Name :- Gokulachander. B

Dept :- Mechanical

Subject :- Design of Transmission Systems.

Year :- III / "A & B"

Sem :- VI

UNIVERSITY PATTERN

11.(a) Flat belt → General procedure
→ From equation [FIND:- T_1 & T_2]

V-belt → General Procedure [Types].
→ From equ^n

(OR)

(b) Chain drives.

(OR)

Rope [2% only chance]

12. (a) Spur Gear → Static (General)
→ Dynamic (Lewis method)

(OR)

(b) Helical Gear → Static [General]
→ Dynamic [Lewis].

13. (a) Bevel Gear. → General.
→ Lewis method

(OR)

Worm Gear → General
→ Lewis method.

14. (a) Gear box :-

↳ 6 Speed]
↳ 9 Speed] → ϕ, Spindle speed, Raydiagram Structural Formula, Kinematic Arrangement.

(OR)

(b) ↳ 12 Speed Gearbox

16 Speed "

18 Speed "

15. (a) Clutch
→ Single plate clutch [Theory / Problems]
→ Cone " " [Theory / "]
→ Multiple " " " "

(OR)

(b) Brake
→ Single brake (Derivation / problem)
→ Double Side " "
→ Band Brake.

(or)

Cam profile [Rare].

Part - c :-

↳ Expected from UNIT - 1 (OR) UNIT - 5.

Problem :- 1

Design flat belt drive to transmit 25 kW at 720 rpm to an aluminium rolling machine with a speed reduction of 3.0. The distance between the shaft is 3m, Diameter of rolling machine pulley is 1.2 m.

Given :-

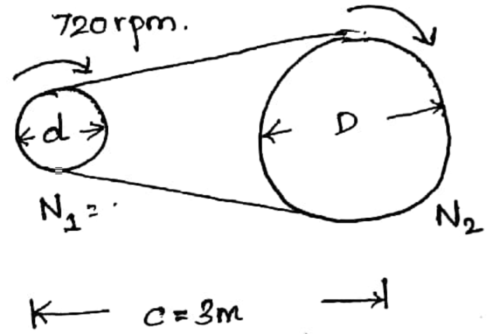
Rated Power (P) = 25 kW = 25×10^3 W

Speed Reduction (i) = 3 $\left(\because \frac{N_1}{N_2} = i\right)$.

C = 3m

D = 1.2 m.

N_1 = 720 rpm.



To find :-

Design Flat belt drive

Solution :-

Step 1 :- Pulley Daimeter (d) :-

$$N_1 \times d = N_2 \times D$$

$$i = \frac{N_1}{N_2} = \frac{D}{d} \qquad \because i = \frac{N_1}{N_2} = 3.$$

$$\therefore \frac{D}{d} = 3$$

Here, Driven Pulley diamter (D) = 1.2m (or) 1200mm.

$$\therefore d = D \div 3.$$

$$d = 400 \text{mm}$$

From data book, Page No. 7.54, Recommended smaller pulley diameter d = 400 mm (available).

Step 2 :- Design Power (Dp) :-

$$D_p = \frac{\text{Rated Power (kW)} \times \text{Load Correction Factor } (K_s)}{\text{Arc of Contact factor } (K_\alpha) \times \text{Smaller Pulley factor } (K_d)}$$

$$D_p = \frac{P \times K_s}{K_\alpha \times K_s}$$

✓ Rated Power ~~(kW)~~ $P = 25$ kW (Given).

✓ Load Correction factor (K_s) :-

~~For Shock $K_s \neq 1.5$~~ (Data book, Page No. 7.53)

From table no. 1.1, For Rolling machine, its on shock load.

So, ~~load~~ $K_s = 1.5$.

✓ Arc of Contact factor (K_a) :-

$$\text{Arc of Contact } (\alpha) = 180 - \left(\frac{D-d}{c}\right) \times 60$$ (Databook Page No. 7.54)

$$\alpha = 180 - \left(\frac{1200-400}{3000}\right) \times 60$$

$$\alpha = 164^\circ$$

For $d = 164^\circ$, table No. 1.2, the arc of contact factor (K_α) = 1.06

✓ Smaller Pulley diameter Factor (K_d) :-

For $d = 400$ mm, table No.

$$K_d = 0.8$$

$$\therefore D_p = \frac{25 \times 1.5}{1.06 \times 0.8}$$

$$D_p = 44.22 \text{ kW}$$

Step 3 :- Belt Type :

For Heavy Load (P = 25 kW), Select belt type in Table No 1.3. Data book, Page No. 7.52, 7.54

FORT Duck belting.

Hence, Load Rating capacity at 10 m/s = 0.0289 kW/mm/ply

Step 4 :- Belt Rating (or) Load Rating :-

$$\text{Load Rating at } V\ m/s \Rightarrow \text{Load Rating at } 10\ m/s \times \frac{V}{10}.$$

Where,

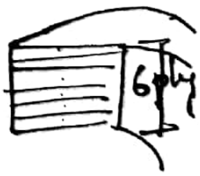
$$\text{Velocity of belt}(V) = \frac{\pi \times D \times N_2}{60} \text{ (or) } \frac{\pi \times d \times N_1}{60} \Rightarrow 15.07\ m/s$$

$$\therefore \text{Load Rating at } 15.07\ m/s \Rightarrow 0.0289 \times 15.07/10.$$

$$= 0.04355\ kW/mm/Ply$$

Step 5 :- Width of Belt (w) :-

✓ From table no. 1.6, For belt Velocity (15.07 m/s) and smaller diameter (400). Let us Select no. of. Plies as 6.



$$\therefore \text{Width of belt (W)} = \frac{\text{Design Power (Dp)}}{\text{Load Rating} \times \text{No. of. Plies.}}$$

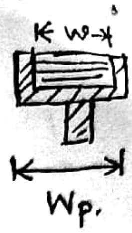
$$W = \frac{44.22}{0.04355 \times 6}$$

$$W = 169.2\ mm$$

✓ Select Standard Width, For no. of. plies (6), from table no. (Data book, Page no. 7.52).

$$\boxed{W = 180\ mm}$$

Step : 6 Putty Width (W_p).



$$W_p = W + (\text{Wider Width})$$

✓ ~~W~~ From table no. 1.7 . Corresponding width of pulley (180 mm). Wider Width = 25 mm.

$\therefore$ Width of Pulley (W_p) = 180 + 25 = **205 mm.**

Step : 7 Length of belt :- (L)

For open belt drive,

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

$$= 2(3000) + \frac{\pi}{4}(1200+400) + \left(\frac{1200^2 - 400^2}{4(3000)}\right)$$

$$= 6000 + 1256.63 + 106.66$$

$$= \mathbf{7363.29\ mm}$$

Problem 3 :-

~~Design of Flat belt drives to transmit 6kW at 900 rpm of the driver pulley. Speed Reduction is to be 2.5. Driving Assume that the Service is 16 hours a day.~~

~~Given~~ :-

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 1m diameter.

Given :-

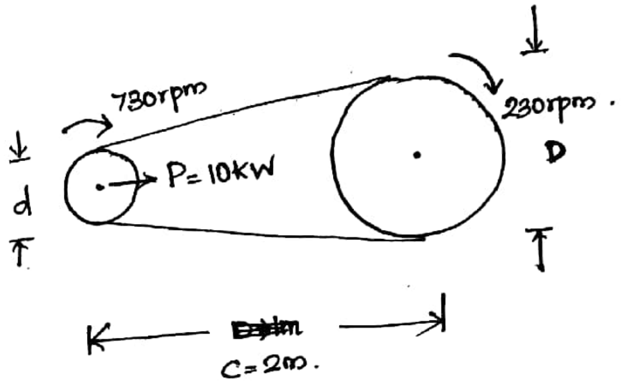
Rated Power (P) = 10 KW

$N_1 = 730$ rpm

$N_2 = 230$ rpm

$C = 2$m

$D = 1$m



To Find :-

Design Flat belt drive.

