Palestine Polytechnic University

College of Engineering

"Development The Control System of Plastic Molding Injection Machine"

Prepared

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-إهداء

إلى معلمنا و قائدنا 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.

إلى الذين عشقوا الحرية التي تفوح منها رائحة الياسمين وتواروا خلف القضبان ليفسحوا لنا النور أسرانا البواسل.

إلى أبي الذي لم يبخل علي يوماً بشيء، وأمي التي زودتني بالحنان والمحبة أقول لهم:

أنتم وهبتموني الحياة والأمل والنشأة على شغف الإطلاع والمعرفة.

إلى إخوتي و زوجتي و أسرتي جميعا.

إلى كل من علمني حرفاً أصبح سنا برقه يضيء الطريق أمامي.

إلى من ضاقت السطور لذكرهم فوسعتهم قلوبنا أصدقاءنا الأعزاء.

إلي كل من أضاء بعلمه عقل غيره، أو هدى بالجواب الصحيح حيرة سائليه، فأظهر بسماحته تواضع العلماء، وبرحابته سماحة العارفين .

إلى من رسم معنا خطوات هذا النجاح الى من بذل جهده ووقته وكان لنا مرشداً وناصحاً وأخاً مشرفنا الحبيب الدكتور سمير خضر.

الملخص

"تطوير نظام التحكم في ماكينة حقن البلاستيك"

تعتبر الصناعات البلاستيكية من اهم المنتجات التي لا يمكن الاستغناء عنها , حيث يتم استهلاكها بشكل كبير , فهي تستخدم في العديد من مجالات الحياة اليومية ,و بالتالي أصبح هنالك الحاجة الى انتاج كمية هائلة من هذه المنتجات .

لكن , يوجد مشاكل متعددة في خط إنتاج البلاستيك : أولا صعوبة في عملية الصيانة و تتبع الخطأ ثانيا كبر حجم لوحة التحكم وكثرة الاسلاك و أخيرا فقد للوقت والجهد غير الفعال. وبناء عليه فقد عملنا على تطوير التكنولوجيا الصناعية , لتحسين خط الانتاج للتغلب على هذه المشكلة.

تم تطوير خط انتاج البلاستيك المتواجد في مصنع الصداقة , حيث استخدمنا مبرمجة PLC حتى تسهل عملية التصنيع وتتم عملية التحكم بالطريقة الآلية , بالإضافة الى وجود عملية ربط للنظام باستخدام شاشة لمس Human Machine Interface .

Abstract

"Development the control system of Plastic Molding Injection Machine"

The plastic products of industrial products that are indispensable, where is consumed significantly, it is used in many areas of daily life; therefore there is a need to produce a tremendous amount of these products.

But there are few problems related to the existing line: first difficulty in the maintenance operation and follow the wrong secondly the large size of the control panel and the large number of wires and finally the time and effort are not effective. We worked on the development of industrial technology, to improve the production line to overcome this problem.

In this project the machine has been development in order to meet the required quality and production rated PLC integrate with HMI system has been apply .

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Chapter One

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1.1 General Overview

In this project, we are going to design a control of injection molding machine operates by traditional method.

The main idea of this project is the development of control in the production line control from classic technology to modern technology using programmable logic control (PLC).

1.2 Background

1.2.1 Plastic Injection Molding Machine (PIMM)

The injection molding has seen steady growth since its beginnings in the late 1800's. The technique has evolved from the production of the simple things like combs and buttons to major consumer, industrial, medical, and aerospace products.

The invention of an injection molding machine was achieved by John Wesley who injected hot celluloid into a mold which resulted in billiard balls which were used as a replacement for ivory which was based on the pressure die casting technique for metals. The industry progressed slowly over the years, producing products such as collar stays, buttons, and hair combs. The industry expanded rapidly in the 1940s because World War II created a huge demand for inexpensive, mass-produced products. In 1946, American inventor James Watson Hendry built the first screw injection molding machine, which allowed much more precise control over the speed of injection and the quality of articles produced. This machine also allowed material to be mixed before injection, so that colored or recycled plastic could be added to virgin material and mixed thoroughly before being injected.

The main concept of plastic molding is placing a polymer in a molten state into the mold cavity So that the polymer can take the required shape with the help of varying temperature and pressure. There are different ways of molding a plastic some of them are blow molding, Injection molding, rotational molding and compression molding. Each technique has their own advantages in the manufacturing of specific item.

1.2.2 Programmable Logic Control (PLC)

The way many industrial processes look today, is the result of many years of research and hard work of people committed to improve their functionality, management, and organization. One could recall the phrase "necessity is the mother of invention", and certainly this would fit the everyday work of control engineers and technicians working in industrial processes during the 50's and 60's. This necessity was the origin of devices such as the Programmable Logic Controller (PLC).

A programmable logic controller (PLC) is an industrially hardened computer based unit that performs discrete or continuous control functions in a variety of processing plant and factory environments. It was originally intended as relay replacement equipment for the automotive industry. Nowadays the PLC is used in virtually every industry imaginable. Though they were commonly referred to as PCs before 1980, PLC became the accepted abbreviation for programmable logic controllers, as the term"PC" became synonymous with personal computers in recent decades.

1.2.3 Human Machine Interface (HMI)

In the beginning was the push button, and with the push button were the lights and the switches. And then hardwired devices appeared and became electronic panels, and the integrated circuit emerged. Personal computers and software programs were born and overran the display playing field, and the Internet paved the way for information to go anywhere and everywhere. Proprietary systems became "open," and the operator display that once watched one machine embraced many, within a single plant and around the world.

Evolution is real at least where the human-machine interface (HMI) is concerned. What began as a simple, dedicated function has grown and changed immeasurably in just a few decades to become quite possibly the biggest influence in the manufacturing environment today.

1.3 Project Objectives

This project is to improvement to PIM by using PLC program and HMI to make this modern technology, the controlling will include all of parts in production line such as motor, vacuum pump, heaters and pullers. Also we are controlling the heat.

1.4 Time Table

Tasks \ weeks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Identification of project idea															
Drafting a preliminary project proposal															
Introduction about the project (Chapter 1)															
Injection Machine (Chapter2)															
Components And Controller System (Chapter 3,4,5)															

1.5 Problem Formulation

In these machines which is controlled by manually an old system, the need for human resources and lack of accuracy, when adding PLC, leading to an increase in the efficiency and accuracy of the machine and save time and effort in the process of industrialization .

The existed machine has the following drawbacks:

- slow producing process and time Consumer.
- lock in conduct felt and accuracy maintenance.

1.6 Problem Solution and Outcomes

With the completion of the work we will have a production line cable of running modern face of previous technology problem using HMI and PLC controller.

2

Chapter Two

Injection Machine

2.1 Plastic Injection Molding Machine

2.2 Injection Molding Machine Components

2.3 Material Analysis

2.4 Some Problems Associated With Injection Molding

2.5 Plastic Injection Molds

2.6 Gates

2.7 Heater Band

2.1 Plastic Injection Molding Machine (PIMM)

Injection molding is a method of forming a plastic product from powdered thermoplastics by feeding the material through the machine component called the hopper to a heated chamber in order to make it soft and force the material into the mold by the use of the screw. In this whole process pressure should be constant till the material is hardened and is ready to be removed from the mold. This is the most common and preferable way of producing a plastic products with any complexity and size. [1] Injection molding permits mass production net shape manufacturing of high precision, three dimensional of plastic parts. [2]

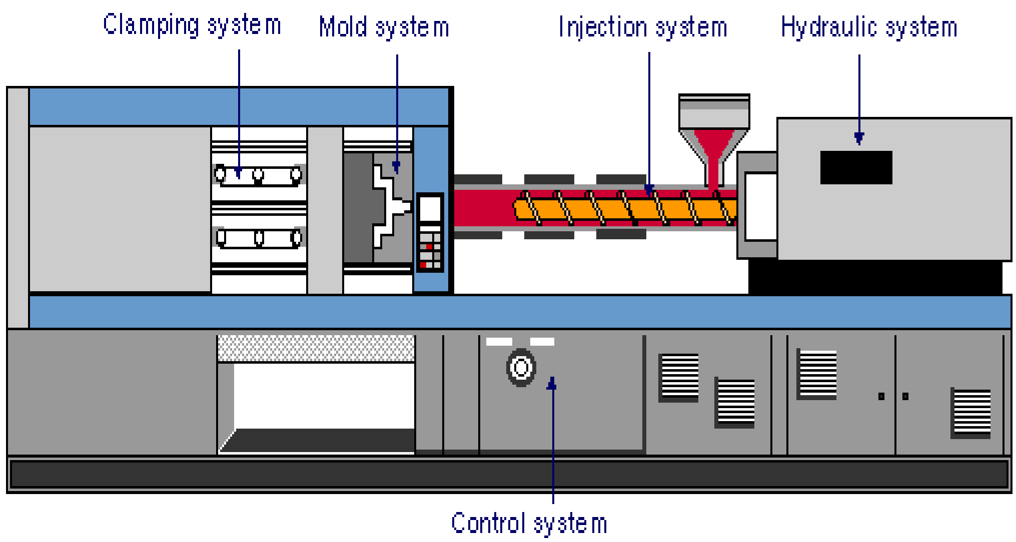

Figure 2.1: Injection Molding Machine [3]

2.1.1. The Injection Molding Process

The injection molding process stages starts with the feeding of a polymer through hopper to barrel which is then heated with the sufficient temperature to make it flow , then the molten plastic which was melted will be injected under high pressure into the mold the process is commonly known as Injection, After injection pressure will be applied to both platens of the injection molding machine(moving and fixed platens) in order to hold the mold tool together afterwards the product is set to cool which helps it in the solidification process. After the product gets its shape the two platens will move away from each other in order to separate the mold tool which is known as mold opening and finally the molded product is ejected or removed from the mold. And the process will repeat itself as shown in Figure 2.2.

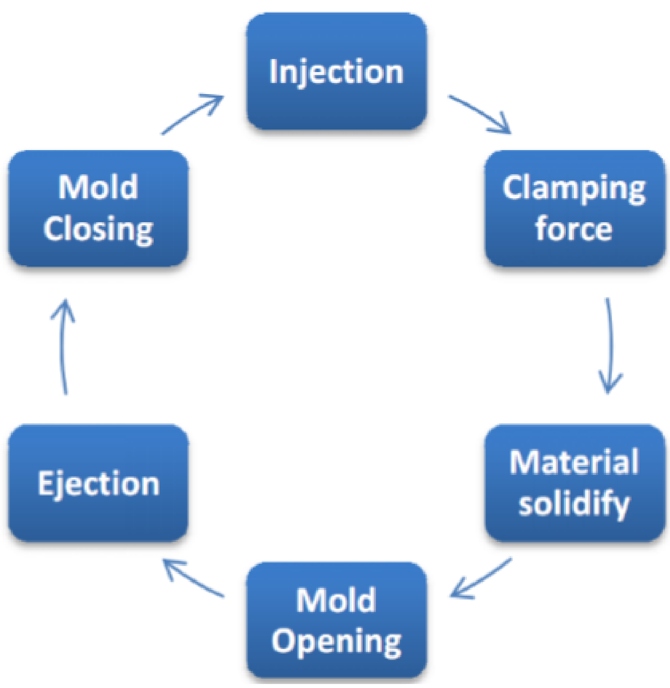

Figure 2.2: Injection molding cycle [4]

The molding cycle starts with the retraction of the ejector plate, followed by closing of the mold. The injection unit melts the polymer resin and injects the polymer melt into the mold. The ram fed injection molding machine uses a hydraulically operated plunger to push the plastic through a heated region. The melt converges at a nozzle and is injected into the mold.

The melt is forced into the mold in two or three stages:

1- Fill stage

During this stage, the mold cavities are filled with molten resin. As the Material is forced forward, it passes over a spreader, or torpedo, within the Barrel, which causes mixing. This stage is determined by an injection velocity (rate), a pressure, and a time. Injection velocity is the rate at which the plunger moves forward.

2- Pack stage

As the melt enters the mold, it cools and introduces shrinkage. The pack stage is necessary to force more melt into the mold to compensate for shrinkage.

