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

Department of Mining and Materials Engineering
Faculty of Engineering
Prince of Songkla University

Final Examination for Semester: 2 Academic Year: 2005
Date: February 23, 2006 Time: 09.00-12.00
Subject: 237-221 Mechanical Metallurgy Room: หัวหุ่น

Instructions

1. There are 6 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 paper.
2. Dictionary, calculator, and stationery are allowed.
3. Text books, course notes and other studying materials are not allowed.
4. This final-term exam is counted for 30% of the total grade.

Asst. Prof. Dr. Thawatchai Plookphol

Problem No.	Full Score (points)	Student's Score (points)
1.	20	
2.	10	
3.	20	
4.	20	
5.	10	
6.	20	
Total	100	

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1. A steel with yield strength in tension of 500 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,

1.1 The maximum-shear-stress theory (Tresca) holds. (10 points)

1.2 The distortion-energy theory (von Mises) holds. (10 points)

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2. Briefly describe the following strengthening mechanisms:

2.1 Precipitation strengthening (5 points)

2.2 Grain boundary strengthening (5 points)

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3. A rod made of 4340 steel with diameter of 50 mm is subjected to a fluctuating axial load that varies from a maximum of 500 kN tension to a minimum of 250 kN compression.

3.1 Calculate the followings:

σ_{max}	(2points)
σ_{min}	(2points)
σ_m	(2points)
σ_r	(2points)
σ_a	(2points)
R (Stress ratio)	(2points)
A (Amplitude ratio)	(2points)

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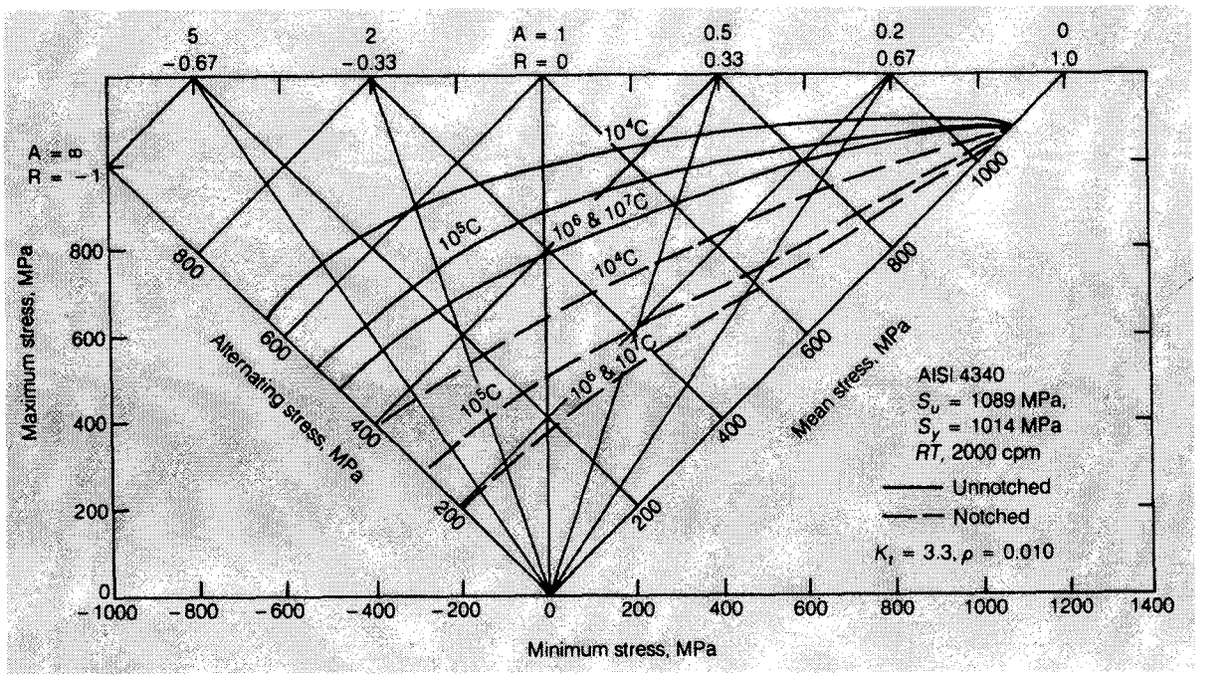
3.2 Use the diagram given below to estimate the fatigue life of the steel rod. (6 points)



