Lecture 20

Mechanics of Metal Working:-

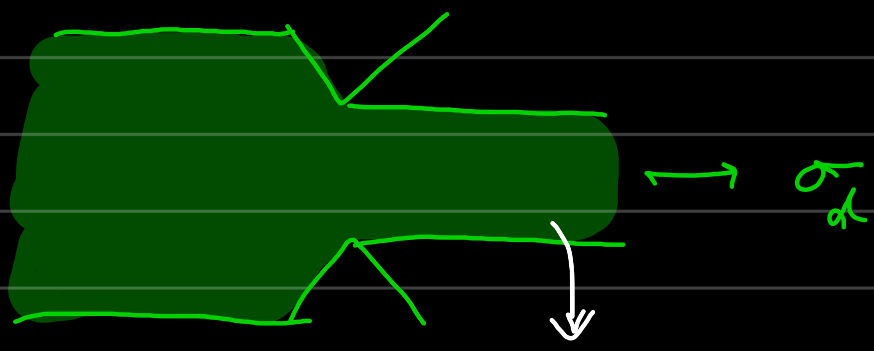
(Ideal work, actual work, redundant work.)

$\sigma_d < \sigma_t$

σ_d → drawing stress

σ_t → tensile stress.

For a given amt of strain drawing stress is smaller.



→ grain refinement can take place at high temperatures due to recrystallization.

→ Otherwise, no grain refinement.

* Maximum drawability ε (max ε that can be imparted

σ_d has an upper limit beyond which wire will fracture.
{ Cold worked wire has negligible ductile region : gap b/w σ_y & σ_{UTS} }.

* $\sigma_{\text{wire drawing}} \leq \sigma_d$ {in industrial working condition}.

→ $\sigma_d(\bar{\varepsilon}_d) \leq \bar{\sigma}_{\text{flow stress}}$

$$\frac{1}{\eta}\int_0^{\varepsilon^*} \bar{\sigma}\, d\bar{\varepsilon} = K\varepsilon^{*n}$$

$$\frac{1}{\eta} \times \frac{\cancel{K}(\varepsilon^*)^{n+1}}{n+1} = K\varepsilon^{*n}$$

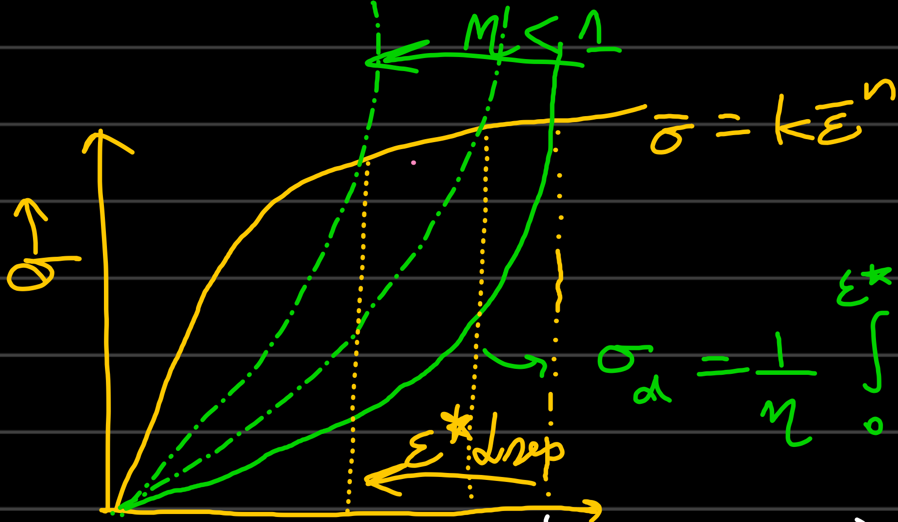
$$\boxed{\varepsilon^* = \eta(n+1)}$$

upper limit of strain that can be imposed in a single pass.

efficiency

→ Let $\varepsilon^* = 1.2$ $\quad \varepsilon = 2\ln\left(\frac{D_f}{D_0}\right)$

