TA201A
Manufacturing Processes

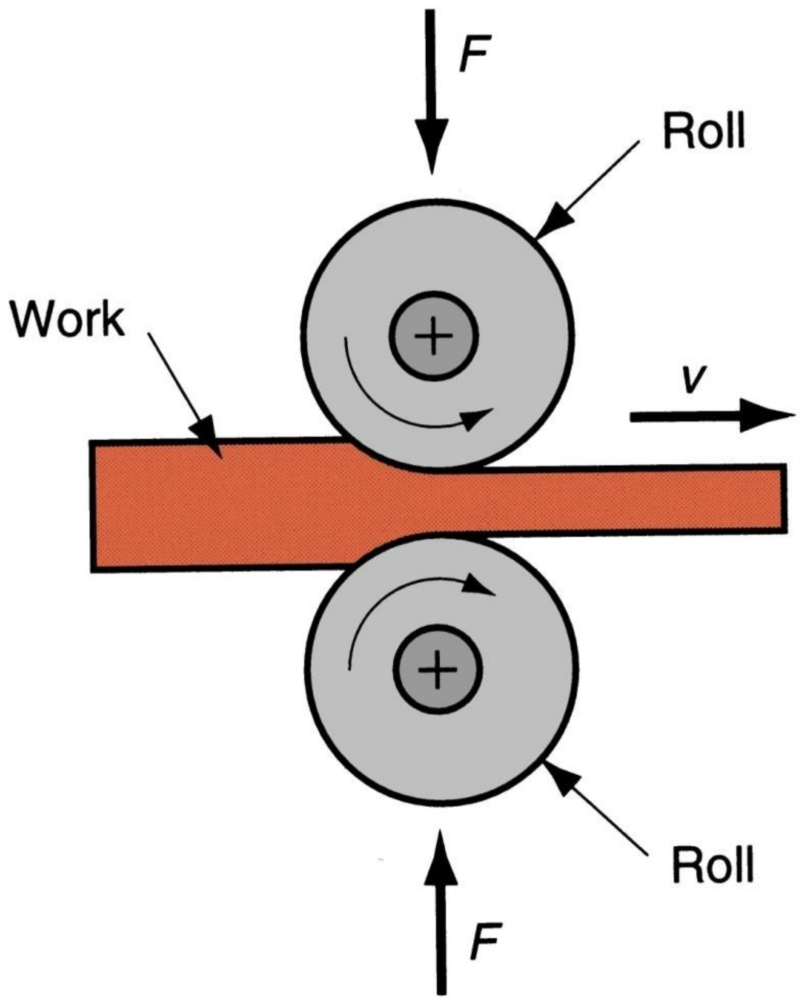
Week-10

25 Oct, 2022

2022-2023 Semester-I

Lecture 10

Basic bulk deformation processes: Rolling

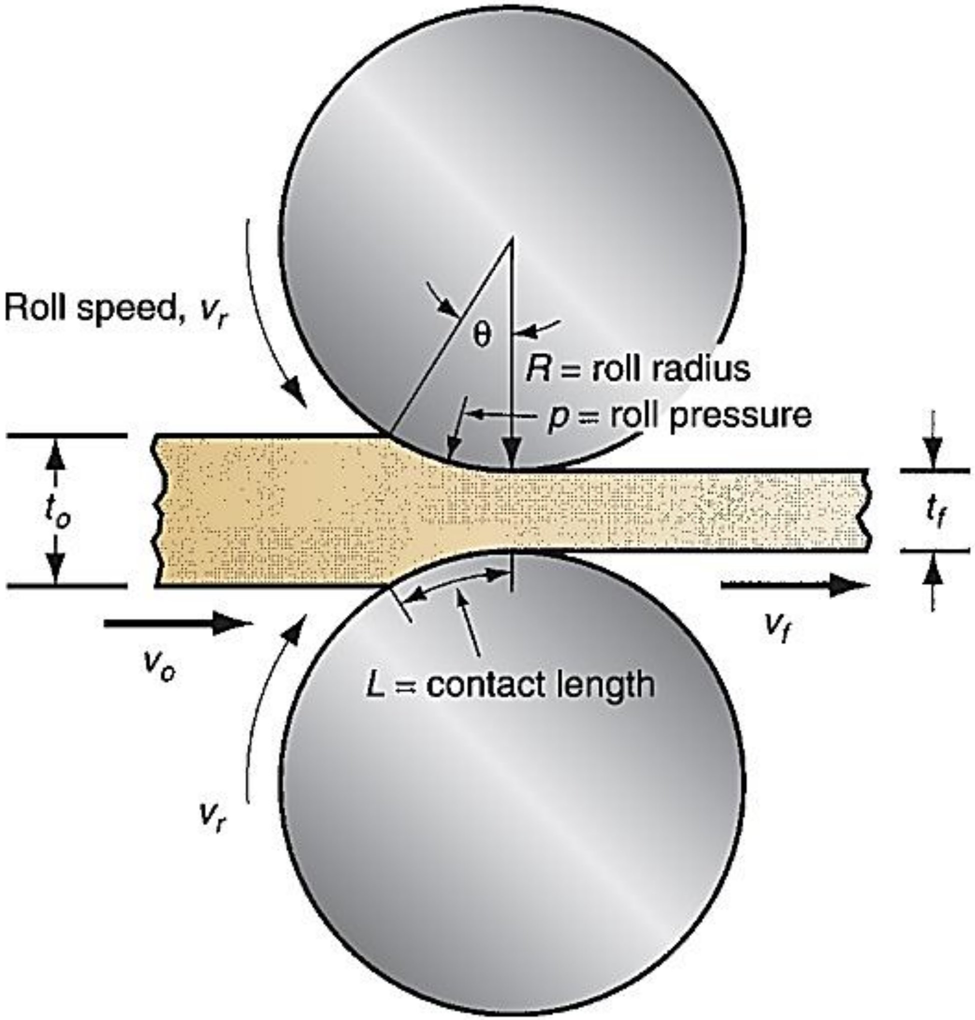


- Rolling process may look very simple
- However, there are lots of intricacies

- Processing parameters?
- They effect on mechanical characteristics?

