

## **Automatic Punching Machine: A Low Cost Approach**

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### **Abstract**

The proposed work describes the design and fabrication of prototype of automatic punching machine controlled by PLC and shedding light on the working principle and the hardware structure of the system. Punching or pressing process is one of the most important and necessary processing step in sheet metal industry. By automating this process one can have a greater control over the process. Programmable Logic Controllers are used for the control of the system. This system can replace existing manual feed and operated punching and pressing machines. By interfacing PLC controls with the conventional machines, it is possible to achieve good results in the form of reduced manufacturing lead time, reduced cost and increased safety of the worker.

**Keywords**— Punching Machine, PLC, Pneumatics, Ladder logic.

### **Introduction**

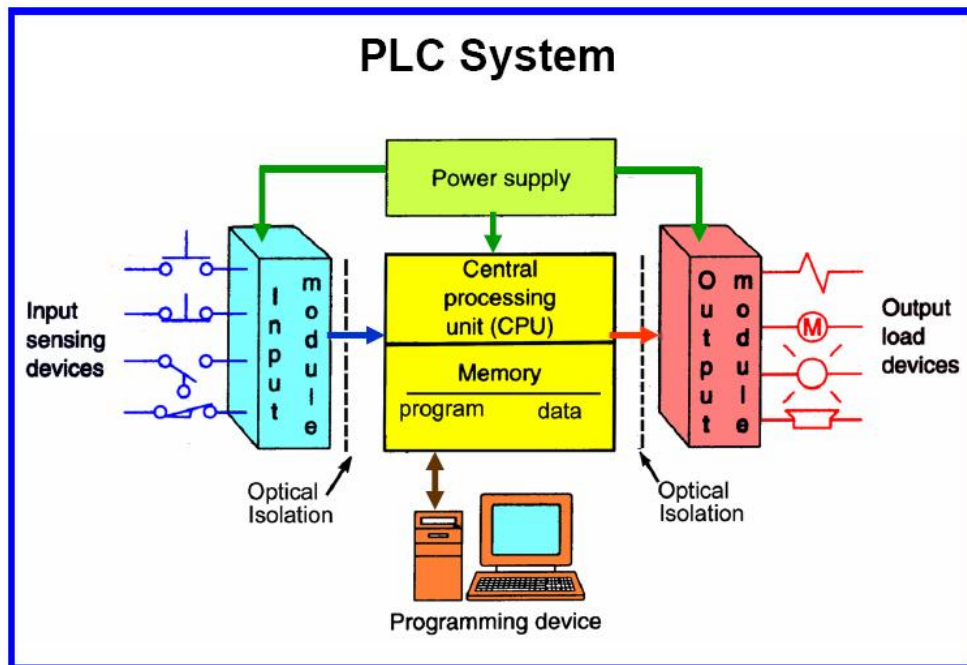
In today's practical and cost-conscious world, sheet-metal parts have already replaced many expensive cast, forged, and machined products. The reason is obviously the relative economy of operation, easier implementation for mass-production, as well as greater control on the technical parameters. In most of the sheet metal operations punching or pressing operation is the main or initial operation in the process sequence. Automating this operation results in reduced lead time and also can reduce human effort.

Automation can be defined as the "technology concerned with application of mechanical, electronic and computer-based systems to operate and control production". There are many reasons for automating the process. The reason may be to reduce manufacturing lead time, to increase labor productivity or to improve the worker safety, etc.

**Punching Process:**

The press is the punching machine tool designed to punch blank of sheet by applying mechanical force or pressure. The presses are exclusively intended for mass production and they represent the fastest and more efficient way to form a metal into a finished punched product. In manual or conventional methods of pressing the disadvantages may be

- angular misalignment of the sheet
- higher material handling time and manufacturing lead times
- reduced safety for the worker

