EDPT 601

MATERIALS MANUFACTURING TECHNOLOGY

Cold Working Processes

Ref. Ch 19 De Garmo

Cold Working Processes

Advantages:

- In crease strength due to work hardening
- Improve surface finish
- Closer dimensional tolerances

Processes are classified as:

- Are classified as :
- I - Squeezing
- II- Shearing
- III- Bending
- IV- Drawing

I- Squeezing Processes:

- Most of these processes have hot working counterparts or are extensions of hot working processes.
- Primary reason for cold deformation is to obtain:
  - better dimensional accuracy
  - improved surface finish
- **but it needs**:
  - more powerful equipment to overcome higher-strength starting material
  - to overcome additional resistance caused by strain hardening

cold rolling of sheet

Is used in order to obtain:

- skin rolled
- quarter-hard
- half – hard
- full hard

swaging (rotary swaging or radial forging)

Is used to

- reduce diameters.

- taper or point round bars or tubes
- to form products with internal shapes of constant cross section using mandrel

It generates as many as 2000 blows per minute

Swaging

FIGURE 19-1 Tube being reduced in a rotary swaging machine. *(Courtesy of Torrington Company.)*

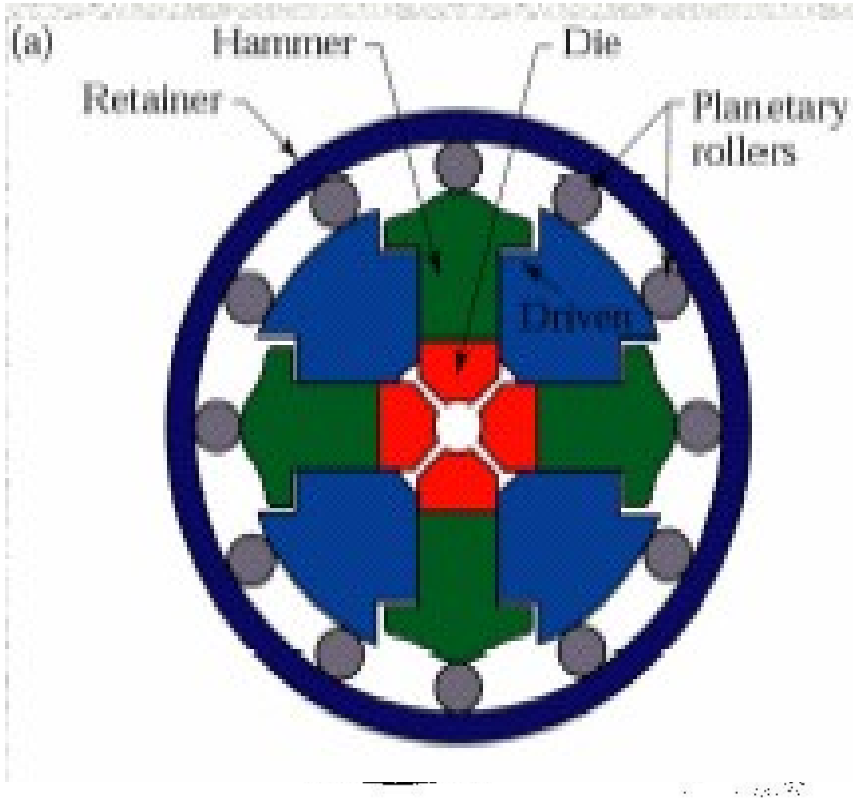
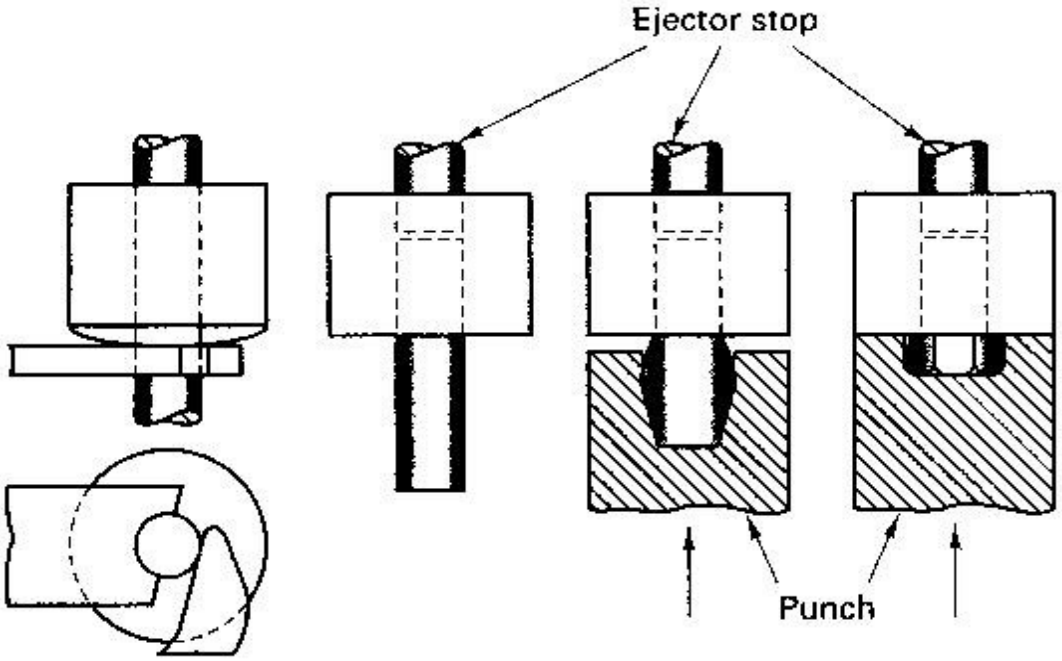


FIGURE 19-2 Basic components and motions of a rotary swaging machine. *Note:* The cover plate has been removed to reveal the interior workings. *(Courtesy of Torrington Company.)*

cold forging (cold forming)

- for heads of nails, bolts, rivets



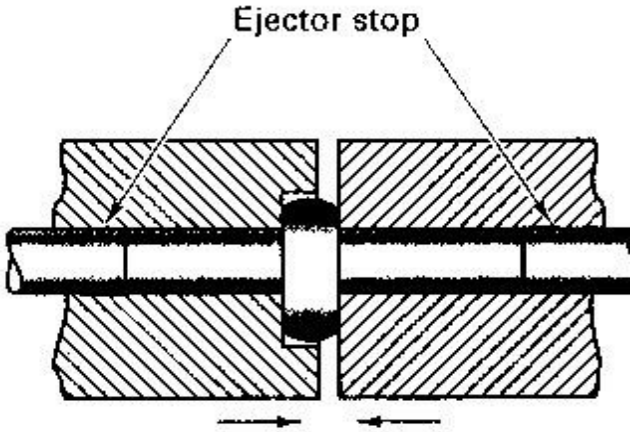


FIGURE 19-5 Method of upsetting the center portion of a rod. The stock is supported in both dies during upsetting.

Cold extrusion

Examples of Cold Extrusion

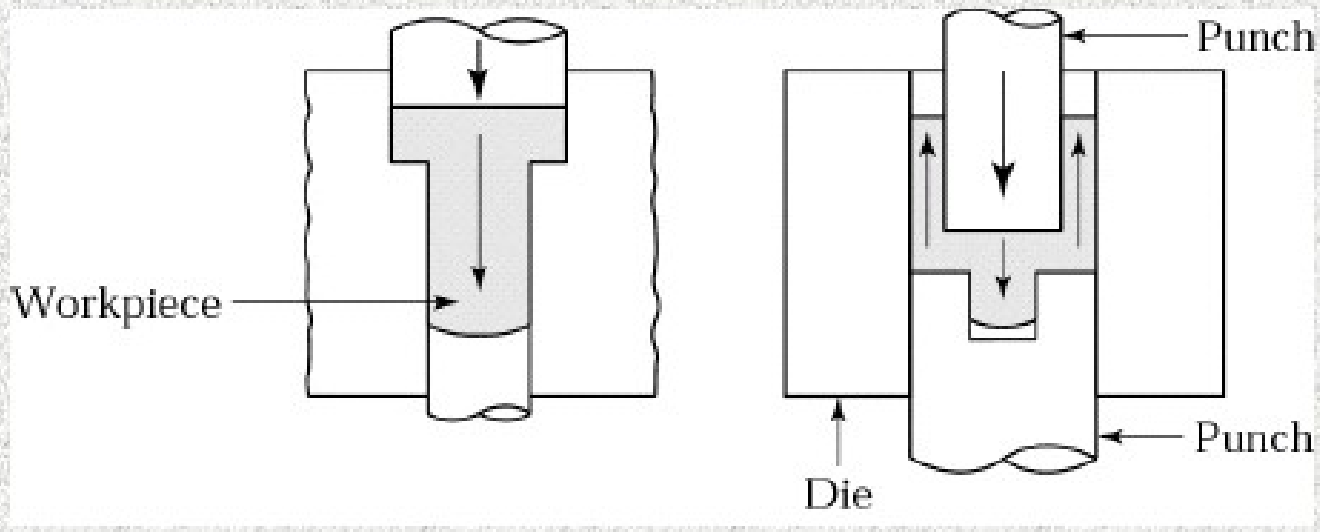
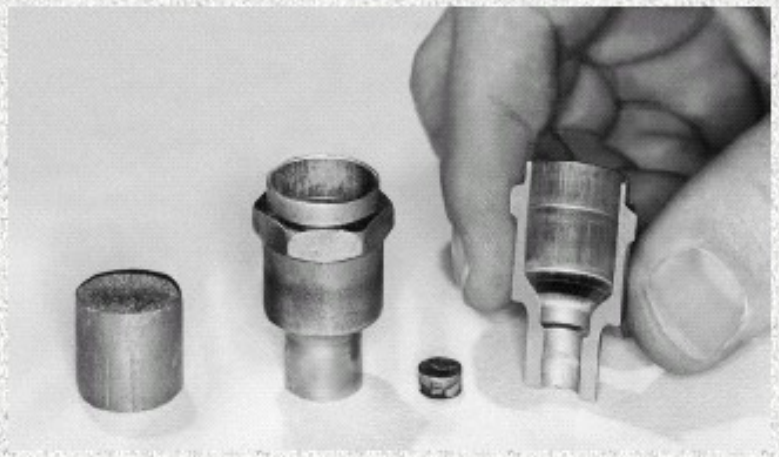


Figure 15.11 Two examples of cold extrusion. Thin arrows indicate the direction of metal flow during extrusion.

Cold Extruded Spark Plug

Figure 15.12 Production steps for a cold extruded spark plug. *Source:* National Machinery Company.



