Tutorial 1

Question 1

A double-stranded no. 60 roller chain is used to transmit power between a 13-tooth driving sprocket at 300 rev/min and a 52-tooth driven socket

INFORMATION

2 strand
No.60 chain
$n_1 = 300$rpm
Driving teeth $N_1 = 13$
Driven teeth $N_2 = 52$

Part a.

What is the allowable horsepower?

$H_a = K_1 K_2 H_{tab}$

From table 17-20, $H_{tab} = 6.20$, from table 17-20, we can see that we are in pre-extreme hp
From table 17-22, $K_1 = 0.75$
From table 17-23, $K_2 = 1.7$ since this is a double roller

$\implies H_a = H_{tab} \cdot K_1 \cdot K_2 = 7.905\text{hp}$

Part b.

Determine the centre-to-centre distance if the chain length is 82 links (pitches)

$\frac{L}{p} = 82$

From table 17-19 pitch $= 0.750$
Equation 17-36: $A = \frac{N_1+N_2}{2} - \frac{L}{p}$

Equation 17-35: $c = \frac{p}{A}\left[-A + \sqrt{A^2 - 8\left(\frac{N_2 - N_1}{2\pi}\right)^2}\right]$

$A = \frac{13+52}{2} - 82 = -49.5$

$c \approx 18$in

Part c.

Determine the torque and chain tension if the power transmitted is 30% less than the corrected (allowable) power

$H = H_a \cdot 70\% = 5.53$hp

$T\omega = H$

$w = \frac{2\pi n}{60} = 31.4$ rad/s

$T = \frac{H}{\omega} = 1163$ lb-in

Now for the tension $T = D \cdot \frac{PD_1}{2}$

From Equation 17-29: $PD_1 = \frac{p}{\sin\left(\frac{180^\circ}{N_1}\right)}$

$PD_1 = \frac{0.75\text{in}}{\sin\left(\frac{180^\circ}{N_1}\right)} = 3.13$ in

$F = \frac{2T}{PD_1} = 742$ lbf

Question 2

A four stranded no. 40 roller chain transmits power from a 21 tooth driving sprocket to an 84 tooth driven sprocket. The angular speed of the driving sprocket is 2000 rpm

INFORMATION

4 strand

No.40 chain

$N_1 = 21$

$N_2 = 84$

$n_1 = 8000$

Part a.

if the centre-to-centre distance needs to be 20 in what is the chain length?

$c = 20, \quad L = ?$

From Equation 17-34: $\frac{L}{p} \approx \frac{2c}{p} + \frac{N_1+N_2}{2} + \frac{(N_2-N_1)^2}{\frac{4\pi^2 c}{p}}$

From table 17-29: $p = 0.5$ in

$\implies L = 67.5$ in

Part b.

Determine the tabulated horsepower

$H_a = ?, \qquad H_a = K_1 K_2 H_{tab}$

From table 17-20: $H_{tab} = 7.72$ hp

From table 17-22: K_1 in the post-extreme region $= \left(\frac{N_1}{17}\right)^{1.5} = 1.84$

From table 17-23: $K_2 = 3.3$

$\implies H_a = 34.9$ hp

Part c.

Estimate allowable horsepower from Equation 17-32 and 17-33 which are the sources for table 17-20 and compare with value found in Part b.

Equation 17-32: **Link plate failure**

$$H_1 = K_{lp} N_1^{1.08} n_1^{0.9} p^{3-0.7p} \cdot K_2$$

$$K_{lp} = \begin{cases} 0.0022 \sim \text{no.41} \\ 0.0040 \sim \text{other} \end{cases}$$

Plug in values to get $H_1 = 12.8 K_2 = 42.4$ hp

> **NOTE**
>
> There is something weird about this calculation, the numbers don't give that answer but TA said the answer is correct

Equation 17-33: **Roller pin failure**

$$H_2 = 1000 K_r N^{1.5} p^{0.8} n_1^{-1.5} \cdot K_2$$

$$K_r = \begin{cases} 2.8 & \sim & \text{no.}25, 35 \\ 3.4 & \sim & \text{no.}41 \\ 17 & \sim & 20 - 240 \end{cases}$$

$$\implies K_r = 17$$

$H_2 = 10.5K_2 = 34.7$ hp

As we can see the failure is going to be roller pin failure for this system

Part d.

