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Automation of a Planer Using Electropneumatic Devices and Programmable Logic Controller

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Abstract:- This paper discusses the case study and comparison of productivity of a Conventional Planer with automated planer, there is an attempt to develop a electro-pneumatic circuit for a planing operation using a planer, which makes the operation semiautomatic producing a plane and flat surface. The movements of a planer namely, reciprocating motion of the table, the crosswise movement of the tool head across the cross-rail and the clamping of the component on the table are being automated using pneumatic components namely, pneumatic cylinders, pneumatic DCV'S, FCV'S and electrical and electronic devices. The electro-pneumatic circuit developed, simulated and executed is interfaced with PLC.

Keywords:- Automation, Productivity, Electro-pneumatic, Relays, Cylinder Switches (Read Switches or magnetic Switches), PLC's.

I. INTRODUCTION

The planer is a machine tool primarily intended to produce plane and flat surface by a single point cutting tool. Automation is a higher degree mechanization in which human participation is replaced by mechanical, electrical and fluid power technologies capable of doing physical and even mental work. In this paper, an effort is made to automate a conventional planer by using electro-pneumatic devices and later on interfacing with PLC.

The technology of degree of automation is decided upon the principles of minimization of cost, improved productivity, both qualitative and quantitative, improved accuracy, better safety, minimum scrap, which is also posed with higher initial investment, higher maintenance cost.

II. DESIGN AND DEVELOPMENT OF ELECTROPNEUMATIC SYSTEM

A. *Functional Diagram*

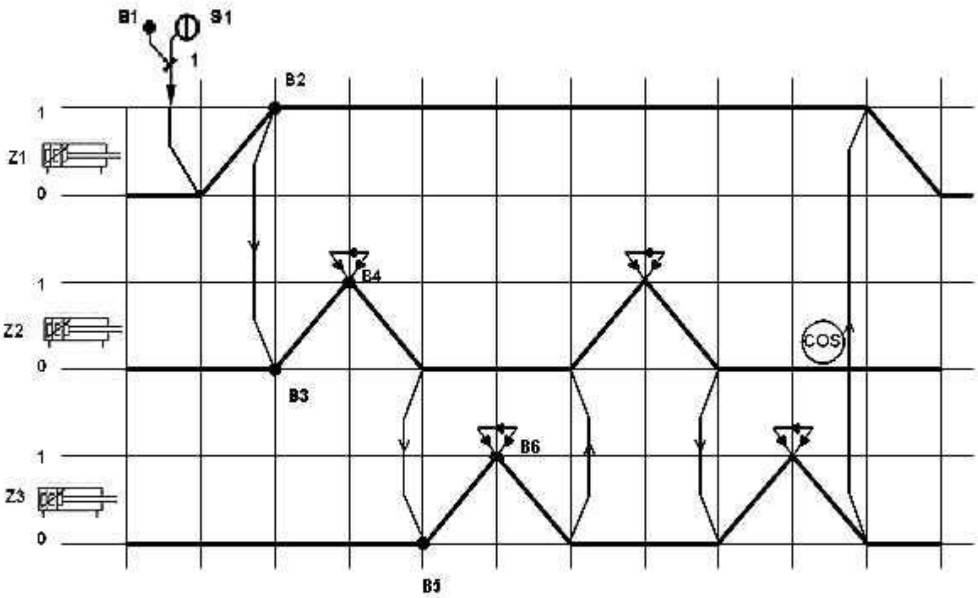


Fig. 8.1: Functional Diagram

In majority of the pneumatic applications more than one cylinder is used. The movement of these cylinders is coordinated as per the required sequence. The functional or motion diagram is that, in which graphically the sequence of operation of each cylinder is shown and it also shows the actuation of each cylinder by the cylinder switches.

In the functional diagram, all the three cylinders are shown according to the sequence of operation. One cylinder has two position i.e. 0 and 1 position.
'0' - indicates that the piston of cylinder is at backward position.
'1' - indicates that the piston of the cylinder is at extreme forward position.

Description of the functional diagram of a planer:

To start with, the push button switch S_1 is pressed, cylinder switch 'B_1' is already in actuation mode it sends signal to solenoid Y_1 by which the piston of the cylinder '1' moves forward, which clamps the component. As, soon as the piston reaches to cylinder switch B_2, it sends signal to solenoid Y_3 by which the 2^{nd} cylinder piston moves forward, resulting in cutting operation. As the piston of the cylinder2 reaches to its extreme forward position i,e, cylinder switch 'B_4' a loop is formed and the piston of the cylinder 2 retracts as the solenoid Y_3 de-energies.

