Metal Cutting, Forming and Drawing

ITCD – 301-001

Making a die

- Begins with the die designer
- Good dies have lesser repair
- Metric vs. Pound, inch system
- Important guidelines
- Cost associated problems
- Repeatability

Simple die punching

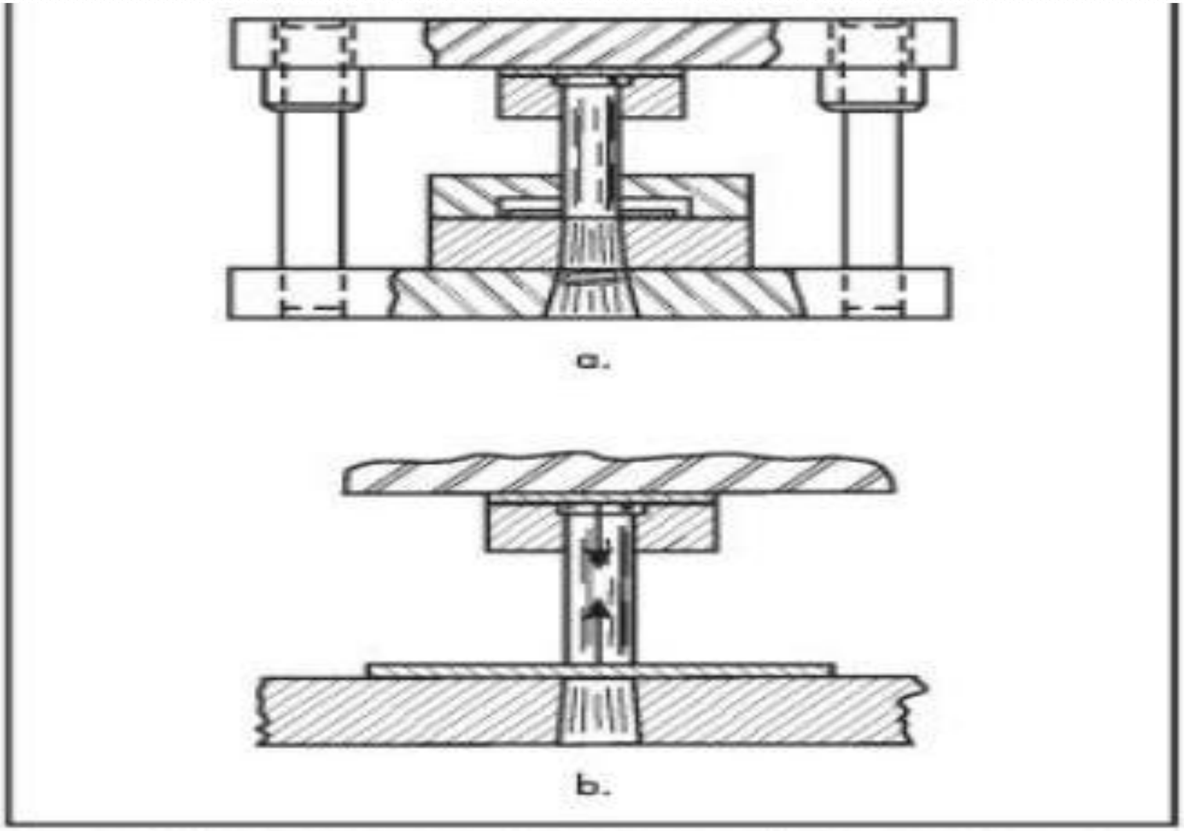


Figure 8-1. (a) *Sectional view of a cutting die for producing round holes;* (b) *the punch is compressed after making initial contact with the stock (Smith 2001).*

Die cutting operations

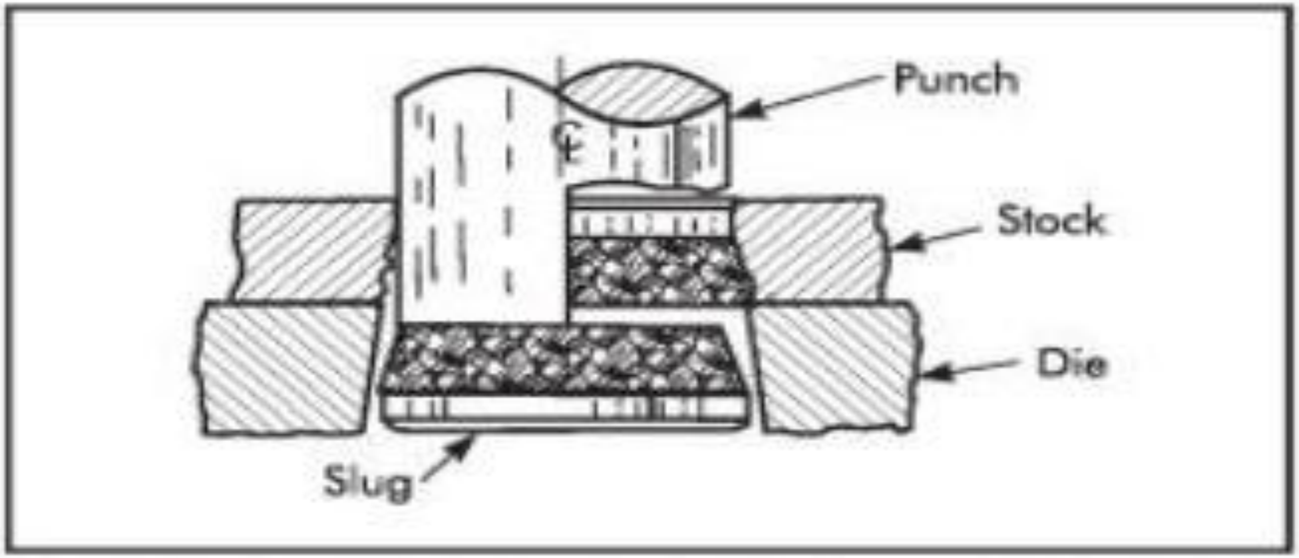


Figure 8-2. *Section view of a successful hole-cutting operation involving normal clearances. Note that both the cut edge and slug have one third of metal thickness as a sheared edge shear and two thirds fracture (Smith 1994).*

Die cutting operations

- Controlled by process of plastic deformation
- Fracture
- Tensile and compressive strains included
- Elastic, plastic and fracture
- Fracture through cleavage planes in the reduced area
- Shearing process

Clearance

- Space left between the punch and die
- No strict rules governing clearance
- Expressed as a percentage of stock thickness per side
- For mild steel, between 5-12 %
- Optimizing die clearance is a good strategy
- Lower cutting pressure
- Extended tool life
- Limiting factors – amount of taper permitted in the hole and allowable burr height

Insufficient clearance

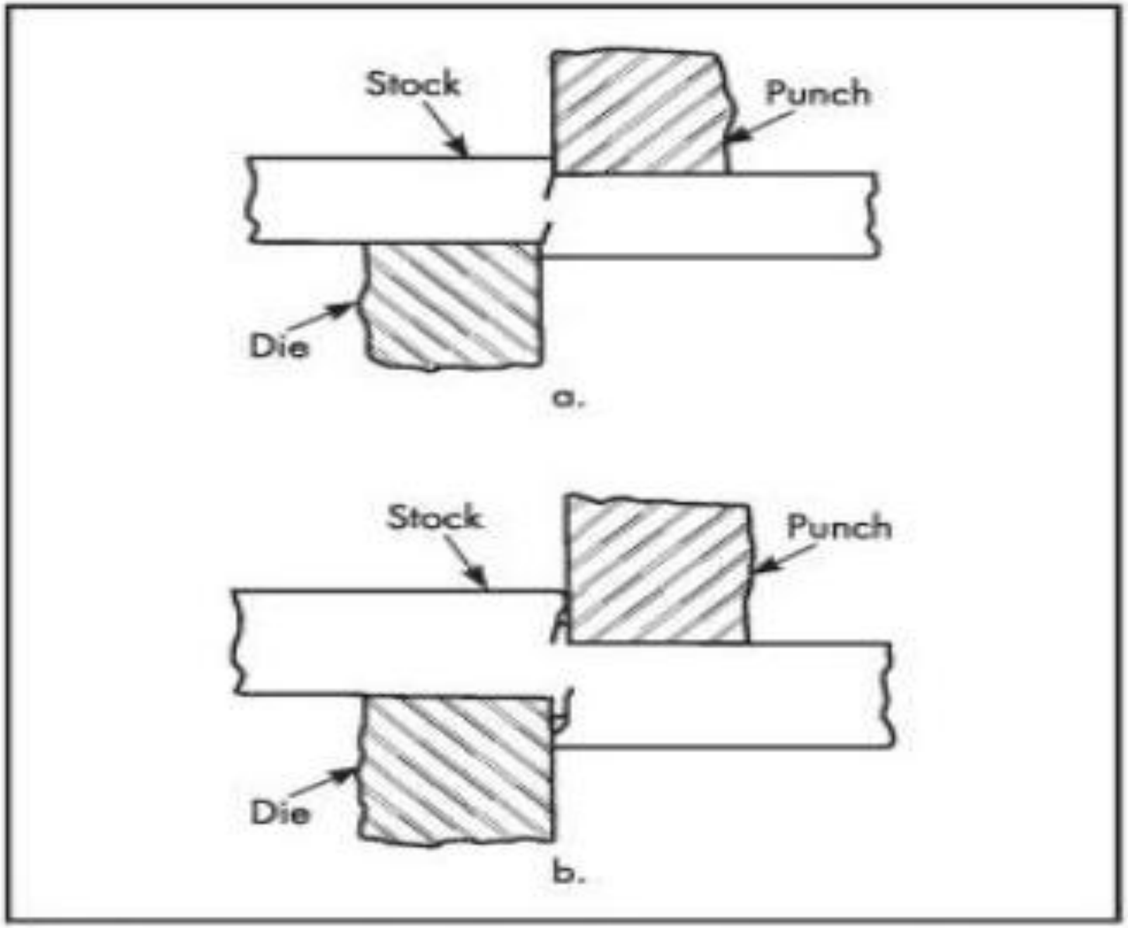


Figure 8-3. *Cutting (a) with insufficient clearance. As fracture continues (b), rough tearing occurs and the fracture paths will not meet.*

