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C H A P T E R

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Flat Belt Pulleys

19.1 Introduction

The pulleys are used to transmit power from one shaft to another by means of flat belts, V-belts or ropes. Since the velocity ratio is the inverse ratio of the diameters of driving and driven pulleys, therefore the pulley diameters should be carefully selected in order to have a desired velocity ratio. The pulleys must be in perfect alignment in order to allow the belt to travel in a line normal to the pulley faces.

The pulleys may be made of cast iron, cast steel or pressed steel, wood and paper. The cast materials should have good friction and wear characteristics. The pulleys made of pressed steel are lighter than cast pulleys, but in many cases they have lower friction and may produce excessive wear.

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19.2 Types of Pulleys for Flat Belts

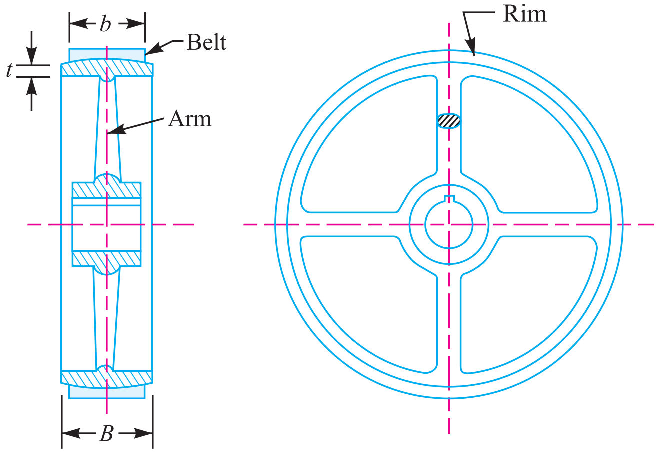
Following are the various types of pulleys for flat belts :

1. Cast iron pulleys, **2.** Steel pulleys, **3.** Wooden pulleys, **4.** Paper pulleys, and **5.** Fast and loose pulleys.

We shall now discuss, the above mentioned pulleys in the following pages.

19.3 Cast Iron Pulleys

The pulleys are generally made of *cast iron, because of their low cost. The rim is held in place by web from the central boss or by arms or spokes. The arms may be straight or curved as shown in Fig. 19.1 (*a*) and (*b*) and the cross-section is usually elliptical.



(*a*) (*b*)

Fig. 19.1. Solid cast iron pulleys.

When a cast pulley contracts in the mould, the arms are in a state of stress and very liable to break. The curved arms tend to yield rather than to break. The arms are near the hub.

The cast iron pulleys are generally made with rounded rims. This slight convexity is known as ***crowning.*** The crowning tends to keep the belt in centre on a pulley rim while in motion. The crowning may be 9 mm for 300 mm width of pulley face.

The cast iron pulleys may be solid as shown in Fig. 19.1 or split type as shown in Fig. 19.2. When it is necessary to mount a pulley on a shaft which already carrying pulleys etc. or have its ends swelled, it is easier to use a split-pulley. There is a clearance between the faces and the two halves are readily tightened upon the shafts by the bolts as shown in Fig. 19.2. A sunk key is used for heavy drives.

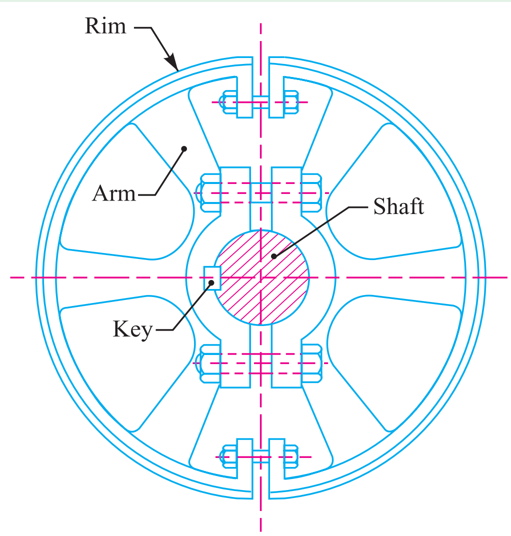


Fig. 19.2. Split cast iron pulley.

