SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
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DEPARTMENT OF MECHANICAL ENGINEERING

DESIGN OF Transmission System

III YEAR VISEM

UNIT 1– Design of Flexible Transmission Elements

TOPIC :Flat Belt Drive

Introduction

Mechanical drives may be classified based on the following conditions.

(a) According to the physical conditions of transmission, they may be classified into,

(i) friction drives such as belts and rope drives, and

(ii) toothed drives such as gears and chain drives.

(b) According to the method of linking the driving and driven members, they may be grouped into,

(i) drives with direct contact between the driving and driven members such as gears,

(ii) Drives with an intermediate link between the driving and driven members such as belts, ropes and chain drives.

Table 3.1 Characteristics of Basic Types of Mechanical Drives

	Drive	Transmitted power, kW	Peripheral speed m/s	Speed ratio	Efficiency %
1.	Flat Belt	Upto 100 (1500)	5 – 30 (100)	upto 4 (10)	92 – 98
2.	V. Belt	Upto 50 (300)	5 – 30	upto 7 (15)	87 – 97
3.	Chain drive	upto 200 (5000)	upto 25	upto 15	94 – 98
4.	Spur gear	upto 10,000	25	upto 6 (10)	92 – 99
5.	Helical gear	upto 50,000	25 (140)	upto 7 (20)	94 – 99
6.	Bevel gear	upto 10,000	20	upto 6	90 – 98
7.	Worm gear	upto 100	upto 35 (worm)	8 – 100 (1000)	10 – 98

CLASSIFICATION OF BELT DRIVES :

Belt drives are classified based on three concepts namely

1. Based on Duty.

2. Based on the centre distance between the axes of driving and driven members.

3. Based on structures.

1. Based on Duty :

Accordingly they may be grouped into

(a) **Light duty drives,** which can transmit power of the order of small fraction to about 5 kW and the belt speed approximately upto 10m/s. Some of the applications are in pumps, blowers, fans and so on.

(b) **Medium duty drives,** which are used to transmit the power approximately from 5 kW to 20 kW and belt speed may be upto 20 m/s as in the case of machine tools, generators, punches, printing machinery etc.

(c) **Heavy duty drives,** which can be operated to transmit the power more than 20 kW and the belt speed is more than 20 m/s.

2. Based on the centre distance, they may be classified into two type such as,

(a) Belts used for long distance, about 5 m to 20 m and even more such as flat belts.

(b) Belts used for short distance, less than 5 m, such as V-belts, toothed belts and so on.

3. Based on structures, the belts are classified into

(a) Flat belt

(b) V – section belt

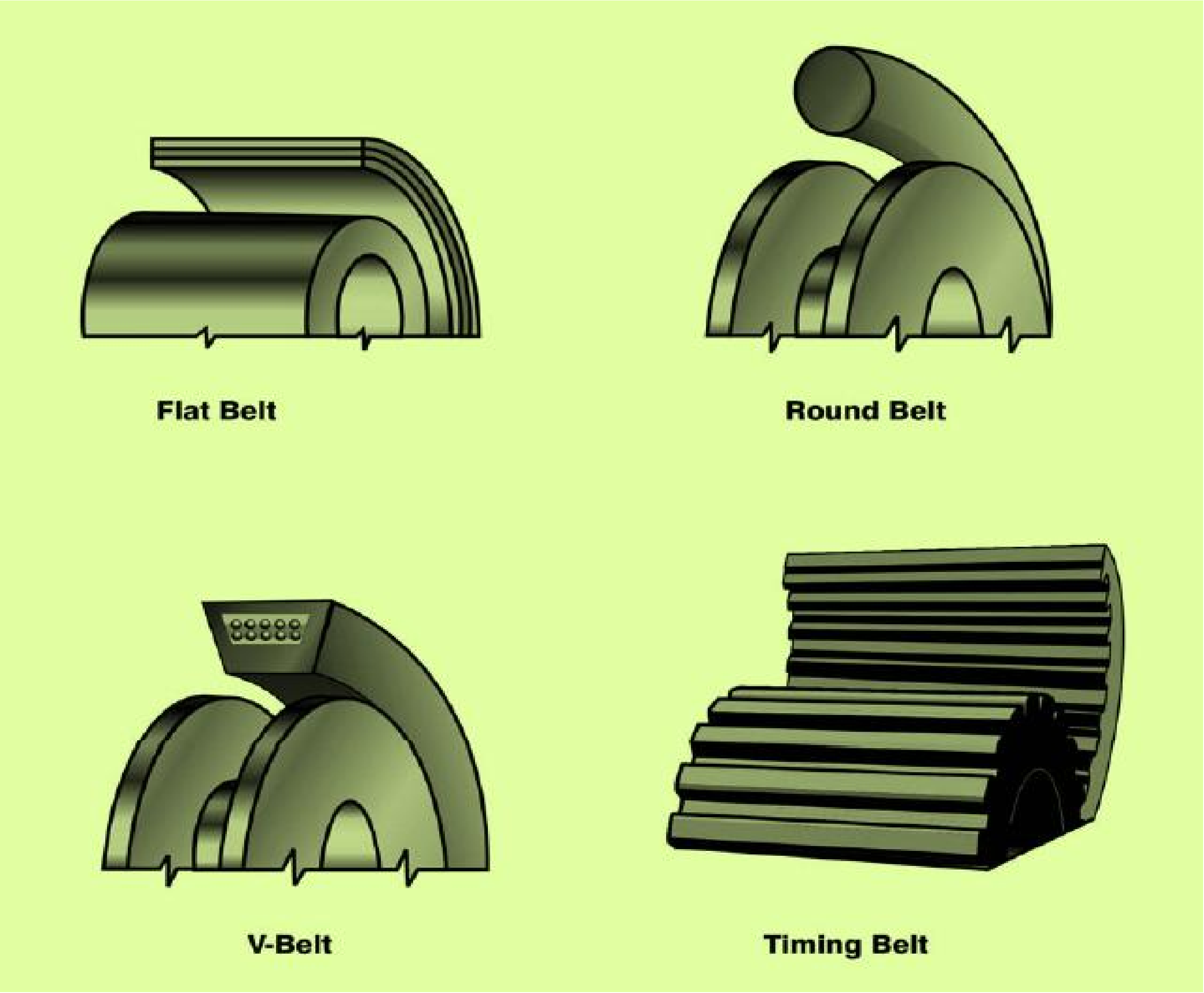
(i) Single V – belt

(ii) Multiple V – belt

(iii) Ribbed belt

(c) Toothed or timing belt

(d) Round belt.



