UNIT - I

Design of Flexible Elements

* Design of flat Belts and pulleys.
  (i) Using Basic equations
  (ii) using Data Book.
* Design of V- belt and Pulleys
  (i) Using data book
  (ii) Using Equations
* Design of wire ropes and Pulleys.
  (i) Using equations
  (ii) Using Data book
* Design of Chains and Sprockets.
  (i) Using data book.

(I) Design of Flat belt and Pulleys

Introduction:

* When ever Power has to be transmitted from one shaft to another shaft flexible machine elements such as belts, ropes or chains are frequently used. Pulleys are mounted on the shaft and continuous belt or rope is passed are them.

* In belts and ropes, Power is transmitted due to friction belt between them and the Pulleys.

* In case of chain drives, Sprocket wheels are used. when the distance between the shaft is Large then belts, ropes or chains are used.

* The amount of Power transmitted depends upon several fact are such as velocity of the belt tensions in the belt. mass of the belt the arc of contact between the belts and the small Pulley etc.

Belt Drive:

Belt drive is a mechanical drive in which the driving shafts and driven shafts are connected by a Loop of flexible material called as belt through Pulleys mounted on the shafts. Belt are used as a source of motion to transmit Power efficiently are to track relative movement.

Classification of Belt Drives:

a) Light duty drive :- 5kws Speed upto 10 m/s.

b) Medium duty drives :- 5kw to 20 kw, belt Speed Upto 20 m/s.

c) Heavy duty drives :- More than 20 kw, belt Speed more than 20 m/s.

Types of Belts:

1, Based on the Centre distance they may be classified in to two types.

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

(b) Belt used for ~~long~~ Short distance less than 5m Such as V belts.

2, Based on Structure the belts are classified in to

(a) Flat belt

(b) V Section belt.

(i) Single V belt

(ii) Multible V belt

(iii) Ribbed belt.

(c) Toothed are Comming belt.

(d) Round Belt.

Factors influencing the Selection of belt drives:

1, Power to be transmitted

2, Space availablility for installation of drive

3, Speed of machinary Shafts.

4, Speed reduction ratio

5, Distance b/w the axes of rotating Shafts.

6, Service Conditions due to operating Period and Surroundings.

Types of flat belt drives:

1, Open belt drive

2, Cross are twist belt drives.

3, Belt drive with an iclear pulley.

4,

Materials used for Belts:

a) Leather

b, Cotton fabrics.

c) Rubber

d, Some animals hair.

e) Silk.

f) rayan.

g) Woolen.

Belt Slip:

* Slip is defined as the relative motion b/w the belt and pulley. The difference b/w the Line are Speeds of the Pulley and belt is the measure of Slip.
* The Presence of Slip reduces the velocity ratio of the drive

Creep :-

when the belt Passes from the slack side to
the tight side a Certain Portion of the belt
extends and it Contracts again when
the belt Passes from the tight side
to Slack Side Due to these changes
of length, there is relative motion.
b/w the belt and the Pulley Surface
This relative motion is termed as Creep.

Centrifugal Tension :

when the belt runs at Lower Speed
the initial tension given to the belt will
be Sufficient to keep the belt on the
Pulley with required gap.

The force applied on the belt due
to Centrifugal action action is Called as
Centrifugal Tension.

Initial tension in the belt:

The belt is not running the belt is
Subjected to some tension (force) at both
Sides of the Pulleys called initial tension.

The Side where more tension occurs as
tight side and tensile, where less tension
occurs in determind as SLack Side.

Design of Flat Belt Drive:

1, Design method using fundamental formula.

2, Design method using manufactures Catalogue

Design method using fundamental formula:

Power transmitting Capacity of belt.

$P = (T_1 - T_2) v$ Nm/s

T_1 = Tension is tight side in N

T_2 = Tension in Slack Side in N

V = Velocity of belt in m.

MKS Unit.

$$P = \frac{(T_1 - T_2) v}{75}$$

T_1 & T_2 are Tension in kgf

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

Velocity

(iii) Ratio between the tension of tight Side and slack side

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

μ = Co-efficient of friction

θ = Arc of Contact in rad.

