Design, Development and Analysis of Press Tool for an Industrial Part

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Abstract: A progressive die performs a number of operations like piercing, blanking, punching, etc in a single die at each workstation. At each stroke of press machine, finished part is obtained. This work deals with design of progressive tool having four workstations by using solidWorks 2013 for modeling the parts and 3dQuick press which is an add on software on solidWorks2013. Tool involves blanking, piercing and bending operations.

Keywords: progressive die, solidWorks 2013 3dQuick press, piercing, blanking, punching.

I. INTRODUCTION

Progressive die is a die which performs two or more operations subsequently in a single stroke. Finished part can be produced in a single stroke. In a Progressive die the strip is feed from one end and final part is collected from the other end. In this paper, the progressive die has four workstations. Cropping and piercing, piercing, bending 1 and bending 2 are the operations performed respectively at workstations one, two, three and four.

II. MATERIAL FOR DIE COMPONENTS

Selecting appropriate tool steel is crucial for achieving good productivity, tooling economy and quality of part. Whole tool is not required high strength material, because all parts of tool does not involve in operation. More important members are die, punch and hitting pad.

The main principle while selecting the material for that part is given as,

i. The tool material have more wear, abrasive or adhesive resistance than the part material. Also its friction force is more than part material.

ii. The hardness of material is more than the part material.

iii. Fatigue, shear, compressive strength is more than part material strength and plastic or elastic deformation strength is less than the part material strength.[9]

Here D2 type of steel is used for punch and die. It has more hardness and strength.

III. DESIGN OF PROGRESSIVE DIE

A. Die Clearance

Die clearance is depend on the part material property. If the material is ductile in nature then the clearance is small and for brittle material it is large clearance. If the clearance is given in reverse then there for ductile material it pass through die means here it draw from die instead of cutting. And in ductile material it damages the cutting edges of punch and die. The die clearance for mild steel is 2.5% or 5% of thickness per side.

C = 2.5 % of thickness

= (2.5/100) x 0.5 = 0.0125 mm
Large clearance increases the tool life. So here take 5% of thickness per side.

B. Force Analysis

1) Shear Force: The force required to be exerted by the punch in order to shear out the stock can be estimated from the actual shear area and shear strength of the material by using formula,

\[ F = f_s \times L_s \times t \]

Where,
\[ f_s = \text{shear strength of the blank material [N/mm}^2\text{]} \]
\[ L_s = \text{shear length [mm]} \]
\[ t = \text{thickness of the blank material [mm]} \]

Shear force at station one (F1)

\[ L_1 = f_s \times L_{1s} \times t \]
\[ L_{1s} = 228.79 \]
\[ F1 = 378.5 \times 228.79 \times 0.5 \]
\[ = 43327.10 \text{ N} \]

Shear force at station two (F2)

\[ L_2 = f_s \times L_{2s} \times t \]
\[ L_{2s} = 36.86 \times F2 \]
\[ = 378.5 \times 36.86 \times 0.5 \]
\[ = 6981.49 \text{ N} \]

Shear force at station four (F3)

\[ L_3 = f_s \times L_{3s} \times t \]
\[ L_{3s} = 32 \]
\[ F2 = 378.5 \times 32 \times 0.5 \]
\[ = 6060 \text{ N} \]

The total shear force is the sum of shear force on each station

\[ F_{\text{Total shearing}} = F1 + F2 + F3 \]
\[ = 43327.10 + 6981.49 + 6060 \]
\[ = 56368.60 \text{ N} \]

2) Bending Force: Bending force required to bend a work piece depends upon the thickness of the work piece. The bending force will be calculated from the knowledge of material properties and the die characteristics. Bending force can be calculated using formula,

\[ B.F = \frac{c \times W \times S \times t^2}{L} \]

Where, \( c = \text{die opening factor, 0.33} \)
\( L = \text{width of die opening in mm} \)
W = width of sheet at bend in mm
Su= tensile strength in kg/mm²

**Bending force at station three (BF1)**

\[
BF_1 = \frac{0.33 \times 40 \times 505 \times 0.5^2}{8.5}
\]

\[
BF_1 = 196 \text{ N}
\]

**Bending force at station four (BF2)**

\[
BF_2 = \frac{0.33 \times 3.4 \times 505 \times 0.5^2}{7.5}
\]

\[
BF_2 = 18.88 \text{ N}
\]

The total bending force is the sum of bending force at each station

\[F \text{ Total bending} = BF_1 + BF_2\]

\[= 196 + 18.88\]

\[= 214.88 \text{ N}\]

**C. Press Tonnage Required**

The capacity of the press is the ability to deliver enough force necessary to perform the metal working operation. And the press machine should be capable of delivering about 33% more force than the required for consistent performance. The plan is to design a progressive die for the multiple operation in a single stroke of the ram, the individual values for shearing and bending should be added.