Fundamentals of Modern Manufacturing Processes_ M Groover

Flat Rolling and its Analysis



Draft $\mathrm{d} = t_0 - t_f$

Reduction, $\mathrm{r} = \dfrac{t_f}{t_0}$

No change in volume during plastic deformation

$$w_f t_f L_f = w_0 t_0 L_0$$

Similarly, before and after volume rates of material flow must be the same

$$w_f t_f v_f = w_0 t_0 v_0$$

where v_0 and v_f are the entering and exiting velocities of the work

Flat Rolling and its Analysis

Flat rolling: Velocities of both rolls must be the same
Thus, their diameters are same

Velocity of the rolls are constant, v_r $\quad v_r = \dfrac{\pi D N}{1000}$ $\quad$ N: Number of rotations/min

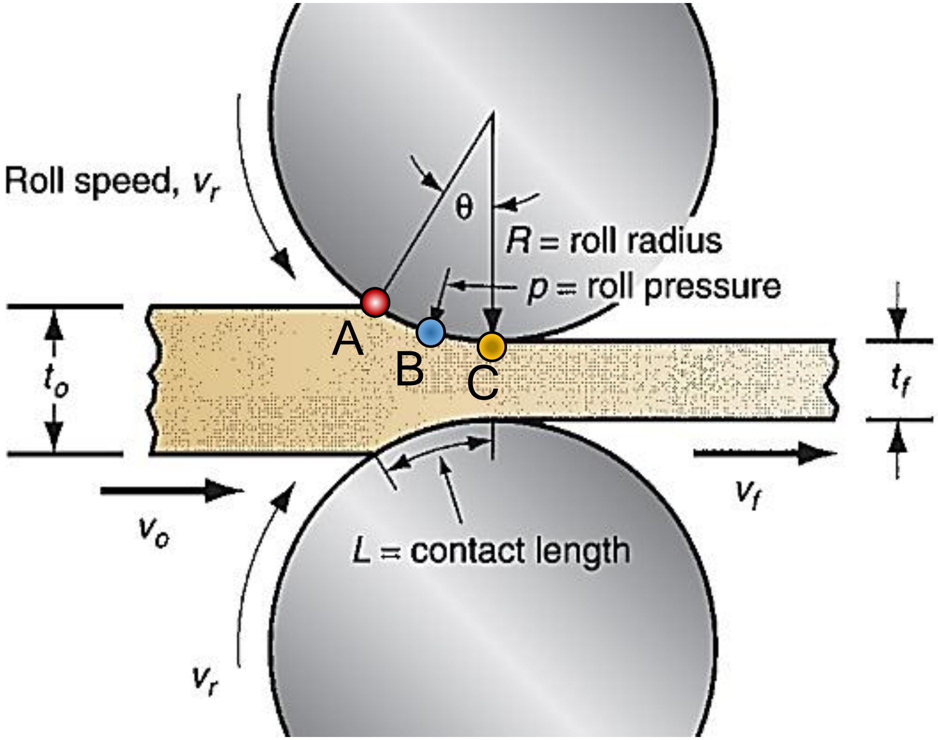
$$v_f > v_r > v_0$$

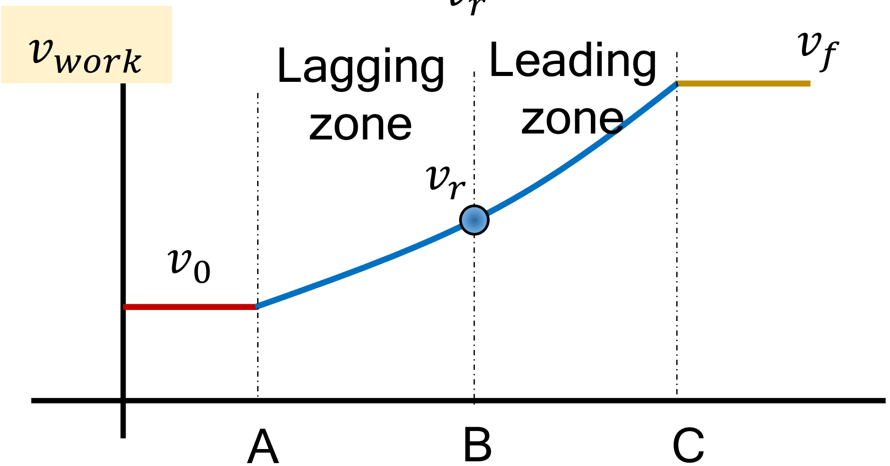
At point B, $v_{work} = v_r$

- neutral point or no-slip point

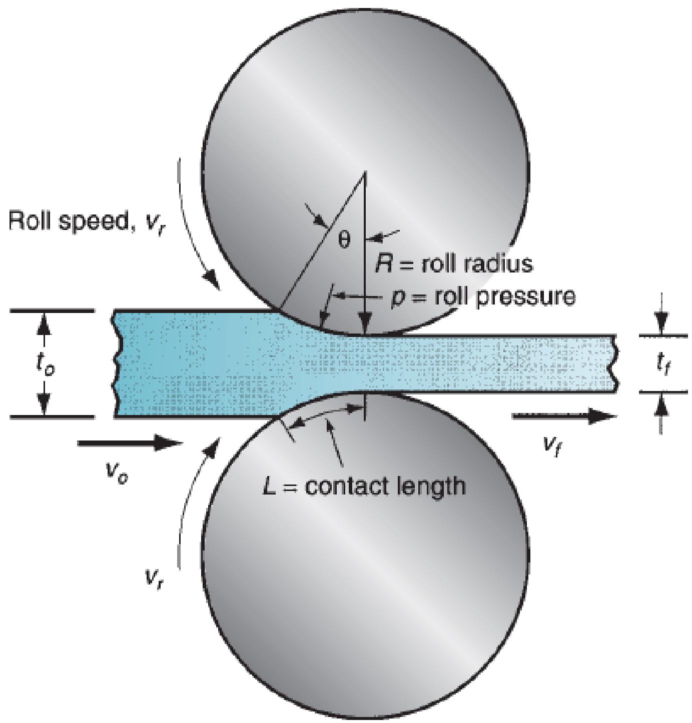
$$\text{Backward slip} = \frac{v_r - v_0}{v_r}$$

