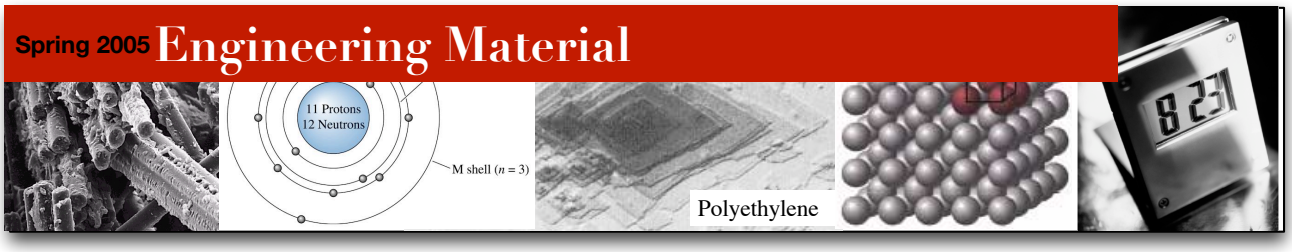


Exam III

Wednesday, 30, May 2005

Duration: 60 minutes

Closed Book Exam

Write clearly your derivations and answers on the question sheet

Name:

ID#:

Miscellaneous Formulas

$$\sigma_y = \sigma_0 + k_y d^{-1/2} \qquad E = 2G(1+\nu) \qquad K_{IC} = Y(a/W)\sigma\sqrt{\pi a} \qquad \sigma_m = 2\sigma_o\sqrt{\frac{a}{r_t}}$$

$$B = 2.5\left(\frac{K_{Ic}}{\sigma_y}\right)^2 \qquad d^n - d_0^n = Kt \qquad \sigma_m = \sigma_0\left[1 + 2\left(\frac{a}{\rho_t}\right)^{1/2}\right]$$

Arrhenius type equation: $A = A_o \exp(-\frac{Q}{RT})$ or $A = A_o \exp(-\frac{Q}{kT})$

I Fracture [30 Pts]

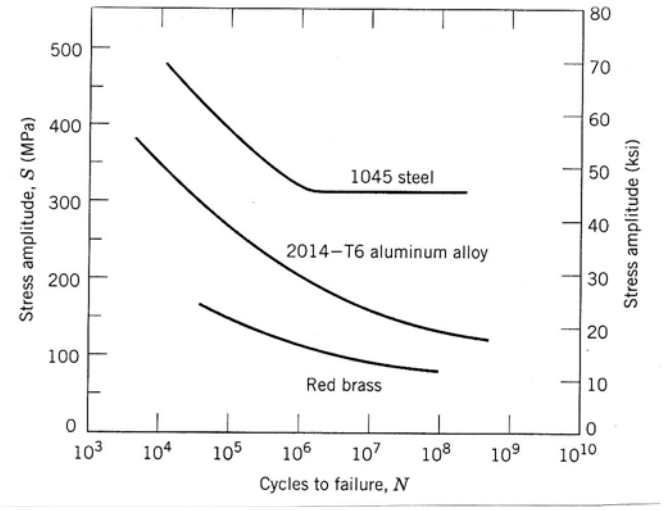
a. A high-strength steel has a yield strength of about 2100 MPa and a plane strain fracture toughness of 66 MPa $m^{0.5}$. A landing gear is to be fabricated from this material using a factor of safety N=1.4 for calculating the safe stress (working stress).
(i) Calculate the largest size of internal flaws that this material can tolerate. Assume the geometrical parameter Y=1.12
(ii) If flaws must be 2.5 mm long to be detectable by the available NDT instrument, is this a reasonable stress at which to operate?

b. Briefly explain what is the difference between failure due to fracture and due to fatigue in terms of the applied load. Would you expect ceramics to be equally susceptible to both?

c. Describe some of the mechanical and physical properties to consider in selecting a material for a supersonic aircraft wing.

II Fatigue [20 Pts]

A cylindrical 1045 steel bar is subjected to repeated compression- tension stress cycling along its axis. If the load amplitude is 22 kN, compute the minimum allowable bar diameter to ensure that fatigue failure will not occur. Assume a factor of safety of 2.0.



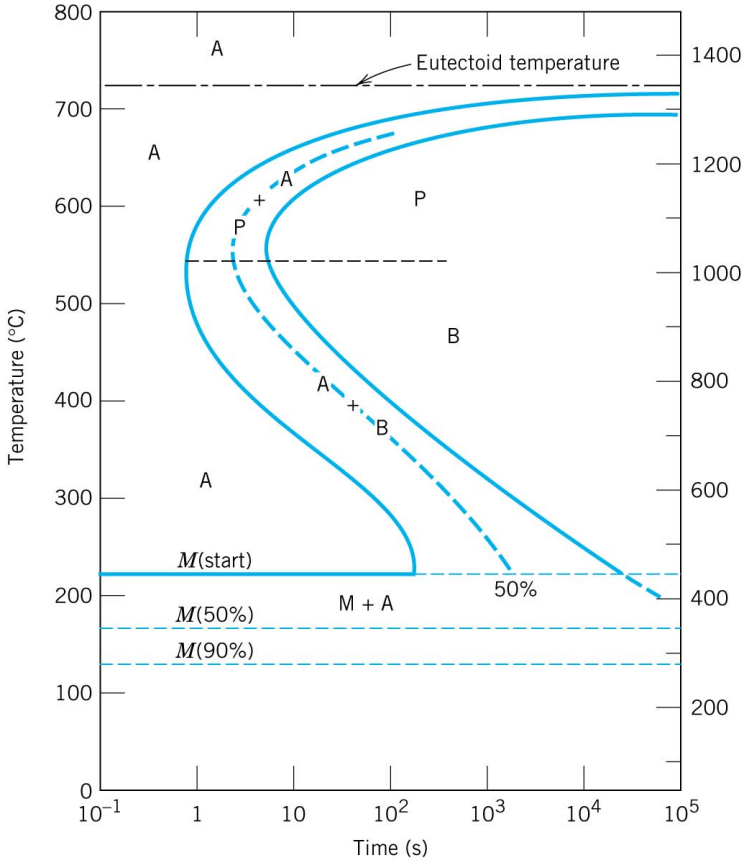
III TTT Diagram [30 Pts]

a. Calculate the microstructure of a 0.77%C steel (at the 250˚C temperature) that has the following heat treatment:
(i) instantly quenched from the g region to 500˚C,
(ii) held for 5 s, and (iii) quenched instantly to 250˚C

b. What will happen if the resulting microstructure is held for 1 day at 250˚C and then cooled to room temperature

c. What will happen if the resulting microstructure from part (a) is quenched directly to room temperature

d. sketch the various thermal histories on the TTT diagram



IV Heat Treatment [20 Pts]

A manufacturer has for several years been making 16 mm diameter toggle pins, which in service are subjected to impact loadings, by machining a mild-steel bar and then case hardening the surface by carburizing. By mistake, the manufacturer was supplied with 0.5% carbon-steel bar which went through the same process

How would the properties of the pins be affected (toughness, ductility , strength). In view of these changes in properties would you recommend that they be allowed to go into service. Explain.