Answer Key

Bolts and Screws

1

$$P = \frac{F}{A} = \frac{F}{\frac{\pi D^2}{4}}$$

$$\left(9\ \frac{kg}{cm^2}\right)\left(\frac{9.81\ m/s^2}{1000\ \frac{kg\text{-}m}{kN\text{-}s^2}}\right) = \frac{F}{\frac{\pi}{4}(40cm)^2}$$

$$F = 110.9485\ kN$$

Force carried per bolt

$$F_b = \frac{F}{n} = \frac{110.9485\ kN}{16} = 6.9343\ kN$$

Hence;

$$S_t = \frac{F}{A}$$

$$\left(250\ \frac{kg}{cm^2}\right)\left(\frac{9.81\ m/s^2}{1000\ \frac{kg\text{-}m}{kN\text{-}s^2}}\right) = \frac{6.9343\ kN}{\frac{\pi}{4}d^2}$$

$$d = (1.8974\ cm)\left(\frac{10mm}{1\ cm}\right)$$

$$d = 18.9737\ mm$$

$$F_e = \frac{S_y}{6}(A_s)^{1.50}$$

$$550\ lbs = \frac{65000\ lb/in^2}{6}(A_s)^{1.50}$$

$$A_s = 0.1371\ in^2$$

$$P = \frac{DNd^{2.3}}{50}$$

$$8hp = \frac{(2in)(850rpm)\,d^{2.3}}{50}$$

$$d = 0.5331\,in$$

$$P = \frac{2\pi T_c N}{60} \quad ; \quad T_c = \frac{W D_c f_c}{2}$$

$$D_c = \frac{D_o + D_i}{2} = \frac{2(0.110 + 0.080)\,m}{2} = 0.19\,m$$

subst;

$$T_c = (600\,kg)\left(\frac{9.81\,m/s^2}{1000\,\frac{kg\text{-}m}{kN\text{-}s^2}}\right)\left(\frac{0.19}{2}\,m\right)(0.20)$$

$$T_c = 0.11183\ kN\text{-}m$$

Hence;

$$P = \frac{2\pi\,(0.11183\ kN\text{-}m)(160\ rpm)}{60}$$

$$P = (1.8737\ kW)\left(\frac{1\,hp}{0.746\,kW}\right)$$

$$\boxed{P = 2.5117\ hp}$$

$$W = S_t(0.55D^2 - 0.25D)$$

$$(12\text{tons})\left(\frac{2000\text{ lbs}}{1\text{ ton}}\right) = S_t\left[0.55\left(\frac{40}{25.4}\text{ in}\right)^2 - 0.25\left(\frac{40}{25.4}\text{ in}\right)^2\right]$$

$$S_t = 32258\text{ psi}$$

$$P = \frac{1}{\text{Thread/inch}} \quad ; \quad L = 3P$$

$$(25\,mm)\left(\frac{1\,in}{25.4\,mm}\right) = 3P$$

$$P = 0.3281\,in$$

Subst;

$$0.3281\,in = \frac{1}{\text{Thread/inch}}$$

$$\text{Thread/inch} = 3.048$$

$$\varepsilon = \frac{\tan\alpha\,(1 - f\tan\alpha)}{\tan\alpha + f + \left[\frac{f_c D_c}{D_m}\right](1 - f\tan\alpha)}$$

using choices:

$\tan\alpha = \tan 14.3^\circ = 0.2549$

substituting $\varepsilon = 0.70$

Hence; $\boxed{\alpha = 14.3^\circ}$

$$\varepsilon = \frac{\tan\alpha\,(1 - f\tan\alpha)}{\tan\alpha + f + \left[\frac{f_c D_c}{D_m}\right](1 - f\tan\alpha)}$$

$$\tan\alpha = \frac{L}{\pi D_m} = \frac{1\,in}{\pi(1.8\,in)} = 0.1768$$

$$0.65 = \frac{0.1768\left[1 - f(0.1768)\right]}{0.1768 + f}$$

$$0.11492 + 0.65f = 0.1768 - 0.03126f$$

$$0.68126f = 0.06188$$

$$\boxed{f = 0.09083}$$

Efficiency of the screw

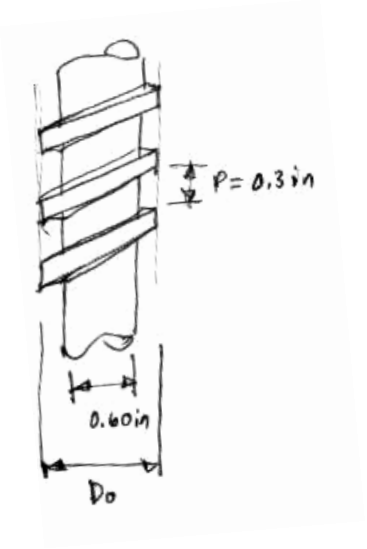
$$\varepsilon = \frac{\text{output}}{\text{input}} * 100\%$$

$$P_{output} = (3000\ \text{lbs})\left(35\ \frac{\text{ft}}{\text{min}}\right)\left(\frac{1\ \text{min}}{60\text{s}}\right)\left(\frac{1\ \text{hp}}{550\ \frac{\text{lb-ft}}{\text{sec}}}\right) = 3.1818\ \text{hp}$$

