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Design and manufacturing of die and punch for RM-800 load cell braided sheet

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ABSTRACT

Now a day's sheet metal working processes are widely used in almost all industries like automotive, defence, mechanical industries. Also, sheet metal working processes are predominantly used as various reasons not only for industrial purpose but also utilized for commercial purpose as well. For that many people are working in developing the new trends using their innovative ideas. Especially indie design, many die sets are made for different functions such as progressive die, compound die, etc. This project is also based on a new design of die punch. The main aim of this project is to design a new die with interchangeable punches also reduce the weight of the material by means of changing the material of die set. The project mainly focuses on different operations done on single die set in a single stroke of the press, presently these operations are done separately in five steps which include four drills and one plasma cutting. These operations are leading to reduce the production rate and increasing the cycle time with cost as well. As per our new die set, this should constantly eliminate the loss in the production time and reduce the manpower for loading and unloading of the work piece. The parts of die sets, punch and die are designed and assembled in the Creo Parametric 1.0.

Keywords— *Purpose, Die, Punch, Cost*

1. INTRODUCTION

A die is a specialized tool used in manufacturing industries to cut, shape and form a wide variety of products and components. Like molds and templates, dies are generally customized and uniquely matched to the product they are used to create. Products made with dies range from simple paper clips to complex pieces used in advance technology. Dies are typically made by tool and die makers put into production after mounting into a press. [1]

For the forming of sheet metal such as automobile body parts, two parts may be used, one, called the punch, performs the stretching, bending, piercing and/ or blanking operation. While another part, called the die block, securely clamps the work piece and provides similar stretching, bending, piercing and blanking operations. The work piece may pass through several stages using different tools or operations to obtain the final form. [1]

Most of the construction machinery equipment parts assembled are made by mild steel. Most of these mild steel parts are manufactured on a machine called "press tools". A proper designing will give accurate mild steel parts in dimensions, shapes and size. In many industries press tool calculations, designing and drafting are done manually. But in the modern era, the computer has played an important role in various fields. One of the major applications of computer in production engineering is "CAD/CAM". [2]

Press tools are provided with an attachment on a press machine with a punch and die as a major part use to perform different cutting and forming operations. Different press tools are used for different operations depending upon the shape and size of the product. Top plate of the die set is attached to the top press ram followed by pressure plate and punch plate in which punches are held, which moves up and down, by means of different power sources like mechanical, hydraulic and manual, while the die is fixed on the bed along with clamping plate and its accessories. A work piece on which operations are to be performed is held on a top of the die supported by stripper plates.

1.1 Types of dies

The theory of sheet metal behaviour kept as a backbone for the development of various kinds of dies which are differentiable through their function. In some of the dies, the sheet metal should be cut off from the strip and the remaining part is removed as scrap. In some other dies, the complete part is finished within the single station. According to their construction and functions, the die is divided into the following groups.

1.1.1 Simple dies: Simple dies or single action dies to perform the single operation for each stroke of the press slide. The operation may be one of the operations listed under cutting or forming dies.

1.1.2 Combination dies: The die which undergone different cutting and forming operations are combined together and carried out in a single operation. The first blank is prepared in the die and then it is held by pressure pads and drawn assembly. All this is achieved entirely within the die assembly using of cam actuated punch and die members or by designing the die for use on a double action press which has two independent rams or slides on moving inside another practically.

1.1.3 Progressive dies: In progressive dies, the work pieces move from the first stage to successive which carries different operations, to be performed in each station. Each station works in the series manner and the work piece is placed in stock till at the end of the station which cuts off the final piece. End of each stroke, the stock is moving towards the station and the complete work piece is constructed in a single stroke of the ram. It can be designed for different complicated operations of bending, forming, punching etc. In these dies, indexing at every station is very important and therefore accuracy is not much looked factor. However, it is simple in designing the die.

1.1.4 Compound dies: The die which undergone to more than two cutting operations like blanking and perforating etc. can be performed continuously in a single stroke is called as compound die. In compound die, the upper punch is connected to the ram comes in constant with metal and pierces the holds it. This punch is moving downward, the springs keep on compressing and after a certain limit, the lower punch moves upward and blanks the outer portion position. Here, the whole operation is performed at a single station, it produces an accurate result but the die design is complicated to design.

