

Development and Fabrication of Electro Pneumatic Automatic Stamping Machine

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ABSTRACT: This research work involves the application of electro pneumatics for stamping of products using pneumatic cylinder. The proposed work involves mainly three operations.

1. Clamping
2. Stamping
3. Ejection of products

A PLC (OMRON with 6 inputs and 4 outputs) is going to be used for controlling sequential operation of three cylinders. A motion diagram is first developed and studied from the required sequences and subsequently translated into electrical control circuit. This is again modified to a ladder program which is utilized by the PLC (Programmable Logic Controller).

The clamping cylinder is used to clamp the work piece, the stamping cylinder is used to stamp on the work piece and ejection cylinder is used to eject the work piece. Two direction control valves with single solenoid is used to control the motion of clamping and ejection cylinder, a direction control valve with double solenoid is used to control the motion of the stamping cylinder. Inductive sensor will be used to check the end position of the cylinders.

KEYWORDS: Clamping,Stamping,Prgrammable Logic Controller(PLC),Actuators.

I. INTRODUCTION

A Programmable logic controller is a solid state user programmable control system with functions to control logic, sequencing, timing, arithmetic data manipulation and counting capabilities. It can be viewed as an industrial computer that has a central processor unit, memory, input output interface and a programming device. The central processing unit provides the intelligence of the controller. It accepts data, status information from various sensing devices like limit switches, proximity switches, executes the user control program store in the memory and gives appropriate output commands to devices like solenoid valves, switches etc.

Input output interface is the communication link between field devices and the controllers; field devices are wired to the I/O interfaces. Through these interfaces the processor can sense and measure physical quantities regarding a machine or process, such as, proximity, position, motion, level, temperature, pressure, etc. Based on status sensed, the CPU issues command to output devices such as valves, motors, alarms, etc.

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Programmer unit provides the man machine interface. It is used to enter the application program, which often uses a simple user-friendly logic. PLCs have been gaining popularity on the factory floor and will probably remain predominant for some time to come.

Pneumatics is a method to transfer energy from one point to other using actuators which are driven by fluids under pressure. Pneumatics restricts itself to gaseous fluids while hydraulics uses liquids to transfer the energy.

The transferring of energy in pneumatics such as pumping air into a pneumatic cylinder must be controlled. You can control the pressure by manually opening a valve, automatically by detecting its pressure, or by sending an electrical signal. The control of pneumatic components by electrical impulses is known as electro pneumatics. This science is fast expanding as it can make use of all electronic developments such as PLCs and PCs. However electro pneumatics has restrictions as it cannot be used in places where electricity cannot be used such as gas factories, etc.

Electro pneumatics is successfully used in many areas of industrial automation. Production, assembly and packaging systems worldwide are driven by electro pneumatic control systems. The change in requirements together with technical advances had a considerable impact on the appearance of controls.

Basics of Electro Pneumatics: Electro Pneumatic control integrates pneumatic and electrical technologies. It is more widely used for large applications. In Electro Pneumatics, the Signal medium is the electrical signal -either AC or DC source is used. Working medium is compressed air. Operating voltages from around 12 V to 220 Volts are often used. The final control valve is activated [setting] by solenoid actuation. The resetting of the valve is either by spring [single Solenoid] or using another solenoid [Double Solenoid]. More often the valve actuation/reset is achieved by using pilot assisted solenoid actuation to reduce the size and cost of the valve. Control of Electro pneumatic system is carried out either using combination of Relays and Contactors or with the help of Programmable Logic Controllers [PLC]. A Relay is often is used to convert signal input from sensors and switches to number of output signals [either normally closed or normally open].Signal processing can be easily achieved using relay and contactor combinations. Finally the output signals are supplied to the solenoids activating the final control valves [Directional Control Valves] which controls the movement of various cylinders.

In Electro pneumatic controls, mainly three important steps are involve

- 1.Signal input devices -Signal generation such as switches and contactor, various types of contact and proximity sensors.
2. Signal Processing – Use of combination of Contactors of Relay or using Programmable Logic Controllers.
3. Signal Outputs – Out puts obtained after processing is used for activation of solenoids. Electro Pneumatic control integrates pneumatic and electrical technologies, is more widely used for large applications.

Pneumatic fluid: It performs three basic functions in a hydraulic system: It transfers energy lubricates moving components, and transports heat and contaminants out of the system. Valves are necessary to control the pressure, flow direction of the fluid. Hydraulic valves are made to a high standard of quality and robustness.

