LANCE DE LA CRUZ
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MAE190 DESIGN CODE PROJECT – PROOF OF CONCEPT / HAND CALC.

GIVEN:

$M_{max} = 5000$ lb in
$M_{min} = 1000$ lb in
$T_{max} = 1800$ lb in.
$T_{min} = 0$ lb in.
$S_y = 50$ kpsi
$S_{ut} = 75$ kpsi
$D/d = 1.2$
$r/d = 0.1$
99.99% reliability
$n = 1.5$

FIND:
min. diameter w/ 1% convergence limit

SOLUTION:

$$M_a = \frac{M_{max} - M_{min}}{2} = 2000 \text{ lb in} \qquad M_m = \frac{M_{max} + M_{min}}{2} = 3000 \text{ lb in.}$$

$$T_a = \frac{T_{max} - T_{min}}{2} = 900 \text{ lb in} \qquad T_m = \frac{T_{max} + T_{min}}{2} = 900 \text{ lb in.}$$

FROM FIG. C-2:
$A = 0.97098 \quad b = -0.21796$
$K_t = A(r/d)^b \simeq 1.60387$

FROM FIG. C-3.
$A = 0.83425 \quad b = -0.21649$
$K_{ts} = A(r/d)^b \simeq 1.37337$

$$\sqrt{a_b} = 0.246 - 3.08(10^{-3})S_{ut} + 1.51(10^{-5})S_{ut}^2 - 2.67(10^{-8})S_{ut}^3 = 0.0887$$

$$\sqrt{a_t} = 0.190 - 2.51(10^{-3})S_{ut} + 1.35(10^{-5})S_{ut}^2 - 2.67(10^{-8})S_{ut}^3 = 0.0664$$

FOR 1ST ITERATION, ASSUME $q = 1$

$$K_{f_1} = 1 + q(K_t - 1) = 1.604 \qquad K_{fs_1} = 1 + q(K_{ts} - 1) = 1.373$$

VIA TABLE 6-2 (MACHINED) $a = 2.00. \quad b = -0.217$

$$k_a = aS_{ut}^b = 0.788369 \simeq 0.784$$

ASSUME $k_{b_1} = 0.879$, $k_c = 1$, $k_d = 1$, $k_e = 0.702$, $k_f = 1$

$$S_e' = 0.5S_{ut} = 37.5 \text{ kpsi} \Rightarrow S_{e_1} = k_a k_b k_c k_d k_e k_f S_e' = 18.142 \text{ kpsi}$$

$$A_1 = \sqrt{4(K_f M_a)^2 + 3(K_{fs} T_a)^2} = 6763.6 \qquad d_1 = \left(\frac{16n}{\pi}\left(\frac{A}{S_e} + \frac{B}{S_{ut}}\right)\right)^{1/3} = 1.5676 \text{ in.}$$

$$B_1 = \sqrt{4(K_f M_m)^2 + 3(K_{fs} T_m)^2} = 9859.1 \qquad r_1 = 0.1 d_1 = 0.15676 \text{ in.}$$

ITERATION 2

$$k_b = 0.879 d_1^{-0.107} = 0.838 \qquad S_{e_2} = 17.282 \text{ kpsi} \qquad K_{f_2} = 1 + \frac{K_t - 1}{1 + \sqrt{a}/\sqrt{r}} = 1.373 \qquad K_{fs_2} = 1 + \frac{K_{ts} - 1}{1 + \sqrt{a}/\sqrt{r}} = 1.252$$

$A_2 = 5827.2 \quad B_2 = 8463.8 \quad d_2 = 1.5093 \quad r_2 = 0.1 d_i = 0.15093$ in.

$$\% \text{ error} = \frac{|1.5676 - 1.5093|}{1.5676}(100\%) = 3.72\%$$

ITERATION 3

$K_b = 0.8411 \quad S_e = 17.353$ kpsi $\quad K_f = 1.370 \quad K_{fs} = 1.251 \quad A = 5816.1 \quad B = 8447.4 \quad d = 1.5068 \quad r = 0.15068$

$$\% \text{ error} = \frac{1.5093 - 1.5068}{1.5093} = 0.17\%$$

$$\therefore \boxed{d_{min} = 1.5068 \text{ inches}}$$