Tutorial 2

Question 1

A 60hp four cylinder internal combustion engine is used to drive a medium-shock brick making machine under a schedule of 2 shifts per day. the drive consists of two 26 inch sheaves about 12 feet apart, with a sheave speed of 400rpm. Select a Gates Rubber V-belt D360 arrangement.

INFORMATION

medium shock
$H_{nom} = 60$hp
D360 V-belt
$d = D = 26$in
$n = 400rpm$

Part a.

Determine the number of belts required

$N_b \geq \frac{H_d}{H_a}$

From table 17-11: $L_p = 360 + 3.3 = 363.3$ this is the pitch length of our belt
From equation 17-16b:

$$c = 0.25\left[\left(L_p - \frac{\pi}{2}\right)(D+d) + \sqrt{L_p - \frac{\pi}{2}(D+d)^2 - 2(D-d)^2}\right]$$

$\implies c = 140.8\text{in} \approx 12\text{ft}$

From table 17-15: $K_s = 1.4$
From equation 17-19: $H_d = H_{nom}K_s n_d, \quad n_d = 1$
$H_d = 60 \cdot 1.4 = 84\text{hp}$

From equation 17-17: $H_a = K_1 K_2 H_{tab}$
$K_1 \equiv$ wrap angle correction factor
$K_2 \equiv$ belt length correction factor

From table 17-13: $K_1 = 1.00$ since the wrap angle is 180°

From table 17-14: $K_2 = 1.1$

$v = \frac{\pi d n}{12} = 2722.7 \frac{\text{ft}}{\text{min}}$

From table 17-12:

This speed is not on the table so we have to do a linear interpolation!!!!!!!!!!!!!!!!!!!!!

at 3000fpm: $H_{tab} = 18.1$hp

at 2000fpm: $H_{tab} = 13.9$hp

Therefore $H_{tab} = 16.94$hp

$H_a = (1)(1.1)(16.94) = 18.63$hp per belt

$N_b = \frac{H_d}{H_a} = 4.5$ so we will use 5 belts :D

Part b.

Estimate the taut side tension, slack tension, and pre-tension values. What is the factor of safety?

From equation 17-22: Force transmitted per belt

$\Delta F = \frac{\left(63025 \cdot \frac{H_d}{N_b}\right)}{n \cdot \frac{d}{2}} = \frac{\left(63025 \cdot \frac{84}{5}\right)}{\frac{400 \cdot 26}{2}} = 203.6$lbf per belt

From equation 17-21: centrifugal tension

$F_c = K_c \left(\frac{v}{1000}\right)^2$

From table 17-16: $K_c = 3.498$

$F_c = 3.498 \cdot \left(\frac{2722.7}{1000}\right)^2 = 25.93$lbf per belt

From equation 17-23: taut side tension

$F_1 = F_c + \frac{\Delta F e^{f\phi}}{e^{f\phi} - 1}$

From page 902 Shigleys (manufacturer) $f = 0.5123$

$\phi = \pi$

$F_1 = 280.4$lbf per belt

From Equation 17-24: slack side tension

$F_2 = F_1 - \Delta F$

$F_2 = 76.83$lbf per belt

From Equation 17-25: pre-tension

$F_i = \frac{F_1 + F_2}{2} - F_c$

$F_i = 152.7$lbf per belt

wtf is this class man I am in belt hell

From equation 17-26: $n_{fs} = \frac{H_a N_b}{H_{nom} K_s} = 1.1$

Part c.

Estimate the life in passes, hours, and days

From equation 17-28: $t = \frac{N_p L_p}{720v}$
$N_p \equiv$ number of passes

From equation 17-27
$N_p = \left[\left(\frac{K}{T_1} \right)^{-b} + \left(\frac{K}{T_2} \right)^{-b} \right]^{-1}$

From table 17-17: Durability parameters
D-belt$=$ $\begin{cases} K = 18726 \\ b = 11.105 \end{cases}$

Pg 906
$T_1 = F_1 + \frac{K_b}{d}$

From table 17-16: $K_b = 5680$
$T_1 = 498$lbf

$\implies N_p = 9.6 \cdot 10^9 > 10^9$ so for some fucking reason $N_p = 10^9$
$\implies t > \frac{10^9 (363.3)}{720(2722.7)} = 185325$hrs $= 16$hrs/day
$\implies t > 31.7$ years

Question 2

Do the same shit from the last question but with Gates Heavy Duty V-Belt Design Manual

Part a.

Pg B2
Table B1 $K_s = 1.5$
$H_d = H_{nom} K_s = 90$hp

Pg B3 Choose CP belt
Table B3 $d > 12$ so lets pick $d = 13$ because we are like that

Pg B191-Table B23

We are going to select a CP330 belt based off the table
$c = 145 > 144$
This also gives us our horsepower correction factor also or service factor $K_s = 1.2$

$v = \frac{\pi d n}{12} = 1361$ fpm

$H_a = K_s H_{tab}$
Pg B230 - Table B33: $H_{tab} = 23.3$hp

$\implies H_a = 1.2 \cdot 23.3 = 27.96$hp
$\implies N_b = \frac{H_d}{H_a} = \frac{90}{27.96} = 3.22$ so we use 4 belts

Part b.

What is the factor of safety? Estimate the taut side tension, slack tension, and pre-tension values

All of this is the same as what was done in Question 1
$n_{fs} = \frac{H_a N_b}{H_{nom} K_s} = 1.29$

Use C-blet parameters

$\Delta F = 545.2$lbf per belt
$F_c = 3.18$lbf per belt
$F_i = 409$lbf per belt
$F_1 = 684.9$ lbf per belt
$F_2 = 139.5$lbf per belt

Part c.

static tension - T_{st}

Pg D24 - TableD27
$M = 1.6 \quad Y = 89$

Pg D24 - Formula D19
$T_{st} = 15 \left(\frac{2.5 - K_\phi}{K_\phi}\right) \left(\frac{\text{motor hp} \cdot 10^3}{N_b v}\right) + \frac{M v^2}{10^6}$

Pg D24 - Table D26

$K_\phi = 1$

$T_{st} = 250.9$ lbf

DO NOT USE EQUATION D25

Formula D35: span length $= t = c\left[1 - 0.125\left(\frac{D-d}{2}\right)^2\right]$

$t = c = 145$in

deflection $= \frac{t}{64} = 2.25$

From equation F20: $F_{min} = \frac{1.4T_{st}+Y}{16} = 27.5$lbf

From equation F21: $F_{max} = \frac{1.5T_{st}+Y}{16} = 29.1$lbf