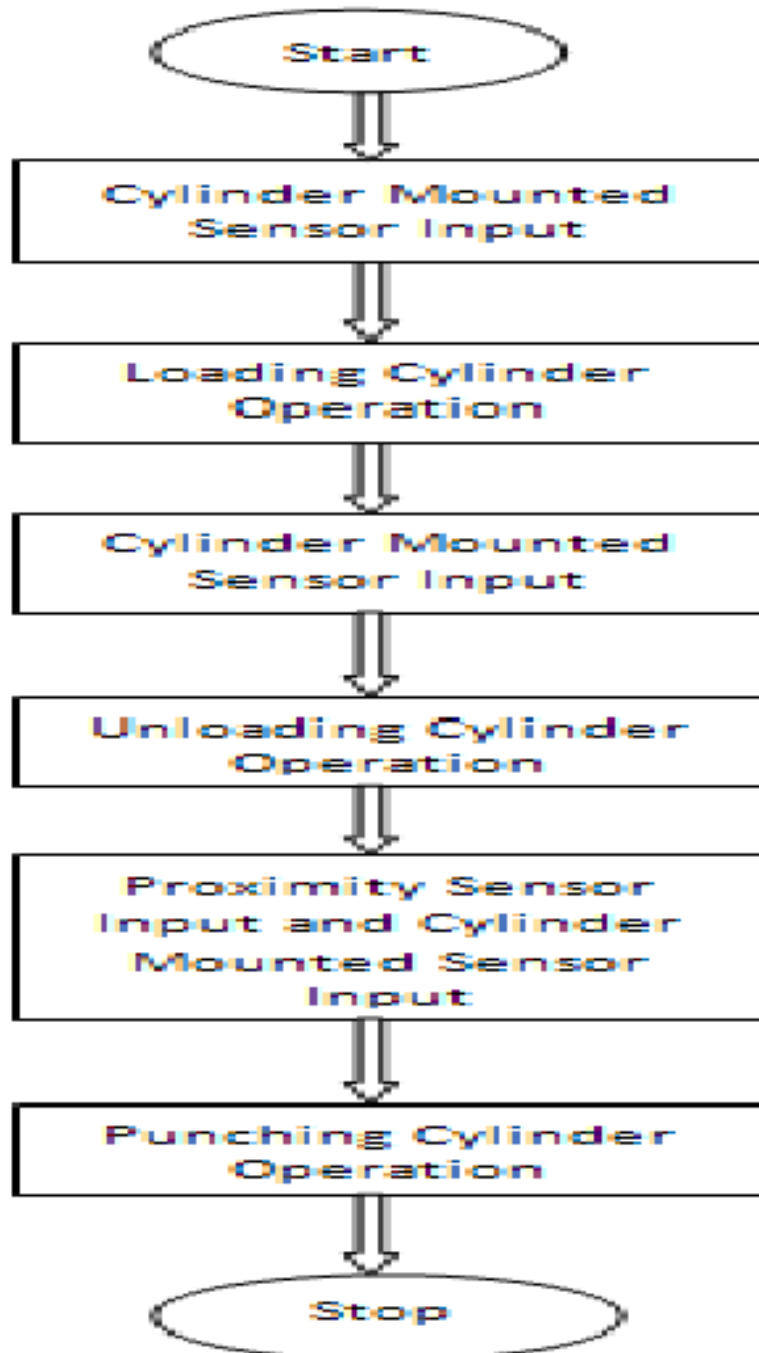
**Programmable Logic Controllers:**

**Fig. 1** PLC System block diagram

A Programmable 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.

In this project, sensors and PLC system is interfaced with the conventional punching process for achieving the automation.

**Working Methodology:**



There are three main components used in this system. They are Loading Cylinder, Unloading Cylinder, and the Punching Cylinder. All these cylinders are operated in a sequence in order to perform the required operation.

