Sheet Metal Forming Processes

- involves workpieces with a high ratio of surface area to thickness
- plates, thickness > ¼ inch
- sheets, thickness ≤ ¼ inch
- typical items produced by sheet-metal forming processes:

metal desks	appliance bodies
hubcaps	aircraft panels
beverage cans	car bodies
kitchen utensils	

- sheet metal is formed by rolling; if the metal is thin, it is generally coiled
- **shearing**, **bending**, **stretching** are the most common processes for working with sheetmetal to create parts that meet our design intent

SHEARING

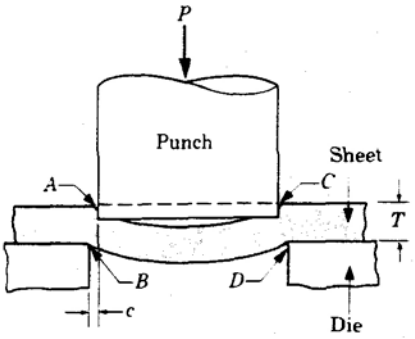


FIGURE 7.4
Schematic illustration of the shearing process with a punch and die. This is a common method of producing various openings in sheet metals.

- cutting sheet metal by subjecting it to shear stresses
- punch and die
- variables of the shearing process
  - punch force
  - speed of the punch
  - lubrication
  - punch and die materials
  - corner radii of punch and die
  - clearance between punch and die

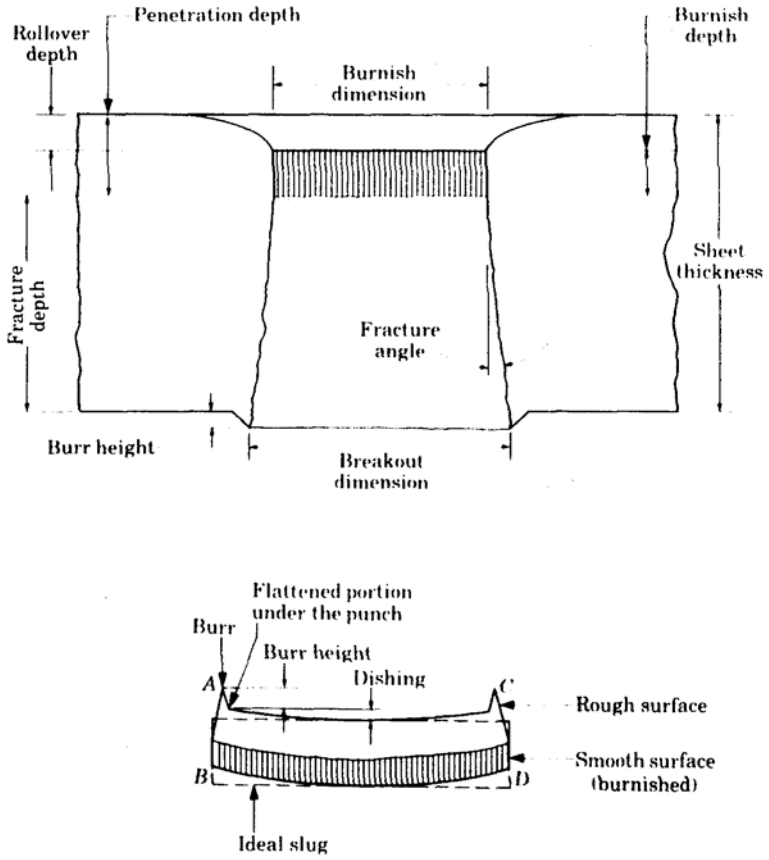


FIGURE 7.5
Characteristic features of a punched hole and the punched slug.

- the clearance distance between the punch and die is the major factor determining the shape and quality of the sheared edge
- as the clearance increases, the edges become rougher
- the punch does not have to go all the way through the sheet
- a burr is usually formed on the sheet and the slug

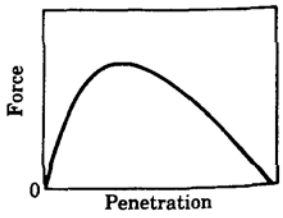


FIGURE 7.8
Typical punch-penetration curve in shearing. The area under the curve is the work done in shearing. The shape of the curve depends on process parameters and material properties.

