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DESIGN AND DEVELOPMENT OF SPECIAL PURPOSE MACHINE USING HYDROPNEUMATIC CYLINDERS TO DO 4 HOLES AND 2 HOLES PIERCING IN A SQUARE TUBE

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ABSTRACT

Piercing is a type of shearing operation which creates a open hole in sheet metal by separating interior section. The removed metal is discarded as strap. In general piercing operation is done in mechanical presses using piercing tool. Piercing tools are developed with indexing method by piercing 1 or 2 holes at a time. To do 4 holes the tool is allowed to do first hole and then the first hole is located to do piercing of other holes. This special purpose machine using hydro pneumatic cylinders to pierce 4 holes and 2 holes at a time in a square tube. The productivity and quality of the work is increased by this machine. The use of Special Purpose Machines minimizes Possibility of Human Errors. These machines are Designed to Operate Continuously for 24 hours a day, with Minimum Supervision

Key words: Piercing tools, mechanical presses, hydro pneumatic cylinders, productivity, Human Errors.

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1. INTRODUCTION

1.1. Special Purpose Machine

Special Purpose Machines (SPM) is that Machine which are not Available Off the Shelf. These are not covered in Standard Manufacturing Programs. Special purpose machines are designed to perform some specific applications which cannot be carried out using conventional machines. We conceptualize the system design understanding the customer needs with a collaborative approach and develop the machine. The purpose is defined first. The constraints are listed. The machine is designed based on these purpose and considering the constraints as well.Therefore they have to be Designed & Tailor Made as Per the Customers Specific Requirements. They are also called as Bespoke Machines**.** The system design, electrical control design work go hand in hand and seamlessly integrate together with mechanical, pneumatic and hydraulic systems to create the special purpose machine.

1.2. Need of Special Purpose Machine

The need of Special Purpose Machines (SPM) is that it gives very High Productivity. The theme can be Further Elaborated by doing a Full Scale Automation of the Industrial Process, wherever Possible. The use of Special Purpose Machines (SPM) and Automation Minimizes Possibility of Human Errors and also Reduces Human Fatigue in Carrying out Repetitive Operations again and again. It also assures the Quality and Interchange ability of Parts, by Carrying out the Same Designed Process each time without any Shortcuts.

The Special Purpose Machines (SPM) And Automatic Machines are designed to Operate Continuously for 24 hours a day, with Minimum Supervision. The Special Purpose Machines are Generally Product Specific & they are required to be Designed & Developed for each Specific Requirement. This Special Purpose Machines (SPM) are either Cam Operated Machine or they use Hydraulics & Pneumatics as Actuating Elements or Combination of all the three of them. Many times a Dedicated Programmable Logic Controller is used in Conjunction with Positional Sensors & Transducers, to give Commands to the Actuating Elements some Times Different Special Motors like Stepper Motor & Servo Motors are used as Actuating Element. The Productivity Achieved after all these Efforts is very high. Productivity of 3 to 10 times are Achievable. However to Fetch the Fruits of these Highly Specialized Machines the Pre Condition is that the Input to the Automatic Machine must have Strict Quality Control.

Most commonly the special purpose machines we design and manufacture are of following types

- Assembly Machines
- Process Machines
    - Semi – Automatic
    - Fully Automatic
- Stand Alone Systems
- Integrated Systems

1.3. Elements of Special Purpose Machine

The special purpose machine consists of two major elements.

