

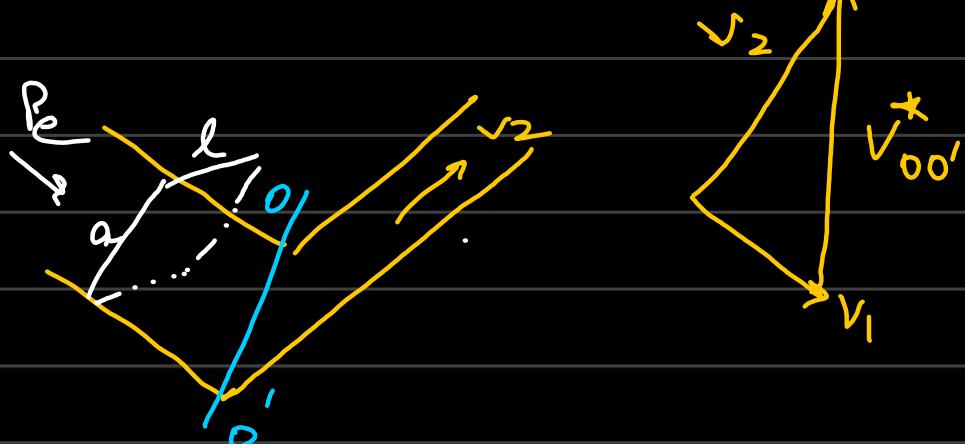
Lecture 21

Mechanics of metal working

Upper Bound Analysis:



Hodograms



* Rate of external work = $F_x \times$ velocity

$$= P_e a l \times v_1$$

* Rate of internal work = $K l v_{00'} l \times v_s^*$

force
shear
strength of material

$$\rightarrow P_{\text{exax}} \propto v_i = K l o o' l \propto v_s^*$$

$$P_e = \frac{K l o o' l v_s^*}{a v_i}$$

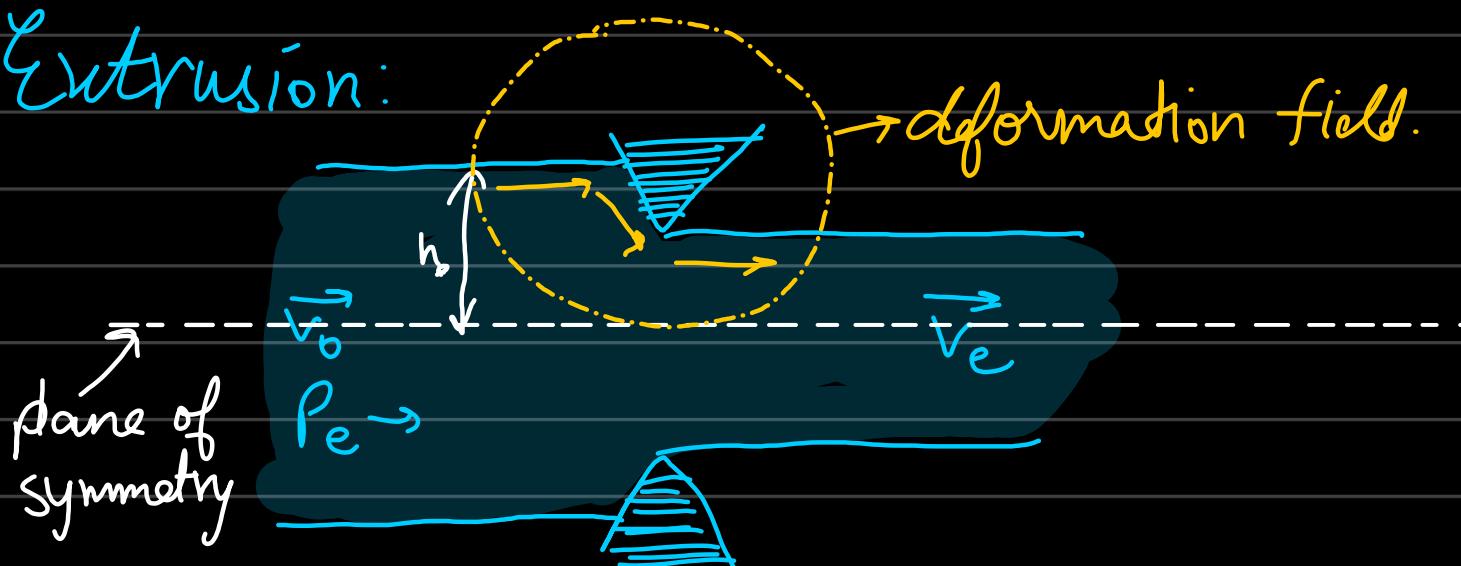
material property dimensionality of problem

