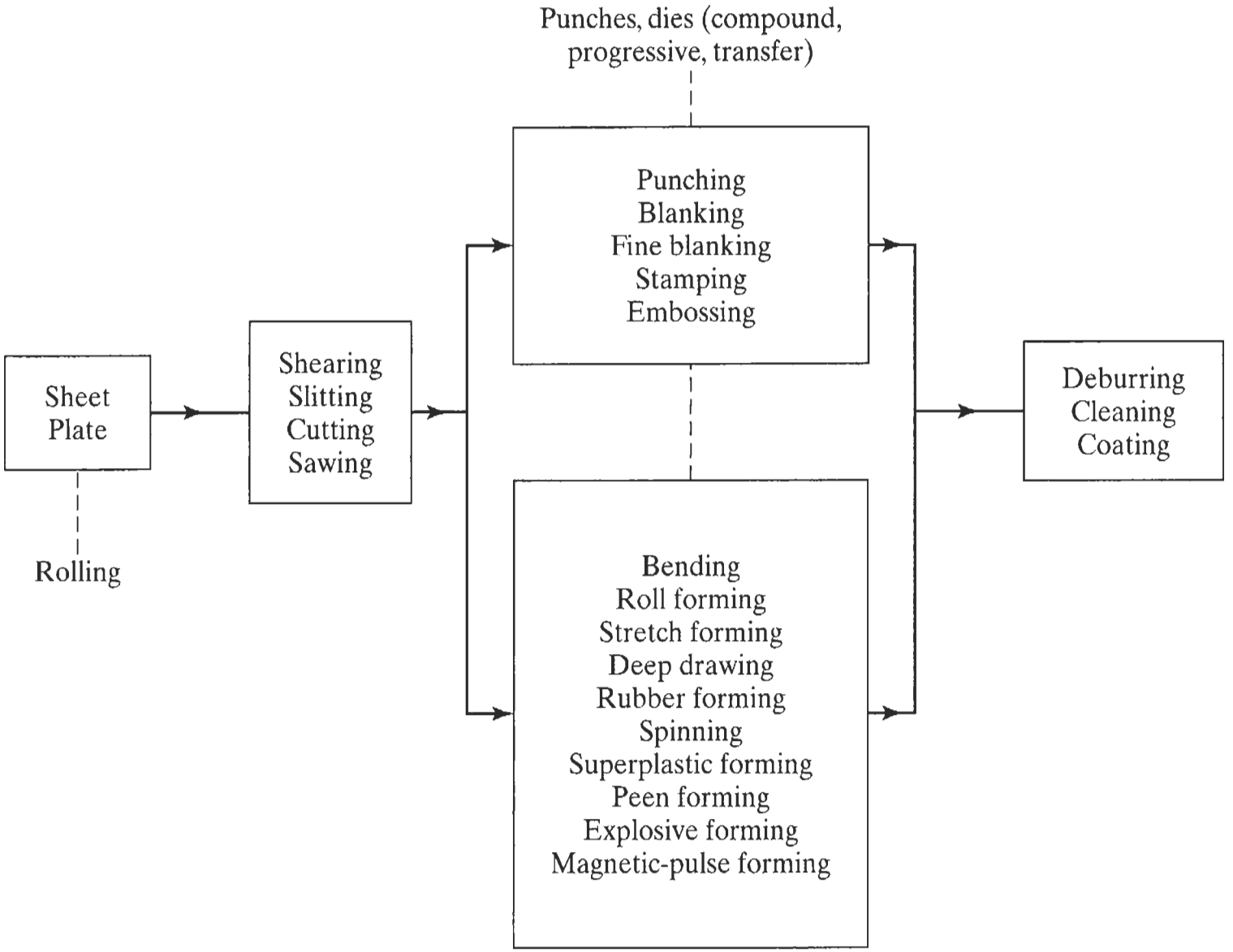
FREDERICK INSTITUTE OF TECHNOLOGY
Mechanical Engineering Department

