Design & Manufacturing of Compound Press Tool for Washer

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Abstract: ***The design & fabrication are the most important elements in translating the idea to a product. Before converting raw material to a finished product we need an accurate design of the product & also tool for manufacturing such product. If the tool design is not accurate then defects will occurs in the manufactured product, small mistakes in tool designing can makes the manufactured product useless & it consumed more amount time to manufacturing than allotted. This project is about design & manufacturing of a Compound tool for a washer component. This project starts from study of component, initial conceptual design, design verification & its validation, manufacturing aspects, process planning. The theoretical study has done and modelling is carried out with use for CAD software SOLIDWORKS and drafting of tool done on AutoCAD.***

Keywords: Tool design, press tool, strip layout, compound tool, solidworks

1. Introduction

1.1 Sheet Metal Forming Processes

Sheet metals are mostly used for industrial & consumer parts because of its capacity for being bent and formed into complex shapes. Galvanised iron, tin plates, copper, brass, zinc, aluminium etc metals are mostly used. Sheet metal parts include automotive, agricultural machinery, and aircraft components as well as consumer equipments. Selection of sheet metal forming operation depends on the selection of a material with adequate formability, appropriate tooling and design of part, the surface condition of the sheet material, proper lubricants, and the manufacturing conditions such as the speed of the forming operation, forces applied, etc. sheet metal forming processes includes:

- Shearing
- Bending
- Drawing
- Squeezing.

Each above process is useful for specific purpose & according need of shape of the final product.

1.1.1 Shearing

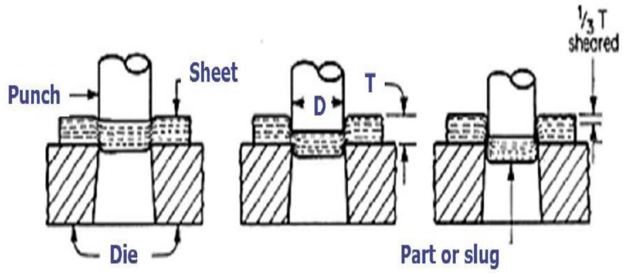

Figure 1: Schematic set-up of shearing operation

Irrespective of the size of the part to be produced, the first step involves cutting the sheet in into appropriate shape by the process called shearing. Shearing operations includes cutting off, parting, blanking, punching, notching, lancing etc. when shearing is conducted between rotary blades, the process referred as slitting. Blanking is the process cutting whole piece from sheet metal. The same process is also used to remove the unwanted part of a sheet, but then the process is called as punching. Similarly, nibbling, trimming are a few more examples of cutting process using the same principle of shearing process.

1.1.2 Bending

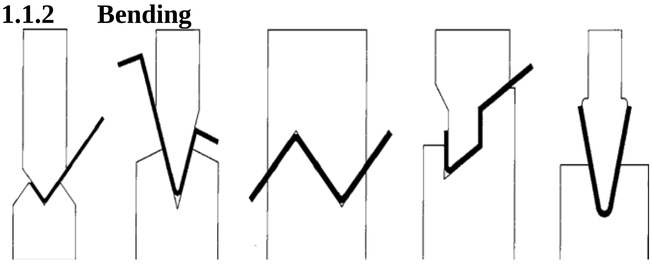

Figure 2: Examples of bending

Bending & forming are sometimes used as synonymous terms. Bending is a very common forming process for changing the sheets and plates into drums, channel, etc. In all metal bends, metal is stressed beyond the elastic limit in tension on outside & compression from inside of the bend. The neutral axis of bend remains in original length. Some of sheet metal bends are single bend, double bend, straight flange, curling & wiring etc.