from hodographs velocity ratio.

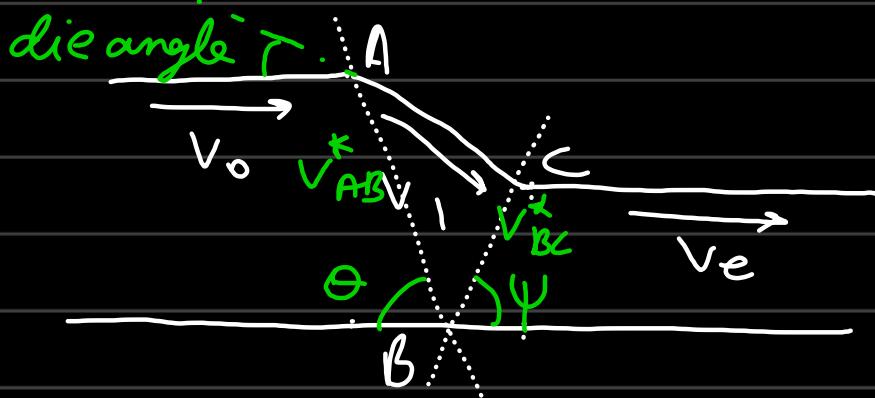
Generalized relation for multiple shear planes.

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

Extrusion:



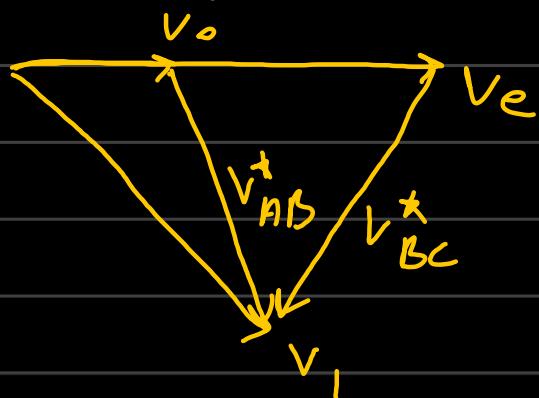
- 1) Find symmetry and break problem accordingly
- 2) Assume deformation field which is self consistent.



3) Label moving region & velocities

4) Create hodograph of problem by defining origin.

Hodograph.