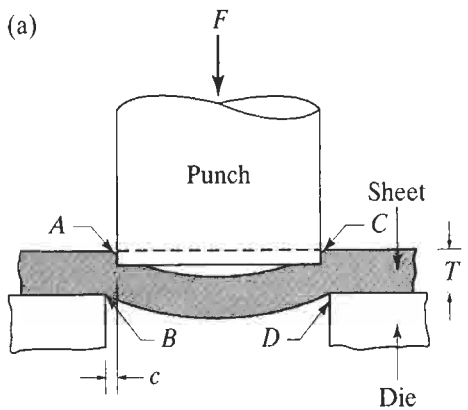
4. SHEET METAL FORMING PROCESSES

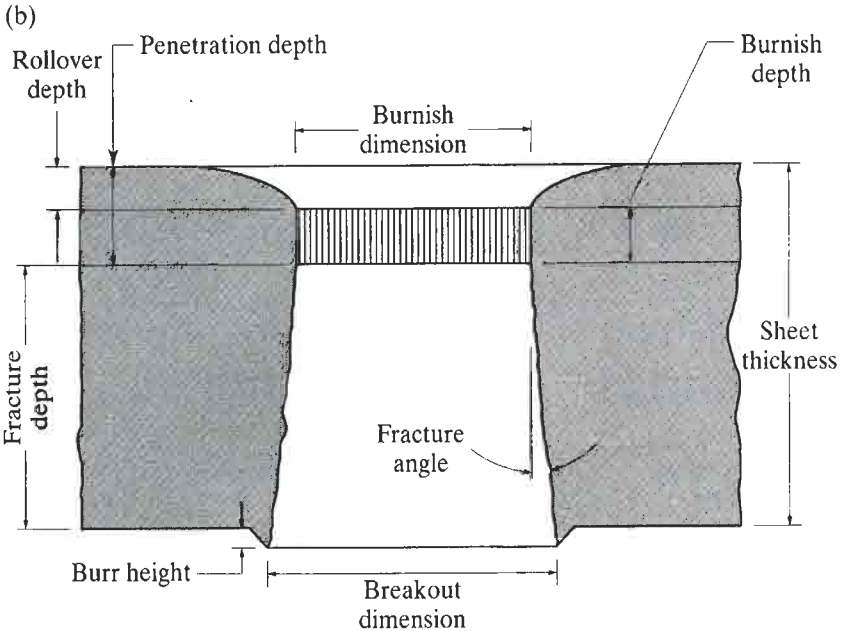


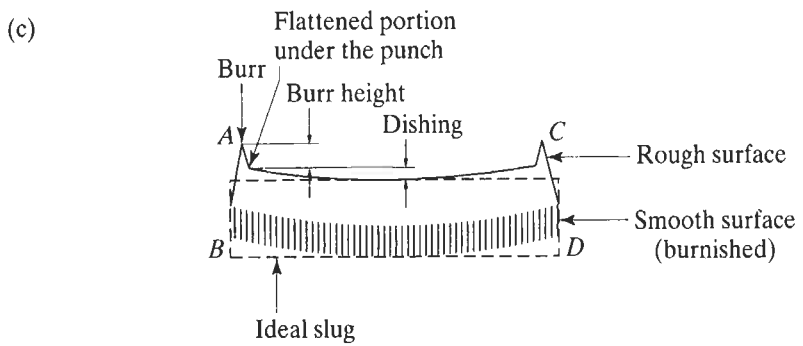
FREDERICK INSTITUTE OF TECHNOLOGY	*Title:* **Sheet metal forming processes**	
	SUBJECT: Manufacturing Processes	
Instructor: Dr. A. Lontos	**Mechanical Engineering Department**	**File:** **Figure 1-a**

Process	Characteristics
Roll forming	Long parts with constant complex cross-sections; good surface finish; high production rates; high tooling costs.
Stretch forming	Large parts with shallow contours; suitable for low-quantity production; high labor costs; tooling and equipment costs depend on part size.
Drawing	Shallow or deep parts with relatively simple shapes; high production rates; high tooling and equipment costs.
Stamping	Includes a variety of operations, such as punching, blanking, embossing, bending, flanging, and coining; simple or complex shapes formed at high production rates; tooling and equipment costs can be high, but labor cost is low.
Rubber forming	Drawing and embossing of simple or complex shapes; sheet surface protected by rubber membranes; flexibility of operation; low tooling costs.
Spinning	Small or large axisymmetric parts; good surface finish; low tooling costs, but labor costs can be high unless operations are automated.
Superplastic forming	Complex shapes, fine detail and close tolerances; forming times are long, hence production rates are low; parts not suitable for high-temperature use.
Peen forming	Shallow contours on large sheets; flexibility of operation; equipment costs can be high; process is also used for straightening parts.
Explosive forming	Very large sheets with relatively complex shapes, although usually axisymmetric; low tooling costs, but high labor cost; suitable for low-quantity production; long cycle times.
Magnetic-pulse forming	Shallow forming, bulging, and embossing operations on relatively low-strength sheets; most suitable for tubular shapes; high production rates; requires special tooling.

(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 that the scales of the two figures are different.







FREDERICK INSTITUTE OF TECHNOLOGY	*Title:* **Shearing**	
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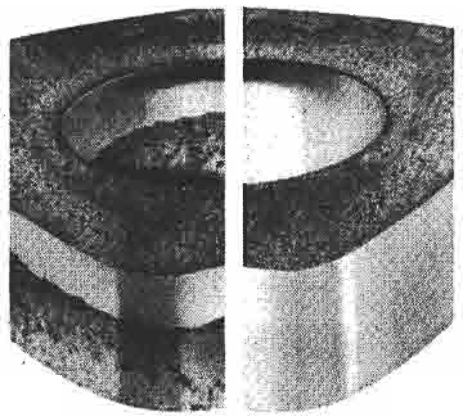
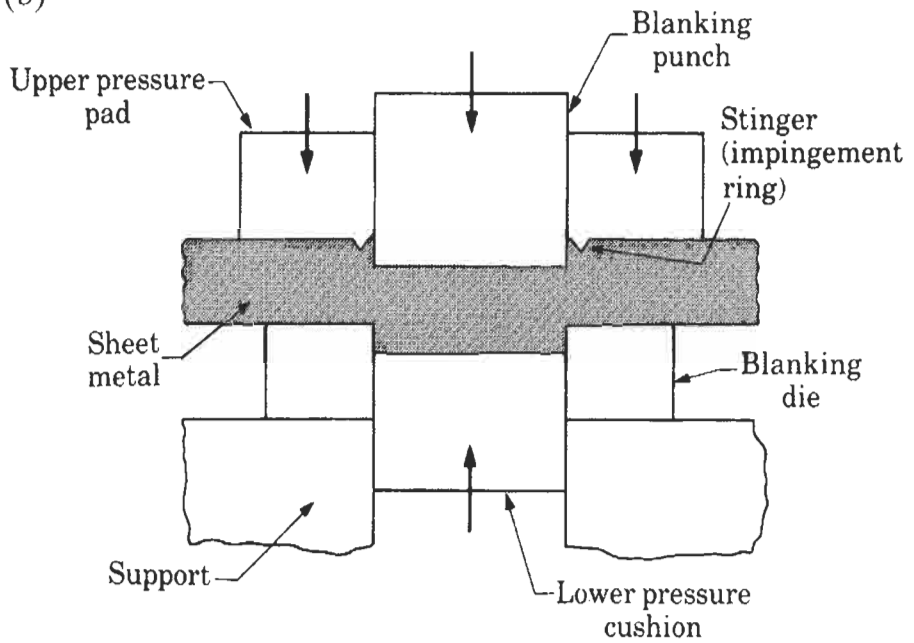
Instructor: Dr. A. Lontos	**Mechanical Engineering Department**	**File:** **Figure 3-a**