Solution :-

Step 1 :- Pulley Diameter :-(d)

$$N_1 \times d = N_2 \times D$$

$$\frac{N_1}{N_2} \Rightarrow \frac{D}{d}$$

$$\frac{730}{230} = \frac{1000}{d}$$

$$\boxed{d = 315 \text{ mm}}$$

∴ From data book, Page No. 7.54. Recommended Smaller pulley diameter $d = 315$ mm (Available).

Step 2 :- Design Power (D_p) :-

$$D_p = \frac{\text{Rated Power (kW)} \times \text{Load Correction Factor } (k_s)}{\text{Arc Of Contact Factor } (k_\alpha) \times \text{Smaller Pulley Factor } (k_d)}$$

✓ Rated Power, $P \Rightarrow 10\,kW$

✓ Load Correction Factor (k_s) :-

From table no. 1.1, For ~~Rolling~~ Mill machine, its on Intermediate Load

$k_s = 1.3$ (Data book, Page No. 7.53).

✓ Arc of Contact factor (k_α) :-

$$\alpha = 180 - \frac{(D-d)}{C} \times 60 \quad \text{(Data book, Page No. 7.54).}$$

$$\alpha = 180 - \left(\frac{1000-315}{2000}\right) \times 60.$$

$$\alpha = 159.5^\circ$$

For 159, table no. 1.2, the arc of Contact factor

$$k_\alpha = 1.08$$

✓ Smaller Pulley Diameter Factor (k_d) :-

For $d = 315\,mm$ table no. 1.3

$$k_d = 0.8$$

$$\therefore D_p \Rightarrow \frac{P \times k_s}{k_\alpha \times k_s}.$$

$$\Rightarrow \frac{10 \times 1.3}{1.08 \times 0.8}$$

$$\boxed{D_p \Rightarrow 11.23\,kW}$$

Step 6 :- Pulley Width (W_p) :-

$$W_p = W + (\text{Wider Width})$$

✓ From table no. 1.7, Corresponding width of pulley (100 mm),
Wider Width = 13 mm.

$$\therefore \text{Width of Pulley } (W_p) = 100 + 13 = 113 \text{ mm}$$

Step 7 :- Length of Belt :- (L)

✓ For Open belt drives,

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

$$= 2(2000) + \frac{\pi}{4}(1000+315) + \frac{1000^2 - 315^2}{4(2000)}$$

$$\Rightarrow 4000 + 283.75 + 112.59$$

$$L \Rightarrow 4396.34 \text{ mm}$$

Calculate the power capacity of the leather belt of 9mm x 250mm is used to drive a CI pulley 900mm in diameter at 400 rpm. If the active arc on the smaller pulley is 120^0 and stress in tight side is 2Mpa, The density of the leather may be taken as 980 kg/m^3 and coefficient of friction of leather on CI is 0.35

Given :-

$d = 900mm$

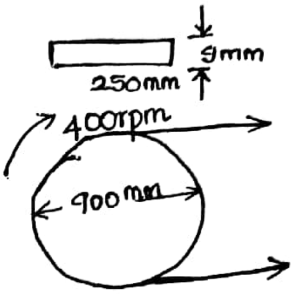
$N = 400 rpm$

$\alpha = 120° = 120 \times \pi / 180 \Rightarrow 2.094 \text{ rad}$

$\sigma = 2Mpa$

$\rho = 980 \; kg/m^3$

$\mu = 0.35$



To find :-

Power Capacity (P) = ?

Solution;

Power Transmitted by belt :-

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

Tension Ratio,

$$\frac{T_1}{T_2} = e^{\mu\alpha}.$$

$$\frac{T_1}{T_2} = e^{0.3 \times 2.094}$$

$$\frac{T_1}{T_2} = 1.87$$

$$\boxed{T_1 = 1.87 T_2} \text{ ——— equ(1)}$$

We know that,

Maximum Tension $(T) = \sigma \times b \times t$

$= 2 \times 10^6 \times 9 \times 10^{-3} \times 0.250$

$T_1 = 4500N$

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Sub T_1 in equ^n (1)

$$4500 = 1.87 T_2$$

$$T_2 = \frac{4500}{1.87}$$

$$T_2 = 2406.41 \text{ N}$$

$\therefore$ Power Transmission, $P = (T_1 - T_2) v$

$$P = (4500 - 2406.41)\, 18.84$$

$$\boxed{P \Rightarrow 39.44 \text{ kW}}$$

$\because v = \frac{\pi d N}{60}$

$= \frac{\pi \times 0.9 \times 400}{60}$

$= 18.84$ m/s.

~~A flat belt drive is required to transmit 12 KW from a motor running at 720 rpm. The belt is 12 mm thick and has mass density of 0.001 gm/mm³. Permissible stress in the belt not to exceed 2.5 N/mm². Diameter of driving pulley is 250 mm whereas the speed of driven pulley is 240 rpm. The two shafts are 1.25 m apart, coefficient of friction is 0.25. Determine the width of the belt.~~

Problem

The following data relates to a flat drives.

Power transmitted = 20 KW

Pulley diameter = 1.8 m

Angle of Contact = 180°

Speed of Pulley = 400 rpm

Co-efficient of friction between pulley and belt = 0.35

Permissible Stress for belt = 300 N/cm²

Thickness of belt = 8 mm

Density of the belt material = 950 kg/m³.

Determine the Width of the ~~pulley~~ belt required taking Centrifugal Tension.

Given :-

$P = 20kW$, $D = 1.8m$, $\alpha = 160° = 160 \times \pi/180 = 2.79$ rad, $N = 400$ rpm.

$\mu = 0.35$, $\sigma = 300$ N/cm², $t = 8mm$, $\rho = 950$ kg/m³.

To find :-

$b = ?$

Solution :-

✓ Power transmitted by belt;

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

Where, $v = \pi dN/60 = 37.69$ m/s.

$$20 \times 10^3 = (T_1 - T_2)\, 37.69$$

$$T_1 - T_2 = 530.51 \quad --- (1)$$

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Flat belt tension, T_1

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

$$\frac{T_1}{T_2} = e^{0.35 \times 2.79}$$

$$T_1 = 2.65 T_2 \quad \text{— (2)}$$

Sub (2) in (1), We get

$$2.65T_2 - T_2 = 530.51$$

$$T_2 = 321.52 \text{ N-m.}$$

$$\therefore T_1 = 852.03 \text{ N-m}$$

Maximum Tension in the belt, ~~T = σ.A + Tc~~

$$T_1 = \sigma.A + T_c$$

$$\cancel{852.03 = 300 \times 10^4 \times (b \times t) + T_c}$$

✓ Area of Cross-Section of belt (A) = b × t

$$= b \times 8$$

$$= 8b \times 10^{-6} mm^2$$

✓ Centrifugal Tension (T_c) :- $(\because m = \rho \times v)$

$$T_c = m.v^2$$

$$= (\rho \times A \times L) \times v^2$$

$$\Rightarrow 980 \times 8b \times 10^{-6} \times (37.69)^2$$

$$\Rightarrow 11.137b$$

$$852.03 = 300 \times (8b \times 10^{-6}) + 11.137b$$

$$852.03 = 2.4 \times 10^{-3} b + 11.137b$$

$$b = 76.48 mm$$

Standard Width, b = 90 mm

Problem :- 1

A 50kW motor Running at 1000 rpm. is required to drive a pump pulley at 400 rpm. The motor pulley diameter is limited to 0.3m. Centre distance Around 2.5m. Select Suitable V-belt and design V-belt.

Given :-

$P = 50 KW$

$N_1 = 1000$ Rpm

$N_2 = 400$ rpm

$d = 0.3m = 300mm$

$C = 2.5m \Rightarrow 2500 mm$.

