7. Design of Press working Tools
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Power Presses
- Operations deal with cutting and forming of sheet metal.
- Press
  - Bed or Bolster plate
  - Frame
  - Ram or slide

Press types
- Open back inclinable (OBI) press
- Straight side press
- Press brake
- Double action press
- Triple action press
- Knuckle press
- Hydraulic press

Open back inclinable (OBI) press
Gap frame press

Figure 7.1: Open-back inclinable (OBI) press.
Fig. From Dr. John G. Nee [revised by], Fundamentals of Tool Design, Fourth Edition, 1998, SME

Rated capacities of ANSI standard single-point, gap-type mechanical power presses (metric)

<table>
<thead>
<tr>
<th>Press capacity, kn (tons)</th>
<th>Rating distance above bottom of slide stroke, mm (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non geared</td>
</tr>
<tr>
<td>20 (2.25)</td>
<td>0.5 (0.02)</td>
</tr>
<tr>
<td>50 – 100 (5.6 – 11.2)</td>
<td>1.0 (0.04)</td>
</tr>
<tr>
<td>140 – 300 (15.7 – 33.7)</td>
<td>1.0 (0.04)</td>
</tr>
<tr>
<td>400 – 1000 (45 – 112)</td>
<td>1.6 (0.06)</td>
</tr>
<tr>
<td>1400 – 2240 (157 – 252)</td>
<td>--</td>
</tr>
</tbody>
</table>
Single-action, straight side, eccentric shaft mechanical press

Figure 7.1. Single-action, straight-side, eccentric-shaft mechanical press. (From Dr. John G. Nee (revised by), Fundamentals of Tool Design, Fourth Edition, 1998, SME.

Figure 7.2. A straight-side mechanical press with double-end drive gears and two connections (Smith 2001).

Figure 7.3. Pneumatic piping, tank, and controls labeled on a straight-side press. (Courtesy Versen Corporation)

Figure 7.4. The rated capacity of a mechanical press is available only at the bottom of the stroke. The full force of a simple hydraulic press can be delivered at any point in the stroke (Smith 1994).

Figure 7.5. Two curves for six different mechanical presses. (Courtesy Daily Machine Corporation)

Figure 7.6. (a) A straight-side hydraulic press is designed for applications requiring close alignment and high forces. This design will withstand moderate lateral loads with very little side deflection. (b) A two-cylinder, four-post hydraulic press is suited for light-to-medium-duty work that does not involve lateral (side) loads. (Courtesy Versen Corporation)
Figure 7-6. (a) A straight-side hydraulic press is designed for applications requiring close alignment and high forces. This design will withstand moderate lateral loads with very little side deflection. (b) A two-cylinder, four-post hydraulic press is suited for light- to medium-duty work that does not involve lateral (side) loads. (Courtesy Vector Cospropagion)

Figure 7-7. Sectional view through a press bed and bolster illustrates a pneumatic die cushion.

Figure 7-13. A four-column three-side transfer press with a force capacity of 66,000 tons (460 MN). (Courtesy Vector Corporation)

Figure 7-14. Transfer feeder bars and fingers showing the motion sequence: (1) clamp (catch part); (2) lift up; (3) advance; (4) lower; (5) unclamp; (6) return. (Courtesy Auto Alliance International)

Press brake
Used for bending

Knuckle press
Coining operations
Press Tool Operations

Table 8.1 Classification of press tool-operations

<table>
<thead>
<tr>
<th>Stresses induced</th>
<th>Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shearing</td>
<td>Shearing, blanking, piercing, trimming, shaving, notching, nibbling</td>
</tr>
<tr>
<td>Tension</td>
<td>Stretch forming</td>
</tr>
<tr>
<td>Compression</td>
<td>Coining, sizing, ironing, hobbing</td>
</tr>
<tr>
<td>Tension and compression</td>
<td>Dressing, spinning, bending, forming, embossing</td>
</tr>
</tbody>
</table>

Spring back

- One of the principal concerns in a sheet metal operation, is the spring back of the metal.
- When the metal is deformed, it is first elastically deformed and then plastically.
- When the applied load is removed, the plastic component of the deformation remains permanently, but the elastic part springs back to its original shape.

