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

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

Final Examination for Semester: 1 Academic Year: 2012
Date: October 8, 2012 Time: 09.00-12.00
Subject: 238-500 Advanced Mechanical Behavior of Materials Room: S201

Instruction

1. There are 4 problems. Please do all of them. Write your answer in the space provided. If you need more space, you can write on the back of paper.
2. Text books and course notes are not allowed.
3. Dictionary, calculator and stationery are allowed.
4. This final exam is counted for 30% of the total grade.

Asst. Prof. Dr. Thawatchai Plookphol

Problem No.	Full Score (points)	Student's Score (points)
1.	30	
2.	20	
3.	20	
4.	20	
Total	90	

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1. Explain the following terms: (2 points each, 30 points in total)

1.1 Theoretical Fracture Strength

1.2 Crack Extension Force, G

1.3 Stress Intensity Factor, K

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1.4 Fracture Toughness, K_{IC}

1.5 Plastic Zone

1.6 High Cycle Fatigue

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1.7 Paris' Law

1.8 Dislocation Glide

1.9 Partial Dislocation

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1.10 Hall-Petch Effect

1.11 Work Hardening

1.12 Creep Curve

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1.13 Power-Law Creep

1.14 Diffusional Creep

1.15 Creep Cavitation

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2. The linear relationship between crack growth rate ($\frac{dc}{dN}$) and stress intensity range (ΔK) can be expressed as

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

2.1 Estimate the value of constants C and p for aluminum alloy from the data shown below. Please use basic SI unit and the data from the upper line. (10 points)

2.2 Describe the microstructural evolution due to the fatigue loading. (10 points)

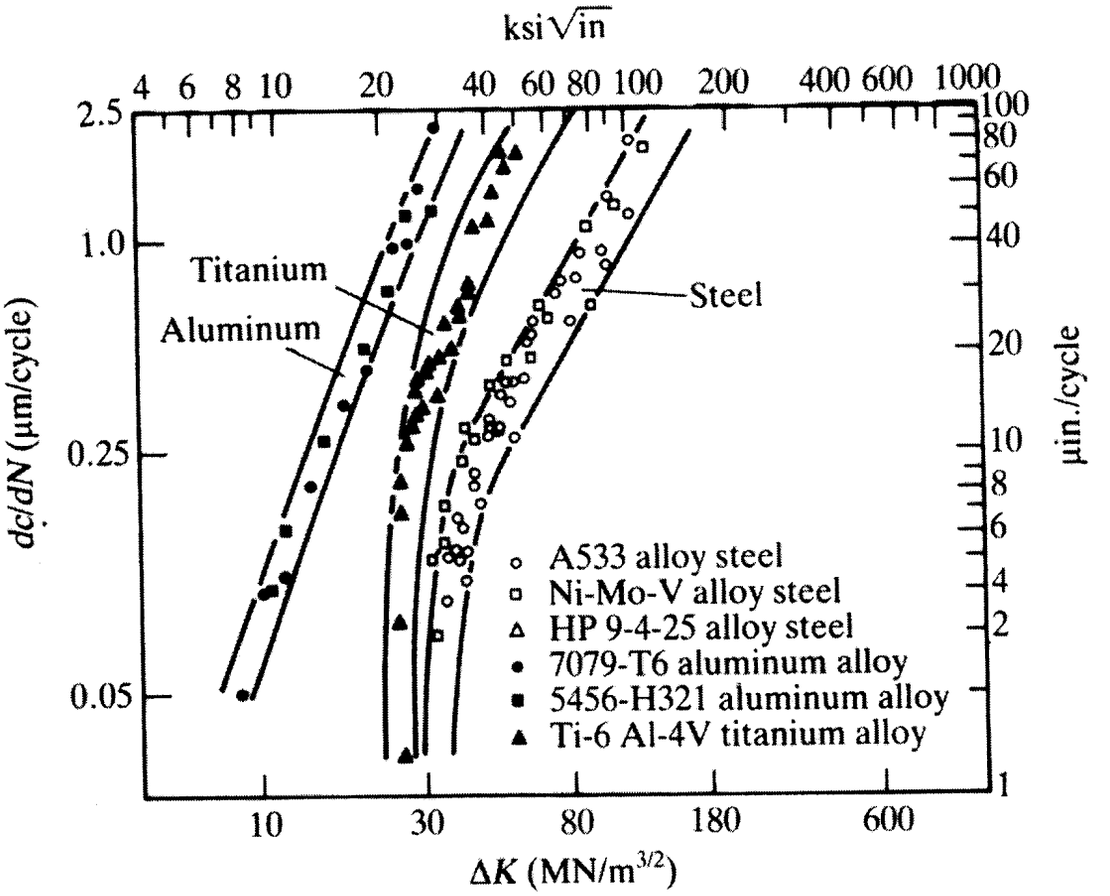

Figure 2 Fatigue crack growth data.

