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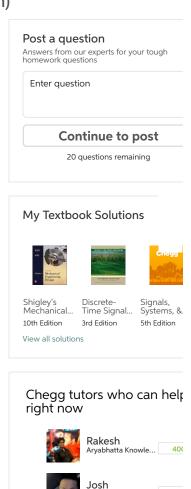


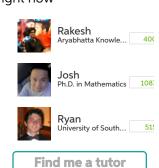


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Shigley's Mechanical Engineering Design (10th Edition)

6 Bookmarks Show all steps: Chapter 14, Problem 22P **Problem** A spur gearset has 17 teeth on the pinion and 51 teeth on the gear. The pressure angle is 20 and the overload factork0 = 1. The diametral pitch is 6 teeth/in and the face width is 2 in. The pinion speed is 1120 rev/min and its cycle life is to be 10^8 revolutions at a reliability R=0.99. The quality number is 5. The material is a through-hardened steel, grade 1, with Brinell hardnesses of 232 core and case of both gears. For a design factor of 2, rate the gearset for these conditions using the AGMA method. Step-by-step solution Step 1 of 17 Obtain the following properties for pinion from the figure 14-6 "spur gear geometry factors J". $N_P = 17T, J_P = 0.292$ Obtain the following properties for gear from the figure 14-6 "spur gear geometry factors J". $N_G = 51T, J_G = 0.396$ Comment Step 2 of 17 Find the diameter of pinion using the equation. Here, N_P is the pinion tooth and P_d is the diametral pitch. Substitute 6 teeth/in for P_d and 17 for N_P . $d_p = \frac{17}{6}$ = 2.833 inFind the diameter of gear using the equation. $d_G = \frac{N_G}{P_d}$ Here, N_G is the gear tooth and P_d is the diametral pitch. Substitute 6 teeth/in for P_d and 51 for N_G . $d_G = \frac{51}{6}$ = 8.5 inComment Step 3 of 17





Find the velocity using the equation.

Substitute 1120 rev/min for n and 2.833 in for d_p .

$$V = \pi \times 2.833 \times 1120$$

$$= 830.7 \text{ ft/min}$$

Comment

Step 4 of 17

Assume constant thickness of the gears.

$$K_B = 1$$

Assume uniform loading.

$$k_{o} = 1$$

Find the value of \boldsymbol{B} using the equation.

$$B = 0.25 (12 - Q_v)^{\frac{2}{3}}$$
$$= 0.25 (12 - 5)^{\frac{2}{3}}$$
$$= 0.9148$$

Here, Q_{v} is quality number.

Find the value of A using the equation.

$$A = 50 + 56(1 - B)$$
$$= 50 + 56(1 - 0.9148)$$
$$= 54.77$$

Comment

Step 5 of 17

Find the dynamic factor using the equation.

$$K_v = \left(\frac{A + \sqrt{V}}{A}\right)^B$$
 when, V in ft/min

Substitute 0.9148 for B and 54.77 for A.

$$K_{\nu} = \left(\frac{54.77 + \sqrt{830.7}}{54.77}\right)^{0.9148}$$
$$= 1.472$$

From elastic coefficient $\,C_{\scriptscriptstyle p}\,$

$$C_p = 2300\sqrt{\text{psi}}$$

Comment

Step 6 of 17

Obtain SI equation from figure of 14-3 "allowable bending stresses number through hardened steels" for grade-1.

The SI equations is

$$S_t = 77.3H_B + 12800$$

= 77.3(232)+12800
= 30734 psi

Stress-cycle factor for bending,

$$Y_N = 1.6831(N)^{-0.0323}$$
$$= 1.6831(10^8)^{-0.0323}$$
$$= 0.928$$

Comment

Step 7 of 17

Find the allowable stress

$$\sigma_{all} = \frac{S_t}{S_E} \frac{Y_N}{K_T K_R}$$

Here, $S_{\scriptscriptstyle F}$ is the AGMA factor of safety, $K_{\scriptscriptstyle T}$ is temperature factor and $K_{\scriptscriptstyle R}$ is the reliability factor.

Substitute 0.928 for $Y_{_{\! N}}$, 30734 psi for $S_{_{\! T}}$, 2 for $S_{_{\! F}}$, 1 for $K_{_{\! T}}$ and 1 for $K_{_{\! R}}$.

$$\sigma_{all} = \frac{30734(0.928)}{2(1)(1)}$$
$$= 14261 \text{ psi}$$

Comment

Step 8 of 17

Obtain the Lewis form factor for pinion from the table of 14-2 "values of the Lewis Form Factor Y (These values are for a normal pressure Angle of 20°, Full depth Teeth and a diametral Pitch of unity in the Plane of Rotation)" at number of teeth of pinion is 17.

Lewis form factor for pinion, $Y_P = 0.303$

Obtain the Lewis form factor for gear from the table of 14-2 "values of the Lewis form factor Y (These values are for a normal pressure Angle of 20° , Full depth Teeth and a diametral Pitch of unity in the Plane of Rotation)" at number of teeth of gear is 51.

Lewis form factor for gear, $Y_G = 0.4103$

Comment

Step 9 of 17

Find the size factor for pinion using the equation.

$$\left(K_s\right)_p = 1.192 \left(\frac{F\sqrt{Y_p}}{p}\right)^{0.053}$$

Here, F is the face width.