To find :-

Design V-belt drives.

Solution :-

Step 1 :- Selection of V-Belt;

✓ Based on power transmission (P=50KW), Select V-belt Section from table no. 1.12 (Data book, Page No. 7.58).

C-section is Selected

Step 2 :- Pulley Diameter (D & d) :-

✓ To find pulley diamter (D), by Using relation,

$$\frac{N_1}{N_2} = \frac{D}{d}$$

$$\frac{1000}{400} = \frac{D}{300}$$

$D = 750$ mm.

✓ Select standard pulley diameter (driven) from table no. 1.0

$D = 800$ MM

Step 3:-

Determine the centre distance:-

To determine the centre distance from the table no: 1.5

but here centre distance is given. "C = 2500mm."

Step 4:

Calculation of design power (Dp)

$$D_p = \frac{\text{Rated Power (kW)} \times \text{Service Factor } (F_a)}{\text{Arc of Contact factor } (F_d) \times \text{Length Correction factor } (F_c)}$$

✓ Rated Power = 50KW (Given).

✓ Service factor (F_a):-

Select Service factor from table no: "1.13" based on application. (pump

So, $F_a = 1.3$ (assume 16 hrs/day).

✓ Arc of Contact factor (F_d):-

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

$$= 180 - \left(\frac{800-300}{2500}\right) \times 60$$

$$\alpha = 168^\circ$$

For 168°, From table no. "1.16"

$$F_d \Rightarrow 0.97.$$

✓ Length Correction Factor (F_c)

✓ Calculate the length Using relation

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

$$L = 2(2500) + \frac{\pi}{2}(800+300) + \frac{(800-300)^2}{4 \times 2500}$$

$$= 5000 + 1727.87 + 25 = 6752.87 \text{ mm}.$$

From data book, Page No. 7.60, standard Nominat Inside length is 6807, Correspending c-section belt length and length Correction factor are 6863 mm & 1.14.

$$L = 6863 \text{ mm}$$

$$F_c = 1.14.$$

$$\therefore D_p = \frac{50 \times 1.3}{0.97 \times 1.14} = 51.09 \text{ kW}$$

Step 5 :- Calculate Maximum Power Capacity :-

✓ For V-belt, "C"- Section," max. power capacity from table No. "7.14'

$$kW = \left(1.47S^{-0.09} - \frac{142.7}{D_e} - 2.34 \times 10^{-4} S^2\right) S.$$

Where,

de = Equivalent pitch diameter $\because d_e = d_p \times F_b$

Note

d_e · Value taken from ~~table~~ data book - page "7.62" (or) Using formula $d_e = d_p \times F_b$.

Here, $d_e = d_p \times F_b$ $\because d_p = 300$ mm (smaller pulley diameter).

$F_b = 1.13$ (DB. Page no. 7.62).

$$\boxed{\therefore d_e = 339 \text{ mm}}$$

S - Speed of belt $\because \frac{\pi d N_1}{60}$. ~~1570.8 m/s~~

$$S = \frac{\pi \times 0.3 \times 1000}{60} \approx 15.707 \text{ m/s}.$$

$$\therefore kW = \left(1.47 (15.707)^{-0.09} - \frac{142.7}{339} - 2.34 \times 10^{-4} (15.707)^2\right) 15.707$$

$$kW = (1.147 - 0.420 - 0.057)\, 15.707 \Rightarrow 10.52\, kW.$$

Step 6 :- No. of belt (n_b) :-

$$n_b = \frac{\text{Design Power } (D_p)}{\text{Maximum Power Capacity } (kW)}$$

$$n_b = \frac{51.09}{10.52} \approx 4.98 \simeq 5 \text{ belts}$$

Step 7 :- Corrected Centre distance (C) :-

✓ Centre distance Corrected by,

$$C_{actual} = A + \sqrt{A^2 - B}.$$

Where,

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

$$\Rightarrow \frac{6863}{4} - \pi \left(\frac{800+300}{8}\right). \Rightarrow 1285.28$$

$$B = \frac{(D-d)^2}{8} = 31250$$

$$\therefore C_{actual} = 1285.28 + \sqrt{1285.28^2 - 31250} \Rightarrow 2558 \text{ mm}$$

Problem 1-2

A Centrifugal pump Running at 340 rpm is to be driven by a 100 kW motor running at 1440 rpm. The drives is to Work for atleast 20 hrs every day. The Centre distance b/w the motor shaft and the pump shaft is 2000 mm. Suggest a Suitable V-belt.

Solution :-

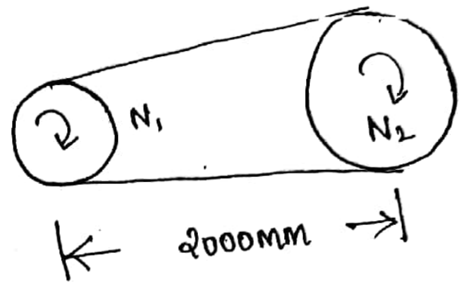
$P \Rightarrow 100\,kW$

$N_1 \Rightarrow 1440\,rpm$

$N_2 = 340\,rpm$.

$C = 2000\,mm$.

Duty $\Rightarrow$ 20 hrs/day.



To find : Suggest Suitable V-belt

Solution :-

Step 1 :- Selection Of V-belt :-

✓ Based On the power transmission (P = 100 kW), Select V-belt Section from Table no. 1.12 (Data book, Page No. 7.58).

D-Section is Selected

Step 2 :- Pulley Diameter (d & D)

✓ Here Smaller pulley diameter pulley is not given, take diameter from Table no. "1.12" based on the V-belt Section (D)

For 'D'-Section, $d = 355\,mm$

$$\frac{N_1}{N_2} = \frac{D}{d}$$

$$\frac{1440}{340} = \frac{D}{355}$$

$\therefore$ $D = 1503\,mm$

✓ Select Standard pulley diameter from table no. 1.10 Data book, page no. ~~1.0~~. 7.54

$$D = 1120 \text{ mm}.$$

Step 3 :- Centre distance :

$$C = 2000 \text{ mm [given]}.$$

Step 4 :- Design power (D_p).

$$D_p = \frac{\text{Rated Power} \times \text{Service Factor}}{\text{Arc of Contact factor} \times \text{Length Correction factor}}$$

✓ Rated Power ⇒ 100 kW.

✓ Service factor (F_a) :-

✓ For 20 hrs/day, (F_a) - Service factor from table no. 1.13 based on the application (pump).

$$F_a = 1.4$$

✓ Arc of Contact factor (F_α).

$$\alpha = 180 - \left(\frac{D-d}{C}\right) \times 60.$$

$$\alpha = 180 - \left(\frac{1120 - 355}{2000}\right) \times 60.$$

$$\alpha = 157^\circ$$

For, 157°, from table no. 1.16

$$F_\alpha = 0.94$$

Length Correction factor (F_c):

✓ Calculate the length Using Relation,

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

$$L = 2(2000) + \frac{\pi}{2}(1120-355) + \frac{(1120-355)^2}{4(2000)}$$

$$= 4000 + 1201.65 + 73.15 \Rightarrow 5274.80 \text{ mm}.$$

✓ From data book, Page No 7.64, Standard Nominal Inside length is 5334 mm, Corresponding D-Section belt length and length Correction factor are 5413 mm and 0.96.

$$L = 5413$$
$$F_c = 0.96.$$

$$\therefore D_p = \frac{100 \times 1.4}{0.94 \times 0.96} \Rightarrow 155.14 \text{ KW}.$$

Step 5:- Calculation of maximum Power Capacity

✓ For V-belt "D" Section maximum Capacity from table no. "1.14"

$$Kw = \left[3.22 S^{-0.09} - \frac{506.7}{de} - 4.78 \times 10^{-4} S^2\right] S.$$