Total Force per component = F Total bending + F Total shearing

\[= 67642.32 + 214.88\]

\[= 67857.20 \text{ N}\]

Therefore, total tonnage required considering factor of safety is 10 Tone

**D. Design of Die Parts**

1) **Die plate.** The die assembly including the stripper and all bottom elements are mounted on the bottom plate. The bottom plate gives cushioning effect to the die and provides enough space for the tool to be clamped to the press bed. There may be an opening in the base plate, which allows the blank, or slug to fall and clear off from the tool.

It is usually made from D2 tool steel material and is hardened to 60-62 HRC. It provides cutting edge. When the cutting action is over, the punch withdraws from the die but the stock strip will also move along with the punch. So for next operation, the strip cannot be moved forward. To facilitate this function one plate is fixed above the die plate. This removes the strip from the punch by the unit called stripper. A good stock guide design always allows for staggering the entryway so that the work piece will not snag; a good design also allows for the stock guide to be removable from the die.
without components having to be disassembled [3]. The die opening has different designs and the design is selected after looking in the requirements and facilities available. The most common die section has straight line and angular clearance. The angular clearance is given in order to allow easy fall of components and slugs. And the land of the die is 1.5t = 0.75 mm die land. First die block for station one and two the cutting perimeter is 265.65 mm and the shearing force is 68751.59 N (7010.71 kg).

**Thickness:**
The thickness of die block is given by the formula;

\[ T_d = \frac{3}{4} \sqrt{\frac{F_{sh}}{E}} \]

Where, \( T_d \) = Thickness of die plate in mm \( F_{sh} \) = Shear force in kg

For first die plate:

\[ T_d = \frac{3}{4} \sqrt{7010.71} \]

\( T_d = 19.14 \text{ mm} \approx 20 \text{ mm} \)

For second die plate:

\[ T_d = \frac{3}{4} \sqrt{917.73} \]

\( T_d = 9.71 \text{ mm} \approx 10 \text{ mm} \)

**Deflection and stress:**

**Deflection:**
It was assumed that the die block (die plate) to be fixed beam. The recommended deflection of the die block should be less than 0.025 mm. [2]

\[ \delta = \frac{FL^3}{16EI} \]

\[ I = \frac{bh^3}{12} \]

Where; \( F \) = 80% of shearing (cutting) force act on the vertical direction [7].

\( E \) = modulus of elasticity = 2.1 \times 105 \text{ N/mm}^2

\( I \) = moment of inertia of the die block

For first die block:

Assumption: The force is uniformly distributed load

\( F = 0.8 \times 68751.59 \text{ N} \)

\( = 55001 \text{ N} \)

Where, \( L \) is the distance between the successive screw = 110 mm

\( b = 110 \text{ mm} \) and \( h = 20 \text{ mm} \), \( I = 73333.33 \text{ mm}^4 \)

\[ \delta = \frac{55001 \times 110^3}{192 \times 2.1 \times 10^5 \times 73333.33} \]

\( = 0.024 \text{ mm} < 0.025 \)

Hence, deflection of die plate is within allowable limit.

For second die block:

\( F = 0.8 \times 8999.85 \text{ N} \)

\( = 7199.88 \text{ N} \)
Where, L is the distance between the successive screw = 125 mm

\[ b = 80 \text{ mm and } h = 10 \text{ mm, } I = 6666.66 \text{ mm}^4 \]

Deflection, \( \delta = \frac{7195 \times 125^3}{182 \times 1 \times 10^5 \times 6666.66} \)

\[ = 0.052 \text{ mm > 0.025} \]

Since the calculated deflection (0.052) value is above the recommended deflection (0.025) value it required to increase the thickness of die block to reduce the deflection. After iteration the proper thickness of the die block is 20 mm, hence the deflection will be below the recommended value

\[ I = 22500 \text{ mm}^4 \]

\[ \delta = 0.015 \text{ mm} \]

Hence, deflection of die plate is within allowable limit.

