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Automation of Drilling Process Using Electro-Pneumatics System

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Abstract: ***Automation is the need of the hour which improves production, reduces time for manufacturing them and helps to manufacture economically on a mass scale. Drilling is one of the important manufacturing processes which need to be automated. In conventional drilling process which is the most common way to originating a hole in metal or other materials, for precise hole location, good finish and accurate size. The electro pneumatic circuit helps in converting the conventional drilling to an automated one. The fluid power (air) which is present abundant in nature is compressed using screw type compressor which helps in developing the pressure to required level. The following studies are carried out 1. Time saved by component handling (loading and unloading) using pneumatic clamp, 2. Increase of productivity quantitative and qualitatively, 3. Improved repeatability and accuracy, 4. Less human intervention, indirectly reduction in operator fatigue, 5. Less rejection due to automatic controls, and 6. Minimization of production cost.***

Keywords: Automation, Drilling process, Electro-pneumatic, Productivity, Electromagnetic Relays.

1. Introduction

It develops a circuit, using electro pneumatic components, which enables converting sensitive type drilling machine to an automated one. Drilling which had its origin in antiquity, is still the most common way of originating a hole in metal or other materials. Thus to automate the drilling process we use electro pneumatic circuit and components. Pneumatics system forms the most primitive and distinct class of mechanical control engineering. They are classified under the terms fluid power control, which describes any process or device that can converts, transmits, distributes or control power through use of pressurized gas or liquid. In a pneumatic system the working fluid is gas which is compressed above atmospheric pressure to impact pressure energy to the molecules. This stored pressure potential is converted to a suitable mechanical work in a appropriate control sequence using control valves and actuators. The blank is initially stacked in the hopper, cylinder1 loads the blank on the plate, cylinder2 clamps the blank in its position and remain in extended position, cylinder3 helps in drilling operation which drills the blank and retracts to its original position, after the drilling process is completed the cylinder2 gets retracted and unclamps the blank, later cylinder1 loads as well as unloads the blank from its current position and sequence of operation continues.

2. Setup Details

A real time multi stationed AUTOMATIC TRANSFER LINE working set up has been fabricated. Drilling and inspecting on a standard block of size 50 X 50 X 75mm are performed using above set up. The drill size diameter 5 x 20 mm deep and countersunk is performed

2.1 First Station

Work is loaded in the hopper and ejected by cylinder 1 to the work holder where it is located.

2.2 Second Station

Inspection of overall size of the rectangular block fitted with micro switches. If inspection doesn't confirm to standard the job is rejected using cylinder 1.

2.3 Third Station

Clamping of the component in the work holder by cylinder 2, and drilling by cylinder 3. Feed and retract of the drill is through rack and pinion connected to the piston of the cylinder.

2.4 Fourth Station

Inspection of the drill hole depth, using micro switches is done. If inspection doesn't confirm to drawing standard the component is rejected.

2.5 Fifth Station

Work piece clamping by cylinder 2 the drilled hole by cylinder 3. Feed and retract of the machine is through rack and pinion connected to the piston of the cylinder.

3. Specifications of Machine

3.1 Mechanical

Drilling capacity	12mm
Stroke length	100mm
Spindle speeds	300,700,1000rpm
Tapping capacity	3 to 10mm
Clamping capacity	100mm

3.2 Pneumatic

Cylinder	**Single/Double acting**
DCV	6.35mm
FCV	6.35mm
FRL	12.7mm

4. Working

The blank is initially stacked in the hopper where the presence is detected by the proximity sensor. The operation starts with the feeding of blank from the hopper to the indexing table and being placed at the fixture by the actuation of cylinder 1. Now the indexing occurs and motor is stopped as soon as the limit switch is actuated at 72°. The length and breadth of the blank is verified using a micro switch setup fixed to the end of cylinder 2. The controller actuates the rejection cylinder depending on the signal from the micro switch. The blank is again indexed to the next station where the drilling operation is to be performed. First the clamping cylinder clamps the work piece to the fixture. The drilling motor is now turned on and the drill feed is given using a rack and pinion arrangement attached to the cylinder. Now the cylinder is retracted. In the next station the drill depth is verified by using a set of micro switches attached to the cylinder. The piece is accepted or rejected depending on the signal from the micro switches.

