



ENGINEERING MATERIALS

Lecture No. 5

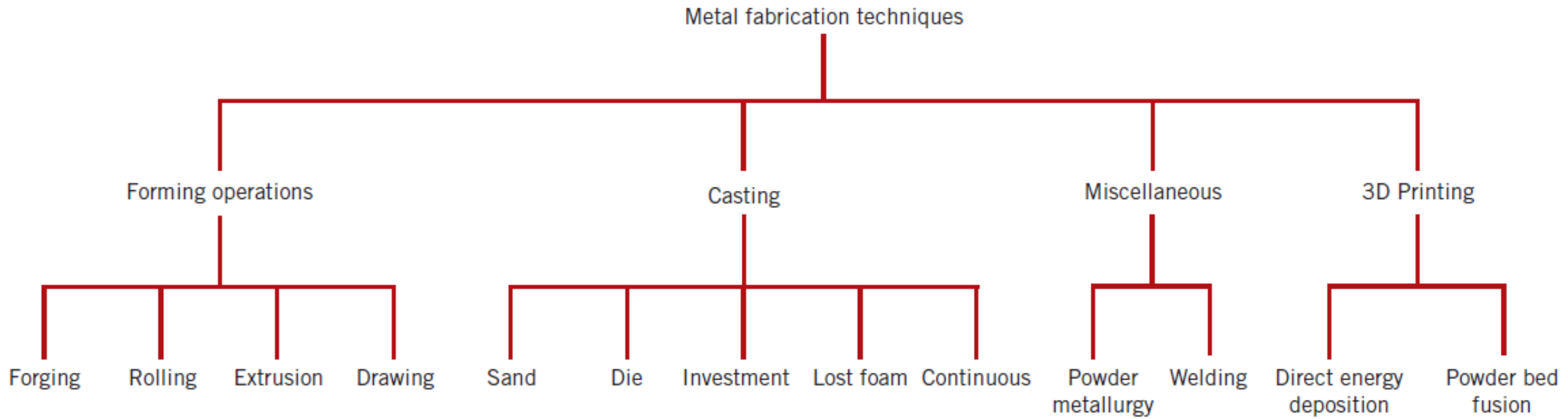
Fabrication of metals ,forming operations ,casting

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Fabrication of Metals

Metal fabrication techniques are normally preceded by refining, alloying, and often heat-treating processes that produce alloys with the desired characteristics. The classifications of fabrication techniques include various metal-forming methods, casting, powder metallurgy, welding, machining, and 3D printing; often two or more must be used before a piece is finished. The methods chosen depend on several factors; the most important are the properties of the metal, the size and shape of the finished piece, and the cost. The metal fabrication techniques we discuss are classified according to the scheme illustrated in Figure 1.