**Stress:**

For first die block:

\[ \sigma = \frac{25001}{2200} \]

\[ \sigma = 25 \text{ N/mm}^2 \]

The stress induced 25 N/mm\(^2\) which is much less than the allowable strength 2,200 N/mm\(^2\), hence it is safe design.

For second die block:

\[ \sigma = \frac{7194.96}{1280} \]

\[ \sigma = 5.99 \text{ N/mm}^2 \]

The stress induced 5.99 N/mm\(^2\) which is much less than the allowable strength 2,200 N/mm\(^2\), hence it is safe design.

2) **Bottom Plate.** The bottom plate gives cushioning effect to the die and provides enough space for the tool to be clamped to the press bed. There may be an opening in the base plate, which allows the blank, or slug to fall and clear off from the tool. The die assembly all bottom elements are mounted on the bottom plate. The material selected for the top plate is St-42.

**Thickness:**

Thickness of the bottom plate is given by,

\[ Tb = 1.5 \times Td \]

\[ = 1.5 \times 23.3 \text{ mm} \]

\[ = 34.95 \text{ mm } \approx 35 \text{ mm} \]

**Deflection and stress:**

**Deflection:**

Bottom plate is considered to be on parallels, the recommended deflection of the die bottom bolster (die shoe) should be less than 0.025 mm by controlling the span between the parallel blocks, or by increasing the bottom bolster thickness in the lower tool. The lower tool can be considered as a simply supported beam with a uniformly distributed load. For the system it is used seven parallel blocks to support the bottom plate.
Deflection,
\[ \delta = \frac{5FL^4}{384EI} \]

\[ F = 0.8 \times 67642.32N \]
\[ = 54113.85 \text{ N} \]

Where, \( L \) is the distance between the successive screw = 180 mm
\( b = 260 \text{ mm and } h = 35 \text{ mm} \)
\( I = 928958.33 \text{ mm}^4 \)
\[ \delta = \frac{5 \times 14112.93 \times 180^4}{384 \times 26 \times 10^6 \times 928958.33} \]
\[ = 0.022 \text{ mm} < 0.025 \]

Hence, deflection of die plate is within allowable limit.

**Stress:**
\[ \sigma = \frac{54113.85}{5100} \]
\[ \sigma = 5.94 \text{ N/mm}^2 \]

The stress induced 5.94 N/mm\(^2\) which is much less than the allowable strength 240 N/mm\(^2\), hence it is safe design.

3) **Top Plate:** The upper working member of the tool is called the top plate. The punch assembly including the punch holder and thrust plate is mounted on the top plate. The tool shank, which locates the whole tool centrally with the press ram, is also screwed into the top plate. Material chosen for the top plate is St-42.

**Thickness:**
Thickness of the bottom plate is given by,
\[ T_t = 1.25 \times T_d \]
\[ = 1.25 \times 23.3 \text{ mm} \]
\[ = 29.12 \text{ mm} = 30 \text{ mm} \]

4) **Punch plate:** The punch is usually fitted to a plate with a light press fit. Punch holder holds all types of cutting and guiding parts to ensure alignment between punch and die made of St-42.

**Thickness:**
Thickness of the punch plate is given by,
\[ T_p = 0.5 \times T_d \]
\[ = 0.5 \times 23.3 \text{ mm} \]
\[ = 11.65 \text{ mm} = 12 \text{ mm} \]

5) **Stripper plate:** The primary purpose of a stripper is to remove the stock from the punch after a blanking or piercing operation. However the stripper serves two other secondary functions also. Firstly it guides the strip if fixed to the die block surfaces. Secondly, it holds the blank under pressure before the punch descends fully if the stripper is of spring loaded type.

**Thickness:**
Thickness of the bottom plate is given by,
\[ T_s = 0.75 \times T_d \]
Deflection and stress for Top Half:

**Deflection:**

It can be considered as a simply supported beam loaded at the center and the deflection is given by:

\[
\delta = \frac{FL^2}{4EI}
\]

F = 0.8 \times 67642.32N = 54113.85 N

Where, L is the distance between the successive screw = 160 mm

\[b = 260 \text{ mm and } h = 30 \text{ mm, } I = 585000 \text{ mm}^4\]

\[\delta = \frac{54113.85 \times 160^2}{48 \times 1.1 \times 15^6 \times 585000} = 0.037 \text{ mm} > 0.025\]

Since the calculated deflection (0.037) value is above the recommended deflection (0.025) value it required to increase the thickness of die block to reduce the deflection. After iteration the proper thickness of the die block is 35 mm, hence the deflection will be below the recommended value

\[I = 928958.33 \text{ mm}^4\]

\[\delta = 0.023 \text{ mm}\]

Hence, deflection of die plate is within allowable limit.

