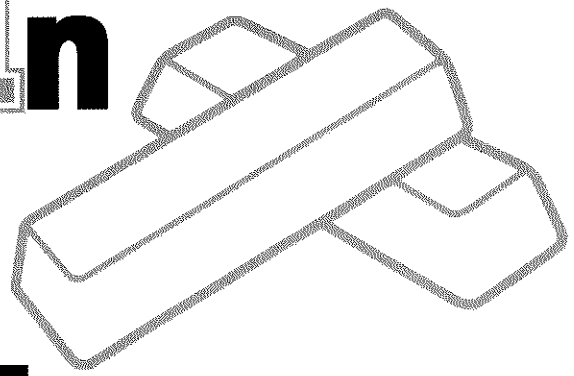
Mechanics In Design and Manufacturing



+ Final Review

- tuesday may 9th 10:15 am - 12:15 pm
- 10-12 problems
  mix of computation + knowledge
- 3 pages of notes from prior exams

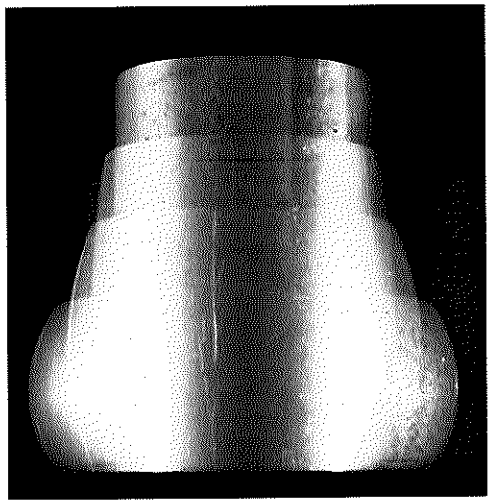
Tension/Compression

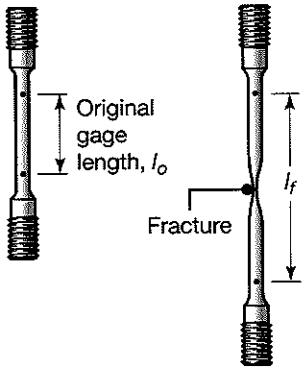
$$e = \frac{L - L_o}{L_o}$$

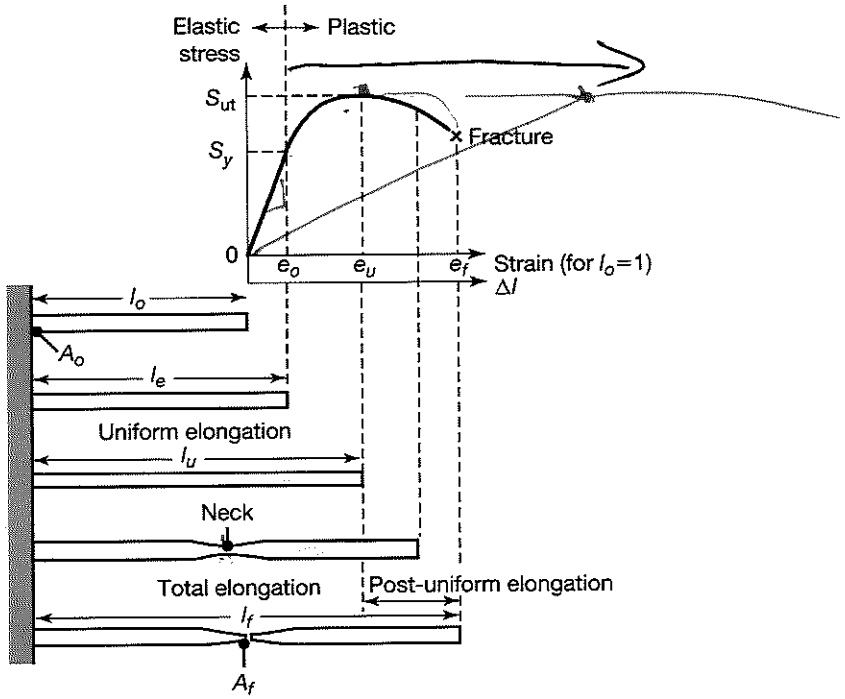
$$\varepsilon = \ln\left(\frac{L}{L_o}\right)$$

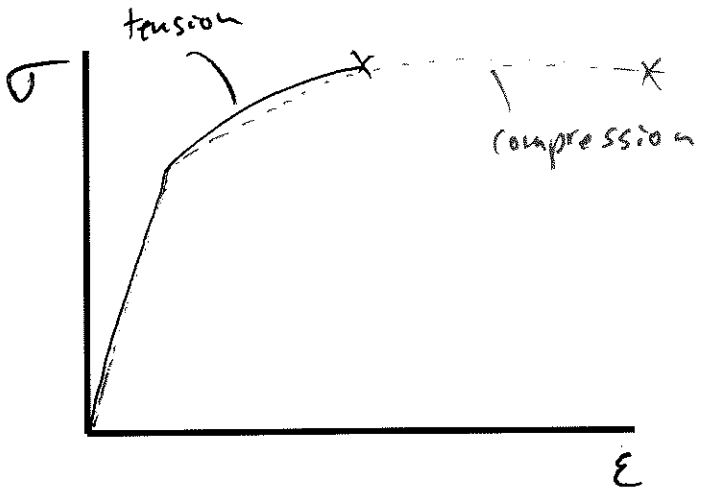
$$e_{forging} = \frac{h_o - h_i}{h_o} \qquad \dot{e} = \frac{-V}{h_o}$$

