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Shaper Automation Using Electro-Pneumatic Devices And Plcs

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Abstract:- Now a days as the industries are developing rapidly, man power reduces gradually in industries. In olden days almost all industries uses conventional machines for manufacturing processes. In conventional machining processes, the time consumption is very high, labour cost is high and which increases the manufacturing cost of the product. The accuracy is also not achieved as per the design requirements. To overcome all these difficulties, the industries are made automated through some devices such as electronic components, pneumatic device electrical equipments etc.

For producing economically better quality products with high productivity, accuracy and quality, the conventional machine tools are being replaced gradually by the automated machine tool devices. Automation of the machines are made with help of Pneumatic device, Sensors, Mechatronics, and PLCs etc.

Here the efforts are made to develop a electro pneumatic circuit for a shaping operations using a shaper machine. This makes the operations semi automatic producing shaping operations by a single point cutting tool. The three movements of the shaper are

a) The reciprocating movement of the ram.
b) The Crosswise movement of the tool lead across the cross rail.
c) The vertical up and down movement of the table.

The above movements are being automated using electropneumatic components such as pneumatic cylinders, direction control valves, flow control valves and other electrical and electronics devices.

For automation of the shaper, an electropneumatic circuit is developed with the help of sensors, solenoids, electrical and electronic devices. The electro pneumatic circuit developed is simulated, executed and will be interfaced with PLCs, L10/L20 manufactured by BOSCH – REXROTH Germany. A prototype of the set up is also planned for better understanding and demonstration purpose.

Keywords:- Automation, Electropneumatic Devices, cutting tool, automated DCVs, Electrical and Electronic Devices

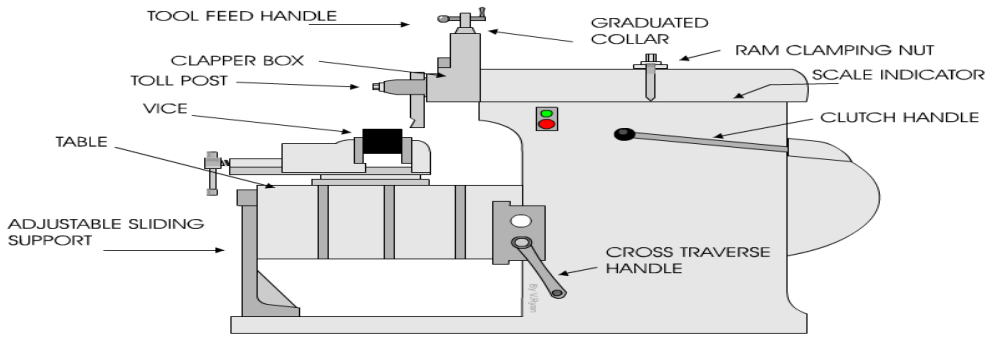
I. INTRODUCTION

The shaper is a reciprocating type of machine tool intended primarily to produce flat surfaces. The metal working shaper was developed in the year 1836 by James Nasmyth an Englishman.

The Shaper machine tool holds and locates a work piece on a table and machines or cuts the work piece by feeding it against a reciprocating single point cutting tool. When the horizontal surface is being machined the table automatically feeds the work to the cutting tool on each return stroke of the ram. The surfaces cut by the shaper may be horizontal, vertical or inclined.

Principal Parts of a Shaper:

The following figure illustrates the different parts of a standard shaper.



[Fig-1]

1. Base: The Base is the necessary bed or support required for all machine tools. The base may be rigidly bolted to the floor of the shop or on the bench according to the size of the machine.
2. Column: The column is a box like casting mounted upon the base. It encloses the ram driving mechanism. Two accurately machined guide ways are provided on the top of the column on which the ram reciprocate.
3. Cross rail: The cross rail is mounted on the front vertical guide ways of the column. The table may be raised or lowered to accommodate different sizes of jobs by rotating an elevated screw which cases the cross rail to slid up and down on the vertical face of the column.
4. Saddle: The Saddle is mounted on the cross rail which holds the table firmly on its top.
5. Table: The table which is bolted to the saddle receives cross wise and vertical movements from the saddle and cross rail.
6. Ram: The ram is the reciprocating member of the shaper. Its slides on the accurately machined dovetail guide ways on the top of the column and are connected to the reciprocating mechanism contained within the column.
7. Tool head: The Tool head of a shaper holds the tool rigidly, provides vertical and angular feed movement the tool and allows the tool to have an automatic relief during its return stroke.

