Design Calculation and Analysis of Progressive Press Tool For Square washer

Shiv Shankar Kumar Prasad 1, Asita Kumar Rath 2*

1PG Scholar, Production Engineering Raajdhani Engineering College (BPUT), Bhubaneswar, Odisha, India.

2Assistant Professor, Dept. of Mechanical Engineering, Raajdhani Engineering College, Bhubaneswar, Odisha, India.

shivshankarprasad2006@gmail.com1, asitr06@gmail.com2

Abstract

A progressive press tool used for different types of sheet metal operation in a single stroke. All operations may be shared or both shearing and non-shearing operation. This press tool design for a single row one pass layout. Scrap strip layout design categorized into three essential stages, namely – piercing, piloting and blanking. To stop forwarding one stage to another pitch punch method were used. Raw material is used in small segment form and strip is manually fed. This project aimed that each stage stopping position was removed like primary, secondary and final stage with the help of pitch punch method, rear and face strip guide and also used insert based die plate. Die block is EN8 steel and material of insert is tool steel. Square washer was used for automobile, construction and aircraft industry. It also enables distribution of load and gyration persistently opposed. “In this project, utilization of three-dimensional computer aided design software specifically SOLIDWORKS for press tool elements designed”. Auto CAD for scrap striped layout and ANSYS for tool element analysis.

Keywords: Scrap strip layout, Design parameters calculation, Die plate layout, Assembly drawing, Element’s analysis.

1. Introduction

Progressive tool is a continuous production to produce sheet metal components with the help of punches, dies and other elements like top plate, thrust plate, stripper plate, bottom plate, etc. In press tool we have done two types of operations shearing and non-shearing. If we go to shearing operation the force is applied to shear the sheet metal has above the plastic deformation and non-shearing force has applied to deform the sheet above the elastic limit and below the plastic deformation. In our case only shearing operation is done, so force is applied above the plastic deformation. The process of shearing sheet has four stage- plastic deformation, penetration, fracture and separation. This tool has minimum two operations which are performed at different stages. Last operation is done in last stage blanking or cut off. We provided pilot to registering the sheet in proper position. The design of punch, die and other elements according to our sheet metal component parameters and press machine specification. The accuracy of component depended upon the manufacturing and design parameters of punch and die accuracy, burr and radius formation on component is dependent upon die clearance provided between cutting edge of punch profile and corresponding cutting edge of die profile. To manufacturing the press tool, we can used conventional and non-conventional machines.[1-6].
1.1 Component drawing and data

Material: CRCA1020
Shear strength: 42 Kg/mm²
General tolerance: +0.4 mm

2. Scrap Strip layout Single Row one pass

2.1 Calculation of margin
Unswerving border profile values of face, rear and bridge margin depend on the higher value of profile length or breadth.
If length or breadth is less than 63.5 mm than margin is 1 times of strip thickness.
If length or breadth is 63.5 mm to 203.2 than margin is 1.25 times of strip thickness.
If length or breadth is over 203.2 mm than margin is 1.5 times of strip thickness.

Data required when find economical strip utilization:
Area of blank profile = 822.83 mm²
Number of rows = 01
Strip breadth = 36.7 mm
Pitch length = 31.7 mm

2.2 Percentage of strip utilization [U]

\[ U = \frac{\text{Area of blank profile} \times \text{Number of rows}}{\text{Strip breadth} \times \text{Pitch length}} \times 100 \]

\[ = \frac{822.83 \times 1}{36.7 \times 31.7} \times 100 \]

\[ = 70.72 \% \]

3 Design parameters calculation

3.1 Die clearance [D]

\[ D = K \times T \times \sqrt{S} \]

\[ = 0.01 \times 3 \times \sqrt{42} \]

\[ = 0.20 \text{ mm/side} \]

Where,

K = Constant 0.01
T = Strip thickness [mm]
S = Shearing strength [kg/mm²]

3.2 Calculation of shearing force [Fsh] and stripping force [Fst]

\[ F_{\text{sh}} = P \times T \times S \]

\[ = 184.13 \times 3 \times 42 \]

\[ = 23200.38 \text{ Kg} \]

\[ = 23.2 \text{ tons} \]

Fst = 10 % of shearing force

\[ = 2320.04 \text{ Kg} \]
3.3 Press machine capacity \([Pc]\]

\[ Pc = 1.15 \times \text{Total shearing force} \]
\[ = 1.15 \times 25520.42 \]
\[ = 29348.48 \text{ Kg} \]
\[ = 29.35 \text{ tons} \]

Total shearing force = Shearing force + Stripping force

3.4 Size of die opening and punch opening

For blank profile

Size of die opening = Size of blank profile

\[
\text{Size of die opening} = \text{Size of blank profile} - \text{die clearance per side}
\]