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4. A high-strength steel has yield strength of 700 MPa and fracture toughness (K_{Ic}) equal to 170 MPa $m^{1/2}$. Based on the level of nondestructive inspection, the smallest size flaw that can be detected routinely, a_i, is 7.6 mm. Assume that the most dangerous crack geometry in the structure is a single-edge notch so that $K_{Ic} = 1.12\sigma\sqrt{\pi a}$. The structure is subjected to cyclic fatigue loading in which σ_{max} = 400 MPa and σ_{min} = 100 MPa. The fatigue-crack growth rate for the steel is given by $\frac{da}{dN} = 2.1\times10^{-10}(\Delta K)^{2.5}$. How many fatigue cycles will be required to break the structure? (20 points)

Given: $$N_f = \frac{a_f^{-(p/2)+1} - a_i^{-(p/2)+1}}{(-(p/2)+1)A\sigma_r^p \pi^{p/2}\alpha^p}$$

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5. Briefly describe the following creep mechanisms:

5.1 Dislocation creep (5 points)

5.2 Nabarrow-Herring creep (5 points)

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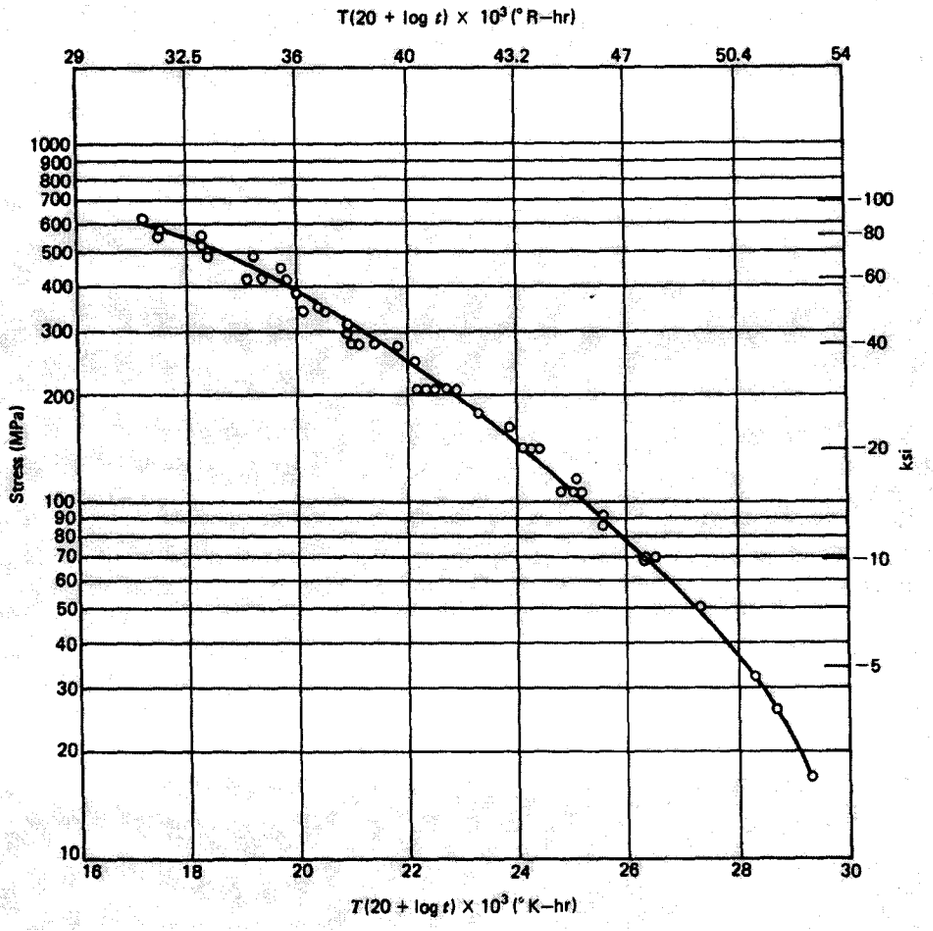
6. A Larson-Miller plot for S-590 iron-based alloy is given below.



6.1 Determine the expected life for a sample tested at 500°C with stress 200 MPa. (10 points)

6.2 What is the maximum operational temperature such that failure should not occur in 10,000 hours at stress level of 100 MPa? (10 points)