(a)



(b)



(a) Comparison of sheared edges produced by conventional (left) and by fine-blanking (right) techniques. (b) Schematic illustration of one setup for fine blanking.

FREDERICK INSTITUTE OF TECHNOLOGY	*Title:* **Fine blanking technique**		
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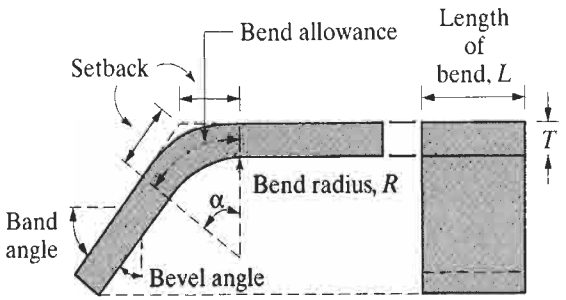
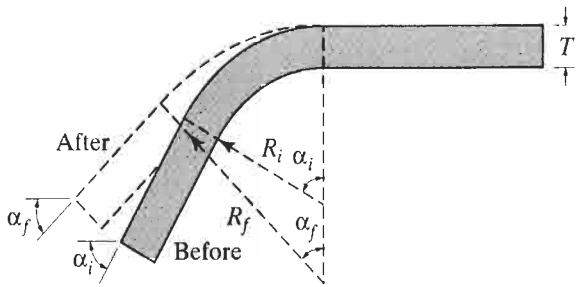
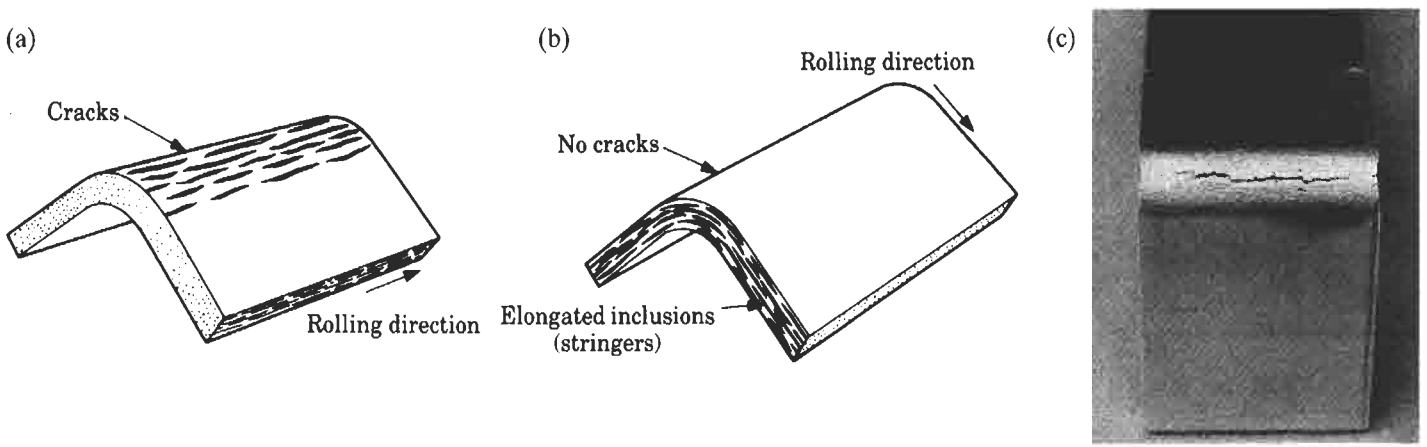
Characteristic	Importance
Elongation	Determines the capability of the sheet metal to stretch without necking and failure; high strain-hardening exponent (n) and strain-rate sensitivity exponent (m) desirable.
Yield-point elongation	Observed with mild-steel sheets; also called Lueder's bands and stretcher strains; causes flamelike depressions on the sheet surfaces; can be eliminated by temper rolling, but sheet must be formed within a certain time after rolling.
Anisotropy (planar)	Exhibits different behavior in different planar directions; present in cold-rolled sheets because of preferred orientation or mechanical fibering; causes earing in drawing; can be reduced or eliminated by annealing but at lowered strength.
Anisotropy (normal)	Determines thinning behavior of sheet metals during stretching; important in deep-drawing operations.
Grain size	Determines surface roughness on stretched sheet metal; the coarser the grain, the rougher the appearance (orange peel); also affects material strength.
Residual stresses	Caused by nonuniform deformation during forming; causes part distortion when sectioned and can lead to stress-corrosion cracking; reduced or eliminated by stress relieving.
Springback	Caused by elastic recovery of the plastically deformed sheet after unloading; causes distortion of part and loss of dimensional accuracy; can be controlled by techniques such as overbending and bottoming of the punch.
Wrinkling	Caused by compressive stresses in the plane of the sheet; can be objectionable or can be useful in imparting stiffness to parts; can be controlled by proper tool and die design.
Quality of sheared edges	Depends on process used; edges can be rough, not square, and contain cracks, residual stresses, and a work-hardened layer, which are all detrimental to the formability of the sheet; quality can be improved by control of clearance, tool and die design, fine blanking, shaving, and lubrication.
Surface condition of sheet	Depends on rolling practice; important in sheet forming as it can cause tearing and poor surface quality; see also Section 13.3.