3- Hold stage

When no more material can be forced into the mold, melt can still leak back through the gate. The hold stage applies forces against the material in the cavity until the gate freezes to prevent leaking of the melt. In some machines, pack and hold are combined into a single second or holding stage.

Each stage is governed by a particular pressure and time duration, as shown in Figure (2.3) once the mold is filled and packed and the gate has cooled, the injection molding machine switches to the cooling stage. The amount of cooling is determined by the cooling time. After the cycle is complete and before the next cycle can be run, the machine must be purged per directions in the manual. [5]

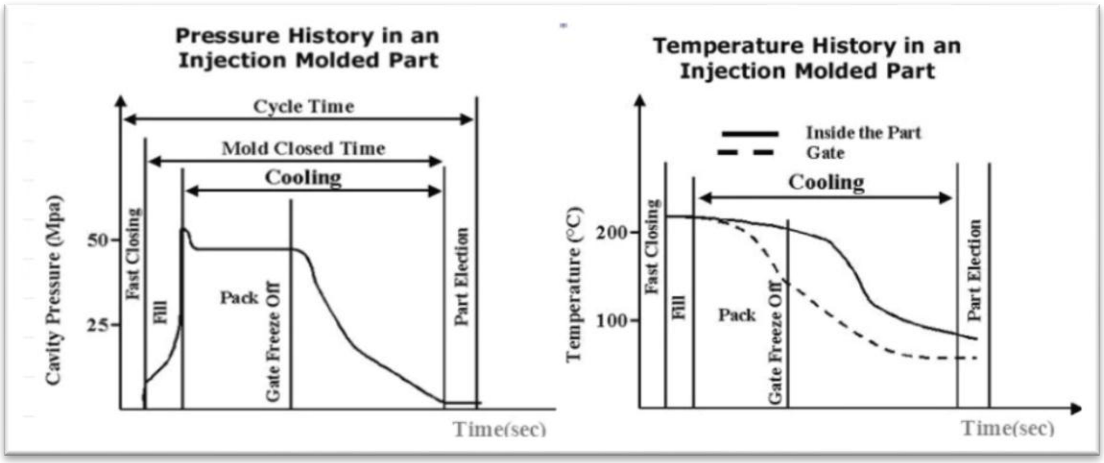

Figure 2.3: Typical pressure and temperature cycle of injection molding [5]

2.2 Injection Molding Machine Components

The injection molding machine consists of the hopper, screw, the barrel and the injection nozzle.

2.2.1 Hopper

In the molding process the plastic materials are supplied in the form of small pellets. The hopper Functions as the holder of these pellets. The pellets are then gravity fed from the hopper to the barrel.

2.2.2 The barrel

The main use of the barrel is to give support for the screw. The Barrel consists of heater bands which function as a temperature recorder for each section of the barrel.

2.2.3 The Screw

Also known as the reciprocating screw is used in compressing, melting and conveying the plastic material. The Screw consists of three zones – The feeding zone, the Transition zone and the metering zone. In the feeding zone there will be no change to the plastic materials and they will remain pellets and will be transferred to the next zone which is the transition zone, In this zone melting of the pellets will occur and the molten plastics will be transferred to the next zone which is the metering zone, In this zone the molten material will be ready for injection shown in Figure 2.4.

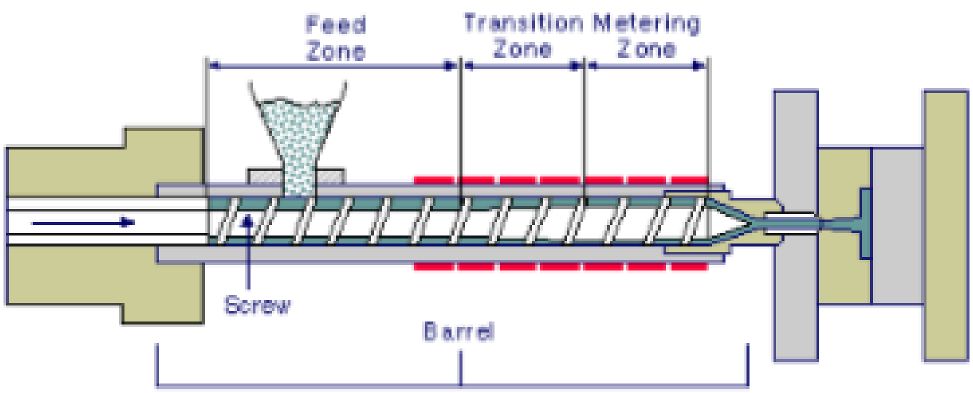

Figure 2.4: Different Zones of the Screw [6]

2.2.4 The Nozzle

The main function of the nozzle is in connecting the barrel to the sprue bushing which in turn forms a seal between the mold and the barrel. It’s essential that the nozzle temperature should be set to the materials melt temperature. [6]

2.3 Material Analysis

Polymers play huge role in the injection molding process; most polymers are classified into three groups - thermoplastics, thermosets, and elastomers. The thermoplastics can be divided into two types - those that are crystalline and those that are amorphous. [8]

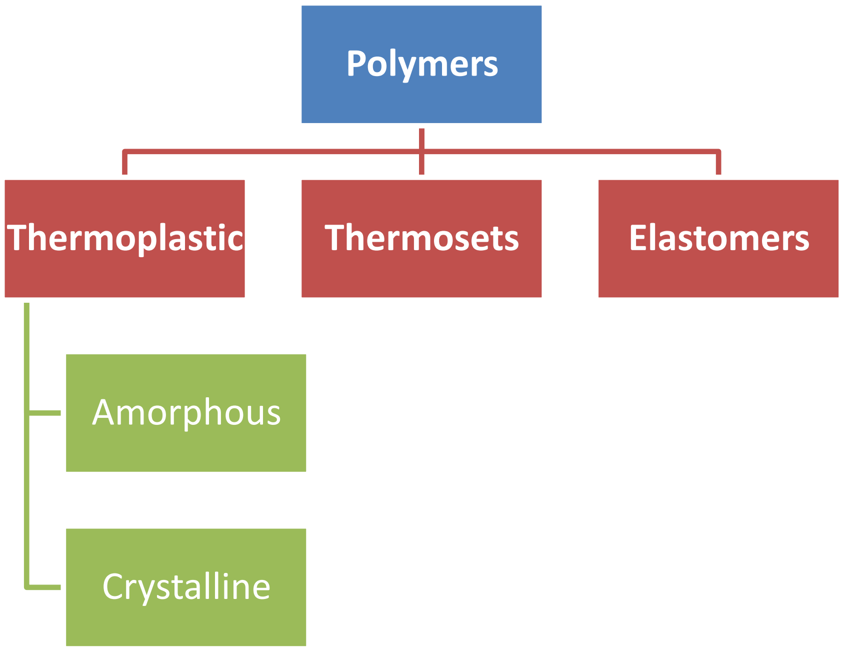

Figure 2.5: Classification of polymers

Polymers are the assembly of small organic repeating molecules called monomers. Properties of monomers include high resistivity to chemicals and can also be thermal and electrical insulators.

Thermoplastic materials generally soften when they are exposed to heat and return to their previous condition when cooled this is because there molecules are held by a weak intermolecular force. The property where they are repeatedly melted and cooled gives them a similar property as that of metals. The major thermoplastic groups are all produced by chain polymerization. Due to their recyclable property they are used in a wide range of applications such as Food packaging, insulation, automobile bumpers and credit card holders.

Themoplastic Groups	Common examples
Polyolefines	LDPE , HDPE, PP
Styrene's	PS, ABS
Vinyl's	PVC
Acrylics	PMMA
Fluor polymers	PVDF
Polyesters	PET
Polyamides (Nylons)	Nylon 6 , Nylon 66
Polyimides	PI
Polyether's	PC
Sculpture containing polymers	PES

Table 2.1: Common thermoplastic groups.

Thermosetting plastics or simply known as thermosets solidifies irreversibly when heated. Thermosets cannot be reshaped by heating. Thermosets are usually three-dimensional networked polymers in which there is a high degree of cross-linking between polymer chains. The rigidity of the material is caused by cross-linking which restricts the motion of the chains. Thermosets are strong and durable. They primarily are used in automobiles and construction. They also are used to make toys, varnishes, boat hulls and glues.

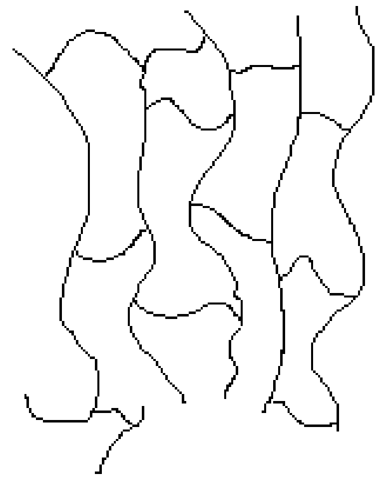

Figure 2.6: Thermoset Structure [9]

Elastomers are rubbery polymers that can be stretched easily to several times and which rapidly return to their original dimensions when the applied stress is released .Elastomers are cross linked، but have a low cross-link density. The polymer chains still have some freedom to move، but are prevented from permanently moving relative to each other by the cross-links.[9] To stretch, the polymer chains must not be part of a rigid solid - either a glass or a crystal. An elastomer must be above its glass transition temperature, TG, and have a low degree of crystallinity. Many elastic materials including rubber bands are made of elastomers.

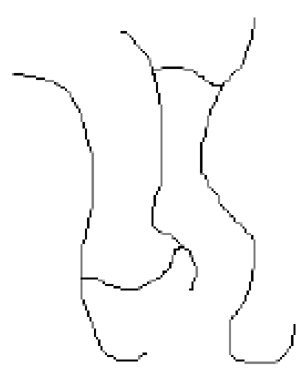

Figure 2.7: Elastomer Structure [9]

Highly crystalline polymers have properties like high rigidity, high melting point and are less affected by solvent penetration. The higher the crytallinity of polymers, the stronger the polymer but there impact resistance will be weakened. Small molecules and ions form a three dimensional lattice with an extended regular structure that makes large crystals possible. Shown in Figure2.8.

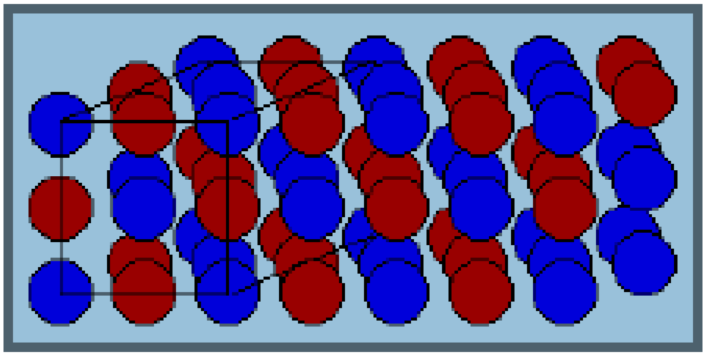

Figure 2.8: Crystalline structure [23].

Polymers which cannot pack together regularly to form crystals and polymer chains with irregular groups are known as Amorphous. These polymers are made of randomly coiled and entangled chains like spaghetti. Amorphous polymers are softer, have lower melting points, and are penetrated more by solvents than are their crystalline counterparts. [9]

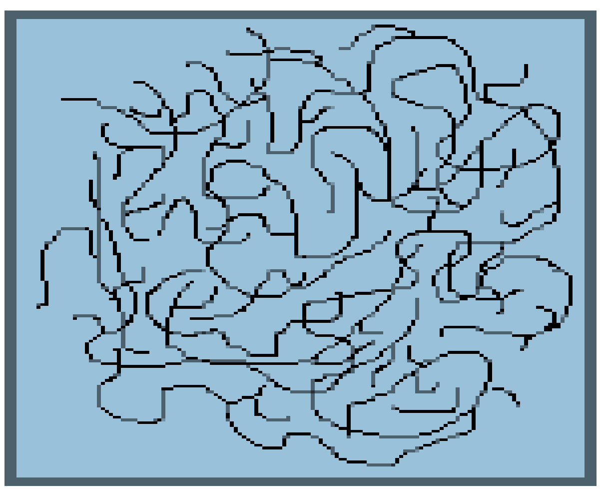

Figure 2.9: Amorphous structure [9].

