Tampereen teknillinen yliopisto
Materiaalitekniikan osasto

MOL-2200 Materiaalien mekaaninen käyttäytyminen
MOL-2206 Mechanical behavior of materials

tentti/exam 1.12.2006

MUISTIINPANOJEN KÄYTTÖ KIELLETTY !
NO LITERATURE ALLOWED!

Vastaa **enintään viiteen** kysymykseen oman valintasi mukaan! Answer **only in five** questions of your choice!

1. Mekaaninen vaimeneminen viskoelastisissa materiaaleissa.
   3 f stress strain loop lissajoun
   Mechanical attenuation (damping) in viscoelastic materials.

2. Tarkastele ns. parabolisen muokkauslujittumisyhtälön ('Hollomonin yhtälö') käyttöä materiaalien lujuusominaisuuksien kuvaamisessa. Esitä, miten yhtälön parametrien arvot määritetään (mistä datasta, miten tehdään, jne....)

   Discuss the use of the parabolic strain-hardening equation ('Hollomon equation') in describing the strength properties of materials. Show how the values for the parameters of the equation can be determined (from which data, how, etc.....)

3. Esitä mitä tapahtuu, kun a) kaksi särmädislokaatiota leikkaa toisensa ja b) särmädislokaatio leikkaa ruuvidislokaation. Oletetaan, että dislokaatiot ovat toisiaan vastaan kohtisuorassa.

   Show what happens when a) two edge dislocations intersect, b) an edge dislocation intersects a screw dislocation. Assume that the dislocations are perpendicular to each other.

4. Vertaile keskenään haurasmurtuman kolmea eri perustyyppiä (Mode I, Mode II ja Mode III).

   Compare the three different types of brittle fracture (Mode I, Mode II and Mode III) muokkauslujitus kerroin
   raeraja taipe ja liukuminen m 0,5-08 $\sigma_T = K'(\varepsilon)^m$

5. Superplastisuuden perusta ja edellytykset. $d < 10\,\mu m$ $T > 0{,}5T_m$ ei rekrist. sanan muot ~~Fäket~~ ☐ ei saa muut

   Background, conditions and material requirements for superplasticity. myötönop 10^{-3} 1/s
   Mg-41

6. Vertaile low cycle (LCF) ja high cycle (HCF) väsymistä toisiinsa. Millaiset materiaalit soveltuvat parhaiten LCF ja HCF tilanteisiin?

   Compare low cycle fatigue (LCF) and high cycle fatigue (HCF). What kind of materials are best suited for LCF and HCF cases ?

$$\sigma_T = \frac{F}{A_i} = \frac{F}{A_0}\cdot\frac{A_0}{A_i} = \sigma_E\left(\frac{A_0}{A_i}\right) = \sigma_E(1+\varepsilon_E) \qquad \sigma_T = K(\varepsilon_T)^n \qquad \tau = \frac{32M_t r}{\pi D^4} \qquad \varepsilon_2 = \varepsilon_3 = -\nu\varepsilon_1$$

$$\frac{\Delta V}{V} = \varepsilon_1(1-2\upsilon) \qquad \sigma_y = m\cdot\tau_{crss} \qquad \tau_B \cong \frac{Gb}{L-2r} \qquad \frac{\Delta V}{V} = \frac{3\sigma}{E}(1-2\upsilon) = \frac{\sigma}{K}$$

$$K = -\Omega_0\left(\frac{\partial\sigma}{\partial\Omega}\right)_{\Omega_0} = +\Omega_0\left(\frac{\partial^2 U}{\partial\Omega^2}\right)_{\Omega_0} \qquad \tau = \tau_{max}\cdot\sin\left(\frac{2\pi x}{b}\right) \qquad \tau_{max} \approx \frac{G}{30} \qquad \tau_f = G\cdot\exp\left(\frac{-2\pi w}{b}\right)$$

$$\tau = \frac{Gb}{2\pi r} \qquad U_s \approx Gb^2 \qquad \sigma_x = \frac{-Gb}{2\pi(1-\nu)r}\sin\theta(2+\cos\theta) \qquad \sigma_y = \frac{Gb}{2\pi(1-\nu)r}\sin\theta\cos2\theta$$

$$\tau_{xy} = \tau_{xy} = \frac{Gb}{2\pi(1-\nu)r}\cos\theta\cos2\theta \qquad \sigma_z = \frac{-Gb\nu\sin\theta}{\pi(1-\nu)r} \qquad v_D = \left(\frac{\tau}{\tau_0}\right)^p \qquad F_s = \frac{Gb^2}{2\pi r}$$

$$F = \tau b \qquad \frac{a}{2}[\bar{1}01] \rightarrow \frac{a}{6}[\bar{2}11] + \frac{a}{6}[\bar{1}\bar{1}2] \qquad \tau = \frac{Gb}{r} \qquad \tau_{rss} = \frac{F\cdot\cos\lambda}{A_s} = \frac{F}{A_0}\cos\phi\cos\lambda = \frac{\sigma}{m}$$