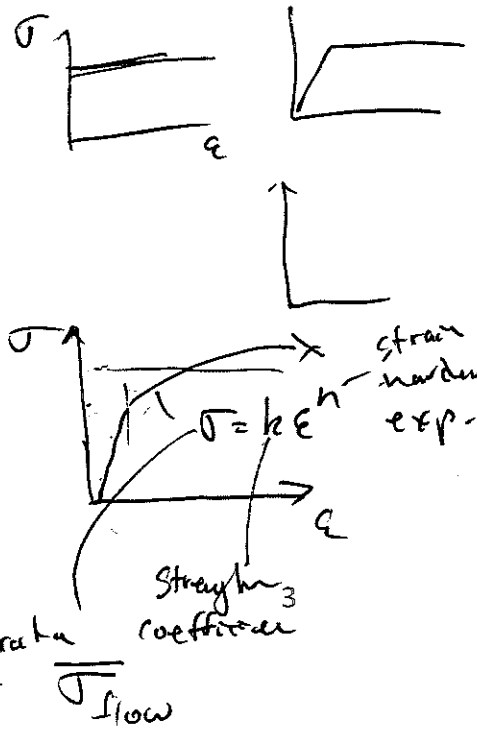
$$\varepsilon_{forging} = \ln\left(\frac{h_o}{h_i}\right) \qquad \dot{\varepsilon} = \frac{-V}{h_o}$$



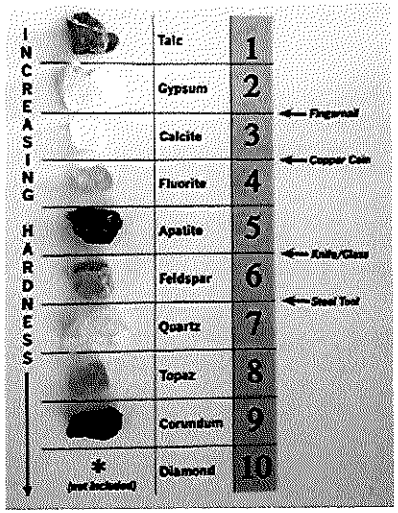








Hardness/Indentation

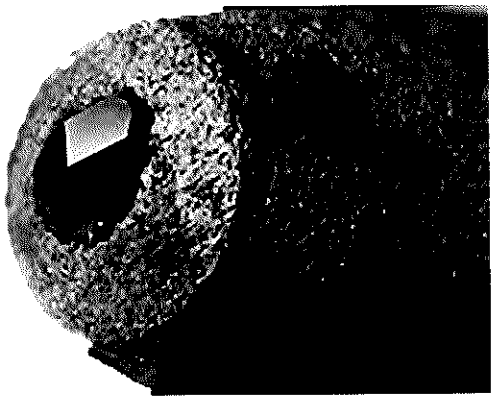


Mohs
Rockwell
Vickers
brinell
Meyer

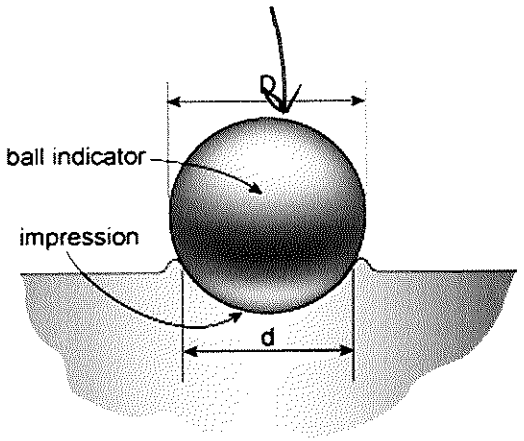
$$H = \frac{F}{A_{projected}}$$

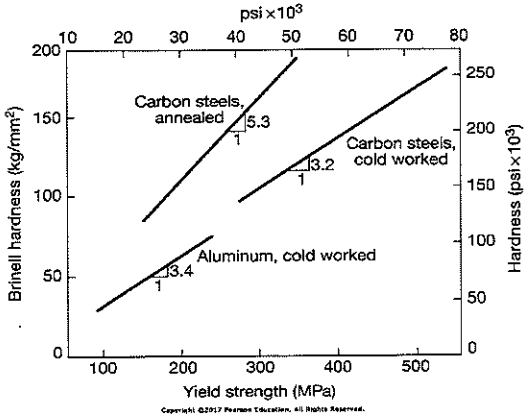
key eq

$$\frac{F}{A_{actual}}$$



Wikipedia

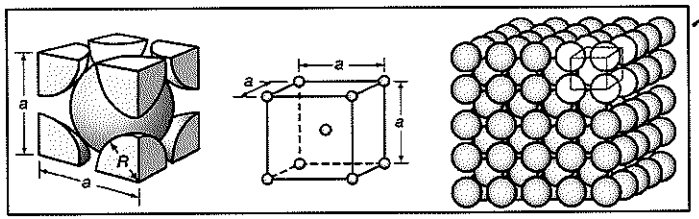




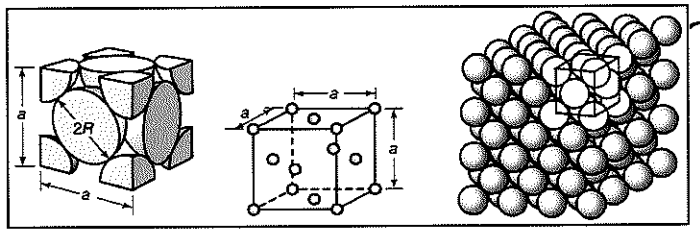
$$H = CS_y$$

$$H = 3S_y$$ — key eq.