Tapping is the operation that is to be performed at the next station. It is same as the drilling station. First the piece is clamped. Then the motor is turned on and tapping feed is given at a very slow speed. A horizontal bar provided between the last and the first station does the unloading of the finished part. The bar slides the work piece out of the fixture.

4.1 Methodology

The blank is initially stacked in the hopper cylinder 1 loads the blank on the plate cylinder2 clamps the blank in its position and remain in extended position cylinder3 helps in drilling operation which drills the blank and retracts to its original position after the drilling process is completed the cylinder2 gets retracted and unclamps the blank later cylinder1 loads as well as unloads the blank from its current position and the sequence of operation continues.

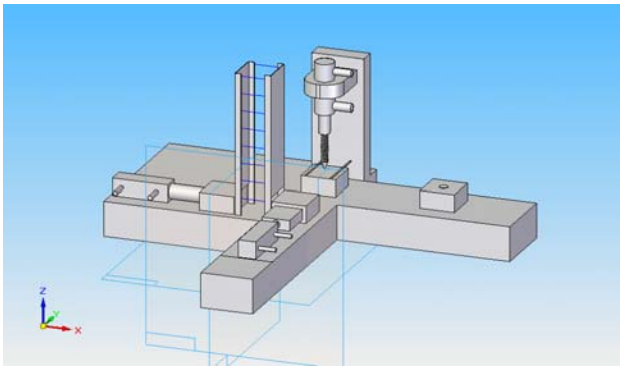
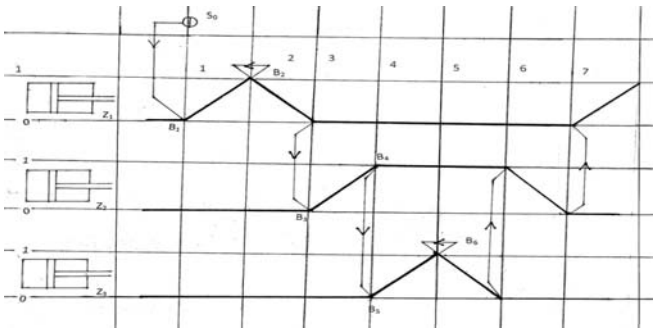
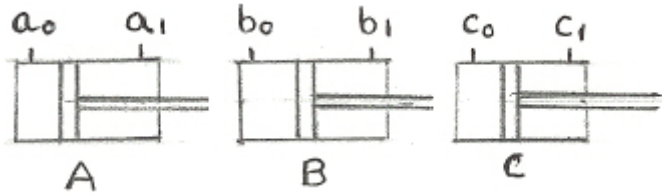


Figure 1: Prototype arrangement

Functional Diagram:



Sequence of Operation:



Loading & Clamping Drilling
Unloading
$Z_1 Z_2 Z_3$

Output Signals:
Cylinder A advancing A +
Cylinder A retracting A –
Cylinder B advancing B +
Cylinder B retracting B –
Cylinder C advancing C +
Cylinder C retracting C –

Sequential motion of cylinders:
It is possible to have the following sequence of operation with three cylinders
A + B C → Loading & Unloading idle idle
A - B + C → Retracting Clamping idle
A B C + → idle idle drilling
A B C – → idle idle Retracting
A B- C → idle unclamp idle

5. Controller

The controller used here is a Microcontroller, which has a reprogrammable flash memory. The Microcontroller is provided with built-in ROM which avoids any external memory interface. It has four 8-bit ports. These ports can be programmed both as input or output ports as per the requirement. In this machine, ports are programmed as two 8-bit input ports and two 8-bit output ports. The inputs include the signals from limit switches, reed switches, micro-switches and proximity sensors. The output signal controls the solenoids and motors through relays and driver circuits. The controller is programmed using assembly language to perform the operations depending on the signals from the switches and sensors. The programming is done in a PC and burned into the ROM using a programmer circuit.

