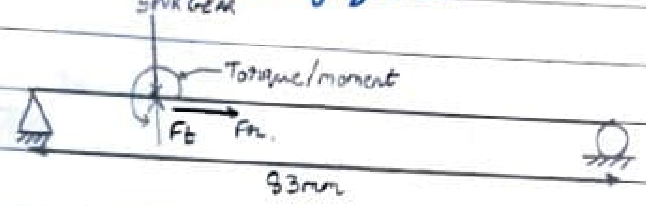
Shaft Calculations.

Input Shaft design.

We have to design the input shaft which is in the form of Simple Supported Beam.

We must first ~~design~~ analyze the loads and reactions produced ~~to~~ on the beam.

Spur Pinion is mounted ~~t~~ on the Input shaft and it produces ~~force~~ Radial, Tangential Force and moment as shown is below drawn figure.



By predefined force analysis we get :-

$F_t = 85.04$ N

$F_r = 30.9520$ N

We plot these forces, moment and length of the shaft onto MD solids software in order to obtain the SFD & BMD.

According to the SFD, BMD diagram :-

$(M_b)_v = 528.05$ N-mm.

$(M_b)_h = 922.75$ N-mm.

$$M_b = \sqrt{M_{b_1}^2 + M_{b_2}^2}$$

$$M_b = 1063.1577 \text{ N-mm.}$$

We know the formula ~~of~~ for diameter of shaft :-

$$d^3 = \frac{16}{\pi \times \tau_{max}} \sqrt{(K_b M_b)^2 + (K_t M_t)^2}$$

Refering to VB Bhandari : Design of Machine Elements :-

$K_b = 1.5$

$K_t = 1$

$S_{ut} = 320 \text{ MPa} = 320 \text{ N/mm}^2$
$S_{yt} = 240 \text{ MPa} = 240 \text{ N/mm}^2$ } → For AL 24534.

~~d~~ $\tau_{max} = 0.30\, S_{yt}$ OR $0.18\, S_{ut}$

$= 96 \text{ N/mm}^2$ $= 43.2 \text{ N/mm}^2.$

As $0.30\, S_{yt} > 0.18\, S_{ut}$

$96 \text{ N/mm}^2 > 43.2 \text{ N/mm}^2.$

we consider

$\tau_{max} = 43.2 \text{ N/mm}^2.$

$$d^3 = \frac{16}{\pi \times 43.2} \sqrt{(1.5 \times 1063.15)^2 + (1 \times 948.5)^2}$$

$d = 5.971 \text{ mm}$

$d \approx 6 \text{mm}.$

b] For intermidiate Shaft.

We have to design intermidiate shaft which is in the form of Simply Supported Beam.

~~we~~ As done in calulation of input shaft, we first analyse all forces produced on the intermidiate shaft.

The forces on the intermidate shaft are produced by spur gear and helical pinion, which are analysed and plotted on MD Solids Software.

By predefined force analysis we get:-

For spur:-

$F_t = 85.04 N$

$F_r = 30.952 N$

$M_t = 3070.5 Nmm$

For Helical:-

$F_t = 188.33 N$

$F_r = 48.528 N$.

$F_a = 48.528 N$

We account for axial force F_a by formula $(F_a \times r_p) = 824.976 N (ccw)$

From MD solids results attached below we get:-

$(M_b)_v = 633.79 N$.

$(M_b)_H = 2981.80 N$.

$(M_b)_{total} = \sqrt{(M_b)_v^2 + (M_b)_H^2}$.

$= \sqrt{633.79^2 + 2981.80^2}$

$= 3048.4138$.

We Know that:-

$$d^3 = \frac{16}{\pi \times \tau_{max}} \sqrt{(K_b M_b)^2 + (K_t M_t)^2}.$$

$K_b = 1.5$ & $K_a = 1$.

$\tau_{max} = 43.2$ (Derived Earlier).

$$d^3 = \frac{16}{\pi \times 43.2} \sqrt{(\cancel{K_b}1.5 \times 3048.4128) + (1 \times 3070.5)}.$$

$d = 7.87$ mm

$d \approx 8$ mm.

3] For output Shaft :-

We have to design output Shaft which is in the form of Simply Supported Beam.

As done in previous calculation of input & intermediate shaft, we first analyse all forces produced on the output shaft.

The force on the output shaft are produced by helical gear, which are analysed and plotted on MD Solids Software.

By predefined force analysis we get :-

$F_t = 188.33 N$

$F_r = 48.528 N$

$F_a = 48.528 N$.

We ~~a~~ i.e. account for axial forces by multiplying F_a with r_g. ~~$F_a \times r_g = 824.976 N$~~.

$F_a \times r_g = 48.528 \times 34$

$= 1649.952 N$.

From MD Solids results attached behind we get :-

$(M_b)_v = 866.49 N\text{-}mm$

$(M_b)_H = 3997.75 N\text{-}mm$.

$(M_b)_{total} = \sqrt{(M_b)_v^2 + (M_b)_H^2}$

$M_b = \sqrt{866.49^2 + 3997.75^2}$

$M_b = 4091.49 N\text{-}mm$.

M_t = Output Torque = 7.5 N-m
= 7500 N-mm.

We know that Shaft diameter (d):

$$d^3 = \frac{16}{\pi \times \tau_{max}} \sqrt{(K_b M_b)^2 + (K_t M_t)^2}.$$

$K_b = 1.5$
$K_t = 1$
$\tau = 43.2 \, N/mm^2$

$$d^3 = \frac{16}{\pi \times 43.2} \times \sqrt{(1.5 \times 4051.49)^2 + (1 \times 7500)^2}$$

$d = 9.59$ mm
$d \approx 10$ mm