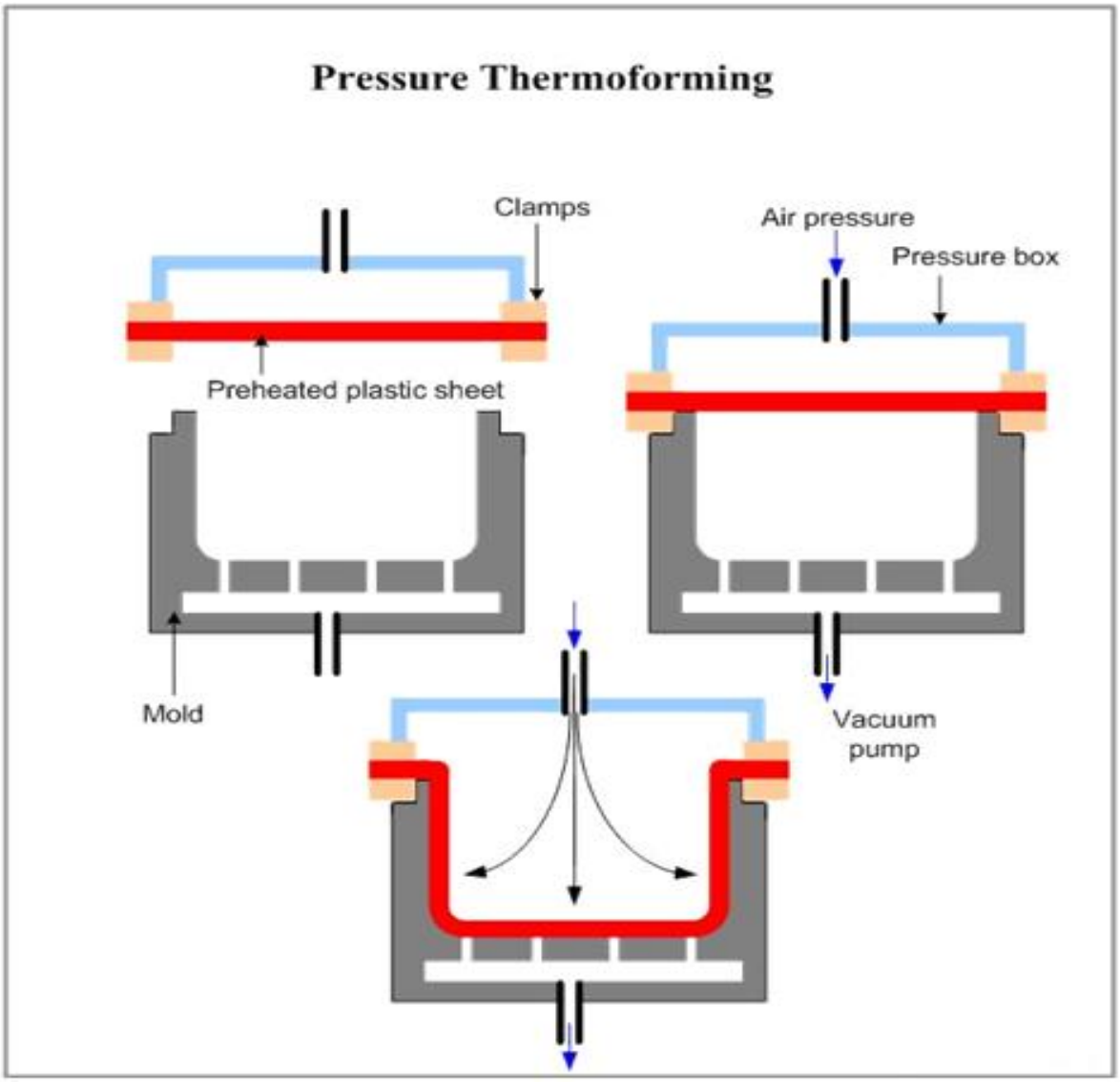


Figure 1.2: Pressure Thermoforming

1.1.4 Mechanical Thermoforming

The third method uses matching positive and negative moulds that are brought against the heated plastic sheet, forcing it to assume their shape. In the pure mechanical forming method, air pressure (positive or negative) is not used at all. Its advantages are better dimensional control and the opportunity for surface detailing on both sides of the part. The disadvantage is that two mould halves are required; the moulds for the other two methods are therefore less costly.(Figure 1.3)

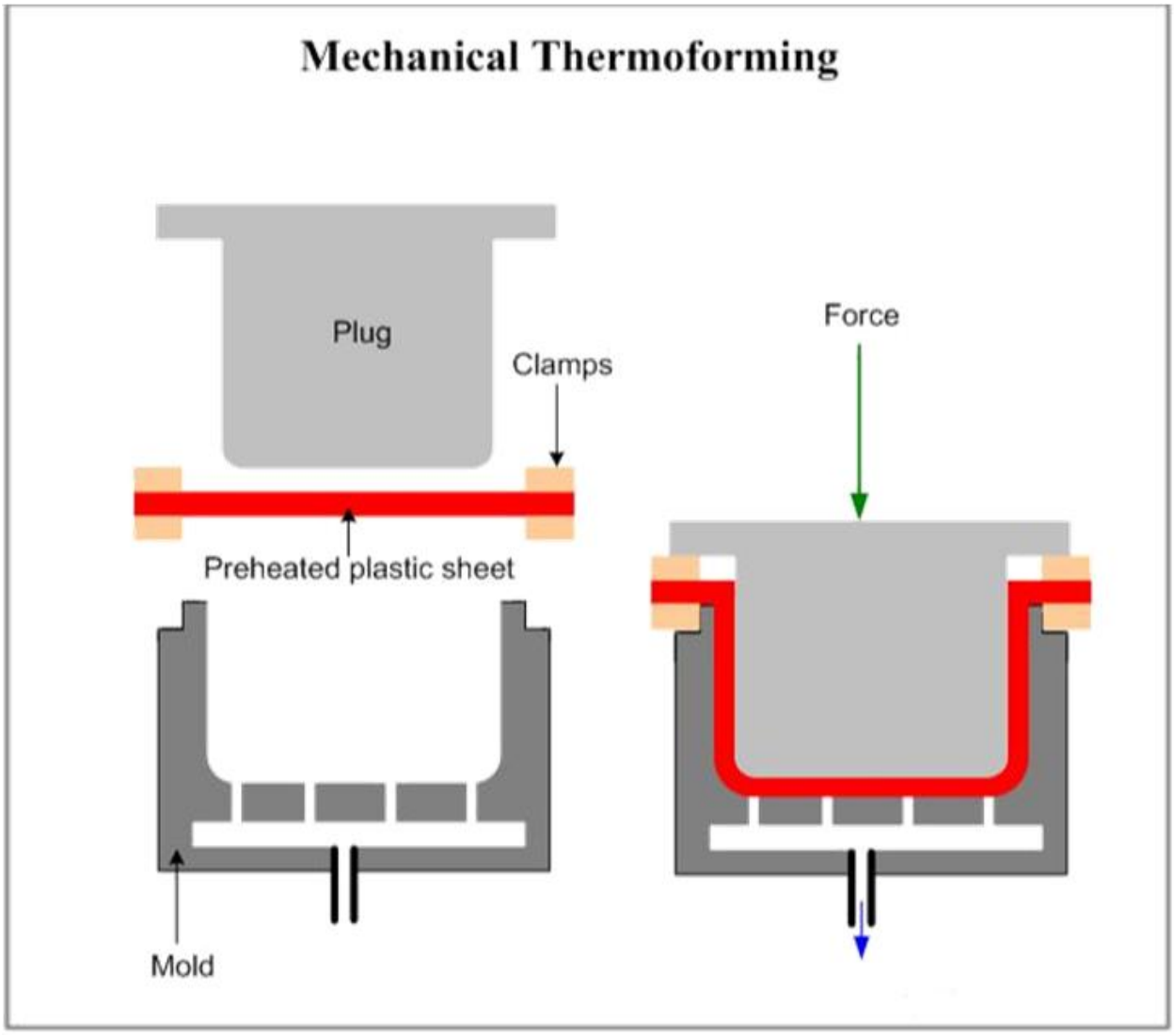


Figure 1.3: Mechanical Thermoforming

1.2 Background

1.2.1 Introduction

The goal is producing professional, quality and high definition vacuum forming on a small/medium scale as required by model makers, development engineers and students quickly, efficiently and consistently. The machine embodies design features, manufacturing techniques and proprietary component specifications unique to our equipment.

1.2.2 History

Vacuum-forming is an excellent method for moulding sheets of plastic into complicated shapes. It is just beginning to be used in the field of rehabilitation medicine where the need to make devices that fit the human form is great. This article describes a new, inexpensive apparatus which enables orthotics and prosthetics to use the vacuum forming process in their work with a very small outlay of capital. Very little training is required to use the apparatus, and it is now being made available in limited quantities.

In the vacuum-forming process a sheet of hot, pliable plastic is drawn either into or around a mould with the use of suction provided by a vacuum pump as show in **figure 1.4**. When the plastic cools and hardens, it retains the shape caused by the mould as show in **figure 1.5**. An example of the usefulness of a moulded orthotic. The process, though simple, when adapted to the needs of mass-production, requires very expensive machinery. Until recently only industrial vacuum-forming equipment was available, with prices ranging from $4,000 to over $125,000.

Because of the large investment in money and space required to obtain and use the machines designed for mass production, very few medical facilities have made use of the vacuum-forming process.

For mass-production expensive equipment results ultimately in low unit costs. But for the specialized, one-of-a-kind world of rehabilitation, expensive equipment does not necessarily justify itself, and a low-volume, low-cost, no automated system seems much more suited to the needs of orthotics and prosthetics. Such a machine is feasible when the inherent simplicity of the vacuum-forming process is fully exploited.

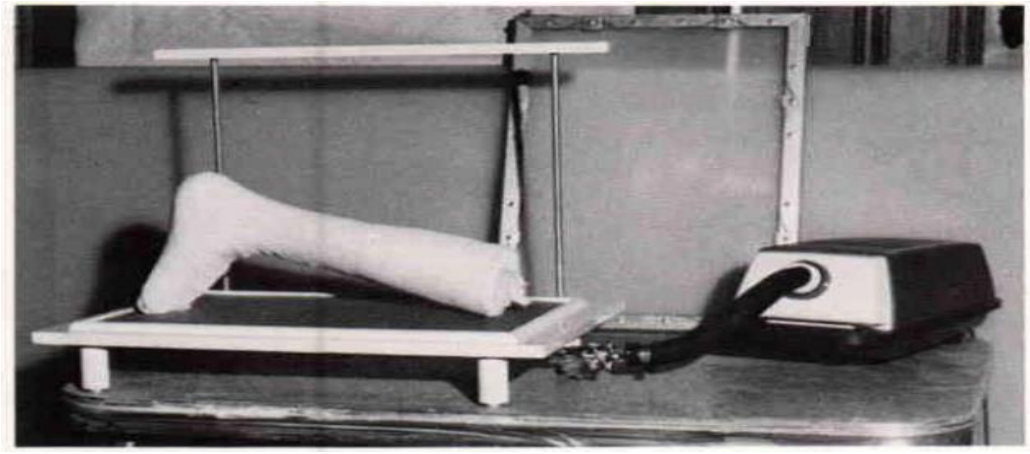


Figure 1.4: Vacuum Pump

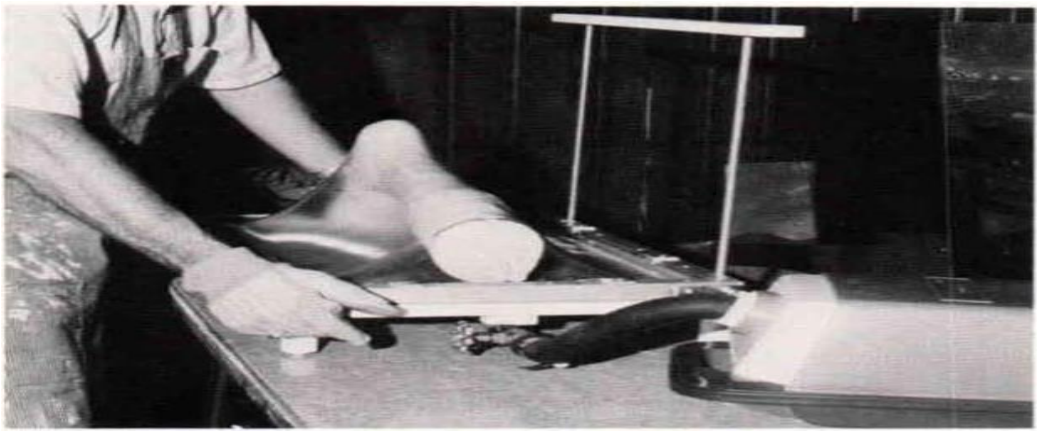


Figure 1.5: Plastic Mould

1.2.3 Stages of vacuum forming

1- The first stage of vacuum forming is to manufacture a precise mould(**Figure 1.6**). This is a skilled job as any imperfections to the mould will show up every time it is used to shape plastic such as high density polystyrene. The mould can be used hundreds and even thousands of times to produce the same plastic part. Each part will be exactly the same.

Figure 1.6: Mould

2- The mould is placed in the vacuum former. It is placed centrally. (**Figure 1.7)**

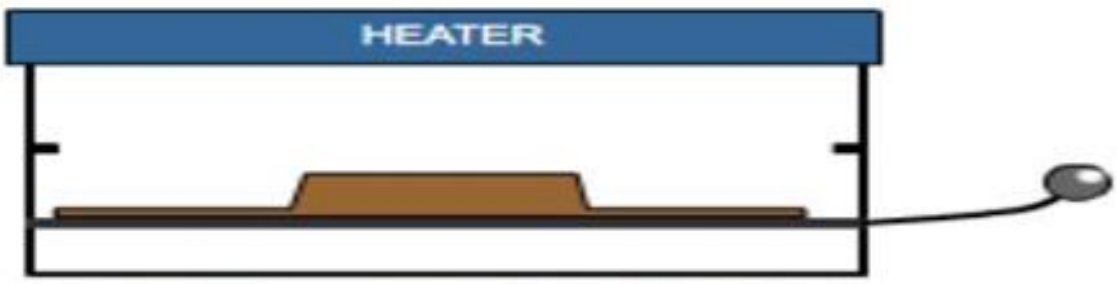


Figure 1.7: Mould Placed

3- A sheet of high density polystyrene is placed above the mould and clamped in position. Various thicknesses are available. Usually material 1mm thick is the most suitable for this type of vacuum forming.(**Figure 1.8**)

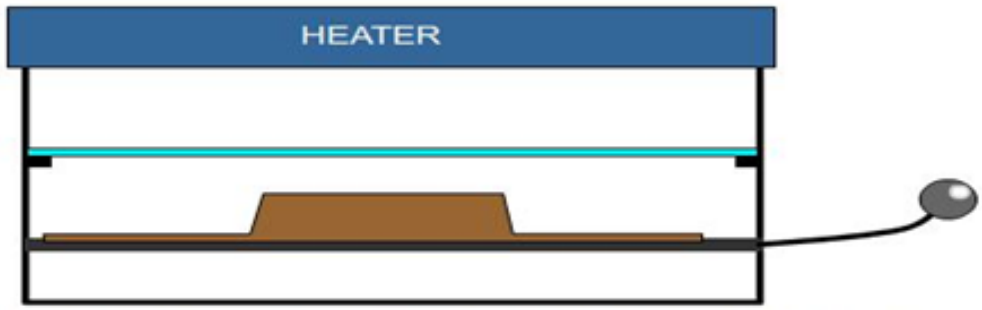


Figure 1.8: Plastic Sheet Placed

4- The heater is turned on. When the machine is being used from 'cold' it takes approximately five to ten minutes to warm up to the temperature needed to heat the polystyrene sufficiently. Once warm, polystyrene of this type takes only four or five minutes to heat up before vacuum forming can begin.(**Figure 1.9**)