Design method Using Manufactures Catalogues:

Design of belts by this method is based mainly two Parameter Such as

(i) How much Power (or) Maximum Power (or) (Design Power) to be transmitted.

(ii) what may be to the Power transmitting Capacity is belt rating of the Selection belt.

Refer PSG Data book, 7.52 to 7.57

Design Procedure for Flat belt Drive based on manufacturing tables:

1, Design Power = Rated Power is Gear passes * Service factor is Load. Correction factor × Belt. Arc of Contact factor.

2, ~~Design~~ Deside the type of belt.

3, Calculate the belt rating.

4, Find the required width.

5, Determine the Length of belt.

6, Find out Pulley dimension.

Design Procedure as Per Fundamental formula:

1, Design Powed Pd,
= Rated Power × Service factor × Arc of Contact factor.

2, Decide the type of belt.

3, Find the maximum tension.

4, Determine the required width of belt.

5, Determine the length of belt & Pulley dimensions.

Flat - Belt Pulley's:

The flat belt Pulley is a Cylindrical member. Similar of flywheel, in which Thickness of rim is Small and width is Large as Compared to flywheel.

Pulleys are also made in to

1, Solid (or) web type.

2, rim.

Materials for Pulleys:

The material for making Pulley depends On Size and Velocity of Pulley working environment etc. The Commonly used pulley materials are

i, Cast iron

ii) Steel.

iii) Wood.

iv) Compressed Paper.

① Problem:

Select a flat belt to drive a mill at 250 rpm from 10 kw, 730 rpm motor, Centre distance is to be arrived 2m, the mill Shaft Pulley is of 1m diameter.

Solution:

Design Power = Rated Power × Service factor × Arc of Contact.

$= P \times k_s \times k_a$

Rated Power $P = 10$ kw.

$K_s = 1.3$ Table 3.4 PSG 7.53 D.B

$$Q = 180° - \left(\frac{(D-d)}{2000}\right) 60°$$

$D = 1m = 1000mm$

$$e = \frac{n}{N} = \frac{730}{250} = 2.92$$

$$d = \frac{1000}{2.92} = 342.46m = 3.45mm$$

Arc of Contact:

$$Q = 180 - \left[\frac{1000 - 345}{200}\right] \times 60$$

$Q = 160.4$

$K_Q = 1.08$ Table 3.5 PSG 7.54

$P_d = 10 \times 1.3 \times 1.08$

$P_d = 14.14$ kw

$$V = \frac{\pi d n}{60 \times 1000} = \frac{\pi \times 345 \times 730}{60 \times 1000}$$

$V = 13.2$ m/s.

Select 6 ply (Table 3.6 PSG D.B Page No - 7.52)

Length of belt:

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

$$= (2 \times 2) + \frac{\pi}{2}(1 + 345) + \frac{(1-345)^2}{4 \times 2}$$

$$= 4 + \frac{\pi}{2}(1.346) + \frac{655^2}{8}$$

$= 6.166$ m

$L = 6186$ mm

Belt Rating:

B_r = 0.0299 kw per mm width per ply at 180° arc of Contact at 10 m/s

$$= \left(0.0289 \times \frac{13.2}{10} \times \frac{160.4}{180} \times 6\right) \text{ kw per mm width}$$

= 0.204 kw per mm width.

$$\text{Total width of belt} = \frac{\text{Design Power}}{\text{Belt Rating}}$$

$$= \frac{P_d}{B_r} = \frac{14.04}{.204} = 69 \text{ mm}$$

Next higher Standard belt width = 112 mm

Table 3.8 PSG 7.52

Initial tension to be Procieu to the belt for f is grip = 1 % of L

= 0.1 × 6166 = 62 mm

Length after Standard dedution for initial Tension is after rad 1% of L

= 6166 − 62 = 6104 mm

= 6100 mm

Pulley width = 112 + 13 = 125 mm

Stand Value of its 12 mm

table 3.9 (21.10 PSG 7.54)

Resulting design dimension:

1, Dunlop for 949 fabric belting of 122mm width may be Selected.
2, Pulley width = 125mm
3, Length of belt = 6100mm
4, Diameter of motor Pulley = 345mm
5, Diameter of mill Shaft pulley = 1000mm
6, Centre distance = 2000mm
7, NO of Plyes = 8.