% reduction ⇒



$$\sigma_d = \frac{1}{\eta}\int_0^{\varepsilon^*} \bar{\sigma}\, d\bar{\varepsilon} \quad \{\eta = 1\}$$

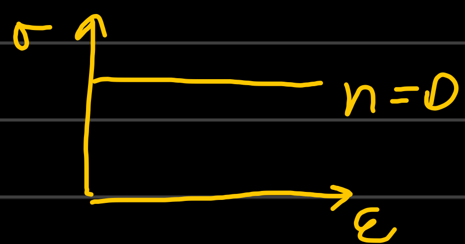
$\varepsilon \rightarrow$ $\quad \varepsilon^* = \eta(n+1)$

below $\varepsilon < \varepsilon^* \Rightarrow \sigma_d < \bar{\sigma}$

beyond $\varepsilon > \varepsilon^* \Rightarrow \sigma_d > \bar{\sigma} \rightarrow$ fracture is imminent.

Q) What is the maximum strain for a material which shows ideal plastic behaviour.

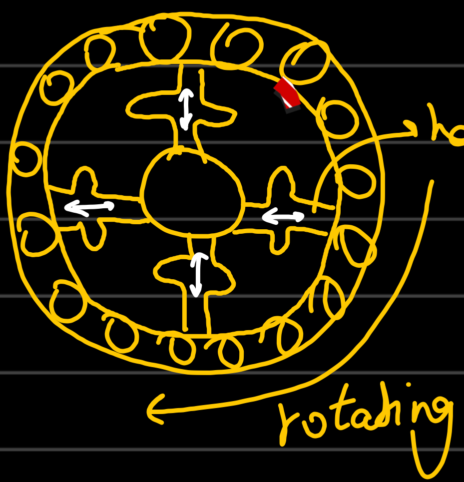
$\{\eta = 0.55\}$ $\quad$ {no work hardening flow stress is constant}



$$\varepsilon^* = \eta(1+n)$$

$$\varepsilon^* = 0.55 = \ln(1-r)$$

⊛ Swaging: – create input material for wire drawing



→ closely resembles forging.

→ specially designed for wire cross-section

Upper Bound Analysis:

↳ Equate internal rate of energy dissipation to external rate of work.

↳ Assumptions: i) material is isotropic & homogenous.

ii) frictionless behaviour or constant shear condⁿ.

iii) Outside deformation zone, we assume material is rigid.

Method:

↳ An internal flow field is to be assumed.

① → It should be self-consistent.

② → calculate energy rate consumed in dry field using material properties.

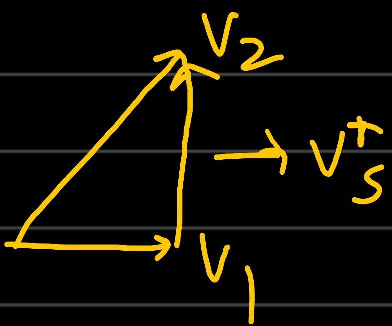
③ → calculate rate of external work.

④ → equate ② & ③

Concepts of Hodographs:

$V_2 > V_1$

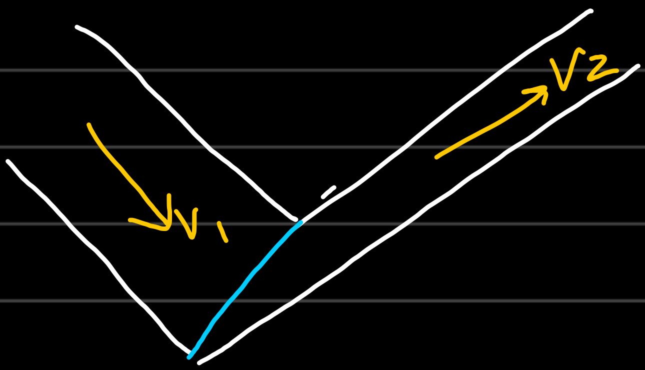
$v_s^* \Rightarrow$ velocity of material at shear plane.



Hodograph:

↳ depicts how material is flowing in die.

→ diagram gets complicated when multiple shear planes exist.



V1
V2

V2
V1
Vs*