MEP 291 METAL FORMING

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Chapter-6 | Sheet Metal Forming

Ch.6 Sheet Metal Forming (Press Working or Press Forming)

- **Sheet metal products:** a very large range of consumer and industrial products such as beverage cans, cookware, file cabinets, metal desks, car bodies, and aircraft bodies.(Fig. 16.1).

- **Sheet metal parts:** are light in weight and versatile in shape.

(a)

(b)

Figure 16.1 Examples of sheet-metal parts. (a) Die-formed and cut stamped parts. (b) Parts produced by spinning. *Source:* (a) Courtesy of Aphase II, Inc. (b) Courtesy of Hialeah Metal Spinning, Inc.

Ch.6 Sheet Metal Forming (Press Working or Press Forming)

- **Commonly used sheet metals:**

  - Low carbon steel is the most common because of its low cost and good strength and formability characteristics.

  - TRIP & TWIP steels are popular for automotive applications because of their high strength.

  - Aluminum is commonly used for beverage cans, aircraft and aerospace applications, packaging, kitchen appliance, and in applications where corrosion resistance is required.

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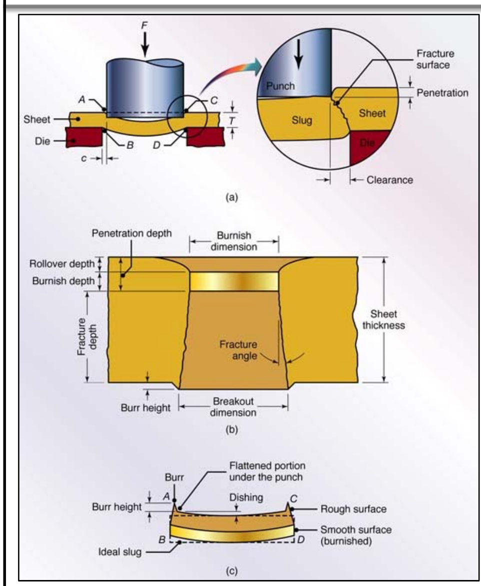
Ch.6 Sheet Metal Forming (Press Working or Press Forming)



- **Before** producing the sheet metal part, a blank of suitable size is removed from a large sheet (coil) by *shearing* using a punch and a die (Fig. 16.2a).

- **The clearance:** is the major factor of the shape and the quality of the sheared edges. As the clearance increases, the zone of deformation get larger and the edge becomes rougher.

Figure 16.2 (a) Schematic illustration of shearing with a punch and die, indicating some of the process variables. Characteristic features of (b) a punched hole and (c) the slug. (*Note:* The scales of the two figures are different.)

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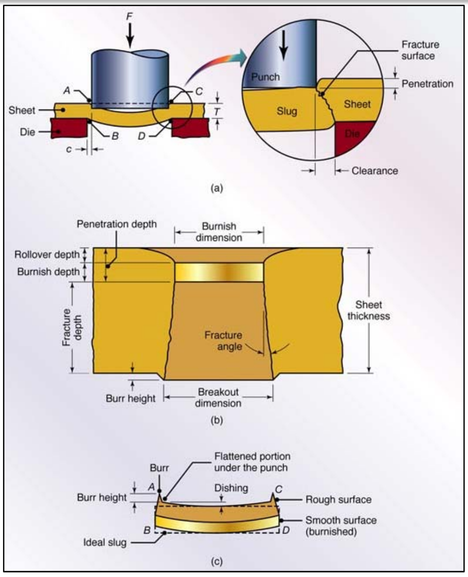
Ch.6 Sheet Metal Forming (Punch Force)



Punch Force:

$$F = 0.7\pi TD\left(UTS\right)$$

Where,

T =*The sheet thickness*

D =*The diameter of the hole*

UTS =*Ultimate tensile strength*

Figure 16.2 (a) Schematic illustration of shearing with a punch and die, indicating some of the process variables. Characteristic features of (b) a punched hole and (c) the slug. (*Note:* The scales of the two figures are different.)

Example-1

Calculate the force required for punching a 1-in diameter hole through a 0.125-in thick annealed titanium alloy (Ti-6Al-4V) sheet at room temperature.
The UTS for this alloy=140,000 Psi.

Solution:

D=1 in
T=0.125 in
UTS=140,000 Psi

Example-1

Punch force:

$$F = 0.7\pi TD\left(UTS\right)$$
$$F = 0.7\pi\left(0.125in\right)\left(1in\right)\left(140,000Psi\right)$$
$$F = 38,500lbf$$

Example-2

Calculate the force required for punching a 25-mm diameter hole through a 3.2-mm thick annealed titanium alloy (Ti-6Al-4V) sheet at room temperature.
The UTS for this alloy=1000 MPa.