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(2) Problem:

A pulley of 900mm diameter revolving at 200 rpm is to transmit 7.5kw. Find the width of a leather belt if the maximum tension is not to exceed 145 N in 10mm width. The tension at the tight side is twice that at 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 exceede 63 mN/m²

Solution:

Pulley diameter D = 900mm
Speed of Pulley N = 200 rpm
Power P = 7.5kw = 7500 w
Max Tension Tm = 145 Nm in 10mm width
Allowable Shear Stress τ = 63 mN/m²
= 63 N/mm²

T_1 = Tension in the tight side of belt
T_2 = Tension in the slack side of belt.

Power transmitted

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

$$= \frac{\pi D N}{60 \times 1000} = \frac{\pi \times 900 \times 200}{60 \times 100}$$

$$= 9.42 \, m/s$$

Hence equation (1) implies that

$$7500 = (T_1 - T_2) \, 9.42$$

$$T_1 - T_2 = \frac{7500}{9.42} = 796 \, N$$

$$T_1 = 2T_2$$

$$2T_2 - T_2 = 796$$

$$T_2 = 796 \, N \text{ and } T_1 = 2 \times 796$$

$$T_1 = 1592 \, N$$

Width of belt (b)

$$b = \frac{\text{maximum tension}}{\text{Belt Rating}} = \frac{1592}{14.5} = 110 \, mm$$

Belt rating = 145 N in 10mm

14.5 N Per mm.

The Standard width of belt = 112mm.

Diameter of the Shaft (d_s)

$$\text{Torque transmitted } T = \frac{60P}{2\pi N} = \frac{60 \times 7500}{2\pi \times 200}$$

$$= 358 \, N\text{-}m$$

$$= 358 \times 10^3 \, N\text{-}mm$$

$$\text{Diameter of the Shaft } d_s = \left(\frac{16T}{\pi \tau}\right)$$

$$= \left(\frac{16 \times 358 \times 10^3}{\pi \times 63}\right)^{1/3}$$

$$= 30.7 \, mm$$

$$= 35 \, mm$$

Dimensions of Pulley

(a) Dimensions of rim

width of Pulley rim $B = b + 13$

$= 112 + 13 = 125\,mm$

Thickness of Pulley rim $t = \frac{D}{200} + 3\,mm$

$= \frac{900}{200} + 3 = 7.5\,mm$

(b) Dimensions of arm

Let x = Major axis of arm

y = minor axis of arm

The bending stress induced in the arm is given by

$$\sigma_b = \frac{2T}{nZ}$$

T = Torque transmitted $= 358 \times 10^3$ mm

Z = Section modulus $= \frac{\pi}{32} x^2 y$

$= \frac{\pi}{32} (2y)^2 y = \frac{\pi y^3}{8}$ $(x = 2y)$

n = number of arms = 6

$\sigma_b = 16\,N/mm^2$ we get

$$16 = \frac{2 \times 358 \times 10^3 \times 8}{6 \times \pi y^3}$$

$$y = \left(\frac{2 \times 358 \times 10^3 \times 8}{6 \times 16 \times \pi}\right)^{1/3} = 26.7$$

$= 30\,mm$

$x = 2y = 2 \times 30 = 60\,mm$

Dimensions of hub:

Inside diameter of hub $d_i = d_s = 35\,mm$

Outside diameter of hub $d_o = 2d_s = 2 \times 35 = 70\,mm$

Length of hub $L = 2/3 \times B$

$= 2/3 \times 125 = 83.3\,mm$

$L = 85\,mm$

— x —

V - Belt Drives:

Design of V- Belt:

V - Belts are made in different Standard Lengths and Cross Section. As Per Indian Standards (IS 2494 -1974) V belt is Specified by a letter which represents Cross Section followed by the Size of the material inside length inner (or Circumferential length of the belt.

