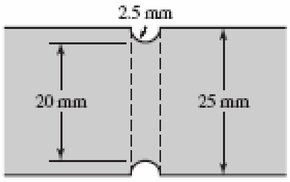
1.



(a) For an AISI 1018 CD-machined steel, the strengths are

Eq. (3-17): $S_{ut} = 440 \text{ MPa} \quad \Rightarrow \quad H_B = \dfrac{440}{3.41} = 129$

$$S_y = 370 \text{ MPa}$$

$$S_{su} = 0.67(440) = 295 \text{ MPa}$$

Fig. A-15-15: $\dfrac{r}{d} = \dfrac{2.5}{20} = 0.125, \quad \dfrac{D}{d} = \dfrac{25}{20} = 1.25, \quad K_{ts} = 1.4$

Fig. 7-21: $q_s = 0.94$

Eq. (7-31): $K_{fs} = 1 + 0.94(1.4 - 1) = 1.376$

For a purely reversing torque of 200 N · m

$$\tau_{max} = \frac{K_{fs} 16T}{\pi d^3} = \frac{1.376(16)(200 \times 10^3 \text{ N} \cdot \text{mm})}{\pi (20 \text{ mm})^3}$$

$$\tau_{max} = 175.2 \text{ MPa} = \tau_a$$

$$S'_e = 0.504(440) = 222 \text{ MPa}$$

The Marin factors are

$$k_a = 4.51(440)^{-0.265} = 0.899$$

$$k_b = \left(\frac{20}{7.62}\right)^{-0.107} = 0.902$$

$$k_c = 0.59, \quad k_d = 1, \quad k_e = 1$$

Eq. (7-17): $S_e = 0.899(0.902)(0.59)(222) = 106.2 \text{ MPa}$

Eq. (7-13): $a = \dfrac{[0.9(295)]^2}{106.2} = 664$

Eq. (7-14): $b = -\dfrac{1}{3} \log \dfrac{0.9(295)}{106.2} = -0.132\,65$

Eq. (7-15): $N = \left(\dfrac{175.2}{664}\right)^{1/-0.132\,65}$

$$N = 23\,000 \text{ cycles} \quad \textit{Ans.}$$

(b) For an operating temperature of 450°C, the temperature modification factor, from Table 7-6, is

$$k_d = 0.843$$

Thus $S_e = 0.899(0.902)(0.59)(0.843)(222) = 89.5 \text{ MPa}$

$$a = \frac{[0.9(295)]^2}{89.5} = 788$$

$$b = -\frac{1}{3} \log \frac{0.9(295)}{89.5} = -0.157\,41$$

$$N = \left(\frac{175.2}{788}\right)^{1/-0.157\,41}$$

$$N = 14\,100 \text{ cycles} \quad \textit{Ans.}$$

2.

Referring to the solution of Prob. 7-17, for load fluctuations of −800 to 3000 lbf

$$\sigma_a = 1.94\left|\frac{3.000-(-0.800)}{2(0.2813)}\right| = 13.1\text{ kpsi}$$

$$\sigma_m = 1.94\left|\frac{3.000+(-0.800)}{2(0.2813)}\right| = 7.59\text{ kpsi}$$

$$r = \frac{\sigma_a}{\sigma_m} = \frac{13.13}{7.60} = 1.728$$

(a) Table 7-10, DE-Gerber

$$n_f = \frac{1}{2}\left(\frac{64}{7.59}\right)^2\left(\frac{13.1}{24.6}\right)\left[-1+\sqrt{1+\left(\frac{2(7.59)(24.6)}{64(13.1)}\right)^2}\,\right] = 1.79 \quad \textit{Ans.}$$

(b) Table 7-11, DE-Elliptic

$$n_f = \sqrt{\frac{1}{(13.1/24.6)^2+(7.59/54)^2}} = 1.82 \quad \textit{Ans.}$$

3.