Rate of external work = $P_{ext} h_{ext} V_o$

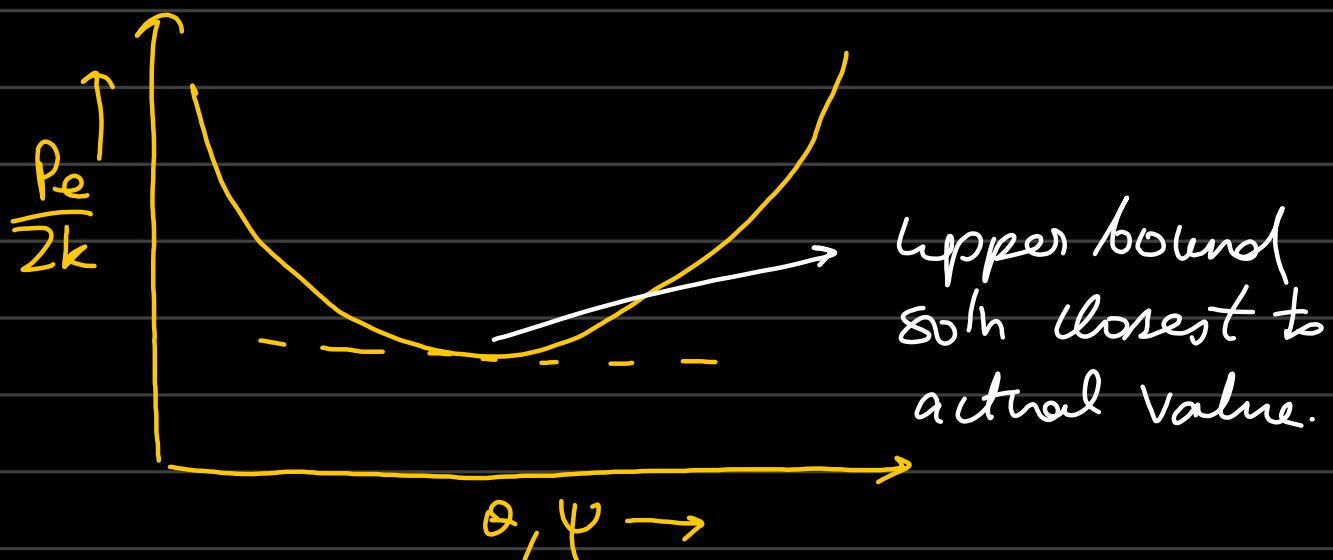
Rate of internal work = $K[(AB)V_{AB}^* + (BC)V_{BC}^*]$

$$P_e = \frac{K[(AB)V_{AB}^* + (BC)V_{BC}^*]}{h_o V_o}$$

$$\frac{P_e}{2k} = \frac{1}{2h_0 V_0} \left[|AB|V_{AB}^+ + |BC|V_{BC}^+ \right]$$

material property
and load.

geometrical dimensions.



Q)

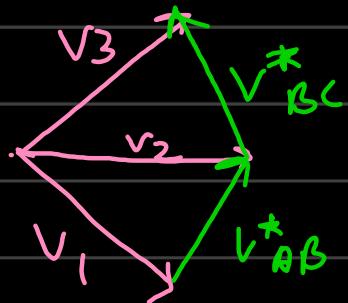
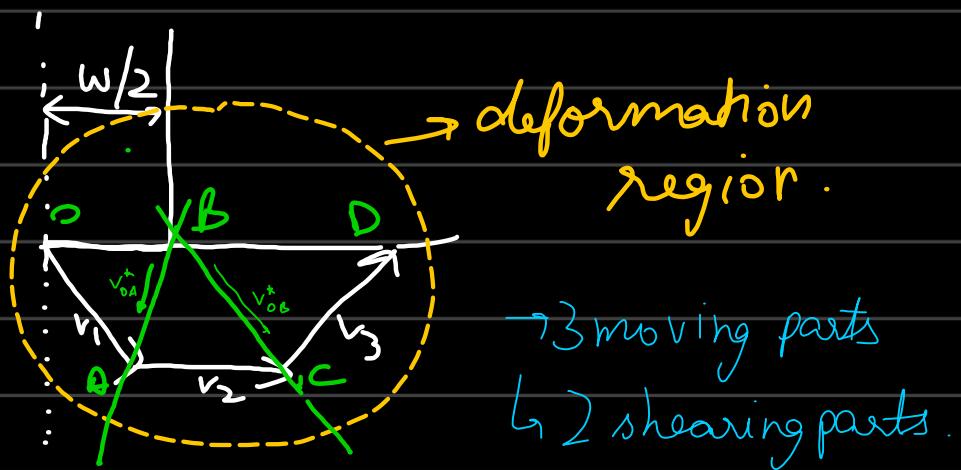
Hardness

$$H = 3\sigma_y \rightarrow \text{yield strength.}$$



determine the load for indentation (P_p)

using upper bound analysis.



Rate of external work
= $P_p \times v_1$

Rate of internal work.