Upsetting

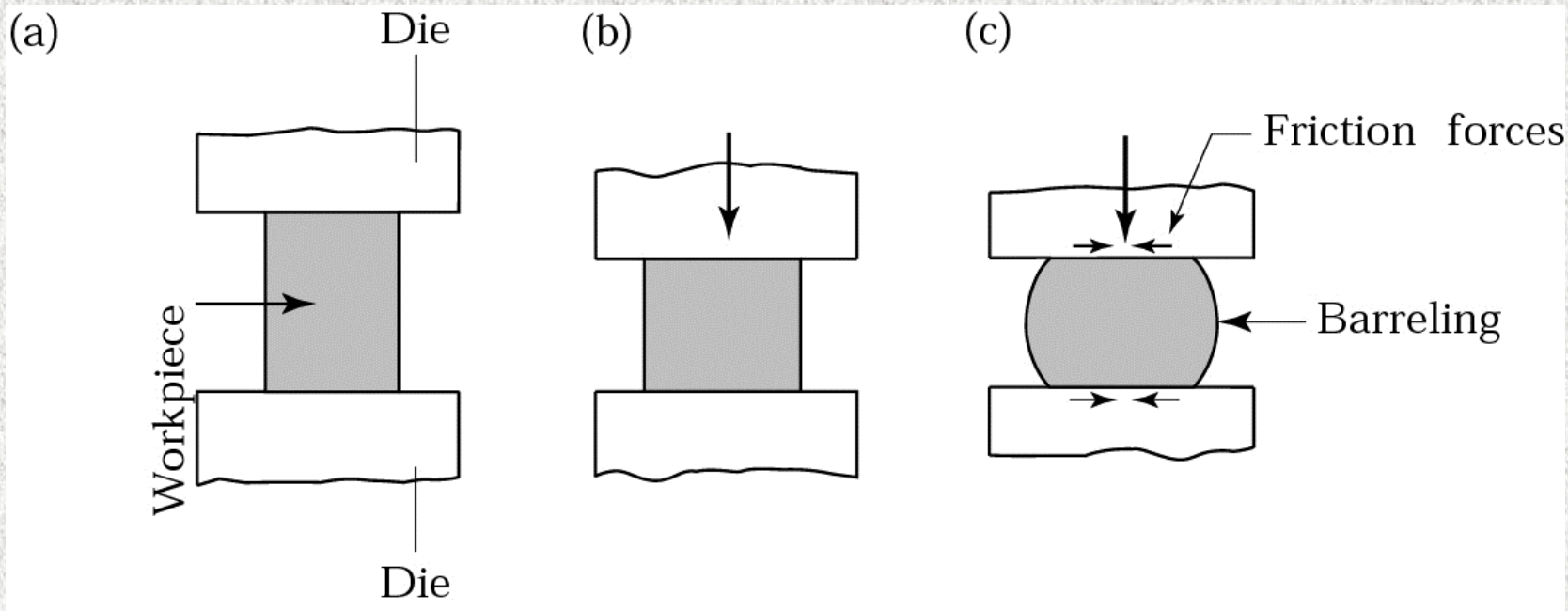


Figure 14.4 (a) Solid cylindrical billet upset between two flat dies. (b) Uniform deformation of the billet without friction. (c) Deformation with friction. Note barreling of the billet caused by friction forces at the billet-die interfaces.

Cogging

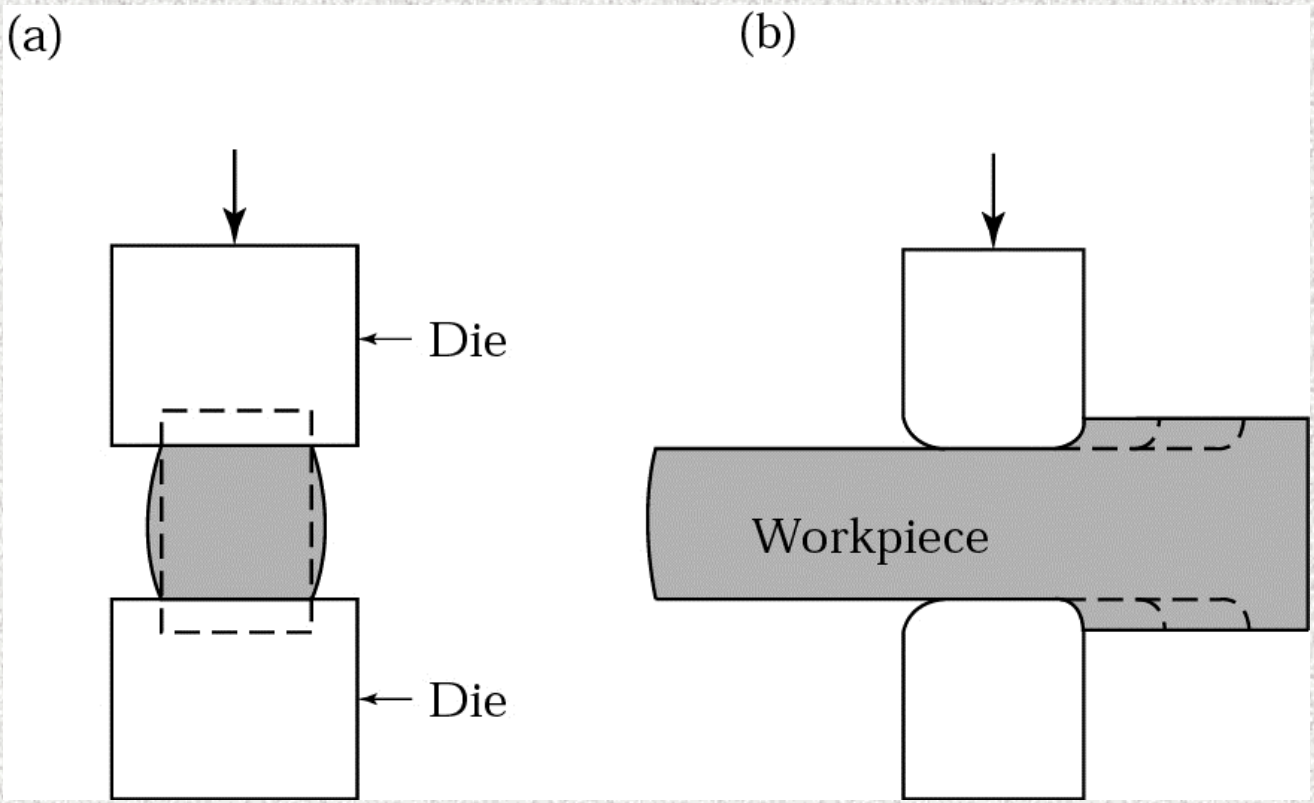


Figure 14.5 Two views of a cogging operation on a rectangular bar. Blacksmiths use this process to reduce the thickness of bars by hammering the part on an anvil. Note the barreling of the workpiece.