Shearing action

- The metal is brought to the plastic stage by pressing the sheet between two shearing blades so that fracture is initiated at the cutting points.
- The fractures on either side of the sheet further progressing downwards with the movement of the upper shear, finally result in the separation of the slug from the parent strip.
Clearance

- When correct clearances are used, a clean break would appear as a result of the extension of the upper and lower fractures towards each other.
- With an insufficient clearance additional cut bands would appear before the final separation.
- Ductile materials require smaller clearances and longer penetration of the punch compared to harder materials.
Clearance

• This clearance depends essentially on the material and thickness of the sheet metal.
• This clearance can be approximated per side \( C \), as

\[
C = 0.0032 \times t \times \sqrt{\tau} \text{ mm}
\]

• where, \( t \) = sheet thickness, mm
• and \( \tau \) = material shear stress, MPa

Clearance

• Blanking
• It is a process in which the punch removes a portion of material from the stock which is a strip of sheet metal of the necessary thickness and width. The removed portion is called a blank and is usually further processed to be of some use, e.g., blanking of a pad lock key.

Clearance

• Piercing
• Also sometimes called punching, the piercing is making holes in a sheet.
• It is identical to blanking except of the fact that the punched out portion coming out through the die in piercing is scrap.
• Normally a blanking operation will generally follow a piercing operation.

Clearances as percentage of stock thickness

<table>
<thead>
<tr>
<th>Material</th>
<th>Round</th>
<th>Other contours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft aluminium &lt; 1 mm</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Hard aluminium</td>
<td>4 to 6</td>
<td>5 to 8</td>
</tr>
<tr>
<td>Soft copper alloys</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Hard copper alloys</td>
<td>4</td>
<td>5 to 6</td>
</tr>
<tr>
<td>Low carbon steel</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Hard steel</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Silicon steel</td>
<td>3</td>
<td>4 to 5</td>
</tr>
<tr>
<td>Stainless steel</td>
<td>4 to 6</td>
<td>5 to 8</td>
</tr>
</tbody>
</table>

Figure 7.14. Control of hole and blank sizes by clearance location.

re 7.15. How to apply clearances.
Punching/Shearing Force

- The force required to be exerted by the punch in order to shear out the blank from the stock can be estimated from the actual shear area and the shear strength of the material.
- \[ P = L \tau \]
- where \( P \) = punching force, N
- \( \tau \) = shear strength, MPa
- \( L \) = Length of cut

Stripper

- Due to the release of the stored elastic energy in the stock left on the die, the stock tends to grip the punch as the punch moves upward.
- This necessitates the use of a stripper to separate the punch from the stock.
- The force required for stripping depends besides the material, on other factors such as the position and size of the punched hole.

Stripping force

- Thicker materials or small hole in the middle of a strip require more stripping force than thin material or a hole towards one of the edges.
- A punch which has smooth side walls would strip very easily.
- Similarly more effort is required to strip punches that are close together.

Stripping force

- A general estimate of the stripping force may vary from 2.5 to 20% of the punch force but 5 to 10 percent is good for most of the applications.
- Stripping force, \( P_s = 1.5 \times L \times t \)
- \( L \) = perimeter of cut, in
- \( t \) = stock thickness, in
- \( P_s \) = Stripping force, tons
**Stripping force**

- A general estimate of the stripping force may vary from 2.5 to 20% of the punch force but 5 to 10 percent is good for most of the applications.
- Stripping force in tons, $P_s = 20,600 \times L \times t$
- $L =$ perimeter of cut, mm
- $t =$ stock thickness, mm
- $P_s =$ Stripping force, kN

**Shear**

- To reduce the required shearing force on the punch, for example to accommodate a component on a smaller capacity punch press, shear is ground on the face of the die or punch.
- The effect of providing shear is to distribute the cutting action over a period of time depending on the amount of shear provided.

Thus the shear is relieved of the punch or die face so that it contacts the stock over a period of time rather than instantaneously.

It may be noted that providing the shear only reduces the maximum force to be applied but not the total work done in shearing the component.

**Figure 6-18**

- Effect of shear on the maximum load on punch
- Shear on punch with the resultant distortion of the slug

**Figure 7-10**

- Reducing casting forces
Angular clearance

- In the shearing operation, first the material is elastically deformed and then plastically, and finally removed from the stock strip.
- After the final breaking, the slug will spring back due to the release of stored elastic energy.
- This will make the blank to cling to the die face unless the die opening is enlarged.

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Angular clearance

- The draft provided depends on the material, thickness and shape of the stock used. For thicker and softer materials, generally higher angular clearances are provided.
- The normal value is from 0.25 to 0.75 deg per side but occasionally a value as high as 2 deg may be used.

