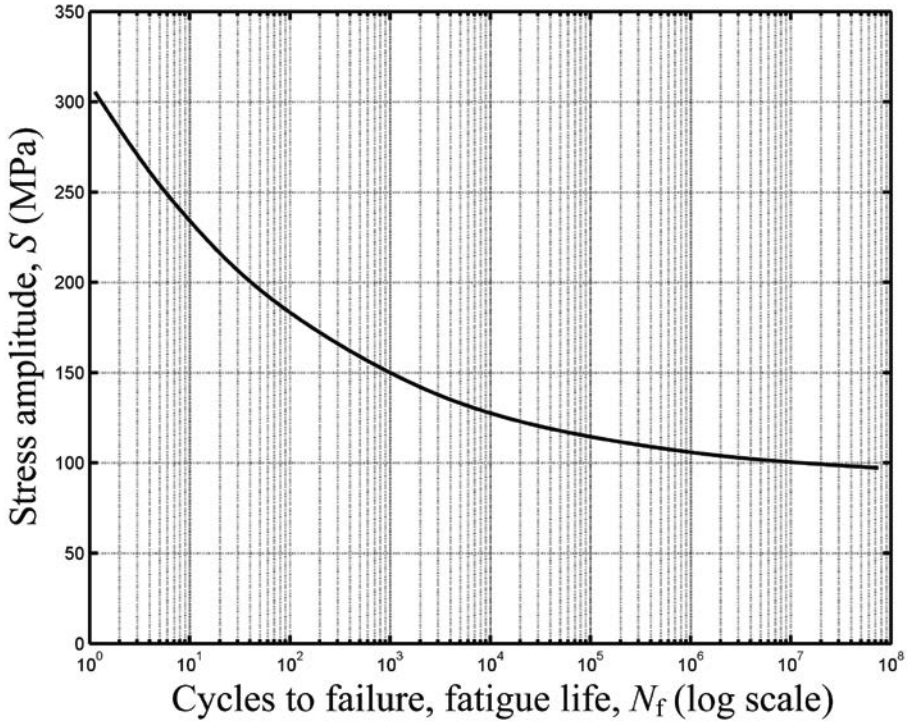
SE104 Homework 13

1. The stiffness, strength, and toughness of a material are 200 GPa, 400 MPa, and 80 MPa·m$^{1/2}$, respectively. (a) What is the critical precrack size that would reduce the failure strength (σ_f) to below the yield strength (σ_y)? (b) Plot the failure strength as a function of the precrack size. Assume $Y = 1$.

2. The S-N curve of a material is shown below. Fatigue life is measured by the number of loading cycles that can be applied. The material is subjected to various fatigue loadings, with the *R*-ratio always being 0. First, the maximum fatigue stress, σ_{max}, is 200 MPa, and this fatigue loading is applied for 10^6 cycles; then, the maximum fatigue stress is changed to 300 MPa, and this fatigue loading is applied for 500 cycles; finally, the maximum fatigue stress is adjusted to 400 MPa. Estimate the remaining fatigue life.



3. On the same material as in the above problem, a fatigue loading is applied and the fatigue life is 1000 cycles. In each loading cycle, the material is first fully loaded and then fully unloaded. (a) What are the maximum stress, the minimum stress, the mean stress, the stress range, the stress amplitude, and the R-raito? (b) We know that the fracture toughness of the material is 40 MPam$^{1/2}$. What is the final fatigue crack length in the last loading-unloading cycle, c_f? Assume that the geometric factor $Y = 1.2$.

4. When the stress range of fatigue loading is 100 MPa, the fatigue life of a material is 1 million cycles; if the stress range is 25 MPa, the fatigue life is 16 million cycles. (a) Determine the parameters of the Basquin's law, b and C_1. (b) When the stress range is 200 MPa, what is the fatigue life?

5. A large flat plate is subjected to a constant-amplitude fatigue loading. Before the fatigue test, the precrack length in the material was 1.25 mm. The yield strength of this material is 300 MPa; the Young's modulus is 211 GPa; the fracture resistance (the critical energy release rate) is 23.16 kJ/m^2. The maximum fatigue stress, σ_{max}, equals to the yield strength. It is measured that the fatigue life $N_f = 2.0\times10^6$ cycles. The Paris' law parameters are $m = 3.0$ and $A = 6.0\times10^{-13}$ in MPa and meter units. Assume the geometric factor $Y = 1.20$. (a) What is the fracture toughness of this material? (b) What is the failure crack length (the final fatigue crack length), a_f? (c) What is the minimum stress of the fatigue loading, σ_{min}?

6. A large flat plate is subjected to a constant-amplitude uniaxial cyclic tensile stress. Compute the surface crack length after 7.0×10^5 loading cycles. Assume the initial edge surface crack length of 1.80 mm and a maximum tensile stress of 160 MPa. The minimum tensile stress is 0. Assume $m = 1.8$ and $A = 7.5\times10^{-12}$ in MPa and meter units. Assume Y = 1.25.