- the maximum needed punch force can be calculated from the formula

$$P = 0.7\ (UTS)\ t\ L$$

where UTS is the *ultimate tensile strength* of the sheet metal, t is the thickness, and L is the total length of the sheared edge

- two operations –

  punching – the sheared slug is discarded

  blanking – the slug is the part and the rest is scrap

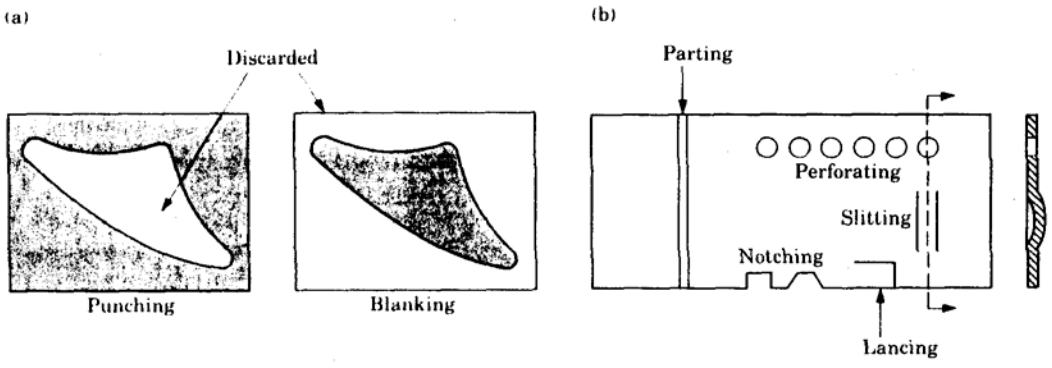


FIGURE 7.9
(a) Punching (piercing) and blanking. (b) Examples of various shearing operations on sheet metal.

- Shearing operations

  punching - the sheared slug is discarded

  blanking - the slug is the part and the rest is scrap

  perforating - punching a number of holes in a sheet

  parting - shearing the sheet into two or more pieces

  notching - removing pieces from the edge

  lancing - leaving a tab without removing any material

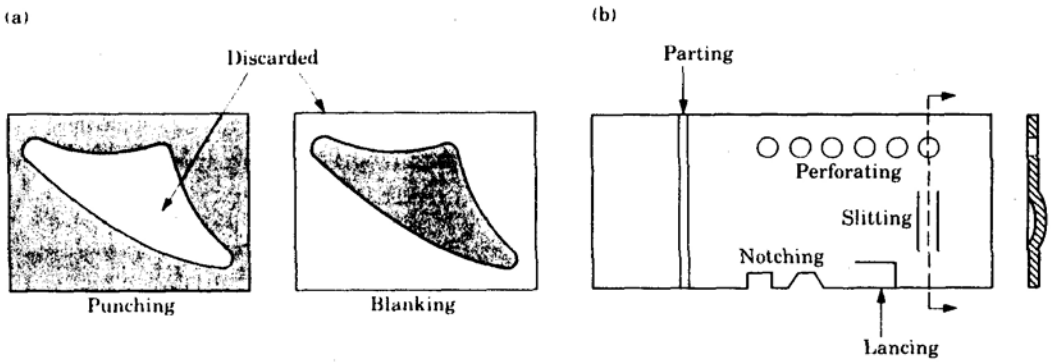


FIGURE 7.9
(a) Punching (piercing) and blanking. (b) Examples of various shearing operations on sheet metal.

