AUTOMATION OF AN INJECTION MOULDING MACHINE USING PLC

PROJECT REPORT

SUBMITTED BY

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Certificate

This is to certify that the Project Report entitled

Automation of injection moulding machine using PLC

has been submitted by

MISS. S. ANANTHI AND S. PADMAPRIYA

in partial fulfillment for the award of the degree of

Bachelor of Engineering

In Electrical and Electronics Engineering branch of the Bharathiyar University during the academic year 2000-2001

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Certified that the candidate was examined by us in the project work Viva-Voce examination held on .....and the university Reg. number was

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Internal Examiner

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TO WHOMSOEVER IT MAY CONCERN

This is to certify that the following students doing final year BE (EEE) at Kumaraguru College of Technology – Coimbatore, underwent project work in our organisation.

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⇒ *S Padmapriya* *97EEE33*

The details are :

- Title of Project : *AUTOMATION OF AN INJECTION MOULDING MACHINE USING PLC*
- Period of Project : *November 2000 to March 2001*
- Department : *Maintenance*
- Attendance & Conduct : *Good*

We wish them the very best for a bright future.

ANTHONY THIAGARAJAN
DEPUTY MANAGER – HUMAN RESOURCES

Dedicated to our beloved parents

Acknowledgement

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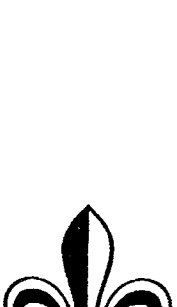

Synopsis

SYNOPSIS

In the fast and advanced scientific world the needs are to be catered efficiently and at a lower cost. For this the evolution of new modern methods in manufacturing is very inevitable. The production in the industries is goverened by certain factors such as time, quality, accuracy etc.Even a small deviation of the above factors will cause economic set back and the quality of the products will be under stake. In modern industries maintenance of quality and time is achieved by the process of automation which facilitates the production of quality products with the less possible time.

For moulding granules of plastics, injection moulding machines are widely used in all industries. To make the injection moulded plastic parts many important processing steps are involved. It is very essential that these steps must come together properly to produce parts consistently meeting performance requirements at the lowest cost. Lack of control of these important processing steps will result in less than desirable moulded parts. In this project it is proposed to automate the injection moulding machine by controlling parameters such as temperature, pressure, cooling time, time taken to complete a machine cycle, number of machine cycles etc.To achieve this PLC man-machine interface is used which makes the model compact. A software is used to program the PLC and the same is developed and tested. To permit production of quality products with less

effort, at a lower cost and with improved security to the operators is the aim of this project.

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CHAPTER I

INTRODUCTION

Injection moulding machine is a machine widely used in industries for moulding plastic materials.The machine can be used for producing a wide range of products . Various products can be obtained by using different patterns in the same machine.

1.1 PRINCIPLE OF OPERATION:

The various steps involved in Injection moulding process are :

a. Feeding the raw material.

b. Heating of the shot material.

c. Closing the mould .

d. Injecting the molten plastic.

e. Cooling of the plastic in the mould.

f. Opening the mould.

g. Ejecting the finished product.

Firstly the temperature of the plastic must be raised to a point where it will flow under pressure. This is usually done by heating the plastic until it forms a melt at an elevated and uniform temperature and uniform viscosity. This is

accomplished in the cylinder of the injection of the injection moulding machine.This process is called plasticizing of the material.

The liquid molten plastic is transferred through various flow channels into the desired object by the confines of the mould cavity.The plastic is then allowed to solidify in the mould which is kept closed.The mould is then opened to eject the plastic after keeping the material confined under pressure as the heat is removed to solidify the plastic and freeze it permanently into the desired shape.

In the above operations the mechanical and thermal inputs of the injection equipment must be coordinated with the fundamental properties of the plastic being processed. These operations are also the prime determinants of the productivity of the process, since manufacturing speed will depend upon how fast we can heat the plastic to the moulding temperature, how fast we can inject it, how long it takes to cool the product in the mould.

The sequence followed in the injection moulding process is shown in the fig(1.1) .

1.2 NEED FOR THE PROJECT:

The system was previously controlled by a control panel consisting of relays and contacts. The operation was in manual mode. The disadvantages of this type are:

1.Relays and contactors have many moving parts so the operation was not smooth. So these are subjected to wear and tear and hence the life of the machine gets

reduced.

2.Interfacing the machine with the external devices is difficult.

3.Trouble shooting of the machine becomes complicated.

4.Even a slight modification in the operation is tedious.

5.Since operations were done manually injuries were caused to the operators.

6.To reprogram conventional controls must be rewired and are often scrapped instead.

Hence inorder to overcome the above disadvantages we go in for automating the machine using PLC.

1.3 *HALL MARKS OF USING PLC:*

*.Reduces manhours.

*.Manual interference is minimum.

*.Ease of change of programming.

*.Improved security.

*.Remarkable speed of operation.

*.Reliability and maintainability.

*.Visual observation is possible.

*.Programming the PLC is easier than wiring the relay control panel.

*.PLCs take less floor space than relay control panels.

*.PLCs can be easily connected to plant computer systems than relays can.

*.The constraints imposed on the mechanical properties of a relay are absent in PLC systems. PLCs can thus survive harsh conditions and are more reliable.

*.The shortest time delays in conventional hardwired connections cannot be lower than a certain limit. The internal timers of the embedded processor in the PLC can produce a short delay of 15ms with a reset period of 15ms. Higher accuracy and increased productivity can thus be achieved. *. PLCs can be designed with communication capabilities that allow them to converse with local and remote user systems or to provide human interfaces.

*. Many PLCs are provided with diagnostic indicators which monitor power supply, CPU faults, low battery power for memory backup, input and output conditions which simplify the trouble shooting.

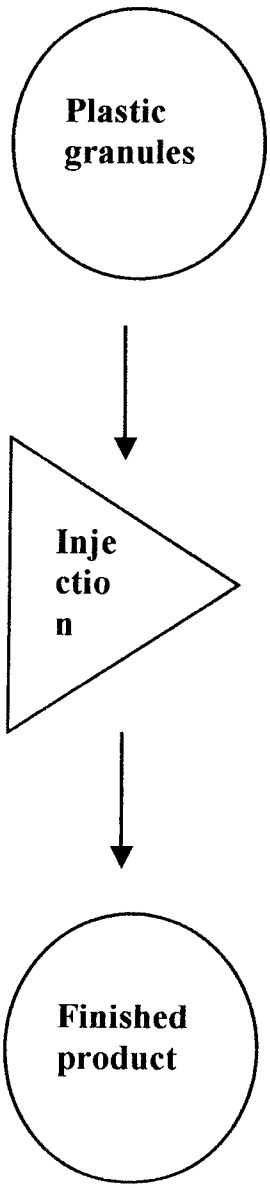


Fig 1.1 PLASTIC MOULDING PROCESS

Injection moulding machine

CHAPTER II

THE INJECTION MOULDING MACHINE

The injection moulding machine used in our project is Batten Feld injection moulding machine. The injection device used in this machine is of reciprocating screw injection type. The machine is hydraulically controlled. The tonnage of the machine is 25 tonnes.

2.1COMPONENTS:

2.1.1.INJECTION PLASTICIZING UNIT:

This is the portion of the injection moulding machine which converts the plastic material from a solid phase to a homogeneous semi liquid phase by raising the temperature. This unit maintains the material at a preset temperature and forces it through the injection unit nozzle into a mould. The plastic material is fed into this unit through the hopper.

2.1.2. PLUNGER UNIT:

The plasticizing unit consists of a plunger to push the plastic material. During the injection cycle the plunger forces the plastic melt from the injection chamber out through the nozzle .

2.1.3.SCREW:

It is a helical shaft that when rotated within the barrel mechanism works and advances the material being processed forward to fill the mould.

2.1.4. CLAMPING UNIT:

This is the portion of the machine in which the mould is mounted and which provides the motion and force to open and close the mould . This also holds the mould closed with force during injection.

2.1.5.MOVING PLATE:

It is the member of the clamping unit which is moved towards a stationary member. The moving section of the mould is bolted to this moving plate.

2.1.6.STATIONARY PLATE:

It is the fixed member of the clamping unit on which the moving plate of the mould is bolted.

2.1.7.TOGGLE CLAMP:

It is the clamping unit with a toggle mechanism directly connected to the moving plate. A mechanical force is connected to the toggle system to exert the opening and closing force and hold the mould closed during injection.

2.1.8.EJECTOR(KNOCK OUT):

It is a part of the clamping unit that actuates a mechanism within the mould to eject the moulded part from the mould. The ejection actuating force may be applied hydraulically or pneumatically by a cylinder attatched to the moving platen.

The schematic diagram of the machine is shown in figure(2.1).

2.2WORKING OF THE MACHINE :

Plastic materials are fed by gravity from an overhead hopper through the heated cylinder via the screw flights as the material becomes fluid. The injection nozzle is blocked by the previous shot, and this causes the screw to pump itself backward through the cylinder. During this step, material is being plasticated and accumulated for the next shot. The volume of the plastic shot is controlled by a limit switch, which shuts off the screw when it has reached its stroke, ending its backward movement.

When the press has locked, the injection phase takes place. At this time the screw advances, acting as a ram. Simultaneously, the non return valve closes off the escape passages in the screw, making it a solid plunger, moving the plastic ahead into the mould. When the injection stroke and the holding cycle is completed, the screw is energized to return, and the non return valve opens, allowing the plastic to flow forward from the cylinder again, thus repeating the cycle. The screw in addition behaves as a plunger and injects the fluid material into

the tightly closed mould. The mould is maintained at a relatively cool temperature which causes the plastic to become rigid after a set length of time. At the end of the cure time the operator opens the gate and the parts are ejected from the mould. The mould is checked to see that it is fully clear of plastic and the gate is closed again to start the next cycle.

The advantages of the reciprocating screw over straight plunger devices are that the reciprocating screw provides precise control of filling pressure and that the rotary shear effect of the screw melts and mixes the materials homogeneously.

A typical 60 second injection moulding cycle is shown in the fig(2.2).

2.3 ADVANTAGES OF HYDRAULIC CONTROL:

The machine is hydraulically controlled. The advantages of hydraulic control over pneumatic control are:

*. Hydraulic control provides more tonnage compared to pneumatic control.

*. Large size components are manufactured using hydraulic control whereas only small size components can be manufactured using pneumatic control.

*. Excessive pressure if required can be supplied through bladders and accumulators in hydraulic control. No such facilities are available in pneumatic control.

*. The number of stages required to produce the specified pressure is more in

pneumatic control when compared to hydraulic control.

