Metal Forming Processes (ME5807)

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Module 03

Bulk Metal Forming Processes

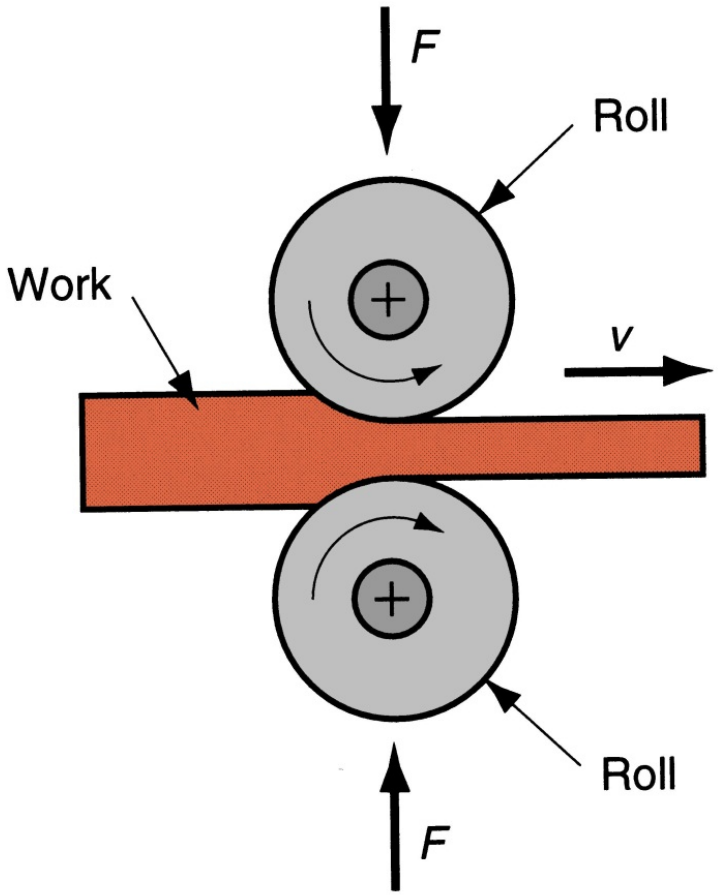
Bulk Metal Forming Processes

- Characterised by significant deformations and massive shape changes
- ”Bulk” refers to workparts with relatively low surface area-to-volume ratios.
- Starting work shapes include cylindrical billets and rectangular bars.

