HW 5

Q1) $\tau_{max} = \frac{\pi}{16} \tau_y d^3 = \frac{\pi}{16} \times 500000000$

$= 98.2\ kNm$

$\tau_{min} = \frac{\tau}{n} = 49.1\ kNm$

$F_s = \tau \times A_s$

$T = F_s \times d/_2$

$T = \tau \times l \times w \times d/_2$

$l = \frac{2T}{\tau \times w \times d} = \frac{2 \times 49.1 \times 10^6}{42 \times 16 \times 50}$

$l = 2921.43mm$

$F_c = \sigma_c A_c$

$T_c = F_c \times d/_2$

$\tau = \sigma_c \times l \times t \times \frac{d}{2}$

$l = \frac{2T}{\sigma_c t d} = \frac{2 \times 49.1 \times 10^6}{70 \times 10 \times 50} = 2805.14mm$

The shear criterion governs the required length.

$l = 2921.43mm$

Q2) $T = \frac{\pi}{16} \tau_y d^3 = \frac{\pi}{16} \times 200 \times 10^6 (0.0637)^3$

$T = 9.964\ kN$

$T = \frac{\tau \cdot k}{d} = \frac{9.964 \times 10^3 \times 0.745}{0.016} = 7.427 \times 10^{5}$

As $T \leq 0.4 \times 10^6$

$l \geq \frac{T}{\tau}$ $\quad l \geq \frac{9.964 \times 10^3}{0.4 \times 10^6}$ $\Rightarrow l \approx 24.9mm$

Date : ______

Q3) $T_{shaft} = \frac{\pi}{16} \times 5\pi_1 \times 10^6 \times (30\times10^{-3})^3 = 1570.5\,N$

$T_{shaft} = P_m$

$1570 = l w \frac{d}{2} \left(\frac{\sigma}{6}\right) = l \times w \left(\frac{30}{1000\times2}\right) \times \left(\frac{650\times10^6}{6}\right)$

$l = \frac{0.00115}{0.0314} = \underline{153.3\,mm}$

Q5) $\frac{\alpha_{95}}{\alpha_{90}} = \left(\frac{\ln(1/R_{95})}{\ln(1/R_{90})}\right)^{1/b} = \left(\frac{\ln(1/0.95)}{\ln(1/0.9)}\right)^{1/1.17}$

$= \left(\frac{0.0513}{0.1054}\right)^{0.5547} = 0.54$

$\therefore \alpha_{90} \times 0.54 = \alpha_{95} \Rightarrow 20\times10^6 \times 0.54 = 10.8\times10^6$

$w = \left(\frac{n_1 w_1^3 + n_2 w_2^3 + n_3 w_3^3 + n_4 w_4^3}{n_1 + n_2 + n_3 + n_4}\right)^{1/3}$

$= \left(\frac{0.1n \times 3^3 + 0.2n \times 2^3 + 0.3n \times 1^3 + 0.4n \times 0^3}{0.1n + 0.2n + 0.3n + 0.4n}\right)^{1/3}$

$\boxed{w = 1.663\ kN}$

dynamic loading,

$c = w\left(\frac{\alpha_{90}}{10^6}\right)^{1/k} = 1.663\left(\frac{20\times10^6}{10^6}\right)^{1/3}$

$= 4.514\ kN$

$\alpha_{90} = \frac{\alpha_{95}}{0.54} \Rightarrow \frac{20\times10^6}{0.54} = 37.04\times10^6$

$\therefore c = w\left(\frac{\alpha_{90}}{10^6}\right)^{1/k} = 1.663 \times \left(\frac{37.04\times10^6}{10^6}\right)^{1/3}$

$\underline{c = 5.54\ kN}$

Date :

Q6) $\alpha_{99} = 60 \times N \times m = 60 \times 720 \times 24000 = 1036.8 \times 10^6$ rev

considering life adjustment factors for operating conditions material to be 0.9 & 0.85

$$\frac{\alpha_{99}}{\alpha_{90}} = \left(\frac{\ln(1/R_{99})}{\ln(1/R_{90})}\right)^{1/b} = \left(\frac{\ln(1/0.99)}{\ln(1/0.9)}\right)^{1/1.17} \times 0.9 \times 0.85$$

$$= \left(\frac{0.01005}{0.1054}\right)^{0.8547} \times 0.9 \times 0.85 = 0.1026$$

$$\alpha_{90} = \frac{\alpha_{99}}{0.1026} = \frac{1036.8 \times 10^6}{0.1026} = 10105 \times 10^6 \text{ rev}$$

$$C = W\left(\frac{\alpha_{90}}{10^6}\right)^{1/k} = 1 \times \left(\frac{10105 \times 10^6}{10^6}\right)^{1/3}$$

$$\underline{\underline{C = 21.62 \text{ kN}}}$$

Q7) $W = C \times V \cdot W_R + Y \cdot W_A$ K_s

radial load factor $= 1$, axial load factor $= 1.5$

$W = (W_R + 1.5 W_A) K_s$

for different opening cycles.

$W_1 = (2000 + 1.5 \times 1200) \times 3 = 11400$ N

$W_2 = (1500 + 1.5 \times 1000) \times 1.5 = 4500$ N

$W_3 = (1000 + 1.5 \times 1500) \times 2 = 6500$ N

$W_4 = (1200 + 1.5 \times 2000) \times 1 = 4200$ N

$L = 60 N \times d_n = 0.9 \times 10^6$ N rev.

$L_1 = \frac{1}{10} \times 0.9 \times 10^6 \times N_1 = 36 \times 10^6$ rev

$L = L_1 + L_2 + L_3 + L_4$

$= 684 \times 10^6$ rev

$L_2 = \frac{1}{10} \times 0.9 \times 10^6 \times 500 = 45 \times 10^6$ rev

$L_3 = \frac{1}{10} \times 0.9 \times 10^6 \times 600 = 105 \times 10^6$ rev.

$L_4 = \frac{1}{10} \times 0.9 \times 10^6 \times 800 = 432 \times 10^6$ rev

$$W = \left(\frac{L_1 W_1^3 + L_2 W_2^3 + L_3 W_3^3 + L_4 W_4^3}{L_1 + L_2 + L_3 + L_4}\right)^{1/3} \Rightarrow \left(\frac{1.191 \times 10^{20}}{\ldots \times 10^{6}}\right)^{1/3}$$

$W = 5707$ N

$C = 5707 \left(\frac{684 \times 10^6}{100}\right)^{1/3}$

$= 49.143$ kN