- Piercing tool. (Punch and Die)
- Hydro pneumatic system - cylinders and controls to develop force to pierce holes

1.3.1. Design of Tool and Die of Special Purpose Machine of 4 holes

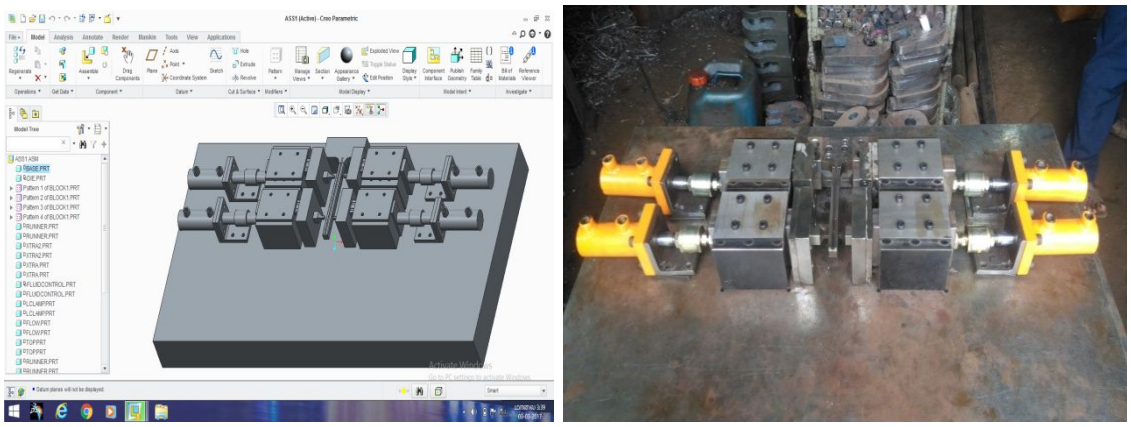

Figure 1 4 holes Special Purpose Machine

1.3.2. Design of Tool and Die of Special Purpose Machine of 2 Holes

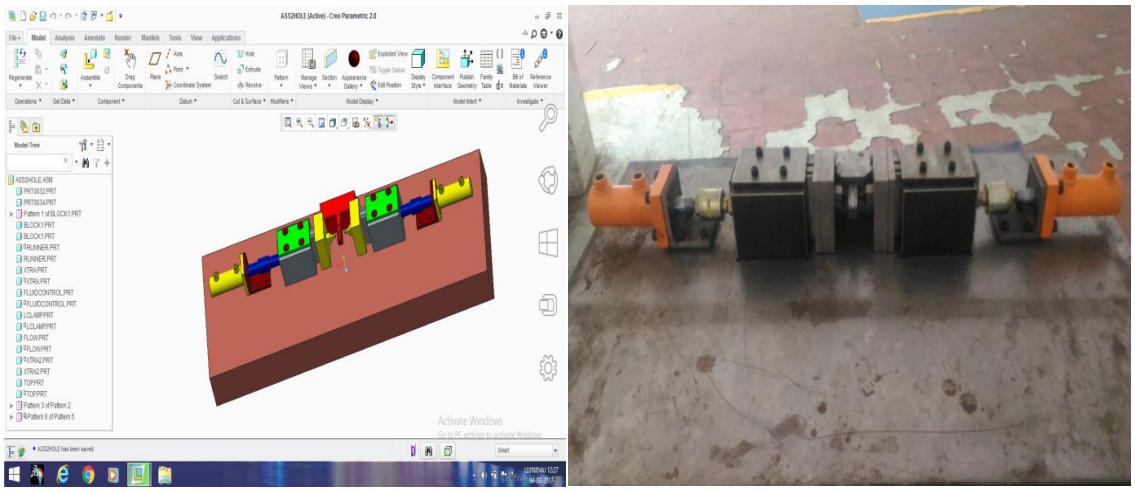

Figure 2 2 holes Special Purpose Machine

2. SHEETMETAL OPERATIONS

Sheet metal is simply metal formed into thin and flat pieces. It is one of the fundamental forms used in metalworking, and can be cut and bent into a variety of different shapes. Countless everyday objects are constructed of the material. Thicknesses can vary significantly, although extremely thin thicknesses are considered foil or leaf, and pieces thicker than 6 mm (0.25 in) are considered plate.

