8.20 Thermoplastic polyester part has no flaw > 0.1 mm. Calculate the max service stress.

From Eq. 8.1, the fracture toughness is

\[ K_{IC} = Y \sigma_f \sqrt{a} \]

\[ \Rightarrow \sigma_f = \frac{K_{IC}}{Y \sqrt{a}} \]

\[ Y \approx 1 \text{ so assume } Y = 1. \text{ From Table 8.2, for polyester } K_{IC} = 0.5 \text{ MPa } \sqrt{\text{m}}. \]

\[ \sigma_f = \frac{0.5}{\sqrt{0.1 \times 10^{-3}}} = 28.2 \text{ MPa} \]

8.23 Structural steel w/ \( K_{IC} = 60 \text{ MPa} \) no surface crack > 3 mm. By how much (\%) would a 3 mm crack need to grow for fast failure @ 500 MPa?

\[ K_{IC} = Y \sigma_f \sqrt{a} \Rightarrow a = \frac{K_{IC}^2}{\sigma_f^2 \pi} \text{ (assuming } Y = 1) \]

\[ a = \frac{(60 \text{ MPa } \sqrt{\text{m}})^2}{(500 \text{ MPa})^2 \pi} \]

\[ \text{Length of failure } \Rightarrow a = 4.58 \times 10^{-3} \text{ m} \]

\[ \frac{4.58 - 3}{3} = \frac{52.7}{10} \]
8.25 Use the data of Fig. 8.15b to specify an upper temp. limit for C11000 Cu to ensure a fatigue strength of at least 100 MPa for a life of $10^7$ cycles.

From the figure, for $10^7$ cycles, F.S. $\leq 95$ MPa @ $100^\circ$, and F.S. $\geq 120$ @ 65$^\circ$C. If F.S. $\leq T$,

$$F.S. = (slope)T = mT$$

$$m = \frac{\Delta F.S.}{\Delta T} = \frac{120-95}{65-100} = -0.714 \text{ MPa/}^\circ\text{C}$$

Then for F.S. = 100 MPa,

$$F.S. = m(T - T_1)$$

$$T = \frac{1}{m}(F.S. - F.S.\_1) + T_1$$

$$= -\frac{1}{0.714}(100-95) + 100$$

/ $\approx 98^\circ\text{C (approx)}$
9.7 Describe the microstructural development during slow cooling of a melt of equal parts (by weight) of Cu and Ni.

From Fig. 9.9: At $T \approx 1320^\circ C$, the solid phase $\alpha$ (1:1 Cu:Ni) begins to nucleate. As $T$ drops, the $\alpha$ particles in the liquid melt grow. At $T \approx 1280^\circ C$, the system has solidified as a homogeneous 1:1 solid solution (alloy).

9.13 Do the same for 20:80 wt% Cu:Al

From Fig. 9.27: At $T \approx 600^\circ C$, the solid phase $\kappa$ (Al rich) begins to nucleate in the liquid melt. These $\kappa$ particles grow as $T$ drops. At the eutectic temp ($549.2^\circ C$), the remaining melt solidifies partly as $\kappa$ and partly as $\theta$ (Cu rich), giving a two-phase microstructure.

9.17 Calculate the amount of each phase present in 1 kg of a 50 wt% Ni-50 wt% Cu alloy at

(a) $1400^\circ C$: From Fig. 9.9, the mixture is a melt. Liquid mass, $M_L = 1$ kg; solid mass, $M_s = 0$

(b) $1300^\circ C$: The fraction that is liquid is given by the inverse lever rule:

$1300^\circ C \quad \frac{a}{a+b} = \frac{44}{50+57}$

$X_L = \frac{b}{a+b} = \frac{50-44}{157-44} = 0.46$

$\Rightarrow M_L = 0.46 \text{ kg}, \quad M_s = 0.54 \text{ kg}$

(c) $1200^\circ C$: The system is solid. $M_L = 0, \quad M_s = 1 \text{ kg}$
9.38 Plot the wt % of phases present as a fn of T for a 20 wt % Si - 80 wt % Al alloy cooled from 800 to 300 °C.

The Si-Al phase diagram is Fig. 4.13.

Above T ≈ 690 °C, the system is melted (100 L). From 690 to 577 °C, the % β increases n linearly to a final value determined by the lever rule:

$$\% \beta = \frac{20 - 12.6}{100 - 12.6} = 9.31 \% \quad \% L = \frac{100 - 20}{100 - 12.6} = 91.53 \%$$

Below 577 °C, the system solidifies, with composition changing very little w/ T:

$$\% \beta = \frac{12.6 - 1.6}{100 - 1.6} = 12.7 \% \quad \% \alpha = \frac{100 - 12.6}{100 - 1.6} = 81.3 \%$$