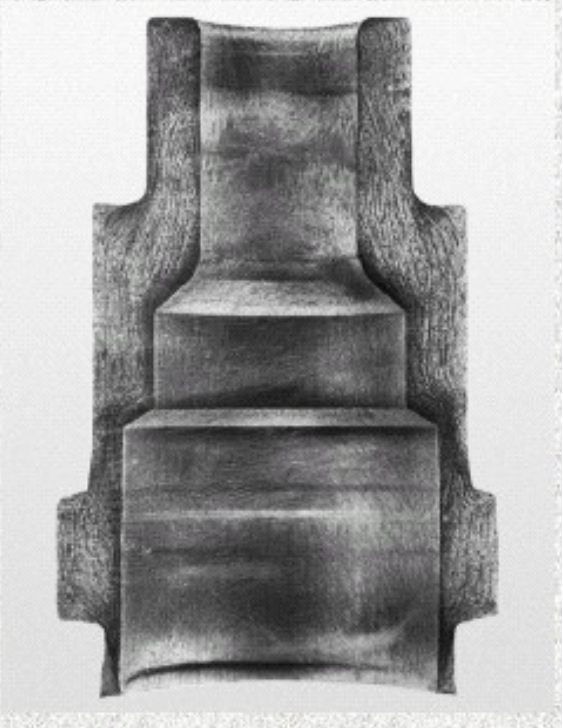
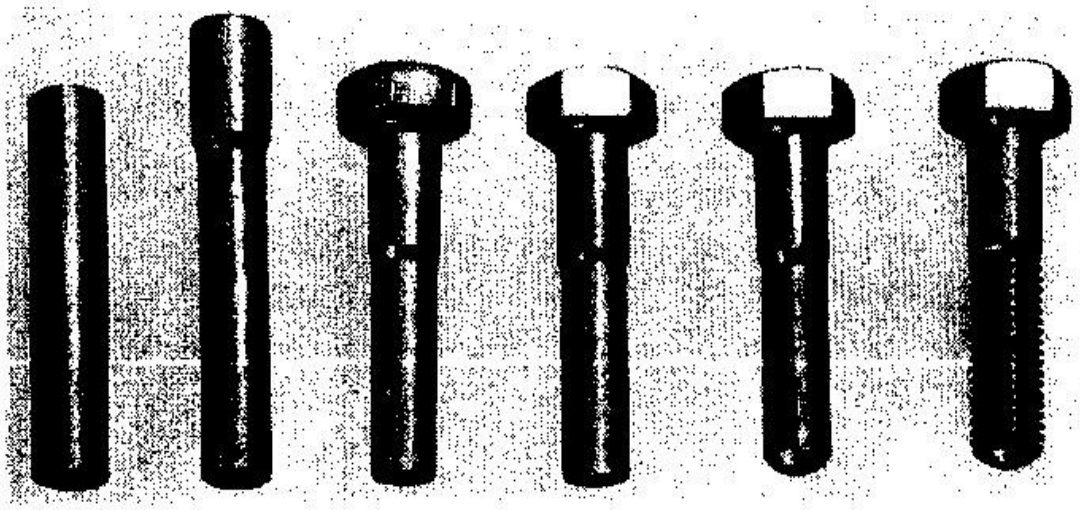
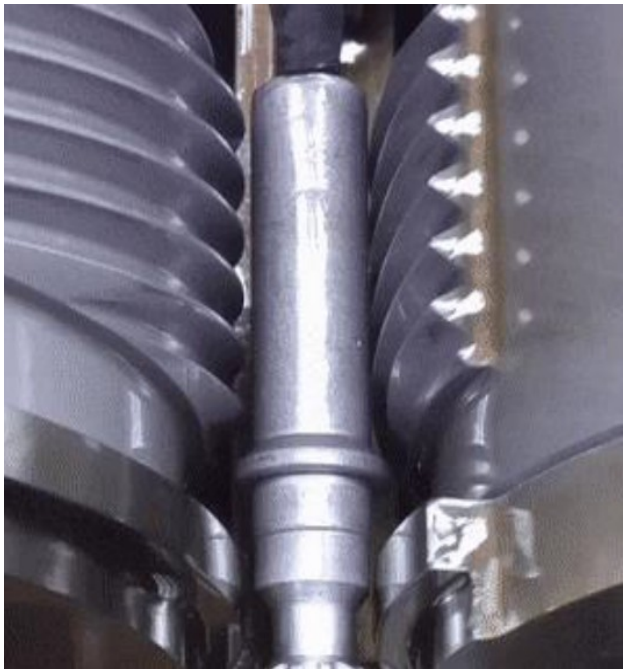


Figure 15.13 A cross-section of the metal part in Fig. 15.12, showing the grain flow pattern. *Source*: National Machinery Company.

Steps of forming bolts by: cold extrusion, cold heading and thread rolling



COLD HEADING/COLD FORGING



Impact extrusion

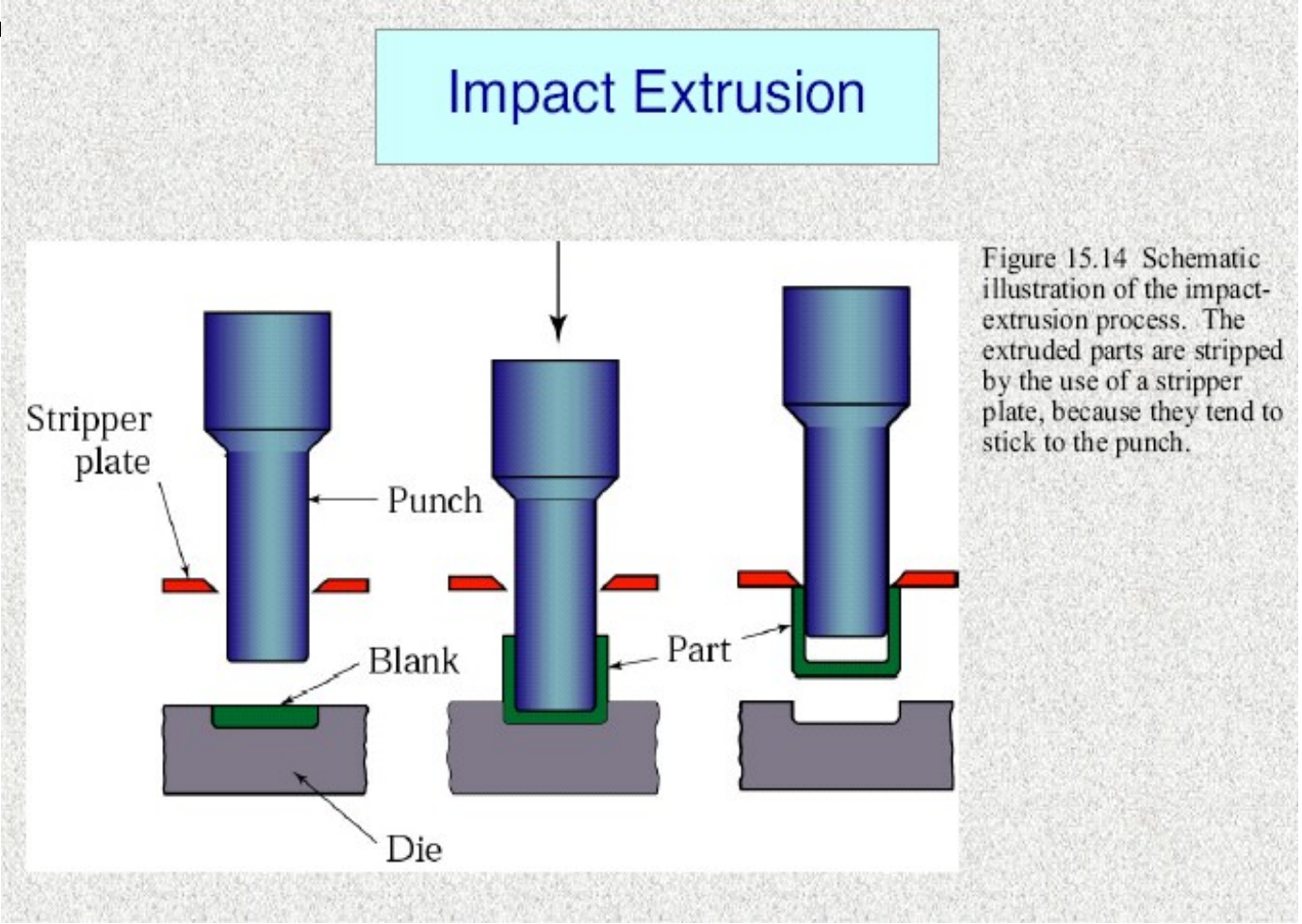


Figure 15.14 Schematic illustration of the impact-extrusion process. The extruded parts are stripped by the use of a stripper plate, because they tend to stick to the punch.

Examples of Impact Extrusion

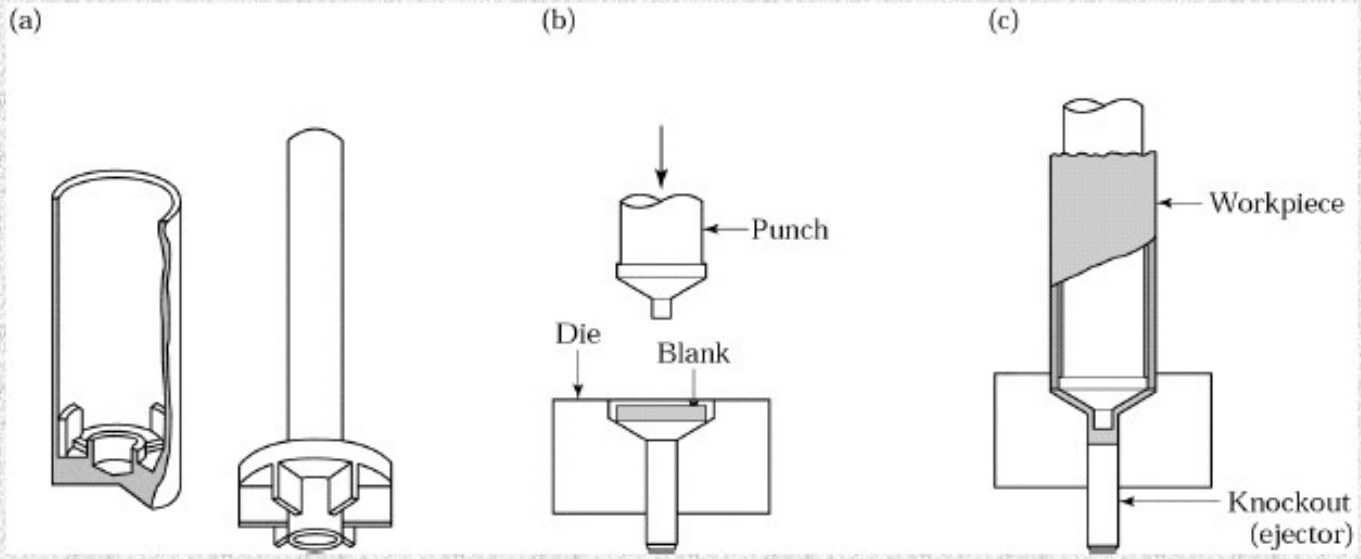


Figure 15.15 (a) Two examples of products made by impact extrusion. These parts may also be made by casting, by forging, or by machining; the choice of process depends on the dimensions and the materials involved and on the properties desired. Economic considerations are also important in final process selection. (b) and (c) Impact extrusion of a collapsible tube by the *Hooker process*.

Impact Extrusion

- for collapsible tubes, for tooth paste and shaving cream tubes
- For soft metals- zinc, lead, tin, aluminium
- Thickness is controlled by the clearance between punch and die
- Typical max thickness 0.1- 0.25mm
- Max length about 300mm
- Low cost- high production rate (100 000 to 20 mill parts per year)
- Excellent surface quality

Riveting - coining

Riveting: Joining components by riveting

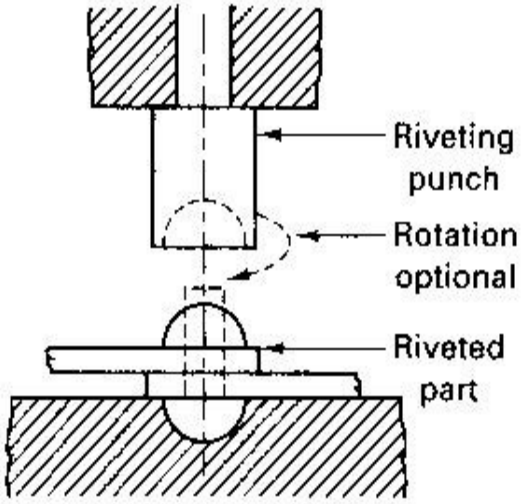


FIGURE 19-14 Joining components by riveting.