Material Structure



BCC

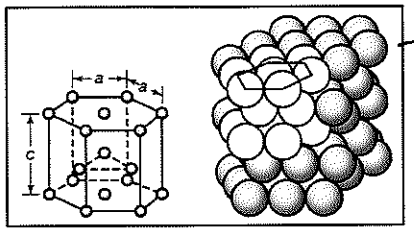


FCC

Softer + more ductile

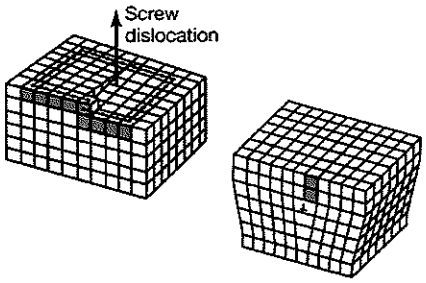
Many slip systems

ductile



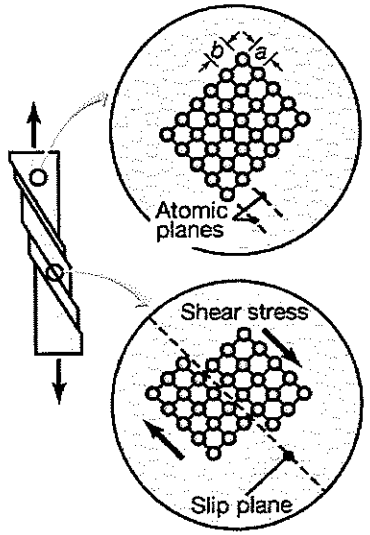
HCP

have fewer slip systems ⇒ higher strength



dislocation

facilitate slip

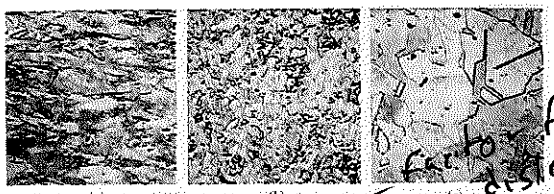


modulus – structure independent

strength – microstructure dependent

Strengthening

1) Grain size reduction

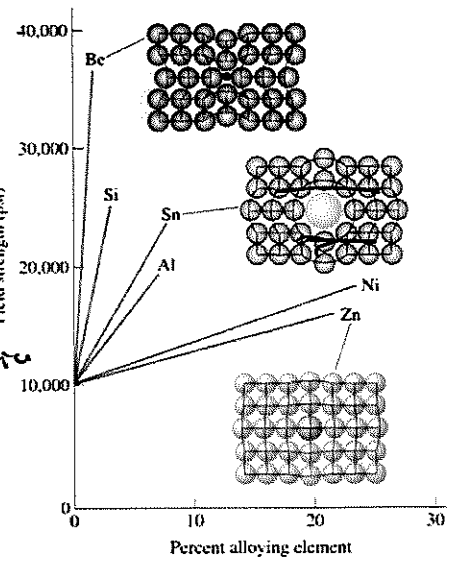


Hall-Petch

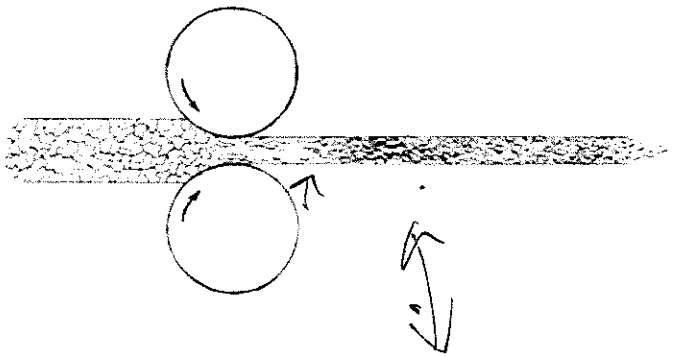
$$\sigma_y = \sigma_i + k D^{-1/2}$$

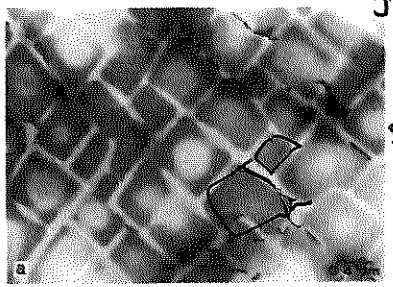
σ_i = strength of grains

Solid solution strength



Cold work





Precipitation hardening

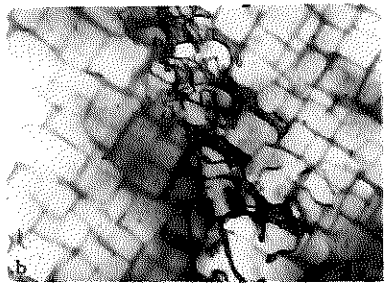
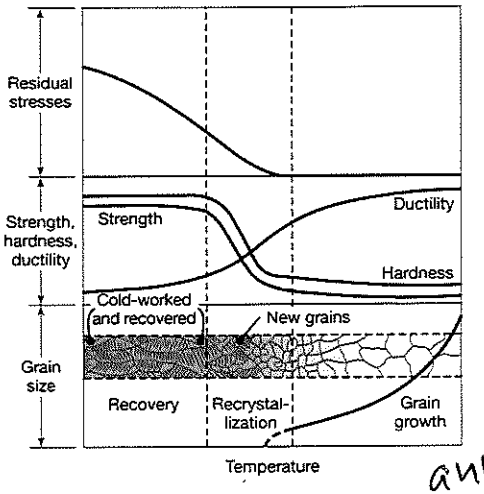