2.4 MACHINE SPECIFICATIONS:

Clamp force	: 25 tonnes
Full stroke	: 75mm
Inclusive sensing	: 5mm
Opening force	: 10 tonnes
Ejector force	:1 ton
Tie bar diameter	:60mm
Plasticizing rate	:3.5 kg per hour
Water connections	:2 litres per minute
Total heating	:3KW

2.5 APPLICATIONS:

The injection moulding machine in the project is used to manufacture Hero Honda spacer.

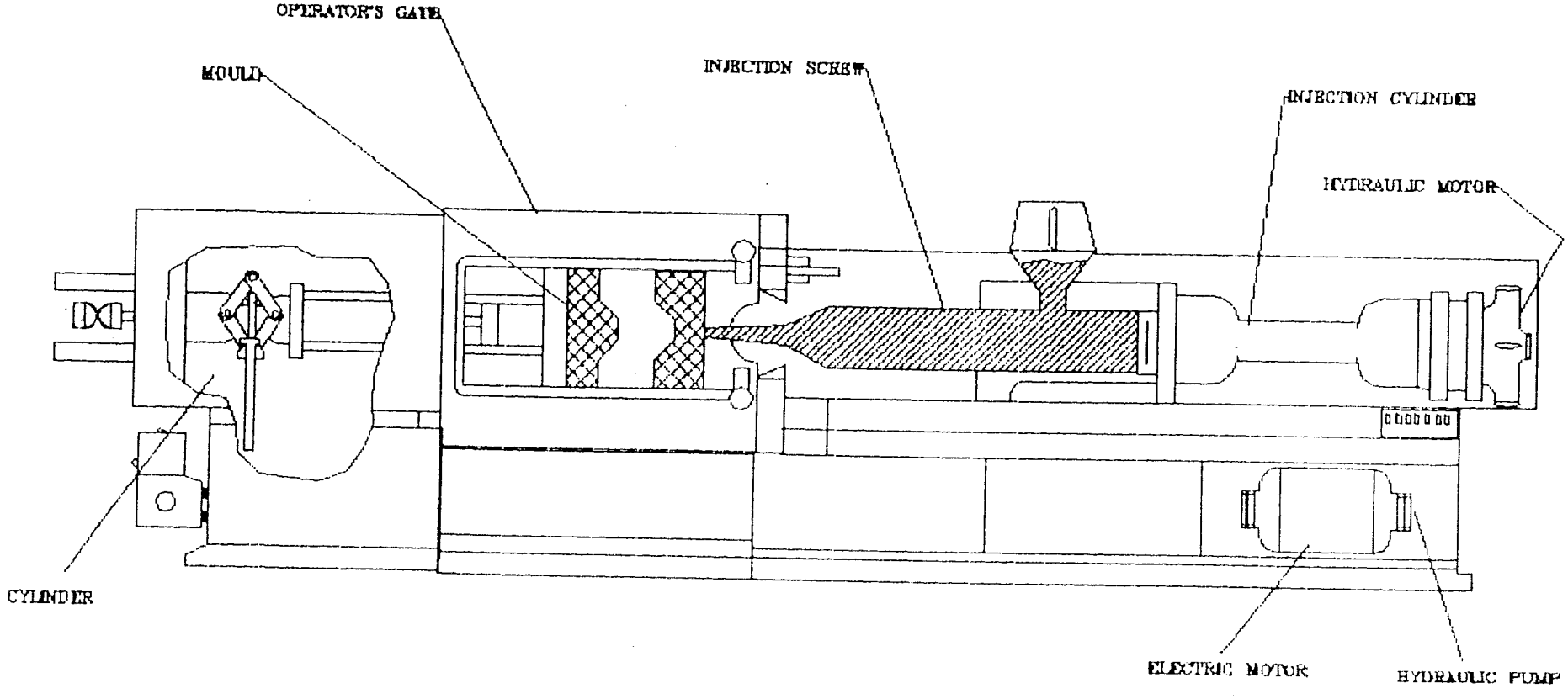


Fig 2.1 INJECTION MOULDING MACHINE

A TYPICAL 60 Sec INJECTION MOULDING

CYCLE TO BE CONTROLLED IS SHOWN BELOW :

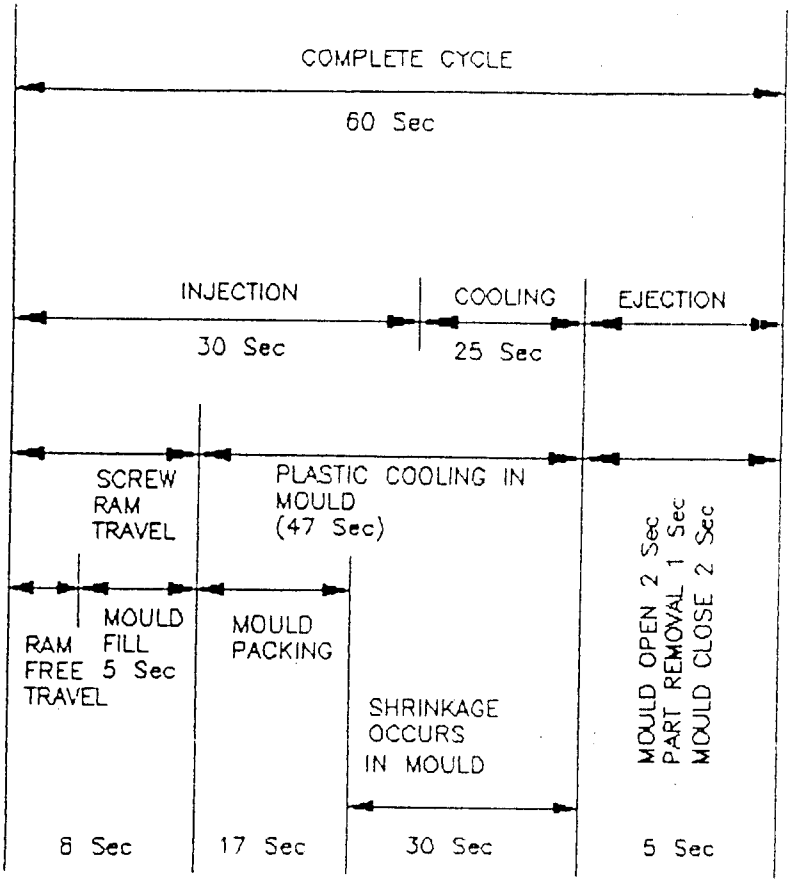


Fig 2.2 INJECTION MOULDING CYCLE

Programmable Logic Controllers

CHAPTER III

PROGRAMMABLE LOGIC CONTROLLER

A programmable logic controller (PLC) is a digitally operating electronic apparatus which uses a programmable memory for the internal storage of instructions for implementing specific functions such as logic, sequencing, timing, counting, and arithmetic to control, through digital or analog input/output modules, various types of machines or processes.

3.1 COMPONENTS OF A PLC:

The basic components of a PLC are the following:

*. Input module

*. Output module

*. Processor

*. Memory

*. Power supply

*. Programming device

The schematic diagram of the components in the PLC is shown in the fig (3.1).

3.1.1 INPUT AND OUTPUT MODULES:

The input module and output module are the connections to the industria process that is to be controlled. The inputs to the controller are signals from limi switches, pushbuttons, sensors,and other on/off devices. The outputs from th controller are on/off signals to operate motors, valves, and other devices require to actuate the process.

3.1.2 PROCESSOR:

The processor is the central processing unit (CPU) of the PLC. It executes the various logical and sequencing functions by operating on the PLC inputs to determine the appropriate output signals.

3.1.3 MEMORY:

The memory refers to the programmable controllers active storage medium. This can be volatile or non-volatile in design and can be configured and used in a variety of ways for both executive program storage, with which the system executes its instruction, and application program storage, for the actual control program. PLCs will use non-volatile memory for a majority of user memory because the program must be retained during a power down cycle.

3.1.4 POWER SUPPLY:

The basic function of the power supply module is to convert the input supply into a form more suitable for the electronic device that comprise the PLC.

3.1.5 PROGRAMMING DEVICE:

The programming of the PLC is done by means of a programming device. The programming device is usually detattachable from the PLC cabinet so that it can be shared between different controllers. Some of the examples of programming devices are PLC programming keyboards and CRT displays.

3.2 METHODS OF PROGRAMMING THE PLC:

There are various approaches for entering and interconnecting the individual logic elements. These include:

*.Ladder logic diagram

*. Low level computer- type languages

*. High level computer- type languages

*. Functional blocks

*. Sequential function charts

3.2.1 LADDER LOGIC DIAGRAM:

This method requires the use of a keyboard and CRT with limited graphics capability to display symbols representing the components and their interrelationships in the ladder logic diagram. The PLC keyboard device is designed with keys for each of the individual symbols. Programming is accomplished by inserting the appropriate components into the rungs of the ladder diagram. The components are of two basic types: contacts and coils. Contacts are used to represent input switches, relay contacts and similar elements. Coils are used to represent loads such as motors, solenoids, relays, timers, counters etc. The programmer inputs the ladder logic circuit diagram into the PLC with the CRT displaying the results for verification.

3.2.2 LOW LEVEL COMPUTER-TYPE LANGUAGES:

The low level computer-type language parallels the ladder logic diagram. Using the language instructions, the programmer constructs the ladder diagram by specifying the various components and their relationships for each rung. The low level languages are generally limited to the types of logic and sequencing functions that can be defined in a ladder logic diagram.

3.2.3 HIGH LEVEL COMPUTER-TYPE LANGUAGES:

The principal advantage afforded by the high level languages for programming the PLC is their capability to perform data processing and calculations on values other than binary. Ladder logic diagrams and low level PLC

languages are usually quite limited in their ability to operate on signals that are other than ON/OFF types. The capability to perform data processing and computation permits the use of more complex control algorithms, communication with computer-based systems, display of data on a CRT console, and input of data by a human operator.

3.2.4 FUNCTIONAL BLOCKS:

These provide another means of inputing high level instructions however, the format in which the instructions are entered is the same as the ladder logic diagram. The instructions are composed of operational blocks. Each block has one or more inputs and outputs. Within the block, operations take place on the inputs to transform the signals into the desired outputs. The functional blocks include operations such as timers and counters, control computations using equations (PID control), data manipulation and data transfer to other computer-based systems.

3.2.5 SEQUENTIAL FUNCTION CHART:

This is also called the Grafcet method, which graphically displays the sequential functions of an automated system as a series of steps and transitions from one state to the system to the next.