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3. Suppose you are planning to perform creep experiment on polycrystalline rock salt (NaCl) and you are interested in the power-law creep behavior of this material.

Use the deformation-mechanism map given below to design conditions for creep test, e.g. what are temperature and stress ranges in which creep experiment will be performed? Show your calculations and explain the reasons to support your answer. (20 points)

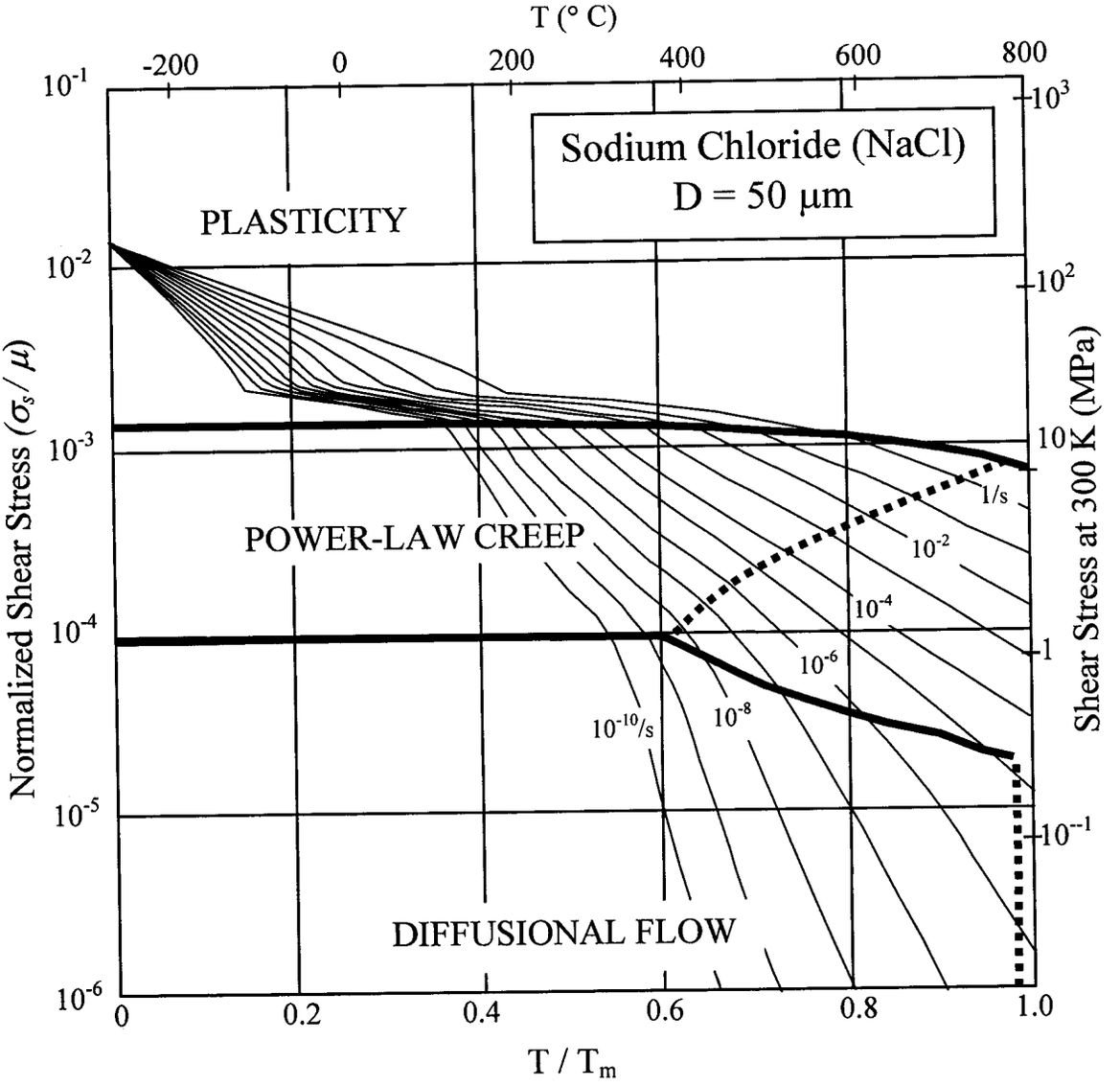

Figure 3 Deformation-mechanism map for sodium chloride (NaCl) of grain size 50 μm. [Redrawn from Frost and Ashby, 1982]

Given:

$$\sigma_s = \frac{\sigma_1}{\sqrt{3}}$$

where σ_s is shear stress, and

σ_1 is normal stress.