2.4 Some problems associated with Injection molding

It's a common coincidence that defects in injection molding arise from the mold design imperfection and inappropriate material compounding.

Mold seal clearance, inappropriate clamping force and melting temperature along with no uniform setting times play the major role in lowering the product quality. Besides, the usage of low grade polymer with inappropriate mass–mass ratio would also be a non-conformance in the production of a quality product.

2.5 Plastic Injection Molds

A mold is simply a machined steel plate with cavities into which plastic resin is injected to form a part. [10] A mold consists of two halves into which the impression of the part product to be molded is cut. The mating surfaces of the molded halves are accurately machined so that no leakage of plastic can occur at the split line. If leakage occurs it would be expensive to remove.

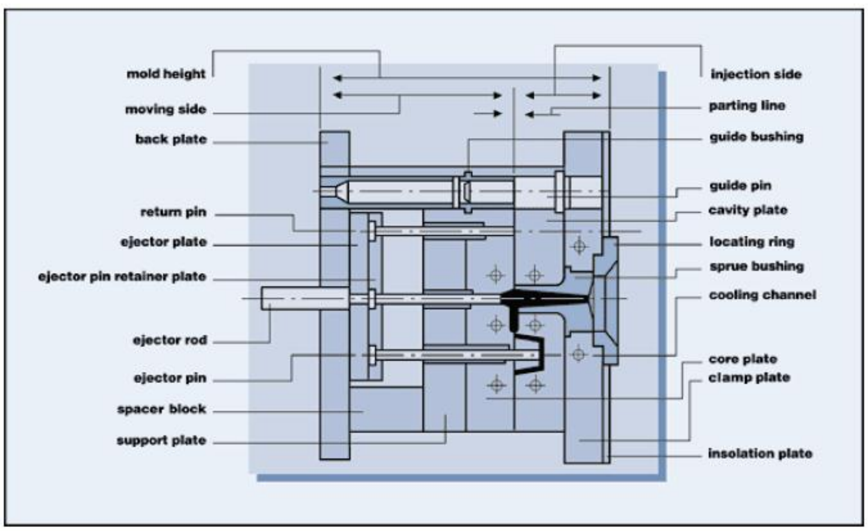

Figure 2.10: Impression of a standard injection mold [11]

Mold Component	Functions
Mold base	Hold cavities in a fixed position relative to machine nozzle
Guide Pins	Maintain proper alignments of two halves of the mold
Sprue bushing	Provides means of entry into mold interior
Gates	Control flow to cavities
Runners	Convey molten plastics from sprue into cavities
Cavity and Core	Control size, shape and surface texture of molded article
Water channels	Control temperature of mold surfaces to cool plastic to rigid state
Vents	Facilitates escaping of trapped air and gas
Ejector mechanism(pins, blades, stripper plate)	Eject rigid molded article from cavity or core
Ejector return pins	Return ejector pins to retracted position as mold closes for next cycle

Table 2.2: Mold component and their function

2.6 Gates

Gates are a transition zone between the runner system and the cavity. The location of gates is of great importance for the properties and appearance of the finished part. The melt should fill the entire cavity quickly and evenly. For gate design the following points should be considered:

- Locate the gate at the thickest section.
- Note gate marks for aesthetic reasons.
- Avoid jetting by modifying gate dimensions or position.
- Balance flow paths to ensure uniform filling and packing.
- Prevent weld lines or direct to less critical sections.
- Minimize entrapped air to eliminate burn marks.
- Avoid areas subject to impact or mechanical stress.
- Place for ease of de-gating.

Commonly Used gate types include Sprue gate, Edge gate, Tab gate and Fan gate Sprue gate is recommended for single cavity molds or for parts requiring symmetrical filling.

A short sprue is favored, enabling rapid mold filling and low-pressure losses. A cold slug well should be included opposite the gate. The disadvantage of using this type of gate is the gate mark left on the part surface after the runner (or sprue) is trimmed off. Freeze-off is controlled by the part thickness rather than determined the gate thickness. Typically, the part shrinkage near the sprue gate will be low; shrinkage in the sprue gate will be high. This results in high tensile stresses near the gate.

2.7 Heater Band

Zone-temperature (Figure 2.11) override occurs when one of the temperature zones on the barrel (not nozzle) is consistently hotter. Zone-temperature override can happen even when the zone-temperature controller never calls for power to turn on the heater band. Temperature controllers should cycle on and off to control the zone temperature. Not all zones will have the same cycle, as each barrel zone has different functions. [12]

The bottom line is that each zone needs to control temperature for the screw and process to work consistently and properly. If the barrel zone is too hot and the controller is not cycling, then all the heat in this zone is being generated by screw rotation or recovery.

Figure 2.11: Heater [12]

3

Chapter Three

Control Modules

3.1 Programmable Logic Control (PLC)

Using of relay-based switches to implement basic logical expressions and some examples of logic-based industrial system control. This type of control system detects the status of inputs like switches and other on-off logical devices(e.g. position directors, liquid level detectors, etc.) and then uses relays, timers and counters to implement logic and drive outputs by energizing the output coil of some sort of valve or other actuator.

3.1.1 Introduction to Programmable Logic Controllers:

- A programmable logic controller (PLC) is a microprocessor-based piece of hardware that is specifically designed to operate in industrial environment.
- Generally PLCs (as the name suggests) implement logic, determining outputs based on some logical combination of inputs.
- PLCs are programmable devices that are capable of taking inputs from sensors and activating actuators in order to control industrial equipment

Figure 3.1: Programmable Logic Controllers - Delta Group

The lack of a keyboard and other input-output devices is immediately apparent. On the front of a PLC the indications are normally limited to status lights used to indicate operating status and others that can be used for system debugging. [7]

Common LED indicators include

- Power on - indicating that power to PLC switched on.
- Program running - (yes), it means a program is running in the PLC.
- Software Fault – PLC code often has self testing code designed into it.
- Module Fault – used by installed modules to show that HW self-test has failed.
- Link Status – modern PLCs often from part of a distributed control system and this indicator is used to show whether the local area network is ok.

A number of pushbuttons/switches can also be provided as part of the PLC hardware:

♦ Run/Program Switch used to switch between program mode usually used during maintenance activities and run mode when the unit is operating in its usual autonomous mode.

♦ PLCs are often protected by a mechanical KEY that stops unauthorized personnel altering a PLC program or stopping its execution.

♦ A PLC will usually not have an on-off switch or reset button on the front panel. This needs to be considered when designing/configuring systems.

3.1.2 Input Output controller and Devices:

The input/output controller provides the interface between the PLC processor and the outside world. It allows connections to be made via input/output channels to sensors actuators.

In PLC, the input/output controller and its interfaces provide important buffering, isolation and signal conditioning to enable direct connection of sensors and actuators.

Typically the PLC will be designed to accept standard modules which plug directly into the I/O Bus and which provide appropriate levels of protection and conditioning (figure 13).

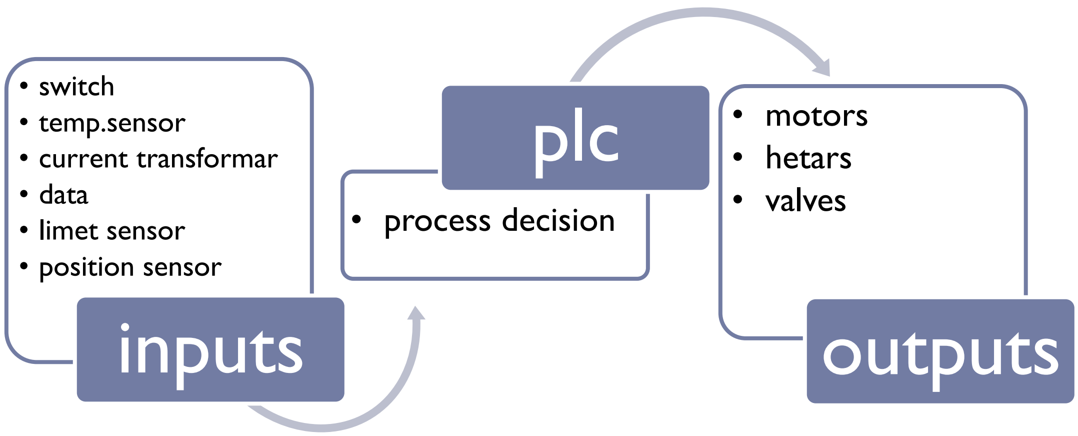

Figure 3.2: input and output parameters

3.2 Human Machine Interface (HMI)

He integration of a human machine interface (HMI) and programmable logic controller (PLC) provides a lean automation solution. Lean manufacturing is a proven, powerful method to boost efficiencies in production processes. Similar concepts and practices that eliminate "waste"-unnecessary equipment and process steps-can are applied to the design, construction, and support of automation systems to enable increased productivity and reliability, yielding increased efficiency. Combining visualization and control means:

- Faster machine design by providing an integrated development environment
- Reduced machine construction costs by eliminating components and wiring
- Reduced machine support cost and improved operation by centralizing remote access and administration

More than any other time, there are a range of trends in both control system architecture and manufacturing that are coming together to support an integrated HMI-PLC. For OEMs and control engineers alike, this means it is easier to build smaller, smarter machines faster-freeing both OEMs and engineers from h

aving to use controllers and equipment simply because of a familiarity and a prohibitive cost to change.

- Control system basics

To understand better the trends driving HMI and PLC technology, it is useful to first examine the basic architecture of a control system and how the control system itself is evolving. Fundamental changes in control system architecture are making HMI-PLC technology a compelling alternative-streamlining functionality, reducing equipment and costs, and propelling the next generation of machine control.

The basic control system structure includes sensing, actuation, operator interface, and logic control devices. Sensors measure a physical quality, like temperature, and convert that information into an electrical signal; the actuation device acts on that information; the operator (or user) interface is where the interplay between equipment and people occurs; and the logic device controls machine operation. The logic control device examines input from the operator and sensor, sending signals to the actuation device. This simple model of sensors, actuators, human interface, and logic applies to control systems in both the discrete and process control space.

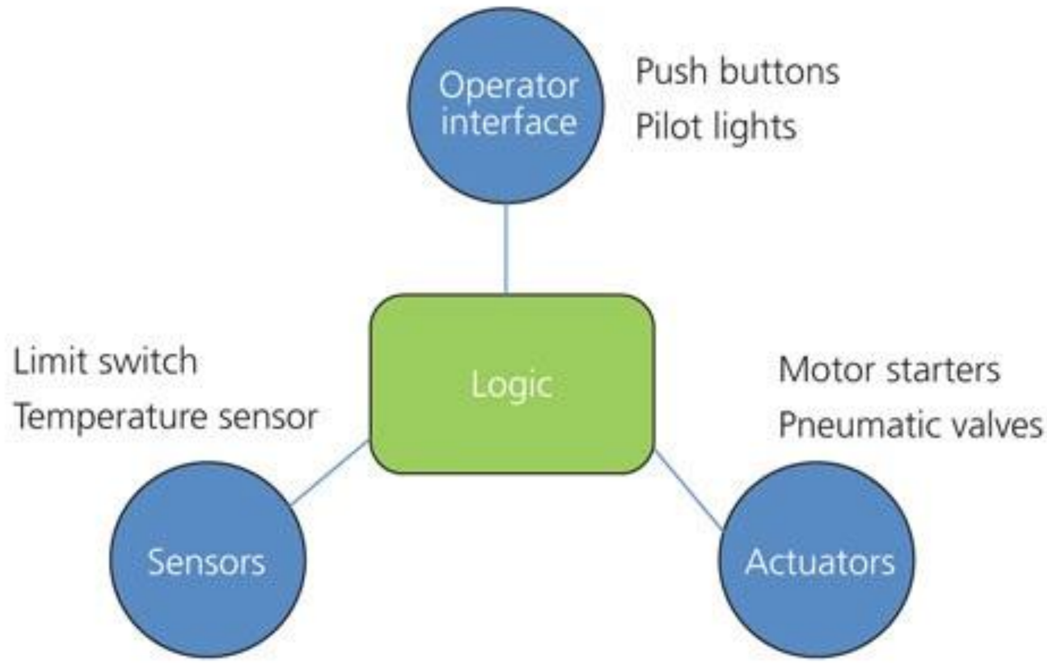

Figure 3.3: the basic component of control system.

