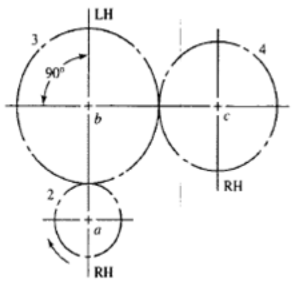
Shigley's Mechanical Engineering Design | (10th Edition)

Chapter 13, Problem 49P | 1 Bookmark | Show all steps: ON

Problem

Gear 2, in the figure, has 16 teeth, a 20º transverse angle, a 15º helix angle, and a module of 4 mm.Gear 2 drives the idler on shaft *b*, which has 36 teeth. The driven gear on shaft *c* has 28 teeth. If the driver rotates at 1600 rev/min and transmits 6 kW, find the radial and thrust load on each shaft.

Problem 13–49



Step-by-step solution

Step 1 of 8

Calculate the diameter of the gear by using the following relation:

$$d = N \times m$$

Here, *N* is the number of teeth on the gear and *m* is the module of the gear.

Calculate the diameter of the gear 2 (d_2).

$$d_2 = N_2 \times m$$

Substitute 16 for N_2 and 4 mm for *m*.

$$\begin{aligned} d_2 &= 16 \times 4 \\ &= 64 \text{ mm} \end{aligned}$$

Calculate the diameter of the gear 3 (d_3).

$$d_3 = N_3 \times m$$

Substitute 36 for N_3 and 4 m for *m*.

$$\begin{aligned} d_3 &= 36 \times 4 \\ &= 144 \text{ mm} \end{aligned}$$

Calculate the diameter of the gear 4 (d_4).

$$d_4 = N_4 \times m$$

Substitute 28 for N_4 and 4 mm for *m*.

$$\begin{aligned} d_4 &= 28 \times 4 \\ &= 112 \text{ mm} \end{aligned}$$

Comment

Step 2 of 8

$$W_t = \frac{}{\pi dn}$$

Here, *H* is the power, *n* is the speed of the driver gear, and *d* is the diameter of the driver gear.

Substitute 6 kW for *H*, 64 mm for *d*, and 1600 rpm for *n*.

$$W_t = 60000\frac{6}{\pi \times 64 \times 1600}$$
$$= 1.119 \text{ kN}$$

Calculate the input torque by using the following relation:

$$T_2 = W_t \times \frac{d_p}{2}$$

Here, d_p is the diameter of the pinion.

$$T_2 = W_t \times \frac{d_p}{2}$$
$$= 1.11 \times \frac{64}{2}$$
$$= 35.52 \text{ kN} \cdot \text{mm}$$

Comment

Step 3 of 8

Calculate the radial component of load (W_r).

$$W_r = W_t \tan \phi_t$$

Substitute 1.119 kN for W_t and $20°$ for ϕ_t.

$$W_r = W_t \tan \phi_t$$
$$= 1.119 \times \tan 20°$$
$$= 0.40728 \text{ kN}$$

Calculate the axial component of load (W_a).

