Int. J. Adv. Res. Sci. Technol. Volume 5, Issue 1, 2016, pp.511-515.

IJARST

International Journal of Advanced Research in Science and Technology

journal homepage: www.ijarst.com

ISSN 2319 – 1783 (Print)

ISSN 2320 – 1126 (Online)

Fault detection and Smart control of sequential operation for punching applications.

Rajesh Kumar Mahapatra[1]*, Rajat Kumar Samantaray[1] , Priyabrata Biswal[2] and Nitai Sundar Das[1]

[1]*Department of Industrial Automation, C.V. Raman College of Engineering, Bhubaneswar, India.*
[2]*School of Minerals, Metallurgical and Materials Engineering, Indian Institute of Technology, Bhubaneswar, India.*

Corresponding Author's E-mail*: *rajeshavit@gmail.com

A R T I C L E I N F O

Article history:
Received 20 Dec. 2015
Accepted 29 Jan. 2016
Available online 05 Feb. 2016

Keywords:
Electro-pneumatics,
Mechatronics,
PLCs,
Watchdog timer,
Sequential control.

A B S T R A C T

The field of mechatronics includes wide range of applications such as development of robot, embedded system, integrated high temperature material processing, controlling of electrical and fluid power actuators. Electro-pneumatic systems are taking a special role in automatic production processes such as food, beverage, plastic industries and many others. The fault detection and control of sequential operation based on fluid power actuators has always been challenging. This paper takes the case study of electro-pneumatic actuator role and its control in the sequential operation for automatically punching and placing the materials in the predefined states. The controlling of sequential operation has been carried out using PLC as well as relay, contactor, solenoid and watchdog timer. Also, in this paper the required actuation system is designed and simulated using Automation studio and it has been carried out experimentally with different fault detection cases.

© 2016 International Journal of Advanced Research in Science and Technology (IJARST). All rights reserved.

PAPER-QR CODE

IJARST

Volume 5, Issue 1

Citation: *Rajesh Kumar Mahapatra. et.al. Fault detection and Smart control of sequential operation for punching applications, Int. J. Adv. Res. Sci. Technol. Volume 5, Issue 1, 2016, pp.511-515.*

Introduction:

Now a day's plastics are being widely used for manufacture of a number of very important items such as, smart ticket for metros, voter ID cards, pan cards, packaging and many other products. These plastic have to be cut or punched to specified dimensions to suit individual requirements. It is therefore necessary to design a machine where this can be done automatically.

Implementing the principle of electro-pneumatics in plastics, food and beverage industries with a smart control system is very important. It requires an integration of timer, counter & watchdog timer in a sequential control system for better safety and control.[1]In this paper we propose to integrate double acting cylinders and solenoid actuated 5/2 directional control valves in the electro-pneumatic system for cutting of plastics to required shape and size.[2] The cutting process is also simulated using automation studio [5]. The extension and retraction of the cylinders are sensed using cylinder switches or reed switches [5, 7].

Electro-pneumatic Actuator and its Control:

Electro-pneumatics is a combination of electrical and pneumatic systems, which helps to transfer energy from electrical domain to mechanical domain using pneumatic actuators driven by fluid under pressure [3].

Applying the principle of automation, we can sequentially control the actuators using a PLC (SIEMENS S7-1200). The program has been successfully simulated as well as practically interfaced with a physical pneumatic system, which consists of air compressor, two directional control valves, two flow control valves, two pneumatic pressure sensors, two double acting cylinders (air cushioning type) as shown in fig.1 & fig.2.

The sequential logic is developed using "TIA Portal" (programming software for S7-1200 PLC) with different languages such as LAD (ladder), FBD (functional block diagram) and STL (statement list) as shown in fig.4, fig.5& fig.6

