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Developing a Sequential Pneumatic Circuit for Sheet Metal Operations Using Multiple Pneumatic Actuators

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Abstract – *Industry is always move fast to produce variety of products. Sheet metal have wide application in manufacturing industry like automobile, aerospace industry and medical industry. In industry sheet metal operations are carried out by manually or with the use of fluid power. Hydraulic fluid power systems are not suitable for small and medium scale industry. Compressed air is the one of the easiest sources of energy. Pneumatic fluid power system has wide range of feasibility in point of view of industrial applications. Objective of the project work is to Simulate and develop a pneumatic system consist multiple actuators used to perform sheet metal operations clamping, bending and forming.*

Key Words*: *Pneumatics, Simulation, Hydraulic fluid power, Sheet metal.

1.INTRODUCTION

Today highly competitive industry needs developing new technologies. Automation plays key role in industry to save material, labour and improving delivering quality product. Sheet metal operations are one of the fundamental operations in metal working. Sheet metal operations are usually carried out by manually or fluid power. In small and medium industry hydra ulic machines are not feasible. Pneumatic power system gained importance in the field of automation. Pneumatics is the branch of technology that deals with use of compressed air to produce motion. In pneumatics air is using as the working fluid. The word pneumatics derived from the Greek pneuma meaning breath or air. Pneumatics is the application of compressed or pressurized air to power machine to control or regulate them. Pneumatics also defined as branch of fluid power that deals with generation, transmission and control of power using pressurized air. An air compressor converts mechanical energy of primover in to pressure energy of compressed air. Pneumatic system consist compressor, FRL unit, direction control valve and actuators. Actuators are either reciprocating actuators or rotating actuators. Actuators convert pneumatic energy into mechanical energy. Simulation always play a vital role in manufacturing industry. Effective pneumatic system requires effective working simulation. Fluid SIM is a software tool for creating simulating hydraulic, pneumatic, electro-hydraulic, electro-pneumatic digital electronic system.

Main aim of project work is design simulate and development of pneumatic sequential circuit A+B+B-C+C-A- configuration. Which is widely used for sheet metal operation like clamping, bending and forming etc.

2 LITERATURE REVIEW

1. Developing Multiple-Actuator Pneumatic Circuits Using the Karnaugh Maps Designing PLC Controlled

Author: AlZahraa N. Fawzi, Maher Y. Salloom

Aim of this work is to develop multiple-actuator pneumatic circuits and reduce start-up times by merging various operational sequences into a single process. The Karnaugh maps is a technique for reducing logical equations or transforming truth tables into logic circuits. The method allows for circuit control using a programmable controller (PLC). The study focuses use Karnaugh Maps to develop a pneumatic control system in difficult cases with three different control sequences for five cylinders. Simulation software for pneumatic/electro-pneumatic circuits is utilized to apply the technique (Automation Studio and Fluid Sim).

2. Design and Development of Pneumatic Sheet Metal Cutting Machine

Author: Sudarshan. U, Sunil Kumar K, Darshan S. R, Kushal. P, Varshith. N

This paper presents an efficient and cost-effective method for shearing sheet metal using a pneumatic actuation system that can be applied in small and medium-scale industries. This work provides a safe and effective way to cut sheet metal with minimal maintenance costs. The cutting thickness range can be increased by arranging a high-pressure compressor and installing more hardened blades.

3. Development of Pneumatic Sheet Metal Shearing Process for Precise Cutting

Author: Durairaj R, Murugu Nachippan, Tamilarasan

This work proposes a pneumatic-based cutting machine that cuts small sheets and pipes instantly. Manual cutting machines waste time and aren't accurate enough for

production. The pneumatic cutting machine always cuts at the same pace, ensuring consistent output. The machine has a pneumatic cylinder with a connecting link. Assembling this joint requires a cutter blade. With a bed, material can be supported horizontally in front of the cutter.

