CLASS PROBLEM 10-11

Material Hard-drawn wire $\sigma_{yp} = 0.75\sigma_{ult}$

$D = 10\,mm$

$d = 2\,mm$

$N_a = 120$

Ends – raised hook

$r_{m,hook} = 6.0\,mm$

$r_{m,bend} = 3.0\,mm$

F_i = pre-tension = 30N

L_H = 264mm ^ distance between hooks

From Table 10-5 (pg 422)

From Juvinal chart, ASTM 227

(a)(b) $\sigma_{ult} = 1500\ MPa$

$\sigma_{yp} = .75 \times 1500$

$$\boxed{\sigma_{yp} = 1125\ MPa}$$

$\tau_{yp} = \tau_{all} = .45\sigma_{ult} = S_{sy}$ (eqn 10-19)

$$\boxed{\tau_{all} = 675\ MPa}$$

(c) $k = \dfrac{dG}{8NC^3}$

$$k = \frac{(2\times10^{-3})(79.3\times10^{9})}{(8)(120)(5)^3}$$

$$\boxed{k = 1320\ N/m}$$

(b) $\tau_i = \frac{8F_i}{\pi d^2} C K_s$ – initial τ in wire

$K_s = 1 + \frac{0.5}{C}$ or Figure 12.4

$K_s = 1 + \frac{0.5}{5}$

$K_s = 1.1$

$\tau = \frac{(8)(30)(5)(1.1)}{(\pi)(.002)^2}$

$\boxed{\tau = 105 \text{ MPa}}$

(d) F_{yp} ?

$\tau = 675 \times 10^6 = \frac{(8)(F_{yp})(5)(1.1)}{(\pi)(.002)^2} = \tau_{all}$

$F_{yp} = \frac{(675 \times 10^6)(\pi)(.002)^2}{(8)(5)(1.1)}$

$\boxed{F_{yp} = 193 \text{ N}}$

Norton – see pa

(e) Hook ends, yield

Figure 10-3

$$\left.\begin{aligned} r_m &= 6 \\ r_i &= r_m - \frac{d}{2} \\ r_i &= 5 \end{aligned}\right\} \text{hook}$$

$$\left.\begin{aligned} r_m &= 3 \\ r_i &= r_m - \frac{d}{2} \\ r_i &= 2 \end{aligned}\right\} \text{bend}$$

$$K = \frac{r_m}{r_w}$$

$$K = \begin{cases} \frac{6}{5} = 1.2, \text{ hook} \\ \frac{3}{2} = 1.5, \text{ bend} \end{cases}$$

eqn (10-3), for the bend ÷ see Fig 10-3

$$\tau = K_s \frac{8FC}{\pi d^2}$$

here we use K instead of K_s,

setting $\tau = \tau_{all}$ for

$$F_{max} = \frac{(625 \times 10^6)(.002)^2(\pi)}{(8)(5)(1.5)}$$

$$\boxed{F_{max} = 141 \text{ N}}$$

For the hook:

$$\sigma = \frac{M}{I/c} + F/A = \sigma_{all} = \sigma_{yp}$$

$$\boxed{\sigma_{yp} = K\left(\frac{32 F_{max} r_m}{\pi d^3}\right) + \frac{4 F_{max}}{\pi d^2}}$$

$$1125 \times 10^6 = \left[\frac{(1.2)(.006)(32)}{(\pi)(.002)^3} + \frac{4}{(\pi)(.002)^2}\right] F_{max}$$

$$\boxed{F_{max} = 118 \text{N}}$$

$\therefore$ $F = \left.\begin{array}{l} 141 \sim \text{bend} \\ 118 \sim \text{hook} \\ 193 - \text{yield} \end{array}\right\}$ $\boxed{F_{max} = 118 \text{ N}}$

$F > 118$, coil yields

(g) F_i must be overcome before spring will deflect (stretch)

$$\delta = \frac{F}{k}$$

$$F = F_{max} - F_i$$

$$F = 118 - 30$$

$$F = 88\ N$$

$$\delta = \frac{88\ N}{1320\ N/m}$$

$$\delta = .067\ m = 67\ mm = \delta$$

$$L = \delta + \delta_o$$

$$\delta_o = 264\ mm$$

$$L = 67 + 264$$

$$\boxed{L \doteq 331\ mm}$$

CLASS PROBLEM 10-15

Extension Spring

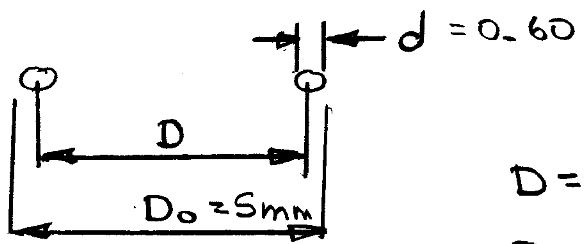
$d = 0.60$ mm   Music Wire

$D_o = 5$ mm

$P_i = 1.0$ N

$P_{max} = 6.0$ N

$n_{fatigue}$ = F.S for fatigue = ?