As soon as the piston of the cylinder 2 reaches the backward position it activates cylinder switch B_3, which sends the signal to solenoid coil 'Y_4', the piston of cylinder '3' moves forward making a cross feed of the tool head. When, the piston of the cylinder 3 reaches the cylinder switch 'B_6' a loop is formed in which it interrupts the voltage supply to the solenoid coil 'Y_4'. Thus the piston of the cylinder '3' retracts.

The movement of cylinder '2' and cylinder '3' in sequence continues till the change over switch is operated. When the change over switch is operated, the voltage supply to the valve solenoid Y_1 is interrupted, but the voltage is supplied to valve, solenoid 'Y_2' by which the piston of the cylinder '1' retracts, unclamping the components.

Thus the whole circuit is reset and the machine stops.

B. Pneumatic Circuit Diagram

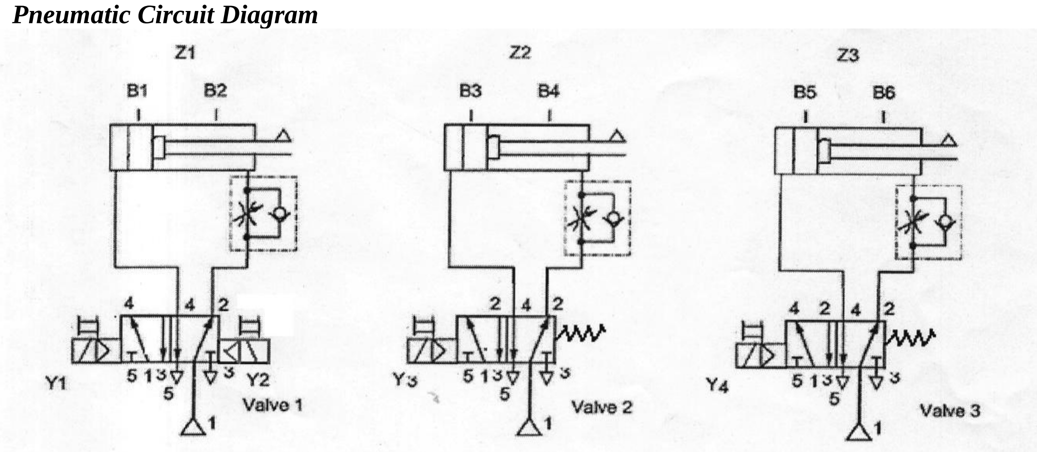


Fig. : Pneumatic Circuit diagram of 3 cylinders

Pneumatic Circuit diagram

- The 3 double acting cylinders are controlled with 5/2 DCV.
- The valves are equipped with visual display and manual override.
- Valve 1, has solenoid coils designated as Y_1 and Y_2, valve 2 has solenoid coils designated Y_3 and valve 3 has solenoid coils designated as Y_4.
- When signal voltage is applied to the solenoid coils, Y_1, Y_3 and Y_4, the cylinders extend and when the voltage is interrupted to the solenoid Y_3 & Y_4, cylinders 2 and cylinders 3 retracts and when the change over switch is operated, the solenoid coil Y_2 is actuated, the solenoid coil Y_1 de-energies or collapses due to the interruption of voltage in line no. 1. The cylinder 1 retracts.
- The extension speed of all the 3 cylinders can be infinitely adjusted with one-way flow control valve.