Coining :Cold squeezing the metal while all surfaces are confined within a set of dies

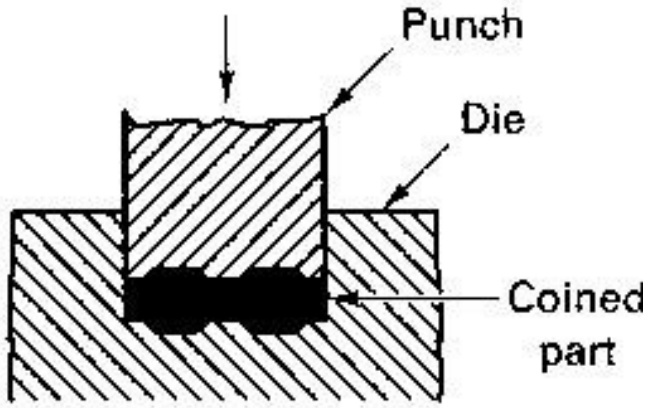


FIGURE 19-17 The coining process.

Surface improvement by cold working

- ***Peening***: by repeated blows of impelled shots to induce compressive stresses on the surface , thus, improving fatigue life of tensile-loaded components , such as shafts, crankshafts, connecting rods, gear teeth and other cyclic – loaded components
- ***Burnishing***: same effect by rubbing smooth hard surface over minute surface irregularities – to improve size and finish internal or external cylindrical or conical surfaces

III - Bending

Is plastic deformation about a linear axis with little or no change in surface area

- Neutral axis
- spring back

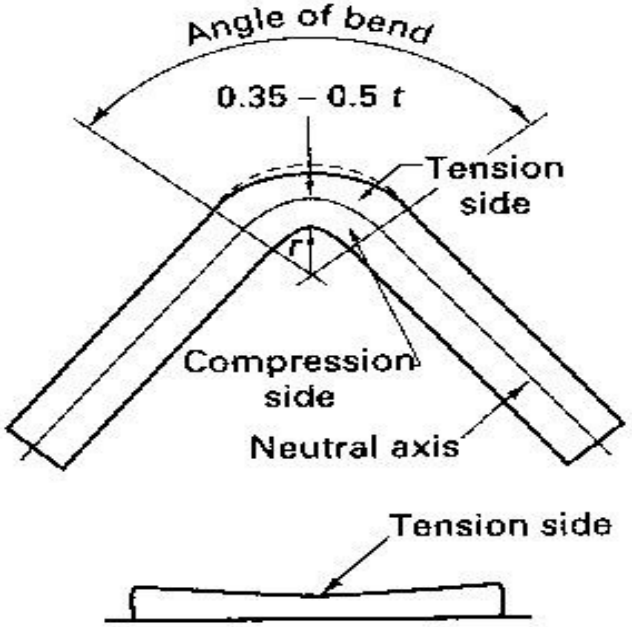
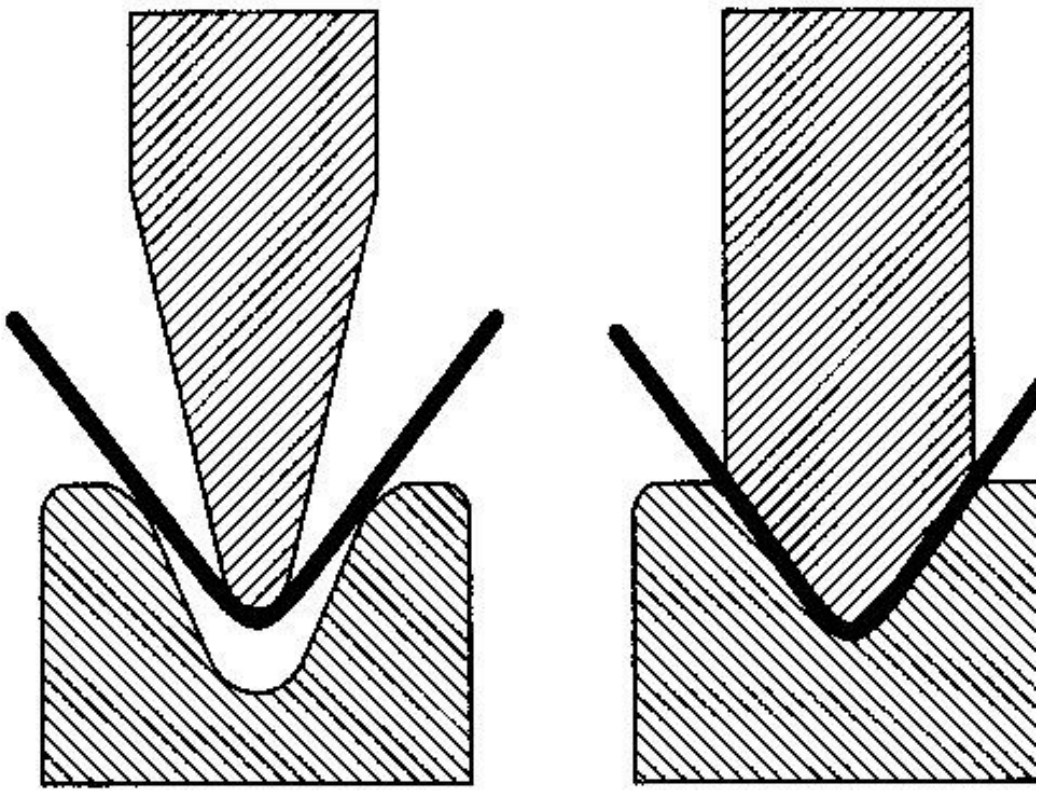


FIGURE 19-20 (*Top*) Nature of a bend in sheet metal showing tension on the outside and compression on the inside; (*bottom*) The upper portion of the bend region, viewed from the side, shows how the center portion will thin more than the edges.

Air bend, bottoming and coining dies

FIGURE 19-28 Comparison of air-bend (*left*) and bottoming (*right*) press brake dies. With the air-bend die, the amount of bend is controlled by the bottoming position of the upper die.



Dies for a variety of angles and contours using Press brake

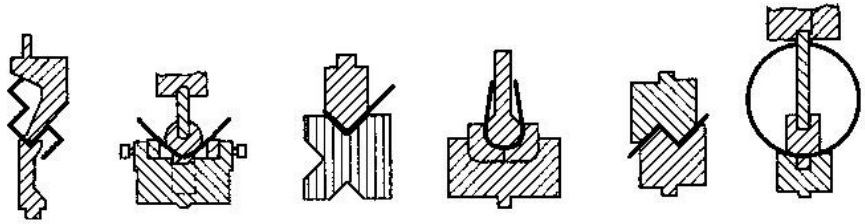


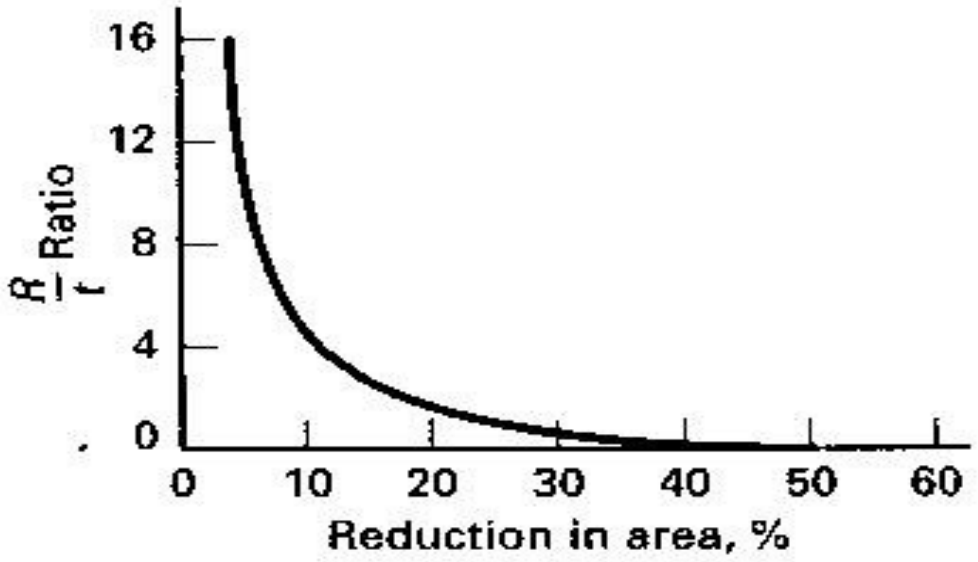
FIGURE 19-23 Press brake dies can form a variety of angles and contours. *(Courtesy of Cincinnati Incorporated.)*

Design for bending

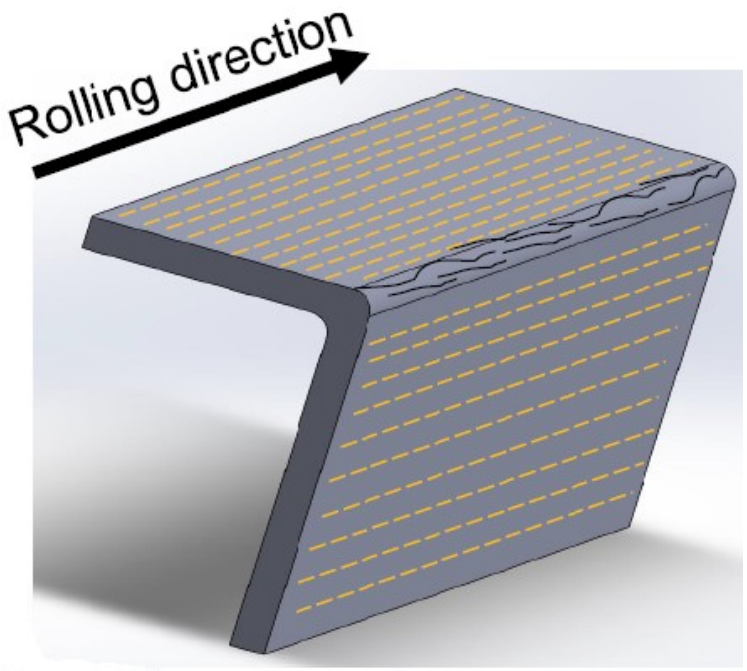
- the minimum bend radius depends on material ductility and thickness
- direction of rolling should be taken in consideration
- spring back compensation
- determination of starting blank length

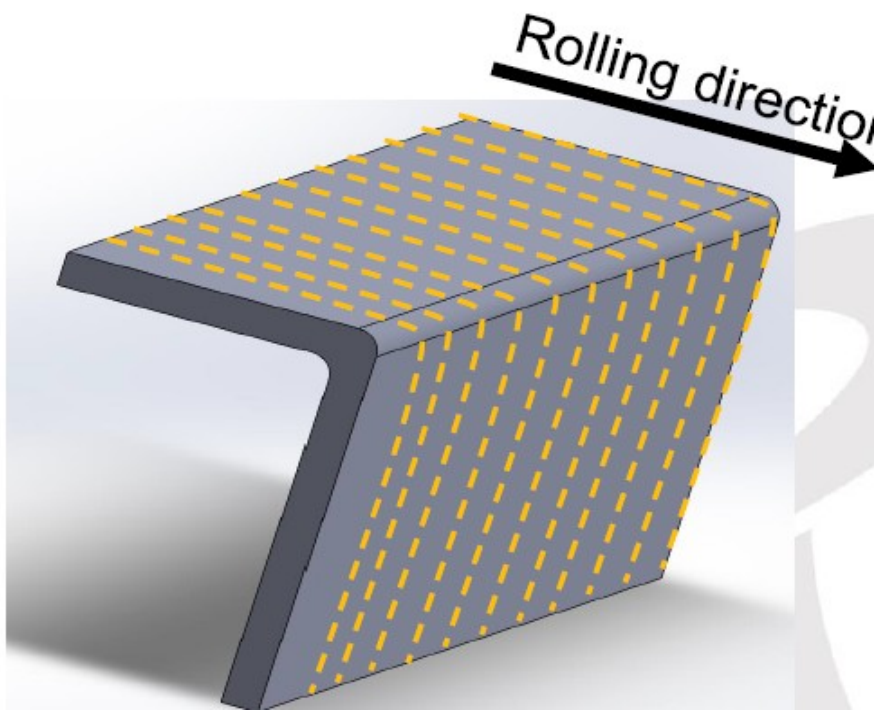
Design for bending

FIGURE 19-25 Relationship between the minimum bend radius, R, (relative to thickness) and the ductility of the metal being bent (as measured by the reduction in area in a uniaxial tensile test).