* For further details, please refer IS : 1691 – 1980 (Reaffirmed 1990).

19.4 Steel Pulleys

Flat belt drive in an aircraft engine.

Steel pulleys are made from pressed steel sheets and have great strength and durability. These pulleys are lighter in weight (about 40 to 60% less) than cast iron pulleys of the same capacity and are designed to run at high speeds. They present a coefficient of friction with leather belting which is atleast equal to that obtained by cast iron pulleys.

Steel pulleys are generally made in two halves which are bolted together. The clamping action of the hub holds the pulley to its shaft, thus no key is required except for most severe service. Steel pulleys are generally equipped with interchangeable bushings to permit their use with shafts of different sizes. The following table shows the number of spokes and their sizes according to Indian Standards, IS : 1691 – 1980 (Reaffirmed 1990).

Table 19.1. Standard number of spokes and their sizes according to IS : 1691 – 1980 (Reaffirmed 1990).

Diameter of pulley (*mm*)	*No. of spokes*	*Diameter of spokes* (*mm*)
280 – 500	6	19
560 – 710	8	19
800 – 1000	10	22
1120	12	22
1250	14	22
1400	16	22
1600	18	22
1800	18	22

Other proportions for the steel pulleys are :

$$\text{Length of hub} = \frac{\text{Width of face}}{2}$$

The length of hub should not be less than 100 mm for 19 mm diameter spokes and 138 mm for 22 mm diameter of spokes.

Thickness of rim = 5 mm for all sizes.

A single row of spokes is used for pulleys having width upto 300 mm and double row of spokes for widths above 300 mm.

19.5 Wooden Pulleys

Wooden pulleys are lighter and possesses higher coefficient of friction than cast iron or steel pulleys. These pulleys have 2/3rd of the weight of cast iron pulleys of similar size. They are generally made from selected maple which is laid in segments and glued together under heavy pressure. They are kept from absorbing moisture by protective coatings of shellac or varnish so that warping may not

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occur. These pulleys are made both solid or split with cast iron hubs with keyways or have adjustable bushings which prevents relative rotation between them and the shaft by the frictional resistance set up. These pulleys are used for motor drives in which the contact arc between the pulley face and belt is restricted.

Wooden pulleys.

19.6 Paper Pulleys

Paper pulleys are made from compressed paper fibre and are formed with a metal in the centre. These pulleys are usually used for belt transmission from electric motors, when the centre to centre shaft distance is small.

19.7 Fast and Loose Pulleys

A fast and loose pulley, as shown in Fig. 19.3, used on shafts enables machine to be started or stopped at will. A fast pulley is keyed to the machine shaft while the loose pulley runs freely. The belt runs over the fast pulley to transmit power by the machine and it is shifted to the loose pulley when the machine is not required to transmit power. By this way, stopping of one machine does not interfere with the other machines which run by the same line shaft.