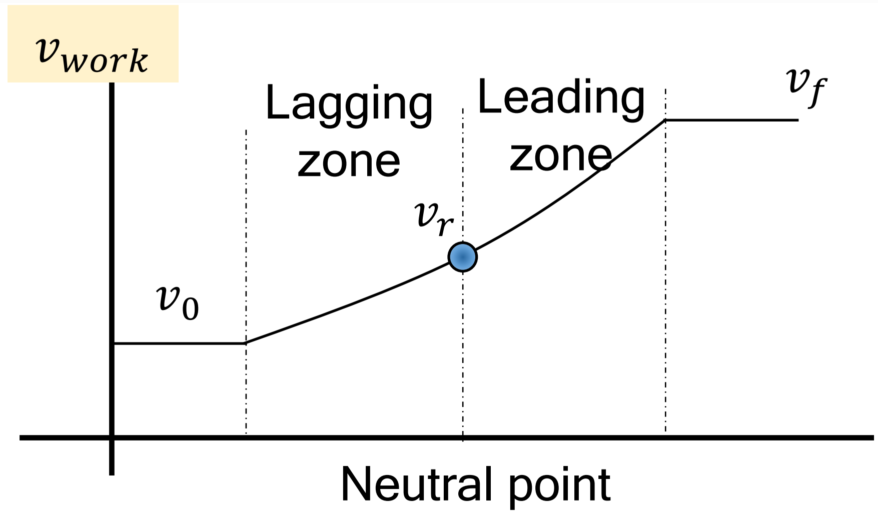
$$\text{Forward slip} = \frac{v_f - v_r}{v_r}$$

