USN :

CMR Institute of Technology, Bangalore
DEPARTMENT OF MECHANICAL ENGINEERING
III - INTERNAL ASSESSMENT

Semester: 6-CBCS 2018
Subject: DESIGN OF MACHINE ELEMENTS II (18ME62)
Faculty: Mr Manikandan

Date: 2 Aug 2021
Time: 09:00 AM - 10:30 AM
Max Marks: 50

Instructions to Students :

Answer all the questions

Answer All Questions

Q.No		Marks	CO	PO	BT/CL
1	The following parameters refers to a pair of right angle bevel gear: Power to be transmitted : 8 kW Speed of pinion: 1600 rpm PCD of pinion : 100 mm Speed of gear : 400 rpm Permissible static stress for both gear materials : 138 MPa Calculate the module, face width of gears, number of teeth on gear and pinion. Also check for dynamic and wear load	25	CO4	PO1,PO3,PO7	L3
2	Select a V belt to transmit 20 kW at 2000 rpm to another pulley to run at 1000 rpm.	25	CO1	PO1,PO3,PO7	L3

(1) * Given, $P = 8kW$ $n_2 = 400$ rpm

$n_1 = 1600$ rpm $d_1 = 100$ mm

$\therefore i = \frac{n_1}{n_2} = 4$ $\therefore d_2 = 100 \times 4 = 400$ mm

Assume $\alpha = 20°$ FDI

$\Sigma = 90°$

$\sigma_{o1} = \sigma_{o2} = 138$ Mpa

* To find i) m ii) b iii) Z_1 & Z_2

Semi pitch cone angles (δ_1, δ_2)

$\tan \delta_1 = \frac{1}{i} = \frac{1}{4} = 0.25$

$\Rightarrow \delta_1 = 14.04°$

$\tan \delta_2 = i = 4$

$\Rightarrow \delta_2 = 75.96°$

1. Design tangential tooth load (F_t)

$F_t = 9550 \times \frac{P}{n} \times \frac{C_s}{r}$ $C_s = 1.5$

$\therefore F_t = 1432.5\,N$

2. Module (m)

$$F_t = \sigma_o\, k_v\, b \cdot y\, m \left(\frac{R-b}{R}\right)$$

Since both pinion and gear are made of same material, pinion is weaker

$\therefore$ Applying Lewis eqn to pinion,

$$F_t = \sigma_{o1}\, k_v\, b\, y_1\, m \left(\frac{R-b}{R}\right)$$

here $V_m = \dfrac{\pi d_1 n_1}{60{,}000} = 8.37\ m/sec$

$$\therefore k_v = \frac{4.5}{4.5 + V_m} = 0.349$$

assume $b = \dfrac{R}{3}$

$$R = \frac{1}{2}\sqrt{d_1^2 + d_2^2}$$

$$= 206.16\,mm$$

$Y = \pi y_i$

For 20° FDI System,

$$y_1 = 0.154 - \frac{0.912}{Z_{v_1}}$$

where $Z_{v_1} = \frac{Z_1}{\cos\delta_1} \quad \frac{(d_1/m)}{\cos\delta_1} = \frac{100}{m\cos 14.04°}$

$$y_1 = 0.154 - \frac{0.912}{\left(\frac{103.08}{m}\right)}$$

$$= (0.154 - 8.85\times 10^{-3} m)$$

$$\therefore Y_1 = \pi y_1$$

$$= \pi(0.154 - 8.85\times 10^{-3} m)$$

$$\frac{R-b}{R} = \frac{2}{3}$$

$$F_t = 138 \times 0.349 \times 69 \times \pi\,(0.154 - 8.85\times 10^{-3} m)\, m \times \frac{2}{3}$$