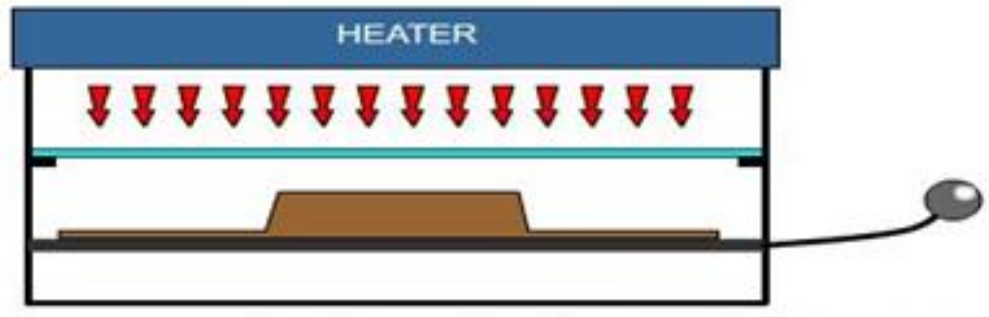


Figure 1.9: Heating Stages

5- The plastic (polystyrene) becomes pliable and flexible after a short time. It must be very flexible before it can be formed properly. (**Figure 1.10**)

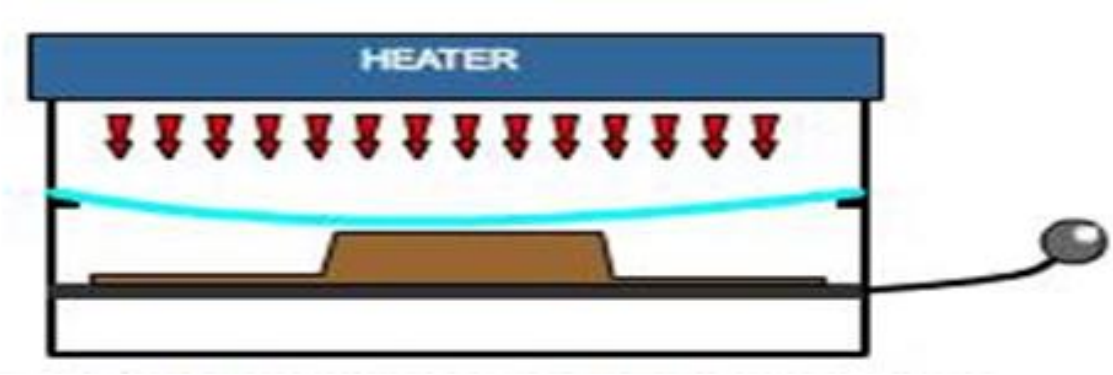


Figure 1.10: Flexible Plastic

6- When the polystyrene is ready the shelf is then lifted up towards the polystyrene sheet. The air underneath the former is pumped out and the polystyrene takes the form of the mould .(**Figure 1.11)**.

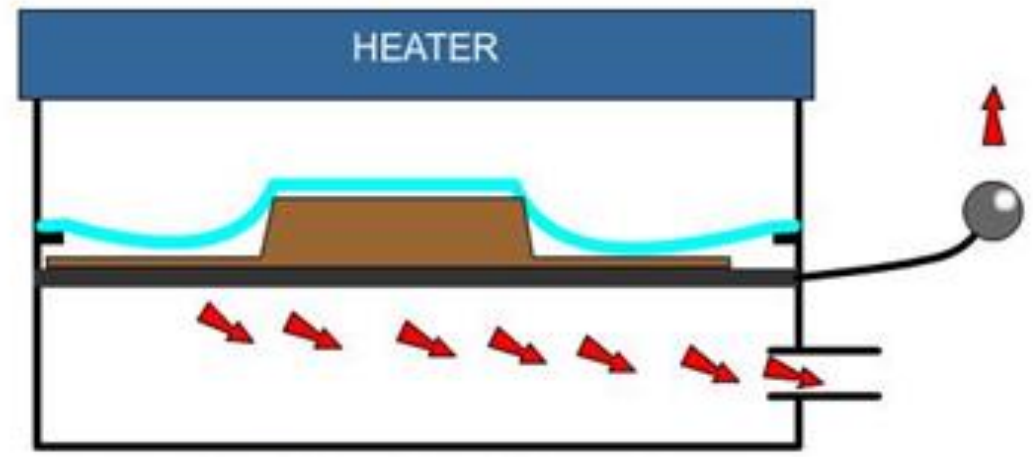


Figure 1.11: Forming Stage

1.3 Machine Description

How machine works:

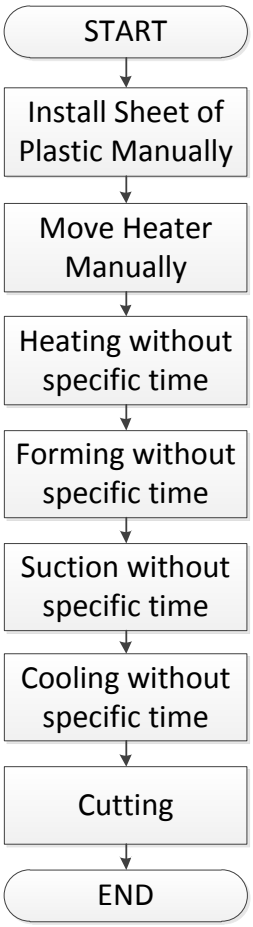


Figure 1.12: Machine Description

1.4 Problem Statement

* The machine is manually operated.

* It need long time to produce one mould.

* The quality is not good enough.

* Inability to adjust heaters temperature.

*Inability to adjust the heating time**.**

1.5 Objectives

* Convert the machine to full automatic.

* Reduce time of production.

* Quality improvement .

* Adding new parts.

*Adding controller.

1.6 Overall Cost

The following table shows the project cost. (**Table 1.3**)

Table 1.3: Cost Table

Item Name	Items No.	Total Cost (NIS)
Emergency Switch	**1**	**50**
Double Acting Cylinder	**3**	**400**
Solenoid Valve	**2**	**120**
Contactor	**3**	**210**
Relay	**4**	**200**
PLC	**1**	**600**
Temperature Extintion	**1**	**750**
HMI	**1**	**1250**
Thermocouple	**4**	**200**
Limit Switches	**4**	**120**
Cables & Pipes & Others	**_**	**400**
Body	**_**	**700**
Total Cost		**5000 NIS**

2

Chapter Two

Main Design Concepts

2.1 Introduction

2.2 Required Components

2.3 Block Diagram

2.4 Vacuum Forming Machine Stages

2.5 Process Flow Chart

2.1 Introduction

The development of machines is an important step in all fields of industry, because of its important effect in increasing production, reducing its errors, increasing quality, reducing effort, reducing time, reducing costs.

2.2 Required Component

2.2.1 Pneumatic Components

What is pneumatics؟

The principles of pneumatics are the same as those for hydraulics, but pneumatics transmits power using a gas instead of a liquid. Compressed air is usually used, but nitrogen or other inert gases can be used for special applications. With pneumatics, air is usually pumped into a receiver using a compressor. The receiver holds a large volume of compressed air to be used by the pneumatic system as needed. Atmospheric air contains airborne dirt, water vapour, and other contaminants, so filters and air dryers are often used in pneumatic systems to keep compressed air clean and dry, which improve reliability and service life of the components and system. Pneumatic systems also use a variety of valves for controlling direction, pressure, and speed of actuators.

Pneumatics holds many advantages that make it more suitable for many applications. Because pneumatic pressures are lower, components can be made of thinner and lighter weight materials, such as aluminium and engineered plastics, whereas hydraulic components are generally made of steel and ductile or cast iron. Hydraulic systems are often considered rigid, whereas pneumatic systems usually offer some cushioning, or “give.” Pneumatic systems are generally simpler because air can be exhausted to the atmosphere, whereas hydraulic fluid usually is routed back to a fluid reservoir.

Pneumatic system Components

Pneumatic systems consist of multiple components that work together or in sequence to perform some action or work.

The major components of our Pneumatic system include:

1. a pumping device
2. conductors
3. valves
4. actuators
5. support components

1) Pumping Device

Air compressor to provide fluid power to the system.

Model: V-0.25/8

Power(KW, HP): 2.2/3.0

Tank(L): 55 L

Piston: 65(piston diameter)/2(piston quantity (

Air Delivery(L/min, C. F. M): 0.25

Pressure(psi, bar): 8 bar

Cylinder diameter: 300 mm

Figure 2.1: Pumping Device

2) Conductors

Tubing, hoses, fittings, manifolds and other components that distribute pressurized air throughout the system.

Figure 2.2: Air Pipes

3) Valves

Devices that control fluid flow, pressure, starting, stopping and direction.

5/2-way solenoid valves.

Figure 2.3: Valve

4) Actuators

Cylinders, motors, rotary actuators, grippers, vacuum cups and other components that perform the end function of the Pneumatic system.
There are 2 types of cylinders:

Figure 2.4: Double Acting Cylinder

1) Table Cylinder

Table 2.1: Table Cylinder Specification

Size:	50x10x10 cm
Motion Pattern:	Double Action
Working Medium:	Filtered Air
Min Operating Pressure:	0.1 MPa
Max Operating Pressure:	1.0 MPa
Compression Pressure:	1.5Mpa
Ambient Temperature:	5 - 60°C
Operating Speed Range:	50- 500mm/s
Operating Life:	Not less than 4000Km
Buffer:	Air Buffer (Standard)
Port Size:	G1/4"
Stroke Size:	350 mm
Bore Size:	50 mm
MATERIAL:	Aluminium alloy
Buffer Stroke:	22
Max Air Pressure:	8 kg/cm
Brand:	Deelat Industrial

2) Heater & Frame Cylinders

Table 2.2: Heater & Frame Cylinders Specification

Part Number	1376478
Number of Items	1
Lower Temperature Rating	-4 degrees_fahrenheit
Upper Temperature Rating	176 degrees_fahrenheit
UPC	743270188794
Actuator Material	High alloy steel
Bore Diameter	32 millimeters
Brand Name	Festo
EAN	0743270188794
Exterior Finish	Aluminum
Fits Pipe Size	G 1/8 unknown_modifier

Item Weight	3.637627323 pounds
Maximum Rod Outside Diameter	12 millimeters
Model Number	1376478
Mounting Type	See Accessories
Piston Stroke Length	500 millimeters
Pressure Range	9-174 pounds_per_square_inch
Seal material	TPE-U(PUR)
Seat Material	Rubber
Thread Size	M10 x 1,25
UNSPSC	27121602

5)Support Component

Filters, manifolds, pneumatic mufflers, and other components that enable the Pneumatic system to operate more effectively.

Service Unit:

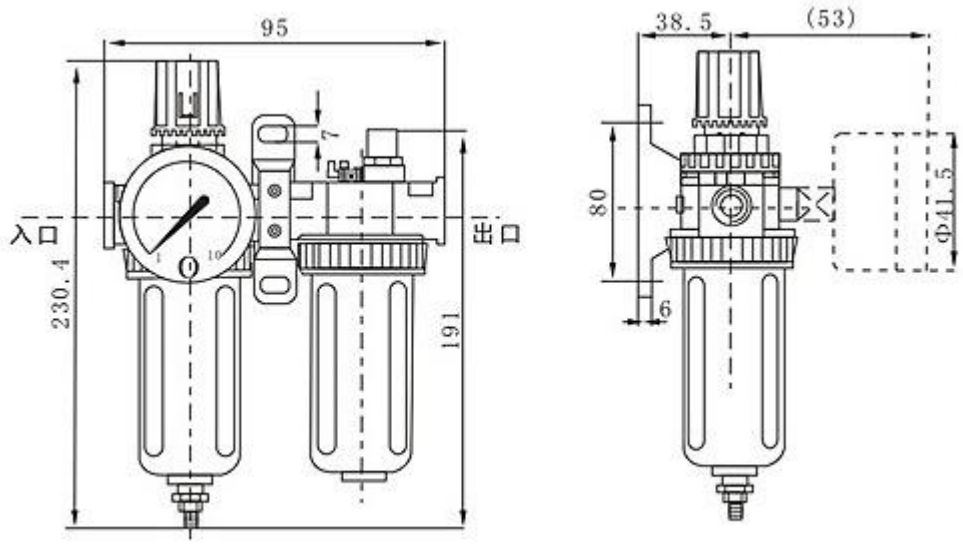


Figure 2.5: Service Unit

Air Source Treatment Group Filter Regulator and Lubricator for Pneumatic Regulating System. S Series air-line service units filter regulator and Lubricator filter regulator Lubricator port size PT1/4,PT3/8,PT1/2 e.g. SFC-200.

Quick Detail

* S Series air service units
* Aluminium die-casting body material
* With Aluminium material bowl guard
* Modular Design different combination for flexible application
* Port size PT1/4”,PT3/8”,PT1/2”
* Pressure range adjustable 0~1.0MPa
* Filter fineness 40 Micron standard
* Stable design pressure-resistance long service life cycle

Applications

S series air service units installing between the air compressor and Pneumatic system equipment close to pneumatic system equipment.
S series air preparation units including FR&L (Filter regulator and Lubricator), FR (Filter Regulator), L(Lubricator)
S Series Air service units can maintain steady of the pneumatic system pressure by air regulator avoid the sudden change of air source pressure to do harm to the pneumatic system components. Filter can be clean the air source separates the water and other impurity from the air source thus improve the quality of air medium effetely.

Specification

1. Working Medium: Air source
2. Body material: Aluminium die-casting
3. Filter bowl and Lubricator bowl material: PC
4. Filter element material: Brass
5.Bowl Guard: Plastic
6. Seal Material: NBR
7. Adjust aping knob: POM
8. Working pressure:0~1.0MPa
9. Working Temperature:5~60℃
10. Filtration fineness:40μ
11. Mounting type: Pipe mounting or bracket support mounting
12. Regulator type: Diaphragm type
13. Lubricator type: Oil volume adjustable during working
14. Port size:PT1/4”, PT3/8”, PT1/2”
15. Design type: Modular

2.2.2 Vacuum (series R3)

R 3000 -It is equipped with a three-phase asynchronous motor, protection IP 55, class F insulation, V.230/400 Hz.50 power 2.2 KW.

Table 2.3: Vacuum Specification

Aspiratori/Exhausters 50 Hz															
Models	Powered	Δpmbar	0	50	75	100	125	150	175	200	225	250	Δpmbar Max		mono phase
	Kw	Art.	m3/h	m3/h	m3/h	m3/h	m3/h	m3/h	m3/h	m3/h	m3/h	m3/h	mbar	m3/h	
R-2	1,1	R20/17	245	185	155	125	114						147	85	
	1,1	R23/18	238	192	158	127	113						145	70	•
	1,5	R24/19	239	190	168	143	118	70					150	70	
	2,2	R25/20	230	193	158	135	125	97					160	80	
	1,5	R26/18	232	208	172	132	125	88					160	75	•
R-3	1,5	Rn30/28	365	322	282	250	238	200					167	180	
	2,2	R30/35	325	318	278	250	235	185	140				200	128	
	3	R31/35	350	315	275	250	240	220	179	140			220	130	
	2,2	R33/35	352	300	262	238	225	190	152	125	121		230	118	•
	4	R34/41	362	330	295	260	248	225	182	140	125	112	270	100	
R-4	5,5	R40/63	640	580	540	485	420	412	330	242	160		240	130	
	7,5	R41/65	625	585	542	495	465	424	350	278	145		240	130	
R-3/GD	4	R34/63-GD	585	515	478	408	380	330	280	220			202	210	
	Kw	Art.	Aspiratori/Exhausters 50 Hz												

Figure 2.6: Vacuum

2.2.3Heaters

Design These heaters are special radiative heaters emitting external surface, its backside reflector adds up uniformity of heat and it is available in single or twin tube arrangements. An additional reflector can also be arranged with these heaters

Application: Drying industrial process for sizing, Lines Industrial driers thermoforming machines, Heating drying for food etc

Figure 2.7: Heater

Figure 2.8: Heaters Group

2.2.4 Fan

uses to cool the sheet of plastic.

Figure 2.9: Fan

2.2.5 Sensors

- Limit Switch

  uses to control movement.

Figure 2.10: Limit Switch

- Temperature Sensor

  uses to measure the temperature at the heaters .(Appendix A)

Figure 2.11: Thermocouple

2.2.6 Protection& Switching Devices

Every motor needs an overload, three-phase circuit breaker that is used to protect the motors and their installations also, an earth leakage circuit breaker. In addition, they need a 24V contactor to control the motor ON/OFF operations. Emergency switch is also needed for emergency cases.