Design of V belts using basic formulas:

Similar of flat belts. V-belts are also designed fundamental formulas and

(2) Manufactures Catalogues:

$$\frac{T_1}{T_2} = e^{\mu \theta / \sin \alpha/2}$$

T_1 and T_2 are tensions at tight side and Slack side respectively.

θ = Angle of Contact in radius

α = Angle Substanded by sides of V belts

Power = $(T_1 - T_2) V$ N-m/s or watts

$$P = \frac{(T_1 - T_2) V}{75} hp$$

(1) Problem:

Design a V belt drive to the following Specifications:

Power to be transmitted = 75 kw

Speed driving wheel = 1440 rpm

Speed driven wheel = 400 rpm

Diameter of driving wheel = 300mm

Centre distance = 2500 mm

Service = 16 h/day

Solution :

For the given Power 75kw ? type (or) E type belts are Suited. Let us Select D type belt from table 4.1 PSG 7.58 JDB = 22.3

Design Power = $\frac{\text{Rated Power} \times \text{Service factor}}{\text{Pitch length factor} \times \text{Arc of Contact factor}}$

$$P_d = \frac{P \times k_s}{k_L \times k_s}$$

Service factor = 1.5 c for heavy duty and 16 h/day with A.C motor high torque (table 4.2) PSG 7.69,

Pitch length of the belt $L = 2c + \frac{\pi}{2}(D+d) + \frac{(D-d)^2}{4c}$

$$d = 300mm$$

$$D = \frac{n}{N} \times d = \frac{1440}{400} \times 300$$

$$= 3.6 \times 300 = 1080mm$$

$$c = 2500 mm$$

$$L = (2 \times 2500) + \frac{\pi}{2}(1080 + 300) + \frac{(1080-300)^2}{4 \times 2500}$$

$$L = 7229 mm$$

The next Standard Pitch length = 7569 mm (table 4.4) PSG 7.60.

Pitch length factor k_L = 1.05

Arc of Contact $\theta = 180° - \left[\frac{D-d}{c}\right] 60°$

$$= 180 - \left[\frac{1080 - 300}{2500}\right] \times 60$$

A.C = 161.3°

Arc of Contact factor $= 0.955$

Design Power $P_d = \frac{P \times k_s}{k_a \times k_a} = \frac{75 \times 1.5}{1.05 \times 955}$

$= 112.0 \, kw.$

Power rating for D type belt:
Power transmitting Capacity of one belt

$P_s = \left(3.22 v^{-0.09} - \frac{506.7}{d_e} - 4.78 \times 10^{-4} v^2\right) v$

$d_e = d \times k_d = 300 \times 1.14 = 342 \, mm < d_{e\,min} = 425 \, mm$

$v = \frac{\pi d n}{60 \times 1000} = \frac{\pi \times 300 \times 1440}{60 \times 1000} = 22.6 \, m/s$

Belt Capacity $P_s = \left(3.22 \times 22.6^{-0.09} - \frac{506.7}{342} - 4.78 \times 10^{-4} \times 22.6^2\right) 22.6$

$= 15.96 \, kw$ at $180°$ arc of Contact

Required Belt Capacity for $161.3°$ arc of Contact $= 15.96 \times \frac{161.3}{180} = 14.3 \, kw$

$r = \frac{\text{Design Power}}{\text{Belt rating}} = \frac{P_d}{P_s}$

$= \frac{112.0}{14.3} = 7.82$ belts

Total no. of belts $r = 8$

Since the Pitch Length is changed from 7229mm to 7648mm, the Centre distance should also be increased in order to place the belt Properly over the Pulley