Impression-Die Forging

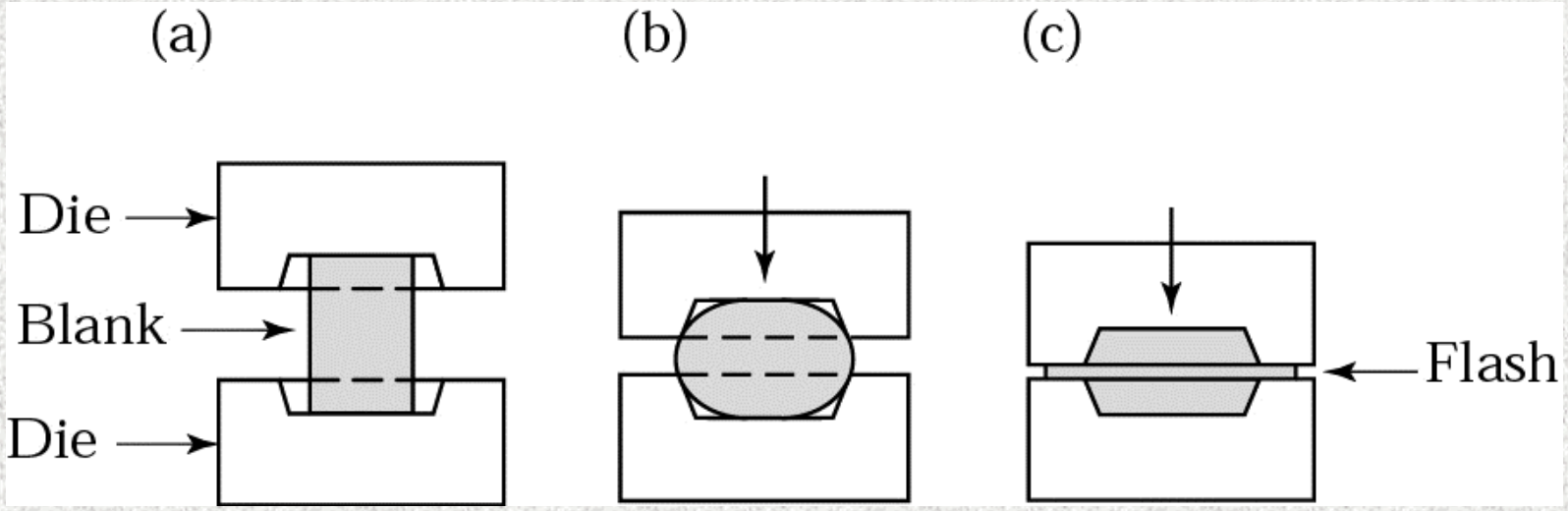
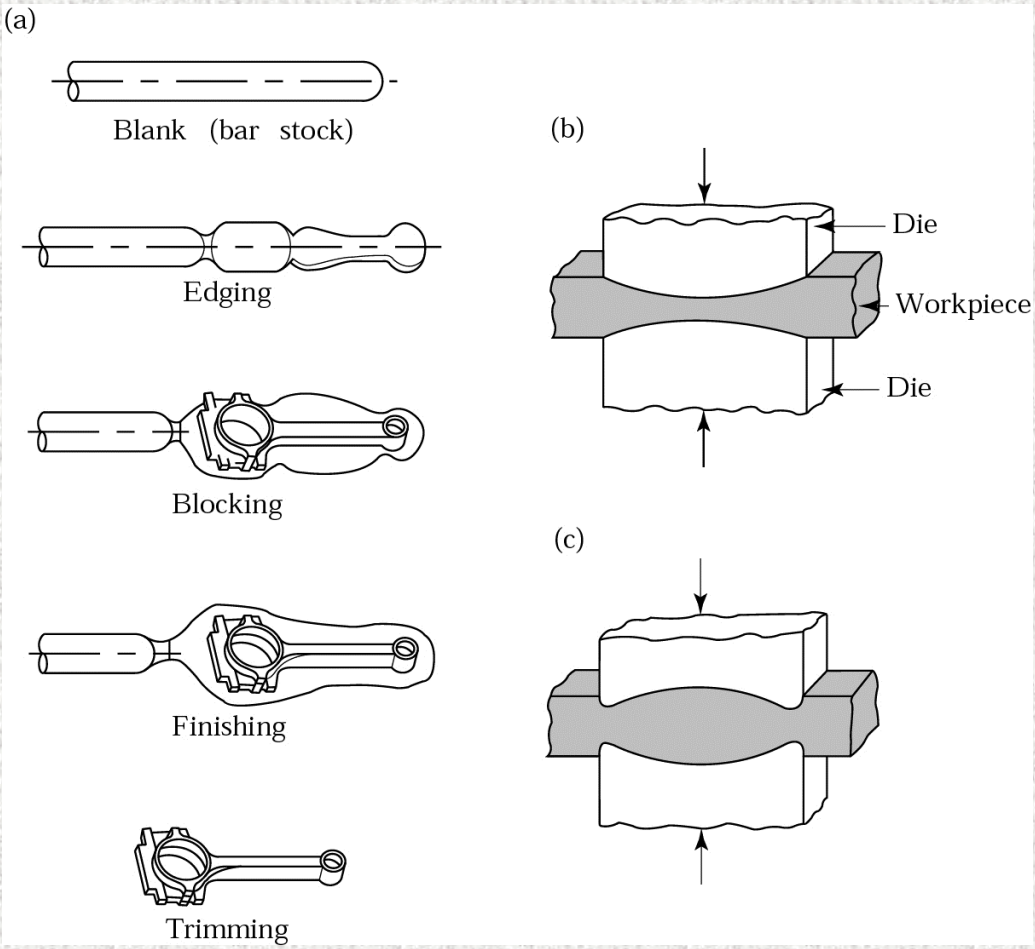


Figure 14.6 Stages in impression-die forging of a solid round billet. Note the formation of flash, which is excess metal that is subsequently trimmed off (see Fig. 14.8).