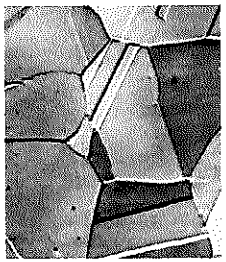
Fig. 7. (a) TEM micrograph of aged microstructure of CMSX-3 with cuboidal γ' and occasional dislocations at the γ/γ' interfaces. (b) TEM micrograph of aged microstructure of CMSX-3. Occasional networks of "grown-in" dislocations contained in the matrix are present, as shown at the center.

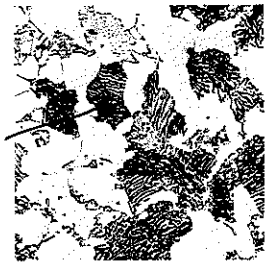


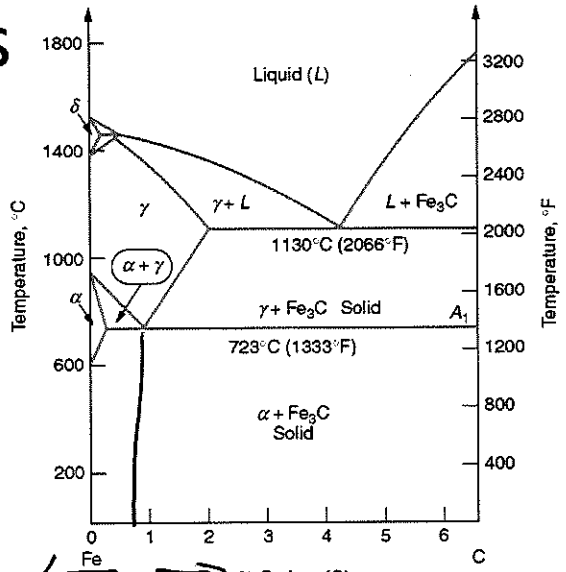
annealing

Iron-C Phases/Microconstituents

- Phases
  - Ferrite
  - Austenite
  - Cementite Fe_3C
- Microconstituents
  - Pearlite /// layers of ferrite + cementite
  - Martensite
  - Bainite

