Example 1.3 *It is required to select a flat-belt drive for a fan running at 360 r.p.m. which is driven by a 10 kW, 1440 r.p.m. motor. The belt drive is open-type and space available for a centre distance of 2 m approximately. The diameter of a driven pulley is 1000 mm.*

Given Data : $N_1 = 1440$ r.p.m. ; $N_2 = 360$ r.p.m. ; $P = 10$ kW $= 10 \times 10^3$ W ;

$C = 2$ m ; $D = 1000$ mm.

To find : Select (or design) a open flat belt drive.

☺ ***Solution :*** The given arrangement is shown in Fig.1.14.

1. Calculation of pulley diameters :

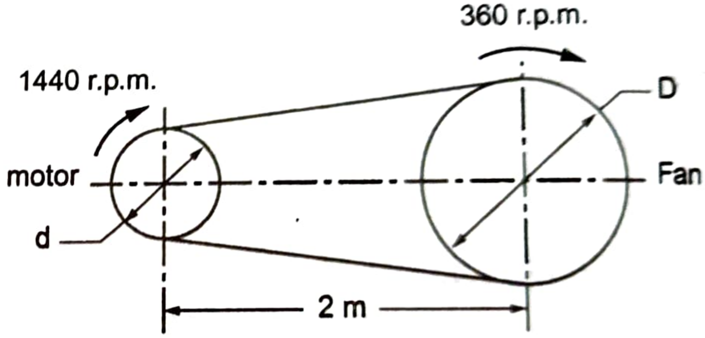

Fig. 1.14.

Driven pulley diameter, $D = \mathbf{1000\ mm}$

We know that velocity ratio $= \dfrac{D}{d}$

$$= \frac{\text{Driver pulley speed}}{\text{Driven pulley speed}} = \frac{N_1}{N_2} = \frac{1440}{360} = 4$$

$$\therefore \quad \text{Driver pulley diameter, } d = \frac{D}{4}$$

$$= \frac{1000}{4} = 250 \text{ mm}$$

P54 7.54 Consulting Table 1.5, the recommended driver pulley diameter = **250 mm** **Ans.** ☜

2. Calculation of design power in kW :

$$\text{Design kW} = \frac{\text{Rated kW} \times \text{Load correction factor } (K_s)}{\text{Arc of contact factor } (K_\alpha) \times \text{Small pulley factor } (K_d)}$$

(i) Rated kW = 10 kW ... [Given]

7.53 (ii) Referring to Table 1.9, load correction factor, $K_s = 1.2$ for steady load.

(iii) To find arc of contact factor (K_α) :

7.54 $$\text{Arc of contact} = 180° - \left(\frac{D - d}{C}\right) \times 60°$$

$$= 180^\circ - \left(\frac{1000 - 250}{2000}\right) \times 60^\circ = 157.5^\circ$$

Consulting Table 1.10, arc of contact factor for 157.5°, $K_\alpha \approx 1.08$.

(iv) Consulting Table 1.11, small pulley factor, $K_d = 0.7$

$$\therefore \quad \text{Design kW} = \frac{10 \times 1.2}{1.08 \times 0.7} = \mathbf{15.873\ kW} \quad \textbf{Ans.}$$

3. *Selection of belt :*

7.54

Consulting Table 1.12, ***HI-SPEED duck belting*** is selected. Its capacity is given as 0.023 kW/mm/ply.

4. *Load rating correction :*

$$\text{Velocity of the belt, } V = \frac{\pi\, d\, N_1}{60} = \frac{\pi \times 0.25 \times 1440}{60} = 18.85 \text{ m/s}$$

$$\text{Load rating at V m/s} = \text{Load rating at 10 m/s} \times \frac{V}{10}$$

$$\therefore \quad \text{Load rating at 18.85 m/s} = \text{Load rating at 10 m/s} \times (18.85/10)$$

$$= 0.023 \times (18.85/10) = 0.04335 \text{ kW/mm/ply}$$

5. *Determination of belt width :*

7.52

For 250 mm smaller pulley diameter and velocity of 18.85 m/s, consulting Table 1.8, the number of plies can be selected as 5.

$$\therefore \quad \text{Width of belt} = \frac{\text{Design power}}{\text{Load rating} \times \text{No. of plies}}$$

$$= \frac{15.873}{0.04335 \times 5} = 73.23 \text{ mm}$$

Consulting Table 1.13, the calculated belt width should be rounded off to the standard belt width.