1.2 Die construction

The die set is the primary portion of every die construction assembly. It made up of upper die and lower die both are machined in parallel in size to each other. The portion of the die is provided with the shank which is used to clamp in the ram of the press tool. Both the upper die and lower die are aligned with the guide pins to each other. They are firmly attached to the stripper and the upper die is equipped with the bushings into which these pins slip-fit inside. The die blocks are mounted in the lower die portion in which they are attached through the die button. The punch plate is kept on the upper shoe in which same manner as the die block. It holds all the punches which are perforated the sheet with the help of die at the bottom side of the assembly. While doing the operations, the punches can be prevented from the cracks by the spring loaded stripper plate assembly. The stripper plate is held in the top plate with an offset location of forces of springs by means of guide pins inside it. This die set is the combination of two die sets; the upper die set is rectangular in shape with four posts die set. The lower die set is rectangular in shape with open die set which is used for simple parts in larger quantities for manufacturing.

1.3 Problem statement

The goal of this project is to design a die which combines operations like drilling, plasma cutting etc. in order to reduce cost, cycle time, man power and increase the production rate.

1.4 Objective of the project

- To reduce the cycle time of operations.
- To reduce the manpower required for the operations.
- To increase the accuracy of operations.
- To increase the production rate.

1.5 Scope

This work can be modified to some extent by changing the design, type etc. Recently press machine with high force that is 100 tons is used in industrial companies. This type of press machines is used to produce high force so that operations with smaller forces are not suitable for this machine. In future, if we use press machines which can have small force are suitable for smaller operations.

In this work, there are three holes with a very small diameter which cannot be produced due to the high force of press machine. There is a possibility to break the punches of smaller diameter holes. So that in future it will possible to produce that small holes by reducing the pressing force. For that, it is essential to change the design of the project.

2. METHODOLOGY

2.1 General Design Parameters/Considerations

2.1.1 Press tonnage: The tonnage of a press is the force that the press ram is able to exert safely. Press slides exert forces greater than the rated tonnage because of the built-in safety factor, but this is not licensed to overload. The tonnage of the hydraulic presses is the piston area multiplied by the oil pressure in the cylinder. Changing the oil pressure varies the tonnage.

The tonnage of the mechanical presses is determined by the size of the bearings for the crankshaft or the eccentric and is approximately equal to the shear strength of the crankshaft metal multiplied by the area of the crankshaft bearings. The tonnage of a mechanical press is always given when the slides are near the bottom of its stroke because it is greatest at this point.

2.2 Die clearance: Clearance is defined as the intentional space between the punch cutting edge and the die cutting edge. Clearance is always expressed as the amount of clearance per side. Theoretically, clearance is necessary to allow the fractures to meet when a break occurs, as shown in the fig. The amount of the clearance depends upon the kind, thickness and harness of material.

The excessive clearance allows large edge radius (rollover) and excessive plastic deformation. The edges of the material tend to be drawn or pulled in the direction work force, and the break is not smooth. Large burrs are present at the broken edge.

2.3 Holding forces: In the press tool, it is very much essential to hold the component properly in order to ensure better press operations. The holding should be proper and adequate. The force required to hold the component during the bending operation is commonly known as holding pressure.

2.4 Centre of pressure: When the contour to be cut is of irregular shape, the simulation of irregular shearing force on one side of center of ram may greatly exceed force on the other side. This results in bending moment in the press ram and undesirable deflection and misalignment. It is, therefore essential to find out the exact center of pressure, which the point about which the summation of shearing force will be symmetrical. While dying out the punch position on the punch holder, it should be ensured that the center of the line of the press ram passes exactly through the center of pressure of blank. This center of pressure is the C.G of the line that is, the perimeter of the blank contour and not the area.

Thus, the press tool should be designed in such a way that the center of pressure will be on the axis of the press ram when the tool is mounted in the ram.

2.5 Selection of the Press: The press tool designer has to select the proper type of press to be used and also the kind of press tools to be provided, considering the economic aspects. For example, it will be more economical to use a tool which will complete a number of operation at one stroke of a press than to employ a number of cheaper and simple tools to perform same work in a series of operation. While selecting the press the quantity that is volume of work should also be taken into consideration.

In selecting proper size and style of press for a given kind of work the following points need to be considered:

- The method of feeding and the direction of feed.
- The size and the shape of the sheet blank, or the work piece.
- The strength of the press and its tonnage capacity.
- The size and type of die required.
- The length of stroke necessary.
- The distance between the top bed (bolster) and the bottom of the ram with tis stroke down.
- Type of drive required.
- Speed of operation.
- The capacity of the motor.
- The thickness of stock, the material of work piece etc.