BENDING

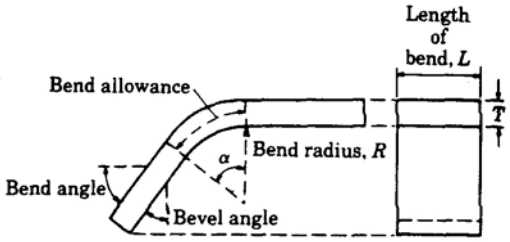


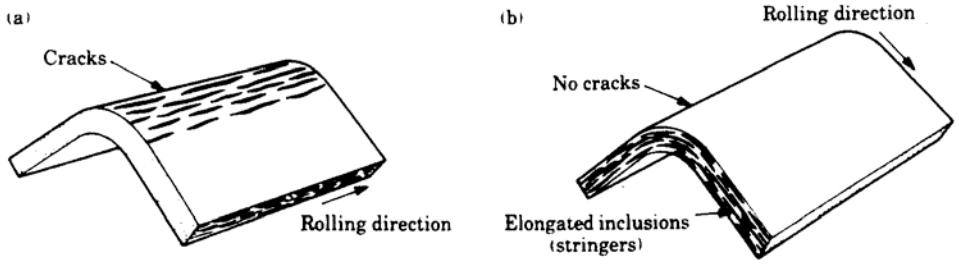
FIGURE 7.15
Bending terminology. The bend radius is measured to the inner surface of the bend. Note that the length of the bend is the width of the sheet. Also note that the bend angle and the bend radius (sharpness of the bend) are two different variables.

- outer fibers are in tension

  inner fibers are in compression
- a minimum bend radius is usually stated in terms of the sheet's thickness (ex. 2T, 3T, 4T)
- the minimum bend radius for various materials has been determined experimentally and is available in handbooks

	Condition	
Material	Soft	Hard
Aluminum alloys	0	6 T
Beryllium copper	0	4 T
Brass, low-leaded	0	2 T
Magnesium	5 T	13 T
Steels		
austenitic stainless	0.5 T	6 T
low carbon, low alloy	0.5 T	4 T

- cracking during bending is related to the rolling direction



- plastic deformation is followed by elastic recovery or *springback*
- the final bend angle after springback is smaller
- the final bend radius after springback is larger

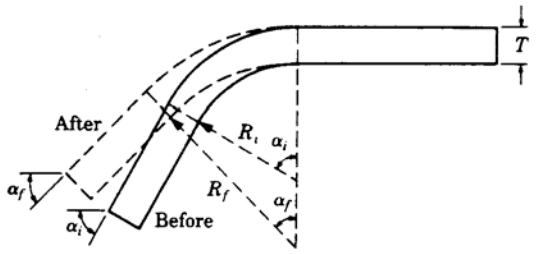


FIGURE 7.19
Terminology for springback in bending. Springback is caused by the elastic recovery of the material upon unloading. In this example, the material tends to recover toward its originally flat shape. However, there are situations where the material bends farther upon unloading (negative springback), as shown in Fig. 7.21.

- springback is usually compensated for by overbending
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- Common Bending Operations
  - press brake forming – press the sheet between two dies

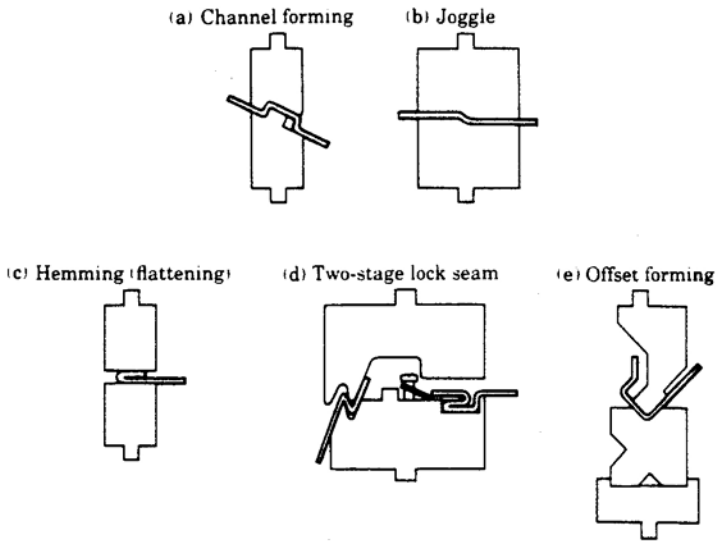

FIGURE 7.25
Schematic illustrations of various bending operations in a press brake.