6. Electronic Circuit

The micro-controller constitutes the brain of the circuit. It generates the required signals for controlling. External

circuits are required to drive the relay depending on the signal. The devices used are opto-isolator, relay driver and relays. Opto-isolator isolates the control circuit from the relay circuit. Control circuit is a low power circuit, whereas the relay circuit is a comparatively high power circuit. Any direct connection between these circuits will destroy the control circuit. The maximum current the opto-isolator can drain is not enough to drive the relay. So an additional relay driver is required. This relay driver can drain the current required to drive the relay. The relays used are 12v DC relays of electro-mechanical type. 5A relays are used for lower loads like solenoids and 20A relays for higher loads like that of motor.

7. Electrical Circuit

The connections of relays, power supplies and devices like motors and solenoids form the electrical circuit. The circuit includes protection circuits, safety features and provisions for manual controls. Protection circuits includes devices like fuses, circuit breakers, overload protection, overvoltage protection circuits etc., Safety features includes emergency stop button, fault indicators, alarms etc. Provision is also given for manual control of the machine. In case of any malfunctions in the automatic control process, manual control can be adopted. Manual control is also used for maintenance purpose.

8. Pneumatic Circuit

The pneumatic circuit comprises of single acting and double acting cylinders, DC valves single solenoid with spring return, Flow control valves, pressure relief valve, FRL unit and compressors. Double acting cylinders are used for feeding drill bit and tap, where the load is to be handled in the forward and return strokes. Elsewhere single acting cylinders are used.5/2 valves are used for controlling double acting cylinders and 3/2 valves are used for single acting cylinders. Flow control valves4 are used to control the speed of actuation of cylinders responsible for feeding drill bit and tap. Other accessories like pressure relief valves, FRL unit are used for specific purposes.