C. Electrical Circuit Diagram

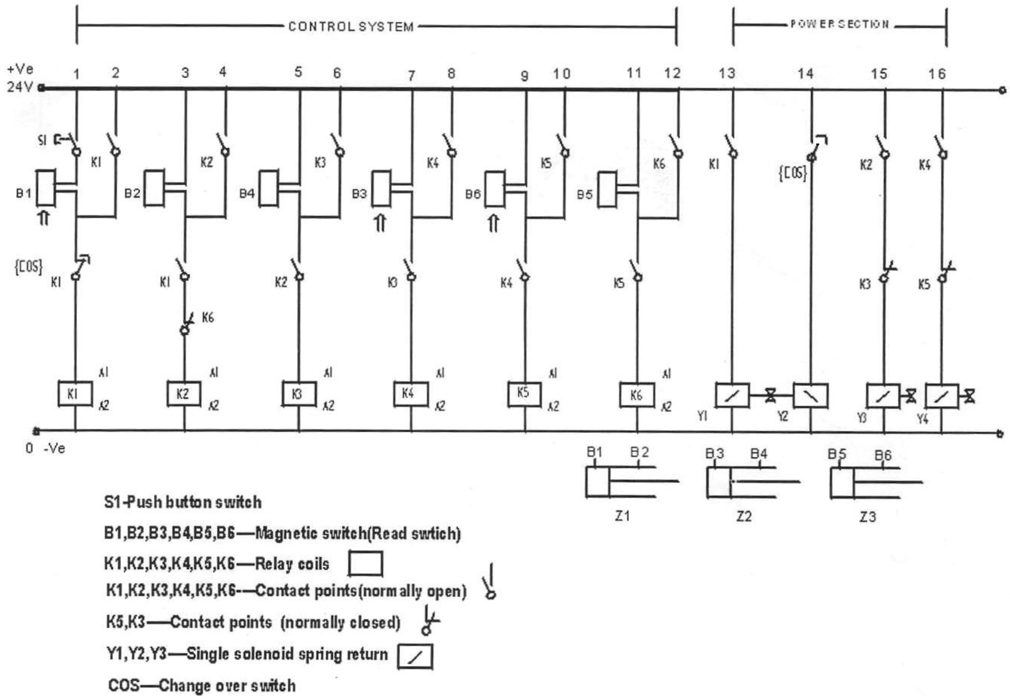


Fig. : Electrical Circuit diagram

Power Section:

In the power section, the contact points switches the valve solenoids corresponding to the step sequence. When using single solenoid spring return valves there is no need of continuous signals, when voltage is present at one side, the valve is operated and when there is no voltage the valve comes to its initial position by means of spring force.

When using double solenoid, there is no need of continuous signals at one side. The valve is operated when there is voltage on one side of the solenoid, and when voltage is present on one side of the solenoid, there should be voltage interruption to the other solenoid. These valves are called as memory valves or impulse valves, because they retain their position even though there is no supply of voltage or current.

Step 1: Contact K_1 in current path 13, switches Y_1 solenoid and in current path 14 change over switch, switches off Y_2 solenoid. Cylinder1 extends and activate the cylinder switch $B_{2.}$

Step 2: Contact K_2 in current path 15 switches the valve solenoid Y_3 via the unopened normally closed contact K_3, cylinder – 2 extends and actuates the cylinder switch B_4.

Step 3: Contact K_3 in current path 15 normally closed contact, now changes to normally open and cut the current path in line no. 15. Thus the solenoid valve Y_2 collapse, the valve regain its original position, by which the cylinder 2 piston retracts actuating the cylinder switch B_3.

Step 4: Contact K_4 in current path 16, switches the valve solenoid Y_4 via the unopened normally closed contact K_5, then the cylinder 3 extends and actuates the cylinder switch B_6.

Step 5: Contact K_5 in current path 16, switches off Y_4, as K_5 is normally closed, now changes to normally open, which interrupts the voltage to Y_4 and the cylinder 3 retracts. Thus actuating the cylinder switch B_5.

Step 6: Contact K_6 in current path 3, interrupt the current supply in line 3, to relay coil K_2 where all other lines are reset. The step sequence continues in cylinder 2 and cylinder 3.

Step 7: To stop the machining cycle completely, the change over switch provided in line no 1 when operated will reset the whole circuit.

TASK:
Conversion of a conventional planer into a automated machine.

Step 1: The component to be machined is placed on the table and when the push button switch is operated, the first cylinder will clamp the components. After clamping operation the signal is sent to the Y_3 solenoid by which the 2nd cylinder actuates so that the table of the planer reciprocates and does the cutting operation.

Step 2: After taking one cut, the cylinder 2 sends the signal to the Y_4 solenoid by which the 3rd cylinder actuates, so that cylinder 3 extends, inturn rotates a screw by a ratchet and pawl mechanism by which the crosswise movement of the tool head is obtained (feed).

Step 3: Once the feed is given, the cylinder 3 sends the signal to Y_3 so that the cylinder 2 operates, by which the table reciprocates to perform a cutting operation.

Step 4: Thus the cycle continues till machining of component is completed.

Step 5: Once the machining of the component is over, the change over switch is actuated by which the machine stops and the component is unclamped. The electrical circuit is reset.

