ME361 – Manufacturing Science Technology

Wire drawing

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Wire drawing

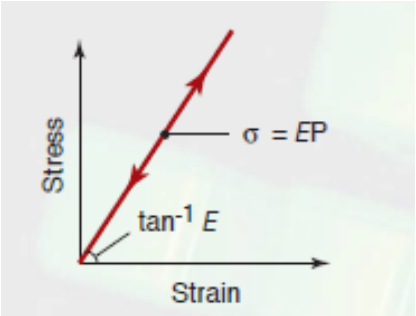
https://www.youtube.com/watch?v=rV9NeLBvasw

Wire drawing

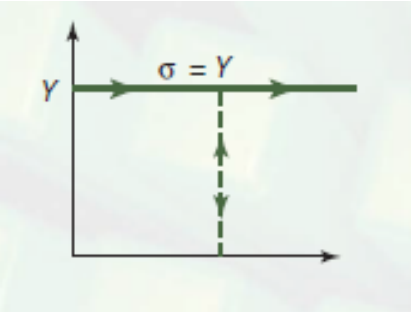
https://www.youtube.com/watch?v=wlWkz9hjASo

Preliminaries. Stress-strain behavior.

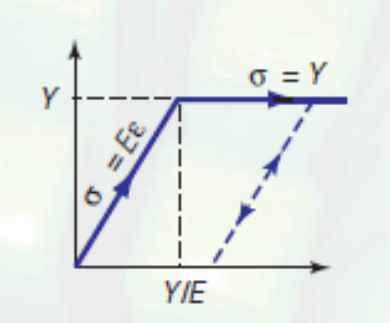
(a) Perfectly elastic



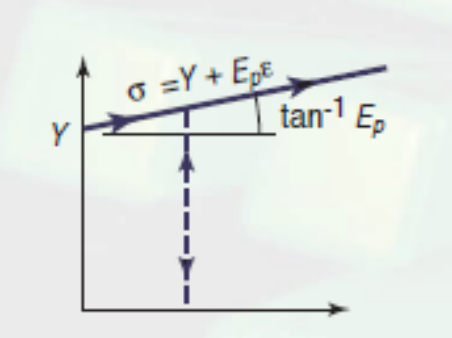
