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BY- Vinod Sir

- Theory
- Explanation
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- Example
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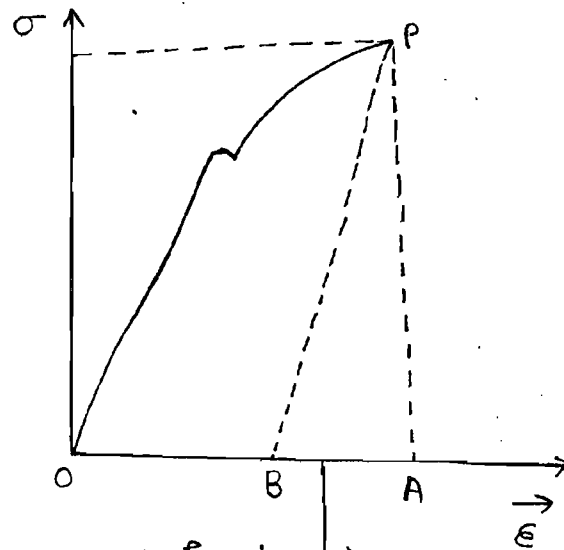
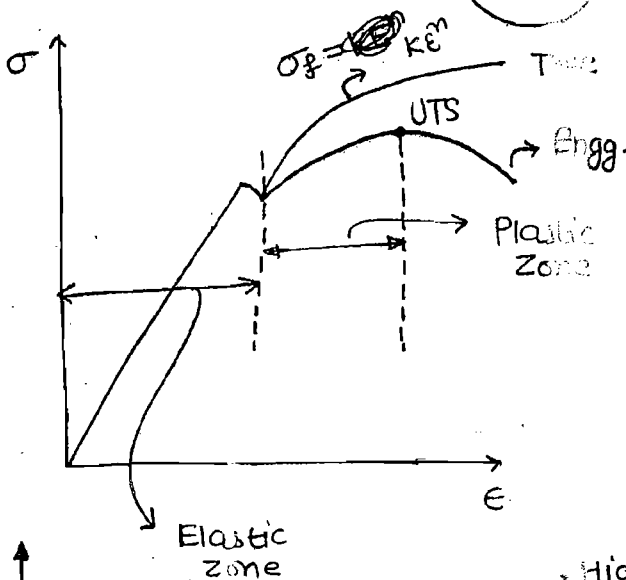
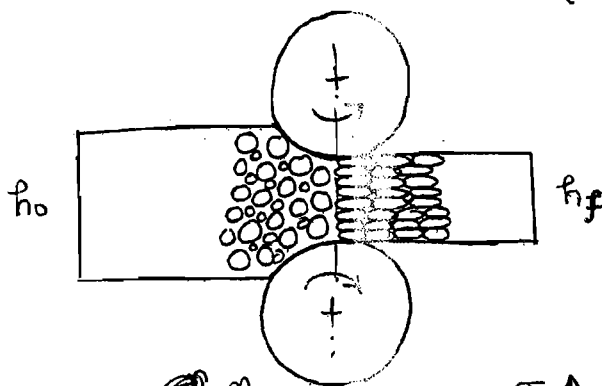
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• Metal Forming :→

- | | |
|---|---|
| <p style="text-align: center;">Bulk forming</p> <ol style="list-style-type: none"> 1. Rolling 2. Forging 3. Drawing 4. Extrusion <p style="text-align: center;">$(\frac{A}{V}) \downarrow$</p> | <p style="text-align: center;">[t < 5mm]</p> <p style="text-align: center;">Sheet Metal forming</p> <ol style="list-style-type: none"> 1. Punching / Blanking 2. Deep drawing 3. Stretch forming 4. Bending <p style="text-align: center;">$(\frac{A}{V}) \uparrow$</p> |
|---|---|



