

Example 1: Design based on velocity factor method

It is required to design a pair of spur gears with 20° full-depth involute teeth based on Lewis equation.

The velocity factor is to be used to account for dynamic load.

The pinion shaft is connected to a 10 kW, 1440 rpm motor. The starting torque of motor is 150% of rated torque. The speed reduction is 4:1.

The pinion as well as gear is made of plain carbon steel 40C8 (UTS = 600 MPa). The factor of safety can be taken as 1.5.

Design the gears, specify their dimensions and suggest suitable surface hardness for the gears.

1.5
 1.5
 1.5

$K_w = 10$ $n = 1440 \text{ rpm}$, $\boxed{z = 4}$, $UTS = 600 \text{ MPa}$
 $C_s = 1.5$ $\boxed{FOS = 1.5}$
 ↑ the factor of equal to starting torque of motor

For $\alpha = 20^\circ$, $Z_{min} = 17$ (DDB T 17.12)

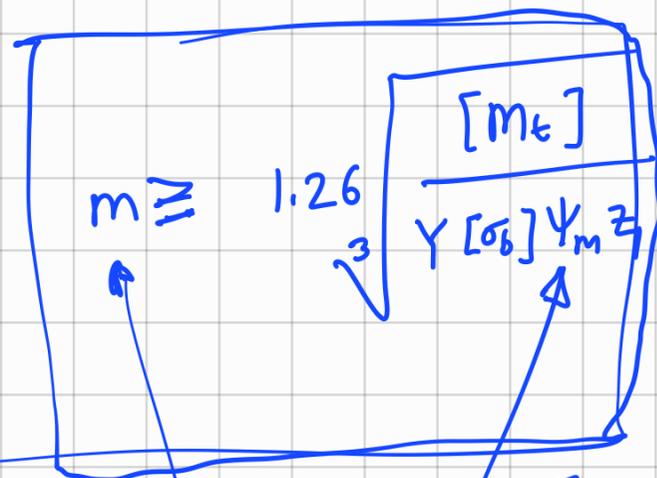
Let $Z_p = 17$

$Z_g = 4 \times 17 = 68$

$\rightarrow M_t = \frac{60 \times 10^6 \text{ kW}}{2\pi \text{ hp}} = \frac{60 \times 10^6 \times 10}{2\pi \times 1440} = 66,314.6 \text{ N}\cdot\text{mm}$

For $z = 17$, $Y = 0.302$ (DDB T 17.15)

Not $\boxed{T 21.26}$



$[M_t] = \frac{C_s \cdot M_t}{C_r} \times \boxed{FOS}$

$C_s = 1.5$

From DDB 17.22 , $C_v = \frac{3}{3 + 29 P}$

$\frac{b}{m} = 10$ $\frac{d_p}{2}$ $\rightarrow r_p \cdot w_p$
 between 8-12 $\circledast m \frac{Z_p}{2}$

Assumed (arbitrarily) $v = 5 \text{ m/s}$

$\Rightarrow C_r = \frac{3}{3 + 5} = 0.375$

$$[M_t] = \frac{C_s \cdot M_t}{C_v} \times FOS$$

$$= \frac{1.5 \times 66,314.6}{0.375} \times 1.5$$

$$= 397,887.6 \text{ N}\cdot\text{mm}$$

$$[\sigma_b] = \frac{UTS}{3} = \frac{600}{3} = 200 \text{ N/mm}^2$$

$$Y_m = b/m = 10$$

$$z_1 = 17$$

$$m \geq 1.26 \sqrt[3]{\frac{397,887.6}{0.302 \times 200 \times 10 \times 17}}$$

$$\geq \underline{4.26} \text{ mm}$$

Selection of module

From DDB T 17.3, $m = 5$ (choice 1)

$$d_p = m z_p = 5 \times 17 = 85 \text{ mm}$$

$$d_g = m z_g = 5 \times 68 = 340 \text{ mm}$$

$$b = 10 m = 50 \text{ mm}$$

Effective load calculation

$$P_t = \frac{2 M_t}{d_p} = \frac{2 \times 66,314.6}{85} = \underline{1560.3 \text{ N}}$$

$$v = \frac{\pi d_p n_p}{60 \times 10^3} = \frac{\pi \times 85 \times 1440}{60 \times 10^3} = \underline{6.41 \text{ m/s}}$$

$$C_v = \frac{3}{3 + v} = \frac{3}{3 + 6.41} = \boxed{0.3188}$$

$$P_{eff} = \frac{C_s \cdot P_t}{C_v} = \frac{1.5 \times 1560.3}{0.3188} = \boxed{7,341.4 \text{ N}}$$

Bending strength

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

$$= 5 \times 50 \times 200 \times 0.302$$

$$= \boxed{15,100 \text{ N}}$$

$$Y \propto z$$

$$Y_g > Y_p$$

$$\Rightarrow (S_b)_g > (S_b)_p$$

$$\text{Actual FOS} = \frac{S_b}{P_{eff}} = \frac{15,100}{7,341.4} = \boxed{2.06}$$

Since actual FOS (2.06) > $\boxed{1.5} \Rightarrow \text{okay}$

Required surface hardness calc

Wear strength of gear

$$\rightarrow S_w = b \cdot Q \cdot d_p \cdot K$$

$$Q = \frac{2 Z_g}{Z_p + Z_g} = \frac{2 \times 68}{68 + 17} = 1.6$$

$$K = 0.16 \left(\frac{\text{BHN}}{100} \right)^2$$

$$S_w = P_{eff} \times \text{FOS}$$

$$50 \times 1.6 \times 85 \times \left[0.16 \times \left(\frac{\text{BHN}}{100} \right)^2 \right] = 7,341.4 \times 1.5$$

$$\Rightarrow \text{BHN} = 318.1 \approx \boxed{320}$$