MEP 291 METAL FORMING

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Chapter-4 | Metal-Extrusion

Ch.4 Metal Extrusion

- **Extrusion:** the material is forced through a die (similar to squeezing a toothpaste) taking the shape of the die opening which me be round, or may have various shapes (Fig. 15.1).
- **Typical products:** window frames, railings for sliding doors, tubing with various cross sections, brackets, gears, coat hangers, and aluminum ladder frames.
- **Commonly extruded materials:** aluminum, copper, steel, magnesium, and lead.

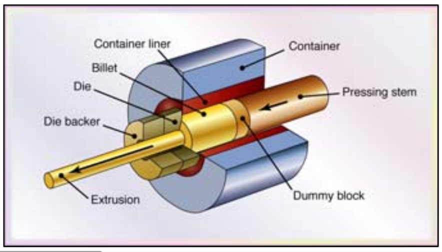


Figure 15.1 Schematic illustration of the direct-extrusion process.

Ch.4 Metal Extrusion

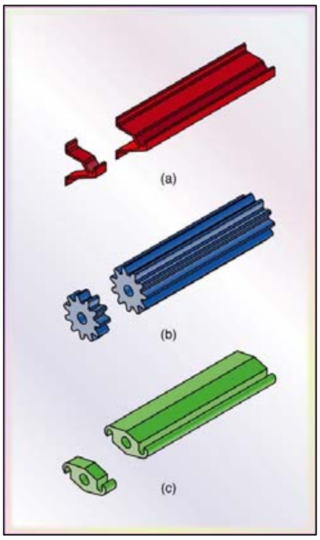


Figure 15.2 Extrusions and examples of products made by sectioning off extrusions. *Source:* Courtesy of Kaiser Aluminum.

Ch.4 Metal Extrusion

- **Die material:** made of hot worked die steels coated by zirconia (which has a good resistance to thermal shock, wear, and corrosion, and has low thermal conductivity and low friction coefficient) to extend their life.

- **Types of extrusion:** indirect, hydrostatic, and lateral (or side).

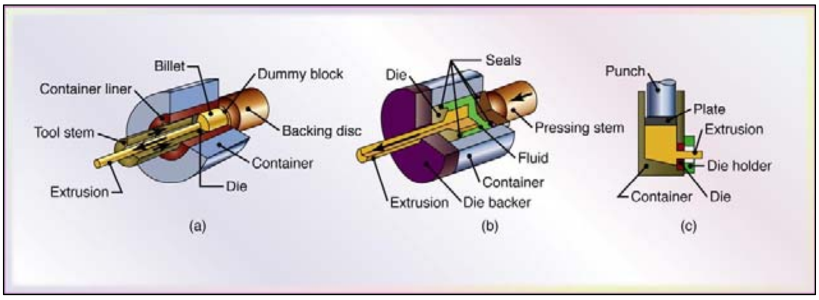


Figure 15.3 Types of extrusion: (a) indirect; (b) hydrostatic; (c) lateral;

Ch.4 Metal Extrusion (Extrusion force)

Extrusion force:

$$F = A_0 k'' \ln\left(\frac{A_0}{A_f}\right)$$

Where,

k'' =The extrusion constant (obtained from fig. 15.5)

A_0 =The billet area

A_f =The extruded product area

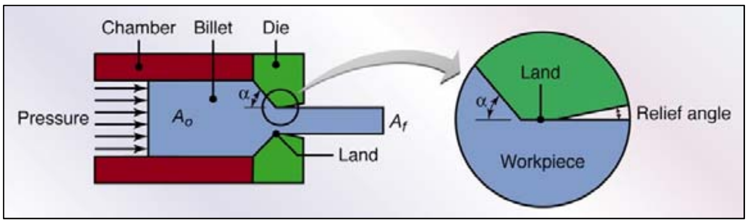


Figure 15.4 Process variables in direct extrusion. The die angle, reduction in cross-section, extrusion speed, billet temperature, and lubrication all affect the extrusion pressure.