Note:- de Value taken from ~~table~~ no. data book Page 7.62 (or) Using formula $\boxed{de = dp \times F_b}$

$\because F_b \Rightarrow \cancel{\frac{D}{d} = \frac{1120}{355}}$ ratio taken by Speed ratio (D/d) from ~~table~~ databook, Page No. 7.62.

$$F_b = 1.14 \quad [\because D/d = 3.14]$$

$$\therefore de \Rightarrow 404 \text{ mm}.$$

$\cancel{K_W} = \cancel{3}.22(\cancel{19.92})^{-0.09}$ $\because S = \frac{\pi D N_2}{60} = \frac{\pi \times 1120 \times 3..}{60}$

$\Rightarrow 19.92 \, m/s.$

$$K_W = \left[3.22\,(19.92)^{-0.09} - \frac{506.7}{404} - 4.78\times10^{-4}\,(19.92)^2\right] 19.92$$

$$\Rightarrow \left[\overset{2.45}{\cancel{0.687}} - 1.254 - \overset{-0.189}{0.1900}\right] 19.92$$

$$K_W = 20.05 \text{ kW}$$

Step 6 :- No. of belt (n_b) :-

$$n_b = \frac{\text{Design Power } (D_p)}{\text{Maximum Power Capacity } (K_W)}$$

$$\Rightarrow \frac{155.14}{20.05} = 7.73 \approx \text{"8 belt"}$$

Step 7 :- Corrected Centre distance (C) :-

✓ Centre distance Corrected by,

$$C_{actual} \Rightarrow A + \sqrt{A^2 - B}$$

Where,

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

$$= \frac{5413}{4} - \pi\left(\frac{1120+355}{8}\right) \Rightarrow 774.32$$

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

$$= \frac{(1120-355)^2}{8} \Rightarrow 73153.125$$

$$\therefore C_{actual} = 774.32 + \sqrt{(774.32)^2 - 73153.12}$$

$$\Rightarrow 1499.86 \text{ mm}$$

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Problem :- 3

A V-belt drive is to transmit 45 kW in a heavy duty saw mill which ~~Work~~ Work in two shifts of 8 hours each. The speed of motor shaft is 1400 rpm with the approximate speed reduction of 3 in the machine shaft. Design the drive and calculate the average stress induced in the belt.

Given :-

$P = 45\,kW$

$N_1 = 1400\ rpm$

$i = 3$

Service duty = 16 hrs/day (heavy duty).

To find :-

✓ Design drives

✓ Average Stress.

Solution :-

Step 1 :- Selection of V-belt :

✓ Based on the power transmission ($P = 50\,kW$), Select V-belt Selection from table no. 1.12 (Data book, Page No. 7.58).

"c - Section" is selected

Step 2 :- Pulley Diameter :- (d & D)

✓ Here Smaller pulley diameter is not given, diameter from table no. based on the V-belt Section, For c-Section $d = 200\,m$

$$\frac{N_1}{N_2} = \frac{D}{d} \qquad \because \frac{N_1}{N_2} = 3$$

$$3 = D/200$$

$$D = 600\,mm$$

✓ Select Standard Pulley diameter from table no. 1.0 (PG, DB: 7.54)

Step 3 :- Centre distance

✓ To determine the Centre distance from table NO: "1.15"

Here, $D/d = 3$, corresponding D/d ratio, $C/D \Rightarrow 1.0$.

$$\frac{C}{630} = 1$$

$$\therefore C = 630 \text{ mm.}$$

Step 4 :- Design Power (D_p) :-

$$D_p = \frac{\text{Rated Power (kw)} \times \text{Service Factor } (F_a)}{\text{Arc Of Contact factor } (F_d) \times \text{Length Correction Factor } (F_c)}$$

✓ Rated Power (kw) :-

$$P = 50 \text{ kw}$$

✓ Service Factor (F_a) :-

✓ For 2 shifts / day and heavy duty Saw mills: From table no: "1.13"

$$F_a = \cancel{1.4}\ 1.3$$

✓ Arc Of Contact factor (F_α) :- From Data book - 7.68.

$$\alpha = 180 - \left(\frac{D-d}{C}\right) \times 60.$$

$$= 180 - \left(\frac{630-200}{630}\right) \times 60$$

$$= 139^\circ$$

From table no: "1.16" Corresponding $\alpha = 139^\circ$.

$$F_\alpha = 0.89.$$

✓ Length Correction factor (F_c) :-

✓ Calculate the length Using Relation,

$$L = 2C + \pi/_2 (D+d) + \frac{(D-d)^2}{4C}$$ DB, Page No. 7.61.

$$= 2(630) + \pi/_2 (630+200) + \frac{(630-200)^2}{4(630)}.$$

$\Rightarrow$ 2637.13 mm

✓ From DB, Page No. 7.64, standard Nominal Inside length is 2667, Corresponding c - Section, &

Belt Length (L) = 2723 mm

F_c = 0.94.

$$\therefore D_p = \frac{50 \times 1.3}{0.89 \times 0.94} = 77.69 \text{ kW}$$

Step 5 :- Maximum Power Capacity

✓ For V-belt "C" - Section, Maximum Power Capacity from Table no. "1, 14"

$$KW = \left[1.47 S^{-0.09} - \frac{142.7}{de} - 2.34 \times 10^{-4} S^2\right] S.$$

Where,

$$S \Rightarrow \frac{\pi \times N_1 \times d}{60} \Rightarrow \frac{\pi \times 1400 \times 0.200}{60} = 14.66 \text{ m/s}.$$

de $\Rightarrow$ dp $\times F_b$, from data book. Page.no. 7.62 Corresponding D/d ratio $F_b = 1.14$ $\because$ de = d.

de = 200 × 1.14 = 228 mm.

$$\therefore kW = \left(1.47\,(14.66)^{-0.09} - \frac{142.7}{228} - 2.34\times10^{-4}\,(14.66)^{2}\right)14.66$$

$$= (1.154 - 0.625 - 0.050)\,14.66.$$

$$kW \Rightarrow 7.02\ \text{kW}.$$

Step 6 :- Number of belt (n_b) :

$$n_b = \frac{\text{Design Power (Dp)}}{\text{Maximum Power Capacity (kW)}}$$

$$= \frac{77.69}{7.02} \simeq 12 \text{ belts.}$$

Step 7 :- Corrected Centre distance (C).

✓ Centre distance Corrected by,

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

Where,

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

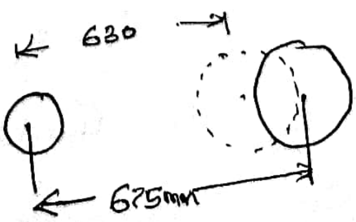
$$\Rightarrow \frac{2723}{4} - \frac{\pi(630+200)}{8}$$

$$\Rightarrow 680.75 - 325.94 = 354.80$$

$$B = \frac{(D-d)^2}{8} = \frac{(630-200)^2}{8} = 23112.5$$

$$\therefore C_{acutal} = 354.80 + \sqrt{(354.80)^2 - 23112.5}$$

$$C_{actual} \Rightarrow 675\ \text{mm}$$

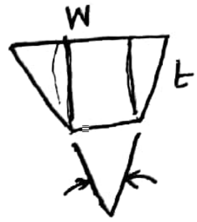


∴ Average Induced stress in the belt :-

$$\text{Stress} \Rightarrow \frac{\text{Maximum Tension}}{\text{Cross - Sectional Area.}}$$

Here, Cross - Sectional area of "c - Section"

$$A = 230 \text{ mm}^2$$



Maximum tension :-

W.k. that,

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

$$45 \times 10^3 = (T_1 - T_2) 14.66 \quad (\because v = 14.66 \text{ m/s})$$

$$T_1 - T_2 = 3069.57 \quad \text{—} (1)$$

Belt tension ratio,

$$\frac{T_1}{T_2} = e^{\mu\alpha . \operatorname{cosec} \beta}$$

Where,

$\mu = 0.3$ (Assume).