II. STRUCTURE OF AUTOMATIC STAMPING MACHINE

The main aim of the stamping machine is to atomize the sequence of stamping with the help of a PLC. The three main steps in the stamping machine are clamping the work piece, stamping the work piece and ejection. The stamping machine is built with respect to the conceptual sketch as shown in figure 1

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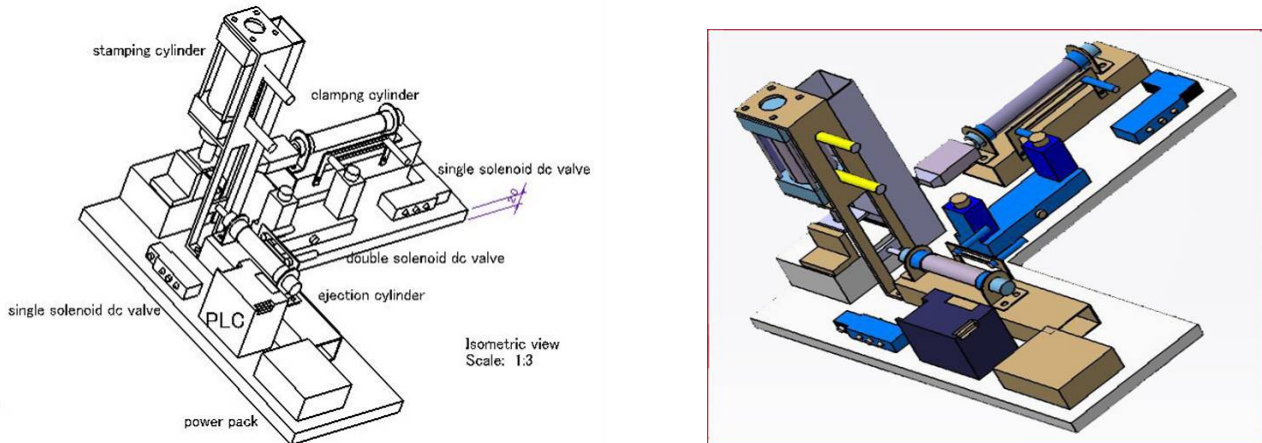


Figure 1 : Structure of automatic stamping machine

Table 1 : List of Major components of automatic stamping machine

1.	Double acting pneumatic cylinder	3 Nos.
2.	Wedge	1 No.
3.	Work piece magazine	1 No.
4.	Die	1 No.
5.	Work pieces	25 Nos.
6.	Support structure	
a.	Stamping cylinder support	1 No.
b.	Sensor support	3 Nos.
c.	Metal pieces to sense	3 Nos.
d.	Extension rod for ejection cylinder	1 No.
e.	Cylinder support magazine	2 Nos.
f.	Wooden bed to stamp	1 Nos.
g.	L-clamp for cylinders	4 Nos.
h.	L-clamp for magazine	2 Nos.
7.	Electrical Control Circuitry	
a.	Direction control valve double solenoid	1 No.
b.	Direction control valve single solenoid	2 Nos.
c.	AC to DC Power pack 24V	1 Nos.
d.	PLC (6 inputs and 4 outputs)	1 No.
e.	Inductive sensors	6 Nos.
f.	Wires and lugs	
8.	Air filter	1 Nos.
9.	PU fits and Tubing	

III. MOTION DIAGRAM AND ELECTRO PNEUMATIC CIRCUIT

Motion Diagram : In order to develop control circuitry for multi actuator applications, it is necessary to draw the motion diagram to understand the sequence of actuation of various signal input switches-limit switches and sensors. Motion diagram represents status of each actuator in step series.

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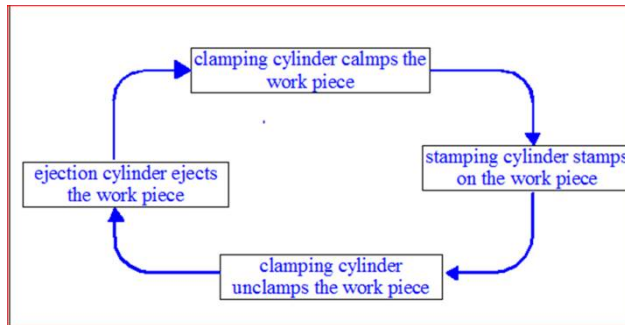


Figure 2 : Block diagram

- Clamping Cylinders: Retarding position- activates inductive sensor S1
Extended position- activates inductive sensor S2
- Stamping cylinder: Retarding position- activates inductive sensor B1
Extended position- activates inductive sensor B2
- Ejection cylinder: Retarding position- activates inductive sensor S3
Extended position Activates inductive sensor S4

Denoting clamping cylinder as 'A'; stamping cylinder as 'B' & ejection cylinder as 'C'. 0 is the Retarding position and 1 is the extended position.