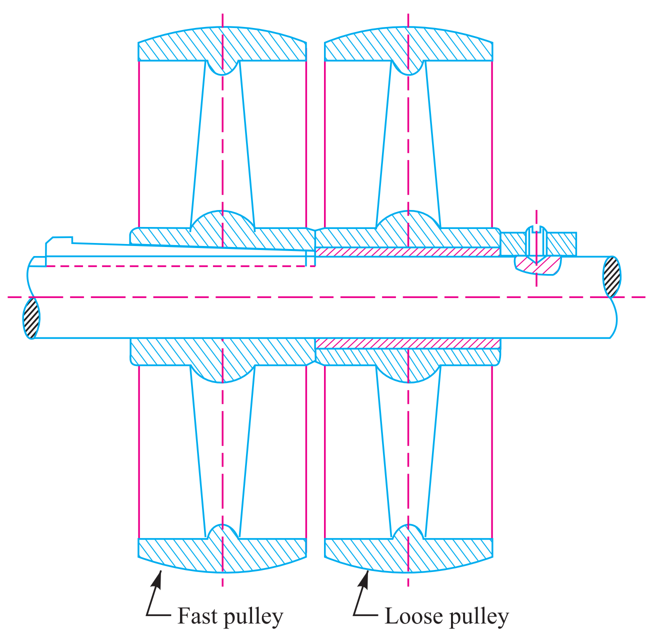

Fig. 19.3. Fast and loose pulley.

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The loose pulley is provided with a cast iron or gun-metal bush with a collar at one end to prevent axial movement.

The rim of the fast pulley is made larger than the loose pulley so that the belt may run slackly on the loose pulley. The loose pulley usually have longer hub in order to reduce wear and friction and it requires proper lubrication.

19.8 Design of Cast Iron Pulleys

The following procedure may be adopted for the design of cast iron pulleys.

1. *Dimensions of pulley*

(i) The diameter of the pulley (*D*) may be obtained either from velocity ratio consideration or centrifugal stress consideration. We know that the centrifugal stress induced in the rim of the pulley,

$$\sigma_t = \rho . v^2$$

where ρ = Density of the rim material

= 7200 kg/m^3 for cast iron

v = Velocity of the rim = $\pi DN / 60$, D being the diameter of pulley and N is speed of the pulley.

The following are the diameter of pulleys in mm for flat and *V*-belts.

20, 22, 25, 28, 32, 36, 40, 45, 50, 56, 63, 71, 80, 90, 100, 112, 125, 140, 160, 180, 200, 224, 250, 280, 315, 355, 400, 450, 500, 560, 630, 710, 800, 900, 1000, 1120, 1250, 1400, 1600, 1800, 2000, 2240, 2500, 2800, 3150, 3550, 4000, 5000, 5400.

The first six sizes (20 to 36 mm) are used for *V*-belts only.

(ii) If the width of the belt is known, then width of the pulley or face of the pulley (*B*) is taken 25% greater than the width of belt.

$$\therefore \quad B = 1.25\, b \text{ ; where } b = \text{Width of belt.}$$

According to Indian Standards, IS : 2122 (Part I) – 1973 (Reaffirmed 1990), the width of pulley is fixed as given in the following table :

Table 19.2. Standard width of pulley.

Belt width in mm	*Width of pulley to be greater than belt width by (mm)*
upto 125	13
125-250	25
250-375	38
475-500	50

The following are the width of flat cast iron and mild steel pulleys in mm :

16, 20, 25, 32, 40, 50, 63, 71, 80, 90, 100, 112, 125, 140, 160, 180, 200, 224, 250, 315, 355, 400, 450, 560, 630.

(iii) The thickness of the pulley rim (*t*) varies from $\frac{D}{300} + 2$ mm to $\frac{D}{200} + 3$ mm for single belt and $\frac{D}{200} + 6$ mm for double belt. The diameter of the pulley (*D*) is in mm.

2. *Dimensions of arms*

(i) The number of arms may be taken as 4 for pulley diameter from 200 mm to 600 mm and 6 for diameter from 600 mm to 1500 mm.

Note : The pulleys less than 200 mm diameter are made with solid disc instead of arms. The thickness of the solid web is taken equal to the thickness of rim measured at the centre of the pulley face.

(ii) The cross-section of the arms is usually elliptical with major axis (a_1) equal to twice the minor axis (b_1). The cross-section of the arm is obtained by considering the arm as cantilever *i.e.* fixed at the hub end and carrying a concentrated load at the rim end. The length of the cantilever is taken equal to the radius of the pulley. It is further assumed that at any given time, the power is transmitted from the hub to the rim or ***vice versa,*** through only half the total number of arms.