  - air bending, roller bending

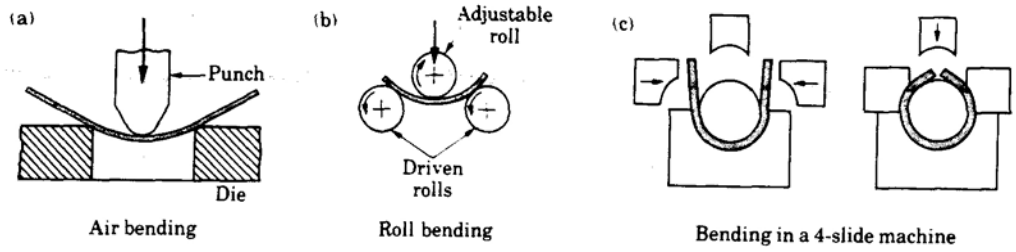

FIGURE 7.26
Examples of various bending operations.

- beading

  the edge of the sheet is bent into the cavity of a die

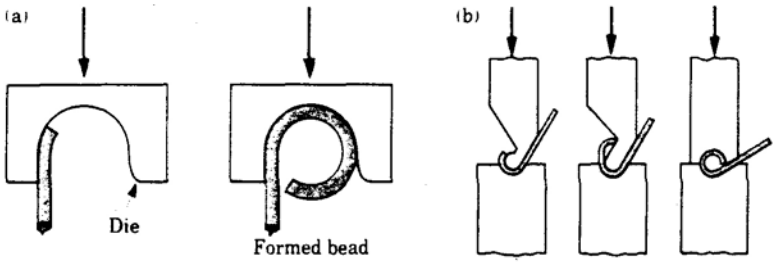

FIGURE 7.27
(a) Bead forming with a single die. (b) Bead forming with two dies in a press brake.

- flanging - bending the edges of the sheet

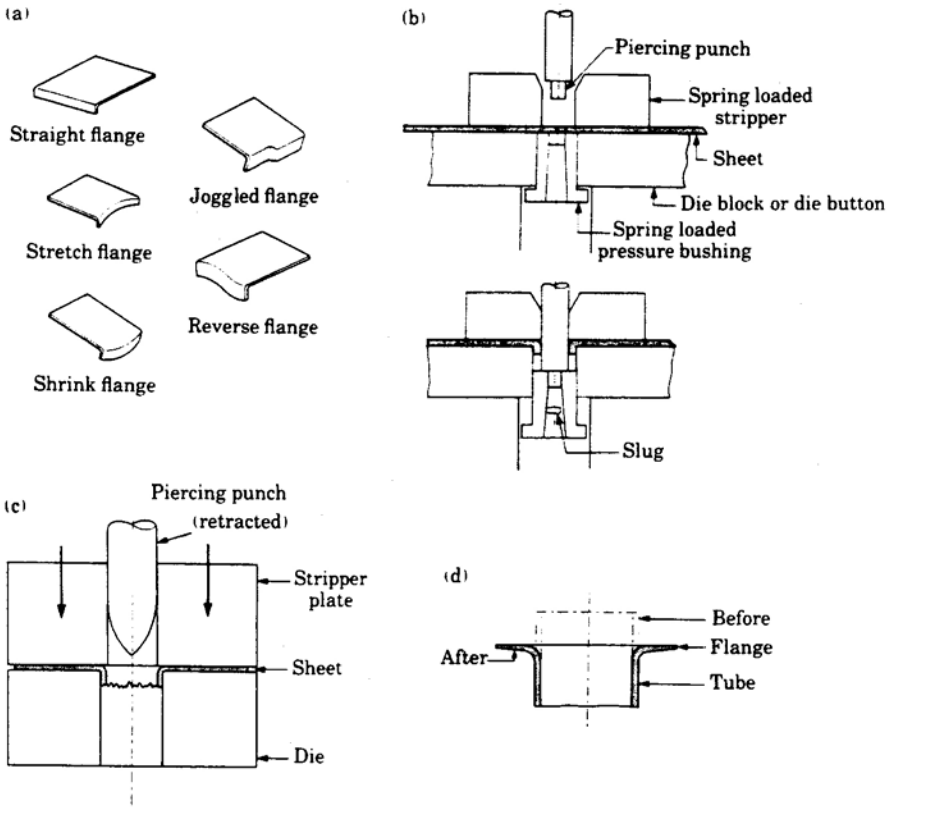

FIGURE 7.28
Various flanging operations. (a) Flanges on flat sheet. (b) Dimpling. (c) Piercing sheet metal to form a flange. In this operation a hole does not have to be prepunched before the punch descends. Note, however, the rough edges along the circumference of the flange. (d) Flanging of a tube. Note thinning of the edges of the flange.