3.3 OPERATION OF PLC:

As far as the operation of the PLC is concerned, the program steps defined by the user are executed simultaneously and continuously. A certain amount of time is required for the PLC to step through the program and execute any changes in outputs. First, the inputs to the PLC are sampled by the processor and the contents are stored in the memory next, the control program is executed. The input values stored in the memory are used in the control logic calculations to determine the values of the outputs. Finally, the outputs are updated to agree with the calculated values. Generally the execution of the program consists of three steps

*. Input operations

*. Execution of program

*. Output operations

Duration of time it takes for one execution cycle to be completed is called "scan time". The various steps involved in the operation of the PLC are shown by the flow diagram in fig(3.2).

3.4 PLC USED IN OUR PROJECT:

The PLC used in the project is Siemens S7-200.The features of this PLC are

*.The processor used is CPU-214.

*.It has an EEPROM of capacity 4KB.

*.It has 14 input pins and 10 outputs.

*.The time taken to process each instruction is 0.8micro seconds.

*.It has 4 hardware interrupts.

*.Real time clocks are available.

The reasons for choosing this PLC are- the application requires 14 inputs an 10 output. Moreover the number of sequential communication ports in othe models is 238 but in Siemens S7-200 it is 486 in number

so networking is easier.

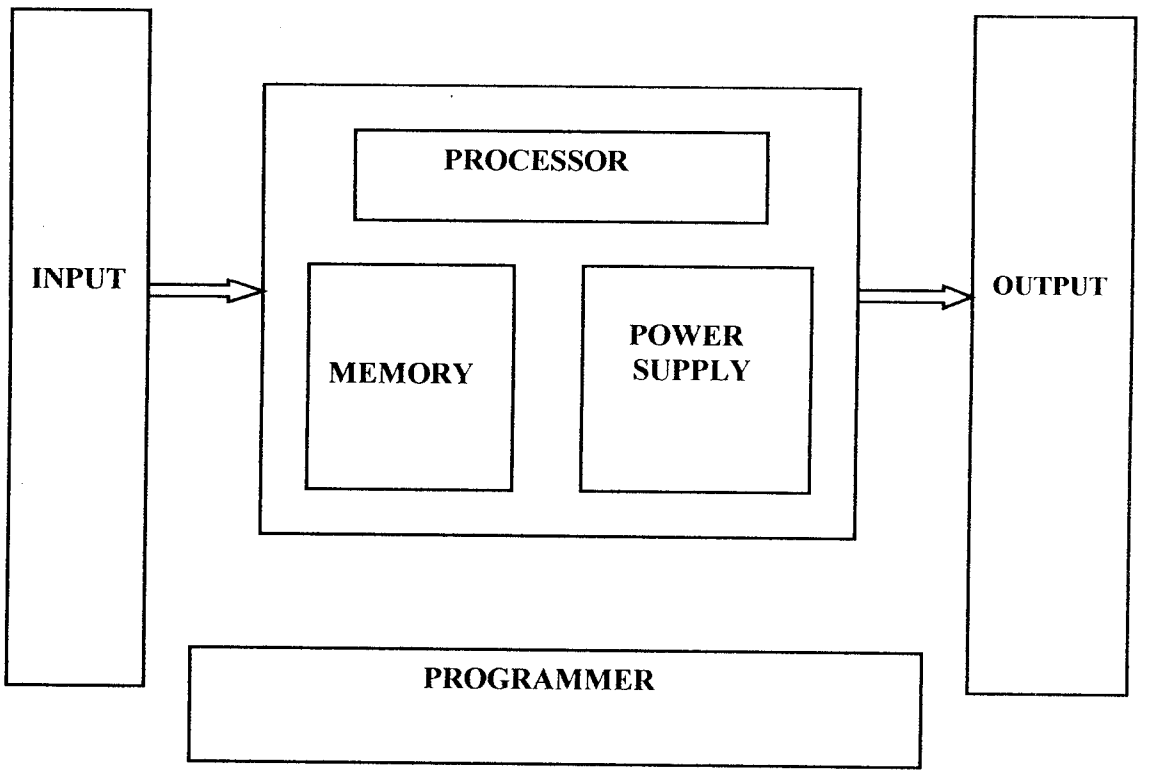


Fig 3.1 PLC ARCHITECTURE

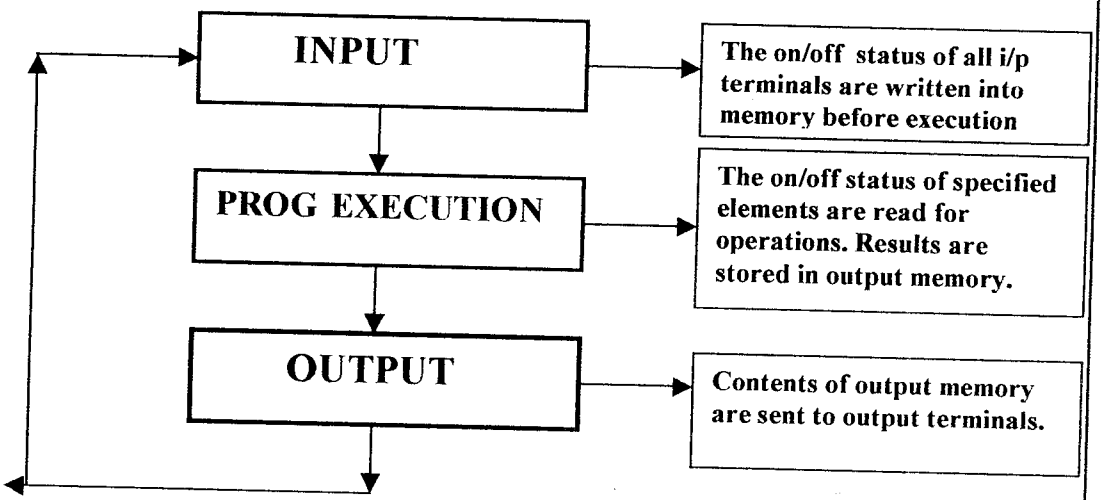


Fig 3.2 OPERATION OF PLC

Control Circuit

CHAPTER IV

CONTROL CIRCUIT

The automated control circuit consists of the following components:

4.1 COMPONENTS:

*. Switched mode power supply

*. PLC

*. Rectifier circuit

*. Relays

*. Solid state relays

*. Exhaust fan

*. Thermocouple

*. Temperature controller

*. Limit switches

*. Proximity sensor

*.Timers

4.1.1.SWITCHED MODE POWER SUPPLY:

The PLC requires 24 volts D.C supply. The 230 volts A.C supply is converted to 24 volts D.C by SMPS.

4.1.2.PLC: The PLC is the heart of the circuit.

4.1.3.RECTIFIER CIRCUIT:

The rectifier circuit used is a bridge rectifier.The valves operate only for 230 volts d.c supply. Hence this rectifier unit rectifies the 230 volts a.c into 230 volts d.c supply. The positive terminal of the d.c supply is given to the relays and the negative terminal of the d.c source is directly fed to the valves.

4.1.4.RELAYS:

Out of the 10 outputs from the PLC 8 outputs are connected to the NO (Normally open) point of the relays. The other NO point is directly connected to the valves which receives a 230 volts D.C supply from the rectifier unit. Since the output from the PLC is only 24 volts D.C this arrangement is essential to operate the valves which operate only for 230 volts D.C supply.

4.1.5.SOLID STATE RELAYS:

The remaining two outputs from the PLC are given to the solid state relays. These relays are connected to the two heaters.

4.1.6EXHAUST FAN:

The PLC is cooled using an exhaust fan. The exhaust fan is supplied with a 230 volts a.c supply directly from the mains.

4.1.7.TEMPERATURE CONTROLLER:

The temperature of the plastic material fed into the injection unit is controlled by a temperature control unit.The temperature of the plastic material is controlled in two zones. Because the plastic material must not be directly heated to its melting point. If it is done so the chemical bonds in the plastic are not strong enough and the desired properties are not obtained. In this machine two heating zones are used out of which the first zone heats the material upto two thirds of its melting point. The remaining temperature raise is brought up by the second zone. The number of the zones required is selected based on the application and desired properties. The temperature in the two heating zones can be varied and set to required value manually by using two temperature controller arrangements found below the push button box.

4.1.8.THERMOCOUPLE:

Thermocouple is a transducer which converts the junction temperature to corresponding voltage. The thermocouple is placed above the injection cylinder. It senses the temperature and if the temperature of the plastic to be heated is below the set temperature, the difference in temperature between the two values is sensed and the LED in the temperature controller glows till it reaches the set value.

4.1.9.LIMIT SWITCH:

These are used to determine the position of the door, mould and ejector. These sense the position and give it as input to the PLC.

4.1.10.PROXIMITY SENSOR:

Proximity sensors are pilot devices that detects the presence of an object or target without physical contact. This is used to sense the position of the refill cut in the injection moulding machine. This sensor is placed in the rear side of the clamp rod. The mould senses any sensor gives the output voltage when malfunctioning. This signal is directly given to the PLC. The processor senses and triggers the next operation when this is sensed, the machine cycle is reset.

4.1.11.TIMERS:

Timers are incorporated in the circuit for making the processes time oriented. The following timers are incorporated in the circuit:

1. **Cycle timer:** This controls the time taken for one machine cycle of the operations.
2. **Injection timer:** The time for which the injection process takes place is controlled by this timer.
3. **Opening timer:** The time taken by the mould door to open after the completion of the process is controlled by this timer.
4. **Ejection forward timer:** The time for ejector to move forwards to push the component is determined by the value set for this timer.

5. **Ejection retraction timer:** The time taken for the ejector to move backwards is determined by this timer.
6. **Cycle delay timer:** The time delay between the completion of a cycle of operation and the beginning of the next cycle is controlled by this timer.
7. **Cooling timer:** The time allowed for the component to cool in the mould before ejecting it out is controlled by this timer. The value of this can be set based on the nature of the component required.
8. **Ejection timer:** The time for ejection is controlled by this timer.

The values for the timers can be set manually by the operator using the man machine interface. The block diagram of the control circuit is shown in the fig(4.1).

4.2 WORKING OF THE CONTROL CIRCUIT

The Programmable logic controller operates only for a 24 volts D.C supply. Hence a switched mode power supply unit is used to convert the 230 volts a.c into a 24 volts d.c.

In the automatic and semiautomatic mode the inputs to the PLC are given through various limitswitches and proximitysensors . The ouput of these limitswitches ,proximitysensors are analog signals. But the PLC operates only for digital signals. Hence these analog signals are converted into digital signals by Analog to Digital converter before giving it to the PLC.