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Angular clearance

- The die opening increases after every sharpening of the die because of the provision of the angular clearance.
- So, to maintain the die size as per the design, the angular clearance is provided in the die opening along with a straight portion called as die land or cutting land.

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Angular clearance

- The length of the cutting land is about 3 mm for sheets which are less than 3 mm thick.
- For greater thicknesses, die land same as the material thickness has been found to be a good practice.
Sheet Metal Die Design

- Progressive dies,
- Compound dies, and
- Combination dies.

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Screws and Dowels

- Dowels – alignment
- Screws – Joining
- Two dowels are required for proper alignment

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Die Construction

- Screws and dowels

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Die Block

- The die block size essentially depends on the workpiece size and stock thickness. Though sometimes, the type of blank contour and the type of die may also influence the choice of die block size.
- A number of thumb rules are available which are essentially based on practical experience.
Die Block

- The die block should be able to withstand the impact of the punch striking the material.
- The value of A should be 1.25 times the die thickness for smaller dies and 1.5 to 2.0 times for larger dies.

Sectional die construction

Punches

- Plain punches
- Pedestal punches
- Punches mounted in punch plates
- Perforator punches
- Quill punches
- Backup plate
- Slug ejection
Pedestal Punch

Punches mounted in punch plates

Perforator Punch

Set screw
Method of preventing rotation of punch in a punch plate

Quill Punch

Slug ejection

Pilots

• The pilots in progressive dies are used in order to bring the stock into the correct position for the succeeding blanking or piercing operations.
Pilots

- The fit between the pilot size and the pierced hole determines the accuracy of the component produced.
- Too tight a fit between the pilot and pierced hole results in friction which would spoil the component as also, there would be excessive pilot wear.

- Solid pilots are sometimes harmful as in case of misfed stocks whose thickness is above 1.5 mm.
- The pilot in such a case would break.
- Though, with thinner sheets, it may simply pierce the sheet with no damage to the die.

- The indirect pilot is not attached to the punch and is on its own. It enters a previously pierced hole.
- The indirect pilot should be positioned at some distance away from the blanking punch to provide for the necessary stock support during the entry of the pilot.

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- The indirect pilot should be positioned at some distance away from the blanking punch to provide for the necessary stock support during the entry of the pilot.

- 0.050 to 0.100 mm average work,
- 0.025 to 0.050 mm close work, and
- 0.013 to 0.018 mm high precision work.

<table>
<thead>
<tr>
<th>Stock thickness, (mm)</th>
<th>0.130</th>
<th>0.400</th>
<th>0.750</th>
<th>1.500</th>
<th>3.000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot diameter, mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td>0.05</td>
<td>0.08</td>
<td>0.13</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>4.5</td>
<td>0.08</td>
<td>0.13</td>
<td>0.20</td>
<td>0.25</td>
<td>--</td>
</tr>
<tr>
<td>6.0</td>
<td>0.10</td>
<td>0.20</td>
<td>0.25</td>
<td>0.40</td>
<td>--</td>
</tr>
<tr>
<td>7.5</td>
<td>0.10</td>
<td>0.20</td>
<td>0.25</td>
<td>0.40</td>
<td>--</td>
</tr>
<tr>
<td>9.0</td>
<td>0.10</td>
<td>0.20</td>
<td>0.30</td>
<td>0.50</td>
<td>0.75</td>
</tr>
<tr>
<td>12.5</td>
<td>0.13</td>
<td>0.25</td>
<td>0.40</td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>20.0</td>
<td>0.13</td>
<td>0.25</td>
<td>0.40</td>
<td>0.75</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Hence for thicker stocks, it is desirable to use spring loaded pilots.

Fig. From P. N. Rao, Manufacturing Technology, Tata McGraw Hill, 1996.
Stripper and Stock Guide

• The stripper removes the stock from the punch after a piercing or blanking operation.
• The function of a stock guide is as the name implies, guide the stock through the various stations.
• The strippers are classified into two types: channel or box stripper and spring operated stripper or pressure pad.

Die Stops

• Stops are essentially used for stopping the stock while feeding, so as to register the correct position under the punch.
• While using in conjunction with a pilot, the strip is stopped at a position from which, the pilot brings it to the registry position.
End mounted Solid Stop

Pin stop

Latch stop
Pivot pin
Feed

Stock
Stop lever
Actuator
Pivot pin