Design and Development of Progressive Tool for manufacturing washer

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Abstract. In a progressive tool the raw material is worked at different station to finally fabricate the component. A progressive tool is a lucrative tool for mass production of components. A lot of automobile and other transport industries develop progressive tool for the production of components. The design of tool involves lot of planning and the same amount of skill of process planning is required in the fabrication of the tool. The design also involves use of thumb rules and standard elements as per experience gained in practice. Manufacturing the press tool is a laborious task as special jigs and fixtures have to be designed for the purpose. Assembly of all the press tool elements is another task where use of accurate measuring instruments for alignment of various tool elements is important. In the present study, design and fabrication of progressive press tool for production of washer has been developed and the press tool has been tried out on a mechanical type of press. The components produced are to dimensions.

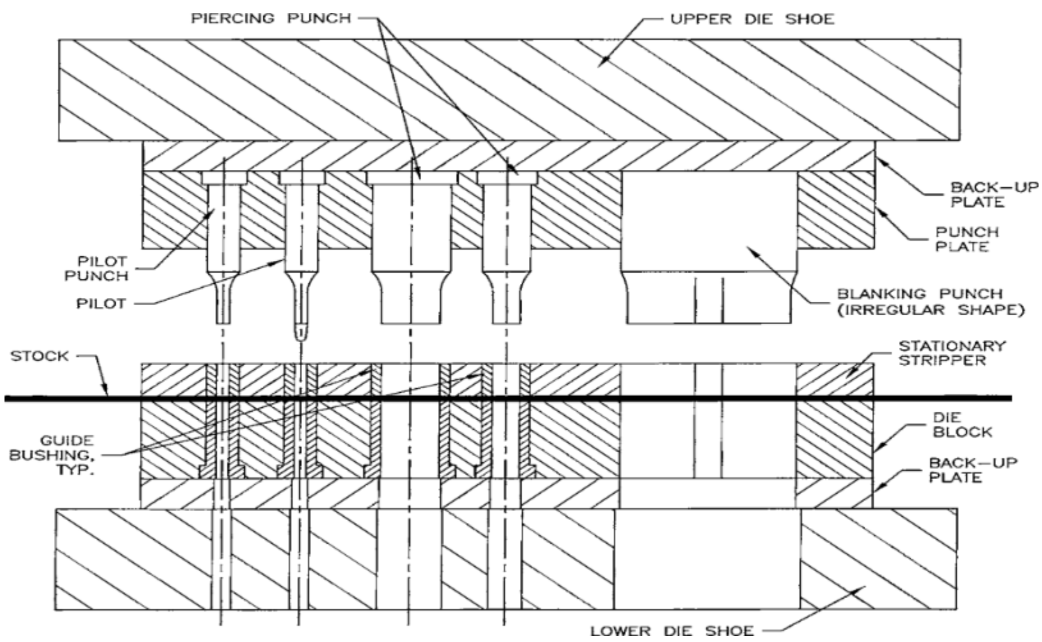
Introduction

Press tools are used to fabricate components in large numbers out of sheet metals. The design of press tool involves common steps to be followed to have an efficient and acceptable outcome. Economy, use of unskilled labour, high degree of precision has made press working indispensable [1].

A washer is a thin plate (typically disk-shaped) with a hole (typically in the middle) that is normally used to distribute the load of a threaded fastener, such as a screw or nut. Other uses are as a spacer, spring (Belleville washer, wave washer), wear pad, preload indicating device, locking device, and to reduce vibration (rubber washer). Washers usually have an outer diameter (OD) about twice the width of their inner diameter (ID). Washers are usually metal or plastic. High quality bolted joints require hardened steel washers to prevent the loss of pre-load due to Brinelling after the torque is applied. Washers are also important for preventing galvanic corrosion, particularly by insulating steel screws from aluminium surfaces. The origin of the word is unknown; the first recorded use of the word was in 1346, however the first time its definition was recorded was in 1611.

In the present design plain washers are being manufactured whose main application is to spread load, prevent damage to the surface being fixed. It is a steel washer with broad tolerances where precision is not critical. The present washer manufactured is not a standard and is a washer of outer diameter 20 millimetres and inner diameter of 10 millimetres. The tolerances on outer dimension and inner dimension are ±0.2 millimetres. The thickness of the washer is 1 millimetre. A progressive press tool has been designed for the purpose. In progressive press tool the final component is obtained by progressing the sheet metal or strip in many stages. In each and every stage the component will get its shape and at the final stage the component is completely ready [2]. In the present design the smaller diameter hole is pierced prior to the blanking of the washer and a pilot has been designed for the proper registering. The strip layout design is based on experience and simple theoretical formula. The shape at each step is designed with the process sequence and all shapes are assembled into a strip. The die design structure is tested in real time to find out the potential defects and hence it is very difficult to obtain an optimum strip layout although this can be reduced by simulation [3]. In the present study, design simulation has not been done.