The ouputs from the PLC are only digital signals. These signals are supposed to actuate the various valves and controllers. These valves operate for a 230 volts D.C. Hence relays are used as a switching device. The 24 volts ouput from the PLC are given to the coils of the relay.A bridge rectifier circuit is used to convert the 230 volts a.c mains to 230 volts d.c. The positive terminal of the 230 volts d.c is given to the NO point of the relay and the other terminal is directly connected to the valves.

An exhaust fan is usually provided inside the control panel to cool the PLC .This fan operates for a 230 volts a.c.

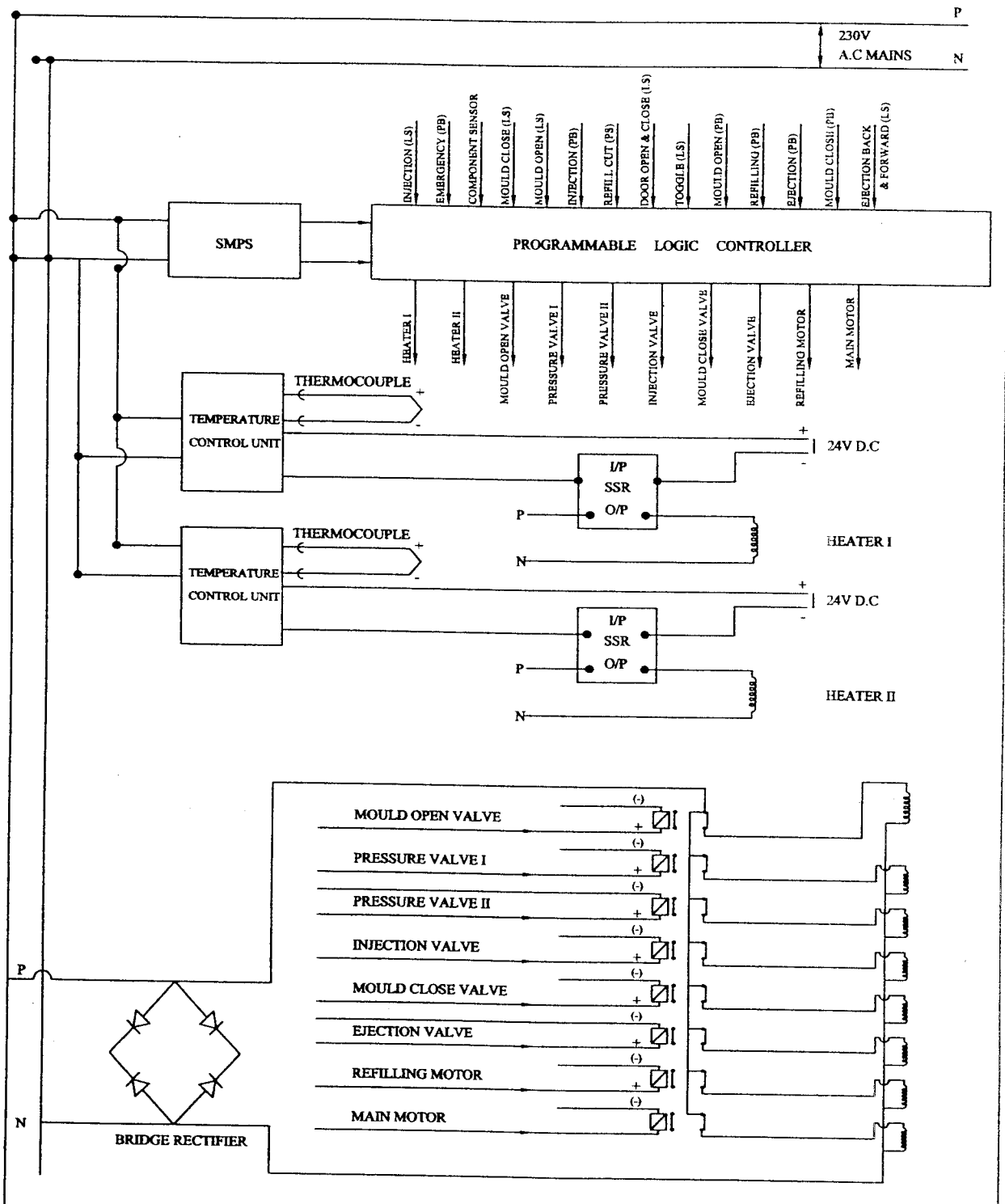


Fig 4.1 CONTROL CIRCUIT

Automation of the machine

CHAPTER V

AUTOMATION OF THE MACHINE

To automate an injection moulding machine the following parameters are to be controlled:

5.1 PARAMETERS TO BE CONTROLLLED:

5.1.1 TEMPERATURE:

The shot material fed through the hopper is heated to convert the raw material into the molten form. The temperature has to be maintained at a particular value, beyond or below which the plastic finishing may deviate from perfection. The temperature in the chambers if exceeds the set value, results in drooling of the molten material. If the temperature is below the set value, the plastic fluid will be unable to move from one chamber to another. So the temperature must be controlled essentially. The areas where temperature is to be controlled are the feed chamber and main chamber.The value of the temperature to be maintained is input to the processor of the PLC using man machine interface which is usually a display screen with functional keys. The temperature is controlled using thermocouples.

5.1.2 PRESSURE:

Pressure is controlled in the injection cylinder and clamping cylinder to maintain the speed of injection and mould close/open. The pressure in the injection cylinder is controlled by the main motor. The pressure valves are preset by the operator using man machine interface. These values are taken as input to the processor.

5.1.3COOLING TIME:

The time for cooling the moulded part before it is ejected from the mould is preset by the operator using man machine interface. It is very essential that the product is to be cooled for sufficient time otherwise the product will get deformed. The cooling time varies for different t ypes of products. There are various methods of cooling the product namely, forced water circulation, air circulation and oil circulation. The method adopted in this machine is water cooling in which cool water is circulated around the mould.

5.1.4 HOLD ON PRESSURE:

To prevent the plastic material which is injected into the mould from flowing backwards into the injection chamber, the injection time is increased slightly so the screw remains in the extreme position adjacent to the nozzle for a short period of time. This allows enough time for the plastic to cool to an extent that it does not flow backwards even after the screw has moved back. The hold on

pressure is also an important parameter to be controlled and it varies with the type of the product.

5.2 INPUTS TO THE PLC:

To control the above parameters and to automate the machine the following inputs are given to the PLC:

5.2.1 Injection:

Once the screw is pushed backwards the toggle comes to the "V" position . This position of the screw is sensed by the limit switch and starts up the refilling motor .The refilling motor pushes the screw forward and injects the material into the mould.

5.2.2 Emergency:

In cases of certain emergencies like power failure or other cases in which the machine must be bought to a halt immediately the PLC is given the emergency input by pushing the push button which in turn stops the machine immediately.

5.2.3 Component sensor:

In fully automatic mode this input is very essential. When the product is completely finished and ejected from the mould it falls on a sensor which gives an input to the PLC so that the next cycle begins.

5.2.4 Mould close (LS):

When the mould closes the limit switch senses it and gives the input to the PLC which in turn starts the injection process.

5.2.5 Mould open (LS):

When the mould opens this operation is sensed by the mould open limit switch and the input is given to the PLC. The PLC on receiving this input starts the ejection process.

5.2.6 Ejection forward & backward (LS):

The extent upto which the ejector pins move forward and backward is given to the PLC as input to start up the next operation.

5.2.7 Refillcut (Proximity sensor):

This input is used to determine the extent upto which the screw can move forward and backward. After receiving this input the PLC gives a corresponding output to open the mould.

5.2.8 Door open &Door close (LS):

This is a safety measure to check if the door is opened or closed. When the door is open, the mould must not close otherwise the operator may get injured. So this input is used to check the status of the door before closing the mould.

5.2.9 Toggle (LS):

The position of the toggle is given as input to the PLC because only when the toggle is in the straight position the injection process must be started.

5.2.10 Mould open (PB):

By pressing this push button the PLC can be made to open the mould. This input is applicable for manual mode only.

5.2.11 Refilling (PB):

This input is used to start the refilling operation in manual mode.

5.2.12 Ejection (PB):

To initiate the ejection process in the manual mode this push button input is used.

5.2.13 Mould close (PB):

This push button is used to close the mould in the manual mode.

5.2.14 Injection (PB):

To start the injection process in the manual mode this pushbutton is used as input to the PLC.

5.3 OUTPUTS FROM THE PLC:

The outputs from the PLC activate appropriate valves to maintain the continuity of the process. The outputs from the PLC are given to the following:

1.Mould open valve

2.Pressure valve I

3.Pressure valve II

4.Injection valve

5.Mould close valve

6.Ejection valve

7.Heater I

8.Heater II

9.Refilling motor

10.Main motor

5.4 MODES OF OPERATION:

The machine is programmed to operate on three modes. They are:

***.Manual mode**

***.Semiautomatic mode**

***.Automatic mode**

The mode of operation can be chosen by pressing the appropriate pushbuttons available in the display screen. The mode of operation is chosen based on the operator's convenience.

5.4.1 MANUAL MODE:

At the beginning of any new process the machine is first run under the manual mode and the time to be allocated for the timers and counters is determined. In this mode all the operations are controlled by the operator manually.

5.4.2 SEMIAUTOMATIC MODE:

In this mode, the PLC is programmed such that the process only after checking if the door of the mould is closed.

After the completion of each cycle the operator opens the door to remove the product and only after he closes the door the next cycle begins.

5.4.3 AUTOMATIC MODE:

This mode is very much similar to the semi automatic mode except that the PLC checks if mould door is closed at the beginning of the first cycle of the process only. For the following cycles this checking is not done and the machine continues the process automatically. Thus the operation is fully free of manual interference in this mode.

5.5 EVENT MESSAGES:

Appropriate event messages are displayed from time to time on the display screen to inform the operator about the process going on. The PLC is programmed to display these event messages. The PLC has been programmed to display the following event messages:

1.Main motor on

2.Main motor off

3.Mould open valve

4.Ejection forward

5.Mould close valve

6.Refilling motor on

7.Manual mode

8.Automatic mode

9.Semiautomatic mode

10.Heater I on

11.Heater II on

12.Ejection valve on

13.Injection valve on

14.Emergency

15.Pressure valve I on

16. Pressure valve II on

17.Refilling motor off

These event messages not only inform the operator about the process going on but also helps him to set the values of timers and to choose the modes of operation by seeing the display.

The automation of the machine in the manual mode and in the semi automatc mode is done based on the following diagram shown in the fig(5.1).