Flat Belt
Round Belt
V-Belt
Timing Belt

FACTORS INFLUENCING THE SELECTION OF BELT DRIVES :

When selecting the belt drive, we should consider some important factors like

- Power to be transmitted.
- Space availability for installation of drives
- Speed of machinery shafts.
- Speed reduction ratio
- Distance between the axes of rotating shafts.
- Service conditions due to operating period and surroundings.

ADVANTAGES AND SHORTCOMINGS OF BELT DRIVES :

The main advantages of the belt drives are that,

1. They may be used to transmit power from one shaft to another when they are situated at a long distance.

2. They can operate smoothly without knocking.

3. They protect the other parts of the machine by making the belt to slip over the pulley when the load becomes higher than the rated value.

4. Belt drives are simple in design and maintenance is easy.

5. Their cost is also comparatively low.

The principal shortcomings are;

1. Large dimensions which need more space.
2. The velocity of driven member sometimes may not be same as driving member because of belt slipping.
3. They exert heavy loads on the shaft and bearings.
4. There may be a loss of power due to friction.
5. Their life is comparatively shorter (around 1000 to 5000 hours).

MATERIALS USED FOR BELTS :

mean values of co-efficient of friction between belts and pulleys

Type of belt	Pulley material			
	Pressed paper	Wood	Steel	Cast iron
1. **Leather**				
(a) Tanned with vegetable compound	0.35	0.30	0.25	0.25
(b) Tanned with mineral compound	0.50	0.45	0.40	0.40
2. **Cotton**				
(a) Solid woven	0.28	0.25	0.22	0.22
(b) Switched	0.25	0.23	0.20	0.20
3. Woolen	0.45	0.40	0.35	0.35
4. Rubber	0.35	0.32	0.30	0.30

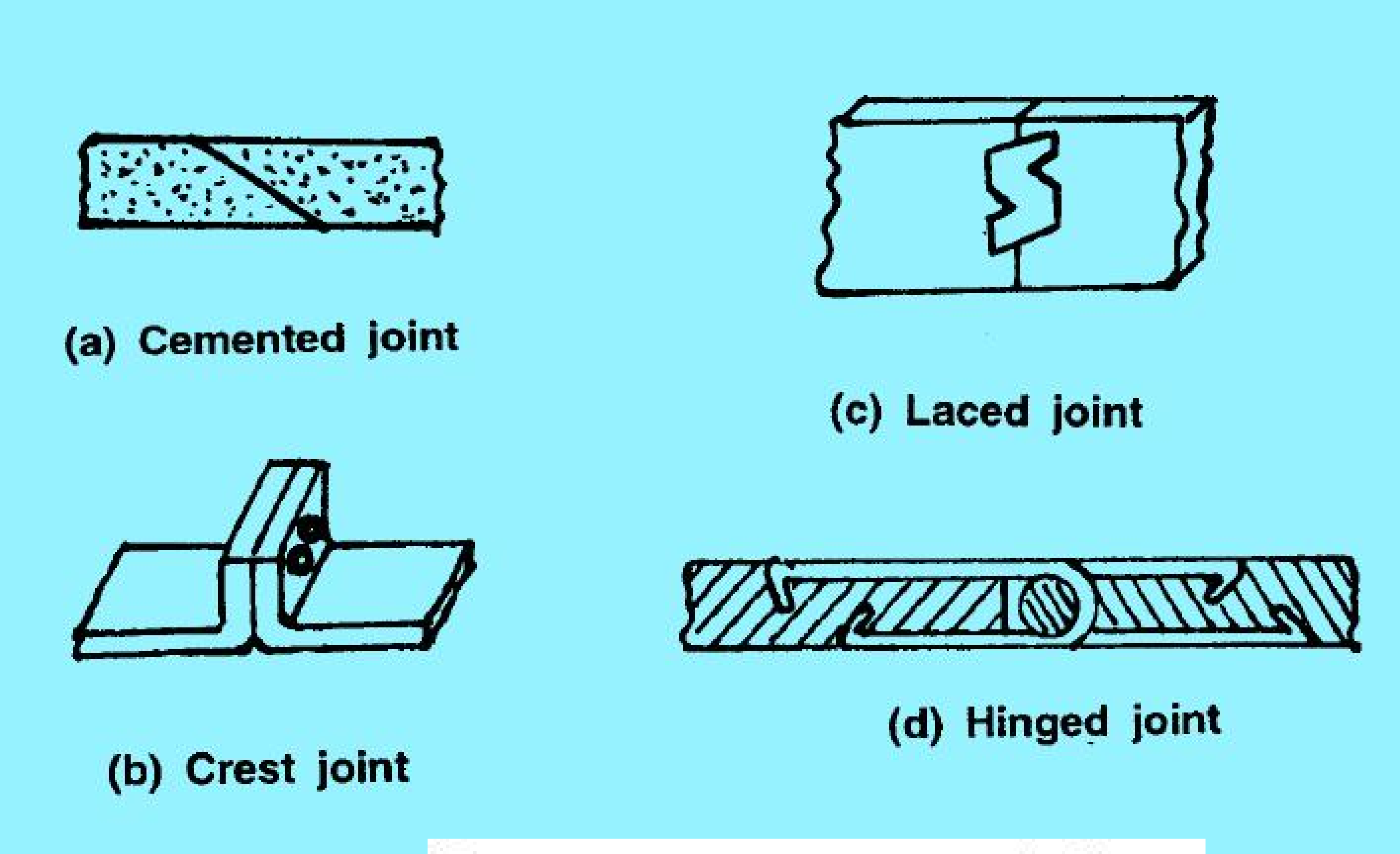
WORKING CHARACTERISTICS OF FLAT BELTS :