4. Design Simulation and Development of Sequential Pneumatic Circuit for Industrial Applications

Author: Muhammed Ishack V, Ahammed Adil P, Amal P K, Rohith V T, Jibi R

This project work consists design simulation and development of cascade pneumatic sequential circuit. Main aim of work is design simulate and development of pneumatic cascade sequential circuit A+B+B-A- configuration. Pneumatic diagram describes the relation between each pneumatic components as per equipment of pneumatic system. Most of the practical pneumatic systems involve the use of multiple actuators (cylinders, semi-rotary actuators, etc.) which when operating in specified sequences carry out the desired control tasks. In multicylinder applications A+B+B-A- has wide applications. Sheet metal operation in a press shop, a stamping operation is to be performed using a stamping machine. The work piece has to be first clamped under the stamping station. Then the stamping tool gets in to position and performs the stamping operation. The work piece must be unclamped only after the operation is completed. The cascade system provides a straightforward method of designing sequential circuits. It will always give a workable circuit.

5. Fabrication Of Pneumatic Forging Machine

Author: Prof. Sunil Parge, Malgudri Saraswati, Rasika Pasare

In this work fabricate the pneumatic circuit with time delay circuit forging machine. It time delay valve has three different times like, low, medium, high. It controls by a button and it consist many more electric and electronic components. This circuit run on adapter this adapter provides 12-volt DC current. This pneumatic circuit also have components like, compressor, FRL unit. Pressure gauge, 3/2 solenoid operated direction control valve, double acting cylinder, etc.

3 METHODOLOGY

Methodology is one of the most critical elements to be considered to make sure the fluent of the project and get expected result. In other words, the methodology can be described as framework where it contains the elements of the work based on the objectives and a scope of the project. A good framework can get the overall view of the project and get the data easily. This included literature study, Design of pneumatic cascade circuit A+B+B-C+C-A-, simulation using Fluid SIM software, fabrication of pneumatic sequential system and cost analysis.

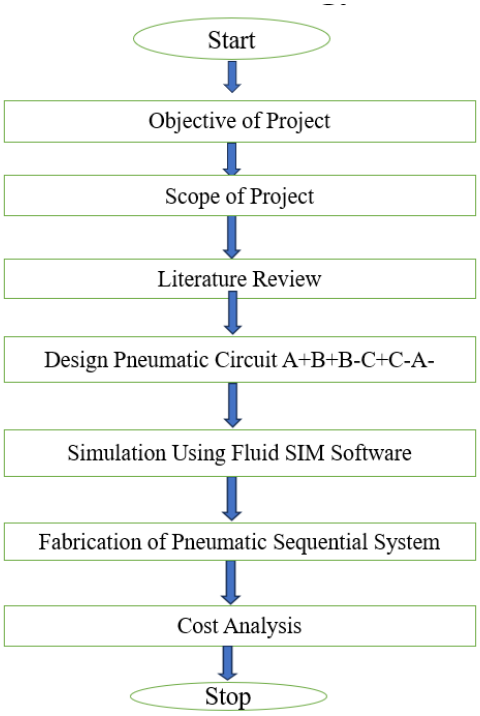

Fig 1: Project Methodology

4. WORK DONE

Metal strip is bend using a bending machine, where they are placed manually in a fixture. Cylinder A clamp the metal strip when a push button is pressed. Cylinder B start the bending operation and retract, and cylinder C completes the operation. After cylinder C returns to its initial position cylinder A releases the part.
Operation has to perform