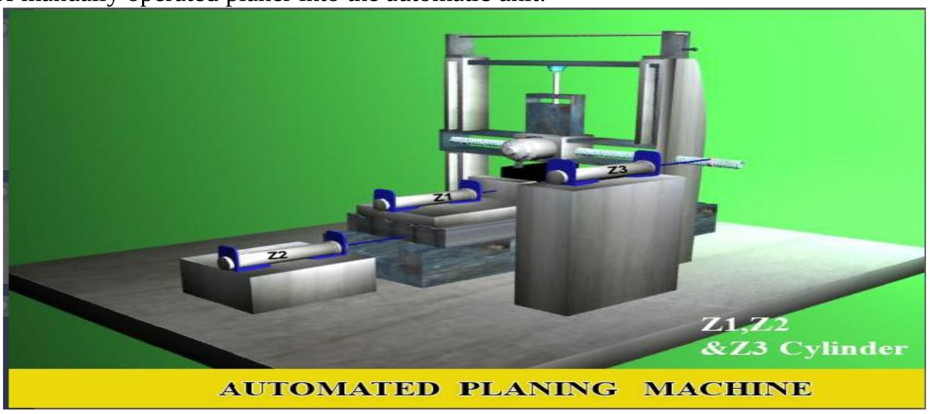
Step 6: The component is manually taken out of the table and the tool head is brought back to its original position by rotating the cross-wise screw.

Step 7: Electrically controlled 5/2 double solenoid and single solenoid spring returned direction control valves are used as actuators.

- Signals used are electrical cylinder switch (Magnetic field sensors or Reed switches)
- The extension speed of all the three cylinders are variably adjustable by flow control check valves.

D. Implementation

Conversion of manually operated planer into the automatic unit:



In case of conversion, we need three double acting cylinders, one cylinder for clamping the jobs, the 2nd one for reciprocating the table and the 3rd cylinder for operating the cross-slide screw.

Six proximity magnetic switches, two each for one cylinder, one change over switch, two single 5/2 solenoid spring return and one double 5/2 solenoid DCV's, three variable flow control valves, one pressure relief valve, compressor and the flexible pipes for necessary connections and 12V D.C power supply, relay system, push button switches, PLC and wires for connections are required.

D. Interfacing the planing operation with PLC

The PLC is an industrial computer. It is capable of storing instructions to implement control functions such as sequencing, timing, counting, arithmetic, data manipulation and communication. The I/O interfaces provide the connection between the PLC and the information providers (inputs like pushbuttons, sensors...) and the controllable devices (outputs like valves, relays, lamps...).

Advantages:

- Less wiring.
- Wiring between devices and relay contacts are done in the PLC program.

- Easier and faster to make changes.
- Trouble shooting aids make programming easier and reduce downtime.
- Reliable components make these likely to operate for years before failure.

Where is the PLC used?

The PLC controls industrial machines and processes. In different areas of the industry, PLC are being applied, e.g.: materials handling, packaging, palletizing, milling, boring, grinding, filling, sorting, weighing, mining, petrochemicals etc.

How does PLC work?

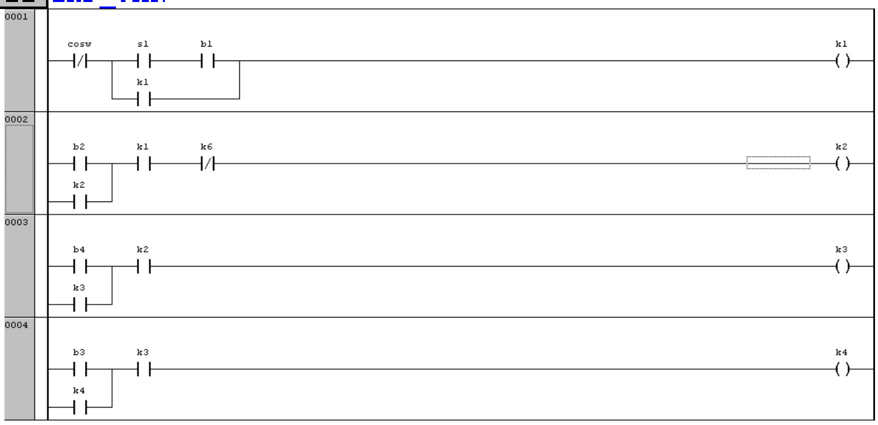
In the past the movements of industrial machines were controlled by relay circuits. These relay-controlled systems were replaced by PLC. The primary function of the PLC was to perform the sequential operations that were previously implemented with relays.