**Stress:**

\[
\sigma = \frac{54113.85}{5100} = 5.94 \text{ N/mm}^2
\]

The stress induced 5.94 N/mm² which is much less than the allowable strength 240 N/mm², hence it is safe design.

6) **Guide Pillar and Guide Bush:** Guide pillar and guide bush are very important elements in press-tool. Pillar and bush guide the moving and fixed half of the tool in the press and they are also used to ensure accurate alignment between the punches and die. These are made of case hardened St-42. Pillar and bushes are hardened and tempered to 56-58 HRC.

**Buckling for guide pillar:**

Guide pillar material, St-42 with a compressive strength of 330 N/mm² and \(E = 2.1 \times 105 \text{ N/mm}^2\)

Where, \(L_e = 2L\) for one end fixed and other end free

\[I = 142\]

\[I = \frac{\pi X D^4}{64} = 51445.76 \text{ mm}^4\]

\[D = 32 \text{ mm}\]

\[A = 804.24 \text{ mm}^2\]

\[r_g = \frac{1}{\sqrt{A}} = 8\]

\[SR = \frac{L_e}{r_g} = 35.5\]
Where, $\text{rg} =$ radius of gyration

$\text{S.R} =$ slenderness ratio

$\text{T.S.R.} =$ transition slenderness ratio

Johnson’s equation will be used to calculate the critical buckling load because of the slenderness ratio (S.R) is less than the transition slenderness ratio (T.S.R).

\[
F_{\text{cri}} = A(S_y) - \frac{S_y^2}{4\pi^2E} \left( \frac{L}{r_g} \right)^2
\]

\[
F_{\text{cri}} = 604.24(240 - \frac{240^2}{4\pi^2E} \times 2) = 264725.40 \text{ N} > 16964.30 \text{ N}
\]

The applying load is less than the critical load carrying capacity of the guide pillar (264725.40 N), therefore the structure is safe.

Load per pillar = \[
\frac{67857.20}{4} = 16964.30 \text{ N}
\]

$F = 80 \% \text{ of } 16934.30$

\[
= 13571.44 \text{ N}
\]

Deflection, $\delta = \frac{FL}{AE}$

\[
= \frac{13571.44 \times 142}{804.24 \times 5.3 \times 10^5} = 0.011 \text{ mm}
\]

Stress, $\sigma = \frac{13571.44}{804.24} = 16.87 \text{ N/mm}^2$

The stress induced 16.87 N/mm$^2$ which is less than the allowable strength 240 N/mm$^2$ hence, the structure is safe.

7) Punch: A punch is the male member of a press tool to get a component from the strip. The shank should be running fit and the length of the shank should be 1 to 2 mm less than shank hole depth to ensure full contact of the ram face with the top bolster of the tool. The shank clamping screw should be almost at the center of the tapered part of the shank. It is made out of good quality alloy steel called HCHCr (D2) material and hardened to 58-62 HRC. The proper length of a punch has a considerable effect on the overall performance of the die. With too long punches, the compressive stress on them may be excessive, resulting in frequent breakages. The maximum length of a punch may be calculated with the aid of Euler’s formula, for punch fixed at one end and guided at the other end the critical force computed by the formula.

\[
F_{\text{cri}} = \frac{2\pi^2E I_{\text{min}}}{L^2}
\]

If critical force $F_{\text{cri}}$ equals punch force, then the maximum length of the punch may be calculated by the following formula:

\[
L_{\text{max}} = \sqrt{\frac{2\pi^2E I_{\text{min}}}{P}}
\]

For cylindrical Punch: $D = 5\text{mm}$, $E = 2.1 \times 105 \text{ N/mm}^2$, $P = 2973.18 \text{ N}$