Bending Operation

Forming Operation

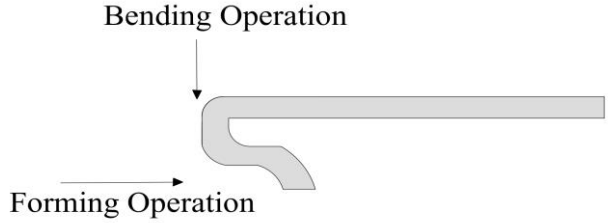

Fig 1: Sheet Metal Component

Positional Diagram

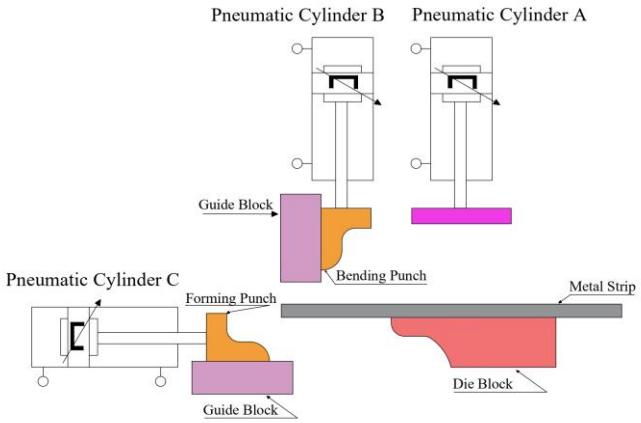

Fig 2: Positional Diagram

Stage 1:Clamping

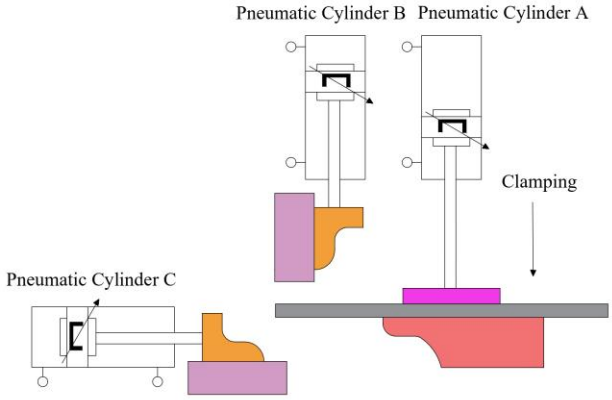

Fig 3: Stage 1 Clamping Process

Stage 2 :Bending

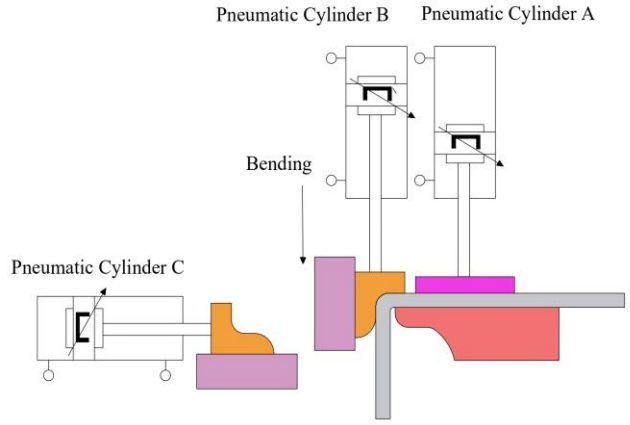

Fig 4: Stage 2 Bending Process

Stage 3:Forming

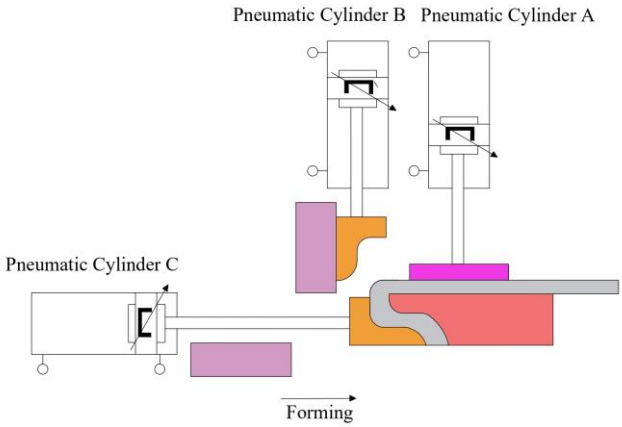

Fig 5: Stage 3 Forming Process

Flow Chart for Pneumatic Circuit Design

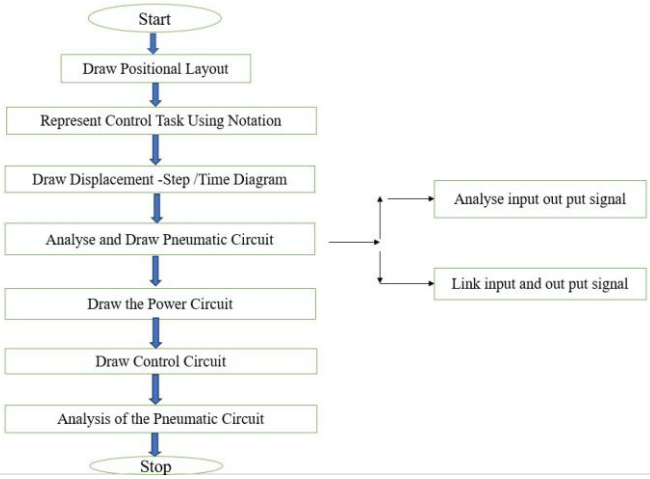

Fig 6: Flow Chart for Pneumatic Circuit Design

Step 1: Positional layout

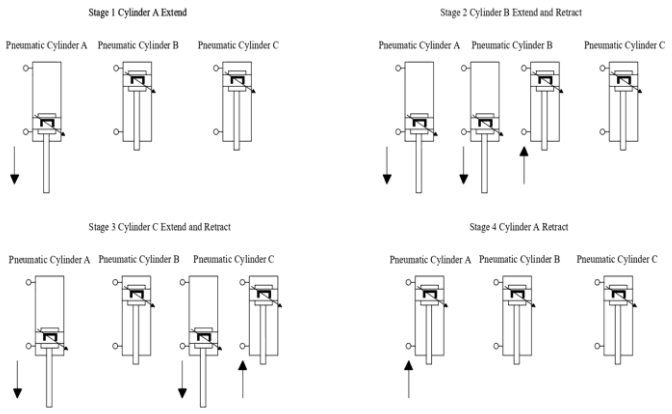

Fig7: Positional Layout

Step 2: Represent Control Task Using Notation

Cylinder A advancing is designated as A+

Cylinder A retracting is designated as A-

Cylinder B advancing is designated as B+

Cylinder B retracting is designated as B-

Cylinder C advancing is designated as C+

