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

Department of Mining and Materials Engineering

Faculty of Engineering

Prince of Songkla University

Mid-term Exam for Semester: 1   Academic Year: 2004

Date: 3 August 2004   Time: 9.00-12.00

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

Instruction

1. There are 3 problem sets. Please do all of them and write your answers on the space provided after each problem set.

2. Only one (1) piece of A4-size note is allowed. You may write on both sides of the note. Please return it with your answers.

3. Dictionary and calculator are also allowed.

4. Text books and course notes are not allowed.

5. This mid-term exam is accounted for 30% of total grade.

Dr. Thawatchai Plookphol

1. A ship steel has a value of $G_c = 35$ kJm^{-2} and $E = 205$ GPa.
   (a) What is the fracture stress in a thin plate that is 300 wide and that contains a central crack 12 mm long? (10 points)
   (b) If the crack is 50 mm long, what is the fracture stress? (10 points)
   (c) Increasing the plate thickness to 120 mm reduces G_c to 18 kJm^{-2}. What is the fracture stress for a 12 mm-long crack? (10 points)

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2. A pipeline for transporting pressurized gas has been fabricated from 4340 steel having an elastic shear modulus $G = 79$ GPa, a tensile yield stress $\sigma_y = 1515$ MPa, and a plane strain fracture toughness $K_{Ic} = 60.4$ MPa $\sqrt{m}$. The pipeline has a circular cross-section with a mean diameter $d = 1.22$ m and a wall thickness $t = 0.0119$ m. Due to imperfect installation, the pipe is twisted an amount $\phi = 0.00145$ rad/m. If the pipe is to carry gas at a pressure of up to 12 MPa,
     (a) What is the smallest through-wall crack that could cause the pipeline to fracture according to Mode I LEFM (Linear Elastic Fracture Mechanics)? (40 points)
     (b) What orientation would such a critical flaw have with respect to the axis of the cylinder? (10 points)

Hint: For a thin-wall pressure vessel,

     Hoop stress, $$\sigma_h = \frac{Pr}{t}$$

     Longitudinal stress, $$\sigma_l = \frac{Pr}{2t}$$

     Radial stress, $$\sigma_r = 0$$

     Shear stress due to twisting, $$\tau_{hl} = Gr\phi$$

where,

     P = pressure in the pipeline
     r = radius of the pipeline
     t = the wall thickness of the pipeline

     For a through-wall crack, $$K_I = \sigma\sqrt{\pi a}$$

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3. Extra credit! Write your opinion about this course, e.g. what have you learned from this course? what do you want the class environment to be? (10 points)

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