- hemming (flattening)
  - the edge of the sheet is folded over itself
  - improves appearance and removes sharp edges
  - seaming involves joining two edges by hemming

- roll forming
  - used for bending continuous lengths of material
  - metal sheet is bent in stages by passing it through a series of rolls
  - typical products

channels	gutters
siding	panels
frames	pipes and tubing with lock seams

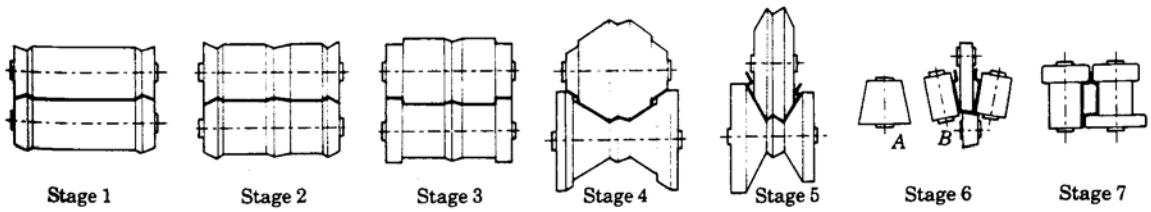

FIGURE 7.30
Stages in roll forming of sheet-metal door frame. In stage 6, the rolls may be shaped as in *A* or *B*. *Source:* G. Oehler.

  - rolling speed is typically about 1.5 m/s (300 ft/min)

- deep drawing
  - a flat sheet is formed into a cylindrical or box shaped part by a punch that presses the blank into the die cavity
  - developed in the 1700's
  - typical products

beverage cans	pots and pans
containers	sinks
automobile panels	

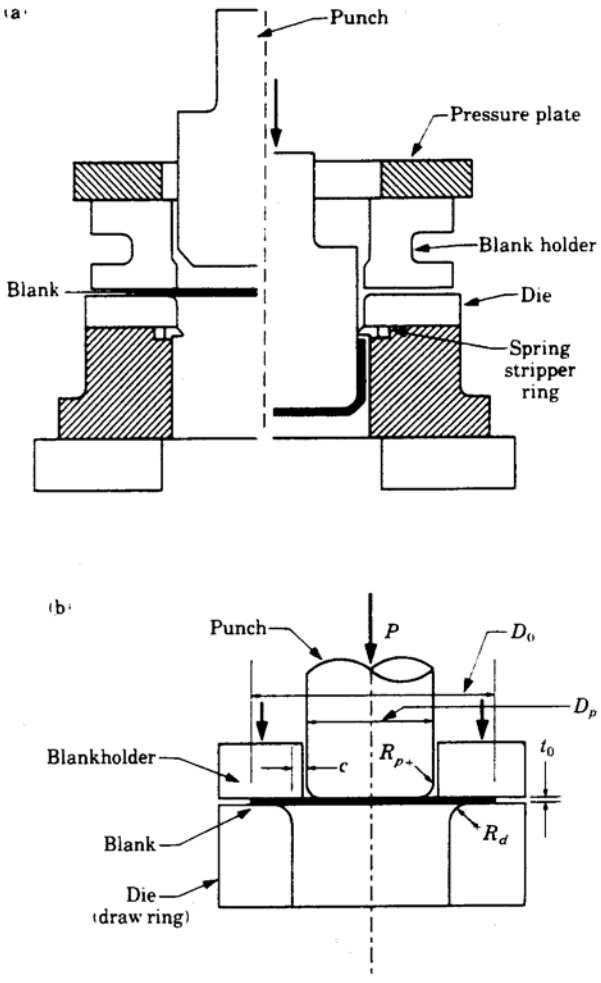

FIGURE 7.52
(a) Schematic illustration of the deep drawing process. This is the first step in the basic process by which aluminum beverage cans are produced today. The stripper ring facilitates the removal of the formed cup from the punch. (b) Variables in deep drawing of a cylindrical cup. Only the punch force in this illustration is a dependent variable; all others are independent variables, including the blankholder force.