Critical max Length =
\[ L_{\text{max}} = \sqrt{\frac{\pi^2 E l_{\text{min}}}{P}} = \sqrt{\frac{2\pi^2 \times 2.1 \times 10^5 \times 30.67}{2973.18}} \]
\[ = 206.68 \text{mm} \]

This is the safe maximum length that can perform without failure.

\[ I = \frac{\pi X D^4}{64} = \frac{\pi \times 20^4}{64} = 30.67 \text{ mm}^4 \]

**Buckling for Punch:**

Punch material, D2 with a compressive strength of 2200 N/mm² and \( E = 2.1 \times 10^5 \text{ N/mm}^2 \)

Where, \( L_e = 2L \) for one end fixed and other end free

\[ I = 62 \]
\[ A = 20 \text{ mm}^2 \]
\[ r_g = \sqrt{\frac{1}{A}} = 1.23 \]
\[ S.R = \frac{L_e}{r_g} = 100 \]
\[ T.S.R. = \sqrt{\frac{2.4L_e^2}{S.R}} = 43.38 \]

Where, \( r_g = \) radius of gyration
\( S.R = \) slenderness ratio
\( T.S.R. = \) transition slenderness ratio

Euler’s equation will be in use to calculate the critical buckling load because the slenderness ratio is greater than the transition slenderness ratio.

\[ F_{\text{cri}} = \frac{\pi^2 E I}{L_e^2} \]
\[ F_{\text{cri}} = \frac{\pi^2 \times 2.1 \times 10^5 \times 30.67}{62^2} \]
\[ = 16519 > 2973.18 \]

The applying load is less than buckling/crippling load; it is safe load.

Assuming the piercing punch as one end is fixed and compressive force is acting on other end. For cutting operation (piercing operation) 80% of cutting force is acting on punch as compressive nature [7].

\[ F = 80 \% \text{ of } 2973.18 \]
\[ = 2378.54 \text{ N} \]

**Deflection,** \( \delta = \frac{FL}{AE} \)
\[ = \frac{2378.54 \times 62}{24 \times 2.1 \times 10^5} \]
\[ = 0.035 < 0.25 \text{ mm} \]

**Stress,** \( \sigma = \frac{1278.54}{20} \]
\[ = 118.95 \text{ N/mm}^2 \]

The stress induced 118.95 N/mm² which is less than the allowable strength 2200 N/mm².
IV. FEM ANALYSIS

In the preceding section critical parts of the die is designed by consulting different die hand book, the validation of this design is preferred to perform on software. The critical parts of the die is modeled and the simulation has been done on solidwork2013, during the analysis the boundary condition are appropriately given to the model and the material properties are specified as per the selection for each component.

A. Material Properties

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Part Name</th>
<th>Modulus of elasticity [N/mm²]</th>
<th>Ultimate compressive strength [N/mm²]</th>
<th>Poisson’s ratio</th>
<th>Density [Kg/m³]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Piercing and bending punches</td>
<td>2.1X 10⁵</td>
<td>2200</td>
<td>0.394</td>
<td>7600</td>
</tr>
<tr>
<td>2</td>
<td>Piercing and bending die</td>
<td>2.1X 10⁵</td>
<td>2200</td>
<td>0.394</td>
<td>7600</td>
</tr>
<tr>
<td>3</td>
<td>Top, bottom, stripper and punch plate</td>
<td>2.1X 10⁵</td>
<td>240</td>
<td>0.3</td>
<td>7800</td>
</tr>
<tr>
<td>4</td>
<td>Guide pillar</td>
<td>2.1X 10⁵</td>
<td>240</td>
<td>0.3</td>
<td>7800</td>
</tr>
</tbody>
</table>

B. Loads

Load for some function elements like top half; bottom plate and die plate are applied on Fz positive direction of magnitude as 80% of cutting force as vertical. And for punches like piercing punch, bending piercing punch, notching punch and blanking punch are applied on Fz positive direction of magnitude as calculated cutting force of that operation as compressive load on surface. And also for guide pillar load applied is on Fx positive direction of magnitude as 10 to 20% of cutting force as thrust load and Fz positive direction of magnitude of 80 to 90% of cutting force as vertical load.

C. Analysis

Load for some function elements like top half; bottom plate and die plate are applied on Fz positive direction of magnitude as 80% of cutting force as vertical. And for punches like piercing punch, bending piercing punch, notching punch and blanking punch are applied on Fz positive direction of magnitude as calculated cutting force of that operation as compressive load on surface. And also for guide pillar load applied is on Fx positive direction of magnitude as 10 to 20% of cutting force as thrust load and Fz positive direction of magnitude of 80 to 90% of cutting force as vertical load.

