(3) EXTRUSION

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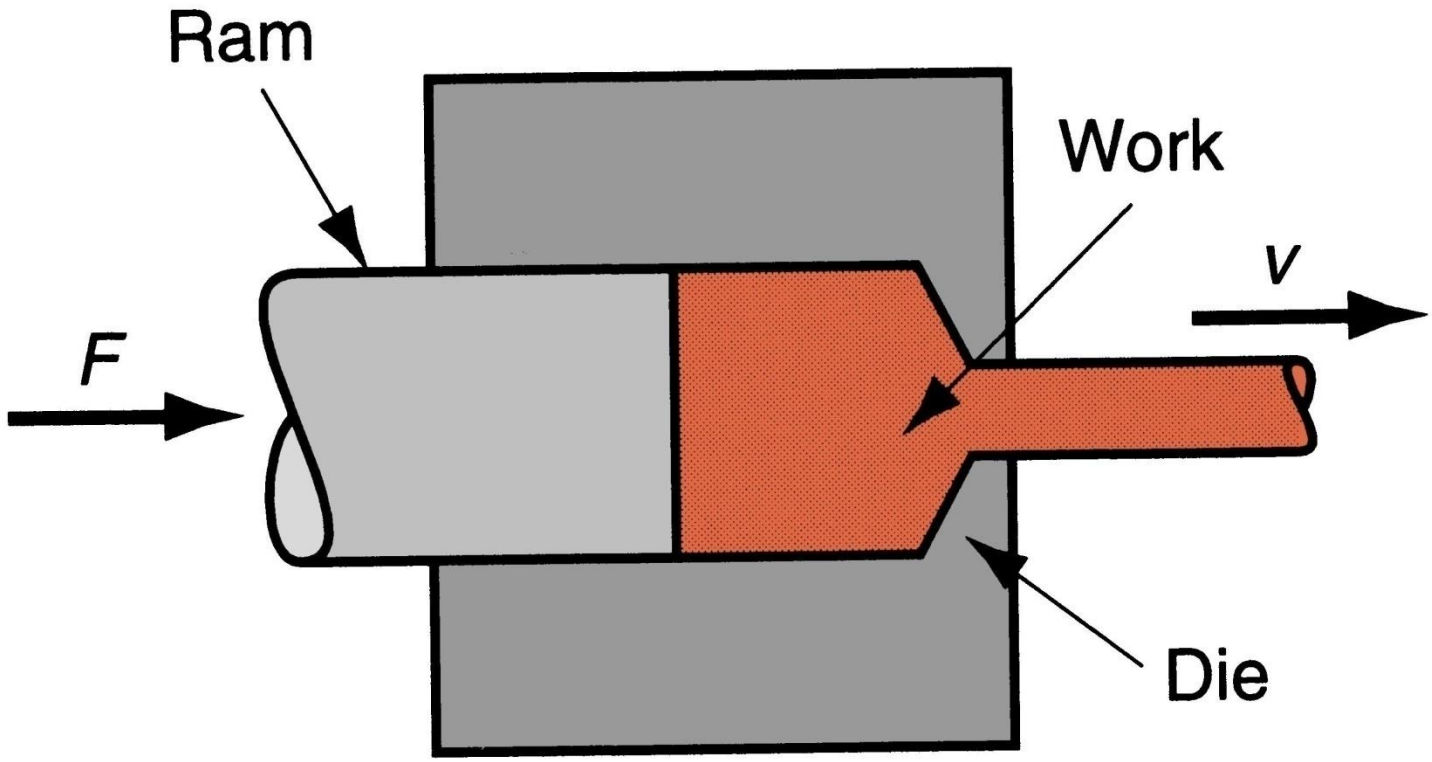
- Extrusion is a ***compression process*** in which the work metal is ***forced to flow*** through a ***die*** opening to produce a ***desired cross-sectional shape.***
- The process can be likened to ***squeezing toothpaste*** out of a toothpaste tube.