New Centre distance

$C = A + \sqrt{A^2 - B}$

$$A = \frac{L}{4} - \frac{\pi}{8}(D+d)$$

$$= \frac{7648}{4} - \frac{\pi}{8}(1080 + 300) = 1370$$

$$B = \frac{(D-d)^2}{8} = \frac{(1080-300)^2}{8} = 76050$$

$$C = 1370 + \sqrt{1370^2 - 76050} = 2712\,mm$$

Initial Tension = 0.75 to 1% of L

Take 1% of L = $7648 \times 1/100$ = 76mm

Final Centre distance = 2712 + 76 = 2788 mm

width of Pulley = $(n-1)P + 2f$ where n = total no of belt

$= (8-1)37 + (2 \times 24) = 307\,mm$

PSG 7:70 table 4.12

Resulting design dimensions:

1, Type of belt = D7756950 IS 2494 V belt

2, No. of belts = 8

3, Pitch dia of smaller Pulley = 300mm

4, Pitch dia of bigger Pulley = 1080mm

5, Centre distance = 2788mm.

Rope - Drives:

1 Designation of fibre ropes:

The diameter of the Cotton and mainly ropes roughs from 19mm to 56mm. The size of the rope is usually designated by their name, nominal diameter and the number of Standard.

1, Factor of Safety.

$$FOS = \frac{\text{Ultimate tensile bracking Load}}{\text{All working Load on the rope}}$$

2, Velocity of fibre ropes:

The Velocity of rope Various b/w 15 to 30m/s. The most economical Speed for rope is from 20 to 25m/s

3, Design formulas:

Total Power transmitted by 2 ropes $P = (T_1 - T_2) \times \frac{v}{2}$

$$\frac{T_1}{T_2} = e^{\mu\theta / \sin(\alpha/2)}$$

$$\mu = 0.15 \text{ to } 0.33$$

Length of the rope $L = 2C + \frac{\pi}{2}(D_1 + D_2) + \frac{(D_2 - D_1)^2}{4C}$

Angle of Contact $\theta = 180° - \frac{(D_2 - D_1)}{C} \times 60°$

4, Selection of wire rope influencing

i) Type of duty

ii) Speed.

iii) Plale of applications

Type of Duty

1, Light duty

2, medium duty

3, Heavy duty

4, Very heavy duty.

1, Hoisting Speed = 25 to 30 m/min

2, Trolly travel Speed = 35 to 50m/min

3, Bridge travel Speed = 100 to 120m/min

5) Stress in Hoisting wire ropes.

1) Direct tensile stress due to hoisting Load and weight of the rope.

2) Bending Stress due to bending of ropes over the sheaves or drum.

3) Stress due to Starting.

Problem:

Select a wire rope for a Vertical main hoist to lift a load of 20kN from a depth of 500 meters. A rope speed of 3m/s is to be attend in 10 sec.

Given:

Load to be lifted $w = 20kN = 20,000N$

Depth $h = 500m$

Rope Speed $V = 3 m/s$

Time $t = 10 s$

Let us select 6×19 rope for main hoist

Refer table 6.4.

d = Dia of rope

Wire dia $d_w = 0.07 d$

Optimum Pulley dia $D = 100 d$

Area of Cross Section of rope $A = 0.4 d^2$

Approximate Weight of rope Permeter length = $0.0375 d$

table 6.7

Tensile Strength of rope wire $\sigma_u = 1800 N/mm^2$

minimum factor of Safety = 10 (for main hoist)

Design fos $n = 2.5 \times 10 = 25$

Design load $P_d = 25 \times w = 25 \times 20000 = 500 \times 10^3 N$

Area of rope $A = \frac{\text{Design load}}{\text{Tensile Strength of wire}} = \frac{P_d}{\sigma}$