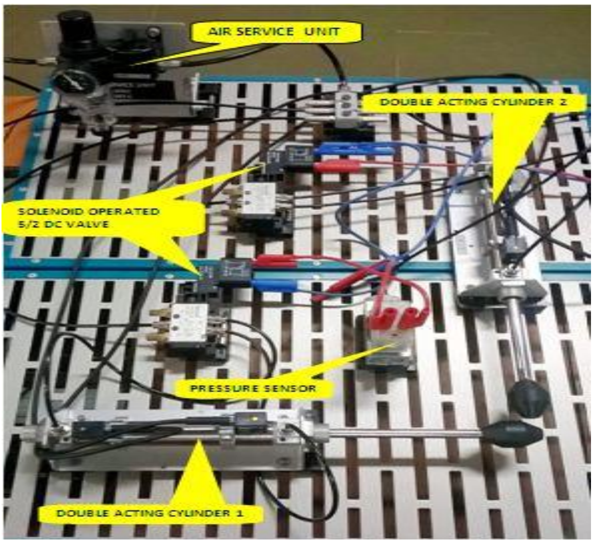


Fig.1: Physical arrangement of pneumatic sequential ckt and interfaced with PLC

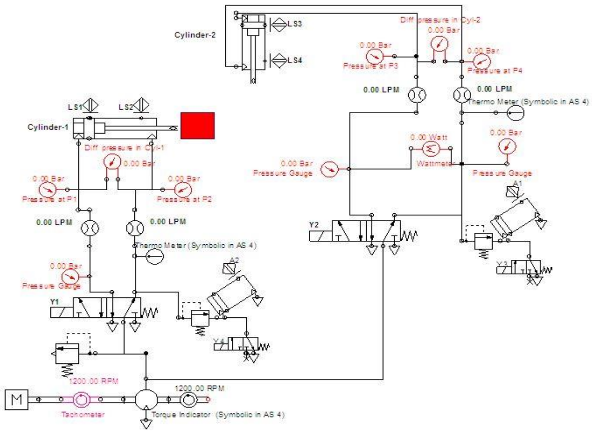


Fig. 2: Simulation diagram of automatic sequential operation of pneumatic actuators

Fault Detection and Control:

For manual operation push button PB1 is used to start the system and push button STOP is used to stop the system. K is the starting contactor. T1 is the timer relay which produces delay in the control of actuators. Y1 and Y2 are the solenoid valves which help to actuate the directional control valves resulting in the extension and retraction of cylinder 1 and 2 respectively. LS1, LS2, LS3 & LS4 are the cylinder switches or reed switches placed over the cylinders and control the position of the cylinders. The concept of Watchdog timer has been proposed for use in the electrical circuit and this has been taken care of in the corresponding program. T2 is the Watchdog timer relay that helps to stop the operation during in case of any fault as mention later. A1 and A2 are the breaking contacts of pressure sensors. CTU is the up counter which counts the no of operation cycles [4, 6].

When PB1 is pressed and released, cylinder 1 extends and its end position is sensed by the cylinder switch or the limit sensor LS2. This helps to place the work piece in working area. The limit sensor LS2 now gives command to the timer relay T1 and after a delay of 3 seconds cylinder 2 extends which helps to punch or shear the work piece. After this action both cylinders retract to their initial positions. This action continues for 5 cycles after which the system resets itself for the next cutting cycle.

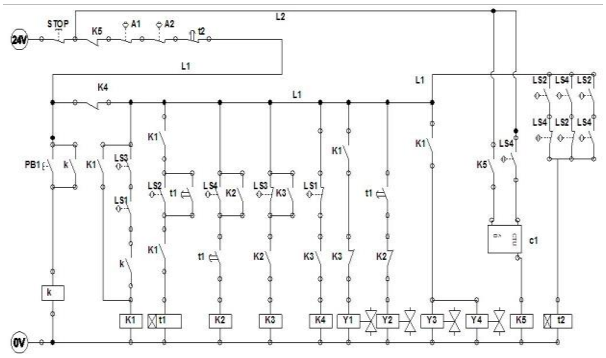


Fig. 3: Electrical circuit for automatic sequential operation of pneumatic actuators

Two faults may occur during the cutting process:

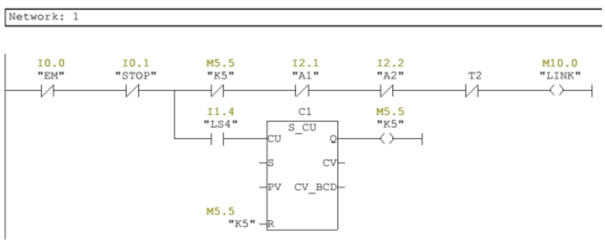
Case 1: If cylinder 1 is not able to place the work piece in proper position the watchdog timer activates after a delay of 5 seconds. This helps to stop the operation cycle and both cylinders return to their initial positions without disturbing the entire process.

Case 2: Cylinder 1 places the work piece in position but does not retract after the preset time. In this case also the process will stop. After rectifying the fault the process can be resume after the fault is rectified.