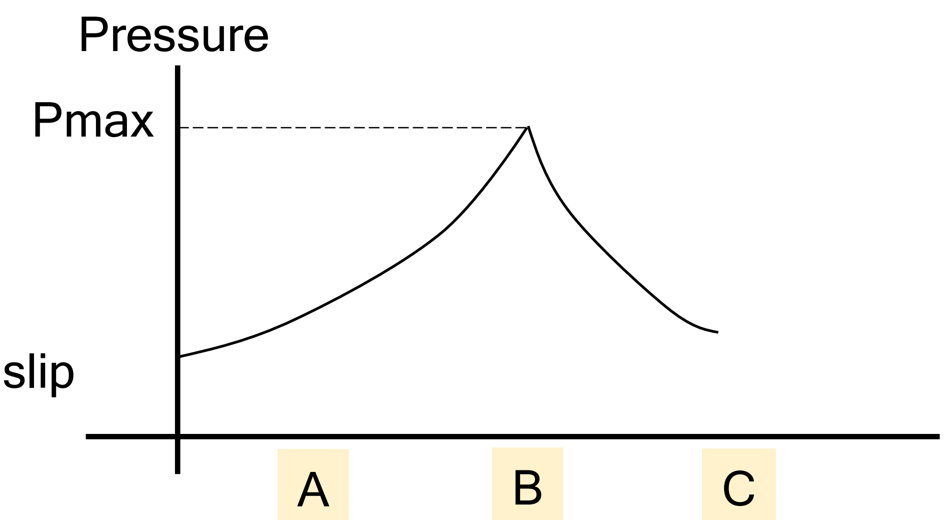




Flat Rolling and its Analysis

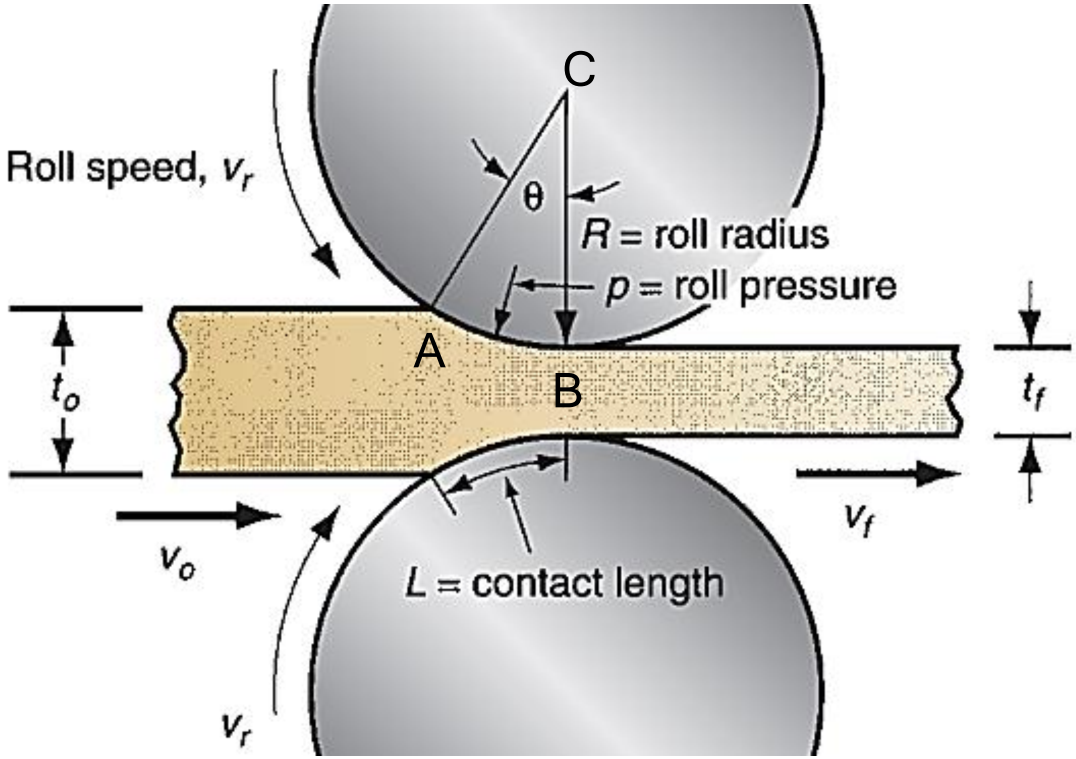






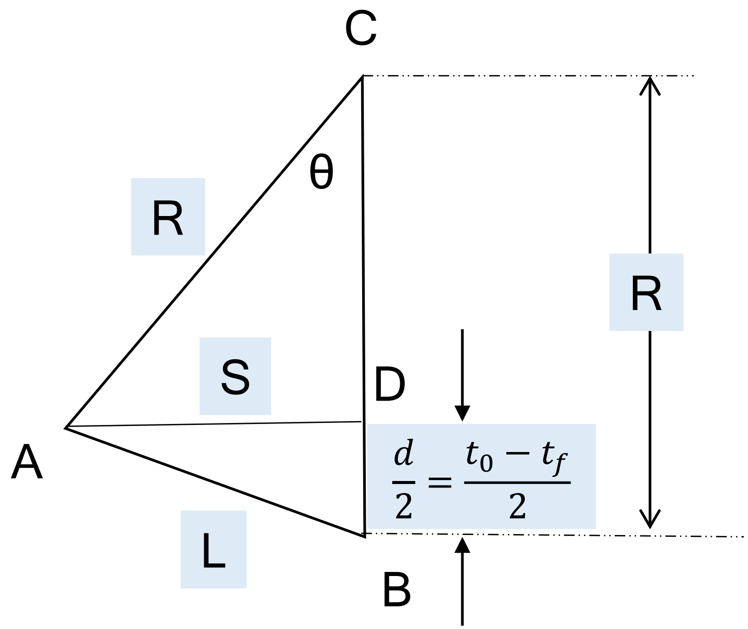
Lagging Zone:
Pressure is inversely proportional to slip