1.1.3 Drawing

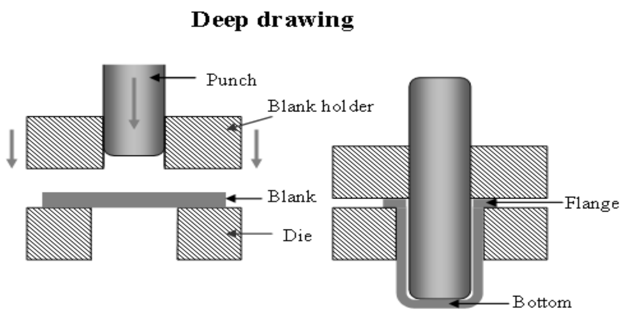

Figure 3: Deep Drawing Process

Drawing is a sheet metal forming process in which a sheet metal produce thin-walled hollow or vessel shaped parts. In deep drawing operation the length of object to be drawn deeper than its diameter, this can be achieved by redrawing the part through a series of dies. The drawing operation is performed by placing a metal blank over a stationary die & exerting calculated pressure from punch.

1.1.4 Squeezing

It‟s a quick & widely used way of forming ductile metal. The squeezing operations are sizing, coining, hobbing, ironing, etc

2. Stages in Shearing Process

Shearing action has basically three stages: plastic deformation, fracture & shear. The Same shearing theory works when punch & die used to form component. The quality of the cut surfaces is depends upon clearance between the two shearing edges.

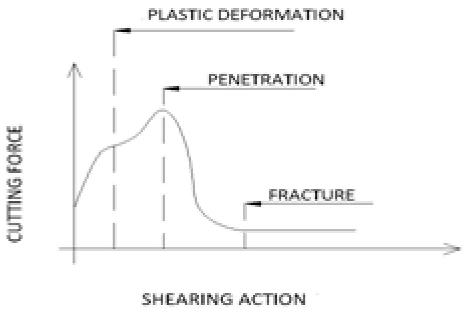

Figure 4: Stages of shearing

3. Component Details

The washer is a component used in an automobile part Assembly. The following component has to be designed to meet its application.

3.1 Material Properties

Material: spring steel sheet
Sheet thickness: 3 mm
Shear strength: 60 kg/mm²

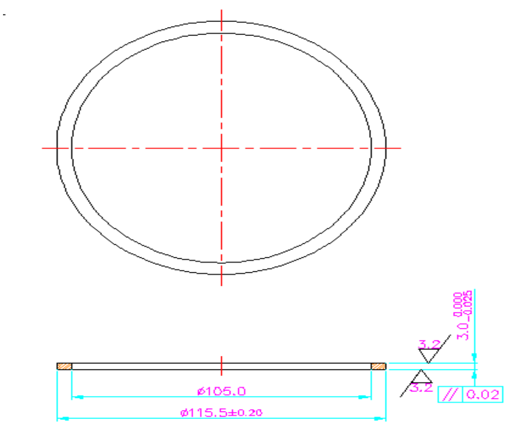

Figure 5: Product Drawing

4. Selection of Press

Designer has to make proper selection of the type of press to be used. The selection of press depends upon various points. While selecting a press the following points should be considered.

1) Force required to cut the metal
2) Stroke length
3) Size and type of die
4) Method of feeding and size of sheet blank
5) Shut height
6) Type of operation

5. Design Consideration

1) The Size, shape & material & Operations to be performed on the component.
2) Selection of the tool such as simple, progressive, compound, combination etc.
3) Selection of proper strip layout.
4) In Progressive tool the strip layout must cover all the stages at proper sequence, considering the rigidity of the die in mind.
5) Considering the Tonnage required & calculations related tool, such as economy factor, plate thicknesses, etc.
6) Try to construct the tool that can be easily modified in future.
7) Shank location should be given at centre of the tool.
8) Tool must be rigid considering its involvement in the type of production such as mass, batch etc.
9) Re-sharpening allowance must be added to punch and die cutting edges.
10) Tool must withstand all the lateral thrust acting on it during operation.

5.1 Strip layout

Economical stock utilization is always should be in mind while designing strip layout. The goal should be at least 60 percent utilization. In preparing the strip layout the distance between the two points of blanks and the edge of strip should not less than the sheet thickness.