Both the cases are not only for the cylinder 1 but also cylinder 2.

Simulation and Performance characteristics:

Simulation and physical interface have been successfully done using PLC with 3 different language shown in fig.4 ,fig.5 and fig.6 shows the translation of a basic motion sequence into its equivalent ladder diagram following the “A+ B+ B- A-“ sequence shown in fig..(i/p position char) A+ & A- (cylinder 1 is in positive and negative direction respectively). B+ & B- (cylinder 2 is in positive and negative direction respectively). The structure showed the versatility of the algorithm from electro-pneumatic into LADDER, FBD & STL.



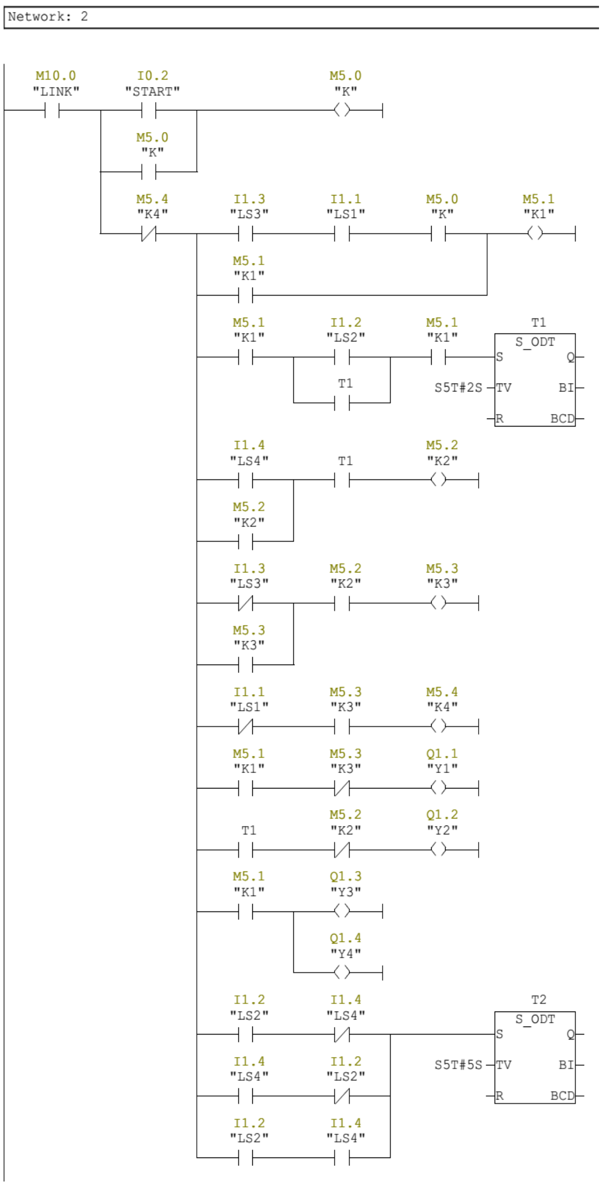
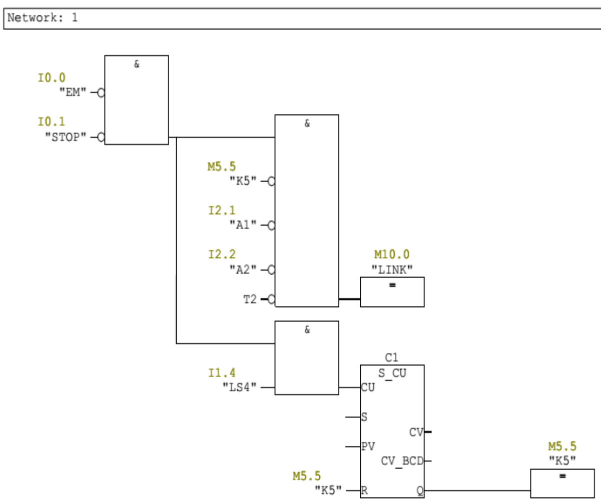