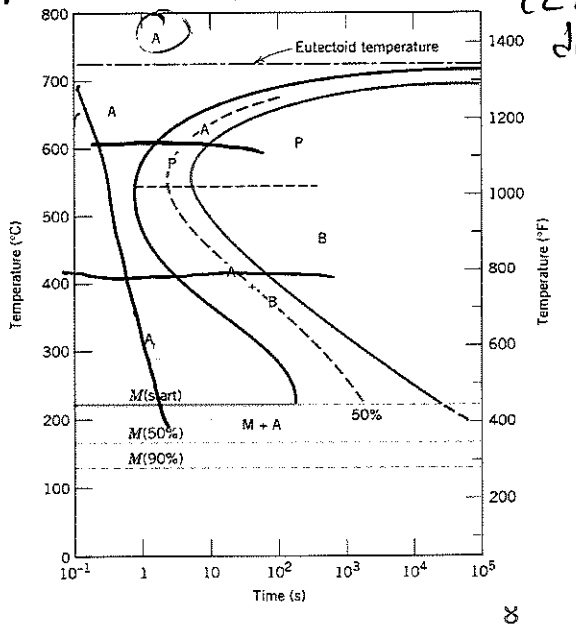




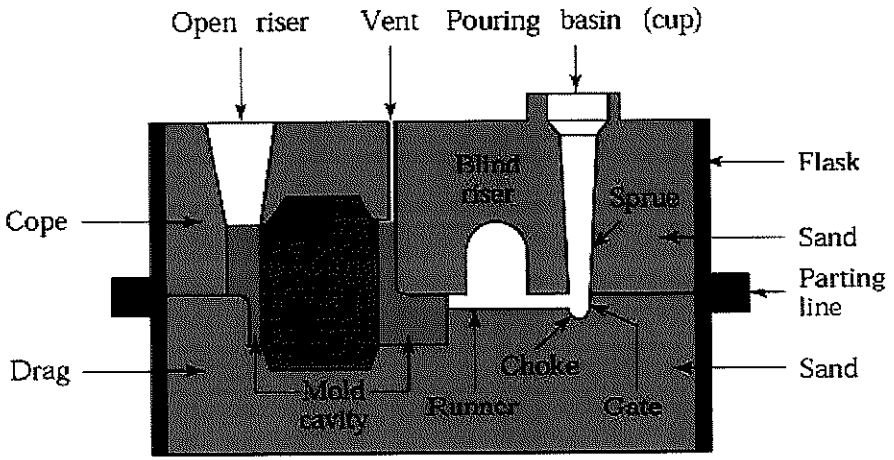


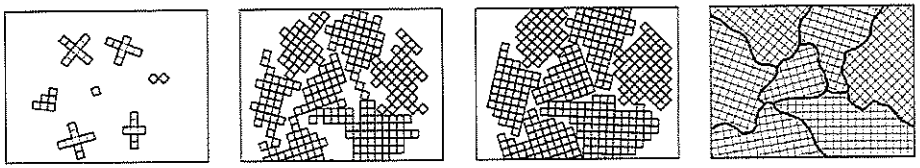
hypo eutectoid hyper eutectoid

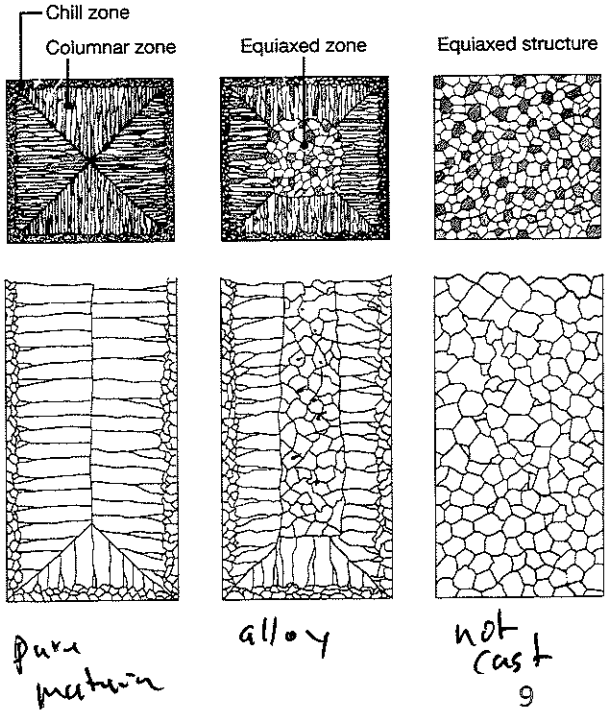
CCT diagram



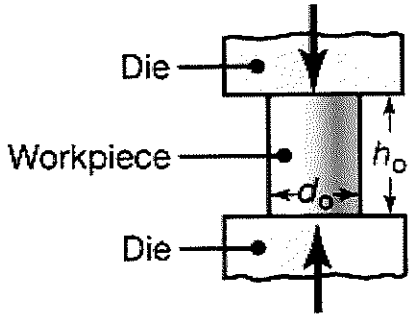
Casting


Open riser
Vent
Pouring basin (cup)
Blind riser
Sprue
Flask
Cope
Sand
Parting line
Drag
Sand
Mold cavity
Runner
Choke
Gate



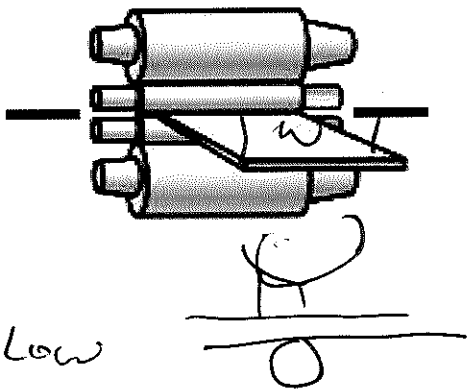

Chill zone
Columnar zone
Equiaxed zone
Equiaxed structure
pure metal
alloy
not cast

