Answer Key

Keys and Splines

ONLINE REVIEW

1

$$P = \frac{2\pi T N}{60} \quad ; \quad S_s = \frac{2T}{dbL} \quad ; \quad FS = \frac{0.6\,S_y}{S_s}$$

Subst;

$$0.6\,\frac{S_y}{FS} = \frac{2T}{dbL}$$

$$\frac{(0.6)(70000\ kPa)}{4} = \frac{2T}{(3\ in)\left(\frac{1\ ft}{12\ in}\right)\left(\frac{1\ m}{3.28\ ft}\right)(0.025\ m)(0.05\ m)}$$

$$T = 0.500\ kN\text{-}m$$

Hence;

$$P = \frac{2\pi\,(0.500\ kN\text{-}m)(380\ rpm)}{60}$$

$$\boxed{P = 19.9043\ kW}$$

For shear

$$S_s = \frac{2T}{dbL}$$

$$62000\ \text{kPa} = \frac{2(0.915\ \text{kN-m})}{(0.064\ \text{m})(0.012\ \text{m})L}$$

$$L = 0.03843\ \text{m}$$

$$L = 38.43\ \text{mm}$$

For compression/Tension:

$$S_c = \frac{4T}{dtL}$$

$$100\ 000\ \text{kPa} = \frac{4(0.915\ \text{kN-m})}{(0.064\ \text{m})(0.016\ \text{m})L}$$

$$L = 0.0357\ \text{m}$$

$$L = 35.7\ \text{mm}$$

Hence;

choose : $\boxed{L = 38.43\ \text{mm}}$

Based on shearing in the key

$$\frac{0.6\,S_y}{FS} = \frac{2T}{dbL}$$

Based on torsional stress:

$$\frac{0.6\,S_y}{FS} = \frac{16T}{\pi d^3}$$

$$\frac{0.6\,(60000\ \text{lb/in}^2)}{4.0} = \frac{16T}{\pi\left(\frac{52}{25.4}\ \text{in}\right)^3}$$

$$T = 15162.8654\ \text{lb-in}$$

Hence;

$$\frac{0.6\,S_y}{4.0} = \frac{2\,(15162.8654\ \text{lb-in})}{\left(\frac{52}{25.4}\ \text{in}\right)\left(\frac{3}{4}\ \text{in}\right)(4.5\ \text{in})}$$

$$\boxed{S_y = 29.2602\ \text{ksi}}$$

Exponential LEAP ONLINE REVIEW

for the shearing stress at key

$$S_s = \frac{2T}{dbL}$$

$$220000\ KPa = \frac{2T}{(0.10m)(0.03m)(0.180m)}$$

$$T = 59.4\ kN\text{-}m$$

from;

$$T_{pulley} = T_{KEY}$$

$$F_{pulley}\left(\frac{D_{pulley}}{2}\right) = T_{KEY}$$

$$F_{pulley}\left(\frac{1m}{2}\right) = 59.4\ kN\text{-}m$$

$$\boxed{F_{pulley} = 118.8\ kN}$$

$$S_c = \frac{F_c}{A_c} = \frac{F_c}{\left(\frac{t}{2}\right)L} \quad ; \quad L = 5t$$

$$420000\ \text{KPa} = \frac{150\ \text{kN}}{\left(\frac{t}{2}\right)(5t)}$$

$$t = 0.01195\ m$$

$$\boxed{t = 11.95\ mm}$$

$$S_c = \frac{4T}{d\,t\,L}$$

$$450\,000\ kPa = \frac{4(2.5\ kN\text{-}m)}{(0.05\ m)\,t\,(0.022\ m)}$$

$$t = 0.02020\ m$$

$$\boxed{t = 20.20\ mm}$$

For Line Shafts

$$P = \frac{D^3 N}{80}$$

$$(18\ kw)\left(\frac{1\ hp}{0.746\ kw}\right) = \frac{D^3(380\ rpm)}{80}$$

$D = 1.4930$ in (shaft diameter)

