Example 7: Design of a V-belt

4 cylinder diesel engine 1
water pump 2

$n_1 = 1800$ rpm
$n_2 = 1200$ rpm
$Pow = 80$ hp
time – less than 6 hrs a day

Design V-belt

Conversion factor:
$1hp = 745.7\ W$
$C_f = 745.7\ \frac{W}{hp}$

TYPE 5V or SPB

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① CALCULATE POWER
Use table to determine service factor:

② $f_s = 1.1$ – service factor

$Pow = 80 \cdot 745.7 \cdot 1.1$
or
$Pow = 88\ kW$

$Pow = 65622\ W$
$Pow = 65,62\ kW$

③ Calculate speed ratio

$$SR = \frac{n_1}{n_2} = \frac{1800}{1200} = 1.5 = \frac{D}{d}$$

④ Determine pulley sizes

$(12 \le v_B \le 40\ m/s)$ select mid range of $v_B = 20\ m/s$

$$v_B = \frac{d}{2} \cdot \pi \cdot n / 60$$

$$d = \frac{v_B}{\pi \cdot n_1} = \frac{20 \cdot 60}{\pi \cdot 1800} = 0,2122\ m$$

$d = 212.2$ mm

$D = SR \cdot d = 1,5 \cdot 212.2$

$D = 318.3$ mm

⑤ Now find standard pulley sizes
Looking at catalogue. Standard sizes of metric pulleys are
190; 212; 224; 236; 250; 280; 315; 355 mm.

Select pulley 1: 212 mm & pulley 2 315 mm

Actual $SR_A = \frac{315}{212} = 1,4858 \Rightarrow$ actual $n_2 = n_1 / SR_A = 1211.4$ rpm

6) Find rated power

212 mm + 1500 rpm ⇒ Pow rating per belt = 17,39 kW

7) Adjust for speed ratio:

For 1500 rpm + S/r of 1.5 ⇒ Pow_a = 1,19 kW

Total power per belt: Pow_B = 17,39 + 1.19 = 18,58 kW

8) Estimated centre distance

$$D \leq C \leq 3(D+d)$$

$$315 \leq C \leq 3 \times 527 = 1581$$

Assume centre distance of 1000 mm = 1 m

Find belt length

$$L = 2C + \frac{2}{\pi}(D+d) + \frac{(D-d)^2}{4C}$$

$$L = 2 \cdot 1 + \frac{2}{\pi} \cdot (0,315 + 0,212) + \frac{(0,315 - 0,212)^2}{4 \cdot 1}$$

$$\boxed{L = 2,338 \text{ m}}$$

9) Select standard belt length of 2360 mm

$$L = 2,360 \text{ m}$$

10) Calculate ~~real~~ actual centre distance

$$B = 4L - 2\pi(D-d) = 4 \cdot 2,36 - 2\pi \cdot (0,315 - 0,212) \; ; \; \boxed{B = 8.19}$$

$$C = \frac{B + \sqrt{B^2 - 32(D-d)}}{16} = \frac{8.19 + \sqrt{8.19^2 - 32(0,315-0,212)^2}}{16}$$

$$\boxed{C = 1,0975 \text{ m}}$$

Example 7 (cont.)

11) Find wrap angle (small pulley)

$$\theta_1 = \pi - 2 \cdot \sin^{-1}\left(\frac{D-d}{2C}\right) = \pi - 2\arcsin\left(\frac{0,315-0,212}{2 \cdot 1,0975}\right)$$

$$\theta_1 = 3,0477 \text{ rad} = 174,6^\circ$$

12) Potentially correct for angle & length → wrap angle, length

$$Pow_{RC} = C_\theta \cdot C_L \cdot Pow_R$$

$$= 0,98 \cdot 0,98 \cdot 18,58 \text{ kW} = 17,844 \text{ kW}$$

13) Number of belts required:

$$\#\text{ of belts} = \frac{Pow}{Pow_{RC}} = \frac{65,62}{17,844} = 3,7$$

use #4 belts

Example 9: Chain

No.25 rolling chain / 21 tooth sprocket

$n = 1200$ rpm $\quad N_1 = 21$

SR = 4:1 ; $C = 254$ mm

Find: a) Rated power $\quad Pow_R = ?$

b) Tension in the chain $\quad F_1 = ?$

c) $f_s = ?$ safety Factor

d) chain length $\quad L = ?$

From table P 27; for 21 ~~tpc~~ tooth sprocket @ 1200 rpm

$Pow_t =$ 1,01 hp with oil lubricate II

From table on P 28: → for 4 strands

$a_2 = 3,3$ —— multiple strand

assume $a_1 = 1$ —— service factor (Table 1)

a) Required power:

$$Pow_R = a_1 \cdot a_2 \cdot Pow_t \cdot 745,7 =$$

$$= 1 \cdot 3,3 \cdot 1,01 \cdot 745,7 = 2,485 \text{ kW}$$

From table P. 25:

$p = 6,35$ mm ; Tensile strength $S_u = 3470 \text{ N} \times 4 = 13,88$ kN

b) velocity: $v_1 = \dfrac{n \cdot p_1 \cdot N_1}{60} = \dfrac{1200 \cdot 6,35 \cdot 10^{-3} \cdot 21}{60} = \dfrac{120}{60} = 2 \text{ m/s}$

$$F = \frac{Pow}{u_1} = \frac{2485}{2} = 1242,5 \text{ N}$$

c) $f_s = \frac{S_w}{F} = \frac{13880}{1242.5} = 11,17$ (15)

d) SR=4

$N_2 = N_1 \cdot SR = 21 \cdot 4 = 84 \rightarrow$ large sprocket

$\frac{C_D}{p_t} = \frac{254}{6,35} = 40$

Recommended value is $c_d = (30-50)\,p$

Within recommended values.

Therefore

$$\frac{L_p}{p_t} = \frac{2C_d}{p_t} + \frac{N_1+N_2}{2} + \frac{(N_2-N_1)^2}{4\pi^2\left(\frac{c_d}{p_t}\right)}$$

- Length of the chain

$$\frac{L_p}{p_t} = 2 \cdot 40 + \frac{21+84}{2} + \frac{(84-21)^2}{4\pi^2(40)} = 135 \text{ pitches}$$