Figure 2.12: Contactor

Figure 2.13: Circuit Breaker

Figure 2.16: Overload

Figure 2.14: Earth Leakage

Figure 2.15: Emergency

2.2.7PLC (Programmable Logic Controller)

-DVB SS2 delta plc .(Appendix B)

Figure 2.17:PLC

-DVB 04TC.(Appendix C)

Figure 2.18: Temperature Extintion

2.2.8 HMI (Human Machine Interface)

A Human Machine Interface (HMI) is the user interface that connects an operator to the controller for an industrial system.

HMIs are usually deployed on Windows based machines, communicating with programmable logic controllers (PLC) and other industrial controllers. (Appendix D)

Figure 2.19:HMI

2.3 Block Diagram

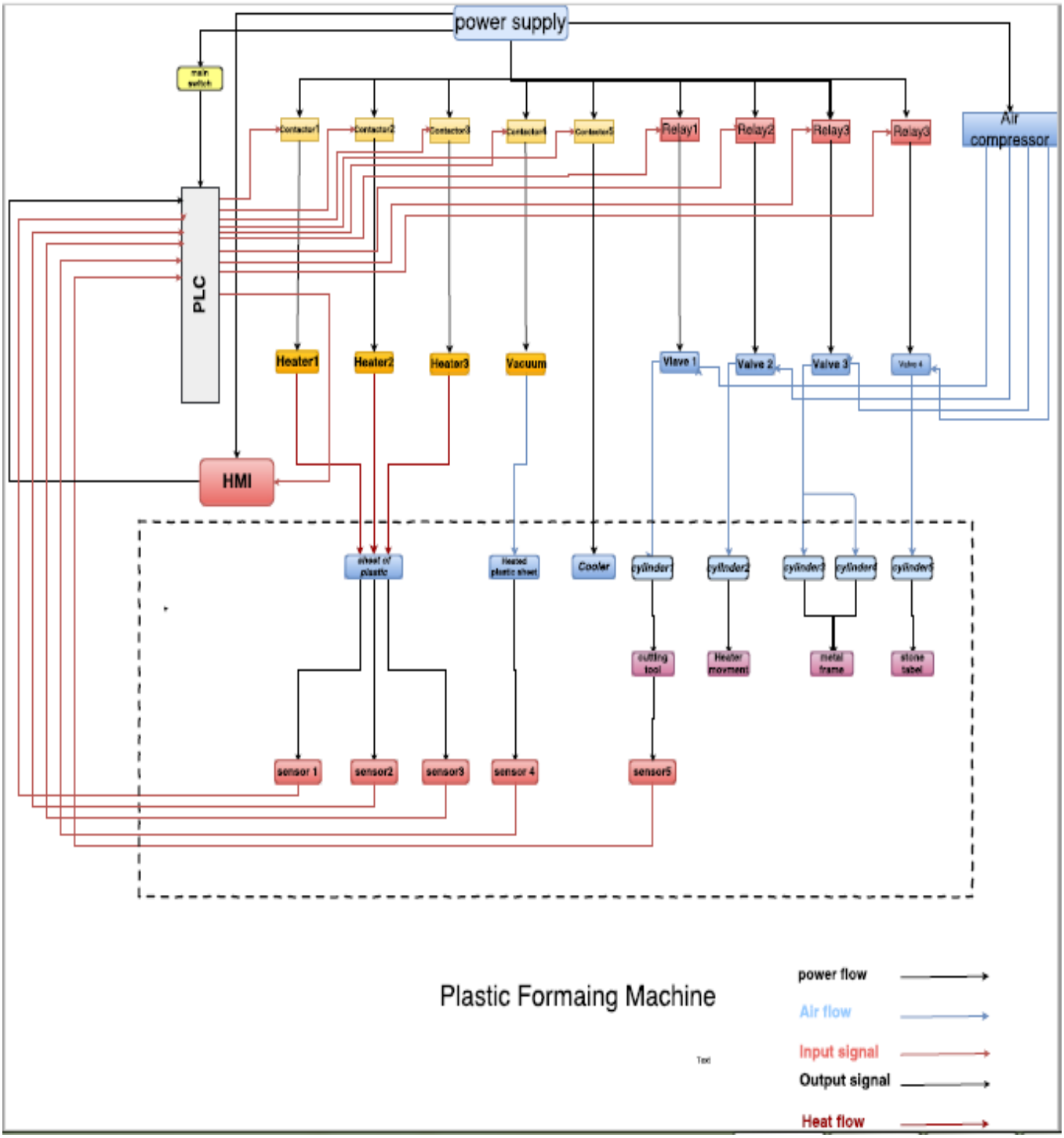


Figure 2.20: Block Diagram(Appendix E)

2.4 Vacuum Forming Machine Stages

2.4.1 Put plastic piece Stage

At this stage a part of the plastic put by worker .

Figure 2.21: Put plastic piece Stage

2.4.2 Install plastic sheet stage

At this stage the plastic is installed using a metal frame operated by an air cylinders

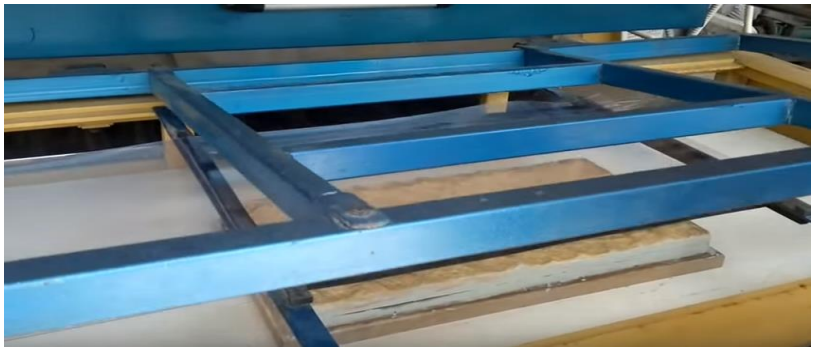


Figure 2.22: Install plastic sheet stage

2.4.3 Heating Stage

The heater is moved by a cylinder that moves the heater in two directions. The heat is heated for a specific time under a certain temperature. It is monitored using a heat sensor.

Figure 2.23: Heating Stage

2.4.4 Forming Stage

At this stage the hot plastic takes the shape of the stone, where the stone is lifted using an antenna lift to stick to the plastic and take shape with the help of a vacuum that pulls the air out of the mold.

Figure 2.24: Forming Stage

2.5 Process Flow Chart

The following flow chart shows the machine principle of operation (See figure 2.24)

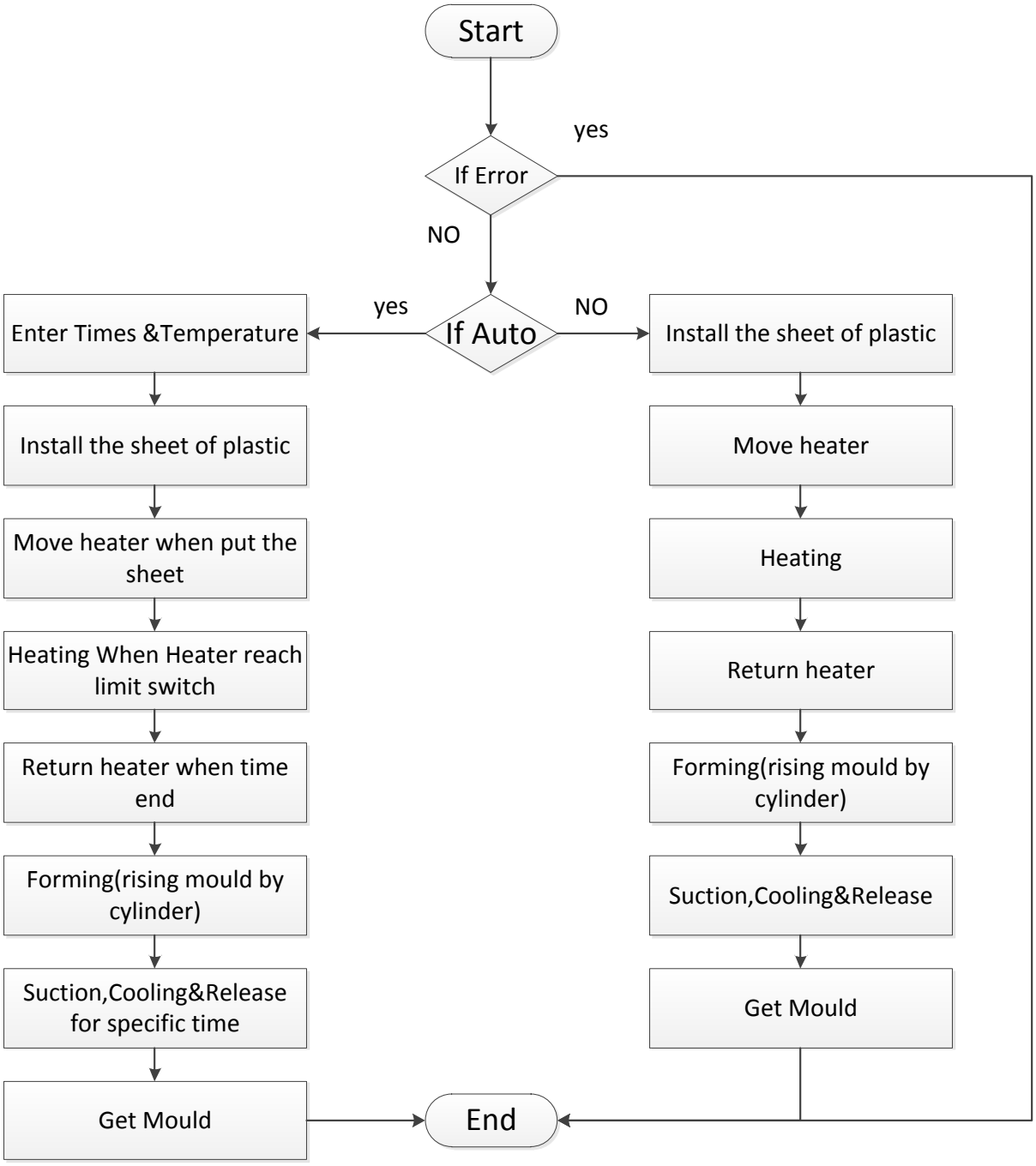


Figure 2.25: Process Flow Chart(Appendix F)

3

Chapter Three

Mechanical Design

3.1 Introduction

This chapter will include the 3D Design for all the machine stages using Catia software. The sequence shown in this chapter is the machine sequence of operation that means it starts with pull plastic roll stage until the mold is completely ready.

3.2 Install plastic piece stage

In this stage, the plastic roll is installed.

this stage consists from 2 parts:

1. metal frame: uses to install plastic (**Figure 3.1**)

   dimension:83*39*4 cm

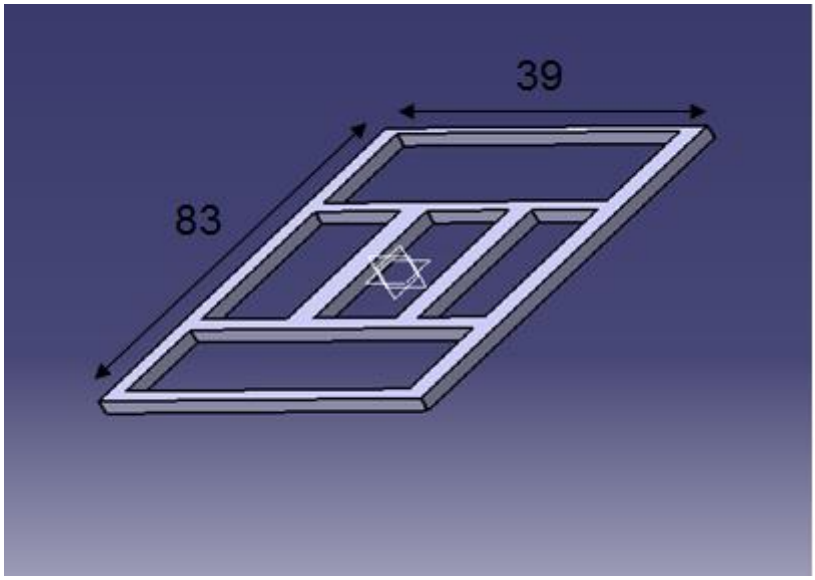


Figure 3.1: Metal Frame

2. cylinder: uses to rise & fall the metal frame. (**Figure 3.2**)

dimension: 55cm, diameter: 3.2cm

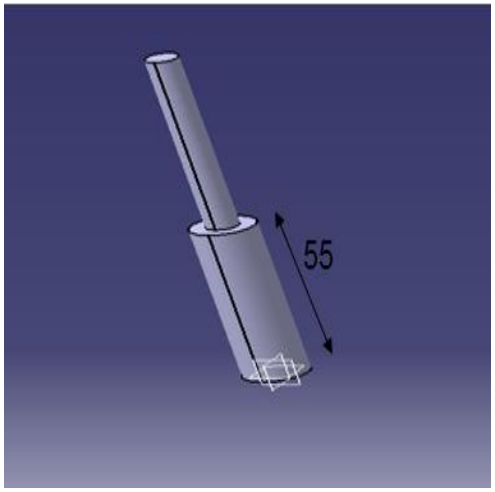


Figure 3.2: Frame Cylinders

3.3 Heating Stage

This stage consist from 2 parts

1. heaters: uses to heat the plastic. (**Figure 3.3**)
dimension:150*54*12 cm

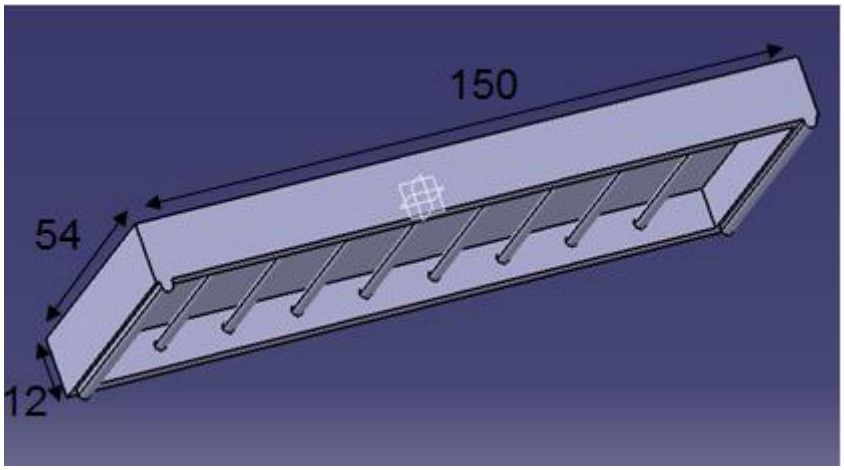


Figure 3.3: Heaters

2. cylinder: uses to move the heaters. (**Figure 3.4**)

dimension: 55 cm, diameter: 3.2cm

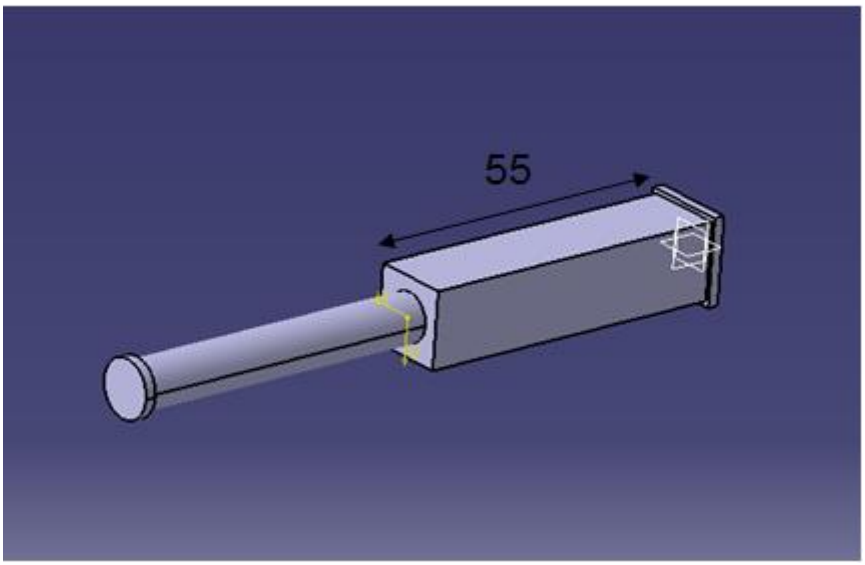


Figure 3.4: Heater Cylinder

3.4 Forming Stage

This stage contains 4 parts as following:

