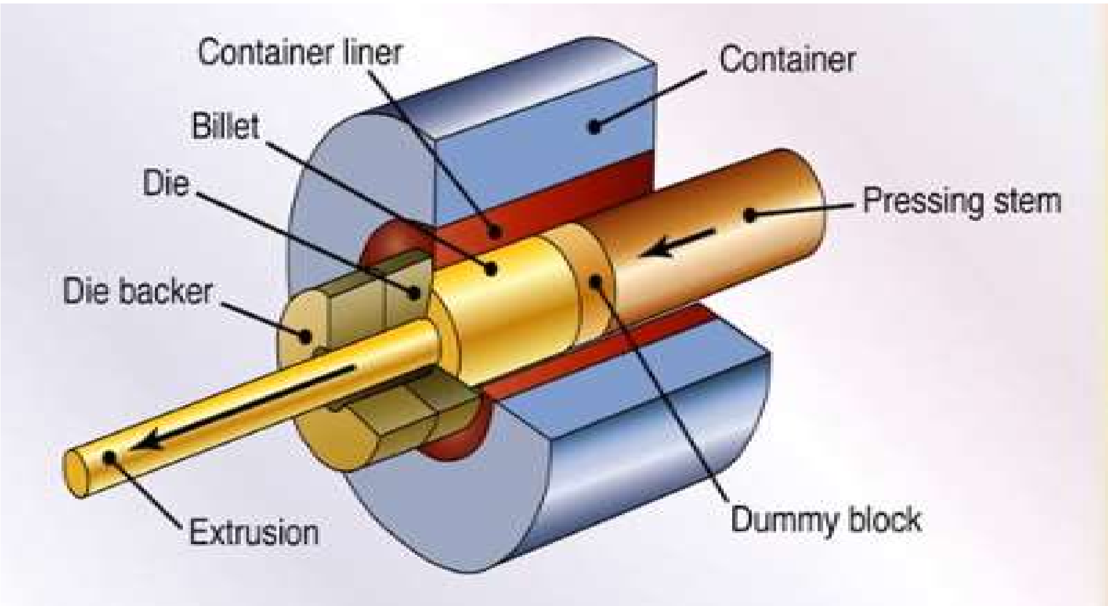
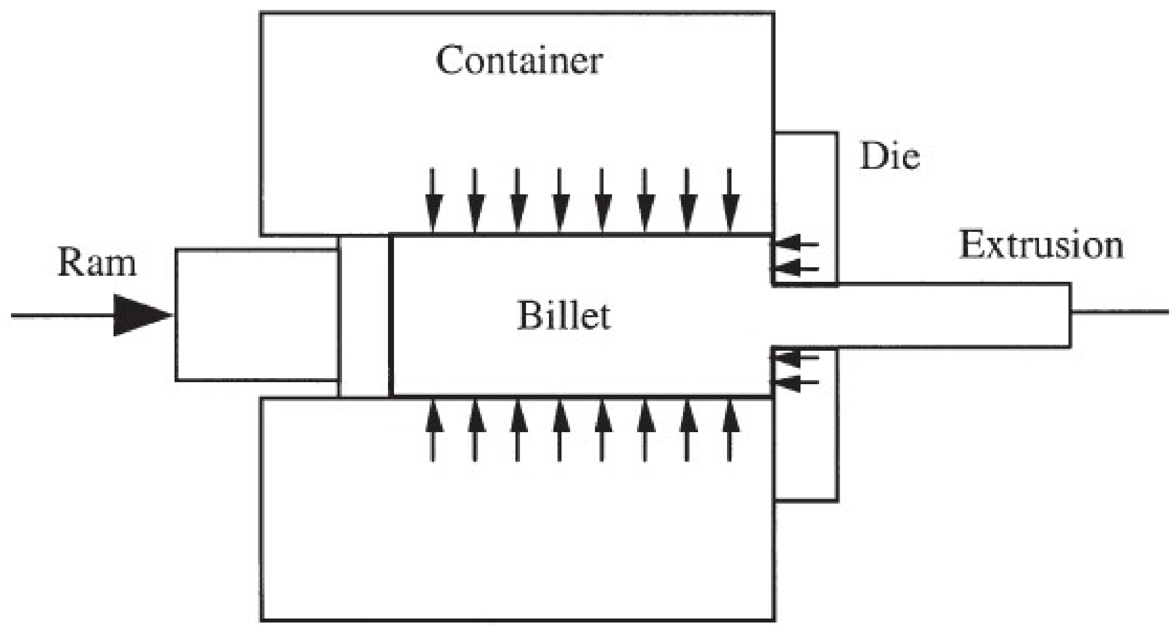
Extrusion Processes





Extrusion Processes

Extrusion is the process by which a block of metal is reduced in cross section by forcing it to flow through die orifice under high pressure.