Today, the basic functionality of a control system remains largely intact, but the architecture that achieves that functionality is shifting. All the devices in each category are evolving-both in terms of their intelligence and how they interface to the logic device. Industrial networking technologies are driving changes in the latter-how devices interface. Simple device networking is replacing I/O points and wiring on the machine, while Ethernet-based system networking is connecting machines to the enterprise and enabling remote access-both of these trends are propelling rapid change in sensors, actuators, logic controllers, and operator interface devices. And the most dramatic changes are happening at the operator interface and controller levels-where functionality overlap makes a combined device a compelling alternative.

4

Chapter Four

System Design

4.1 Functional Block Diagram.

4.2 Power Circuit.

4.3 Power Driving Circuit Calculation.

4.4 Control Circuit.

4.5 Comparison Table.

4.1 Functional Block Diagram

Hopper serves as a funnel into the barrel. The hopper is where the plastics resin is placed for injection. Plastic resin can be compromised of flakes, shavings or pellets. The plastic resin can be fed manually, automatically or via vacuum.

The injection molding screw has dual purpose in the function of an injection molding machine as it rotates, melts plastic and injects it into the mold. There are a series of bands (heater bands) around the barrel. The purpose of these bands is to keep the barrel at an even temperature throughout the injection molding process. The machine clamp opens and closes the mold (shown figure 4.1).

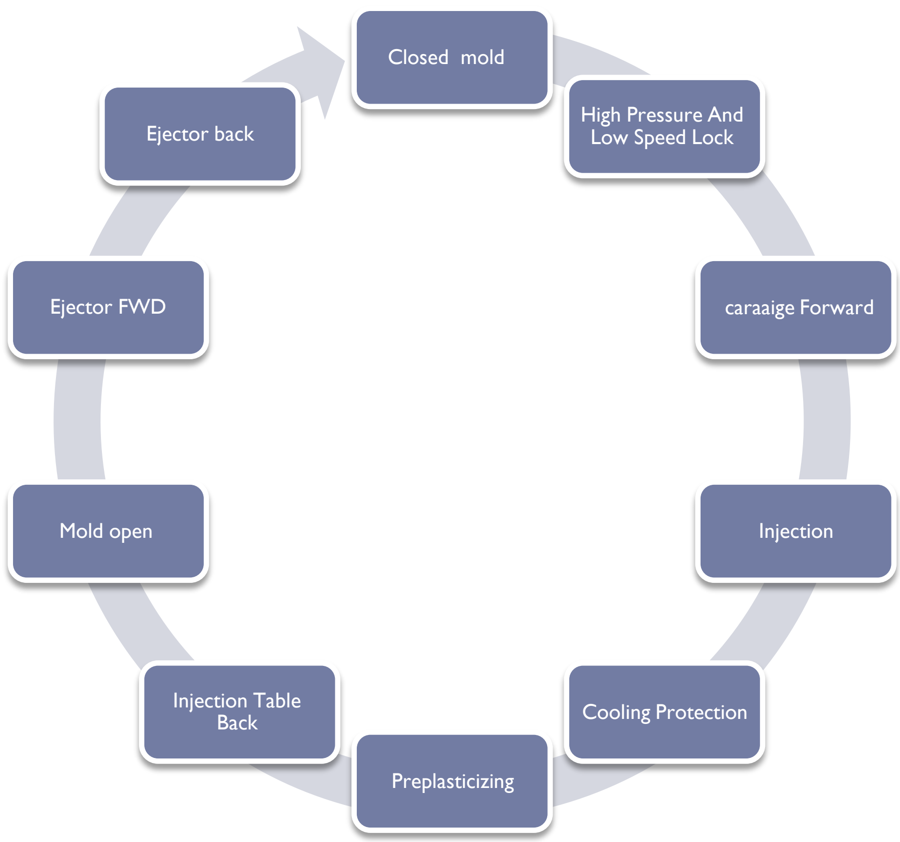

Figure 4.1: function block diagram.

4.2 Power Circuit

4.2.1 The electrical Circuit

Figure 4.2 illustrates the overall eclectic logout where motor and related protection device are present. The element can be selected based on the following calculation in section 4.3 .

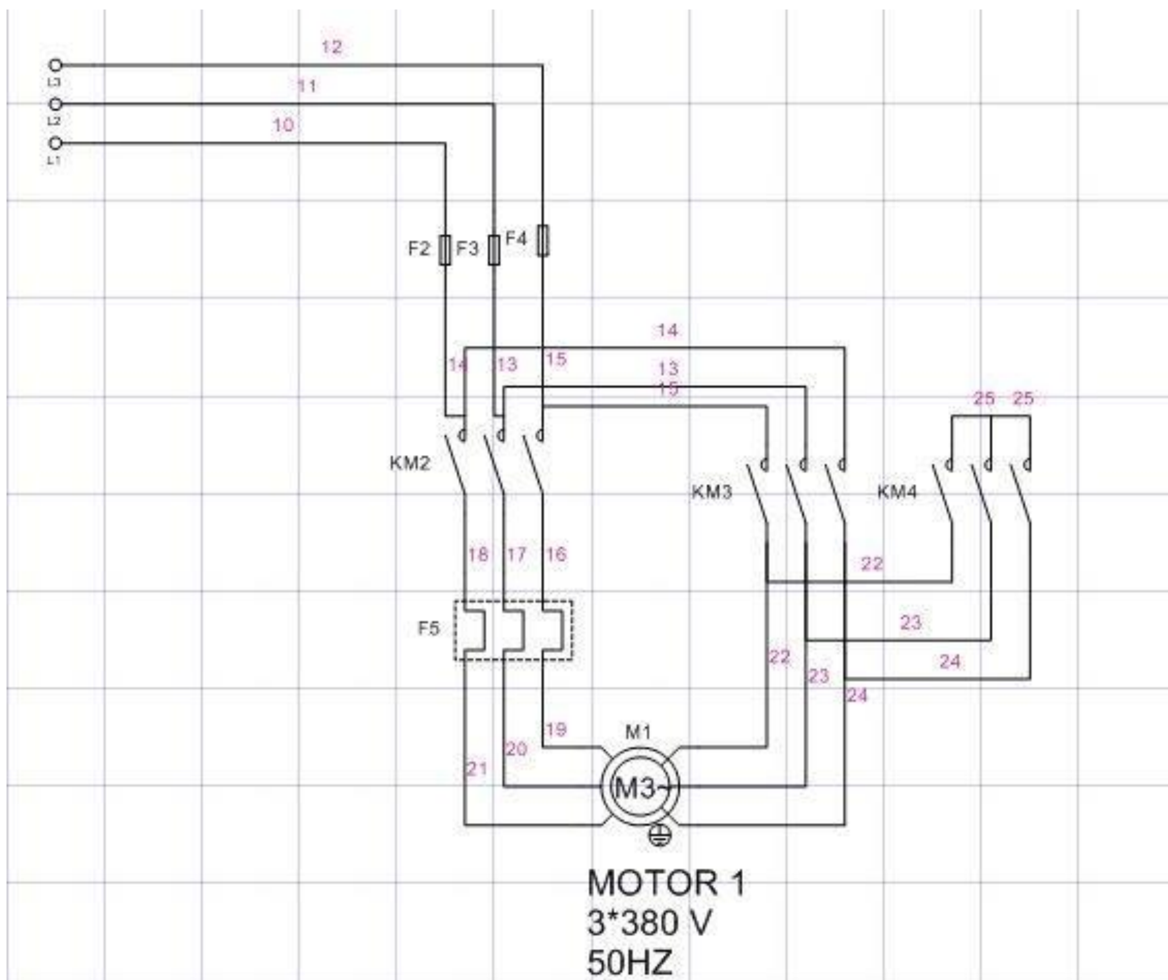

Figure (4.2.a): Main Pump Motor

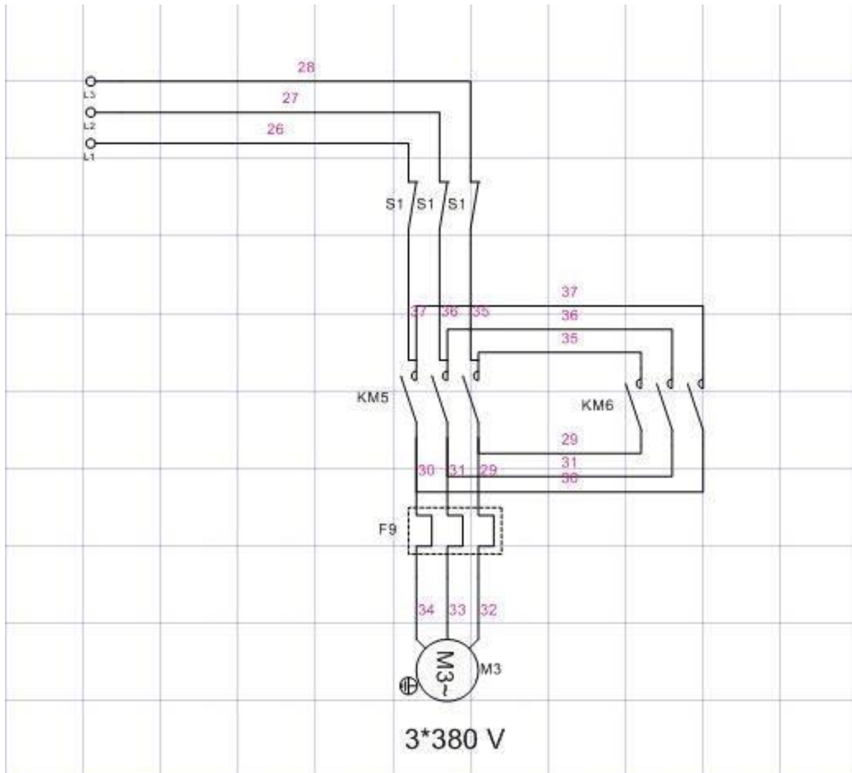

Figure (4.2.b):mold height adjusting motor

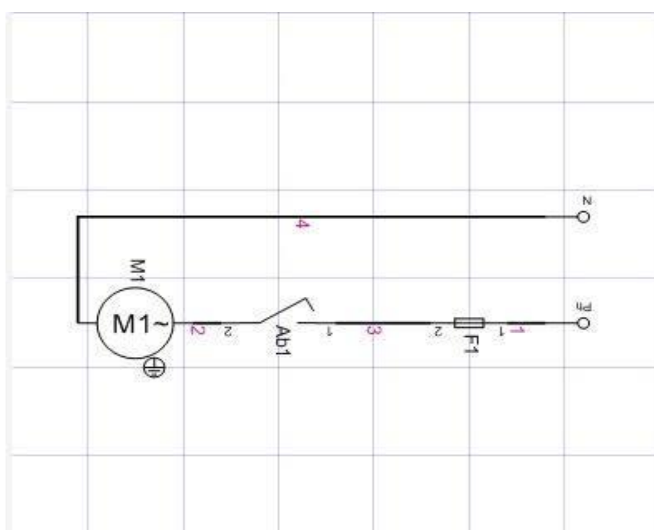

Figure (4.2.c): central lubrication pump motor

4.2.2 Heating system.

In the injection machine contains four hotplates, which melts the plastic on the inside of the screw, and preparing it for injection into the mold, the controls as shown in Figure(4.2.d) and (4.2.e).

