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

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

Final Exam for Semester: 2 Academic Year: 2012
Date: March 1, 2013 Time: 09.00-12.00
Subject: 237-221 Mechanical Behavior of Materials Room: หัวหุ่น

Instruction

1. There are 4 problem sets. Please do all of them. Write your answers in the space provided. If you need more space, you can write on the back of paper.
2. Text books, course notes, and other studying materials are not allowed.
3. Dictionary, calculator, and stationery are allowed.
4. This final exam is counted for 25% of the total grade.

Asst. Prof. Thawatchai Plookphol, Ph.D.

Problem No.	Full Score (points)	Student's Score (points)
1.	30	
2.	10	
3.	30	
4.	30	
Total	100	

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1. Explain the following terms (please draw diagram or picture to support your answer)

1.1 Solid-solution strengthening (5 points)

1.2 Precipitation strengthening (5 points)

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1.3 Work-hardening strengthening (5 points)

1.4 Grain–boundary strengthening (5 points)

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1.5 Fatigue S-N curve (5 points)

1.6 Creep curve (5 points)

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2. A fatigue specimen made of AISI 4340 steel with diameter of 12.5 mm is subjected to cyclic axial load that varies from a maximum of 60,000 N tension to a minimum of 30,000 N compression. Calculate the followings: (10 points)

   2.1 The mean stress, σ_m

   2.2 The stress range, σ_r

   2.3 The alternating stress, σ_a

   2.4 The stress ratio, R

   2.5 The amplitude ratio, A

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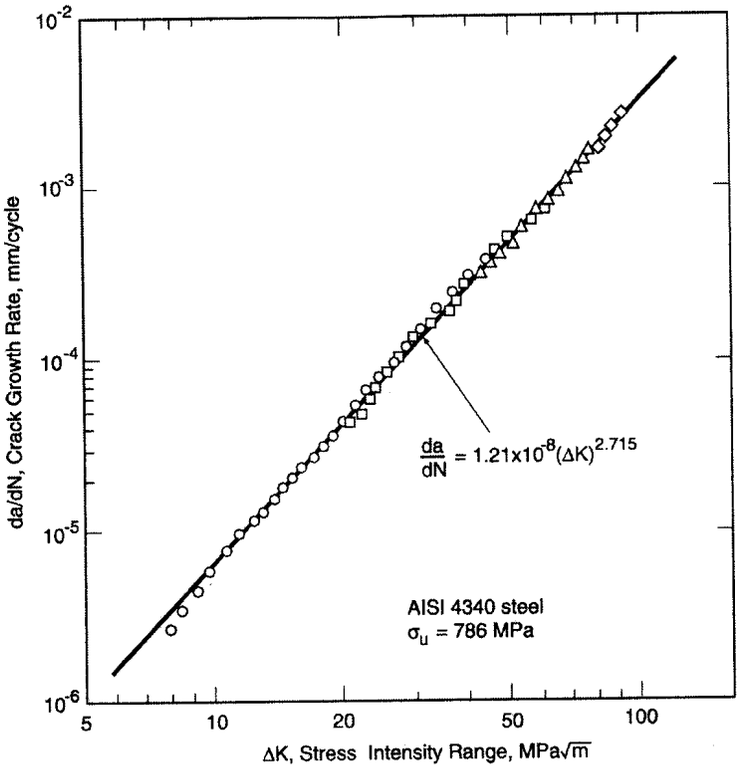
3. A plate made of AISI 4340 steel is subjected to constant amplitude uniaxial fatigue load to produce stresses varying from σ_{max} = 200 MPa and σ_{min} = 100 MPa. The properties of steel are σ_U = 786 MPa and K_{IC} = 95 MPa$\sqrt{m}$. If the plate contains an initial through thickness edge crack of 1 mm, how many fatigue cycle will be required to break the plate. The fatigue crack growth data is shown the figure below. (30 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 fracture:
$$K_{IC} = \alpha\sigma_{max}\sqrt{\pi a_f}$$