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



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).



(a) and (b) The effect of elongated inclusions (stringers) on cracking, as a function of the direction of bending with respect to the original rolling direction of the sheet. (c) Cracks on the outer surface of an aluminum strip bent to an angle of 90°. Note the narrowing of the top surface due to Poisson effect.

FREDERICK INSTITUTE OF TECHNOLOGY	*Title:* **Bending sheet and plate**		
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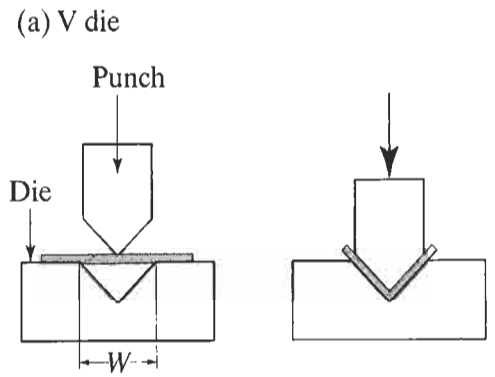
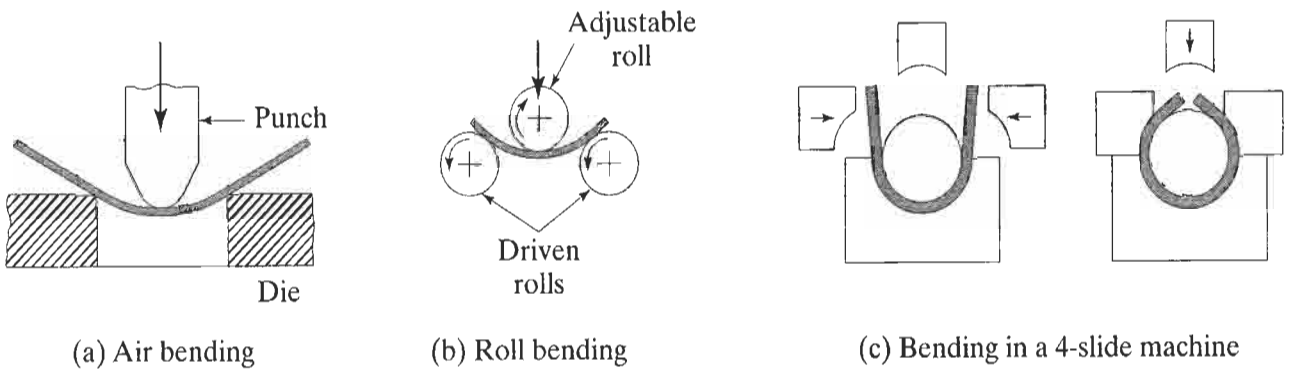


Common die-bending operations, showing the die-opening dimension, W, used in calculating bending forces.



Examples of various bending operations.