(b) Rigid, perfectly plastic



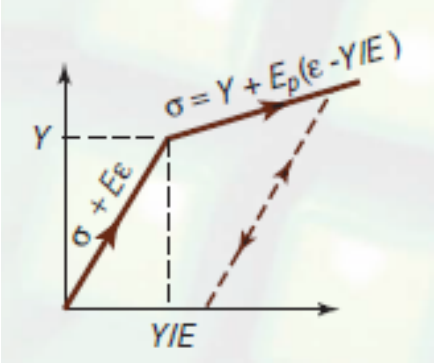
(c) Elastic, perfectly plastic



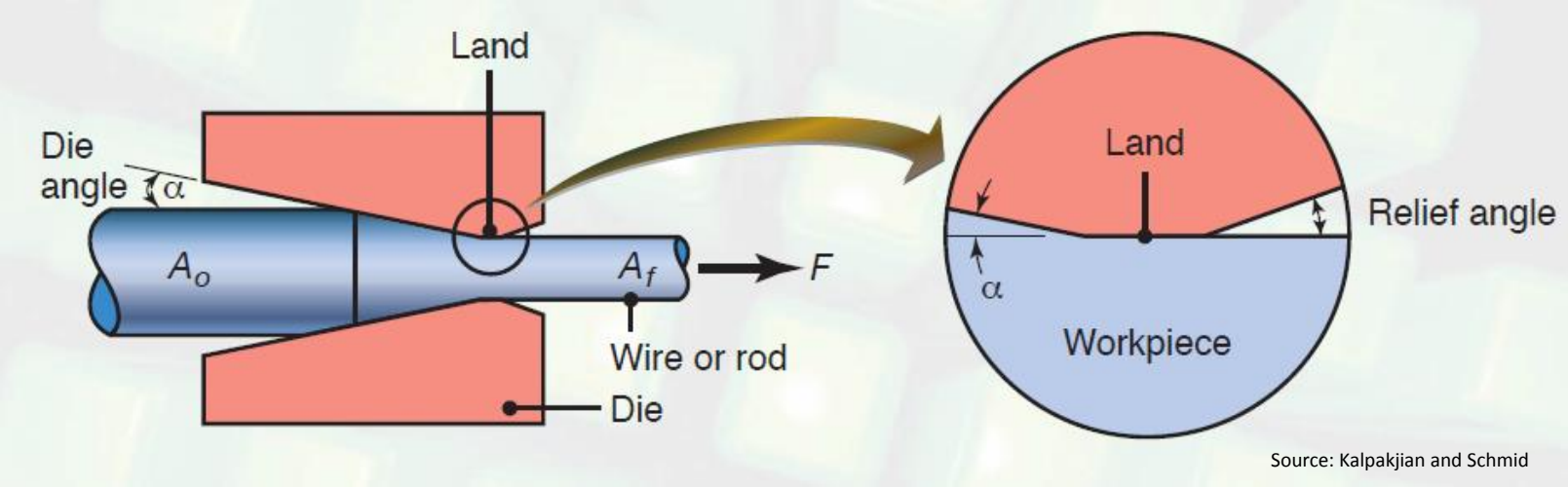
(d) Rigid, linearly strain hardening



(e) Elastic, linearly strain hardening

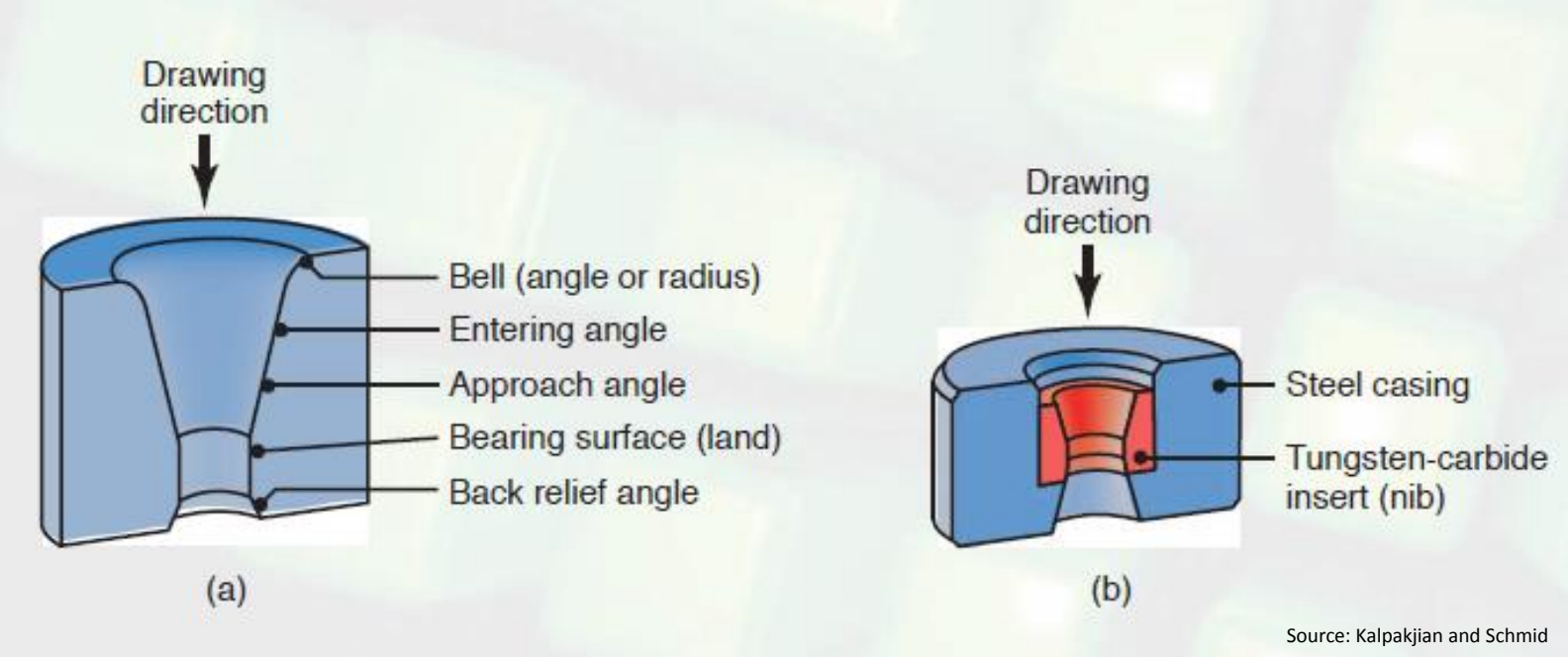


Wire drawing



Source: Kalpakjian and Schmid

Wire drawing: actual die



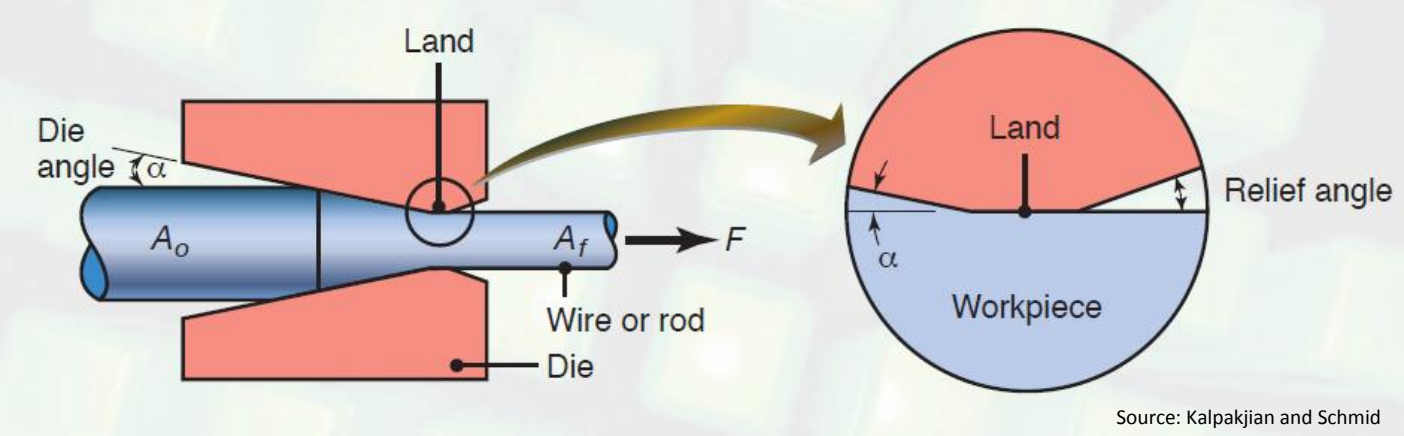
Source: Kalpakjian and Schmid

Source: Kalpakjian and Schmid

Wire drawing: objectives and assumptions

- Objectives:
  - To determine drawing stresses and forces
  - To determine maximum reduction possible
- Assumptions:
  - Specimen is cylindrical
  - Coefficient of friction and the half-cone angle are small
  - The coefficient of friction is low and constant over the entire die-workpiece interface
  - Wire drawing is a continuous operation, with the wire being pulled and hence being in tension always

Wire drawing: ideal deformation (frictionless)