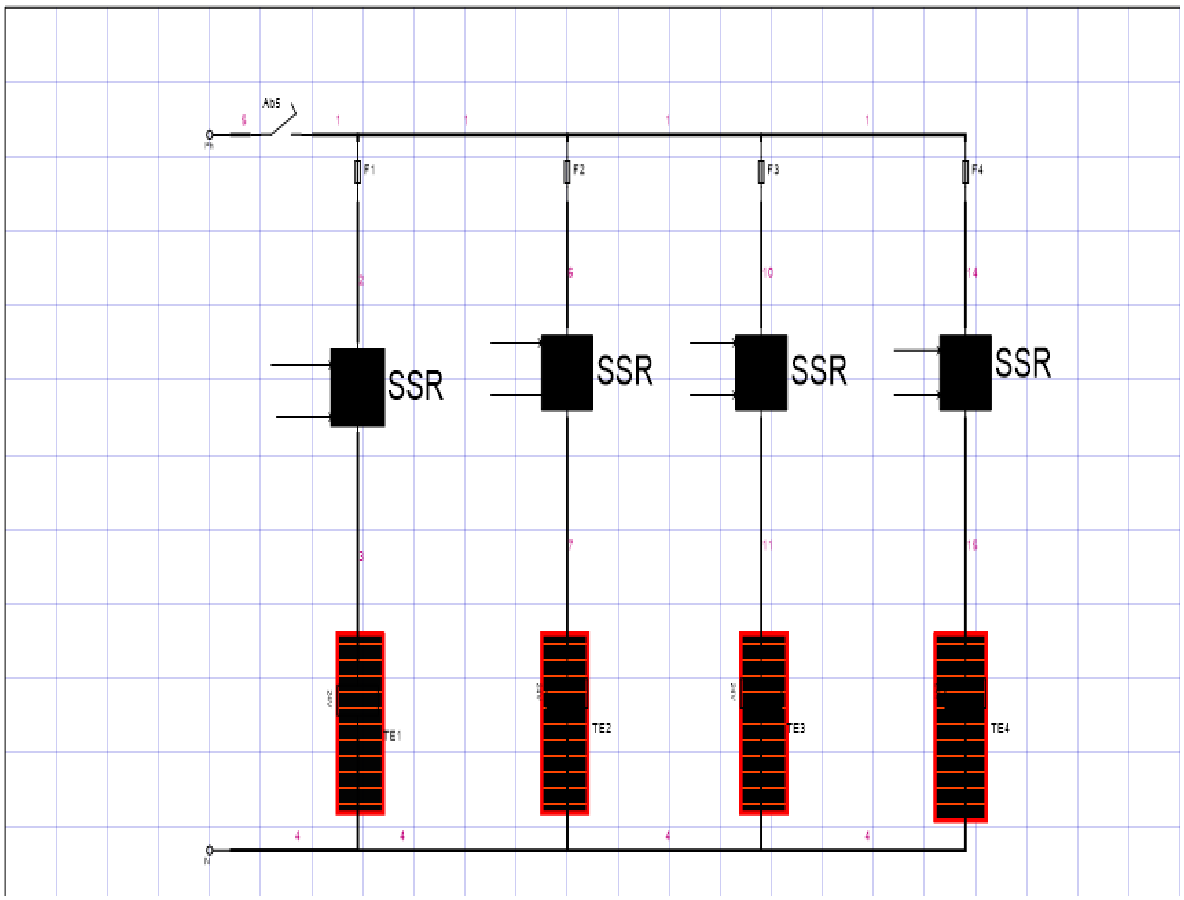

Figure (4.2.d) : Heaters Power Circuit.

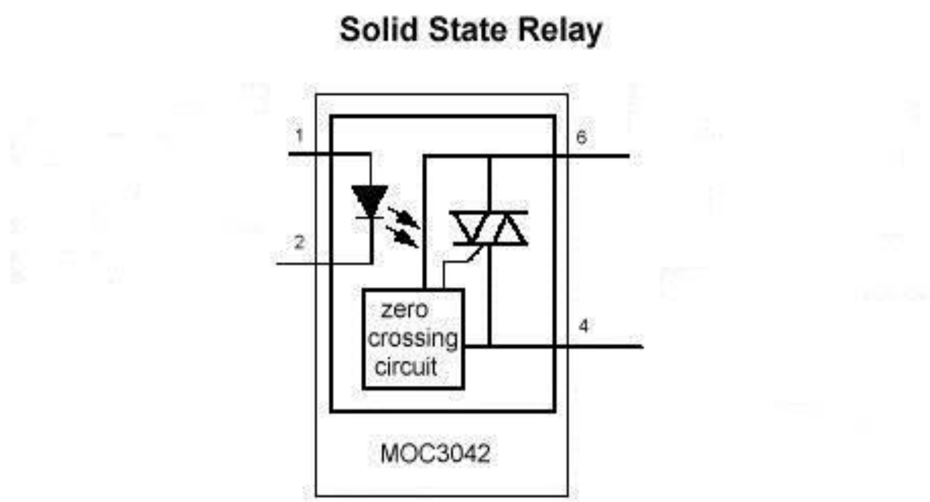

Figure (4.2.e): SSR circuit.

4. 3 Power driving circuit calculation

We collect the name plate for motor that used in injection machine in table (4.1)

Table (4.1): name plates of the motors.

Name	Phase	P / kw	V	A	Rpm	f/Hz
Main Pump Motor	3Φ	30	380	58.5	985	50
Mold height adjusting motor	3Φ	0.75	380	2	1450	50
Central lubrication pump motor	1Φ	0.02	220	0.41	*	50

Calculation the protection elements

Motor 1:

1) Over load

   OL=In=58.5A

2) Main circuit breaker

   MCB=1.25*In

   = 1.25*58.5=73.125A

3) contactor Size = 1.1*Pin”kW”

   = 1.1*(380*58.5)=24.4 KW

4.4 Control Circuit

The machine has two types of control, digital and analog valves.

4.4.1 Digital Valves

The digital control is in the machine movements through the PLC controls relay which will connect and disconnect the contactor to control digital valves shown figure(4.4.1.a) and (4.4.1.b).

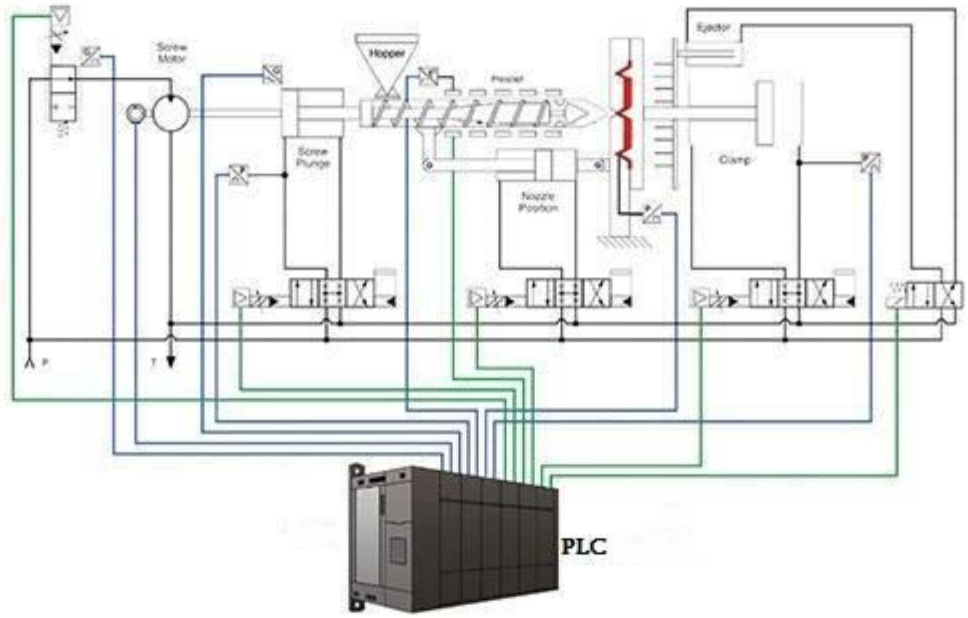

Figure (4.4.1.a): connect the machine with PLC.

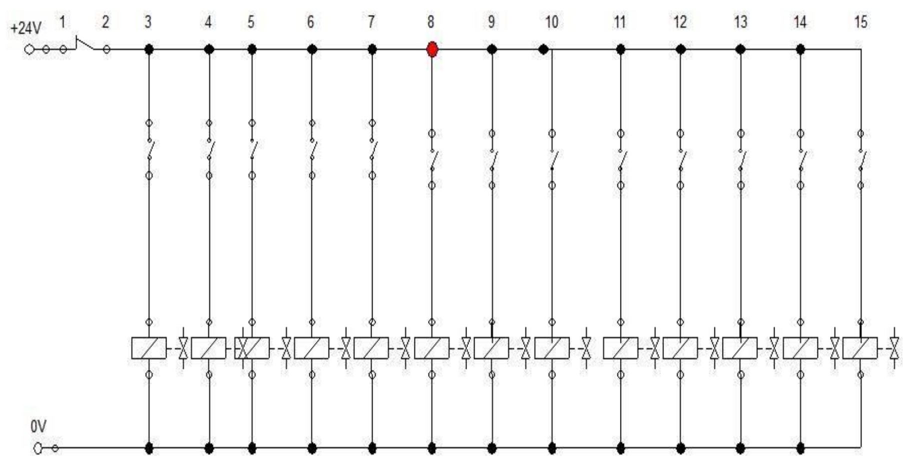

Figure (4.4.1.b): control circuit solenoid valves.

4.4.2 Analog Valves

The analog control is in the machine movements through the controls driver which will control circuit analog valves shown this in figure (4.4.2.a) and (4.4.2.b).

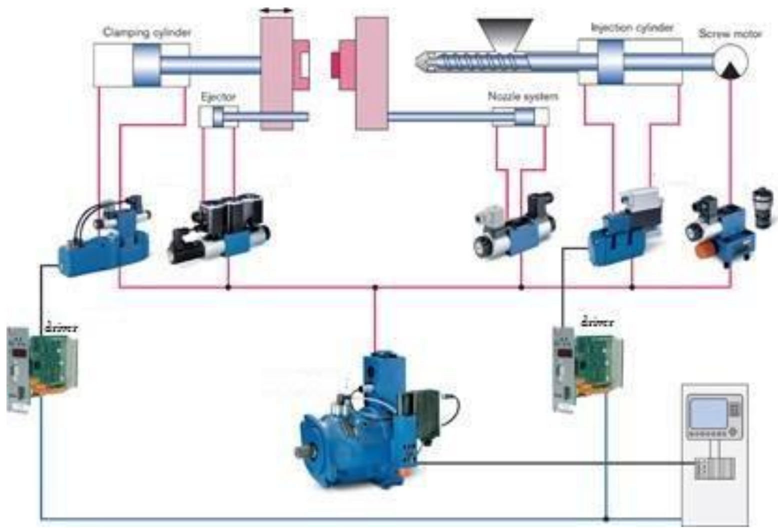

Figure (4.4.2.a): Driver connection.

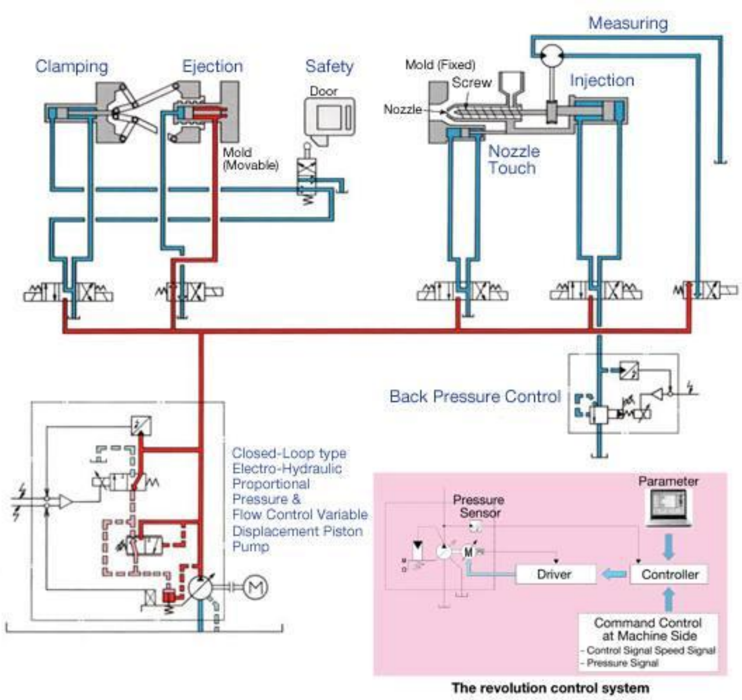

Figure (4.4.2.b): Pump control system.