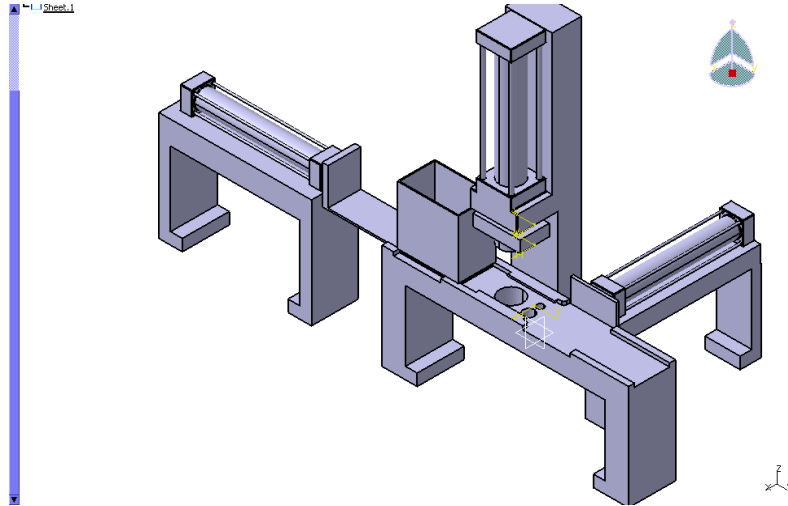
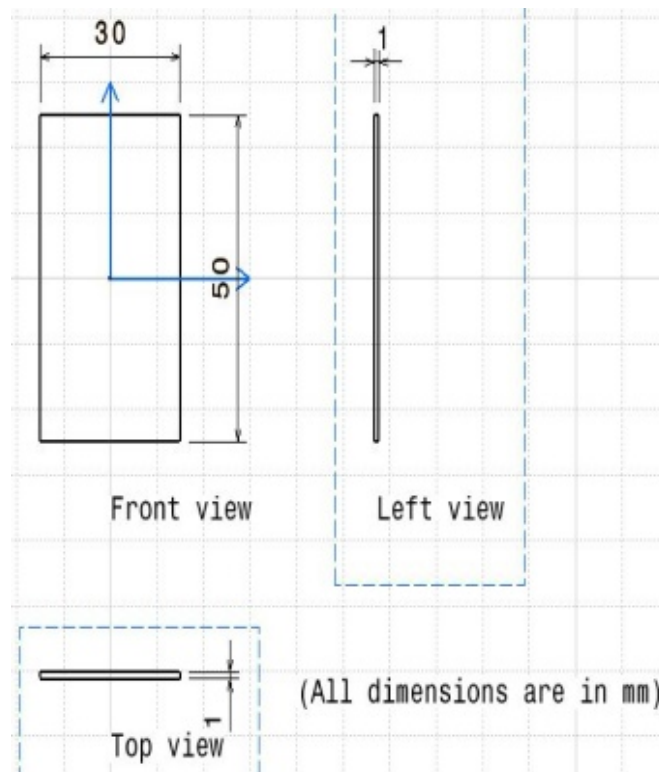
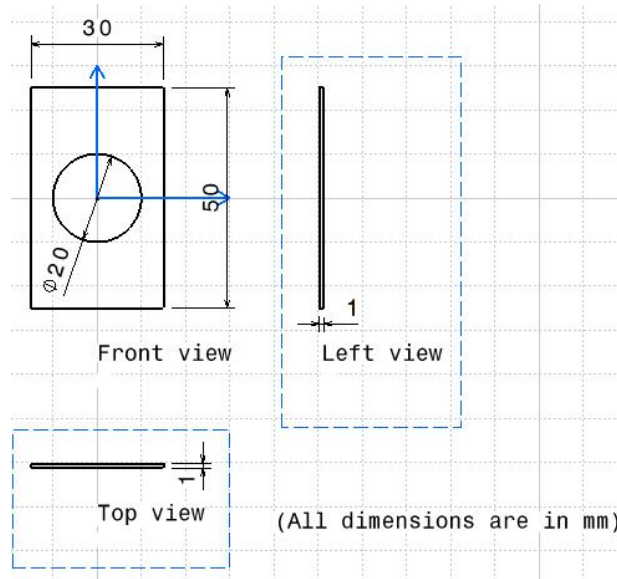
**Design and modeling of the system:****Fig. 2** Model of the punching machine**Actual Component:**

Figure shows the actual dimensions of the part needed to be punched.