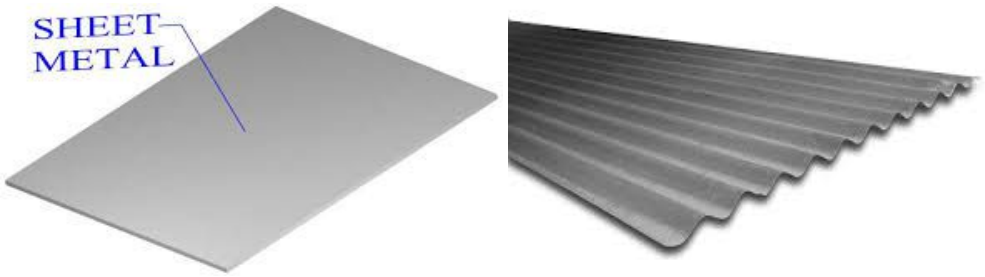

Figure 3 Sheet Metal

2.1. Sheet Metal Processing

The raw material for sheet metal manufacturing processes is the output of the rolling process. Typically, sheets of metal are sold as flat, rectangular sheets of standard size. If the sheets are thin and very long, they may be in the form of rolls. Therefore the first step in any sheet metal process is to cut the correct shape and sized 'blank' from larger sheet.

2.2. Sheet Metal Forming Processes

Sheet metal processes can be broken down into two major classifications and one minor classification

- **Shearing processes** -- processes which apply shearing forces to cut, fracture, or separate the material.
- **Forming processes** -- processes which cause the metal to undergo desired shape changes without failure, excessive thinning, or cracking. This includes bending and stretching.
- **Finishing processes** -- processes which are used to improve the final surface characteristics.

3. HYDROPNEUMATIC CYLINDERS

Figure 4 Hydro pneumatic Cylinders

3.1. General Description

The Hydro pneumatic cylinder HPL converts the energy from processed compressed air into a steady linear movement. The internal hydraulic cycle is regulated using control elements. The working energy is supplied through an external air power supply system. The internal closed hydraulic circuit can be precisely regulated using control units. This enables the piston rod, whose feed rate can be controlled separately, to move in a steady linear fashion.

3.2. Design

Due to the nature of the appliance, it is helpful to divide the hydropneumatic drives into two main areas. Depicted below is a longitudinal section through the drive which is generally designed as a fluid cylinder. The possible control features will be shown and described further down.

