MADE EASY

MECHANICAL ENGINEERING

Metal Forming

BY- Vinod Sir

- Theory
- Explanation
- Derivation
- Example
- Shortcuts
- Previous Years Question With Solution

- Metal Forming :→

Bulk forming

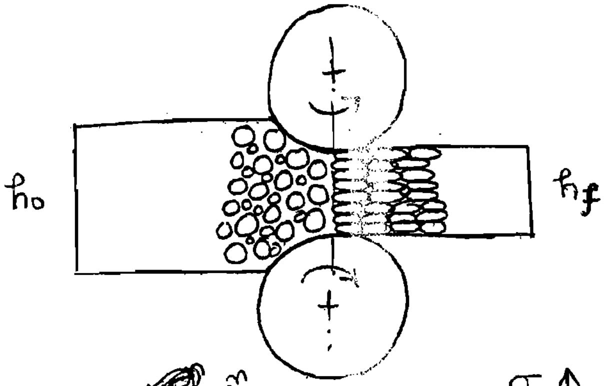
1. Rolling
2. Forging
3. Drawing
4. Extrusion

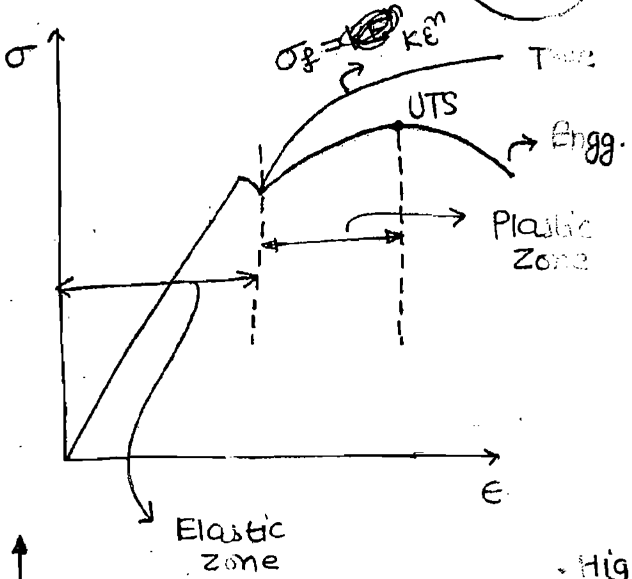
$\left(\frac{A}{V}\right)\downarrow$

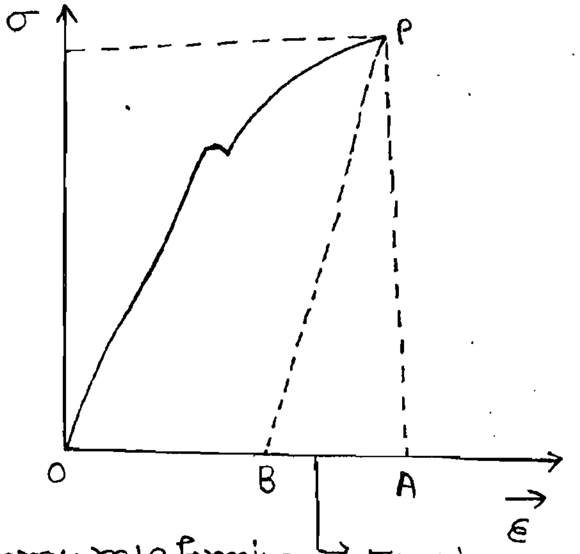
Sheet Metal Forming [t < 5mm]

1. Punching / Blanking
2. Deep drawing
3. Strech forming
4. Bending

$\left(\frac{A}{V}\right)\uparrow$







$$\boxed{\sigma_f = KE^n}^{*}$$

↳ flow ~~curve~~ Stress

Hollomon Equation

$0 < n < 1$

n: Strain Hardening Exponent

- High Energy rate forming

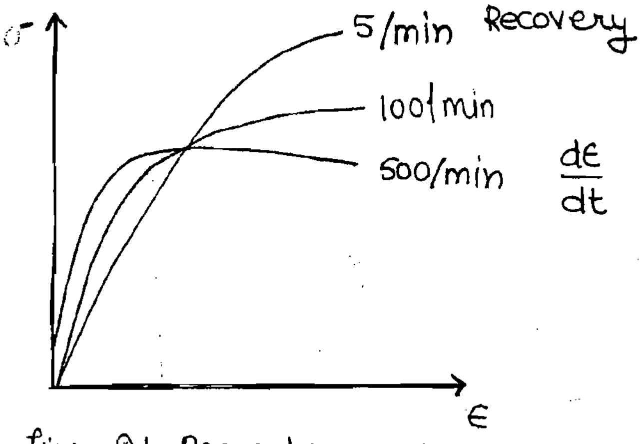
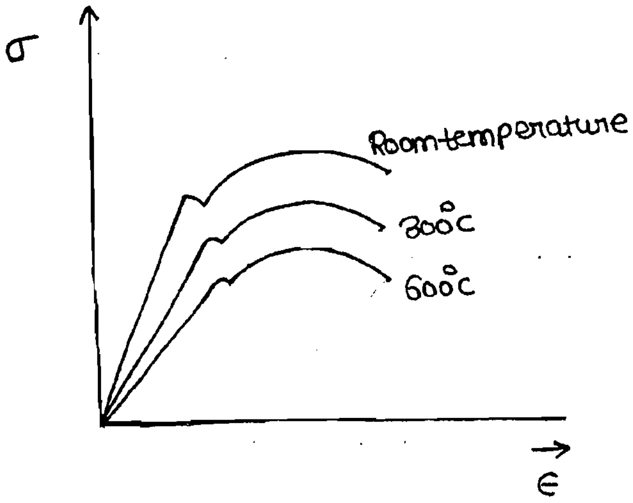