1. Table: base to carry the stone.(**Figure 3.5**)

dimension: 80*35*5 cm

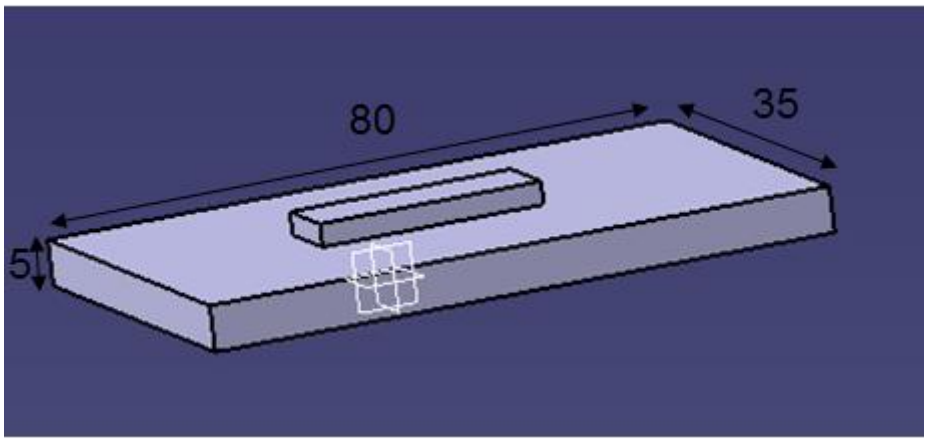


Figure 3.5: Table

2. Pneumatic Cylinder**:** uses to rise & fall the base (**Figure 3.6**)

dimension: 40 cm, diameter: 5cm

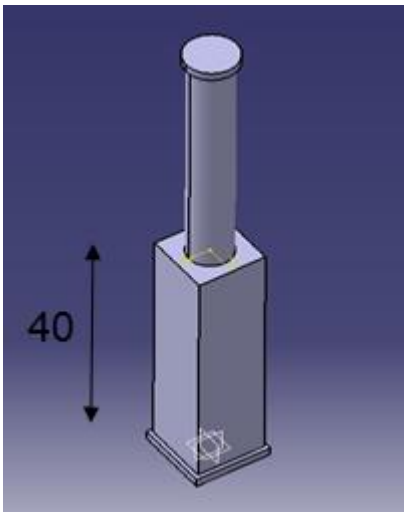


Figure 3.6: Table Cylinder

3.fan: uses to cooling the plastic after forming. (**Figure 3.7**)

diameter: 20 cm

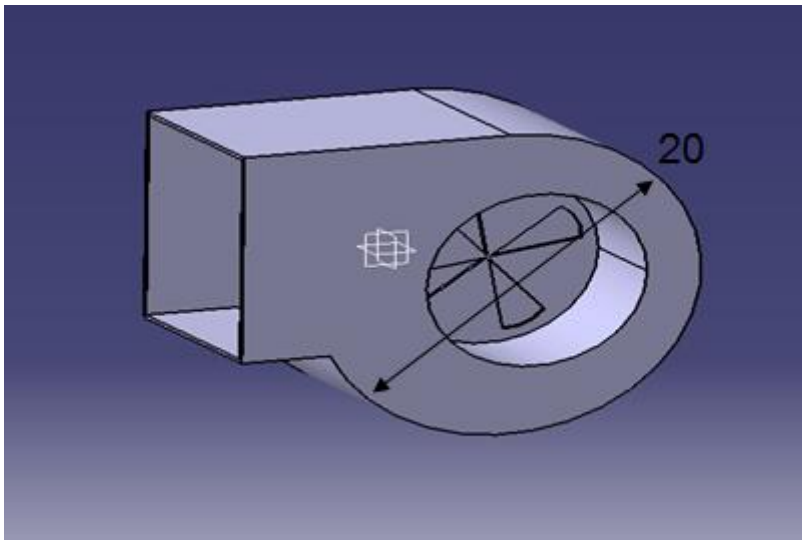


Figure 3.7: Fan

4. vacuum: uses to pull air from molds.(**Figure 3.8**)

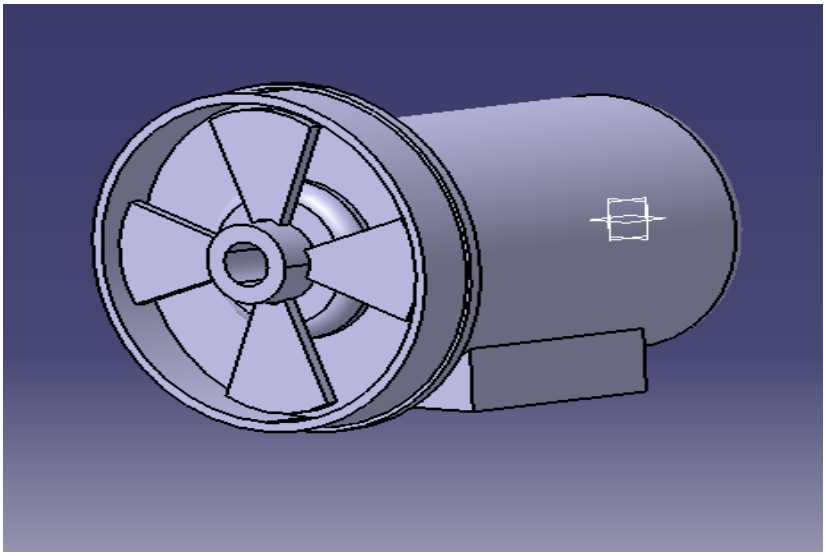


Figure 3.8: Vacuum

3.5 Extra Designed Parts

1- machine body(**Figure 3.9**)
dimension :190*150*(70+30) cm

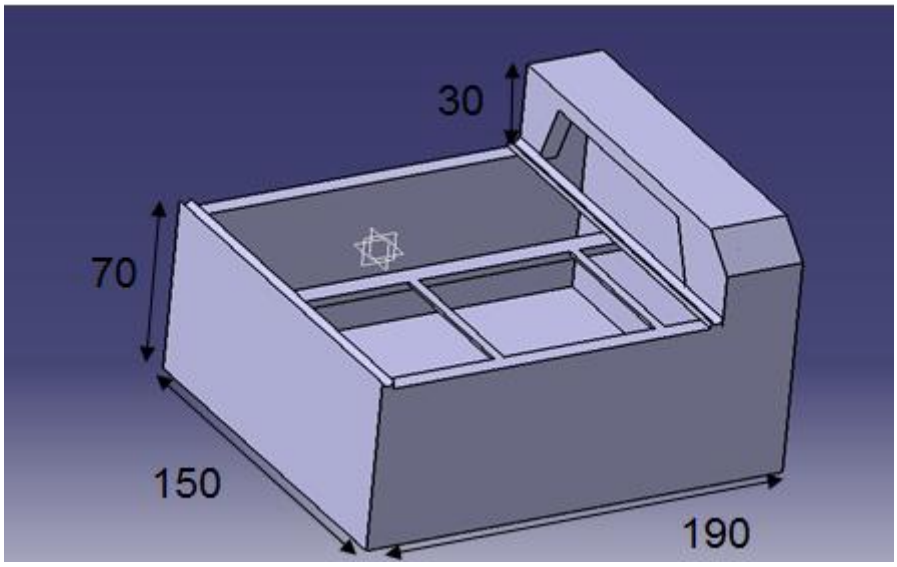


Figure 3.9: machine body

2- Electrical Panel: This Panel contains electrical parts like contactors, MCB's, RCD, etc. (**Figure 3.10**)

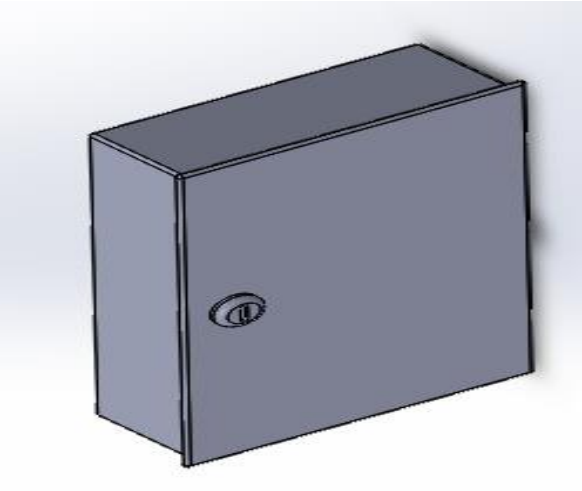


Figure 3.10: Electrical Panel

3- HMI Screen: This part is responsible for calibrate the machine, input the commands, and monitor the machine status. (**Figure 3.11**)

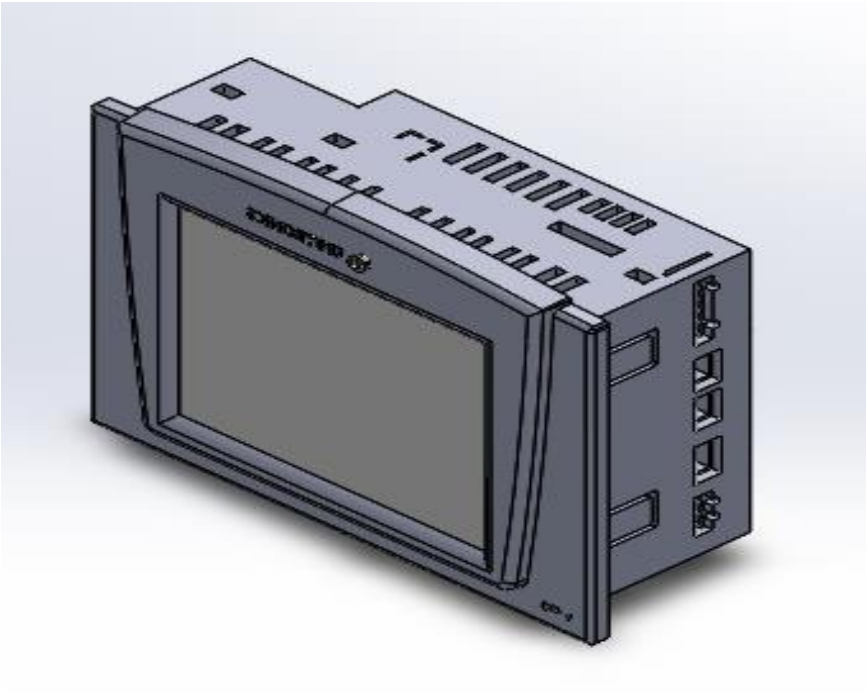


Figure 3.11:HMI Screen

3.7 Overall Machine Assembly

The following figure shows all up mentioned parts assembled together in one design.(**Figure 3.12**)

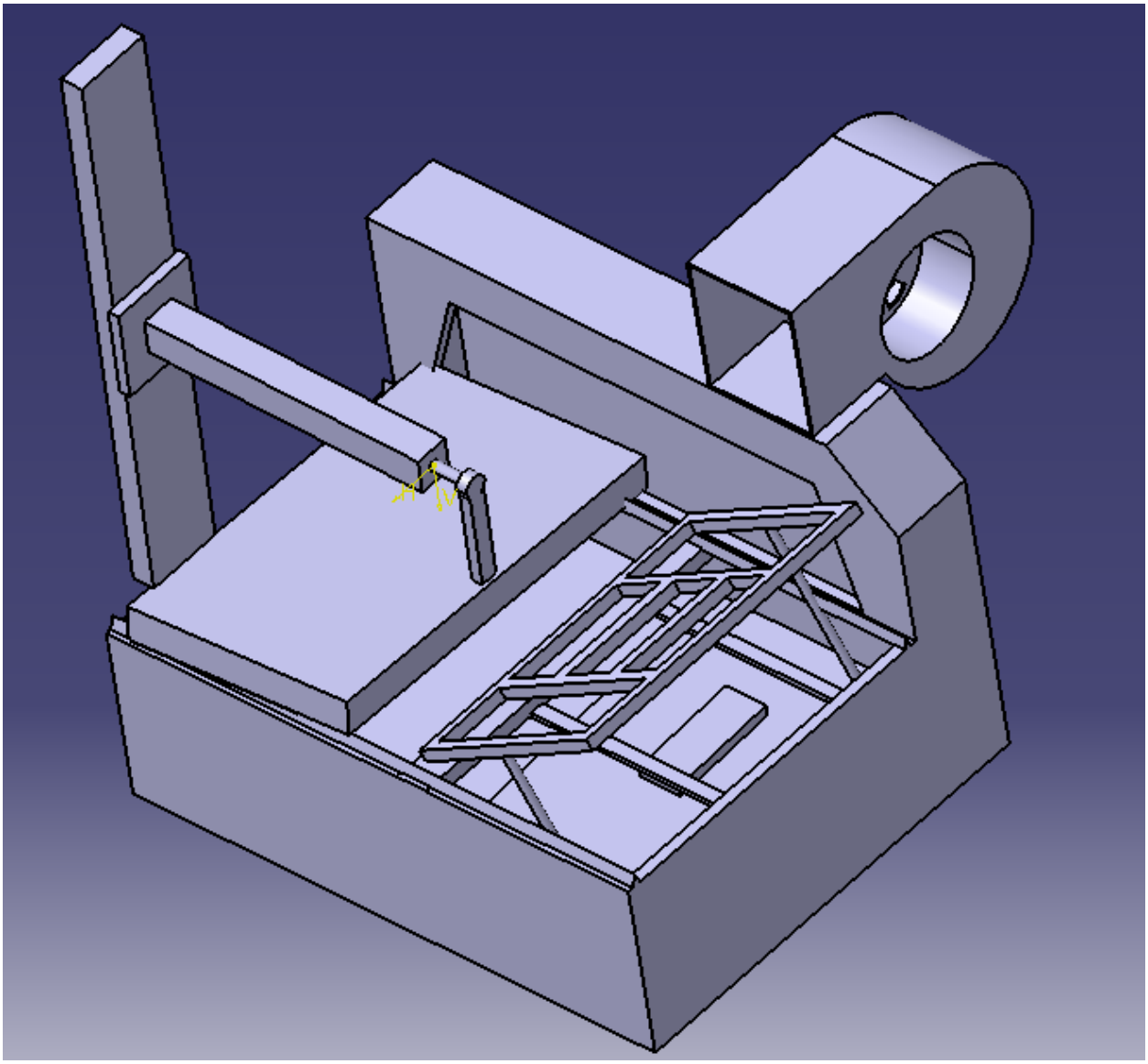


Figure 3.12: Overall Machine Assembly

4

Chapter Four

Electrical Design

4.1 Introduction

In this chapter, we will size compressor; also, Protection circuits will be size. Power circuit and control circuit will be explained in this chapter.

4.2Cylinders Calculation

$F = A * P$ ..... Equation (4.1)

$A=\pi/4 * D^2$ ..... Equation (4.2)

Compression ratio =(101.3 + Operating pressure (in kPa))/101.3 ... Equation (4.3)

AC= 2*Compression ratio * Piston surface * Stroke * Strokes per minute ..... Equation (4.4)

when F: Force P: Pressure A: Cross Area AC: Air Consuming

1- Frame & Heater Cylinders

we need 3 Cylinders.

F=250 N .....(weight of metal frame)

D=32 mm ..... (Diameter of cylinder)

$A=8.03CM^2$ ..... (By using Equation (4.2))

P= 301.204 KPa=3 Bar ..... (By using Equation (4.1))

Compression ratio = 3.971 ..... (By using Equation (4.3))

AC=3.188 L ..... (By using Equation (4.4))

2) Table Cylinder

F=1000 N .....(weight of table)

D=50mm ..... (Diameter of cylinder)

$A=19.62\ CM^2$ ..... (By using Equation (4.2))

P= 509.683 KPa=5 Bar ..... (By using Equation (4.1))

Compression ratio =6.03 ..... (By using Equation (4.3))

AC=4.14 L ..... (By using Equation (4.4))

So we need 10.5 Litter each cycle.