The press should be capable of exerting 33% more force than required for the operation

3. CALCULATIONS

3.1 Design and calculation

3.1.1 Design of die

(a) Selection of Suitable Material.
(b) Modelling of the die.
(c) Manufacturing of model.

3.1.2 Selection of Material: For selecting the suitable material for a die component, the die designer has to check the mechanical properties and possible causes, which may result in the failure of a component. The tool designer must know certain fundamentals of press operations for successfully designing press tooling.

To obtain longer life high productivity of die, steels are being widely used as materials for die component. The most important advantage of using steels is they are originally soft and Machin able, by applying suitable heat treatment on it, they become extremely hard and wear resistant. The geometry of the part to be manufacture on dies affects the hardness range of selected materials of die component. According to this, we are using high carbon steel for punch and mild steel to die.

3.1.3 Properties of High carbon steel:

- It has a granular structure
- It has less impact resistance
- This can be magnetized permanently
- High carbon steel cannot readily forge and welded
- High carbon steel can be easily hardened and tempered

3.1.4 Applications of High carbon steel

- Punches
- Taps
- Drills
- Drifts
- Press dies
- Springs
- Broaches
- Gauges
- Boiler maker's tools

3.1.5 Properties of mild steel material

- Mild steel is soft, ductile and malleable.
- Good forming properties.
- It can be easily forged and welded.
- Mild steel can be magnetized permanently.
- It cannot easily have hardened and tempered.
- It has a bright fibrous structure.
- It has tougher and more elastic than wrought iron.
- Tensile strength is better than cast iron and wrought iron, while compressive strength is better than wrought iron but less than cast iron.
- It`s melting point is 1400°C.
- Ultimate compressive strength varies from 8 ton/cmˆ2 to 12 ton/cmˆ2.

3.1.6 Applications of Mild steel material

- Dies
- Wires
- Forgings
- Stampings
- Bars and rods
- Tubes and castings
- Nut and bolts
- Plates for boilers and ships
- Structural section such as angles and channels

3.1.7 Design Parameters

Following design, parameters are to be considered while designing die for stripping.

- The perimeter of the component
- The total length of the component
- Total width of the component
- Press tonnage
- Shear cut area
- Vertical shearing force

3.2 Calculation

3.2.1 Cutting Force Calculations: The Die set assembly was designed as per the following specifications:
The diameter of 10.3mm and 7mm holes is to be pierced which is 3.15mm thickness.

Solution:
F = Spt.
Where,

F = cutting force.
S = shear strength of stock material.
P = circumference of cutting edge.
T = thickness of material

S = 35.15 kg/mm^2 ……. (As per standard table)
S = 35.15 kg/mm^2……. (As per standard table)

Cutting force for ø25mm

P = π d
P = 78.5342 mm
t = 3.15 mm
F = Spt
F1= 8695.50 kg

For ø8.5mm (ø0.3149inch)

$P = \pi d$

$P = 26.69$ mm

$t = 3.15$ mm

$F = Spt.$

$= 2955.18$ kg ……. (For single hole)

$= 11820.73$ kg ……. (For double hole)

$F2 = 11820.73$ kg ……. (2)

$F = F1 + F2$

$F = 8695.50 + 11820.73$

$F = 20516.23$ kg

∴ Total vertical shearing force = 20516.23 kg

3.2.2 Die clearance

Clearance is defined as the intentional space between the punch cutting edge and the die cutting edge.

Clearance = 5% of Thickness

= 0.05 * 3.15

= 0.1575 mm

$$\text{Factor of safety} = \frac{\text{Maximum stress}}{\text{Working or design stress}}$$

$$= \frac{100000 \text{ kg}}{20516.23 \text{ kg}}$$

∴ **The factor of safety = 4.87**

4. MODELING

4.1 Modelling of Die

Commercially CAD/CAM software like creo, catia, AutoCAD, ansys, solid works, pro-E etc. are providing a great deal of assistance in drafting and analysis in die design process. These software's are easily available, affordable and easy to handle. 3D modelling improves drawing efficiency and accuracy.

Modelling involves dimensions of all component such as punch holding plate, guide plate, base plate, Allen screw, punch, pressure plate etc. These dimensions are given by the company. All parts are designed in creo software. Drawing commands in creo such as rectangle, circle, extrude, line, revolve, mirror, hole etc. have been used in modelling of the die.