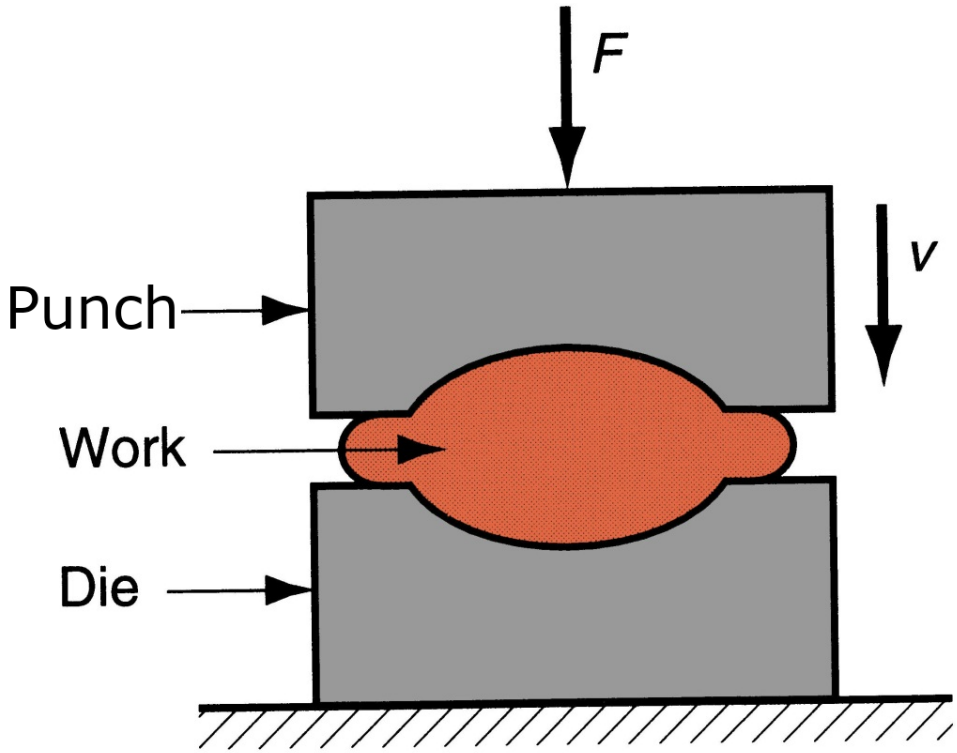
Bulk Metal Forming Processes

- Rolling
- Forging
- Extrusion
- Wire and bar drawing

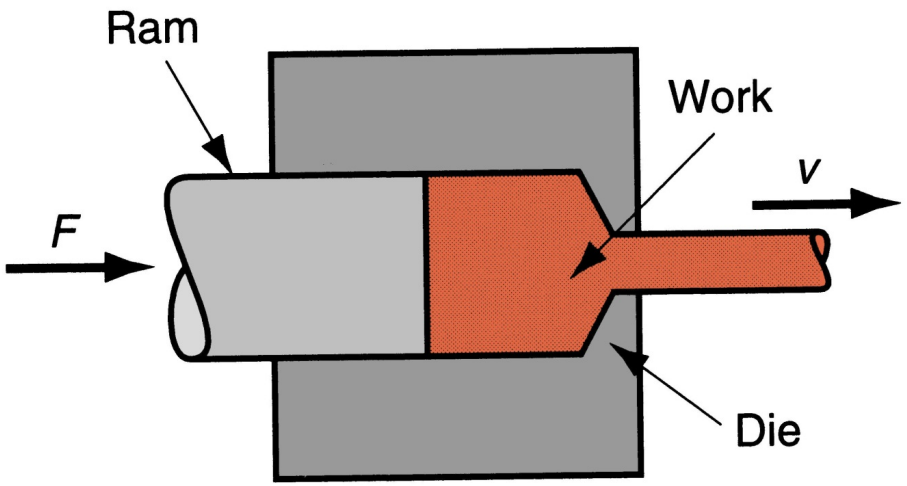
Rolling



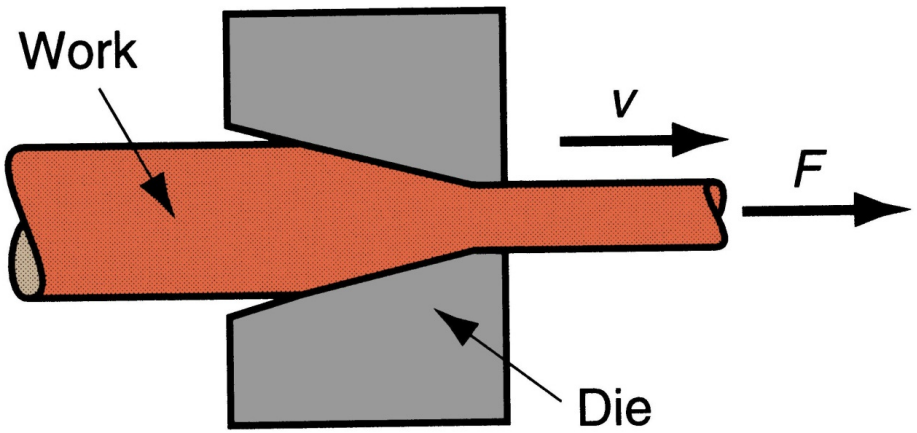
Forging



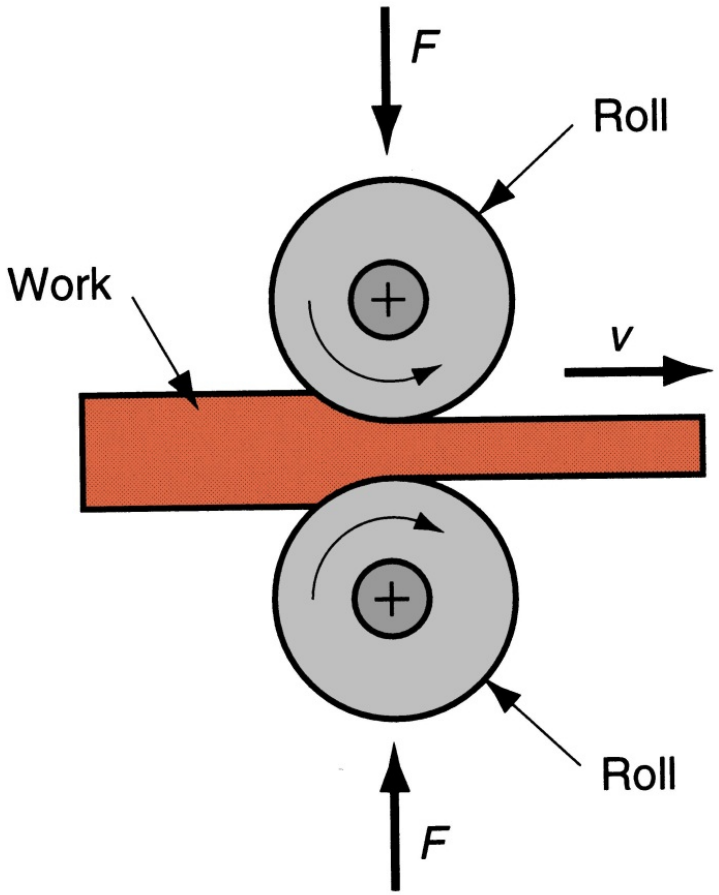
Extrusion



Wire and Bar Drawing



Rolling



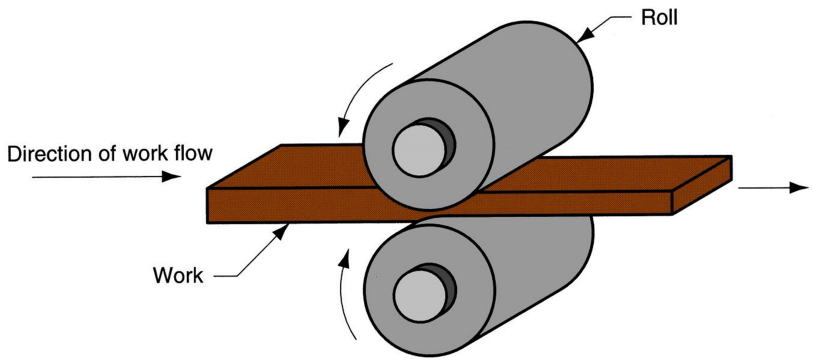
Rolling

- The Process of plastically deforming metal / alloy by passing it between rolls is known as Rolling.
- Rolling done either at Hot or cold.
- The metal is drawn into the opening between the rolls by frictional forces.
- Work piece is subjected to high compressive forces due to squeezing action of rolls, resulting in reduced area of cross-section and increased length.

Rolling-Terminology

- **Ingot**: An ingot is a mass of metal cast into a size and shape convenient to store, transport, and work into a semifinished or finished product.
  - **Bloom** has a square cross-section of 150*mm* x 150*mm* (6*inch* x 6*inch*) or larger.
  - **Billet** has a square cross-section of 38*mm* x 38*mm* (1.5*inch* x 1.5*inch*) or larger.
  - **Slab** has a rectangular width cross-section of 250*mm* (10*inch*) and a thickness of 38*mm* (1.5*inch*) or larger.

