Selecting the Right Tooth Thickness

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QUESTION

We are currently revising our gear standards and tolerances, and a few problems with the new standard AGMA 2002-C16 have arisen. Firstly, the way to calculate the tooth thickness tolerance seems to need a "manufacturing profile shift coefficient" that isn't specified in the standard; neither is another standard referred to for this coefficient. This tolerance on tooth thickness is needed later to calculate the span width as well as the pin diameter. Furthermore, there seems to be no tolerancing on the major and minor diameters of a gear.

Expert Response provided by John M. Rinaldo. AGMA 2002-C16 does not specify any tolerances; it is up to the designer to select the tooth thickness and tolerance, or maximum and minimum tooth thickness, appropriate for the application. The designer must also select the tolerances for the major and minor diameters of the gear.

Figure 1 Span measurement from AGMA 2002-C16, Figure 7. (All graphics courtesy of AGMA.)

The manufacturing profile shift coefficient—commonly referred to as "the x factor"—is not required by AGMA 2002-C16. In fact, if the manufacturing profile shift is known, the only thing it is used for is to calculate the normal circular tooth thickness at the reference diameter. The standard provides methods to convert not only profile shift coefficients, but almost any other specification of tooth thickness to other ways of specifying tooth thickness or to measurements that can be checked when the parts are manufactured. For example, if the maximum/minimum transverse tooth thickness is specified at a given diameter, equations are provided to find the maximum/minimum normal circular tooth thickness at the reference diameter. Then the maximum/minimum acceptable measurement over balls or any of the other measurements covered can be calculated with the equations provided.

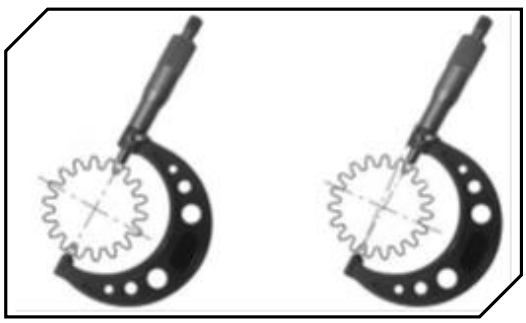

Figure 2 Measurement over balls from AGMA 2002-C16, Figure 10.

AGMA 2002-C16 also provides methods to determine tooth thickness based on measurements that are indirect. For example, if a span measurement is taken, then the normal circular tooth thickness at the reference diameter can be found using Equation 67.

Although AGMA 2002-C16 does not specify tolerances for tooth thickness, annexes B and C provide guidance on establishing tooth thickness specifications in either the nominal or functional system. The nominal system is more commonly used, and allows measurement over pins or balls or with span. The functional system allows a more direct calculation of expected backlash, but requires the tooth thickness to be measured in relation to the datum axis. Such measurements are typically performed on a double flank tester, a gear measuring machine, or from a datum surface to a single pin or ball.

Tooth thickness and backlash are intimately related, which is why AGMA 2002-C16 covers both topics in a single standard. In establishing tooth thickness, the goal is generally to ensure that the expected range of backlash will be appropriate for the application. In many applications—particularly when rotation is unidirectional—backlash is not particularly important. In these cases, allowing a wide range of backlash and, therefore, a large tooth thickness tolerance, will keep manufacturing costs down. When tight control of backlash is required, as in indexing applications, then not only does the tooth thickness need to be tightly controlled, but the other gear tolerances may also need to be tighter to allow the tooth thickness tolerance to be met. The gear tooth

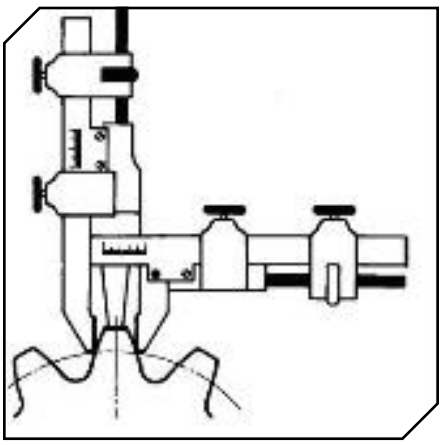

Figure 3 Chordal measurement from AGMA 2002-C16, Figure 21.

thickness measuring method may also need to be carefully chosen, since the method selected can affect both the ability to tightly control the tooth thickness and manufacturing cost. For example, for a large gear a chordal tooth thickness measurement can provide a quick and inexpensive measurement, but unless the radius to the outside diameter has been accurately determined from the datum surfaces, there will be a considerable uncertainty in the calculation of functional tooth thickness. Measurement of pitch on a gear measurement machine will give a direct measurement of functional tooth thickness, but at a high cost. Double flank measurement can be used to quickly measure the functional tooth thickness of all the teeth on a gear, but generally is only applicable to small gears produced in high volumes.

The selection of the appropriate range of tooth thickness is no easier than the selection of any of the myriad other choices the designer faces, such as selecting the appropriate numbers of teeth, the module, the helix angle, the face width, the material and heat treatment and the elemental or composite tolerances.

John M. Rinaldo is a retired senior development engineer (Atlas Copco Comptec), a current member of the AGMA Accuracy Committee, and U.S. delegate to the ISO Accuracy Committee.

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