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

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

Final Exam for Semester: 2 Academic Year: 2009
Date: February 24, 2010 Time: 09.00-12.00
Subject: 237-221 Mechanical Behavior of Materials Room: A401

Instructions

1. There are 4 problem sets. Please do all of them. Write your answers in the space provided after each problem set. If you need more space, you can write on the back of the paper.
2. Only two pieces of A4-size note are allowed. You may write on both sides of the note. Please return them with your answers.
3. Dictionary, calculator, and stationery are allowed.
4. Text books, course notes, and other studying materials are not allowed.
5. This final exam is counted for 25% of the total grade.

Asst. Prof. Dr. Thawatchai Plookphol

Problem No.	Full Score (points)	Student's Score (points)
1.	20	
2.	20	
3.	20	
4.	25	
Total	85	

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1. Explain the following strengthening mechanisms:

1.1 Solid-solution strengthening (5 points)

1.2 Precipitation strengthening (5 points)

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1.3 Work hardening (5 points)

1.4 Grain–boundary strengthening (5 points)

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2. Explain the following terms related to creep and fatigue:

2.1 Fatigue (5 points)

2.2 Stages of fatigue crack growth (5 points)

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2.3 Creep and creep curve (5 points)

2.4 Dislocation creep mechanism (5 points)

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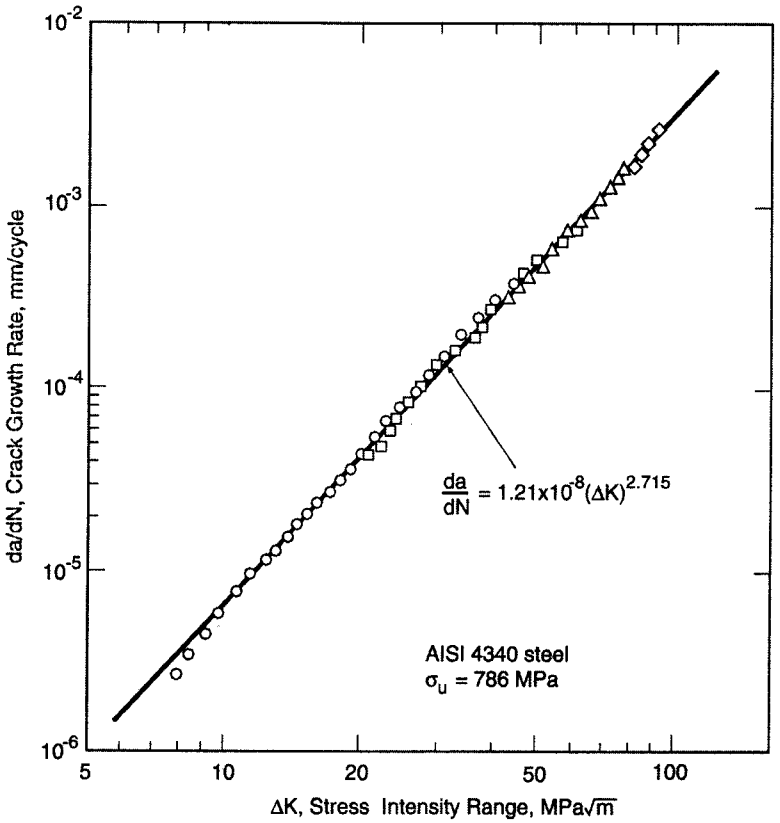
3. A plate made of AISI 4340 steel is subjected to constant amplitude uniaxial fatigue load to produce stresses varying from σ_{max} = 180 MPa and σ_{min} = 80 MPa. The properties of steel are σ_U = 786 MPa and K_{IC} = 95 MPa$\sqrt{\text{m}}$. If the plate contains an initial through thickness edge crack of 1 mm, how many fatigue cycle will be required to break the plate. The fatigue crack growth data is shown below. (20 points)