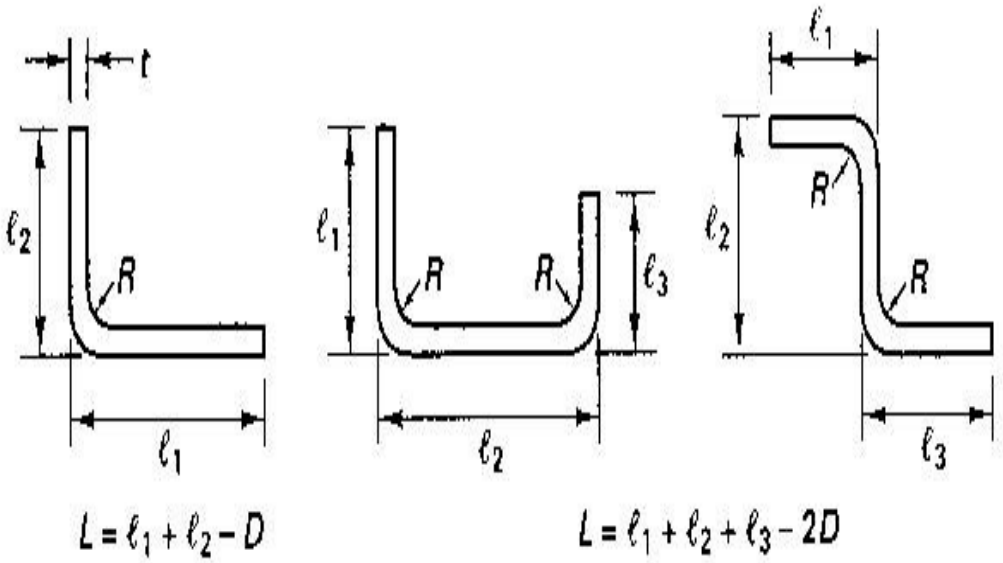
Design for bending





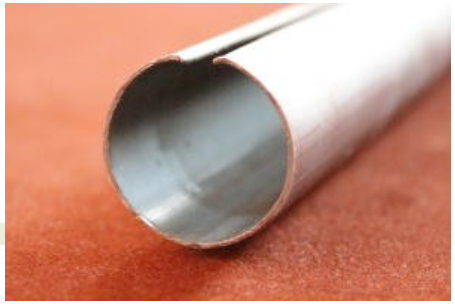
Design for bending

FIGURE 19-27 One method of determining the starting blank size (L) for several bending operations. Due to thinning, the product will lengthen during forming. ℓ_1, ℓ_2, and ℓ_3 are the desired product dimensions. See table to determine D based on size of radius R where t = stock thickness.

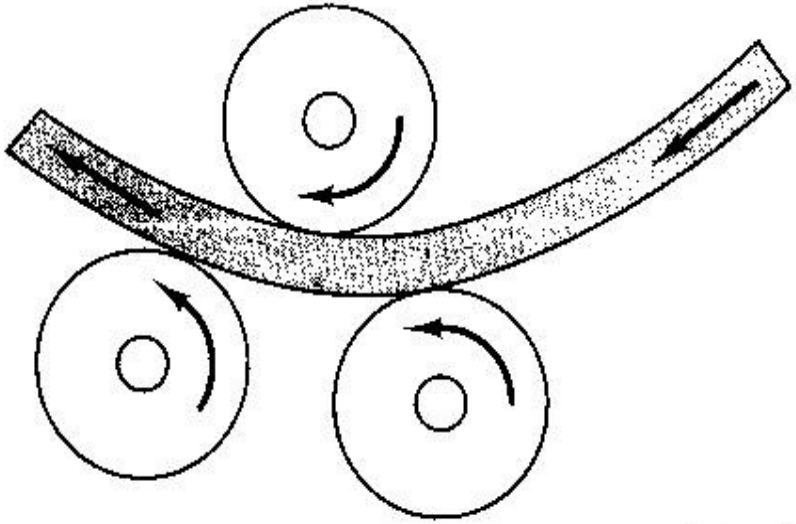


For an R	Let D be
t	1.7 t
2 t	2.0 t
3 t	2.5 t

Roll bending



- continuous
- for plates, beams, pipes and even rolled shapes



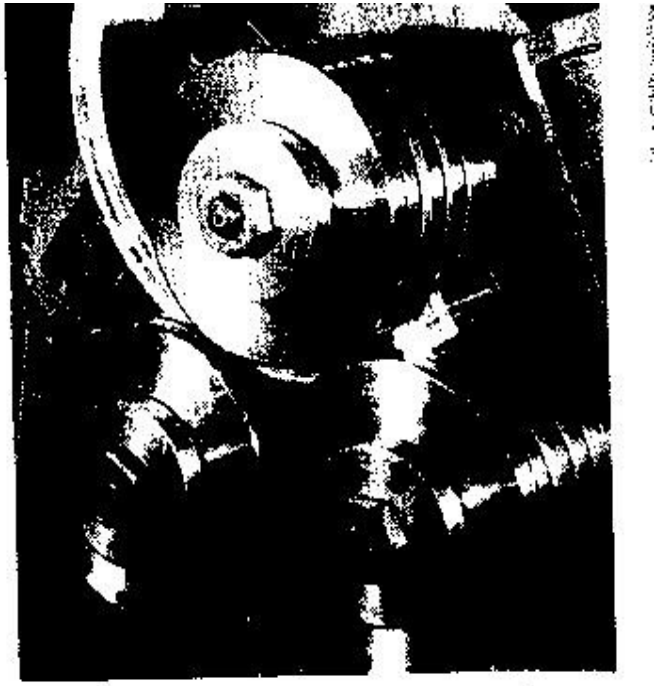
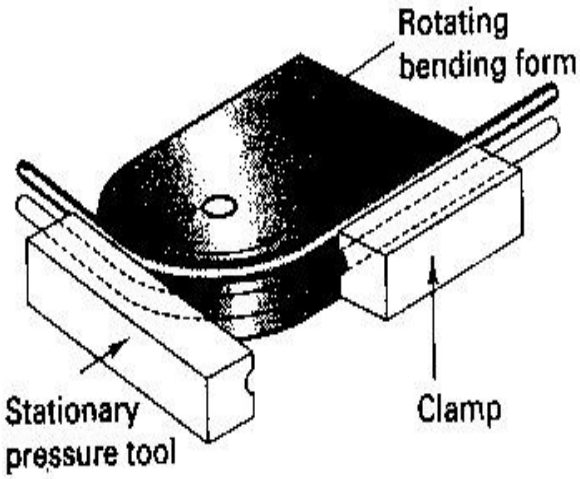


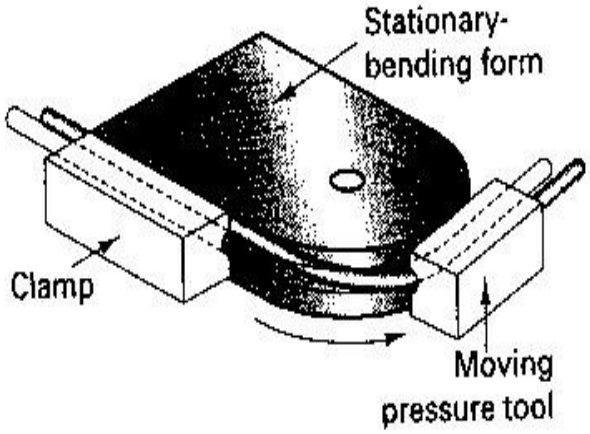
FIGURE 19-29 (*Left*) Schematic of the roll-bending process; (*right*) the roll bending of an I-beam section. Note how the material is continuously subjected to three-point bending. *(Courtesy of Buffalo Forge Company.)*

Draw bending, compression bending, press bending

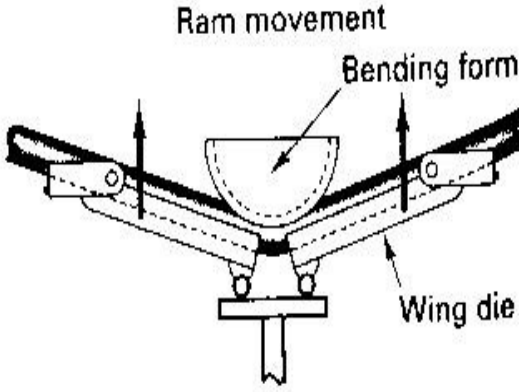
FIGURE 19-30 (a) Draw bending, in which the form block rotates; (b) compression bending, in which a moving tool compresses the workpiece against a stationary form, (c) press bending, where the press ram moves the bending form.



(a) Draw bending

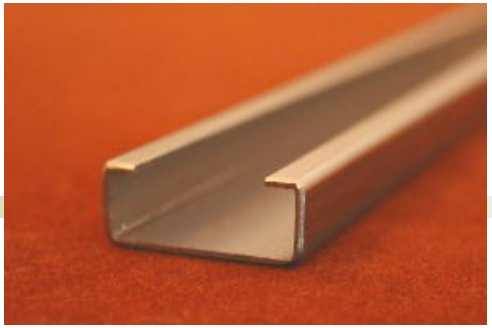


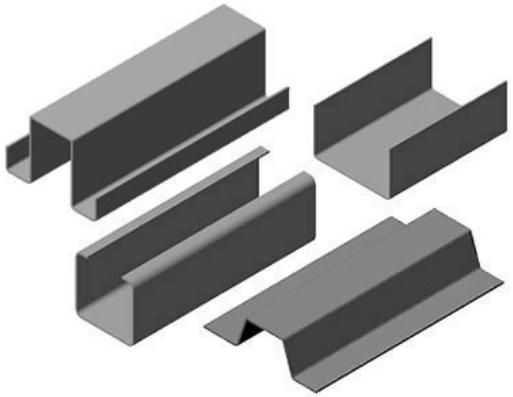
(b) Compression bending



(c) Press bending

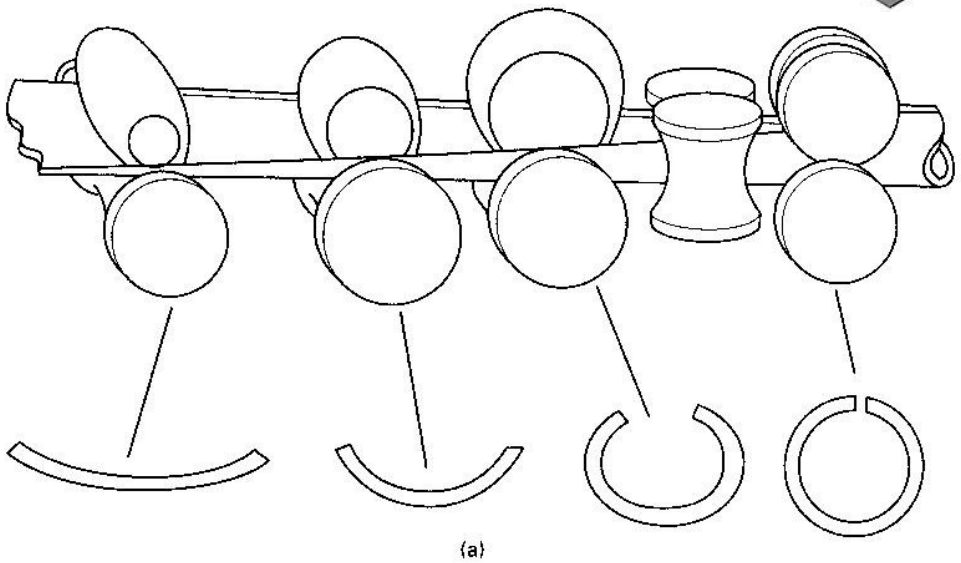
Roll forming:





Transforms a flat strip into complex sections by a continuous process - progressive bending

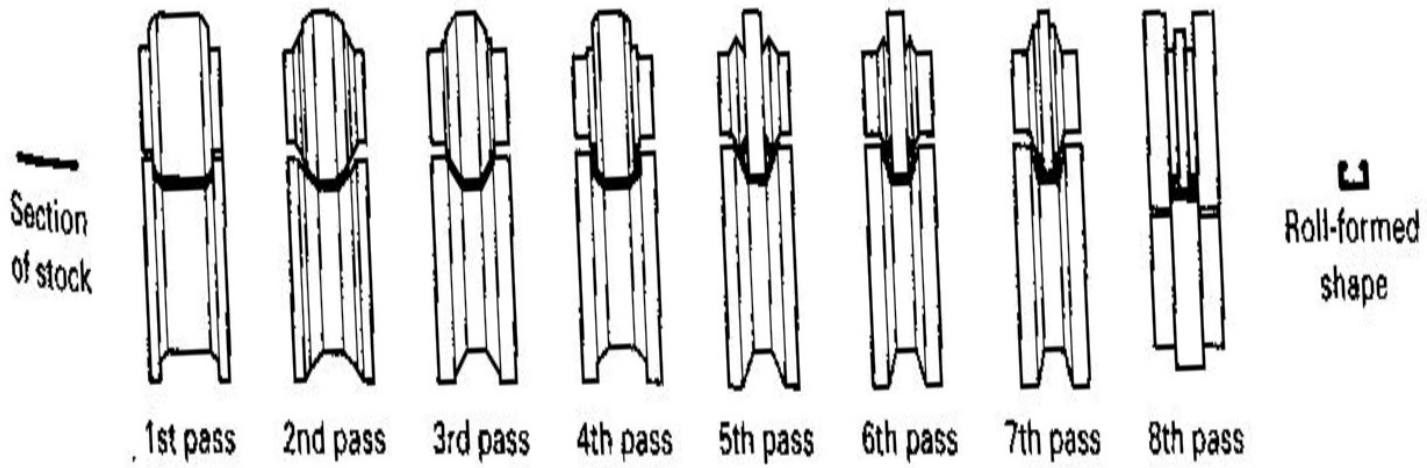
- a) cold roll forming to convert sheet into tube
- b) Some typical shapes produced by roll forming



Roll Forming

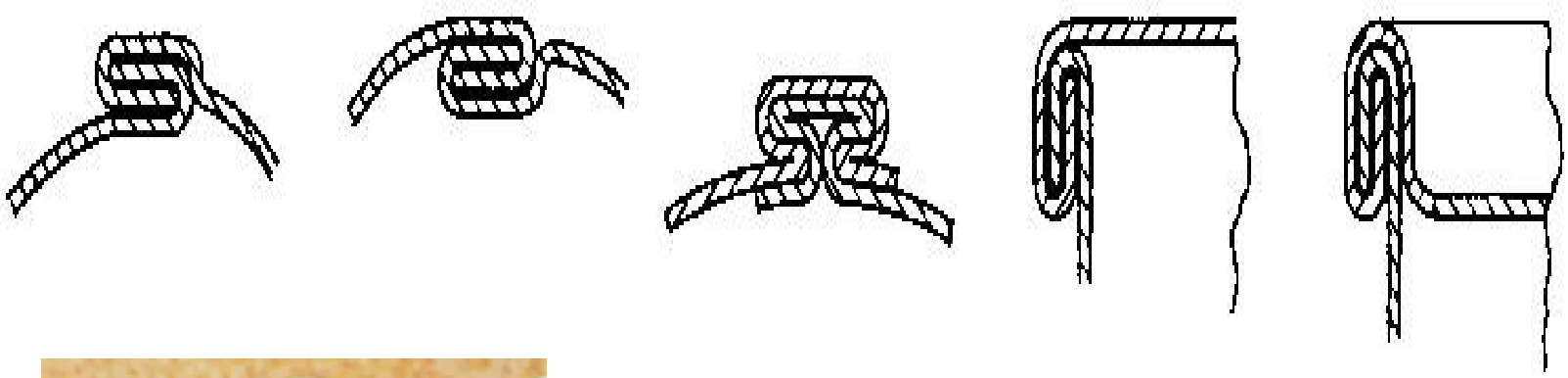
Eight –roll sequence for roll forming of a box channel

FIGURE 19-32 Eight-roll sequence for the roll forming of a box channel. *(Courtesy of the Aluminum Association, New York.)*



Seaming:

various types of seams used in sheet metal



Method of straightening rods or sheets by passing it through a set of straightening rolls

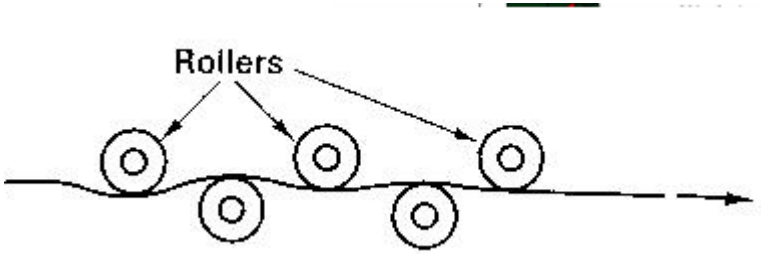
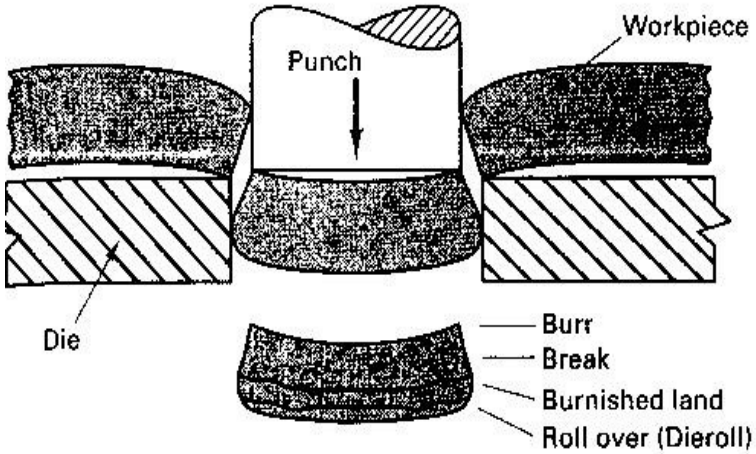


FIGURE 19-34 Method of straightening rod or sheet by passing it through a set of straightening rolls. For rods, another set of rolls is used to provide straightening in the transverse direction.

II- Shearing Operations

Is the mechanical cutting of materials without formation of chips

Ex: Blanking and piercing



IGURE 19-35 Simple blanking with a punch and die.

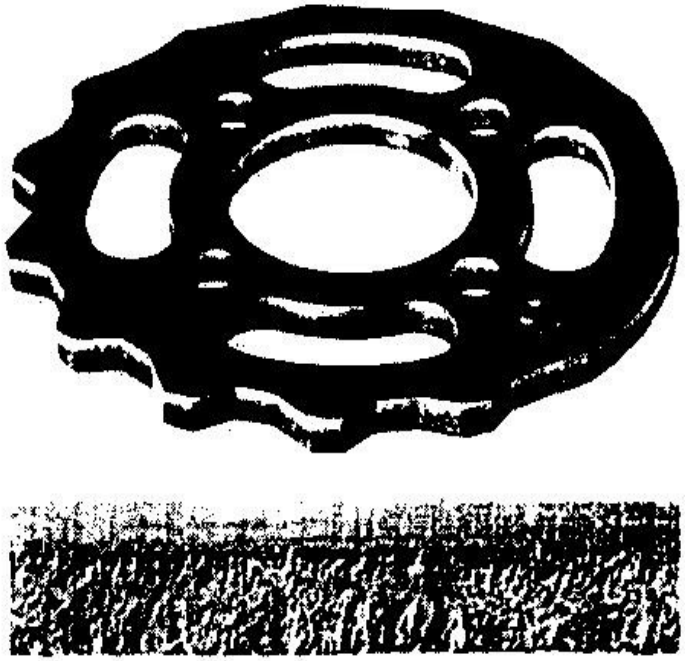


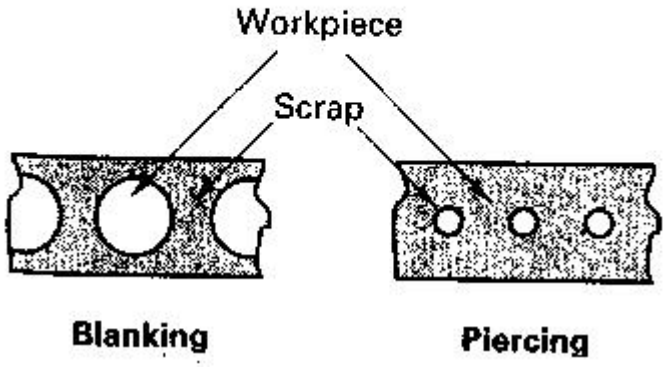
FIGURE 19-36 (*Top*) Conventionally sheared surface showing the distinct regions of deformation and fracture, and (*bottom*) magnified view of the sheared edge. *(Courtesy of American Feintool, Inc.)*

- **Clearance between punch and die= 5 to 10% thickness of sheet depending on the material**

Forming and blanking for knives

Slitting
Piercing and blanking

FIGURE 19-41 Schematic showing the difference between piercing and blanking.



Blanking with a square faced punch and one containing angular shear.