Flat belts are made of leather, cotton fabrics, rubber, synthetic fibres etc. The maximum tensile strength (i.e., ultimate strength) varies as follows :

1. For leather belting, it varies from 20 N/mm^2 to 35 N/mm^2.

2. For cotton or fabric belting, it varies from 35 N/mm^2 to 40 N/mm^2

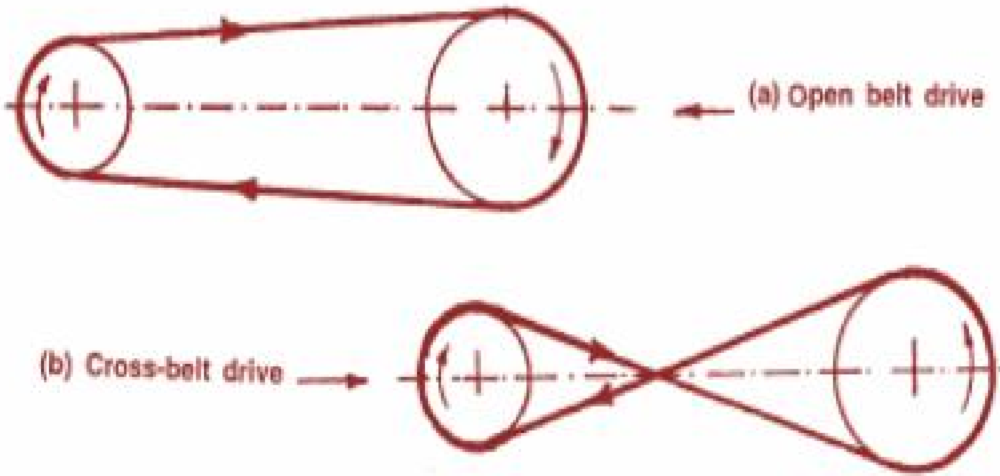
By assuming the factor of safety as 8 to 10, the working stress may be considered from 1.75 N/mm^2 to 2.8 N/mm^2 which may make the belt to have the life of about 15 years.

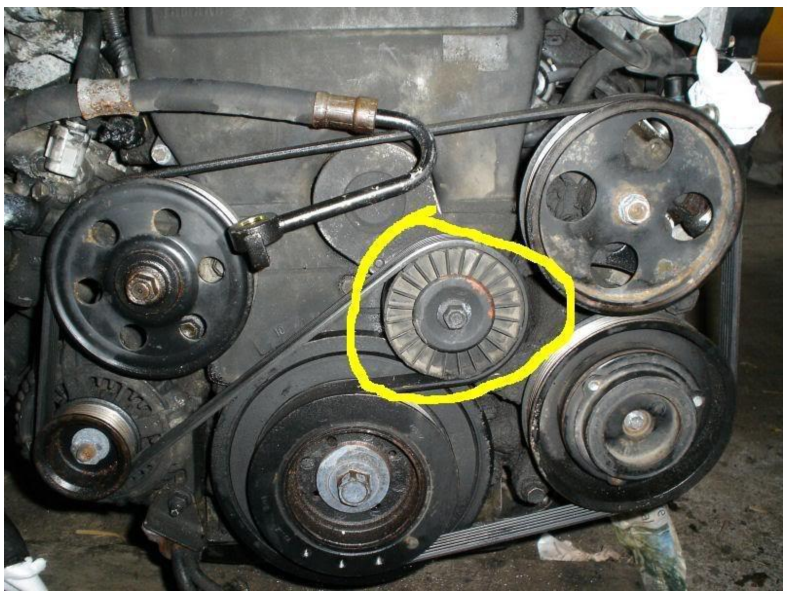


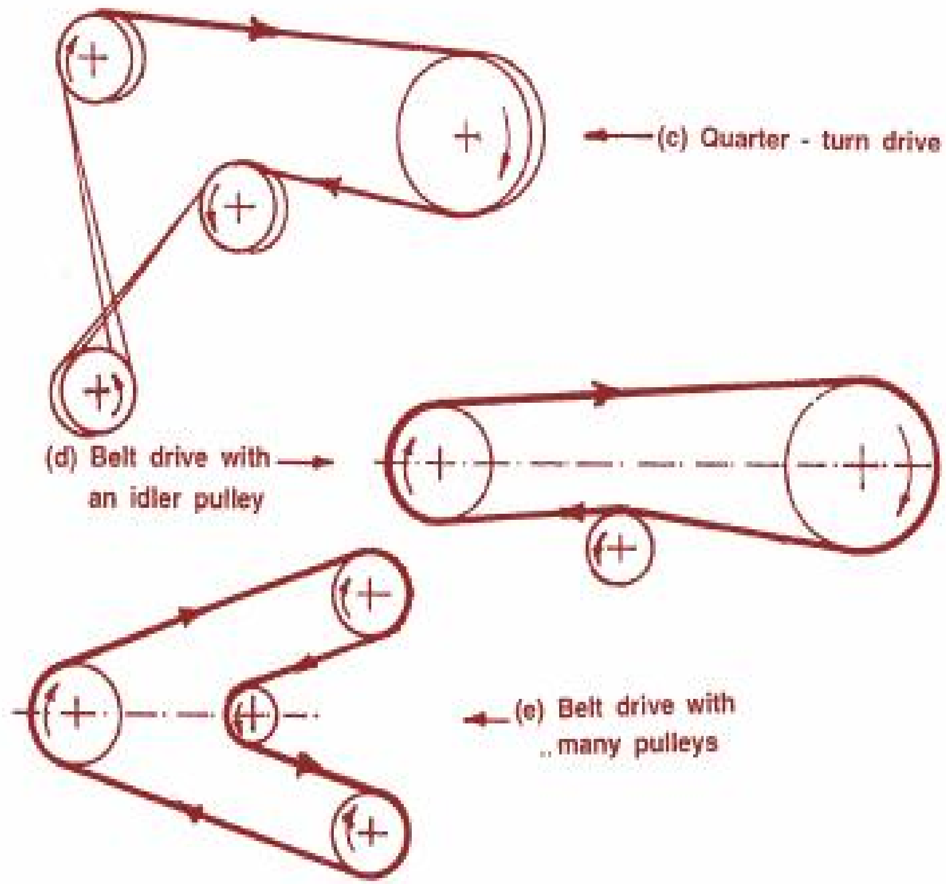
Types of flat-belt joints

Efficiencies of Belt Joints

Type of Joint	Efficiency %
Cemented joint	80 – 90
Laced joint	40 – 50
Crest joint	25 – 35
Hinged joint	30 – 40







Types of Flat belt Drives

DESIGN OF FLAT BELTS :

1. Using fundamental formulas.
2. Using manufacturer's catalogues.

(1). Using fundamental formulas :

(i) Power transmitted by belt.

