MCA Consultants, Inc.
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JOB
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SCALE

Nathan Stenseng

$100 \frac{rev}{min} \cdot \frac{1 min}{60 sec} \cdot \frac{2\pi rad}{1 rev} = 10.47 \frac{rad}{sec}$

B: 150 mm C = 250 mm, 30 teeth F = 125 mm
$\phi = 20°$

ABCD: 1018 CD

spherical ball bearing

square key: $K_t = 2.14$, $K_{ts} = 3.0$, $\frac{r}{d} = 0.02$

a. The largest stress is due to $M_{max} = \sqrt{M_{xy}^2 + M_{xz}^2}$

$\boxed{@B: M_{max} = 181.9 \ N{\cdot}m}$

@C: $M_{max} = 180.4 \ N{\cdot}m$

Since B and C have the same torque and stress concentration factor, we will only look at the applied moment and this is larger in $\boxed{\text{point B}}$

b. $S_y = 370$ MPa from table A-20

@B: $\sigma = \frac{Mc}{I} = \frac{32 \cdot 181.9 \cdot 10^3}{\pi (30)^3} = 68.62 \text{ MPa} \cdot 2.14 = 146.8$

$\tau = \frac{16T}{\pi d^3} = \frac{16 \cdot 200 \cdot 10^3}{\pi (30)^3} = 37.72 \text{ MPa} \cdot 3.0 \rightarrow 113.6$

$\sigma_{ave} = \frac{\sigma}{2} = 74.3$ MPa

$R = \sqrt{\left(\frac{\sigma}{2}\right)^2 + \tau^2} = 135.25$ MPa

$\sigma_1 = \sigma_{ave} + R = 209.6$ MPa

$\sigma_3 = \sigma_{ave} - R = -60.9$ MPa

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$\sigma_1 > 0 > \sigma_3$

$\therefore S_y = \underbrace{\sigma_1 - \sigma_3}_{270.5\,MPa}$ $\quad n = \dfrac{S_y}{\sigma_1 - \sigma_3} = \boxed{1.37}$ for MSS

$\sigma' = \sqrt{\sigma^2 + 3\tau^2} = 245.5\ MPa$

$n = \dfrac{S_y}{\sigma'} = \boxed{1.5}$ for DE

in both cases, this part does not experience yielding

c. Goodman: $n = \dfrac{\pi d^3}{16}\left(\dfrac{A}{S_e} + \dfrac{B}{S_{ut}}\right)^{-1}$

$A = \sqrt{4(K_f M)^2 + 3(K_{fs} T)^2}$

$B = 0$ since completly reversible

$S_{ut} = 440\ MPa$ $\quad r = r/d \cdot 30 = 0.6$

$K_f = 1 + q(K_t - 1)$ $\quad q = 0.7$

$K_{fs} = 1 + q(K_{ts} - 1)$ $\quad q = 0.75$

$K_f = 1.798$ $\quad K_{fs} = 2.5$

$A = 1085203.98$

$S_e = K_a K_b S_e'$

$S_e' = 0.5 \cdot 440 = 220$

$K_a = 0.8114 = a S_{ut}^{\,b}$ for CD

$K_b = 1.24\, d^{-0.107} = 0.86$

$S_e = 153.828\ MPa$

$\boxed{n_f = 0.75}$

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d. $y_z = \frac{1600 \cdot 125 \cdot 325}{6\,E \cdot 450 \cdot \frac{\pi}{64}(d)^4}(325^2 + 125^2 - 450^2)$

$= 0.237$ mm

$y_y = \frac{2667 \cdot 75\,(450-325)}{6\,E \cdot 450 \cdot \frac{\pi}{64}(30)^2}(325^2 + 75^2 - 2 \cdot 450 \cdot 375)$

$+ \frac{582.4 \cdot 125 \cdot 325}{6\,E \cdot 450 \cdot \frac{\pi}{64}(30)^2}(325^2 + 125^2 - 450^2)$

$= -0.255$ mm

y_{max} @ C $= \sqrt{y_z^2 + y_y^2} = \boxed{0.349 \text{ mm}}$
$= 0.0137$ in

P for C $= \frac{N}{d} = \frac{30}{9.84} = 3$

250 mm to in

For P = 3, max y = $\boxed{0.010 \text{ in}}$
Our deflection $\boxed{\text{exceeds}}$ this

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e. $\theta_{Axz} = \dfrac{-Fab(l+b)}{6EIl} = -9.5 \cdot 10^{-4}$ rad

$\theta_{Dxz} = \dfrac{Fab(l+a)}{6EIl} = +0.00168$ rad

$\theta_{Axy} = \dfrac{-2667ab(l+b)}{6EIl} - \dfrac{582.4\, ab(l+b)}{6EIl} = +0.003397$ rad

$\theta_{Dxy} = \dfrac{2667\, ab(l+a)}{6EIl} + \dfrac{582.4ab(l+a)}{6EIl} = -0.002597$ rad

$\theta_A = 0.0035$ rad $\qquad \theta_D = 0.0031$ rad

allow 0.026-0.052 rad

We do not exceed the max allowable slope at either A or D.

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f. $\sigma = \frac{K_v W^t P}{F Y}$ $\qquad P = 3 \frac{\text{teeth}}{\text{in}}$

$F = 4 \cdot \frac{\pi}{P} = 4.189$

$W^t = \frac{1600}{V} = 358.69 \text{ lbf}$

$Y = 0.358$

$K_v = \frac{1200 + V}{1200} = 100$

$\boxed{\sigma = 71.75 \text{ Kpsi}}$