For the key

$$S_s = \frac{F_s}{A_s} = \frac{F_s}{bL} \quad ; \quad b = \frac{1}{4}d$$

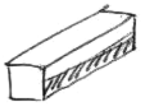
$$250\,000\ kPa = \frac{F_s}{\frac{1}{4}(1.4930\ in)(1\ in)\left(\frac{1\ ft^2}{144\ in^2}\right)\left(\frac{1m}{3.28ft}\right)^2}$$

$$\boxed{F_s = 60.2331\ kN}$$

$$S_c = \frac{4T}{dtL}$$

$$28000\ \frac{lb}{in^2} = \frac{4T}{(2.5\ in)\left(\frac{7}{16}\ in\right)(3.5\ in)}$$

$$\boxed{T = 26796.875\ in\text{-}lb}$$



$F = 2fN$; $P = \frac{2\pi TN}{60}$

$$120\ kW = \frac{2\pi T(1300\ rpm)}{60}$$

$$T = 0.8815\ kN\text{-}m$$

Then;

$$T = F\left(\frac{d}{2}\right)$$

$$0.8815\ kN\text{-}m = F\left(\frac{0.055\ m}{2}\right)$$

$$F = 32.0536\ kN$$

Hence; the force required to remove shaft from Hub

$$F = 2(0.50)(32.0536\ kN)$$

$$\boxed{F = 32.0536\ kN}$$

$$P = \frac{2\pi T N}{60}$$

$$200\ kW = \frac{2\pi\ T\ (420\ rpm)}{60}$$

$$T = 4.5473\ kN\text{-}m$$

and from;

$$S_s = \frac{2T}{dbL}$$

$$220000\ kPa = \frac{2(4.5473\ kN\text{-}m)}{(0.075\ m)(0.018\ m)\ L}$$

$$L = 0.0306\ m$$

$$\boxed{L = 30.6\ mm}$$

exponential LEAP ONLINE REVIEW

$A_c = 2.5\ in^2$

$A_c = tLN_s$

$(2.5\ in^2) = (0.10D)(2.25\ in)(6)$

$D = 1.8519\ in$

$A_s = 3.5\ in^2$

$A_s = bLN_s$

$(3.5\ in^2) = (0.25D)(2.25\ in)(6)$

$D = 1.0370\ in$

choose: $\boxed{D = 1.0370\ in}$

14

4 spline shaft

$d = 0.85D = 0.85(1.5\text{ in}) = 1.275\text{ in}$

$b = 0.241D = 0.241(1.5\text{ in}) = 0.3615\text{ in}$

$t = 0.075D = 0.075(1.5\text{ in}) = 0.1125\text{ in}$

$$S_s = \frac{F}{A_s} = \frac{F}{bLN_s}$$

$$900\,\frac{lb}{in^2} = \frac{F}{(0.3615\text{ in})(2\text{ in})(4)}$$

$$\boxed{F = 2602.8\text{ lbs}}$$

15

$$S_c = \frac{4T(1.1)}{(D+d)(t)(L)N_c} \quad ; \quad HP = \frac{2\pi TN}{33000}$$

$$120\,Hp = \frac{2\pi T(1850\,rpm)}{33000}$$

$$T = 340.6776 \text{ lb-ft}$$

Subst:

$$S_c = \frac{4(340.6776 \text{ lb-ft})\left(\frac{12\,in}{1\,ft}\right)(1.1)}{(2.5\,in + 2\,in)(0.1875\,in)(0.18)(2.5\,in)(6)}$$

$$\boxed{S_c = 7895.8693\,psi}$$

EXPONENTIAL LEAP ONLINE REVIEW

$$HP = \frac{2\pi T N}{33000}$$

$$(100\ kW)\left(\frac{1\ hp}{0.746\ kW}\right) = \frac{2\pi T\,(2000\ rpm)}{33000}$$

$$T = 352.0183\ lb\text{-}ft$$

from: $T_s = \dfrac{T}{N_s}$; $T_s = F\left(\dfrac{D+d}{4}\right)$

$$F\left(\frac{D+d}{4}\right) = \frac{T}{N_s}$$

$$F = \frac{4T}{(D+d)N_s} = \frac{4\,(352.0183\ lb\text{-}ft)\left(\frac{12\ in}{1\ ft}\right)}{(1.8+1.62)\,in\,(8)}$$