In S.I. Units :

$P = (T_1 - T_2)\,v$ N – m/s or watts

where T_1 = Tensions in the tight side in newtons

T_2 = Tensions in the slack side in newtons

v = Velocity of belt in m/s.

(ii) Velocity of belt $v = \frac{\pi d n}{60 \times 1000}$ m/s

where d = Diameter of smaller pulley in mm

n = Speed of smaller pulley in r.p.m

Note :

1 N – m/s = 1 watt

75 kgf m/sec = 1 h.p

π radians = 180°

(iii) Ratio between the tensions of tight side and slack side,

$$\frac{T_1}{T_2} = e^{\mu \theta}$$

where μ = Coefficient of friction between the contact surfaces of pulley and belt

θ = Arc of contact in radians

(iv) The relationships used to find out the length and arc of contact are common with manufacturer's method.

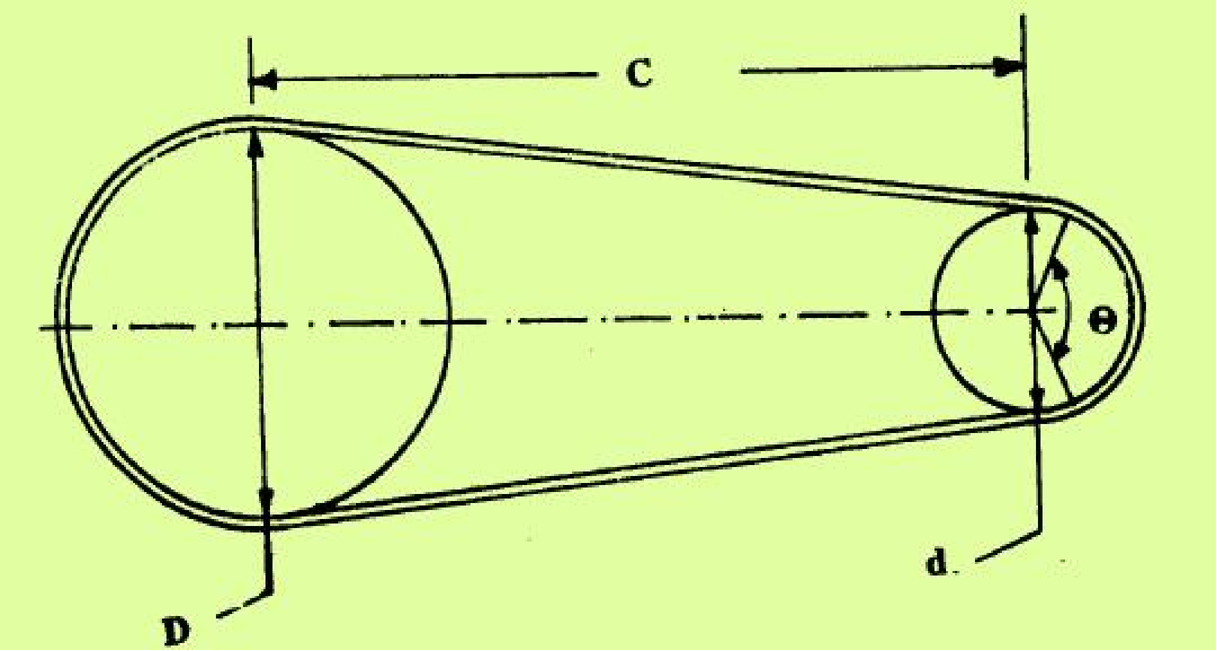
In this text, flat belts are designed mainly based on manufacturer's catalogues.

(2) Using Manufacturer's catalogues :

Design of belts by this method is based mainly on two concepts.

1. How much power (i.e., Maximum power (or) Design power) to be transmitted.
2. What may be the power transmitting capacity (i.e., belt rating) of the selected belt.

(i) Arc of contact :



Let d = Diameter of smaller pulley

D = Diameter of bigger pulley

C = Centre distance between pulleys .

Then, Arc of contract (θ) for smaller pulley

1. Open belt drive, $\theta = 180^\circ - \left(\frac{D - d}{C}\right) 60^\circ$

2. Cross belt drive, $\theta = 180 + \left(\frac{D + d}{C}\right) 60^\circ$

3. Quarter-turn drive, $\theta = 180 + \left(\frac{d}{C}\right) 60^\circ$

Table 3.6 Arc of contact factor :

Arc of contact	90	120	130	140	150	160	170
Correction factor	1.68	1.33	1.26	1.19	1.13	1.08	1.04
Arc of contact	180	190	200	210	220	230	240
Correction factor	1.00	0.97	0.94	0.91	0.88	0.86	0.84

Table 3.7 : Minimum pulley diameter in mm for given speed and belting plies.

No. of Plies	Maximum belt speed, m/s				
	10	15	20	25	30
3	90	100	112	140	180
4	140	160	180	200	250
5	200	224	250	315	355
6	250	315	355	400	450
8	450	500	560	630	710

(ii) Load rating (or) Belt capacity :

The load ratings have been developed for 180° of arc of contact, 10m/s belt speed per mm width, and per ply and they are to be corrected for actual arc of contact, actual speed, actual plies and then the required width is determined.