Shaper Mechanism:

In a shaper, rotary movement of the drive is converted in to reciprocating movement by the mechanism contained within the column of the machine. The ram holding the tool gets the reciprocating movement. In a slandered shaper metal is removed in the forwarded cutting stroke, while the return stroke goes idle and no metal is removed during this period. The different types of the mechanisms are

1. Crank and slotted link mechanism.
2. Whit worth quick return mechanism.
3. Hydraulic shaper mechanism.

II. GENERAL CONCEPTS ON DESIGN AND DEVELOPMENT OF PNEUMATIC SYSTEMS

Development of Pneumatic System

The solution to a control problem is worked out according to a system with documentation playing an important role in communicating the final result. The circuit diagrams are drawn using standard symbols and labeling. Comprehensive documentation is required including most of the following

- Function diagram
- Circuit diagram
- Description of the operation of the system
- Technical data of the components.

Supplementary documentation comprising

- Parts list of all components in the system
- Maintenance and fault-finding information
- Spare parts list

A. FUNCTIONAL DIAGRAM

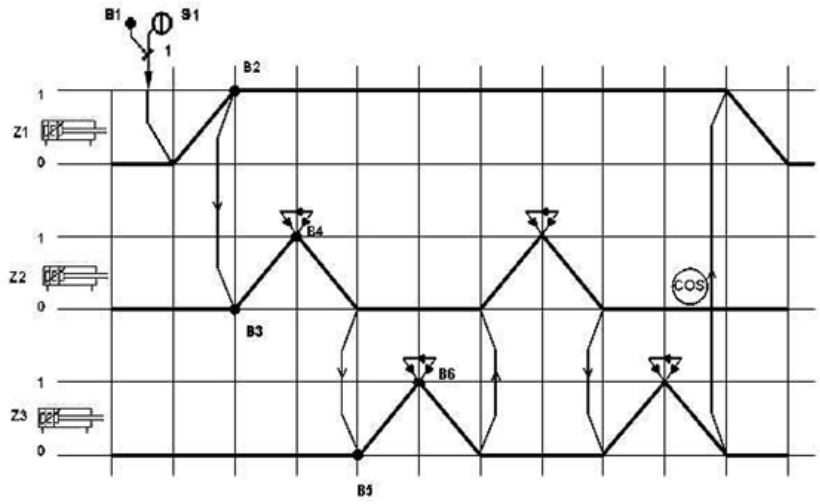


Fig. 8.1: Functional Diagram

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 activation of the limit switches of different cylinders will provide set or reset signal to the final control valves for further controlling the movement of various cylinders.

The limit switches have to be arranged in the proper location with the help of motion diagram.

In order to develop control circuitry for multicylinder applications, it is necessary to draw the motion diagram to understand the sequence of actuation of various signal input switches-limit switches and sensors. Multicylinder applications with three cylinders A, B and C.

The status of the cylinder displacement and actuation of set and reset signals at single piloted directional control value is shown by functional diagram.

Fig-Functional Diagram

In majority of the pneumatic application more than one cylinder is used. The movement of these cylinder is co-ordinated as per the required sequence.

In order to develop control circuitry for multi cylinder application, it is necessary to draw the motion or functional diagram, by which one will be able to understand the sequence of actuation of various signal input, by limit switches and sensors.

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 cylinder are shown according to the sequence of operation. One cylinder has to 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 S1 is pressed, cylinder switch 'B1' is already in actuation mode it sends signal to solenoid Y1 by which the piston of the cylinder '1' moves forward, which clamps the component.