Insufficient clearance

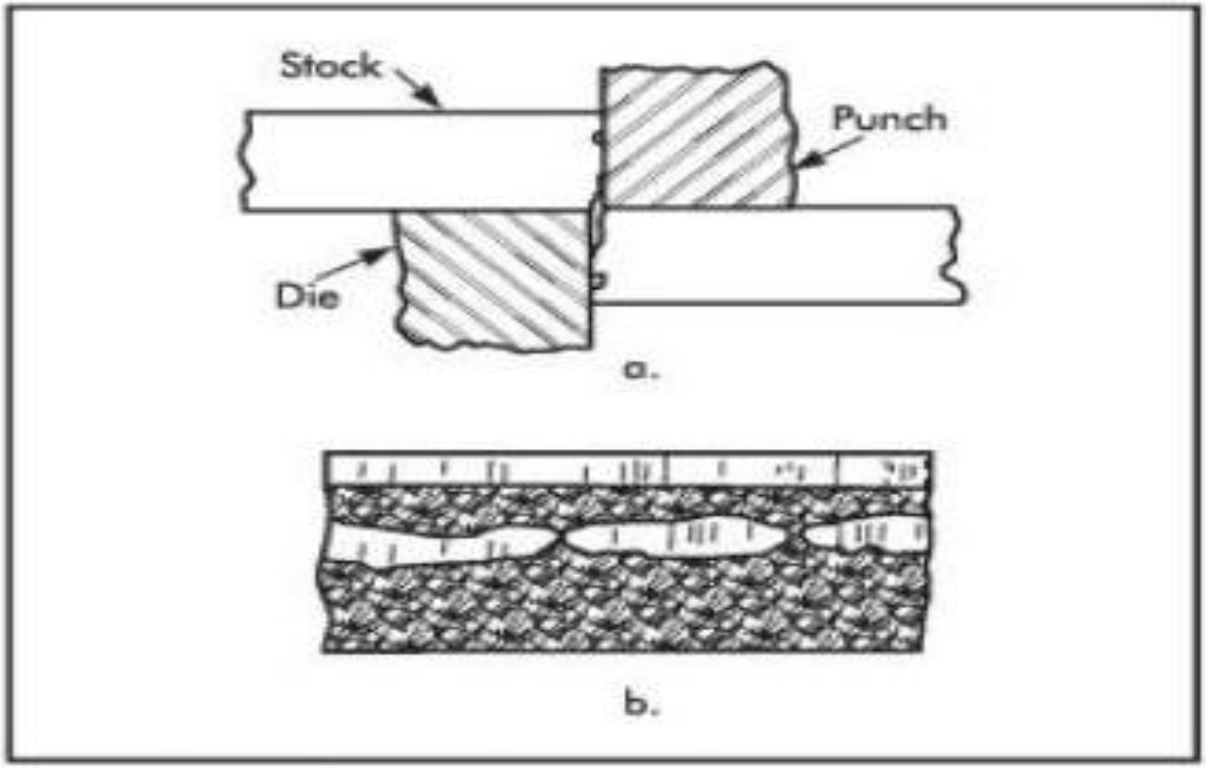


Figure 8-4. *Insufficient clearance (a) results in a double fracture or breakage condition. Appearance of a cut edge with a double-breakage condition (b).*

Clearance facts

Tight clearances in the 3-5% range results in,

•Less taper
•Slug pulling reduced
•High cutting forces
•Double breakage problems in thick materials

Large clearances in the 7-25% range results in,

• Longer life for die and punch
•A means to protect against slug pulling
•Low cutting forces
•No double breakage
•Great edge taper and more burr height

Double breakage solution

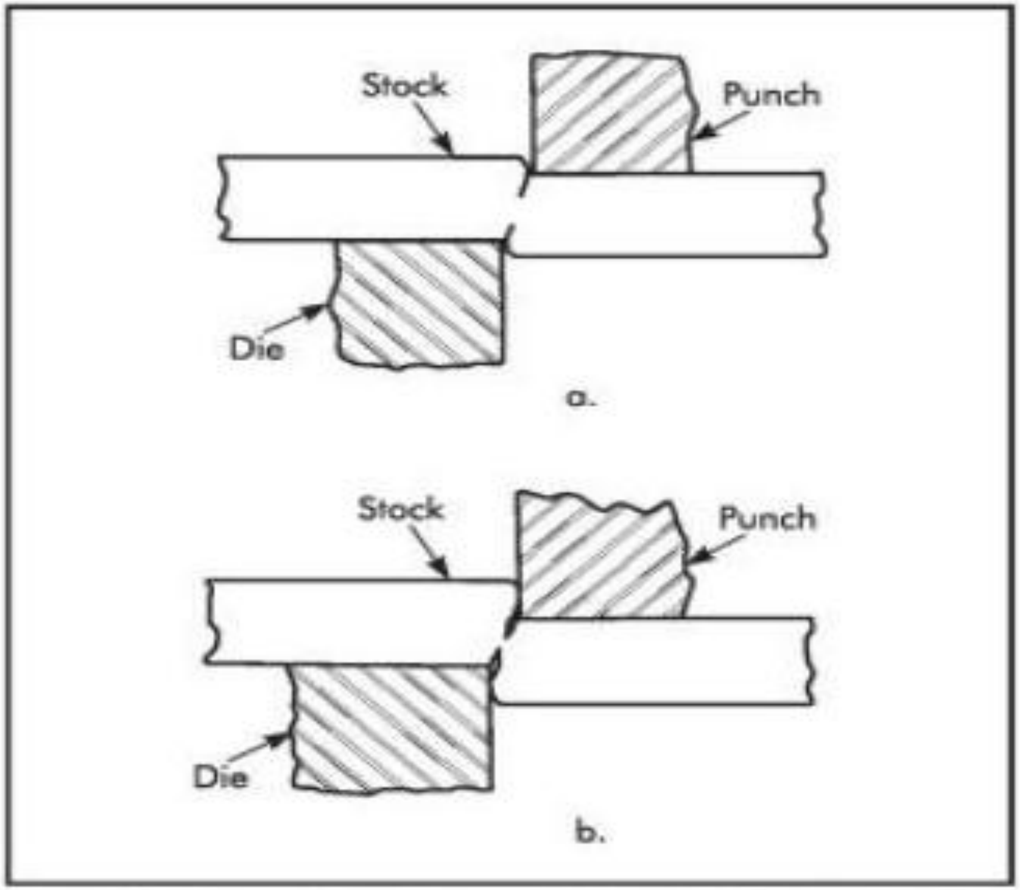


Figure 8-5. *Start of punch penetration and fracture* (a) *with a relatively large punch-to-die clearance. The fracture paths* (b) *will meet evenly.*

Double breakage solutions

- Increase the punch-to-die clearance
- Make the punch smaller
- Increase in taper of the fracture
- Reduction of the cutting force
- Efficiency goes up as less tool sharpening is required
- Clearance of 12-15% per side for soft steels
- Clearance of 25% per side for thick blanks
- Too much clearance is not good either as higher forces are required
- High lateral forces results that lower tool life

Generous punch-to-die clearance

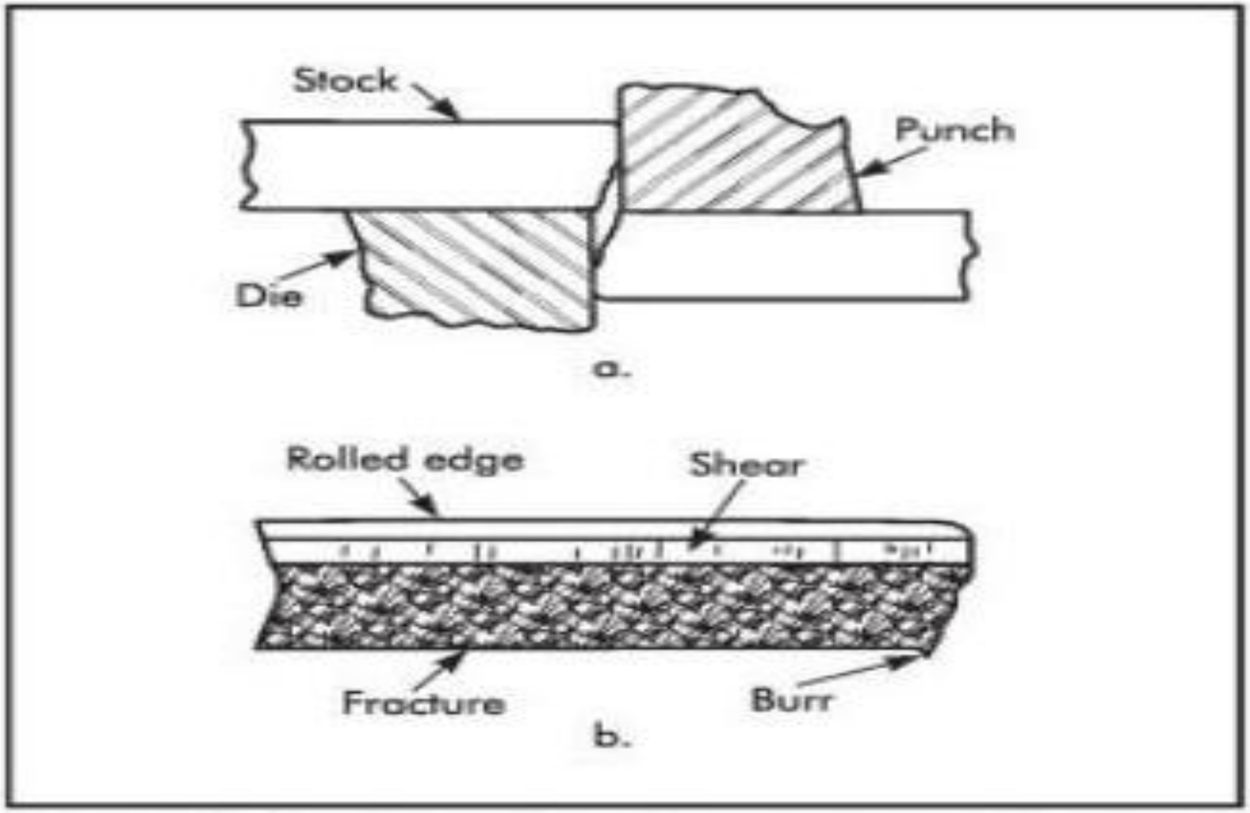


Figure 8-6. *Completion of punch penetration and fracture (a) with a generous punch-to-die clearance. View of a cut edge (b) with large punch-to-die clearances.*