Regular Cross-section

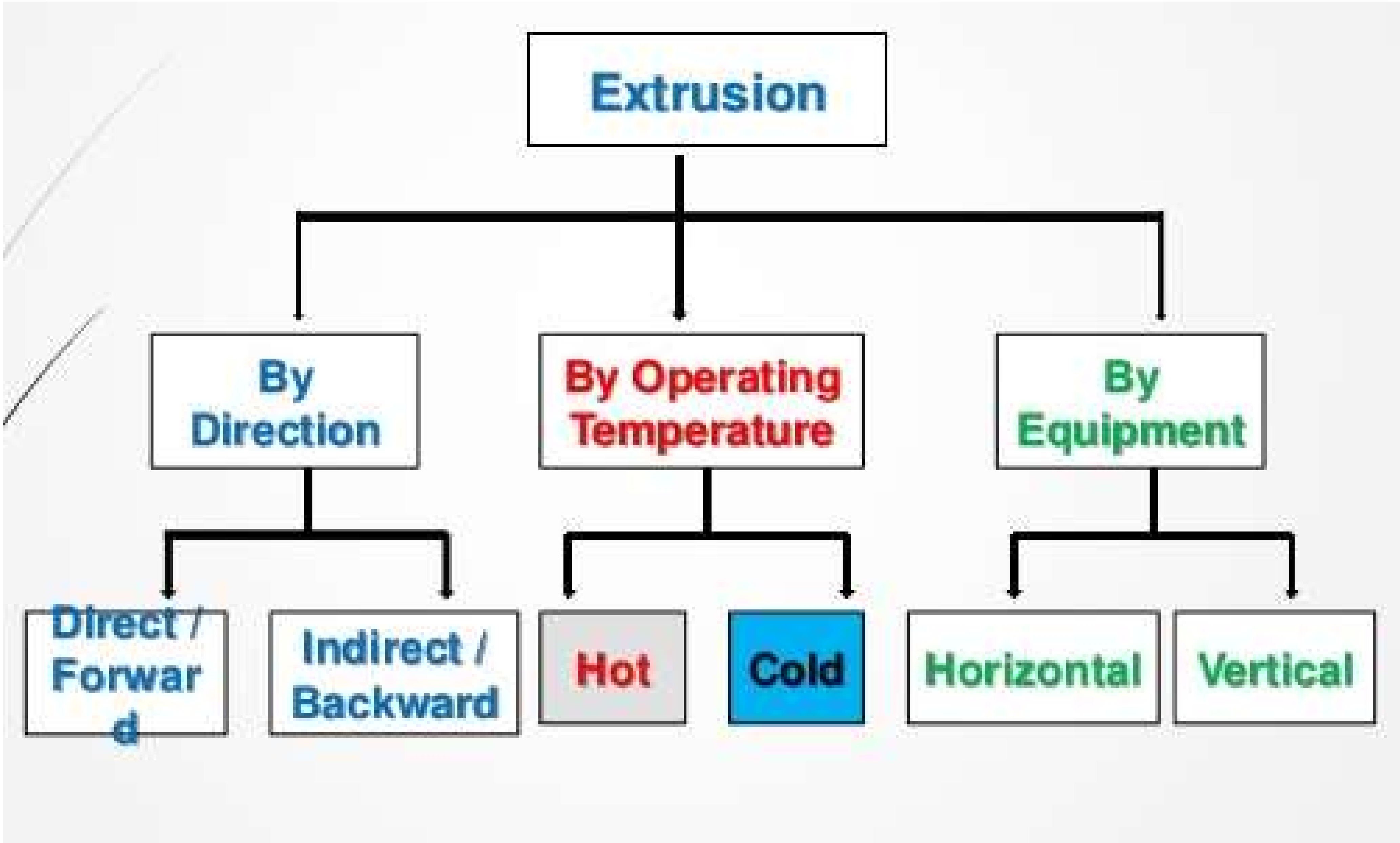
Cylindrical bars

Hollow tubes

Hot Extrusion &
Cold Extrusion

Irregular Cross-section

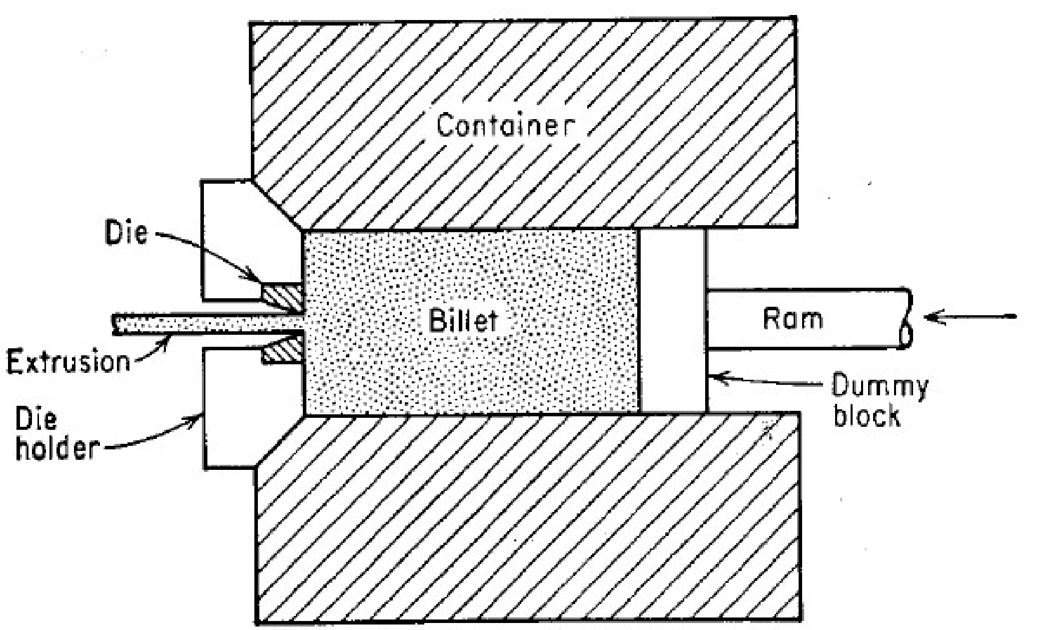
Classification of Extrusion Processes



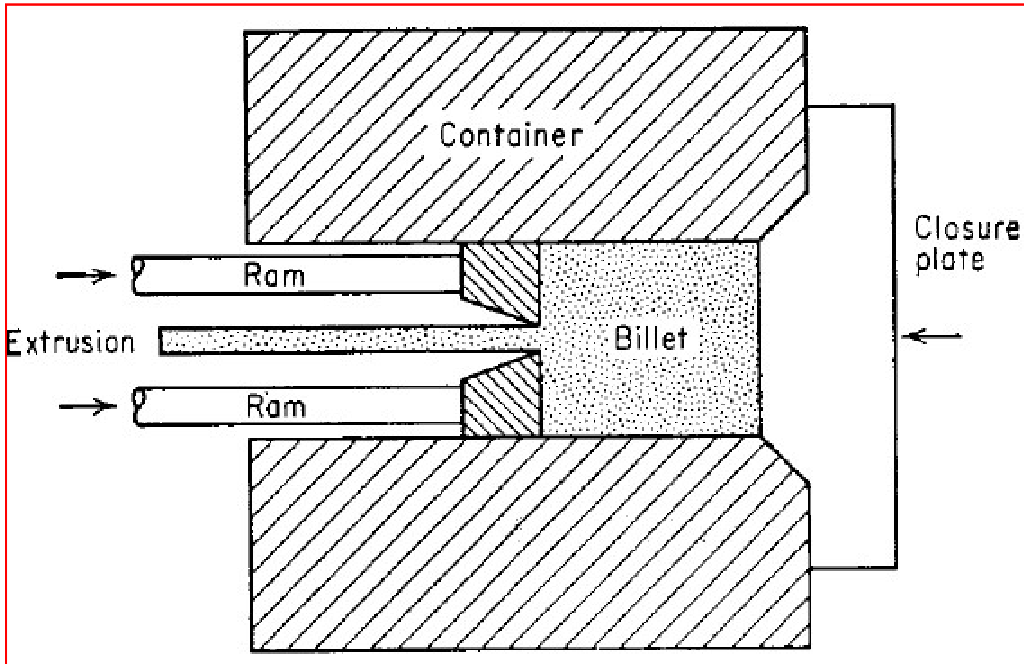
Classification of Extrusion Processes

Direct Extrusion

In-Direct Extrusion / Inverted / Back Extrusion



Direct extrusion

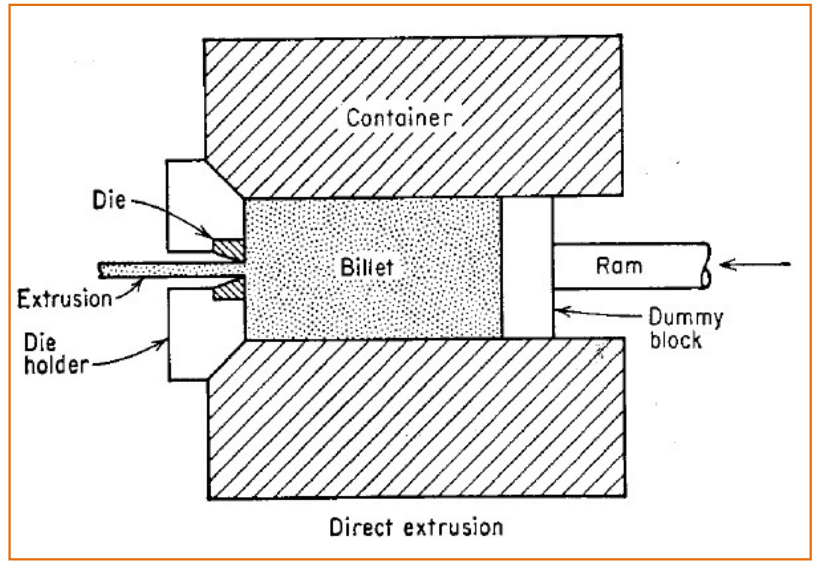


Indirect extrusion

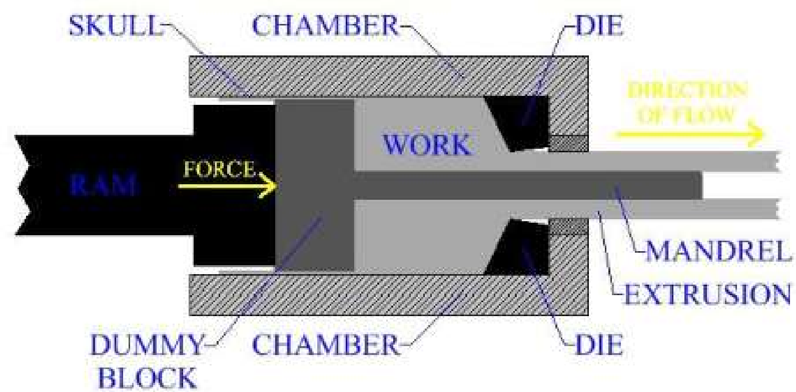
Classification of Extrusion Processes

Direct Extrusion

The metal billet is placed in a container and driven through the die by the ram.



A dummy block / Pressure plate is placed at the end of the ram in contact with the billet.



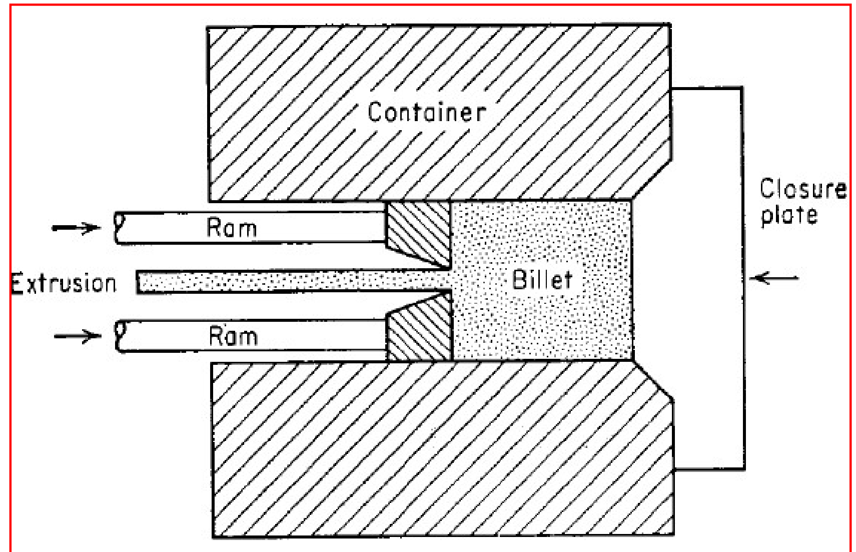
The direction of metal flow will be in the same direction as ram travel

Billet is having relative motion with container walls and die. Friction is high

Classification of Extrusion Processes

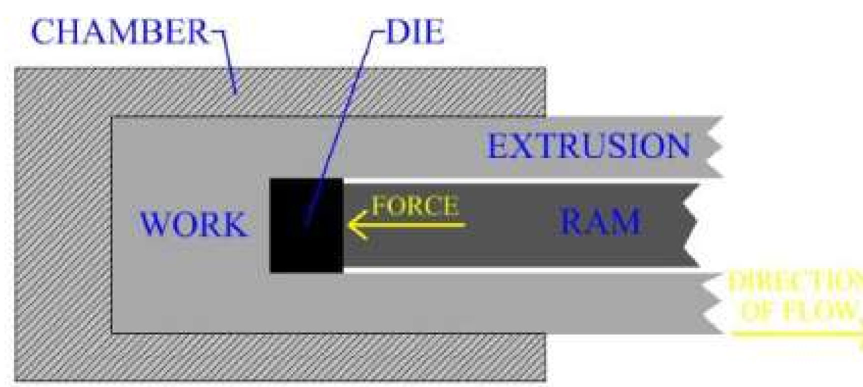
Indirect Extrusion

Indirect extrusion (backward extrusion) is a process in which punch moves opposite to that of the billet.



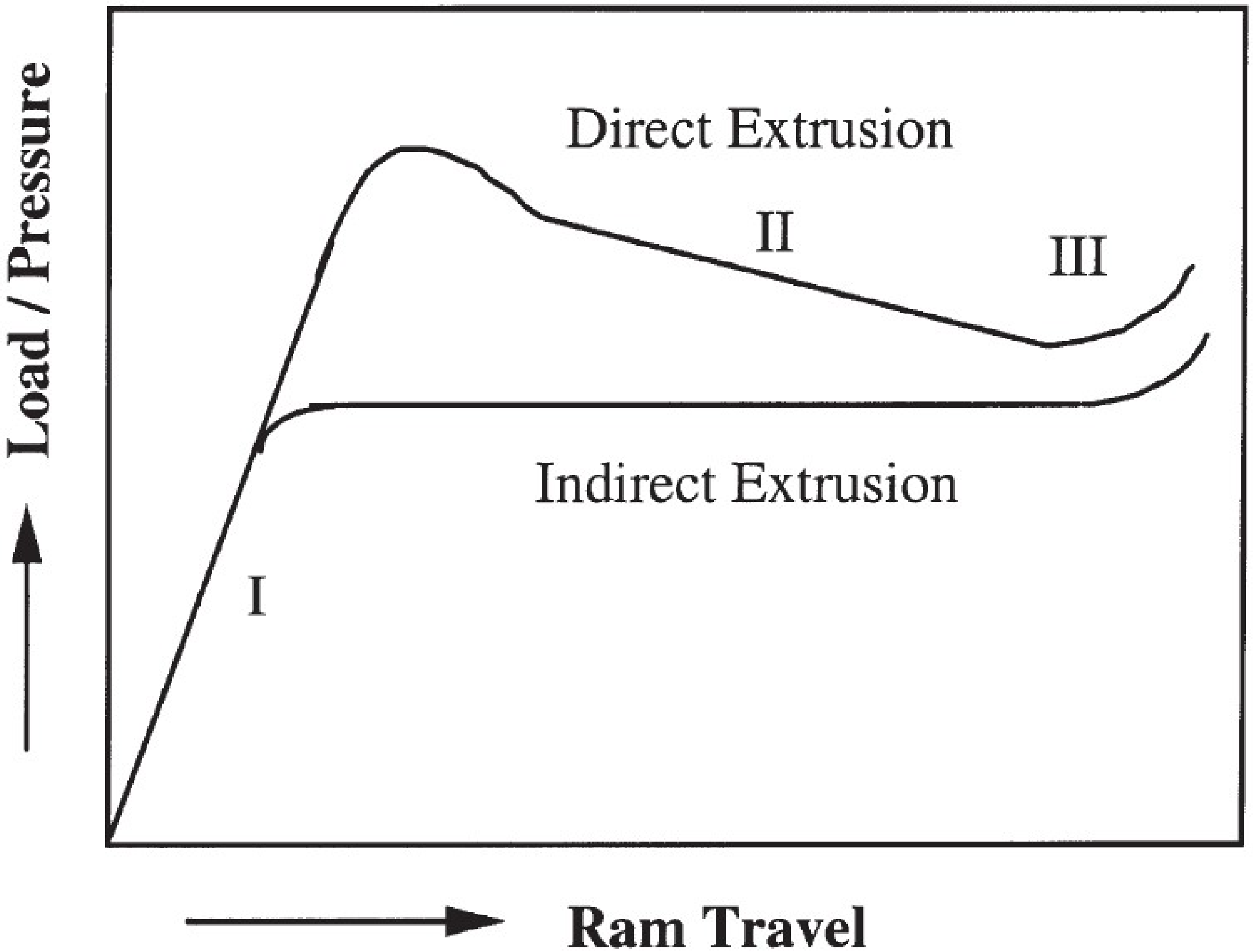
Indirect extrusion

Ram containing die is kept constant and the container with the billet is caused to move.