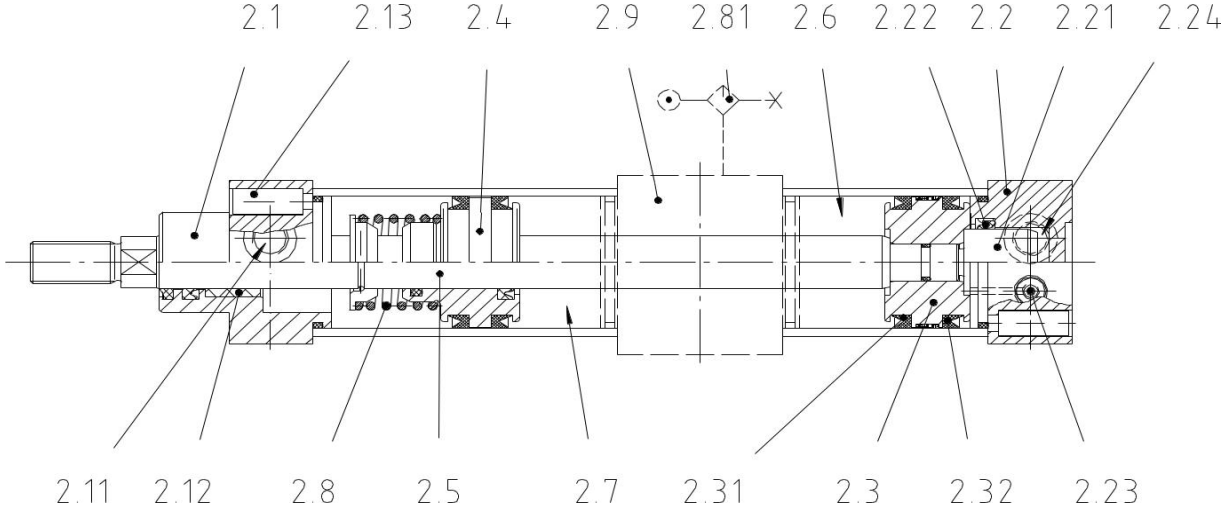

Figure 5 Hydro pneumatic Cylinders lay out

2.1. Front plate
2.11. Air connection (Back stroke)
2.12. Rod bearing
2.13. Fastening nut
2.2. Front cap
2.21. Cushioning
2.22. Seal element for cushioning
2.23. Cushioning regulator
2.24. Air connection (Forward stroke)
2.3. Piston
2.31. Hydraulic seal
2.32. Pneumatic seal
2.4. Compensation and Backstroke piston
2.5. Rod
2.6/2.7. Hydraulic pressure medium
2.8. Spring compensation (only HPL-B)
2.81. Pressure compensation system (only HPL-C with HPL-B: Oil refilling fitting
2.9. Function control unit

4. PIERCING IN SHEET METAL

Piercing is a metal forging technique that is used to create a cavity or hole in the work piece. Piercing does not break through the metal's surface, like a drilling operation. Instead, the cavity is pressed into the work, hence it is a forging operation. Similar to other metal forging processes, piercing will change the properties of the work material, and affect the grain structure of the part.

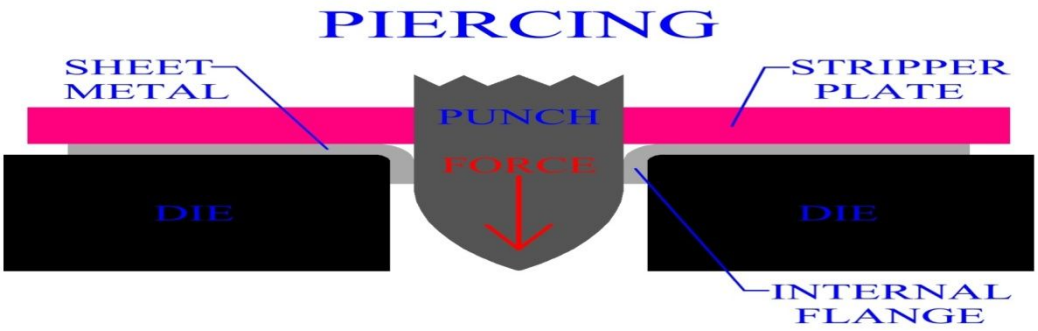

Figure 6 Piercing

4.1. Principle of Piercing

The product of a punch and die cutting operation is partially finished or semi-finished part or scrap. The process of making hole is called piercing and it produces a scrap slug. If the produced blank is useful, it is called blanking. Cutting of metal strip takes place due to the shearing in blanking and piercing operations. The cutting operation of metal strip takes place due to the plastic deformation, shear and break

