6] Design of Helical Pair for 2^{nd} stage.

Given data :-

Material for gear and pinion = AL 7075 $\quad$ ψ = helix angle = 20°

S_{ut} = 570 MPa $\quad$ α = pressure angle = 20°

$Z_p = 17$

$Z_g = 34 \; (\because i = 2)$ $\quad$ $f(s) = \cancel{1.5}\; 2$

Solution:-

In order to estimate module, we first find Bending strength and wear strength in terms of module.

We find the bending strength using the formula:-

$$S_b = m_n \cdot b \cdot \sigma_b \cdot Y$$

$$b = 10 m_n$$

$$\sigma_b = \frac{1}{3} \times S_{ut}$$

$$= \frac{1}{3} \times 570$$

$$= 210 \; N/mm^2$$

$$Y = 0.484 - \frac{2.87}{Z'_p}$$

Y = Lewis form factor → depends upon virtual no. of teeth Z'_p

$$Z'_p = \frac{Z_p}{\cos^3 \psi}$$

$$= \frac{17}{\cos^3 20}$$

$$Z'_p = 20.48 \approx 20$$

→ For 20° full depth involute system, $Z'p = 20$ we get value of $Y = 0.320$.

→ This value has been written on the basis of Table 17.15 of VB Bhandari Design Data book.

$\therefore \quad S_b = m_n \times 10 m_n \times 210 \times 0.320$

$S_b = 672\, m_n^2$

We can calculate the bending strength by using formula:-

$$S_w = \frac{b\, Q\, d_p\, K}{\cos^2 \psi}$$

$b = 10 m_n$

$$Q = \frac{2 z_g}{z_g + z_p}$$

$$= \frac{68}{51}$$

$$= 1.33$$

$$d_p = \frac{z_p \times m_n}{\cos \psi}$$

$$= \frac{17\, m_n}{\cos 20}$$

$$K = \sigma_c^2 \sin\alpha \cos\alpha \left(\frac{1}{E_p} + \frac{1}{E_g} \right)$$

$$= 280^2 \times \sin 20^\circ \times \cos 20^\circ \times (2.857 \times 10^{-5})$$

$$= 0.514.$$

$$S_w = \frac{10 m_n \times 1.33 \times 17 m_n \times 0.514}{\cos^3(20)}$$

$$= 140.05\ m_n^2.$$

* As the gear & the pinion are made from the same material, the pinion is weaker.
Hence we design according to the strength of the pinion.

The bending strength of the pinion is $672\ m_n^2$
The wear strength of the pinion is $140.05\ m_n^2$.

As $S_b > S_w$,
failure will happen due to wear, hence S_w must be considered for determination of module.

Now we find Feff:-
To find Feff we use formula:-

$$F_{eff} = \frac{C_s \cdot F_t}{K_v}$$

$$F_t = \frac{2 M_t}{d_p}$$

$$M_t = \frac{60 \times 10^6}{2 \times \pi \times n_p}$$

(Output speed)spur = (Input speed)Helical = $n_p = 3110$

$$\therefore \quad M_t = \frac{60 \times 10^6}{2 \times \pi \times 3110}$$

$$M_t = 3070.5 \text{ N-mm}$$

$$F_t = \frac{2 \times 3070.5}{Z_p \times m_n} \times \cos\psi \qquad \left(\because d_p = \frac{Z_p \times m_n}{\cos\psi}\right)$$

$$= \frac{2 \times 3070.5 \times \cos 20^\circ}{17 \times m_n}$$

$$F_t = \frac{339}{m_n}$$

To find K_v, we must first find v,

$$v = \frac{\pi d_p n_p}{60 \times 1000}$$

$$= \frac{\pi \times Z_p \times m_n \times n_p}{60 \times 1000 \times \cos\psi}$$

$$= \frac{\pi \times 17 \times m_n \times 3110}{60 \times 1000 \times \cos 20}$$

$$v = 2.9453 \, m_n \approx 3 m_n$$

$$K_v = \frac{5.6}{5.6 + \sqrt{3 m_n}}$$

$C_s = 0.7$ [Standard consideration for AL helical gears]

$$\therefore F_{eff} = \frac{0.7 \times 339}{m_n} \div \frac{5.6}{5.6 + \sqrt{3 m_n}}$$

$$F_{eff} = \frac{237.3}{m_n} \times \frac{5.6 + 1.732\sqrt{m_n}}{5.6}$$

We know that :-

$$S_w = F_{eff} \times f(s).$$

$$140.05 m_n^2 = \left[\frac{237.3}{m_n} \times \frac{5.6 + 1.732\sqrt{m_n}}{5.6}\right] \times \cancel{1.5}\ 2$$

Solving further we get :-

$$\left(\frac{237.3}{m_n} \times \frac{5.6 + 1.732\sqrt{m_n}}{5.6}\right) \cancel{- 93.36 m_n} = \cancel{93.367 m_n^2}$$

$$= \cancel{120.}\ 70.025 m_n^2$$

$$\therefore \overset{70.025 m_n^2}{\cancel{93.367 m_n^2}} - \left(\frac{237.3}{m_n} \times \frac{5.6 + 1.732\sqrt{m_n}}{5.6}\right) = 0$$

We use bisection method in order to obtain positive value of m_n from following equation.

We get $m_n = 1.8$

Now, we know that $m_n = 1.8$
$\therefore$ We obtain all other values of Helical Pair

$m_t = m_n / \cos\psi \approx 2.$

1) $z_p = 17$
2) $z_g = 34$
3) $d_p = z_p \times m_t = 34$ mm
4) $d_g = z_g \times m_t = 68$ mm
5) $b = 20$ mm
6) backlash $= 0.24$ mm.
7) ~~Addendum =~~
8) Whole depth $= 2.25 \times m_t = 4.5$ mm
9) Addendum $= m_t = 2$ mm.
10) Dedendum $= 1.25 m_t = 2.5$ mm

FORCE ANALYSIS:-

$$F_t = \frac{339}{m_n}$$

$$= \frac{339}{1.8}$$

$$= 188.33 \text{ N}$$

$$F_r = F_t \tan\alpha$$

$$= 188.33 \times \tan 20^\circ$$

$$= 48.528 \text{ N}$$

$$F_a = F_t \tan\psi$$

$$= 188.33 \times \tan 20^\circ$$

$$= 48.528 \text{ N}$$