Ch.4 Metal Extrusion (Extrusion force)

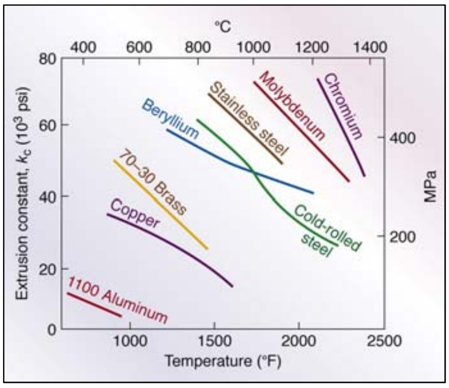


Figure 15.5 Extrusion constant *k''* for various metals at different temperatures. *Source*: After P. Loewenstein

Extrusion force:

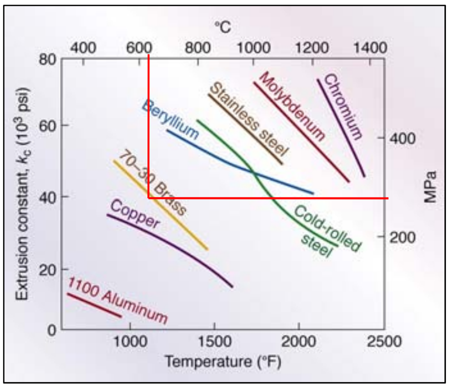
$$F = A_0 k'' \ln\left(\frac{A_0}{A_f}\right)$$

Example-1

A round billet made of 70-30 brass is extruded at a temperature of 675°C. The billet diameter is 125 mm, and the diameter of the extrusion is 50 mm. Calculate the required extrusion force.

Solution:

k''=250 Mpa (From fig. 15.5)
D_0=125 mm
Df=50 mm



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Example-1

Continue:

$$A_0 = \frac{\pi}{4} D_0^2 = \frac{\pi}{4}(125)^2 \Rightarrow A_0 = 12,272 mm^2$$

$$A_f = \frac{\pi}{4} D_f^2 = \frac{\pi}{4}(50)^2 \Rightarrow A_f = 1,963.5 mm^2$$

$$F = A_0 k'' \ln\left(\frac{A_0}{A_f}\right)$$

$$F = (12,272 mm^2)(250 MPa)\ln\left(\frac{12,272 mm^2}{1,963.5 mm^2}\right)$$

$$F = (3,068,000)\ln(6.25) = 5,622,360 N \times \frac{1MN}{10^6 N} = 5.6MN$$

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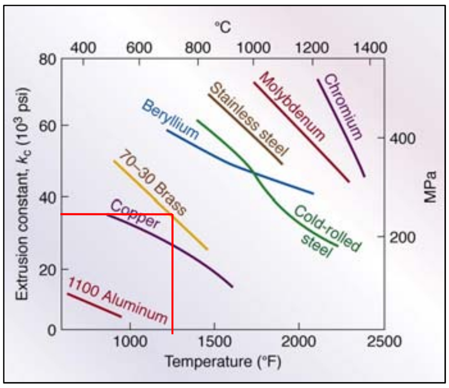
Example-2

A round billet made of 70-30 brass is extruded at a temperature of 1250°F. The billet diameter is 5 in, and the diameter of the extrusion is 2 in. Calculate the required extrusion force.