Configuring the default setup as cylinders in home position.

The required sequence is "A+ B+ B- A- C+ C-"

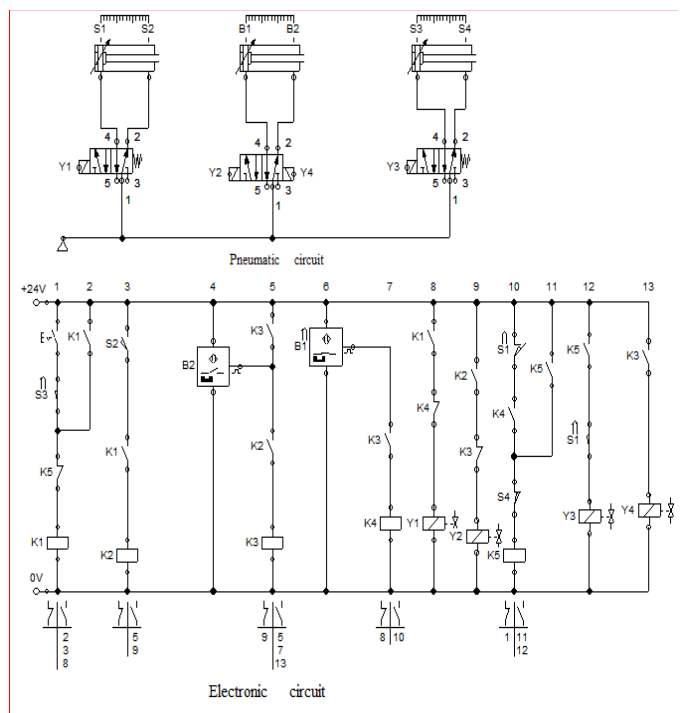
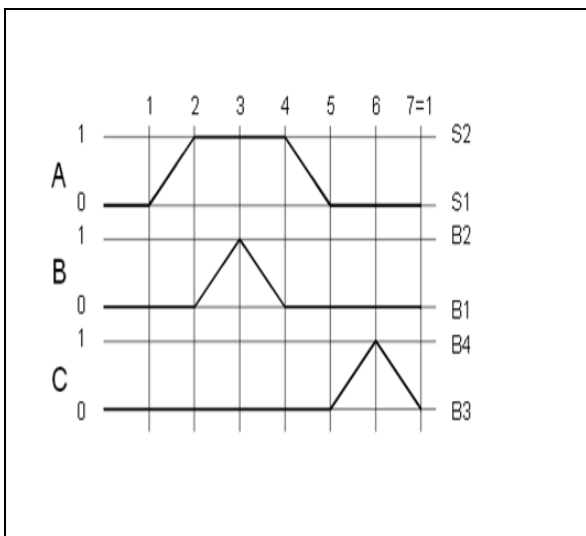


Figure 3: Motion diagram & Electro pneumatic circuit for the sequence

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The motion diagram can be explained in a series of six steps:

Step1: Signal from the ejection cylinder 'C' activates the clamping cylinder 'A'. Cylinder A moves to the extended position.

Step 2: Signal S2 activates the stamping cylinder 'B'. It moves to the extended position.

Step 3: Signal B2 activates the stamping cylinder 'B' again. It moves to the Retarded position.

Step 4: Signal B1 activates the clamping cylinder 'A'. It moves to the Retarded position.

Step 5: Signal S1 activates the ejection cylinder 'C'. It moves to the extended position.

Step 6: Signal S4 activates the ejection cylinder 'C'. it moves back to the Retarded position.

