home / study / engineering / mechanical engineering / machine design / machine design solutions manuals / shigley's mechanical engineering design / 10th edition / chapter 13 / problem 44p

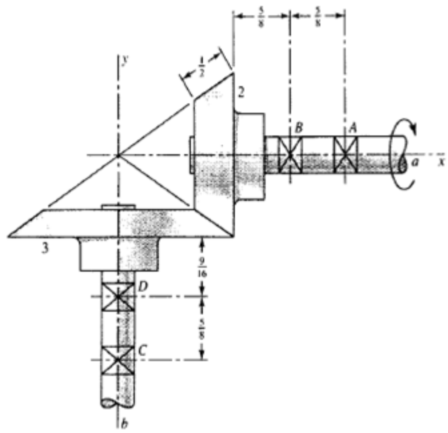
Shigley's Mechanical Engineering Design | (10th Edition)

Chapter 13, Problem 44P | 4 Bookmarks | Show all steps: ON

Problem

The figure shows a 10 diametral pitch 18-tooth 20 straight bevel pinion driving a 30-tooth gear. The transmitted load is 25 lbf. Find the bearing reactions at *C* and*D* on the output shaft if*D* is to take both radial and thrust loads.

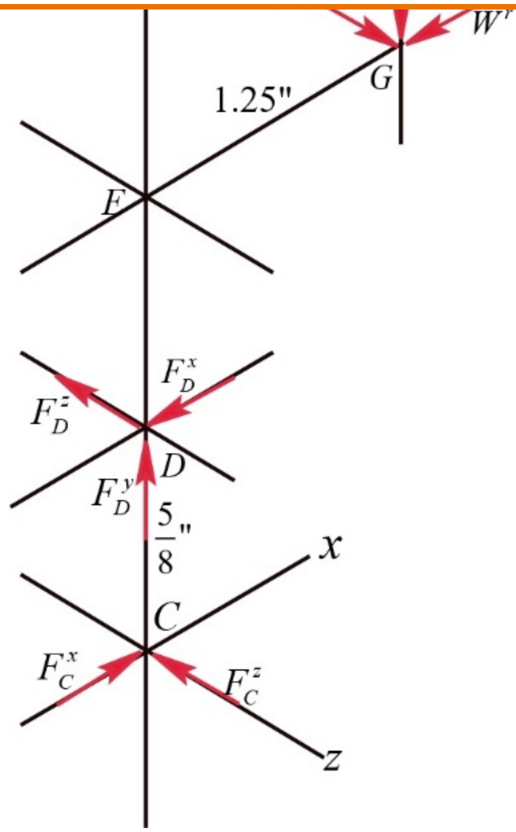
Problem 13–44
Dimensions in inches.



Step-by-step solution

Step 1 of 12

Draw the free body diagram of the gear set.



Comment

Step 2 of 12

Calculate the diameter of gear 2.

$$d_2 = \frac{N_2}{p_d}$$

Here, N_2 is the number of teeth on gear 2 and p_d is the diametric pitch.

Substitute $18\,\text{teeth}$ for N_2 and $10\,\text{teeth/in}$ for p_d.

$$d_2 = \frac{18}{10}$$
$$= 1.8\,\text{in}$$

Calculate the diameter of gear 3.

$$d_3 = \frac{N_3}{p_d}$$

Here, N_3 is the number of teeth on gear 3.

Substitute $30\,\text{teeth}$ for N_3 and $10\,\text{teeth/in}$ for p_d.

$$d_3 = \frac{30}{10}$$
$$= 3\,\text{in}$$

Comment

Step 3 of 12

Calculate the pitch angles.

Substitute $1.8\,\text{in}$ for d_2 and $3\,\text{in}$ for d_3.

$$\Gamma = 180° - \gamma$$

Substitute $30.96°$ for γ.

$$\begin{aligned}\Gamma &= 180° - 30.96° \\ &= 59.04°\end{aligned}$$

Comment

Step 4 of 12

Calculate the distance between D and E.

$$DE = \frac{9}{16} + 0.5\cos\Gamma$$

Substitute $59.04°$ for Γ.

$$\begin{aligned}DE &= \frac{9}{16} + 0.5\cos 59.04° \\ &= 0.8197\,\text{in}\end{aligned}$$

Calculate the radial load.

$$W^r = W^t \tan\phi \cos\Gamma$$

Here, the transmitted load is W^t and the pressure angle is ϕ.

Substitute $25\,\text{lbf}$ for W^t, $20°$ for ϕ, and $59.04°$ for Γ.

$$\begin{aligned}W^r &= 25\tan(20°)\cos(59.04°) \\ &= 4.681\,\text{lbf}\end{aligned}$$

Comment

Step 5 of 12

Calculate the total load.

$$W^a = W^t \tan\phi \sin\Gamma$$

Here, the transmitted load is W^t and the pressure angle is ϕ.