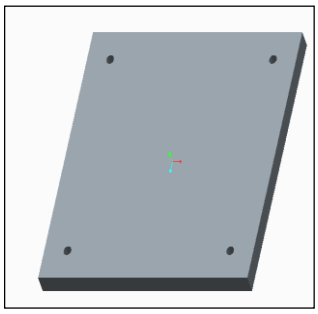

Fig. 1: Top plate

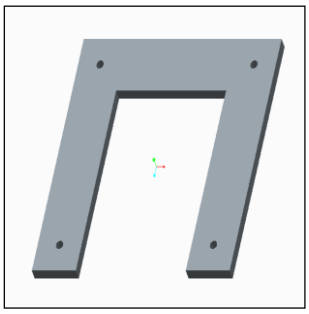

Fig. 2: Stripper plate

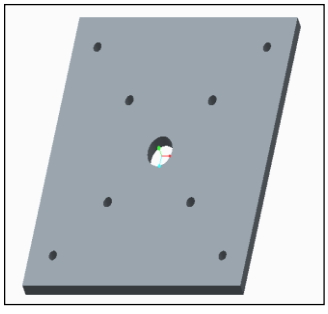

Fig. 3: Punch plate

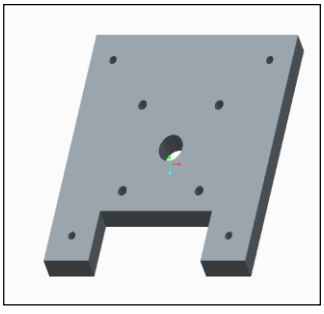

Fig. 4: Punch guide plate

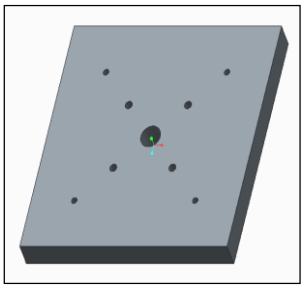

Fig. 5: Base plate

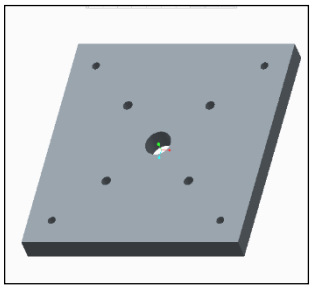

Fig. 6: Die plate

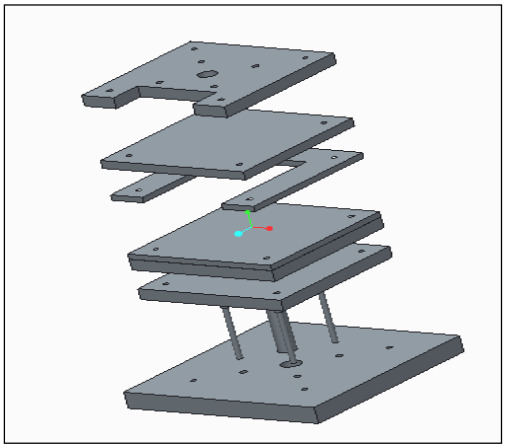

Fig. 7: Assembly

4.2 Components of die assembly

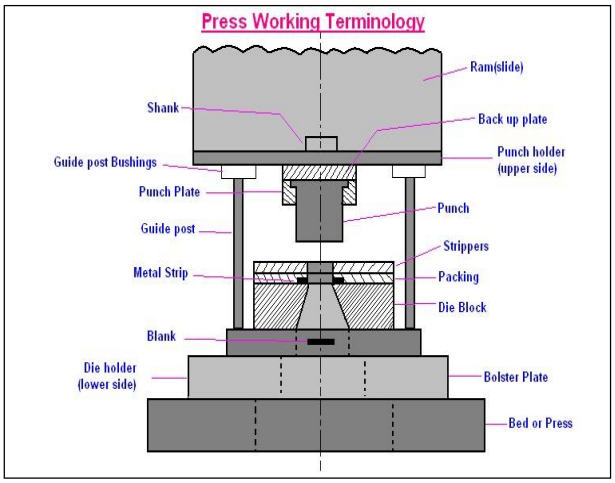

Fig. 8: Sketch of the die assembly

Die assembly consists of the following parts.

4.2.1 Punch: A punch is the upper member of the press tool. It is mounted on the lower end of the ram secured by punch holder and slides with it. During the operation, it enters into the cavity formed in the die section. The punch is made of hard, wear resistant metal and is finally found to predetermined size providing just optimum clearance between the die and punch.

