ME 325 – Homework #2
Due: Wed., Feb. 4, 2009

1. Problem 7-4
2. Problem 7-10. Neglect the requirement about the reliability. Compute the applied force so that the component has an infinite fatigue life.
3. Problem 7-12.

(7-4) AISI 1137 cold-drawn $S_{ut} = 734$ MPa

(a) Endurance limit of a laboratory specimen:

$$S_e' = 0.504\,(734) = 370 \text{ MPa}$$

Surface finish factor $a = 4.51$ MPa $b = -0.265$

$$K_a = a \cdot S_{ut}^{\,b} = 4.51 \cdot 734^{-0.265} = 0.785$$

$$S_e = K_a \cdot S_e' = 0.785 \cdot 370 = 291 \text{ MPa}$$

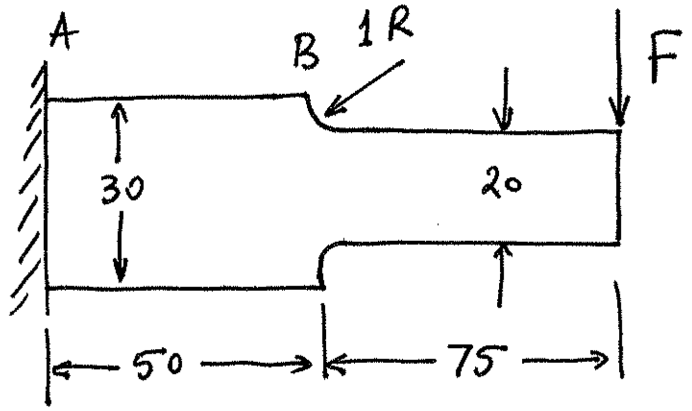
(b) $S_f = a \cdot N^b$ $N = 130 \cdot 10^3$ cycles

$$a = \frac{(0.9\,S_{ut})^2}{S_e} = \frac{(0.9 \cdot 734)^2}{291} = 1500 \text{ MPa}$$

$$b = -\frac{1}{3}\log\frac{0.9\,S_{ut}}{S_e} = -\frac{1}{3}\log\frac{0.9 \cdot 734}{291} = -0.119$$

$$S_f = 1500 \cdot (130 \cdot 10^3)^{-0.119} = 369.5 \text{ MPa}$$

(7-10)



AISI 1050 steel
- tempered at 800°F
- ground finish

Table A-21

$S_{ut} = 1090$ MPa

$S_{yt} = 793$ MPa

Monotonic (static) stress concentration factor:

$$\left.\begin{aligned} \frac{D}{d} &= \frac{30}{20} = 1.5 \\ \frac{r}{d} &= \frac{1}{12} = 0.05 \end{aligned}\right\} \Rightarrow K_t = 2.4$$

The axial stress is given by the bending moment. The question is which point is critical, A or B? It can be observed that at A, the moment arm is only $\frac{125}{75} = 1.67$ times greater than at point B. But at B the stress concentration is 2.4, which means that the stress at B is larger than the stress at A. In addition, the cross-sectional area at B is smaller than the cross-section at A. In conclusion, B is the critical location with the largest stress.

$$S_e' = 0.504 \cdot 1090 = 549 \text{ MPa}$$

$$K_a = a \cdot S_{ut}^{\,b} = 1.58 \cdot (1090)^{-0.085} = 0.872$$

$$d_e = 0.808 \sqrt{20 \cdot 10} = 11.43 \text{ mm}$$

$$K_b = \left(\frac{11.43}{7.62}\right)^{-0.1133} = 0.955$$

Fig. 5-16 → $q = 0.85$

$$K_f = 1 + 0.85(K_t - 1) = 1 + 0.85(2.4 - 1) = 2.19$$

$$K_e = \frac{1}{K_f} = 0.457$$

$$S_e = K_a \cdot K_b \cdot K_e \cdot S_e' = 0.872 (0.955)(0.457) \, 549 = 209 \text{ MPa}$$