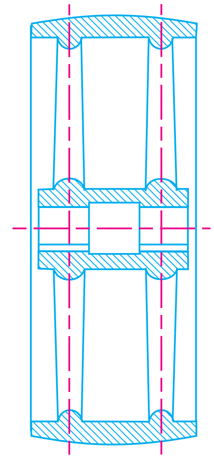

Fig. 19.4. Cast iron pulley with two rows of arms.

Let T = Torque transmitted,

R = Radius of pulley, and

n = Number of arms,

∴ Tangential load per arm,

$$W_T = \frac{T}{R \times n / 2} = \frac{2\,T}{R \cdot n}$$

Maximum bending moment on the arm at the hub end,

$$M = \frac{2\,T}{R \times n} \times R = \frac{2\,T}{n}$$

and section modulus,

$$Z = \frac{\pi}{32} \times b_1\,(a_1)^2$$

Now using the relation,

σ_b or σ_t = M / Z, the cross-section of the arms is obtained.

(iii) The arms are tapered from hub to rim. The taper is usually 1/48 to 1/32.

(iv) When the width of the pulley exceeds the diameter of the pulley, then two rows of arms are provided, as shown in Fig. 19.4. This is done to avoid heavy arms in one row.

3. *Dimensions of hub*

(i) The diameter of the hub (d_1) in terms of shaft diameter (d) may be fixed by the following relation :

$$d_1 = 1.5\,d + 25 \text{ mm}$$

The diameter of the hub should not be greater than 2 d.

(ii) The length of the hub,

$$L = \frac{\pi}{2} \times d$$

The minimum length of the hub is $\frac{2}{3}$ B but it should not be more than width of the pulley (B).

Example 19.1. *A cast iron pulley transmits 20 kW at 300 r.p.m. The diameter of pulley is 550 mm and has four straight arms of elliptical cross-section in which the major axis is twice the minor axis. Find the dimensions of the arm if the allowable bending stress is 15 MPa. Mention the plane in which the major axis of the arm should lie.*

Solution. Given : P = 20 kW = 20 × 10^3 W ; N = 300 r.p.m. ; *d = 550 mm ; n = 4 ; σ_b = 15 MPa = 15 N/mm²

Let b_1 = Minor axis, and

a_1 = Major axis = $2b_1$ ...(Given)

We know that the torque transmitted by the pulley,

$$T = \frac{P \times 60}{2\,\pi\,N} = \frac{20 \times 10^3 \times 60}{2\,\pi \times 300} = 636 \text{ N-m}$$

* Superfluous data.

∴ Maximum bending moment per arm at the hub end,

$$M = \frac{2T}{n} = \frac{2 \times 636}{4}$$

$$= 318 \text{ N-m} = 318 \times 10^3 \text{ N-mm}$$

Cast iron pulley.

and section modulus,

$$Z = \frac{\pi}{32} \times b_1 (a_1)^2 = \frac{\pi}{32} \times b_1 (2b_1)^2$$

$$= \frac{\pi (b_1)^3}{8}$$

We know that the bending stress (σ_b),

$$15 = \frac{M}{Z} = \frac{318 \times 10^3 \times 8}{\pi (b_1)^3} = \frac{810 \times 10^3}{(b_1)^3}$$

∴ $(b_1)^3 = 810 \times 10^3 / 15 = 54 \times 10^3$ or $b_1 = 37.8$ mm **Ans.**

and $a_1 = 2\,b_1 = 2 \times 37.8 = 75.6$ mm **Ans.**

The major axis will be in the plane of rotation which is also the plane of bending.