Load rating per mm width per ply at 180° arc of contact at 10 m/s belt speed:

'HI SPEED, 878 g duck belting : 0.023 kW (or) 0.0314 h.p

'FORT' 949 g duck belting : 0.0289 kW (or) 0.0392 hp

3.13 DESIGN PROCEDURE FOR FLAT BELT BASED ON MANUFACTURER'S TABLES :-

1. From the given conditions like power, type of working conditions, diameters of pulleys, speed ratio etc, determine maximum power (i.e., design power) as

   Design power = Rated power (i.e., Given power)

   x Service factor (i.e., load correction factor) x Arc of contact factor.

   Select service factor based on nature of load and applications (Table 3.5) (PSG 7.53) and choose arc of contact factor based on the arc of contact of the belt on the smaller pulley (Table 3.6) (PSG 7.54)

2. Decide the type of belt (i.e., number of plies of the belt) depending upon the belt speed and diameter of smaller pulley (Table 3.7) (PSG 7.52).

3. Then calculate the belt rating (i.e., power transmitting capacity per mm width) for the above said belt using corresponding relations.

4. Find the required width by dividing the design power by belt capacity, and adopt the next standard available width.
5. Determine the length of belt based on type of drive and then reduce certain amount of length so as to get initial tension (i.e., to make the belt to hold the pulley firmly for getting proper grip).
6. Find out pulley dimensions and draw the arrangement of belt drive.

Note : If the calculated width is not available in the manufacturer's table, then higher capacity belt (i.e., belt of higher ply) may be selected.

According to Manufacturer's Data :

Problem 1

Select a flat belt to drive a mill at 250 rpm from a 10 kW, 730 rpm motor. Centre distance is to be around 2m. The mill shaft pulley is of 1 m diameter.

Solution :

Design power = Rated power × Service factor × Arc. of contact factor.

Rated power = 10 kW

Service factor = 1.3 (Assuming heavy duty intermittent load). (Table 3.5) (PSG 7.53)

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

$$D = 1\text{ m} = 1000\text{ mm}$$

$$i = \frac{n_1}{n_2} = \frac{730}{250} = 2.92$$

$$d = \frac{1000}{2.92} = 342.46\text{ mm} = 345\text{ mm (say)}$$

$$\text{Arc of contact} = 180° - \left[\frac{1000-345}{2000}\right]60° = 160.4°$$

Arc of contact factor = 1.08 (Table 3.6) (PSG 7.54)

Now

Design power $= 10 \times 1.3 \times 1.08 = 14.04$ kW

Select Dunlop Fort 949 g fabric belting: For finding the number of plies, let us find the belt speed.

Belt speed $= \dfrac{\pi\, d\, n}{60 \times 1000} = \dfrac{\pi \times 345 \times 730}{60 \times 1000}$

$= 13.2$ m/s.

Select 6 ply belt. (Table 3.7) (PSG 7.52)

Belt Rating :

Belt capacity = 0.0289 kW per m.m. width per ply at 180° arc of contact and at 10 m/s.

$= 0.0289 \times \dfrac{13.2}{10} \times \dfrac{160.4}{180} \times 6$ kW per m.m. width

$= 0.204$ kW per m.m width

Now total width of belt $= \dfrac{\text{Design power}}{\text{Belt Rating}}$

$= \dfrac{14.04}{0.204} = 69.0$ mm

Next higher standard belt width = 112 mm (Table 3.8) (PSG 7.52)

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

$$= (2 \times 2) + \frac{\pi}{2}(1 + 0.345) + \frac{(1 - 0.345)^2}{4 \times 2}$$

$$= 4 + \frac{\pi}{2}(1.345) + \frac{(0.655)^2}{8}$$

$$= 6.166 \text{ m}$$

$$= 6166 \text{ mm}$$

Length after standard deduction for initial tension (i.e.; after reducing 1% of L).

$$= 6166 \times 0.99 = 6104 \text{ mm} = 6100 \text{ mm}$$

Pulley width = 112 + 13 = 125 mm (standard value itself is 125 mm)

(Table 3.9, 3.10) (PSG 7.54)

Specifications :

Dunlop fort 949 g fabric belting of 112 mm width may be selected.

Pulley width = 125 mm

Length of belt = 6100 mm

Problem 2

A stone crushing machine receives power from a motor rated at 50 kW at 1800 rpm by means of flat belts. The pulley diameters are 200 mm and 700 mm. Centre distance between the two pulleys is 4000 mm. Design the belt drives if the direction of rotation of two pulleys are opposite to each other.

Solution :

Design power = Rated power × Service factor × Arc of contact factor

Rated power = 50 kW

Service factor = 1.5 (Table3.5)

Arc of contact, $\theta = 180° + \left(\frac{D+d}{C}\right)60°$ (for cross belt drive)

$= 180° + \left(\frac{700+200}{4000}\right)60°$

$= 193.5°$

∴ Arc of contact factor = 0.96 (Table 3.6)

∴ Design power $= 50 \times 1.5 \times 0.96 = 72$ kW

Design power $= 72$ kW

To find out the number of ply, let us find the belt speed

$$\text{Belt speed} = \frac{\pi\, d\, n}{60 \times 1000} = \frac{\pi \times 200 \times 1800}{60 \times 1000}$$

$$= 18.8 \text{ m/s.}$$

For belt speed of 18.8 m/s and small pulley diameter of 200 mm, the no.of plies required

$= 4$ plies (Table 3.7)

Since the power is moderately high power, Dunlop Fort 949 g fabric belting may be selected. Now Belt rating for the above belt

$= 0.0289$ kW per mm width per ply at 180° arc of contact and 10 m/s belt speed

$$= 0.0289 \times \frac{18.8}{10} \times \frac{193.5}{180} \times 4$$

$= 0.234$ kW per mm width for 4 plies and arc of contact of 193.5° and belt speed of 18.8 m/s.

$$\therefore \text{ Belt width required } = \frac{\text{Design power}}{\text{Belt rating}}$$

$$= \frac{72}{0.234} = 307.6 \text{ mm}$$

Since the width calculated is not available, let us select next higher ply belt, say 5 ply belt.