MANUAL MODE:

When the machine is operated in the manual mode, the PLC actuates the corresponding valves and carries out the process after checking a number of operations done sequentially.

In thc manual modc push buttons arc uscd. Intially thc cmcrgcncy push button is normally in the open condition. The output of the PLC(24 volts d.c) is directly given to the push button. Oncc thc button is closcd or prcssed thc cntirc circuit is disconnected from the supply and the machine is protected.

Similarly when the mould close push button is pressed the PLC checks whether the door of the mould is closed, the ejection is in the backward position and the mould close limit switch is turned on only then the PLC operates the mould close valve.

When the mould open valvc push button is pressed thc PLC chccks whether the mould open limit switch is turned on .Only when this condition is satisfied the PLC operates the mould open valvc. Similarly when thc injcction push button is pressed the PLC actuates the injection valvc.

When the ejection push button is pressed the PLC checks whether the mould open limit switch is turned on and the ejection limit switch is turned off. Only then the PLC operates the ejection forward and ejection backward valve.

When the refilling push button is pressed the PLC checks whether the refill cut limit switch is in the off position. Only then the PLC actuate sthe refilling motor.

SEMI AUTOMATIC MODE:

In this mode the door is opened and closed after every cycle is completed. Once the door is closed the PLC checks for the door close limit switch to be turned on, ejection backward limit switch and the mould close limit switch to be turned off. Only then the PLC actuates the mould close valve. At the same time the PLC checks for the toggle limit switch to turned on. Besides this the PLC checks if injection limit switch is turned on and it also checks for the cooling timer. Once the set value of the cooling timer is reached the PLC checks the mould open limit switch and the ejection forward limit switch to be turned on. After these conditions are satisfied a cycle delay timer is introduced to invoke a delay time between the consecutive cycles.When the set time is reached the door of the mould is opened and the PLC starts the next cycle.

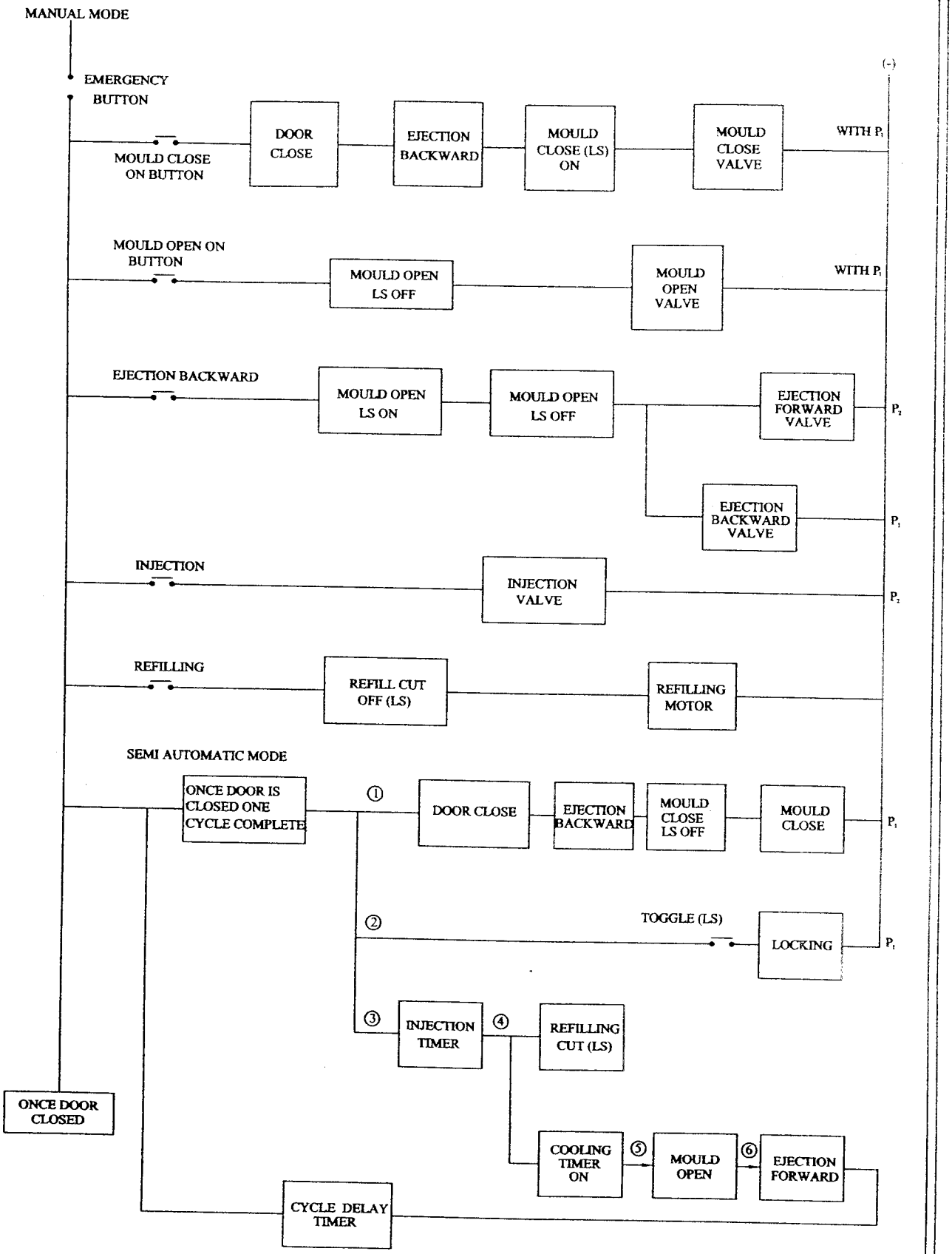


Fig 5.1 AUTOMATION OF THE MACHINE

PLC Program

CHAPTER VI

PROGRAM

The program written to automate the machine is shown below. The program is written, compiled and fed to the PLC. The programming technique used is statement list programming (STL).

PROGRAM:

```
NETWORK 1          //NETWORK TITLE (single line)
                   //NETWORK COMMENTS

LD   SM0.1                    //INITIALIZATION
MOVD  +0, MD0
MOVD  +0, MD4
MOVD  +0, MD8
MOVD  +0, MD12
MOVD  +0, MD16
MOVD  +0, MD20
MOVD  +0, VD12
R    M0.4, 4
MOVB  0, QB1
MOVB  0, QB0
S    M20.0, 1
//S   M0.2, 1

NETWORK 2                     //EMERGENCY

LD   SM0.0
S    V15.0, 8
S    V16.0, 2
AN   I0.1
S    V14.4, 1
R    V13.0, 8
R    V12.0, 8
R    V14.0, 4
R    V14.5, 3
```

```
MOVD  +0, MD0
MOVD  +0, MD4
MOVD  +0, MD8
MOVD  +0, MD12
MOVD  +0, MD16
MOVD  +0, MD20
MOVD  +0, VD12
R     Q0.0, 8
R     Q1.0, 2
```

NETWORK 3

```
LD    M20.0
S     V12.7, 1
S     V15.0, 8
S     V16.0, 1
```

NETWORK 4

```
LD    M0.4                    //MAIN  MOTOR ON
S     V13.0, 1
R     V13.1, 7
R     V14.0, 8
R     V12.1, 1
S     Q1.1, 1
R     M0.4, 1
```

NETWORK 5

```
LD    M0.5                    //MAIN MOTOR OFF
S     V12.1, 1
R     V13.0, 8
R     V14.0, 8
R     Q1.1, 1
R     M0.5, 1
```

NETWORK 6

```
LD    M0.6                    //REFILLING MOTOR ON
S     Q1.0, 1
S     V13.4, 1
R     V13.0, 4
R     V13.5, 3
R     V14.0, 8
R     V12.1, 1
S     M10.0, 1
R     M0.6, 1
```

NETWORK 7

```
LD    M10.0                   //REFILLING MOTOR OFF
```

```
A    I0.6
R    Q1.0, 1
S    V14.1, 1
R    V13.0, 8
R    V12.1, 1
R    V14.2, 6
R    V14.0, 1
R    M10.0, 1
```

NETWORK 8

```
LD   M0.0                    //MANUAL MODE
S    M13.0, 1
R    M13.1, 2
S    V13.3, 1
R    V13.1, 2
R    M0.0, 3
R    M1.1, 7
```

NETWORK 9

```
LD   M13.0
CALL 1
```

NETWORK 10

```
LD   M0.1                    //SEMI AUTO MODE
S    M1.1, 1
S    V13.1, 1
R    V13.2, 2
S    M13.1, 1
R    M13.0, 1
R    M13.2, 6
S    V15.0, 8
S    V16.0, 2
R    M0.0, 3
R    M1.0, 1
R    M1.2, 6
```

NETWORK 11

```
LD   M13.1
CALL 2
```

NETWORK 12

```
LD   M0.2                    //AUTO MODE
S    V15.0, 8
S    V16.0, 2
S    V13.2, 1
R    V13.1, 1
```

```
R    V13.3, 1
S    M1.2, 1
S    M13.2, 1
R    M13.0, 2
R    M13.3, 5
R    M0.0, 3
R    M1.0, 2
R    M1.3, 5
```

NETWORK 13

```
LD   M13.2
CALL 3
```

NETWORK 14

```
MEND
```

NETWORK 15

```
SBR  1
```

NETWORK 16

```
LD   I1.1                    //MOULD OPEN
A    I0.7
S    Q0.1, 1
S    Q0.0, 1
S    V13.7, 1
R    V14.0, 8
R    V13.0, 7
```

NETWORK 17

```
LD   I1.1
A    I0.4
R    V14.0, 8
R    V13.0, 8
R    Q0.1, 1
R    Q0.0, 1
```

NETWORK 18

```
LDN  I1.1
A    Q0.1
A    Q0.0
R    Q0.1, 1
R    Q0.0, 1
```

NETWORK 19

```
LD   I1.4                    //MOULD CLOSE
A    I0.7
S    V13.6, 1
R    V13.7, 1
S    Q0.1, 1
S    Q0.4, 1
```

NETWORK 20

```
LD   I1.4
A    I0.3
R    V14.0, 8
R    V13.0, 8
R    Q0.1, 1
R    Q0.4, 1
```

NETWORK 21

```
LD   I1.4
A    I1.0
R    V14.0, 8
R    V13.0, 8
R    Q0.1, 1
R    Q0.4, 1
```

NETWORK 22

```
LDN  I1.4
A    Q0.1
A    Q0.4
R    Q0.1, 1
R    Q0.4, 1
```

NETWORK 23

```
LD   I0.0                    //INJECTION
S    Q0.2, 2
R    V13.6, 1
S    V14.5, 1
```

NETWORK 24

```
LDN  I0.0
A    Q0.2
A    Q0.3
R    V14.0, 8
R    V13.0, 8
R    Q0.2, 2
```

NETWORK 25

```
LD   I1.3                    //EJECTION
A    I0.4
S    V13.5, 1
R    V14.5, 1
S    Q0.2, 1
S    Q0.5, 1
```