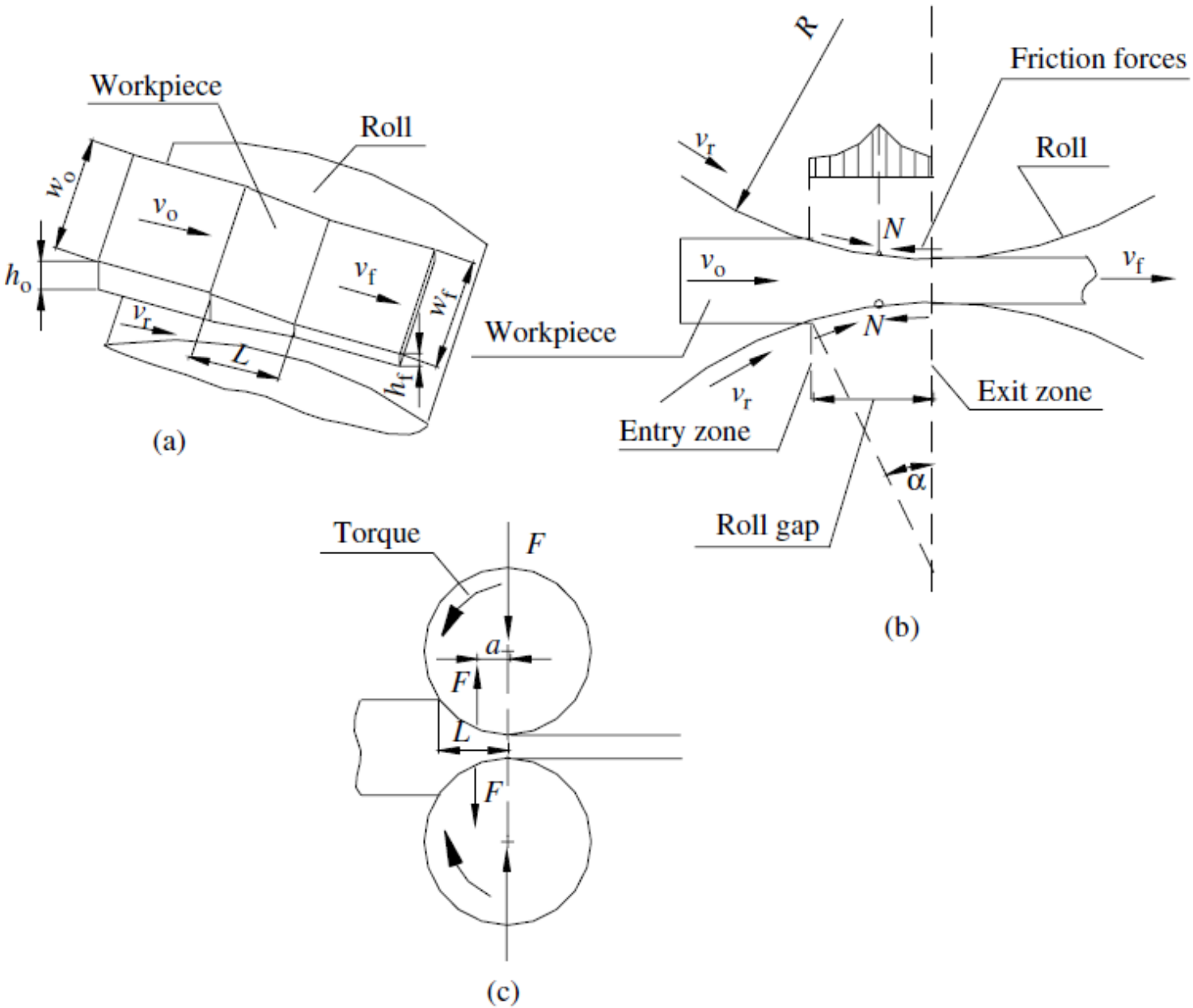
Flat Rolling



- Metal strip enters the roll gap
- The strip is reduced in size by the metal rolls
- The velocity of the strip is increased the metal strip is reduced in size

- Factors affecting Rolling Process
  - Frictional Forces
  - Roll Force and Power Requirement

Analysis of Flat Rolling



(a) Draft: The maximum possible draft is defined as the difference between the initial and final thicknesses of the strip.

$$\Delta = h_o - h_f = \mu^2 R$$

Where,

$\Delta =$ draft, mm (in.)
$h_o =$ starting thickness, mm (in.)
$h_f =$ final thickness, mm (in.)
$\mu =$ coefficient of friction between roll and material
$R =$ roll radius, mm (in.)