(3) EXTRUSION



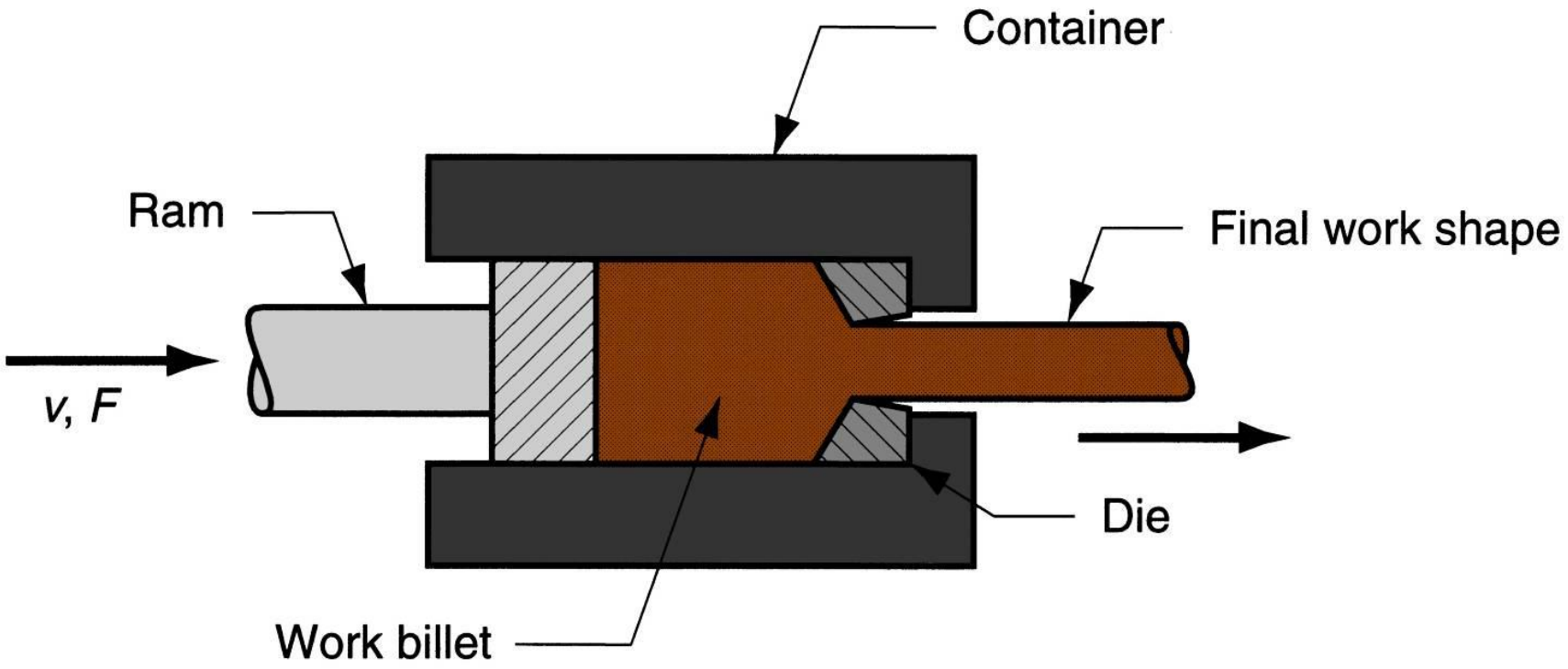
(3) TYPES OF EXTRUSION

- In general, extrusion is used to **produce long parts** of **uniform cross sections**
- Two basic types:
  - **Direct extrusion**
  - **Indirect extrusion**

(3) TYPES OF EXTRUSION (DIRECT)

- ***Direct extrusion*** (also called ***forward extrusion***)is shown in Figure.
- A ***metal billet*** is loaded into a container, and a ***ram compresses*** the material, forcing it to ***flow*** through one or more ***openings*** in a die at the opposite end of the container.
- As the ram approaches the die, a small portion of the billet remains that cannot be forced through the die opening.

