Tutorial # 7 - Solution

1- The gear train shown below (figure 7-1) consists of two stages. The first stage is a helical gear set while the second stage is a bevel gear set. The pressure angle (φ for spur bevel gears and φ_n for helical gears) is 20°.
Determine and show the magnitude and directions of the forces acting on the gears at the mesh points. The helical pinion 2 transmits 3 kW of power and rotates in the direction shown at 1500 rpm. Determine the reactions at bearings E an F.

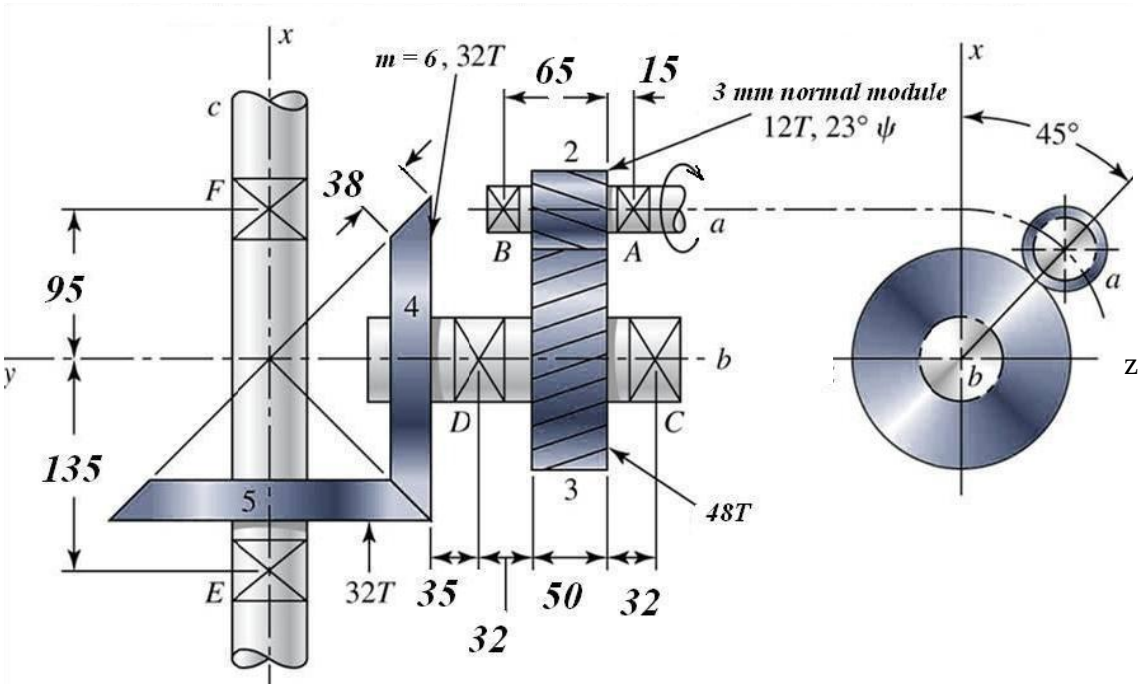


Figure 7-1

Solution:

Helical Gears :

$$d_2 = \frac{m_n}{\cos\psi} N_2 = \frac{3}{\cos 23} 12 = 39.109 \quad \text{mm}$$

$$v_{23} = \omega_2 r_2 = \frac{2\pi n_2}{60}\frac{d_2}{2} = \frac{2\pi\times 1500}{60}\frac{39.109}{2} = 3071.61 \quad \text{mm/s} = 3.0716 \quad \text{m/s}$$

$$W_{t_{23}} = \frac{H}{v_{23}} = \frac{3\times 1000}{3.0716} = 976.686 \quad \text{N}$$

$$W_{r_{23}} = W_{t_{23}} \tan\varphi_t = W_{t_{23}} \frac{\tan\varphi_n}{\cos\psi} = 976.686\times\frac{\tan 20}{\cos 23} = 386.2 \quad \text{N}$$

$$W_{a_{23}} = W_{t_{23}} \tan\psi = 976.686\times\tan 23 = 414.58 \quad \text{N}$$

Bevel Gears :

