Homework 10
Assigned: April 17, 2015, Due: April 22, 2015

1. Draw a free body diagram of each gear for two gears in mesh, one driven by an input torque, the other resisted by an output torque. Identify the vector forces on the FBDs. Write a vector expression for the tooth contact force on one of the gears in terms of force magnitude and pressure angle.

2. You have the following gears in mesh.

Stage 1: 12 teeth with 24 teeth (20 degree PA, 32 pitch, brass, .25" face width)
Stage 2: 14 teeth with 40 teeth (20 degree PA, 24 pitch, steel, .375" face width)
Stage 3: 18 teeth with 60 teeth (20 degree PA, 20 pitch, steel, .5" face width)

Calculate the bearing loads and stresses in the gear teeth (see attached table) for an input torque of 300 oz-in. Compare the tooth stresses against the yield strength and comment on the viability of this gear box.

3. You have access to 32 pitch, 20 degree PA gears with the following teeth (12, 24, 36, 48, 60), both in brass (yield strength=70 MPa) and steel (yield strength=1500 MPa). Design a gear box with a gear ratio between 36 and 40. If the maximum speed of the motor is 10000rpm, calculate the output speed. Calculate bearing loads and stresses in the gear teeth (use attached table) assuming an input torque of 400 oz-in.

Formulae

$$\sigma = \frac{54 W_t P_d}{\pi^2 F}$$

$$\omega_o = \frac{Z_i}{Z_o}\omega_i$$

$$\tau_o = \frac{Z_o}{Z_i}\tau_i$$

$$W_t = \frac{2\tau_i P_d}{Z_i}$$

$$L = \frac{Z_i + Z_o}{2P_d}$$

Nomenclature

P_d diametral pitch in teeth per inch

Z_i number of teeth on the i^{th} gear

ϕ pressure angle in degrees or radians

τ_i input torque, in $N \cdot m$

τ_o output torque, in $N \cdot m$

W_t tooth contact force, tangential to pitch circle in N

W_n tooth contact force, normal to pitch circle in $N = W_t tan(\phi)$

Fgear face width, in mm

σnormal bending stress at tooth root, in Pa

$\sigma_y$normal yield stress, in Pa

$\omega_o$output speed in $\frac{rad}{sec}$

ω_i input speed in $\frac{rad}{sec}$

Loptimal gear spacing, in mm

Conversions

$$1inch = 25.4mm$$