(3) TYPES OF EXTRUSION (DIRECT)



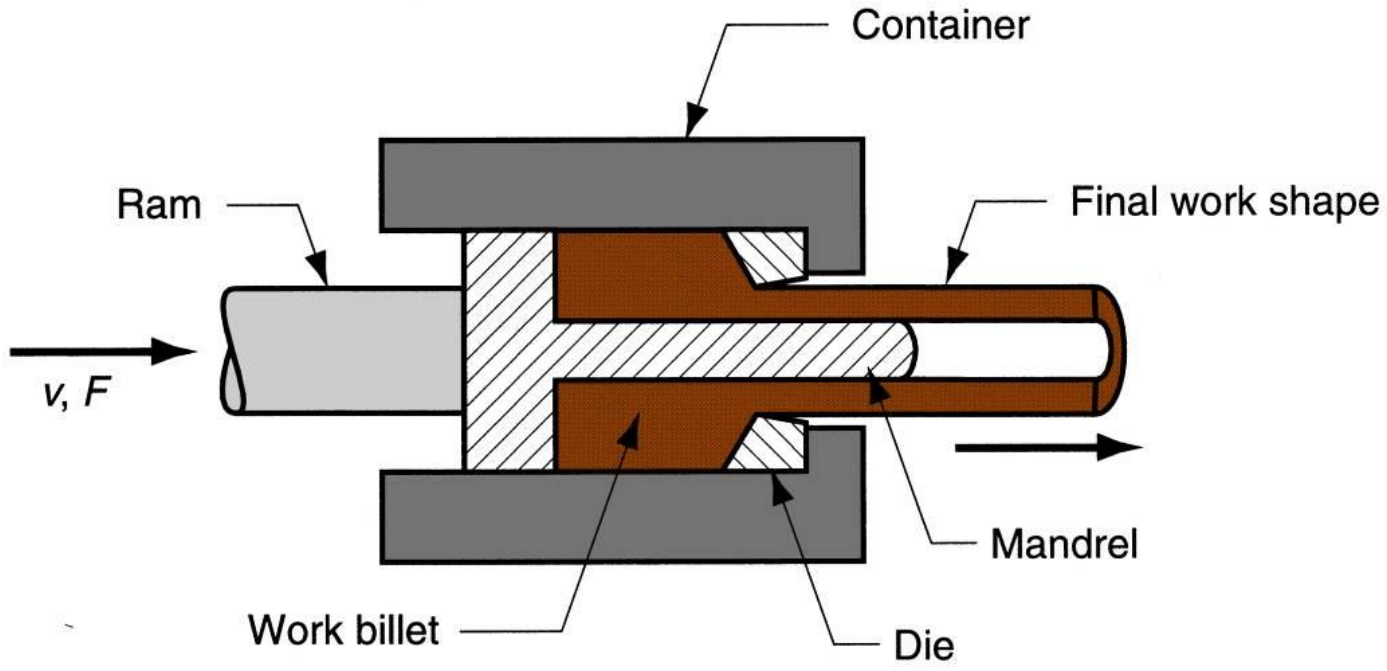
(3) TYPES OF EXTRUSION (DIRECT)

- This extra portion, called the ***butt*** ,is separated from the product by ***cutting*** it just ***beyond the exit of the die.***
- One of the problems in direct extrusion is the significant ***friction*** that exists between the ***work surface and the walls*** of the container as the billet is forced to slide to ward the die opening.
- This friction causes a substantial increase in the ram force required in direct extrusion.

(3) TYPES OF EXTRUSION (DIRECT)

- Hollow sections (e.g., tubes) are possible in direct extrusion by the process setup in Figure.

(3) TYPES OF EXTRUSION (DIRECT)(hollow sections)



(a)