4.3Protection Circuit Sizing

The following table describes selected loads specifications. (Table 4.1)

Table 4.1:Loads

Name	phase	P / kw	V	A	rpm	f/Hz
Vacuum	3Φ	3	380	6	1450	50
Heater	3Φ	9	380	18	___	50

Vacuum Protection Circuit

- Overload

  OL = In = 6 A

- MCB(Miniature Circuit Breaker)

  MCB = 1.25In = 7.5A

Heater Protection Circuit

- MCB(Miniature Circuit Breaker)

  MCB = 1.25In = 22.5A

The following table shows the selected components ratings. (Table 4.2)

Table 4.2: Protection Components

Name	Overload size	MCB size
Vacuum	6 A	10 A
Heater	_____	25 A

4.4 PLC Control Circuit

PLC Control Circuit for all the machine is shown below. (Figure 4.1)

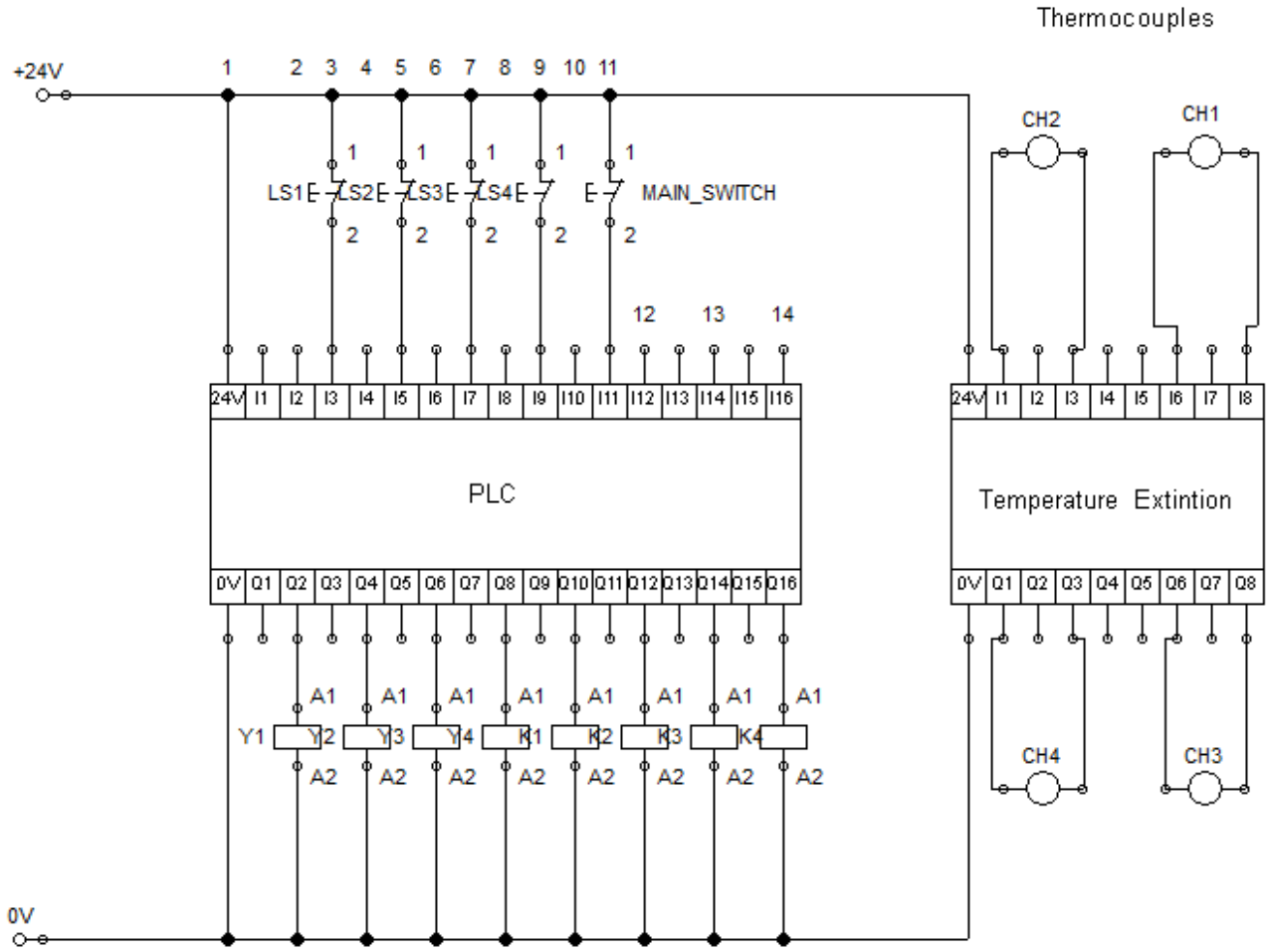


Figure 4.1: PLC Control Circuit

4.5PLC Input-Output Table

The following table shows the PLC I/O's table. (Table 4.3)

Table 4.3: PLC I/O's

Symbol	Function	Address
Inputs		
LS1	**Limit Switch**	**X0**
LS2	**Limit Switch**	**X1**
LS3	**Limit Switch**	**X2**
LS4	**Limit Switch**	**X3**
HMI	**HMI**	**COM3**
Temperature Extintion		
CH1	**Thermocouple**	**D0**
CH2	**Thermocouple**	**D1**
CH3	**Thermocouple**	**D2**
CH4	**Thermocouple**	**D3**
Outputs		
Y1+Y2	**Solenoid Valve Relay**	**Y1**
Y3	**Solenoid Valve Relay**	**Y2**
Y4	**Solenoid Valve Relay**	**Y3**
Y5	**Solenoid Valve Relay**	**Y4**
K1	**Vacuum Contactor**	**Y5**
K2	**Fan Contactor**	**Y20**
K3	**Heater Contactor**	**Y21**
K4	**Heater Contactor**	**Y22**

4.6Motors Power Circuit

The following figure show motors power circuit. (Figure 4.2)

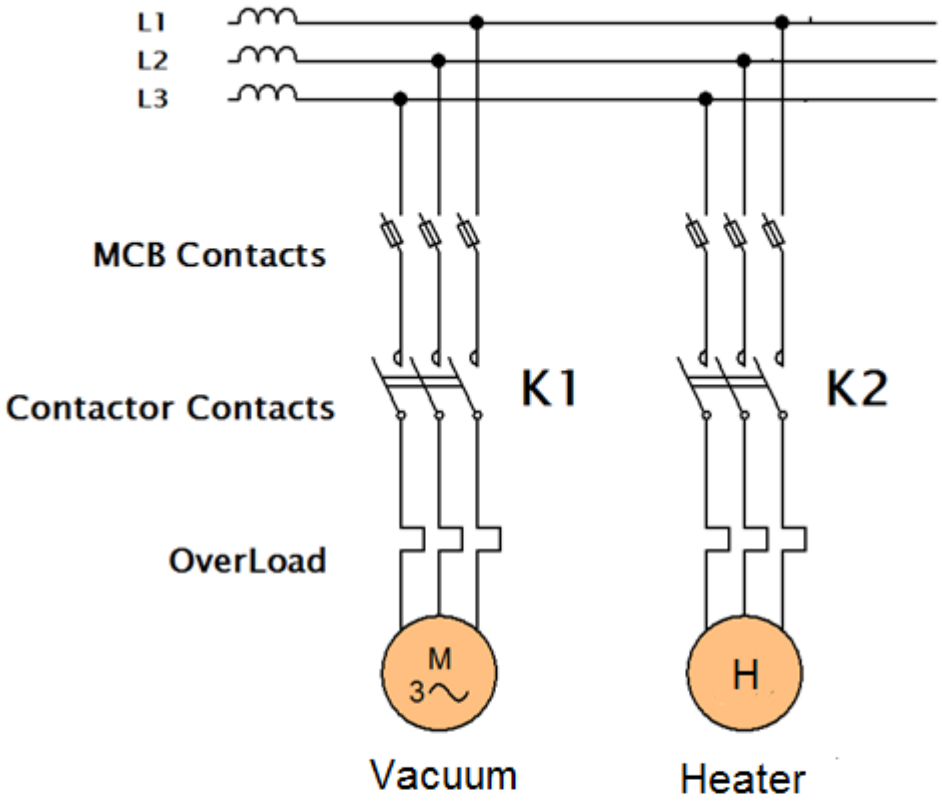


Figure 4.2: Motors Power Circuit

4.7 Pneumatic Circuit

Pneumatic Circuit is shown below. (Figure 4.3)

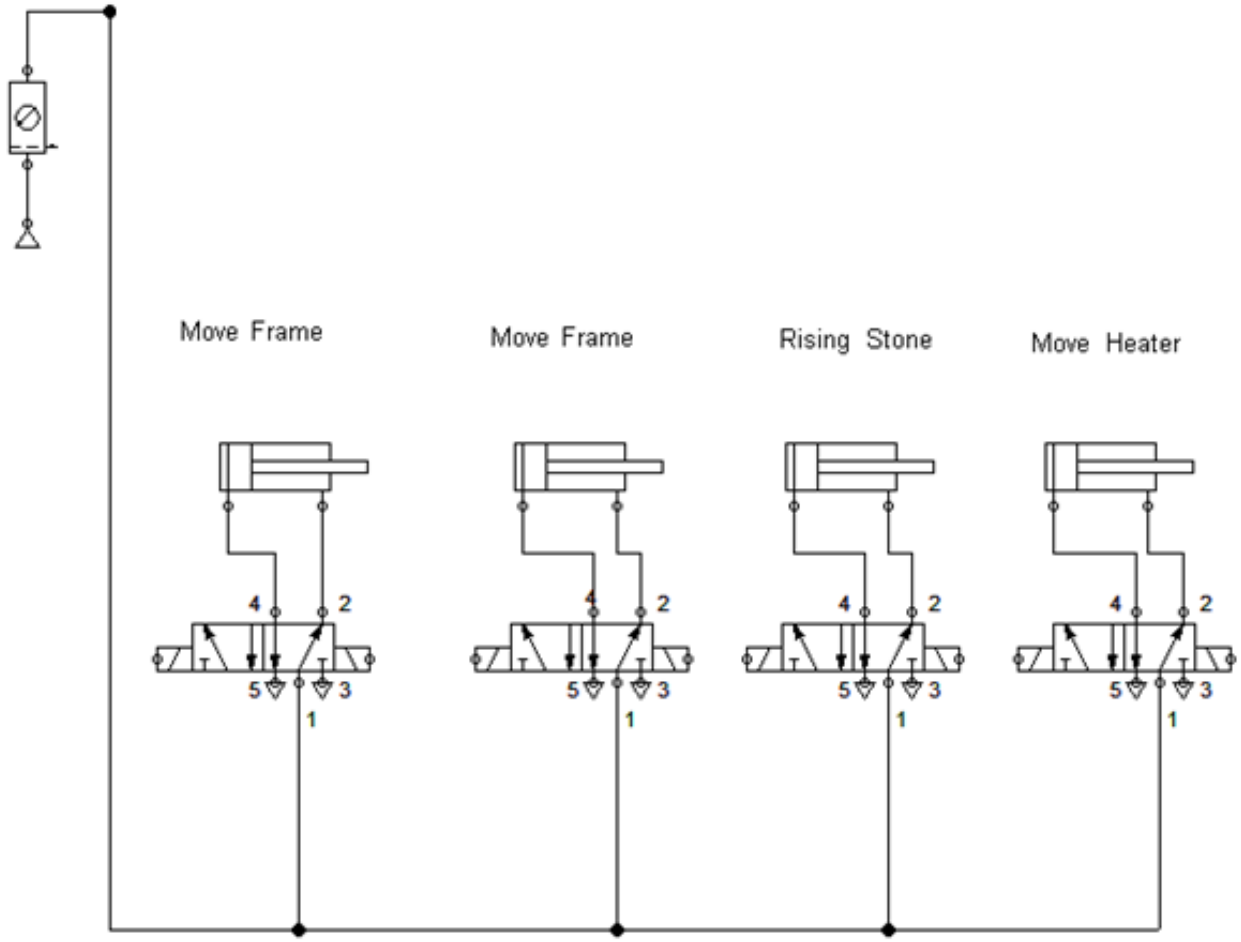


Figure 4.3: Pneumatic Power Circuit

5

Chapter Five

Results And Conclusions

4.1 Results

(Table 5.1) show the difference in machine before & after developing

Table 5.1:Results

Component /Operation name	Before	After
Temperature	Senses by one sensor	Senses by four sensor consist of four parts.
Heaters	• Distributed three random parts • Move manually	• Distributed four balanced part • Move by cylinder
Metal Frame	Open manually	Open by cylinder
Mould frame	Fixed	Adjustable
control	Traditional Control	PLC Control
Entry/Input	Switches	HMI
Monitoring	Heat Clock	HMI
Suction	Non distributed suction	distributed suction
Operation	Manual	Manual/Auto

4.2Conclusions

1. Air trapped between the mould and the sheet - check that you have enough evacuation holes
2. The sheet be not hot enough, must increase the heating time or temperature
3. The vacuum pumps filter need cleaning/replacing.
4. The material be not vacuum forming, must check source and type.
5. The moulds have become too hot, must turn the machine off and wait for the mould to cool before attempting another forming.
6. The mould material have bonded with the forming material, must put a thin coating of silicone oil or similar on the mould before forming.
7. The sheet be hygroscopic and moisture in the sheet is causing it to blister, must dry the sheet thoroughly before heating.

4.3 Recommendations

1. Convert the machine to production line to produce moulds without worker.
2. Adding roll of Plastic.
3. Using laser cutting.
4. Adding Pressing up the mould.
5. Using inverter for output of heaters.

4.4 Reference

References

[1] Book of Festo Company "Standards based cylinders DSBC to ISO 15552"

[2] A Low Cost Vacuum-Forming System Paper "James P.O'Leary ,1976"

[3] Zoher Wazwaz , *Pneumatic System*, PPU, Hebron-Palestine, 2017.

[4] م. الجيلاني، *المرجع في التركيبات والتصميمات الكهربية*، القاهره ،٢٠١٣

4.5 Photo for the Machine

(Appendix G).

Appendix A

Thermocouples

General Applications

Over 90 years of manufacturing, research and design makes Watlow a world class supplier of temperature measurement products. We have designed and manufactured millions of thermocouples for industrial and commercial equipment. People involved in critical process control of food, plastics and metal rely on our sensors.

We are ready to meet your sensing needs with our extensive offering of thermocouples. However, if the variations listed in this catalog are unable to satisfy your requirements, Watlow can custom manufacture sensors to your exacting specifications. Contact your Watlow representative for details.

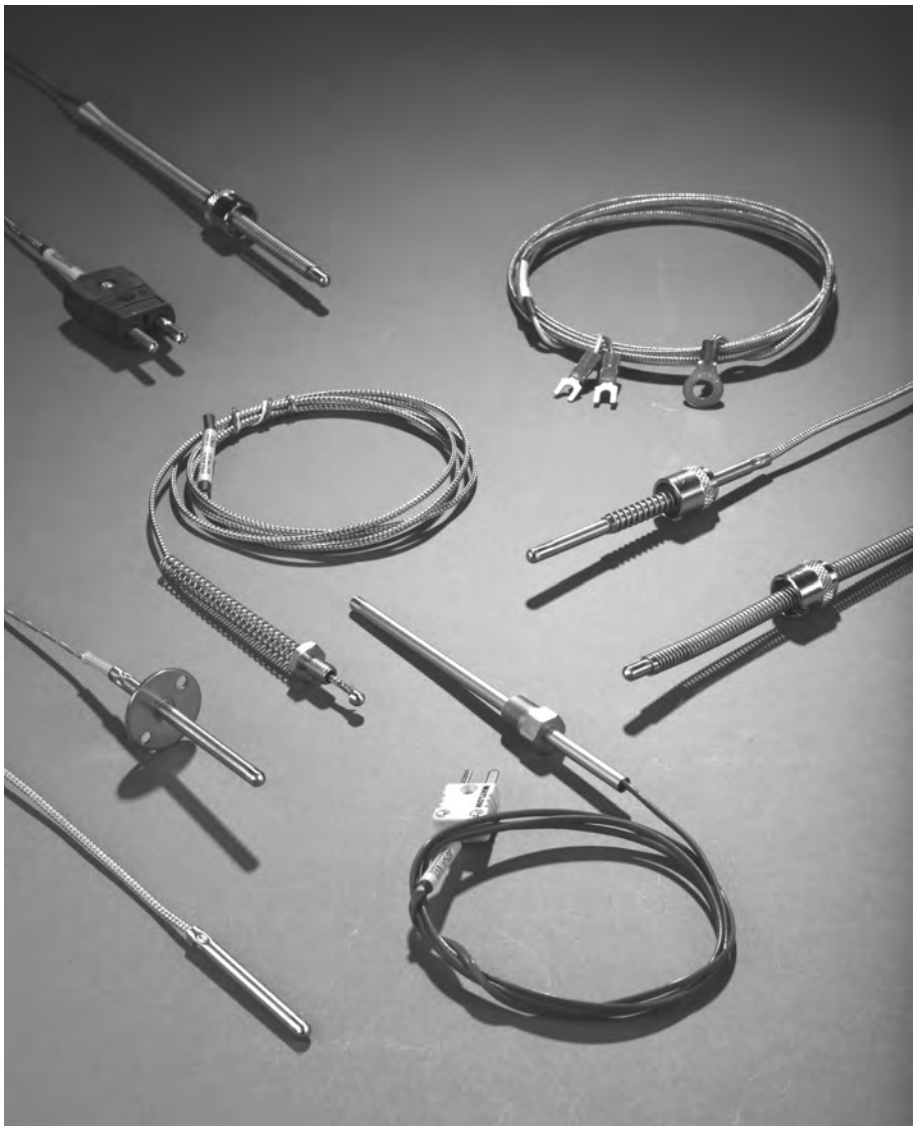
Performance Capabilities

- Fiberglass insulated thermocouples are capable of temperatures up to 480°C (900°F) for continuous operation.

