toothTIPS

williamCROSHER
Author, engineer, and former director of the National Conference on Power Transmission

The following is the second of a two-part column on the importance of factoring backlash into your gear mesh designs.

In the present day a precision reducer's backlash is typically three to six arc minutes, and on an eight inch pitch diameter that is a deflection of 0.0035 to 0.0070. What applications such as indexing may require is an inclusive assessment of the total deflections. Backlash in precision drives should include the no-load portion of lost motion, brought about by the clearances in other components of the assembly. Various standards provide tolerances, B.S. 721 provides normal backlash at an ambient of 68º F for five gear grades.

When minimum backlash is specified, depending on the type of gear there are numerous methods to achieve this condition. Adjusting tolerances on tooth thickness, and center distance adjustment, are rarely successful. Theoretically it is poor assembly that allows worm gears to be adjusted on center distances different from which they were cut and designed to mesh, if more than 0.001 to 0.002 inch adjustment improper tooth contact and a loss of smooth running may result, especially with high lead angles. Although in practice the wheel will cold work and conform to the hardened worm with up to 0.010 inch of adjustment. When the tooth thickness is adjusted it is customary to adjust the thickness on the larger gear only, except with worm gears all the allowance is made on the worm because of its stronger material. Spring loaded, magnetic gears, dual gear trains, and sandwich gears with nylon laminated between them have all been tried at one time or another.

"AN INCREASING DEMAND FOR MINIMAL BACKLASH HAS BEEN CREATED BY THE PRECISION REQUIRED FOR MODERN INDEXING DRIVES."

The simplest worm gear method is to produce the worm wheel to mate with a master worm so there is 0.002-0.005 inch circular shake. In low torque applications spring loaded or split gears may be used. Low backlash globoidal gearing is obtained by measuring the thread thickness of an unmatched worm, and by using a radial feed the wheel gear teeth are hobbed slightly larger than the worm thread space. The worm threads are then with a special cutter to a precise thread thickness.

With dual lead circular worms there are many advantages, starting with a kinematically correct without interference, and with a load capacity and life equivalent to the standard set. When different modules are produced on the opposite flanks the worm thread increases in thickness from one end of the worm to the other by the module difference over one pitch. Moving the worm in an axial direction adjusts for the required backlash. The initial backlash is achieved at a set center distance relative to a datum plane on the worm. For each inch of axial movement the adjustment can be between 0.005-0.020 inches.

Dual lead gears must be manufactured to close tolerances. The least eccentricity will create tight spots during rotation. Similarly the housing center distance must be held within 0.002-0.000 inch. The advantages include:

- Simple and infinitely variable backlash adjustment.
- Improved performance on the same center distance.
- Higher maximum torque rating.
- Insensitive to normal deflections.
- Manufacturing accuracy with a worm produced to close tolerances.
- High efficiency.
- Extended service life.
- Accommodation for wear.

Leading manufacturers have developed their own innovative designs. Zahradfabrik OTT designs provide backlash limits of no more than 0.008 inch. Many threads/teeth have to be engaged, and this is achieved with low pressure angles, extended tooth flanks, and by selecting a complementary basic rack profile and a large number of wheel teeth. The design is limited by the worm helix and the width at the tooth tip.

An increasing demand for minimal backlash has been created by the precision required for modern indexing drives, which frequently will require for the backlash to be periodically adjusted. Although it is not covered here due to space limitations, bevel gear backlash is another important consideration for optimal gear design.

ABOUT THE AUTHOR:

William P. Crosher is former director of the National Conference on Power Transmission, as well as former chairman of the AGMA's Marketing Council and Enclosed Drive Committee. He was resident engineer-North America for Thyssen Gear Works, and later at Flender Graffenstaden. He is author of the book *Design and Application of the Worm Gear.*