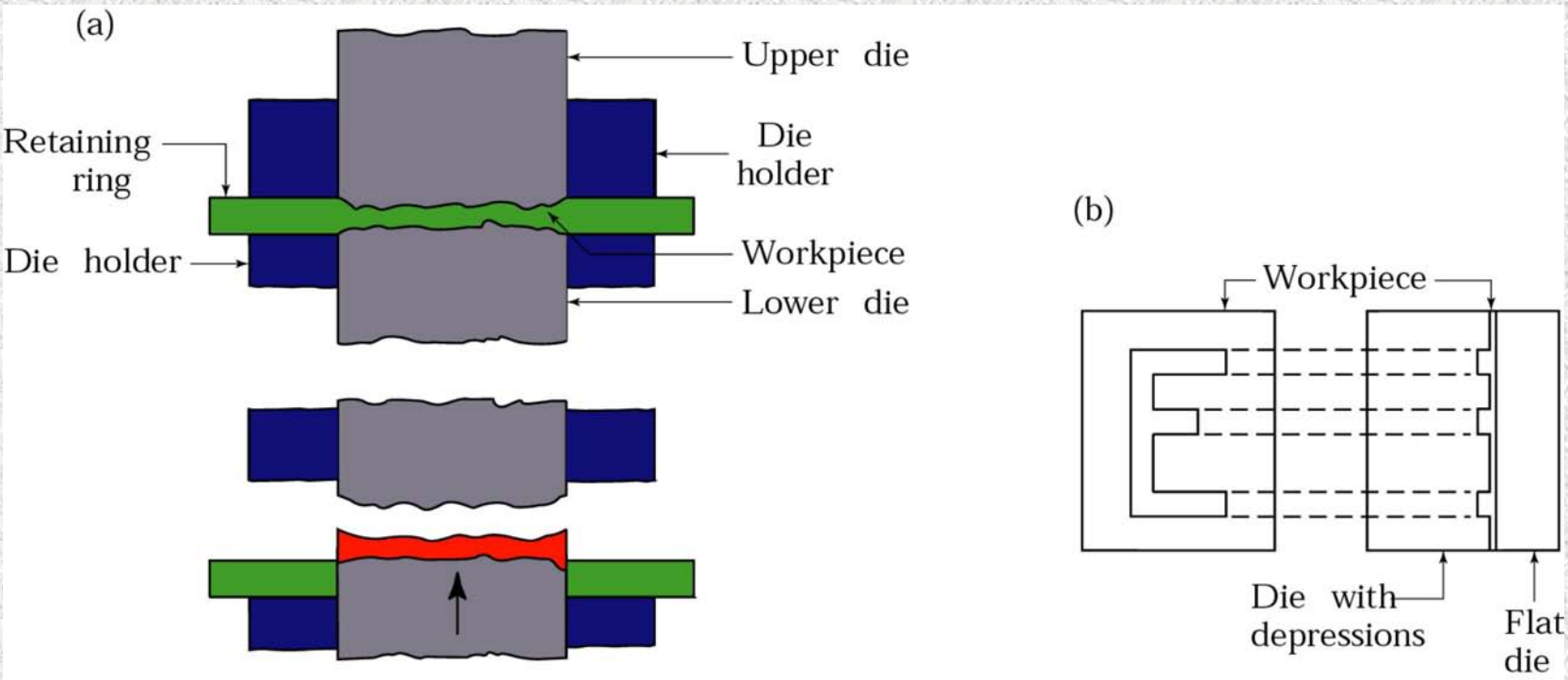
Forging a Connecting Rod

Figure 14.7 (a) Stages in forging a connecting rod for an internal combustion engine. Note the amount of flash required to ensure proper filling of the die cavities. (b) Fullering, and (c) edging operations to distribute the material when preshaping the blank for forging.



Coining

Figure 14.10 (a) Schematic illustration of the coining process. the earliest coins were made by open-die forging and lacked sharp details. (b) An example of a coining operation to produce an impression of the letter E on a block of metal.



Heading/Upset Forging

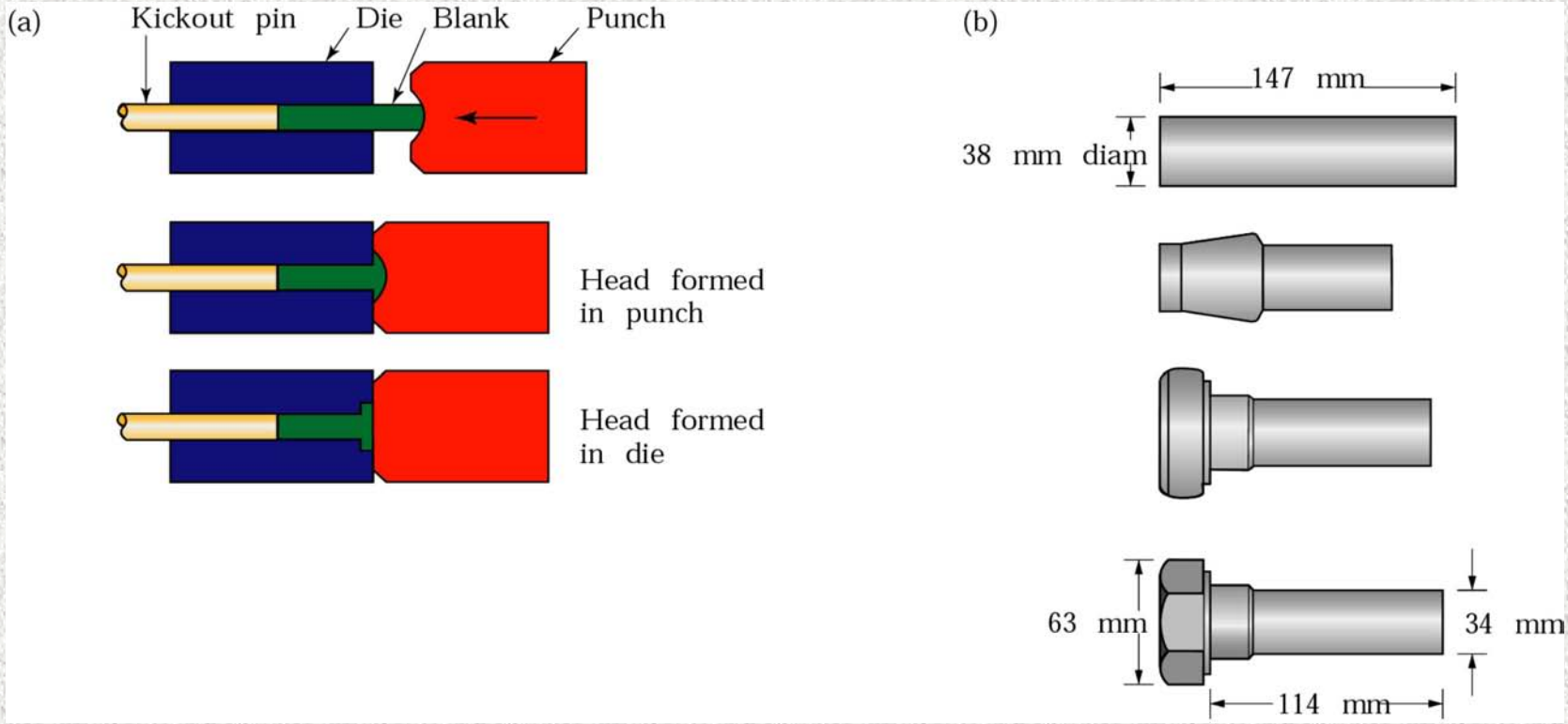


Figure 14.11 (a) Heading operation, to form heads on fasteners such as nails and rivets. (b) Sequence of operations to produce a bolt head by heading.

Heading

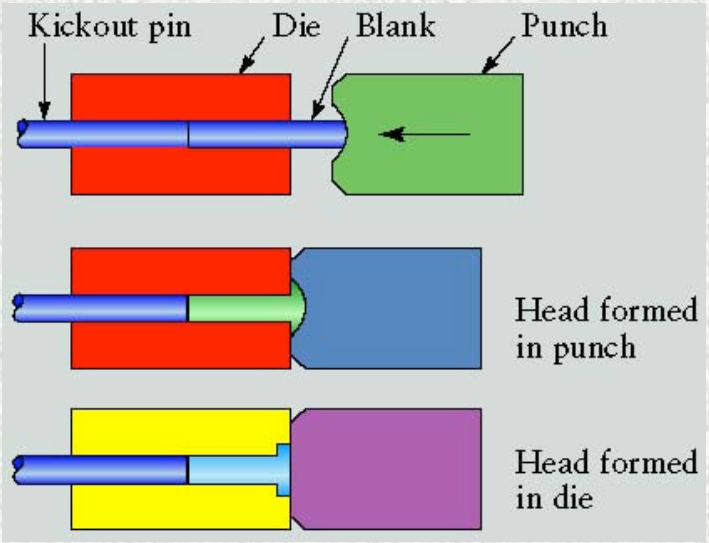


FIGURE 6.17 Forging heads on fasteners such as bolts and rivets. These processes are called *heading*.

