Fracture Mechanics ME 6104 **National University of Singapore**

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Assignment # 1

Problem 1

Structural parts of modern battle ships are made of aluminum alloys so as to reduce their weight and increase their maneuverability. A lateral partition in a missile boat made of aluminum 6061-T651 is subjected to uniaxial tension. The partition is 2h=2m high, and 2b=4m wide. During a periodical inspection a crack of length 2a=0.4m was discovered in the center of the plate as described in figure 1.

(a) Determine the maximum tensile stress the partition can withstand prior to fracture (Assume a safety factor of 1).

(b) How would your answer to (a) change if the partition geometry were 2h=08m, 2b=1.6m?

(c) Compare cases (a) and (b), explain the origin of the different results and their implications.

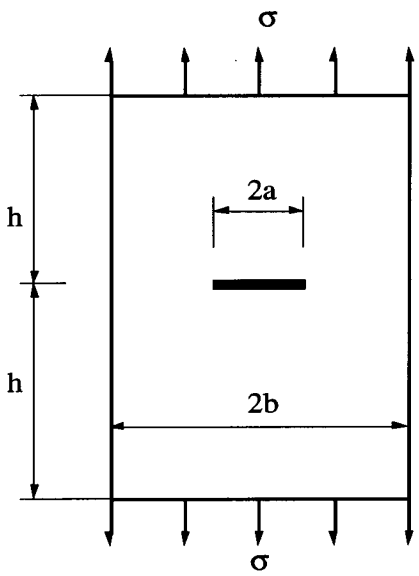


Fig. 1

Problem 2

In the same missile boat there is another partition of height 2h=0.4m and width 2b=1.0m made of the same material. As a result of cyclic uniaxial loading, central cracks develop in the partition, as shown in Fig. 1.

(a) If, the maximal tensile stress acting on the partition is σ=6 Kg/mm^2, determine the critical crack length a_{cr} prevailing at fracture (Assume a safety factor of 1).

(b) How would your answer to (a) change if the partition's width were 2b=0.5m.

(c) How would your answer to (a) change if the partition were made of A533B reactor steel, which has a similar yield strength as aluminum 6061-T651. Explain your result.

Problem 3

A plate under uniaxial tensile loading having an edge crack of length a=2" failed experimentally when the load reached the value of 75,000 lb. Estimate the plate's material fracture toughness given: plate width W=5"

plate thickness B=0.5"

material yield stress σ=80ksi

Problem 4

Two metals of the same density, *A* and *B*, are being considered for the design of a large plate that is 6 ft wide and 10 ft long. A maximum tensile load of 4.5 MN is applied perpendicular to the 6-ft dimension and the possibility of pre-existing cracks must be considered. For this problem, through the thickness cracks at the center of the plate and perpendicular to the applied load are of major concern. Because of inspection limitations, the smallest detectable crack is of the order of 0.100 in. The plane strain fracture toughness and the yield strength of the metals are:

material *A* K_{IC}=115 Mpa $(m)^{1/2}$; σ_{yp}=910 MPa

material *B* K_{IC}=55 Mpa $(m)^{1/2}$; σ_{yp}=1035 Mpa

(a) Which material would you recommend if the plate is to be of minimum weight? In essence, only a minimum thickness, t, is required.

(b) How would your answer change if the NDT method could detect cracks as small as a=0.05". Explain.