Cylinder C retracting is designated as C-

The sequencing of pneumatic cylinder is A+B+B-C+C-A-

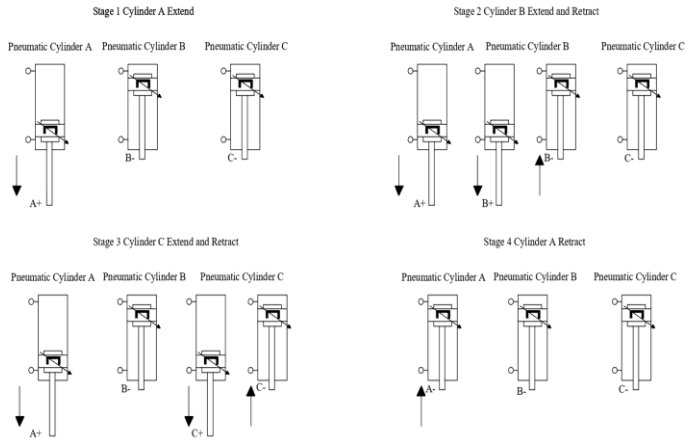

Fig 8: Positional Layout with Notation

Step 3: Displacement –Step Diagram

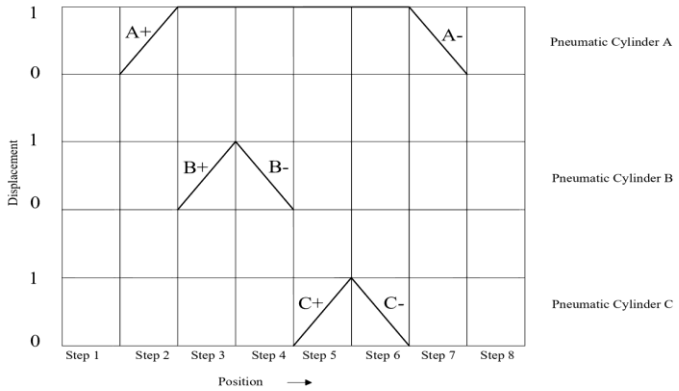

Fig 9: Displacement -Step Diagram

Step 4: Displacement –Time Diagram

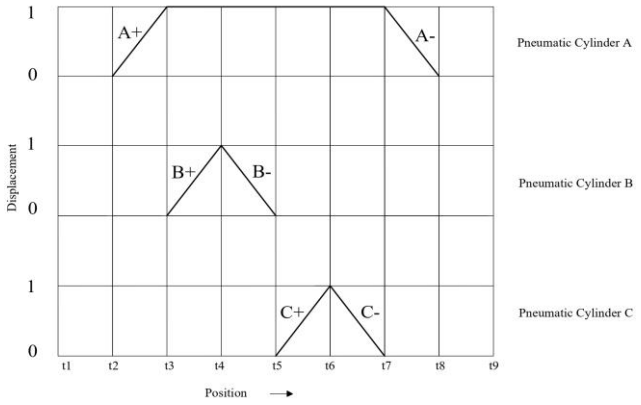

Fig 10: Displacement -Time Diagram

Step 5: Analyse and Draw the Pneumatic Circuit

Step 5.1 Analyse input and Output Signal

Input Signals

Cylinder A: Limit switch at home position a0

Limit switch at home position a1

Cylinder B: Limit switch at home position b0

Limit switch at home position b1

Cylinder C: Limit switch at home position c0

Limit switch at home position c1

Output Signal

Forward motion of cylinder A(A+)

Return motion of cylinder A(A-)

Forward motion of cylinder B(B+)

Return motion of cylinder B(B-)

Forward motion of cylinder B(C+)

Return motion of cylinder B(C-)