Figure 1 : Figure of a standard progressive tool with different elements. [8]



Design of press tool [6]

The design of press tool depends on the dimensions of the washer and the strip layout. Following are the design calculations done based on the dimensions of the washer.

Percentage of economic utilization of strip[6]

Pitch is the adjacent distance between two consecutive points in the strip layout for the fabrication of washer.

Figure 2. Strip Layout

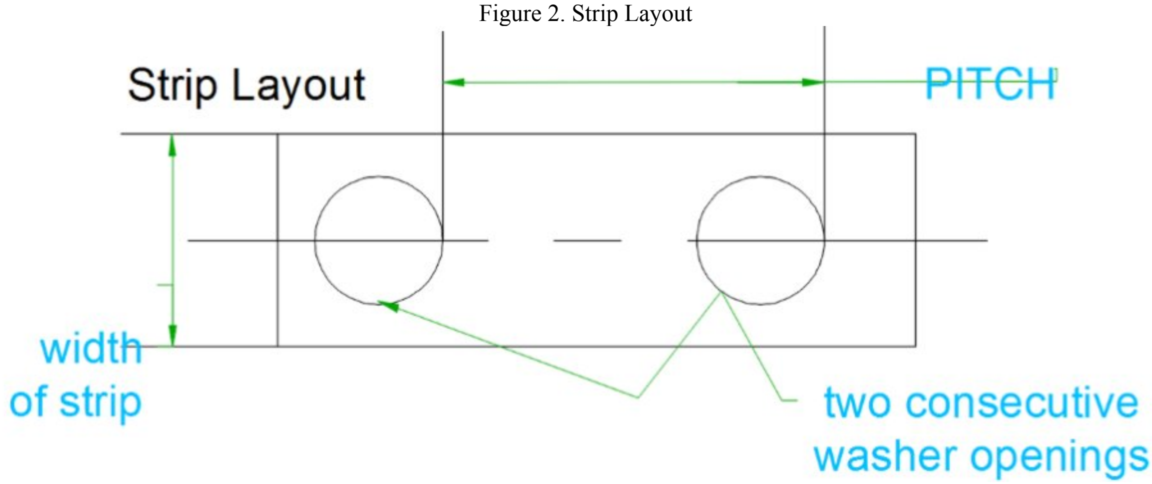


Table 1. Pitch value reference

Material thickness	Stock allowance
0.625-0.75	0.75
0.75-4.5	Thickness of the material
4.5 and above	4.5

From the above table [6] the thickness of the material falls between 0.75 to 4.5, and hence stock allowance is taken as 1 mm (thickness of the strip).

Percentage economic utilization = (Area of component x number of rows x100)/(width of strip x pitch)

$= (3.14/4 \text{x} 20^2 \text{x} 1)/(22 \text{x} 32)$

= 44.60 %

Calculation of press capacity

Material choosen for washer is mild steel[7] which is cold worked of 0.1%carbon and shear strength of 30.22 kgf/mm^2 [6].The formula for cutting force is as follows:

Cutting force = Shear area x Shear strength x thickness

=(2x3.14x10 + 2x3.14x5) x 30.22 x 1

= 2848.16 kgf

= 2.848 tonnes ≈ 3 tonnes

Press capacity is increased by 20% and hence press capacity is 1.2 x 3 = 3.6 tonnes

Flywheel type mechanical press is selected for the fabrication.

Clearance Calculation [6]

Clearance = 0.005 x thickness of washer x √shear strength

= 0.005 x 1 x √30.22

= 0.027 mm/side

Punch Size [6]

For piercing operation

Punch size = Actual diameter size = Ø 10mm

Die Size = Punch size + 2 * Clearance

= 10 + 2 * 0.027

= 10.054 mm

For blanking operation [6]

Punch size = Actual punch size – 2 * clearance

= 20 – (2* 0.027) = 19.946 mm

Die size = Actual outer diameter dimension = Ø20mm

Die Block Size [6]

Die block thickness= $\sqrt[3]{\text{Cutting force in tonnes}}$

$= \sqrt[3]{3}$

= 1.44 cm ≈ 14.4mm≈ 15 mm

Draft Allowance [6]