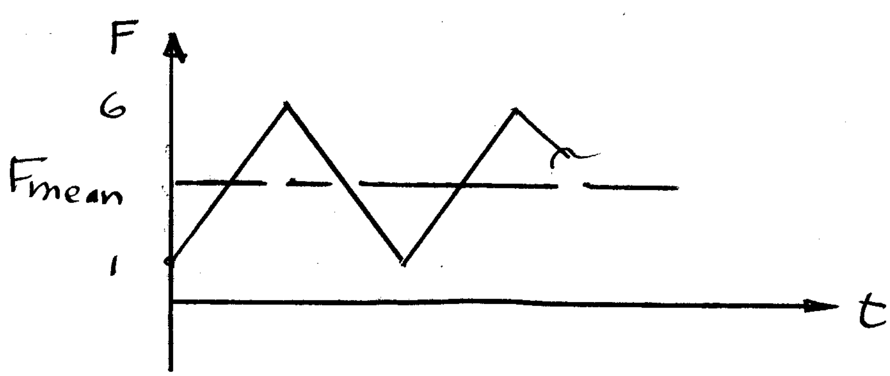


$D = D_o - d$

$D = 4.4$ mm

For fatigue, we need F_{max}, F_{min}

$$\left.\begin{array}{l} F_{min} = 1.0 \text{ N} \\ F_{max} = 6.0 \text{ N} \end{array}\right\} \quad \begin{array}{l} F_{mean} = 3.5 \text{ N} \\ F_{alt} = 2.5 \text{ N} \end{array}$$



$C = \dfrac{4.4}{.6} \doteq \underline{7.3 = C}$

$\underline{\sigma_{ult} = 2400 \text{ MPa}}$

For fatigue, we need τ_{mean} and τ_{alt} plus the Wahl factor (fatigue)

$$K_w = \frac{4C-1}{4C-4} + \frac{0.615}{C} = \frac{[(4)(7.3)-1]}{[(4)(7.3)-(4)]} + \frac{0.615}{7.3}$$

$$\underline{K_w = 1.2} \qquad K_s = 1 + \frac{.5}{C} = \underline{1.07 = K_s}$$

$$\tau = \frac{8FDK_s}{\pi d^3} = \frac{8FC}{\pi d^2}K_s \qquad \tau_i = \frac{(8)(1)(7.3)(1.07)}{(\pi)(.6)^2}$$

$$\tau_i = 55\,MPa$$

$$\tau_m = \frac{8F_m C}{\pi d^2}(K_s)$$

$$\tau_m = \frac{(8)(3.5)(7.3)(1.07)}{(\pi)(.6)^2} = 193\,MPa = \tau_m$$

$$\tau_a = \frac{(8)(F_a)(7.3)(1.2)}{(\pi)(.6)^2}$$

$$= \frac{(8)(2.5)(7.3)(1.2)}{(\pi)(.6)^2} = 155\,MPa = \tau_a$$

$$\tau_{su} = 0.67\,\sigma_{ult}$$

$$\underline{\tau_{su} = 1600}\ MPa = S_{us}$$

Assume an unpeened spring - choose unpeened because limits

pg 436: $\underline{S_{se} = 310\,MPa}$

Eqn 10-31, pg 437: $\frac{\tau_a}{S_{se}} + \frac{\tau_m}{S_{su}} = \frac{1}{n}$

$$\frac{155}{310} + \frac{193}{1600} = \frac{1}{n} = .63$$

$$\boxed{n = 1.6}$$

$$N_{fs} = \frac{S_{es}(S_{us} - \tau_i)}{S_{es}(\tau_m - \tau_i) + S_{us}\tau_a}$$

$$S_{es} = 0.707 \frac{S_{ew} S_{us}}{S_{us} - .707 S_{ew}}$$

unpeened

$S_{ew} = 310 \text{ MPa}$ Pg 20 of notes

$S_{us} = .67 \sigma_{ult}$ A228 $d = 0.6$

$S_{us} = 1600 \text{ mPa}$ $\sigma_{ult} = 2400 \text{ MPa}$

$$S_{es} = 0.707 \frac{(310)(1600)}{(1600) - (.707)(310)}$$

$\boxed{S_{es} = 254}$

$$N_{fs} = \frac{254(1600 - 55)}{254(193 - 55) + (1600)(155)}$$

$\boxed{N_{fs} = 1.3}$ Fatigue

$$N_{fs,\,yield} = \frac{\tau_{yp}}{\tau_{max}}$$

$\tau_{yp} = .45 \sigma_{ult}$

$\tau_{yp} = 1080 \text{ MPa}$

$$\tau_{max} = \frac{(8)(6)(7.3)(1.07)}{(\pi)(.6)^2} = 330 \text{ MPa} = \tau_{max}$$

$\boxed{FS_{yield} = 3.3}$ ~ yield

Peened

$$S_{ew} = 465 \text{ MPa}$$

$$S_{es} = 0.707 \frac{(465)(1600)}{(1600) - (.707)(465)}$$

$$S_{es} = 414 \text{ mPa}$$

$$N_{fs} = \frac{414\,(1600 - 55)}{414\,(193 - 55) + (1600)(155)}$$

$$\boxed{N_{fs} = 2.10}$$