Substitute $25\,\text{lbf}$ for W^t, $20°$ for ϕ, and $59.04°$ for Γ.

$$\begin{aligned}W^a &= 25\tan(20°)\sin(59.04°) \\ &= 7.803\,\text{lbf}\end{aligned}$$

Comment

Step 6 of 12

Write the load vector on the gear.

$$\mathbf{W} = -W^r\mathbf{i} - W^a\mathbf{j} + W^t\mathbf{k}$$

Substitute $4.681\,\text{lbf}$ for W^r, $7.803\,\text{lbf}$ for W^a, and $25\,\text{lbf}$ for W^t.

$$\mathbf{W} = -4.681\mathbf{i} - 7.803\mathbf{j} + 25\mathbf{k}$$

Write the position vector between D and G.

$$\mathbf{R}_{DG} = 0.8197\mathbf{j} + 1.25\mathbf{i}$$

Write the position vector between D and C.

$$\mathbf{R}_{DC} = -0.625\mathbf{j}$$

Comment

Calculate the moment about point D.

$$\sum M_D = 0$$
$$\mathbf{R}_{DG} \times \mathbf{W} + \mathbf{R}_{DC} \times \mathbf{F}_C + \mathbf{T} = 0$$

Substitute $0.8197\mathbf{j} + 1.25\mathbf{i}$ for $\mathbf{R}_{DG}$, $-4.681\mathbf{i} - 7.803\mathbf{j} + 25\mathbf{k}$ for $\mathbf{W}$, $-0.625\mathbf{j}$ for $\mathbf{R}_{DC}$, $F_C^x\mathbf{i} + F_C^z\mathbf{k}$ for $\mathbf{F}_C$, and $T\mathbf{j}$ for $\mathbf{T}$.

$$(0.8197\mathbf{j} + 1.25\mathbf{i}) \times (-4.681\mathbf{i} - 7.803\mathbf{j} + 25\mathbf{k}) + (-0.625\mathbf{j}) \times (F_C^x\mathbf{i} + F_C^z\mathbf{k}) + T\mathbf{j} = 0$$
$$(20.49\mathbf{i} - 31.25\mathbf{j} - 5.917\mathbf{k}) + (-0.625F_C^z\mathbf{i} + 0.625F_C^x\mathbf{k}) + T\mathbf{j} = 0$$
$$(20.49 - 0.625F_C^z)\mathbf{i} + (-31.25 + T)\mathbf{j} + (-5.917 + 0.625F_C^x)\mathbf{k} = 0$$

Equate $\mathbf{i}$, $\mathbf{j}$, and $\mathbf{k}$ components to zero.

$$20.49 - 0.625F_C^z = 0$$
$$F_C^z = 32.784\ \text{lbf}$$
$$-31.25 + T = 0$$
$$T = 31.25\ \text{lbf} \cdot \text{in}$$
$$-5.917 + 0.625F_C^x = 0$$
$$F_C^x = 9.4672\ \text{lbf}$$

Comment

Step 8 of 12

Calculate the bearing reaction at C.

$$F_C = \sqrt{(F_C^x)^2 + (F_C^z)^2}$$

Substitute $9.4672\ \text{lbf}$ for F_C^x and $32.784\ \text{lbf}$ for F_C^z.

$$F_C = \sqrt{(9.4672)^2 + (32.784)^2}$$
$$= 34.123\ \text{lbf}$$

Therefore, the bearing reaction at *C* is $\boxed{34.123\ \text{lbf}}$.

Comment

Step 9 of 12

Apply force equilibrium for the system.

$$\sum \mathbf{F} = 0$$
$$\mathbf{W} + \mathbf{F}_C + \mathbf{F}_D = 0$$

Substitute $-4.681\mathbf{i} - 7.803\mathbf{j} + 25\mathbf{k}$ for $\mathbf{W}$, $9.4672\mathbf{i} + 32.784\mathbf{k}$ for $\mathbf{F}_C$, and $F_D^x\mathbf{i} + F_D^y\mathbf{j} + F_D^z\mathbf{k}$ for $\mathbf{F}_D$.

$$-4.681\mathbf{i} - 7.803\mathbf{j} + 25\mathbf{k} + 9.4672\mathbf{i} + 32.784\mathbf{k} + F_D^x\mathbf{i} + F_D^y\mathbf{j} + F_D^z\mathbf{k} = 0$$
$$(-4.681 + 9.4672 + F_D^x)\mathbf{i} + (-7.803 + F_D^y)\mathbf{j} + (25 + 32.784 + F_D^z)\mathbf{k} = 0$$

Equate $\mathbf{i}$, $\mathbf{j}$, and $\mathbf{k}$ components to zero.

$$-4.681 + 9.4672 + F_D^x = 0$$
$$F_D^x = -4.7862\ \text{lbf}$$
$$-7.803 + F_D^y = 0$$
$$F_D^y = 7.803\ \text{lbf}$$
$$25 + 32.784 + F_D^z = 0$$
$$F_D^z = -57.784\ \text{lbf}$$

Step 10 of 12

Therefore, the bearing reactions at *D* in *x*, *y*, and *z* directions are $\boxed{-4.7862\text{ lbf}}$, $\boxed{7.803\text{ lbf}}$, and $\boxed{-57.784\text{ lbf}}$ respectively.

Comment

Step 11 of 12

Calculate the radial load at *D*.

$$F_{D(radial)} = \sqrt{\left(F_D^x\right)^2 + \left(F_D^z\right)^2}$$

Substitute -4.7862 lbf for F_D^x and -57.784 lbf for F_D^z.

$$\begin{aligned} F_{D(radial)} &= \sqrt{(-4.7862)^2 + (-57.784)^2} \\ &= 57.98\text{ lbf} \end{aligned}$$

Therefore, the radial load at *D* is $\boxed{57.98\text{ lbf}}$.

Comment

Step 12 of 12

Calculate the thrust load at *D*.

$$F_{D(thrust)} = F_D^y$$

Substitute 7.803 lbf for F_D^y.

$$F_{D(thrust)} = 7.803\text{ lbf}$$

Therefore, the thrust load at *D* is $\boxed{7.803\text{ lbf}}$.

Comment

Was this solution helpful? 4 0

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