$\sigma_f = KE^n$ *

→ flow stress

Hollomon Equation

$0 < n < 1$

n: Strain Hardening Exponent

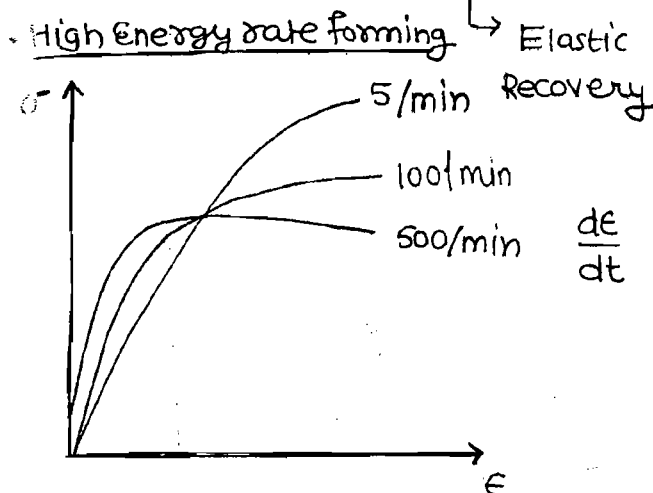
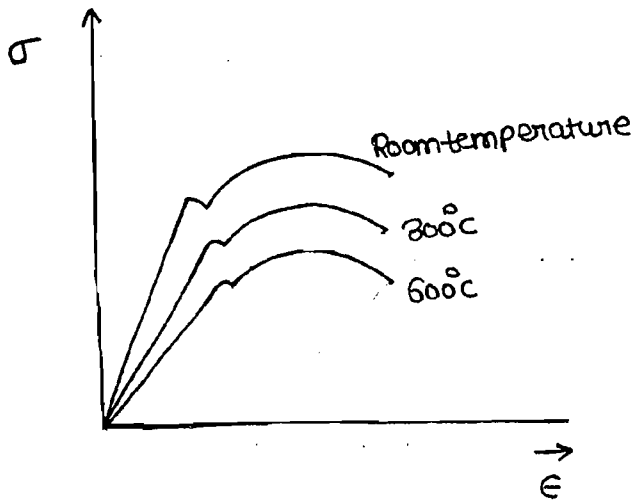


fig: At Room temperature



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

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

K = strength coefficient

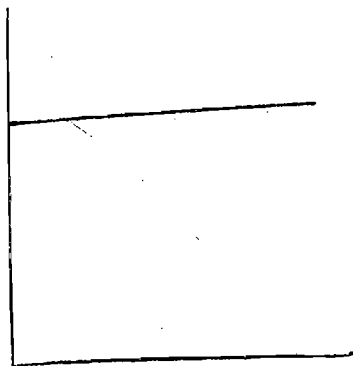
n = true strain

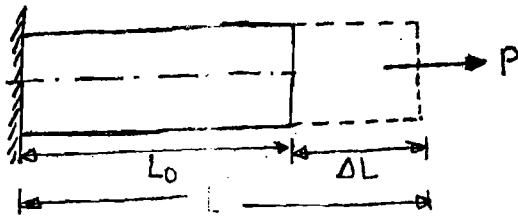
$$\frac{\sigma}{\epsilon} = \frac{K}{E} \left(\frac{\sigma}{E} \right)^n$$

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.





$A_0 \rightarrow$ Initial Area
 $L_0 \rightarrow$ Initial Area Length
 $A \rightarrow$ Instantaneous Area
 $L \rightarrow$ Instantaneous Length
 $e \rightarrow$ Engg. Strain = $\frac{\Delta L}{L_0}$
 $\epsilon \rightarrow$ True strain
 $\sigma \rightarrow$ Engg. Stress
 $\sigma_T =$ True Stress

$$L = L_0 + \Delta L$$

$$\frac{L}{L_0} = 1 + \frac{\Delta L}{L_0} \Rightarrow$$

$$\boxed{\frac{L}{L_0} = 1 + e}$$

$$\sigma_T = P/A$$

$$= \frac{P}{A} \times \frac{A_0}{A_0}$$

$$\sigma_T = \frac{P}{A_0} \times \frac{A_0}{A}$$

$$\boxed{\sigma_T = \sigma \cdot (1 + e)}^*$$

$$A_0 L_0 = A L$$

$$\frac{A_0}{A} = \frac{L}{L_0}$$

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

$$\epsilon = \int_{L_0}^L \frac{dL}{L} = \ln\left(\frac{L}{L_0}\right)$$

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

$$\boxed{\epsilon = \ln\left(\frac{l_f}{l_0}\right) = \ln\left(\frac{A_0}{A_f}\right) = \ln\left(\frac{d_0}{d_f}\right)^2}^*$$

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

For rod which is double in Length

Solⁿ

$$l_f = 2l_0 \Rightarrow \boxed{\frac{l_f}{l_0} = 2}$$

$$e = \frac{2l_0 - l_0}{l_0} = 1$$

$$\boxed{e = 1}$$

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

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

$$A_0 l_0 = A_f l_f$$

$$\frac{l_f}{l_0} = \frac{A_0}{A_f} = 2$$

% Reduction in Area =

$$\frac{A_0 - A_f}{A_0} = \left(1 - \frac{1}{2}\right) \times 100 = 50\%$$

% elongation = 100%

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$e = ?$

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

~~$e = 0.99$~~

$$\epsilon = 0.099\%$$

→

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$$d_0 = 12.8 \text{ mm}$$

$$\sigma_e = 460 \text{ MPa}$$

$$\sigma_t = \sigma(1 + e)$$

$$d = 10.7 \text{ mm}$$

$$\sigma_t = ?$$

$$\epsilon = \ln\left(\frac{d_0}{d_f}\right)^2$$

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

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

$$e = 0.4310$$

$$\sigma_t = 460 \times 1.4310$$

$$\sigma_t = 658.2774 \text{ MPa}$$

At Max. Load \otimes at UTS \otimes Neck Formation*

$$\eta = \epsilon = \text{True strain}$$

↳ Strain Hardening exponent