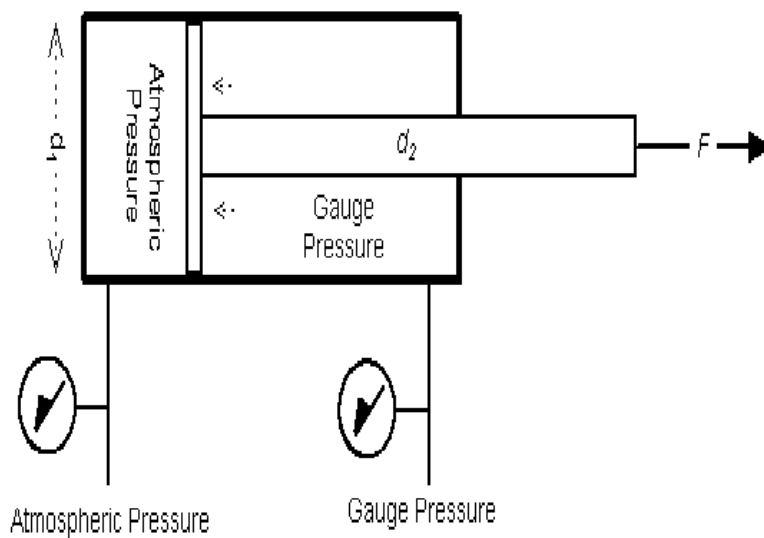
**Fig. 3** Blank before punching operation



**Fig. 4** Blank after punching operation

The component or blank that is needed to be punched is of dimension 50mm length and 30mm breadth. The operation is planned to be carried on three types of materials, like cardboard material, aluminium, and galvanized iron sheet. The thickness of the material is less than 1mm and it depends on the load capacity of the system. A hole of 20mm in diameter is to be punched on the blank as shown in fig.

**Force or Load Calculations:**



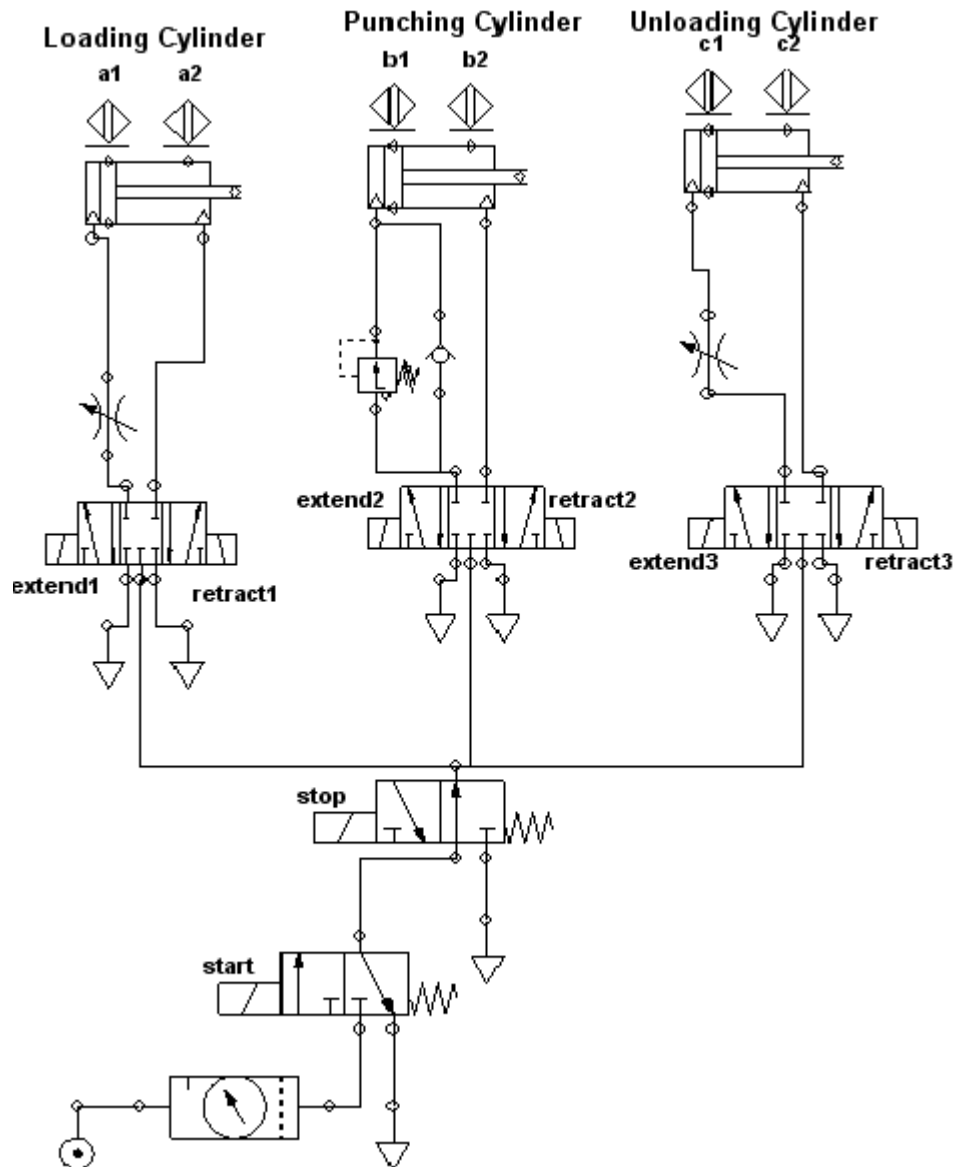
**Fig. 5** Force exerted during extension stroke

