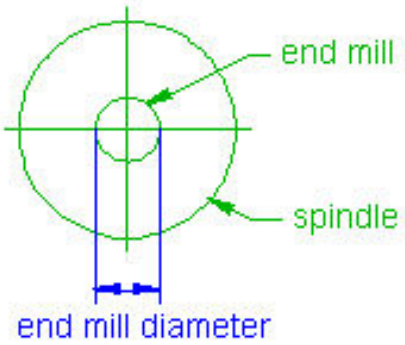
Using an End mill's Effective Diameter with a Digital Read-Out

By R.G. Sparber

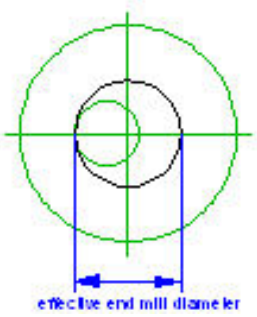
March 30, 2007

Vertical mills often use end mills. They come in a variety of styles and diameters. Although end mill diameter is typically specified as a given fraction of an inch, say 7/16", they are in fact typically ground to a precise diameter. Using a micrometer to measure a new 7/16" end mill should show .4375". That value is useful when you make a cut on the side of an end mill if you have defined zero as the center of the spindle.

If you are using a Digital Read-Out (DRO), then you probably have this situation. Zero is set with an Electronic Edge Finder (EEF). Then the tool offset is selected. If you are using an end mill, the diameter is entered. If this diameter is .002" too small, then the DRO will have an offset that is .001" too small. The result is a cut that is .001" too deep. If you input the effective diameter instead, the cut should be closer to the expected value.



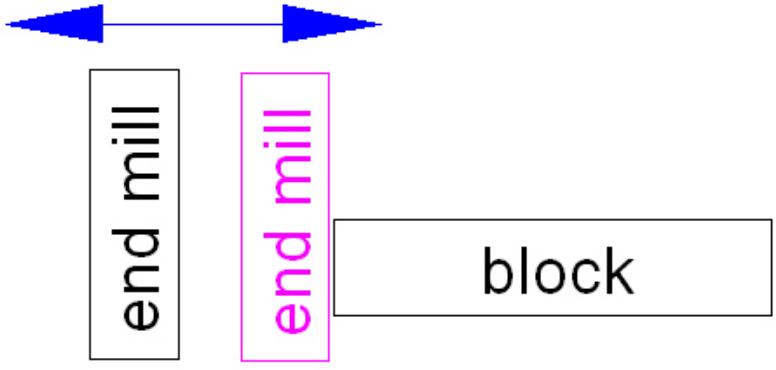
First consider the ideal case. We are looking up into the end of the spindle holding an end mill. The center of the end mill is perfectly aligned with the center of rotation of the spindle.



Now I will greatly exaggerate the problem of misalignment. The end mill's center is not aligned with the spindle's center of rotation. Note that as the spindle rotates, it will swing the end mill around and only the outer most face will cut. The result is an effective end mill diameter that is greater than what you would measure with a mic directly on the end mill. This misalignment is often presented as Total Indicated Runout (TIR). Some people prefer to hold an end mill in a collet rather than an end mill holder because the collet will often have a smaller TIR. Over the years I have had problems with end mills being held in collets. I tend not to tighten the draw bar enough. As the end mill cuts, it tends to pull down into the work. I recently changed to end mill holders. They require less tension on the drawbar and the end mill does not pull out. These holders probably do have more TIR than my collets so I wanted a way to compensate for this error.

So how much does your TIR matter? The answer depends on how closely you look. For those working to the nearest 1/4", all end mills and spindles are perfect. I sometimes try to want to work to the nearest .0005", then the difference between effective diameter and diameter matters.

If you are working to very close tolerance, than you know that the finish cut must be light. On side milling, I typically take about .005" on my final pass but would then make a few more passes without advancing the cutter in order to permit any bending of the end mill to be relieved. In measuring the effective diameter, it is important to do so under the same conditions as when you plan to use the information.



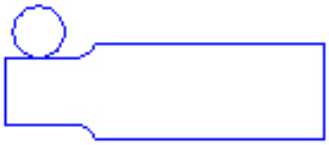
So far we have talked about static error. We also have a dynamic error source. Picture the head of the mill vibrating from side to side. This will cause the end mill to alternately move

closer to the cut surface and then farther away from it. This dynamic error adds to the static errors to increase the effective diameter.

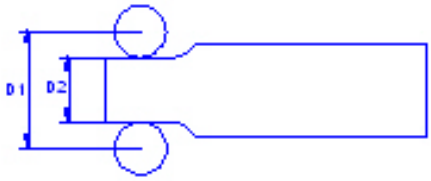
One way to measure the effective diameter is to mill a channel through a block of metal and then measure the width of the channel. The problem is that you are not taking a light side cut. I propose the following procedure.

Start with a small block of metal mounted in your mill vise. Ideally it would be the same metal as you plan to machine to those very close tolerances.

Set your axis indicator to zero and take a standard depth light cut with your end mill.



Move the end mill to the backside of the block. Take another standard depth light cut. Note the change in position front to back and call it D1.



Now mic the resulting thickness of the test block and call it D2. If you subtract D2 from D1 you will get the effective diameter of the end mill for a light cut.

Questions and comments are always welcome.

Rick Sparber
rgsparber@AOL.com
rick.sparber.org