FREDERICK INSTITUTE OF TECHNOLOGY	*Title:* **Die bending operations**		
	SUBJECT: Manufacturing Processes		
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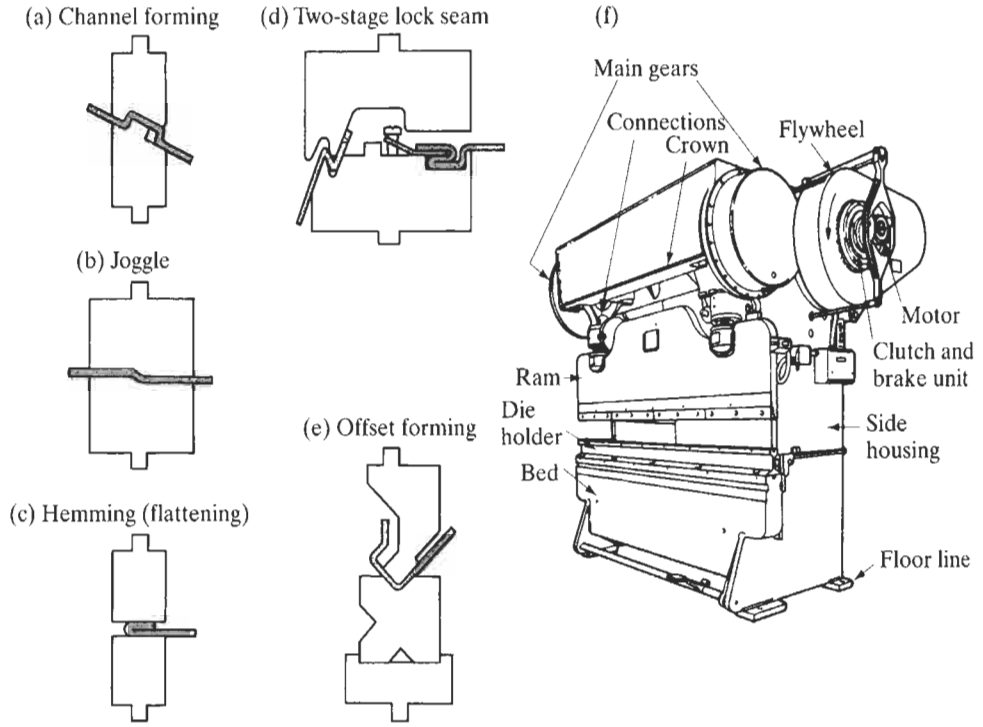
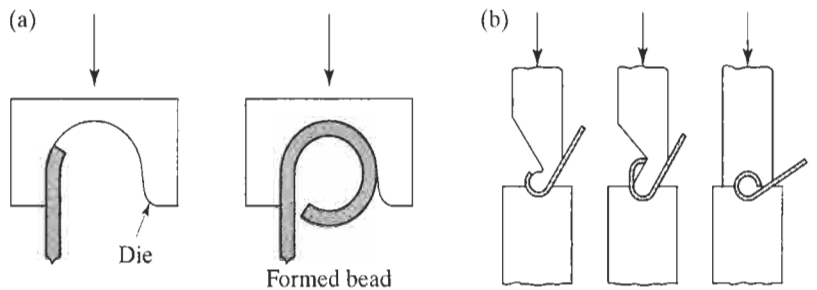
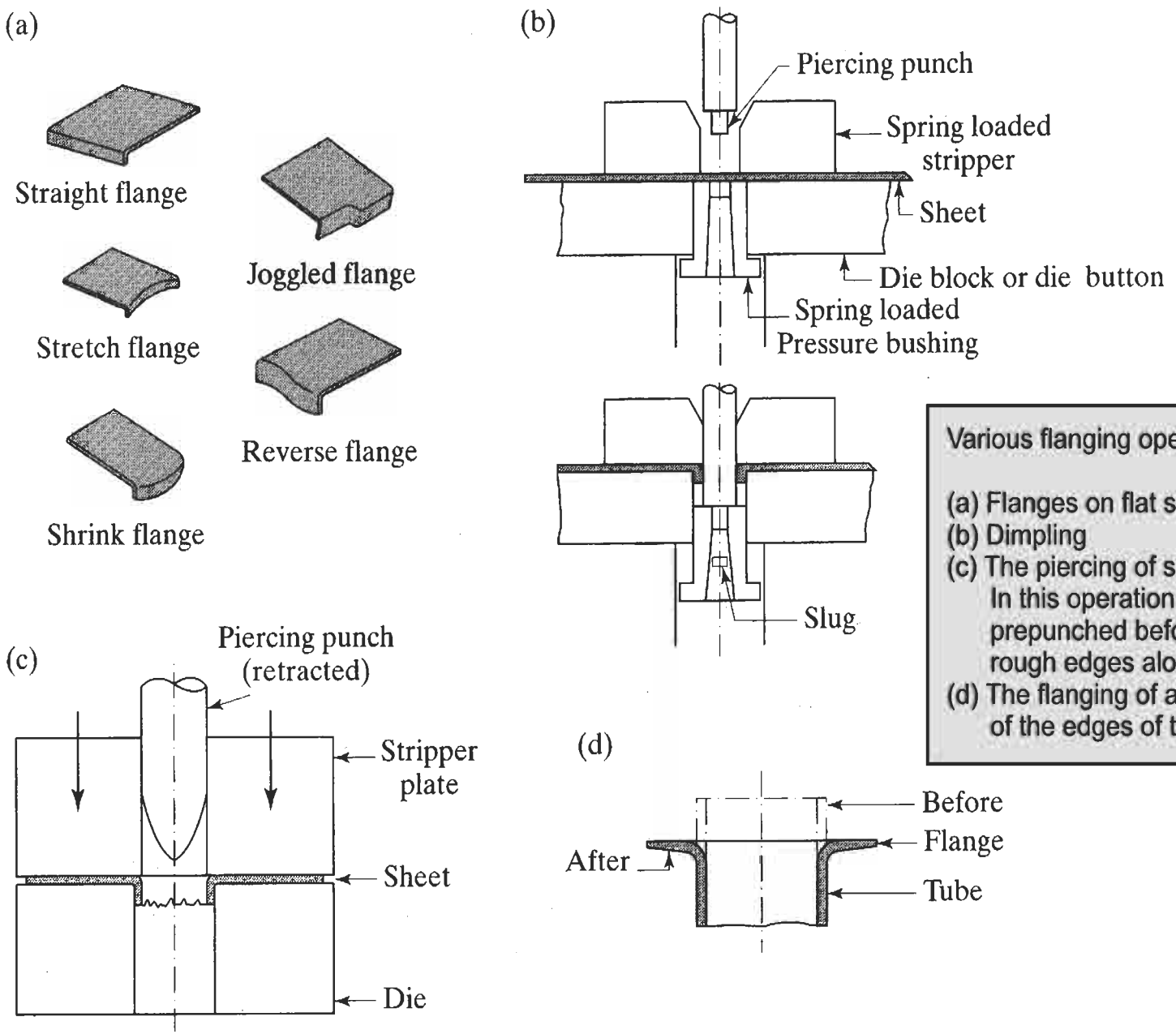