The pneumatic circuit of automatic stamping machine is as shown in the figure 2. It consists of 3 cylinders which is controlled by the DC valves as shown in the figure. The inductive sensors sense the extended and retarded positions of the cylinders. The sensors sense the cylinder position and send the signal to the PLC. The PLC executes the sequential program and activates the required solenoid valve accordingly. The ladder program of the PLC is similar to that of the electronic circuit as shown in the figure 4.2. It consists of 6 inputs and 4 outputs. S1 & S2 are the input signals from the clamping cylinder and Y1 is the output from the PLC that activates the clamping cylinder. The cylinder is controlled by a 3/2 way solenoid actuated spring return DCV .B1 & B2 are the input signals from the stamping cylinder. Y2 is the output from the PLC to activate the stamping cylinder. Y3 is the output signal to retard the stamping cylinder to its home position. There are two solenoids provided to the stamping cylinder to ensure more control over the stamping operation. The cylinder is controlled by a 5/2 way double solenoid DCV

S3 & S4 are the input signals from the ejection cylinder. Y4 is output from the PLC to activate the ejection cylinder. The cylinder is controlled by a 3/2 way solenoid actuated spring return DCV. A two stage reciprocating air compressor is used to obtain compressed air at 6 bar and an air filter is used to filter out moisture and dust from air.

IV. DESCRIPTION OF COMPONENTS

Working components

1. Cylinders
 - a. Clamping cylinder
 - b. Stamping cylinder
 - c. Ejection cylinder
2. Solenoids
 - a. 5/2 way double solenoid valve
 - b. 3/2 way single solenoid valve
3. Air filter
4. PU fitting and tubing

CLAMPING CYLINDER



STAMPING CYLINDER



PU FITS AND TUBING



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EJECTION CYLINDER

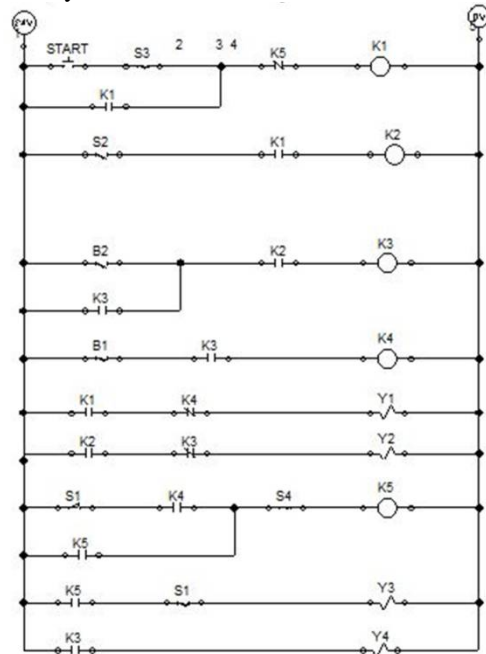


5/2 WAY SINGLE SOLENOID DCV



V. PROGRAMMABLE LOGIC CONTROLLER

It can be called as Heart of the system. It is the one which executes the sequential operation. It takes the input from the sensors and gives the output to the solenoids to actuate the cylinder



Ladder program for stamping machine

The ladder program for the sequence “A+ B+ B- A- C+ C-“ which is used in the currently demonstrated automatic stamping machine is as shown below. It contains 4 outputs Y1, Y2, Y3, Y4. Y1 is the output for clamping cylinder extending, Y2 is for the stamping cylinder extending, Y3 is the output for the stamping cylinder retarding and Y4 is the output for ejection cylinder extending. Clamping cylinder and Ejection cylinder are retarded with an inbuilt spring. Stamping cylinder is providing with 2 solenoids just to make sure there is more control over stamping of products. The circuit contains 5 relays K1 to K5 as shown in the figure. It takes the input from the 6 proximity sensors which activates corresponding to the motion of the cylinder.

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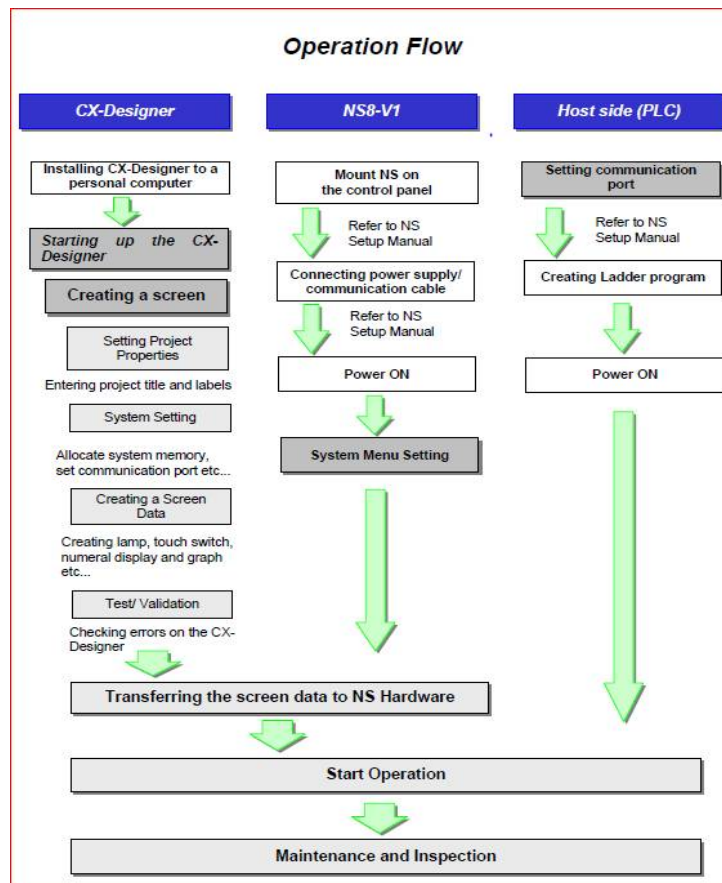
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CX- Programmer