Example 19.2. *An overhung pulley transmits 35 kW at 240 r.p.m. The belt drive is vertical and the angle of wrap may be taken as 180°. The distance of the pulley centre line from the nearest bearing is 350 mm. μ = 0.25. Determine :*

1. *Diameter of the pulley ;*
2. *Width of the belt assuming thickness of 10 mm ;*
3. *Diameter of the shaft ;*
4. *Dimensions of the key for securing the pulley on to the shaft ; and*
5. *Size of the arms six in number.*

The section of the arm may be taken as elliptical, the major axis being twice the minor axis.

The following stresses may be taken for design purposes :

Shaft	*Tension and compression*	— *80 MPa*
Key	*Shear*	— *50 MPa*
Belt : *Tension*		— *2.5 MPa*
Pulley rim : *Tension*		— *4.5 MPa*
Pulley arms : *Tension*		— *15 MPa*

Steel pulley.

Solution. Given : $P = 35$ kW $= 35 \times 10^3$ W ; $N = 240$ r.p.m. ; $\theta = 180° = \pi$ rad ; $L = 350$ mm $= 0.35$ m ; $\mu = 0.25$; $t = 10$ mm ; $n = 6$; $\sigma_{ts} = \sigma_{tk} = 80$ MPa $= 80$ N/mm^2 ; $\tau_s = \tau_k = 50$ MPa $= 50$ N/mm^2 ; $\sigma = 2.5$ MPa $= 2.5$ N/mm^2 ; $\sigma_t = 4.5$ MPa $= 4.5$ N/mm^2 ; $\sigma_b = 15$ MPa $= 15$ N/mm^2

1. *Diameter of the pulley*

Let D = Diameter of the pulley,

σ_t = Centrifugal stress or tensile stress in the pulley rim

$= 4.5$ MPa $= 4.5 \times 10^6$ N/m^2 ...(Given)

ρ = Density of the pulley material (*i.e.* cast iron) which may be taken as 7200 kg/m^3.

We know that centrifugal stress (σ_t),

$$4.5 \times 10^6 = \rho.v^2 = 7200 \times v^2$$

$$\therefore \quad v^2 = 4.5 \times 10^6 / 7200 = 625 \quad \text{or} \quad v = 25 \text{ m/s}$$

and velocity of the pulley (v),

$$25 = \frac{\pi\, D \,.\, N}{60} = \frac{\pi\, D \times 240}{60} = 12.568\, D$$

$$\therefore \quad D = 25 / 12.568 = 2 \text{ m} \quad \textbf{Ans.}$$

2. *Width of the belt*

Let b = Width of the belt in mm,

T_1 = Tension in the tight side of the belt, and

T_2 = Tension in the slack side of the belt.

We know that the power transmitted (P),

$$35 \times 10^3 = (T_1 - T_2)\, v = (T_1 - T_2)\, 25$$

$$\therefore \quad T_1 - T_2 = 35 \times 10^3 / 25 = 1400 \text{ N} \qquad \ldots(i)$$

We also know that

$$2.3 \log \left(\frac{T_1}{T_2}\right) = \mu.\theta = 0.25 \times \pi = 0.7855$$

$$\therefore \quad \log \left(\frac{T_1}{T_2}\right) = \frac{0.7855}{2.3} = 0.3415 \quad \text{or} \quad \frac{T_1}{T_2} = 2.195 \qquad \ldots(ii)$$

... (Taking antilog of 0.3415)

From equations (*i*) and (*ii*), we find that

$$T_1 = 2572 \text{ N} \; ; \text{ and } T_2 = 1172 \text{ N}$$

Since the velocity of the belt (or pulley) is more than 10 m/s, therefore centrifugal tension must be taken into consideration. Assuming a leather belt for which the density may be taken as 1000 kg/m^3.