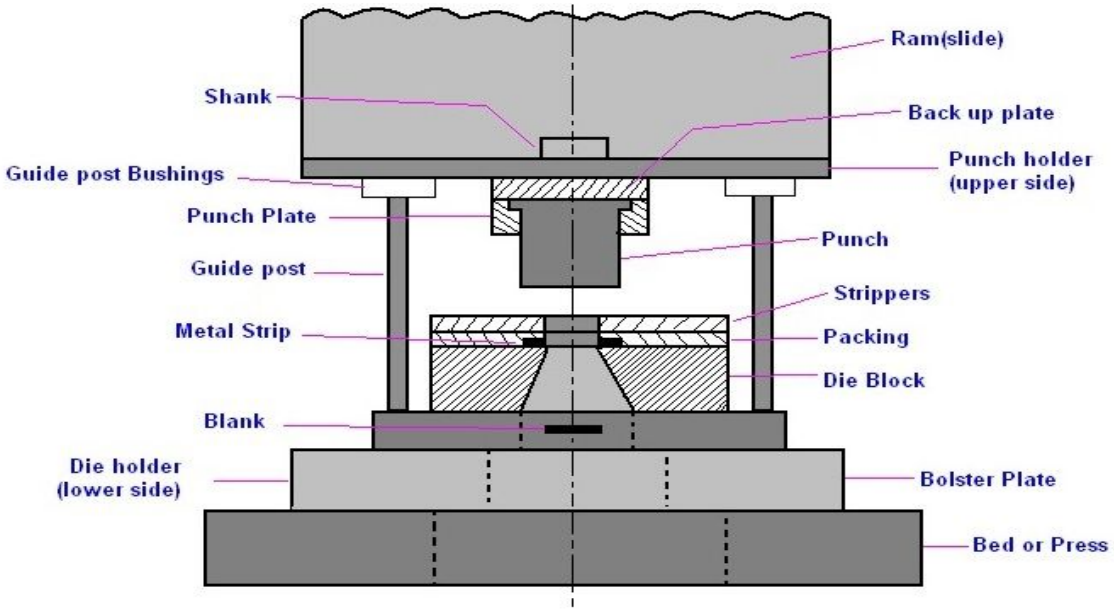

Figure 7 Principle of Piercing

4.2. Principle of Sheet Metal Working and Piercing Tools

4.2.1. Plastic Deformation

As the punch descends, it touches the work piece. The downward movement of punch exerts a force on the work piece material. Plastic deformation starts as soon as the material exceeds elastic deformation. The combination of elastic and plastic deformation results in upper radius band on the scrap strip and a lower radius band on the work piece.

4.2.2. Shear

The cutting of strip material is known as shearing. The principle of sheet metal working is shown in Figures 8. The diameter of punch is smaller than the diameter of die opening. Here, the material is subjected to both tensile and compressive stresses as shown in Figures 6.4(a) and (b). The stresses start to develop at this point. If the clearance between the die and punch is correct, the crack starting from the edges of punch and die meet, whereas the cracks do not meet up if the clearance is slightly more or less. Hence, shearing action does not take place.

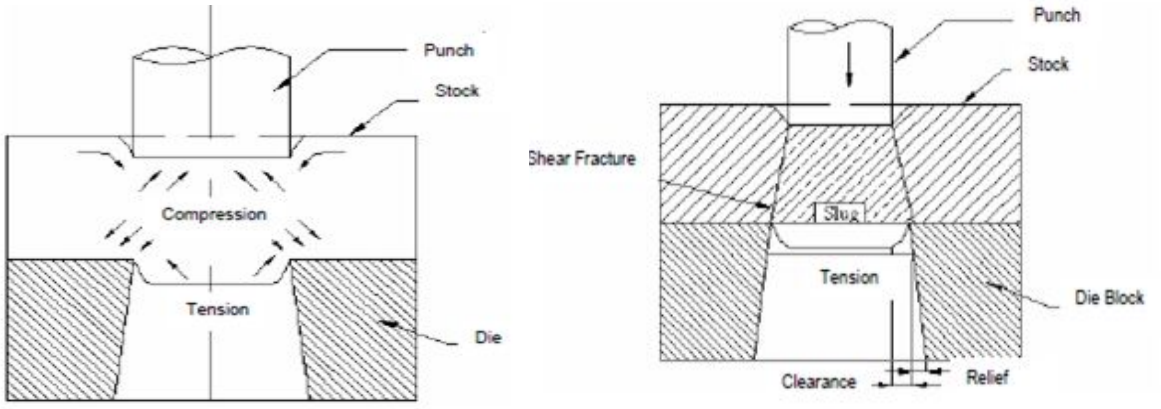

Figure 8 Shearing Process

5. THEORETICAL CALCULATIONS

5.1. Force Required For Piercing

Dimension of the removed work piece=6*6*0.8

Perimeter =2*(6+6)