$$W_a = W_t \tan \psi$$

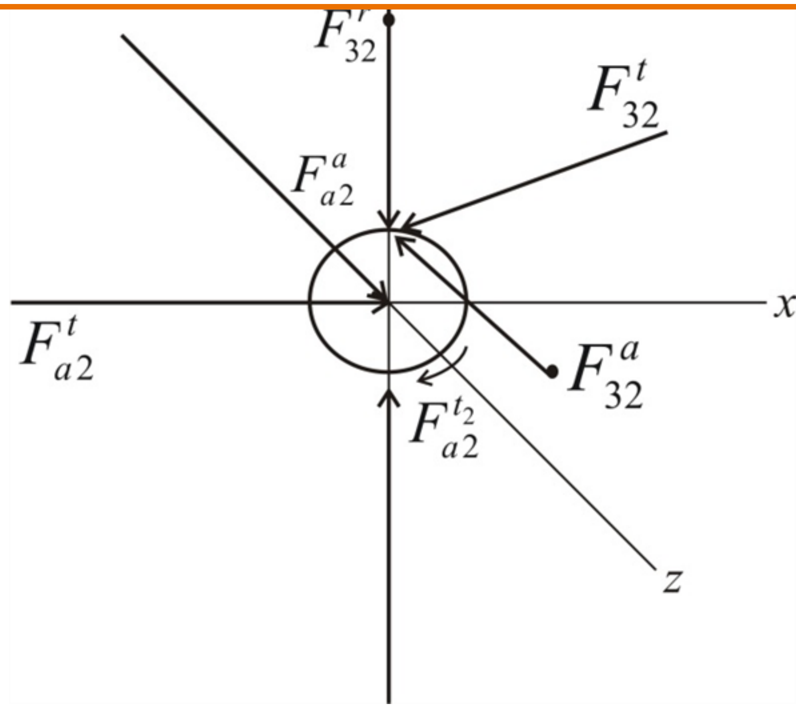
Substitute 1.119 kN for W_t and $15°$ for ψ .

$$W_a = W_t \tan \psi$$
$$= 1.119 \times \tan 15°$$
$$= 0.299 \text{ kN}$$

Comment

Step 4 of 8

Draw the free body diagram of the forces acting on the gear 2.



Here, F_{32}^t is the tangential force exerted by gear 3 against gear 2, F_{32}^a is the axial force exerted by the gear 3 against gear 2, F_{32}^r is the radial force exerted by the gear 3 against the gear 2, F_{a2}^t is the tangential force of gear 2 against shaft *a*, F_{a2}^a is the axial force of gear 2 against shaft *a*, and F_{a2}^r is the radial force of gear 2 against shaft *a*.

Calculate the load on shaft *a* in the vector form as follows:

$$F_{2a} = \left(-W_t\mathbf{i} - W_r\mathbf{j} - W_a\mathbf{k}\right)\text{ kN}$$

Substitute 1.11 kN for W_t, 0.4 kN for W_r, and 0.29 kN for W_a.

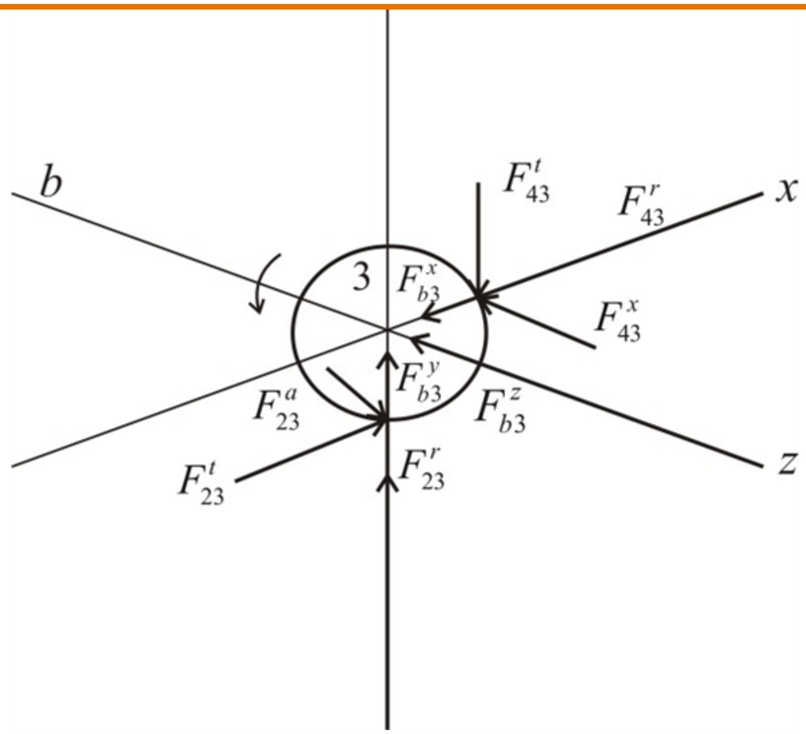
$$F_{2a} = \left(-1.11\mathbf{i} - 0.4\mathbf{j} - 0.29\mathbf{k}\right)\text{ kN}$$

Therefore, the forces acting on the shaft *a* is $\boxed{\left(-1.11\mathbf{i} - 0.4\mathbf{j} - 0.29\mathbf{k}\right)\text{ kN}}$.