Here there is no relative motion between container and billet. Hence, there is less friction and hence reduced forces are required for indirect extrusion.

Classification of Extrusion Processes



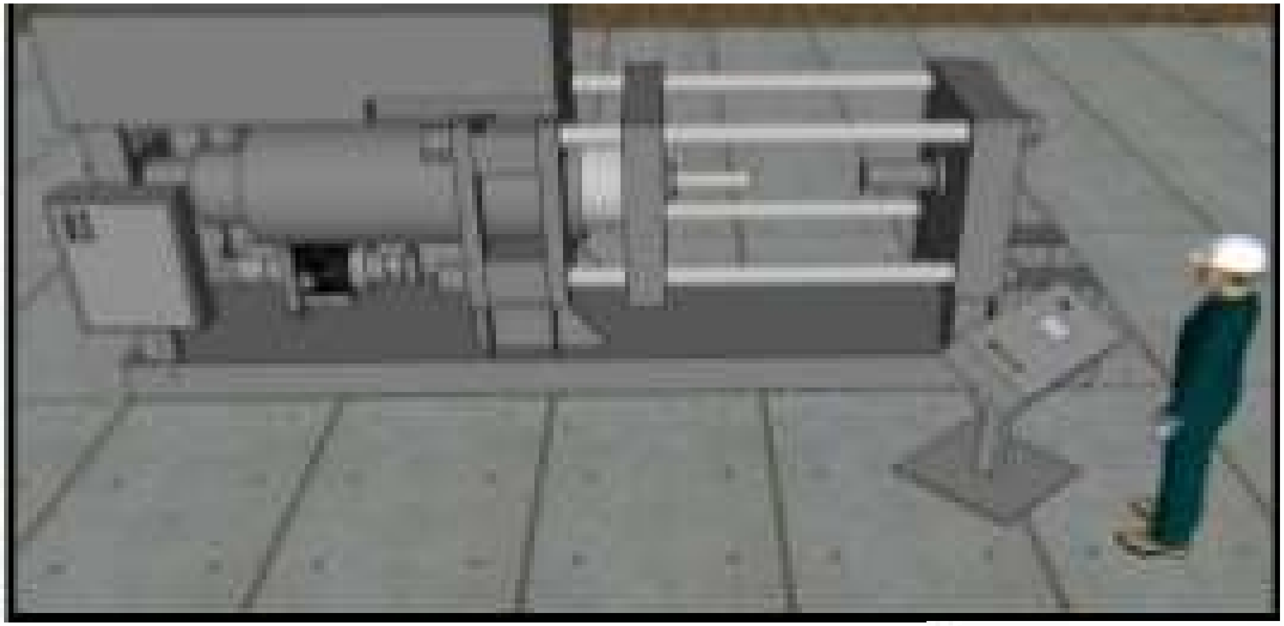
1. The billet is upset, and pressure rises rapidly to its peak value.

2. The pressure decreases, and what is termed “steady state” extrusion proceeds.

3. The pressure reaches its minimum value followed by a sharp rise as the “discard” is compacted.

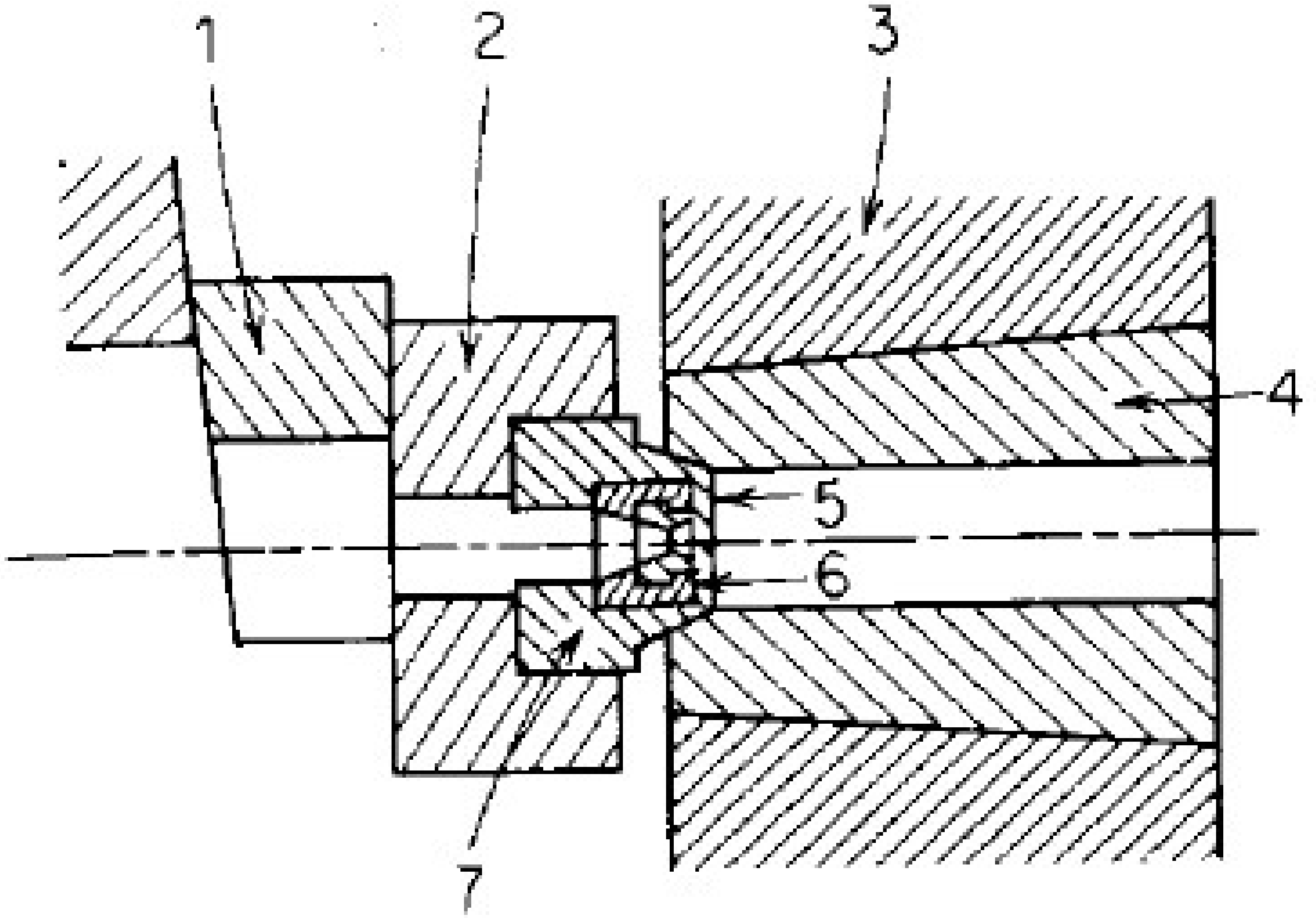
Variation of load or pressure with ram travel for both direct and indirect extrusion process