4.2.2 Punch retainer or punch pad: The punch retainer fits closely over the body of punch and holds it in its proper relative position. The retainer is, in turn, bolted to the punch and punch holder to provide some cushioning effect.

4.2.3 Punch holder: The punch retainer is bolted to punch holder. On its top, it ends in the shank, which is anchored to the press ram, and it exactly fits it to the ram opening for proper positioning and aligning of the punch.

4.2.4 Pressure plate: It is also called as backing plate. It is introduced between the punch and punch holder to distribute the pressure over the wide area and thus reduce the intensity of pressure on the holder to avoid its crushing.

4.2.5 Die or die block: The die is a lower member of the press tool. It has an opening or cavity to receive the punch. It is clamped on the bolster plate fitted on press body remains stationary. The punches and dies are generally made of HSS, M.S. & HcHCR. Dies with a working surface made of cemented carbide are mostly used in the production process.

The profiles of the working portion of the punch and of the hole on the die are made exactly the same as the profile to produce on the blank. However, some clearance is allowed between the punch and die depending on the quality and thickness of the material. The clearance is increased with hardness and thickness of the work piece.

4.2.6 Die holder (lower shoe): The lower shoe of the die set is generally mounted on the bolster plate of the press. The die block is mounted on the lower shoe. Also, guideposts are mounted on it.

4.2.7 Guide posts and bushing: The punch and die members are held in alignment by means of guide posts and bushings. They resist deflection of die members as operating pressures increase.

4.2.8 Stripper: The function of the stripper is to strip off or to make the punch and die free from the work at the end of cutting or forming operation.

4.3 Operation performed in manufacturing of die

4.3.1 Blanking: The material used is called stock and is generally ferrous or non-ferrous strips. During the working stroke, the punch goes through the material and on the after stroke the material is lifted with the punch and is removed by the stripper plate mechanism. The restrict pin is a gage for the operator. In practice, he feeds the stock by the hand and locates the hole to be punched as shown. The part that is removed from the strip is always the work piece in a blanking operation.

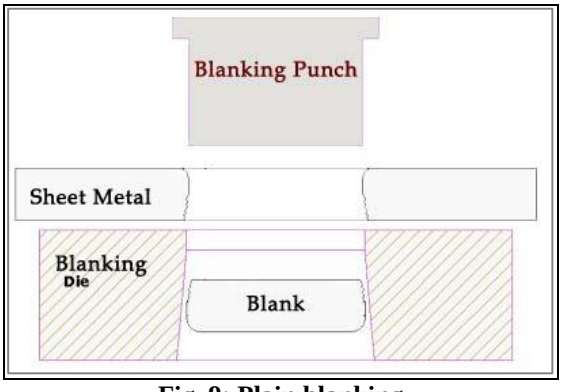

Fig. 9: Plain blanking

4.3.2 Piercing: This operation consists of a simple hole punching operation. It differs from blanking in that the punching is the scrap and the strip is the work piece which is useful. Piercing is nearly always accompanied by a blanking operation before, after or at the same time of operation.

4.3.3 Lancing: This is a combined two operations that is bending, cutting and lancing operation along a line in the work material. No metal is cut free during this operation. The punch is design to cut on two or three sides and bend along the north side.

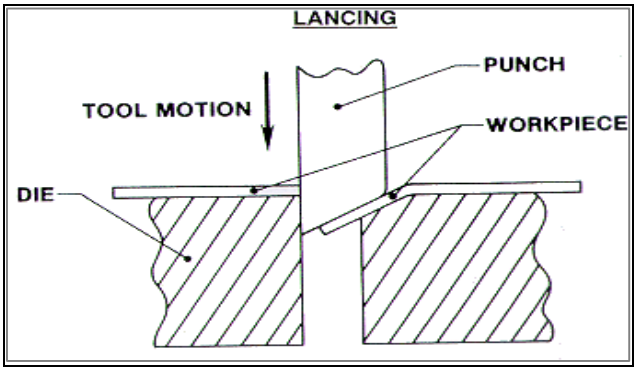

Fig. 10: Lancing

4.3.4 Cutting off and parting off metal: A cutoff operation separates the work material along the straight line in a single line cut. Cutting off and parting off operations are used to separate the workpiece from the scrap strip. Cutting off and parting off usually, occur in the final stages of a progressive die. Figure11 shows the basic principle of cutting off and parting off.