We know that cross-sectional area of the belt,

$$= b \times t = b \times 10 = 10\, b \text{ mm}^2 = \frac{10\, b}{10^6} \text{ m}^2$$

Mass of the belt per metre length,

$$m = \text{Area} \times \text{length} \times \text{density}$$

$$= \frac{10\, b}{10^6} \times 1 \times 1000 = 0.01\, b \text{ kg / m}$$

We know that centrifugal tension,

$$T_C = m.v^2 = 0.01\, b\, (25)^2 = 6.25\, b \text{ N}$$

and maximum tension in the belt,

$$T = \sigma.b.t = 2.5 \times b \times 10 = 25\, b \text{ N}$$

We know that tension in the tight side of the belt (T_1),

$$2572 = T - T_C = 25\, b - 6.25\, b = 18.75\, b$$

$$\therefore \quad b = 2572 / 18.75 = 137 \text{ mm}$$

The standard width of the belt (b) is 140 mm. **Ans.**

3. *Diameter of the shaft*

Let d = Diameter of the shaft.

We know that the torque transmitted by the shaft,

$$T = \frac{P \times 60}{2\,\pi\, N} = \frac{35 \times 10^3 \times 60}{2\,\pi \times 240} = 1393 \text{ N-m} = 1393 \times 10^3 \text{ N-mn}$$

and bending moment on the shaft due to the tensions of the belt,

$$M = (T_1 + T_2 + 2T_C)\,L = (2572 + 1172 + 2 \times 6.25 \times 140) \times 0.35 \text{ N-m}$$
$$= 1923 \text{ N-m} \qquad \text{... } (\because T_C = 6.25\, b)$$

We know that equivalent twisting moment,

$$T_e = \sqrt{T^2 + M^2} = \sqrt{(1393)^2 + (1923)^2} = 2375 \text{ N-m}$$
$$= 2375 \times 10^3 \text{ N-mm}$$

We also know that equivalent twisting momnt (T_e),

$$2375 \times 10^3 = \frac{\pi}{16} \times \tau_s \times d^3 = \frac{\pi}{16} \times 50 \times d^3 = 9.82\, d^3$$

$$\therefore \quad d^3 = 2375 \times 10^3 / 9.82 = 242 \times 10^3 \quad \text{or} \quad d = 62.3 \text{ say } 65 \text{ mm}$$ **Ans.**

4. *Dimensions of the key*

The standard dimensions of the key for 65 mm diameter shaft are :

Width of key, w = 20 mm **Ans.**

Thickness of key = 12 mm **Ans.**

Let l = Length of the key.

Considering shearing of the key. We know that the torque transmitted (T),

$$1393 \times 10^3 = l \times w \times \tau_k \times \frac{d}{2} = l \times 20 \times 50 \times \frac{65}{2} = 32\,500\, l$$

$$\therefore \quad l = 1393 \times 10^3 / 32\,500 = 42.8 \text{ mm}$$

The length of key should be atleast equal to hub length. The length of hub is taken as $\frac{\pi}{2} \times d$.

$$\therefore \quad \text{Length of key} = \frac{\pi}{2} \times 65 = 102 \text{ mm}$$ **Ans.**

5. *Size of arms*

Let b_1 = Minor axis, and

a = Major axis = $2b_1$ ... (Given)

We know that the maximum bending moment per arm at the hub end,

$$M = \frac{2\,T}{n} = \frac{2 \times 1393}{6} = 464.33 \text{ N-m} = 464\,330 \text{ N-mm}$$

and section modulus,

$$Z = \frac{\pi}{32} \times b_1\,(a_1)^2 = \frac{\pi}{32} \times b_1\,(2b_1)^2 = 0.393\,(b_1)^3$$

We know that bending stress (σ_b),

$$15 = \frac{M}{Z} = \frac{464\,330}{0.393 \times (b_1)^3} = \frac{1.18 \times 10^6}{(b_1)^3}$$

$$\therefore \quad (b_1)^3 = 1.18 \times 10^6 / 15 = 78.7 \times 10^3 \quad \text{or} \quad b_1 = 42.8 \text{ say } 45 \text{ mm}$$ **Ans.**

and $a_1 = 2b_1 = 2 \times 45 = 90$ mm **Ans.**

Example 19.3. *A pulley of 0.9 m diameter revolving at 200 r.p.m. is to transmit 7.5 kW. Find the width of a leather belt if the maximum tension is not to exceed 145 N in 10 mm width. The tension in the tight side is twice that in the slack side. Determine the diameter of the shaft and the dimensions of the various parts of the pulley, assuming it to have six arms. Maximum shear stress is not to exceed 63 MPa.*