Extrusion Equipment



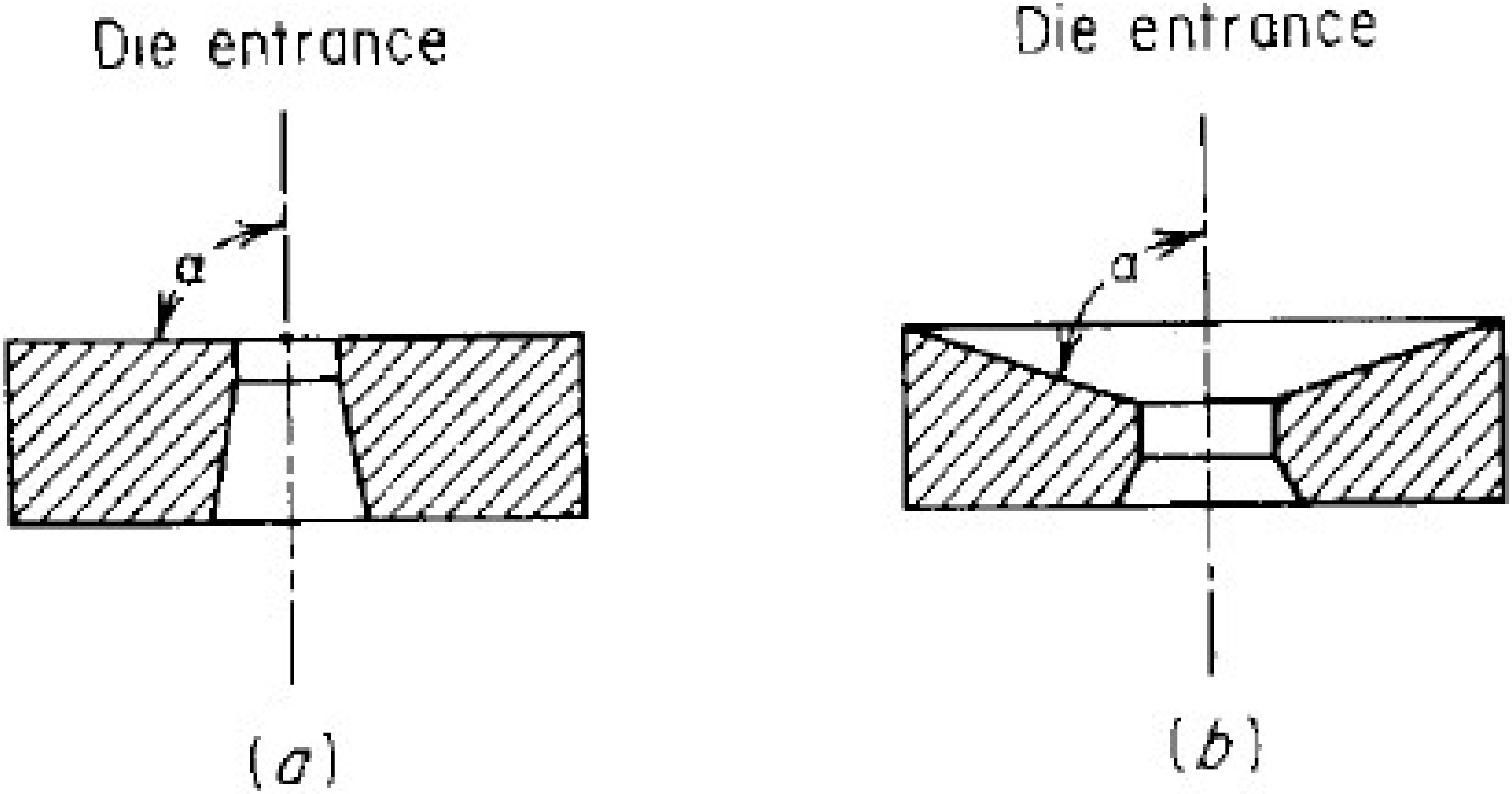
Horizontal & Vertical
Extrusion Press

Extrusion Equipment



Typical arrangement of Extrusion Tooling

Extrusion Equipment



Typical Extrusion Dies (a) Flat-faced (square) die; (b) Conical Die

Extrusion Equipment

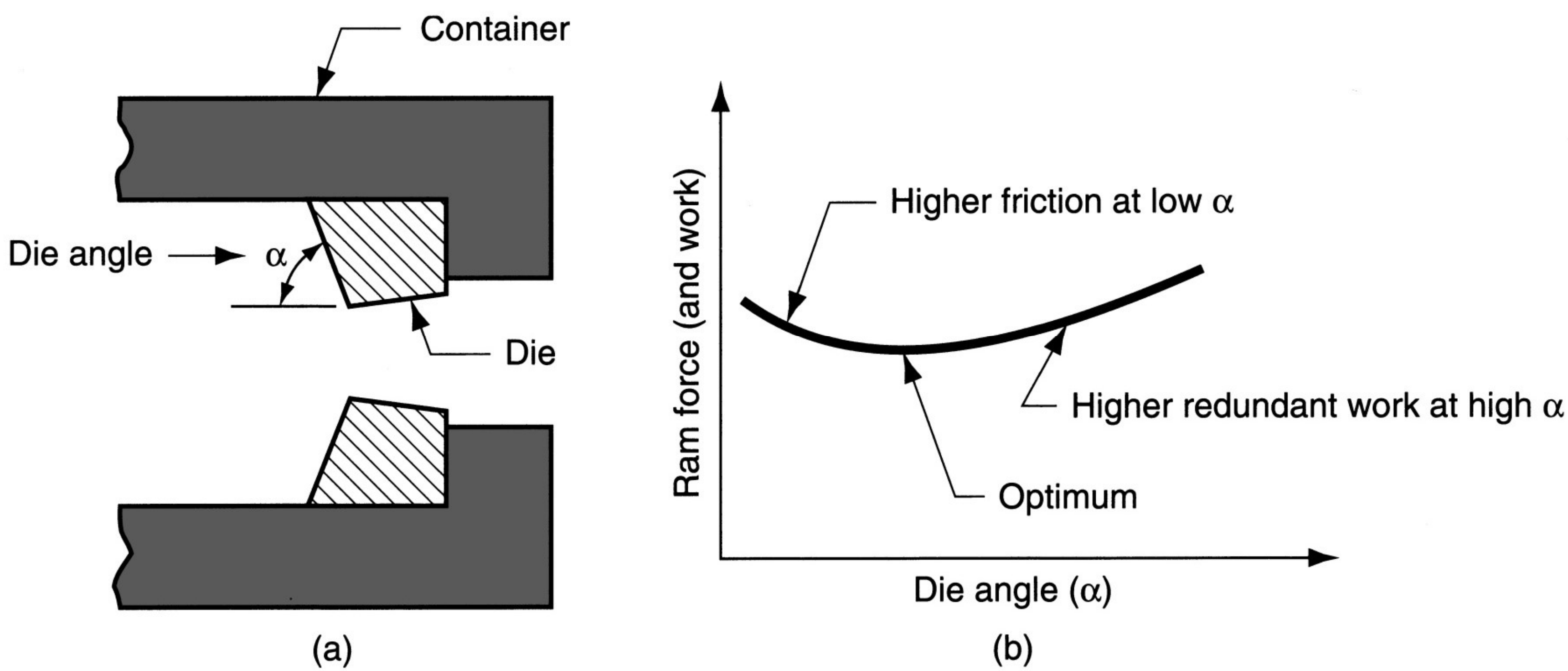


Figure 19.36 -

(a) Definition of die angle in direct extrusion;

(b) effect of die angle on ram force

Comments on Die Angle

- Low die angle - surface area is large, leading to increased friction at die-billet interface
  - Higher friction results in larger ram force
- Large die angle - more turbulence in metal flow during reduction
  - Turbulence increases ram force required
- Optimum angle depends on work material, billet temperature, and lubrication

Extrusion Process

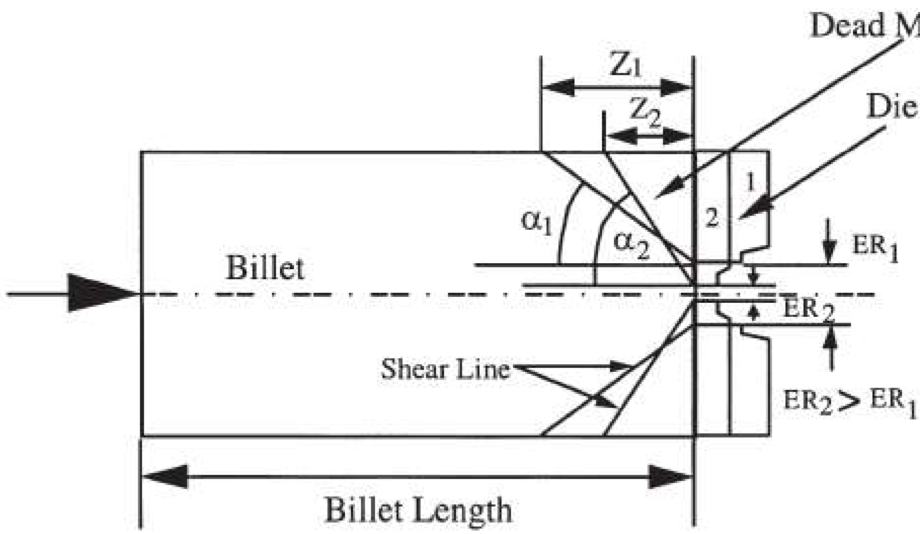


Fig. 9 Relationship between extrusion ratio and semidead-metal zone angle

The dead-metal zone semiangle may be represented in the functional form:

$$\alpha = f(\mathrm{ER}, \bar{\sigma}, m, m') \quad \text{(Eq 1)}$$

where ER is the extrusion ratio, which is defined by the ratio of container bore area and the total cross-sectional area of extrusion, $\bar{\sigma}$ is the flow stress, m is the friction factor between billet and container interface, and m' is the friction factor between flowing metal and die-bearing interface.