4.5 Comparison Table

It is expected to achieve better performances comparing with the exiting status of mental in table4.2

Table (4.2): The comparison between the old system and PLC system.

Comparisons	Existing machine	expected result
Accuracy	Less Than	More Than
Human resources	Working Group	Supervisor
The controlling	Switch	PLC & HMI
Safety	Less Than	Highest
Quality	Less Than	Highest
Easy control	Difficult	Easy
Productivity	Less Than	Highest
Connections	Wires	HMI
Interface	Panel Keys	Touch Panel
Control system	Manual	Manual & Automatic

5

Chapter Five

PLC Implementation

5.1 PLC Hardware Configuration

As for the temperature output is the Digital Output, taken from Delta DI\DO, for the machine control need [13]:

32- Digital Inputs, 32-Digital Output, 3 -Analog Inputs and 4 -Analog Outputs

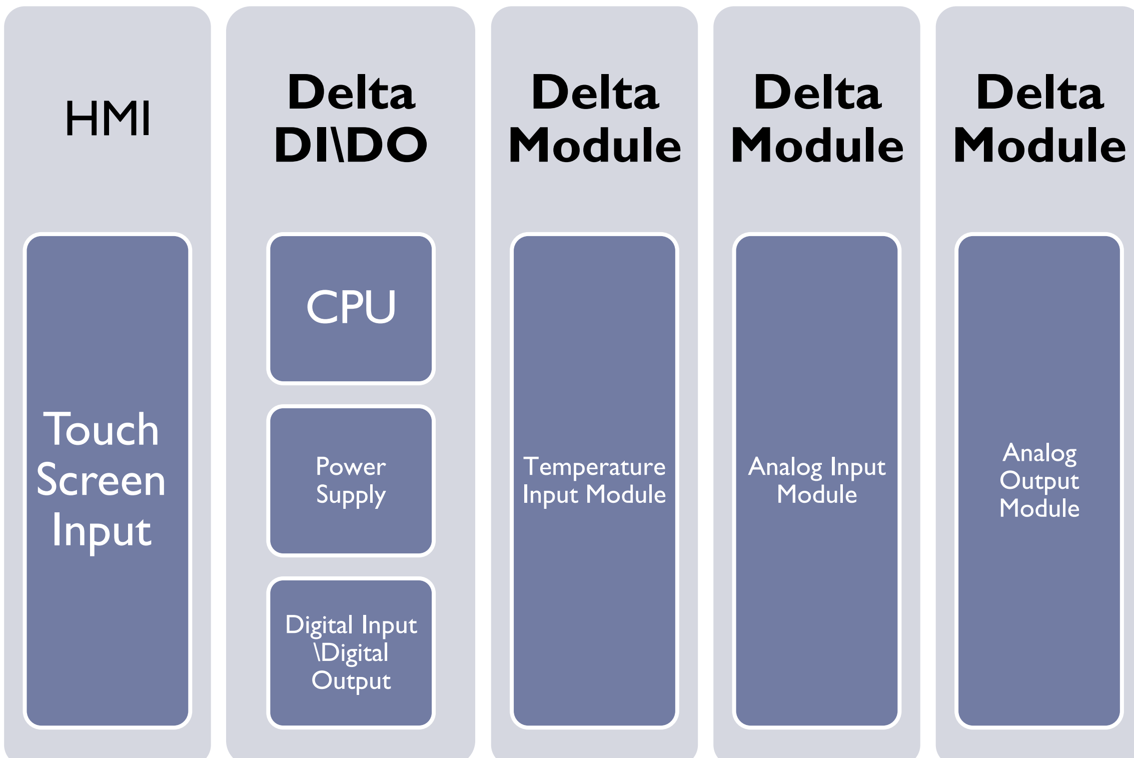

Figure 5.1: PLC Hardware configuration

5.2 Hardware modules

The modules in our project is summarized in the Table (5.2)

Module	Name	num	Price (sheqel)
	PLC DVP60ES2-8DO-O8XN2	1	1600
	4AI-OUAD-E2	1	750
	4AO-OUDA-E2	1	750
	4AI-TC-OUTC-E2	4	750
	DOP-B07S411 65536 COLORS	1	1500
			7600

Table (5.2) : modules data .

5.3 Symbol Table

Through a symbol table (in **appendix A**) we can know the variables of the system and understand what each variable meaning, and we can refer to address of variable in PLC program by using it.

5.4 PLC Program

We wrote the program in a SFC and ladder languages .The extruder program is existing in **appendix B**, you can refer to it.

5.5 HMI program

The HMI program is designed in an easy way the user controls all machine movements as in **appendix C**, you can refer to it.

5.6 Results

1. **The machine has become fully operational and successful programming.**
2. **The work of the machine in three ways which is automatic، manual and half-automatic.**
3. **Careful Control the speed and pressure.**
4. **The user with the machine has become much easier.**
5. **The machine under surveillance in all phases of the production process.**

5.7 Recommendations.

1. **The driver industry manually instead of Chinese driver ready.**
2. **To study the possibility of introducing the SCADA and LABVIEW in the programming of these machines.**
3. **The development of the project by adding the animation to control.**
4. **The temperature control through the PID controller.**

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[12] http://mica-band-heaters-metric.com/

[13] http://profsite.um.ac.ir/~shoraka/user%20manual%20ex-es-ss.pdf

APPENDIX

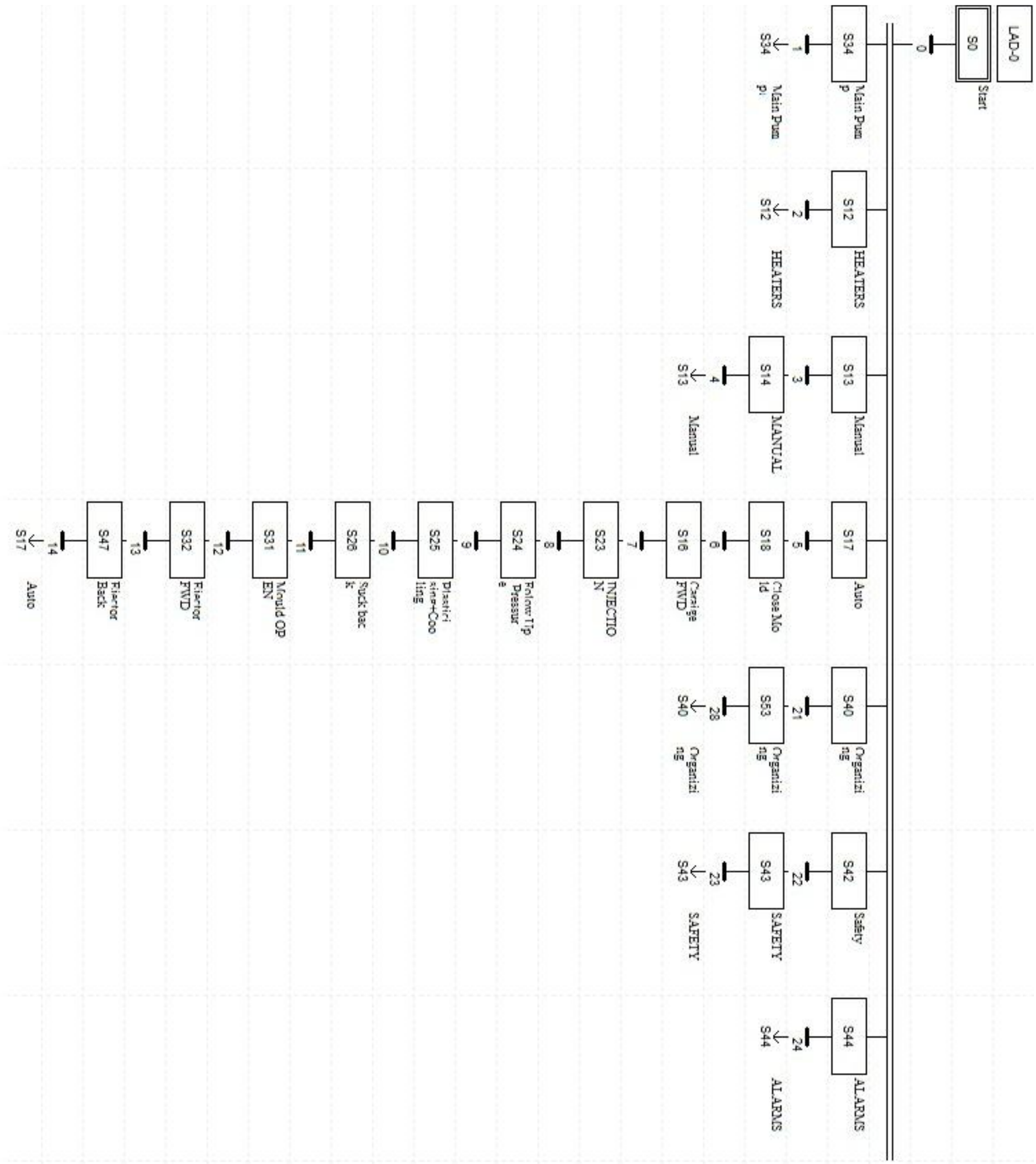
Appendix A: Symbol Table

I/O'S	Function	PLC
DIGITAL OUTPUTS		
	M-Stare-To-Delta	Y0
		Y1
S4a	Start accumulator	Y2
	Core 1 back	Y3
	Core 1 fwd	Y4
	Core 2 back	Y5
	Core 2 fwd	Y6
S12a	Fast closing (change from Y6)	Y7
S2	Mold open	Y10
S1	Mold close	Y11
	Empty (problem)	Y12
		Y13
		Y14
S5	Carriage FWD	Y15
S6	Carriage BWD	Y16
S9	Pump 2 idle (You may not exist)	Y17
S4+s4'	Injection +fast injection(Y30)	Y20
S3	Screw?	Y21
S24	Suck back	Y22
S3a	Cut of back presser	Y23
S10	Pump 1 idle	Y24
	Air 1	Y25
	Air 2	Y26
	Air 3	Y27
		Y30
	K fwd – mold adjusting	Y31
	K back – mold adjusting	Y32
	K lub.	Y33
	Heater 0 (head)	Y34
	Heater 1+2	Y35
	Heater 3+4	Y36
	Oil temperature?	Y37

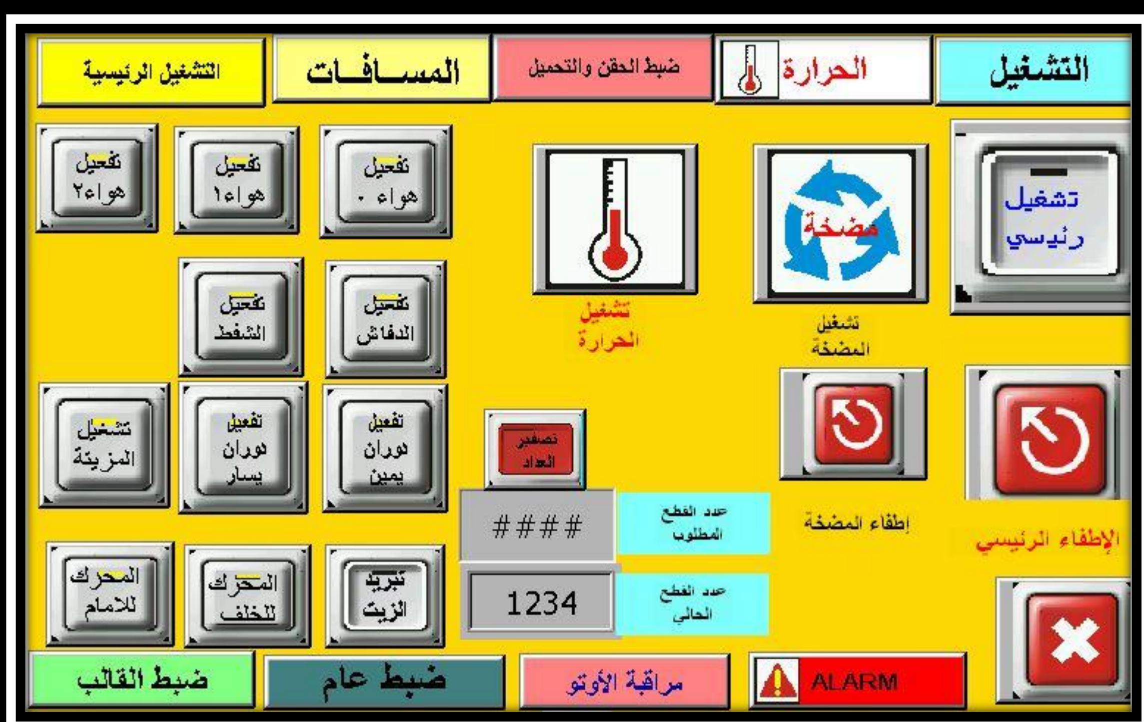
ANALOG OUTPUTS		
	T.C 0	D9900
	T.C 1+2	D9901
	T.C 3+4	D9902
A.O	(K) Main pressure	D9914
A.O	(Y) main speed	D9915
A.O	(L) Back pressure	D9920
	T.C oil	D9903
Input		
DIGITAL INPUT		
	Emergency	X0
bE1	Safety gate 1-actuated	X1
bE2	Safety gate 2-not actuated	X2
Ba	Mold back	X3
Bb	Mold FWD (closed)	X4
	Oil temperature safety	X5
bW2	Slow mold closing	X6
bW2	Slow mold opening	X7
bG1	Start of mold protection?	X10
bG2	End of mold protection?	X11
bG3	End of mold protection?	X12
bL1	End of mold protection (mold closed)?	X13
bL	Ejector backward	X14
Bj	Carriage FWD	X15
Bk	Carriage backward	X16
		X17
		X20
bC1	Feeding stroke (The amount of material)	X21
bC2	Suck back position	X22
bC3	Start post pressure	X23
bC4	Start reset of cycle timer	X24
bC12	Start injection speed 2	X25
bC13	Start injection speed 3	X26
		X27
		X30
		X31