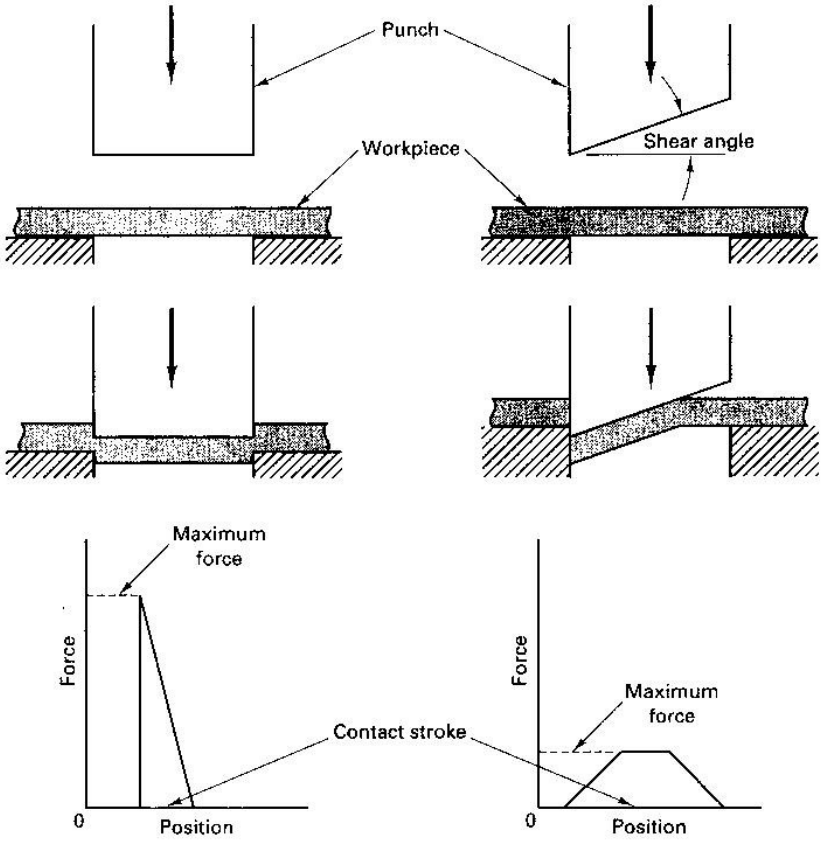
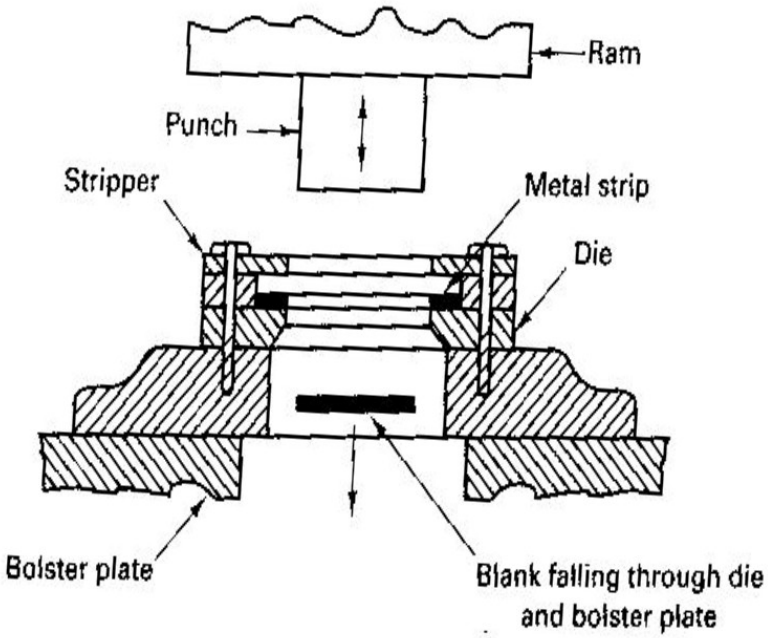


FIGURE 19-46 Blanking with a square-faced punch (*left*) and one containing angular shear (*right*). Note the difference in maximum force and contact stroke. The total work (the area under the curve) is the same for both processes.

- The use of angular shear edge reduces the maximum force and contact stroke

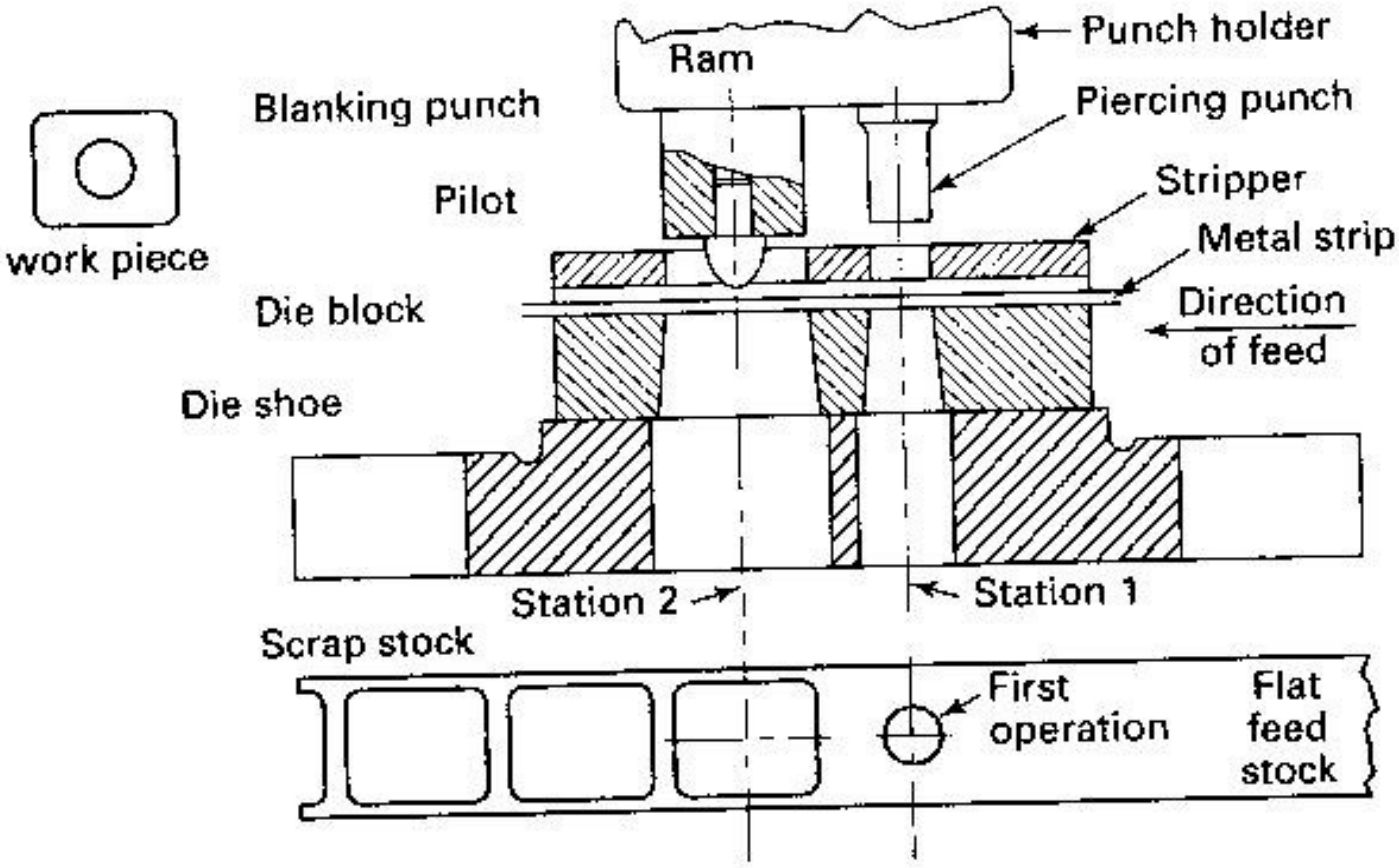
Tools and dies for piercing and blanking

FIGURE 19-45 The basic components of piercing and blanking dies.

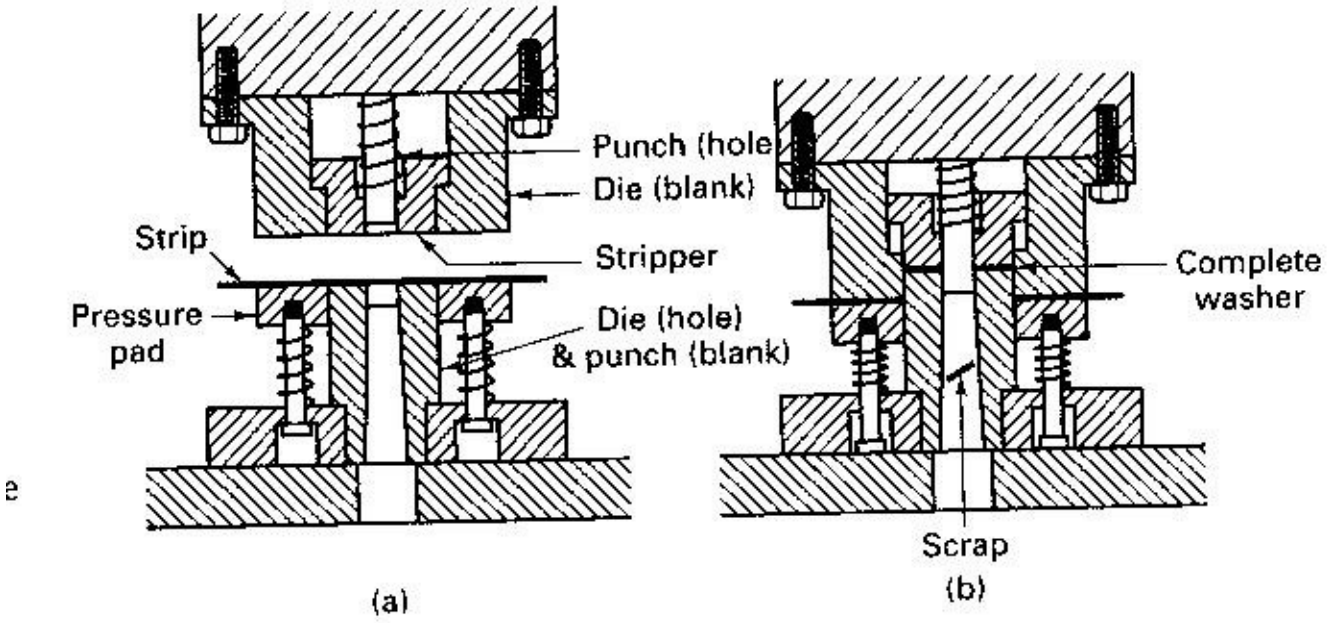


- **Punch**
- **Die**
- **Stripper plate**

Progressive piercing and blanking die for making a square washer



Method of making a simple washer in a compound piercing and blanking die



- compound dies are more precise but more expensive and more susceptible to breakage

Design for piercing and blanking

- diameters of pierced holes should be ≥ the thickness (t) of the metal, with a min. of 0.3mm.
- smaller holes can be made but difficult
- min distance between holes or hole and edge should be at least ≥t
- width of a projection should be ≥t and never less than 2.5mm
- keep tolerances as large as possible. Tolerances ≤ 0.075mm will require shaving
- arrange parts on the strip with minimum scrap

IV- Drawing and Sheet Metal Forming

- Rod, bar and tube drawing

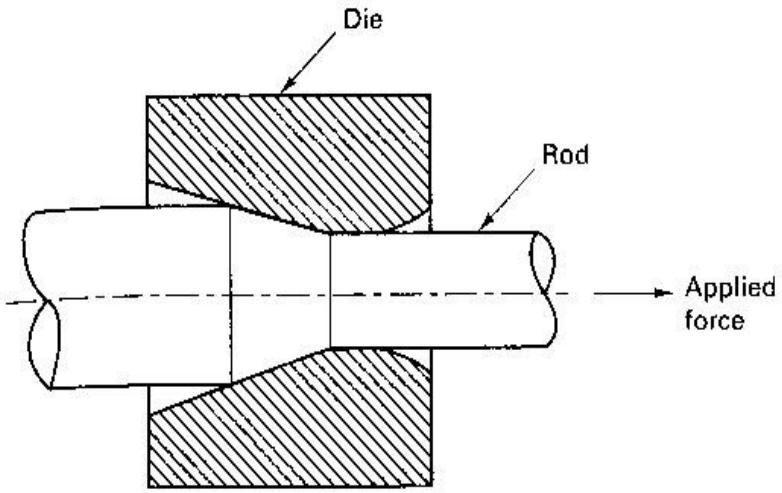


FIGURE 19-53 Schematic diagram of the rod or bar-drawing process.