Step 5.2 Displacement Step diagram linked to input output signal

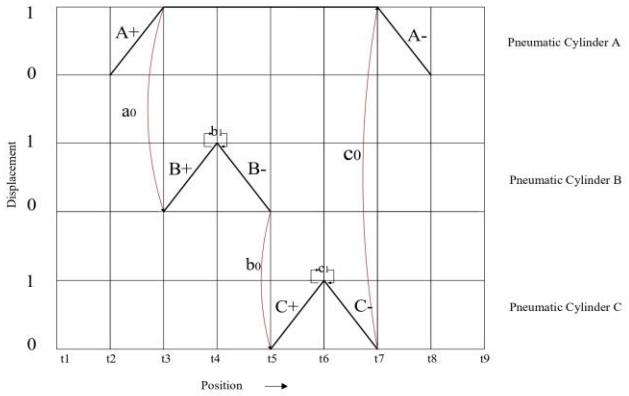

Fig 11: Displacement Step diagram linked to input output signal

A+ generate sensor signal a1, which is used for movement B+

B+ generate sensor signal b1, which is used for group changing

B- generate sensor signal b0, which is used for movement C+

C+ generate sensor signal c1, which is used for group changing

C- generate sensor signal c0, which is used for movement A-

Step 6: Pneumatic Cascade Circuit A+B+B-C+C-A-

No of groups =3

Group 1: A+B+

Group 2: B-C+

Group 3: C-A-

No of pressure line=No of group =3

Selection of valve

No of piolet operated 5/2 valve=No of cylinders =3

No of limit valve=No of cylinderx2=3x2=6

No of group changing valve = No of group -1=3-1=2

Components of Pneumatic Sequential System

Sl No	Components	Nos
1	3/2 Push Button Spring Valve	1
3	5/2 Double Piolet Valve	5
4	3/2 Roller Spring Valve	6
5	Pneumatic Double Acting Cylinder	3
6	Flow Control Valve	6