Extrusion Process

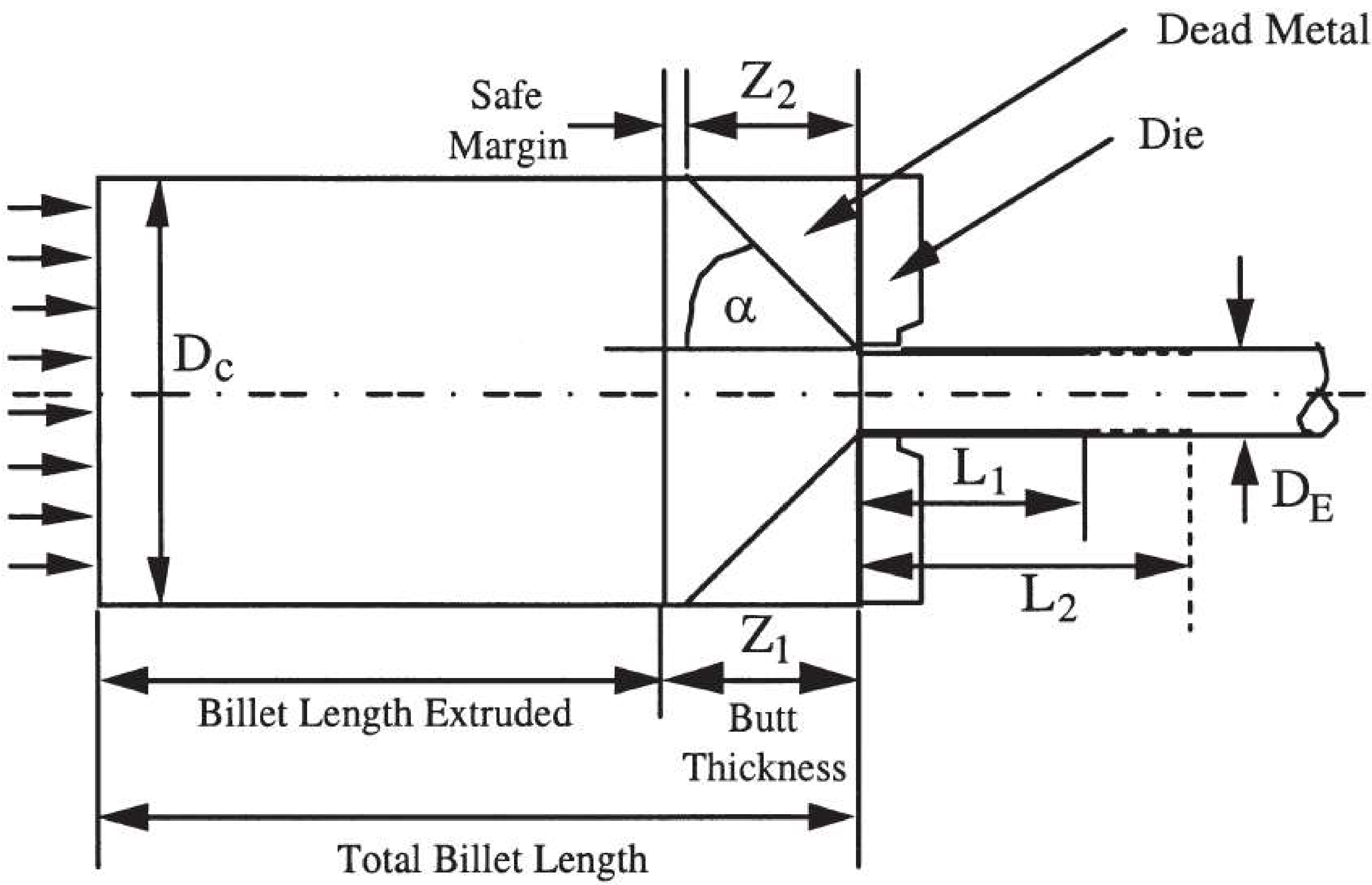


Fig. 10 Relationship between dead zone and butt thickness

Extrusion Process

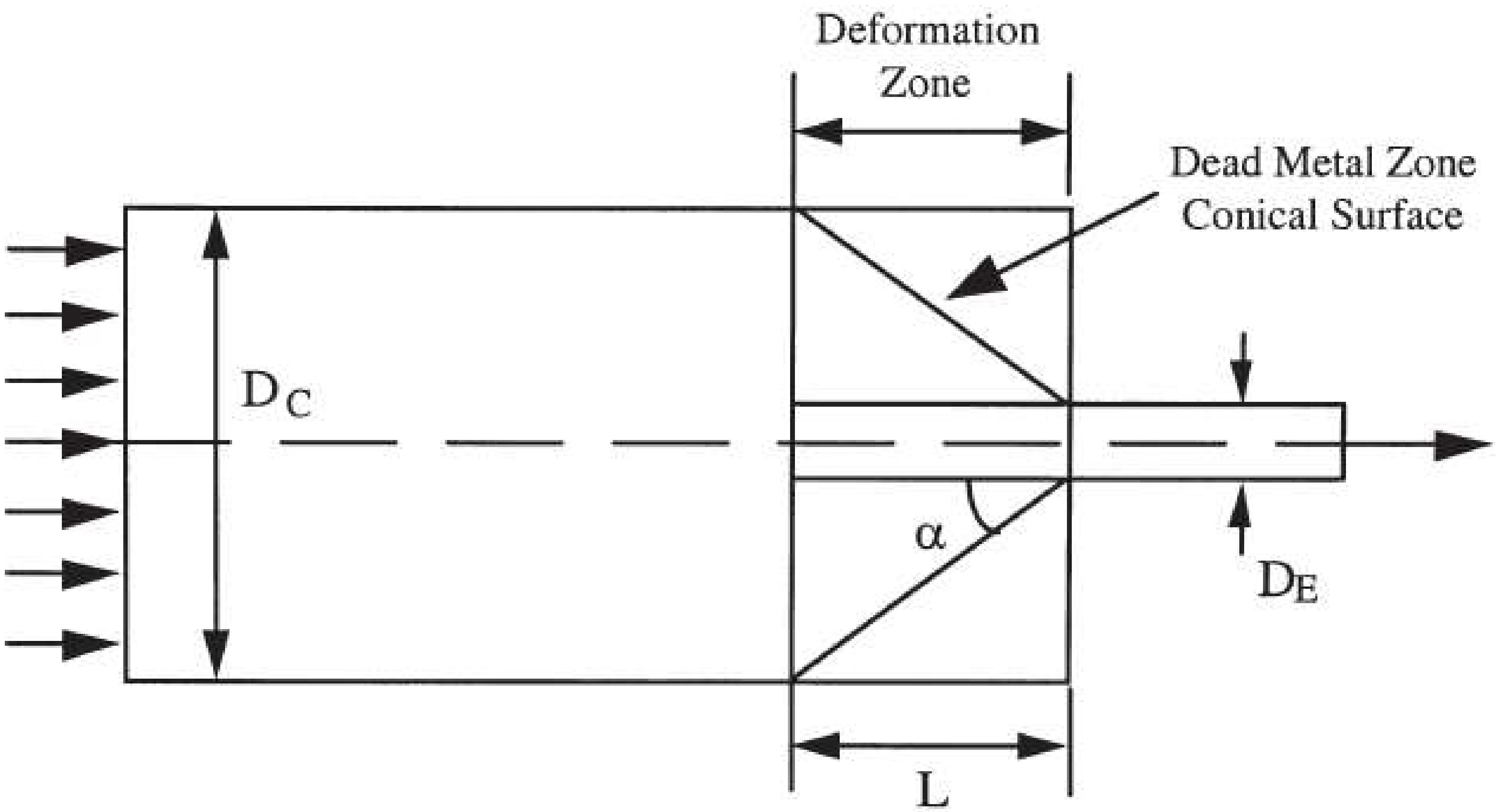
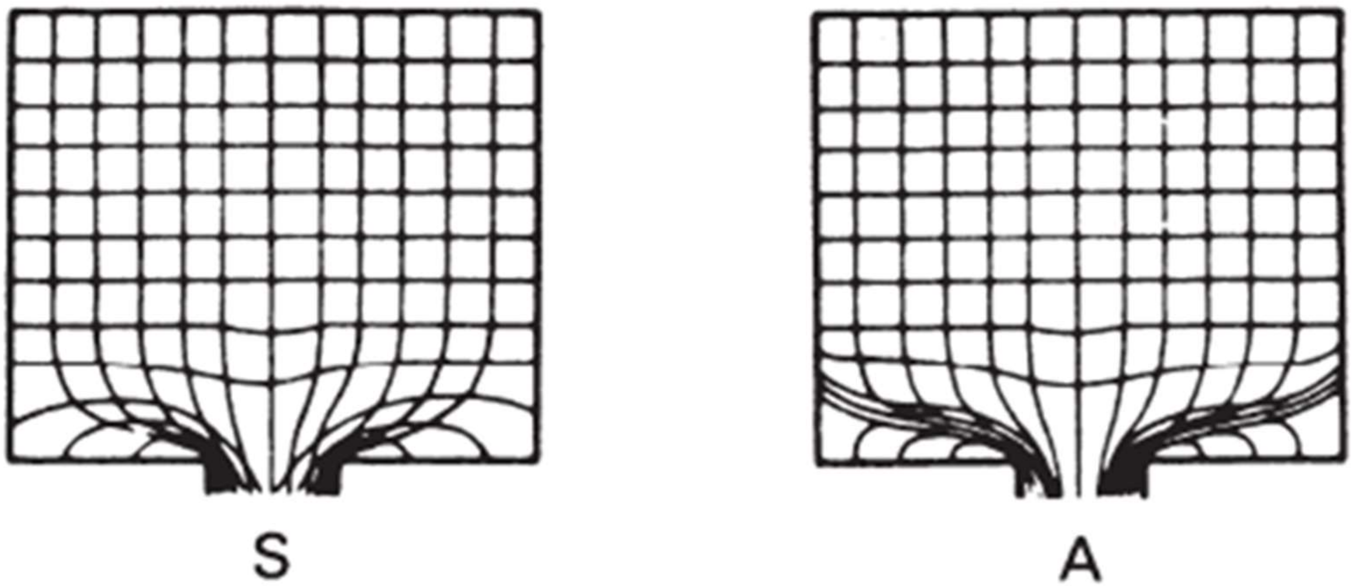
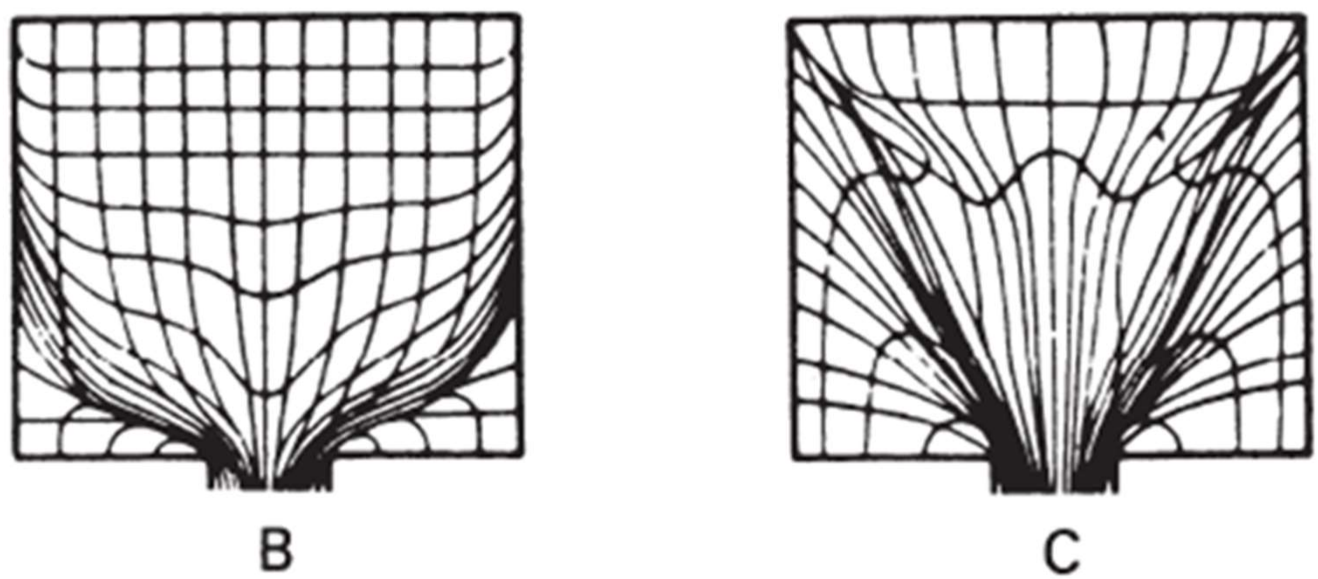


Fig. 11 Billet geometry inside the container

Deformation, Lubrication & Defects





Schematic of the four different types of flow in extrusion

Deformation, Lubrication & Defects

The properties of the extruded aluminum shapes are affected greatly by the way in which the metal flows during extrusion. The metal flow is influenced by many factors:

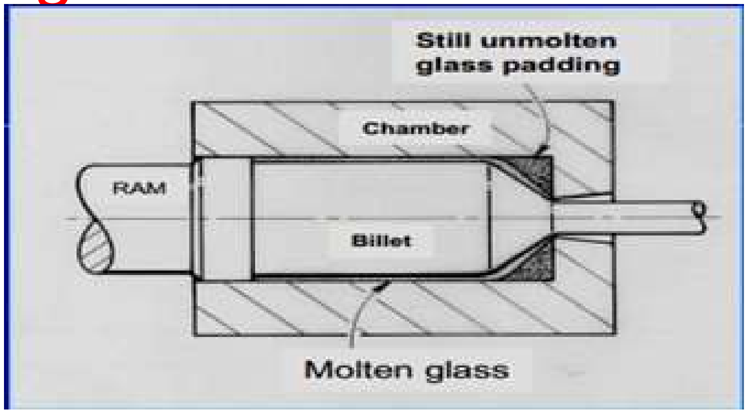
- Type of extrusion, direct or indirect
- Press capacity and size and shape of container
- Frictional effects at the die or both container and die
- Type, layout, and design of die
- The length of billet and type of alloy
- The temperature of the billet and container
- The extrusion ratio
- Die and tooling temperature
- Speed of extrusion

Flow in Extrusion

Deformation, Lubrication & Defects

Glass as Lubricant for Hot Working

Lubrication thickness - depends on the rate at which lubricant becomes available by melting or softening rather than on its shear stress



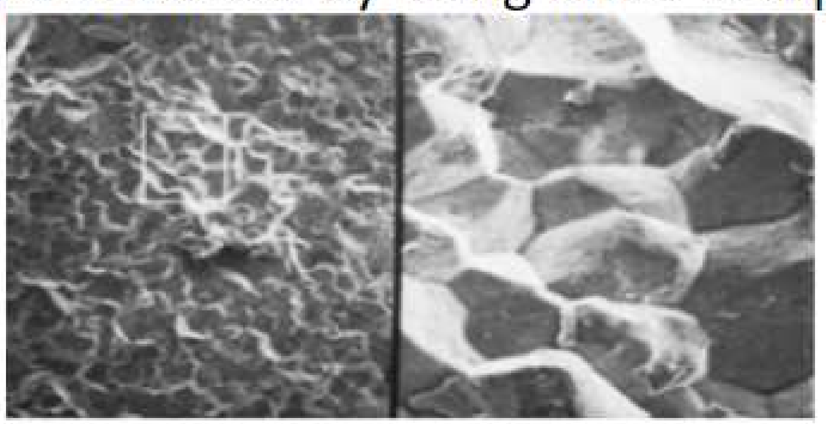
The lubricant film must be complete and continuous to be successful. Gaps in the film will serve to initiate shear zones which can develop into surface cracks. Also, lubricant film may be carried into the interior of the extrusion along shear bands to show up as longitudinal laminations in the product. Laminations of oxide can be created in the same way.

Deformation, Lubrication & Defects

- *There are three principal defects in extrusion as described below:*

1. ***Surface cracking:***

- High extrusion temperature, friction, speed cause high surface temperatures [surface temperatures rise significantly and can lead to surface cracking and tearing (*Fir-tree cracking or speed cracking*)].
- In hot extrusion, this form of cracking usually is intergranular (along grain boundaries)and is associated with high temperature
- Caused by hot shorting: local cooling of constituents or impurities at grain boundaries
- This situation can be avoided by using lower temperatures and speeds.



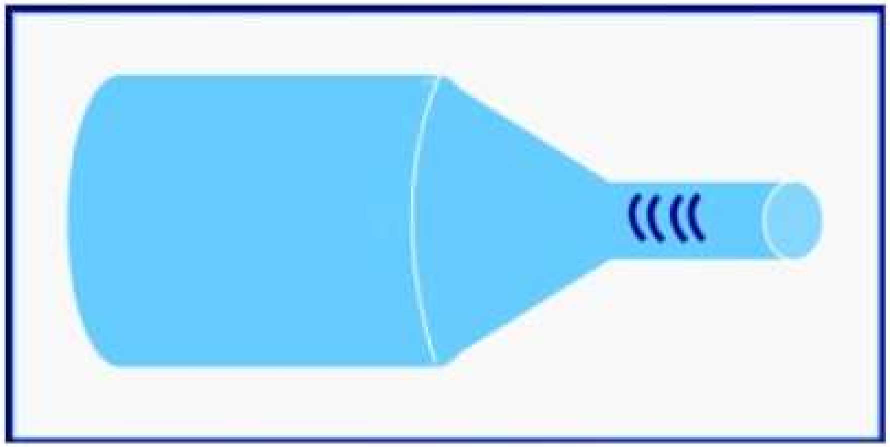
surface cracking

Deformation, Lubrication & Defects

1. ***Surface cracking:***

❑ Surface cracking also may occur at lower temperatures where it has been attributed to periodic sticking of the extruded product along the die land during extrusion (At lower temperature, sticking in the die land and the sudden building up of pressure will cause transverse cracking).

- Caused by sticking of extrusion along die land
- Sticking raises pressure

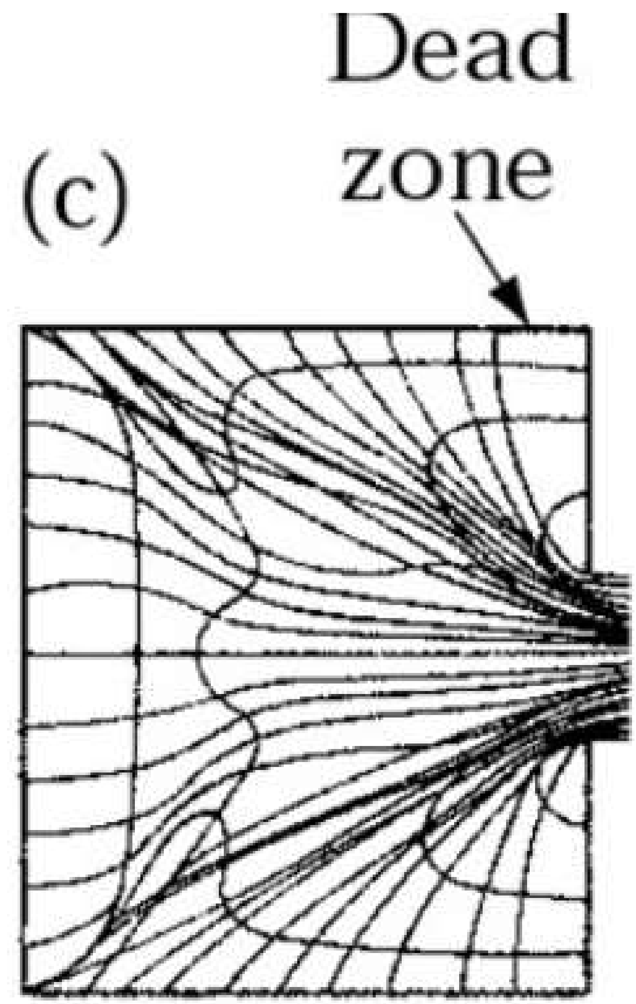


transverse cracking

Deformation, Lubrication & Defects

2. Extrusion Defects it can be noted that the type of metal flow as shown will tend to draw surface oxides and impurities toward the center of billet.

- This defect is known as extrusion defect, pipe, tailpipe, or fishtailing, renders a considerable portion of the extruded materials useless, by as much as one-third the length of the extrusion
- The metal flow tends to draw surface oxides and impurities toward the center of the billet much likes a funnel.

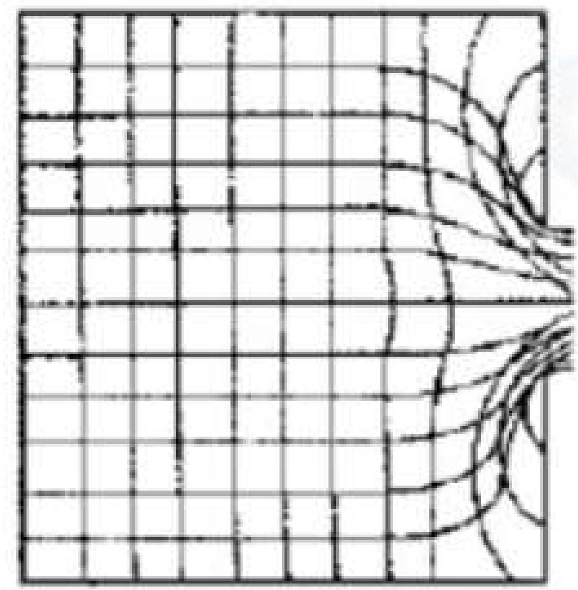


Deformation, Lubrication & Defects

2. Extrusion Defects

- ***This defect can be reduced by:***
- Modifying the flow pattern to a less inhomogeneous one to be more uniform, such as by controlling friction and minimizing temperature gradients.
- Another method is to machine the surface of the billet prior to extrusion to eliminate scale and impurities
- The extrusion defect can also be avoided by using a dummy block that is smaller in diameter than the container, thus leaving a thin shell along the container wall as extrusion progresses.

(a)

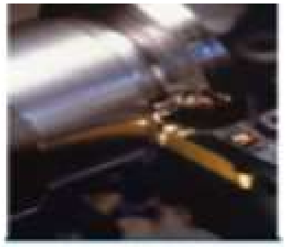


Deformation, Lubrication & Defects

3. Internal Cracking

- Cracks variously known as centerburst, center cracking, arrowhead fracture, or chevron cracking, can develop at the center of an extruded product
- These cracks are attributed to a state of tensile stresses at the centerline of the deformation zone in the die. This situation is similar to the necked region in a uniaxial tensile-test specimen.
- The major variables affecting this defects are the *die angle [*Increases with increasing die angle], *extrusion ratio [*Decreases with increasing extrusion ratio the deformation zones will meet], *friction [*Decreases with increasing friction], and *the die contact length* (the smaller the die angle, the longer is the contact length).