Ladder Diagram (LD)

Ladder diagrams are used to describe the logic of electrical control system. Ladder diagrams are specialized schematics commonly used to document industrial control logic system. They are called “ladder” diagrams because they resemble a ladder, with two vertical rails (supply power) and as many “rungs” (horizontal lines) as there are control circuits to represent.

PLC_PRG (PRG-LD)

```
VAR
    cosw AT %IX0.4: BOOL;
    s1 AT %IX0.5: BOOL;
    b1 AT %IX1.6: BOOL;
    k1: BOOL;
    b2 AT %IX1.7: BOOL;
    k6: BOOL;
    k2: BOOL;
    b4 AT %IX2.0: BOOL;
    k3: BOOL;
    k4: BOOL;
    b3 AT %IX2.1: BOOL;
    k5: BOOL;
    b6 AT %IX2.2: BOOL;
    b5 AT %IX2.3: BOOL;
    y1 AT %QX2.0: BOOL;
    y2 AT %QX2.1: BOOL;
    y3 AT %QX2.2: BOOL;
    y4 AT %QX2.3: BOOL;
END_VAR
```



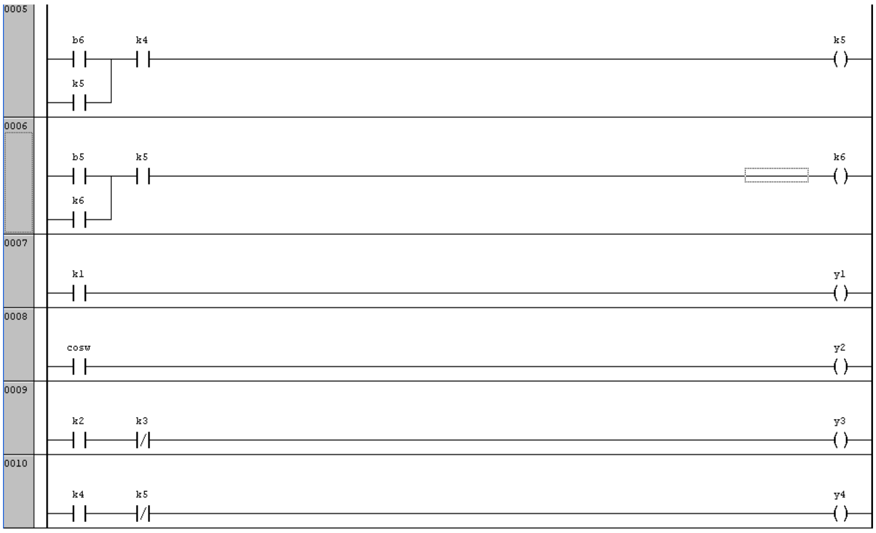


Fig : Ladder Diagram

OPERATIONAL ANALYSIS

Operational Analysis of Manual and Automated Planing Machine

Depending upon the size of the machine the cost varies. Let us consider a minimum size of the machine and do the analysis.

Production time

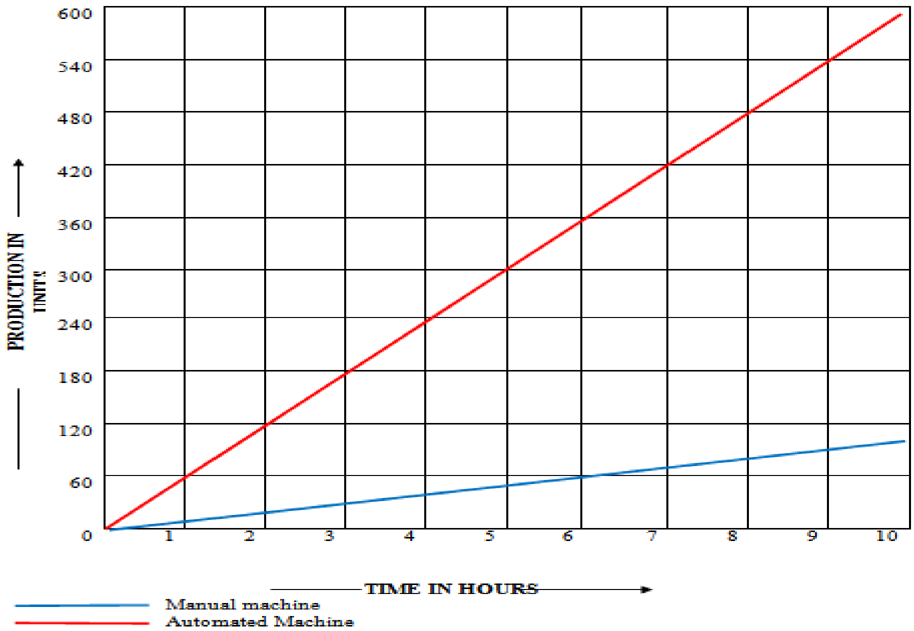
Lets us consider a square flat M.S plate with a 50x50 mm and thickness 5mm in which the top face has to be machined flat.