As, soon as the piston reaches to cylinder switch B2, it sends signal to solenoid Y_2 by which the 2nd cylinder piston moves forward, resulting in cutting operation. As the piston of the cylinder-2 reaches to, cylinder switch 'B4' a loop is formed and the piston of the cylinder-2 retracts as the solenoid Y_2 de-energies.

As soon as the piston of the cylinder 2 reaches the backward position it activates cylinder switch B3, which sends the signal to solenoid coil 'Y_3', 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 'B6' a loop is formed by 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, the voltage supply to valve, solenoid 'Y_1' by which the piston of the cylinder '1' retracts, unclamping the component.

Thus the whole circuit is reset and the machine stops.

B: PNEUMATIC CIRCUIT DIAGRAM OF THREE (03) DOUBLE ACTING CYLINDERS

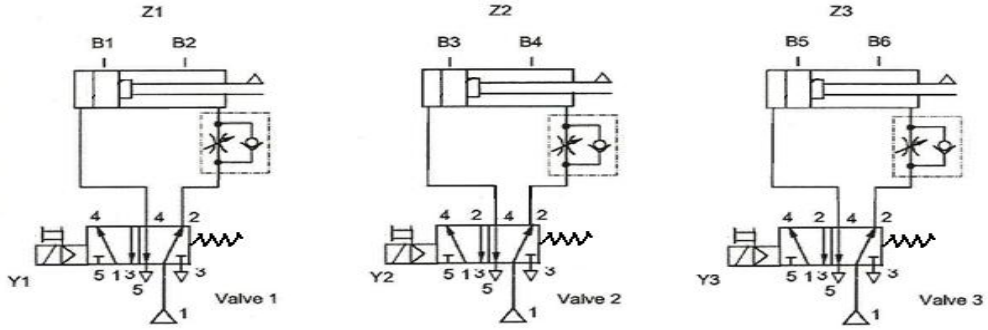


Fig. Pneumatic Circuit diagram of 3 cylinders

Pneumatic circuit diagram

- The 3 double-acting cylinders are controlled with 5/2 directional control valves.
- The valves are equipped with visual display and manual override.
- Valve 1 has the solenoid coils designated Yl, valve 2 has solenoid designated as Y2 and valve 3 has coil designated as Y3

- When signal voltage is applied to the solenoid coils Yl, Y2 and Y3, the cylinders extend, when voltage is interrupted to the solenoid the cylinder retract.
- The extension speed of all 3 cylinders can be infinitely adjusted with a one-way flow control valves

C: ELECTRICAL CIRCUIT DIAGRAM

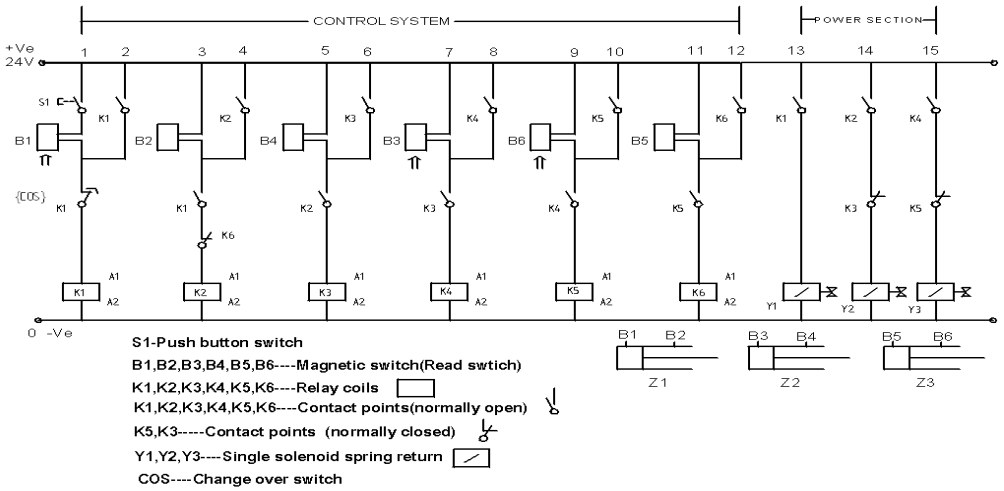


Fig. Electrical Circuit diagram

CONTROL SECTION:

The control section of the electric circuit diagram consist of a standing step sequence diagram with 6 steps (6 storing step and 1 reset by C.O.S.) which are made up of the relays K1 to K6 and the assigned latching circuits.