Piercing Operations

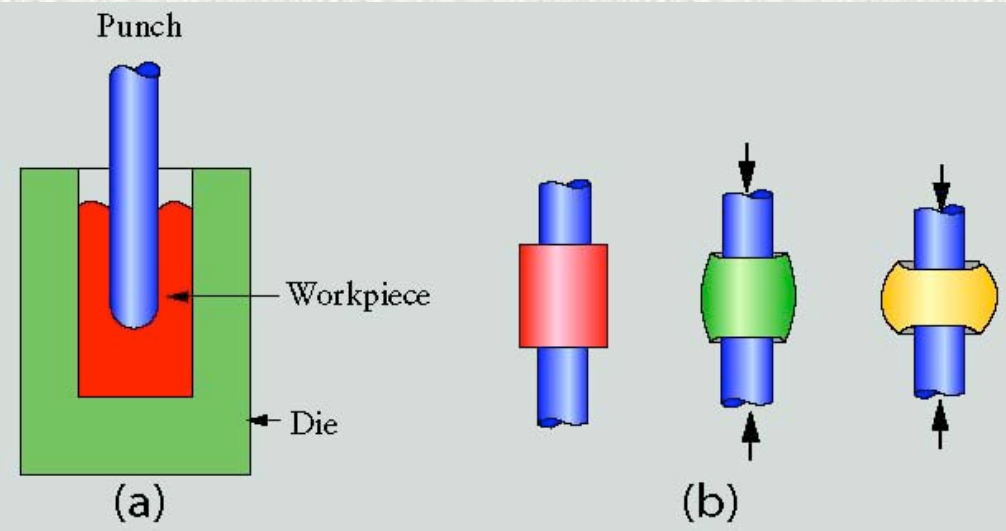
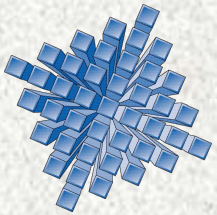
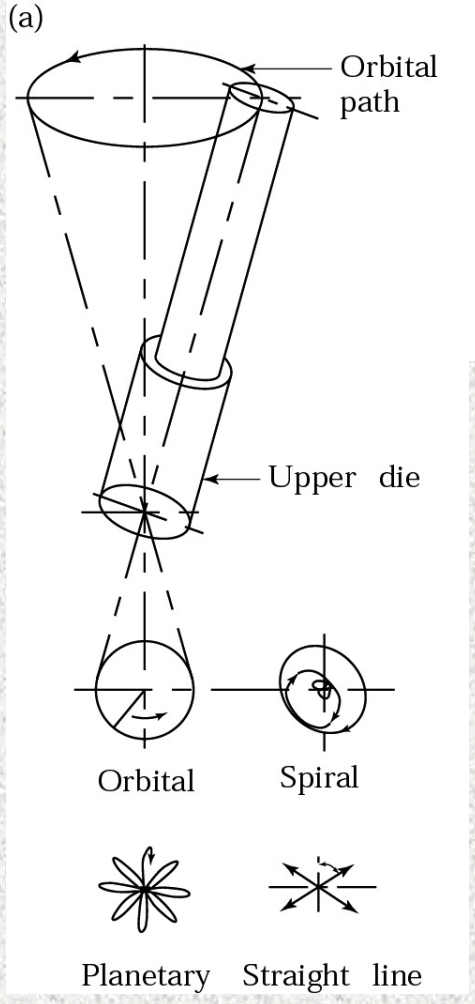


FIGURE 6.18 Examples of piercing operations.



Orbital Forging



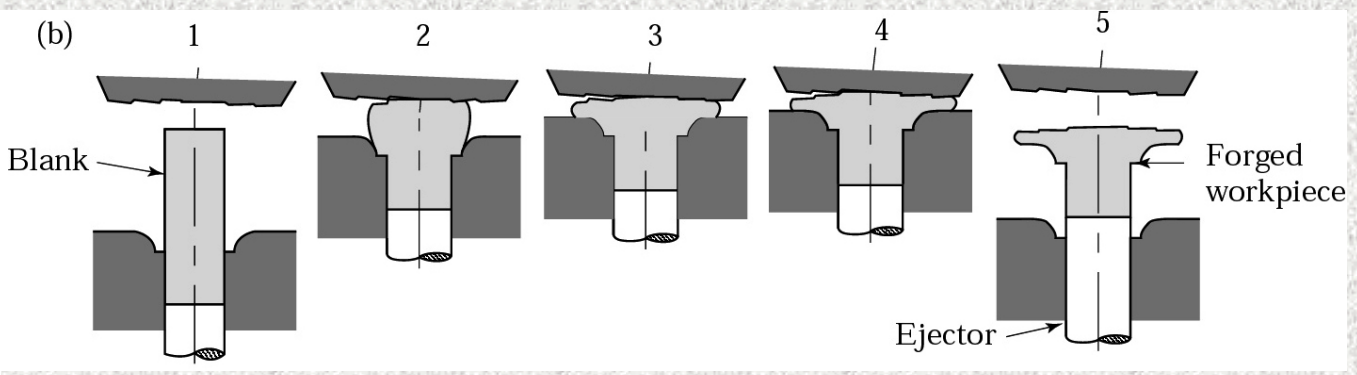
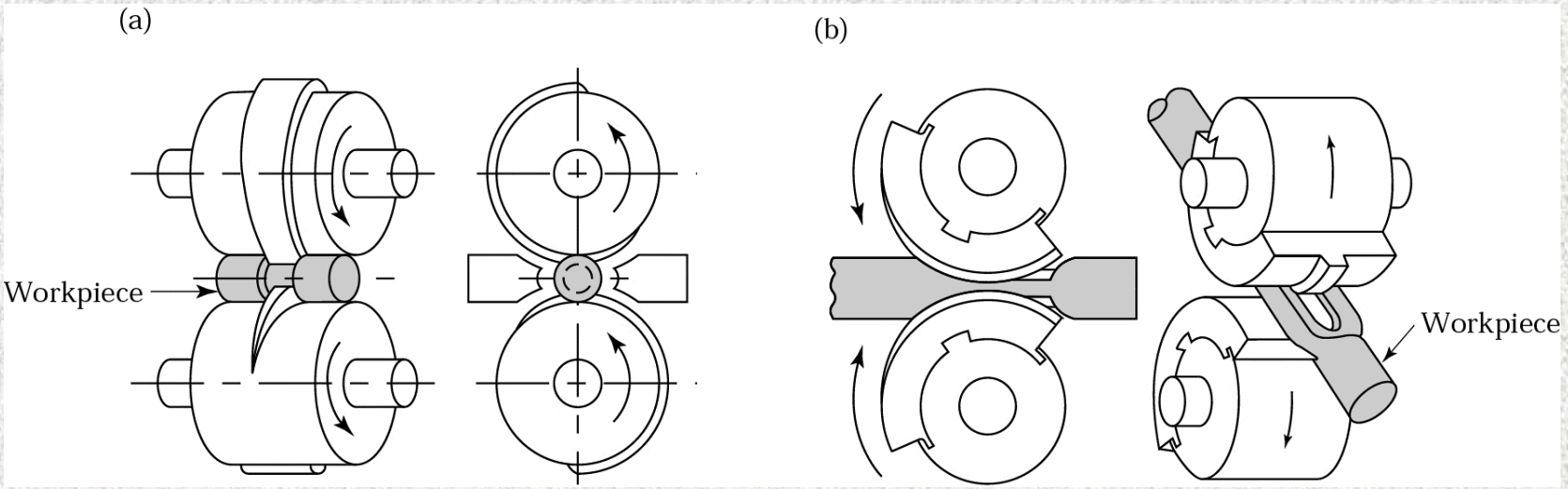


Figure 14.15 (a) Various movements of the upper die in orbital forging (also called rotary, swing, or rocking-die forging); the process is similar to the action of a mortar and pestle. (b) An example of orbital forging. Bevel gears, wheels, and rings for bearings can be made by this process.