(a) through (e) Schematic illustrations of various bending operations in a press brake. (f) Schematic illustration of a press brake. *Source*: Verson Allsteel Company.

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



FREDERICK INSTITUTE OF TECHNOLOGY	***Title:*** **Various bending operations**		
	SUBJECT: Manufacturing Processes		
Instructor: Dr. A. Lontos	**Mechanical Engineering Department**	**File:**	**Figure 8-a**



Various flanging operations

(a) Flanges on flat sheet,
(b) Dimpling
(c) The piercing of sheet metal to form a flange. In this operation, a hole does not have to be prepunched before the punch descends. The rough edges along the circumference of the flange
(d) The flanging of a tube; note the thinning of the edges of the flange.

FREDERICK INSTITUTE OF TECHNOLOGY	*Title:* Various flanging operations		
	SUBJECT: Manufacturing Processes		
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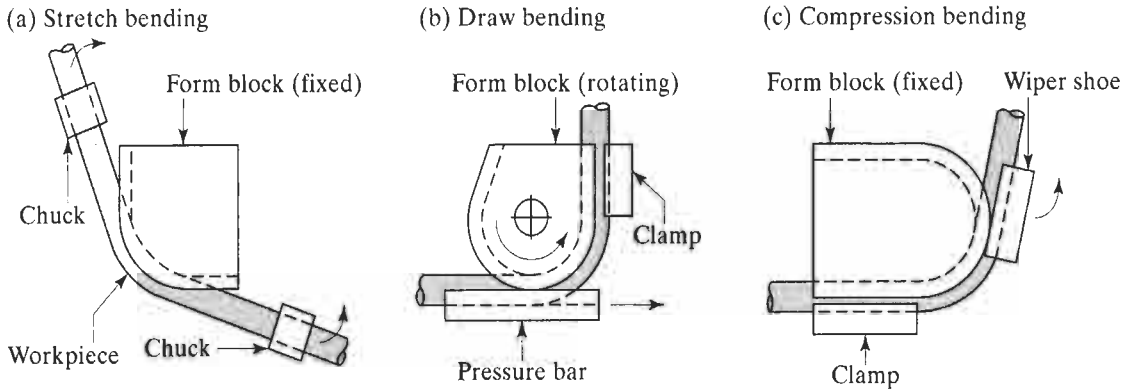
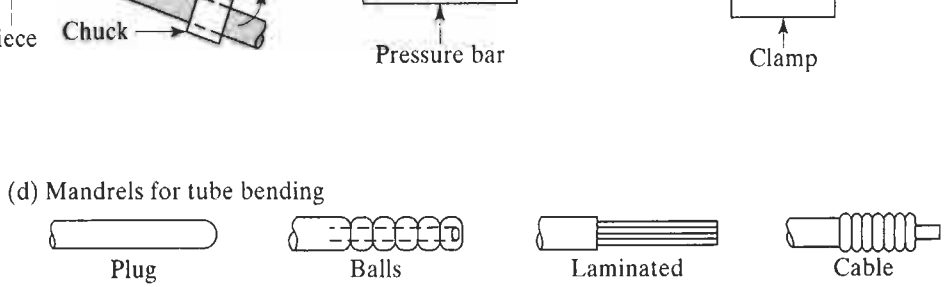
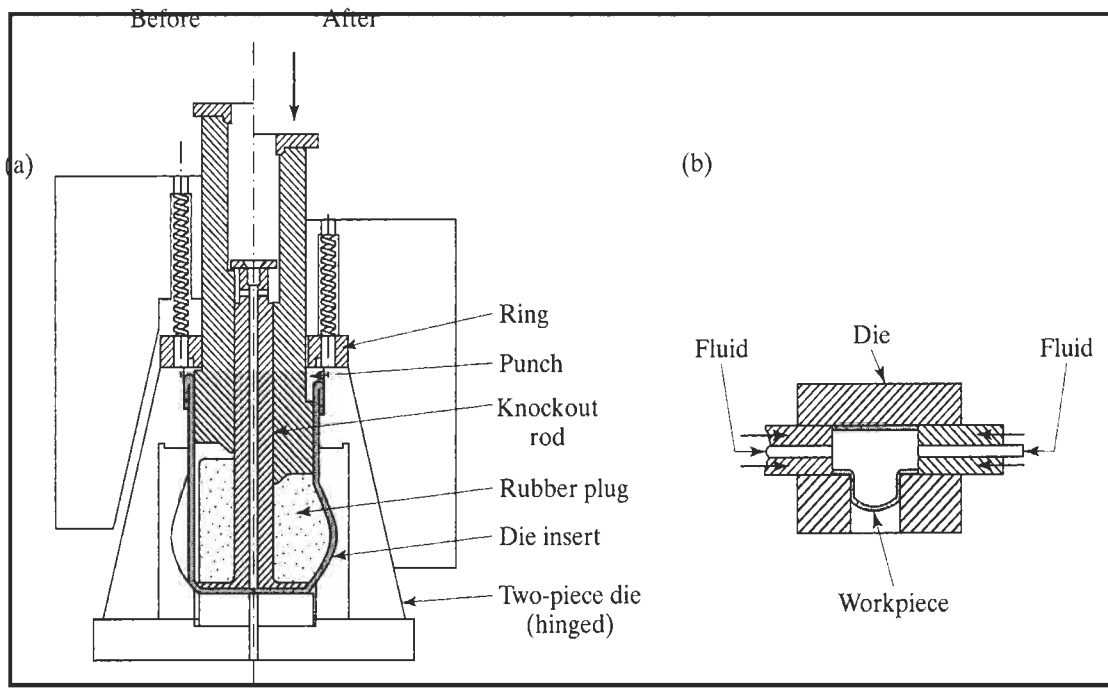