1) Punch1: Material: D2; Yield strength 2,200MPa; F (applied load): 80% of the cutting force = 2379.75N

<table>
<thead>
<tr>
<th>Part Name</th>
<th>Von Misses Stress</th>
<th>Resultant Displacement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min (N/M²)</td>
<td>Max (N/M²)</td>
</tr>
<tr>
<td>Punch 1</td>
<td>2,362,757.8</td>
<td>131,122,688.0</td>
</tr>
</tbody>
</table>

![Fig.1 Displacement plot of punch 1](image1)

![Fig.2 Stress plot of punch 1](image2)
2) **Guiding Pillar**: Material: St-42; Yield strength 240 MPa; F(applied load): 80% of the cutting force = 13571.44 N

**Table III: Stress plots and resultant displacement for guide pillar**

<table>
<thead>
<tr>
<th>Part Name</th>
<th>Von Misses Stress</th>
<th>Resultant Displacement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min (N/M²)</td>
<td>Max (N/M²)</td>
</tr>
<tr>
<td>Guide pillar</td>
<td>4,501.1</td>
<td>14,535,453.0</td>
</tr>
<tr>
<td></td>
<td>0.0</td>
<td>0.0095</td>
</tr>
</tbody>
</table>

![Fig. 3 Displacement plot of guide pillar](image1)

![Fig. 4 Stress plot of guide pillar](image2)

**Table IV: FEM simulation and calculated results**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Part Name</th>
<th>FEM Simulation Results</th>
<th>Calculated Results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Deflection (mm)</td>
<td>Stress (MPa)</td>
</tr>
<tr>
<td>1</td>
<td>Punch 1</td>
<td>0.0097</td>
<td>132</td>
</tr>
<tr>
<td>2</td>
<td>Punch 2</td>
<td>0.047</td>
<td>85</td>
</tr>
<tr>
<td>3</td>
<td>Punch 3</td>
<td>0.023</td>
<td>58</td>
</tr>
<tr>
<td>4</td>
<td>Punch 4</td>
<td>0.014</td>
<td>95</td>
</tr>
<tr>
<td>5</td>
<td>Punch 5</td>
<td>0.00042</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>Punch 6</td>
<td>0.0011</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>Die Block1</td>
<td>0.017</td>
<td>32</td>
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<tr>
<td>8</td>
<td>Die Block2</td>
<td>0.0083</td>
<td>24</td>
</tr>
<tr>
<td>9</td>
<td>Bottom plate</td>
<td>0.0079</td>
<td>20</td>
</tr>
<tr>
<td>10</td>
<td>Top Plate</td>
<td>0.0041</td>
<td>16</td>
</tr>
<tr>
<td>11</td>
<td>Punch plate</td>
<td>0.0045</td>
<td>31</td>
</tr>
<tr>
<td>12</td>
<td>Stripper plate 1</td>
<td>0.0032</td>
<td>25</td>
</tr>
<tr>
<td>13</td>
<td>Stripper plate 2</td>
<td>0.0023</td>
<td>25</td>
</tr>
<tr>
<td>14</td>
<td>Guide Pillar</td>
<td>0.0095</td>
<td>15</td>
</tr>
</tbody>
</table>

V. CONCLUSION

Progressive die is an economical way to form metal components with variety of characteristics, including strength, durability and wear resistance. In this research work, four stage progressive die has been designed for manufacturing of given industrial part.

Finite element method (FEM) analysis is done for piercing punches, bending punches, piercing block, bending block, bottom plate, top half plate and pillars. The analytical and FEM result of critical components of the die is sound and the percentage of error is within the acceptable range.
All the results of stress and displacement which were used as a parameter to check the appropriateness of the design of each component shows that it is within the allowable limit. The results obtained from Solid-works simulation, the stress values for all parts are less than the respective yield stress value of the material. So, the designed progressive die parts are safe under the given loading conditions. The tools which are exposed to wear will work in optimum condition by satisfying structural stability; furthermore parts which are not directly in contact with the blank material give their required function without any difficulty of structural integrity and stability. The deflections of all the parts during operation are kept below 0.025mm as per the recommendation of die manufacturer.

REFERENCES