Now Belt rating for 5 ply belt

$$= 0.0289 \times \frac{18.8}{10} \times \frac{193.5}{180} \times 5 \times 10^{3}$$

$$= 0.2925 \text{ kW per mm width}$$

$$\therefore \text{ Belt width required } = \frac{72}{0.2925} = 246.2 \text{ mm}$$

Select next higher standard width of belt as 250 mm width of 5 ply belt. (Table 3.8)

Pulley width $= 250 + 25 = 275$ mm

Standard width of pulley $= 280$ mm (Table 3.9, 3.10)

Length of belt for cross belt drive is given by

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

$$= (2 \times 4) + \frac{\pi}{2}(0.7 + 0.2) + \frac{(0.7 + 0.2)^2}{4 \times 4}$$

$= 9.464$ metre

$= 9464$ mm.

Standard reduction of length for initial tension $= 1\%$ of L

$\therefore$ Actual length required $= 9464 \times \frac{(100 - 1)}{100}$

$= 9464 \times 0.99$

$= 0.9370$ mm

Cast Iron pulley may be selected.

Specifications :-

1.	Material of the belt	=	Dunlop "Fort" 949 g fabric belting.
2.	Material of pulley	=	Cast Iron pulley
3.	Type of drive	=	Cross belt drive
4.	Length of belt	=	9370 mm
5.	Width of belt	=	250 mm
6.	No. of plies	=	5 plies
7.	Width of pulley	=	280 mm
8.	Diameter of motor pulley	=	200 mm
9.	Diameter of machine pulley	=	700 mm
10.	Centre distance	=	4000 mm.

Problem 3

Design a fabric belt to transmit 12 kW from an engine running at 1200 rpm to machine shaft at 480 rpm. The diameter of engine shaft pulley is 300 mm and the distance of engine shaft from machine shaft is 2 m. Coefficient of friction is 0.2.

Solution :

Power,	$P = 12\ kW = 12000\ W$
Speed of engine,	$n_1 = 1200$ rpm
Speed of machine,	$n_2 = 480$ rpm
Diameter of engine pulley,	$d = 300$ mm
Centre distance,	$C = 2m = 2000$ mm
Coefficient of friction,	$\mu = 0.2$

Let T_1 and T_2 be the tensions (tangential forces) acting in the tight side and slack side of the driving pulley.

We know that, the power, $P = (T_1 - T_2)\, v$ watts .....(1)

$$\text{and } \frac{T_1}{T_2} = e^{\mu\theta} \qquad \text{.....(2)}$$

Where T_1 & T_2 = Tensions in newtons.

v = Belt speed in m/s

μ = Coefficient of friction

θ = Angle of contact in radians

$$\text{Now } v = \frac{\pi d n_1}{60 \times 1000} = \frac{\pi \times 300 \times 1200}{60 \times 1000} = 18.85 \text{ m/s}$$

$$\therefore \text{Equation (1)} \Rightarrow T_1 - T_2 = \frac{P}{v} = \frac{12000}{18.85} = 636.6 \text{ N}$$

$$\text{Angle of contact, } \theta = 180^\circ - \left(\frac{D - d}{C}\right)60^\circ$$

Now D = Diameter of machine shaft pulley

$$= id = \frac{n_1}{n_2} \times d = \frac{1200}{480} \times 300 = 750 \text{ mm}$$

$$\therefore \theta = 180^\circ - \left(\frac{750 - 300}{2000}\right)60^\circ = 166.5^\circ$$

$$= 166.5 \times \frac{\pi}{180} = 2.9 \text{ radians}$$

Now $\frac{T_1}{T_2} = e^{\mu \theta} = e^{0.2 \times 2.9} = 1.79$

$$\therefore T_1 = 1.79 \, T_2$$

Substituting in equation (1), we get

$$(1.79 \, T_2 - T_2) = 636.6 \text{ N}$$

$$T_2 = \frac{636.6}{0.79} = 806 \text{ N}$$

$$\therefore T_1 = 1.79 \times 806 = 1443 \text{ N}$$

Let us select 5 ply, Dunlop Fort fabric belt, for d = 300 mm and v = 18.85 m/s (Refer Table 3.7)

Allowable tension for this belt = 8.83 N per mm width (Table 3.11)

$$\therefore \text{Total width of belt} = \frac{\text{Maximum tension}}{\text{Allowable tension}}$$

$$= \frac{1443}{8.83} = 163 \text{ mm}$$

Next standard width = 180 mm

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

$$= (2 \times 2000) + \frac{\pi}{2}(750 + 300) + \frac{(750 - 300)^2}{4 \times 2000}$$

$$= 5675 \text{ mm.}$$

Giving for initial tension, reduce 1% of L,

Then the corrected length, $L = 5675 \times 0.99 = 5618$ mm

$$= 5620 \text{ mm (say)}$$

Specifications :

1.	Type of belt	:	Dunlop Fort 949 g fabric belt
2.	Length of belt	:	5620 mm
3.	Width of belt	:	180 mm
4.	Number of plies	:	5

Problem 4

Design a belt drive to transmit 30 H.P. at 740 rpm to an aluminium rolling machine, the speed ratio being 3.0; The distance between the pulleys is 3 metre. Diameter of the rolling machine pulley is 1.2 metre.

Solution :

Design power = Rated power × Service factor × Arc of contact factor.

Rated power = 30 H.P (Given)

Service factor = 1.5 (Table 3.5) (PSG 7.53)

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

where D = Diameter of larger pulley = 1.2 m (Given)

d = Diameter of smaller pulley

C = Centre distance = 3 m (Given)

Let i = speed ratio

$= \frac{D}{d}$

$\therefore d = \frac{D}{i} = \frac{1.2}{3} = 0.4 \text{ m}$

$\therefore$ Arc of contact $\theta = 180° - \left(\frac{1.2-0.4}{3}\right)60°$

$= 164°$

Hence Arc of constant factor $= 1.06$ (Table 3.6) (PSG 7.54)

Therefore Design power $= 30 \times 1.5 \times 1.06 = 47.7$ H.P.

Assuming this as high power, let us select Dunlop Fort 949 g fabric belting.