Table 1: Components of Pneumatic Sequential System

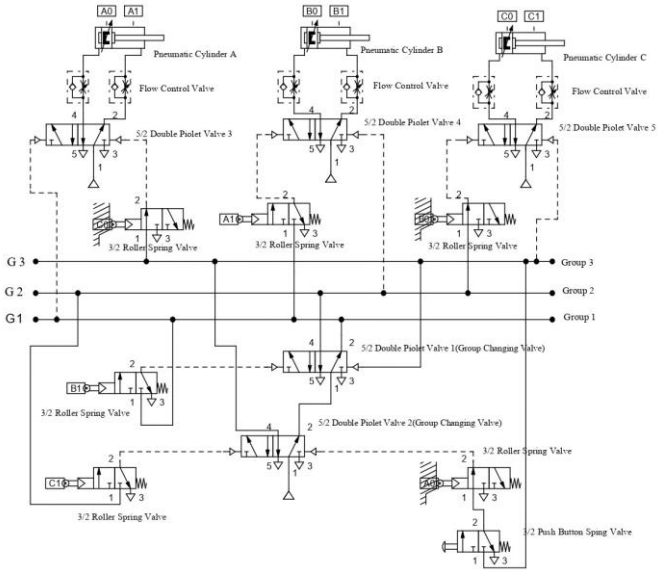

Fig 12: Pneumatic Circuit A+B+B-C+C-A-

First Cycle A+B+ Group 1 Selected

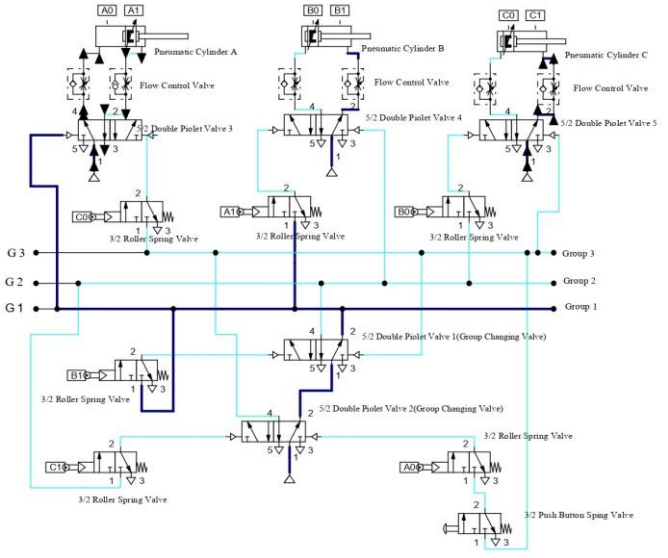

Fig 13: Pneumatic Circuit A+B+

Second Cycle B-C+ Group 2 Selected

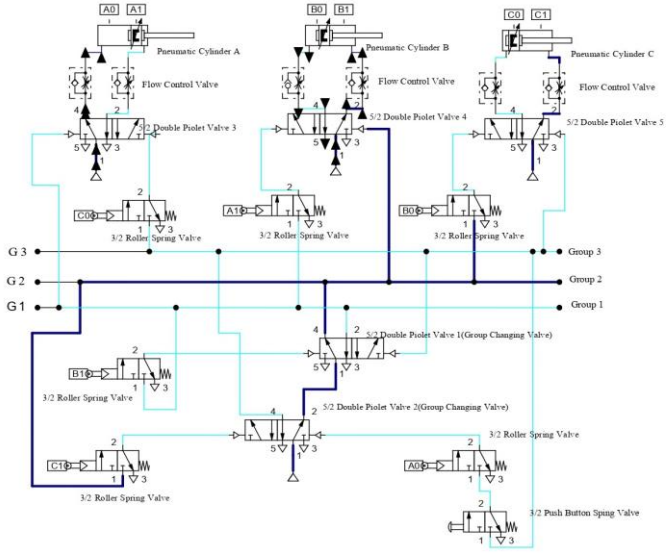

Fig 14: Pneumatic Circuit B-C+

Third Cycle C-A- Group 3 Selected