Control switch S1 is actuated, signaler B1 is actuated and signals B2, B4, B3, B6 and B5 are switched by the sequence order.

In this order, one latching cicuit (step) is respectively set.

- Signal B5 triggers the reset step at line 3.
- The first latching circuit is not broken, but line No. 3 is reset by normal closed contact K6 in current path 3.
- This causes all further latching circuits (steps) to be reset from left to right. Now as contact point K1 is closed the continuity of current will energize coil K2.
- Thus the cylce continues from line no. 3 to line no. 12 the change over switch is operated in the line no. 1 to stop the maching cycle.

POWER SECTION:

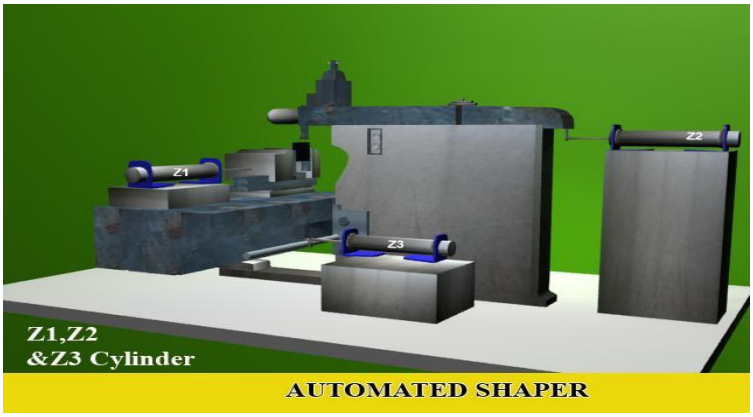
- In the power section, the contact point switches the valve solenoids corresponding to the step sequence.
- When using single solenoid spring return valve, there is need of continuous signals, when voltage is present at one side, the valve is operated and when there is no voltage, the valve goes to its initial position by means of spring force.
- Step 1: Contact K1 in current path 13 switches Y1 solenoid cylinder 1 extends and actuate the cylinder switch B2.
- Step 2: Contact K2 in current path 14 switches the valve solenoid Y2 via the unopened normally closed contact K3 cylinder 2 extends and actuates cylinder switch B4.
- Step 3: Contact K3 in current path 14 normally closed contact, now changes to normally open, and cut the current path in line 14 thus the solenoid Y2 collapse, the valve regains its original position by which the cylinder 2 piston retracts actuating the cylinder switch B3.
- Step 4: Contact K4 in current path 15 switches valve solenoid Y3 via the unopened normally closed contact K5, then cylinder 3 extends and actuates cylinder switch B6.
- Step 5: Contact K5 in current path 15 switch off Y3, as K5 is normally closed, now changes to normally open which interrupts the voltage to Y3 and cylinder 3 retracts thus actuating actual cylinder switch B5.
- Step 6: Contact K6 in current path 3 interrupts the current supply on line 3 to relay coil K2 where all the other lines are reset. The step sequence continues in the cylinder 2 and 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. The machine stops.

TASK:

Conversion of conventional shaper into a automated machine:

- The component to be machined is placed on the table and when the push button switch is operated, the first cylinder will clamp the component. After clamping operation, the signal is sent to the Y_2 solenoid by which the second cylinder actuate, so the ram of the shaper reciprocate and does the cutting operation.
- After taking one cut the cylinder 2 sends the signal to the Y_3 solenoid by which the cylinder 3 actuates so that cylinder the 3 extends inturn rotates a screw by a ratchet and pawl mechanism, the crosswise movement of the table is obtained (feed).
- Once the feed is given the cylinder 3 sends the signal to cylinder 2 so that the ram operates, taking a cut.
- Thus the cycle continue till the machining of the component is completed.
- 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.
- The work piece is manually taken out of the table and the table is brought back to the original position with the help of a screw.
- Electrically controlled 5/2 single solenoid spring returned DCV are used as actuator.
- Signals used are electrical cylinder switch (Magnetic field sensors or reed switches).
- The extension speed of all the 3 cylinder are variable, adjustable, by the flow control check valve.