Bulk Deformation Processes



$F = K_p \bar{\sigma}_f A_{projected}$

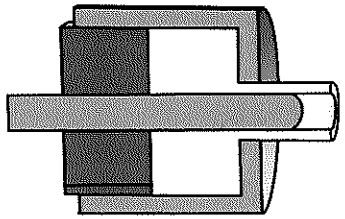
from table



$F = Lw \frac{2}{\sqrt{3}} \bar{\sigma}_{flow}$

high — a

$F = a\left(1 - \frac{\mu \cdot L}{2h_{avg}}\right)$



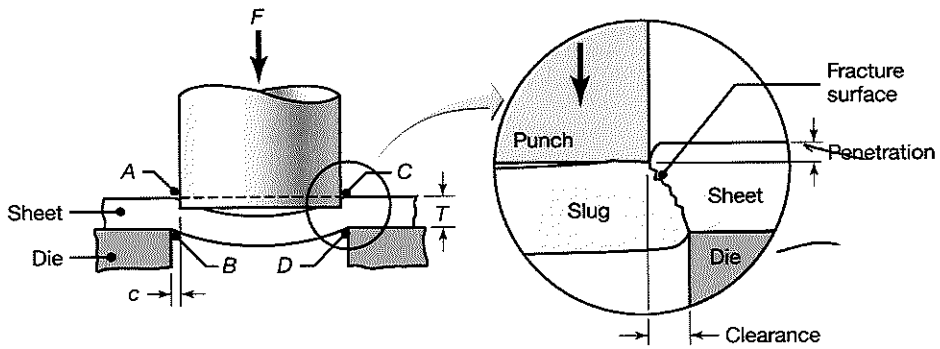
$F = A_o S_y (a + b L_n R_e)$

better to use Flow

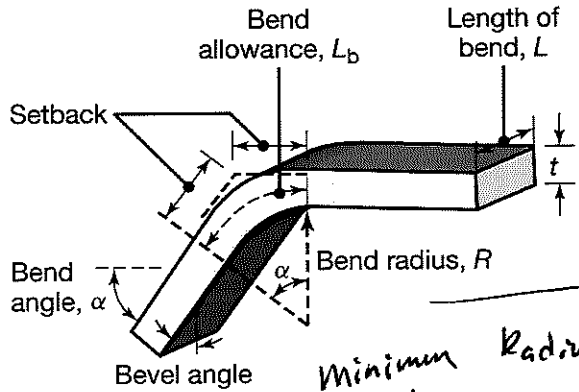
$a \sim 0.8$

$b = 1.2 - 1.5$

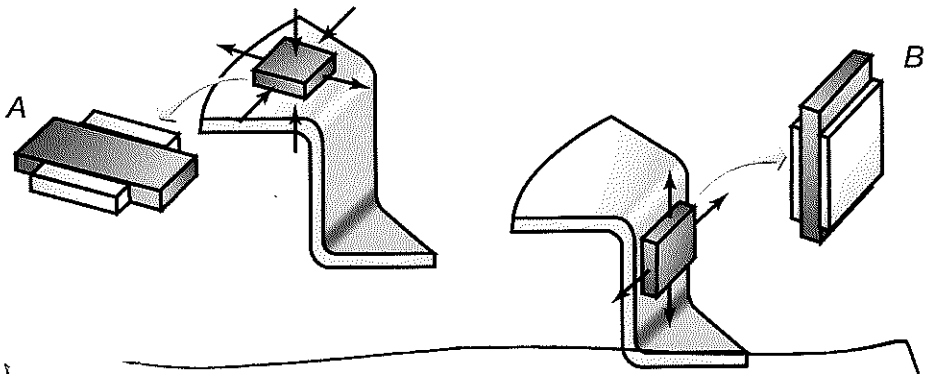
Sheet Metal Processes



$$F_{max} = 0.7\, S_{uT} \cdot t \cdot L$$



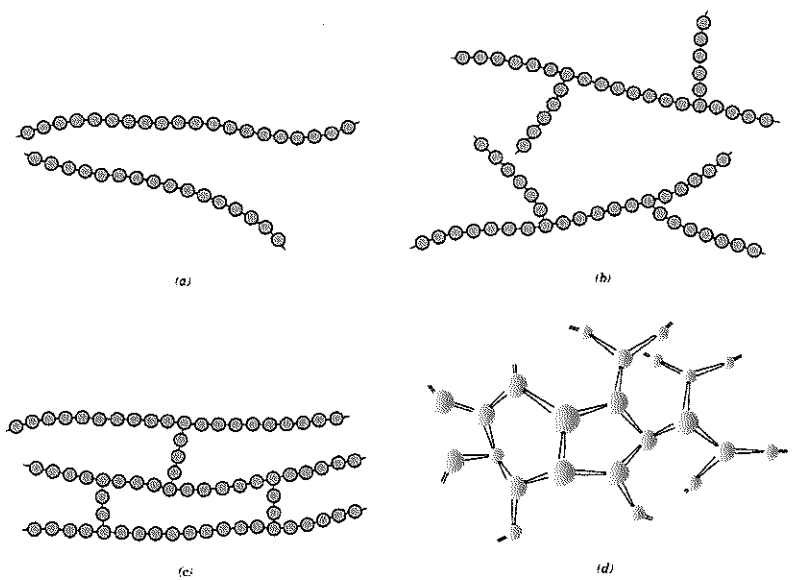
Minimum Bend Radius $\frac{R}{t} = \frac{60}{r} - 1$



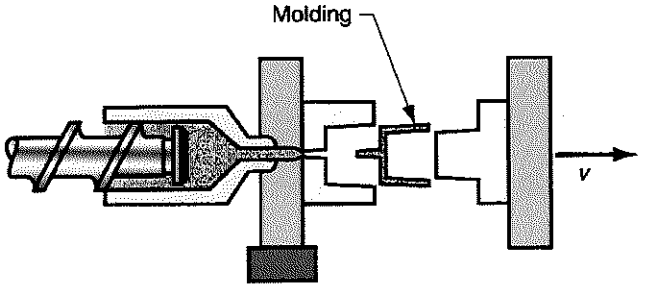
$$F_{max} = \pi D_p T_o S_{uT} \left(\frac{D_o}{D_p} - 0.7 \right)$$