Features and Benefits

"Custom-tailored" standard products including:

- 32 standard sheath lengths
- Lead lengths from six to 360 inches
- Stainless steel braid or hose protection
- J, K, T and E calibrations
- Grounded, ungrounded and exposed junctions
- Flat and drill point
- Epoxy sealed cold ends
- Adjustable depths
- Flexible extensions
- Washers, nozzles and clamp bands
- Custom diameters
- PFA coated and stainless steel sheaths
- Straight, 45° bend or 90° bend
- Locking bayonet caps in standard, 12 mm and 15 mm



Custom manufactured thermocouples

- Units designed and built to your specifications

Applications

- Plastic injection molding machinery
- Food processing equipment
- Deicing
- Plating baths
- Industrial processing
- Medical equipment
- Pipe tracing control
- Industrial heat treating
- Packaging equipment
- Liquid temperature measurement
- Refrigerator temperature control
- Oven temperature control

Thermocouples

General Applications

Construction and Tolerances

Construction

Thermocouples feature flexible SERV-RITE® wire insulated with woven fiberglass or high temperature engineered resins. For added protection against abrasion, products can be provided with stainless steel wire braid and flexible armor. ASTM E 230 color-coding identifies standard catalog thermocouple types (see reference chart on inside back cover).

The addition of a metal sheath over the thermocouple provides rigidity for accurate placement and added protection of the sensing junction. Mounting options include springs, ring terminals, specialized bolts, pipe style clamps and shims.

How to Order

- Determine style of thermocouple required
- Complete the eleven digit part number as determined by the following parameters:
  - Construction
  - Diameter
  - Calibration
  - Lead protection
  - Junction
  - Sheath length
  - Lead length
  - Terminations/options

Note: All eleven spaces must be filled in.

Availability

Rapid Ship sensors are available for same or next day shipment.

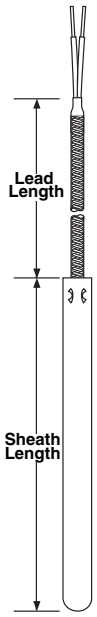
Preferred sensor options are available for shipment in approximately three days.

For **custom built** products consult factory for approximate shipment time.

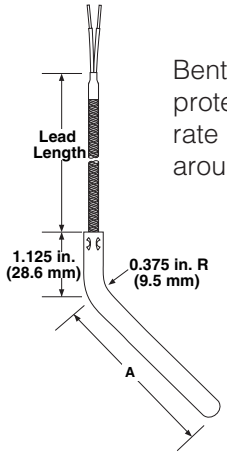
Thermocouples

General Applications

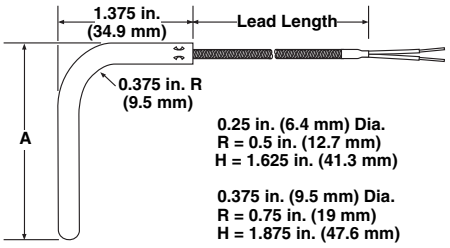
Rigid Sheath
Styles 20, 21 and 22
⅛ and 3/16 inch Diameter



Rigid sheath provides protection and accurate placement through bulkheads or platens. Use with a compression fitting for water tight immersion application.



Bent rigid tube offers protection and accurate lead placement around machinery.



*Not available with ⅛ inch diameter sheath.

Metric sizes available for made-to-order units, consult factory. Minimum order quantity may apply.

Rapid Ship Sensors

Rapid Ship sensors come with 3/16 inch diameter sheath, 24 gauge stranded fiberglass lead with stainless steel overbraid, grounded junction and split lead termination.

Calibration	Sheath Length in.	Sheath Length (mm)	Lead Length in.	Lead Length (mm)	Part Number
J	1	(25)	48	(1219)	20DJSGB048A
			96	(2438)	20DJSGB096A
	2	(51)	48	(1219)	20DJSGD048A
			96	(2438)	20DJSGD096A
	4	(102)	48	(1219)	20DJSGH048A
			96	(2438)	20DJSGH096A

Custom Ordering Information—Items in **Bolded Green Type** are preferred with shorter lead times.

1 2 3 4 5 6 7 8 9 10 11

1-2. Construction Style
20 = Plain sheath, straight
21 = Plain sheath, 45° bend
22= Plain sheath, 90° bend

3. Sheath Diameter (inch), 316 SS
C = ⅛ T = 3/16 epoxy sealed 149°C (300°F)
D = 3/16

4. Calibration
J = Type J T = Type T
K = Type K E = Type E

5. Lead Protection
F = Fiberglass (24 gauge stranded)
S = Fiberglass with stainless steel overbraid (24 gauge stranded)
H = Fiberglass with stainless steel hose (24 gauge stranded)
*P = Fiberglass (20 gauge stranded)
*B = Fiberglass with stainless steel overbraid (20 gauge stranded)
*C = Fiberglass with stainless steel hose (20 gauge stranded)
O = Plug or jack termination on sheath fiberglass (24 gauge stranded)
T = PFA (24 gauge stranded)
U = PFA with stainless steel overbraid (24 gauge stranded)
K = PFA with stainless steel hose (24 gauge stranded)
*V = PFA (20 gauge stranded)
*W = PFA with stainless steel overbraid (20 gauge stranded)
*Y = PFA with stainless steel hose (20 gauge stranded)

6. Junction
F = Grounded, flat tip
G = Grounded, round tip
D = Grounded, drill point
R = Ungrounded, flat tip
P = Ungrounded, drill point
E = Exposed
*H = Grounded, round tip, dual element
*S = Ungrounded, round tip, dual element
U = Ungrounded, round tip

7. Sheath Length (inches)
A = ½ **D = 2** G= 3 ½ K = 5 N = 6 ½ R = 8 U = 9 ½ Z = 12
B = 1 E = 2 ½ **H= 4** L = 5 ½ P = 7 S = 8 ½ W= 10
C = 1 ½ F = 3 J = 4 ½ M = 6 Q = 7 ½ T = 9 Y = 11

8-10. Lead Length (inches)
012, 024, 036, 040, 048, 060, 072, 079, 096 and 120
Available lengths: 006 to 360, over 360 consult factory

11. Terminations/Options
A = Standard, 2 ½ inch split leads
B = 2 ½ inch split leads with #6 spade lugs
C = 2 ½ inch split leads with #6 spade lugs and BX connector
D = Standard male plug, quick disconnect
E = Standard female jack, quick disconnect
F = Miniature male plug, quick disconnect
G = Miniature female jack, quick disconnect
H = ¼ inch push-on connector

Appendix B

Delta DVP-SS2 Series

We provide all Delta AC Drives, VFD's, Delta AC Servo Motors, Delta Rotary Optical Encoders, Delta Motion Control Network, Delta Programmable Logic Controller, Delta Human Machine Interfaces, Delta Text Panels, Delta Temperature Controllers, Delta Industrial Field bus Solutions, Delta Pressure Sensor, Delta Brushless DC Motors as well as Delta Brushless DC Drives.

Delta DVP-SS2 Series Second Generation Standard Slim MPU

FEATURES

The 2nd generation DVP-SS2 series slim type PLC keeps the basic sequential control functions from the DVP-SS series PLC but with faster execution speed and enhanced real-time monitoring capability.

SPECIFICATIONS

MPU points: 14 (8DI + 6DO)
Max. I/O points: 494 (14 + 480)
Program capacity: 8k steps
COM port: Built-in RS-232 & RS-485 ports, compatible with Modbus ASCII/RTU protocol. Can be master or slave.
High-Speed Pulse Output: Supports 4 points (Y0 ~ Y3) of independent high-speed (max. 10kHz) pulse output
Supports PID Auto-tuning:DVP-SS2 saves parameters automatically after the PID auto temperature tuning is completed.
Built-in High-Speed Counters

APPLICATIONS: Spinning machine, conveyer belt (rotation speed control), winding machine (tension control)

Appendix C

2005-06-20

5011620601-T4E1

http://www.delta.com.tw/industrialautomation/

DVP04TC-S

Thermocouple Sensors Instruction Sheet

1 WARNING

Always read this manual thoroughly before using the DVP04TC-S.

In order to avoid electric shock, do not touch the terminals or conduct any maintenance while power is applied to the PLC. Never open the PLC. Only qualified Delta personell should conduct any internal electrical work on the PLC.

This is an OPEN-TYPE device and must be placed in an environment away from high temperatures, high humidity, exceessive vibration, corrosive gases, liquids, airborne dust, and metallic particles when installed in an enclosure.

Do not apply AC power to any of the input/output terminals, this will cause permanent damage to the DVP04TC-S. Do NOT touch terminals when power on.

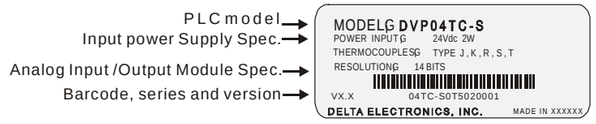
Make sure that the DVP-04TC is properly grounded ⏚, to avoid any electromagnetic noise.

2 INTRODUCTION

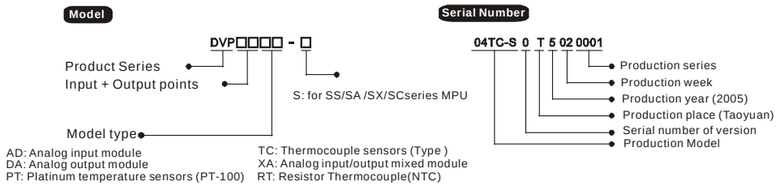
2.1 Model Explanation and Peripherals

- Thank you for choosing DELTA's DVP Series PLC. The DVP04TC-S allows the connection of four thermocouple sensors (Type J.K.R.S.T). The DVP04TC-S series can read/write the data by using commands FROM / TO via DVP-PLC SS/SA/SX/SC MPU program. There are 49 CR (Control Register) in each module and 16 bits per register.
- DVP04TC-S thermocouple sensor can update software version by RS-485. Power supply and main processing units are sold separately.
- The DVP04TC-S works with both Centigrade and Fahrenheit. The input resolution for Centigrade is 0.1 degrees and for Fahrenheit is 0.18 degrees.

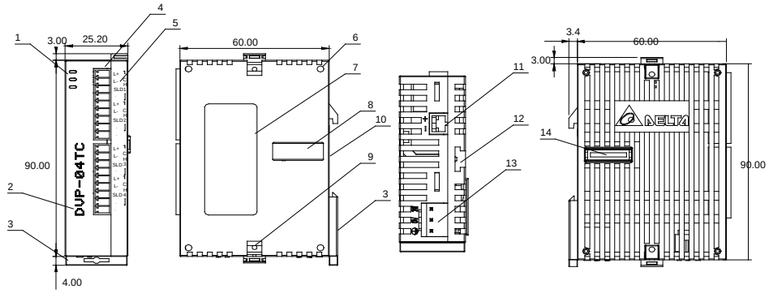
■ **Nameplate Explanation**



■ **Model Explanation**



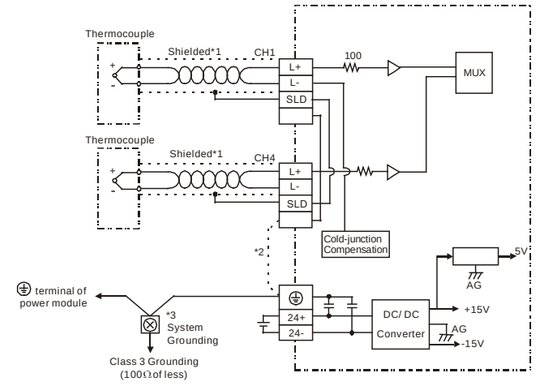
2.2 Product Profile and Outline



Unit:mm

1. Status indicator (Power, RUN and ERROR)	8. Expansion port
2. Model Number	9. Expansion Clip
3. DIN rail clip	10. DIN rail location (35mm)
4. I/O terminals	11. RS-485 Communication port
5. I/O point indicator	12. Expansion Clip
6. Expansion hole of the expansion unit mounting pins	13. DC Power input
7. Specification Label	14. Expansion port

2.3 External wiring



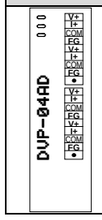
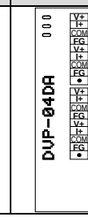
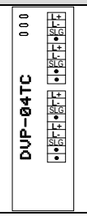
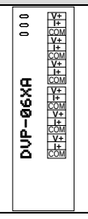
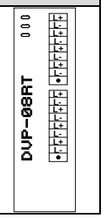
Note 1: Use only the wires that are supplied with your thermocouple sensor. Tighten PLC terminal screws to a torque of 1.95 kg-cm (1.7 in-lbs).

Note 2: Terminal SLD is a grounding location for noise suppression.

Note 3: Please connect ⏚ terminal of power supply module and ⏚ terminal of DVP04TC-S thermocouple sensors module to system earth ground.

Warning: DO NOT connect wires to the No Connection (●) terminals. Use copper conductor only, 60/75℃

2.4 Terminals of analog module

DVP04AD-S	DVP02DA-S	DVP04DA-S	DVP04PT-S	DVP04TC-S	DVP06XA-S	DVP08RT-S
						

3 STANDARD SPECIFICATIONS

3.1 Function Specifications

Platinum Temperature Module (04TC)	Centigrade (˚C)	Fahrenheit (˚F)
Power supply voltage	24 VDC(20.4VDC~28.8VDC) (–15%~+20%)	
Analog input channel	4 channels per module	
Sensors type	J-type K-type R-type S-type T-type thermocouple	
Temperature input range	J type : -100℃~700℃ K type : -100℃~1000℃ R type : -10℃~1700℃ S type : -10℃~1700℃ T type : -100℃~350℃	J type : -148℉~1292℉ K type : -148℉~1832℉ R type : -14℉~3092℉ S type : -14℉~3092℉ T type : -148℉~662℉
Digital conversion range	J type : K-1000~K7000 K type : K-1000~K10000 R type : K-100~K17000 S type : K-100~K17000 T type : K-1000~K3500	J type : K-1480~K12920 K type : K-1480~K18320 R type : K-140~K30920 S type : K-140~K30920 T type : K-1480~K6620
Resolution	14 bits(0.1˚C)	14 bits(0.18˚F)
Overall accuracy	±0.5% of full scale of 25°C(77°F), ±1% of full scale during 0~55˚C (32~131°F)	
Response time	350 ms × channels	
Isolation Method	Isolation between digital and analog circuitry. There is no isolation	

	between channels.
Digital data format	2's complement of 16-bit, (13 Significant Bits)
Average function	Yes (CR#2~CR#5 may be set and the range is K1~K4096)
Self diagnostic function	Yes
Communication mode (RS-485)	MODBUS ASCII/RTU Mode. Communication baud rate of 4800 / 9600 / 19200 / 38400 / 57600 / 115200. For ASCII mode, date format is 7Bits, even, 1 stop bit (7 E 1). For RTU mode, date format is 8Bits, even, 1 stop bit (8 E 1). The RS-485 is disabled when the DVP04AD-S is connected in series to an MPU.
Connection to a DVP-PLC MPU in series	When DVP04-TC modules are connected to an MPU, the modules are numbered from 0 – 7. 0 is the closest to the MPU and 7 is the furthest. The Maximum number of modules is 8 modules and they do not occupy any digital I/O points of the MPU.