Clearance for irregular shaped blanks

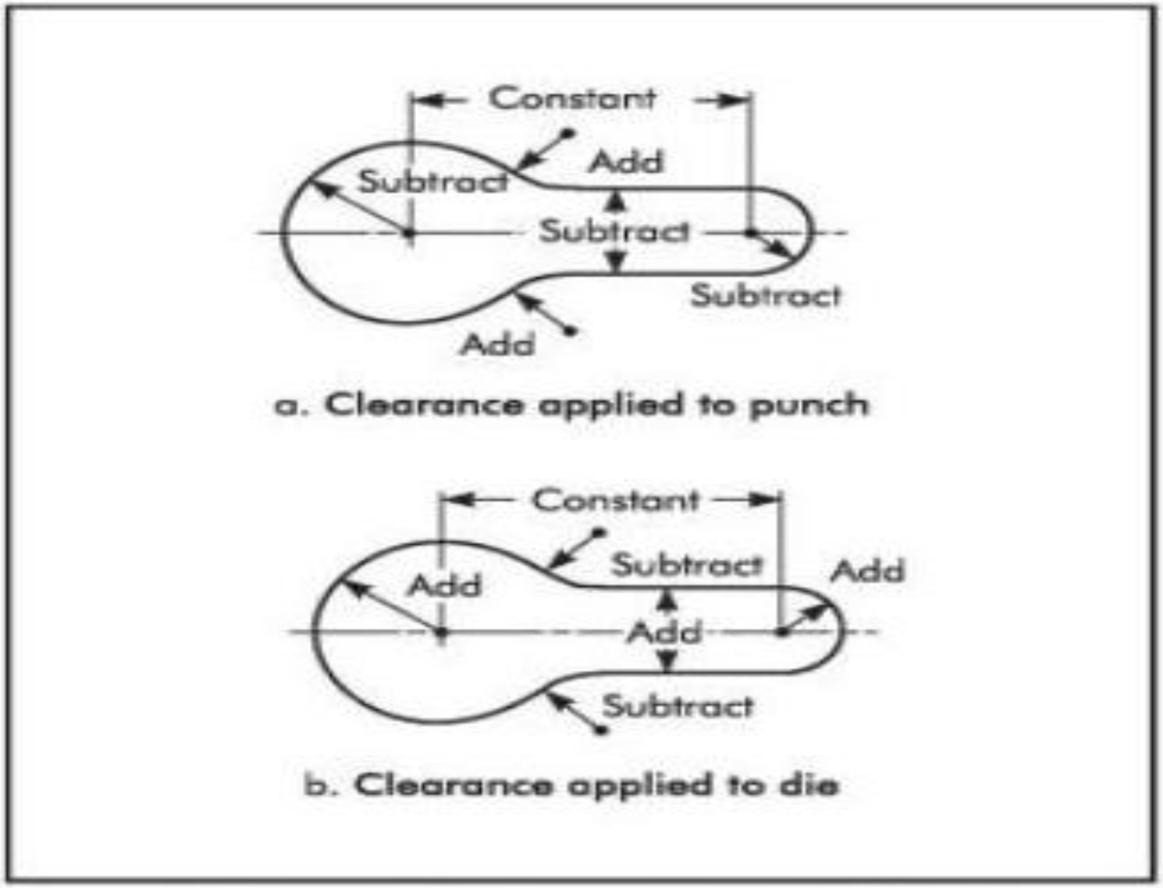


Figure 8-7. *How to apply clearances to irregularly shaped holes (Paquin 1962).*

Center of pressure

- For irregularly shaped contours
- Balance the shearing forces on both sides of the ram
- If unbalanced, result is bending moment in the ram
- Undesirable deflections and misalignment
- Find a point about which summation of shear forces are symmetrical
- This point is the center of pressure
- Essentially the center of gravity of the line that is the perimeter of the blank
- Not the center of gravity of the area
- Calculations required to find the center of pressure

Parameters

- Forces – Lesser than tensile force required(shear strength is 60-80% of tensile strength), shear strength increases with faster strain rate
- Length of cut, material thickness and shear strength
- Theoretical peak cutting force, $F_s=L*t*S_s$
- Stripping forces, F=L*T*1.5, F=L*T*20,600 (metric)
- Press tonnage – sum of all the forces required to cut and form the part (cutting, stripping and miscellaneous)
- Lateral and side-thrust forces

Forces

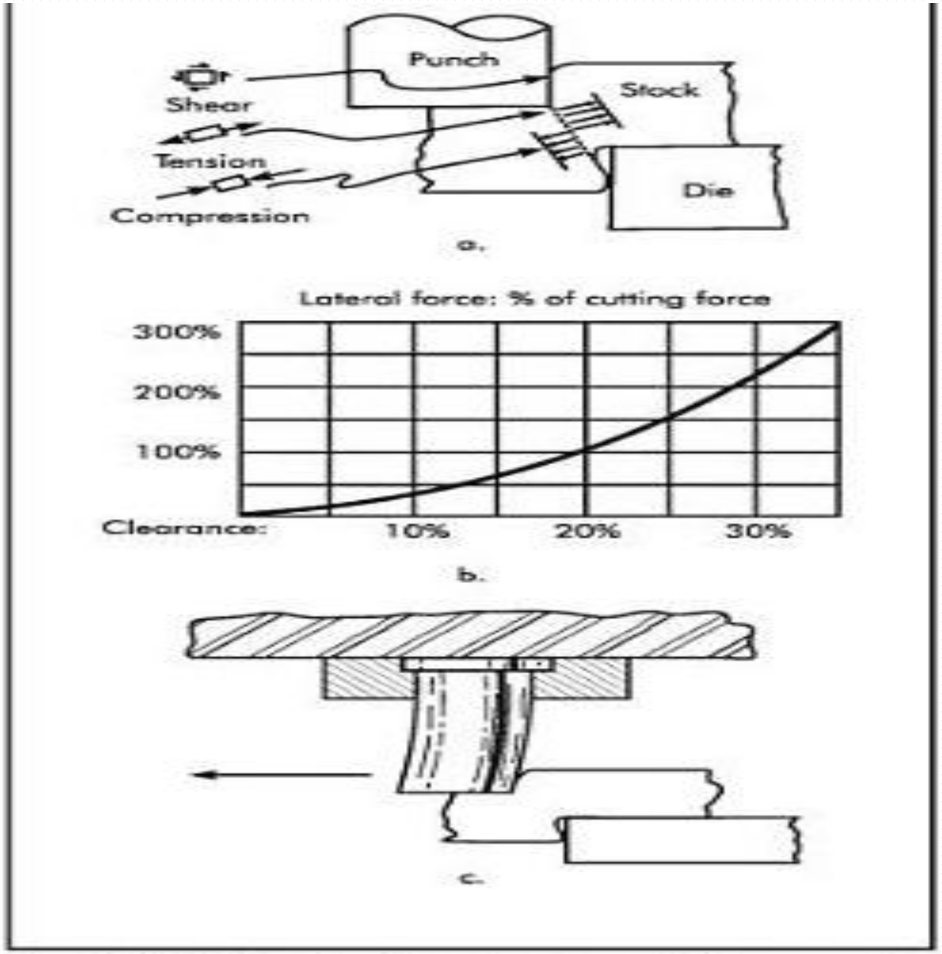
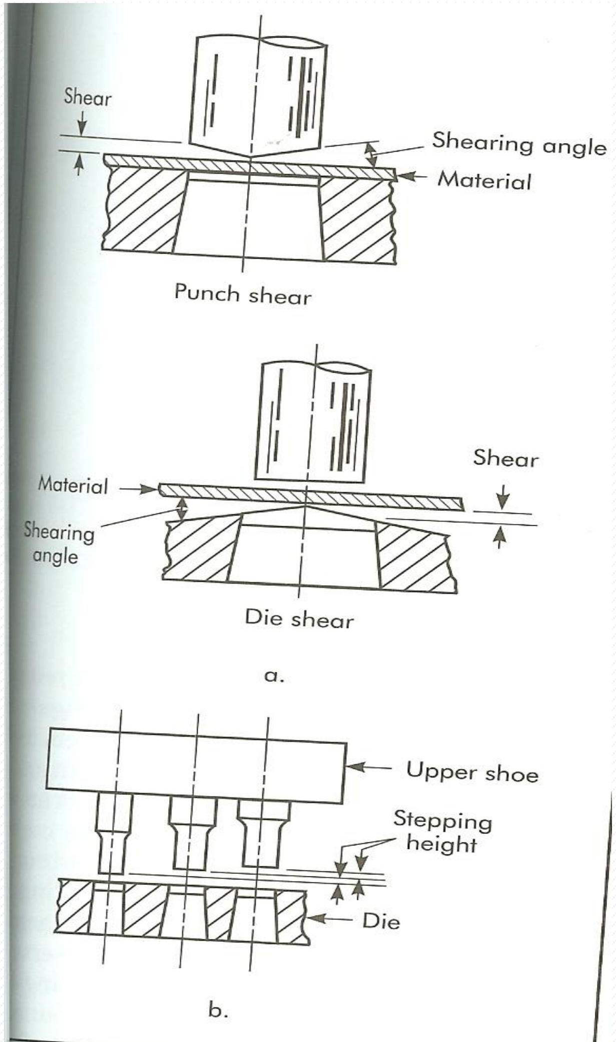