fig: At Room temperature



$$\boxed{\text{Elastic Recovery} \propto \frac{1}{E} \propto \text{Yield Stress}}$$

$$\propto \frac{1}{(B/t)}$$

K = Strength coefficient

ϵ = true strain

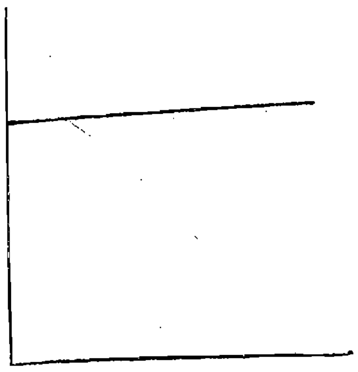
$$\frac{\sigma}{e} = \boxed{E}$$

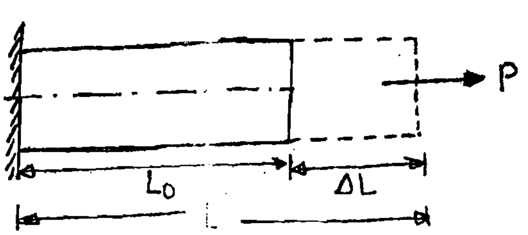
$$e = \frac{\sigma}{E}$$

Mechanical Properties appearing in stress-strain diagram like yield strength, ultimate tensile strength and % of elongation depends upon rate of deformation. (Strain rate)

As the rate of deformation increases stress-strain diagram shift towards Left and there is an increase in yield strength of the material and elastic Recovery is Reduced. In case of High Energy rate forming techniques due to high strain rates Elastic Recovery is Negligible and the accuracy of the Component is High.

If the temperature is increasing stress-strain diagram shift towards right and yield strength of this material is decrease.





$A_o \rightarrow$ Initial Area

$L_o \rightarrow$ Initial ~~Area~~ Length

$A \rightarrow$ Instantaneous Area

$L \rightarrow$ Instantaneous Length

$e \rightarrow$ Engg. Strain $= \frac{\Delta L}{L_o}$

$\epsilon \rightarrow$ True strain

$\sigma \rightarrow$ Engg. Stress

$\sigma_t =$ True Stress

$$L = L_o + \Delta L$$

$$\frac{L}{L_o} = 1 + \frac{\Delta L}{L_o} \Rightarrow \boxed{\frac{L}{L_o} = 1+e}$$

$$\sigma_t = P/A$$

$$= \frac{P}{A} \times \frac{A_o}{A_o}$$

$$\sigma_t = \frac{P}{A_o} \times \frac{A_o}{A}$$

$$\boxed{\sigma_t = \sigma(1+e)} \star$$

$$A_o L_o = A L$$

$$\frac{A_o}{A} = \frac{L}{L_o}$$

$$d\epsilon = \frac{dL}{L}$$

$$\epsilon = \int_{L_o}^{L} \frac{dL}{L} = \ln\left(\frac{L}{L_o}\right)$$

$$\boxed{\epsilon = \ln(1+e)} \star$$

$$\boxed{\epsilon = \ln\left(\frac{l_f}{l_o}\right) = \ln\left(\frac{A_o}{A_f}\right) = \ln\left(\frac{d_o}{d_f}\right)^2} \star$$

Q Determine engineering strain, true strain, % elongation, % Reduction in Area.

For Rod which is double in Length

Sol^n

$$L_f = 2L_o \Rightarrow \boxed{\frac{L_f}{L_o} = 2}$$

$$e = \frac{2L_o - L_o}{L_o} = 1$$

$$\boxed{e = 1}$$

$$\epsilon = \ln(1+e)$$

$$\boxed{\epsilon = \ln 2 = 0.693}$$

$$A_o l_o = A_f l_f$$

$$\frac{l_f}{l_o} = \frac{A_o}{A_f} = 2$$

% Reduction in Area =

$$\frac{A_o - A_f}{A_o} = \left(1 - \frac{1}{2}\right) \times 100$$

$$= 50\%$$

% elongation = 100%

Que→ 14/WB/P-289

~~$e=$~~

$$\epsilon = \ln\left(1+\frac{0.1}{100}\right)$$

$$\boxed{\epsilon = 0.099\%}$$

→

Que→ 15/WB/P-289

$d_o = 12.8\,mm$

$\sigma_e = 460\,MPa$ $\qquad\qquad \sigma_t = \sigma(1+e)$

$d = 10.7\,mm$

$\sigma_t = ?$

$$\epsilon = \ln\left(\frac{d_o}{d_f}\right)^2$$

$$\epsilon = 2\ln\left(\frac{12.8}{10.7}\right) = 0.3584$$

$$\epsilon = \ln(1+e)$$

$$e = 0.4310$$

$$\sigma_t = 460 \times 1.4310$$

$$\boxed{\sigma_t = 658.2774\,MPa}$$

★ At Max. Load (or) at UTS (or) at Neck Formation

$\eta = \epsilon$ = True strain

↳ strain Hardening exponent