The draft is sometimes defined as a function of the starting thickness of rolling material, called relative reduction:

$$r = \frac{h_o - h_f}{h_o} = \frac{\Delta}{h_o}$$

(b) Lateral Spread: The elongation in the transverse direction results in an increase in the width of the workpiece by an amount called lateral spread.

$$\Delta w = w_f - w_o$$

Where,

$\Delta w =$ lateral spread, mm (in.)
$w_o =$ starting thickness, mm (in.)
$w_f =$ final thickness, mm (in.)

Lateral spread is often expressed by the width spread factor.

$$s = \frac{w_f}{w_o}$$

(c) Forward Slip in Rolling: On either side of neutral point N, slipping and friction occur between rolls and workpiece. The amount of slip between the rolls and the workpiece can be measured by mean forward slip

$$S = \frac{v_f - v_r}{v_r}$$

Where,

S = forward slip

v_f = final (exiting) workpiece velocity, m/s (ft/s)

v_r = roll speed, m/s (ft/s).

(d) Average Flow Stress: Average flow stress applied to the workpiece in flat rolling can be expressed by

$$\sigma_{f(m)} = \frac{K\epsilon^n}{1+n}$$

Where,

$\epsilon = ln(\frac{h_o}{h_f}) =$ true strain on the workpiece in rolling.

Analysis of Flat Rolling

(e) Pressure in the roll gap: There is often significant variation in the roll pressure along the contact length in flat rolling.

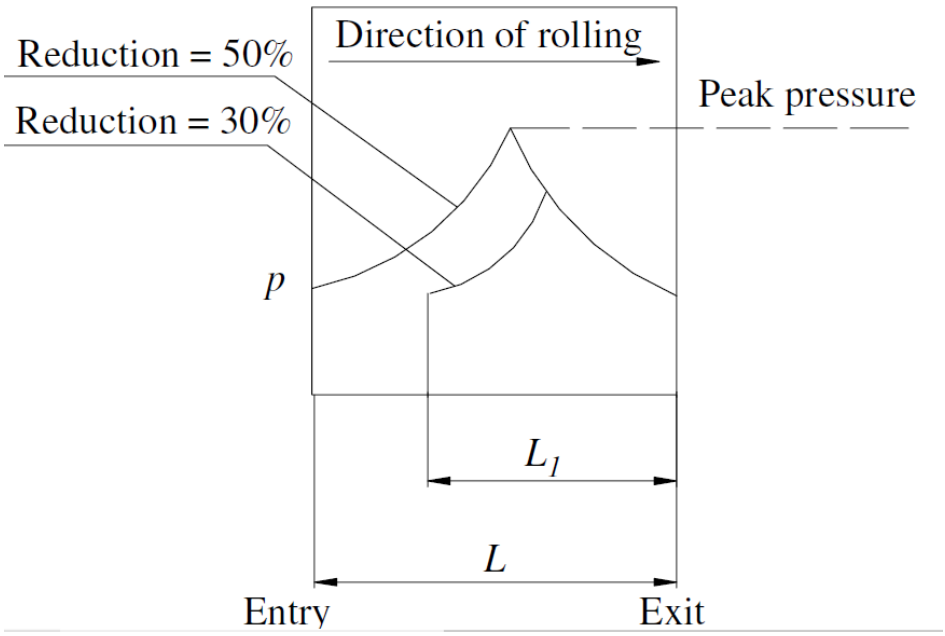


Figure: Typical variation in pressure along the contact length in flat rolling

- Maximum pressure is at the neutral point N and trails off on either side of the entry and exit points
- Pressure in the roll gap is calculated as average pressure:

$$p = \frac{F}{A_a}$$

Where,
F = roll separating force, N
A_a = projected area on the surface plane of contact between roll and workpiece, MPa

Thank You