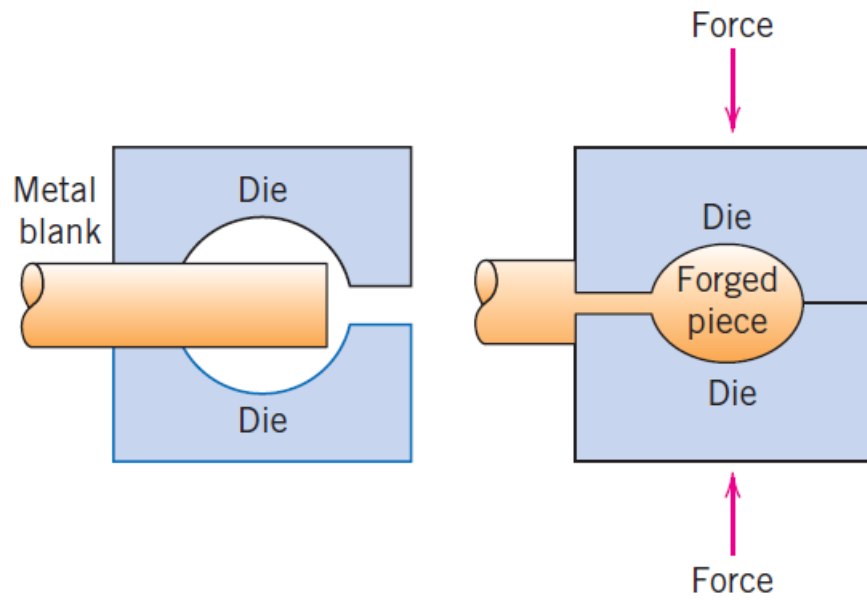


FORMING OPERATIONS

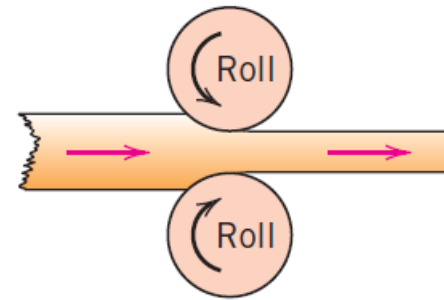
Forming operations are those in which the shape of a metal piece is changed by plastic deformation; for example, forging, rolling, extrusion, and drawing are common forming techniques. The deformation must be induced by an external force or stress, the magnitude of which must exceed the yield strength of the material. Most metallic materials are especially amenable to these procedures, being at least moderately ductile and capable of some permanent deformation without cracking or fracturing.

When deformation is achieved at a temperature above that at which recrystallization occurs, the process is termed **hot working** otherwise, it is cold working. With most of the forming techniques, both hot- and cold-working procedures are possible.

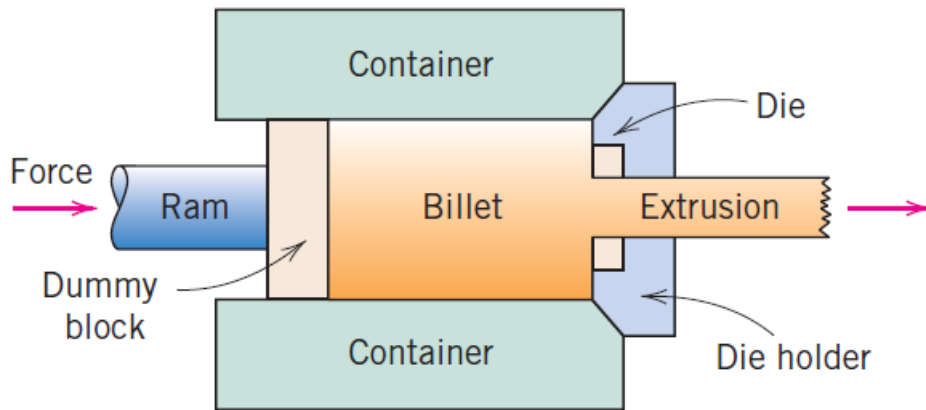
Cold working produces an increase in strength with the attendant decrease in ductility because the metal strain hardens; **advantages over hot working include a higher quality surface finish, better mechanical properties and a greater variety of them, and closer dimensional control of the finished piece.**



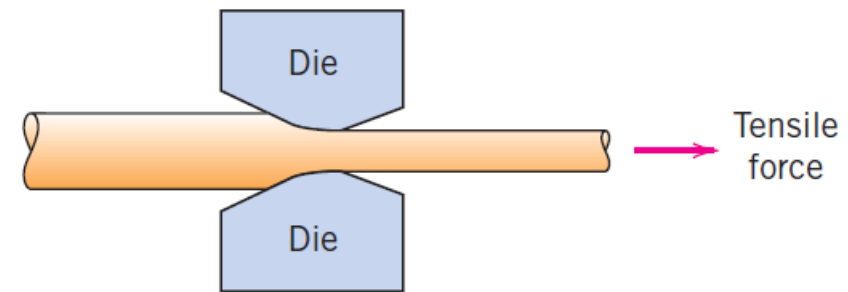
(a)



(b)



(c)