For piercing profile

Size of die opening = Size of piercing profile + die clearance per side

3.5 Size of pilot

Diameter of pilot \([Pd]\)

\[ Pd = \text{Piercing punch diameter} - 2.5 \% \text{ of strip thickness.} \]
\[ = n_{11} - (3 \times 0.025) \]
\[ = 10.92 \text{ mm} \]

Length of pilot \([Pl]\)

\[ Pl = \text{Length of highest punch} + \text{Strip thickness} + 1 \]
\[ = 72 + 3 + 1 \]
\[ = 76 \text{ [mm]} \]

3.6 Screw size calculation

Required number of screws = 4

Stripping force = 2320.04kg

Load withstand per screw = Stripping force / Number of screws

\[ = 2320.04 / 4 \]
\[ = 580.01 \text{ Kg.} \]

Root area of the screw = Load withstand per screw / Permissible stress

Permissible stress = 8 \([\text{Kg} / \text{mm}^2]\)

\[ = 580.01 / 8 \]
\[ = 72.50 \text{ mm}^2 \]

Core area = \(\pi / 4 (D - 1.227P)^2\)

D= outer diameter of thread [mm]
P = Pitch of thread [mm]

Die plate design take screw size M12 and dowel size n10

3.7 Die design calculation

Die plate thickness \([Td]\)

\[ Td = \sqrt[3]{23.2} \]
\[ = 2.852 \text{ cm} \]
\[ = 28.52 \text{ mm} \]
\[ \approx 29 \text{ mm} \]

Die margin = 1.5 X Td

\[ = 1.5 \times 29 \]
\[ = 43.50 \text{ mm} \]
\[ \approx 44 \text{ mm} \]

Die plate length =
Length of cutting profile + (2 X Die margin) = 92.1 + (2 X 44) = 180.10 mm ≈ 180 mm

Die plate breadth = Breadth of cutting profile + (2 X Die margin) + 4d

Where “d” is diameter of screw [mm] = 33.7 + (2 X 44) + (4 X 12) = 169.70 mm ≈ 170 mm

Die land = 1.5 X Strip thickness = 1.5 X 3 = 4.5 mm ≈ 5 mm

Die relief = 1.5° per side

3.8 Based on the die plate design data the other press tool elements sizes

Top plate thickness = 1.25 to 1.75 times of die plate thickness = 1.75 X 23 = 40.25 mm ≈ 40 mm

Bottom plate thickness = 1.75 to 2 times of die plate thickness = 2 X 23 = 46 mm

Thrust plate thickness = 10 mm

Length and breadth of thrust plate same as die plate

Punch holder plate thickness

Same as die plate thickness = 23 mm

Length and breadth of punch holder plate same as die plate

Punch length = Punch holder plate thickness + 15 mm (Gap between punch holder plate and stripper plate) + Stripper plate thickness + strip guide thickness + strip thickness = 29 + 15 + 19 + 6 + 3 = 72 mm

Guide pillar diameter calculation for diagonal pillar

\[ W = \frac{W_1 \times A}{4B} \]

Where

\[ W_1 = \text{Weight of top half tool assembly [Kg]} \]

\[ A = \text{Span between pillars [mm]} \]

\[ B = \text{Pillar length [mm]} \]

\[ W_1 = \text{Weight of (top plate + thrust plate + punch holder plate + cutting punch) X 1.05 [Kg]} \]

\[ = 37.65 \times 23 \]

\[ = 37.65 \times 328.94 / 4 \times 180 \]

\[ = 17.20 \text{ Kg} \]

\[ = \frac{4}{61.2} \times (180)^3 / 61.2 \]

\[ = 35.78 \text{ mm} \]

\[ \approx 36 \text{ mm} \]

4. Die plate layout

![Fig. 6. Die plate layout]
5. Assembly drawing

Fig. 7. Progressive tool assembly

SECTION A-A

Fig. 8. Progressive assembly in isometric view

SECTION B-B

INVERTED TOP VIEW

6. Element’s analysis

Static structural analysis is used to find out the stresses, strains, induces forces and displacement in the elements. When the system structure subjected various loads, developed stresses and strains are calculated using structural analysis. The analysis is done by taking different material properties for different elements which are listed below.[7-10].