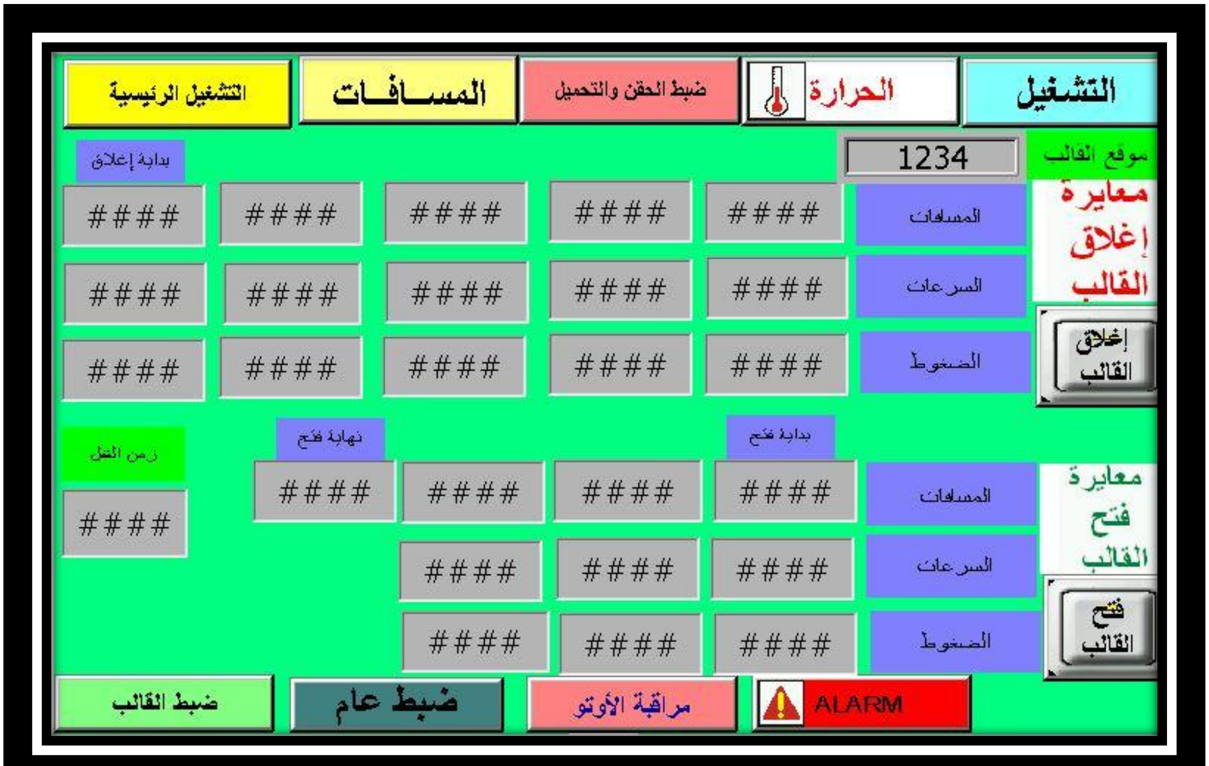
		X32
	Core safety switch	X33
	Core 1 out	X34
	Core 1 in	X35
	Core 2 out	X36
	Core 2 in	X37
ANALOG INPUT		
M	Mold	D9910
E	Ejector	D9911
S	Screw	D9912
C	Carriage	D9913

Appendix B: PLC program



Appendix C: HMI program

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نهاية فتح
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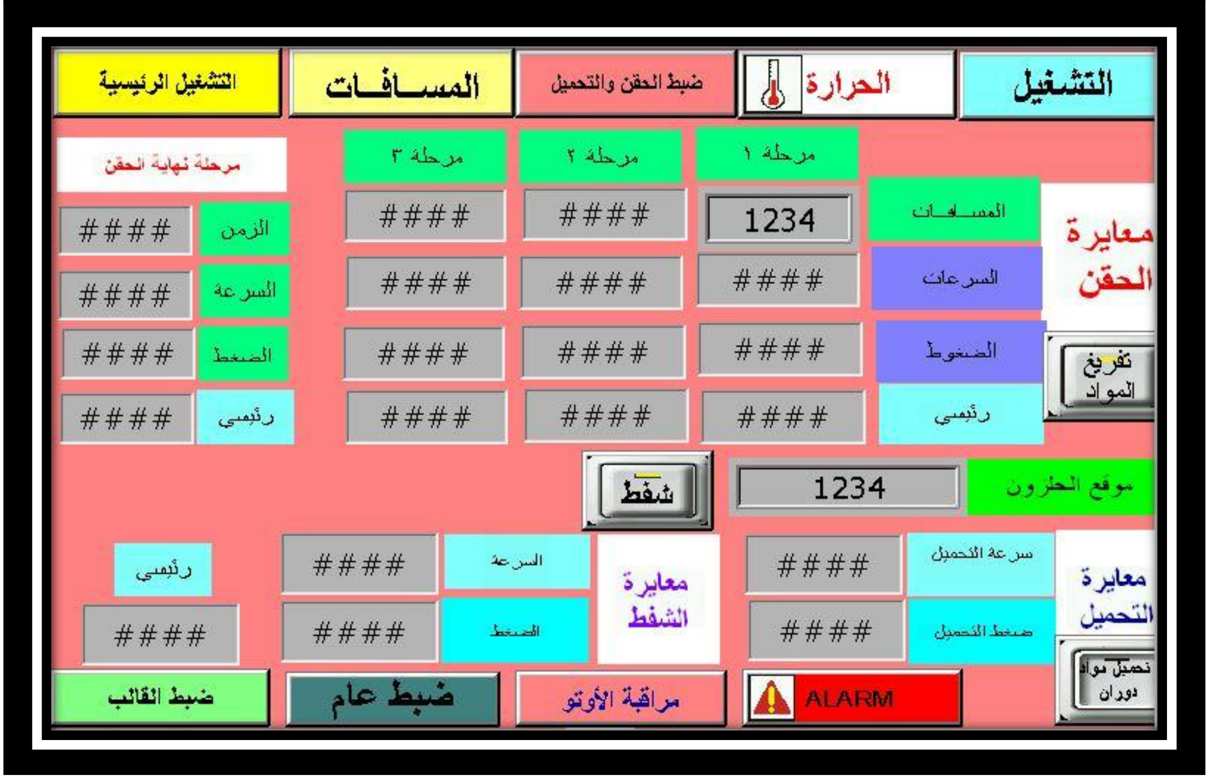
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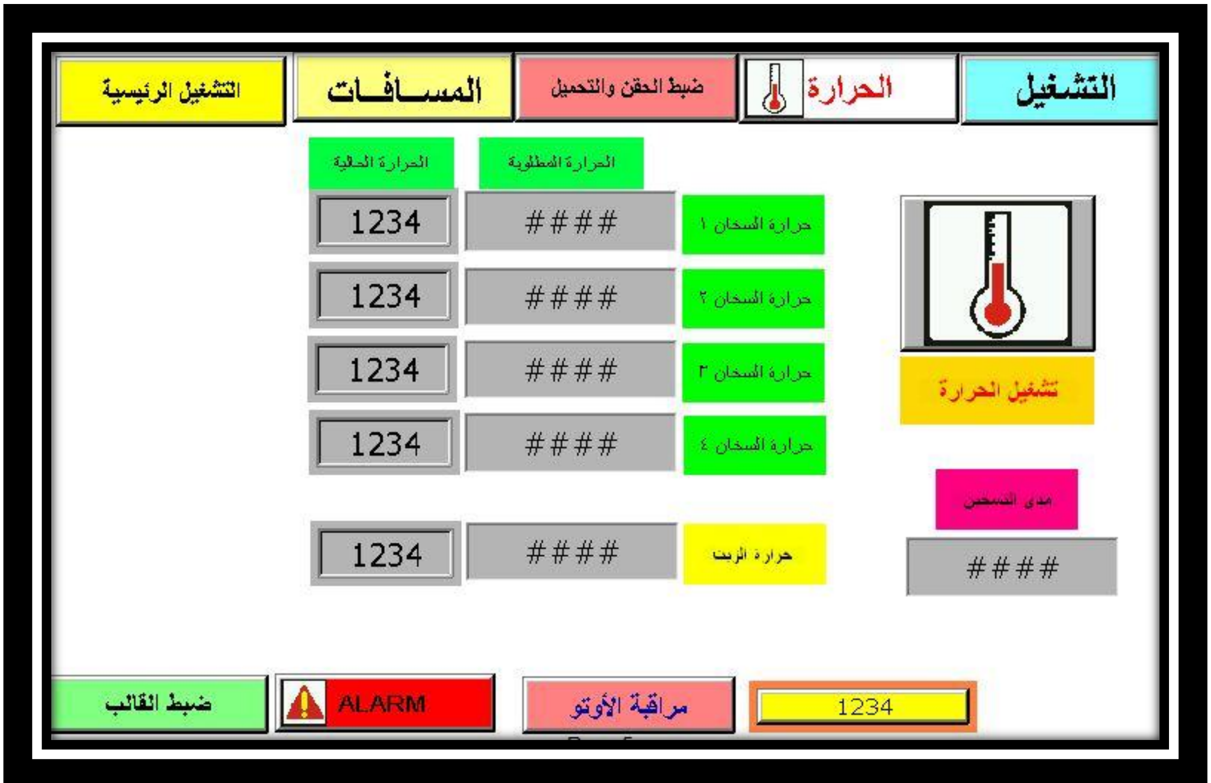
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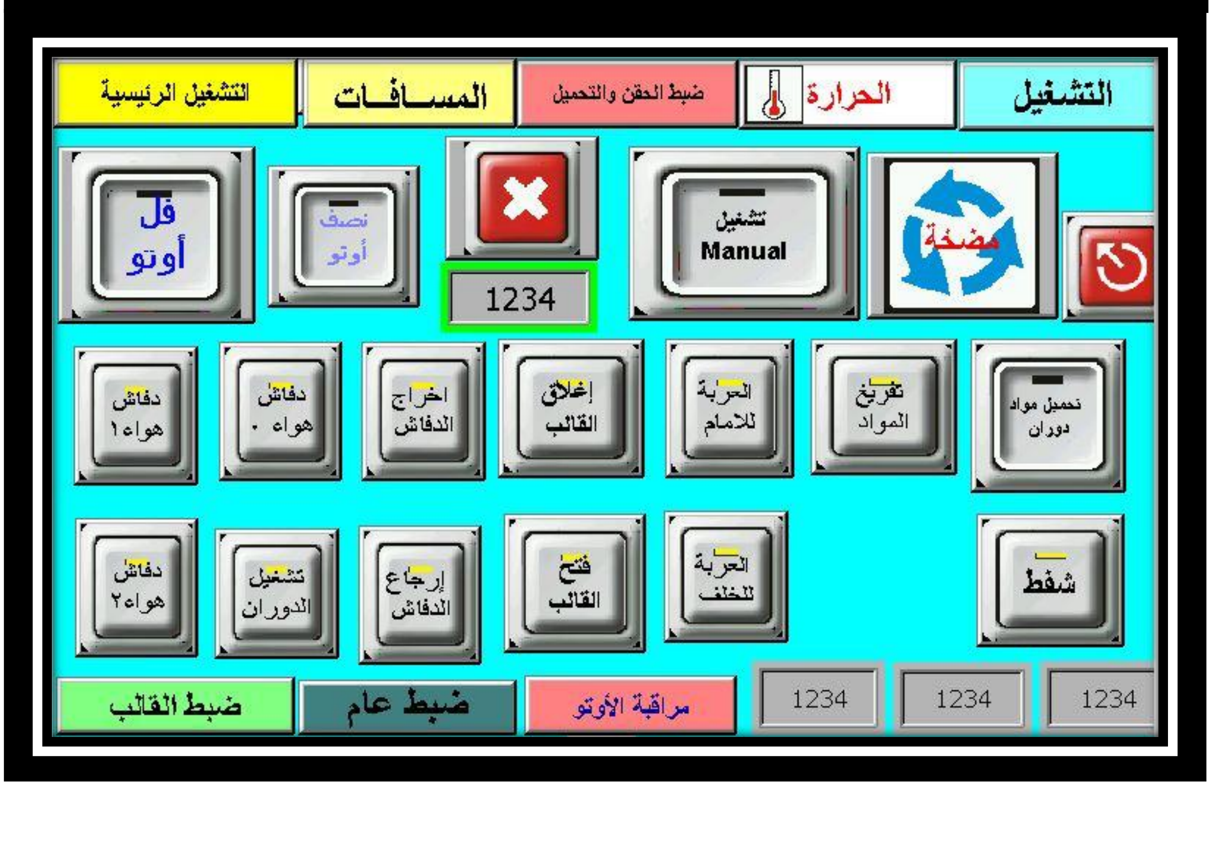
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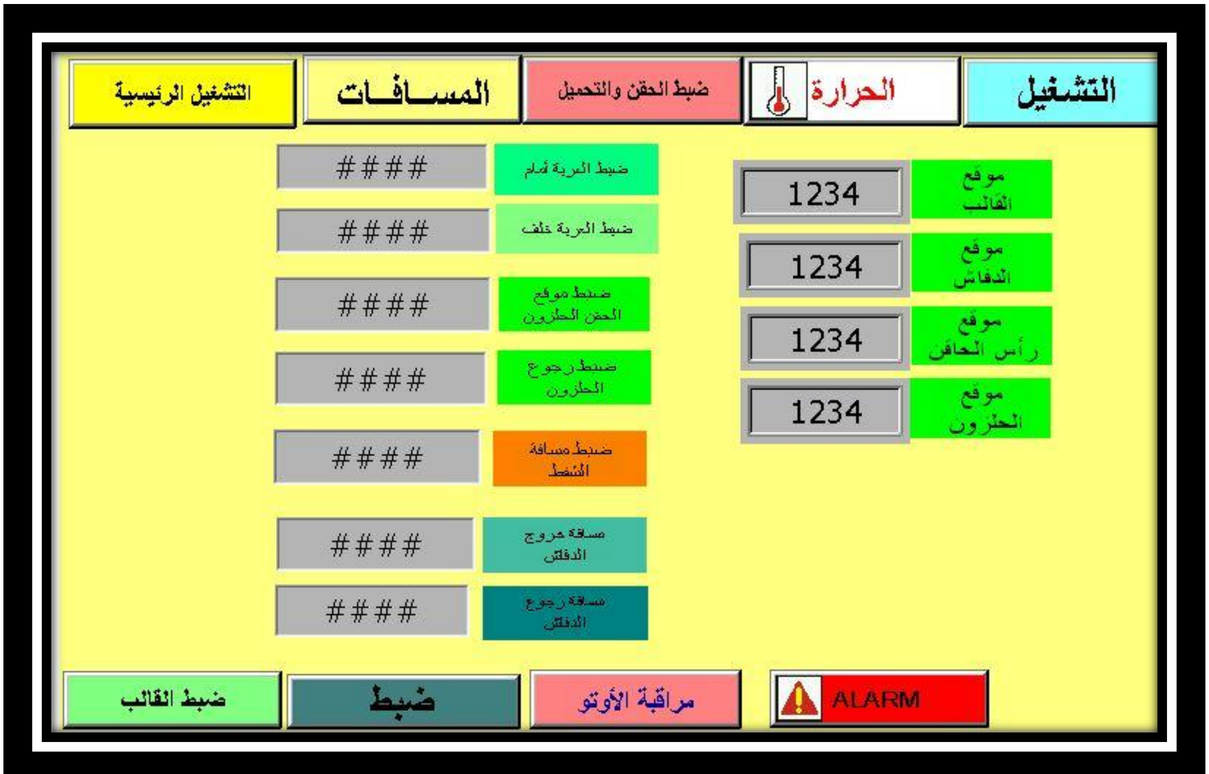