Solution:

k''=35 x 10^3 Psi (From fig. 15.5)
D_0=5 in
Df=2 in



Example-2

Continue:

$$A_0 = \frac{\pi}{4} D_0^2 = \frac{\pi}{4}(5)^2 \Rightarrow A_0 = 19.63 in^2$$

$$A_f = \frac{\pi}{4} D_f^2 = \frac{\pi}{4}(2)^2 \Rightarrow A_f = 3.14 in^2$$

$$F = A_0 k'' \ln\left(\frac{A_0}{A_f}\right)$$

$$F = \left(19.63 in^2\right)\left(35,000 Psi\right)\ln\left(\frac{19.63 \cancel{in}^2}{3.14 \cancel{in}^2}\right)$$

$$F = (687,050)\ln(6.25) = 1,259,075\ lbf$$

Ch.4 Metal Extrusion (Impact extrusion)

- **Impact extrusion:** The punch descends on the blank and force it to extrude backwards (Fig. 15.14).

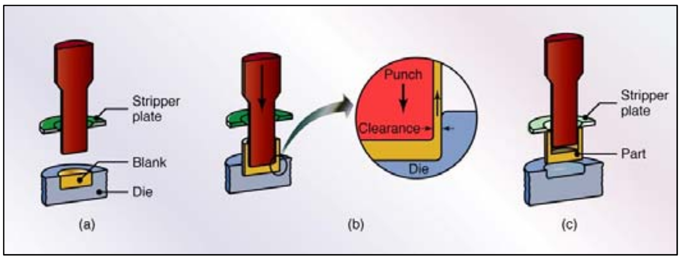


Figure 15.14 Schematic illustration of the impact-extrusion process. The extruded parts are stripped by use of a stripper plate, because they tend to stick to the punch.

Ch.4 Metal Extrusion (Impact extrusion)

- **The impact extrusion** can produce thin walled sections having thickness/diameter ratio as small as 0.005.

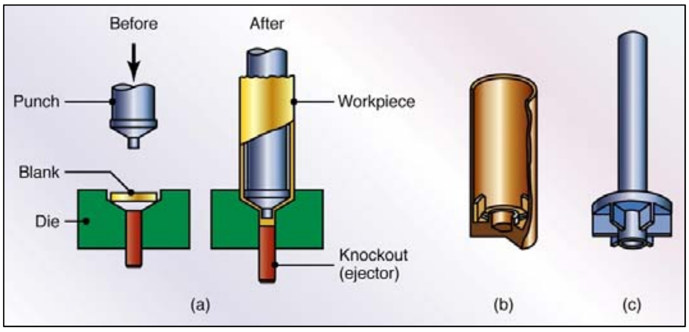


Figure 15.15 (a) Impact extrusion of a collapsible tube by the *Hooker process*. (b) and (c) Two examples of products made by impact extrusion. These parts also may be made by casting, forging, or machining. The choice of process depends on the materials involved, part dimensions, and wall thickness,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

Ch.4 Metal Extrusion

- **Benefits of lubrication:**

  - Material flow during extrusion.
  - Surface finish.
  - Product quality.
  - Extrusion forces.

Ch.4 Metal Extrusion (Die design)

- **Guideline for proper die design:**

  - Symmetry of cross section.
  - Avoidance of sharp corners.
  - Avoidance of extreme changes in die dimensions within the cross section.

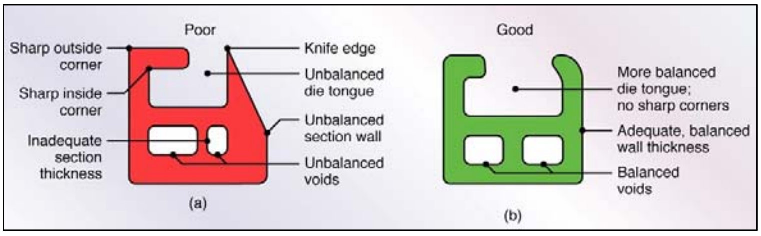


Figure 15.9 Poor and good examples of cross-sections to be extruded. Note the importance of eliminating sharp corners and of keeping section thicknesses uniform. *Source:* J.G. Bralla (ed.); *Handbook of Product Design for Manufacturing.* New York: McGraw-Hill Publishing Company, 1986. Used with permission.