Leading Zone:
Pressure is directly proportional to slip



Contact length = L

Bite angle = θ



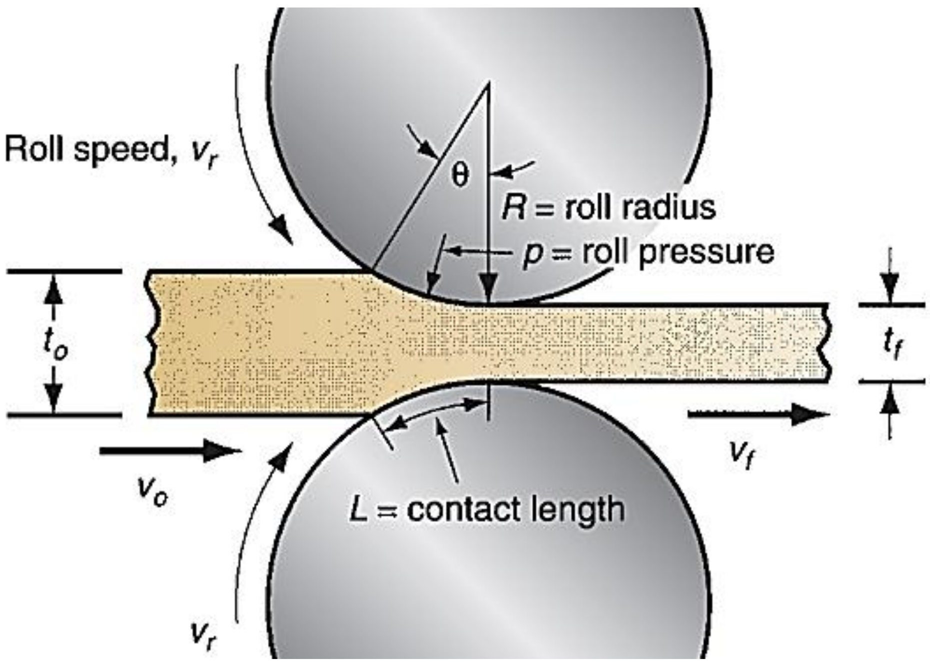
$$S^2 = Rd - \frac{d^2}{4}$$

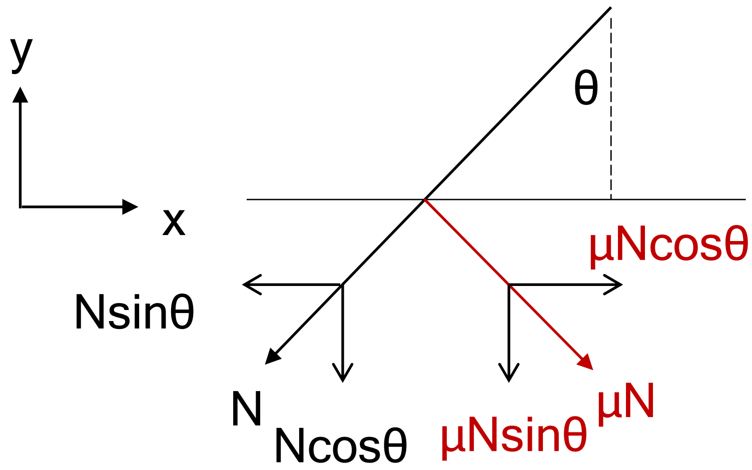
$$L = \sqrt{Rd} = \sqrt{R(t_0 - t_f)}$$

$$tan\theta = \frac{\sqrt{Rd - \frac{d^2}{4}}}{R - \frac{d}{2}}$$

As d<<< R $\quad tan\theta = \sqrt{\frac{d}{R}}$

Flat Rolling and its Analysis





For rolling in X direction

$$\mu N\cos\theta - N\sin\theta \geq 0$$

$$\mu \geq \tan\theta$$

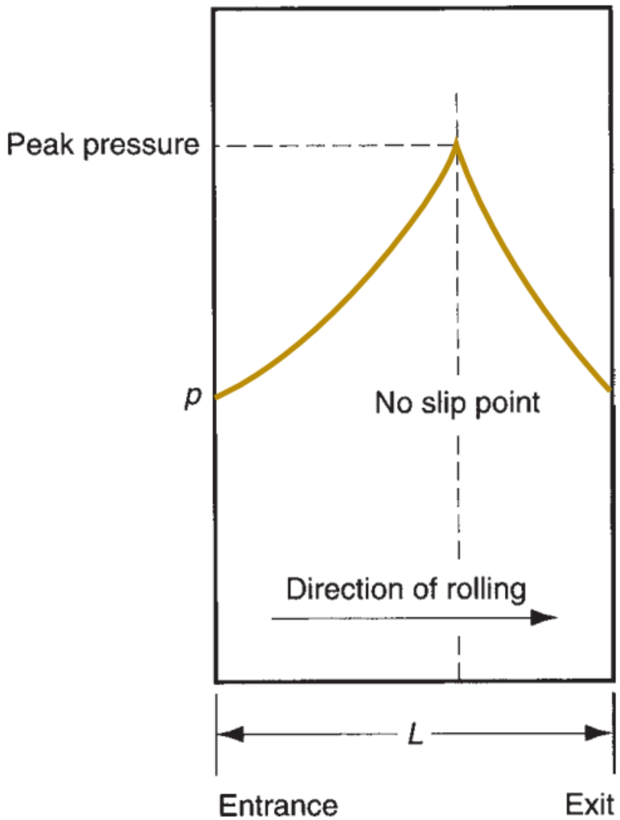
$$\tan\theta = \sqrt{\frac{d}{R}}$$

Maximum draft

$$d_{max} = \mu^2 R$$

Coefficient of friction (μ) in rolling depends on lubrication, work material, and working temperature.

- Cold rolling, $\mu \approx 0.1;$
- Warm working, $\mu \approx 0.2,$
- Hot rolling, $\mu \approx 0.4.$
- Hot rolling is often characterized by a condition called ***sticking***, with $\mu \approx 0.7$



Roll force *F* required to maintain separation between the two rolls

$$F = w\int_0^L p\,dL \qquad F = \overline{Y}_f wL$$

Where, $\overline{Y_F} = \dfrac{k\varepsilon^n}{1+n}$ $\quad \varepsilon = \ln\dfrac{t_0}{t_f} = \ln\left(\dfrac{1}{1-r}\right)$

$$L = \sqrt{Rd} = \sqrt{R(t_0 - t_f)}$$

Torque for each roll is $T = 0.5\ FL$

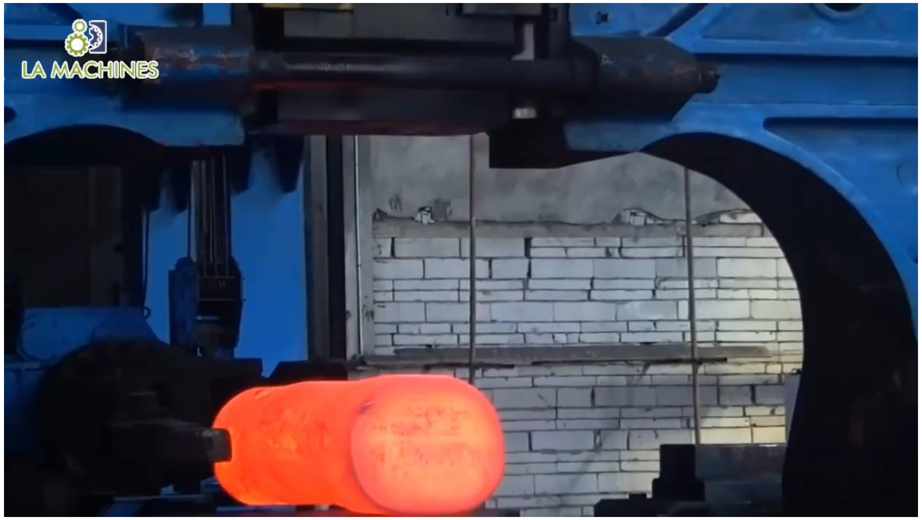
The power (P) required to drive each roll is the product of torque and angular velocity $(2\pi N)$.

$$P = 2\pi NFL$$

Basic bulk deformation processes: Forging

Dalmadal Canon (West Bengal)

Forging video



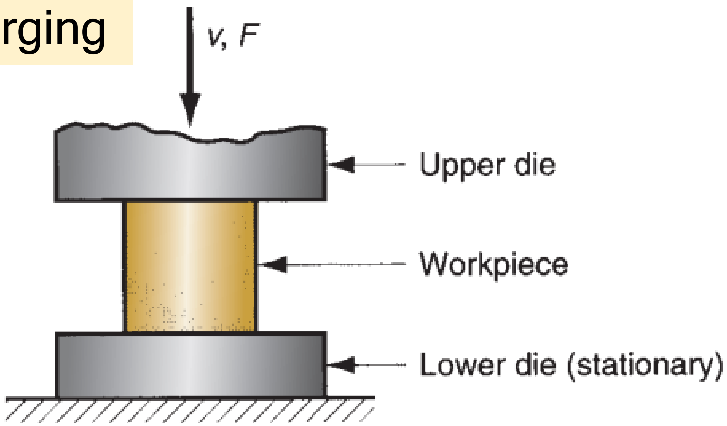
Made by forging rings of wrought iron
Forging operation also welds two side-by rings….Forge welding operation

https://www.youtube.com/watch?v=G60llMJepZI&list=RDCMUCUIz7yBnnxc0OjwhzIHNfOQ&index=4

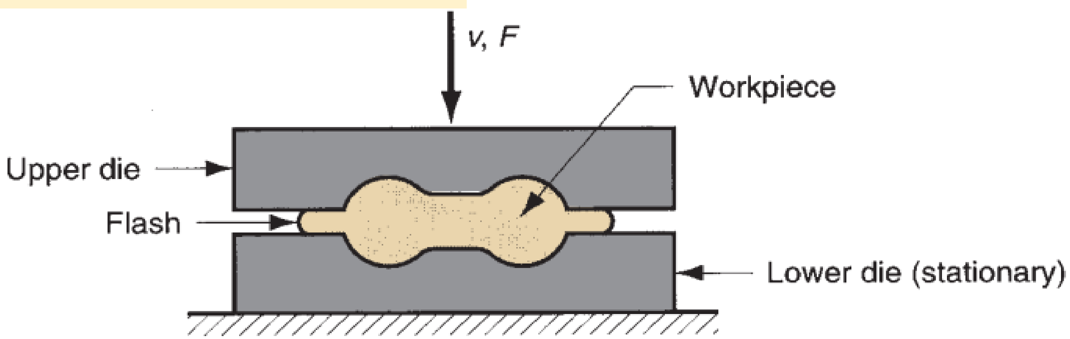
Forging

- Work is compressed between two dies and force is applied
- Pressure can be gradual or can be impact
- Components include engine crankshaft, connecting rods, turbine parts
- Mostly performed at elevated temperatures, however cold forging are also common