3.2 Other Specification

Power Specification	
Maximum Power Consumption	2W at 24 VDC (20.4VDC~28.8VDC) (-15 % ~ +20 %)

Environment Condition	
Environment Condition	Follow the DVP-PLC MPU.

4 CR (CONTROLLED REGISTER)

DVP-04TC platinum temperature sensors					Explanation
CR No.	RS-485 Parameter address	Latched		Register name	b15 b14 b13 b12 b11 b10 b9 b8 b7 b6 b5 b4 b3 b2 b1 b0
#0	H 4096	○	R	Model type	System used,. DVP-04TC model code = H 8B
#1	H 4097	○	R/W	Thermocouple type	Reserved | CH4 | CH3 | CH2 | CH1 Example: Setting of CH1 1. b2~b0: set (0,0,0) to use J-type 2. b2~b0: set (0,0,1) to use K-type 3. b2~b0: set (0,1,0) to use R-type 4. b2~b0: set (0,1,1) to use S-type 5. b2~b0: set (1,0,0) to use T-type
#2	H 4098	○	R/W	CH1 average number	The number of readings used for "average" temperature on channels CH1~CH4. Setting range is K1~K4096 and factory setting is K10.
#3	H 4099	○	R/W	CH2 average number	
#4	H 409A	○	R/W	CH3 average number	
#5	H 409B	○	R/W	CH4 average number	
#6	H 409C	×	R	CH1 average degrees(˚C)	Average degrees for channels CH1~CH4. (unit: 0.1 degrees C)
#7	H 409D	×	R	CH2 average degrees(˚C)	
#8	H 409E	×	R	CH3 average degrees(˚C)	
#9	H 409F	×	R	CH4 average degrees(˚C)	
#10	H 40A2	×	R	CH1 average degrees(˚F)	Average degrees for channels CH1~CH4. (unit: 0.1 degrees F)
#11	H 40A3	×	R	CH2 average degrees(˚F)	
#12	H 40A4	×	R	CH3 average degrees(˚F)	
#13	H 40A5	×	R	CH4 average degrees(˚F)	
#14	H 40A8	×	R	Present temperature of CH1 (˚C)	Present temperature of channels CH1~CH4. (unit: 0.1 degrees C)
#15	H 40A9	×	R	Present temperature of CH2 (˚C)	
#16	H 40AA	×	R	Present temperature of CH3 (˚C)	
#17	H 40AB	×	R	Present temperature of CH4 (˚C)	
#18				Reserved	
#19	H 40AE	×	R	Present temperature of CH1 (˚F)	Present temperature of channels CH1~CH4. (unit: 0.1degrees F)
#20	H 40AF	×	R	Present temperature of CH2 (˚F)	
#21	H 40B0	×	R	Present temperature of CH3 (˚F)	
#22	H 40B1	×	R	Present temperature of CH4 (˚F)	
#23				Reserved	
#24	H 40AE	○	R	CH1 OFFSET Value	Adjust offset value of channels CH1~CH4. The range is -1000~+1000 and factory setting is K0. (unit: 0.1 degrees C)
#25	H 40AF	○	R	CH2 OFFSET Value	
#26	H 40B0	○	R	CH3 OFFSET Value	
#27	H 40B1	○	R	CH4 OFFSET Value	
#28~#29				Reserved	
#30	H 40B4	×	R	Error status	Data register stores the error status, refer to fault code chart for details.
#31	H 40B5	○	R/W	Communication address setting	RS-485 communication address. Setting range is 01~255 and factory setting is K1
#32	H 40B6	○	R/W	Communication baud rate setting	Communication baud rate (4800, 9600, 19200, 38400, 57600 and 115200 bps). b0: 4800 bps (bit/sec). b1: 9600 bps (bit/sec). (factory setting) b2: 19200 bps (bit/sec). b3: 38400 bps (bit/sec). b4: 57600 bps (bit/sec). b5: 115200 bps (bit/sec). b6~b13: Reserved. b14: switch between low bit and high bit of CRC code (only for RTU mode) b15: RTU mode.
#33	H 40B7	○	R/W	Reset to factory setting	b15 b14 b13 b12 b11 b10 b9 b8 b7 b6 b5 b4 b3 b2 b1 b0 Definition of ERR LED | CH4 | CH3 | CH2 | CH1

					Example: Setting of CH1 1. b0 Reserved 2. b1 Reserved 3. b2: Set to 1 and PLC will be reset to factory settings. Definition of ERR LED: b12~b15=1111(factory settings) 1. b12 corresponds to CH1: when b12=1, scale exceeds the range, ERR LED flashes. 2. b13 corresponds to CH2: when b13=1, scale exceeds the range, ERR LED flashes. 3. b14 corresponds to CH3: when b14=1, scale exceeds the range, ERR LED flashes. 4. b15 corresponds to CH4: when b15=1, scale exceeds the range, ERR LED flashes.
#34	H 40B4	○	R	Software version	Display software version in hexadecimal. Example: H 010A = version 1.0A.
#35~#48				System used	

○ means latched.
╳ means not latched.
R means can read data by using FROM command or RS-485.
W means can write data by using TO command or RS-485.

Explanation:

1. CR#0: The PLC model type.
2. CR#1: Used to set the working mode of four channels (CH1~CH4). There are 2 modes (J-type and K-type) for each channel and allow to set separately. For example, If you want to set CH1~CH4 as CH1: mode 0 (b2~b0=000), CH2: mode 1(b5~b3=001), CH3: mode 0(b8~b6=000) and CH4: mode 1(b11~b9=001), you should set CR#1 to H0208. The higher bits (b12~b15) will be reserved and the factory setting is H0000.
3. CR#2 ~ CR#5: Used to set the number of input readings used for the average temperature calculation. The available range is K1~K4096 and factory setting is K10. (Note: When PLC sets average times via TO/DTO instructions, please use rising-edge/falling-edge detection instruction (such as LDP and LDF) to get correct average times.)
4. CR#6 ~ CR#9: The average temperature (˚C). The average temperature is calculated using multiple temperature readings. Example: If CR#2 is 10, the temperature in CR#6 will be the average of the last 10 readings on CH1.
5. CR#10 ~ CR#13: The average temperature (˚C). The average temperature is calculated using multiple temperature readings. Example: If CR#2 is 10, the temperature in CR#12 will be the average of the last 10 readings on CH1.
6. CR#14 ~ CR#17: display present temperature (˚C) of CH1~CH4 input signal.
7. CR#18, CR#23, CR#28, CR#29 are reserved.
8. CR#19 ~ CR#22: display present temperature (˚F) of CH1~CH4 input signal.
9. CR #24 ~ CR #27: display offset value of channels CH1~CH4. The range is -1000~+1000 and unit is 0.1 degrees C. The definition of OFFSET is Actual temperature = temperature measured by DVP-04TC – OFFSET value.
10. CR#30 is a fault code register. Refer to the following chart.

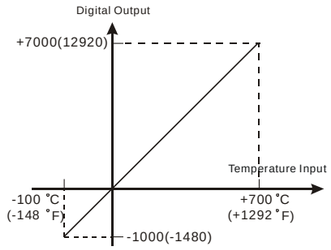
Fault description	Content	b15~b8	b7	b6	b5	b4	b3	b2	b1	b0
Power source abnormal	K1(H1)	Reserved	0	0	0	0	0	0	0	1
Analog input value error	K2(H2)		0	0	0	0	0	0	1	0
Setting mode error	K4(H4)		0	0	0	0	0	1	0	0
Offset/Gain error	K8(H8)		0	0	0	0	1	0	0	0
Hardware malfunction	K16(H10)		0	0	0	1	0	0	0	0
Digital range error	K32(H20)		0	0	1	0	0	0	0	0
Average times setting error	K64(H40)		0	1	0	0	0	0	0	0
Command error	K128(H80)		1	0	0	0	0	0	0	0
Note: Each fault code will have corresponding bit (b0~b7). Two or more faults may happen at the same time. 0 means normal and 1 means fault occurs.										

11. CR#31: RS-485 communication address. Setting range is 01~255 and factory setting is K1.
12. CR#32: RS-485 communication baud rate: 4800, 9600, 19200, 38400, 57600 and 115200. b0:4800bps, b1:9600bps (factory setting), b2:19200bps, b3:38400 bps, b4:57600 bps, b5:115200 bps, b6~b13: Reserved, b14: switch between low bit and high bit of CRC code (only for RTU mode) b15: ASCII / RTU mode. For ASCII mode, date format is 7Bits, even, 1 stop bit (7 E 1). For RTU mode, date format is 8Bits, even, 1 stop bit (8 E 1).
13. CR#33: Used to reset the settings of CR registers to factory defaults.
14. CR#34: software version.
15. CR#35~ CR#48: Reserved for internal system use.
16. The corresponding parameters address H 4096~H 40C7 of CR#0~CR#48 may provide users to read/write data via RS-485 communication.
    a) Communication baud rate: 4800, 9600, 19200, 38400, 57600, 115200 bps.
    b) Communication format: ASCII mode is 7Bit, even bit, 1 stop bit (7 E 1). Communication format of RTU mode is 8Bit, even bit, 1 stop bit (8 E 1).
    c) Function code: 03H—read data from register. 06H—write a WORD into register. 10H—write many WORDs into register.

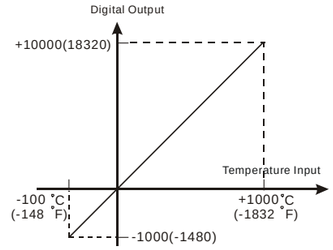
5 TEMPERATURE/DIGITAL CHARACTERISTIC CURVE

Temperature mode: (Centigrade/Fahrenheit)

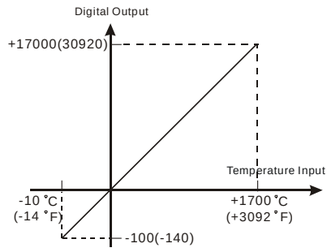
J-type thermocouple sensors



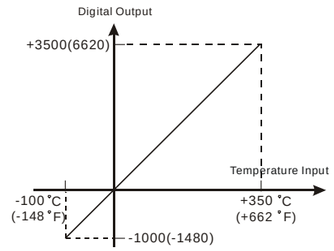
K-type thermocouple sensors



R/S-type thermocouple sensors



T-type thermocouple sensors

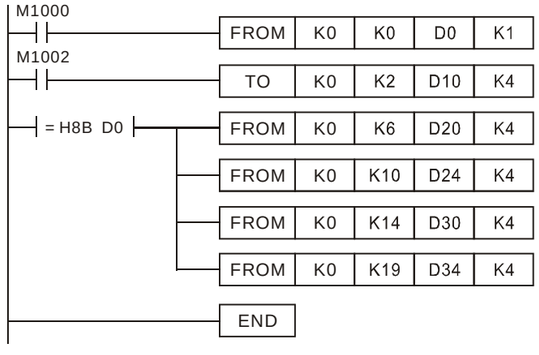


6 INITIAL PLC START-UP

LED display:

1. Upon power-up, the ERROR LED will light for 0.5 seconds the POWER LED will light continuously.
2. No errors= POWER LED on and ERROR LED off.
   Low Voltage error (lower than 19.5V), ERROR LED will blink continuously till the power supply rises above 19.5V.
3. DVP04TC-S connected to PLC MPU in series = RUN LED on MPU will be lit and A/D LED or D/A LED should blink.
4. After receiving the first RS-485 command the A/D LED or D/A LED will blink.
5. If the input or output exceeds the upper or lower bounds, then the ERROR LED will blink.

Example:



Explanation:

- Reading the model type of expansion module K0 (should be H8B for DVP04TC-S model type).
- The averaging number for CH1~CH4 will be D10~D13.
- If the model type is DVP04TC-S. Reading the average temperature (˚C) of CH1~CH4 (4 data) from CR#6~CR#9 and save them into D20~D23.
- Reading the average temperature (˚F) of CH1~CH4 (4 data) from CR#10~CR#13 and save them into D24~D27.
- Reading the present temperature (˚C) of CH1~CH4 (4 data) from CR#14~CR#17 and save them into D30~D33.
- Reading the present temperature (˚F) of CH1~CH4 (4 data) from CR#19~CR#22 and save them into D34~D37.

7 RELATED INSTRUCTIONS EXPLANATION

API	D	FROM	P	m1	m2	D	n	Read special module CR data
78								

Explanations:

m1: number of special module (m1=0~7). **m2**: CR number of special module that will be read. **D**: address for saving reading data. **n**: data number for reading once.

Example:

Writing special module #0 of CR#24 into D0 and special module #0 of CR#25 into D1. only write two data once (n=2).

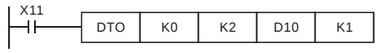
API	D	TO	P	m1	m2	S	n	Special module CR data write
79								

Explanations:

m1: number of special module (m1=0~7). **m2**: CR number of special module that will be wrote in. **S**: data to write in CR. **n**: data number to write in once.

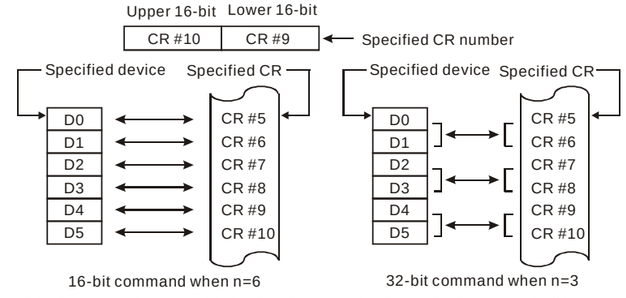
Example:

Using 32-bit instruction DTO to write D11 and D10 into special module#0 of CR#3 and CR#2. only write a data once (n=1).



The rule of instruction operand:

1. m1: number of special module. The special module closest to the ELC controller will be assigned 0, the next closest will be assigned 1, etc. for a total of 8 modules(0~7).
2. m2: number of CR. Built-in of 48 groups of 16-bit memory of special module are called CR (Control Register). Each CR uses decimal digits (#0~#48).



3. In PB models, flag M1083 is not provided. When the FROM/TO instruction is executed, all interrupts (including external or internal interrupt subroutines) will be disabled. All interrupts will be executed after the FROM/TO instruction is completed. The, FROM/TO instruction can also be executed in an interrupt subroutine.
4. The function of the flag M1083 (FROM/TO mode) provided in PC/PA/PH models:
   a. When M1083=OFF, FROM/TO instruction is executed, all interrupts (including external or internal interrupt subroutines) will be disabled. All interrupts will be executed after FROM/TO instruction is completed.
   b. When M1083=ON, if an interrupt occurs while the FROM/TO instruction has been programmed, The FROM/TO instruction will be interrupted to execute the interrupt. The FROM/TO instruction cannot be executed in the interrupt subroutine.

Appendix D

2014-11-18

5012611105-B705

DOP-*B07*

High Color • Wide Screen • User-Friendly HMI Products

Instruction Sheet

❶ Preface

Thank you for purchasing DELTA's DOP-B series. This instruction sheet will be helpful in the installation, wiring and inspection of Delta HMI. Before using the product, please read this instruction sheet to ensure correct use. You should thoroughly understand all safety precautions before proceeding with the installation, wiring and operation. Place this instruction sheet in a safe location for future reference. Please observe the following precautions:

- Install the product in a clean and dry location free from corrosive and inflammable gases or liquids.
- Ensure that all wiring instructions and recommendations are followed.
- Ensure that HMI is correctly connected to a ground. The grounding method must comply with the electrical standard of the country (Please refer to NFPA 70: National Electrical Code, 2005 Ed.).
- Do not disassemble HMI, modify or remove wiring when power is applied to HMI.
- Do not touch the power supply during operation. Otherwise, it may cause electric shock.

If you have any questions during operation, please contact our local distributors or Delta sales representatives.