Roll-Forging

Figure 14.13 Two examples of the roll-forging operation, also known as *cross-rolling*. Tapered leaf springs and knives can be made by this process. *Source*: (a) J. Holub; (b) reprinted with permission of General Motors Corporation.



Production of Bearing Blanks

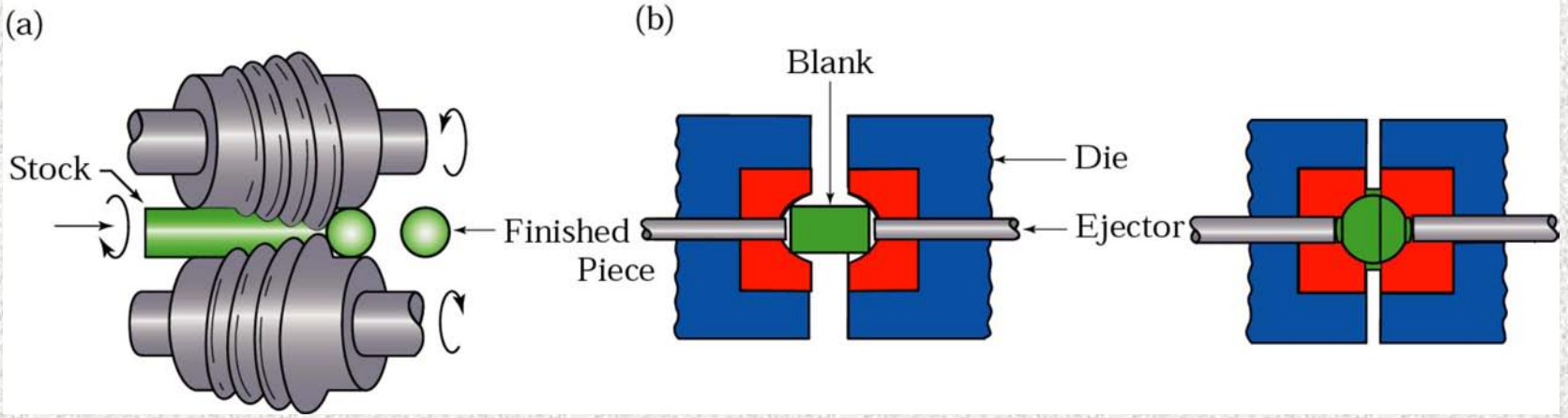


Figure 14.14 (a) Production of steel balls by the skew-rolling process. (b) Production of steel balls by upsetting a cylindrical blank. Note the formation of flash. The balls made by these processes are subsequently ground and polished for use in ball bearings (see Sections 25.6 and 25.10).

Swaging

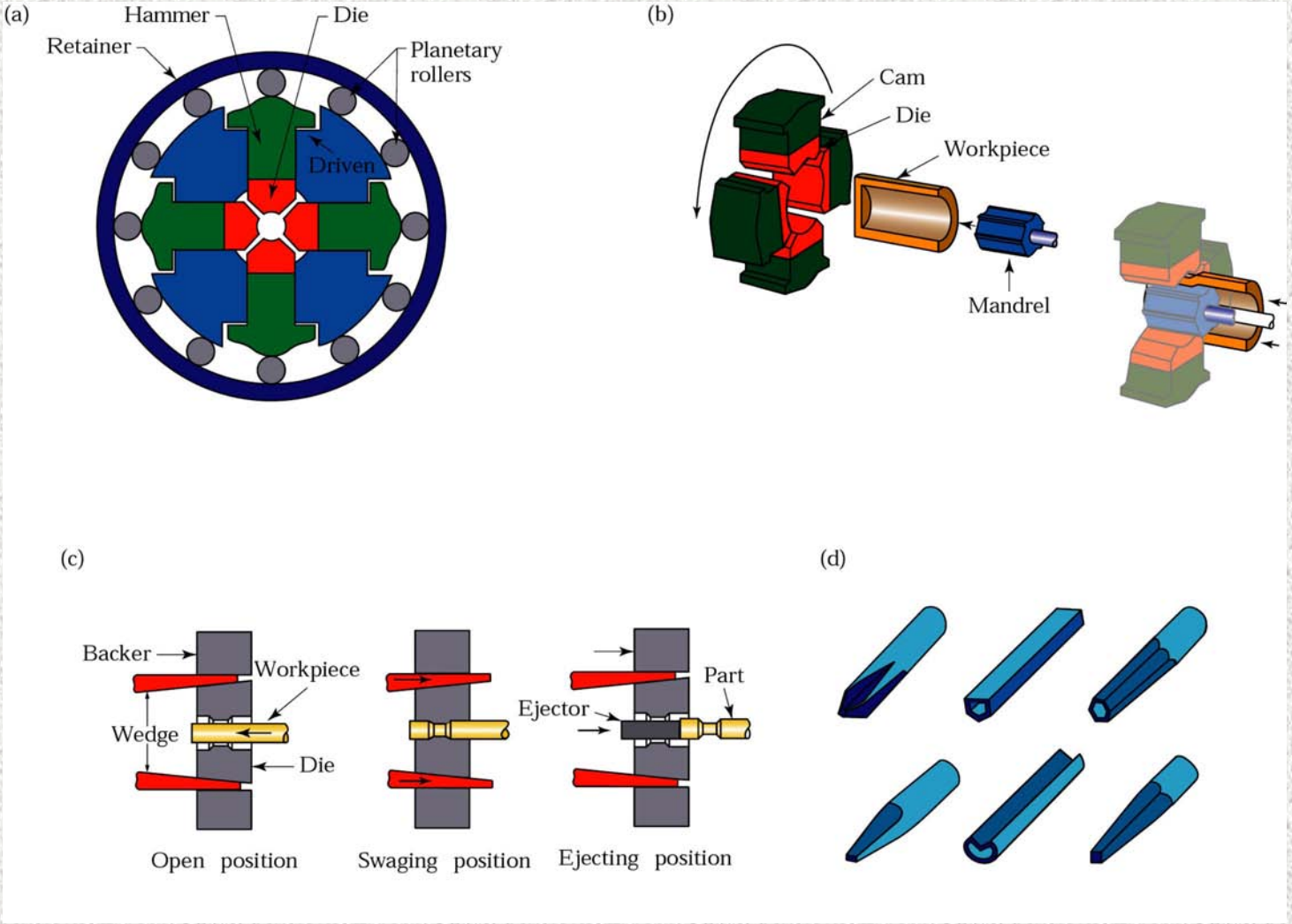


Figure 14.16 (a) Schematic illustration of the rotary-swaging process. (b) Forming internal profiles on a tubular workpiece by swaging. (c) A die-closing type swaging machine, showing forming of a stepped shaft. (d) Typical parts made by swaging.