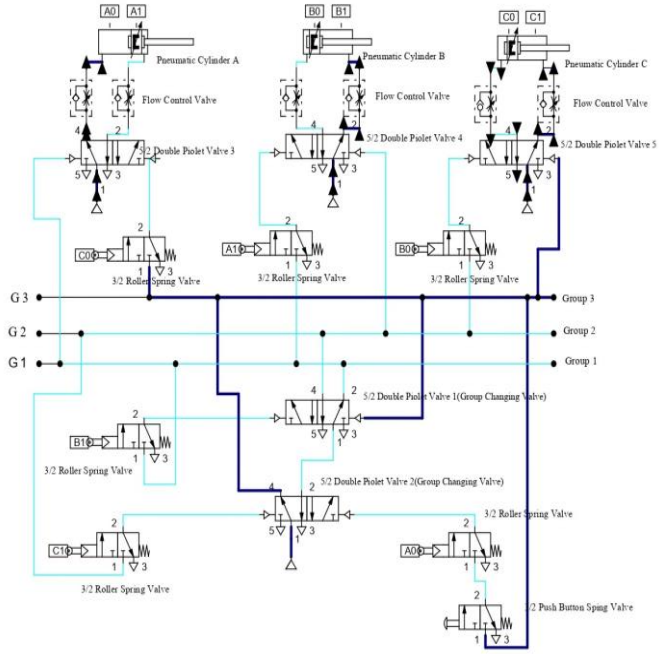

Fig 15: Pneumatic Circuit C-A-

Group Changing Valve

For grouping changing cascade valve 5/2 double piolet valve using

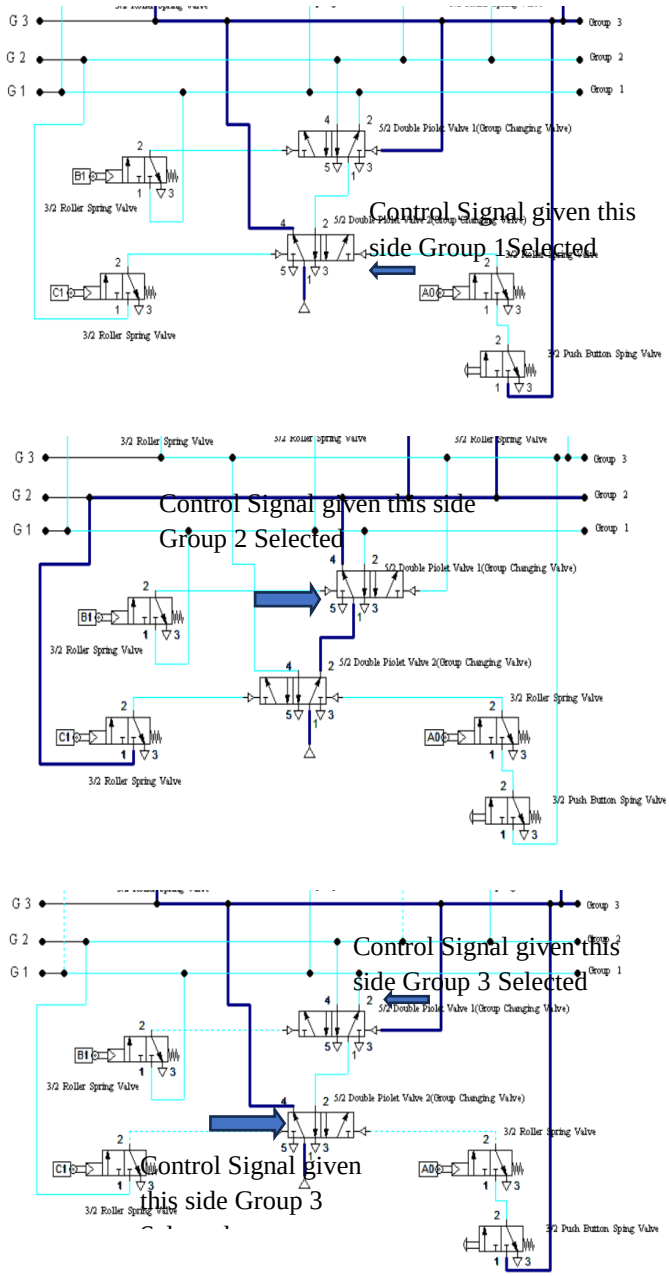

Fig 16: Group Changing Valve

Power Circuit –Pneumatic Cylinder

5/2 Double Piolet valve used for actuating double acting cylinder. Flow control valve used to control flow of compressed air in to cylinder.