$2\beta = 35°$, $\beta = 17.5°$

α = Wrap angle (or) Arc of contact in rad.

$\alpha = 139°$ (or) 2.44 rad.

$$\therefore T_1/T_2 = e^{0.3 \times 2.44 \times 1/\cos 12.5}$$

$$T_1/T_2 = 2.15$$

$$T_1 = 2.15 T_2 \quad \text{—} (2)$$

Design a v-belt drive to transmit 50kW at 1440rpm from an electric motor to a textile machine running 24 hrs a day. The speed of the machine shaft is 480 rpm.

Given :-

Power (P) = 50 kW

N_1 = 1440 rpm

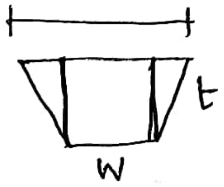
N_2 = 480 rpm

Service duty = 24 hrs/day.

To find : Design V-belt.

Solution :-

Step 1 :- Selection of v-belt :-



Sub equ^n (2) in (1)

$\therefore \quad 2.15\,T_2 - T_2 = \cancel{2045}\ 3069.57$

$T_2 = 2669.19$ N.

Sub. $T_2 = 2669.19$ in equ^(1) (or) equ^2

$T_1 = 2.15\,T_2$

$T_1 = 5738.75$ N.

Here, $T_1 = 5738.75$ is maximum tension :

$\therefore$ Stress $= \dfrac{5738.75}{230} = 24.95\ N/mm^2$

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Chain drive :-

↳ Given data :-

$P = 50 \, kW$

$N_1 = 1000 \, Rpm$

$N_2 = 300 \, Rpm$

$a_0 = 500 \, mm$

Procedure :-

1. Transmission ratio :-

$$i = \frac{N_1}{N_2} = \frac{Z_2}{Z_1}$$

$$i = 1000/300 = 2.85$$

$$\boxed{Std \; i = 3.15}$$

2. No. of. teeth in Sprokets :- Z_1 & Z_2

↳ Based 'i' Value

$Z_1 = 27$

$Z_2 = i \times 27 = 78$

3. Standard Pitch :- (P)

$a = (30 \text{ to } 50)P$

$a = 30p$, $a = 50p$

$P_{max} = 500/30$, $P_{min} = 500/50$

$P_{max} = 16.6 \, mm$, $P_{min} = 10 \, mm$

Standard pitch, $P = 15.875 \, mm$

4. chain Selection :- (7.71 to 7.73)

↳ Set. chain based on standard pitch,

10A-2 / DR50

↳ Bearing Area = $1.40\ cm^2$

↳ Weight = 17.8 N

↳ Breaking Load = 44400 N.

5. Total Load :- (P_T) (7.78)

$$P_T = P_t + P_c + P_s$$

↳ $P_t = \frac{1020}{v} \times N$ ∵ N = kW

$\Rightarrow 7139.10\ N$

$v = \frac{Z_1 \times P_1 \times N_1}{60 \times 1000}$

$= 7.14\ m/s.$

↳ $P_c = mv^2$

$\Rightarrow 1.78 \times 7.14^2$

$\Rightarrow 90.74\ N$

↳ $P_s = K.W.a$

$\Rightarrow 6 \times 17.8 \times 0.500$

$\Rightarrow 107.3\ N.$

$\therefore P_T = 7139.10 + 90.74 + 107.3$

$$\boxed{P_T \Rightarrow 7340.89\ N}$$

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6. Service Factor :- K_s.

$$K_s = K_1 . K_2 . K_3 . K_4 . K_5 . K_6$$

$$\boxed{K_s = 1.5}$$

7. Design load :- D_L

$$D_L = P_T \times K_s.$$

$$= 7340 \times 1.5$$

$$\boxed{D_L = 11.05 \, KN}$$

8. FOS :-

$$F_{sw} = \frac{\text{Breaking Load}}{D_L}$$

$$\Rightarrow \frac{44400}{11.05 \times 10^3}$$

$$\boxed{F_{sw} = 4.08}$$

9. Bearing Stress :- σ_b

$$\hookrightarrow \sigma_b = D_L / \text{Area}$$

$$= 11.05 \times 10^3 / 1.40$$

$$\Rightarrow 7.86 \, N/cm^2$$

10. Length of the chain :-

$$\hookrightarrow L = l_p . P$$

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

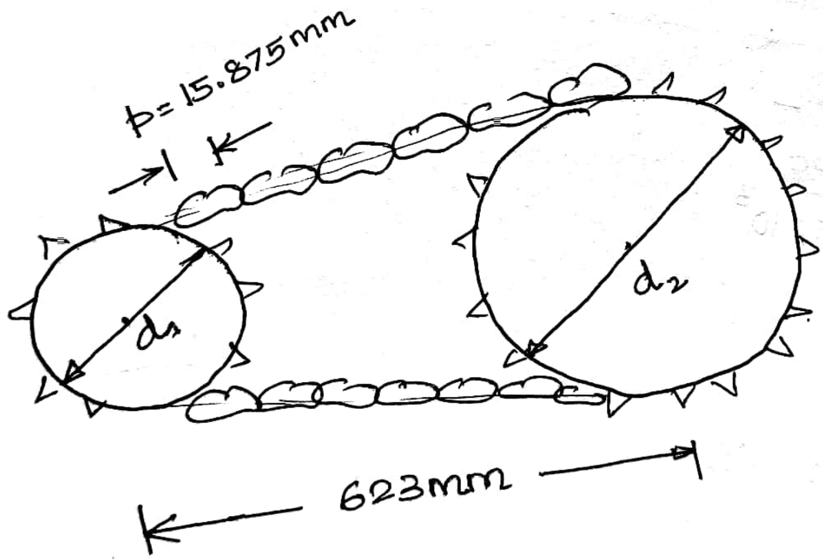
$\Rightarrow 116$ [EVEN]

$\therefore L = 1860$ mm

12. Exact Centre distance :-

$$a = \frac{e + \sqrt{e^2 - 8M}}{4} \cdot p$$

$$\boxed{a = 623\,\text{mm}}$$



UNIT - 2

Spur Gear And Helical Gear.

1. Design Of Spur Gear Drive to Transmit 22.5 kW At 900 rpm. Speed Ratio is 2.5. Material for Pinion And Wheel are C45 Steel. Working life = 10,000 hrs.

Given Data :-

↳ $P = 22.5$ kW

$N_1 = 900$ Rpm

$i = 2.5$

$\phi = 20^\circ$

$N = 10,000$ hrs.