Swaging of Tubes With and Without a Mandrel

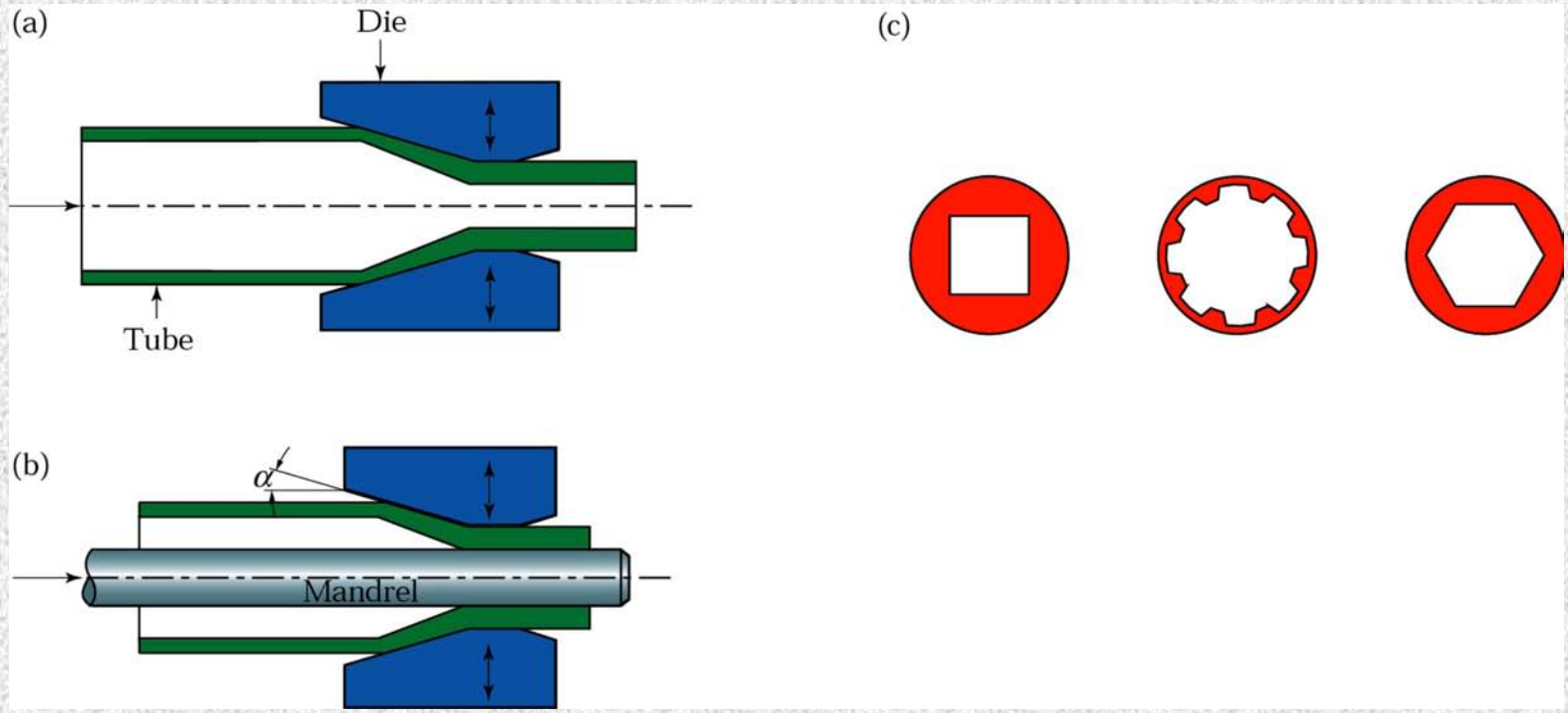


Figure 14.17 (a) Swaging of tubes without a mandrel; not the increase in wall thickness in the die gap. (b) Swaging with a mandrel; note that the final wall thickness of the tube depends on the mandrel diameter. (c) Examples of cross-sections of tubes produced by swaging on shaped mandrels. Rifling (spiral grooves) in small gun barrels can be made by this process.

Presses Used In Metalworking

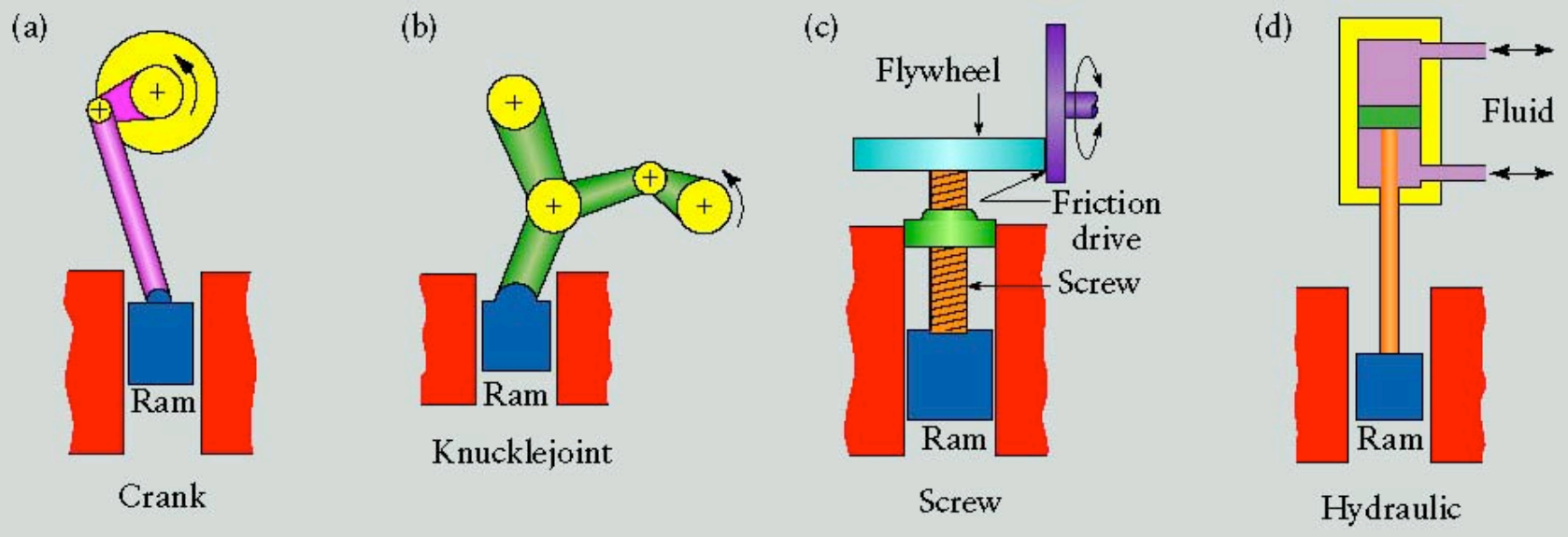
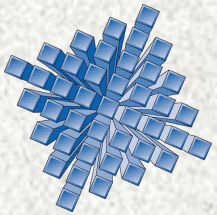
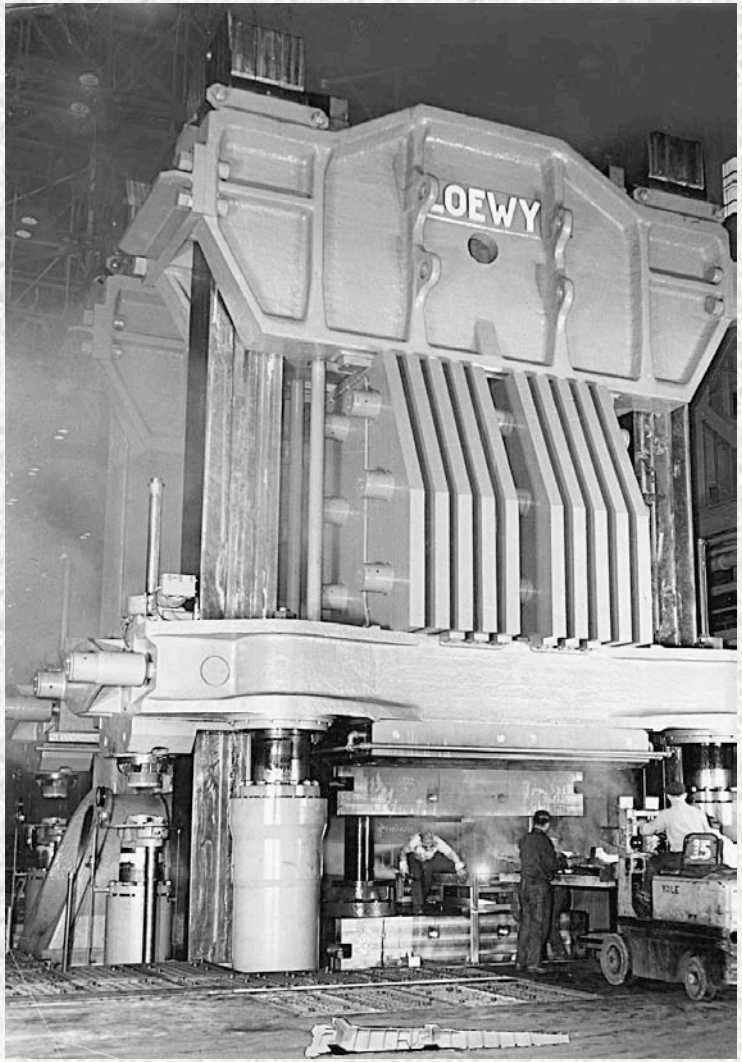
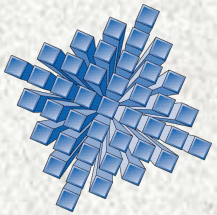