Die opening = 3 mm, Critical distance = 2 x die plate thickness = 2 x 15 = 30mm

Draft allowance = 1/2° - 2°= 1/2°

Plate Thickness

Plate thickness calculations were referred from [6]

Bottom plate thickness	= 1.75 x die plate thickness = 1.75 x 15 = 27mm
Top plate thickness	= 1.25 x die plate thickness = 1.25 x 15 = 19mm
Punch holder thickness	= 0.75 x die plate thickness = 0.75 x 15 = 12mm
Punch back plate thickness	= 5mm [8]

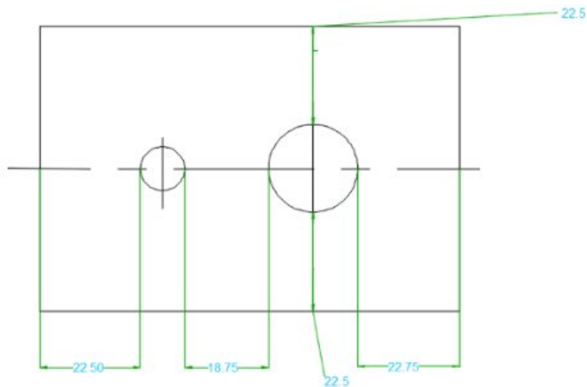
Length and width of die [6]

Length = 1.125 x 20 (diameter of bigger hole in die plate) + 10 (Diameter of inner hole of washer) + 18.75 + 20 + 20 + 1.125 x 20 = 93.75mm≈ 94mm

Width = 1.125 x 20 + 20 + 1.125 x 20= 65mm

Calculation of centre of pressure [8]

Figure 3. Die Plate



Centre of pressure (X-axis) = (2x 3.14x5) x (22.5 + 5) + (2 x 3.14x10) x (18.75 + 10)/ 94.24 = 50 mm
Centre of pressure (Y-axis) = (2x3.14x5) x (22.5 + 5) + (2x3.14x10) x (22.5 + 10)/ 94.24 = 32.5 mm
Hence, the centre of pressure location is (50, 32.5) and this is the position of shank.

Screw dimensions

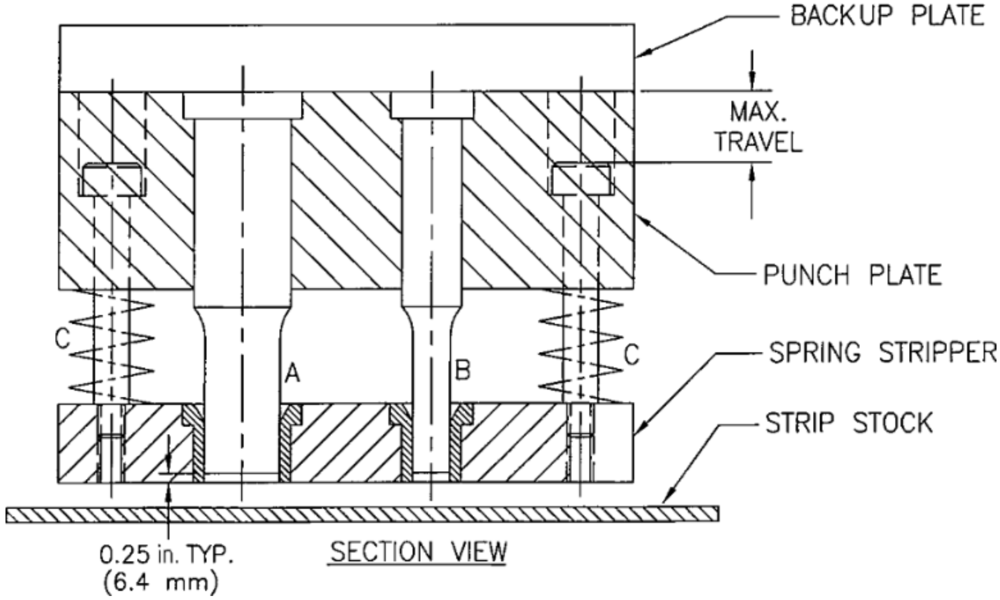
As the force acts in the transverse direction, the force exerted is assumed to be 10% of the shear force applied.
10% of shear force [6] = 10% of 3000 kg = 300kg
Force = stress x Area
300 = 35 (for high strength steel) x (3.14/4) x diameter^2
Diameter of screw is 3.3≈ 4mm

Table 2. Stripping Pressure in terms of Percentage of Cutting Pressure [9]

Stock thickness (mm)	Percentage of Cutting force
up to 1.00	3–8
1.01–2.50	8–10
2.51–4.00	10–13
4.01–6.50	13–20

