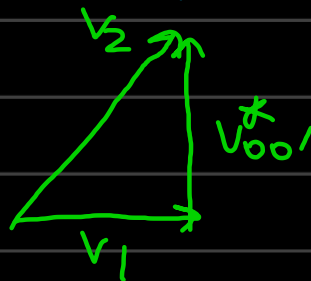
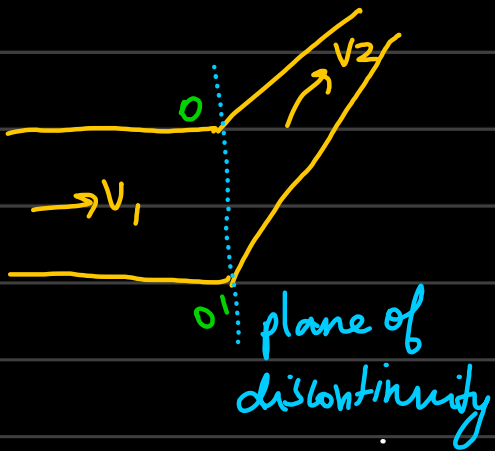


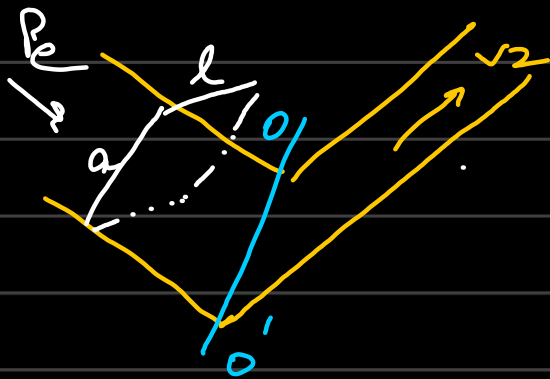
Lecture 21

Mechanics of metal working

Upper Bound Analysis:



Hodograms



* Rate of external work = $F \times \text{velocity}$

$$= P_e a l \times v_1$$

* Rate of internal work = $\underbrace{K}_{\text{shear strength of material}} \underbrace{l o o'}_{\text{force}} \times l \times v_s^*$