∴ For 5 ply belt, standard belt width = **76 mm** **Ans.**

6. *Determination of pulley width :*

Consulting Table 1.6(a), the pulley width is given by

$$\text{Pulley width} = \text{Belt width} + 13 \text{ mm} = 76 + 13 = 89 \text{ mm}$$

∴ Referring Table 1.6(b), the standard pulley width is **90 mm** **Ans.**

7. *Calculation of length of the belt (L) :*

We know that the length of an open belt, 7.53

7.53

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

$$= 2 \times 2000 + \frac{\pi}{2}(1000 + 250) + \frac{(1000 - 250)^2}{4 \times 2000} = \mathbf{6033.8\ mm} \quad \textbf{Ans.}$$

1A

Example 1.7 *A flat belt is required to transmit 35 kW from a pulley of 1.5 m effective diameter running at 300 r.p.m. The angle of lap is 165° and $\mu = 0.3$. Determine, taking centrifugal tension into account, width of the belt required. It is given that the belt thickness is 9.5 mm, density of its material is 1.1 Mg/m³ and the related permissible working stress is 2.5 MPa.*

Given Data : $P = 35$ kW $= 35 \times 10^3$ W ; $d = 1.5$ m; $N = 300$ r.p.m. ;

Mu Rho

$\alpha = 165° = 165° \times \dfrac{\pi}{180°} = 2.88$ rad; $\mu = 0.3$; $t = 9.5$ mm ; $\rho = 1.1$ Mg/m³ $= 1100$ kg/m³

Sigma

$\sigma = 2.5$ MPa $= 2.5 \times 10^6$ N/m².

To find : Width of the belt (b).

☺ ***Solution :*** Velocity of belt, $v = \dfrac{\pi\, d\, N}{60} = \dfrac{\pi \times 1.5 \times 300}{60} = 23.56$ m/s.

Let b = Belt width in mm.

We know that,

$$P = (T_1 - T_2)\, v$$

$$35 \times 10^3 = (T_1 - T_2)\, 23.56 \quad \text{or} \quad T_1 - T_2 = 1485.45 \qquad \ldots \text{(i)}$$

$$\frac{T_1}{T_2} = e^{\mu\alpha} = e^{0.3 \times 2.88} = 2.373 \quad \text{or} \quad T_1 = 2.373\, T_2 \qquad \ldots \text{(ii)}$$

Solving (i) and (ii), $T_1 = 2568$ N and $T_2 = 1082.19$ N

Cross-sectional area of the belt $= b \times t = 9.5\, b$ mm² $= 9.5\, b \times 10^{-6}$ m²

We know that mass of the belt per meter length,

$$m = \text{Density} \times \text{Area} \times \text{Length} = \rho \times (b \times t) \times l$$

$$= 1100 \times 9.5\, b \times 10^{-6} \times 1 = 0.01045\, b \text{ kg/m}$$

$\therefore$ Centrifugal tension, $T_C = m\, v^2 = 0.01045\, b\, (23.56)^2 = 5.8\, b$ N and Maximum tension in the belt, $T = \sigma(b \times t)$

$$= 2.5 \times 10^6 \times 9.5\, b \times 10^{-6} = 23.75\, b \text{ N}$$

We also know that

$$T = T_1 + T_C$$

$$23.75\, b = 2568 + 5.8\, b \quad \text{or} \quad b = 143 \text{ mm}$$

Consulting Table 1.13, standard width of the belt = **152 mm** **Ans.**