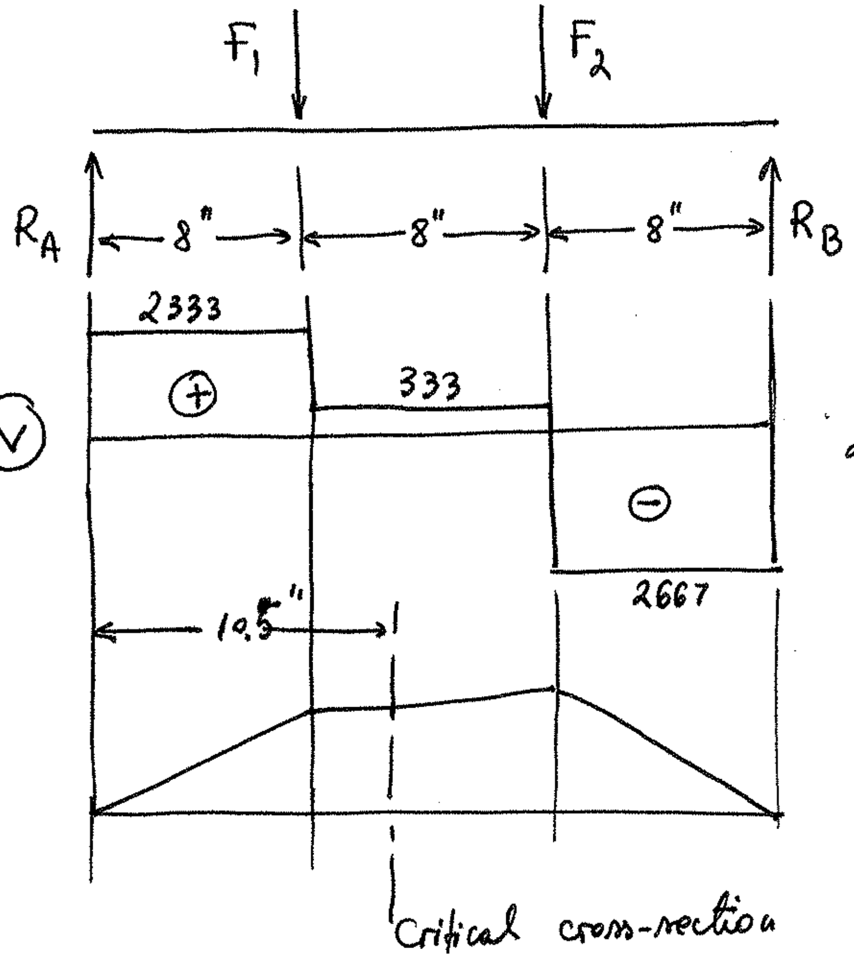
$$\sigma = \frac{M \cdot y}{I} = \frac{(F \cdot 75) \cdot 10}{\frac{10 \cdot 20^3}{12}} = \frac{F \cdot 75 \cdot 12}{20^3} = 0.113 F$$

(we put dimensions in mm, stress in MPa, thus the force will be in N)

$$S_e = 0.113 F \Rightarrow F = \frac{S_e}{0.113} = \frac{209}{0.113} = 1850 \text{ N}$$

7-12 $S_{ut} = 89$ ksi, ground finish, $n = 1720 \frac{rev}{min}$

$F_1 = 2000$ lb $\quad F_2 = 3000$ lb.



$R_A = 2333$ lb

$R_B = 2667$ lb

The critical location is at the center shoulder

$M = 2333 \cdot 10.5 - 2000 \cdot 2.5 =$
$= 19500$ lb.in

$$S_e' = 0.504(89) = 44.856 \text{ ksi}$$

$$K_a = a \cdot S_{ut}^{b} = 1.34 \cdot (89)^{-0.085} = 0.915$$

$$K_b = \left(\frac{d}{0.3}\right)^{-0.1133} = \left(\frac{1.625}{0.3}\right)^{-0.1133} = 0.826$$

$$K_c = K_d = 1$$

$$\left.\begin{aligned} \frac{D}{d} &= \frac{1.875}{1.625} = 1.154 \\ \frac{r}{d} &= \frac{0.0625}{1.625} = 0.03846 \end{aligned}\right\} \xrightarrow{\text{Table A-15-9}} K_t = 2.1$$

Fig. 5-16 $\Rightarrow q = 0.78$

$$K_f = 1 + q(K_t - 1) = 1 + 0.78(2.1 - 1) = 1.86$$

$$K_e = \frac{1}{K_f} = \frac{1}{1.86} = 0.538$$

$$S_e = K_a K_b K_c K_d K_e S_e' = 0.915(0.826)(0.538) \cdot 44.856 = 18.2 \text{ ksi}$$

$$\sigma = \frac{My}{I} = \frac{32M}{\pi d^3} = \frac{32 \cdot 19500}{\pi (1.625)^3} = 46.29 \text{ ksi}$$

$$\sigma = S_f$$

$$S_f = a \cdot N^b$$

$$a = \frac{(0.9 \cdot S_{ut})^2}{S_e} = \frac{(0.9 \cdot 89)^2}{18.2} = 352.5 \text{ ksi}$$

$$b = -\frac{1}{3} \log \frac{0.9(S_{ut})}{S_e} = -\frac{1}{3} \log \frac{0.9 \cdot 89}{18.2} = -0.2145$$

$$N = \left(\frac{S_f}{a}\right)^{\frac{1}{b}} = \left(\frac{46.29}{352.5}\right)^{-\frac{1}{0.2145}} = 12{,}893 \text{ cycles}$$

$$\text{Life } t = \frac{12893}{1720} = 7.5 \text{ min}$$