$= \frac{500 \times 10^3}{1800} = 278 mm^2$

$A = 0.4 d^2$

$d = \sqrt{\frac{A}{0.4}} = \sqrt{\frac{278}{0.4}} = 26.4 mm$

Next Standard dia of rope $d = 29 mm$

breaking Strength $P = 472 kw$

Weight of rope per midle length $= 30.5 N$

During normal working

Total Load applied $P = F_t + F_b$

= Load to be lifted + weight of rope

$= W + w = 20000 + (30.5 \times 500)$

$= 35250 N = 35.25 kw$

Bending Load $F_b = A \sigma_b = 0.4 d^2 \times \frac{d_w}{D_{min}} \times E$

$= 0.4 \times 29^2 \times \frac{0.07 d}{100 d} \times 0.8 \times 10^3$

$= 18840 N = 18.84 kN$

$F = F_t + F_b = 35.25 + 18.84$

$= 54.1 kN$

$FOS = \frac{P}{F} = \frac{472}{54.1} = 8.72$

During acceleration :-

Force due to acceleration $F_a = F_t \times \frac{a}{g}$

$= \frac{F_t \times v}{t g} \quad (a = v/t)$

$= \frac{35.25 \times 3}{10 \times 9.81} = 1.1 kN$

Total Load applied during acceleration

$F = F_t + F_b + F_a$

$= 35.25 + 18.84 + 11$

$= 55.2$ kw

$FoS = \frac{472}{55.2} = 8.6$

During Starting:

Force at Starting $F_{st} = 2f_1$

$= 2 \times 35.25$

$= 70.5$ kN

Total Load at starting $F = F_{st} + F_b$

$= 70.5 + 18.84$

$= 89.34$ kN

Factor of Safety $= \frac{472}{89.34}$ kN

— x —

chains & Sprockets

Design of chain & Sprockets;

1, Pitch Circle diameter of the Sprocket

$$D = \frac{P}{\sin \frac{188}{z}}$$

where P = Pitch of chain

z = number of teeth of Sprocket

2, Roller sealing radius

$z_s = 0.505$

3, Roller seating angle

$$Q = 140' - \frac{90'}{Z}$$

4, Tooth flank radius

$$r_f = 0.12 d_r (z + 2)$$

5, Tip diameter of the Sprocket

$$D_a = \frac{P}{\tan\left(\frac{180}{z}\right)} + 0.6P$$

6, Root diameter of the Sprocket (inner dia)

$$D_f = D - 2r_s$$

r_s = seating radius of roller

7, Tooth higher above the pitch Polygon

$$h_a = 0.5 (p - d_1)$$

8, Tooth width

$P \leq 12.7 mm$

$b = 0.93b$ for Simplex chain wheels

$= 0.91b$ for duplex and triplex

9, Tooth side relief

$t_a = 0.1P$ to $0.15P$, P = pitch

10, Tooth side radius

$r_x = p$

11, Should radius $r_s = 0.76mm$ (max)

12, width over teeth

B = (Number of strands − 1) $P_t + b$

P_t = Transverse Pitch.

Pitch P(mm)	9.525	12.70	15.875	19.05	25.4	31.75
Transverse pitch P_t	10.24	13.92	16.59	19.46	31.88	36.45

Problem:

Design a Chain Drive to actuate a Compressor from a 10kw electric motor at 960rpm. The Compressor Speed is to be 350rpm. Minimum Centre distance Should be 0.5m, Motor is mounted on an auxiliary bed, Compressor us to work for 8hr/day.

Solution

Power to be transmitted P = 10 kw

Motor Speed n_1 = 960 rpm

Compressor Speed n_2 = 350 rpm

min Centre distance a = 0.5 m = 500mm

Service = 8 hr/day

Let the operating chain may be a roller Chain Since the optimum Centre distance 30 to 50 Pitches Let us assume.

a = 35P Where P = pitch of chain

$$P = \frac{a}{35} = \frac{500}{35} = 14.3mm$$

The next Standard Pitch value

P = 15.875

Table 5.2 PSG 7.72

Transmission ratio $c = \frac{n_1}{n_2} = \frac{960}{350} = 2.74$

i = 2.74 - number of teeth on Pinion Sprocket

Z_1 = 25 (Assumed) from table 5.3 PSG 7.74

Then the number of teeth on wheel Sprocket

$Z_2 = i Z_1 = 2.74 \times 25 = 69$

$$Q = \frac{P k_s k_p}{V}$$

P = Power to be transmitted = 10 kw = 10000 Watts

V = Chain Velocity in m/s

k_n = factor of Safety

k_s = Service factor

Now Service factor

$k_s = k_1 k_2 k_3 k_4 k_5 k_6$ (table 5.1)

$k_1 = 1.5$ Load with heavy Shock.