1. Material Selection :-

Pinion / Gear ⇒ C45 Steel

2. Compressive Stress & Bending Stress :- $[\sigma_c]$ & $[\sigma_b]$

$$[\sigma_b] = \frac{1.4 K_{bl} \sigma_{-1}}{n K_\sigma}$$

↳ $\sigma_{-1} = 0.25\,[\sigma_u + \sigma_y] + 50$

$\sigma_u = 490\,N/mm^2,\ \sigma_y = 240\,N/mm^2$

$\therefore\ \sigma_{-1} = 232.5\ N/mm^2$

↳ $n = 2.0$

↳ $K_\sigma = 1.2$ [Case Hardened]

$$\therefore\ [\sigma_b] = \frac{1.4 \times 1 \times 232.5}{2 \times 1.2}$$

$$\boxed{[\sigma_b] \Rightarrow 135.625\ N/mm^2}$$

$[\sigma_c] = C_R \cdot HRC \cdot K_{ct}$

↳ $C_R = 220$

↳ $HRC = 63$

↳ $K_{ct} = 0.585$

$$\therefore\ [\sigma_c] = 220 \times 63 \times 0.585$$

$$\boxed{[\sigma_c] = 810.81\ N/mm^2}$$

3. Min. Centre Distance :-

$$a \geq (i+1)\sqrt[3]{\left(\frac{0.74}{[\sigma_c]}\right)^2 \cdot \frac{E\,[M_T]}{i\,\psi}}$$

↳ $E = 2.15 \times 10^5\ N/mm^2$

↳ $[M_T] = T.k.k_d$

$[M_T] \Rightarrow 239.73\ N/mm^2$

↳ $\psi \Rightarrow 0.3$

$$T = \frac{60 \times P}{2\pi N_1}$$

$T = 239.73\ N/mm^2 \times 1.3.$

$\therefore\ a \geq 135.94 \simeq 136\ mm.$

4. Module :-(m)

$$m \geq 1.26\sqrt[3]{\frac{[M_T]}{Y.[\sigma_b]\,\psi_m Z_1}}$$

↳ $y = 0.377$

↳ $Z_1 = 18$

↳ $\psi_m = 10$

$\therefore\ m \geq 4.07\ mm$

$\boxed{m = 5\ mm}$ [8.2]

5. Corrected No. Of. teeth :-(8.22)

$$Z_1 = \frac{2a}{m(i+1)}$$

$$\Rightarrow \frac{2 \times 136}{5\,(2.5+1)}$$

$\boxed{Z_1 \Rightarrow 16 \text{ teeth}}$

$Z_2 = i \times Z_1$

$\boxed{Z_2 \Rightarrow 40 \text{ teeth}}$

6. Actual Centre Distance :-

$$a = \frac{m(Z_1 + Z_2)}{2}$$

$$\boxed{a \Rightarrow 140\,mm}$$

7. Pitch dia, Velocity & Facewidth :-

↳ $d_1 = m \times Z_1 \Rightarrow 5 \times 16 = 80\,mm$

$d_2 = m \times Z_2 \Rightarrow 5 \times 40 = 200\,mm$

↳ $b = \psi \times a \Rightarrow 0.3 \times 140 = 42\,mm$

$b = \psi_m \times m \Rightarrow 10 \times 5 = 50\,mm$

8. ↳ $v = \frac{\pi \times d_1 \times N_1}{60 \times 1000} = 6.03\,m/s.$

8. Actual torque :-

↳ $(M_T) = T.K.K_d$

$\boxed{(M_T) = 242.\ N\text{-}mm}$

$K = 1.02$

$K_d = 1.3.$

(8.15)

9. Checking Compressive and Bending Stress :-

$$(\sigma_c) = 0.74 \frac{(i+1)}{a} \sqrt{\frac{i+1}{ib} . E.[M_T]}$$

$$(\sigma_c) \Rightarrow 711.05\ N/mm^2 \leq 810.81\ N/mm^2$$

∴ Hence is Safe

$$(\sigma_b) = \frac{(i+1)}{a.m.b.y} (M_T) \leq [\sigma_b]$$

$$\Rightarrow 87.42\ N/mm^2 \leq 135.625\ N/mm^2$$

∴ Hence is Safe.

10. Parameters :-

1. $m \Rightarrow 5$ mm

2. Add $\Rightarrow f_o \times m \Rightarrow 1 \times 5 \Rightarrow 5$ mm

3. Ded $\Rightarrow (f_o + c)m \Rightarrow (1 + 0.25) \times 5 \Rightarrow 6.25$ mm

4. Working depth $\Rightarrow 2 \times$ Add $\Rightarrow 10$ mm.

2. Design of Spur gear drives required to transmit 45KW at a pinion Speed of 800 rpm. The Velocity ratio is 3.5:1. The teeth are 20° FD Involute with 18 teeth. Both pinion and gear made up of Steel. with Static load 180 N/mm². Assume medium shock load..

Given :-

$P \Rightarrow 45 KW = 45 \times 10^3 N$

$N_1 \Rightarrow 800$ rpm

$i \Rightarrow 3.5$

$\phi \Rightarrow 20°$

$z_1 \Rightarrow 18$

$[\sigma_b] \Rightarrow 180 \ N/mm^2$

Sol :-

1. Material Selection :-

↳ Pinion & Gear - Steel

2. No. of. teeth :-

↳ $z_1 = 18$, $z_2 = i \times 18$

$= 3.5 \times 18$

$\Rightarrow 63$ teeth.

3. Tangential load on teeth :-

SHOCK	K_o
Steady	1.0
Light	1.25
Medium	1.5
Heavy	2.0

$$F_T = \frac{P \times K_o}{v}$$

$$F_T = \frac{45 \times 10^3 \times 1.25}{\frac{\pi \times m \times z_1 \times N_1}{60 \times 1000}}$$

$$\Rightarrow 89641.43/m$$

4. Initial Dynamic Loading (F_d)

$$F_d \Rightarrow F_T \times C_v$$

$$\Rightarrow \frac{89641.43}{m} \times 3$$

$$\Rightarrow \frac{268.9 \times 10^3}{m}$$

$$C_v = \frac{6 + V_m}{6} \quad \because V_M = 12\ m/s$$

$$\boxed{C_v = 3}$$

5. Beam Strength :-(F_s)

$$F_s \Rightarrow \pi \times m \times b \times [\sigma_b] \times y$$

$$\Rightarrow \pi \times m \times 10m \times 180 \times 0.103$$

$$\boxed{F_s \Rightarrow 582.54 m^2}$$

$$y = 0.154 - \frac{0.912}{z_1}$$

$$\boxed{y \Rightarrow 0.103}$$

6. Module :-(m)

$$F_d = F_s$$

$$\frac{268.92 \times 10^3}{m} \Rightarrow 582.45 m^2$$

$$\boxed{m \Rightarrow 7.72\ mm} \simeq 8mm$$

7. Pitch diameter (d), Velocity (v) & Facewidth (b) :-

$\hookrightarrow d_1 = mz_1 \;,\; d_2 = mz_2$

$\Rightarrow 8 \times 18 \;,\; d_2 = 8 \times 63$

$\Rightarrow 144\,mm \qquad \Rightarrow 480\,mm$

$\hookrightarrow b \Rightarrow 10m \Rightarrow 10 \times 8 \Rightarrow 80\,mm$

$\hookrightarrow v \Rightarrow \dfrac{\pi \times d_1 N_1}{60 \times 1000} \Rightarrow 6.03\,m/s.$

8. Re-calculation of beam Strength :-(8.51)

$$F_d = F_T + \frac{0.164\,V_m\,[Cb + F_T]}{0.164\,V_m + 1.52\sqrt{Cb + F_T}}$$

$C = 11860e$

$e = 0.038$

$\boxed{F_d \Rightarrow 11345.80\,N}$

9. Max. Wear load :-

$F_W = d_1 \times Q \times K \times b$

$Q = \dfrac{2i}{i+1} = 1.5$

$K = 0.35$

$\boxed{F_W \Rightarrow 6249.6\,N}$

10. Check for beam Strength :-

$F_S > F_d$

$\therefore$ Design is safe

11. Check for wear load :-

$F_W > F_d$

$\therefore$ Design is safe.

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3. Helical Gear :-

$P = 140 KW, N_1 = 1440 rpm, N_2 = 360 rpm. \phi = 20° FD, \beta = 25°$

$a = 400 mm.$

Sol :-

1. Material Selection :-

↳ Gears - cast Steel

2. No. of teeth :- $(Z_1 \& Z_2)$

↳ $Z_1 = 18, Z_2 = i \times Z_1$

$\Rightarrow$ 65 teeths

3. Module :-

↳ $a = \left(\frac{m_n}{\cos\beta}\right)\left(\frac{Z_1 + Z_2}{2}\right)$

$m_n \Rightarrow 7.25 \simeq 8 mm$

4. $d, v \& b$:-

↳ $d_1 = \frac{10 m_n}{\cos\beta} \times Z_1$.