NETWORK 26

```
LD   I1.3
A    I0.4
A    I0.5
R    V14.0, 8
R    V13.0, 8
R    Q0.5, 1
```

NETWORK 27

```
LDN  I1.3
A    Q0.1
A    Q0.5
R    Q0.2, 1
R    Q0.5, 1
```

NETWORK 28

```
LD   I1.2                    //REFILLING
S    Q0.1, 1
S    Q1.0, 1
S    V13.4, 1
R    V13.5, 1
```

NETWORK 29

```
LD   I1.2
A    I0.6
R    Q0.1, 1
R    Q1.0, 1
R    V14.0, 8
R    V13.0, 8
```

NETWORK 30

```
LDN  I1.2
A    Q0.1
A    Q1.0
R    Q0.1, 1
R    Q1.0, 1
```

NETWORK 31

RET

NETWORK 32

SBR 2

NETWORK 33

```
LD   M1.1
AN   I0.7
R    Q0.0, 8
S    M2.0, 1
R    M1.1, 1
```

NETWORK 34

```
LD   M2.0
A    I0.7
R    Q0.5, 1
S    Q0.1, 1        //PRESSURE I
S    M2.1, 1
R    M2.0, 1
```

NETWORK 35

```
LD   M2.1
S    Q0.4, 1        //MOULD CLOSE ON
S    V13.6, 1
R    V14.0, 8
R    V13.0, 6
R    V13.7, 1
S    M2.2, 1
R    M2.1, 1
```

NETWORK 36

```
LD   M2.2
A    I0.3
A    I1.0
A    Q0.4
A    Q0.1
R    Q0.4, 1
R    Q0.1, 1        //MOULD CLOSE OFF
R    V13.0, 8
R    V14.0, 8
S    M2.3, 1
R    M2.2, 1
```

NETWORK 37

```
LD   M2.3
A    I0.6
S    Q0.2, 2          //INJECTION + PRESSURE II
S    M2.4, 1
R    M2.3, 1
```

NETWORK 38

```
LD   M2.4
AN   M2.5
AN   M2.6
AN   M2.7
AN   M3.0
AN   M3.1
AN   M3.2
AN   M3.3
AN   M7.1
AN   M7.2
AN   M7.4
AN   M8.2
AN   M8.6
TON  T37, VW1310      //INJECTION TIMER
S    V14.5, 1
A    T37
R    Q0.2, 2
R    V13.0, 8
R    V14.0, 8
S    M2.5, 1
R    M2.4, 1
```

NETWORK 39

```
LD   M2.5
AN   I0.6
S    Q1.0, 1          //REFILLING MOTOR ON
S    V13.4, 1
S    M2.6, 1
R    M2.5, 1
```

NETWORK 40

```
LD   M2.6
A    I0.6
R    Q1.0, 1          //REFILLING MOTOR OFF
R    V13.0, 8
R    V14.0, 8
S    M2.7, 1
R    M2.6, 1
```

NETWORK 41

```
LD   M2.7
AN   M3.0
AN   M3.1
AN   M3.2
AN   M3.3
AN   M7.1
AN   M7.2
AN   M7.4
AN   M8.2
AN   M8.6
TON  T38, VW1028          //COOLING TIMER
A    T38
R    Q1.0, 1
R    Q0.2, 2
S    M3.0, 1
R    M2.7, 1
```

NETWORK 42

```
LD   M3.0
S    Q0.0, 1              //MOULD OPEN ON
S    Q0.1, 1
S    V13.7, 1
S    M7.1, 1
R    M3.0, 1
```

NETWORK 43

```
LD   M7.1
A    I0.4
R    Q0.0, 1
R    Q0.1, 1              //MOULD OPEN OFF
S    M3.1, 1
R    M7.1, 1
```

NETWORK 44

```
LD   M3.1
AN   M3.2
AN   M3.3
AN   M7.4
AN   M8.2
AN   M8.6
TON  T39, +0
A    T39
R    V13.0, 8
R    V14.0, 8
S    M3.2, 1
```

```
R    M3.1, 1
```

NETWORK 45

```
LD   M3.2
AN   M3.3
AN   M7.4
AN   M8.2
AN   M8.6
S    M8.0, 1
TON  T50, VW1108        //EJECTION TIMER 1
S    Q0.5, 1            //EJECTION VALVE
S    Q0.2, 1
A    T50
R    Q0.5, 1
S    M8.6, 1
R    M3.2, 1
```

NETWORK 46

```
LD   M8.6
TON  T59, +10           //EJECTION PRESSURE DELAY
A    T59
R    Q0.2, 1
S    M3.3, 1
R    M8.6, 1
```

NETWORK 47

```
LD   M8.0
A    I0.5
R    Q0.5, 1
R    M8.0, 1
```

NETWORK 48

```
LD   M3.3
AN   M7.4
TON  T60, VW1150        //EJECTION DELAY TIMER 1
A    T60
S    M8.1, 1
S    Q0.5, 1
S    Q0.2, 1            //EJECTION 2 ON
S    M7.4, 1
R    M3.3, 1
```

NETWORK 49

```
LD   M7.4
TON  T61, VW1189        //EJECTION TIMER 2
A    T61
```

```
R    Q0.5, 1
S    M8.2, 1
S    M3.4, 1
R    M7.4, 1
```

NETWORK 50

```
LD   M8.1
A    I0.5
R    Q0.5, 1
R    M8.1, 1
```

NETWORK 51

```
LD   M3.4
A    I0.5
R    Q0.5, 1
R    M3.4, 1
```

NETWORK 52

```
LD   M8.2
TON  T58, +10        //EJECTION PRESSURE DELAY
A    T58
R    Q0.2, 1
S    M1.1, 1
R    M8.2, 1
```

NETWORK 53

```
RET
```

NETWORK 54

```
SBR  3
```

NETWORK 55

```
LD   M1.2
AN   I0.7
R    Q0.0, 8
S    M11.0, 1
R    M1.2, 1
```

NETWORK 56

```
LD   M11.0
A    I0.7
```

```
S    Q0.1, 1
S    M11.1, 1
R    M11.0, 1
```

//PRESSURE VALVE 1

NETWORK 57

```
LD   M11.1
S    Q0.4, 1
S    V13.6, 1
R    V14.0, 8
R    V13.0, 6
R    V13.7, 1
S    M11.2, 1
R    M11.1, 1
```

//MOULD CLOSE VALVE ON

NETWORK 58

```
LD   M11.2
A    I0.3
A    I1.0
A    Q0.4
A    Q0.1
R    Q0.4, 1
R    Q0.1, 1
R    V13.0, 8
R    V14.0, 8
S    M11.3, 1
R    M11.2, 1
```

//MOULD CLOSE VALVE OFF

NETWORK 59

```
LD   M11.3
A    I0.6
S    Q0.2, 2
S    M11.4, 1
R    M11.3, 1
```

//INJECTION VALVE ON

NETWORK 60

```
LD   M11.4
AN   M11.5
AN   M11.6
AN   M11.7
AN   M12.0
AN   M12.1
AN   M12.2
AN   M12.3
AN   M14.4
AN   M14.3
AN   M14.2
AN   M14.6
```

```
AN   M12.5
TON  T37, VW1310          //INJECTION TIMER
S    V14.5, 1
A    T37
R    Q0.2, 2
R    V13.0, 8
R    V14.0, 8
S    M11.5, 1
R    M11.4, 1
```

NETWORK 61

```
LD   M11.5
AN   I0.6
S    Q1.0, 1              // REFILLING TIMER ON
S    V13.4, 1
S    M11.6, 1
R    M11.5, 1
```

NETWORK 62

```
LD   M11.6
A    I0.6
R    Q1.0, 1              //REFILLING TIMER OFF
R    V13.0, 8
R    V14.0, 8
S    M11.7, 1
R    M11.6, 1
```

NETWORK 63

```
LD   M11.7
AN   M12.0
AN   M12.1
AN   M12.2
AN   M12.3
AN   M14.3
AN   M14.4
AN   M14.2
AN   M14.6
AN   M12.5
TON  T38, VW1028          //COOLING TIMER
A    T38
S    M12.0, 1
R    M11.7, 1
```

NETWORK 64

```
LD   M12.0
S    Q0.0, 1              //MOULD OPEN ON
S    Q0.1, 1
```

```
S    V13.7, 1
S    M14.3, 1
R    M12.0, 1
```

NETWORK 65

```
LD   M14.3
A    I0.4
R    Q0.0, 1          //MOULD OPEN OFF
R    Q0.1, 1
S    M12.1, 1
R    M14.3, 1
```

NETWORK 66

```
LD   M12.1

AN   M12.2
AN   M12.3
AN   M14.4
AN   M12.5
AN   M14.2
AN   M14.6
TON  T39, +0
A    T39
R    V13.0, 8
R    V14.0, 8
S    M12.2, 1
R    M12.1, 1
```

NETWORK 67

```
LD   M12.2
AN   M12.3
AN   M14.4
AN   M14.2
AN   M14.6
AN   M12.5
S    M14.0, 1
TON  T50, VW1108      //EJECTION TIMER 1
S    Q0.5, 1          //EJECTION
S    Q0.2, 1
A    T50
R    Q0.5, 1
S    M14.6, 1
R    M12.2, 1
```

NETWORK 68

```
LD   M14.6
```

```
AN   M14.4
AN   M14.2
AN   M12.5
AN   M12.3
TON  T59, +10          //PRESSURE DELAY TIMER
A    T59
R    Q0.2, 1
S    M12.3, 1
R    M14.6, 1
```

NETWORK 69

```
LD   M14.0
A    I0.5
R    Q0.5, 1
R    M14.0, 1
```

NETWORK 70

```
LD   M12.3
AN   M14.4
AN   M14.2
AN   M12.5
TON  T60, VW1150       //EJECTION DELAY TIMER
A    T6
S    M14.1, 1          //EJECTION 2 ON
S    Q0.5, 1
S    Q0.2, 1
S    M14.4, 1
R    M12.3, 1
```

NETWORK 71

```
LD   M14.4
AN   M14.2
TON  T61, VW1189       //EJECTION TIMER 2
A    T61
R    Q0.5, 1
S    M14.2, 1
S    M12.4, 1
R    M14.4, 1
```