FIGURE 6.28 Schematic illustration of various types of presses used in metalworking. The choice of the press is an important factor in the overall operation.





Chapter 6
Bulk Deformation Processes



Manufacturing Processes for Engineering Materials, 4th ed.
Kalpakjian • Schmid
Prentice Hall, 2003

Grain Flow Lines

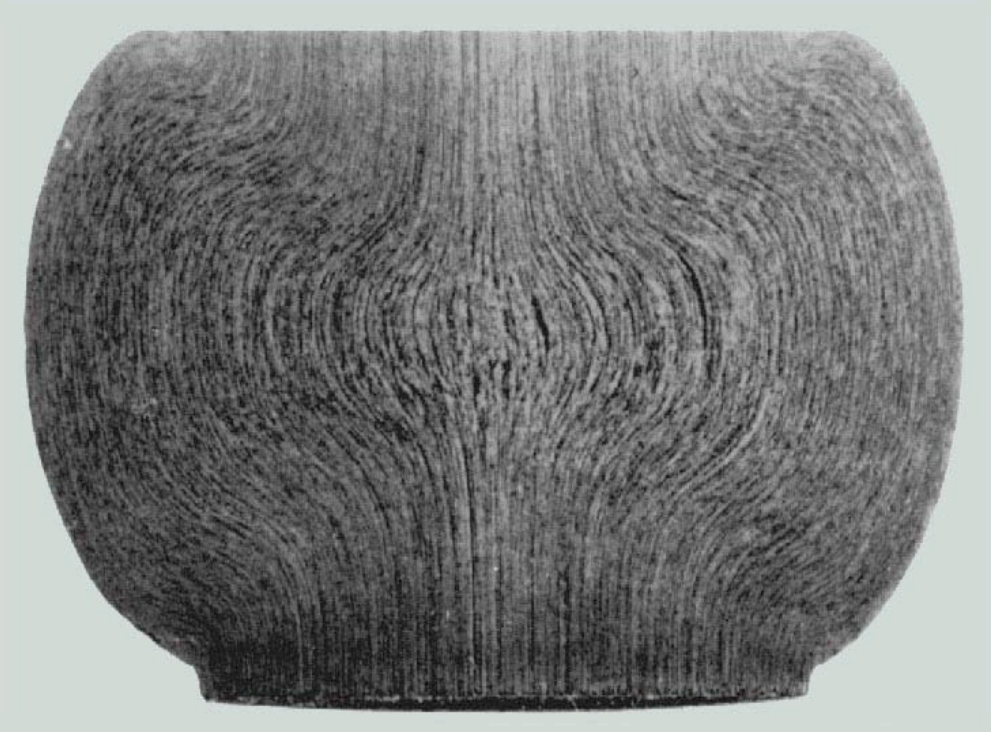


FIGURE 6.2 Grain flow lines in upsetting a solid steel cylinder at elevated temperatures. Note the highly inhomogenous deformation and barreling. The differnet shape of the botte, section of the specemen (as compared with the top) results from the hot specimenresting on the lower, cool die before deformation proceeded. The bottom surface was chilled; thus it exhibits greater strength and hence deforms less than the top surface. *Source*: J. A. Schey et al., IIT Research Institute.