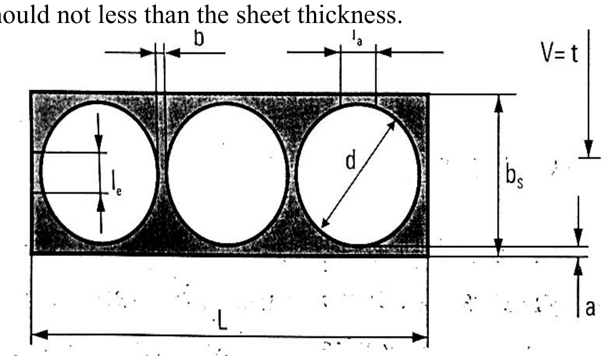

Figure 6: Strip layout

Where,
L= length of strip, d = length of part, a = front scrap,
b = back scrap, bs = strip width, D = scrap bridge.
D= diameter of component.

5.2 Strip layout for tool

Choice of the strip layout method depends on the following factors.

1) Grain direction
2) Production requirement.
3) Stock material.
4) Shape of blank.
5) Burr side.

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5.3 Cutting Force

It is the force which acts on stock material in order to cut out the blank. It determines the capacity of the press to be used for the particular tool.

Cutting force = L X S X f (max)

Where,

L= Length of periphery to be cut in mm. (perimeter)
S= Sheet thickness in mm.
f (max) = shear strength of stock material in kg/mm2

5.4 Method of reducing press force

To prevent press overloading it is necessary to reduce cutting force. Following are the methods used to reduce press force by providing shear angle. It reduces shock to press & smooth cutting operation. Shear angle should be 1 to 1.5 times the sheet thickness. Double shear angle is preferred over singe shear angle because it does not create lateral forces.

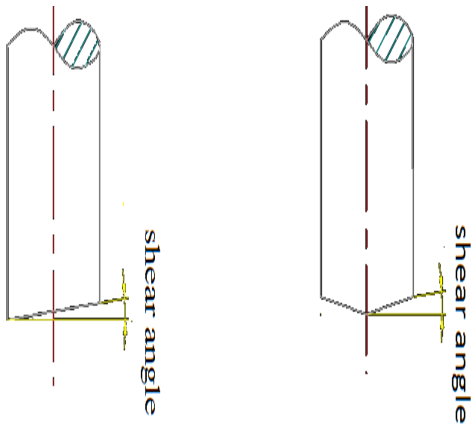


Figure 7: Single shear & double shear

To prevent distortion on the stock material For Blanking operation the shear angle is provided on die member. For Piercing operation the shear angle is provided on punch member.

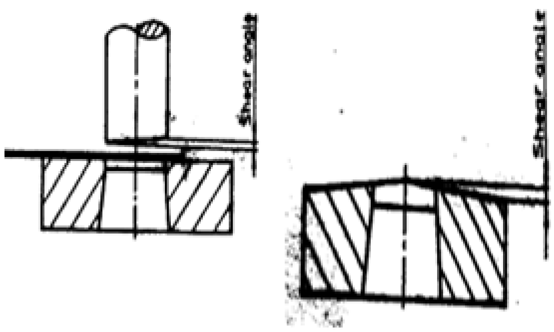


Figure 8: Shears angle punch & die

6. Tool Design

Before designing the tool, the above shown points in design considerations should be followed with Component study, Thickness of the Component, Material, and Machine to accommodate the process, Critical dimensions of the component. On the bases of the Study made try to obtain the component with the accurate dimensions, functional, acceptable quality, appropriate for the production process & economic.

