Gear Design

Failure is primarily due to bending stress at the root tip and to pitting of the flank surface.

Consider bending first:

$$s = \frac{W_t P}{FY}$$

W_t is the tangential component of loading on the gear at the pitch point
P is the diametral pitch
F is the face width
Y is the Lewis form factor

AGMA has modified this bending equation since the time Lewis first derived it to its present form

$$s = \frac{W_t P}{FJ} \frac{K_a K_m}{K_v} K_s K_B K_I$$

J is a modified form of the Lewis form factor and the K values account for various service conditions

J factors are published on pages 716 - 718

K_v is the **dynamic factor** and accounts for the possibility of non-conjugate contact of the gears (this causes impact loads between gear teeth).

$$K_v = \left(\frac{A}{A + \sqrt{V_t}} \right)^B \ (english)$$

$$K_v = \left(\frac{A}{A + \sqrt{200 V_t}} \right)^B \ (metric)$$

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

$$B = \frac{(12 - Q_v)^{\frac{2}{3}}}{4} \quad 6 \le Q_v \le 11$$

Q_v is called the **quality index** and it is a measure of the lowest quality gear in a gear mesh.

If the quality index, Qv is < 5 then use the following for the dynamic factor

$$K_v = \left(\frac{50}{50 + \sqrt{V_t}} \right) (english)$$

$$K_v = \left(\frac{50}{50 + \sqrt{200 V_t}} \right) (metric)$$

Km is called the **Load Distribution Factor** accounts for the fact that the tangential load may not be evenly distributed across the face. The larger the face of a gear, the more likely the load is to be non-uniformly distributed. Face widths in spur gears should following the following rule of thumb

$$8/P < F < 16/P$$

Table 11-16 (720) lists load distribution factors, Km values.

Ka is called the **application factor**; if an engineer is aware that the gears will see shock loads, then he or she should apply an appropriate application factor. If the service application is not likely to see time varying torques or forces, then the application factor can be set to 1.00. Suggested Ka values are listed on page 721, Table 11-17.

Ks is the called the **size factor**. This factor has essentially the same meaning as the Marin factor for sizing in fatigue. However, AGMA suggests that Ks be set to 1.00 unless the engineer is concerned about gear teeth that are large; Ks should be set to between 1.25 and 1.5 in that case.

K_B is called the **rim thickness factor**. If the gear is too large to make as a solid disk, then it must be made with a rim and spokes. The rim is is generally much thinner than the gear teeth and is therefore vulnerable to radial fracture. Use the following to determine K_B

$$K_B = -2m_B + 3.4 \quad 0.5 \le m_B \le 1.2$$
$$K_B = 1 \quad m_B > 1$$
$$m_B = \frac{t_R}{h_t}$$

t_r is the rim thickness, and h_t whole depth of a tooth; m_B is referred to as the **backup ratio.**

K_I is called the **idler factor.** K_I is set to 1.42 for idlers and to 1.00 for non-idlers.

Sample Problem:

Determine the torques and transmitted loads in a 3-gear train containing a pinion, and idler, and a gear. Find the gear diameters and the mean and alternating components of load on each gear. The pinion gives 20 hp at 2500 RPM. The train ratio is 3.5:1. The pinion has 14 teeth, a 25° pressure angle, and a diamteral pitch, P, of 6. The idler has 17 teeth. The gear teeth are AGMA full-depth profiles; the load on the gears and its source is uniform. Use a gear Quality Index, Q_v of 6. All gears are steel with $\nu = 0.28$

Find the face width and bending stresses in the gear teeth of this train. Also find the surface stresses.