The force that is generated by the punching cylinder can be calculated by using the formula

Force,  $F = \text{Pressure} * \text{Area}$

Therefore  $F = P * \pi d^2 / 4$

**Design of Pneumatic circuit of the system:**



**Fig. 6** Pneumatic circuit of the system

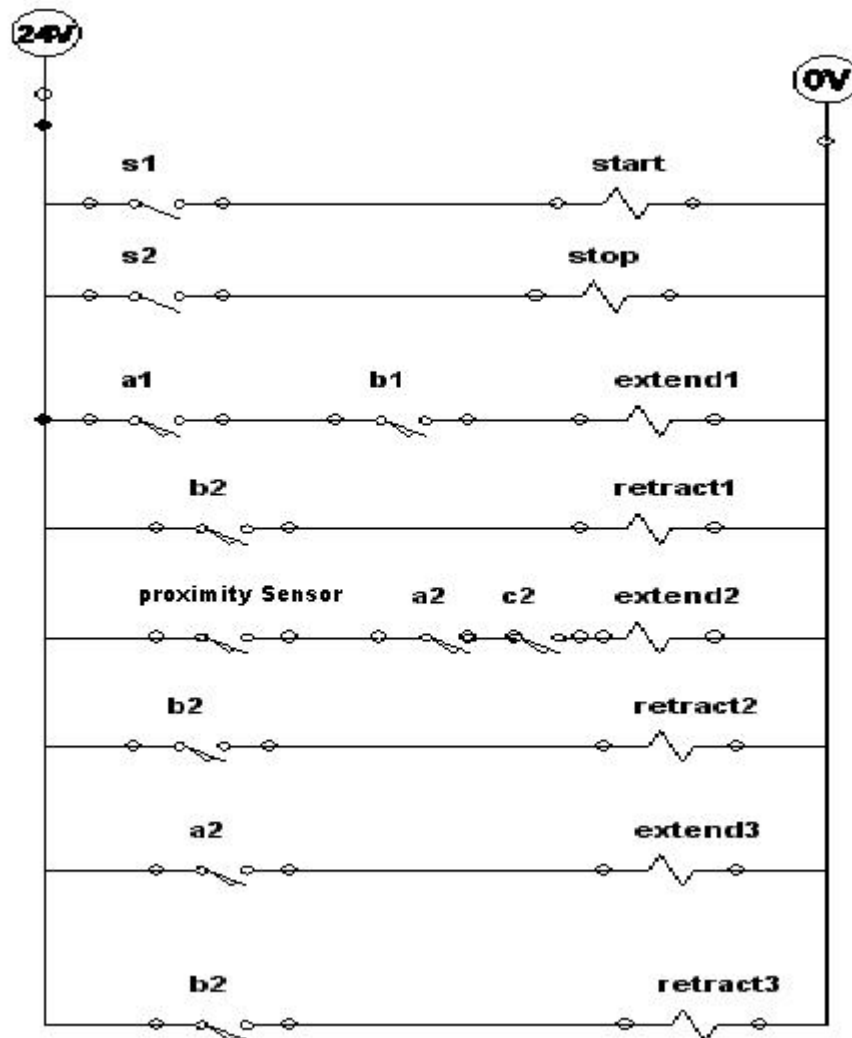


Fig. 7 Ladder diagram to control the pneumatic system

#### Sequence of Operation:

1. When the switch s1 is pressed, START solenoid is energized and the START solenoid valve position changes. Thus air supply will flow to all the valves of the system.
2. Initially a1 and b1 magnetic position sensors are actuated because of retracted position of loading and punching cylinder. Since these two sensors are actuated, EXTEND1 solenoid is actuated and its valve position changes. Hence air is supplied to the blank end of loading cylinder and loading cylinder takes the extension stroke. During the extension stroke, loading cylinder pushed the blank or workpiece into position for punching operation.
3. When the loading cylinder is fully extended, it actuates the magnetic position sensor a2. When this sensor is actuated solenoid EXTEND3 is actuated and its

- valve position changes. Hence air is supplied to the blank end of unloading cylinder and unloading cylinder takes the extension stroke.
4. When the loading cylinder and unloading cylinders are fully extended, they actuate the magnetic position sensor a2 and c2.
  5. When the workpiece is in position, capacitive sensor and inductive sensor senses the presence and type of material. They actuate the proximity sensor switch and it will adjust the pressure required for operation by sending signal to the electrically controlled pressure regulator.
  6. After the pressure adjustments are made, solenoid valve EXTEND2 is actuated and the punching cylinder takes the extension stroke, thus punching the required geometry.
  7. When the punching cylinder is fully actuated, it actuates the magnetic position sensor b2. When the magnetic sensor b2 is actuated, it actuates the solenoid valves RETRACT1, RETRACT2, RETRACT3. All the three cylinders take the retraction stroke simultaneously.