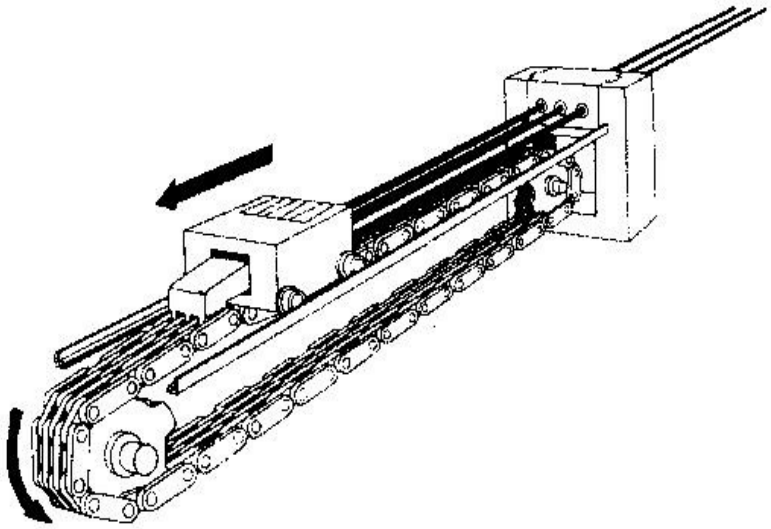


FIGURE 19-54 Schematic diagram of a chain-driven multiple-die-draw bench used to produce finite lengths of straight rod or tube. *(Courtesy of Wean United, Inc.)*

Tube drawing with stationary mandrel and with floating plug

FIGURE 19-55 Cold-drawing smaller tubing from larger tubing. The die sets the outer dimension while the stationary mandrel sizes the inner diameter.

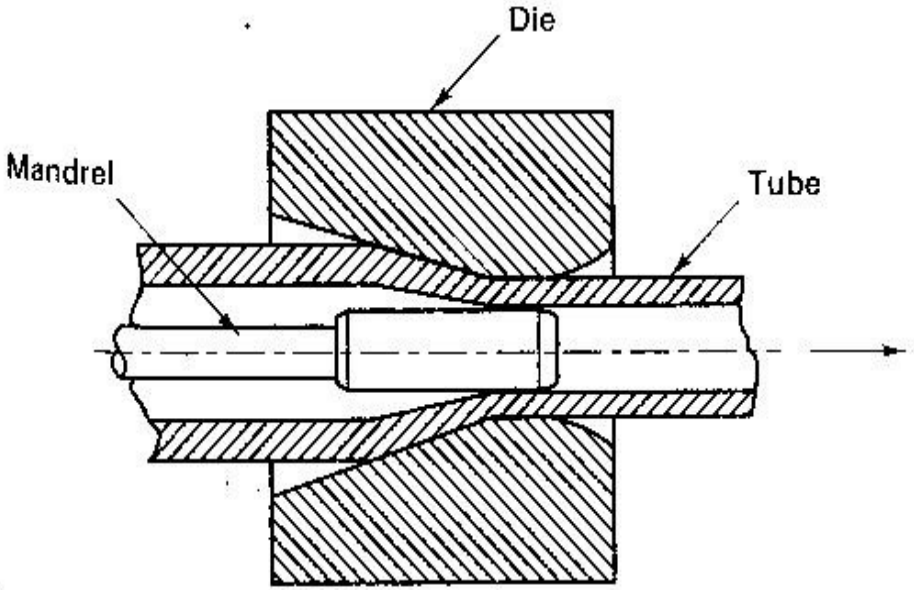
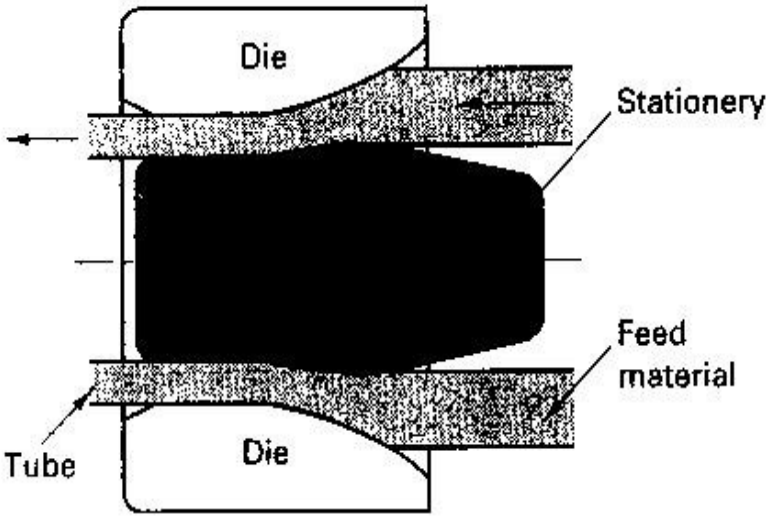


FIGURE 19-56 Tube drawing with a floating plug.



Wire drawing

Materials for wire drawing dies :

- Wear resistant tungsten carbide or polycrystalline diamond
- Single – crystal diamond with very fine wires
- Low friction coating and lubrication boxes
- Because of the tensile load applied , the amount of reduction is limited and multiple draws are usually required
- To minimize handling, a multi station synchronized wire drawing machine is used.

Wire Drawing

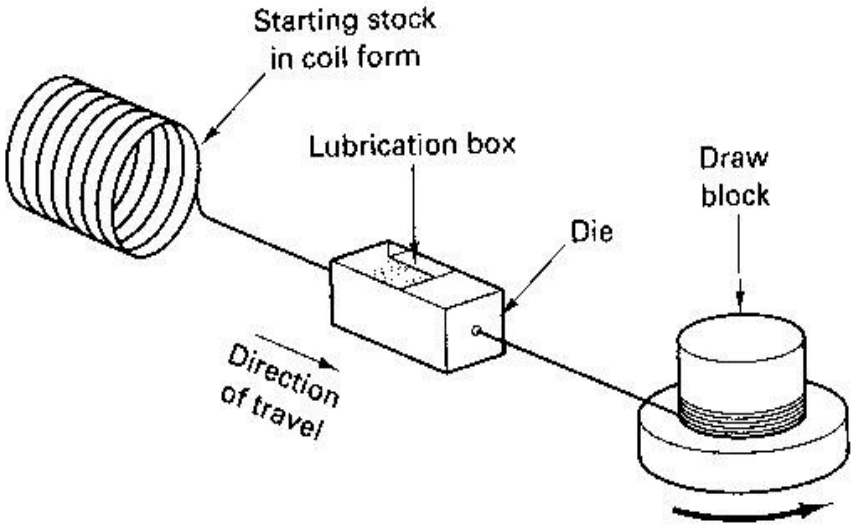


FIGURE 19-57 Schematic of wire drawing with a rotating draw block. The rotating motor on the draw block provides a continuous pull on the incoming wire.

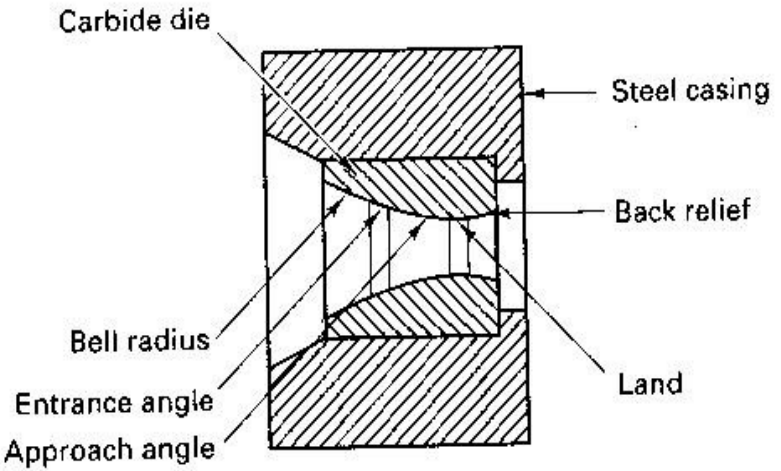
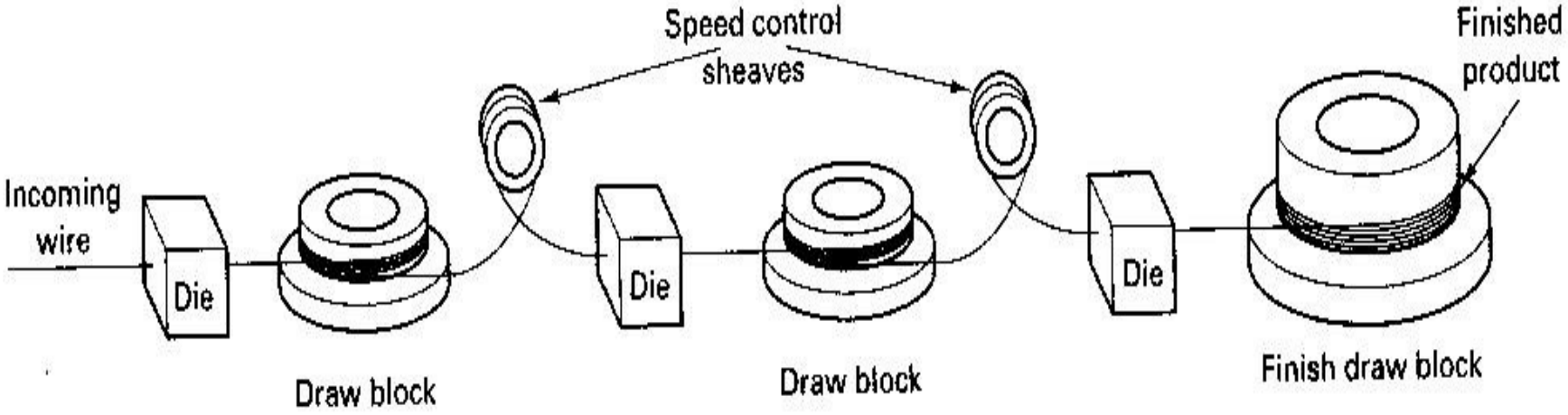


FIGURE 19-58 Cross section through a typical carbide wire drawing die showing the characteristic regions of the contour.

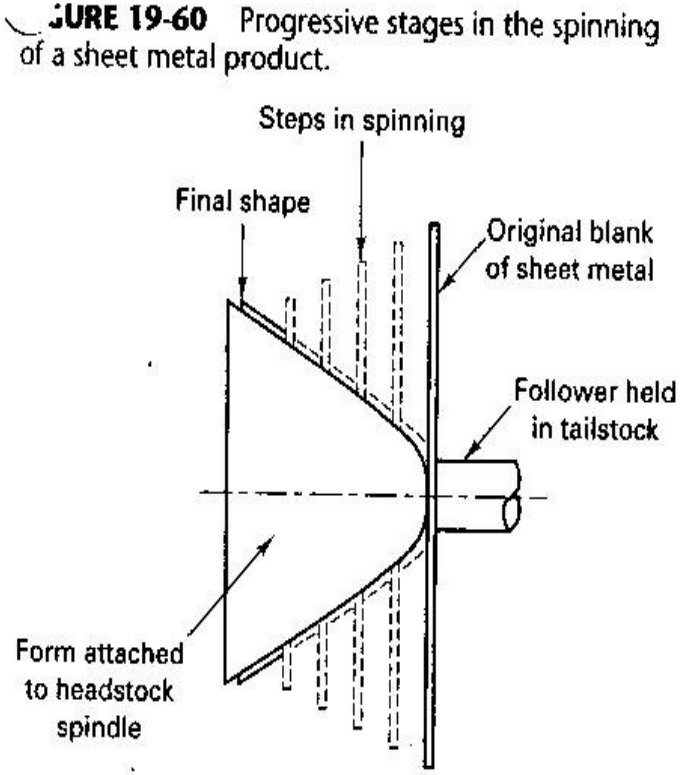
Wire Drawing

To prevent accumulation or breakage, it is necessary to have a speed control

FIGURE 19-59 Schematic of a multistation synchronized wire drawing machine. To prevent accumulation or breakage, it is necessary to assure that the same volume of material passes through each station in a given time. The loops around the sheaves between the stations use wire tensions and feedback electronics to provide the necessary speed control.