Solution. Given : D = 0.9 m ; N = 200 r.p.m. ; P = 7.5 kW = 7500 W ; T = 145 N in 10 mm width ; $T_1 = 2T_2$; n = 6 ; τ = 63 MPa = 63 N/mm^2

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We know that velocity of the pulley or belt,

$$v = \frac{\pi\, D.N}{60} = \frac{\pi \times 0.9 \times 200}{60} = 9.426 \text{ m/s}$$

Let T_1 = Tension in the tight of the belt, and

T_2 = Tension in the slack side of the belt.

We know that the power transmitted (P),

$$7500 = (T_1 - T_2)\, v = (T_1 - T_2)\, 9.426$$

$$T_1 - T_2 = 7500 / 9.426 = 796 \text{ N}$$

or $2T_2 - T_2 = 796$ N ... ($\because T_1 = 2T_2$)

$\therefore$ $T_2 = 796$ N ;

and $T_1 = 2T_2 = 2 \times 796 = 1592$ N

Note : Since the velocity of belt is less than 10 m/s, therefore the centrifugal tension need not to be considered.

Width of belt

Let b = Width of belt.

Since the maximum tension is 145 N in 10 mm width or 14.5 N/mm width, therefore width of belt,

$$b = T_1 / 14.5 = 1592 / 14.5 = 109.8 \text{ mm}$$

The standard width of the belt (b) is 112 mm. **Ans.**

Diameter of the shaft

Let d = Diameter of the shaft,

We know that the torque transmitted by the shaft,

$$T = \frac{P \times 60}{2\,\pi\, N} = \frac{7500 \times 60}{2\,\pi \times 200} = 358 \text{ N-m} = 358\,000 \text{ N-mm}$$

We also know the torque transmitted by the shaft (T),

$$358\,000 = \frac{\pi}{16} \times \tau \times d^3 = \frac{\pi}{16} \times 63 \times d^3 = 12.4\, d^3$$

$\therefore$ $d^3 = 358\,000 / 12.4 = 28\,871$ or $d = 30.67$ say 35 mm **Ans.**

Dimensions of the various parts of the pulley

1. Width and thickness of pulley

Since the width of the belt is 112 mm, therefore width of the pulley,

$$B = 112 + 13 = 125 \text{ mm } \textbf{Ans.}$$

and thickness of the pulley rim for single belt,

$$t = \frac{D}{300} + 2 \text{ mm} = \frac{900}{300} + 2 = 5 \text{ mm } \textbf{Ans.}$$

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2. *Dimensions of arm*

Assuming the cross-section of the arms as elliptical with major axis equal to twice the minor axis.

Let b_1 = Minor axis, and

a_1 = Major axis = $2b_1$

We know that maximum bending moment on the arm at the hub end,

$$M = \frac{2T}{n} = \frac{2 \times 358\,000}{6} = 119\,333 \text{ N-mm}$$

and section modulus,
$$Z = \frac{\pi}{32} \times b_1\,(a_1)^2 = \frac{\pi}{32} \times b_1\,(2b_1)^2 = 0.393\,(b_1)^3$$

Assume the arms of cast iron for which the tensile stress may be taken as 15 N/mm². We know that the tensile stress (σ_t),

$$15 = \frac{M}{Z} = \frac{119\,333}{0.393 \times (b_1)^3} = \frac{303\,646}{(b_1)^3}$$