CX-one

- CX-One is an FA Integrated Tool Package that integrates Support Software for OMRON's PLC and other Components.
- To construct an FA System based mainly on PLC, traditionally it was necessary to purchase and install Individual Support Software compatible with each Unit, start the software individually, and then connect to PLC and individual Components.
- Installation of this FA Integrated Tool Package "CX-One" on a personal computer allows integrated operation from setup of OMRON's CPU Bus Units and Special I/O Units (SIOU) and Components to network start-up/monitoring and improving efficiency of PLC System start-up.



Features of CX-One.

- CX-One allows integrated management of Support Software for OMRON's PLC/Components.
 - Installation on only one personal computer allows a user to handle Support Software for OMRON's products.
 - Only one licensing key is required to install all Support Software.
 - It allows integrated management of one save location for files created by Support Software.
- Support Software dedicated to CPU Bus Units and Special I/O Units can be started on the I/O Table.
 - The appropriate dedicated Support Software can be automatically started by specifying a registered Unit in the I/O Table (Unit configuration table attached to a PLC). In addition, setup information

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such as PLC model can be passed to the dedicated Support Software at start-up, allowing easier switching between Support Software.

- The following functions are available by the introduction of the ID information file (CPS) for OMRON Components.
 - Setup of CPU Bus Units and Special I/O Units without manual setting and address recognition. (Parameter and selection item names as well as available range of setup are automatically displayed)
 - CPU Bus Units and Special I/O Units setting on personal computer and data on actual PLC (CPU Unit) can be verified online, and unmatched item/readout data is displayed graphically.
 - Unit configuration is displayed on the I/O Table based on Unit model.
 - Device type on the network can be checked for its Unit model, allowing exact verification of network configuration.

What is CPS?

- CPS (Component and network Profile Sheet) is definition information of CS/CJ series Unit/Components in CX-One. It is provided as a CPS file (XML format file).
- CX-One recognizes CS/CJ series Unit by information in this CPS file. CPU Bus Units and Special I/O Units settings created based on this CPS file.

Operation flow of CX- programmer

- The operation flow of a program in CX- Programmer is as shown in the figure below.
- A CX- software has three parts in it CX-programmer, CX designer and CX- simulator
- CX-programmer is used to program the PLC i.e., loading the program in to the PLC and executing the program
- CX- simulator is used to execute the program i.e., to run the program online or offline and check whether the program is running correctly.

CX- designer is used to design the program i.e., to write the program in the software. The place where we write the program is called the CX- designer

Major Characteristics of CX-Simulator

- **Program execution, monitoring, debug without actual PLC**
 - Monitoring of programs and IO memory present values is enabled. Moreover, normal debugs such as force on/off, differential monitoring, data trace and online edit are enabled from CX-Programmer. Also, any cyclic task can be started/stopped and interrupt tasks can be started in simulation.
- **Cycle time check without actual PLC**
 - It is possible to check estimated cycle time (current, minimum, maximum, and mean values, servicing time) when the program is executed in an actual PLC in advance.
- **Program execution per step or scan, I/O brake condition settings**
 - Debugs that cannot be realized in actual PLCs are provided.
 - Step Run: Executes a program per instruction
 - Scan Run: Executes a program per scan (cycle)
 - I/O Break Condition Settings: Aborts execution when the conditions set in I/O memory are satisfied.
 - Designation of the start and break points
- **Debugs in connection with display devices and serial communications devices**
 - Regarding the serial communications port of a PC as the communications port of a PLC, it is possible to debug a program in combination with display devices or serial communications devices (barcode reader, ID sensor, etc.).
- **Display of the send messages of serial communications and network communications**
 - It is possible to check the send messages issued by TXD instruction (communications port output), SEND instruction (network send), and CMND instruction (command send). It is useful for the debugs of serial communications and network communications.