Solution:

D= 25 mm
T= 3.2 mm
UTS=1000 MPa

Example-2

Punch force:

$$F = 0.7\pi TD\,(UTS)$$
$$F = 0.7\pi(3.2mm)(25mm)(1000MPa)$$
$$F = 175{,}929N$$

Ch.6 Sheet Metal Forming (Sheet Metal Characteristic)

- **Elongation:** must be uniform (no necking).
- **Anisotropy (directionality):** mechanical properties are different in different planar direction.
- **Grain size:** determines surface roughness and affects materials strength and ductility.
- **Wrinkling:** caused by compressive stress in the surface of the sheet

Ch.6 Sheet Metal Forming (Bending Sheets & Plates)

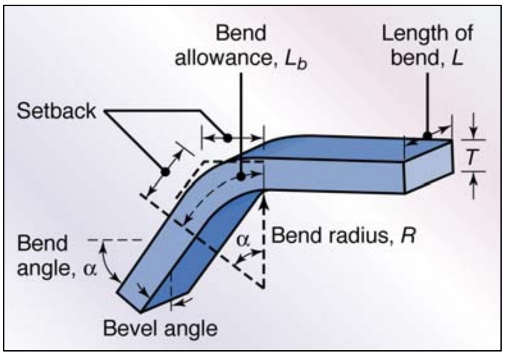


Figure 16.16 Bending terminology. Note that the bend radius is measured to the inner surface of the bent part.

Minimum Bend Radius:

$$R = T\left(\frac{50}{r} - 1\right)$$

Where,

r = *The tensile reduction of area*

T = *The sheet thickness*

Ch.6 Sheet Metal Forming (Bending Sheets & Plates)

Bending Force:

$$F = \frac{kYLT^2}{W}$$

Where,

k = *Is a constant* [0.3 *for wiping die*, 0.7 *for a U-die*, 1.3 *for a V-die*]

T = *The sheet thickness*

Y = *The Yield stress of the material*

L = *The length of the bend*

W = *The width of die opening*

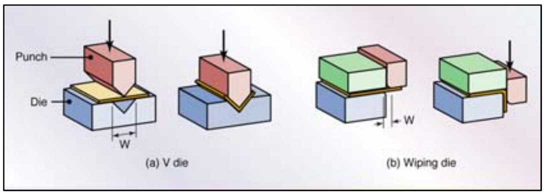
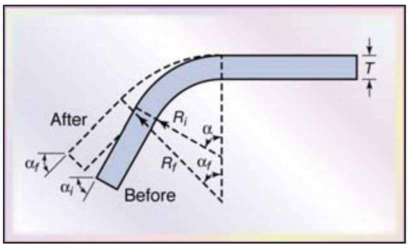


Figure 16.21 Common die-bending operations showing the die-opening dimension, *W,* used in calculating bending forces.

Ch.6 Sheet Metal Forming (Bending Sheets & Plates)

- **Springback:** plastic deformation is always followed by elastic recovery when the load is removed. In bending such recovery is known as *springback*.



Springback:

$$\frac{R_i}{R_f} = 4\left(\frac{R_i Y}{ET}\right)^3 - 3\left(\frac{R_i Y}{ET}\right) + 1$$

Figure 16.19 Springback in bending. The part tends to recover elastically after bending, and its bend radius becomes larger. Under certain conditions, it is possible for the final bend angle to be smaller than the original angle (negative springback).

Example-3

What is the minimum bend radius for a 1.5-mm thick sheet metal with a tensile reduction of area of 30%.

Solution:

T= 1.5 mm
r= 30%

Example-3

Minimum bend radius:

$$R = T\left(\frac{50}{r} - 1\right)$$

$$R = 1.5mm\left(\frac{50}{30} - 1\right) = 1mm$$

Example-4

What is the force required to bend a sheet of thickness 2-mm by using a by a wiping die. The length of the bend is 180-mm and the width of the bend is 50-mm. The yield strength of the sheet is 89.6 MPa.

Solution:

T= 2 mm
L= 180 mm
W= 50 mm
Y=89.6 Mpa
k=0.3

Example-4

Minimum bend radius:

$$F = \frac{kYLT^2}{W}$$

$$F = \frac{(0.3)(89.6MPa)(180mm)(2mm)^2}{50mm} = 387N$$