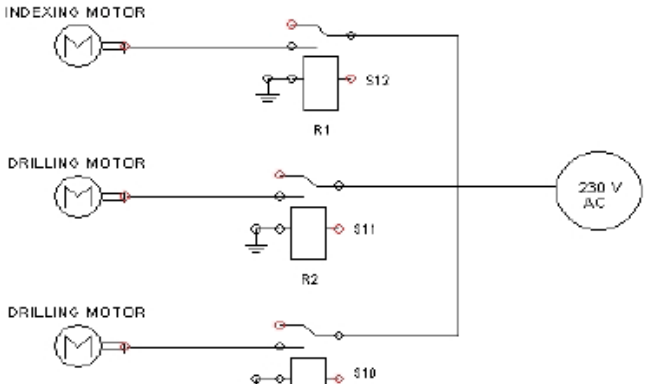


Figure 2: Motor Circuit

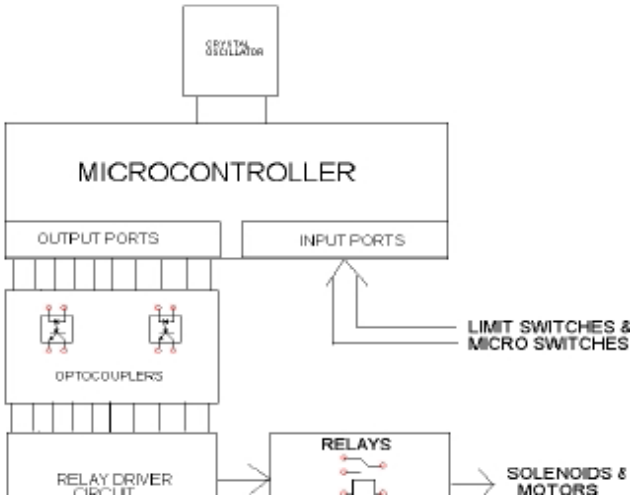
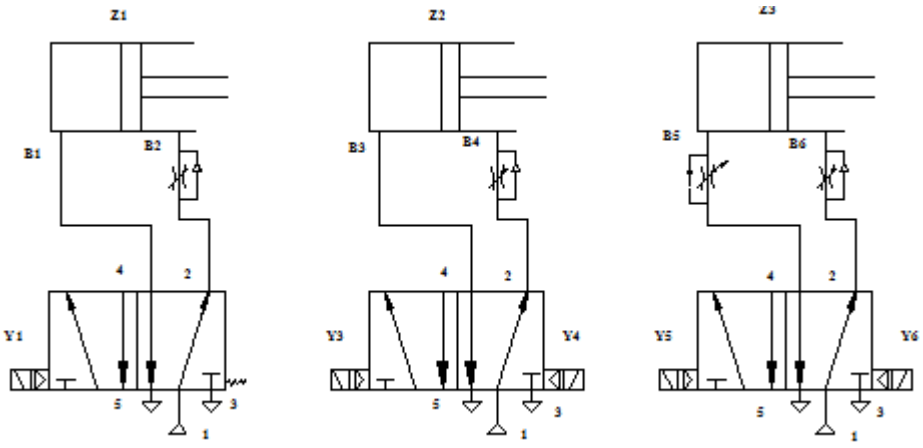
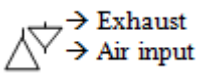


Figure 3: Micro Controller Interface



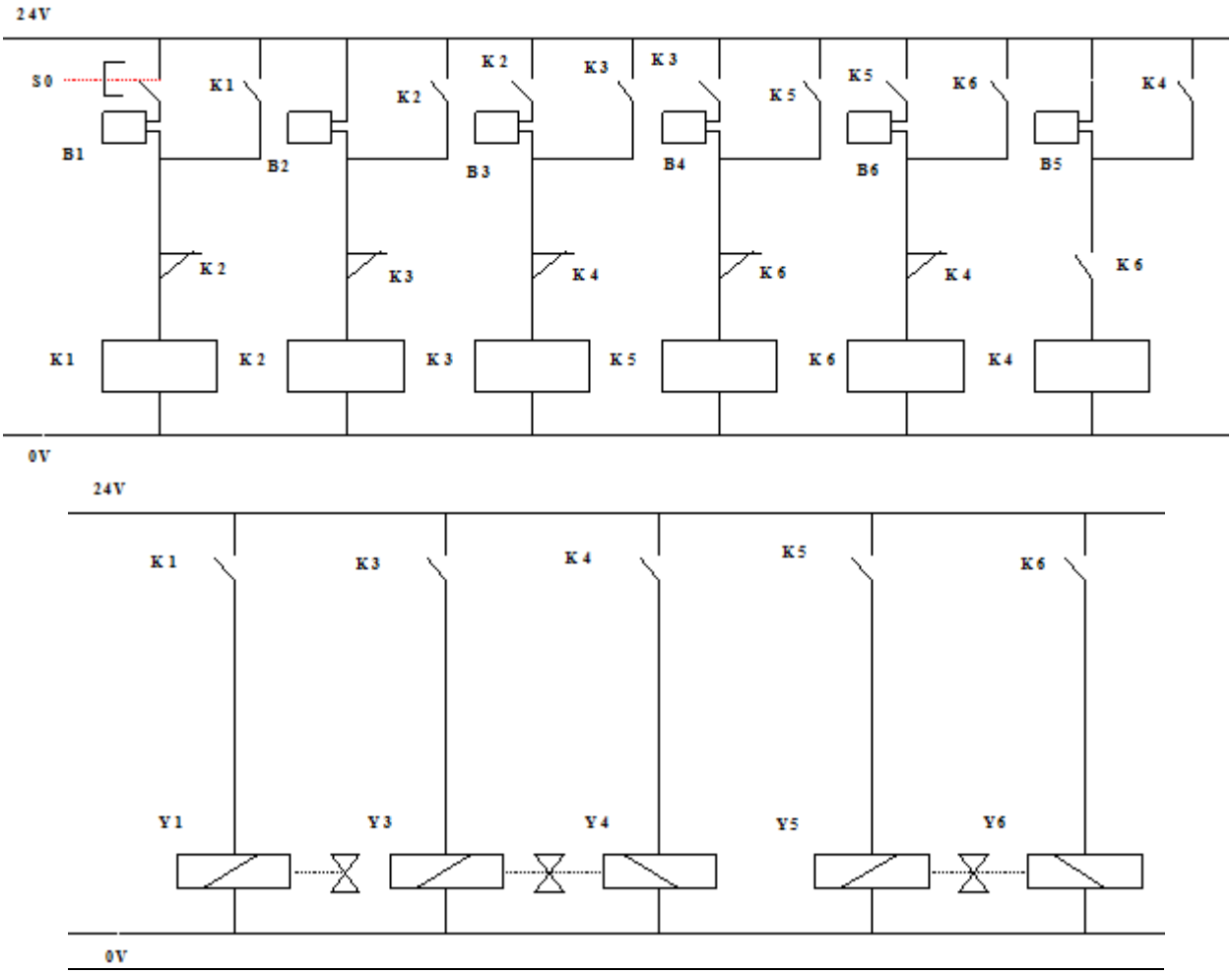
Z_1 – Cylinder-1 of fork type , Z_2-Cylinder-2, Z_3 – Cylinder-3
Valve 1- solenoid spring return operated 5/2 DCV
Valve 2, 3 – double solenoid pilot operated 5/2 DCV