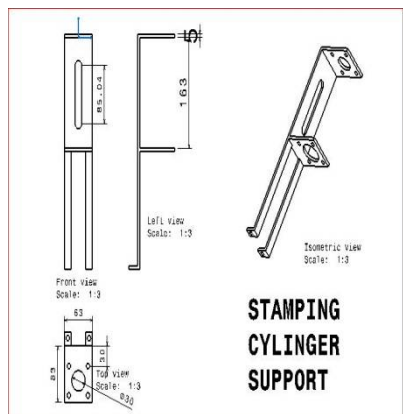
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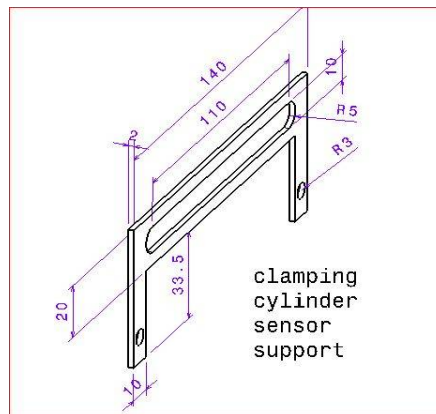
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VI. FABRICATION

Stamping Cylinder Support



Clamping and ejection cylinder sensor support



work piece magazine

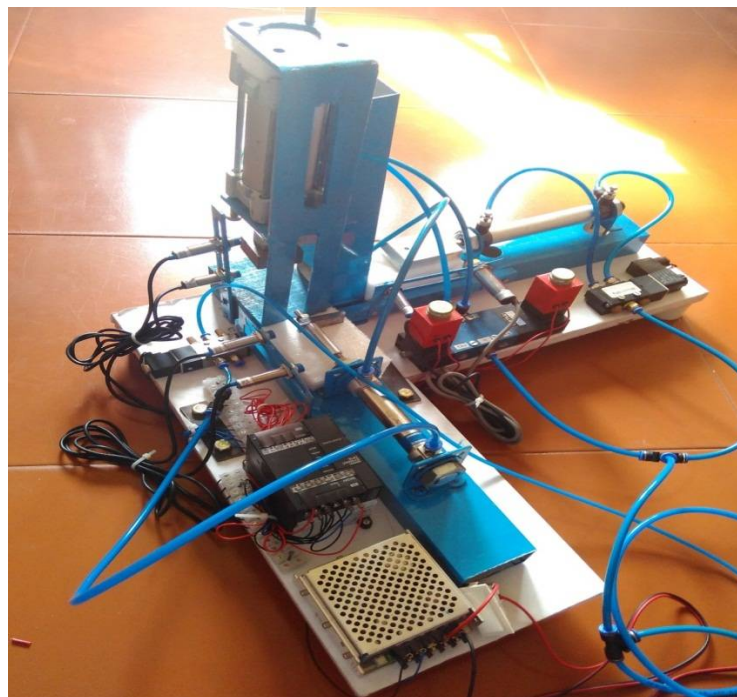
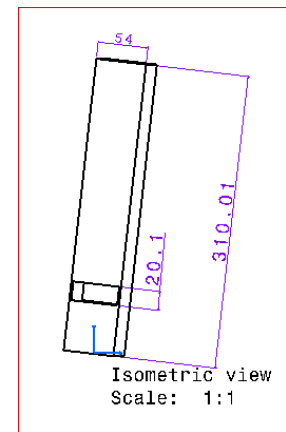


Image of Fabricated Electro Pneumatic Automatic Stamping Machine

VII. RESULTS AND CONCLUSION

- An automatic stamping machine working on the principle of electro-pneumatics and PLC was successfully designed and developed.
- The sequencing of three actuators of the system was achieved effectively using PLC. The simple double acting cylinder gave good output for linear clamping, stamping and ejection of work pieces.

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- Any ductile material of low impact strength of up to 6bar can be stamped using this machine. If a higher strength machine has to be stamped then the system can be replaced by a hydraulics where the material impact strength can be up to 100bar.
- PLC based Electro Pneumatic control was studied in depth.
- The stamping was successfully commissioned, although the concept of using PLC in pneumatic is new, it was successfully proved that the sequential operation can be achieved..

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