=24mm=0.024m

Thickness of the material =0.8mm=0.0008m

Shear strength of mild steel =400Mpa

$=4*10^8$ N/m^2

$=4*10^7$ Kgf/m^2

Force for piercing $=0.024*0.0008*4*10^7$

=768 Kgf =76.8N

30% factor of safety is considered. Hence the force required for piercing is 1 Tonne**.**

5.2. Pneumatic Cylinder

Diameter of the cylinder =100mm Air Pressure=5 bar

Area of the cylinder $=\pi/4\ d^2$

=0.785*10*10

$=78.5m^2$

Force =P*A

=5.1*78.5

=400.35 Kgf =40.035N

Force produced in pneumatic cylinder is 40.035N

5.3. High Pressure Chamber

Diameter of the chamber rod =22mm =0.022m

Area of the chamber rod =0.022*0.022*0.785

=3.79*10^-4m^2

To determine the pressure in the hydraulic cylinder

40.035 =P*3.79*10^-4

P=105.633*10^3N/m^2

5.4. Hydraulic Cylinder

Diameter of the cylinder =40mm=0.04mPressure=105.633*$10^3$$N/m^2$

Area of the cylinder =0.04*0.04*0.785

=12.56*10^{-4}

Force =P*A

=105.633*10^3*12.56*10^{-4}

=132.6N

Hence we attained the required force for piercing the workpiece.

Ratio=area of pneumatic/area of high pressure chamber

=78.5/3.79

=20.71

By applying 5 bar pressure in pneumatic cylinder we can get 20 times boost up pressure in hydraulic cylinder

6. RESULT AND CONCLUSION

Figure 9 Development of Tool and Die of 2 Holes

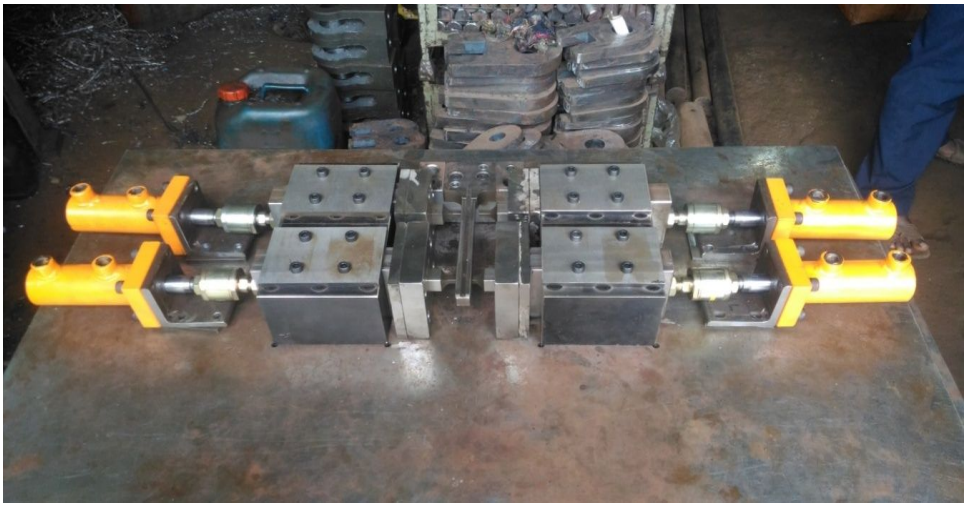

Figure 10 Development of Tool and Die of 4 Holes

7. CONCLUSION

Piercing operation is done in mechanical presses using piercing tool. Piercing tools are developed with indexing method by piercing one or two holes at a time and then by locating first hole and do piercing of other holes. This needs 75/100 ton press and 6 strokes. Also the position of holes accuracy can vary due to location of problem. By making 6 strokes for one part only 50 parts can be produced (300 strokes per hour) and 400 parts per shift against the requirement of 2000 parts per shift Hence the material is produced with minimum usage of energy and accuracy of the produced component is improved.

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