Development of PLC based Sequential Pneumatic Punching System

Soppari Bhanu Murthy1, Narendra Pothula2, Dr.M.S.Sreenivasa Rao3 and Naresh Kumar Goud Ranga4

1Department of Mechanical Engineering, Vallurupalli Nageswara Rao Vignana Jyothi Institute of Engineering and Technology, Hyderabad, Telangana, India.

2Department of Mechanical Engineering, Anurag University, Hyderabad, Telangana, India.

E-mail: sopparibhanumurthy@gmail.com

Abstract. Programmable logic sequential pneumatic system is developed for mechanical applications, like sealing, name punching, plate designing, etc. Punching machine is considered as inevitable in almost all the industries like mechanical, electronic, food industries and automobile, etc. To print the hallmarks, logos as a brand. In respect to reducing the processing time by upgrading the conventional system to automation by integrating with Programmable logic control (PLC) as the system works with the interfacing of hardware (punching machine) and solenoids to control the actuation sequence. A sequential pneumatic PLC-based automatic punching machine is designed to have great control over the process of punching the hallmarks and logos with an automating feeding system followed by the punching process, which leads to a high production rate and reduces the process lead time, and increases the safety of workers.

1. Introduction

Pneumatic drive system is considered as one of the most effective drive systems among others in terms of production rate as well as operating cost, which it needs a compressor, filter, regulator and lubricator (FRL) to provide clean (dust free air) for smooth working and high reliability as well.[1,2] Sequential pneumatic punching machine is designed and developed using PLC to control the process to increase the production rate and decrease the process time.[3] The hardware pneumatic system is developed using the set of double acting cylinders, direction control valve solenoid valves operated and controlled by the logic program for sequencing operation.[4] The integration of sequential pneumatic circuit with PLC and sensors respectively to detect the motion/movement of the individually actuators is considered as the feedback mechanism in order to control the process one after the other as a sequenceis Punching considered as the most inevitable process in any field especially in the engineering science[6,7].
2. Design:

Three pneumatic cylinders are employed in the system, two for clamping workpiece and third one for punching process. The entire system is controlled with programable logic along with the solenoid valves and infrared, respectively.

![Pneumatic circuit diagram for punching machine.](image)

**Figure 1.** Pneumatic circuit diagram for punching machine.

2.1. Sequence of Pneumatic System

- **TA**-Cylinder A Retracted Sensor
- **TA+**Cylinder A Extended Sensor
- **TB**-Cylinder B Retracted Sensor
- **TB+**Cylinder B Extended Sensor
- **TC**-Cylinder C Retracted Sensor
- **TC+**Cylinder C Extended Sensor
- **A+A**-Solenoid A signals
- **B+B**-Solenoid B signals
- **C+C**-Solenoid C signals.
3. Working

As start button is operated the two clamping cylinders i.e. cylinder 1 and 2 extends out and clamps the workpiece. Two photoelectric sensors give the feedback to the PLC. There after punching cylinder extends with a required force maintained by the pressure value it punches on to the workpiece with the cycle time and retracts back and gives the feedback to the PLC then the two- clamping cylinder retracts back to its original position and the process continues.
3.1 Sequence of Operation:
1. The start button (IN0) is pressed it checks whether all the pneumatic cylinders are at initial position or not. If all cylinders are at initial position, then Control(M00) will go ON. In this same network when the emergency button is pressed the Control will go OFF and whole sequence will be stopped.
2. After first rung is true then Control is ON and clamping cylinder will be activated, before the activating the clamping cylinder (M01) it checks whether all cylinders are at initial position.
3. In this sequence two clamping cylinders (O:0.02, O:0.03) so two cylinders are to be activated. M01 gives signal to two clamping cylinders.

Figure 4. Logic of sequential pneumatic punching
4. The two cylinders are extending out and clamps the workpiece later it gives signal to M02.
5. M02 gives the input to the process cylinder (O:0.01), then the process cylinder will be activated.
6. The process cylinder extends out and performs the operation in the time.
7. Once the operation process is completed the cylinder retracts back, return to its initial position it gives signal to M04.
8. The two-clamping cylinder de-clamp the work piece and return to its initial position.
9. Once process is completed then M05 output will gets on and closes all output signals.
10. The machine is ready for next cycle.

Figure 5. Controlling circuit
4. Calculations:

The calculations were drawn by considering the shear strength of material respectively among few materials as shown below in the table.

Considering aluminium material

- Punch diameter = 5mm
- Sheet thickness = 0.2mm

**Piston diameter of punching cylinder = 30mm Common material**

**Shear strength units KN / mm**

| Material | Punch force calculation | Pneumatic pressure calculation |
|----------|-------------------------|--------------------------------|
| Aluminium | Shear strength for aluminium is 0.1724 | The force required to punch a hole on the aluminium sheet is 0.541 kn. |
|          | Perimeter for punch $= \pi \times d = \pi \times 5$ | Area of the piston $= \pi/4 \ d^2$ (d is piston diameter – 0.03m) |
|          | $= 15.7 \text{mm}$ | $= \pi/4 \ [0.03] ^2 = 7.06e-4 \text{ m}^2$ |
|          | Punching force (KN) = perimeter X plate thickness X shear strength (KN/mm2) $= 15.7 \times 0.2 \times 0.1724$ | Air pressure $= F/A = 0.541/(7.06e^{-4}) = 821 \text{ kpa} = 8.2 \text{ bar}$ |
|          | $= 0.541 \text{ KN}$ |                                   |

**Figure 6.** Extracted position of all three cylinders.
5. Conclusion:-

1. About 60% of time is reduced in handling process which in turn increased the production rate.

2. By using sequential pneumatic Programmable Logic Controller, the process is controlled automatically like clamping and punching the work piece where cycle time is reduced.

3. By developing automated clamping mechanism, worker safety is multiplied with the aid of reducing the human involvement and angular misalignment of sheets is approximately decreased. Finally, this machine is eco-friendly.

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