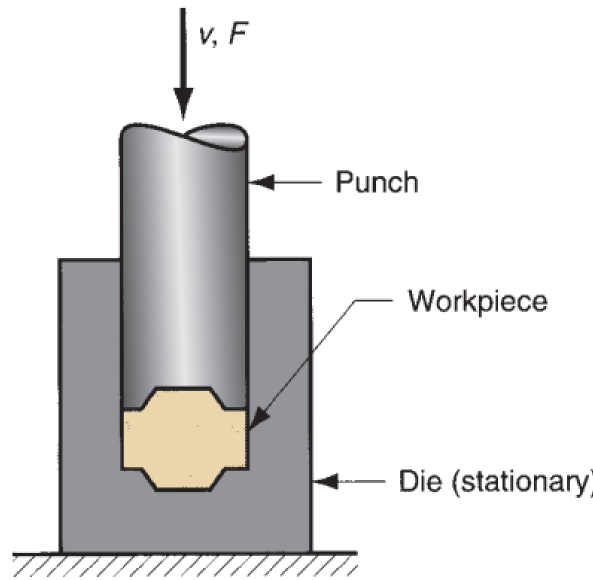
Open-die forging



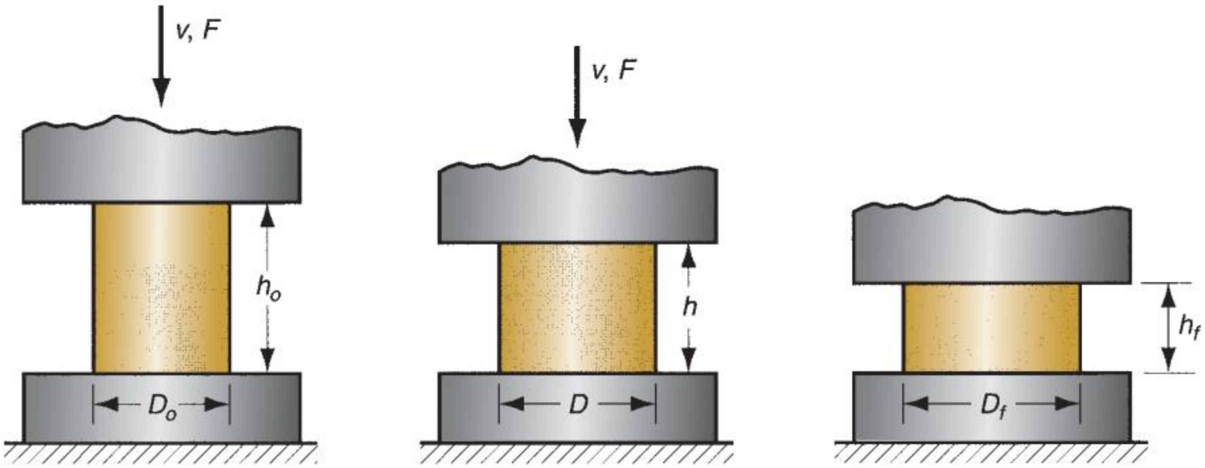
Impression-die forging



Flashless forging



Analysis of Open-Die Forging



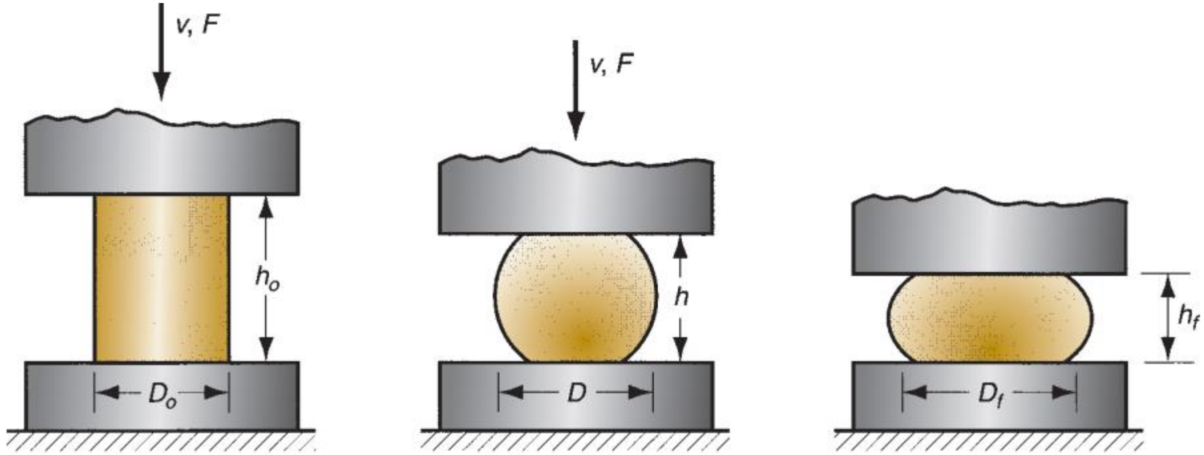
When no friction

$$\varepsilon = \ln\left(\frac{h_0}{h}\right)$$

$$F = \overline{Y_F}A$$

$$\overline{Y_F} = \frac{k\varepsilon^n}{1+n}$$

In practice, because of friction, barreling occurs

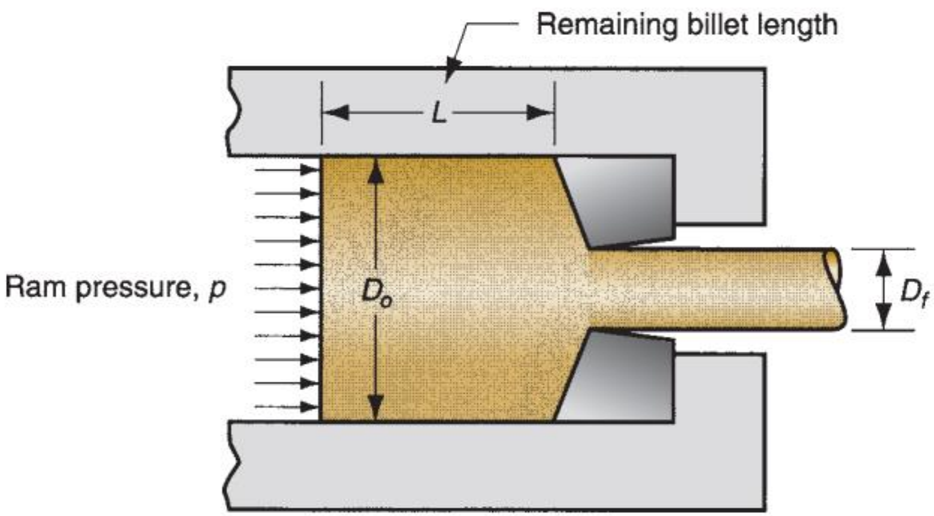


$$F = K_f\overline{Y_F}A$$