Figure 8-9. (a) *Shear, tensile, and compressive forces occur during the cutting process;* (b) *as punch-to-die clearance increases, the lateral force, or the side thrust, rapidly increases;* (c) *as side thrust increases, the cutting clearance may increase, leading to greater side thrust or lateral forces, and potential tool failure.*

Reducing cutting forces

- High forces exerted for a short period
- Spread the force over a longer period of press stroke
- By adjusting the punch height so they differ in length by 1/3'rd the material thickness and cut in sequence
- Add shear to the die or punch equal to 1/3'rd the material thickness – tonnage reduced by 50%

Cutting force reduction



-10. *Three methods to reduce cutting forces.*

Bending

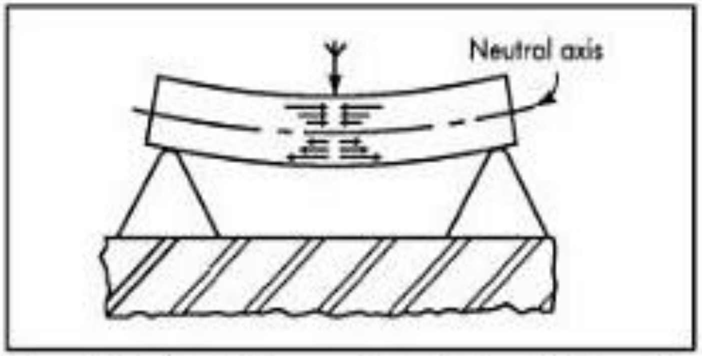


Figure 8-15. *A metal beam supported at two points, with a load applied at the midpoint, resulting in bending or deflection.*

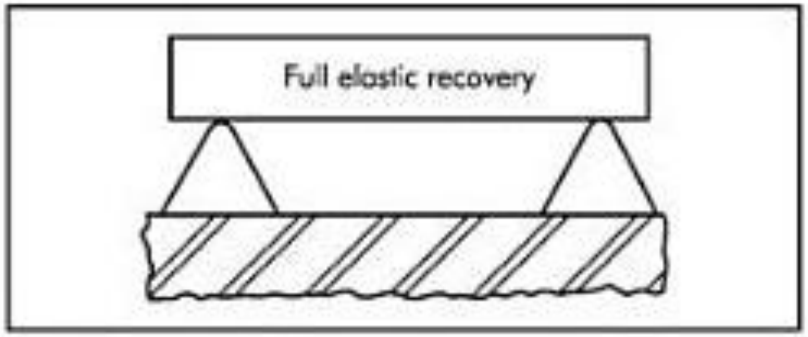


Figure 8-16. *If the applied force does not exceed the material-yield strength, the beam returns to its undeflected shape.*

Bending

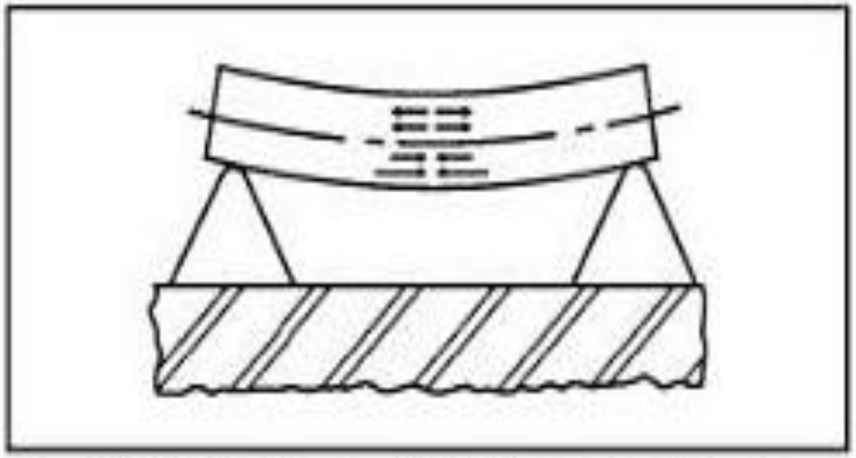


Figure 8-17. Simple beam deflection occurs in air bending. If the applied force exceeds the material-yield strength, the beam retains a permanent set or bend when the load is removed.

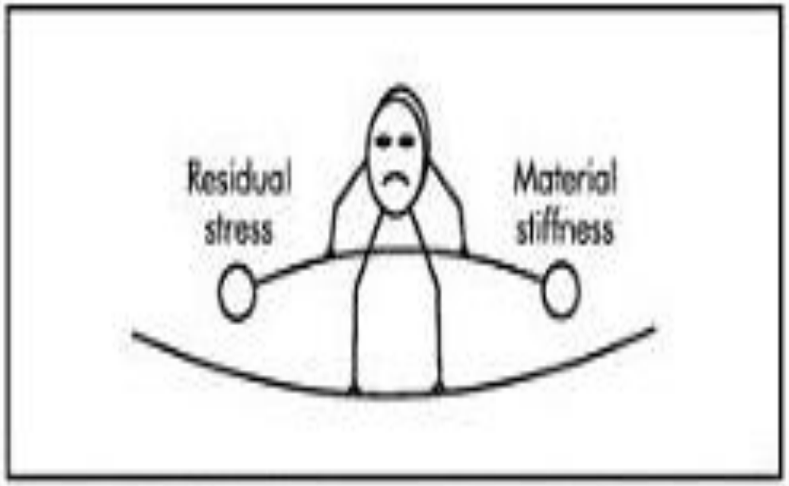


Figure 8-18. Springback occurs until the residual stress forces are balanced by the stiffness of the material.

Factors affecting Springback

- Higher material strength
- Thinner material
- Lower E
- Larger die radius
- Greater clearance
- Flatter part-surface contour
- Less irregularity in part outline

Air bending and Coining

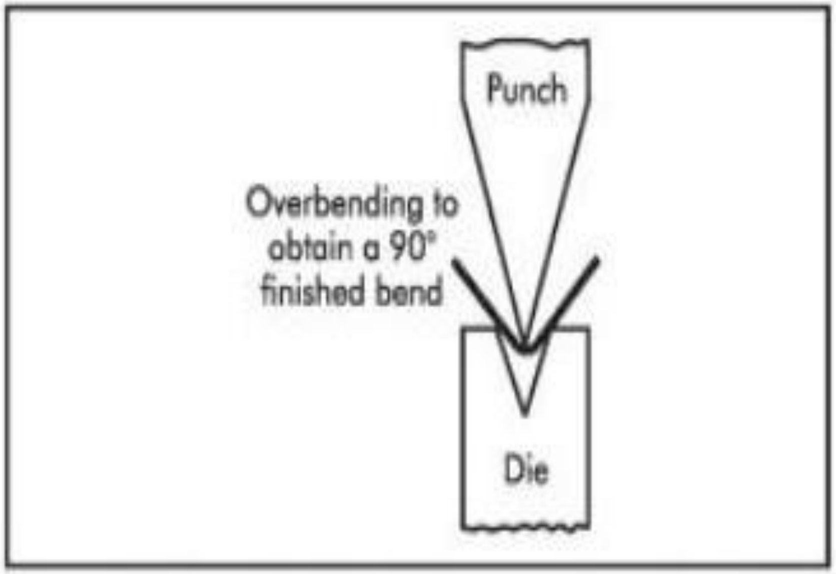


Figure 8-19. *Simple tooling of the type used to air-bend sheet-metal parts in press brakes. The upper die is lowered a little and a hit is made until the desired bend angle is obtained.*

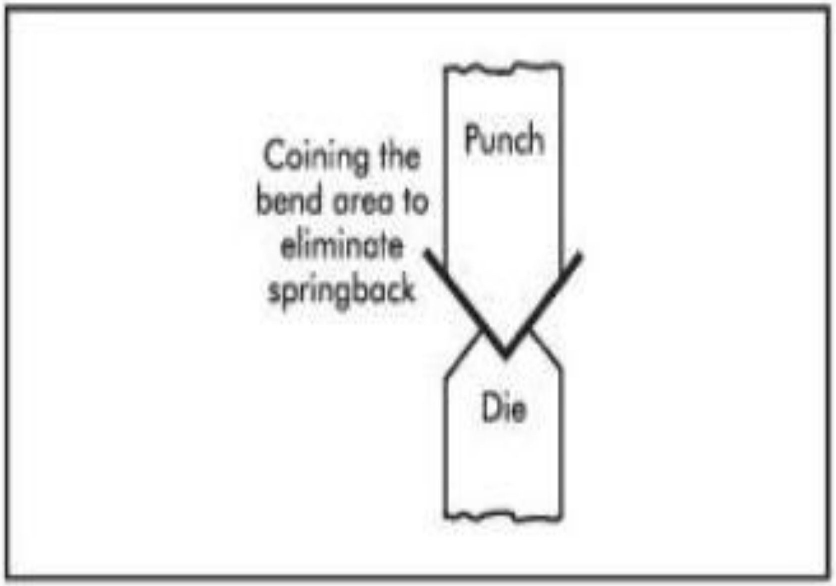


Figure 8-20. *Coining the bend requires high tonnage to obtain a sharp, accurate bend.*