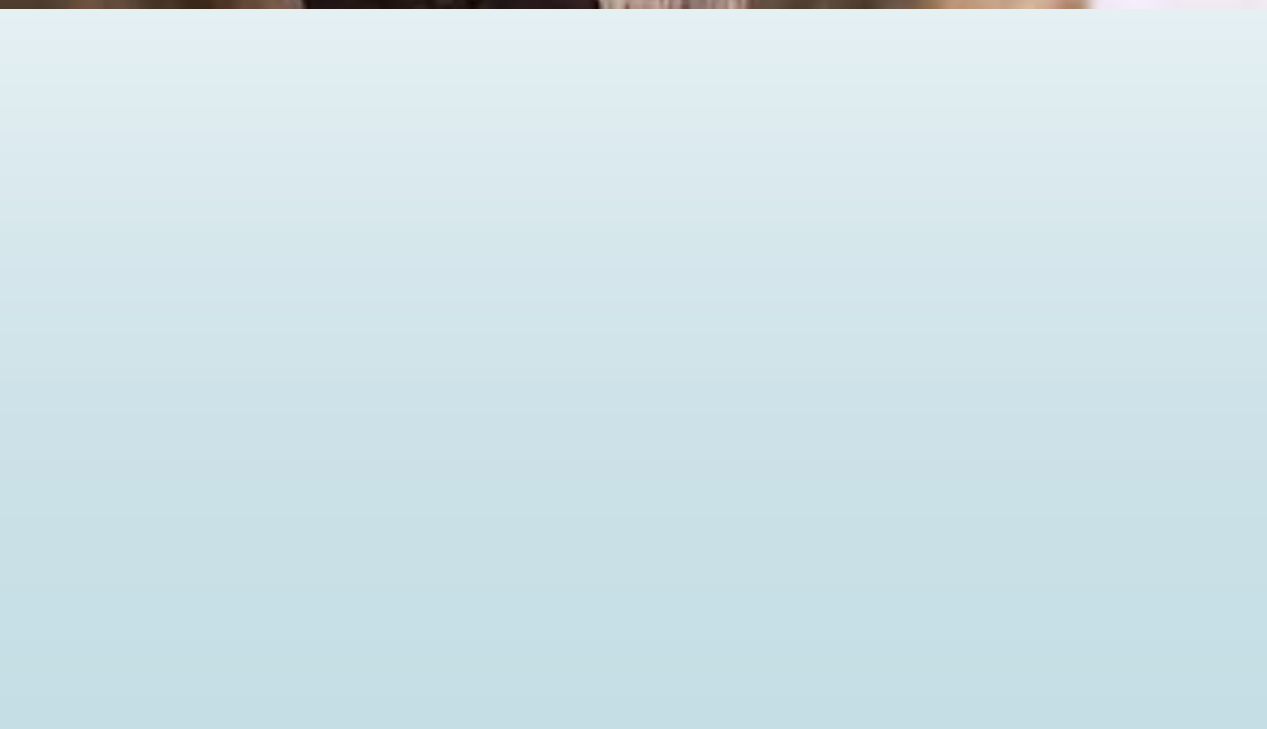


(d)

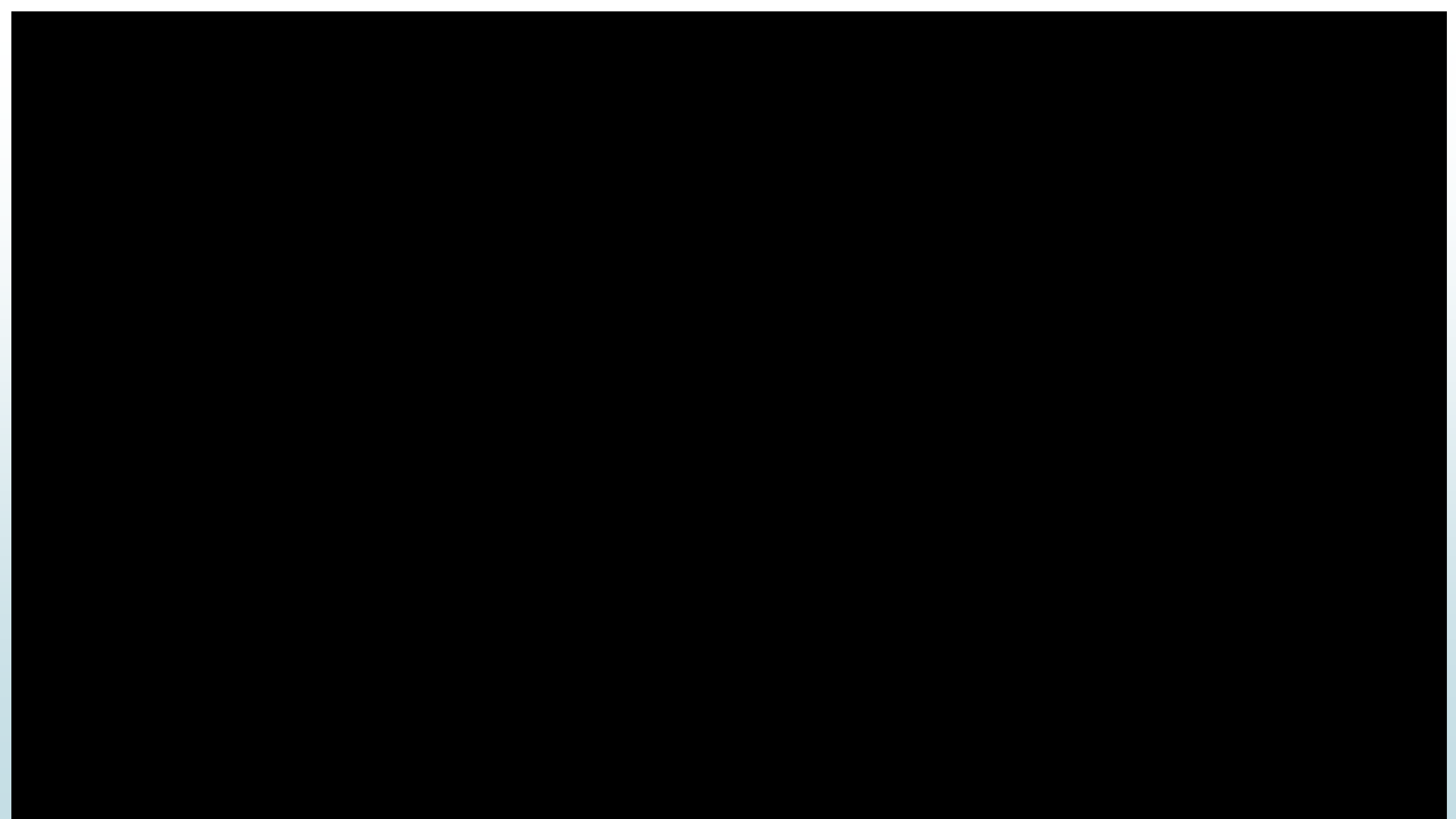
Metal deformation during (a) forging, (b) rolling, (c) extrusion, and (d) drawing.