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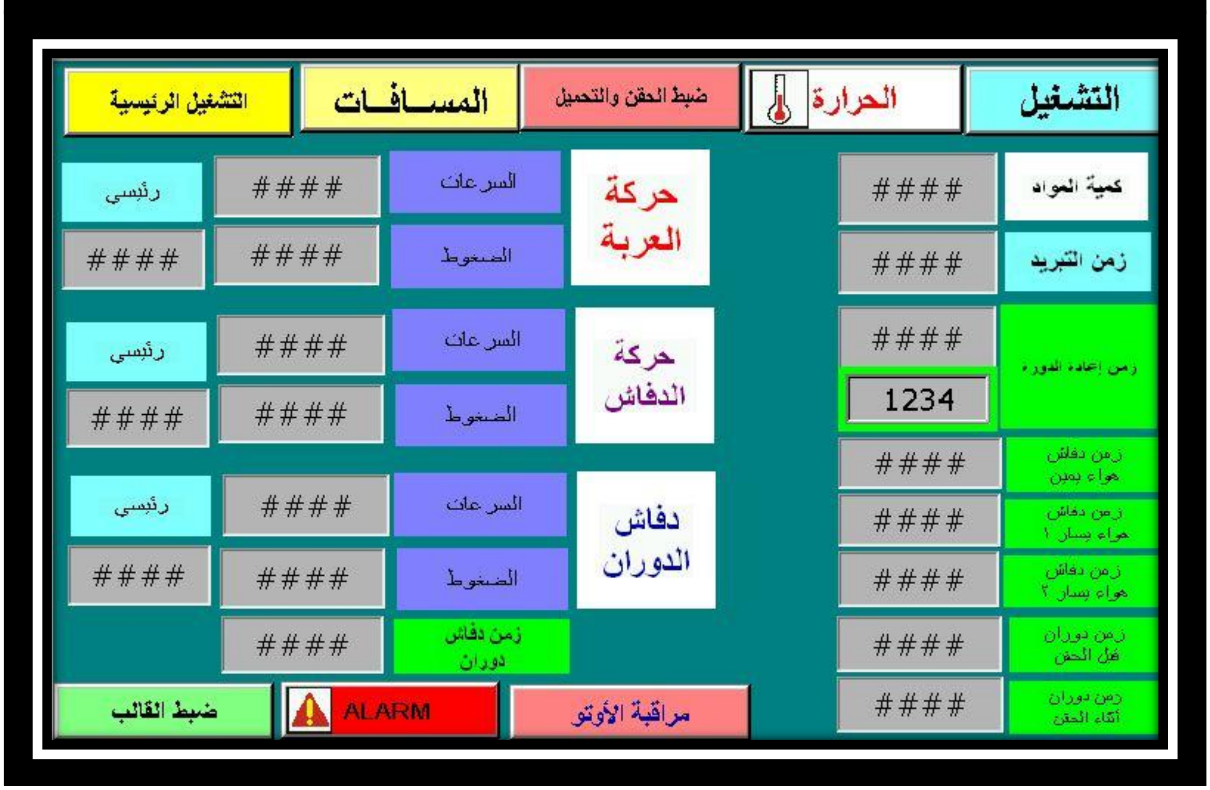

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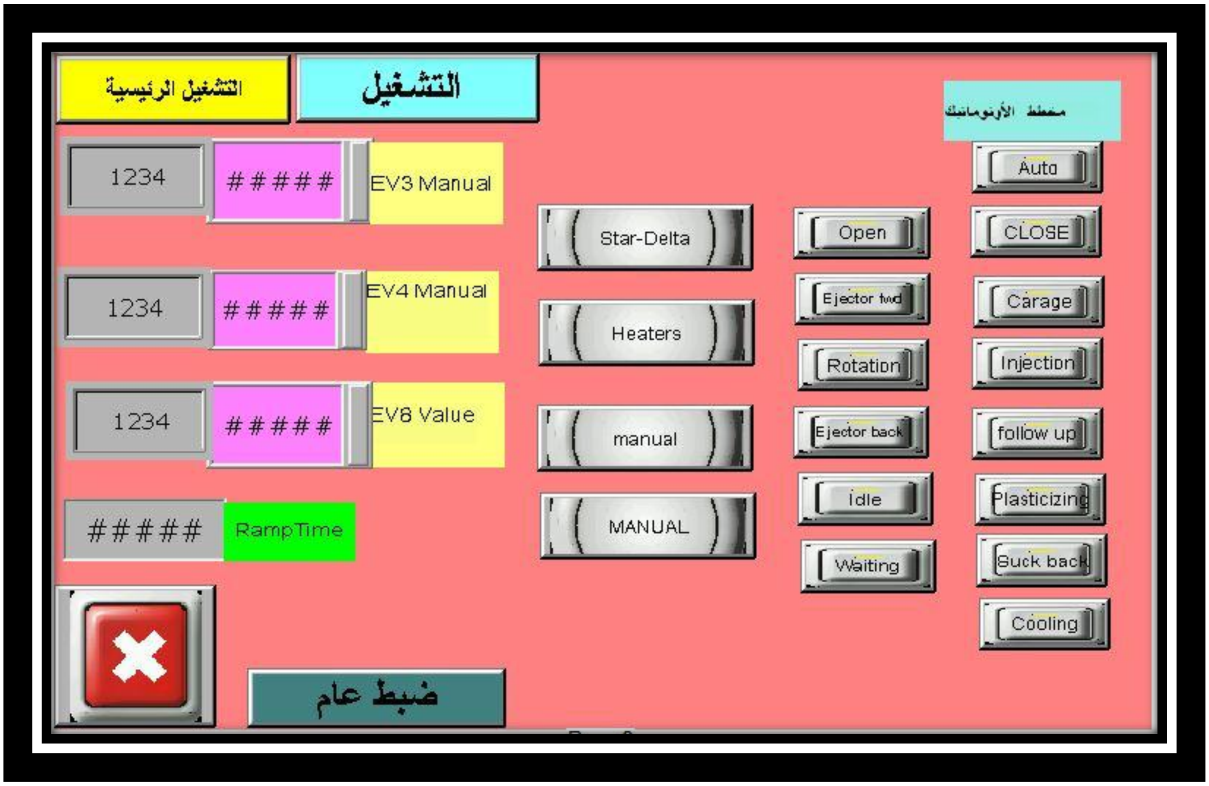

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EV4 Manual
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EV8 Value
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Star-Delta
Heaters
manual
MANUAL
Open
Ejector fwd
Rotation
Ejector back
idle
Waiting
Auto
CLOSE
Carage
Injection
follow up
Plasticizing
Suck back
Cooling
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