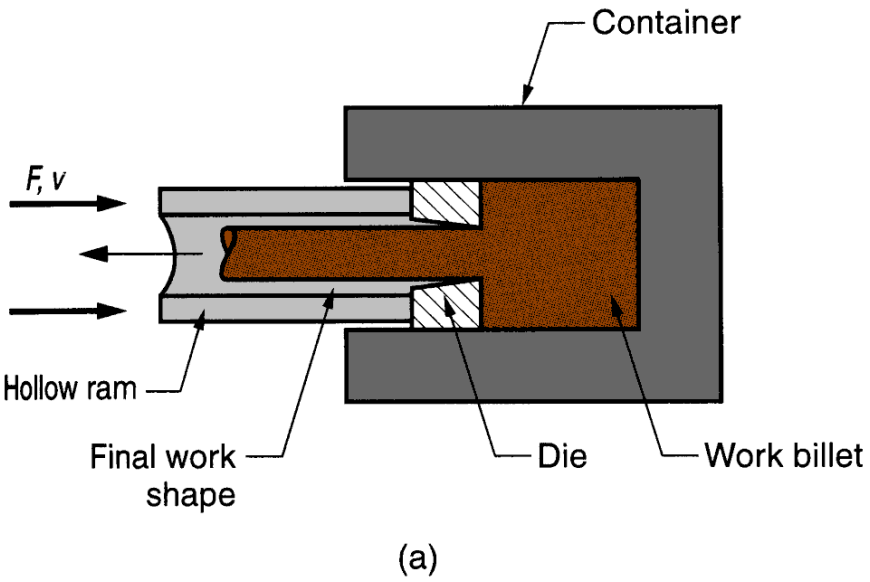
(3) TYPES OF EXTRUSION (INDIRECT)

- In ***indirect*** extrusion, also called ***backward*** extrusion and ***reverse*** extrusion, the ***die is mounted to the ram*** rather than at the opposite end of the container.
- As the ram penetrates into the work, the ***metal*** is forced to ***flow*** through the ***clearance*** in a ***direction opposite*** to the motion of the ram.

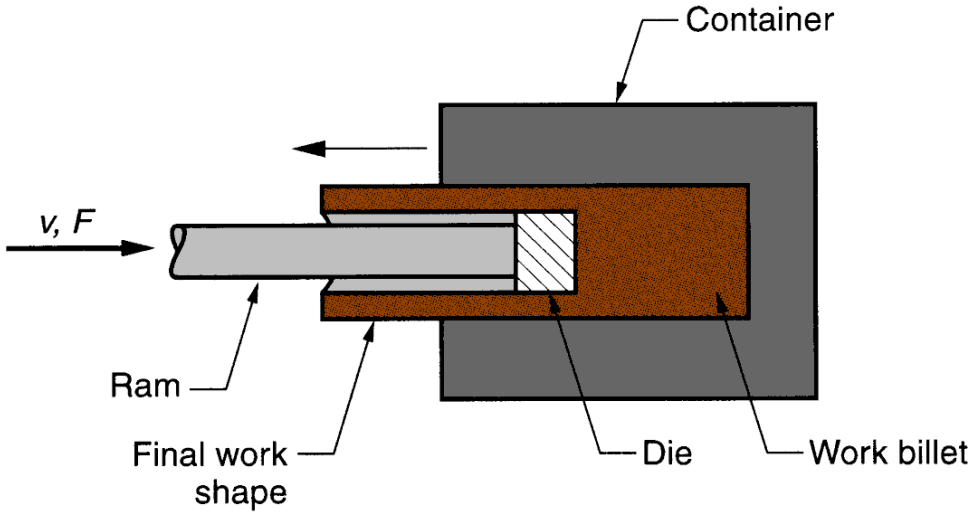
(3) TYPES OF EXTRUSION (INDIRECT)

- Since the billet is not forced to move relative to the container, there is ***no friction*** at the container walls, and the ram force is therefore lower than in direct extrusion.
- ***Limitations*** of indirect extrusion are imposed by the ***lower rigidity of the hollow ram*** and the ***difficulty in supporting*** the extruded product as it exits the die.
- Indirect extrusion can produce hollow (tubular) cross sections, as in Figure.

(3) TYPES OF EXTRUSION (INDIRECT)



(a)



(b)