$$\sigma_T = K'(\dot\varepsilon)^m \qquad \tau = \tau_0 + \alpha Gb(\rho)^{1/2} \qquad \tau \approx \frac{Gb}{L'}\cos\frac{\phi_c}{2} \qquad \tau^* = (\tau_{app} - \tau_0)\left(\frac{d}{4r}\right)^{1/2}$$

$$\tau = \tau_0 + \alpha Gb\sqrt{\rho} \qquad \sigma_a = \sigma_{fat}\left(1 - \frac{\sigma_{mean}}{T.S.}\right) \qquad \sigma_{th} = \left(\frac{\gamma E}{a_0}\right)^{1/2} \qquad \sigma_E = F/A_0 \qquad \varepsilon_E = \Delta l/l_0$$

$$\gamma = \frac{\tau}{G} \qquad \frac{1}{E_{[hkl]}} = \frac{1}{E_{\langle100\rangle}} - 3\left(\frac{1}{E_{\langle100\rangle}} - \frac{1}{E_{\langle111\rangle}}\right)(\alpha^2\beta^2 + \alpha^2\gamma^2 + \beta^2\gamma^2)$$

$$\tau_{app} = \tau_0 + 2\tau^* r^{1/2} d^{-1/2} = \tau_0 + k'_y d^{-1/2} \qquad \sigma_y = \sigma_0 + k_y d^{-1/2} \qquad \varepsilon = \frac{\sigma}{E} \qquad \sigma_T = F/A_i$$

$$\sigma_T = \frac{F}{A_i} = \frac{F}{A_0}\cdot\frac{A_0}{A_i} = \sigma_E\left(\frac{A_0}{A_i}\right) = \sigma_E(1+\varepsilon_E) \qquad \sigma_T = \sigma_E(1+\varepsilon_E) \qquad \varepsilon_T = \ln(1+\varepsilon_E)$$

$$\dot\varepsilon_{ll} = A\sigma^{m'}\exp(-Q_c/RT) \qquad \dot\varepsilon_{dg} = \dot\varepsilon_0\exp\left(-\frac{U_0}{kT}\right)\left[\exp\left(\frac{\delta U}{kT}\right) - 1\right] \qquad \sigma_F = \frac{K_c}{(\pi c)^{1/2}} \qquad \frac{dc}{dN} \approx A(\Delta K)^m$$

$$N_v(\text{veto}) \approx \exp\left(-\frac{Q_f}{kT}\right)\exp\left(\frac{\sigma\Omega}{kT}\right) \qquad U_{el} \approx \frac{\sigma^2}{2E}\pi c^2 \qquad \sigma_F = \left(\frac{EG_c}{\pi c}\right)^{1/2} \qquad \sigma_F = \left(\frac{2\gamma E}{\pi c}\right)^{1/2}$$

$$N_v(\text{puristus}) \approx \exp\left(-\frac{Q_f}{kT}\right)\exp\left(-\frac{\sigma\Omega}{kT}\right) \qquad \dot\varepsilon_{NH} = A_{NH}\left(\frac{D_L}{d^2}\right)\left(\frac{\sigma\Omega}{kT}\right) \qquad \dot\varepsilon_C = A_C\left(\frac{D_{GB}\delta'}{d^3}\right)\left(\frac{\sigma\Omega}{kT}\right)$$

$$\dot\varepsilon_i = A_i D_i\left(\frac{\sigma}{G}\right)^{m''}\left(\frac{\sigma\Omega}{kT}\right)\left(\frac{b}{d}\right)^{n'} \qquad \sigma_{th} = \frac{\lambda E}{2\pi a_0} \cong \frac{E}{2\pi} \cong \frac{E}{10} \qquad \Delta K \sim \Delta\sigma(c)^{1/2} \qquad \sum\frac{n_i}{N_{fi}} = 1$$

$$\sigma_{max} \approx 2\sigma\left(\frac{c}{\rho}\right)^{1/2} \qquad \sigma_F = \left(\frac{\gamma E\rho}{4a_0 c}\right)^{1/2} \qquad \sigma_F = \left(\frac{2\gamma E\rho}{3\pi a_0 c}\right)^{1/2} \qquad \frac{d}{dc}\left[4c\gamma - \frac{\pi\sigma^2 c^2}{E}\right]_{\sigma=\sigma_F} = 0$$

$$\tfrac{1}{2}\Delta\varepsilon_{el} = \frac{\sigma'_f}{E}(2N_f)^{-b} \qquad \tfrac{1}{2}\Delta\varepsilon_{pl} = \varepsilon'_f(2N_f)^{-c} \qquad \tfrac{1}{2}\Delta\varepsilon = \tfrac{1}{2}\Delta\varepsilon_{el} + \tfrac{1}{2}\Delta\varepsilon_{pl} = \frac{\sigma'_f}{E}(2N_f)^{-b} + \varepsilon'_f(2N_f)^{-c}$$