Wipe flanging

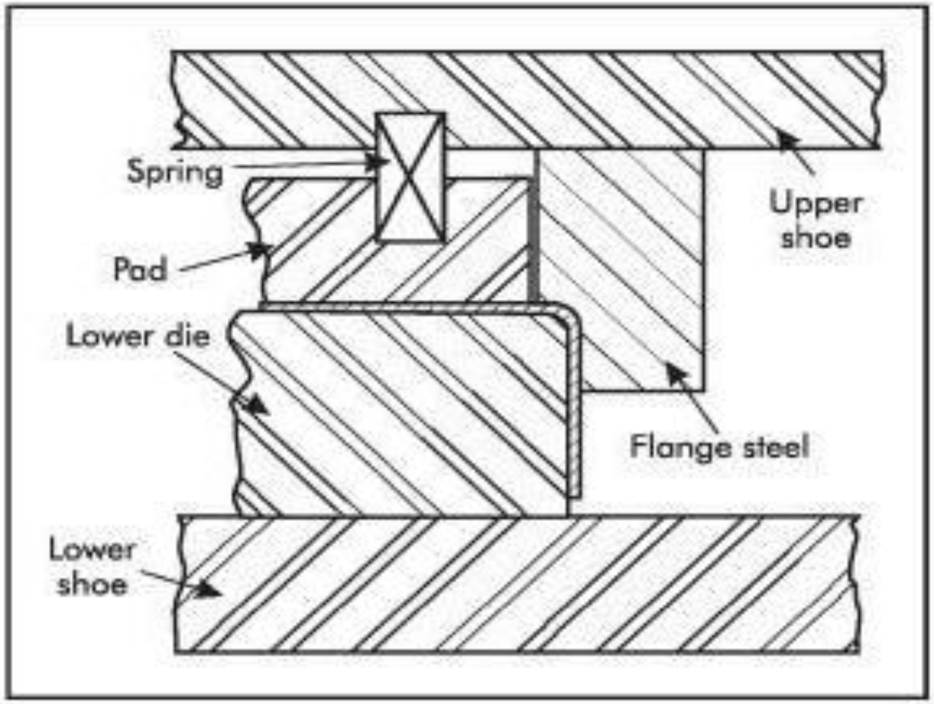


Figure 8-21. *Sectional view of a wipe-flanging die.*

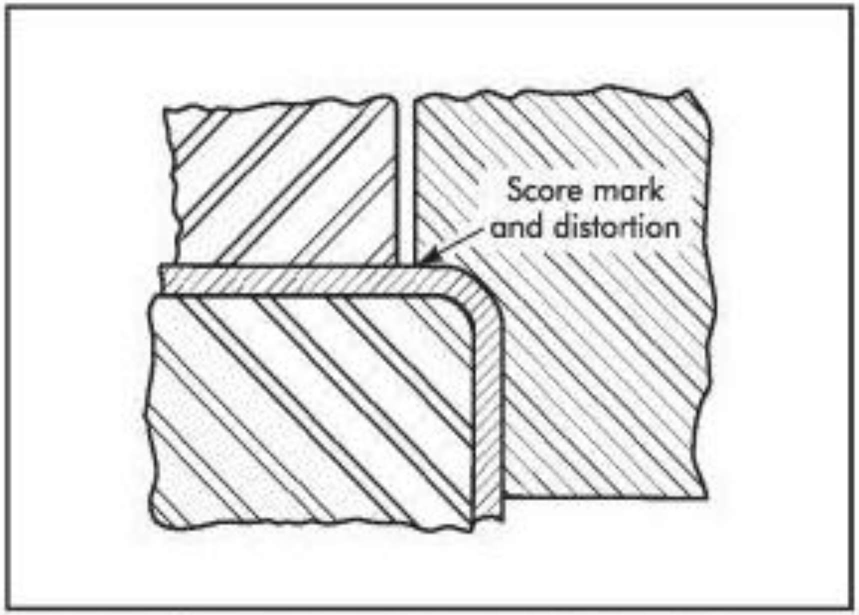


Figure 8-22. *Close-up view of the point of flange steel contact on the bend radius in a wipe-flanging die.*

Wipe flanging

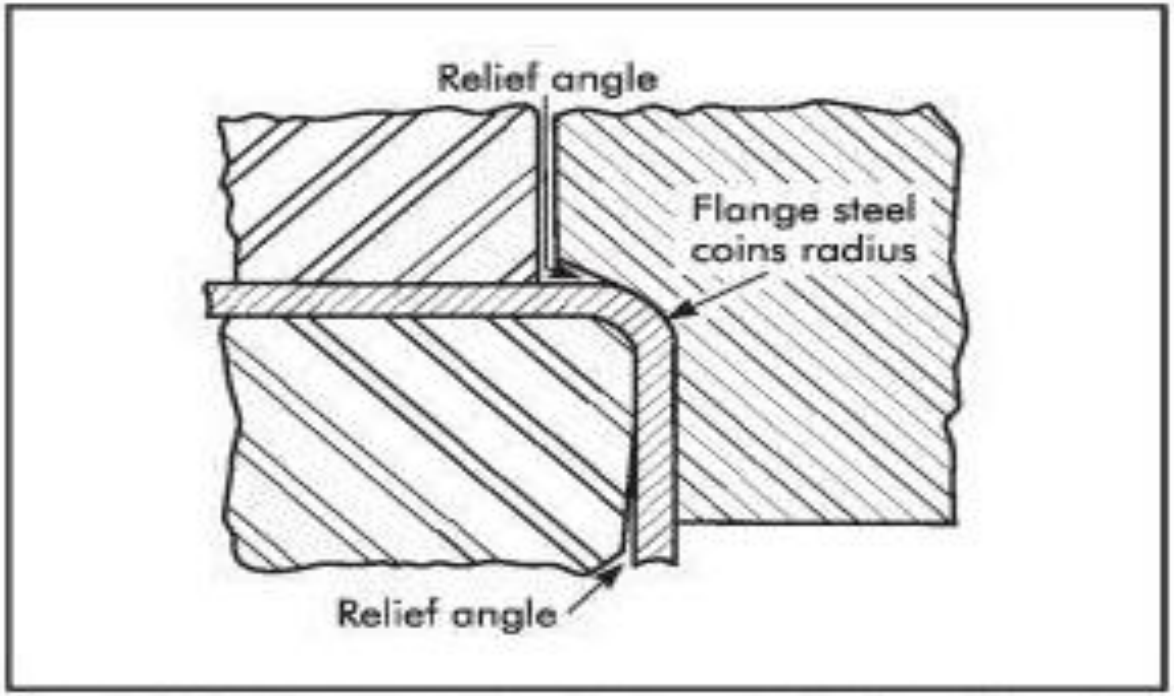


Figure 8-23. *The side of the radius is coined and a relief angle is provided in the lower-die steel in this improved springback control method.*

Rotary action die bending

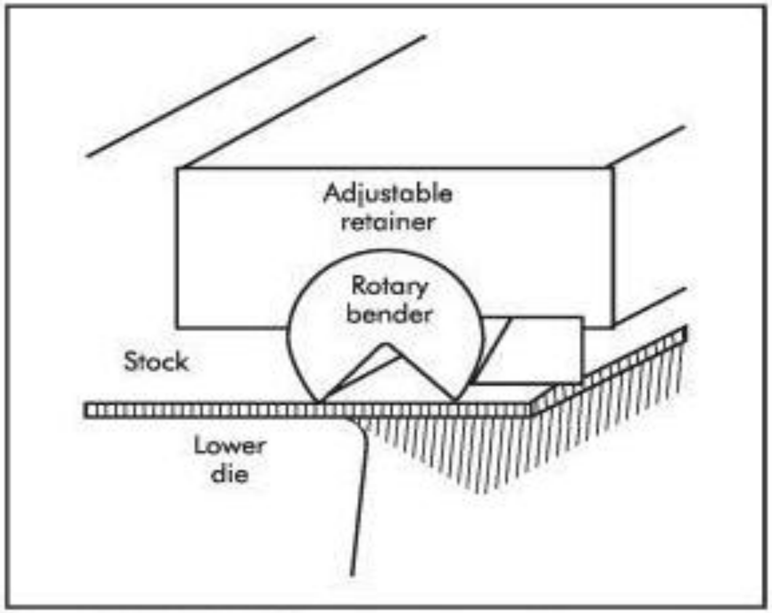


Figure 8-24. A Ready™ bender makes initial contact with the stock. As the die closes, the bender clamps and bends the stock. (Courtesy Ready Tools, Inc.)

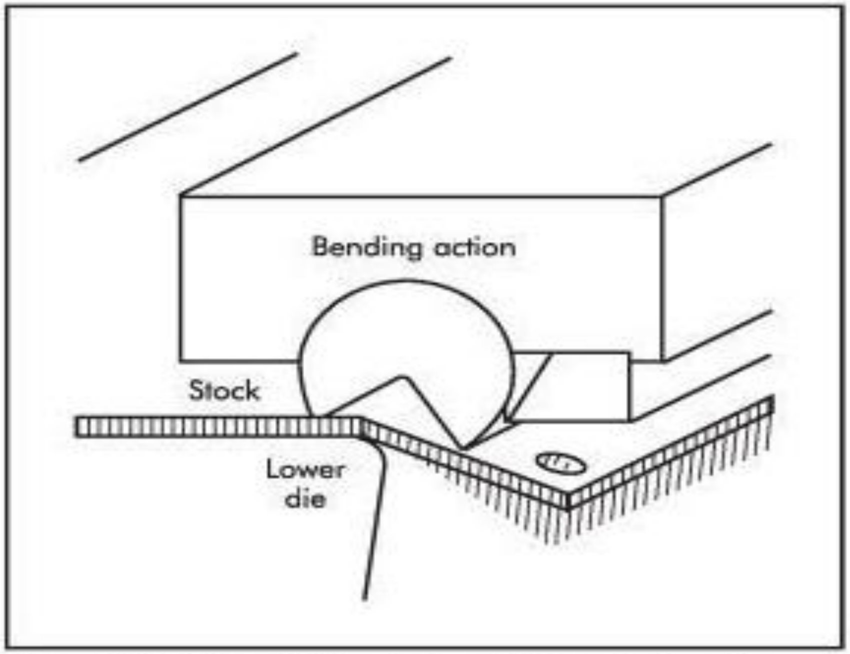


Figure 8-25. A Ready™ bender bends the stock through rotary action of the circular member. (Courtesy Ready Tools, Inc.)

