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

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

Final Exam for Semester: 2 Academic Year: 2013
Date: March 6, 2014 Time: 09.00-12.00
Subject: 237-221 Mechanical Behavior of Materials Room: A303

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**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. | 20 | |
| 2. | 20 | |
| 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 Fatigue endurance limit (5 points)

1.2 Paris' law (5 points)

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1.3 Creep test (5 points)

1.4 Diffusional creep (5 points)

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2. A fatigue specimen made of 7075-T6 aluminum alloy with diameter of 12.5 mm is subjected to cyclic axial load that varies from a maximum of 30,000 N tension to a minimum of 30,000 N compression. Calculate the following parameters: (20 points)

2.1 The mean stress, $\sigma_m$ (4 points)
2.2 The stress range, $\sigma_r$ (4 points)
2.3 The alternating stress, $\sigma_a$ (4 points)
2.4 The stress ratio, $R$ (4 points)
2.5 The amplitude ratio, $A$ (4 points)

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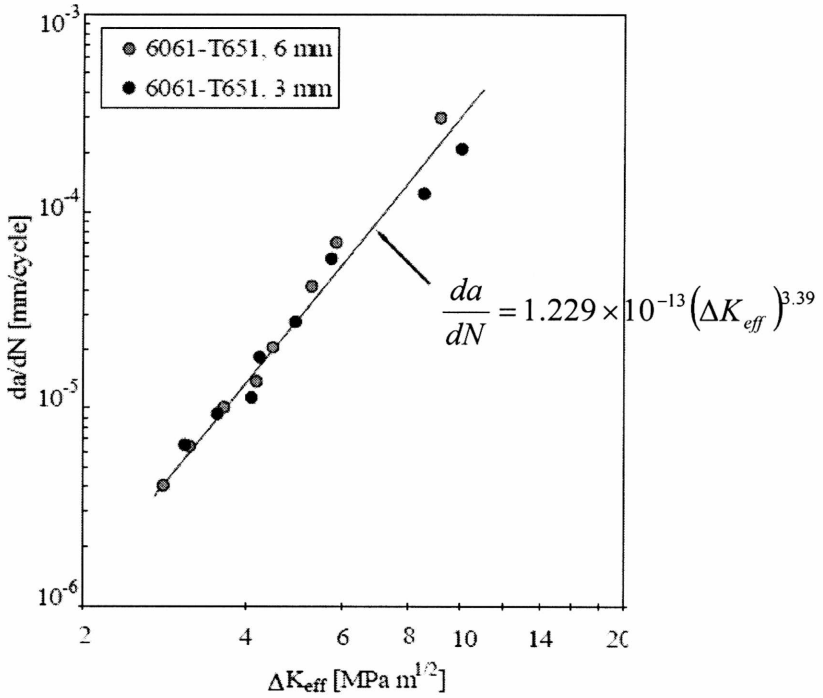
3. A plate made of 6061-T651 aluminum alloy is subjected to constant amplitude uniaxial fatigue load to produce stresses varying from $\sigma_{max}$ = 200 MPa tension and $\sigma_{min}$ = -20 MPa compression. The properties of alloy are $\sigma_U$ = 310 MPa and $K_{IC}$ = 29 MPa$\sqrt{m}$. If the plate contains an initial through thickness edge crack of 2 mm, how many fatigue cycle will be required to break the plate. (30 points)

The fatigue crack growth data is shown below.




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, $\alpha$ = 1.12

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4 An engineering part made of A356 aluminum alloy was designed to operate at stress of 140 MPa and temperature of 100 °C. A Larson-Miller plot of A356 alloy is given in Figure 4.

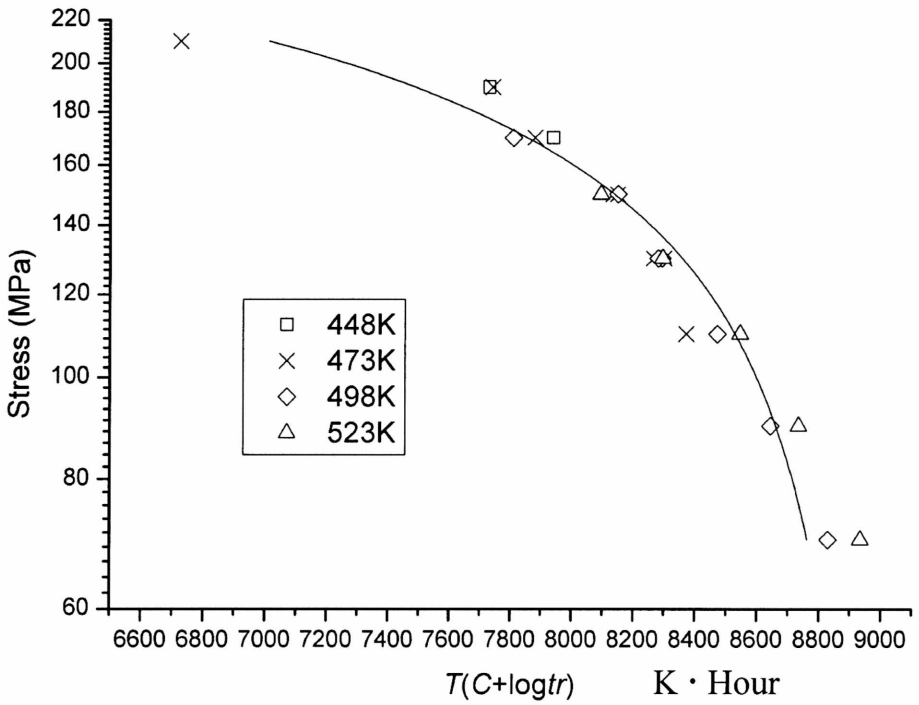


Figure 4. A Larson-Miller plot of A356 aluminum alloy. $T$ is the absolute temperature in K; $C = 16.4$; $t_r$ is the rupture time in hour.

4.1 For the original design, what is the maximum service life of the part (in hours)? (15 points)

4.2 If the part is re-designed to operate at temperature of 120 °C and the service life of 100,000 hours, what is the maximum allowable stress (in MPa)? (15 points)

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