$$= 1071.85m - 61.6m^2$$

$$\therefore 61.6m^2 - 1071.85m + 1432.5 = 0$$

Solving $m = 15.94$ mm and 1.458 mm

Selecting smaller value, select $m = 1.5$ mm

3. <u>No. of teeth (z_1, z_2)</u>

$$z_1 = \frac{d_1}{m} = \frac{100}{1.5} = 66.67 \simeq 66$$

$$z_2 = i \times z_1 = 4 \times 66 = 264$$

4. <u>Face width (b)</u>

$$b = \frac{R}{3} = \frac{206.16}{3} = 68.72\,mm.$$

<u>Check for dynamic & wear load</u>

(i) <u>Dynamic load</u>

$$F_d = \frac{F_t + 21 V_m (F_t + bc)}{21 V_m + \sqrt{F_t + bc}}$$

based on $V_m = 8.37$ m/s & $f = 0.050$

Based on assumption for steel & steel combination for f (0.050) , C = 580 N/mm

f	C
0.050	2
0.050	580

C = 580 N/mm

$$F_d = 1432.5 + \frac{21 \times 8.37 (1432.5 + 68.8 \times 580)}{21 \times 8.37 + \sqrt{1432.5 + 68.8 \times 580}}$$

$F_d = 20613.46\ N$

(ii) <u>Check for wear load</u>

$F_w > F_d$

$$Q = \frac{2 Z V_2}{Z V_1 + Z V_2} \qquad Z V_1 = \frac{Z_1}{\cos \delta_1} = \frac{100}{(1.5) \times (10514.04)}$$

$Z V_1 = 68.719$

$$Z V_2 = \frac{Z_2}{\cos \delta_2} = \frac{264}{\cos(75.96)} = 1088.21$$

$$Q = \frac{2 \times 1088.21}{68.719 \times 1088.21} = 1.881$$

$$\frac{100 \times 68.72 \times 1.88 \times k}{\cos(14.04)} > 20613.46$$

$$13324.27\,k > 20613.46$$

$$k > \frac{20613.46}{13324.27}$$

$$k > 1.54$$

For steel steel combination

20° FDI

$k > 1.54$

Pinion surface hardness = 450 BHN

Gear surface hardness > 450 BHN

(2) (I)

$P = 20 kw$

$n_1 = 2000 rpm$

$n_2 = 1000 rpm$

$d_1 = 100 mm = d$

Average centre distance, $C = 2D$

(1) $n_1 d_1 = n_2 d_2$

$100 \times 2000 = d_2 \times 1000$

$d_2 = D = 200 mm$

$C = 2D = 400 mm$

(2) → $V = \frac{\pi d_1 n_1}{60000} = \frac{\pi \times 100 \times 2000}{60000}$

$= 10.471 m/s$

(3)

→ $d_e = d_1 f_b$

$\frac{n_1}{n_2} = \frac{2000}{1000} = 2$, $F_b = 1.13$

$d_e = 100 \times 1.13 = 113 mm$

(4) (8)

→ Maximum power capacity

$$N^* = V\left(\frac{0.45}{V^{0.09}} - \frac{19.62}{d_e} - \frac{0.765\,V^2}{10^4}\right)$$

$$= 10.471\left(\frac{0.45}{(10.471)^{0.09}} - \frac{19.62}{113} - \frac{0.765(10.471)^2}{10^4}\right)$$

$$N^* = 1.908\ kW$$

(5)

→ $$i = \frac{N F_a}{N^* F_c F_d}$$

$N = P = 20kW$

Assume $F_a = 1.2$

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

$$= 2\times 400 \times \frac{\pi}{2}(200+100) + \frac{(200-100)^2}{4\times 400}$$

$L = 1277.5\ mm$

A $\quad \& L = 1277.5$

$F_c = 0.93$

$$\theta = 2\cos^{-1}\left(\frac{D-d}{2c}\right)$$

$$= 2\cos^{-1}\left(\frac{200-100}{2\times 400}\right) = 165.64^\circ$$

$$\theta = 165.64^\circ$$

$F_d = 0.97$

$$i = \frac{20 \times 1.2}{1.908 \times 0.93 \times 0.97} \qquad \left[\because\ i = \frac{N F_a}{N^{+} F_c F_d}\right]$$

$$\boxed{i = 14\ \text{belts}}$$