NETWORK 72

```
LD   M14.1
A    I0.5
R    Q0.5, 1
R    M14.1, 1
```

NETWORK 73

```
LD    M12.4
A     I0.5
R     Q0.5, 1
R     M12.4, 1
```

NETWORK 74

```
LD    M14.2
AN    M12.5
TON   T58, +10          //PRESSURE DELAY TIMER
A     T58
S     M12.5, 1
R     Q0.2, 1
R     M14.2, 1
```

NETWORK 75

```
LD    M12.5
TON   T54, VW1230       //CYCLE DELAY TIMER
A     T54
R     T54, 1
S     M11.0, 1
R     M12.5, 1
```

NETWORK 76

```
RET
```

Ladder Diagram

CHAPTER VII

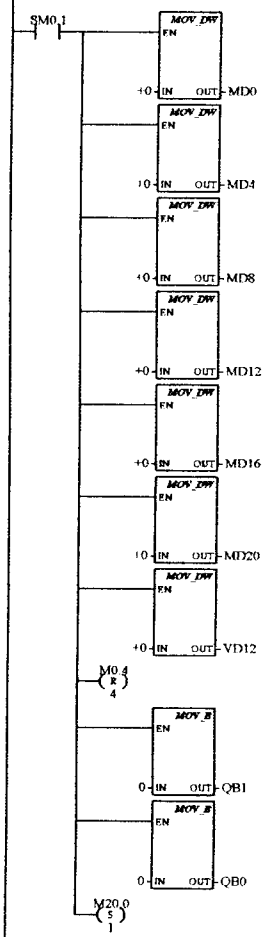
LADDER LOGIC DIAGRAM

PLC is programmed in statement list language. This statement list language can be converted into ladder network.In this type of cvonversion specific symbols are given to each component of the circuit. Contacts are used to represent input switches,relay contacts and similar elements. Coils are used to represent loads such as motors,solenoids, relays,timers, counters etc.The programmer inputs into the PLC with the CRT displaying the results for verification.

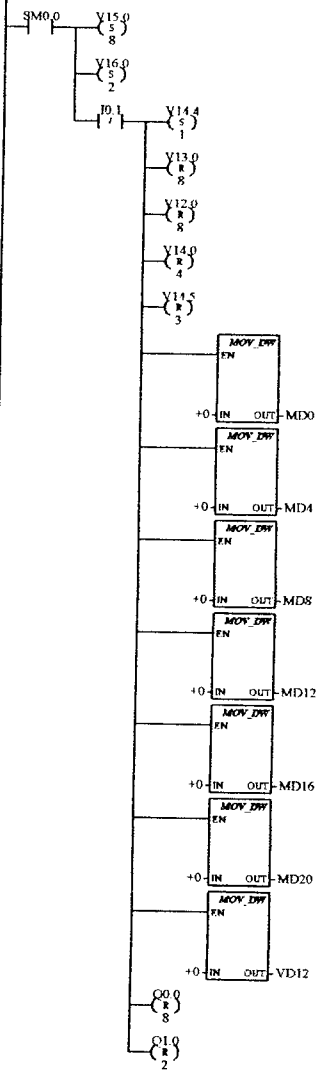
But in our project the programming is done in statement list language .The written program is compiled and fed into the machine.Just a ladder conversion of this program is shown in the forth coming pages.However ladder logic diagrams and low level PLC languages are usually quite limited in their ability to operate on signals that are other than ON/OFF types

Network 1 NETWORK TITLE (single line)

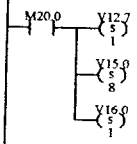
NETWORK COMMENTS



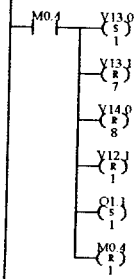
Network 2



Network 3



Network 4



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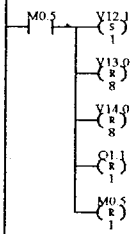

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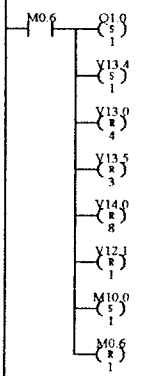

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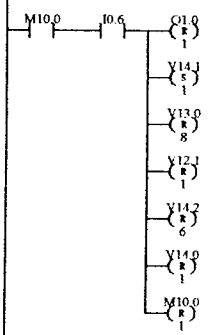

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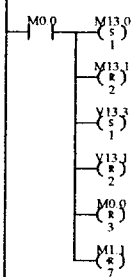

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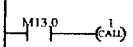

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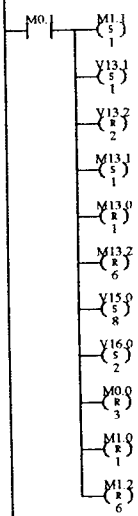

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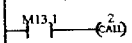

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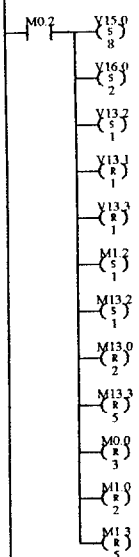

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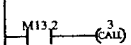
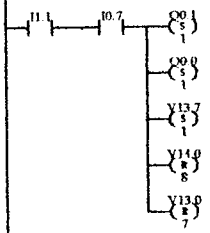


Network 14

Network 15

Network 16



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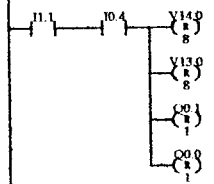

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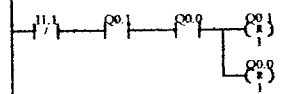

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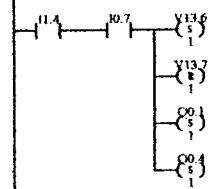

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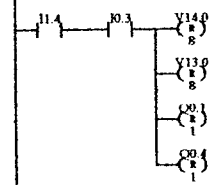

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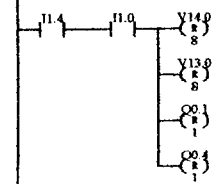

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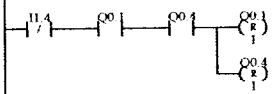

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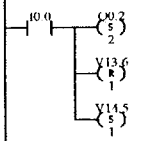

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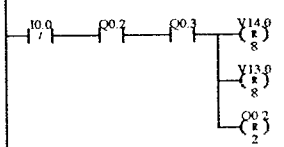

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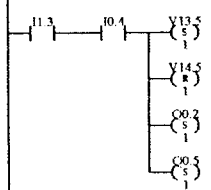

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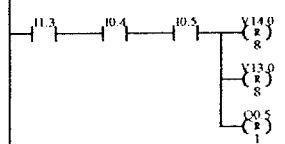

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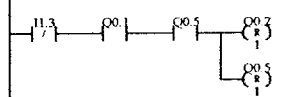

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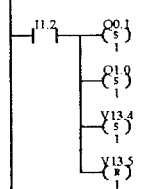

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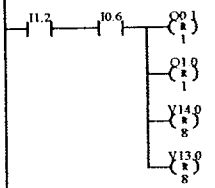

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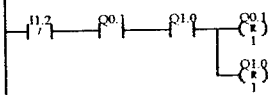
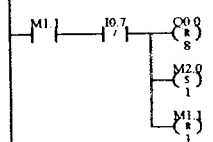


Network 31

Network 32

Network 33



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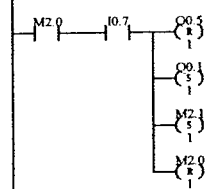

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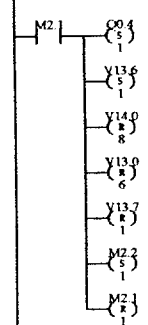

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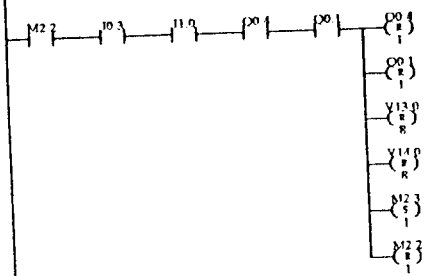

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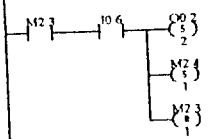

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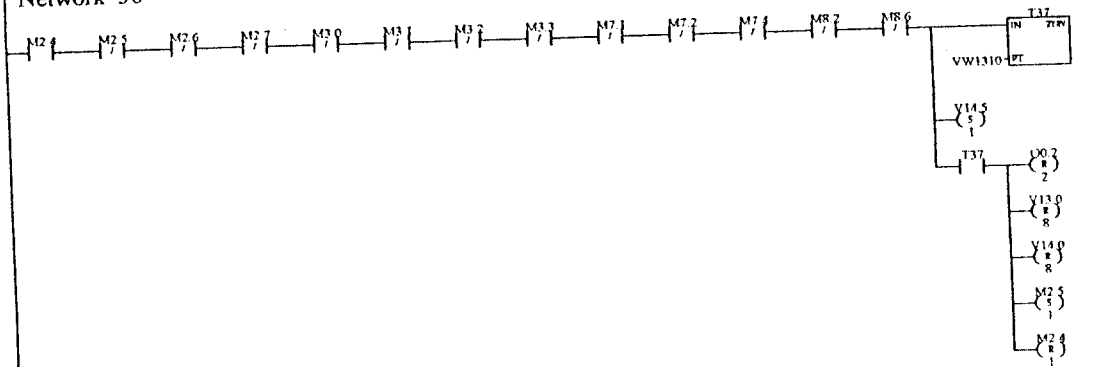

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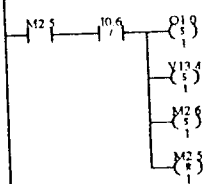

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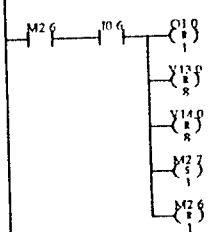

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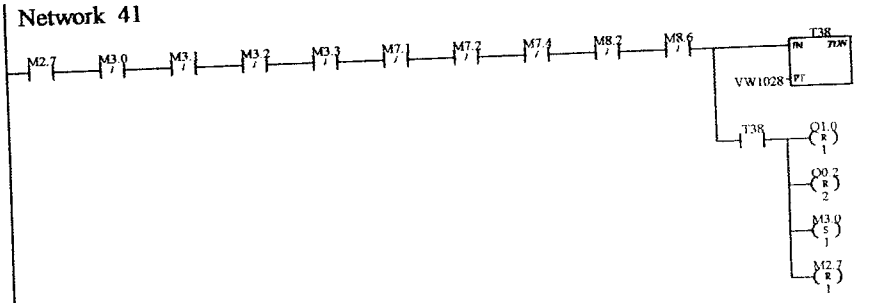

