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

Department of Mining and Materials Engineering

Faculty of Engineering

Prince of Songkla University

Mid-term Examination for Semester: 1 Academic Year: 2008

Date: July 30, 2008 Time: 09.00-12.00

Subject: 237-407 Failure Mechanics and Analysis Room: R201

Instructions

1. There are 3 problem sets. Please do all of them. Write your answers in the space provided after each problem sets.
2. Dictionary and calculator are allowed.
3. Text books and course notes are not allowed.
4. This mid-term exam is accounted for 25 % of total grade.

Asst. Prof. Dr. Thawatchai Plookphol

Problem no.	Full score	Student's score
1	10	
2	20	
3	20	
Total	50	

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Problem 1

Explain the following terms: (please give an example or draw a related diagram to support your answer)

1.1 Plane stress (2 points)

1.2 Plane strain (2 points)

1.3 Griffith's fracture theory for brittle materials (2 points)

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1.4 Irwin's concept of stress intensity factor (K) (2 points)

1.5 Plain strain fracture toughness (K_{Ic}) (2 points)

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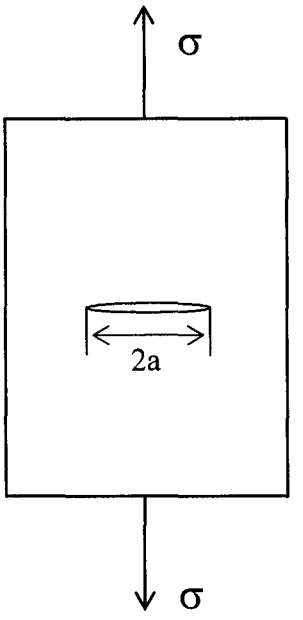
Problem 2 (20 points)

In a plate of aluminum alloy 7075 a central defect is present with a total length of 3 mm.

2.1 Calculate the critical stress for fracture using the Griffith criterion and using K_{Ic}.

2.2 Explain possible differences.



Given: surface tension $\gamma_s = 1.14$ J/m^2

Young's modulus $E = 70$ GPa

Fracture toughness $K_{Ic} = 32.9$ MPa$\sqrt{\text{m}}$

$$\sigma_f = \sqrt{\frac{2E\gamma_s}{\pi a}}$$

$$K_I = \sigma\sqrt{\pi a}$$

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Problem 3 (20 points)

In service a construction part made of high strength steel is subjected to a constant stress of 1200 MPa. However, in course of time the part fails. Inspection of the fracture surface points to non-stable crack extension from an embedded circular crack, normal to the load direction and with a diameter of 100 μm.

3.1 How high is the stress intensity factor K_I for this defect as a result of the externally applied load?

It is suspected that the failure is due to hydrogen-induced cracking, i.e. a high hydrogen pressure which has developed inside the crack.

3.2 How high was the hydrogen pressure inside the crack at the moment of failure? For this situation it may be assumed that plane strain conditions are present.

Given: Fracture toughness of high strength steel, $K_{Ic} = 27.5\,\text{MPa}\sqrt{\text{m}}$.

For an embedded circular crack, $K_I = \frac{2}{\pi}\sigma\sqrt{\pi a}$.

For crack containing internal pressure P, $K_I = CP\sqrt{\pi a}$, where $C = 1$