K_f-forging shape factor

$$K_f = 1 + \frac{0.4\mu D}{h}$$

Bulk deformation process: Extrusion



Extrusion ratio or reduction ratio

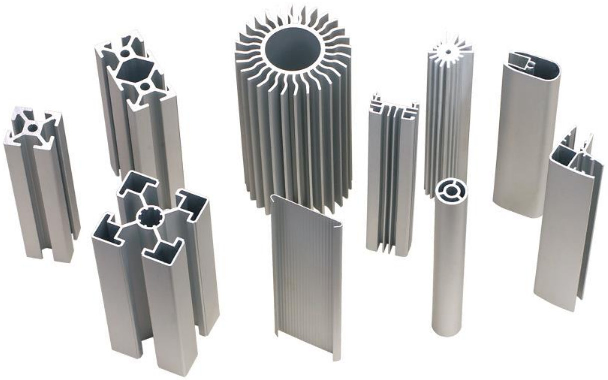
$$r_x = \frac{A_0}{A_f}$$

$$\varepsilon = \ln\left(\frac{A_0}{A_f}\right)$$ ...when no friction

Pressure applied by the ram to compress the billet through the die opening

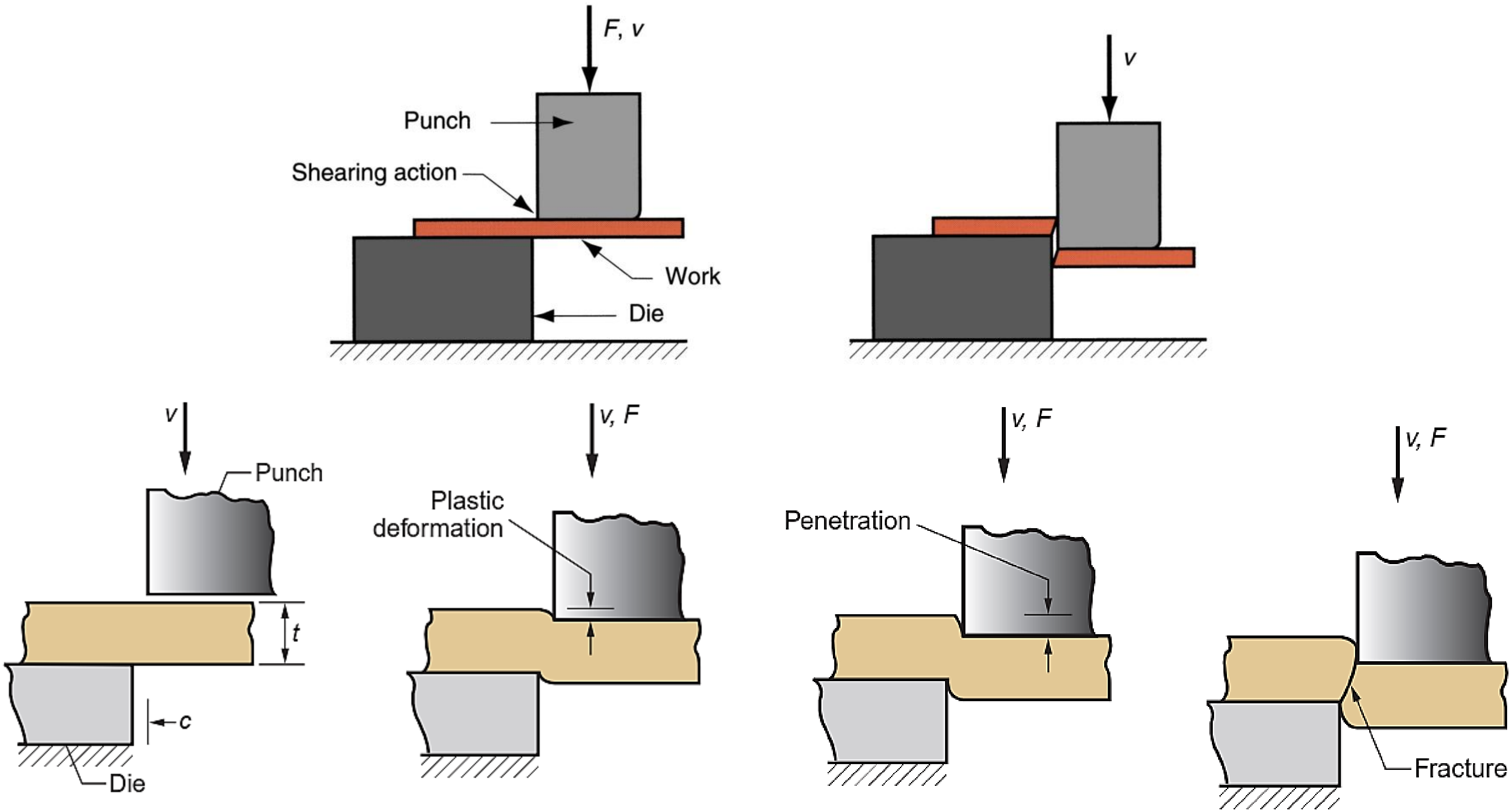
$$p = \overline{Y_F} \ln r_x \qquad \overline{Y_F} = \frac{k\varepsilon^n}{1+n}$$