Rotary action die bending

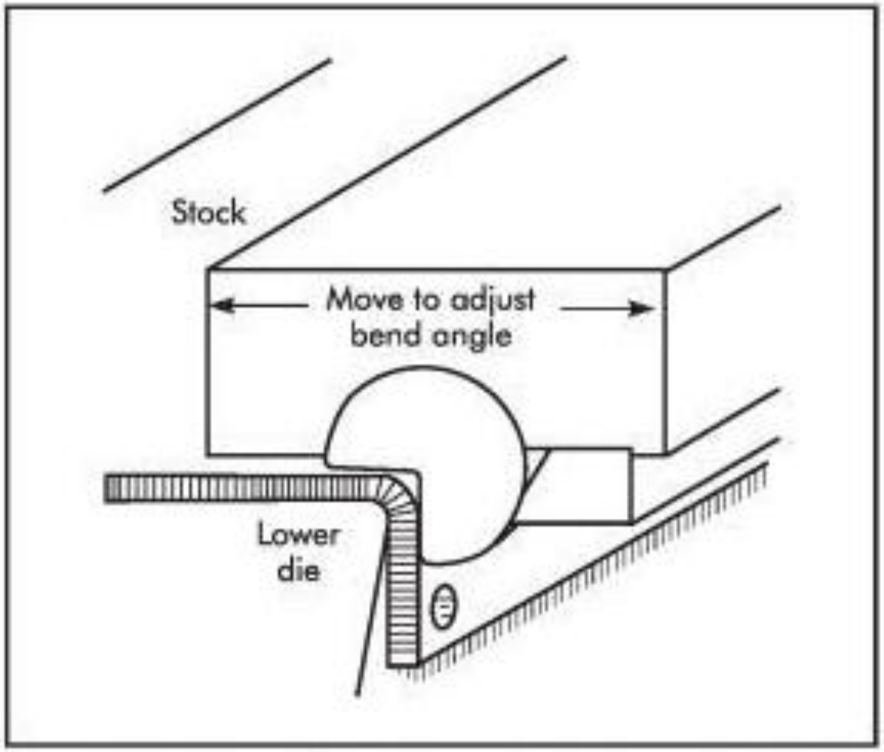


Figure 8-26. *A Ready™ bender overbends the stock at the bottom of the stroke to provide for springback.* (Courtesy Ready Tools, Inc.)

Forming

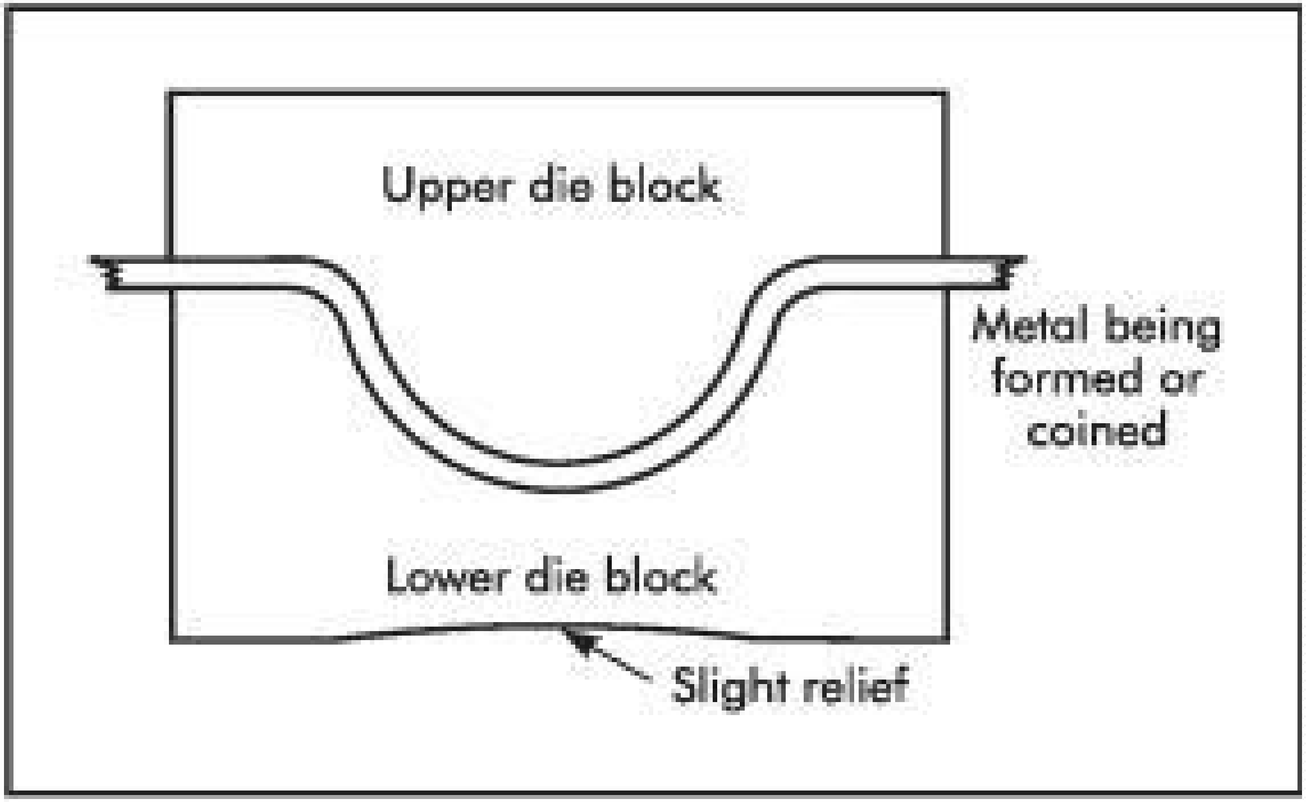


Figure 8-27. *A set of forming blocks used without a die set.*

Forming

- Large % of stampings
- Both simple and complicated
- Plastic flow
- Localized plastic flow
- Forming dies
- Number of stampings required
- Solid forming dies
- Coining dies