Drawing ratio

$$R = \left(\frac{A_o}{A_f}\right)$$

True strain

$$\epsilon = \ln\left(\frac{A_o}{A_f}\right) = \ln R$$

Drawing stress

$$\sigma_d = Y \ln\left(\frac{A_o}{A_f}\right)$$

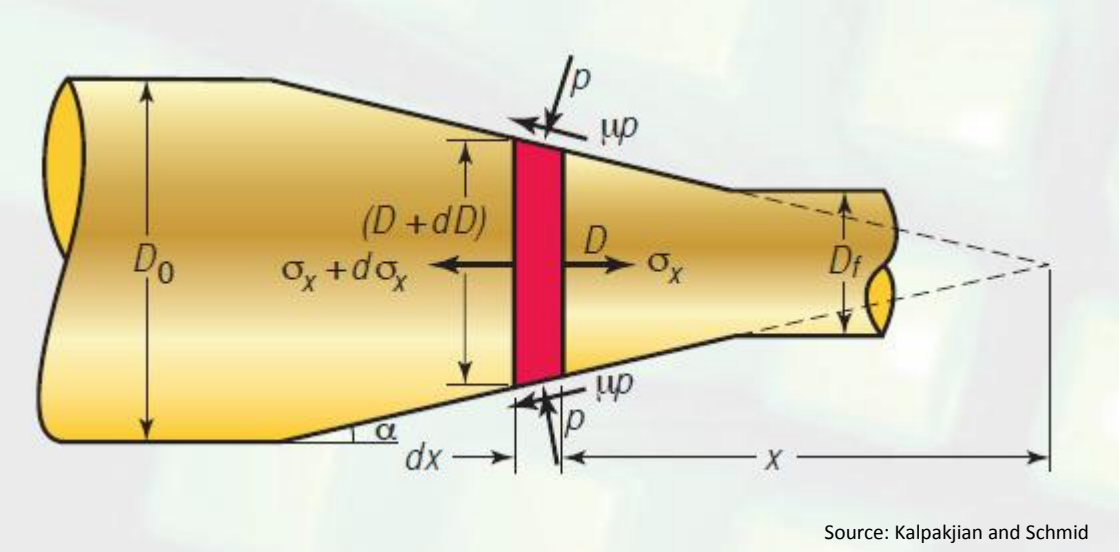
with strain hardening, avg. flow stress

$$\overline{Y} = \frac{K{\varepsilon_1}^n}{n+1}$$

Drawing force

$$F = \overline{Y} A_f \ln\left(\frac{A_o}{A_f}\right)$$

Wire drawing: with friction



Source: Kalpakjian and Schmid

- Use the slab method; resolve forces in the horizontal direction and use a yield criterion:

$$\sigma_d = Y\left(1 + \frac{tan\,\alpha}{\mu}\right)\left[1 - \left(\frac{A_f}{A_o}\right)^{\mu\,cot\,\alpha}\right]$$

for strain hardening material, replace Y by $\overline{Y}$

Wire drawing: maximum reduction per pass

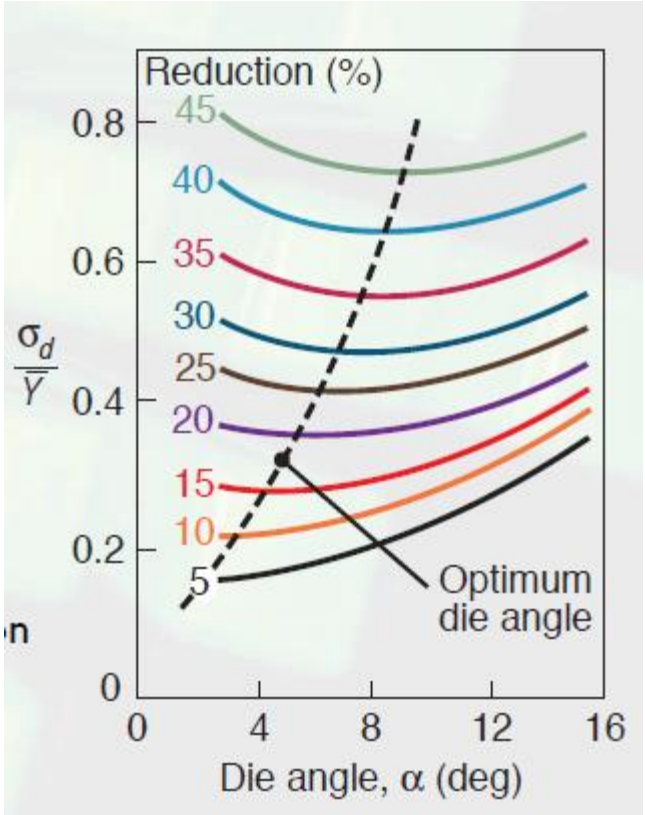
Drawing stress: $$\sigma_d = Y\left(1 + \frac{tan\,\alpha}{\mu}\right)\left[1 - \left(\frac{A_f}{A_o}\right)^{\mu\, cot\, \alpha}\right]$$

