Name.....Student I.D.....

Department of Mining and Materials Engineering

Faculty of Engineering

Prince of Songkla University

Final Examination for Semester: 2 Academic Year: 2004

Date: March 4, 2005 Time: 13.30-16.30

Subject: 237-221 Mechanical Metallurgy Room: R300

Instructions

1. There are 5 problem sets. Please do all of them and write your answers on the space provided after each problem set. If you need more space, you can write the answer on the back of the problem set.
2. Only two (2) pieces of A4-size note are allowed. You may write on both sides of them. Please return them with your answers.
3. Dictionary, calculator, and stationery are also allowed.
4. Text books and other studying materials are not allowed.
5. This final-term exam is accounted for 30% of the total grade point.

Note for exam instructor

Please distribute a normal graph paper for each student.

Dr. Thawatchai Plookphol

Problem No.	Full Score (points)	Student's Score (points)
1.	20	
2.	20	
3.	15	
4.	45	
5.	20	
Total	120	

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1. A steel with yield strength in tension of 300 MPa is tested under a state of stress where $\sigma_2 = \frac{\sigma_1}{2}$, $\sigma_3 = 0$. What is the stress at which yielding will occur if it is assumed that

(a) the maximum-shear-stress theory (Tresca) holds, and (10 points)
(b) the distortion-energy theory (von Mises) holds, (10 points)

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2. Briefly describe the following strengthening mechanisms:

(a) Working hardening (10 points)

(b) Grain boundary strengthening (10 points)

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3. Briefly describe the following creep mechanisms:

(a) Power-law (Dislocation) creep (5 points)

(b) Diffusional creep (10 points)

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4. A cylindrical tube in a chemical plant is subjected to an excess internal pressure of 6 MPa, which leads to a circumferential stress in the tube wall. The tube wall is required to withstand this stress at a temperature of 510°C for 9 years. A designer has specified tubes of 40 mm inside diameter and 2 mm wall thickness made from a stainless alloy of iron with 15% by weight of chromium. The manufacturer's specification for this alloy gives the following information:

Temperature (°C)	618	640	660	683	707
Steady-state creep rate, $\dot{\varepsilon}_{ss}$ (s^{-1}), for an applied tensile stress of 200 MPa	1.0×10^{-7}	1.7×10^{-7}	4.3×10^{-7}	7.7×10^{-7}	2.0×10^{-6}

Over the present ranges of stress and temperature the alloy can be considered to creep according to the equation

$$\dot{\varepsilon}_{ss} = A\sigma^5 \exp\left(\frac{-Q}{RT}\right)$$

where, A and Q are constants, R is the universal gas constant, and T is the absolute temperature. Given that failure is imminent at a creep strain of 0.01 for the present alloy, R = 8.314 J/mol K.

(a) Calculate the values of constants A and Q (20 points)
(b) Determine creep stress due to the internal pressure of 6 MPa (5 points)
(c) Estimate creep strain (ε) at the time of 9 years (15 points)
(d) Comment on the safety of the design (safe or not safe), Why? (5 points)

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5. The linear relationship between crack growth rate ($\frac{dc}{dN}$) and stress intensity range (ΔK) on the log-log scale can be expressed as

$$\frac{dc}{dN} = C(\Delta K)^p$$

Estimate the values of constants C and p for aluminum alloy from the data shown in Figure 1 below. (20 points)

Please use basic SI units.

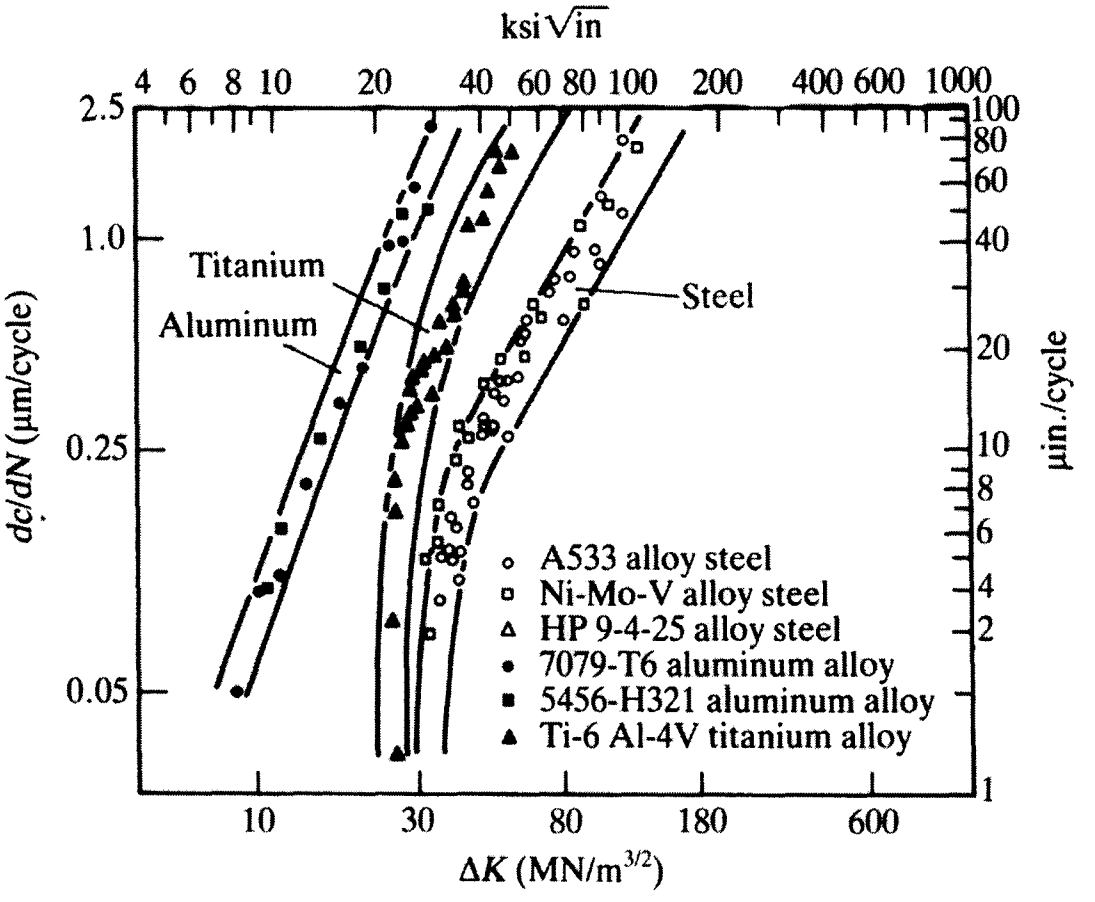

Figure 1