Radii considerations

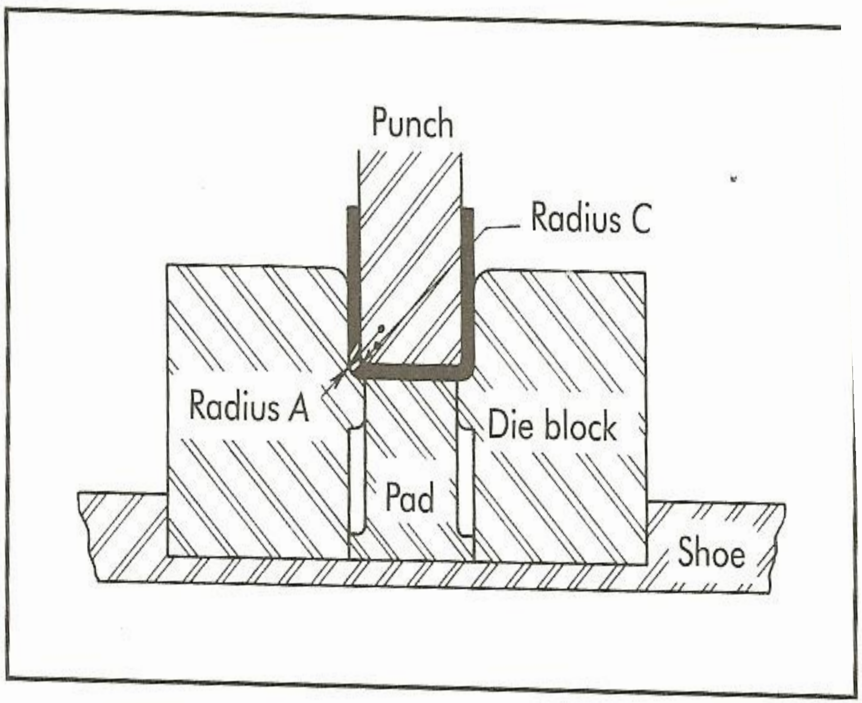


Figure 8-30. *Radii considerations for form die design.*

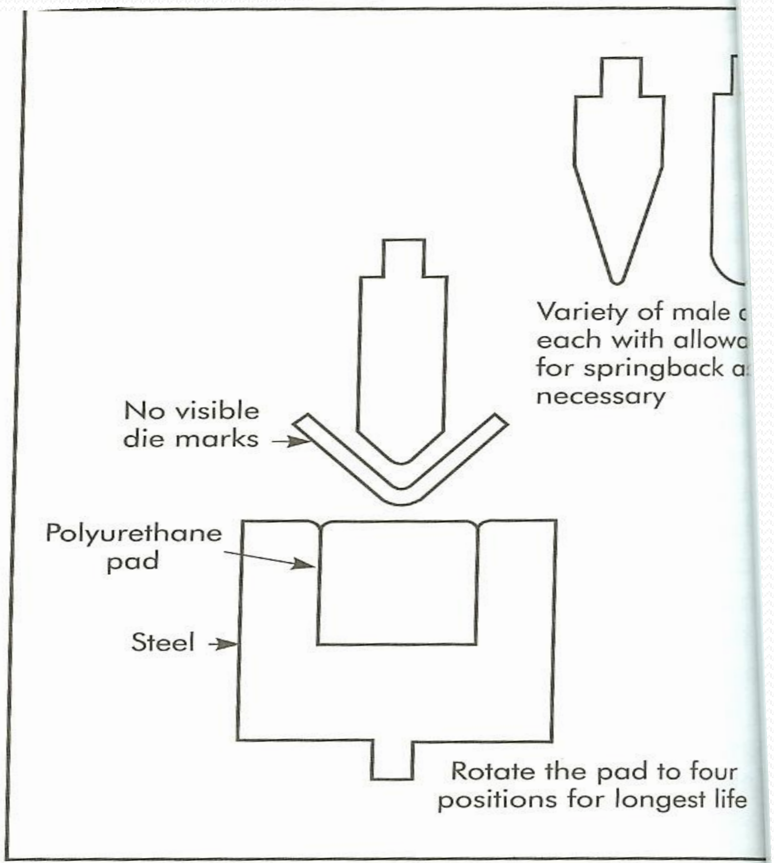


Figure 8-31. *Rubber or polyurethane forming die and pun*

Beading and curling

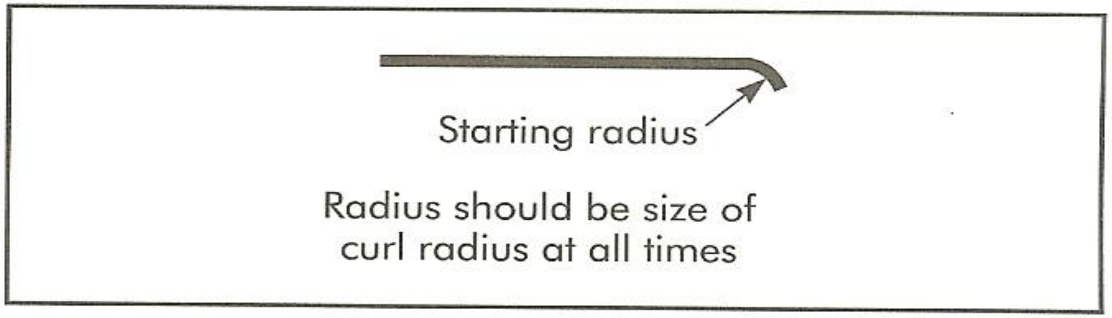


Figure 8-32. *Starting curl radius.*

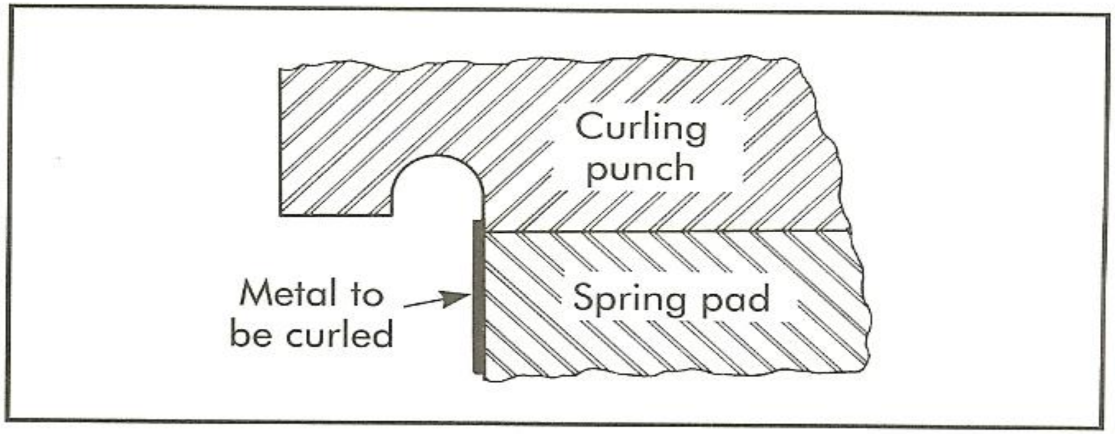


Figure 8-33. *Curling punch design.*

Beading and Curling

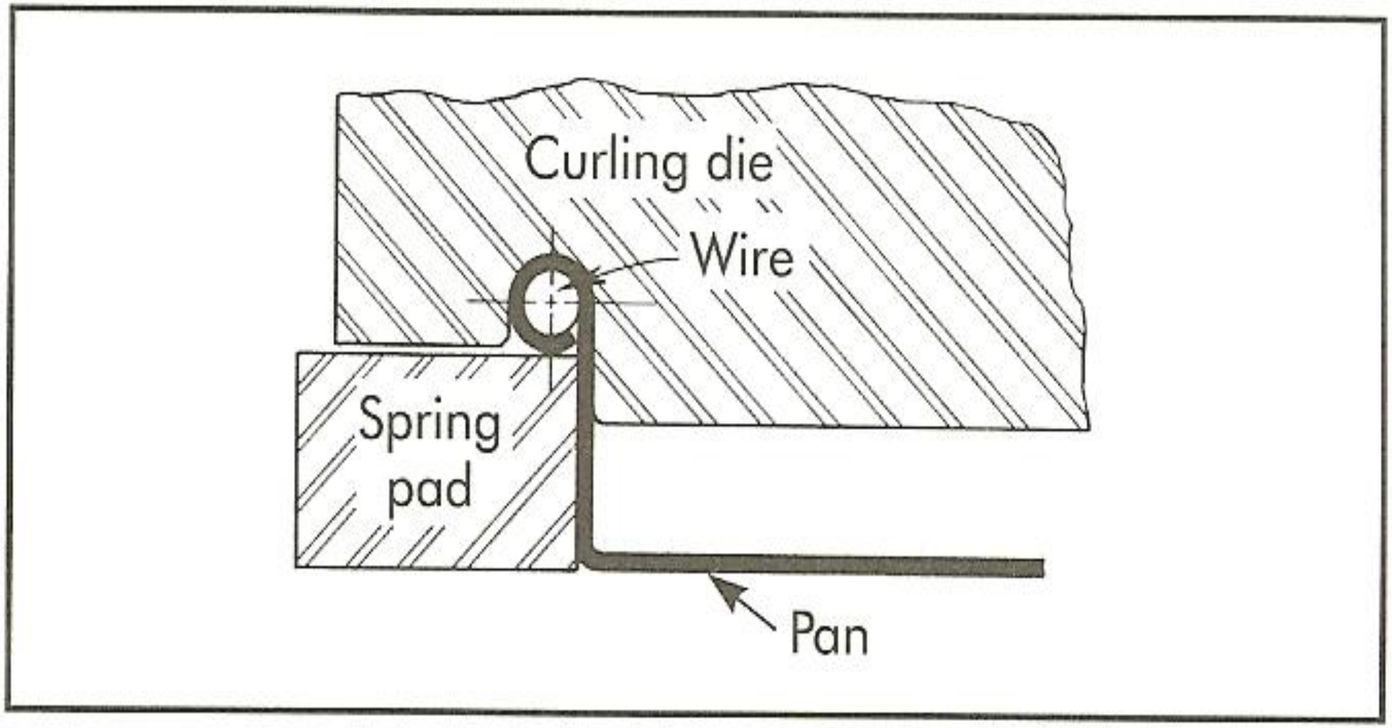


Figure 8-34. *Curling die design.*

Deep Drawing of cups

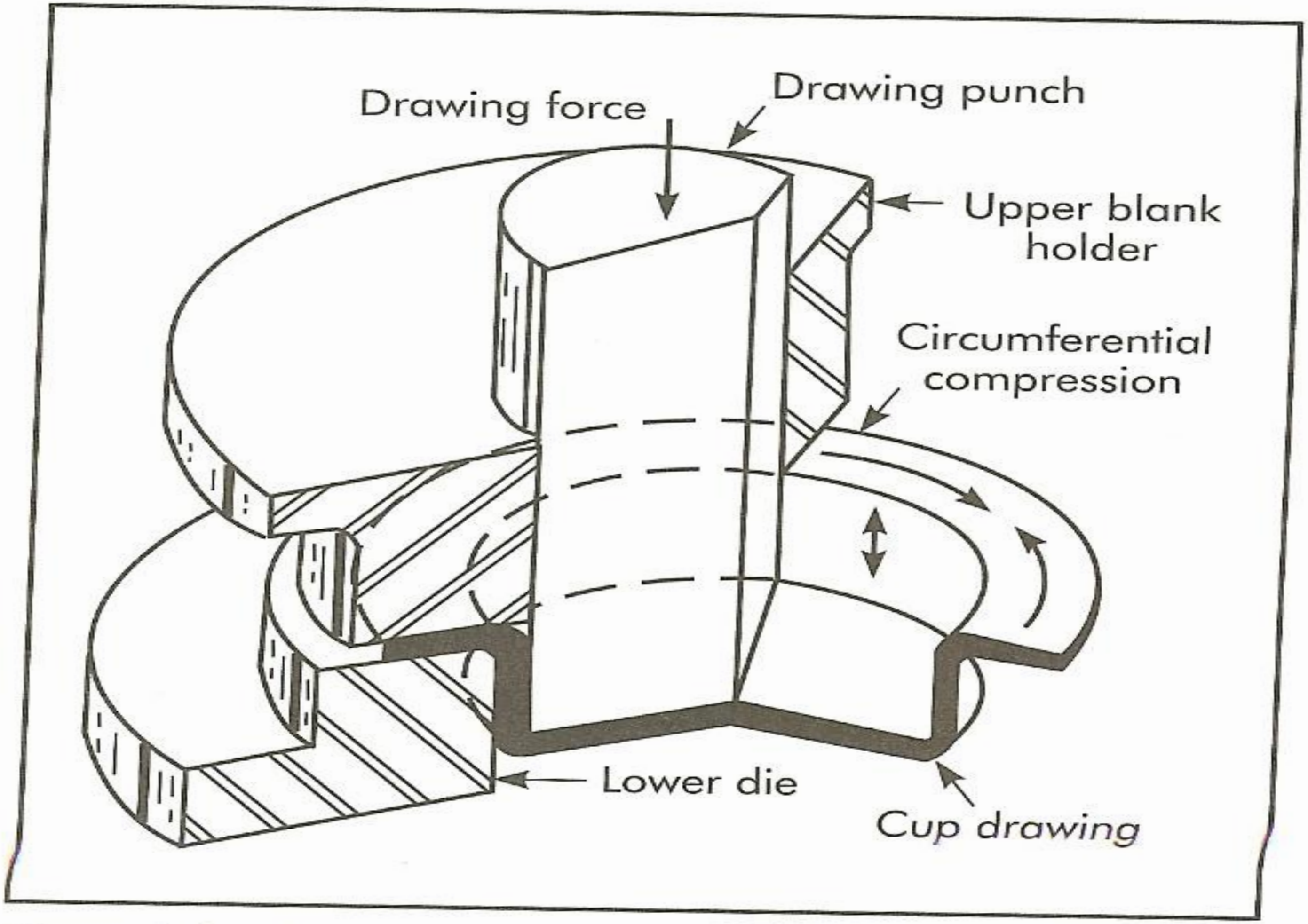


Figure 8-48. *A simple drawing die.*

Draw dies

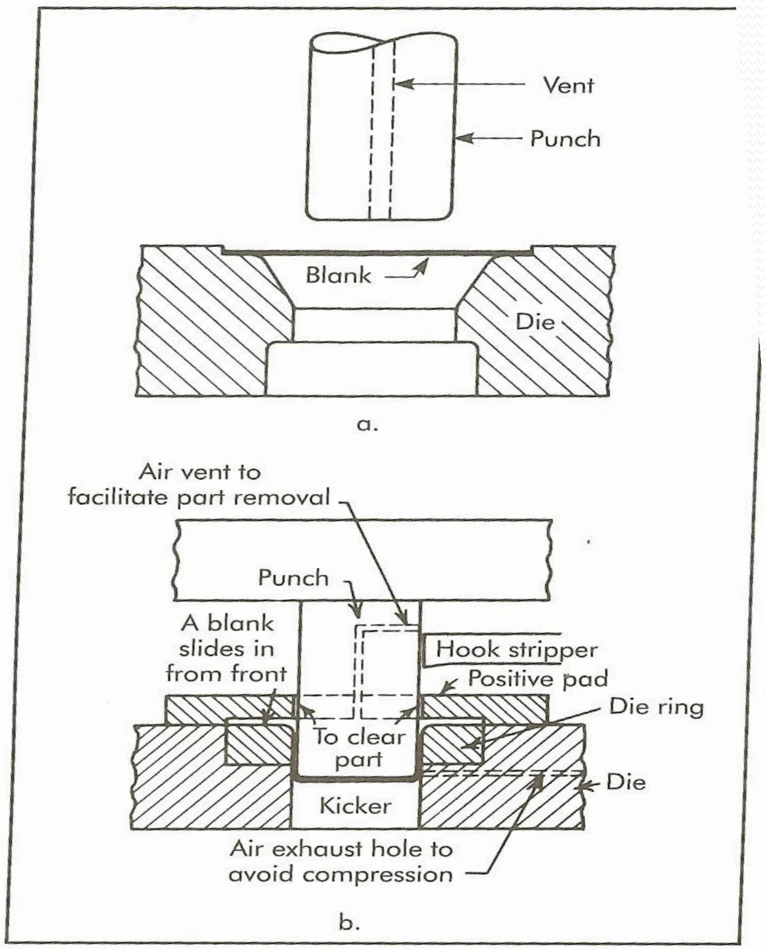


