Design of Spur Gear
Dynamic and Wear Load Calculation

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Problem Statement

Example

A gear drive is required to transmit a maximum power of 22.5 kW. The velocity ratio is 1:2 and r.p.m. of the pinion is 200. The approximate centre distance between the shafts may be taken as 600 mm. The teeth has 20° stub involute profiles. The static stress for the gear material (which is cast iron) may be taken as 60 MPa and face width as 10 times the module. Find the module, face width and number of teeth on each gear.

Check the design for dynamic and wear loads. The deformation or dynamic factor in the Buckingham equation may be taken as 80 and the material combination factor for the wear as 1.4.

Solution

Given

$P = 22.5$ kW $= 22500$ W; V.R. $= D_G/D_P = 2$; $N_P = 200$ r.p.m.; $L = 600$ mm; $\sigma_{OP} = \sigma_{OG} = 60$ MPa $= 60$ N/mm^2; $b = 10\ m$; $C = 80$; $K = 1.4$.

Module

Let $m =$ Module in mm,
$D_P =$ Pitch circle diameter of the pinion, and
$D_G =$ Pitch circle diameter of the gear.
We know that centre distance between the shafts (L),

$$600 = \frac{D_P}{2} + \frac{D_G}{2} = \frac{D_P}{2} + \frac{D_P \times V.R.}{2} = \frac{D_P(1 + V.R.)}{2}$$

$$600 = \frac{D_P(1+2)}{2} = 1.5 D_P \implies D_P = 400 \text{ mm}$$

$$D_G = D_P \times \text{V.R.} = 400 \times 2 = 800 \text{ mm}$$

We know that pitch line velocity of the pinion,

$$v = \frac{\pi D_P N_P}{60} = \frac{\pi \times 0.4 \times 200}{60} = 4.2 \text{ m/s}$$

Since v is less than 12 m/s, therefore velocity factor,

Module Continue

$$C_v = \frac{3}{3+v} = \frac{3}{3+4.2} = 0.417$$

We know that number of teeth on the pinion,

$$T_P = D_P/m = 400/m$$

Tooth form factor for the pinion,

$$y_P = 0.175 - \frac{0.841}{T_P} = 0.175 - \frac{0.95 \times m}{400}$$

Assuming steady load conditions and 8-10 hours of service per day, the

service factor (C_S) from Table 28.10 is given by

$$C_S = 1$$

Module Continue

We know that design tangential tooth load,

$$P_t = \frac{P}{v} \times C_S = \frac{22500}{4.2} \times 1 = 5357 \text{ N}$$

We also know that tangential tooth load (P_t),

$$5357 = \sigma_{op} \cdot b \cdot \pi \cdot m \cdot y_p = (60 \times 0.417)\ 10\ m \times \pi\ m(0.175 - 0.0021\ m)$$

$$5357 = 137.6\ m^2 - 1.65\ m^3$$

Solving this equation by hit and trial method, we find that
$m = 6.5$ say 8 mm **Ans.**

Number of teeth on the gears

We know that face width,
$b = 10\ m = 10 \times 8 = 80$ mm **Ans.**

We know that number of teeth on the pinion,
$T_P = D_P/m = 400/8 = 50$ **Ans.**
and number of teeth on the gear,
$T_G = D_G/m = 800/8 = 100$ **Ans.**

Checking the gears for dynamic and wear load

We know that the dynamic load,

$$P_D = P_t + P_I$$

$$Where, P_I = \frac{21v(b.C + P_t)}{21v + \sqrt{b.C + P_t}}$$

$$P_D = P_t + \frac{21v(b.C + P_t)}{21v + \sqrt{b.C + P_t}}$$

$$5357 + \frac{21 \times 4.2(80 \times 80 + 5357)}{21 \times 4.2 + \sqrt{80 \times 80 + 5357}}$$

$$= 5357 + \frac{1.037 \times 10^6}{196.63} = 5357 + 5273 = 10630 \text{ N}$$

From equation (i), we find that tooth form factor for the pinion,

$$y_p = 0.175 - 0.0021\ m = 0.175 - 0.0021 \times 8 = 0.1582$$

Maximum or limiting load for wear

From Table 28.8, we find that flexural endurance limit (σ_e) for cast iron is 84 MPa or 84 N/mm^2.

$$P_S = \sigma_e \cdot b \cdot \pi \cdot m \cdot y_p = 84 \times 80 \times \pi \times 8 \times 0.1582 = 26722 \text{ N}$$

We know that ratio factor,

$$Q = \frac{2 \times \text{V.R.}}{\text{V.R.} + 1} = \frac{2 \times 2}{2 + 1} = 1.33$$

$$P_W = D_P \cdot b \cdot Q \cdot K = 400 \times 80 \times 1.33 \times 1.4 = 59584 \text{ N}$$

Since both W_S and W_W are greater than W_D, therefore the design is safe.