Comment

Step 5 of 8

Draw the free body diagram of the forces acting on the gear 3.



Comment

Step 6 of 8

From the free body diagram, calculate the load on the shaft *b* in the vector form as follows:

$$F_{3b} = \left(W_t - W_r\right)\mathbf{i} - \left(W_t - W_r\right)\mathbf{j}\ \text{kN}$$

Substitute 1.11 kN for W_t and 0.4 kN for W_r.

$$F_{3b} = (1.11 - 0.4)\mathbf{i} - (1.11 - 0.4)\mathbf{j}$$

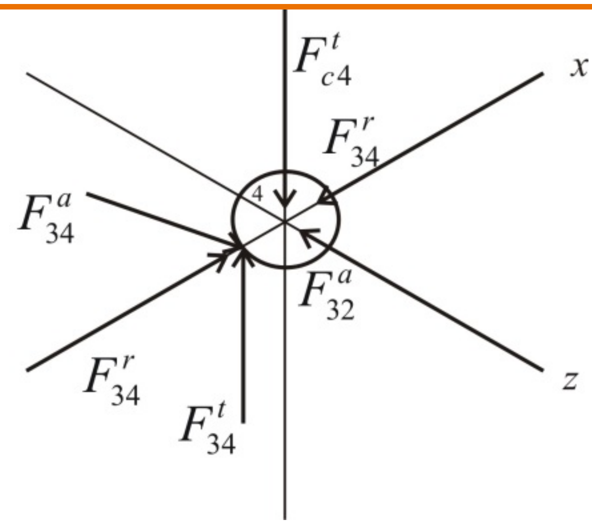
$$F_{3b} = \left(0.71\mathbf{i} - 0.71\mathbf{j}\right)\ \text{kN}$$

Therefore, the forces acting on the shaft *b* is $\boxed{\left(0.71\mathbf{i} - 0.71\mathbf{j}\right)\ \text{kN}}$.

Comment

Step 7 of 8

Draw the free body diagram of forces acting on the gear 4.



Comment

Step 8 of 8

Calculate the forces acting on the shaft *c* in the vector form as follows:

$$F_{4c} = \left(W_r\mathbf{i} + W_t\mathbf{j} + W_a\mathbf{k}\right)\ \text{kN}$$

Substitute 1.11 kN for W_t, 0.4 kN for W_r, and 0.29 kN for W_a.

$$F_{4c} = \left(0.4\mathbf{i} + 1.11\mathbf{j} + 0.29\mathbf{k}\right)\ \text{kN}$$

Therefore, the forces acting on the shaft *c* is $\boxed{\left(0.4\mathbf{i} + 1.11\mathbf{j} + 0.29\mathbf{k}\right)\ \text{kN}}$.

Comment

Recommended solutions for you in Chapter 13

Chapter 13, Problem 38P

For the countershaft in Prob. 3?72, p. 138, assume the gear ratio from gear B to its mating gearis 2 to 1.(a) Determine the minimum number of teeth that can be used on gear B without an interference problem in the teeth.(b) Using the number of...

See solution

Chapter 13, Problem 7P

A parallel helical gearset consists of a 19-tooth pinion driving a 57-tooth gear. The pinion has a left-hand helix angle of 30º, a normal pressure angle of 20º, and a normal module of 2.5 mm. Find:(a) The normal, transversa and axial circular...

See solution