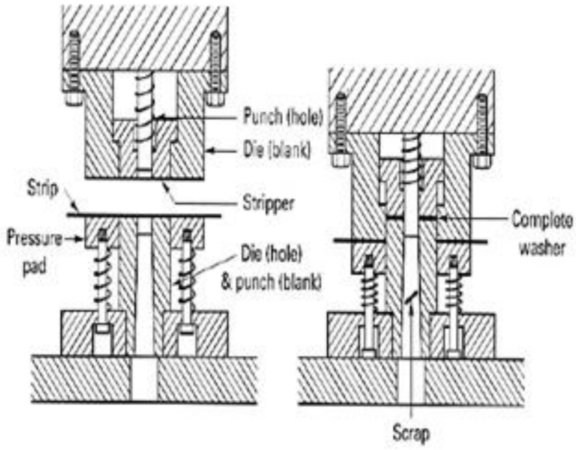


Figure 9: making of simple washer in compound tool

6.1 Material Selections

On the bases of the study made, the D2 material is used for die. The other parts material shown in below table as:

Table 1: Materials for press tool

Sr No.	*Elements*	*Material*
01	Pilot	Heat treated steel (56 to 60HRC)
02	Bottom Plate	Mild Steel
03	Top Plate	Mild Steel
04	Stripper Plate	OHNS (45 to 50 HRC) for higher production
05	Stopper	Hardened steel
06	Dowels	Alloy steel (case hardened 58 HRC)
07	Screws	Mild steel
08	Die	D2
09	Punch holder plate	Cast iron, semi steel, rolled steel
10	Thrust plate	Hardened (45 to 50 HRC)
11	Punch	Alloy steel (hardened and tempered 58 to 60 HRC)

Table 2: composition of D2

C	Si	cr	Mo	V
1.50%	0.30%.	12.00%	0.80%	0.90%

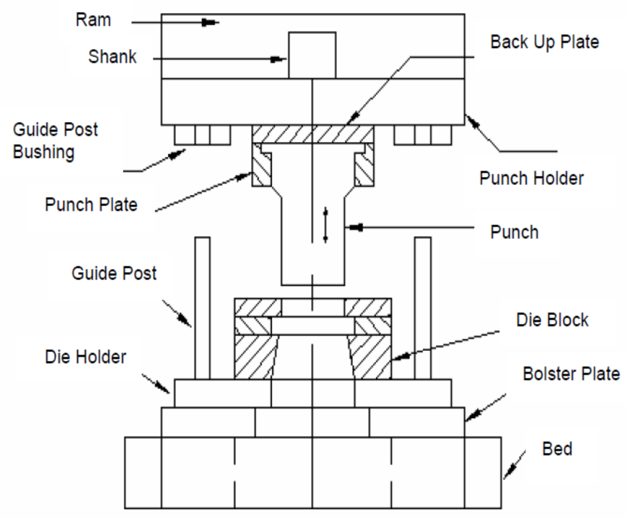


Figure 10: Elements of press tool

6.2. Calculations

6.2.2 Economy Factor

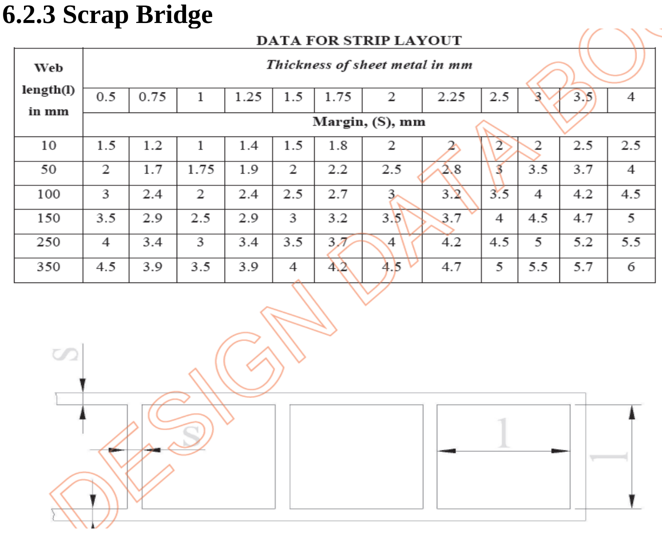
$$\text{Economy factor} = \frac{\text{Area of blank} \times \text{no. of rows}}{\text{pitch} \times \text{strip width}} \times 100$$