$\Rightarrow 176 mm$

↳ $b \Rightarrow 10 m_n \Rightarrow 80 mm$

↳ $v \Rightarrow \pi d_1 N_1 / 60 \times 1000 \Rightarrow 13.0 m/s.$

5. Beam Strength :- (F_s)

$F_s \Rightarrow \pi \times m_n \times b \times [\sigma_b] \times y_v$

$\boxed{F_s \Rightarrow 27.0 \times 10^3 N}$

6. F_d :-

$$F_d = F_T + \left[\frac{0.164 V_m (C b \cos^2\beta + F_T) \cos\beta}{0.164 V_m + 1.485 \sqrt{C b \cos^2\beta + F_T}}\right]$$

$$\boxed{F_d = 46.86\ \text{kN}}$$

7. F_W :-

$$F_W = \frac{d_1 \times b \times Q \times K}{\cos^2\beta}$$

$$\boxed{F_W \Rightarrow 88.8\ \text{kW}}$$

8. checking (F_W)

$F_W > F_d$ (Safe)

9. checking (F_S)

$F_S > F_d$ (Safe)

1. Design a cast iron bevel gear drives for a pillar drilling m/c to transmit 1875 W at 800 rpm. to a spindle at 400 rpm. The gear is to work for 40 hours per week for 3 years. Pressure angle is 20°.

Given :-

↳ $P = 1875\ W$

↳ $N_1 = 800\ rpm$

↳ $N_2 = 400\ rpm$

↳ $i = 2$

↳ $T = 40 \times 52 \times 3 = 6240$ cycles

$\alpha = 20^\circ$

1. Material :-

↳ Gears - C45 [8.5]

2. $[\sigma_c]$ and $[\sigma_b]$

↳ $[\sigma_c] = C_B\ HB\ K_{cl}$ (or) $C_R\ HRC\ K_{cl}$ [8.18]

$C_B = 23$

$H_B = 260$

$K_{cl} = 0.636$

$K_{cl} = \sqrt[6]{10^7/N}$

$\because N = 60nT$

$\Rightarrow 60 \times 400 \times 6240$

$\Rightarrow 149.7 \times 10^6$

$[\sigma_c] = 23 \times 260 \times 0.636$

$\boxed{[\sigma_c] \Rightarrow 380.328\ N/mm^2}$

$\hookrightarrow [\sigma_b] = \dfrac{1.4 K_{bl} \sigma_{-1}}{n K_\sigma}$

$\rightarrow K_{bl} \Rightarrow 0.685$

$\sigma_{-1} \Rightarrow 0.4\,\sigma_u$ $\quad\because \sigma_u = 350\ N/mm^2$

$\rightarrow \sigma_{-1} = 157.5\ N/mm^2$

$\rightarrow n = 2.0$

$\rightarrow K_\sigma = 1.2$

$$\boxed{\therefore [\sigma_b] = 62.93\ N/mm^2}$$

3. Gear ratio and pitch angle :- $(\delta_1 \& \delta_2)$

$\hookrightarrow i = 2$

$\hookrightarrow \tan \delta_2 = i$

$\delta_2 = 63.43°$

$\delta_1 = 90 - 63.43 \Rightarrow 26.57°$

4. Cone distance :-

$$R \geq \psi_y \sqrt{i^2+1}\ \sqrt[3]{\left(\frac{0.72}{\psi_y - 0.5\,[\sigma_c]}\right)^2 \frac{E(M_T)}{i}} \quad (8.13)$$

$$\boxed{R = 71.63\ mm\ (or)\ 72\ mm}$$

5. No. of. teeth :- $(z_1 \& z_2)$

$z_1 = 18,\ z_2 = i \times 18 = 36$ teeths.

6. Transverse module :- (m_t)

$$m_t = \frac{R}{0.5\sqrt{z_1^2+z_2^2}}$$

$$= 3.21 \text{ mm}$$

(8.2)

$\boxed{m_t = 3.5 \text{ mm}}$

7. Cone distance :-

$$R = 0.5 m_t \sqrt{z_1^2+z_2^2} \quad (8.38)$$

$\boxed{R = 79 \text{ mm}}$

8. cal. b, v, d :-

$d_{av_1} = m_{av} \times z_1$, $d_{av_2} = m_{av} \times z_2$

$$m_{av} = m_t - \frac{b \sin \delta_2}{20}$$

$$m_a = 2.91 \text{ mm}$$

$\therefore d_{av_1} = \underline{58.22 \text{ mm}}$ //

$v = \pi d_{av_1} N_1 / 60 \times 1000 \Rightarrow \underline{2.43 \text{ m/s}}$ //

$b = R/\psi_y = \underline{26.33 \text{ mm}}$ /

9. Torque :- (M_T)

$$(M_T) = M_t \cdot K \cdot K_d$$

$$= 22.38 \times 10^3 \times 1.1 \times 1.35$$

$$(M_T) \Rightarrow 33.23 \times 10^3 \text{ N-mm}$$

10. Checking (σ_b) and (σ_c)

$$(\sigma_b) = \frac{R\sqrt{i^2+1}\,(M_T)}{(R-0.5b)^2\, b m y_v} \cdot \frac{1}{\cos\alpha} \le [\sigma_b]$$

$$\boxed{(\sigma_b) \Rightarrow 37.78 \text{ N/mm}^2}$$

$$(\sigma_c) = \frac{0.72}{(R-0.5b)} \sqrt{\frac{\left(\sqrt{i^2+1}\right)^3}{i \times b} \times \Sigma(M_T)} \le [\sigma_c]$$

$$(\sigma_c) \Rightarrow 351.01 \text{ N/mm}^2 \le [\sigma_c]$$

11. Parameter :-

- $m_t = 3.5$ mm
- $z_1 = 18$, $z_2 = 36$ teeths
- $R = 79$ mm

2. Bevel Gear drives to transmit 3.5 KW. at Speed ratio of 4. Driving shaft = 200 rpm. Non-reversible pinion is of Steel and wheel of CI. Assume gear life = 20,000 hrs.

Given data :-

↳ $P = 3.5$ KW, $i = 4$, $N_2 = 200$ rpm, $T = 25{,}000$ hrs.

1. Materials :-

↳ Gears – CI

↳ pinion – Steel

2. 'i' and (δ_1 & δ_2)

↳ $i = 4$,

↳ $\tan \delta_2 = i$

$\delta_2 = 75.96^\circ$

$\delta_1 = 90 - 75.96$

$\Rightarrow 14.04^\circ$

3. $[\sigma_b]$ and $[\sigma_c]$

$[\sigma_c] = C_R \, HRC \, K_{cr}, \; C_B HB \, K_{cl}$.