Manually operated planing machine:

The time needed to produce one flat plate is 6 minutes. Components produced in one hour are 10. Therefore in one day 100 components are machined (total machining time taken in a day is 10 hours).

Automated planer machine:

The time needed to produce one flat plate is one minute. Total number of components machined in one hour, 60 components. Therefore in one day 600 components are machined (total machining time taken in a day is 10 hours).



Graph shows **the productivity of two machines**

AUTOMATED MACHINE	MANUAL OPERATED MACHINE
1 HOUR-60 UNITS	1 HOUR-10 UNITS
10 HOURS-600 UNITS	10 HOURS-100 UNITS

As seen from the graph the rate of production is very high in case of the automated machine as compared with the manually operated machine. Hence the productivity is high on the automatic machines.

III LITERATURE SURVEY

Planers are now obsolescent, because other machine tools (such as milling, broaching and grinding machines) have eclipsed them as the tools of choice for doing such work [1].

The correct incentive for applying automation is to increase productivity, and/or quality beyond that possible with current human labor levels so as to realize economies of scale, and/or realize predictable quality levels. The automatic or semi-automatic controls can be electronic, electrical, electro-hydraulic, or mechanical [2].

The old imported machine tools can be thoroughly improved by the modern auto control method and renovation cost can be greatly saved by proper design programs. So it is worth to be promoted and publicized. Thus it all lead to the invention of computer controlled machine tools [3, 4].

By means of conducting many experiments it was found in Oklahoma State University that low cost automation is achieved by means of using pneumatic devices [5]. By using micro controllers along with pneumatic devices i.e. the use of electro-pneumatic devices, low cost automation is possible with all the advantages of the automation [6].

A low cost PLC system will provide accurate, timely information to the unit operators. By getting the information of the concerned motor displayed in the control room, the operators have been able to operate the motor closer to its limits and hence getting more yields [7]. With a simple proportional integral (PI) controller, much better cutting quality is achieved, with lower cycle time, lower wear, of the disc and machine [8].

Simulation enabled to track the performance of the sensory based control of operation system and carry out the required modifications in order to reduce sensors faults and machine malfunctioning[9].

The effectiveness of PLC based control software is satisfactory up to 96% of the synchronous speed. Thus, the PLC proved to be a versatile and efficient control tool in industrial electrical drives application [10]. The miniaturization of machine tool system for producing meso, micro parts gives many benefits for saving resources, energy and cost [11].

Flexibility, accuracy, elimination of manual skill and greater work potential result from the addition of digital data processing for machine tool control. It seems reasonable to expect that the benefit of digital information processing can be extended beyond the area now explored which covers only a portion of the over-all process of translating the need for a part into the finished product [12].

IV. CONCLUSION

The conventional machines are converted into automatic machine by which maximum operating time will be saved. Thus the output of the product will be increased. The human intervention is required only for loading and unloading of the components in semiautomatic machines. But this machine can be made fully automatic by using more number of cylinders by which the work piece is loaded automatically. By doing so the machine may run for longer time and loading and unloading can be made without stopping the machine. The number of workers is also reduced and by which more number of machines can be operated by a single operator.

This project is made keeping in mind that, any conventionally operated machines can be converted into automatic or semi automatics machines by using these devices. For this purpose one should have the full know-how of the devices which are being used. By doing so the existing old machines can be modified and made automatic and the initial cost, the procuring cost of automatic machines may be reduced. Thus there is a lot of scope in this area (automation).

The detailed study of various articles revealed that, this is an easy and low cost way of automating the conventional machine tool which is used for simple work. The prototype built will help in micro-manufacturing resulting in effective controlling and cost reduction. It can also be used as a laboratory set up for the mechanical engineering students.

In this project, it is shown or calculated, that the production rate is very high as compared with conventional machine. Hence, the productivity is high on the automatic machines.

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