Methods of bending tubes.
Internal mandrels, or the filling of tubes with particulate materials such as sand, are often necessary to prevent collapse of the tubes during bending. Solid rods and structural shapes can also be bent by these techniques.



(a) The bulging of a tubular part with a flexible plug. Water pitchers can be made by this method,

(b) Production of fittings for plumbing, by expanding tubular blanks under internal pressure. The bottom of the piece is then punched out to produce

FREDERICK INSTITUTE OF TECHNOLOGY	*Title:* **Tube bending and forming**	
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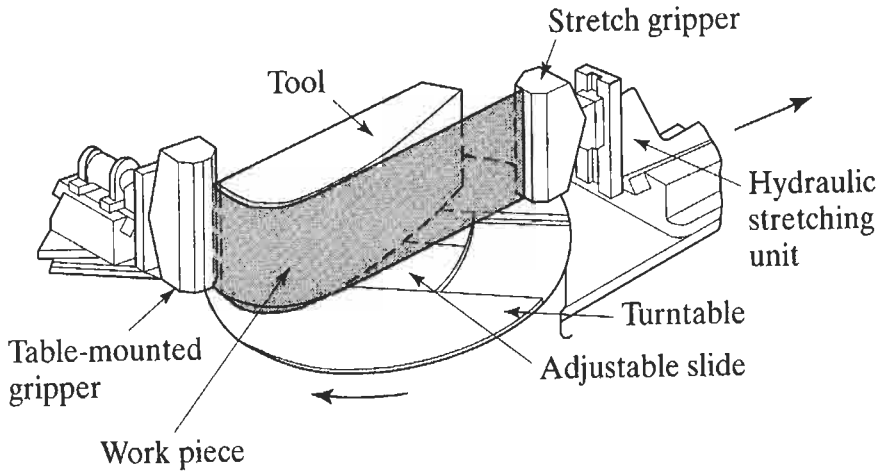
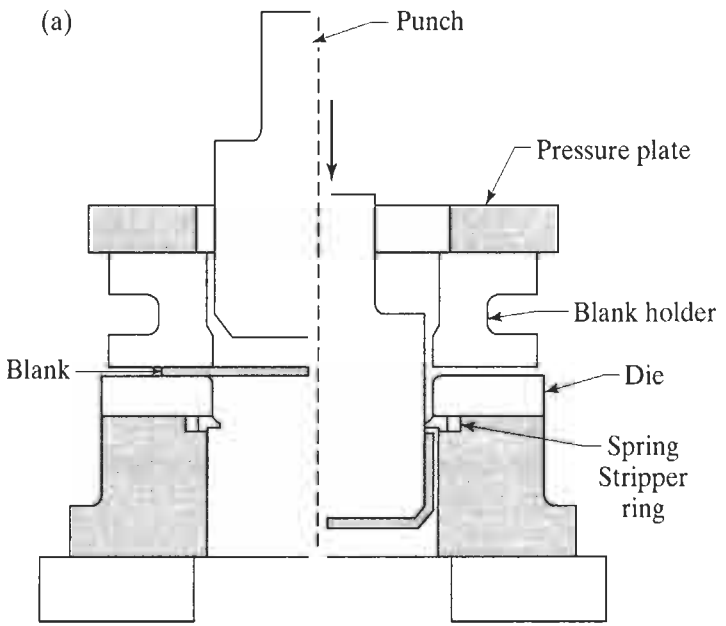
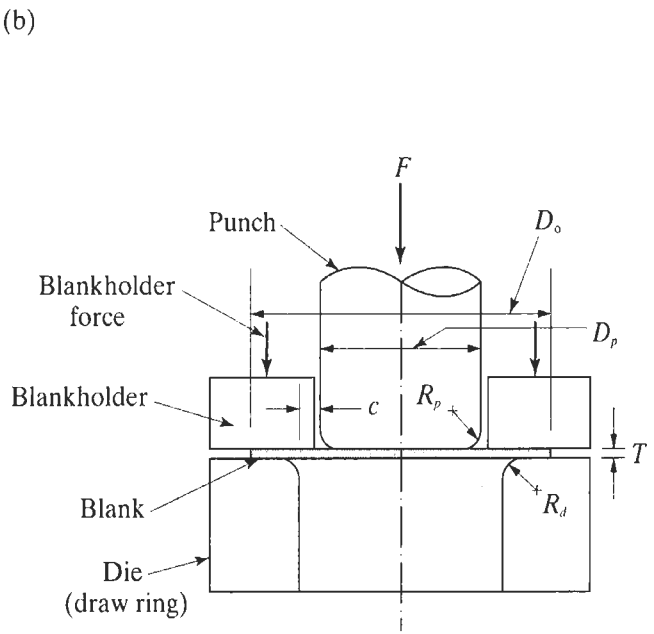


Schematic illustration of a stretch-forming process. Aluminum skins for aircraft can be made by this method.