$$\boxed{F = 617.5759\ lbs\ \text{(Force per spline)}}$$

$$Hp = \frac{2\pi TN}{33000} \quad ; \quad S_c = \frac{4T}{(D+d)tLN_s}$$

$$820\,\frac{lb}{in^2} = \frac{4T}{(2.5+2)in(0.25\,in)(1.625\,in)(6)}$$

$$T = 2248.5938 \text{ in-lb}$$

Substi:

$$Hp = \frac{2\pi(2248.5938 \text{ in-lb})\left(\frac{1\,ft}{12\,in}\right)(3000\,rpm)}{33000}$$

$$\boxed{Hp = 107.0328\ hp}$$

$$S_c = \frac{F}{A_c} = \frac{F}{t\,L\,N_s}$$

$$800\,\frac{lb}{in^2} = \frac{F}{(0.1750\,in)(2.5\,in)(4)}$$

$$\boxed{F = 1400\ lbs}$$

Based on Shearing of Spline

$$T_s = \frac{T}{N_s} \quad ; \quad F = \frac{2T_s}{d}$$

$$T = \frac{F d N_c}{2} = \frac{(2300\,lbs)(2.38\,in)(6)}{2} = 16422\ in\text{-}lbs$$

subst;

$$HP = \frac{2\pi T N}{33000} = \frac{2\pi\,(16422\,in\text{-}lb)\left(\frac{1\,ft}{12\,in}\right)(2600\,rpm)}{33000}$$

$$\boxed{HP = 677.4607\ hp}$$

Exponential LEAP ONLINE REVIEW

Based on Compression of Spline

$$T_s = \frac{T}{N_s} \; ; \quad F = \frac{T_s}{\left(\frac{D+d}{4}\right)}$$

$$T = F\left(\frac{D+d}{4}\right)N_s = 2000\ lbs\left[\frac{(1.5 + 1.365)in}{4}\right](10)$$

$$\boxed{T = 14325\ in-lb}$$

Based on Shearing of Spline

$$S_s = \frac{F}{A_s}$$

$$S_s = \frac{F}{bLN_s} = \frac{2400\ \text{lbs}}{(0.625\ \text{in})(2\ \text{in})(4)}$$

$$\boxed{S_s = 480\ \text{psi}}$$

23

Based on Compression of Spline

$$S_c = \frac{F}{A_c} = \frac{F}{t L N_s} = \frac{2200 lbs}{(0.1 in)(1.5 in)(6)}$$

$$\boxed{S_c = 2444.4444 \text{ psi}}$$

24 to 27

$d = 0.81D = 0.81(2.25\,in) = 1.8225\,in$

$b = 0.156D = 0.156(2.25\,in) = 0.351\,in$

$t = 0.095D = 0.095(2.25\,in) = 0.2138\,in$

$L = 1.625\,in$

$N = 2800\,rpm$

$S_c = 850\,psi$

a) $A_c = tL = (0.2138\,in)(1.625\,in)$

$\boxed{A_c = 0.3474\,in^2}$

b) $S_c = \dfrac{F}{A_c} = \dfrac{F}{A_c N_s}$

$850\,\dfrac{lb}{in^2} = \dfrac{F}{0.3474\,in^2}$

$\boxed{F = 295.29\,lbs}$

c) $T = T_s N_s = \dfrac{F_s d}{2} N_s$

$= (295.29\,lbs)\left(\dfrac{1.8225\,in}{2}\right)(10)$

$\boxed{T = 2690.8301\,in\text{-}lbs}$

d) $Hp = \dfrac{2\pi T N}{33000} = \dfrac{2\pi(2690.8301\,in\text{-}lbs)\left(\frac{1\,ft}{12\,in}\right)(2800\,rpm)}{33000}$

$\boxed{Hp = 119.5443\,hp}$