6-34 NORTON

SEE SOLUTION OF 5-34 FOR MORE DETAIL OF STATICS

POINTS A & B ARE BOTH SUBJECT TO A FLUCTUATING STRESS DUE TO TORSION...

$$\tau_{min} = 0$$
$$\tau_{max} = \frac{16Fa(od)}{\pi(od^4 - id^4)}$$

$$\tau_{alt} = \frac{1}{2}\frac{16Fa(od)}{\pi(od^4 - id^4)}K_{f(T)} \quad \& \quad \tau_m = \frac{1}{2}\frac{16Fa(od)}{\pi(od^4 - id^4)}K_{t(T)}$$

POINT A IS SUBJECT TO BENDING STRESS...

$$\sigma_{min} = 0$$
$$\sigma_{max} = \frac{32F\ell(od)}{\pi(od^4 - id^4)}$$

$$\sigma_{alt} = \frac{1}{2}\frac{32F\ell(od)}{\pi(od^4 - id^4)}K_{f(B)} \quad \& \quad \sigma_m = \frac{1}{2}\frac{32F\ell(od)}{\pi(od^4 - id^4)}K_{t(B)}$$

POINT B IS ALSO SUBJECT TO SHEAR DUE TO BENDING. SINCE POINT A IS THE MOST HIGHLY STRESSED (IE, CRITICAL POINT) WE WON'T BOTHER TO CALCULATE THE SHEAR $\left[\tau = \frac{4}{3}\frac{V}{A}\right]$.

VON MISES MEAN STRESS FOR POINT A IS $\sigma_m' = \sqrt{\sigma_m + 3\tau_m}$

VON MISES ALT STRESS FOR POINT A IS $\sigma_a' = \sqrt{\sigma_a + 3\tau_a}$

NOTE: $K_{f(T)} = 1 + q\left(K_{t(T)} - 1\right)$ TORSION

AND

$K_{f(B)} = 1 + q\left(K_{t(B)} - 1\right)$ BENDING

WE WANT TO FIND A MATERIAL SPECIFICATION, IE; ULTIMATE STRENGTH BASED ON A FACTOR OF SAFETY, SO WE USE

$$N_f = \frac{S_e S_{ut}}{\sigma_a' S_{ut} + \sigma_m' S_e} \qquad \text{EQN } 6.18e \quad \text{pg } 416$$

AND WE NEED TO COMPUTE THE ENDURANCE LIMIT

$$S_e = \tfrac{1}{2} S_{ut} C_{LOAD} C_{SIZE} C_{SURF} C_{TEMP} C_{RELIAB} \qquad \text{EQN } 6\text{-}6 \quad p376$$

$C_{LOAD} = 1$ EQN 6-7(a)

$C_{SIZE} = 1.189\,(od)^{-0.097}$ EQN 6-7b

$C_{SURF} = 4.51\, S_{ut}^{-0.265}$ EQN 6-7e (ASSUME MACHINED)

$C_{TEMP} = 1$ EQN 6-7f

$C_{RELIAB} = 1$ TABLE 6-4

HAND CALCULATIONS FOR ROW A:

$$\tau_{alt} = \frac{1}{2}\frac{16 F a (od)}{\pi (od^4 - id^4)} K_f = \frac{1}{2}\frac{16(50N)\,.4m\,(.020m)}{\pi(0.020^4 m^4 - 0.014^4 m^4)} 2.65 = 22.2\text{ MPa}$$

$$k_f = 1 + .75(3.2-1) = 2.65$$

$q = .75$ FROM FIGURE 6-36; GUESS $S_{ut} \approx 275$ MPa AND ASSUME LARGE NOTCH RADIUS.

$$\tau_m = \frac{1}{2}\frac{16 F a (od)}{\pi (od^4 - id^4)} k_t = \frac{1}{2}\frac{16(50N)\,0.4m\,(0.020m)}{\pi(0.020^4 m - 0.014^4 m)} 3.2 = 26.8\text{ MPa}$$

$$\sigma_{alt} = \frac{1}{2}\frac{32 F l (od)}{\pi (od^4 - id^4)} k_f = \frac{1}{2}\frac{32(50N)\,0.1m\,(0.020m)}{\pi(0.02^4 m - 0.014^4 m)} 2.35 = 9.84\text{ MPa}$$

$K_f = 1 + 0.75(2.8-1) = 2.35$

$$\sigma_m = \frac{1}{2}\frac{32 F l (od)}{\pi (od^4 - id^4)} k_t = \frac{1}{2}\frac{32(50N)\,0.1m\,(0.020m)}{\pi(0.02^4 m - 0.014^4 m)} 2.8 = 11.7\text{ MPa}$$

