HW#7

1a) the modulus of elasticity is impossible to discern w/ the picture.

maybe $\frac{250\text{ MPa}}{0.0005} = \frac{\sigma}{\epsilon} = 500\text{ GPa}$

b) proportionality limit of 250 MPa

c) 0.2% YS ≈ 300 MPa

d) UTS ≈ 650 MPa

e) w/ $D = 10e{-3}\,m$, $l = 500e{-3}\,m$, $F = 50000\,N$

$A = (10e^{-3})^2 \frac{\pi}{4} = 7.854e^{-5}\,m^2$

$\sigma_e = \frac{F}{A} = \frac{7.854e^{-5}\,m^2}{50{,}000\,N} = 636.620\text{ MPa}$

@ σ of 636.620 MPa ~@ max stress, so $\epsilon = 0.0325$

$\epsilon = \frac{\Delta l}{l_0}$ w/ Δl being elongation ∴ $\Delta l = \epsilon l_0 = (0.0325)(500\,mm)$

$\boxed{\text{elongation } \Delta l = 16.25\,mm}$

$\boxed{\text{the deformation is plastic}}$

HW #7 - cont

f) The treatment increases the TS, 0.2% YS, & proportionality limit. The elasticity modulus should also increase, in theory, however, the increase is difficult to observe. The ductility also decreased.

g) Cold-work / cold-rolling would lead to a similar effect as observed.

2) slip normal w/ $\varphi = 65°$. $\lambda = [30°, 48°, 78°]$.

a) most favored slip plane is one w/ highest SF.

$SF = \cos\varphi \cos\lambda = \cos(65°)\cos(30°) = \underline{0.366}$

$\cos(65°)\cos(48°) = 0.283$

$\cos(65°)\cos(78°) = 0.0879$

$\boxed{\text{max SF of } 0.366 \text{ : slip along } \lambda = 30°}$

b) critical resolved shear stress along these parameters is:

$\boxed{\tau_{CR} = \sigma\, SF_{max} = 0.915 \text{ MPa}}$

HW #7 - cont

3a) Hall Petch Eq: $\sigma_y = \sigma_0 + k_y d^{-1/2}$

d = average grain size & σ_0, k_y are constants

$\boxed{\sigma_0 = 30\,MPa}$; YS @ $d = 0$

@ $d^{-1/2} = 8$, $\sigma = 130 = \sigma_0 + k_y d^{-1/2} = 30 + k_y d^{-1/2}$

$\Rightarrow k_y = \frac{(130-30)}{8\ mm^{-1/2}} = \boxed{12.5\ MPa\sqrt{mm} = k_y}$

b) @ $d = 2\,\mu m = 2e3\ mm$, $d^{1/2} = 0.01826\ mm^{-1/2}$

$\sigma_y = 30 + (12.5)(0.01826) = \boxed{30.228\ MPa = \sigma_y}$

c) $2\,\mu m \rightarrow 3.4\,\mu m$ in 250 min @ 450°C
how long to get to $4.7\,\mu m$? $n = 2.1$

use Eq. 7-9 $d^n - d_0^n = Kt$

need K first $\Rightarrow K = \frac{d^n - d_0^n}{t} = \frac{(3.4)^{2.1} - (2)^{2.1}}{250} = 0.03511$

w/ K, now solve for t $\Rightarrow t = \frac{d^n - d_0^n}{K} = \frac{(4.7)^{2.1} - (3.4)^{2.1}}{} = 362.35$ min

$\boxed{\text{∴ the treatment should continue for 362.35 more minutes for } d = 4.7\,\mu m}$

HW# 7-cont

4) SS creep @ 200°C (473K), $Q_c = 140e3$ J/mol

find $\dot{\epsilon}_s$ @ 250°C (523K) & $\sigma = 48$ MPa

$\dot{\epsilon}_s$ [1/hr]	σ [MPa]
2.5e-3	55
2.4e-2	89

$[R] = \frac{J}{mol \cdot K} \Rightarrow R = 8.314$

use eq 8.25 $\dot{\epsilon}_s = K_2 \sigma^n \exp\left(\frac{-Q_c}{RT}\right)$

$\Rightarrow \ln(\dot{\epsilon}_s) = \ln K_2 + n \ln \sigma - \frac{Q_c}{RT}$

have 2 eqs: (1) $\ln(2.5e{-3}) = \ln(K_2) + n \ln(55) - \frac{140e3}{(8.314)(473)}$

(2) $\ln(2.4e{-2}) = \ln(K_2) + n \ln(89) - \frac{140e3}{(8.314)(473)}$

matrix system: $\begin{bmatrix} 1 & \ln(55) \\ 1 & \ln(89) \end{bmatrix} \begin{bmatrix} \ln(K_2) \\ n \end{bmatrix} = \begin{bmatrix} \ln(2.5e{-3}) + \frac{140e3}{(8.31)(473)} \\ \ln(2.4e{-2}) + \frac{140e3}{(8.31)(473)} \end{bmatrix}$

then $\ln(K_2) = C \Rightarrow K_2 = \exp(C)$

from numpy.linalg.solve $\Rightarrow K_2 = 47937.15$

$n = 4.699$

$\Rightarrow \dot{\epsilon}_s = K_2 \sigma^n \exp\left(\frac{-Q_c}{RT}\right) = \boxed{1.3186 \text{ 1/hr} = \dot{\epsilon}_s}$

HW # 7 - cont

5.1) 50 %wt Ni, 50%wt Cu w/ 1400°C → 1200°C

a) first solid phase, α, forms @ 1320°C

b) 100% L, 0% α

c) liquid starts to solidify @ 1320°C, but all liquid is solidified @ 1260°C

d) 0% L, 100% α

2) 65 %wt Ni, 35 %wt Cu, in α+L w/ 70%wt Ni α

e) temp ~1330°C

f) α composition of 57 %wt Ni

g) $W_L = \frac{C_\alpha - C_0}{C_\alpha - C_L} = \frac{70-65}{70-57} = \boxed{0.3846 = W_L}$

$W_\alpha = \frac{C_0 - C_L}{C_\alpha - C_L} = \frac{65-57}{75-57} = \boxed{0.6154 = W_\alpha}$