No. of rows = 1, Pitch = 120 mm, Strip width = 124 mm

$$\text{Economy factor} = \frac{1845 \times 1}{120 \times 124} \times 100$$

=12.40 **%**

6.2.3 Scrap Bridge



DATA FOR STRIP LAYOUT

Web length(l) in mm	Thickness of sheet metal in mm											
	0.5	0.75	1	1.25	1.5	1.75	2	2.25	2.5	3	3.5	4
	Margin, (S), mm											
10	1.5	1.2	1	1.4	1.5	1.8	2	2	2	2	2.5	2.5
50	2	1.7	1.75	1.9	2	2.2	2.5	2.8	3	3.5	3.7	4
100	3	2.4	2	2.4	2.5	2.7	3	3.2	3.5	4	4.2	4.5
150	3.5	2.9	2.5	2.9	3	3.2	3.5	3.7	4	4.5	4.7	5
250	4	3.4	3	3.4	3.5	3.7	4	4.2	4.5	5	5.2	5.5
350	4.5	3.9	3.5	3.9	4	4.2	4.5	4.7	5	5.5	5.7	6

Figure 11: data for strip layout

From the above table Scrap Bridge thickness is 4.35 mm taken.

6.2.4 Cutting Force:

$$\text{CUTTING FORCE, F} = \text{S} \times \text{P} \times \text{T}$$

Where,

S = Shear strength of the component material in kg/mm²

P = Perimeter of the component in mm, T = Thickness of the component in mm

$$\text{CUTTINGFORCE} = 60 \times 693 \times 3$$
$$= 124740 / 1000$$
$$= 124.7 \sim 125\ \textit{TONNE}$$

6.2.5 Stripping Force:

$$\text{STRIPPING FORCE} = 20\%\ \text{OF CUTTING FORCE}$$
$$\text{STRIPPING FORCE} = \frac{20}{100} \times 125$$
$$\text{STRIPPING FORCE} = 25\ \textit{TONNE}$$

6.2.6 Press Capacity:

$$= (\text{CUTTING FORCE} + \text{STRIPPING FORCE}) \times \text{FACTOR OF SAFETY}$$
$$\text{PRESS CAPACITY} = (125 + 25) \times 1.2$$
$$\text{PRESS CAPACITY} = 180\ \textit{TONNE}$$

Table 3: fits in press elements

S. No	*Elements*	*Fit*
01	Between Punch & Die	Clearance (clearance per side)
02	Dowel and Plates	Interference fit (h7k6, h7p6 or h7m6)
03	Guide pillar & Guide bush	Clearance (h7g6)
04	In Guide pillar & Bottom plate	Interference fit (h7k6, h7p6 or h7m6)
05	In Guide bush & Top plate	Interference fit (h7k6, h7p6 or h7m6)
06	In Pilot and Die opening	Clearance (h7g6)
07	In Punch holder & Punch	Press fit (H7p6)

Table 4: For calculations

Sheet thickness (S) =3mm				
	Farmulae	Cal.	Value	Assumed Value
Scrap Bridge	T to 1.2T	1.2x3 mm	3.6 mm	4.35 mm
Margin	1.25 to 1.5T	1.5x3 mm	4.5 mm	4.25 mm
Pitch	Length + scrap Bridge	-	120 mm	-
Width		-	124mm	-
Cutting Clearance	8 – 10%	8% per side	0.08 mm	-
Area of Component	-	10504 - 8659 mm	1845 sq. mm	-
Perimeter of Component	-	363+330 mm	693 mm	-
Cutting Force	(LxSxShear Strength)	(693x3x60)/1000	124.68 Tonne	125
Stripping Force	10-20% of cutting force	.0.2x125	25	-
Press Tonnage	Total Cutting force X factor of safety	150x1.2	180	-
Shut height – 375±10 **Shank size** - Ø55x72mm **Brawn Spring** - Ø50x60mm **Yellow Spring** - Ø40x51mm				