$\therefore$ $(b_1)^3 = 303\,646 / 15 = 20\,243$ or $b_1 = 27.3$ say 30 mm **Ans.**

and $a_1 = 2\,b_1 = 2 \times 30 = 60$ mm **Ans.**

Dimensions of the hub

Diameter of the hub $= 2\,d = 2 \times 35 = 70$ mm **Ans.**

$$\text{Length of the hub} = \frac{\pi}{2} \times d = \frac{\pi}{2} \times 35 = 55 \text{ mm}$$

Since the length of the hub should not be less than $\frac{2}{3}$ B, therefore the length of hub

$$= \frac{2}{3} \times B = \frac{2}{3} \times 125 = 83.3 \text{ say } 85 \text{ mm } \textbf{Ans.}$$

EXERCISES

1. Design the elliptical cross-section of a belt pulley arm near the hub for the following specifications:

   The mean pulley diameter is 300 mm and the number of pulley arms are 4. The elliptical section has major axis twice the minor axis length. The tight and slack sides tension in the belt are 600 N and 200 N respectively. Assume half number of arms transmit torque at any time and the load factor of 1.75 to account for dynamic effects on the pulley while transmitting torque. The permissible tensile stress for cast iron pulley material is 15 MPa. The pulley hub diameter is 60 mm.

   [Ans. a_1 = 40 mm, b_1 = 20 mm]

2. Design a cast iron driven pulley to transmit 20 kW at 300 r.p.m. The diameter of the pulley is 500 mm and the angle of lap is 180°. The pulley has four arms of elliptical cross-section with major axis twice the minor axis. The coefficient of friction between the belt and the pulley surface is 0.3. The allowable tension per metre width of the belt is 2.5 N. The following allowable stresses may be taken :

   Shear stress for the shaft material = 50 MPa, and

   Bending stress for the pulley arms = 15 MPa.

3. An overhung cast iron pulley transmits 7.5 kW at 400 r.p.m. The belt drive is vertical and the angle of wrap may be taken as 180º. Find :

   (*a*) Diameter of the pulley. The density of cast iron is 7200 kg/m³.

   (b) Width of the belt, if the coefficient of friction between the belt and the pulley is 0.25.

   (*c*) Diameter of the shaft, if the distance of the pulley centre line from the nearest bearing is 300 mm.

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(*d*) Dimensions of the key for securing the pulley on to the shaft.

(*e*) Size of the arms six in number.

The section of the arms may be taken as elliptical, the major axis being twice the minor axis. The following stresses may be taken for design purposes :

Shaft and key :	Tension – 80 MPa
	Shear – 50 MPa
Belt :	Tension – 2.5 MPa
Pulley rim :	Tension – 4.5 MPa
Pulley arms :	Tension – 15 MPa

QUESTIONS

1. Discuss the different types of pulleys used in belt drives.
2. Why the face of a pulley is crowned?
3. When a split pulley is used and how it is tightened on a shaft?
4. Explain the 'fast and loose pulley' with the help of a neat sketch.
5. Discuss the procedure used in designing a cast iron pulley.

OBJECTIVE TYPE QUESTIONS

1. The crowning on a 300 mm width of pulley face should be
   (*a*) 9 mm (*b*) 12 mm
   (*c*) 15 mm (*d*) 18 mm
2. The steel pulleys are .... in weight than cast iron pulleys of the same capacity.
   (*a*) heavier (*b*) lighter
3. For a steel pulley of 500 mm, the recommended number of spokes are
   (*a*) 2 (*b*) 4
   (*c*) 6 (*d*) 8
4. The thickness of rim for all sizes of steel pulleys should be
   (*a*) 5 mm (*b*) 10 mm
   (*c*) 15 mm (*d*) 20 mm
5. The width of the pulley should be
   (*a*) equal to the width of belt (*b*) less than the width of belt
   (*c*) greater than the width of belt

ANSWERS

1. (*a*) **2.** (*b*) **3.** (*c*) **4.** (*a*) **5.** (*c*)