$$\rightarrow P_{\text{exax}} \propto v_1 = K 100' \propto v_s^2$$

$$P_e = \frac{K 100' / V_s^*}{a v_l}$$

material
property

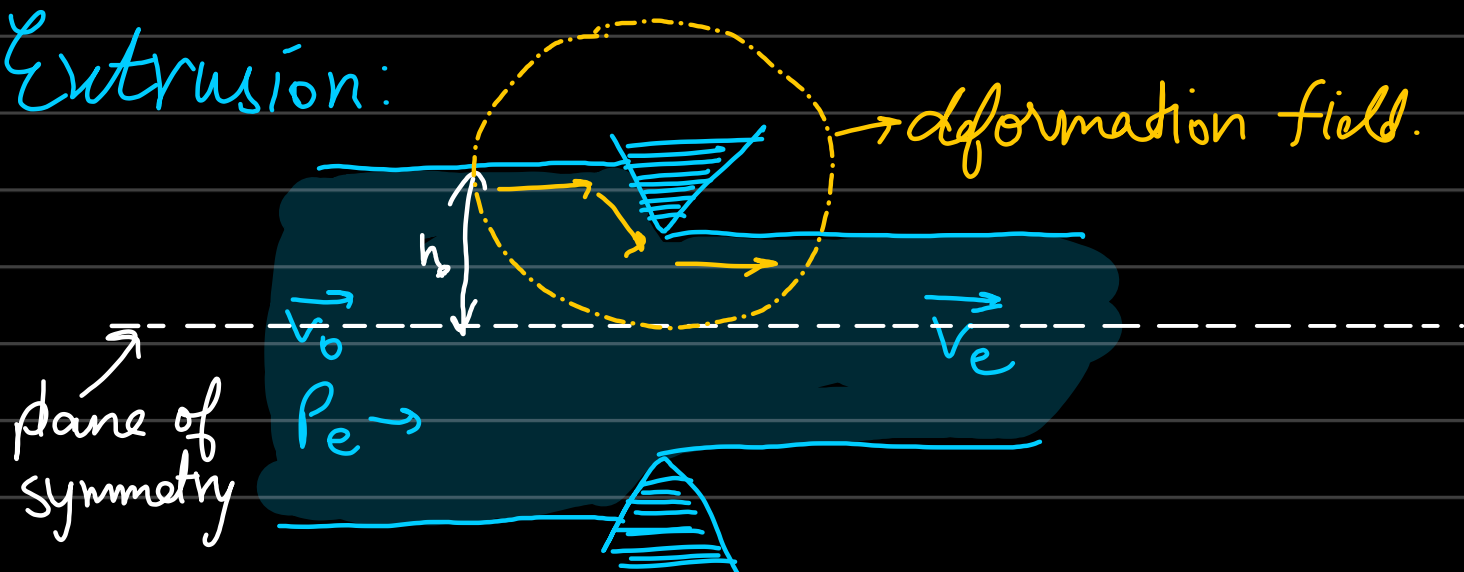
dimensionality
of problem

from
hodographs
velocity
radius.

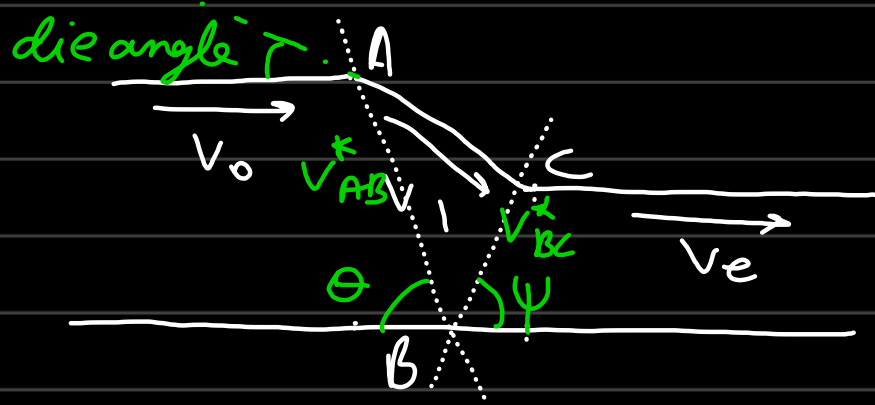
* Generalized relation for multiple shear planes.

$$P_e = K \ell \left(\sum_{i=AB} |AB| v_{AB}^* \right)$$

Extrusion:



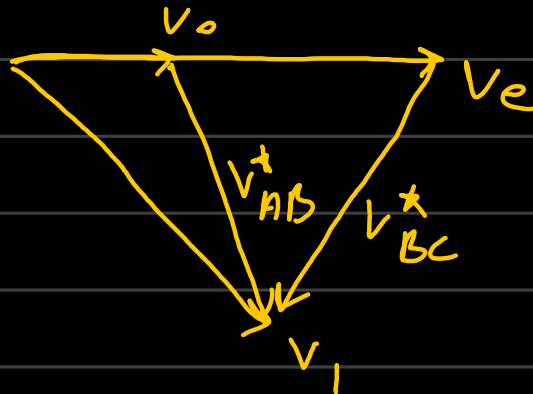
- 1) Find symmetry and break problem accordingly
- 2) Assume deformation field which is self consistent.



3) Label moving region & velocities

4) Create hodograph of problem by defining origin.

Hodograph.