  8. And hence the cycle repeats.

#### Sensors:

A sensor is a device which receives and responds to a signal. A sensor's sensitivity indicates how much the sensor's output changes when the measured quantity changes. The sensor play an important role in automation with regard to achieving important criteria such as cost reduction, rationalization, automation, flexibility and environmental protection. The sensors which are used in this project are capacitive sensor, magnetic sensor and inductive sensor.

#### IndraControl L20:



**Fig. 8:** PLC kit



The IndraControl L20 is a modular and scalable control. It combines the benefits of a compact small control with a standardized I/O system on the basis of terminal technology. It is a hardware platform that can be used for PLC applications. It provides onboard interfaces, e. g. high-speed inputs and outputs (8 each) and communication interfaces, such as Ethernet, PROFIBUS and RS232. The locally available I/O units can be extended by the Rexroth Inline I/O system, just by simply mounting the components side by side.

### **Ladder Logic Programming:**

Ladder logic is a programming language that represents a program by a graphical diagram based on the circuit diagrams of relay logic hardware. It was primarily used to develop software for programmable logic controllers (PLCs) used in industrial control applications. The name is based on the observation that programs in this language resemble ladders, with two vertical rails and a series of horizontal rungs between them.

### **Conclusion:**

In this paper a method of controlling the operations of punching machines is discussed. By using Programmable Logic Controllers as the controller of the system, good control over the system can be achieved, manufacturing lead time of the system can be reduced by developing automatic feeding mechanism and worker safety can be increased by reducing the human participation in the process.

### **Reference**

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