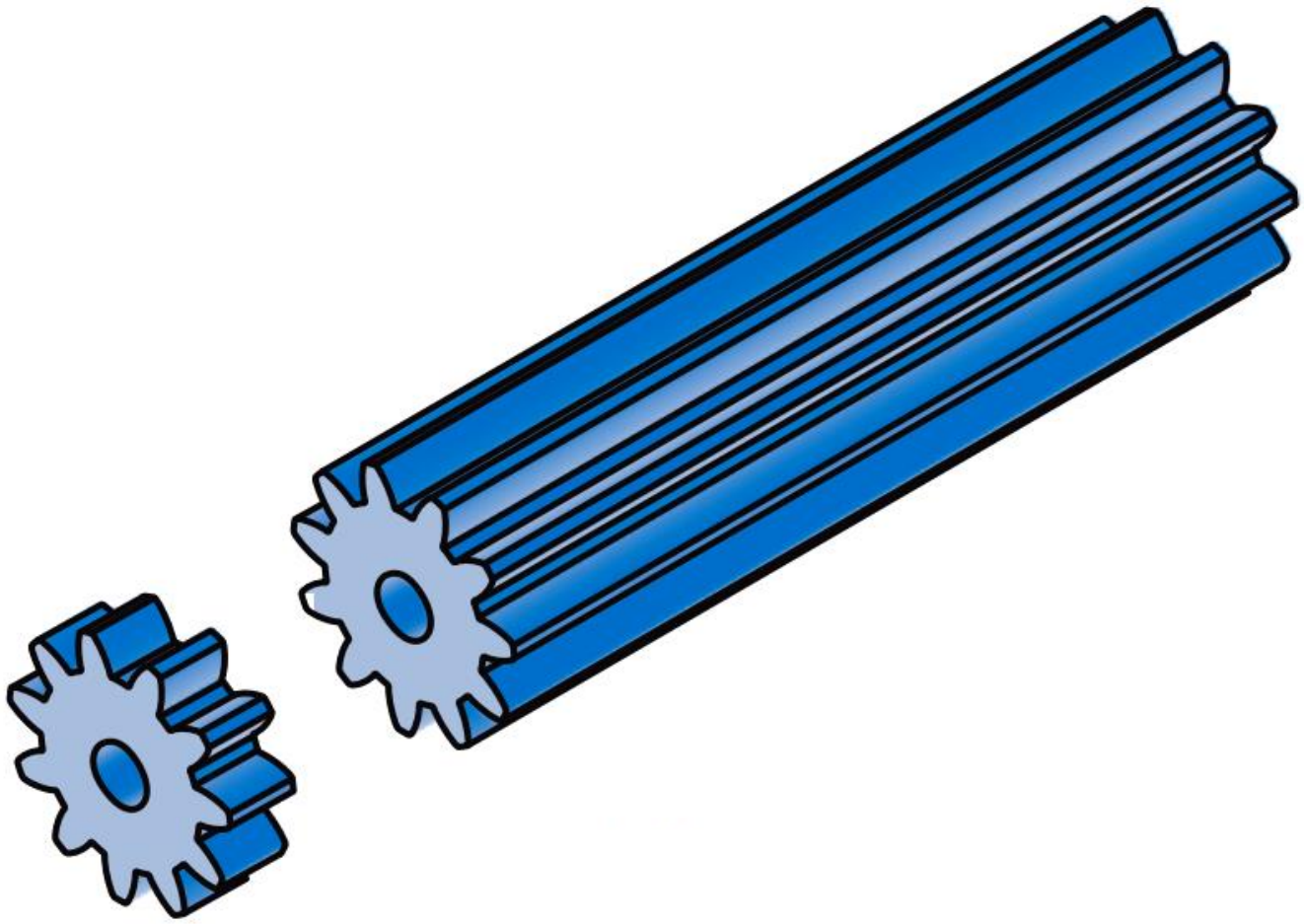
(3) TYPES OF EXTRUSION (HOT vs COLD)

- ***Hot extrusion*** - prior heating of billet to above its recrystallization temperature
  - Reduces strength and increases ductility of the metal, permitting more size reductions and more complex shapes
- ***Cold extrusion*** - generally used to produce discrete parts
  - The term impact extrusion is used to indicate high speed cold extrusion