$k_2 = 1.0$

$k_3 = 1.0$ (a_p = 30 to 50 p)

$k_4 = 1.0$

$k_5 = 1.0$ (Assuming drop Lubrication)

$k_6 = 1$

$k_s = 1.5 \times 1 \times 1 \times 1 \times 1 \times 1 = 1.5$

Let the min factor of Safety $k_n = 1$ for $k_s = 1$ and $z_1 = z_5$

Table 5.5 PSG 7.77

Chain Velocity $v = \frac{z_1 n_1 p}{60 \times 100} = \frac{25 \times 960 \times 15.875}{60 \times 100}$

$= 6.35$ m/s

$Q = \frac{P k_n . k_s}{v} = \frac{10000 \times 11 \times 1.5}{6.35} = 2.598$ N

Actual factor of Safety $k_b = \frac{Q}{\Sigma F}$

$\Sigma F = F_t + F_t + F_s$ and Q is the breaking strength of Selected chain.

F_t = Tangential force.

$= \frac{P}{v}$ newtons $= \frac{10000}{6.35} = 1575$ N

F_c = Centrifugal tension

$= \frac{wv^2}{g} = \frac{17.8 \times 6.35^2}{9.81} = 73.2$ N

F_s = Tension due to Sagging of Chain in newtons

Table 5.6 PSG 7.78 and a = 0.5 m

$= 4 \times 17.8 \times 0.5 = 35.6N$

$\Sigma F = 1575 + 73.2 + 35.6 = 1684N$

$k_N = \frac{Q}{\Sigma F} = \frac{44400}{1684} = 26.4$

$\sigma = \frac{P \cdot k_s}{Av}$

P = 10000 watts (given)

$k_s = 1.5$

A = Bearing area = 140 mm^2
table 5.2 PSG T 7.72

$v = 6.35$ m/s

$\sigma = \frac{1000 \times 1.5}{140 \times 6.35} = 17 N/mm^2$

$L_p = 2ap + \frac{z_1 + z_2}{2} + \frac{\left(\frac{z_2 - z_1}{2\pi}\right)^2}{ap}$ table 5.8 PSG Page 7.3

$= 2 \times 31.5 + \left(\frac{25+69}{2}\right) + \frac{\left(\frac{69-25}{2\pi}\right)^2}{31.5} = 111.5$

$L = L_p, P = 112 \times 15.875 = 1778mm$

Now the Corrected Centre distance

$a = \left(\frac{e + \sqrt{e^2 - 8m}}{4}\right) \times p$ table 5.8 PSG 7.75

$e = L_p - \left(\frac{z_1 + z_2}{2}\right)$

$= 112 - \left(\frac{25+69}{2}\right) = 65$

$m = 49$ for $z_2 - z_1 = 44$

Hence $a = \left[\frac{65 + \sqrt{65^2 - 8 \times 49}}{4}\right] \times 15.875$

$= 504 mm$

initial chain $\Delta = 0.5 f$

$= 0.5 \times 0.02 \times a$

$= 0.5 \times 0.02 \times 504$

$= 5.04 mm$

Hence required Centre differance $= 504 - 5.04$

$= 499 mm = 500 mm$

Now Pitch diameter of Pinion Sprocket

$d_1 = \frac{P}{\sin\left(\frac{180}{z_1}\right)} = \frac{15.875}{\sin\left(\frac{180}{25}\right)} = 127 mm$

Pitch dia of wheel Sprocket

$d_2 = \frac{P}{\sin\left(\frac{180}{z}\right)} = \frac{15.875}{\sin\left(\frac{180}{69}\right)}$

$= 349 mm$

Resulting Design Dimansions:

1, Type of chain = 10A - 2 DR 50 Roller chain

2, Centre distance = 500mm

3, Number of teeth of Sprocket Pinion = 25

4, Number of teeth of Sprocket wheel = 69

5, Length of Chain = 1778mm

6, Pitch diameter of Pinion Sprockets = 127mm

7, Pitch dia of wheel Sprocket = 349mm

— x —