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: 2011

Date: August 3, 2011 Time: 09.00-12.00

Subject: 237-407 Failure Mechanics and Analysis Room: S817

Instructions

1. There are 4 problem sets. Please do all of them. Write your answers in the space provided.
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	15	
2	10	
3	20	
4	30	
Total	75	

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Problem 1 (30 points)

1.1 What is the factor K? (5 points)

1.2 What is plastic zone in Fracture Mechanics? (5 points)

1.3 Size and shape of plastic zone are influenced by what factors? (5 points)

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Problem 2 (10 points)

Calculations based on the cohesion force suggest that the tensile strength of glass should be 10 GPa. However, a tensile strength of only 1.5 % of this value is found experimentally. Griffith supposed that this low value was due to the presence of cracks in the glass. Calculate the size $2a$ of a crack normal to the tensile direction in a plate.

Given: Young's modulus $E = 70$ GPa.
Surface tension $\gamma = 0.5$ J/m^2.

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Problem 3 (20 points)

A plate of maraging steel has a tensile strength of 1900 MPa. Calculate the reduction in strength caused by a crack in this plate with a length $2a = 3$ mm oriented normal to the tensile direction.

Given: Young's modulus $E = 200$ GPa.
Surface tension $\gamma_e = 2$ J/m^2.
Plastic energy per unit crack surface area $\gamma_p = 2\times10^4$ J/m^2.

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Problem 4 (30 points)

Corner crack in a longitudinal section of a pipe-vessel intersection in a pressure vessel:

$$\frac{K_I}{\sigma_H \sqrt{\pi a}} = F_m \left(1 + \sqrt{\frac{rt}{RB}} \right)$$

where σ_H is the hoop stress in the vessel wall. The solution for F_m is given in Figure 4.3.

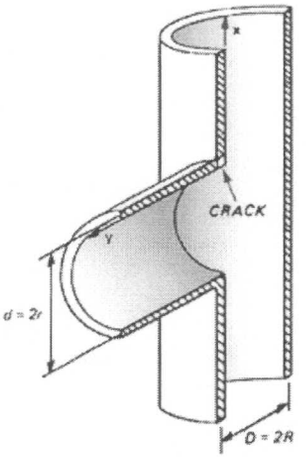

Figure 4.1

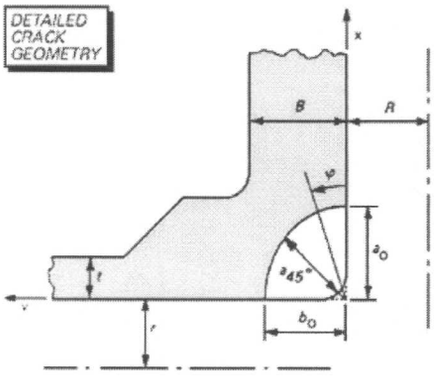

Figure 4.2

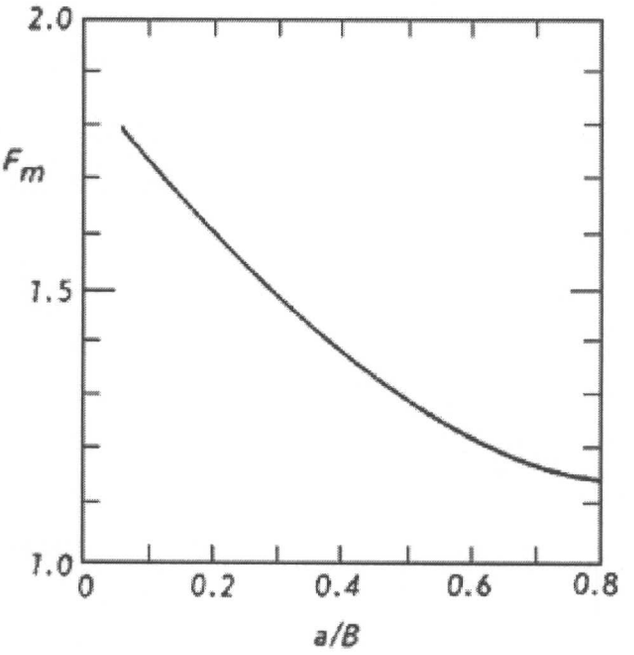

Figure 4.3 Correction factor for a corner crack in a longitudinal section of a pipe-vessel intersection on a pressure vessel.

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Given: Internal pressure in the vessel (p) = 10 MPa.

Radius of the pressure vessel (R) = 300 mm.

Thickness of the pressure vessel wall (B) = 5 mm.

Radius of the pipe (r) = 12.5 mm.

Thickness of the pipe (t) = 2 mm.

Crack size, $a_0 = b_0 = 2$ mm.

4.1 Estimate K_I for the pressure vessel (20 points)

4.2 If pressure vessel is made of steel with $K_{IC} = 80$ MPa·m$^{1/2}$, what is the maximum internal pressure that will cause fracture? (10 points)

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Given Formula

For thin-walled pressure vessel:

Spherical tank:

$$\sigma_1 = \sigma_2 = \frac{pR}{2B}$$

$$\sigma_3 = 0$$

Cylindrical tank:

$$\sigma_{hoop} = \frac{pR}{B}$$

$$\sigma_{longitudinal} = \frac{pR}{2B}$$

$$\sigma_{radial} = 0$$

where p is the internal pressure

R is the radius

B is the thickness

Griffith's equation:

$$\sigma = \sqrt{\frac{2E\gamma_e}{\pi a}}$$

Modified Griffith's equation:

$$\sigma = \sqrt{\frac{2E(\gamma_e + \gamma_p)}{\pi a}}$$