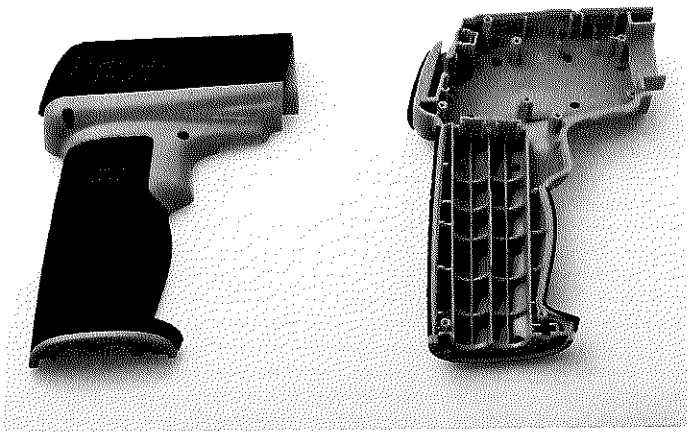
Key slot

Polymers – Properties/Processing/Design



$$DP = \frac{MW_{avg}}{MW_{mer}}$$

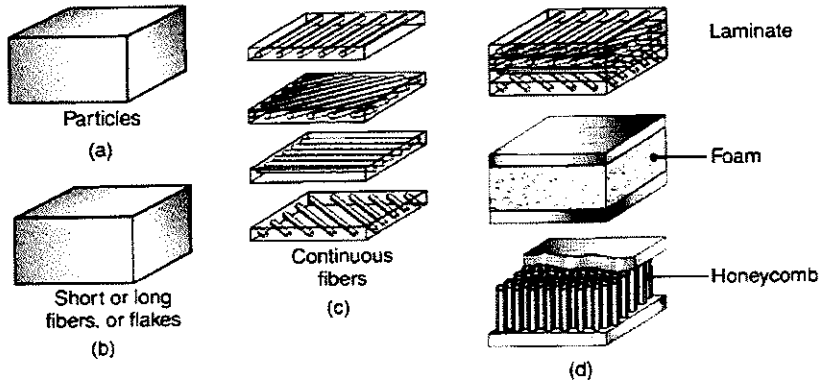


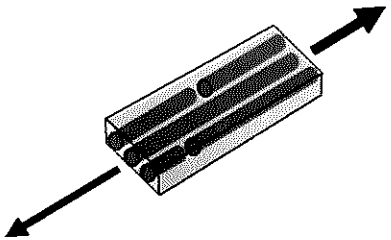


$$D_c = D_p + D_p \cdot S + D_p S^2$$

D_c: cavity, D_p: part

Composites



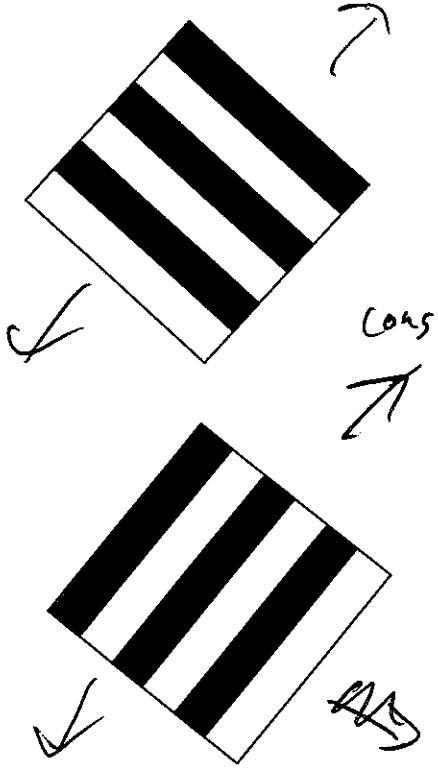


long fiber composites

$E_1 = Y_{matrix} E_{matrix} + Y_{fiber} E_{fiber}$

$S_{fail}^{(+)} = S_{fiber} Y_{fiber} + S_{matrix} E_{matrix}$

const eq. Stress



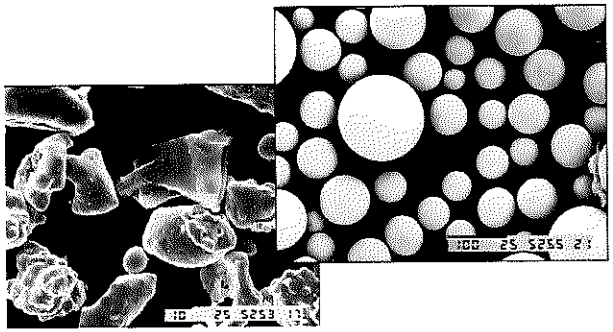
const eq. Strain

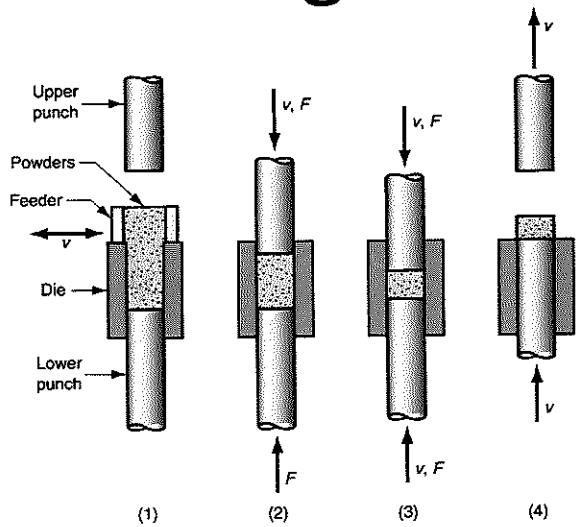
particle composites

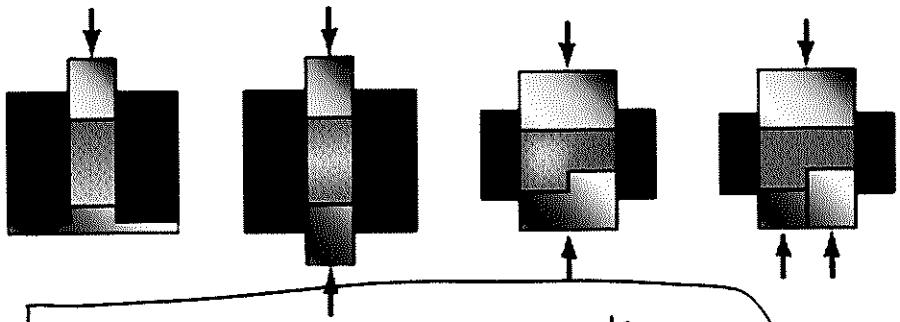
↓

Nasa

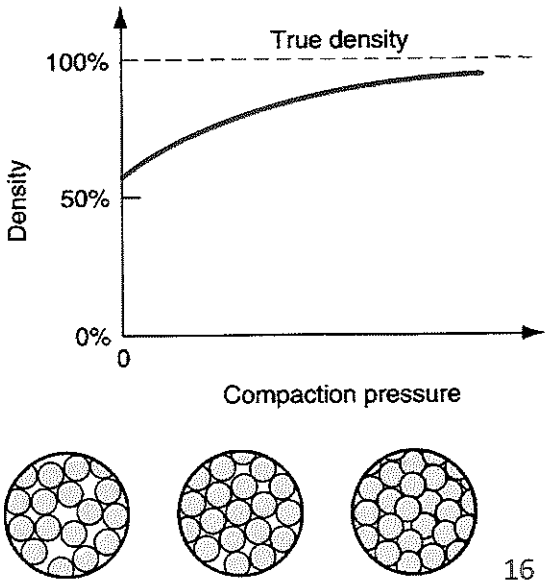
Powder Metallurgy Processing







