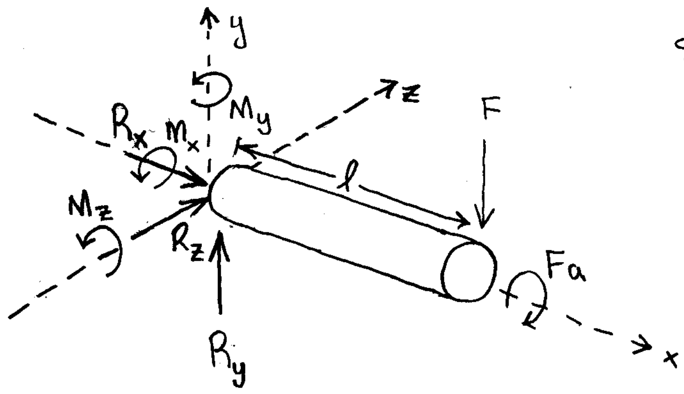
6-33 NORTON

FBD OF TUBE



STATICS:

$\Sigma F_x = 0;\quad 0 = 0$

$\Sigma F_y = 0;\quad R_y - F = 0 \rightarrow R_y = F$

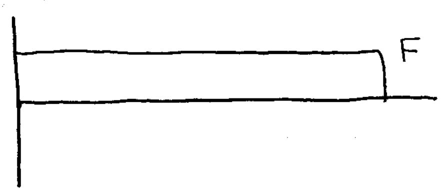
$\Sigma F_z = 0;\quad 0 = 0$

$\Sigma M_x = 0;\quad M_x - F_a = 0 \rightarrow M_x = F_a$

$\Sigma M_y = 0;\quad 0 = 0$

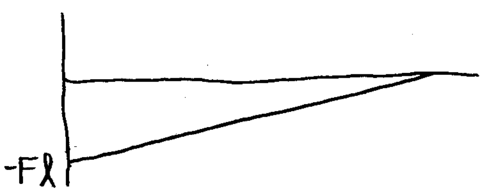
$\Sigma M_z = 0;\quad M_z - F\ell = 0 \rightarrow M_z = F\ell$

SHEAR DIAGRAM:

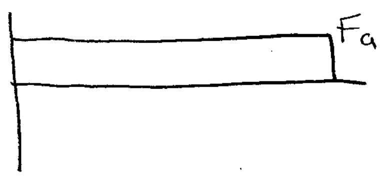


[SIGN CONVENTION]

MOMENT DIAGRAM:



TORQUE DIAGRAM:



TORSIONAL STRESS = $\frac{Tr}{J}K_f$ AT BOTH POINTS A AND B. SINCE FORCE F VARIES FROM +F TO −F, THIS IS AN ALTERNATING STRESS.

$$\tau_{xz} = \frac{Tr}{J}K_f = \frac{F_a\left(\frac{od}{2}\right)K_{fT}}{\frac{\pi}{32}\left(od^4 - id^4\right)}$$

THE BENDING STRESS AT POINT B IS ZERO, SINCE $\sigma = \frac{Mc}{I}K_f$ AND $c = 0$ (POINT B IS ON THE NEUTRAL AXIS). AT POINT A THE BENDING STRESS IS AN ALTERNATING LOAD (+F TO −F) AND IS...

$$\sigma_x = \frac{Mc}{I}K_f = \frac{F\ell\left(\frac{od}{2}\right)K_{fB}}{\frac{\pi}{64}\left(od^4 - id^4\right)}$$

THE VON MISES MEAN STRESS AT POINTS A AND B ARE BOTH ZERO. (NO MEAN STRESSES)

THE VON MISES ALTERNATING STRESSES ARE...

AT POINT A: $\sigma_{eq,a} = \sqrt{\sigma_x^2 + 3\tau_{xz}^2}$

AT POINT B: $\sigma_{eq,a} = \sqrt{3}\,\tau_{xz}$

POINT A IS THE MOST HIGHLY STRESSED POINT ON THE COMPONENT AND IS THEREFORE THE CRITICAL POINT.

SINCE THE MEAN STRESS IS ZERO, THE LOAD LINE IS VERTICAL, AND WE NEED ONLY COMPARE THE ENDURANCE LIMIT, S_f, TO THE EQUIVALENT ALTERNATING STRESS, $\sigma_{eq,a}$, FOR DESIGN PURPOSES.

$$S_f = S_f' C_{LOAD} C_{SIZE} C_{SURF} C_{TEMP} C_{RELIAB}$$

(EQN 6.2 a & b TEXT) $S_f'(@5\times10^8 \text{ CYCLES}) = S_e' = 0.5 S_{ut}$ FOR STEELS

(EQN 6.2 c & d TEXT) $S_f'(@5\times10^8 \text{ CYCLES}) = 0.4 S_{ut}$ FOR ALUMINUM

ASSUME MACHINED SURFACE, TEMP = ROOM TEMP, RELIAB = 50%

$\therefore$ $C_{TEMP} = C_{RELIAB} = 1$ (EQN 6.7f & TABLE 6-4 TEXT)

& $C_{LOAD} = 1$ (EQN 6.7a, TEXT)

& $C_{SIZE} = 1.189 d^{-0.097}$ (EQN 6.7b, TEXT)

NOTE: C_{SURF} AND K_f (PAGE 1) DEPEND ON S_{ut}, SO WE WILL HAVE TO ITERATE TO FIND THE SOLUTION.