D: IMPLEMENTATION



CONVERSION OF MANUALLY OPERATED SHAPER INTO THE AUTOMATIC UNIT:

- In case of conversion of the machine we need 3 double acting cylinder. One cylinder for clamping the job, the second cylinder for reciprocating the ram and the third cylinder for operating the cross slide screw (feed).
- Six proximity magnetic switches, two each for one cylinder, one change over switch, 3 DCV 5/2 single solenoid spring returned, 3 variable flow control valve, one pressure relief valve, compressor and the flexible pipes for necessary connections are required.
- 12 V DC power supply, relay system, push button switch, PLC and wires for connection are also used.

WORKING OF THE MACHINE:

- To start, the push button switch is pressed. The cylinder mounted on the table will move slowly for clamping the job. Once the clamping is over the switch B2 sends the signal to Y2 solenoid, so that the piston of the cylinder 2 moves forward moving the ram. Thus the cutting or machining stroke, takes place and the piston moves along with the ram.
- As the piston of cylinder 2 returns to its extreme backward position, the cylinder switch B3 will send the signal to solenoid Y_3 by which the piston of cylinder 3 moves forward by which the cross feeding screw is rotated with the help of ratchet and pawl mechanism. When the piston of cylinder 3 reaches its forward position, and it returns back quickly and as the piston reaches to its extreme backward position, magnetic switch B5, sends the signal to solenoid Y_2 causing the cylinder 2 to move. This process continues till the table of the machine comes in contact with the change over switch. The complete electrical circuit and is reset the machine is stopped.

E: INTERFACING THE SHAPER OPERATION WITH PLC

HISTORY OF PLC:

Before the PLC, control, sequencing, and safety interlock logic for manufacturing automobiles and was accomplished by using hundreds or thousands of relays, cam timers, and drum sequencers and dedicated closed-

loop controllers. The process for updating such facilities for the yearly model change-over was very time consuming and expensive, as electricians needed to individually rewire each and every relay.

WHAT IS A 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.

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. If we want to draw a simple ladder diagram showing a lamp that is controlled by a hand switch, it would look like this.

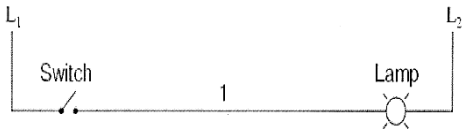
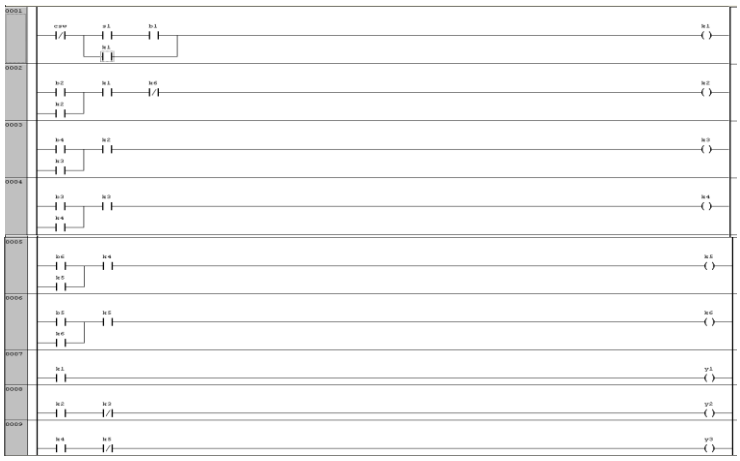