Grain Flow Pattern of Pierced Round Billet

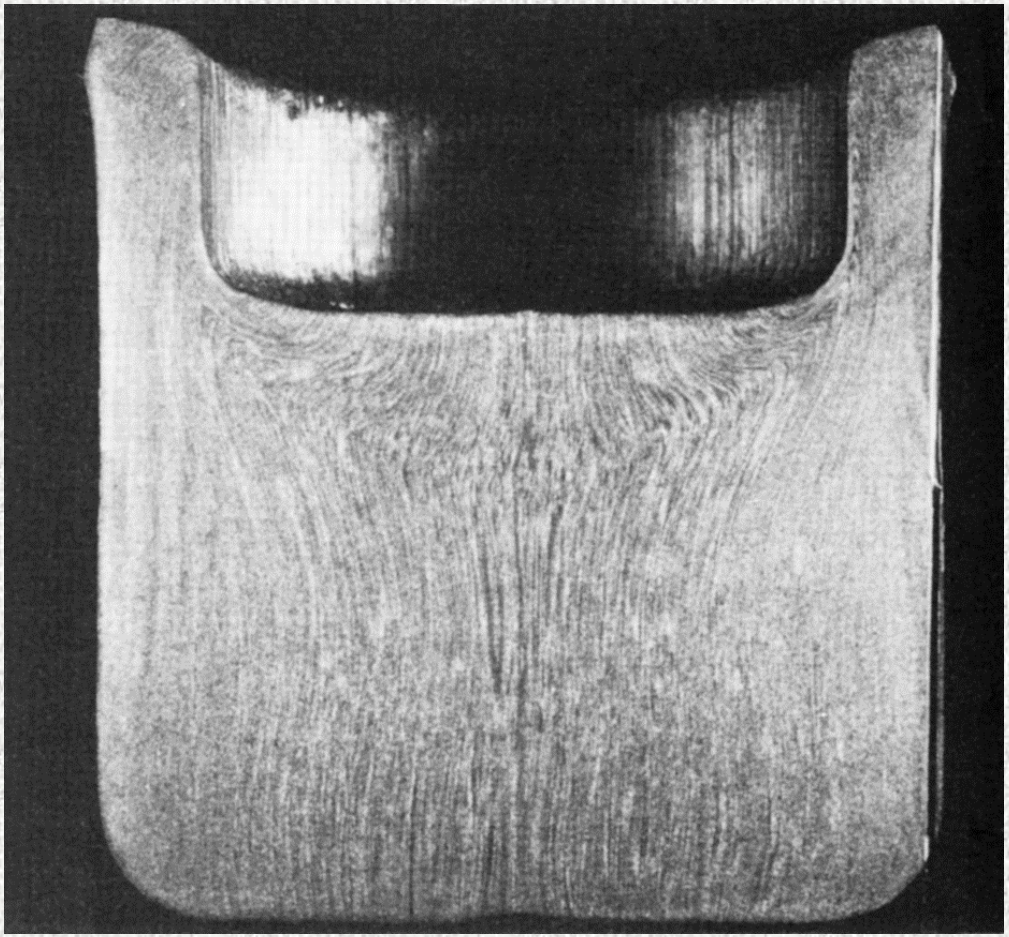


Figure 14.12 A pierced round billet, showing grain flow pattern. *Source*: Courtesy of Ladish Co., Inc.

Internal Defects In Forging

FIGURE 6.23 Laps formed by buckling of the web during forging.

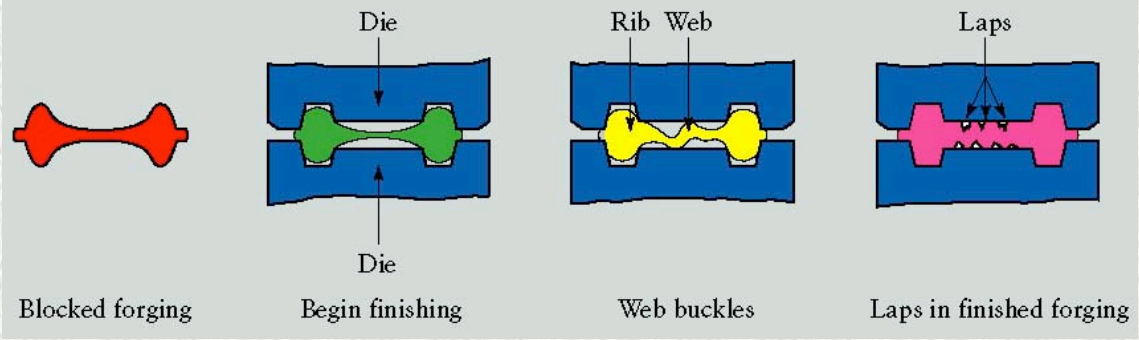
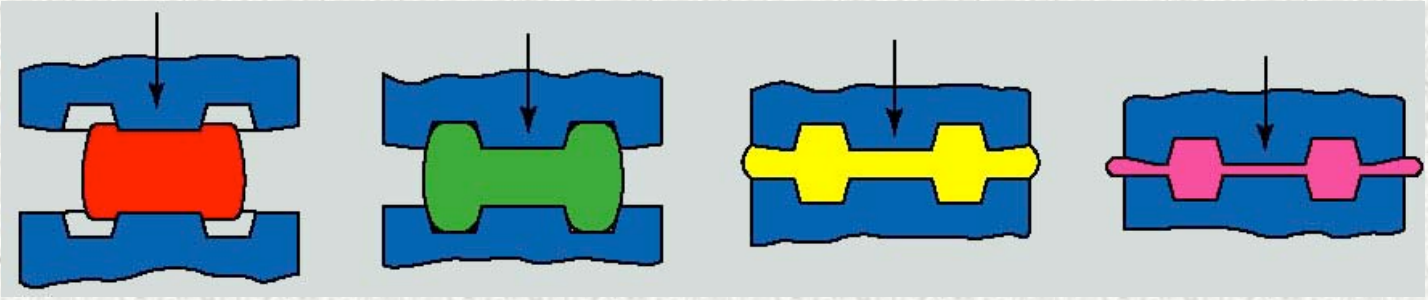


FIGURE 6.24 Internal defects produced in a forging because of an oversized billet. The die cavities are filled prematurely, and the material at the center of the part flows past the filled regions as deformation continues.



Defect Formation In Forging

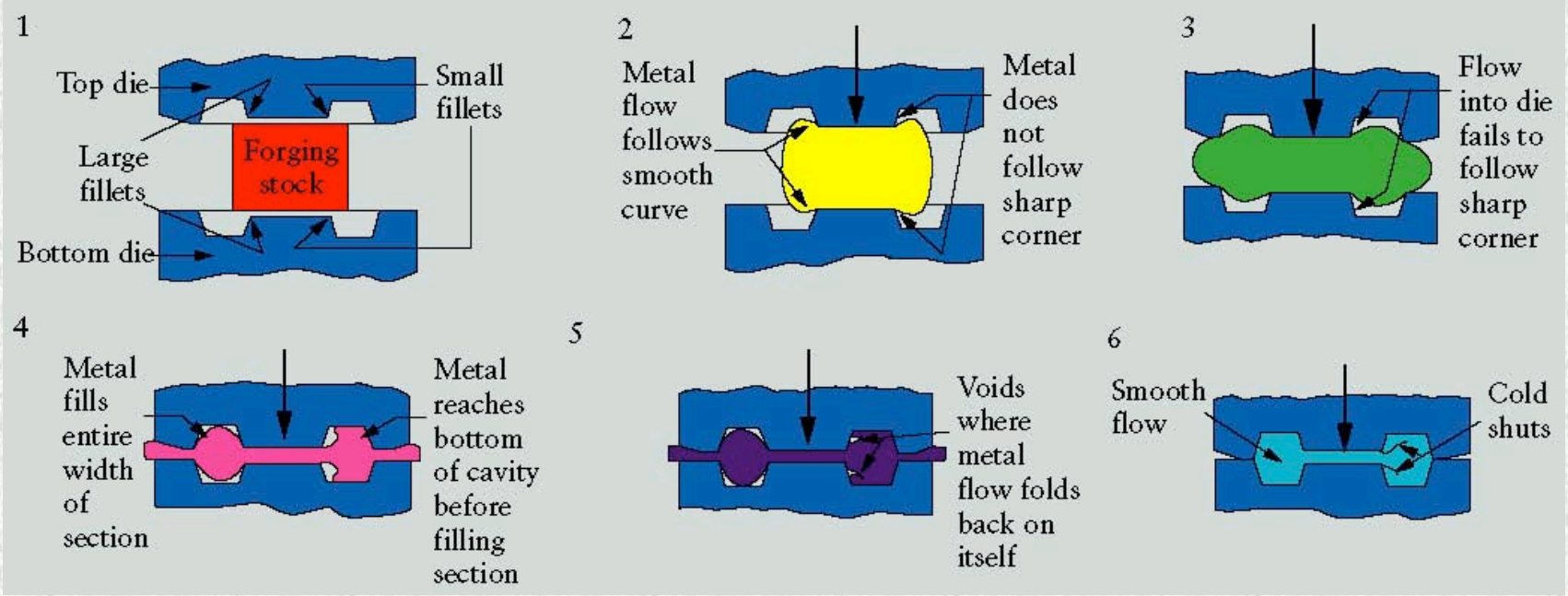


FIGURE 6.25 Effect of fillet radius on defect formation in forging. Small fillets (right side of drawings) cause the defects. *Source*: Aluminum Company of America.