WORCESTER POLYTECHNIC INSTITUTE
MECHANICAL ENGINEERING DEPARTMENT

DESIGN OF MACHINE ELEMENTS
ME-3320, A’2005

Lecture 26-27
11 September 2005
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Spur Gears

**Forces on pinion and gear sets -- alternating forces**

**Tangential force component:** \[ W_t = \frac{T_p}{r_p} = \frac{2T_p}{d_p} = \frac{2p_d T_p}{N_p} \]

**Radial force component:** \[ W_r = W_t \tan \phi \]

**Resultant force:** \[ W = \sqrt{W_r^2 + W_t^2} \]

Note: for contact ratios > 1, there exists a HIGHEST POINT OF SINGLE-TOOTH CONTACT (HPSTC)
Examples

- Review and Master: Example 11-4
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Bending stresses (note that contact stresses are also generated)

AGMA standard 2001-B88 subjected to following general constraints:

- Contact ratio between 1 and 2 (\# of teeth in contact at a given time)
  \[ m_p = \frac{Z}{p_b}; \quad p_b = p_c \cos \phi \]
- No interference between tips and roots
- No teeth are pointed
- There is nonzero backlash
- Root fillets are standard
- Friction forces are neglected (assumed good lubrication)
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Bending stresses (note that contact stresses are also generated)

Cantilever beam in bending:

\[
\sigma_b = \frac{Mc}{I} = \frac{6Wtl}{Ft^2}
\]
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Bending stresses (note that contact stresses are also generated)

Bending stresses (Lewis’ equation):

\[ \sigma_b = \frac{Mc(x)}{I(x)} = \frac{W_t \cdot p_d}{F \cdot Y} \]

- \( W_t \) is the tangential force
- \( p_d \) is the diametral pitch
- \( F \) is the face width
- \( Y \) is the geometric factor (Lewis dimensionless geometric factor)
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Bending stresses (note that contact stresses are also generated)

AGMA bending stress equation:

\[
\sigma_b = \frac{W_t P_d}{FJ} \frac{K_a K_m}{K_v} K_s K_B K_I \quad \text{U.S. specifications}
\]

\[
\sigma_b = \frac{W_t}{FmJ} \frac{K_a K_m}{K_v} K_s K_B K_I \quad \text{SI specifications - } m \text{ is the metric module}
\]

- \(F\) is face width (minimum face width is 3 to 5 times \(p_c\))
- \(J\) is bending strength geometric factor (AGMA; Tables 11-8 through 11-15; pg. 716)
- \(K_v\) is dynamic factor (depends on tangential velocity -- Figure 11-22; pg. 719)
- \(K_m\) is load distribution factor (to account for misalignments -- Table 11-16; pg. 720)
- \(K_a\) is application factor (application dependent; “Shocks” -- Table 11-17; pg. 721)
- \(K_s\) is size factor (similar concept as Equation 6.7b -- AGMA recommends value of 1)
- \(K_B\) is rim thickness factor (for gears made of rims and spokes -- Figure 11-23; pg. 721)
- \(K_I\) is idler factor (set to 1.42 for an idler gear and 1 for a non-idler gear)
Examples

Review and Master: Example 11-5
Reading

- Chapters 10 of textbook: Sections 11.0 to 11.8
- Review notes and text: ES2501, ES2502, ES2503

Homework assignment

- Author's: 11-2
- Solve: 11-12, 11-16, 11-21