Fig. 4: Sequential program in LADDER language



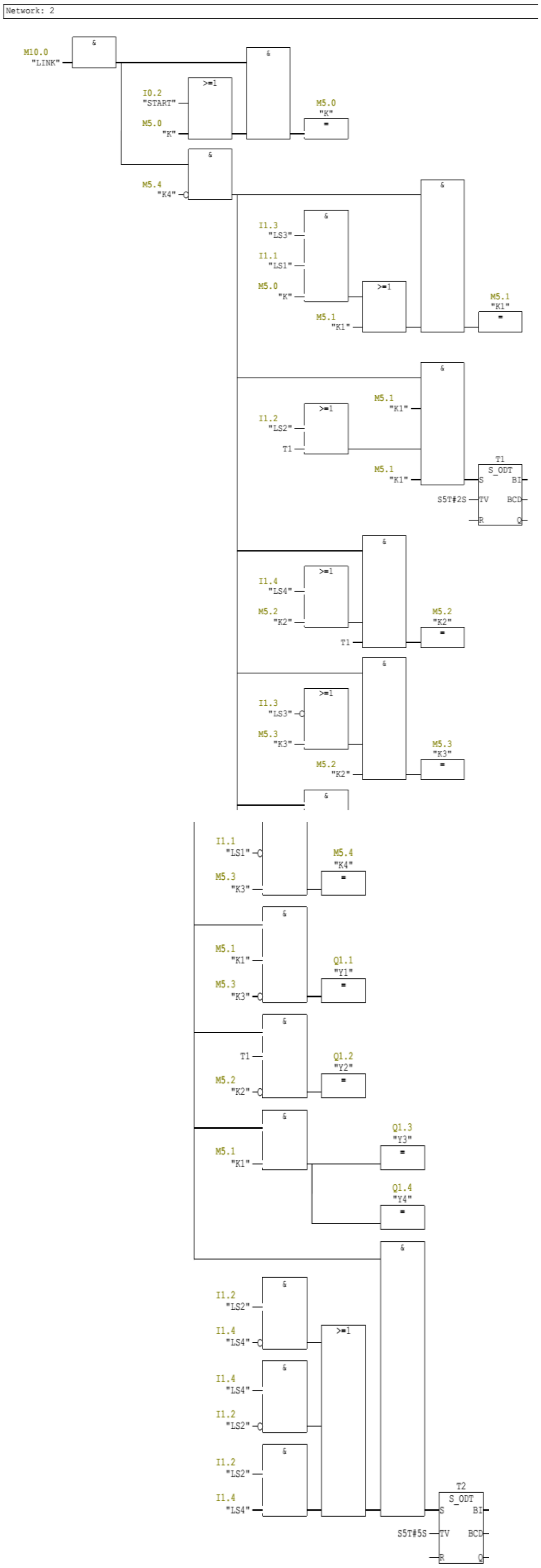


Fig. 5: Sequential program in FBD language

```
Network: 1

AN      "EM"             I0.0
AN      "STOP"           I0.1
=       L        20.0
A       L        20.0
AN      "K5"             M5.5
AN      "A1"             I2.1
AN      "A2"             I2.2
AN      T          2
=       "LINK"           M10.0
A       L        20.0
A       "LS4"            I1.4
CU      C          1
BLD     101
NOP     0
NOP     0
A       "K5"             M5.5
R       C          1
NOP     0
NOP     0
A       C          1
=       "K5"             M5.5

Network: 2

A       "LINK"           M10.0
=       L        20.0
A       L        20.0
A(
O       "START"          I0.2
O       "K"              M5.0
)
=       "K"              M5.0
A       L        20.0
AN      "K4"             M5.4
=       L        20.1
A       L        20.1
A(
A       "LS3"            I1.3
A       "LS1"            I1.1
A       "K"              M5.0
O       "K1"             M5.1
)
=       "K1"             M5.1
A       L        20.1
A       "K1"             M5.1
A(
O       "LS2"            I1.2
O       T          1
)
A       "K1"             M5.1
L       S5T#2S
SD      T          1
NOP     0
NOP     0
NOP     0
NOP     0
A       L        20.1
A(
O       "LS4"            I1.4
O       "K2"             M5.2
)
A       T          1
=       "K2"             M5.2
A       L        20.1
A(
ON      "LS3"            I1.3
O       "K3"             M5.3
)
A       "K2"             M5.2
=       "K3"             M5.3
A       L        20.1
AN      "LS1"            I1.1
A       "K3"             M5.3
=       "K4"             M5.4
A       L        20.1
A       "K1"             M5.1
AN      "K3"             M5.3
=       "Y1"             Q1.1
A       L        20.1
A       T          1
AN      "K2"             M5.2
=       "Y2"             Q1.2
A       L        20.1
A       "K1"             M5.1
=       "Y3"             Q1.3
=       "Y4"             Q1.4
A       L        20.1
A(
A       "LS2"            I1.2
AN      "LS4"            I1.4
O
A       "LS4"            I1.4
AN      "LS2"            I1.2
O
A       "LS2"            I1.2
A       "LS4"            I1.4
)
L       S5T#5S
SD      T          2
NOP     0
NOP     0
NOP     0
NOP     0
```

