AGMA STANDARD 2002-C16

Email your question—along with your name, job title and company name (if you wish to remain anonymous, no problem) to: *jmcguinn@geartechnology.com*; or submit your question by visiting *geartechnology.com*.

QUESTION

We are currently revising our gear standards and tolerances and a few questions with the new standard AGMA 2002-C16 have risen. 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, retired from Atlas Copco Comtec and AGMA Accuracy committee. AGMA 2002 is not a design guide; it does not specify or provide calculations to establish tolerances. It is a standard for the measurement of gears and provides methods for predicting backlash. Before using AGMA 2002-C16, the designer must select the tooth thickness and tolerance (or maximum and minimum tooth thickness) that is appropriate for the application. The designer must also select the tolerances for the major and minor diameters of the gear.

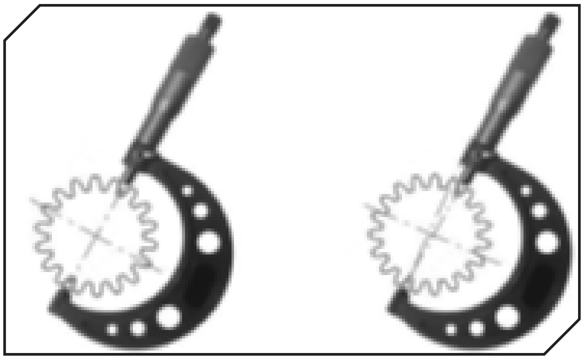

Figure 1 Measurement over balls.
From AGMA 2002-C16 Fig 10

There are two general methods used to establish tooth thickness. One uses profile shift coefficient, commonly referred to as the x factor. If the gears are designed using x factors, DIN 3967 provides a method for establishing appropriate values for x_e. This method is commonly used in Europe but is less common in the US. Another method is to just select the backlash and then distribute the remaining space on the operating pitch circle between the tooth thickness of the gears, annexes B and C give some guidance on this method.

Manufacturing profile shift coefficient is just one of many ways to specify the tooth thickness of a gear. It is not required by AGMA 2002-C16. If the manufacturing profile shift, x_e, is known, then in this standard it is only used 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. For example, if the maximum and minimum transverse tooth thickness are specified at a given diameter, equations are provided to find the maximum and minimum normal circular tooth thickness at the reference diameter. Then the maximum and minimum acceptable measurement over balls or any of the other measurements covered can be calculated with the equations provided.

While AGMA 2002-C16 is focused on calculating measurement limits from a specified tooth thickness, it 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. AGMA 2002 also provides information that can help those who take the measurements.

It should be noted that tooth thickness specifications may use 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, ball, or block. Fully understanding the differences between the nominal and functional systems is essential to proper use of the standard.

Figure 2 Span measurement.
From AGMA 2002-C16 Fig 7

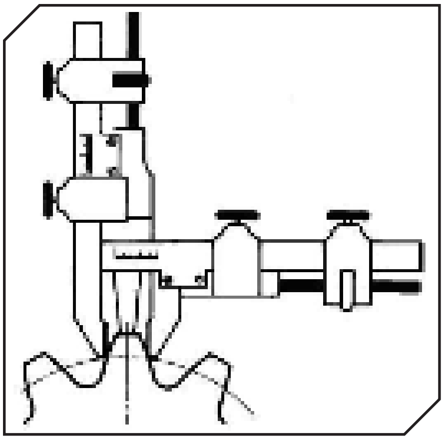

Figure 3 **Chordal Measurement. From AGMA 2002-C16 Fig 21**

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 generally is 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 hence a large tooth thickness tolerance will keep manufacturing costs down. When tight control of backlash is required, such 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 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 the 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 similar to 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.

In summary, while AGMA 2002 can indirectly aid in the design phase to verify that the specified range of tooth thickness will result in the desired range of backlash, it is not intended to guide the basic design of the gears. But once the design is set, it provides equations to calculate test limits for the tooth thickness. *Editor's note:* ***Robert Errichello*** *assisted in presenting the above response.*