Rate of external work = $P_e \times h_e + v_0$

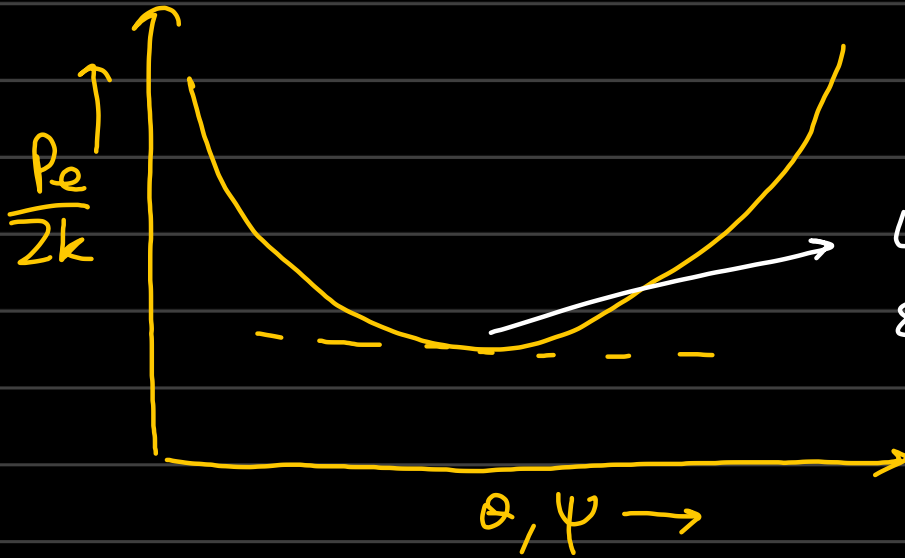
Rate of internal work = $K [|AB| v_{AB}^* + |BC| v_{BC}^*]$

$$P_e = \frac{K [|AB| v_{AB}^* + |BC| v_{BC}^*]}{h_e v_0}$$

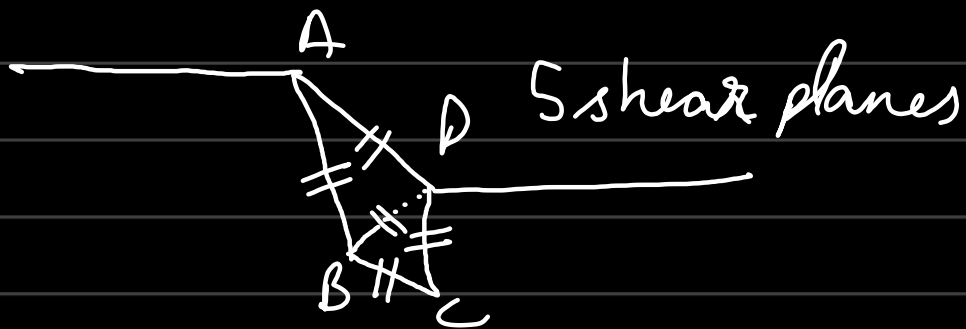
$$\frac{P_e}{2k} = \frac{1}{2h_0 v_0} \left[|AB| v_{AB}^+ + |BC| v_{BC}^+ \right]$$

material property
and load.

geometrical dimensions.



Q)



Q)

$$H = 3\sigma_y$$

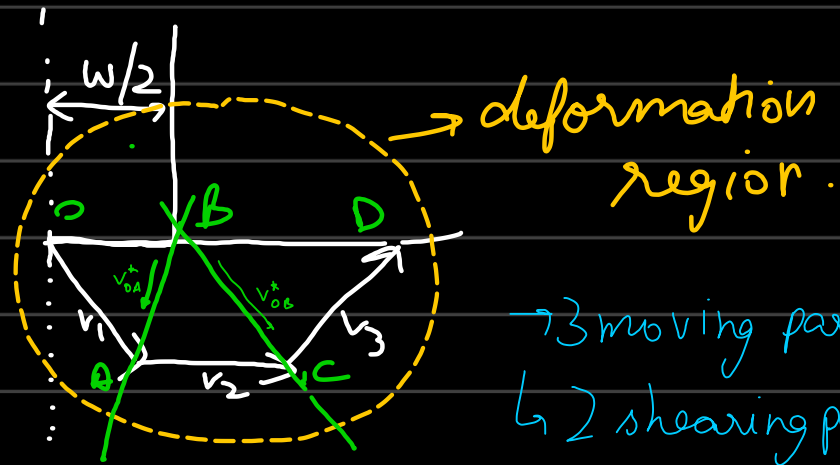
Hardness

yield strength.

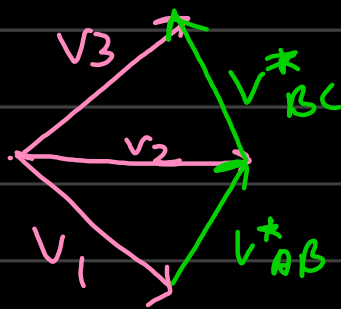


determine the load for indentation (P_p)

using upper bound analysis.



→ 3 moving parts
↳ 2 shearing parts.



Rate of external work
= $P \times v_1$

Rate of internal work.