Deformation, Lubrication & Defects



Chevron Cracking

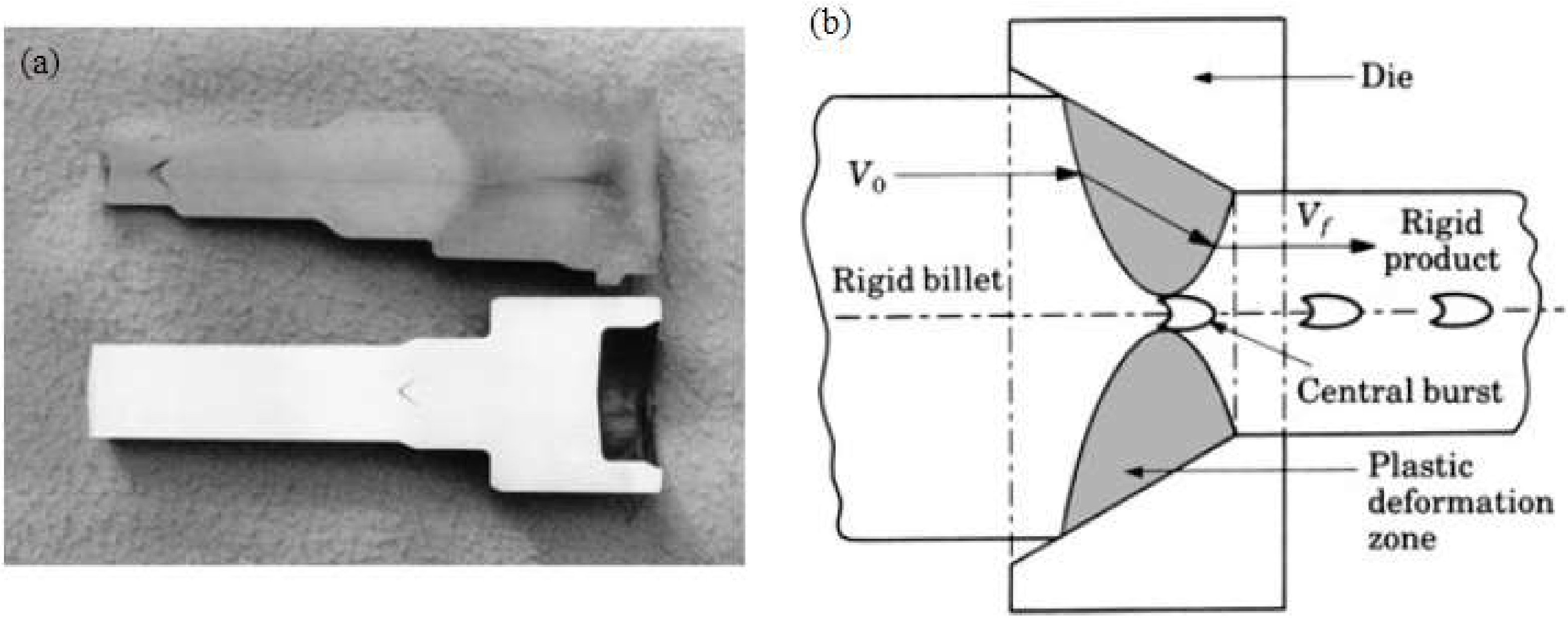
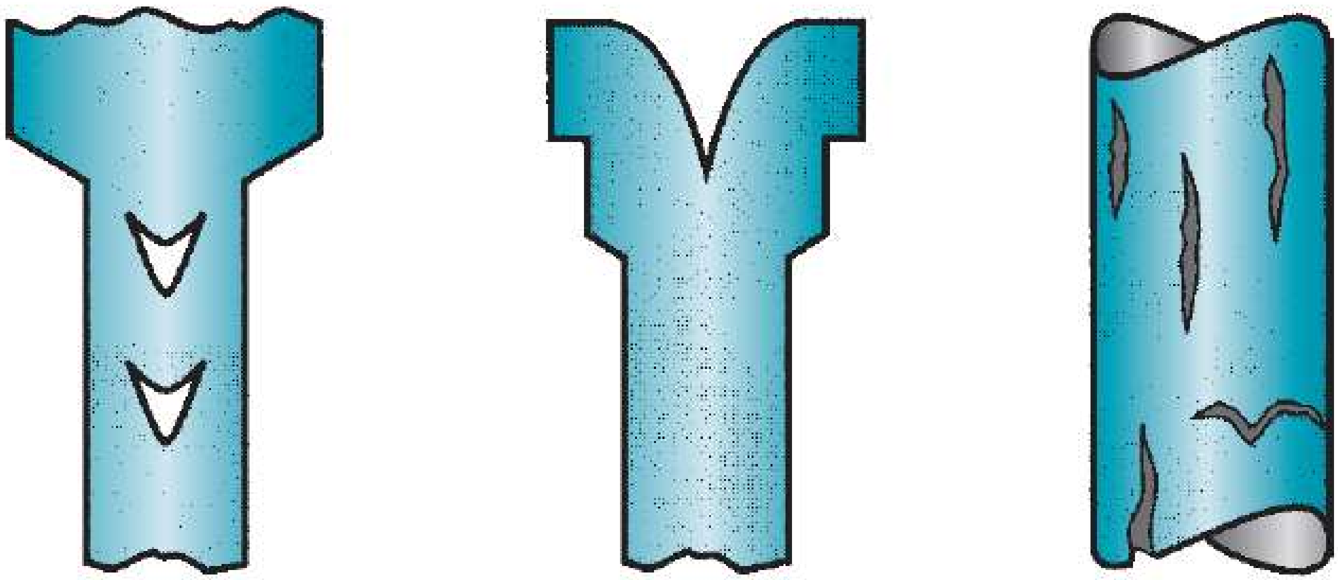


Figure 15.16 (a) Chevron cracking (central burst) in extruded round steel bars. Unless the products are inspected, such internal defects may remain undetected, and later cause failure of the part in service. This defect can also develop in the drawing of rod, of wire, and of tubes. (b) Schematic illustration of rigid and plastic zones in extrusion. The tendency toward chevron cracking increases if the two plastic zones do not meet.

Deformation, Lubrication & Defects

Extrusion defects

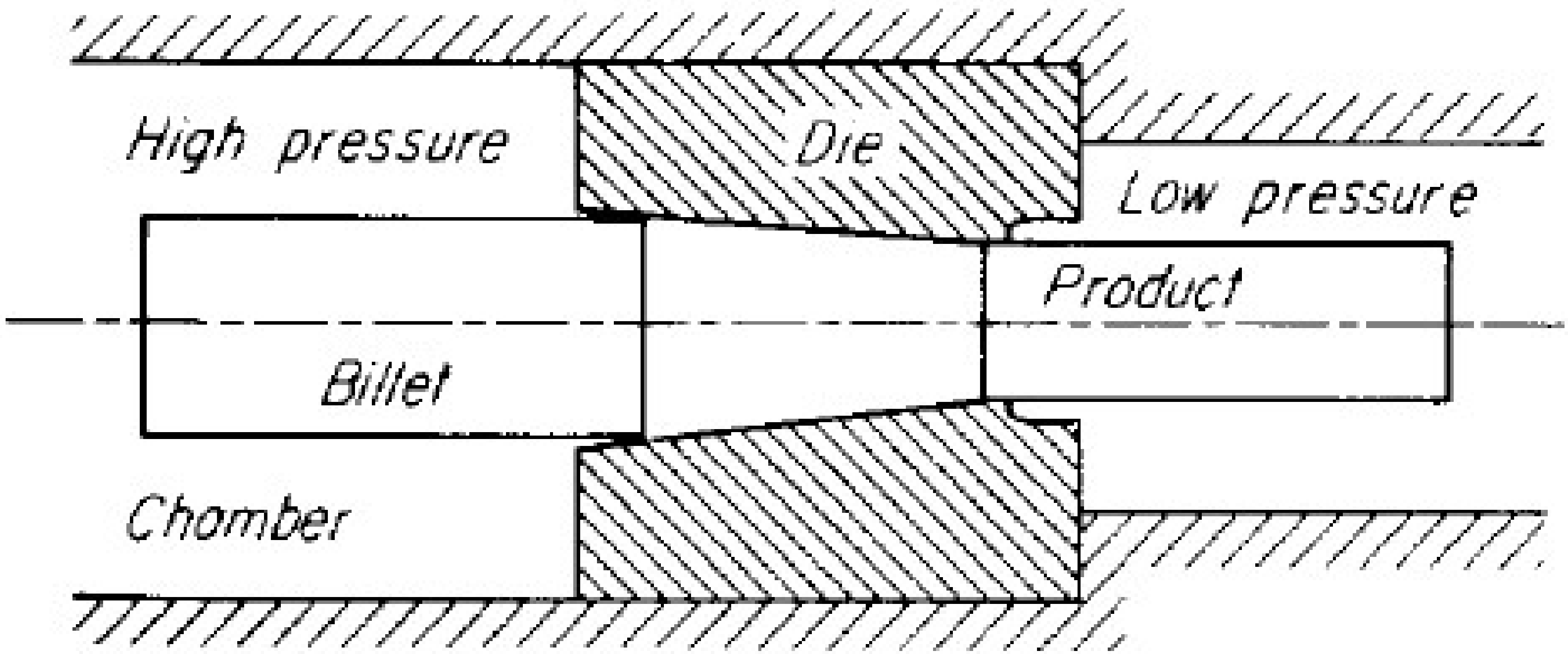


(a) centerburst

(b) Fishtailing

(c) surface cracking

Hydrostatic Extrusion



Hydrostatic Extrusion

wire.

No billet residue is left on the walls of container.

Disadvantages of Hydrostatic Extrusion

The billets have to be prepared by tapering one end so that it matches the die entry angle. This is essential for forming a seal at the starting of the cycle. Generally, the complete billet is required to be machined for the removal of surface defects.

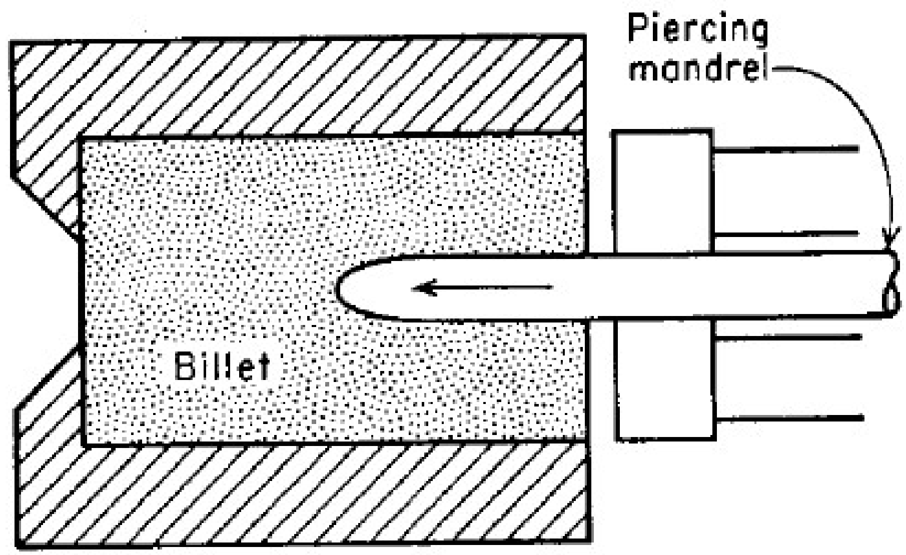
It can be difficult to contain the fluid, under the effects of high pressures (up to 2 GPa, or 290 ksi).