Substitute 2 in for F and 0.303 for Y_p .

$$(K_s)_p = 1.192 \left(\frac{2\sqrt{0.296}}{6}\right)^{0.0535}$$

Find the size factor for gear using the equation.

$$(K_s)_G = 1.192 \left(\frac{F\sqrt{Y_G}}{p}\right)^{0.0535}$$

= 1.192 $\left(\frac{2\sqrt{0.4103}}{6}\right)^{0.0535}$



Find the load distribution factor using the equation.

$$\begin{split} K_m &= C_{mf} \\ &= 1 + C_{mc} \left(C_{pf} C_{pm} + C_{ma} C_e \right) \end{split}$$

Here,

 $C_{\it mf}$ is load distribution factor

$$C_{mc} = \begin{cases} 1 & \text{for uncrowned teeth} \\ 0.8 & \text{for crowned teeth} \end{cases}$$

$$C_{pf} = \begin{cases} \frac{F}{10d} - 0.025 & F \le 1 \text{ in} \\ \frac{F}{10d} - 0.0375 + 0.0125F & 1 \le F \le 17 \text{ in} \\ \frac{F}{10d} - 0.1109 + 0.0207F - 0.000228F^2 & 17 \le F \le 40 \text{ in} \end{cases}$$

$$C_{pm} = \begin{cases} 1 & \text{for straddle mounted pinion with } S1/S < 0.175 \\ 1.1 & \text{for straddle mounted pinion with } S1/S \ge 0.175 \end{cases}$$

$$C_{ma} = A + BF + CF^2$$
 Where A, B, C are Empirical constants

$$C_e = \begin{cases} 0.8 & \text{for gearing adjusted assembly} \\ 1 & \text{for all other conditions} \end{cases}$$

Comment

Step 11 of 17

Find the following values.

$$C_{pf} = \frac{F}{10d} - 0.0375 + 0.0125F$$
$$= \frac{2}{10(2.833)} - 0.0375 + 0.0125(2)$$
$$= 0.0581$$

$$C_{mc} = 1$$

$$C_{pm} = 1$$

$$C_{ma} = A + BF + CF^{2}$$

= 0.127 + 0.0158(2) - 0.093(10⁻⁴)(2²)
= 0.1586

$$C_e = 1$$

Comment

Substitute 0.1586 for $C_{\it ma}$, 1 for $C_{\it pm}$, 1 for $C_{\it mc}$, and 1 for $C_{\it e}$ in equation (1).

$$K_m = C_{mf}$$
= 1 + $C_{mc} (C_{pf} C_{pm} + C_{ma} C_e)$
= 1 + 1 $\left[0.0581(1) + 0.1586(1) \right]$
= 1.2167

Comment

Find the load acting using the equation.

$$W' = \frac{FJ_p \sigma_{all}}{K_o K_v (K_s)_p P_d K_m K_B}$$

Substitute 1 for K_B ,1 for K_o , 1.2167 for K_m , 2 in for F, 0.292 for J_P , 14261 psi for σ_{all} , 1.088 for $(K_s)_n$.

$$W' = \frac{2(0.292)(14261)}{1(1.472)(1.088)(6)(1.2167)(1)}$$

= 712 lbf

Find the horse power required using the equation.

$$H = \frac{W'V}{33000}$$

Substitute 712 lbf for W' and 830.7 ft/min.

$$H = \frac{775(830.7)}{33000}$$
$$= 17.92 \text{ hp}$$

Comment

Step 14 of 17

Consider the pinion wear

Obtain the stress cycle factor from figure of 14-15 "pitting resistance stress cycle" for 10^8 .

$$Z_N = 2.466N^{-0.056}$$
$$= 2.466(10^8)^{-0.056}$$
$$= 0.879$$

Find the gear ratio using the equation.

$$m_G = \frac{N_G}{N_P}$$
$$= \frac{51}{17}$$
$$= 3$$

Comment

Step 15 of 17

Find the geometry factor using the equation.

$$I = \frac{\cos \phi_t \sin \phi_t}{2m_N} \left(\frac{m_G}{m_G + 1} \right)$$

Here, ϕ_i is the pressure angle.

Substitute 1 for m_N , and 3 for m_G .

$$I = \left[\frac{\sin 20^{\circ} \cos 20^{\circ}}{2(1)}\right] \left(\frac{3}{3+1}\right)$$
$$= 0.1205$$

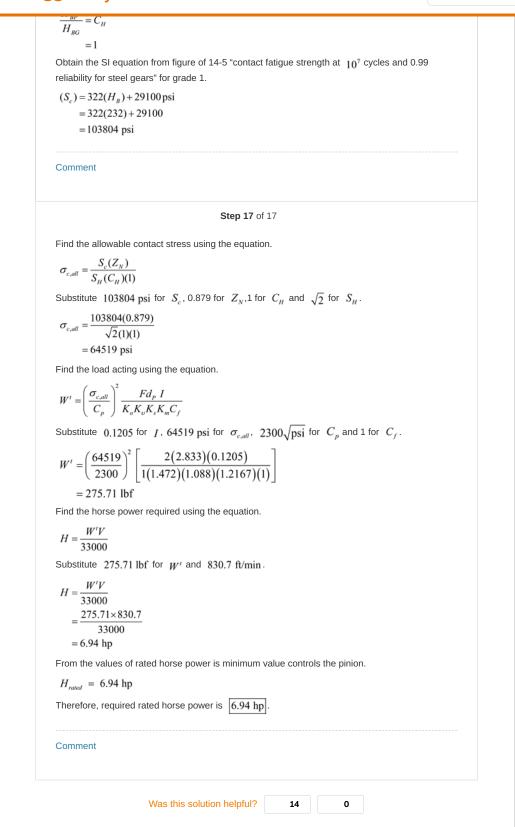
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Step 16 of 17

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Chapter 14, Problem 11P

Chapter 14, Problem 16P