- ✓ It is a deformation process in which the work metal is forced to flow through a die opening to produced a desired cross-section shape.
- ✓ Product will have constant cross-section



Courtesy: Google images

Sheet Metalworking: Cutting

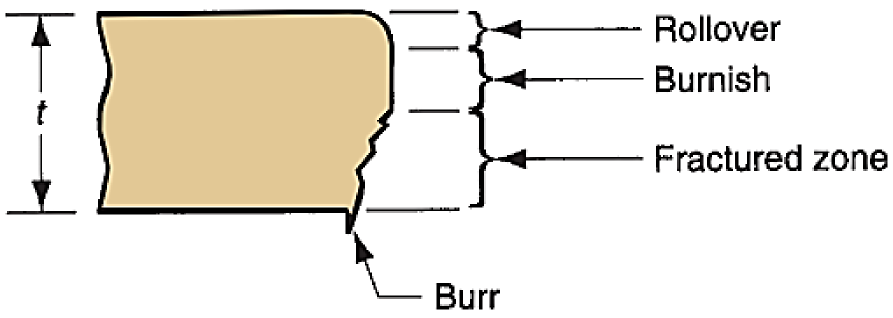


t: stock thickness,
c: clearance

Fundamentals of Modern Manufacturing Processes by Groover

Cutting

Sheared edges of the work



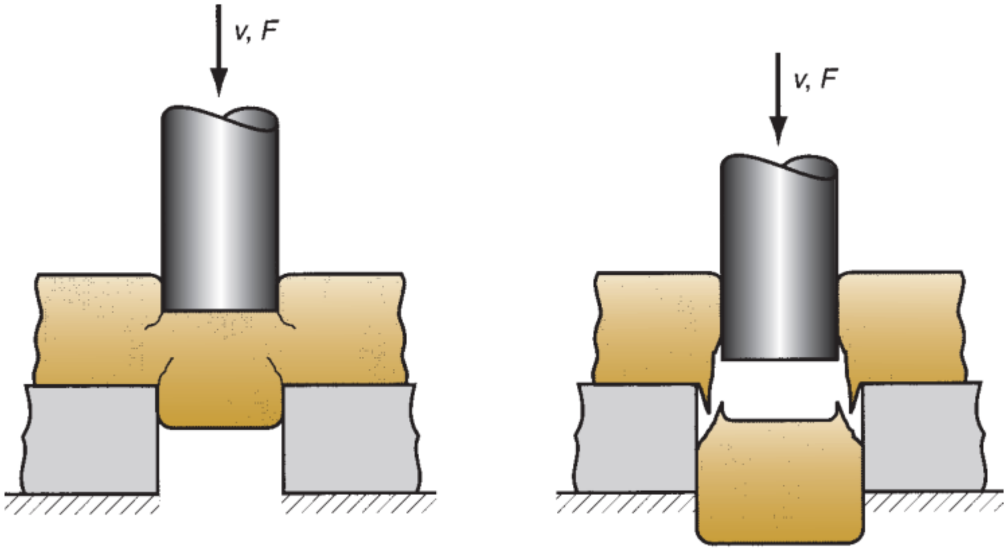
Clearance:

$c = A_c t$

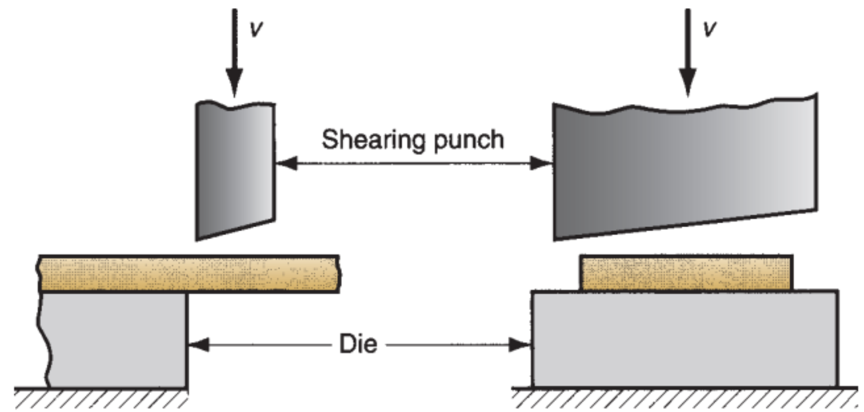
A_c= clearance allowance parameter
(0.045 to 0.075)

- Clearance too small requires
- much larger forces are needed

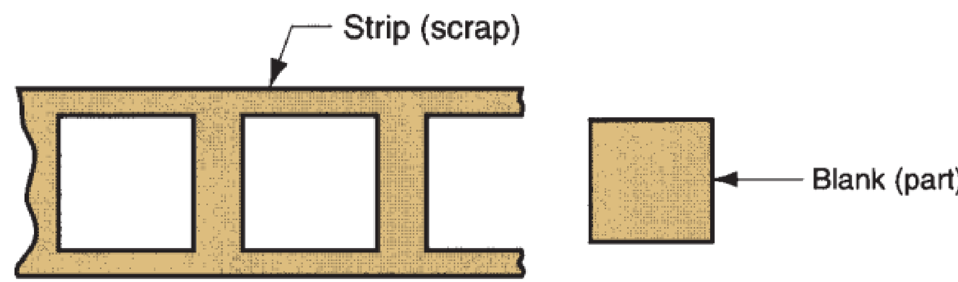
- Clearance too large
- causes oversized burr



- **Shearing:**
  Sheet-metal cutting operation along a straight line between two cutting edges



- **Blanking:**
  Cutting of the sheet metal along a closed outline in a single step



- **Punching:**
  Similar to blanking for producing holes