Figure 8-50. *Draw dies:* (a) *simple type;* (b) *simple draw die for heavy stock.*

Draw dies

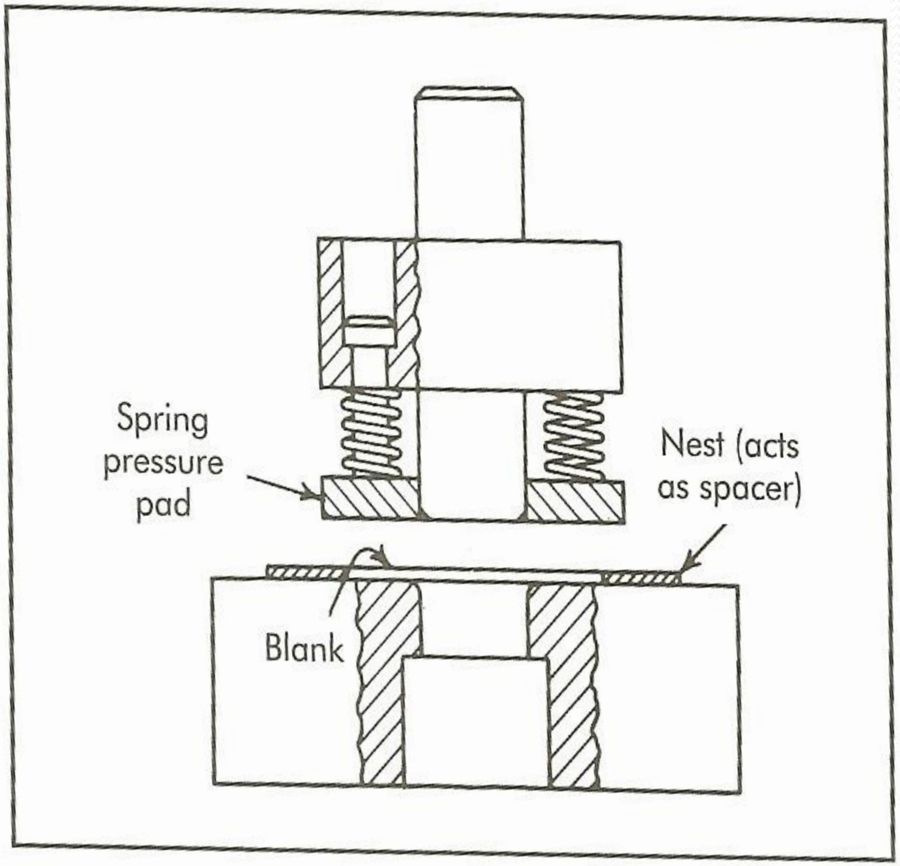


Figure 8-51. *Draw die with spring pressure pad.*

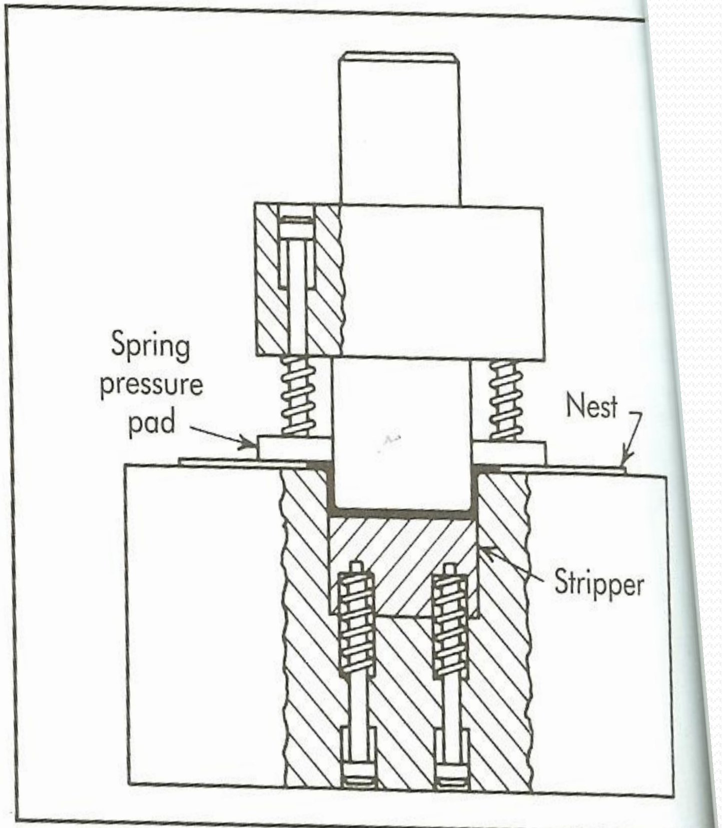
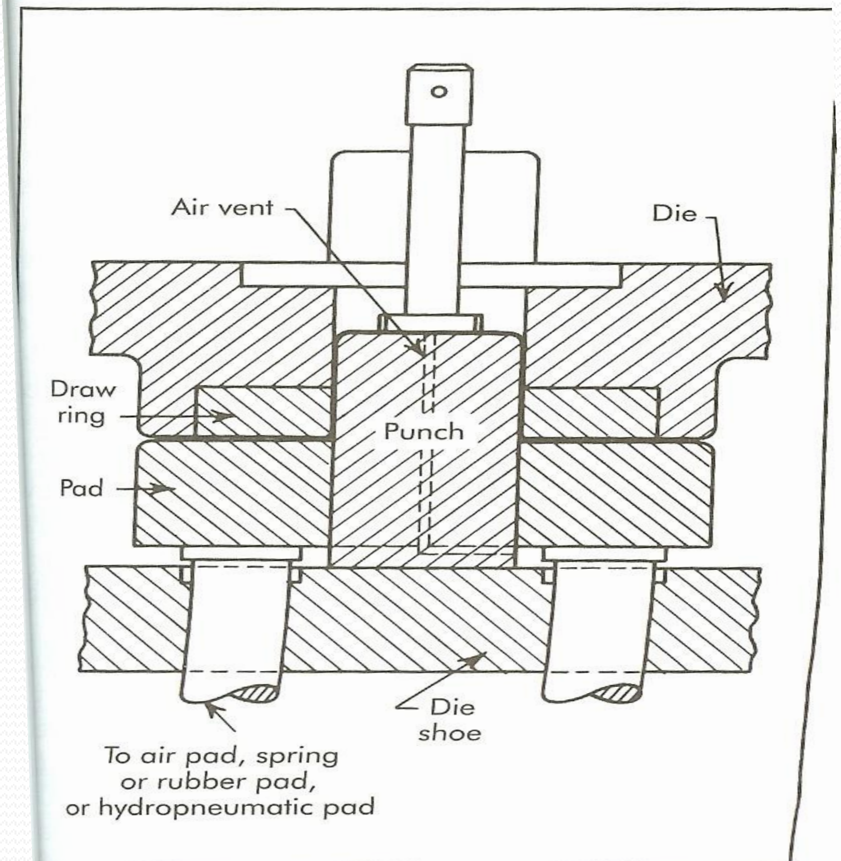


Figure 8-52. *A draw die with spring pressure pad and stripp*

Inverted draw die



re 8-53. Cross section of an inverted draw die for a single-n press; die is attached to the ram; punch and pressure ıre on the lower shoe.

References

- Fundamentals of tool design, fifth edition, Society of Manufacturing Engineers
- Donaldson, and Lecain, Tool Design, McGraw Hill

Questions?