To find the type of ply and width of belt, first find the belt velocity

$$\text{Belt velocity} = \frac{\pi\, d\, n}{60} = \frac{\pi \times 0.4 \times 740}{60} = 15.5 \text{ m/sec}$$

For $v = 15.5$ m/sec and $d = 0.4$ m (or 400 mm)

select 6 ply belt. (Table 3.7) (PSG 7.52)

Belt capacity for Dunlop Fort 949 g duct belting

$= 0.0392$ h.p. per mm width per ply at 10m/sec belt speed and at 180° arc of constant.

∴ Belt capacity of the selected 6 ply belt with corresponding arc of contact of 164° and belt speed of 15.5 m/sec

$$= 0.0392 \times \frac{15.5}{10} \times \frac{164}{180} \times 6 \text{ h.p. per mm width}$$

$$= 0.332 \text{ h.p./mm width.}$$

$$\therefore \text{ Required width of belt } = \frac{\text{Design power}}{\text{Belt capacity}}$$

$$= \frac{47.7}{0.332} = 144 \text{ mm}$$

Next standard width of belt = 152 mm (Table 3.8) (PSG 7.52)

Length of belt, $L = 2C + \frac{\pi}{2}(D + d) + \left(\frac{D - d}{4C}\right)^2$

$$L = (2 \times 3) + \frac{\pi}{2}(1.2 + 0.4) + \frac{(1.2 - 0.4)^2}{4 \times 3}$$

$$= 8.566 \text{ metres.}$$

Reduction of length for initial tension $= 1\%$ of L

$\therefore$ Required Length $= 8.566 \times \frac{(100 - 1)}{100} = 8.48$ m

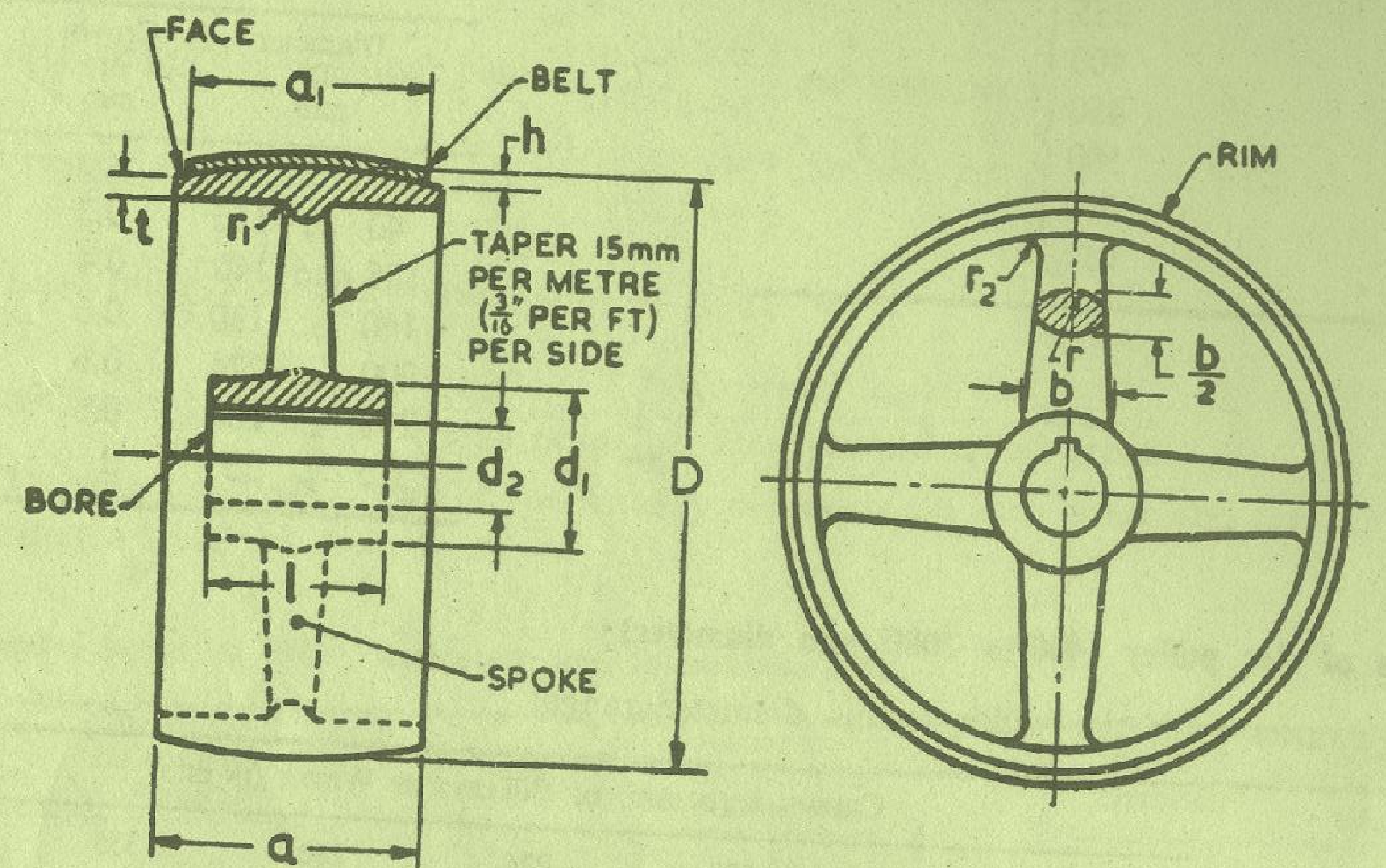
$= 8500$ mm

Pulley width	=	Belt width + 25 mm	Cast Iron pulley may be selected
	=	$152 + 25 = 177$ mm	
	=	180 mm (standard)	[Table 3.9, 3.10]

Specifications of drive :

1.	Type of drive	–	Flat Belt drive
2.	Material of belt	–	Dunlop Fort 949 g fabric belting
3.	Material of pulley	–	Cast Iron
4.	Diameter of motor pulley	–	400 mm
5.	Diameter of rolling m/c pulley	–	1200 mm
6.	Centre distance	–	3000 mm
7.	Length of belt	–	8500 mm
8.	Width of belt	–	152 mm
9.	No. of plies	–	6
10.	Width of pulley	–	180 mm