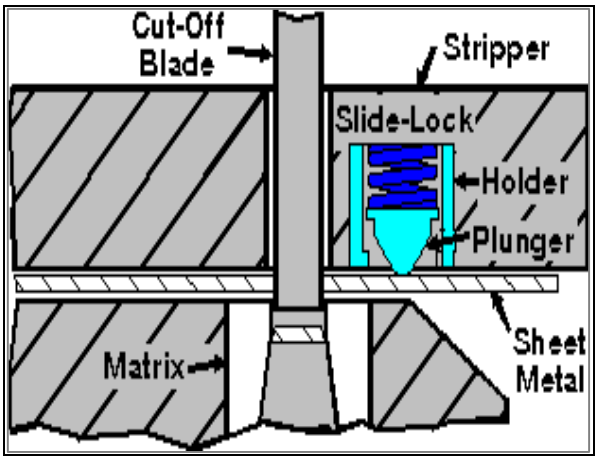

Fig. 11: Cutting off

4.3.5 Notching: This operation removes metal from either or both edges of the strip of metal. Nothing serves to shape the outer contours of the work piece in a progressive die or to remove excess metal before or drawing or forming operation in die. The removal of excess metal allows to flow or from without interference from excess interference from excess metal on the sides. Fig shows a typical example of nothing.

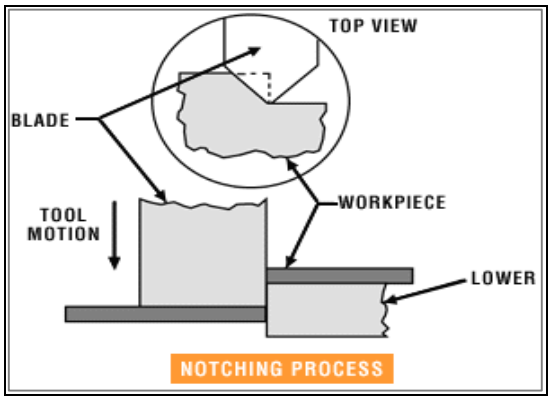

Fig. 12: Notching

4.3.6 Shaving: Shaving is a secondary operation, usually following punch, in which the surface of the previously cut edge is then finished smoothly to accurate dimensions that are required. The excess metal is removed as a chip with a metal-cutting tool. There is very little clearance (close to zero) between

the punch and die, and only a thin section of metal can pass through it.

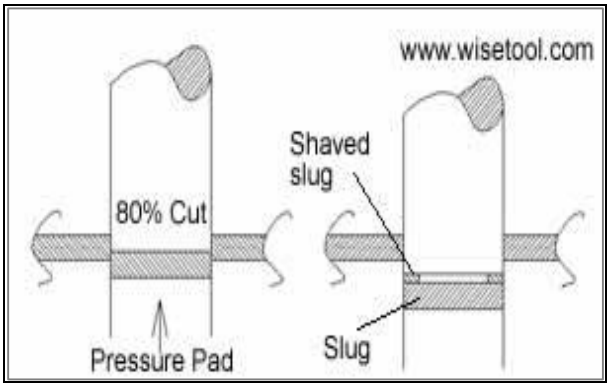

Fig. 13: Shaving

4.3.7 Trimming: This operation removes the distorted excess metal from drawn or formed parts. It also provides a smooth edge.

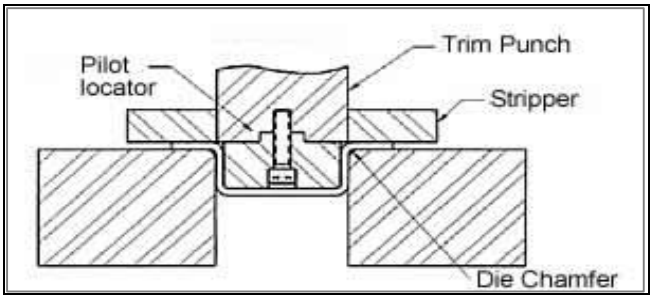

Fig. 14: Trimming

5. CONCLUSION AND SCOPE

This work can be modified to some extent by changing the design, type etc. Recently press machine with high force that is 100 tons is used in industrial companies. This type of press machines is used to produce high force so that operations with smaller forces are not suitable for this machine. In future, if we use press machines which can have small force are suitable for smaller operations.

In this work, there are three holes with a very small diameter which cannot be produced due to the high force of press machine. There is a possibility to break the punches of smaller diameter holes. So that in future it will possible to produce that small holes by reducing the pressing force. For that, it is essential to change the design of the project.

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