Hence;

$$\varepsilon = \frac{3.1818\ \text{hp}}{5\ \text{hp}} * 100\%$$

$$\varepsilon = 63.64\ \%$$



$$D_o = D_i + \frac{L}{2}$$

$$= 0.60\,in + \frac{2(0.3\,in)}{2}$$

$$\boxed{D_o = 0.90\,in}$$

Total torque required

$$T_T = T + T_c$$

$$T = W \frac{D_m}{2} \tan(\alpha + \phi)$$

$$\alpha = \tan^{-1}\left(\frac{\text{Lead}}{\pi D_m}\right)$$

$$\alpha = \tan^{-1}\left[\frac{2\,(12\text{mm})}{\pi\,(180\text{mm})}\right] = 2.4302°$$

$$\phi = \tan^{-1} f = \tan^{-1}(0.14) = 7.9696°$$

subst;

$$T = \frac{(90000\,N)(0.180m)}{2} \tan(2.4302° + 7.9696°)$$

$$T = 1486.5989\ N\text{-}m$$

Hence:

$$T_T = \left[1486.5989 + (0.25)(1486.5989)\right] N\text{-}m$$

$$T_T = 1858.2486\ N\text{-}m$$

Acme thread

$$T = W \frac{D_m}{2} \left[\frac{\tan\alpha + \frac{\tan\phi}{\cos\theta}}{1 - \tan\alpha \left(\frac{\tan\phi}{\cos\theta} \right)} \right]$$

$$\tan\phi = 0.95$$

$$\cos\theta = \cos 14.5^\circ = 0.9681$$

$$\tan\alpha = \frac{\text{lead}}{\pi D_m} = \frac{6\,mm}{\pi(28\,mm)} = 0.06821$$

Hence;

$$T = (800\,kg)\left(\frac{9.81\,m/s^2}{1000\,\frac{kg\text{-}m}{kN\text{-}s^2}}\right)\left(\frac{0.028\,m}{2}\right)\left[\frac{0.06821 + \frac{0.95}{0.9681}}{1 - 0.06821\left(\frac{0.95}{0.9681}\right)}\right]$$

$$T = 0.1236\,kN\text{-}m$$

Square thread

$$T = W\frac{D_m}{2}\tan(\alpha + \phi)$$

$$\alpha = \tan^{-1}\left(\frac{\text{lead}}{\pi D_m}\right) = \tan^{-1}\left[\frac{7\,mm}{\pi(35\,mm)}\right] = 3,64\,26°$$

$$\phi = \tan^{-1} f = \tan^{-1} 0,18 = 10,2040°$$

Subst;

$$T = 30\,kN\left(\frac{0,035\,m}{2}\right)\tan\left(3,6426° + 10,2040°\right)$$

$$\boxed{T = 0,1294\ kN\text{-}m}$$

$P = \frac{2\pi TN}{60}$; Linear velocity

$v = NL$

$\frac{8\,ft}{min} = N\left(9\,mm\right)\left(\frac{1\,in}{25.4\,mm}\right)\left(\frac{1\,ft}{12\,in}\right)$

$N = 270.9333\ rpm$

Substi

$P = \frac{2\pi\left(55\ N\text{-}m\right)\left(270.9333\ rpm\right)}{60}$

$P = \left(1560.4639\ W\right)\left(\frac{1\,hp}{746\,W}\right)$

$P = 2.0918\ hp$

$T = CDF_i$; $P = \frac{F}{A}$

$$\left(100\ \frac{kg}{cm^2}\right)\left(\frac{14.7\ psi}{1.033\ kg/cm^2}\right) = \frac{F}{90\ cm^2\left(\frac{1\ in}{2.54\ cm}\right)^2}$$

$$F = 19851.4434\ lbs$$

Force per bolt

$$F_b = \frac{F}{n} = \frac{19851.4434\ lbs}{6} = 3308.5739\ lbs$$

Hence;

$$T = (0.20)\left(\frac{3}{5}\ in\right)(3308.5739\ lbs)$$

$$T = 397.0289\ in\text{-}lb$$

$$F_e = \frac{S_y}{6}(A_s)^{1.50}$$

$$= \frac{(450\,000\ kPa)\left(\frac{14.7\ psi}{101.325\ kPa}\right)}{6}(0.14\ in^2)^{1.50}$$

$$F_e = 569.9727\ lbs/_{bolt}$$

Hence;

$$P = \frac{F}{A} = \frac{(569.9727\ lbs)(6)}{\frac{\pi}{4}\left[(14\ cm)\left(\frac{1\ in}{2.54\ cm}\right)\right]^2}$$

$$P = 143.3266\ psi$$

working strength

$$W = S_t\left(0.55D^2 - 0.25D\right)$$

$$(95\,kN)\left(\frac{1000N}{1\,kN}\right)\left(\frac{0.0459\,lbs}{1N}\right) = (55\,mPa)\left(\frac{1000\,kPa}{1\,mPa}\right)\left(\frac{14.7\,psi}{101.325\,kPa}\right)\left[0.55D^2 - 0.25D\right]$$

$D = 1.0607\,in$

$$W = S_t\left(0.55D^2 - 0.25D\right)$$

$$= 14000\,\frac{lb}{in^2}\left[0.55(1.50\,in)^2 - 0.25(1.50\,in)\right]$$

$$W = 12075\ lbs$$

$$F_a = C(A_r)^{1.418}$$

$$= 5000\left(0.75\,in^2\right)^{1.418}$$

$$F_a = 3325.1166\ lbs$$

$$S_w = C(A_r)^{0.418}$$

$$= 15000\left(0.60\ in^2\right)^{0.418}$$

$$S_w = 12115.9782\ psi$$