The content of this instruction sheet may be revised without prior notice. Please consult our distributors or download the most updated version at http://www.delta.com.tw/ia.

❷ Pin Definition of Serial Communication

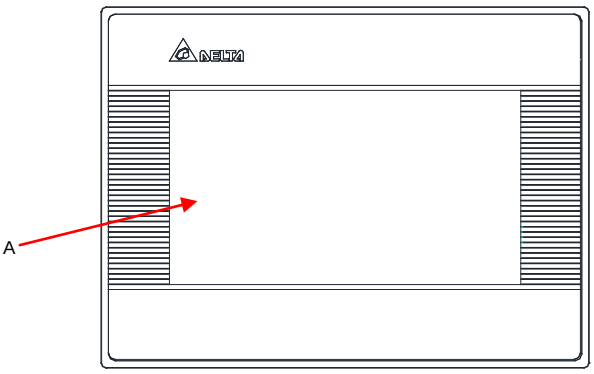
B07S410 COM Port

COM Port	Pin	MODE1	MODE2	MODE3
		RS-232	RS-422	RS-485
PIN1 	1		TXD+	D+
	2	RXD		
	3	TXD		
	4		RXD+	
	5	GND	GND	GND
	6		TXD-	D-
	7	RTS		
	8	CTS		
	9		RXD-	

Note1: Blank = To avoid malfunction, it must be left unconnected.

❸ Parts Names

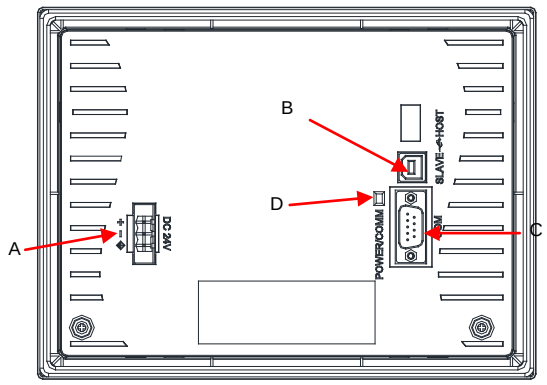
DOP-B07S410 (Front View)



A	Touch Screen / Display

Please note DOP-B07S410 model has not system key, user could press at blank space for a while to enter system menu.

DOP-B07S410 (Rear View)

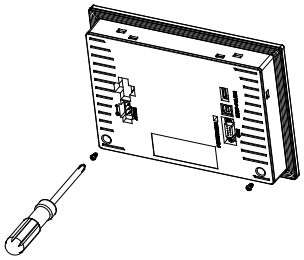


A	Power Input Terminal	B	USB Slave
C	COM	D	Power and Communication LED Light.

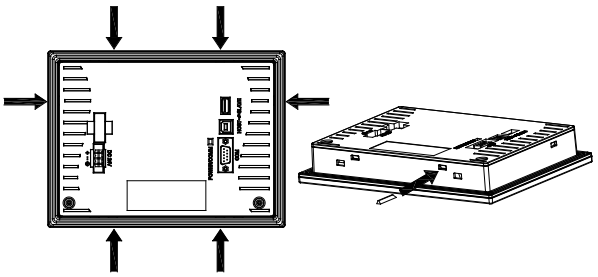
❹ DOP-B07S410 Battery change notice

Please do not use other company battery in DOP-B07S410. If users need to buy the battery, please look for Delta suppliers.

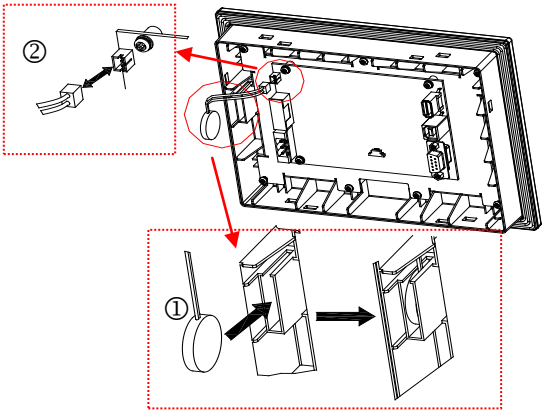
Step1. Please dismantle a screw of back cover.



Step2. Use the implement to dismantle the back cover with tenon-mortise like as arrow figures out.

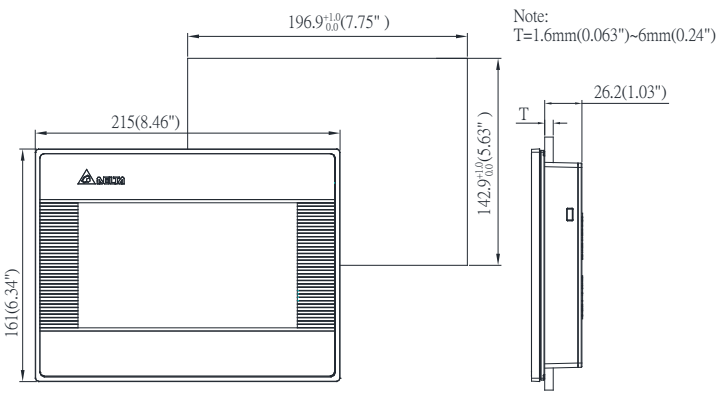


Step3. Please follow as below figure to change(①) and install the battery(②)



❺ Dimensions

DOP-B07S410



❻ Specifications

Model Name		DOP-B07S410
LCD MODULE	Display Type	7" TFT LCD (65536 colors)
	Resolution	800 x 480 pixels
	Backlight	LED Back Light (less than 20,000 hours half-life at 25°C) (Note 1)
	Display Size	154.08 x 85.92mm
Operation System		Delta Real Time OS
MCU		32-bit RISC Micro-controller
NOR Flash ROM		Flash ROM 4 MB (OS System: 2MB / User Application: 2MB)
SDRAM		64Mbytes
Backup Memory		32Kbytes
Buzzer		Multi-Tone Frequency (2K ~ 4K Hz) / 85dB
USB		1 USB Slave Ver 2.0
Serial COM Port	COM1	RS-232 (supports hardware flow control) / RS-422 / RS-485
Perpetual Calendar (RTC)		Built-in
Cooling Method		Natural air circulation
Safety Approval		CE
Waterproof Degree		IP65
Operation Voltage (Note2)		DC +24V (-10% ~ +15%) (please use isolated power supply)
Voltage Endurance		AC500V for 1 minute (between charging (DC24V terminal) and FG terminals)
Power Consumption (Note 2)		3.5W
Backup Battery		3V lithium battery CR2032 × 1
Backup Battery Life		It depends on the temperature used and the conditions of usage, about 3 years or more at 25°C.
Operation Temperature		0°C ~ 50°C
Storage Temperature		-20°C ~ +60°C
Ambient Humidity		10% ~ 90% RH [0 ~ 40°C], 10% ~ 55% RH [41 ~ 50°C] Pollution Degree 2
Vibration		IEC 61131-2 compliant 5Hz≦f < 8.3Hz = Continuous: 3.5mm, 8.3Hz≦f≦150Hz = Continuous: 1.0g
Shock		IEC 60068-2-27 compliant 15g peak for 11 ms duration, X, Y, Z directions for 6 times
Dimensions (W) x (H) x (D) mm		215 x 161 x 35.3
Panel Cutout (W) x (H) mm		196.9 x 142.9
Weight		Approx.700g

NOTE

1) The half-life of backlight is defined as original luminance being reduced by 50% when the maximum driving current is supplied to HMI. The life of LED backlight shown here is an estimated value under 25°C normal temperature and humidity conditions.
2) The value of the power consumption indicates the electrical power consumed by HMI only without connecting to any peripheral devices. In order to ensure the normal operation, it is recommended to use a power supply which the capacity is 1.5 ~2 times the value of the power consumption.
3) The content of this instruction sheet may be revised without prior notice. Please consult our distributors or download the most updated version at http://www.delta.com.tw/ia

Appendix E

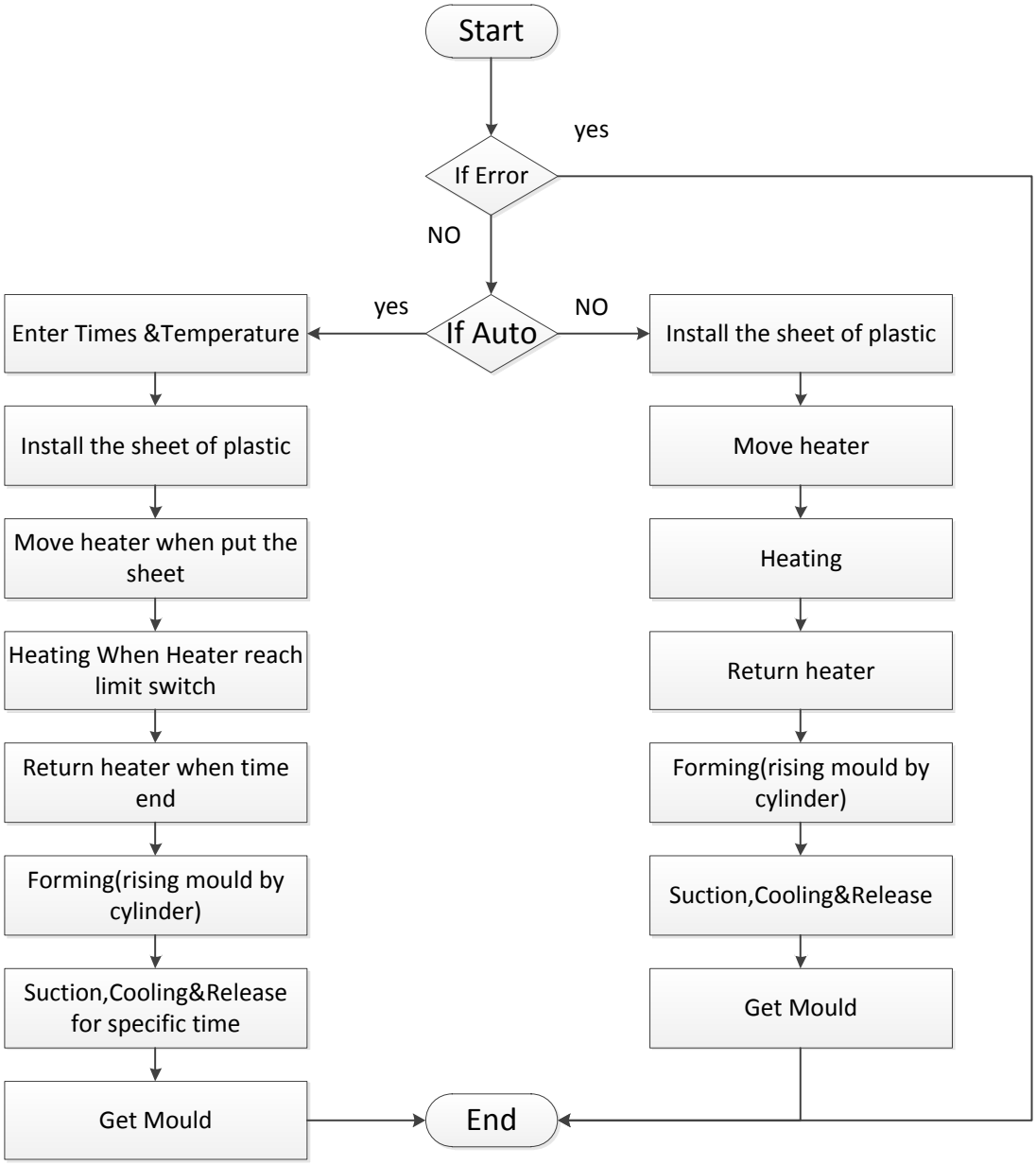
power supply
main switch
Contactor1
Contactor2
Contactor3
Contactor4
Contactor5
Relay1
Relay2
Relay3
Relay3
Air compressor
PLC
Heater1
Heater2
Heater3
Vacuum
Vlave 1
Valve 2
Valve 3
Valve 4
HMI
sheet of plastic
Heated plastic sheet
Cooler
cylinder1
cylinder2
cylinder3
cylinder4
cylinder5
cutting tool
Heater movment
metal frame
stone tabel
sensor 1
sensor2
sensor3
sensor 4
sensor5

Plastic Formaing Machine

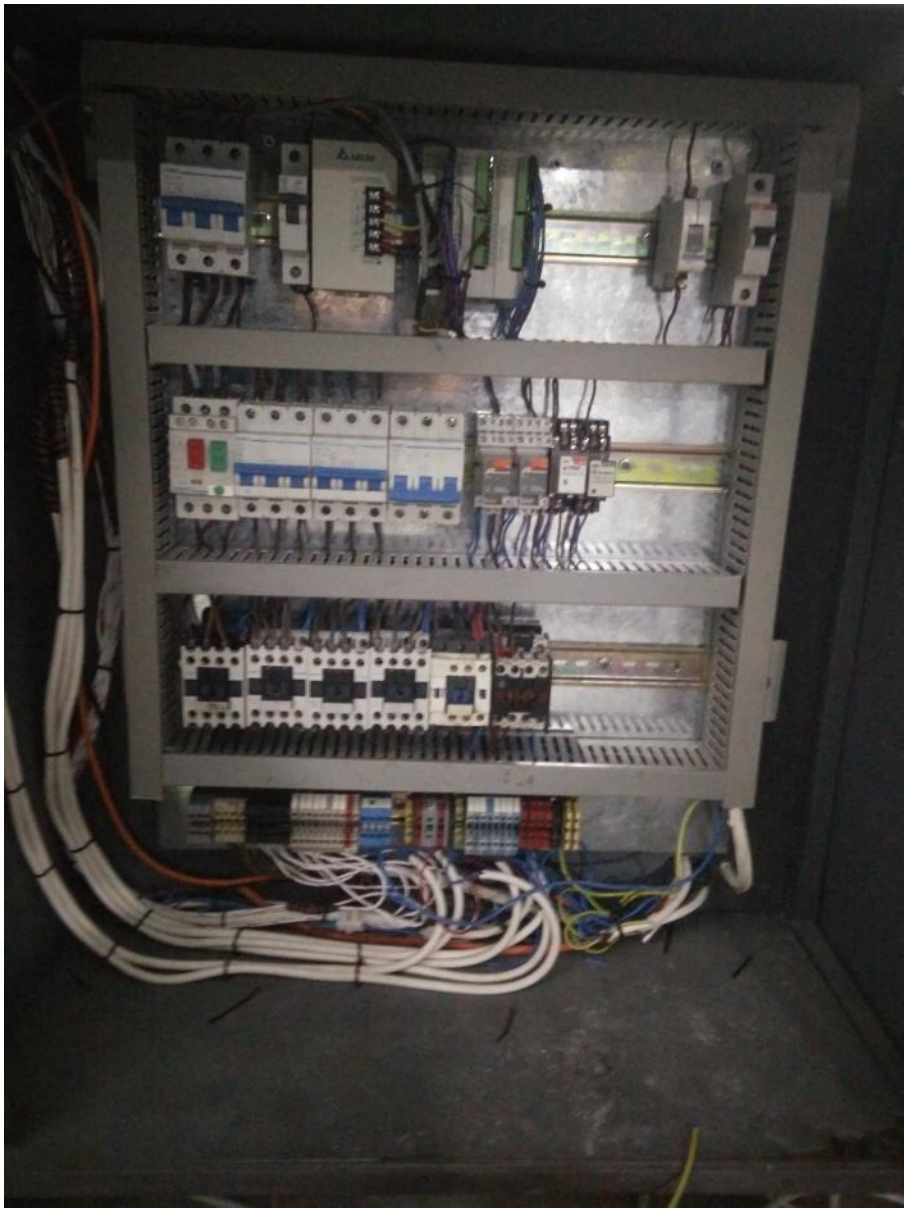
Text

power flow
Air flow
Input signal
Output signal
Heat flow

Appendix F


Start
If Error
yes
NO
If Auto
yes
NO
Enter Times &Temperature
Install the sheet of plastic
Move heater when put the sheet
Heating When Heater reach limit switch
Return heater when time end
Forming(rising mould by cylinder)
Suction,Cooling&Release for specific time
Get Mould
Install the sheet of plastic
Move heater
Heating
Return heater
Forming(rising mould by cylinder)
Suction,Cooling&Release
Get Mould
End

Appendix G

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