T_m = 797 °C

$\mu \cong$ 10,000 MPa

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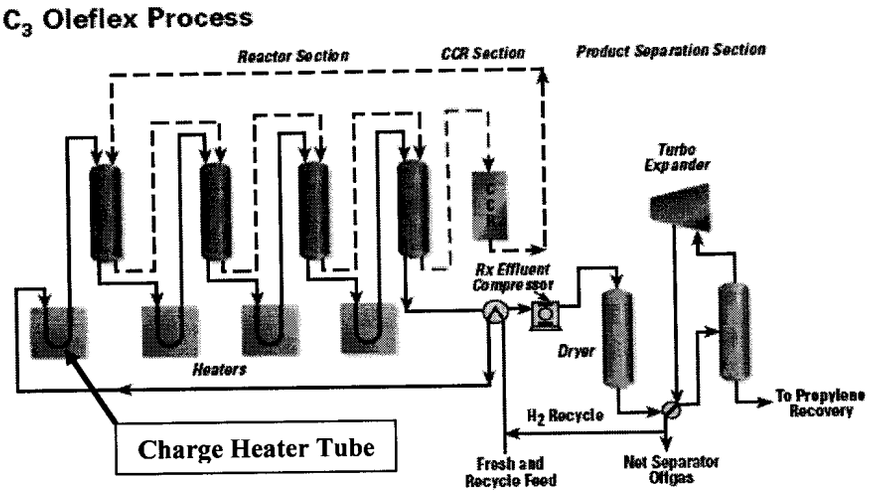
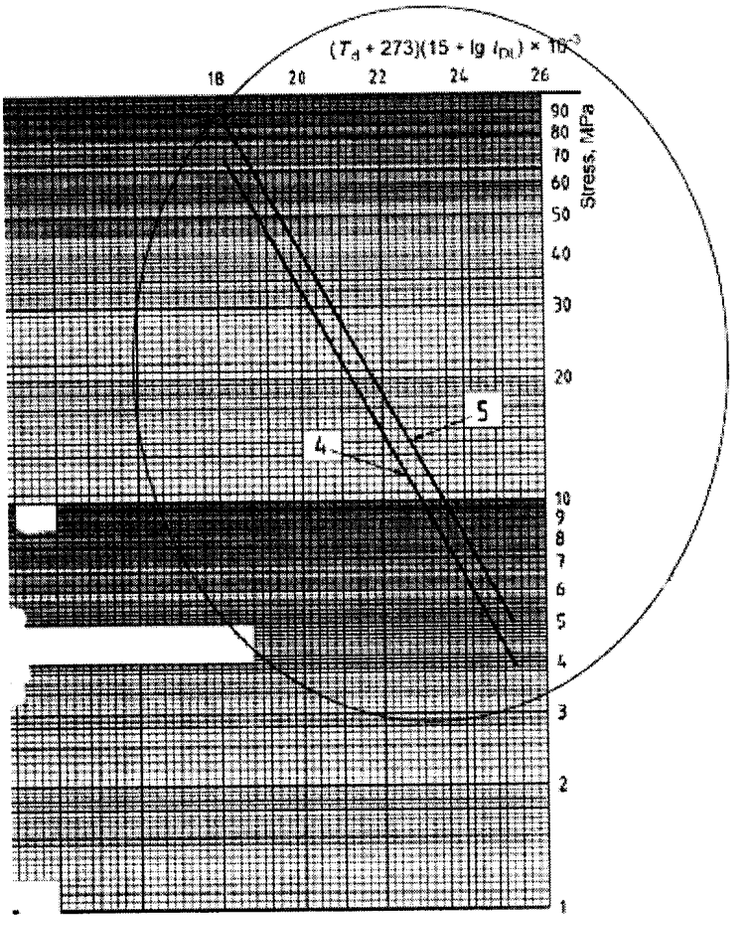
4. The SS347 alloy is used for charge heater tube in oleflex petrochemical plant at Maptaput, Rayong, Thailand. The tube was designed to operate at internal pressure (p) of 550 kPa, T = 754 °C. The tube has diameter (d) of 73 mm and thickness (t) of 3.05 mm. Design safety factor = 2.



A Larson-Miller plot for SS347 alloy is given below. Note that curve 4 is the lower limit and curve 5 is the upper limit for new material.



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4.1 Determine the hoop stress of the tube (in MPa) (5 points)

4.2 What is the maximum life of the tube (in year) if it is operated at the design conditions? Please use data curve no. 5 for calculation. (15 points)

Given: Larson-Miller Parameter (*LMP*) for SS347 alloy is as follows:

$$LMP = T(C + \log t)$$

where

T = Absolute temperature in K

C = Material constant (15 for austenitic stainless steels)

t = time in hour.