Limitations of Hydrostatic Extrusion

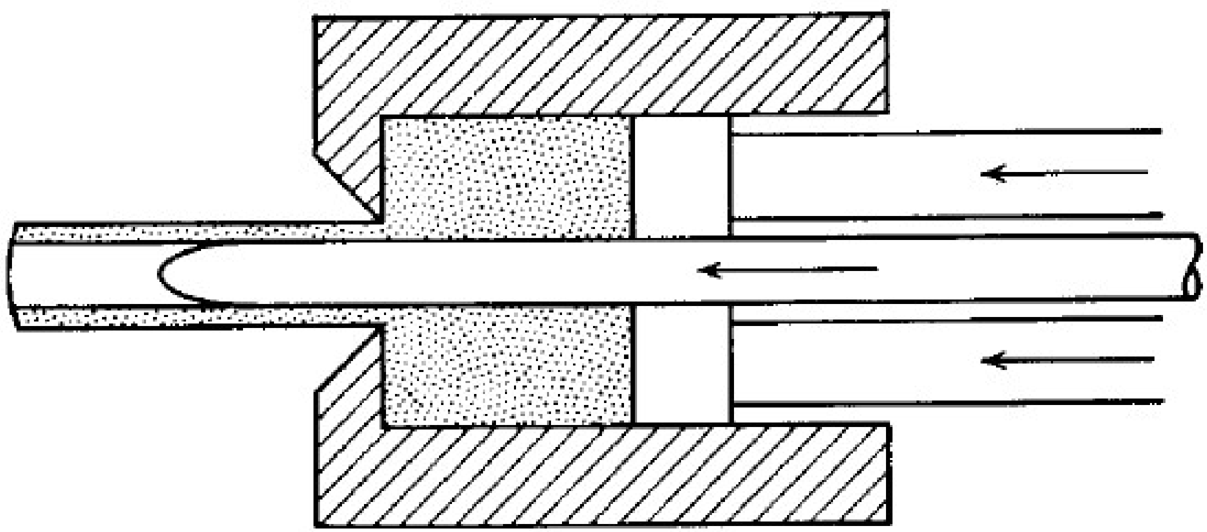
There are a number of limitations in the hydrostatic extrusion, especially when a large volume of fluid is used in comparison with the billet volume, which is to be extruded. These limitations are as follows:Increased handling for the injection and removal of the fluid for every extrusion cycle

Decreased control of speed of the billet & stopping because of potential stick-slip and enormous stored energy in the compressed

Tube Extrusion

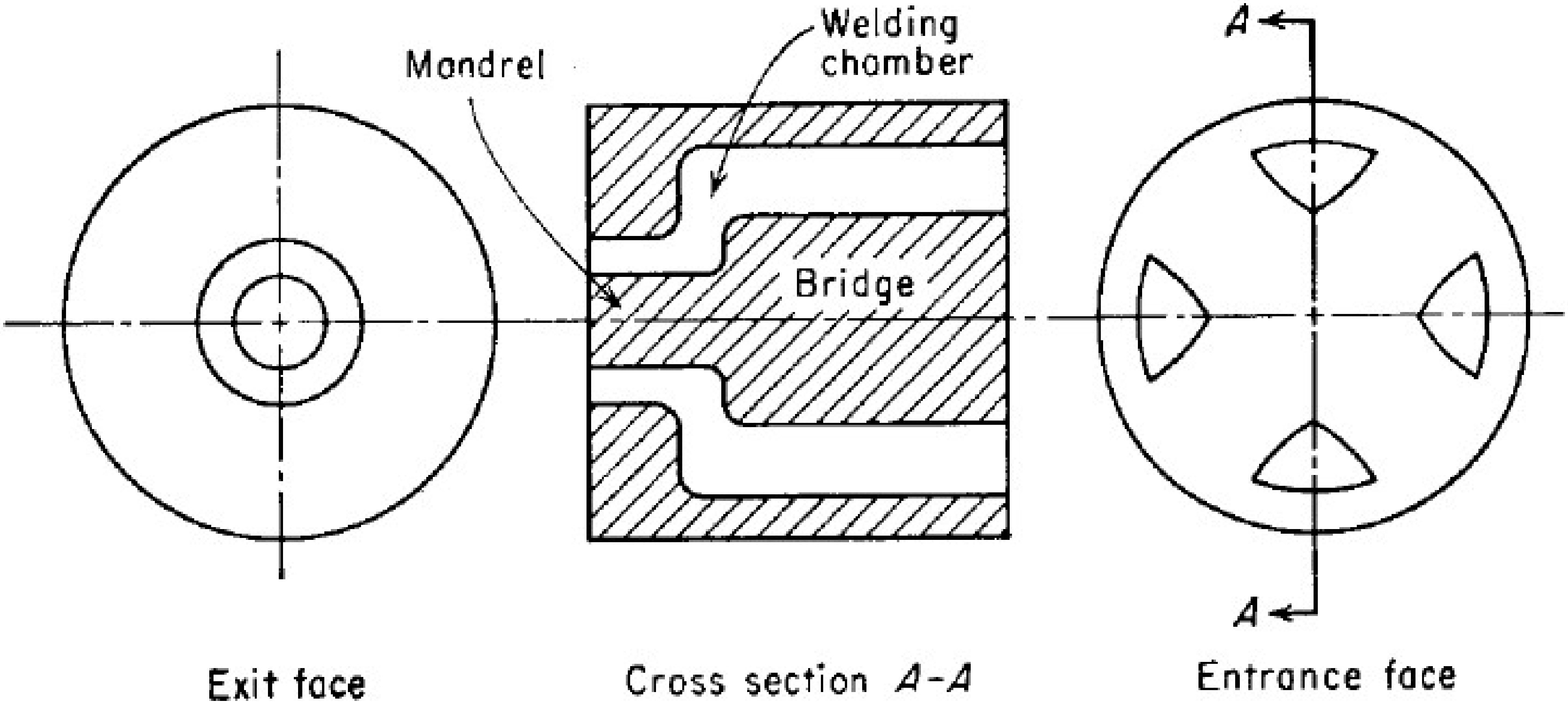


(a) Piercing



(b) Extrusion

Tube Extrusion



Porthhole Extrusion Die

Seamless Pipe & Tubing

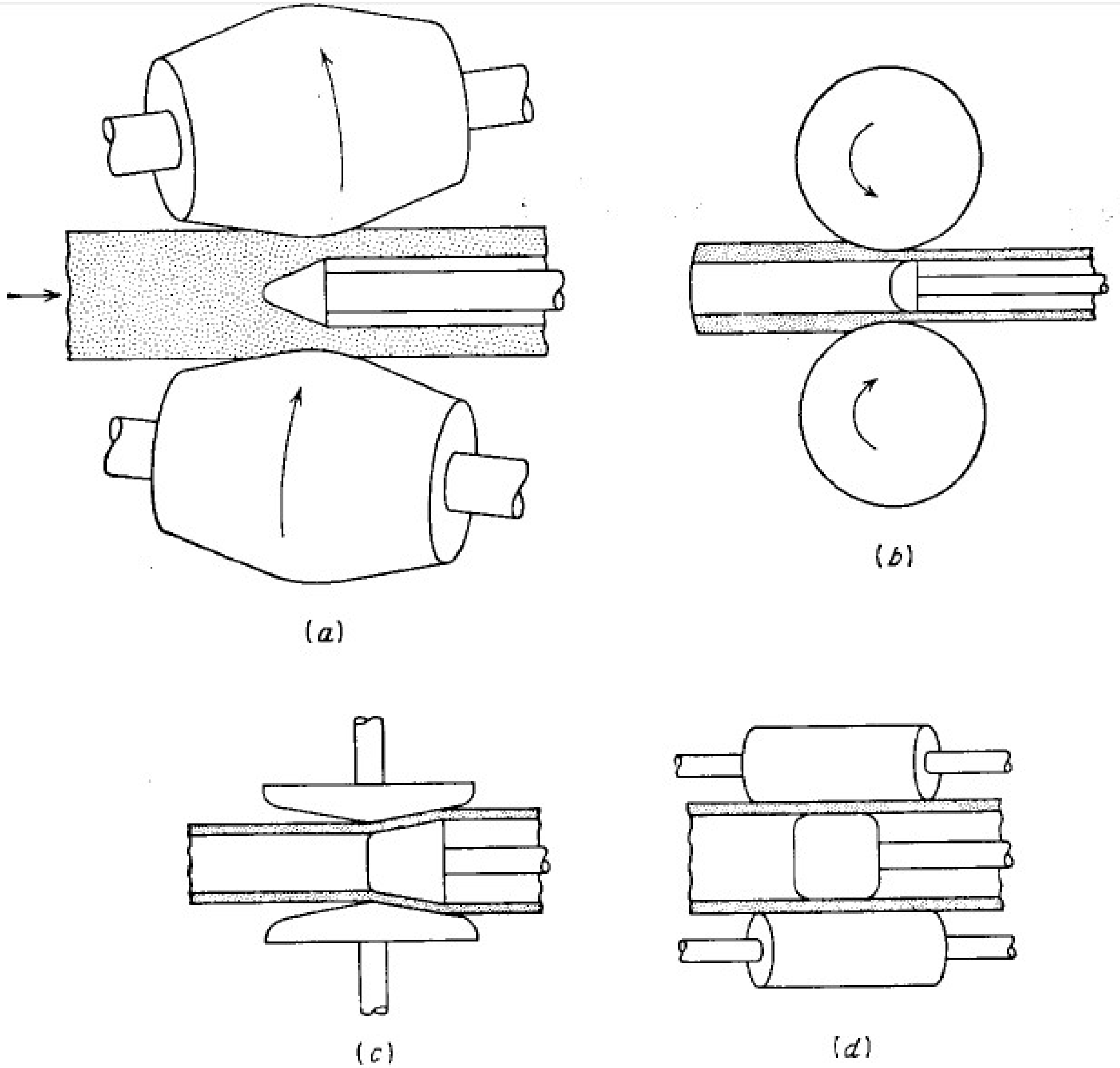


Figure 18-10 (*a*) Mannesmann mill; (*b*) plug rolling mill; (*c*) three-roll piercing mill; (*d*) reeling mill.