Forging

Forging is mechanically working or deforming a single piece of a usually hot metal; this may be accomplished by the application of successive blows or by continuous squeezing. Forgings are classified as either **closed or open die**. For closed die, a force is brought to bear on two or more die halves having the finished shape such that the metal is deformed in the cavity between them. For open die, two dies having simple geometric shapes are employed, normally on large workpieces. automotive crankshafts, and piston connecting rods are typical articles formed using this technique.



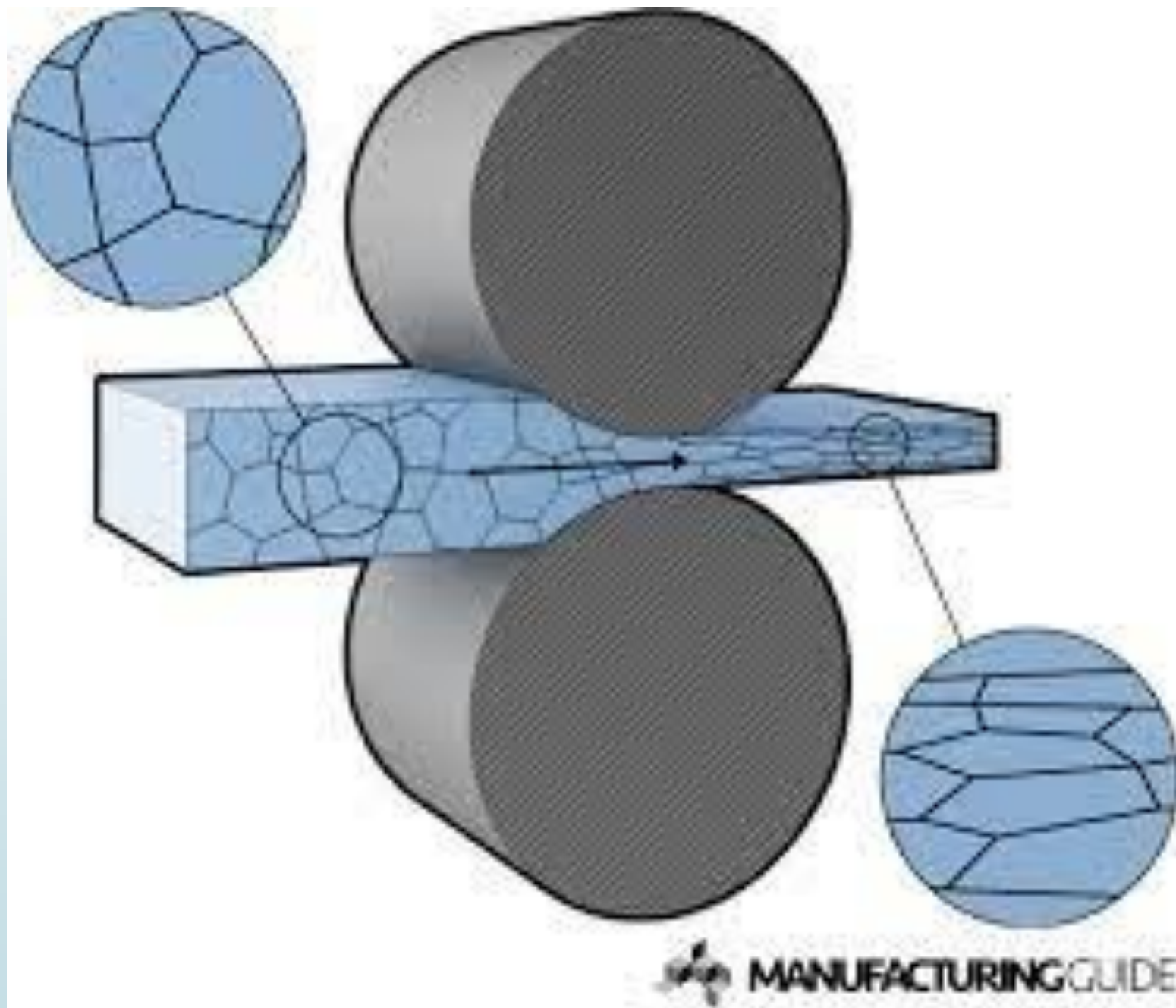






Rolling

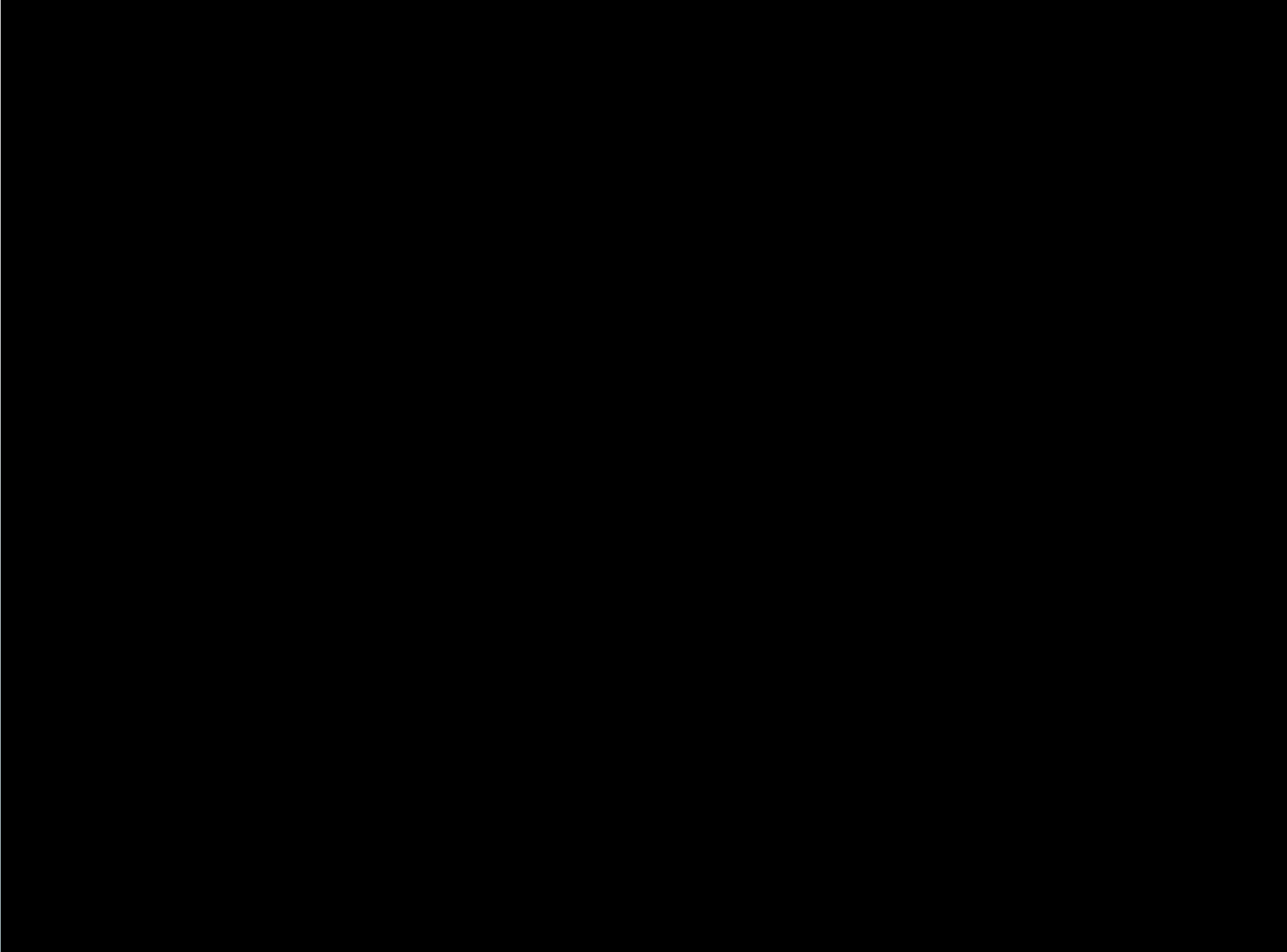
Rolling, the most widely used deformation process, consists of passing a piece of metal between two rolls; a reduction in thickness results from compressive stresses exerted by the rolls. Cold rolling may be used in the production of sheet, strip, and foil with a high-quality surface finish. Circular shapes, as well as I-beams and railroad rails, are fabricated using grooved rolls.