Fig. 6: Sequential program in STL language

The performance characteristics of the system have been carried out with "input" versus "flow, pressure, position of cylinders, torque" as shown in fig.7, fig.8, fig.9 and fig.10.

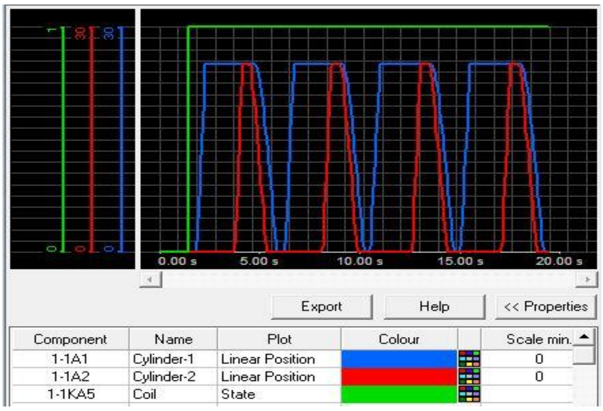


Fig. 7: Input vs. positions characteristics of two cylinders

Fig. 8: Input vs. differential pressure of two cylinders

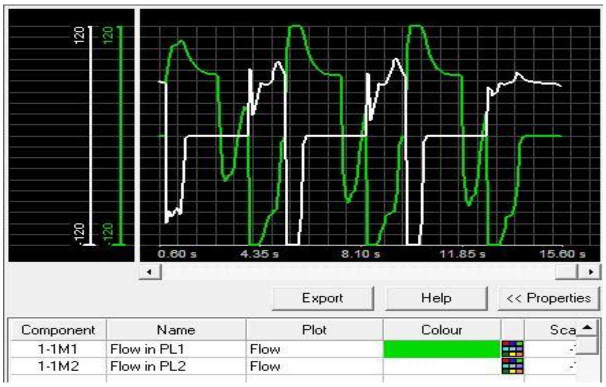


Fig. 9: Flow characteristics of pipe line 1 & 2

Fig. 10: Input vs. output pressure of sequence valve

Conclusion and Future Work:

This paper takes a case study of electro-pneumatic applications in punching applications where the sequential operation is controlled by watchdog timer and PLC. Also, the system has been practically implemented using SIEMENS S7-1200 PLC and it is found that the material moves into predefined states and the motion of electro-pneumatic actuators has been controlled to the requirement of the present system.

In future we can improve the performance of the actuator as well as flow control in the means of velocity control and introduction of the PID or fractional PID to the present system.

Acknowledgement:

The authors would like to thank Prof.G.S.Rath,Professor,Applied electronics & Instrumentation Engineering,C.V.Raman College of Engineering,Odisha.

References:

1. Bolton, William. Mechatronics: a multidisciplinary approach. Vol. 10. Pearson Education, 2008.
2. C.W.de Silva: Control Sensors and Actuators, Prentice Hall. New Jersey: 1989.
3. D. Shetty and R.Kolk, Mechatronics system Design. CL-engineering, 1997
4. Evans, D. S. "Condition monitoring of sequential fluid power systems using programmable logic controllers." (1995): 4-4.
5. Kumar, Ravi, and Jay Robert B. del Rosario. "Design and Simulation of Electro-Pneumatic Motion Sequence Control Using FluidSim." Applied Mechanics and Materials. Vol. 446. 2014.
6. M Wong, P. K., et al. "Object-oriented CAD for electro-pneumatic sequential circuit design in low cost automation." Emerging Technologies and Factory Automation, 1994. ETFA'94., IEEE Symposium on. IEEE, 1994.
7. Vyasraj Koppar "Automation of a Planer Using Electropneumatic Devicesand Programmable Logic Controller".e-ISSN: 2278-067X, p-ISSN: 2278-800X,Volume 7, Issue 11 (July 2013), PP. 18-25.