- With greater reduction, drawing stress increases, but up to a limit
- If drawing stress reaches the yield stress of the material, the material will simply yield, which is not desirable, since wire/rod will undergo further deformation
- For ideal perfectly plastic material with a yield stress of Y, the limit condition is:

$$\sigma_d = Y \ln\left(\frac{A_0}{A_f}\right) = Y \longrightarrow \ln\left(\frac{A_0}{A_f}\right) = 1 \longrightarrow \frac{A_0}{A_f} = e$$

Hence, maximum reduction per pass: $$\frac{A_0 - A_f}{A_0} = 1 - \frac{1}{e} = 0.63 = 63\%$$

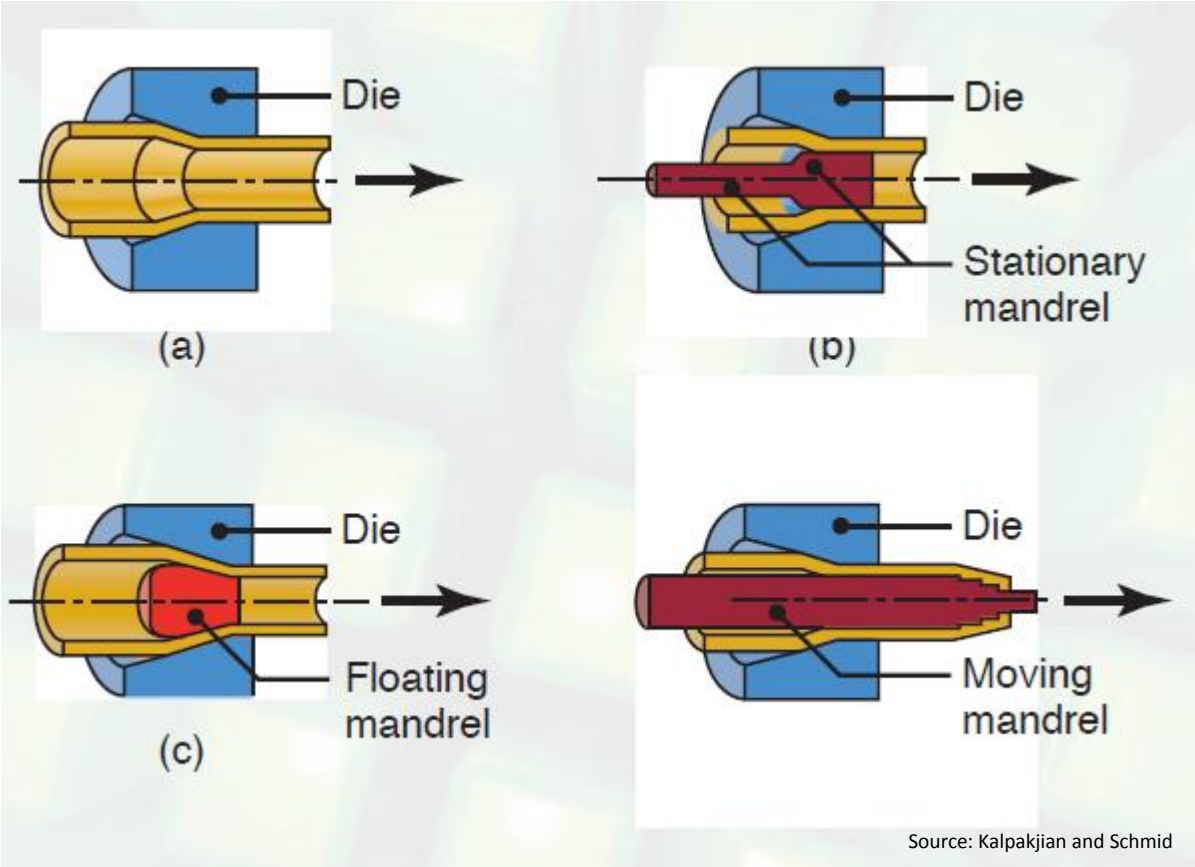
Wire drawing: optimum die angle



$$\frac{\sigma_d}{\overline{Y}} = \left(1 + \frac{tan\,\alpha}{\mu}\right)\left[1 - \left(\frac{A_f}{A_o}\right)^{\mu\,cot\,\alpha}\right]$$

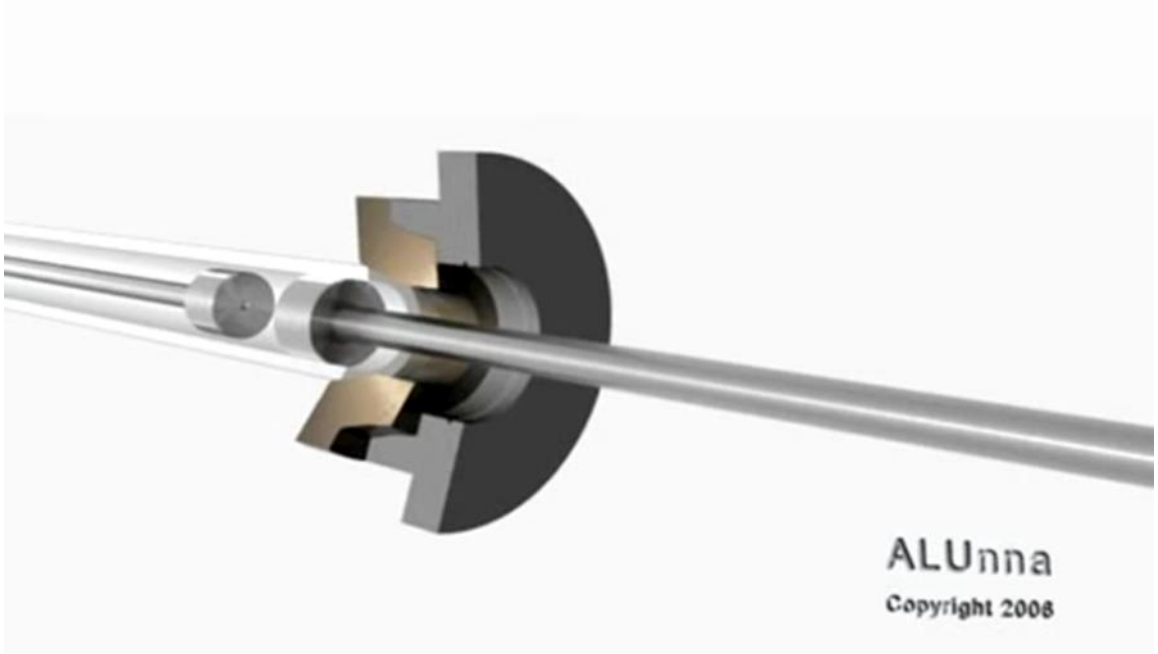
- Drawing stress depends on ideal and frictional work
- There exists a drawing angle at which the force is minimum
- Friction ranges from 0.01 to 0.1

Tube drawing



Source: Kalpakjian and Schmid

Tube drawing



https://www.youtube.com/watch?v=QKAg1yMZIpY