Extrusion

For **extrusion**, a bar of metal is forced through a die orifice by a compressive force that is applied to a ram; the extruded piece that emerges has the desired shape and a reduced cross-sectional area. Extrusion products include **rods and tubing** that have rather complicated cross-sectional geometries.





Casting

Casting is a fabrication process in which a completely molten metal is poured into a mold cavity having the desired shape; upon solidification, the metal assumes the shape of the mold but experiences some shrinkage. Casting techniques are employed when (1) the finished shape is so large or complicated that any other method would be impractical; (2) a particular alloy is so low in ductility that forming by either hot or cold working would be difficult; and (3) in comparison to other fabrication processes, casting is the most economical. The final step in the refining of even ductile metals may involve a casting process. A number of different casting techniques are commonly employed, including sand, die, investment, lost-foam, and continuous casting. Only a cursory treatment

Sand Casting

With sand casting, probably the most common method, ordinary sand is used as the mold material. A two-piece mold is formed by packing sand around a pattern that has the shape of the intended casting. A *gating system* is usually incorporated into the mold to expedite the flow of molten metal into the cavity and to minimize internal casting defects. Sand-cast parts include automotive cylinder blocks, fire hydrants, and large pipe fittings.

SAND CASTING

Die Casting

In die casting, the liquid metal is forced into a mold under pressure and at a relatively high velocity and allowed to solidify with the pressure maintained. A two-piece permanent steel mold or die is employed; when clamped together, the two pieces form the desired shape. When the metal has solidified completely, the die pieces are opened, and the cast piece is ejected. Rapid casting rates are possible, making this an inexpensive method; furthermore, a single set of dies may be used for thousands of castings. However, this technique lends itself only to relatively small pieces and to alloys of zinc, aluminum, and magnesium, which have low melting temperatures.

Continuous Casting

At the conclusion of extraction processes, many molten metals are solidified by casting into large ingot molds. The ingots are normally subjected to a primary hot-rolling operation, the product of which is a flat sheet; these are more convenient shapes as starting points for subsequent secondary metal-forming operations (forging, extrusion, drawing). These casting and rolling steps may be combined by a *continuous casting* (sometimes termed *strand casting*) process. Using this technique, the refined and molten metal is cast directly into a continuous strand that may have either a rectangular or circular cross section; solidification occurs in a water-cooled die having the desired cross-sectional geometry. The chemical composition and mechanical properties are more uniform throughout the cross sections for continuous castings than for ingot-cast products. Furthermore, continuous casting is highly automated and more efficient.



Hammer forging



Thank you for listening