- The 3 double acting cylinders are controlled with 5/2 directional control directional values.
- The valves are equipped with visual display and manual override in case of double solenoid valve.
- Valve-1,2 &3 has the solenoid coils designated as Y_1,Y3,Y4,Y5,Y6

- The extension and retraction of the cylinder 2 & 3 are controlled by one way flow control valves.

9. Electro Pneumatic Circuit



Description of electro pneumatic circuit:

1. S0 – push button.
2. B1-B6 – sensor
3. K1-K6 – relay switches
4. Y1- Y6 – solenoid representation

10. Applications

Productivity improvement both qualitative and quantitative 2: Productivity increases by decreasing the lead time of the component, increasing the production rate, reducing WIP. Manufacturing lead time2
MLT = Ns (Tt + longest to)
Where, Ns = number of stations,
To = operating time.
MLT = 5 (15 + 10) r
= 125 sec = 2 minutes and 5 sec.

1. Improved repeatability and accuracy: Half degree accuracy is achieved in indexing the table through the limit switches beneath the fixed table. Repeatability of 0.95 is achieved for indexing operation and the central axis of the job in drilling and tapping operation.
2. Less human intervention: Drastic reduction in the work load is attained through the automation process which directly helps in less operator fatigue. This reduces the labour cost.
3. Less rejection due to automatic controls: Because of high accuracy and repeatability achieved due to automatic control system, rejection of components is reduced.
4. Minimization of production costs: Increased production rate, reduced production costs, reduced labour costs, reduced WIP, minimizes the production costs.

11. Conclusion

The concept of automated part transfer line fabricated as an experimental setup can be extended to an industrial application with further modification in the manufacturing and assembly process to achieve quality in the machine as per the test charts provided by leading machine tool manufacturer. On a whole, it is concluded that the automation is an inevitable process though the rate at which

it should be introduced will have to be carefully planned in order to bring social justice and to accrue economic benefits.

12. Outcome and Scope of Present Work

By developing goals and measurable objectives for automation one can determine the project contribution to the business to improve the operating environment. Nowadays everyone is concerned about the automation in various fields of engineering. The scope of this work is wide because, if any one understands the concept of automation and the methods which are to be adapted one can easily convert conventional machine to automatic unit. It benefits one to include reduced cycle time, costs and improved product quality. The advantages obtained from this work are lighter quality control, higher efficiency, increased productivity, minimum product cost, reduced manpower, and lesser scrap. The outcome of this work is to get enough knowledge of the pneumatic devices, pneumatic systems, automation and the analysis by which one can be able to select a proper machine according to ones need.

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Author Profile

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