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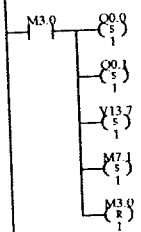

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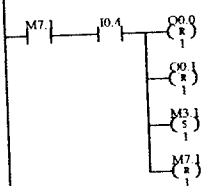

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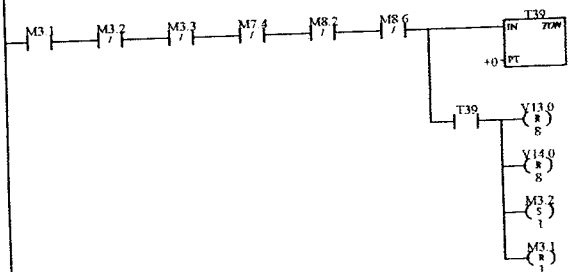

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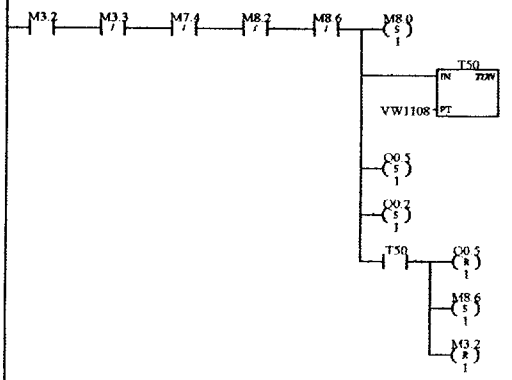

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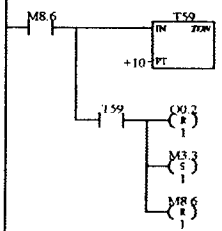

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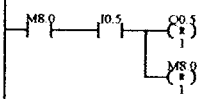

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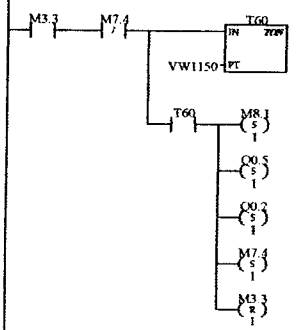

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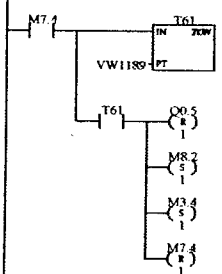

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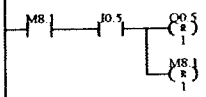

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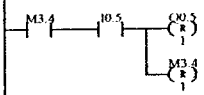

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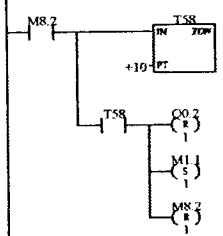
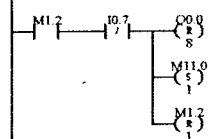


Network 53

Network 54

Network 55



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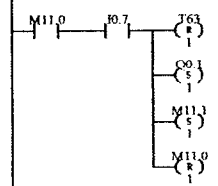

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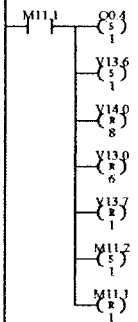

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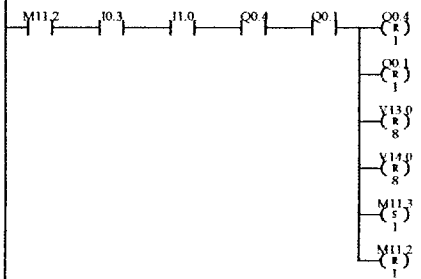

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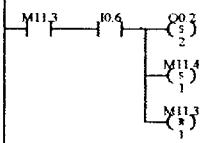

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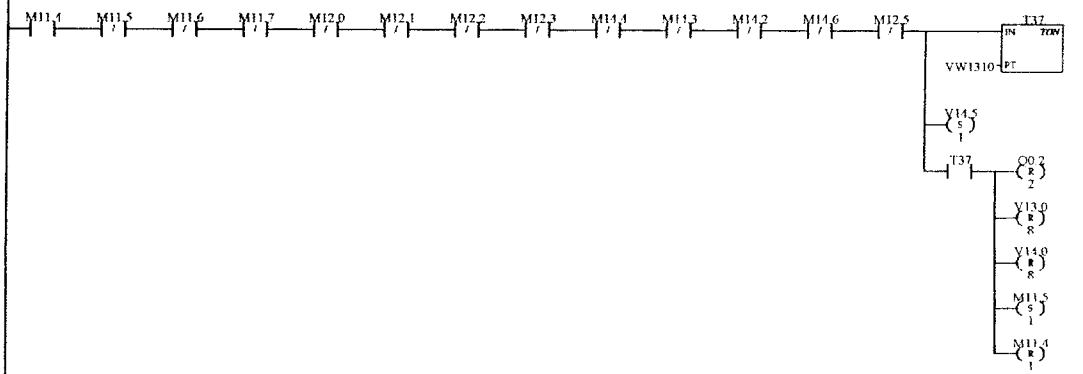

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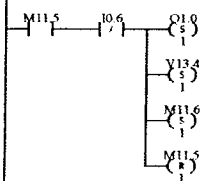

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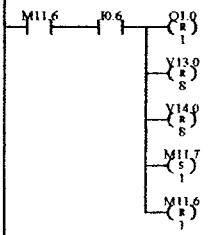

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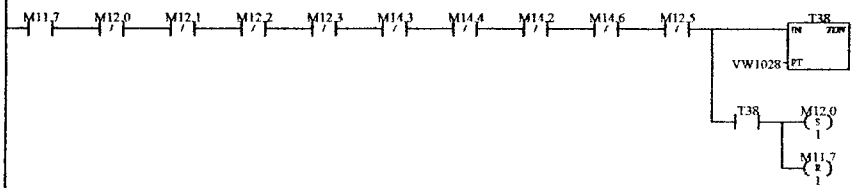
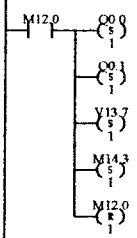
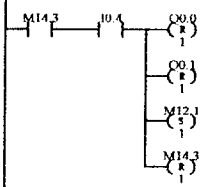


Network 64



Network 65



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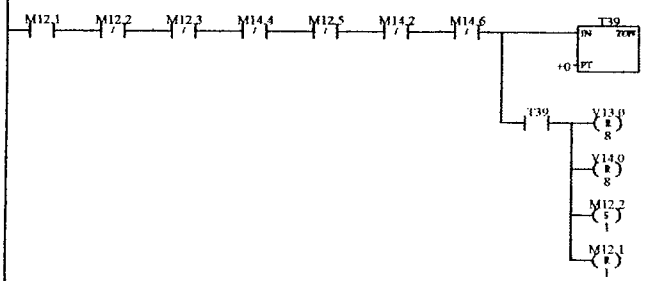

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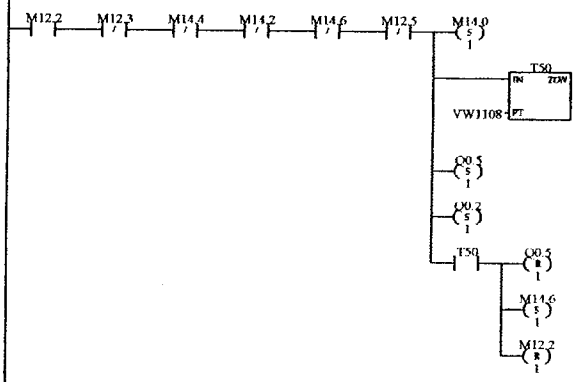
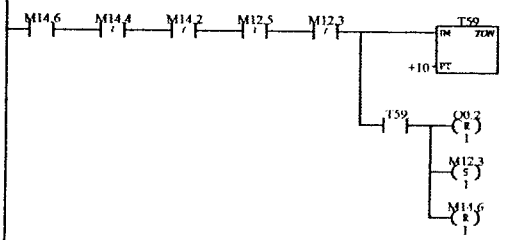


Network 68



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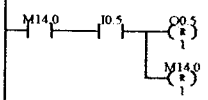

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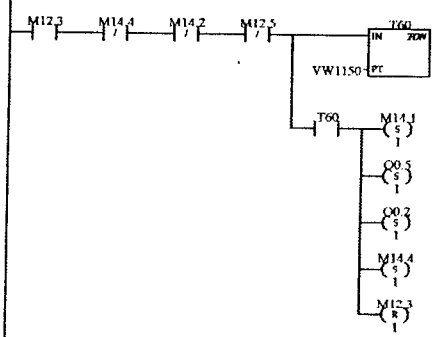

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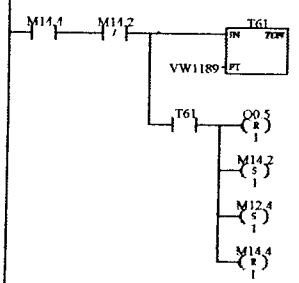

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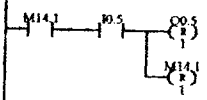

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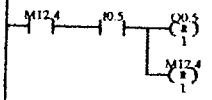

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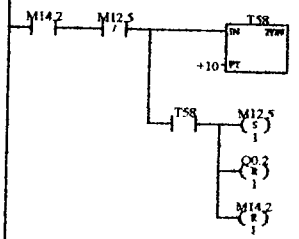

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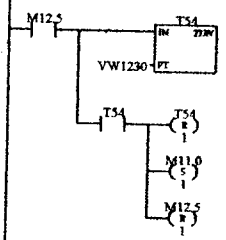

Network 76

Conclusion

CHAPTER VIII

CONCLUSION

The simatic S7-200 has been programmed and interfaced for automating the injection moulding machine. The automated injection moulding machine is fast operating and does not compel operators presence after the setting is over. Though a costly circuit, it is compact less noisy, accurate, and highly reliable. For injection moulding machines of similar capacities around 1.5 to 2 gm shot weight, this programmable logic controller based circuit can be interfaced. Since the control parameter can be set by the operators using man-machine interface, the overall machine cycle can be adjusted to suit the industrial environment.

Further Development Suggested:

The simatic S7-200 PLC used in the project has the unique RS 486 serial communication port which allows data transmission to longer distances compared to the conventional RS 232 serial communication port. So networking is easier. Thus the project can be extended for several machines which are automated using the PLC by connecting them in a single network. So a single operator can at a time control several machines easily and the manual interference is very much

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