Fig. Simple ladder diagram



```
0001 PROGRAM PLC_PRG
0002 VAR
0003     s1 AT %IX0.4: BOOL;
0004     b1 AT %IX1.6: BOOL;
0005     csw AT %IX0.5: BOOL;
0006     k1: BOOL;
0007     b2 AT %IX1.7: BOOL;
0008     k6: BOOL;
0009     k2: BOOL;
0010     b4 AT %IX2.0: BOOL;
0011     k3: BOOL;
0012     b3 AT %IX2.1: BOOL;
0013     k4: BOOL;
0014     b6 AT %IX2.2: BOOL;
0015     k5: BOOL;
0016     b5 AT %IX2.3: BOOL;
0017     y1 AT %QX2.0: BOOL;
0018     y2 AT %QX2.1: BOOL;
0019     y3 AT %QX2.2: BOOL;
0020 END_VAR
```

F: OPERATIONAL ANALYSIS

OPERATIONAL ANALYSIS OF MANUAL AND AUTOMATED SHAPER 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:

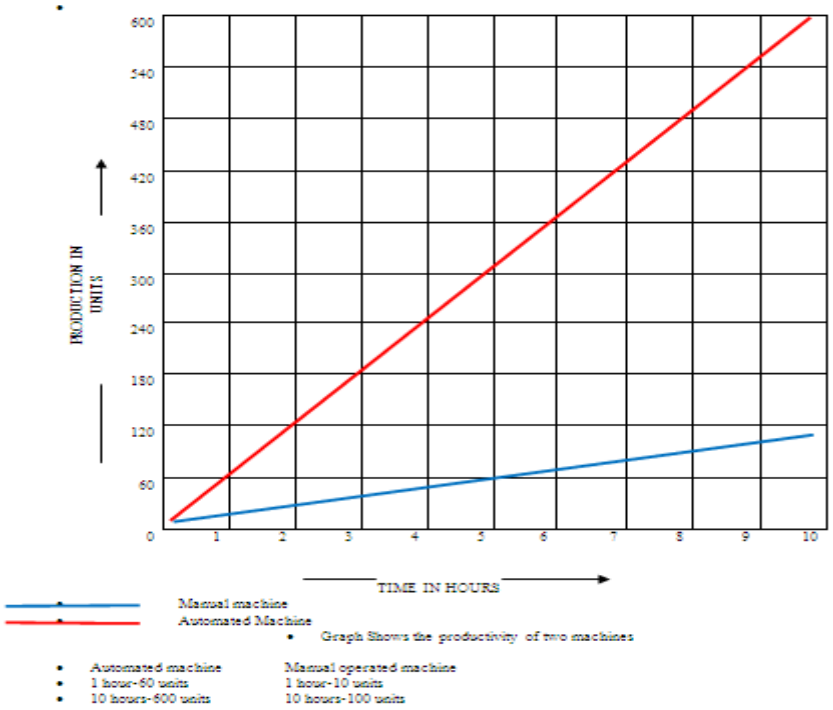
- Lets us consider a square flat M.S plate with a 50x50 mm and thickness 5mm in which the top face has to be machined flat.

MANUALLY OPERATED SHAPER MACHINE:

- The time need to produce one flat plate is 6 minutes.
- Total number of components produced in one hour is 10 nos.
- Therefore in one day 100 components are machined (total machining time taken in a day is 10 hours).

AUTOMATED SHAPER MACHINE:

- The time need 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).



- 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 CONCLUSION

- The conventional controlled 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 interventions during the machining operations are reduced. As far as this project is concerned, the machine is not fully converted into automatic machine but it is converted as a semi automatic machine, because the loading and unloading of the workpiece is done manually.
- 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 are also reduced and by which the number of machines can be operated by a single operator.
- To conclude, this project is made keeping in mind that, any conventionally operated machines can be converted into automatic or semi automatic machines by using these devices. Late the machine is interfaced with PLCs. For this purpose one should have the full knowhow of the devices which are being

used. By doing so the existing old machines can be modified and made automatic and the procuring cost automatic machines may be reduced. Thus there is a lot of scope in this area (automation).

- Hence there is still wide scope in the automation area where lots of improvement can be made with the help of the latest technology.

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