(a)
$$\tau_{\max} = \frac{16K_{fs}T_{\max}}{\pi d^3}$$

Fig. 7-21 for $H_B > 200, r = 3\text{ mm}, q_s \doteq 1$

$$K_{fs} = 1 + q_s(K_{ts} - 1)$$
$$K_{fs} = 1 + 1(1.6 - 1) = 1.6$$
$$T_{\max} = 2000(0.05) = 100\ \text{N}\cdot\text{m}, \quad T_{\min} = \frac{500}{2000}(100) = 25\ \text{N}\cdot\text{m}$$
$$\tau_{\max} = \frac{16(1.6)(100)(10^{-6})}{\pi(0.02)^3} = 101.9\text{ MPa}$$
$$\tau_{\min} = \frac{500}{2000}(101.9) = 25.46\text{ MPa}$$
$$\tau_m = \frac{1}{2}(101.9 + 25.46) = 63.68\text{ MPa}$$
$$\tau_a = \frac{1}{2}(101.9 - 25.46) = 38.22\text{ MPa}$$
$$S_{su} = 0.67S_{ut} = 0.67(320) = 214.4\text{ MPa}$$
$$S_{sy} = 0.577S_y = 0.577(180) = 103.9\text{ MPa}$$
$$S_e' = 0.504(320) = 161.3\text{ MPa}$$
$$k_a = 57.7(320)^{-0.718} = 0.917$$
$$d_e = 0.370(20) = 7.4\text{ mm}$$
$$k_b = \left(\frac{7.4}{7.62}\right)^{-0.107} = 1.003$$
$$k_c = 0.59$$
$$S_e = 0.917(1.003)(0.59)(161.3) = 87.5\text{ MPa}$$

Modified Goodman, Table 7-9,

$$n_f = \frac{1}{(\tau_a/S_e) + (\tau_m/S_{su})} = \frac{1}{(38.22/87.5) + (63.68/214.4)} = 1.36 \quad \textit{Ans.}$$

(b) Gerber, Table 7-10

$$n_f = \frac{1}{2}\left(\frac{S_{su}}{\tau_m}\right)^2 \frac{\tau_a}{S_e}\left[-1 + \sqrt{1 + \left(\frac{2\tau_m S_e}{S_{su}\tau_a}\right)^2}\,\right]$$
$$= \frac{1}{2}\left(\frac{214.4}{63.68}\right)^2 \frac{38.22}{87.5}\left\{-1 + \sqrt{1 + \left[\frac{2(63.68)(87.5)}{214.4(38.22)}\right]^2}\,\right\} = 1.70 \quad \textit{Ans.}$$

4.

$S_y = 800$ MPa, $S_{ut} = 1000$ MPa

(**a**) From Fig. 7-20, for a notch radius of 3 mm and $S_{ut} = 1$ GPa, $q \doteq 0.92$.

$$K_f = 1 + q(K_t - 1) = 1 + 0.92(3 - 1) = 2.84$$

$$\sigma_{\max} = -K_f \frac{4P}{\pi d^2} = -\frac{2.84(4)P}{\pi(0.030)^2} = -4018P$$

$$\sigma_m = \sigma_a = \frac{1}{2}(-4018P) = -2009P$$

$$T = fP\left(\frac{D+d}{4}\right)$$

$$T_{\max} = 0.3P\left(\frac{0.150 + 0.03}{4}\right) = 0.0135P$$

From Fig. 7-21, $q_s \doteq 0.95$. Also, K_{ts} is given as 1.8. Thus,

$$K_{fs} = 1 + q_s(K_{ts} - 1) = 1 + 0.95(1.8 - 1) = 1.76$$

$$\tau_{\max} = \frac{16K_{fs}T}{\pi d^3} = \frac{16(1.76)(0.0135P)}{\pi(0.03)^3} = 4482P$$

$$\tau_a = \tau_m = \frac{1}{2}(4482P) = 2241P$$

$$\sigma_m' = \left(\sigma_m^2 + 3\tau_m^2\right)^{1/2} = [(-2009P)^2 + 3(2241P)^2]^{1/2} = 4366P$$

$$\sigma_a' = \sigma_m' = 4366P$$

$$S_e' = 0.504(1000) = 504 \text{ MPa}$$

$$k_a = 4.51(1000)^{-0.265} = 0.723$$

$$k_b = \left(\frac{30}{7.62}\right)^{-0.107} = 0.864$$

$k_c = 0.85$ (Note that torsion is accounted for in the von Mises stress.)

$$S_e = 0.723(0.864)(0.85)(504) = 267.6 \text{ MPa}$$

Modified Goodman: $$\frac{\sigma_a'}{S_e} + \frac{\sigma_m'}{S_{ut}} = \frac{1}{n}$$

$$\frac{4366P}{267.6(10^6)} + \frac{4366P}{1000(10^6)} = \frac{1}{3} \quad \Rightarrow \quad P = 16.1(10^3)\text{ N} = 16.1 \text{ kN} \quad \textit{Ans.}$$

Yield: $$\frac{1}{n_y} = \frac{\sigma_a' + \sigma_m'}{S_y}$$

$$n_y = \frac{800(10^6)}{2(4366)(16.1)(10^3)} = 5.69 \quad \textit{Ans.}$$