Tutorial # 8 - Solution

1- A 2-tooth case hardened worm of forged steel is to drive a 40-tooth sand cast bronze gear. The worm is running at 1720 rpm, has an axial pitch of 7.85 mm, a normal pressure angle of 14.5°, a pitch diameter of 30 mm and its right hand helix teeth are ground and polished. If the gear has 15 mm face width and the coefficient of friction between the worm and the worm wheel is 0.03, **determine:**

a- The directions of forces acting on the worm
b- The maximum power that could be transmitted through this gear set
c- The efficiency of the system

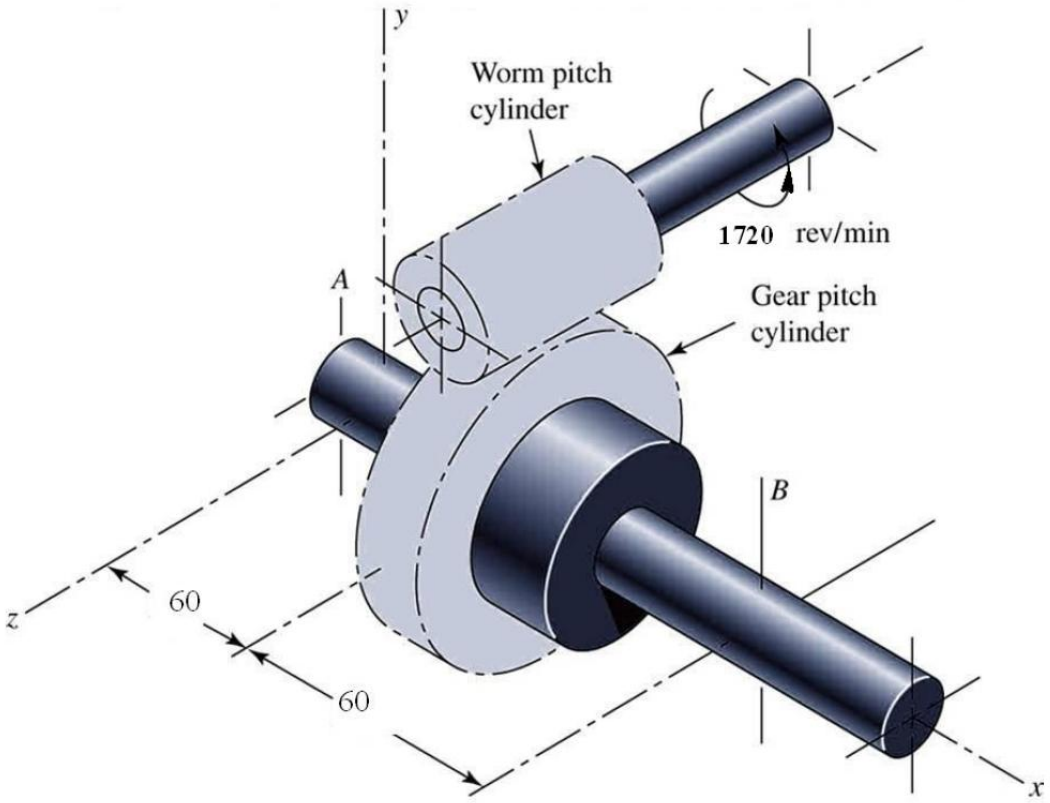

Figure 8-1

Solution:

1. a- Direction of forces on the worm

$W_{wt} \Rightarrow -X$

$W_{wa} \Rightarrow +Z$

$W_{wr} \Rightarrow +Y$

b- For 90° Shafts

$P_{x_w} = P_{t_G} = 7.85$ mm

$d_G = \frac{N_G P_t}{\pi} = \frac{40 \times 7.85}{\pi} = 100$ mm

$L = P_x N_w = 15.7$ mm $\quad \lambda = \tan^{-1}\left(\frac{L}{\pi d_w}\right) = 9.45°$

$v_w = \omega_w r_w = \frac{2\pi \times 1720}{60} \times 15 \times 10^{-3} = 2.7$ m/s

$v_s = \frac{v_w}{\cos\lambda} = 2.74$ m/s

$\beta = 0.0131$ $\quad K_s = 700$ (table 1)

$\frac{2}{3} d_w = 20$ mm $> F_g$ $\quad \therefore F_e = 20$ mm

Tr. ratio $= 20$ $\quad K_m = 0.82$

$v_s = 2.74$ m/s $\quad K_v \cong 0.36$

$W_{tg_{max}} = 2155.34$ N $\quad v_{tg} = \frac{2\pi \times 1720}{60} \times \frac{2}{40} \times 50 = 0.45$ m/s