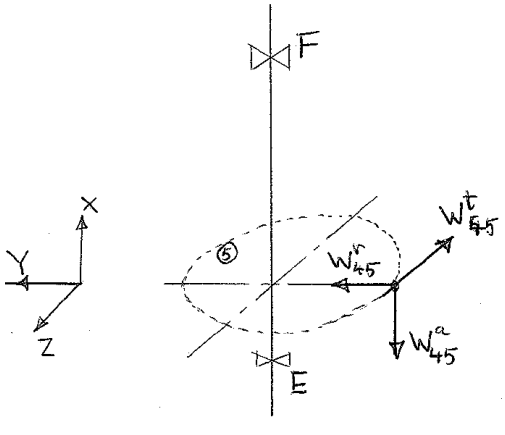
$$r_{4_{av}} = \frac{mN}{2} - \frac{b}{2}\sin\gamma = \frac{6\times 32}{2} - \frac{38}{2}\sin 45 = 82.565 \quad \text{mm}$$

$$v_{45_{av}} = \omega_4 r_{4_{av}} = \frac{2\pi n_2}{60}\frac{1}{i_{23}} r_{4_{av}} = \frac{2\pi\times 1500}{60}\frac{12}{48}\times 82.565 = 3242.32 \quad \text{mm/s} = 3.242 \quad \text{m/s}$$

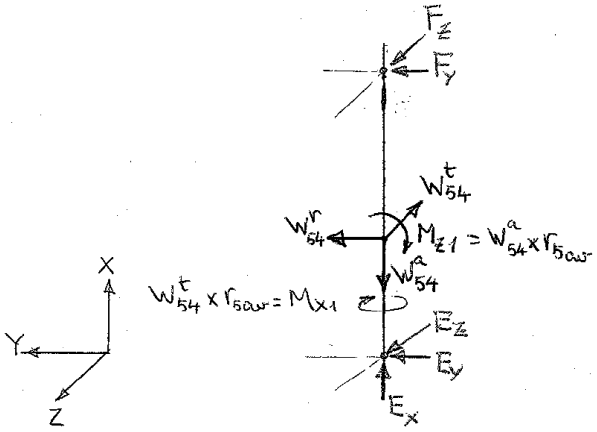
$$W^*_{t_{45}} = \frac{H}{v_{45_{av}}} = \frac{3\times 1000}{3.242} = 925.26 \quad \text{N}$$

$$W^*_{r_p} = W^*_{a_g} = W^*_{t_{45}} \tan\varphi\cos\gamma = 925.26\times\tan 20\cos 45 = 238.1 \quad \text{N}$$

$$W^*_{a_p} = W^*_{r_g} = W^*_{t_{45}} \tan\varphi\sin\gamma = 925.26\times\tan 20\sin 45 = 238.1 \quad \text{N}$$



Forces on gear 5



Forces and moments on Shaft c

$$R_E^y = \frac{-238.1\times82.565-238.1\times177.565}{230} = -269.29 \text{ N}$$

$$R_F^y = \frac{238.1\times82.565-238.1\times52.435}{230} = 31.19 \text{ N}$$

$$R_E^z = \frac{925.26\times177.565}{230} = 714.32 \text{ N}$$

$$R_F^z = 210.94 \text{ N}$$

$$R_E = 238.1\,i - 269.29\,j + 714.32\,k$$

$$R_F = 31.19\,j + 210.94\,k$$

2- An uncrowned straight-bevel pinion has 22 teeth, a module of 4 mm, and a quality number 5. The pinion and the gear are made of through-hardened steel, both having core and case hardness of 180 HB. The pinion speed is 1800 rpm and drives the 24-tooth bevel gear with a shaft angle of 90°. The face width is 25 mm, and the pressure angle is 20°. Both gears are outboard mounting.
Find the power rating of this gear set based on AGMA bending and pitting resistances if the expected service life is 10^9 revolutions of the pinion at a reliability of 0.999

Solution:

Bending

Factor	Pinion	Gear
b	25mm	25mm
m	4mm	4mm
J	0.218	0.20
Kv	B = 0.915 A = 54.769 V = 8.289 m/sec Kv =1.663	1.663
Ko	1	1
Ks	1.075	1.075
KH	1.3	1.3
Bending stress	0.1066 Wt	0.121 Wt
Temp.factor	1	1
Yz	1.253	1.253
YN	0.8618	0.8642
σ_{FP}	68,48 MPa	68,48 MPa
Bending strength	47.0998 M Pa	47.233 M Pa
Wt	441.837 N	390.353 N

Contact

Factor	Pinion	Gear
Cp	191	191
Cxc	2	2
I	0.067	0.067
Kv	1.667	1.667
Ko	1	1
Ks	1.075	1.075
KH	1.3	1.3
Contact stress	$33.96\sqrt{Wt}$	$33.96\sqrt{Wt}$
Temp.factor	1	1
Yz	1.253	1.253
Zn	1.000	1.00538
σ_{Hp}	585,85 MPa	585,85 MPa
Contact strength	467.557 M Pa	470 M Pa
Wt	189.58 N	191.6 N

Power rating = $T.\ \omega\ |_{least} = W_{tp}|_{contact}.r_p.\ \omega_p$
= $189.58\ (2\ \pi\ (1800)/60).((4\ .\ 22\ .\ 10^3)/2) = 1.57$ kW