CASE 1: Tip is flexed ±0.075 in. What is life for 95% survival?

\[ y_{\text{max}} = \frac{Fl^3}{3EI} = \frac{Fl^312}{3Ebh^3} \]

\[ 0.075 = \frac{F(4)^3(12)}{(3)(30 \times 10^6)(0.75)(0.1094)^3} \]

\[ F = 8.631 lb \]

Stiffness \( k = \frac{F}{\delta} = \frac{8.631}{0.075} = 115.1 lb/in \)

\[ M = Fl = (8.631)(4) = 34.52 lb.in. \]

\[ \sigma = \frac{Mc}{l} = \frac{(34.52)(0.1094/2)(12)}{(0.75)(0.1094)^3} = \pm 23,076 psi \]

Since \( S_{ut} = 245 \text{ ksi} > 200 \text{ ksi} \), we set \( S_e' \) not equal to \( S_{ut}/2 = 122.5 \text{ ksi} \), but limit it to the maximum of 100 ksi.

Surface Factor (Figure 7.10a with \( S_{ut} = 245 \text{ ksi} \)) = 0.63

Check: Table 7.3: \( e = 2.70 \text{ ksi} \), \( f = -0.265 \)

\[ k_f = 2.7(245)^{-0.265} = (2.7)(0.233) = 0.628 \]

Size Factor

Area = \((0.75)(0.1094) = 0.08205 \text{ in}^2 \)

Area loaded > 95% stress is 5% of Area = \((0.05)(0.08205) = 0.0041 \text{ in}^2 \)

Equivalent diameter from Eqn. 7.20:

\[ d = \sqrt{\frac{A_{vs}}{0.0766}} = \sqrt{\frac{0.0041}{0.0766}} = \sqrt{0.05356} = 0.2314 \text{ in}. \]

Because this diameter is less than 0.3 in, we don't use \( k_s = 0.869d^{-0.112} \), but just set \( k_s = 1 \).

Reliability

From Table 7.4, \( k_r = 0.87 \)
Derated Endurance Strength

\[ S_e = k_f k_s k_r S_e' = (0.63)(1)(0.87)(100) = 54.8 \text{ ksi} \]

\[ \sigma_{alt} = 23.1 \text{ ksi} < 54.8 \text{ ksi} \text{ Endurance Strength}, \therefore \text{ Life is } \infty. \]

Question: How big could the stress concentration at the attachment be and still have 100,000 cycles of life?

Draw the S-N Diagram

\[ a = \frac{S_L^2}{S_e} = \frac{220.5^2}{54.8} = 887.2 \text{ ksi} \]

\[ b = -\frac{1}{3} \log_{10} \left( \frac{S_L}{S_e} \right) = -\frac{1}{3} \log_{10} \left( \frac{220.5}{54.8} \right) = -\frac{1}{3} \log_{10}(4.024) = -\frac{0.605}{3} = -0.202 \]

\[ S_f = aN^b = 887.2(100,000)^{-0.202} = (887.2)(0.098) \]

\[ S_f = 87.16 \text{ ksi} \]

So the stress concentration would have to be \( \frac{87.16}{23.1} = 3.77 \).
CASE 2: Tip is flexed between 0.075 in and 0.225 in. What is life for 95% survival?

By proportioning, the force now fluctuates between 8.631 lb and $3 \times 8.631 = 25.893$ lb. Stresses go from $+23.1$ ksi to $+69.3$ ksi.

![Graph showing alternating and mean stresses](Image)

\[
\sigma_{\text{mean}} = \frac{\sigma_{\text{max}} + \sigma_{\text{min}}}{2} = \frac{69.3 + 23.1}{2} = 46.2 \text{ ksi}
\]

\[
\sigma_{\text{alt}} = \frac{\sigma_{\text{max}} - \sigma_{\text{min}}}{2} = \frac{69.3 - 23.1}{2} = 23.1 \text{ ksi}
\]

What is the Factor of Safety?

A) If both alternating and mean stresses increase proportionately:

\[
\frac{1}{n} = \frac{\sigma_A}{S_e} + \frac{\sigma_M}{S_{ut}} = \frac{23.1}{54.8} + \frac{46.2}{245} = 0.422 + 0.189 = 0.611
\]

\[n = \frac{1}{0.611} = 1.64\]

B) If only alternating stress increases:

\[
\sigma_{a_{\text{max}}} = S_e (1 - \frac{\sigma_M}{S_{ut}}) = 54.8(1 - \frac{46.2}{245}) = 54.8(1 - 0.189) = 44.5 \text{ ksi}
\]

\[n = \frac{\sigma_{a_{\text{max}}}}{\sigma_A} = \frac{44.5}{23.1} = 1.92\]