Table 5: For plate thickness

	Farmulae	Calculation	Value	Assumed Value
Die Plate (Td)	$\sqrt[3]{\text{cutting force}}$	$= \sqrt[3]{125}$	50 mm	30 mm
Bottom plate	1.75 Td to 2Td	1.75x30 to 2x30 mm	-	-
Stripper plate	0.75Td	0.75x30 mm	22.50 mm	30 mm
Thrust plate	15 to 20 mm	-	-	25 mm

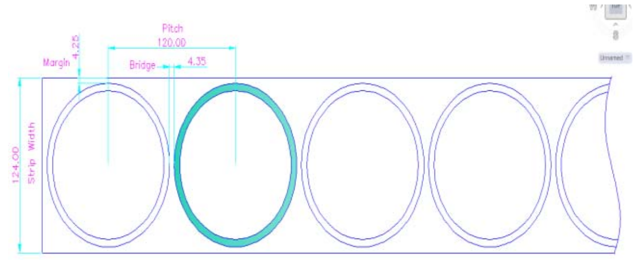


Figure 12: Strip Layout

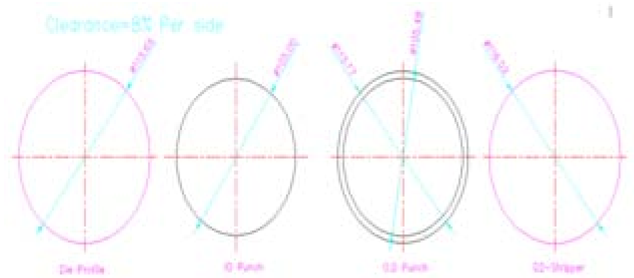


Figure 13: Clearance on punch & die

7. Assembly and 3-D View of Press Tool

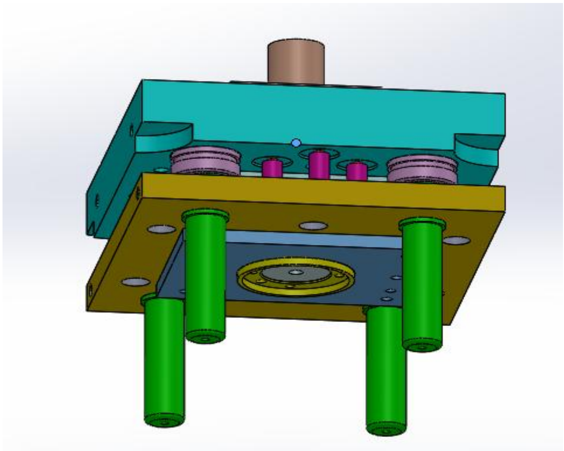


Figure 14: Top half of tool

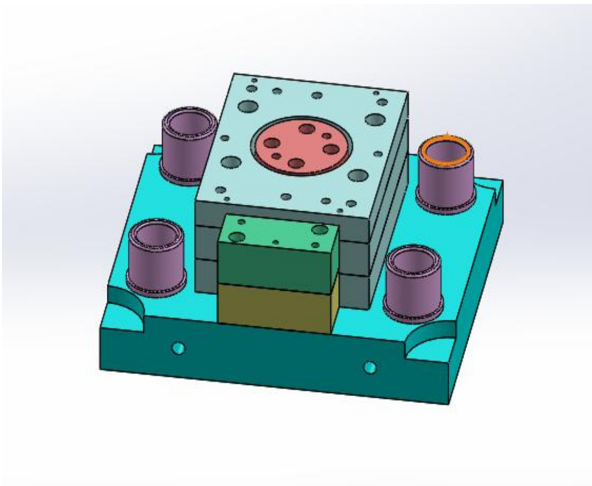


Figure 15: Bottom half of tool

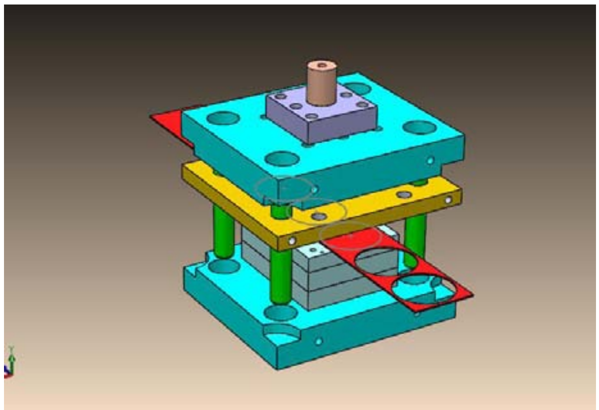


Figure 16: Tool with strip layout

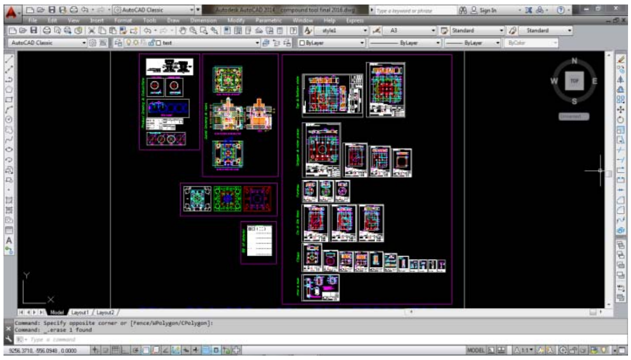


Figure 17: Drafting done in AutoCAD

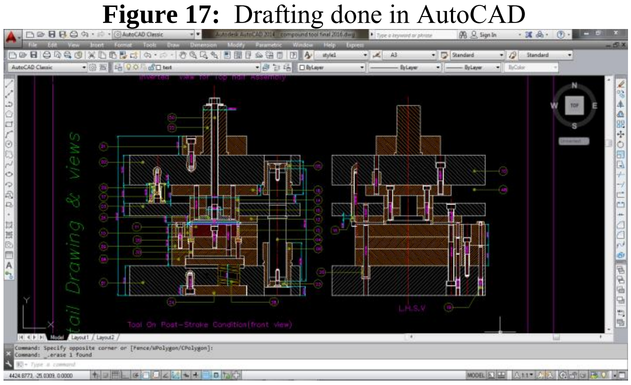


Figure 18: Tool in AutoCAD

8. Methodology and Process Planning

8.1 Process Planning

It generally includes the following considerations.

- Quantity required – total and annual.
- Work piece – shape & size.
- Work piece – dimensional tolerances.
- Work piece – material limitations.
- Equipment available for manufacture.

In every tool design the process planning plays important role .it‟s always necessary to fallow proper methodology for manufacturing tool, so that one can get accurate dimensional stability for that particular part within appropriate time.

6.2 Manufacturing process planning for each part

- All the features of the part with dimensions & their references with respect to the assembly.

- Planning for sequence of process like non-conventional, conventional, & CNC machining, heat treatment requirements in process & stage inspection etc.
- Plan in advance for Special requirements of the tooling, electrode, and CAD/CAM support for the programs required for the punch & dies that are to be machined on the CNC machines etc.
- Stage drawings of each parts coming & going out from process should be understandable to machine operator showing the references, manufacturing allowances, tolerance analysis, using the ordinate dimensioning and inspection methodology.
- For the completion of the job in the planned time period a continuous follow-up of machine availability is made to maintain the delivery date.

9. Conclusion

This project which I carried was a medium for me to enhance my knowledge in the field of tool design. It helped me lot in better understanding of the concept of press tool & design process.

During the project, I had communicated with various departments and authorities to solve the problems and difficulties around in between. It has helped to improve my abilities to work in design field. In my 45 days training in IGTR Aurangabad I have studied following things-

- Actual design of press tool.
- Gone through the working process in tool room from the stage of design to assembly of tool.
- Manufacturing of press tool on CNC machines.
- 2D & 3D designing of tool using higher end software.
- Studied various parameters, design considerations & calculations involved in the Press tool design.

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