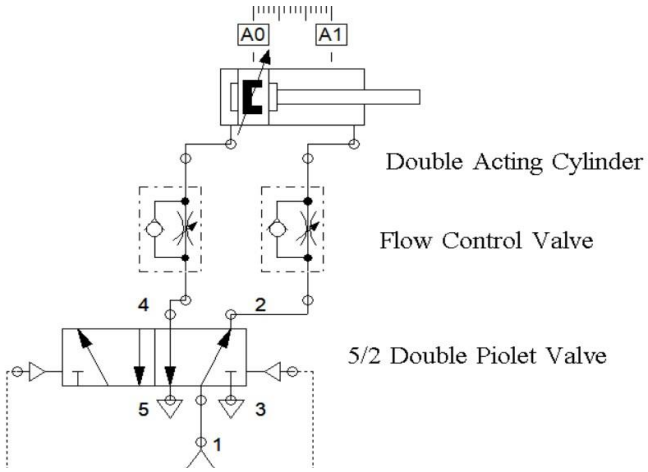

Fig 17: Power circuit 5/2 Double Piolet operated DCV

Development of A+B+B-C+C-A- Circuit

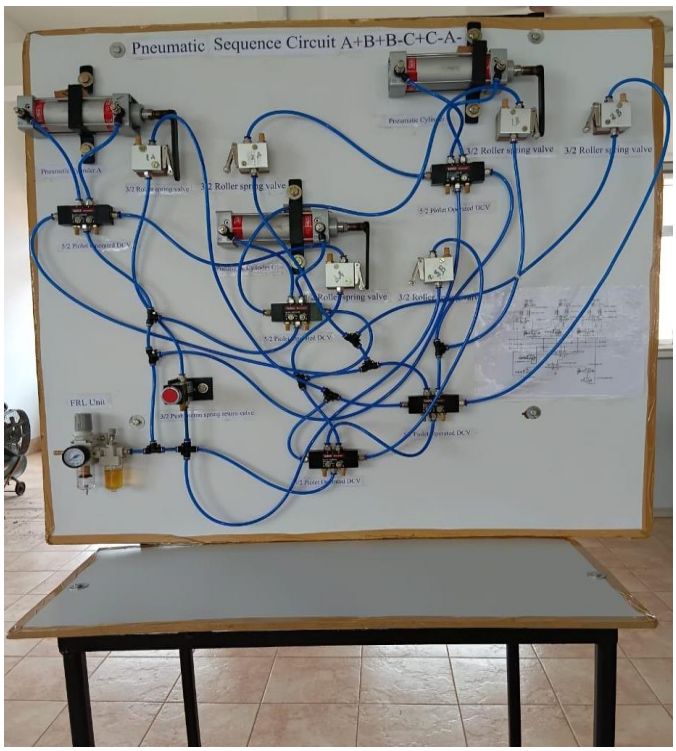

Fig 18: Assembly of Model

Cost Analysis

Sl No	Item	Unit/Cost	Total No	Cost/RS
1	Pneumatic Cylinder	1020	3	3060
2	5/2 Double Piolet Valve	520	5	2600
3	3/2 Push Button Valve	450	1	450
4	3/2 Roller Spring Valve	430	6	2580
5	Flow Control Valve	66	6	396
6	FRL Unit	1060	1	1060
7	Pneumatic Air Compressor Tubing	220per 5meter	15m	1100
8	Brass Connector	114	1	114
9	6mm 3way T Quick Joint	35	10	350
10	4 Ways Push in Air Pneumatic Fitting Connector	589	1	589
11	1/8 Inch Silencer	15	10	150
12	1/4 Inch Silencer	28	6	168
13	Qick Connector 1/4inchx6mm	13	22	286
14	Qick Connector 1/8inchx6mm	13	12	156
15	Miscellaneous Expense			1000
Total Cost				14059

Table 2: Components Cost

5. FUTURE WORK

Future work is developing an electro-pneumatic circuit for pneumatic sequential circuit A+B+B-C+C-A-Simulation of electrical ladder diagram easily converted in to a PLC programming ladder diagram for above sequential motion and simulated using Fluid Sim -Pneumatic software.

6.CONCLUSIONS

In multicylinder applications A+B+B-C+C-A- has wide applications. Sheet metal operation in a press shop, Metal strip is bend using a bending machine operation like clamping bending and forming will take place sequentially.

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