$W_{tg} = W(\cos\phi_n \cos\lambda - \mu \sin\lambda) \rightarrow W = 2268.6$ N

$H_o = 2155.34 \times 0.45 = 970$ W

$H_f = 0.03 \times 2268.6 \times 2.74 = 186.47$ W

$H_{max} = 1156.7$ W

c- $\eta = \frac{\cos 14.5 - 0.03 \tan 9.45}{\cos 14.5 + 0.03 \cot 9.45} = 0.84 = 84\%$

2- For the gear train shown in the figure 8-2, find the required input power and speed of the 18-tooth spur pinion (magnitude and direction of rotation) knowing that the required output torque is 3 kN.m. at 1.5 rad/s CW on worm wheel 9.. All gears have a normal pressure angle of 20° and the coefficient of friction between the worm and the worm wheel is 0.03. (All gears data are shown in figure 8-2)

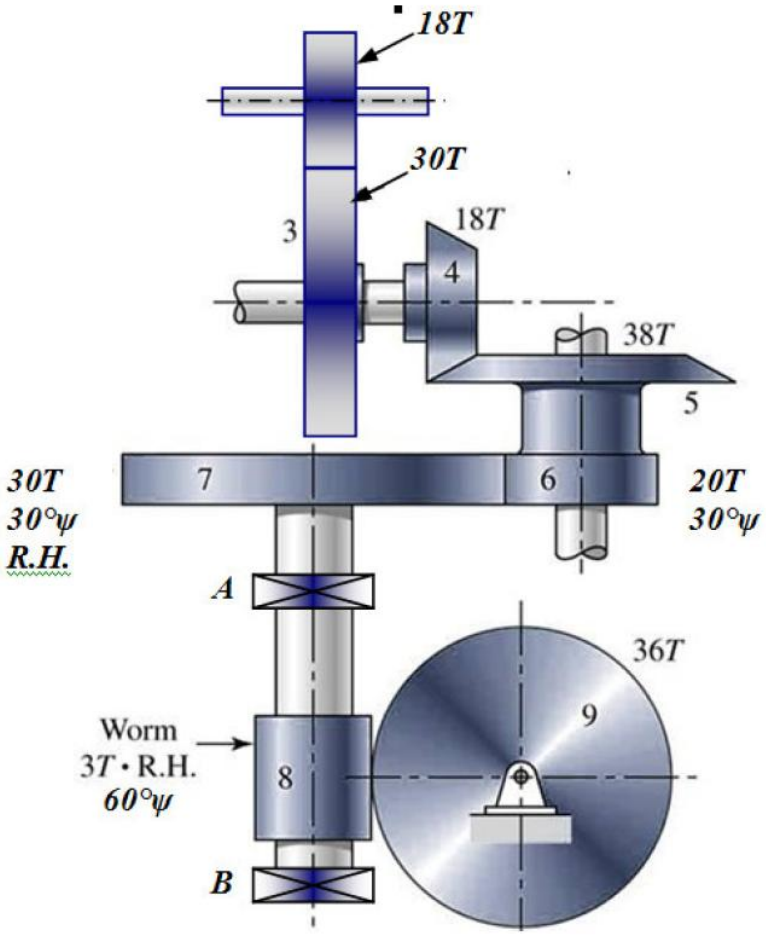

Figure 8-2

Solution:

2. $\psi_g = 60^\circ \rightarrow \lambda_g = 90^\circ - 60^\circ = 30^\circ$

$$W_{tg} = W(\cos\phi_n \cos\lambda - \mu \sin\lambda) = \frac{T_g}{r_g} \Rightarrow \text{unknown?}$$

$$\eta = \frac{H_o}{H} \qquad H_o = T_g \omega_g = 4.5 \text{ kW}$$

$$\eta = \frac{\cos 20^\circ - 0.03 \tan 30^\circ}{\cos 20^\circ + 0.03 \cot 30^\circ} = 0.93$$

$H = 4.84$ kW $\Rightarrow$ input power.

$$\frac{\omega_2}{\omega_g} = \frac{N_g}{N_8} \cdot \frac{N_7}{N_6} \cdot \frac{N_5}{N_4} \cdot \frac{N_3}{N_2} = 6.333$$

$\omega_2 = 95$ rad/s (down.