$C_R \geq 23$

$HR_c \geq 260$

$K_{cl} = 0.567$

$\boxed{\sigma_c = 339.06 \, N/mm^2}$

$$[\sigma_B] \Rightarrow \frac{1.4\, K_{bl}\, \sigma_{-1}}{n\, K_\sigma}$$

$$\Rightarrow \frac{1.4 \times 1 \times 220}{2 \times 1.2}$$

$$\Rightarrow 91.66\ N/mm^2$$

$K_{bl} = 1$

$\sigma_{-1} = 220$ (8.5)

$n = 2.0$

$K_\sigma = 1.2$

4. Cone distance :- (R_{min})

$$R_{min} \geq \psi_y \sqrt{(i^2+1)}\ \sqrt[3]{\left(\frac{0.72}{(\psi_y - 0.5)(\sigma_c)}\right)^2 \frac{E(M_T)}{i}}$$

$$\geq 139.35\,mm \simeq 140\,mm$$

$\psi_y = 3$

$(M_T) = M_T \times \frac{K \times K_d}{1.3}$

$M_T = \frac{P \times 60}{2\pi N}$

5. m_t :- (module)

$$m_t = \frac{R}{0.5\sqrt{z_1^2 + z_2^2}}$$

$$\Rightarrow \frac{140}{0.5\sqrt{18^2 + 72^2}}$$

$$\boxed{m_t \Rightarrow 4\,mm}$$

6. R :-

$$R = 0.5\, m_t \sqrt{z_1^2 + z_2^2}$$

$$\boxed{R = 182\,mm}$$

7. $m_{av}, d_{av}, \& v$:-

$\rightarrow m_{av} = m_t - \dfrac{b \sin \delta_1}{z_1}$

$m_{av} \Rightarrow 3.33\,mm$ //

$\rightarrow d_{av} = m_{av} \times z_1$

$\boxed{d_{av} = 73.26\,mm}$ //

$\rightarrow v = \pi d_{av} \times N / 60 \times 1000$

$\boxed{v \Rightarrow 3.06\,m/s}$ //

8. (M_T) :-

$(M_T) = M_t \cdot K \cdot K_d$

$(M_T) \Rightarrow 62.028 \times 10^3\,N\text{-}mm$ //

9. checking (σ_b) & (σ_c) :-

$$(\sigma_c) = \frac{0.72}{(R - 0.5b)} \cdot \sqrt{\frac{(\sqrt{i^2+1})^3}{ib} \times E(M_T)}$$

$(\sigma_c) = 242.75\,N/mm^2 \leq 339.06$

$\because (\sigma_c) \leq [\sigma_c]$ safe //

$$(\sigma_b) = \frac{R\sqrt{i^2+1}\,(M_T)}{(R - 0.5\,b)^2\, b\, m_{av}\, y_v} \times \frac{1}{\cos\alpha}.$$

$= 22.07 \leq 91.66\,N/mm^2$

$\because (\sigma_b) \leq [\sigma_b]$ safe.

Parameter :-

↳ $m_t = 4mm$

↳ $z_1 = 18$, $z_2 = 72mm$

↳ $R = 180 mm$

↳ $d_1 = 95.76 mm$, $d_2 = 352.94$ mm.

3. Design a pair of bevel gear to transmit 10kw at 1440 rpm Reqd. transmission ratio is 4. material for gears are 15Ni2Cr1Mo / steel.

Given :- $P = 10KW$, $N_1 = 1440 rpm$, $i = 4$, $\alpha = 20°$.

1. material :-

↳ Pinion and gears - 15Ni2Cr1Mo15 / steels.

2. Gear ratio and pitch angle :-

↳ $i = 4$,

↳ $\tan \delta_2 = i$, $\delta_2 = 75.96°$

$\delta_1 = 90 - 75.96 \Rightarrow 14.03°$

3. Teeths :- (z_1 and z_2)

$z_1 = 18$, $z_2 = i \times 18 = 72$ teeths.

4. Tangential load :- (F_T)

$$F_T = \frac{P \times K_o}{V}$$

$$= \frac{10 \times 10^3 \times 1.25}{1.507 m_t}$$

$K_o = 1.25$

$$V = \frac{\pi \times m \times z_1 \times N_1}{60 \times 1000}$$

$$= \pi \times m \times 18 \times 1440 / 60 \times 1000$$

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$F_T \Rightarrow \dfrac{8294.625}{m_t}$

5. Dynamic Load :- (F_d)

$F_d = C_v \times N_{sf} \times K_m \times F_T$

$\therefore F_d \Rightarrow \dfrac{10401.4}{m}$

$C_v = \left(\dfrac{5.5 + V_m^{1/2}}{5.5}\right)^{1/2}$

$= 1.254.$

$K_m = 1,\ N_{sf} = 1.$

6. Beam Strength (F_s) :-

$F_s = \pi \times m_t \times b \times (\sigma_b) \times y \times \left(\dfrac{R - b}{R}\right)$

$(F_s) \Rightarrow 120 m_t^2$

$(\sigma_b) = 320 N/mm^2$

$y = 0.154 - \dfrac{0.912}{Z_1} = 0.110$

$R = 41.23 m_t$

7. module :- (m_t)

$\boxed{F_s = F_d}$

$\therefore m_t = 2.31$ mm

$\boxed{\text{Std } m_t = 3 \text{ mm}}$

8. b, d and v :-

$\hookrightarrow b = 10 \times 3 \Rightarrow 30$ mm

$\hookrightarrow d = m z_1 = 3 \times 18 \Rightarrow 44$ mm

$\hookrightarrow v = \pi \times d \times N_1 / 60 \times 1000 \Rightarrow 4.52$ m/s

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9. Re-Cal beam Strength $[F_s]$:-

$$F_s = \pi \times m \times b \times [\sigma_b] \times y \times \left(\frac{R-b}{R}\right)$$

$$\boxed{F_s \Rightarrow 7544.68\,N}$$

10. Accurate dynamic loading :- (F_d)

$$F_d = F_T + \left[\frac{0.164V + C_b + F_T}{0.164V + 1.485\sqrt{C_b + F_T}}\right]$$

$$\boxed{F_d = 2818.55\,N}$$

11. Max. Wear Load :-

$$F_W = \frac{0.75 \times d_1 \times b \times Q \times k}{\cos \delta_1}$$

$$\boxed{F_W = 2746.84\,N}$$

12. Checking F_s & F_W :-

$F_s > F_d$:- Design is safe.

$F_W > F_d$: "

13. Parameter :-

↳ $m_t = 3\,mm$

↳ $z_1 = 18$, $z_2 = 72$ teeths.

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Bevel gear drives to transmit 7.36 kW at 1440 rpm. Gear ratio 3, material for pinion and gears are C45 hardened

Given :-

↳ $P = 7.36\,kW$, $N_1 = 1440\,rpm$, $i = 3$, C45 steels.

1. Materials :-

↳ Pinion/Gears — C45 steel hardened.

2. No. of teeth :- z_1 and z_2

$z_1 = 18$, $z_2 = 54$ teeths

3. Tangential load :- (F_T)

$F_T = \frac{P \times K_o}{v}$ | $v = \frac{\pi D \times N_1}{60 \times 1000}$ ∵ $D = m z_1$.

↳ $F_T = 6133.3/m_t$

4. Dynamic load :- (F_d)

↳ $F_d \Rightarrow F_T \times C_v \times N_{sf} \times K_m$ | $C_v = \left(\frac{5.5 + \sqrt{V_m}}{5.5}\right)^{1/2}$

$\Rightarrow 6378.66/m_t$

5. Beam Strength :- (F_s)

↳ $F_s = \pi \times b \times m_t \times [\sigma_b] \times y_v$

$F_s = \pi \times 10 m_t \times m_t \times (\sigma_b) \times y_v$

$\boxed{F_s = 406.14\, m_t^2}$

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6. Module :- (m)

$F_s = F_d$

$$406.14 m_t^2 = \frac{6378.66}{m_t}$$

$$\boxed{m_t = 2.5 mm}$$

7. cal, ~~Z~~, b, v, and d_1 :-

↳ $b = 10 \times 2.5 = 25 mm$

↳ $d_1 = m z_1 = 2.5 \times 18 = 45 mm$

↳ $v = \pi d_1 N_1 / 60 \times 1000 \Rightarrow 3.27 m/s.$

8. Recal beam Strength (F_s) :-

$F_s = 406.10 m_t^2$

$$\boxed{F_s = 2538.375 N}$$

9. Dynamic Load :- (F_d)

$$F_d = F_T + \frac{0.164 V_m (Cb + F_T)}{0.164 V_m + 1.465 \sqrt{Cb + F_T}}$$

$$\boxed{F_d = 8606.77 N}$$

10. Max. Wear Load :- (F_w)

$F_w = d_1 Q . k . b \times 1/\cos\alpha$

$$\boxed{F_w = 2754.7 N}$$

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