Spinning


URE 19-60 Progressive stages in the spinning of a sheet metal product.
Steps in spinning
Final shape
Original blank of sheet metal
Follower held in tailstock
Form attached to headstock spindle

Shear forming process

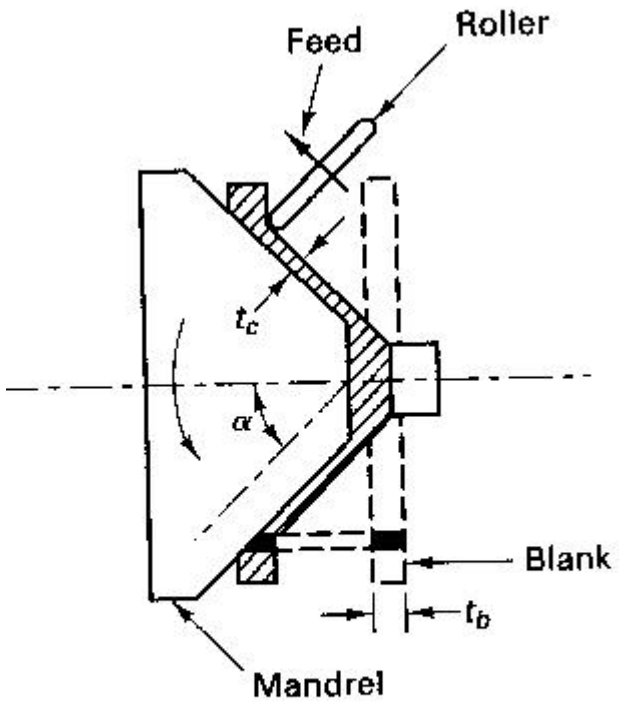


FIGURE 19-62 Schematic representation of the basic shear-forming process.

IV- Sheet metal drawing- Deep drawing

FIGURE 19-66 Schematic of the deep drawing process.

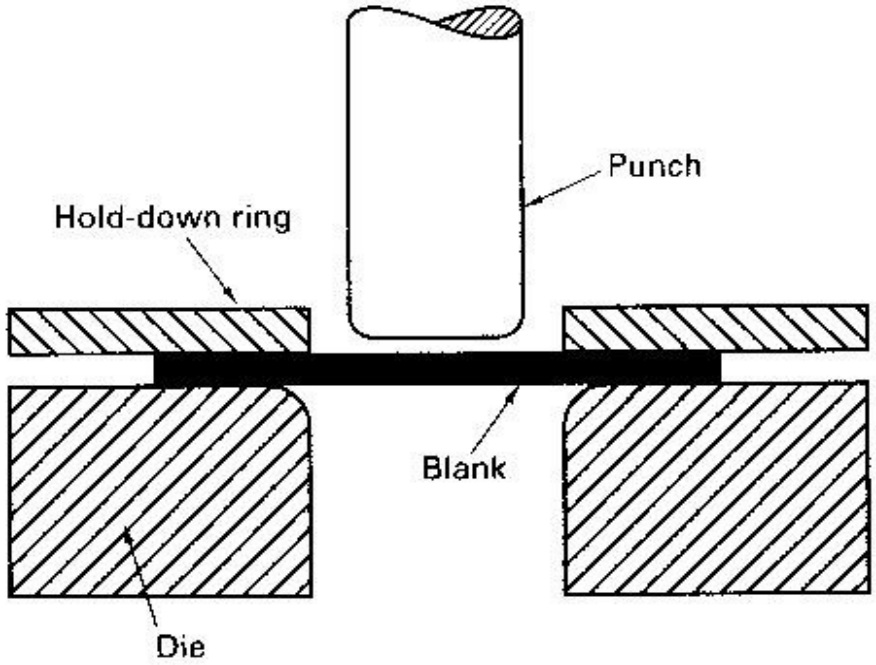
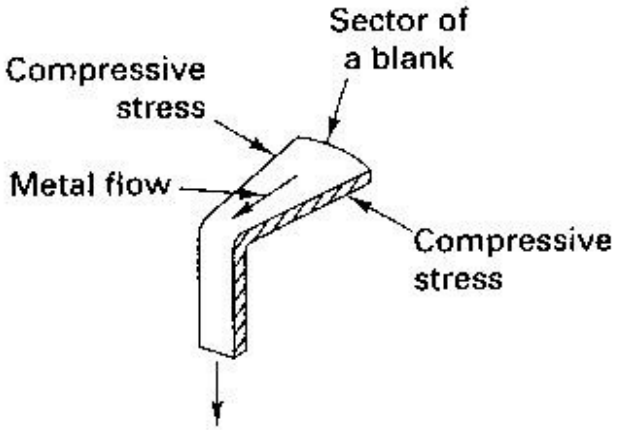
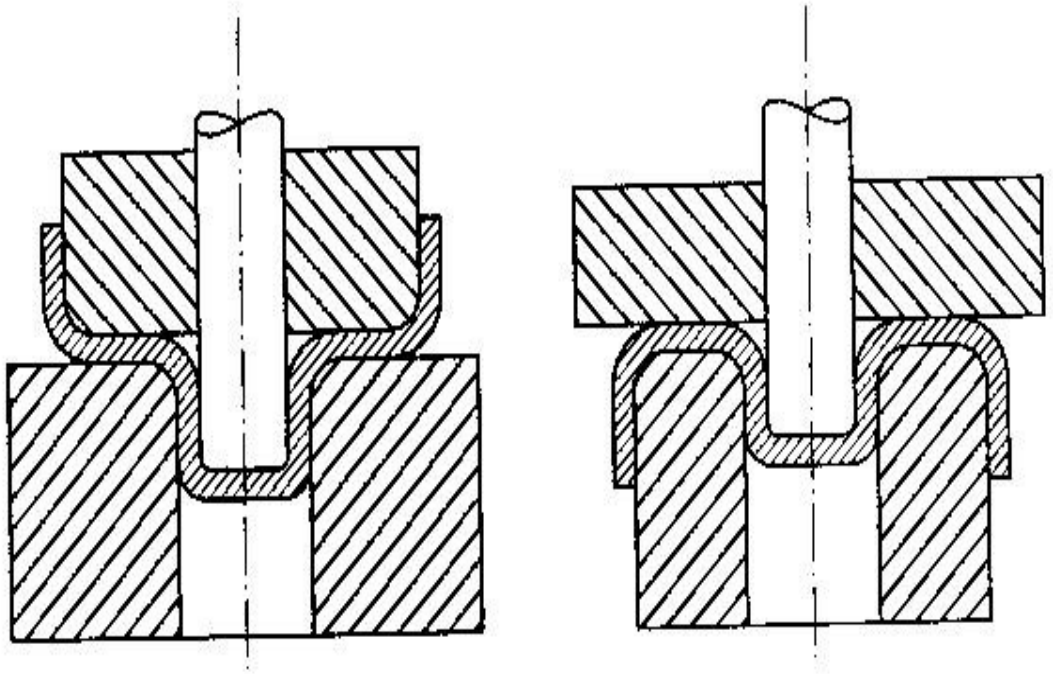


FIGURE 19-67 Flow of material during deep drawing. Note the circumferential compression as the radius is pulled inward.



Cup redrawing

FIGURE 19-70 Cup redrawing to further reduce diameter and increase wall height. (*Left*) forward redraw, (*right*) reverse redraw.



Ironing - embossing

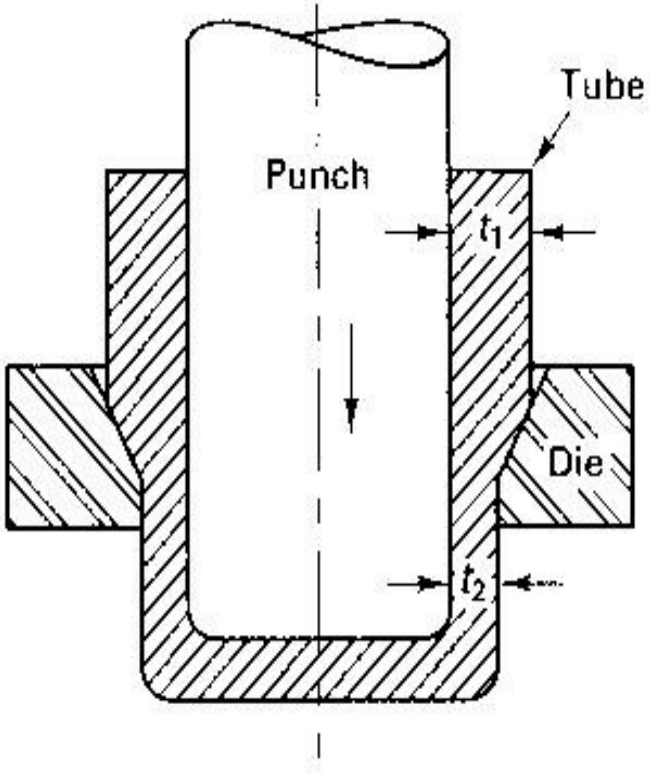


FIGURE 19-82 Schematic of the ironing process.

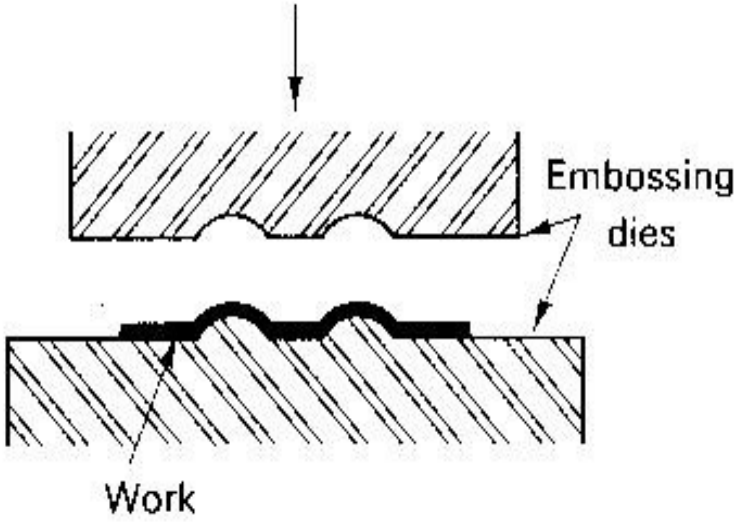


FIGURE 19-83 Embossing.

Sheet Metal work Products

Review questions

- What are the advantages of cold working processes?
- What is the effect of cold rolling of sheets? How can we control the hardness of the sheet?
- What is swaging? And what are the main products?
- How can cold forging be used to substantially reduce material waste?
- What are some processes using cold forging? Sketch
- What is impact extrusion and what materials and products can be obtained?
- How can the surface quality and hardness be improved by cold working processes? Which processes are used?
- Sketch : bending – air bending- piercing- drawing- wire drawing- tube drawing- metal spinning
- What is difference between piercing and blanking?
- What is spring back and how it can be remedied?
- What is embossing and coining? sketch