6-34 NORTON (CONT'D)

$$C_{SIZE} = 1.189\,(20)^{-0.097} = 0.889$$

$$C_{SURF} = 4.51\,(275)^{-0.265} = 1.00 \qquad \text{(GUESS 275 MPa } S_{ut}\text{)}$$

$$S_e = 0.5(S_{ut})\,1(0.889)\,1.000(1)\,1 = 0.444\,S_{ut} \rightarrow \frac{S_e}{S_{ut}} = 0.444$$

$$\sigma_a' = \sqrt{(9.84)^2 + 3(22.2)^2} = 39.7 \text{ MPa}$$

$$\sigma_m' = \sqrt{(11.7)^2 + 3(26.8)^2} = 47.9 \text{ MPa}$$

$$N_f = 2 = \frac{S_e S_{ut}}{\sigma_a' S_{ut} + \sigma_m' S_e} = \frac{0.444\,S_{ut}}{\sigma_a' + 0.444\,\sigma_m'} \rightarrow S_{ut} = \frac{2(\sigma_a' + 0.444\,\sigma_m')}{0.444}$$

AND FINALLY:

$$S_{ut} = \frac{2(39.7 + 0.444(47.9))}{0.444} = 275 \text{ MPa}$$

{PREVIOUS GUESS OF 275 TO FIND $\frac{S_e}{S_{ut}}$ & q IS O.K.}

SEE SPREADSHEET ON NEXT PAGE FOR ADDITIONAL ROWS.

Prob. 6-34

Data from Table P5-3						Stress Conc. Factors					Stresses at Point A (Mpa)						Endurance limit and corrections				
ROW	l (m)	a (m)	F (N)	od (m)	id (m)	Ktb	Ktt	q	Kfb	Kft	Tau mean	Tau alt	Sigma mean	Sigma alt	eq mean	eq alt	Csize	Sut Guess	Csurf	Se/Sut	**Sut (MPa)**
a	0.100	0.400	50	0.020	0.014	2.8	3.2	0.75	2.35	2.65	26.8	22.2	11.7	9.8	47.9	39.7	0.89	275	1.0	0.445	**274**
b	0.070	0.200	85	0.020	0.006	2.8	3.2	0.75	2.35	2.65	17.5	14.5	10.7	9.0	32.1	26.6	0.89	184	1.0	0.445	**184**
c	0.300	0.100	95	0.025	0.017	2.8	3.2	0.75	2.35	2.65	6.3	5.2	33.1	27.8	34.9	29.2	0.87	204	1.0	0.435	**204**
d	0.800	0.500	160	0.046	0.022	2.8	3.2	0.75	2.35	2.65	7.1	5.9	19.8	16.6	23.3	19.5	0.82	142	1.0	0.410	**142**
e	0.085	0.350	900	0.055	0.024	2.8	3.2	0.75	2.35	2.65	16.0	13.3	6.8	5.7	28.6	23.7	0.81	175	1.0	0.403	**175**
f	0.050	0.180	950	0.050	0.030	2.8	3.2	0.75	2.35	2.65	12.8	10.6	6.2	5.2	23.1	19.1	0.81	140	1.0	0.407	**140**
g	0.160	0.280	850	0.045	0.019	2.8	3.2	0.75	2.35	2.65	22.0	18.2	22.0	18.5	44.0	36.5	0.82	266	1.0	0.411	**266**
h	0.200	0.100	800	0.040	0.024	2.8	3.2	0.75	2.35	2.65	11.7	9.7	41.0	34.4	45.7	38.3	0.83	276	1.0	0.416	**276**
i	0.400	0.150	950	0.065	0.037	2.8	3.2	0.75	2.35	2.65	4.7	3.9	22.1	18.5	23.5	19.7	0.79	146	1.0	0.397	**146**
j	0.200	0.100	600	0.045	0.032	2.8	3.2	0.75	2.35	2.65	7.2	6.0	25.2	21.2	28.2	23.6	0.82	171	1.0	0.411	**171**
k	0.120	0.180	880	0.060	0.047	2.8	3.2	0.75	2.35	2.65	9.6	7.9	11.2	9.4	20.0	16.7	0.80	123	1.0	0.400	**123**
l	0.150	0.250	750	0.052	0.028	2.8	3.2	0.75	2.35	2.65	11.9	9.8	12.5	10.5	24.0	20.0	0.81	147	1.0	0.405	**147**
m	0.070	0.100	500	0.036	0.030	2.8	3.2	0.75	2.35	2.65	16.9	14.0	20.7	17.4	35.8	29.8	0.84	213	1.0	0.420	**213**
n	0.085	0.150	820	0.040	0.015	2.8	3.2	0.75	2.35	2.65	16.0	13.2	15.9	13.3	31.9	26.5	0.83	191	1.0	0.416	**191**

NOTE: Use Kt in place of Kf in order to get the answers shown in the solution manual.
Use of Kf above is as per Dr. Dippery's instructions to class. The above values for q are based on assumptions of notch radius and your assumptions may vary.