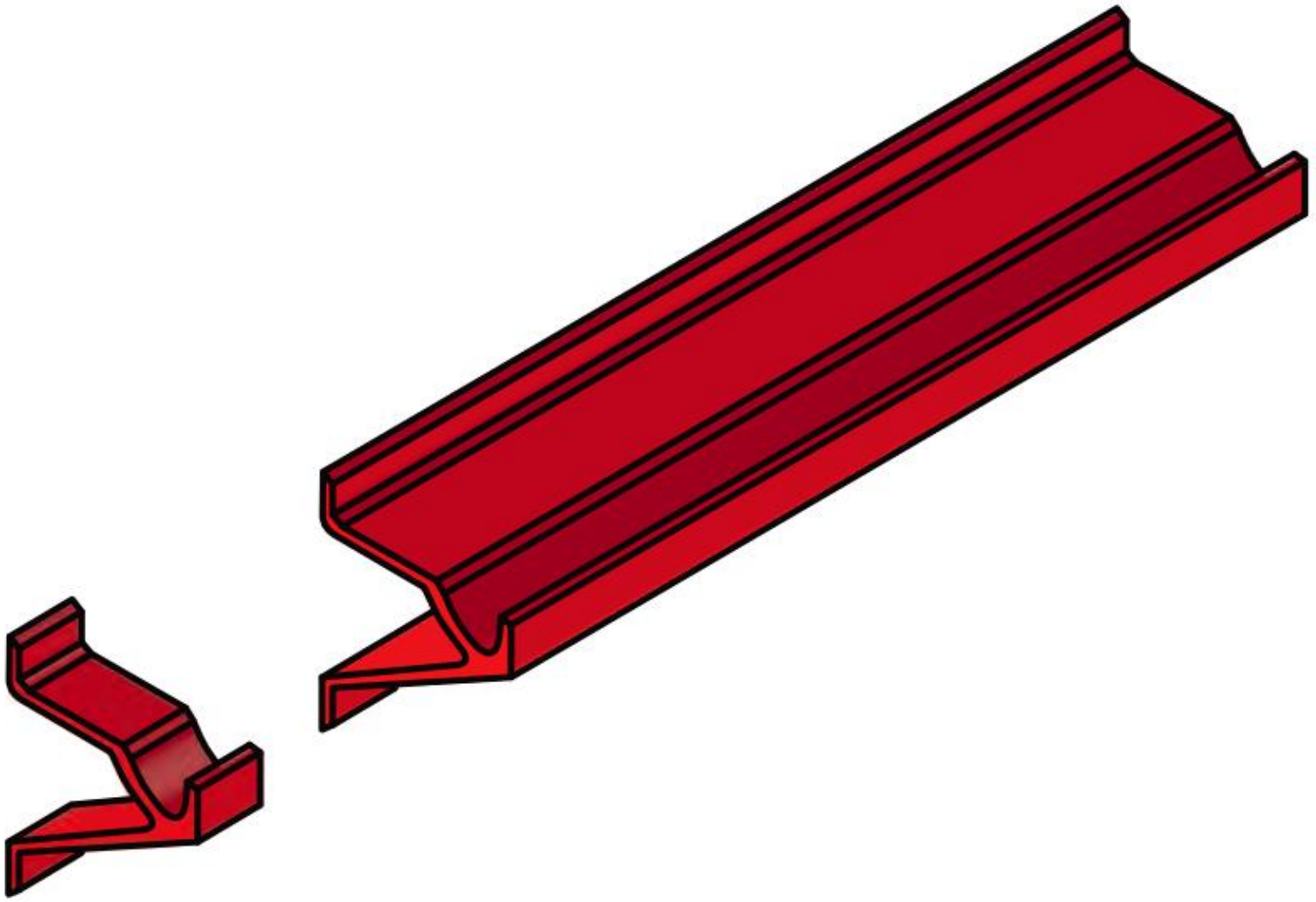
(3) TYPES OF EXTRUSION (HOT vs COLD))

- Variety of shapes possible, especially in ***hot extrusion***
  - ***Limitation***: part cross section must be uniform throughout length
- Grain structure and strength enhanced in cold and warm extrusion
- Close tolerances possible, especially in cold extrusion
- In some operations, little or no waste of material