Key eq: $P_x = P_o e^{\frac{-\mu m k x}{D}}$



Ceramics Properties

Brittle failure

$$E = E_0 \left(1 - 1.9P + 0.9P^2\right)$$

E_0: zero porosity

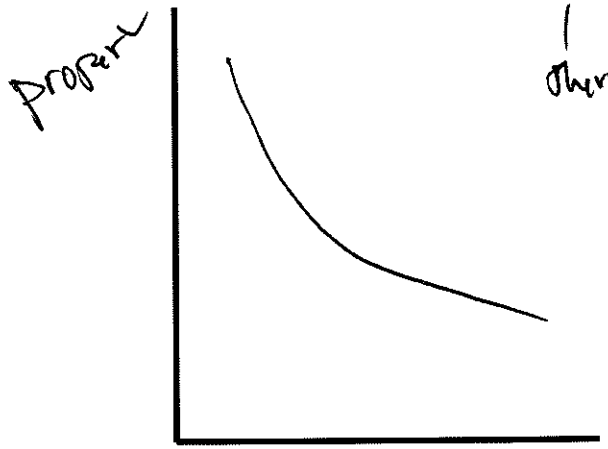
$P \equiv$ volume fraction of pores

$$S_{ut} = S_{ut,0}\left(e^{-nP}\right)$$

n: cons.

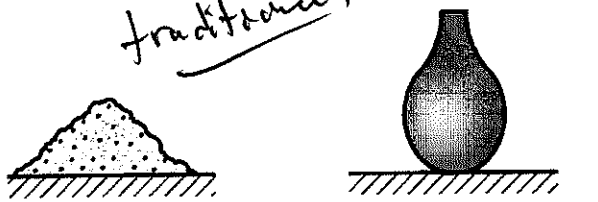
$$k = k_0(1-P)$$

k: thermal conductivity

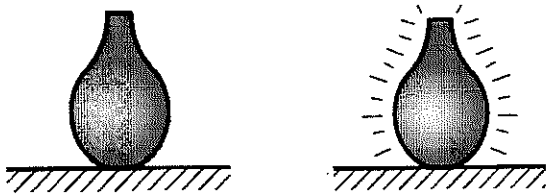


Ceramics Processing

traditional

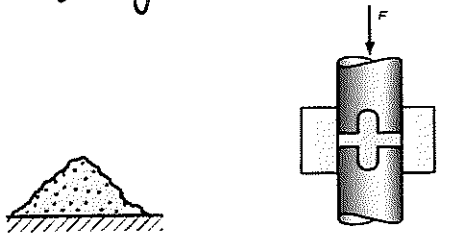


(1) Preparation of powders (2) Shaping of wet clay

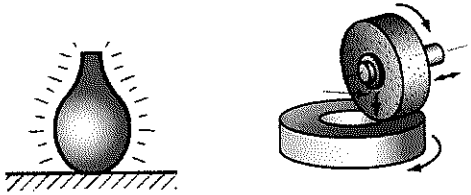


(3) Drying (4) Firing

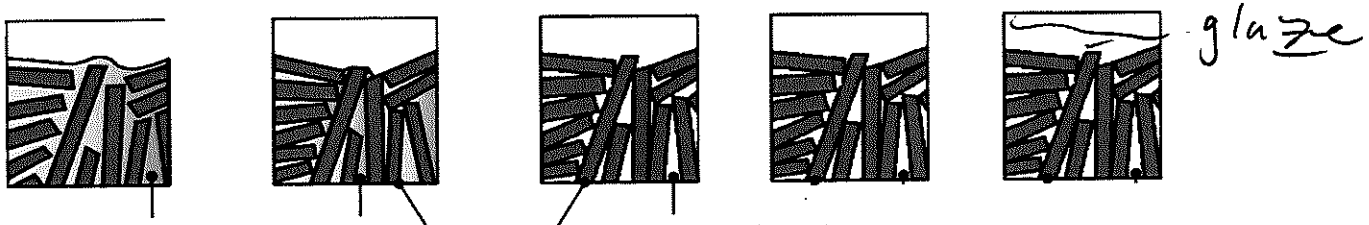
Engineering



(1) Preparation of powders (2) Dry shaping



(3) Firing (4) Finishing



glaze

interparticle water

bonding

shrinkage