For an infinite wide plate, α = 1.12

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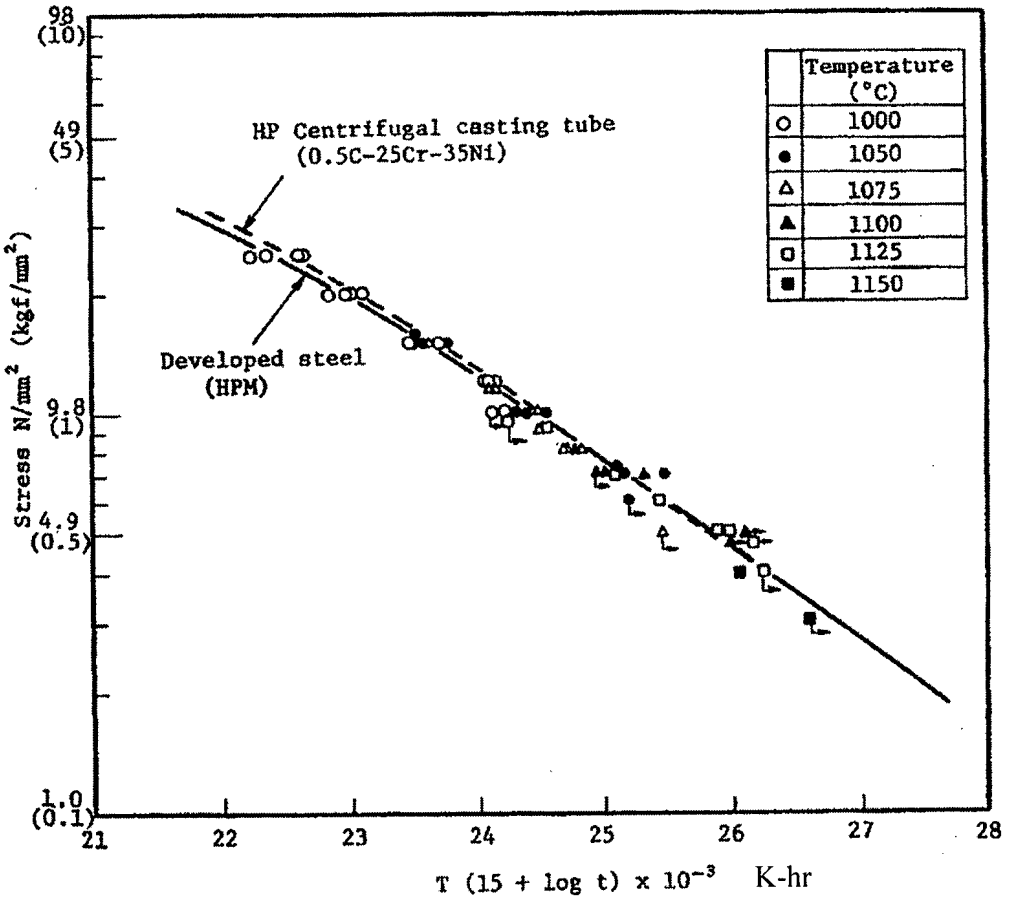
4 The heater tube in the ethylene plant (a petrochemical plant) at Maptaput, Rayong, was made of 25Cr-38Ni-Mo-Ti wrought alloy steel (HPM). The tube was designed to operate at internal pressure p = 550 kPa and T = 750 °C. The tube has diameter (d) of 70 mm and thickness (t) of 3 mm. A Larson-Miller plot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



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

4.1 For the original design, the operating internal pressure p = 550 kPa and temperature T = 750 °C

4.1.1 Determine the hoop stress (in MPa) (5 points)

4.1.2 What is the maximum life of the tube (in hours)? (10 points)

4.2 If the temperature of the tube is increased to T = 850 °C and the internal pressure is kept at 700 kPa, what is the maximum tube life? (15 points)