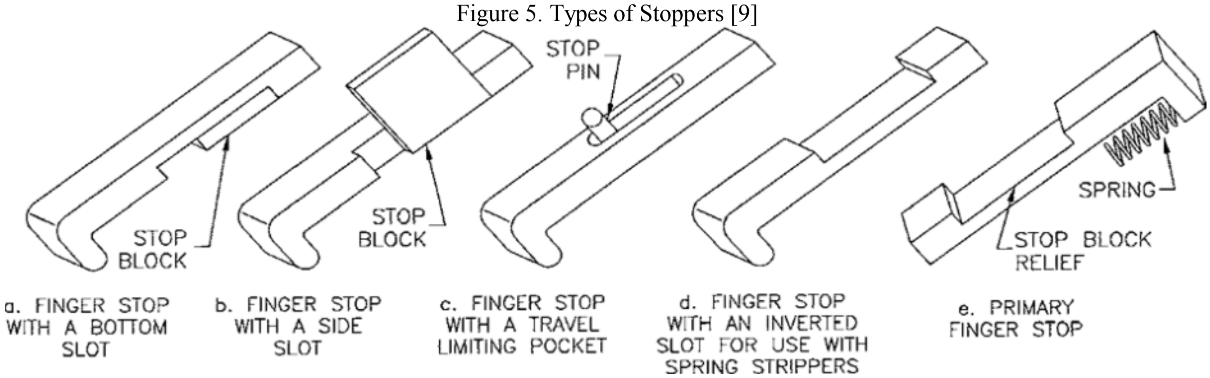
Stripping force = 3% of 3000kgf = 90kgf

Figure 4. Stripper Plate



A rear pillar die set is manufactured on the basis of above dimensions.

Figure 5. Types of Stoppers [9]



In the present design finger stop with a bottom slot has been selected since it is easy to fabricate.

Table.3 Materials selection

Sl.No.	Name of element	Material	Remarks
1	Bottom Plate	C20	
2	Top Plate	C20	
3	Shank	C20	
4	Punches	T105Cr1Mn60 (Tool steel)	Hardened
5	Dies	T105Cr1Mn60 (Tool steel)	Hardened
6	Screws	High tensile strength steel	Standard
7	Gauges	Mild steel (C10)	
8	Stopper	Medium carbon steel (C30)	Hardened
9	Punch plate	Medium carbon steel (C30)	Hardened
10	Stripper plate	Medium carbon steel (C30)	Hardened
11	Springs	Spring steel	Standard
12	Guide Pillar	17Mn1Cr95	Case hardened

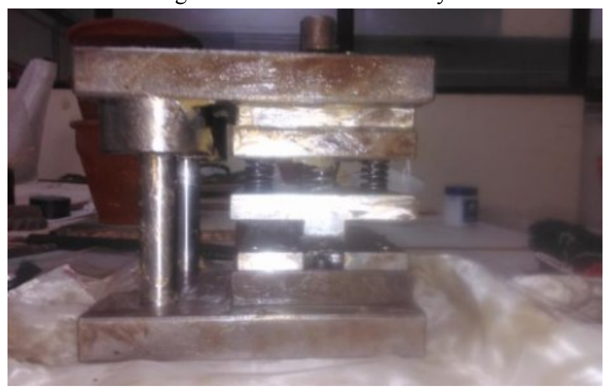
13	Guide bush	low carbon steel (C20)	Case Hardened
14	Dowel pin	C40	Standard
15	Retainer bolt	Medium carbon steel	Hardened

According to Hermann Jutz et al. [8] materials were selected for fabrication of progressive tool. Following are the images of the progressive tool after fabrication

Figure 6. Photos of Progressive Press tool

Figure 6.1 Bottom half of press tool

Figure 6.2 Press tool assembly



6.3 Top half of press tool

Results and Conclusions

The press tool so designed was manufactured using the best manufacturing techniques. The dimensions on the washer manufactured after trying out the press tool on the press were to dimensions. The burr produced was also too less and can be removed with secondary operations if required. It is also to be reported that the design procedure adopted gives correct dimensions of the press tool elements. The concentricity of the centre hole of washer was also maintained in the tool with the use of a pilot. The flatness of the washer was also maintained within requirement which was checked with simple inspection methods. The edges of the blanked washer were sharp and no damage was found on it. The outer and inner diameter of the washer is 20 and 10 mm with thickness of 1 mm with a tolerance of ± 0.2 mm. The flatness of the washer is within ± 0.1 mm.

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