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Element name</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Top plate</td>
<td>Mild steel</td>
</tr>
<tr>
<td>02</td>
<td>Thrust plate</td>
<td>OHNS</td>
</tr>
<tr>
<td>03</td>
<td>Punch holder plate</td>
<td>EN8</td>
</tr>
<tr>
<td>04</td>
<td>Piercing punch</td>
<td>D2</td>
</tr>
<tr>
<td>05</td>
<td>Blanking punch</td>
<td>D2</td>
</tr>
<tr>
<td>06</td>
<td>Pitch punch</td>
<td>D2</td>
</tr>
<tr>
<td>07</td>
<td>Pilot</td>
<td>OHNS</td>
</tr>
<tr>
<td>08</td>
<td>Stripper plate</td>
<td>EN8</td>
</tr>
<tr>
<td>09</td>
<td>Face strip guide</td>
<td>EN8</td>
</tr>
<tr>
<td>10</td>
<td>Rear strip guide</td>
<td>EN8</td>
</tr>
<tr>
<td>11</td>
<td>Die block</td>
<td>EN8</td>
</tr>
<tr>
<td>12</td>
<td>Die insert</td>
<td>D2</td>
</tr>
<tr>
<td>13</td>
<td>Bottom plate</td>
<td>Mild steel</td>
</tr>
<tr>
<td>14</td>
<td>Guide bush</td>
<td>EN36</td>
</tr>
<tr>
<td>15</td>
<td>Guide pillar</td>
<td>EN36</td>
</tr>
</tbody>
</table>

6.1 Equivalent stress results

Equivalent (von-mises) stress result of top half assembly.

Fig. 9. Top half assembly diagram

Equivalent (von-mises) stress result of bottom half assembly.
Fig. 10. Bottom half assembly diagram
Equivalent (von-mises) stress result of piercing punch

Fig. 11. Piercing punch diagram
Equivalent (von-mises) stress result of blanking punch

Fig. 12. Blanking punch diagram
Equivalent (von-mises) stress result of pitch punch

Fig. 13. Pitch punch diagram
Equivalent (von-mises) stress result of pilot

Fig. 14. Pilot diagram
Equivalent (von-mises) stress result of die plate

Fig. 15. Die plate diagram
6.2 Deformation results
Deformation result of top half assembly

![fig16]

**Fig. 16. Top half assembly diagram**

Deformation result of bottom half assembly

![fig17]

**Fig. 17. Bottom assembly diagram**

Deformation result of piercing punch

![fig18]

**Fig. 18. Piercing punch diagram**

Deformation result of blanking punch

![fig19]

**Fig. 19. Blanking punch diagram**

Deformation result of pitch punch

![fig20]

**Fig. 20. Pitch punch diagram**

Deformation result of pilot

![fig21]

**Fig. 21. Pilot diagram**
Deformation result of die plate

Fig. 22. Die plate diagram

6.3 Result
From the structural analysis carried out above it was found that maximum deformation for punch and die plate were 0.01781 & 4.1901X10^-5 mm. And the limiting stress [11-15],i.e., equivalent stress was found to be 0.258 & 0.8816 MPa. So, it can be concluded that our design is safe as 100% load was applied after which only very small amount of deformation was found in die plate and punch. The details of all stress and deformation value are listed below.

Table 1. Equivalent Stress (MPa) & Deformation in mm

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Assembly Name</th>
<th>Equivalent Stress (MPa)</th>
<th>Deformation (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Minim &amp; Maxi</td>
<td>Mini &amp; Maximu</td>
</tr>
<tr>
<td>01</td>
<td>Top half assembly</td>
<td>2.9904 X10^-5 &amp; 0.83 95</td>
<td>0 &amp; 0.00015</td>
</tr>
<tr>
<td>02</td>
<td>Bottom half assembly</td>
<td>5.8995 X 10^-11 &amp; 0.69 58</td>
<td>0 &amp; 6.3781 X 10^-5</td>
</tr>
<tr>
<td>03</td>
<td>Piercing punch</td>
<td>0.0049 &amp; 0.05 75</td>
<td>0 &amp; 1.65 X10^-5</td>
</tr>
<tr>
<td>04</td>
<td>Blanking punch</td>
<td>0.0066 &amp; 0.10 36</td>
<td>0 &amp; 0.0178</td>
</tr>
<tr>
<td>05</td>
<td>Pitch punch</td>
<td>0.0086 &amp; 0.25 85</td>
<td>0 &amp; 0.0002</td>
</tr>
<tr>
<td>06</td>
<td>Pilot</td>
<td>0.0522 &amp; 0.51 58</td>
<td>0 &amp; 0.0001</td>
</tr>
<tr>
<td>07</td>
<td>Die plate</td>
<td>0.0039 &amp; 0.88 16</td>
<td>0 &amp; 4.1901 X10^-5</td>
</tr>
</tbody>
</table>

Conclusions
In this paper design and analysis of progressive press tool for square washer is done. The complete layout and tool were developed using AutoCAD and solid works. Further structural analysis of tool was done to check the strength of die plate and punches. It was found from analysis that strength of die plate and punches are sufficient to resist the force generated on it.

References

Journals

Book


