a] Design of Spur Pair for the first stage :-

- In order to obtain all dimensions of the spur gear pinion and gear we must first find the module.
- Given Data :-

Given material Al 7075, Factor of Safety = 2

S_{ut} = ₹ 570 N/mm², $(Z_{min})_{spur\ pinion} = 17$, $Z_g = 51$, Pressure Angle = 20°

- Solution :-

Bending Stress = $\sigma_b = \frac{1}{3} S_{ut}$

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

$= 211.6\ N/mm^2 \approx 210\ N/mm^2$

Bending Strength can determined by the formula :-

$S_b = m\, \sigma_b\, Y \cdot b$

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

Y = Lewis Form Factor = $0.484 + \frac{2.87}{Z_p}$

$= 0.484 + \frac{2.87}{17}$

$= 0.6528$

$b = 10 \times m$ (Standard formula)

$\therefore S_b = m \times 210 \times 0.6528 \times 10m$

$S_b = 1370.92\ m^2$

We find the wear strength using the formula:-

$$S_w = b\, Q\, d_p\, K$$

$b = 10m$

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

$$= \frac{2 \times 51}{17 + 51}$$

$$Q = 1.5$$

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

σ_c (For AL 7075) = 280 MPa.

α = Pressure angle = 20°

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

$$= 0.514$$

$$d_p = m \times z_p$$

$$= m \times 17$$

$$= 17m.$$

$$\therefore S_w = 10m \times 1.5 \times 17m \times 0.514$$

$$S_w = 131.12\, m^2$$

* As Gear and Pinion are made of the same material, Pinion will be weak.
Hence design must be done w.r.t pinion.

bending Strength of pinion = $1370.92\,m^2$
wear strength of pinion = $131.12\,m^2$.

As $S_b > S_w$,
failure will happen through wear.

Now, we calculate F_{eff}.

$$F_{eff} = \frac{K_a \cdot K_m \cdot F_t}{K_v}$$

$$F_t = \frac{P}{V}$$

$P = 1130\,W$

$$V = \frac{\pi d_p n_p}{60 \times 1000} \quad m/s$$

$$= \frac{\pi \times 17m \times 9330}{60 \times 1000}$$

$V = 8.304\,m$.

$$\therefore F_t = \frac{1130}{8.304m}$$

$$F_t = \frac{136.07}{m}$$

K_v = velocity factor.

For high speed application we consider value of K_v as

$$K_v = \frac{5.6}{5.6 + \sqrt{v}}$$

$$K_v = \frac{5.6}{5.6 + \sqrt{8.304\,m}}$$

$$F_{eff} = 1.2 \times 1.5 \times \frac{136.07}{m} \times \frac{5.6}{5.6 + \sqrt{8.304\,m}}$$

[$\because K_a = 1.2$, $K_m = 1.5$ based on table from VB Bhandari]

Given $f(s) = 2$.

Now, we create equation for finding module.

We know that :- $S_w = F_{eff} \times f(s)$.

$$113.12\,m^2 = \left[1.2 \times 1.5 \times \frac{136.07}{m} \times \frac{5.6}{5.6 + \sqrt{8.304\,m}}\right] \times 2$$

$$56.56\,m^2 = \left[\frac{244.926}{m} \times \frac{5.6 + \sqrt{8.304\,m}}{5.6}\right]$$

Now, we use bisection method for finding positive value of m that satisfies the given equation.

Using bisection method we ~~find~~ get $m = 1.6$

Based on following module, we obtain all other dimensions of the spur pair.

1. Module = m = 1.6 mm
2. d_p = 27.2 mm ≈ 28 mm
3. d_g = 82 mm
4. b = $10 \times m$ = 10×1.6 = 16 mm
5. backlash = 0.24 mm
6. Centre to centre distance = $a = \frac{2p+2g}{2}$ = 55 mm
7. Addendum = m = 1.6 mm
8. Dedendum = $1.25m$ = 2 mm
9. Clearance = $0.25m$ = 0.4 mm
10. Working depth = $2m$ = 3.2 mm
11. Whole depth = $2.25m$ = 3.6 mm
12. Tooth thickness = $1.5708m$ = 2.513 mm.