(a) Schematic illustration of the deep-drawing process on a circular sheet-metal blank. The stripper ring facilitates the removal of the formed cup from the punch,

(b) Process variables in deep drawing. Except for the punch force, F, all the parameters indicated in the figure are independent variables.

FREDERICK INSTITUTE OF TECHNOLOGY	*Title:* **Stretch and deep drawing forming**	
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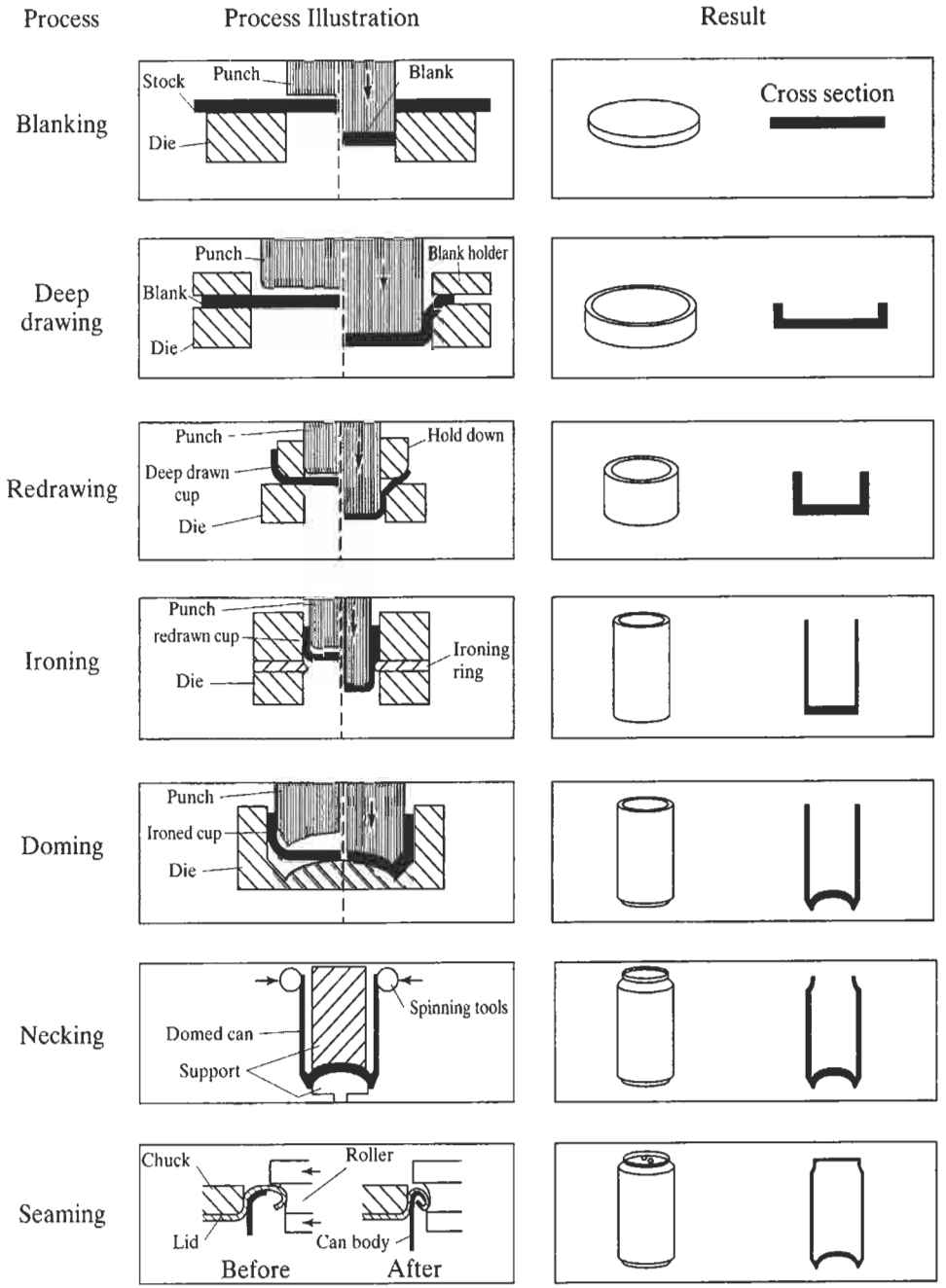

The metal-forming processes involved in manufacturing a two-piece aluminum beverage can.

FREDERICK INSTITUTE OF TECHNOLOGY	*Title:* **Deep drawing**	
	SUBJECT: Manufacturing Processes	
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