7-27 $S_y = 800$ 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: $$\frac{\sigma'_a}{S_e} + \frac{\sigma'_m}{S_{ut}} = \frac{1}{n}$$

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

Yield: $$\frac{1}{n_y} = \frac{\sigma'_a + \sigma'_m}{S_y}$$

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

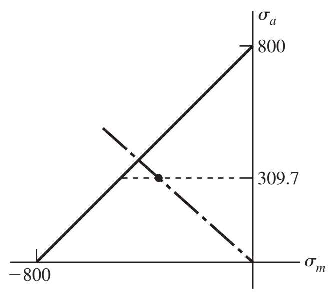
(b) If the shaft is not rotating, $\tau_m = \tau_a = 0$.

$\sigma_m = \sigma_a = -2009P$

$k_b = 1$ (axial)

$k_c = 0.85$ (Since there is no tension, $k_c = 1$ might be more appropriate.)

$S_e = 0.723(1)(0.85)(504) = 309.7$ MPa



$$n_f = \frac{309.7(10^6)}{2009P} \quad \Rightarrow \quad P = \frac{309.7(10^6)}{3(2009)} = 51.4(10^3)\text{ N}$$
$$= 51.4\text{ kN} \quad Ans.$$

Yield: $$n_y = \frac{800(10^6)}{2(2009)(51.4)(10^3)} = 3.87 \quad Ans.$$