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

At failure:
$$K_{IC} = \alpha\sigma_{max}\sqrt{\pi a_f}$$

For an infinite wide plate, α = 1.12

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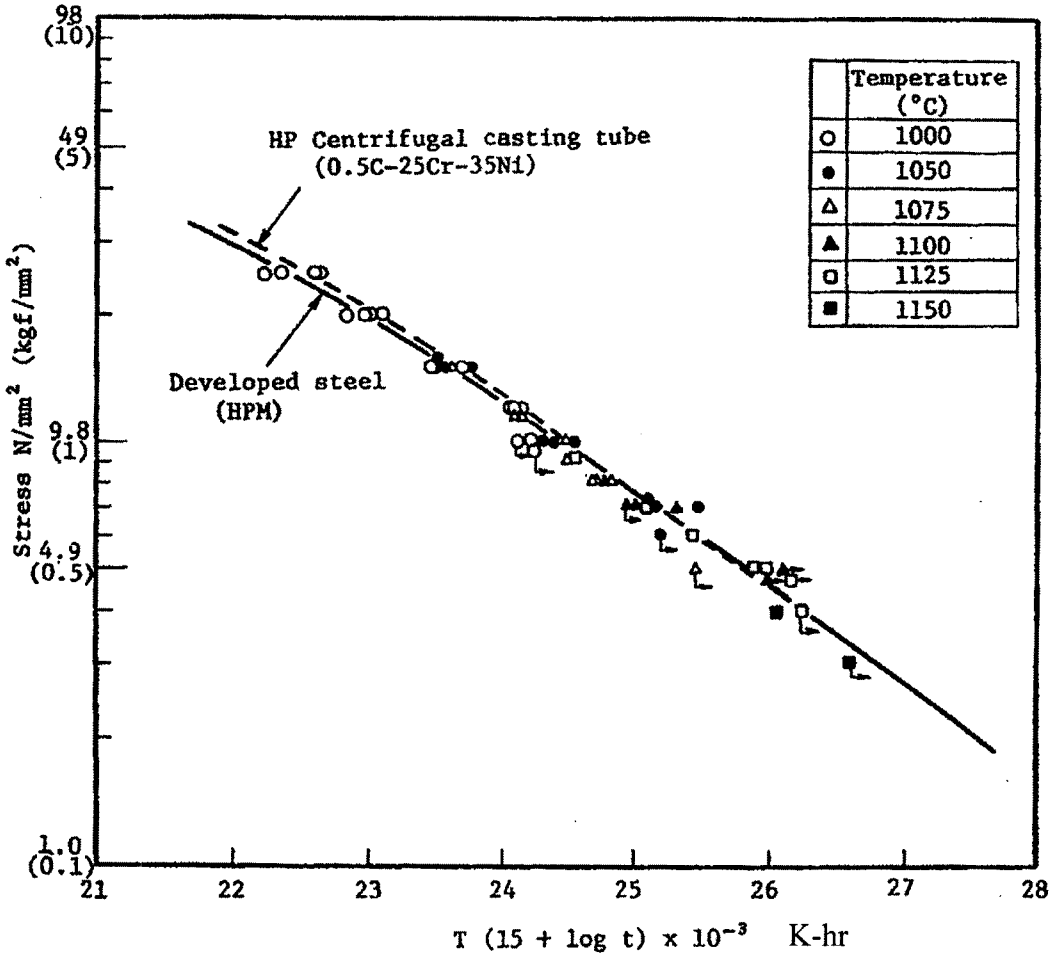
4. The cracking heater tube in an ethylene plant (a petrochemical plant) at Maptaput, Rayong, was made of 25Cr-38Ni-Mo-Ti wrought alloy steel (HPM). The tube was designed to operate at internal pressure p = 550 kPa and T = 750 °C. The tube has diameter (d) and thickness (t) of 70 mm and 3 mm respectively. A Larson-Miller plot of HPM is given below.



Assume that the tube is a thin-walled pressure vessel, $\sigma_{hoop} = \dfrac{pd}{2t}$.

4.1 Determine hoop stress of the tube (in N/mm^2 or MPa) (5 points)

4.2 What is the maximum life of the tube (in hour)? (5 points)

4.3 If temperature of the tube is increased to T = 850 °C while the internal pressure is kept at 550 kPa, what is the tube life? (5 points)

4.4 If the internal pressure is increased to p = 2,000 kPa while the temperature is increased to T = 1,000 °C, what is the tube life? (10 points)