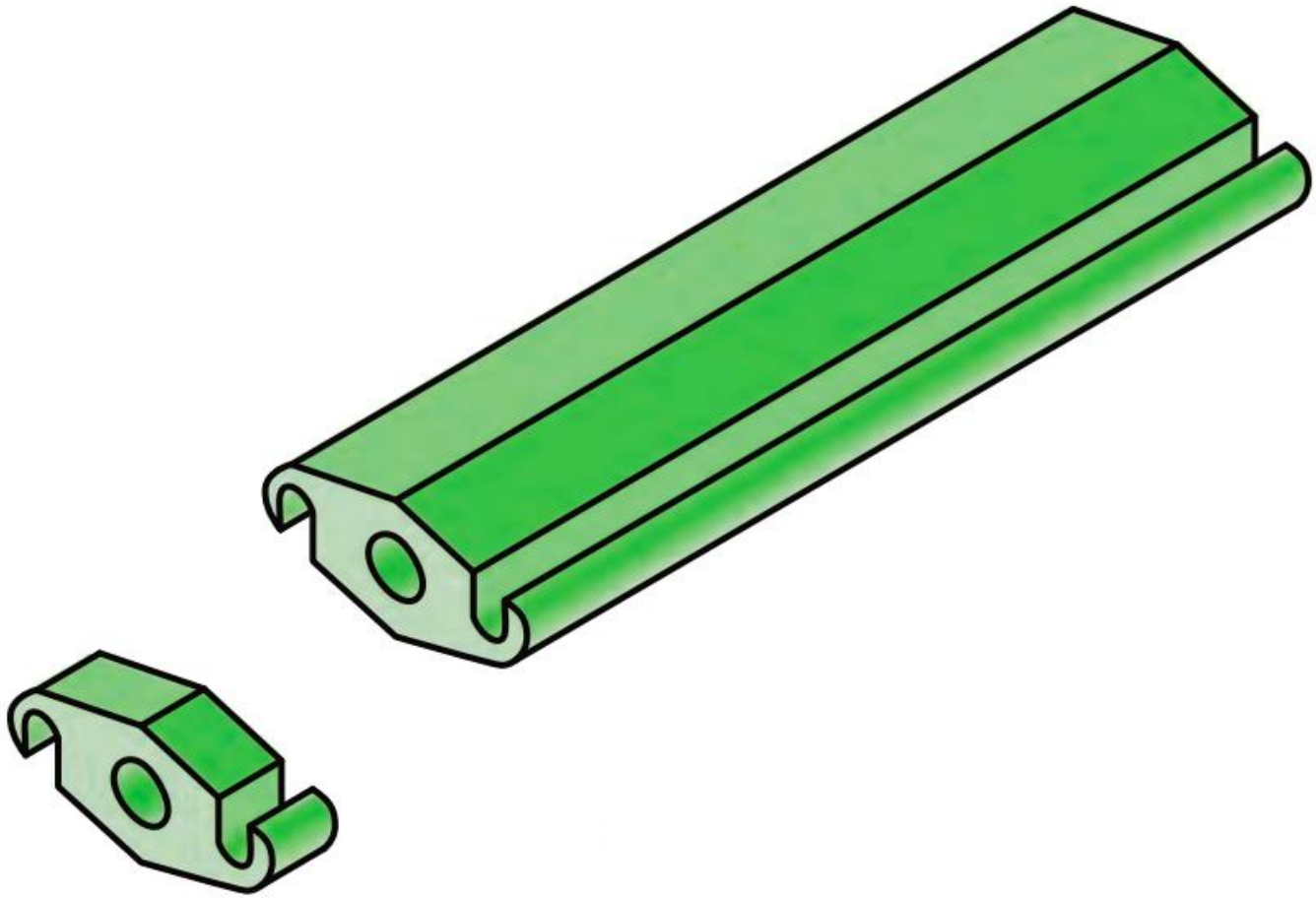
Types Of Extruded Products



Types Of Extruded Products



Types Of Extruded Products



Extrusion Force

Extrusion Force = $\sigma A_o \ln (A_o / A_f)$

σ = average flow stress of material during deformation

A_o = area of cross-section of billet

A_f = area of cross-section of extruded product

Extrusion Force

A_o / A_f is called extrusion ratio.

$\varepsilon = \ln (A_o / A_f)$

ε = true strain in extrusion

Extrusion Force - Numerical

- A billet of metal **800 mm long X 150 mm dia** is to be extruded into a cylindrical component. Direct extrusion process is to be used. If the estimated **extrusion ratio is 40** and the average flow **stress** experienced by the metal during deformation is **100 Mpa**, calculate the true strain and the force required for the extrusion process.