Name:

Student Id. #

Question 1: *{4 marks}*

(1) A metal block with an internal crack of length 40 micrometers is subjected to a nominal tensile stress of 50 MPa. The radius of curvature of crack tip is 5 micrometer. The safe operational stress limit of the material is given as 300 MPa.
Determine the value of maximum stress that occurs at the crack tip and suggest if the block is susceptible to failure at this loading condition?

(2) Using sketches, explain briefly the three modes of crack surface displacements?

Solution:

(1) Stress concentration factor $K_t = (\sigma_m / \sigma_0) = 2*(a/\rho_t)^{1/2}$

Internal crack of length 2a = 40 micrometers

a = 20 micrometers

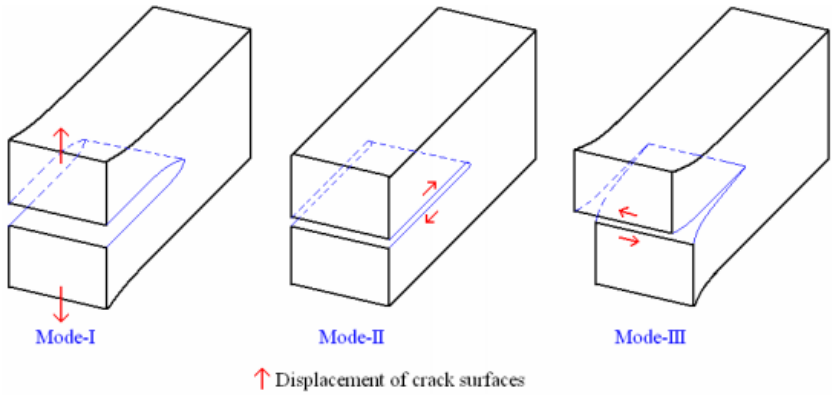
$K_t = 2*(20/5)^{1/2} = 4$

Given that $\sigma_0 = 50$ MPa

$\sigma_m = K_t * \sigma_0 = 4*50 = 200$ MPa.

It is clear that the maximum stress at the crack tip is less than the safe operational stress limit, so the block can be assumed not to fail by crack propagation in this loading condition

(2)



Mode-I is a tensile type of fracture, in this mode fracture the crack surfaces are displaced normal to themselves.

Mode-II is a shear mode of fracture, crack surfaces are sheared relative to each other in a direction normal to the edge of the crack.

Mode-III is also a shear mode of fracture, shearing action is parallel to the edge of the crack.

Question 2: *{6 marks}*

(1) Suggest two component design precautions that can be taken to reduce the risk of fatigue failure?

(2) Explain the effect of environmental factors on the fatigue behavior of metals and also suggest methods to avoid these failures.

Solution

(1)

a. Avoid notches and stress raisers that acts as a crack initiation sites for the failure.
b. Including rounded filler on the face corners are beneficial.
c. Avoid sharp corners and discontinuity in the design.

(2) Thermal fatigue

Thermal fatigue occurs at elevated temperatures by fluctuating thermal stresses and mechanical stresses from an external sources. The origin of these thermal stresses is the restraint to the dimensional expansion or contraction that would normally occur in a structural member with variations in temperature.
Thermal stresses do not arise if this mechanical restraint is absent. The method that can be employed to reduce the effect of thermal changes in fatigue behavior is to provide supports that do not hinder the dimensional changes.
Another method is to select material that have a very low coefficient of thermal expansion.

Corrosion fatigue

Failure that occurs by the simultaneous action of a cyclic stress and chemical attack is called corrosion fatigue. The gases and moisture in the atmosphere adversely affects the fatigue life of components. Small pits may form as a result of chemical reactions between the environment and the material, which may serve as points of stress concentration and therefore as crack nucleation sites. The crack propagation rate is enhanced as a result of the corrosive environment.

The corrosion fatigue can be reduced by the following methods

1. Applying protecting surface coatings.
2. Selecting more corrosion resistant material
3. Reduce corrosive environment.