TO SPECIFY A MATERIAL, WE NEED TO SATISFY THE FOLLOWING EQN:

$$\frac{S_f}{\sigma_{eq,a}} = FOS, \quad \text{OR} \quad 0.5 S_{ut} C_{SIZE} C_{SURF} = 2\sigma_{eq,a}$$

NOTE: 0.5 IS REPLACED BY 0.4 FOR ALUMINUM

HAND CALCULATIONS FOR ROW A:

$$\tau_{xz} = \frac{50N(.400m)(.010m)}{\frac{\pi}{32}(.020^4 - .014^4)m^4} 2.35 = 39.39 \text{ MPa}$$

$$\sigma_x = \frac{50N(.100m)(.010m)}{\frac{\pi}{64}(.020^4 - .014^4)m^4} 2.125 = 17.80 \text{ MPa}$$

(GUESSING $S_{ut} \approx 350\text{MPa} \rightarrow q \sim 0.75$, BASED ON STRESS MAGNITUDE)

$$\sigma_{eq,a} = \sqrt{17.8^2 + 3(39.4)^2} = 70.5 \text{MPa}$$

$$C_{SIZE} = 1.189(20)^{-0.097} = 0.89$$

$C_{SURF} \approx 0.9$ (AGAIN GUESSING $S_{ut} \sim 350$ mPa)

$$S_{ut} = \frac{2(70.5\text{mPa})}{0.5(0.89)(0.9)} = 352 \text{ MPa}$$

1010 COLD ROLLED STEEL ($S_{ut} = 365$ mPa IS APPROPRIATE)

NOTE: TO GET THE ANSWER SHOWN IN TABLE 6-33 FROM THE SOLUTION MANUAL, YOU MUST USE K_T INSTEAD OF K_F FOR THE FATIGUE STRESS CONCENTRATION FACTORS. (USING K_T IS MORE CONSERVATIVE, BUT THE RESULTS DIFFER BY LESS THAN 15% AND PROF. DIPPERY HAS SPECIFIED "USE K_F FOR FATIGUE", WHICH IS A COMMON PRACTICE.)

Data from Table P6-6						Prob. 6-33															
									Stresses at Point A (Mpa)				Stresses at Point B (Mpa)						
ROW	l (m)	a (m)	F (N)	od (m)	id (m)	q	Kf (bend)	Kf (tors)	Sigma bend	Tau-torsion	Tau-bending	von mises	Sigma bend	Tau-torsion	Tau-bending	von mises	Csize	Csurf	Sut
a	0.100	0.400	50	0.020	0.014	0.75	2.13	2.35	17.81	39.40	0	70.5	0	39.40	0.42	69.0	0.89	0.9	**352**
b	0.070	0.200	85	0.020	0.006	0.75	2.13	2.35	16.24	25.65	0	47.3	0	25.65	0.40	45.1	0.89	0.9	**236**
c	0.300	0.100	95	0.025	0.017	0.75	2.13	2.35	50.24	9.26	0	52.7	0	9.26	0.48	16.9	0.87	0.9	**269**
d	0.800	0.500	160	0.046	0.022	0.65	1.98	2.17	27.93	9.59	0	32.5	0	9.59	0.17	16.9	0.82	0.9	**220**
e	0.085	0.350	900	0.055	0.024	0.65	1.98	2.17	9.60	21.72	0	38.8	0	21.72	0.62	38.7	0.81	0.9	**268**
f	0.050	0.180	950	0.050	0.030	0.65	1.98	2.17	8.79	17.38	0	31.4	0	17.38	1.01	31.8	0.81	0.9	**214**
g	0.160	0.280	850	0.045	0.019	0.75	2.13	2.35	33.38	32.30	0	65.1	0	32.30	0.87	57.5	0.82	0.9	**352**
h	0.200	0.100	800	0.040	0.024	0.75	2.13	2.35	62.20	17.20	0	69.0	0	17.20	1.33	32.1	0.83	0.9	**369**
i	0.400	0.150	950	0.065	0.037	0.75	2.13	2.35	33.48	6.94	0	35.6	0	6.94	0.56	13.0	0.79	0.9	**199**
j	0.200	0.100	600	0.045	0.032	0.65	1.98	2.17	35.61	9.78	0	39.4	0	9.78	1.02	18.7	0.82	0.9	**267**
k	0.120	0.180	880	0.060	0.047	0.65	1.98	2.17	15.78	13.01	0	27.5	0	13.01	1.07	24.4	0.80	0.9	**191**
l	0.150	0.250	750	0.052	0.028	0.65	1.98	2.17	17.58	16.10	0	33.0	0	16.10	0.66	29.0	0.81	0.9	**226**
m	0.070	0.100	500	0.036	0.030	0.75	2.13	2.35	31.38	24.79	0	53.2	0	24.79	2.14	46.6	0.84	0.9	**281**
n	0.085	0.150	820	0.040	0.015	0.75	2.13	2.35	24.06	23.48	0	47.2	0	23.48	1.01	42.4	0.83	0.9	**253**

NOTE: Use Kt in place of Kf and use the equations for Csurf instead of the chart in order to get the answers shown in the solution manual.
Use of Chart for Csurf and 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.