What is the tension using the result from Part b.

$F = ?$

$T = \frac{H}{\omega}$ $\qquad \omega = \frac{2\pi n}{60} = 209.4$ rad/s

$T = \cdots = 1096$ lb-in

$F = \frac{2T}{PD_1}$
From equation 17-29: $PD_1 = \frac{P}{\sin\left(\frac{180°}{N_1}\right)} = 3.36$ in
$\implies F = 654$ lbf

Question 3.

A **six** inch wide polyamide F-1 flat belt connects a 2 in diameter pulley to drive a larger pullet with an angular velocity ratio of 0.5. The centre-to-centre distance is nine feet, the
angular velocity of the small pulley is 1750 rev/min as it delivers 2hp. The application is such that a service factor K_s of 1.25 is appropriate

Part a.

Find $F_c, F_i, F_{1a}, \& F_2$

$F_c \equiv$ tension from centrifugal force
$F_1 \equiv$ initial tension
$F_{1a} \equiv$ largest allowable tension
$F_2 \equiv$ loose side tension

From equation 17-8e: $F_c = \frac{W}{g} \cdot \left(\frac{v}{60}\right)^2$

$v = \frac{2\pi n}{60} \cdot \frac{d_1}{2} = 183.3$ in/s $= 916$ ft/min

$W = \gamma b t \cdot \frac{12\text{in}}{1\text{ft}}$

$t \equiv$ thickness of belt

$b \equiv$ belt width $= 6$in

From table 17-2:

$t = 0.05$in

$\gamma = 0.095 \frac{\text{lbf}}{\text{in}^3}$

$F_a = 35 \frac{\text{lbf}}{\text{in}}$

$f = 0.5$

$\implies W = 0.025 \cdot 6 \cdot 0.05 \cdot 12 = 0.126 \frac{\text{lbf}}{\text{ft}}$

$\implies F_c = \frac{0.126}{32.17} \cdot \left(\frac{916}{60}\right)^2 = 0.913$lbf

From equation 17-8h: $F_{1a} - F_2 = \frac{2T}{d}$

$T = \frac{H}{\omega}$

From equation 3-42: $H = H_{nom} \cdot K_s n_d$

$n_d \sim$ design factor

$n_d = 1$

$T = \frac{63025 \cdot H_{nom} K_s n_d}{n} = 90$lbf-in

$F_2 = F_{1a} - \frac{2T}{d} = 147 - 2 \cdot \frac{90}{2} = 57$lbf

From equation 18-8i: $F_i = \frac{F_1 + F_2}{2} - Fc = 101.11$lbf

Part b.

What is H_a

From equation 17-11j: $H_a = \frac{(F_{1a} - F_2)V}{33{,}000} = 2.5$hp

Part c.

What is the factor of safety $n_{fs} =$?

$n_{fs} = \frac{H_a}{H_{nom} K_s} = 1$

Part d.

What is the belt length?

From equation 17-2:

$$L = \sqrt{4c^2 - (D-d)^2} + \frac{1}{2}(D\phi_D + d\phi_d)$$

$\frac{d}{D} = VR = 0.5 \implies D = 4$in

$\phi_d = \pi - 2\arcsin\left(\frac{D-d}{2c}\right) = 3.12$rad
$\phi_D = \pi + 2\arcsin\left(\frac{D-d}{2c}\right) = 3.16$rad

$\implies L = 225$in

Part e.

Find belt dip

From equation 17-13: dip$= \frac{c^2W}{96F_i} = \frac{(9\cdot12)^2(0.126)}{96*101.1} = 0.151$in