Design of Pulley



Cast Iron Pulley

Procedure :

a) Number of arms $\begin{cases} 4 \text{ for diameters up to 450 mm} \\ 6 \text{ for diameters over 450mm} \end{cases}$

b) Cross section of arms: elliptical

c) (1) Thickness of arm,

$$b, \text{ near boss} = 2.94 \sqrt[3]{\frac{aD}{4n}} \text{ for single belt, and}$$

$$= 2.94 \sqrt[3]{\frac{aD}{2n}} \text{ for double belt}$$

where, a, width of pulley

D, diameter of pulley

n number of arms in the pulley

(2) Thickness of arm, b, near rim $= \frac{2}{3} \times$ breadth of boss (or taper 4 mm per 100 mm)

d) Radius of the cross section of arms, $r = \frac{3}{4} b$

e) Minimum length of bore, $l = \frac{2}{3} a$ (it may be more for loose pulley, but in no case it exceeds a).

Example 1.1 *Design a cast iron 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 belt tension is not to exceed 250 N in 10 mm width. The allowable shear stress for the shaft material may be taken as 50 N/mm².*

Given Data: $P = 20\text{ kW} = 20 \times 10^3\text{ W}$; $N = 300$ r.p.m.; $D = 500\text{ mm} = 0.5\text{ m}$;

$\alpha = 180° = \pi$ rad; $n = 4$; $\mu = 0.3$; $T_1 = 2.5$ N in 10 mm width of the belt;

$\sigma_s = 50\text{ N/mm}^2$.

To find : Design a cast iron pulley.

☺ ***Solution :*** Velocity of the pulley or belt, $v = \frac{\pi \cdot D \cdot N}{60} = \frac{\pi \times 0.5 \times 300}{60} = 7.854$ m/s

1. Dimensions of pulley :

(i) Diameter of the pulley (D) is given as 500 mm. Now referring Table 1.5, the recommended diameter of the pulley is also ***500 mm. Ans.***

(ii) Width of the pulley (a) : In order to find the width of the pulley, let us find the width of the belt first.

Let T_1 and T_2 = Tensions on the tight and slack sides of the belt respectively.

We know that the power transmitted,

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

$$20 \times 10^3 = (T_1 - T_2)\, 7.854 \quad \text{or} \quad T_1 - T_2 = 2546.47 \qquad \text{... (i)}$$

and ratio of tensions, $\frac{T_1}{T_2} = e^{\mu\alpha}$

$$\frac{T_1}{T_2} = e^{0.3 \times \pi} \quad \text{or} \quad T_1 = 2.566\, T_2 \qquad \text{... (ii)}$$

From equations (i) and (ii), we get

$$T_1 = 4171.68 \text{ N} \quad \text{and} \quad T_2 = 1625.75 \text{ N}$$

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

Let b = Width of belt

Since the allowable tension (*i.e.*, maximum tension) is 250 N in 10 mm width or 25 N/mm width, therefore width of the belt

$$b = \frac{T_1}{25} = \frac{4171.68}{25} = 166.86 \text{ mm}$$

Referring to Table 1.13, the standard width of 4 ply belt is **200 mm.**

Therefore width of the pulley (a), referring the Table 1.6(a), is given by

$$= \text{Belt width} + 25 \text{ mm} = 200 + 25 = 225 \text{ mm}$$

Then, referring to Table 1.6(b), the standard pulley width is **250 mm. Ans.**

(iii) Thickness of the pulley rim (t) :

For single belt, $t = \frac{D}{200} + 3 \text{ mm}$ .... [From data book, page no. 7.57]

$= \frac{500}{200} + 3 = \mathbf{5.5 \text{ mm}}$ **Ans.** ☜

2. *Dimensions of arms :*

(i) Number of arms, n = 4 ... [Given]

(ii) Cross-section of arms : Major axis of elliptical section near the boss is given by

$$b = 2.94 \sqrt[3]{\frac{a\,D}{4\,n}} \text{ for single belt} \quad \text{... [From data book, page no. 7.56]}$$

where a = Width of the pulley = 250 mm,

D = Diameter of the pulley = 500 mm, and

n = Number of arms = 4

$$\therefore \text{Major axis} = 2.94 \sqrt[3]{\frac{250 \times 500}{4 \times 4}} = \mathbf{58.34\ mm\ \ say\ \ 60\ mm\ \ Ans.}$$

$$\text{and Minor axis} = \frac{\text{Major axis}}{2} = \frac{60}{2} = \mathbf{30\ mm\ \ Ans.}$$

(iii) Radius of the cross-sections of arms $= \frac{3}{4} \times$ Major axis

$$= \frac{3}{4} \times 60 = \mathbf{45\ mm\ \ Ans.}$$

3. *Dimensions of the hub :*

(i) Diameter of the hub : In order to find the diameter of the hub, let us find the diameter of the shaft first.

Let d = Diameter of the shaft

We know that the torque transmitted by the shaft,

$$T = \frac{P \times 60}{2\pi N} = \frac{20 \times 10^3 \times 60}{2\pi \times 300} = 636.62 \text{ N-m} = 636620 \text{ N-mm}$$

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

$$T = \frac{\pi}{16} \times \sigma_s \times d^3$$

$$636620 = \frac{\pi}{16} \times 50 \times d^3 \quad \text{or} \quad d = 40.17 \text{ mm say } 45 \text{ mm}$$

Therefore, Diameter of the hub = 2 × Diameter of the shaft

= 2 × 45 = 90 mm **Ans.**

(ii) *Length of the hub* $= \frac{2}{3} \times$ Width of the pulley $(a) = \frac{2}{3} \times 250$

$= 166.67$ **mm** **Ans.**

4. ***Crown height of the pulley (h) :*** For 500 mm pulley diameter and 250 mm pulley width, from Table 1.7(b), the crown height is selected as $h =$ **1.5 mm** **Ans.**


Thank You