

# Measuring an End Mill's Effective Diameter, version 1.1

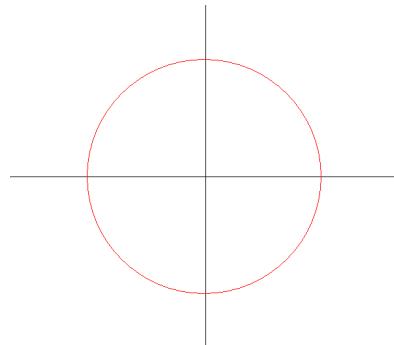
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By R. G. Sparber

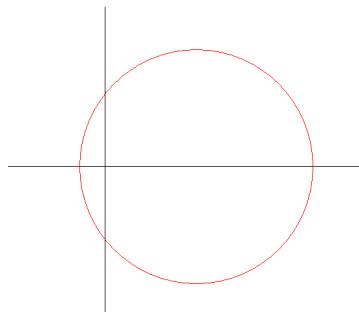
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You take a new end mill out of its box and it is stamped 0.250". Then you mount it into a collet and cut a test square using your Computer Numerical Control system. The finished dimensions are larger than predicted. You check your Digital Read Out (DRO) and it is correct. This leaves the likely possibility that the end mill is cutting with a diameter larger than marked on its body.



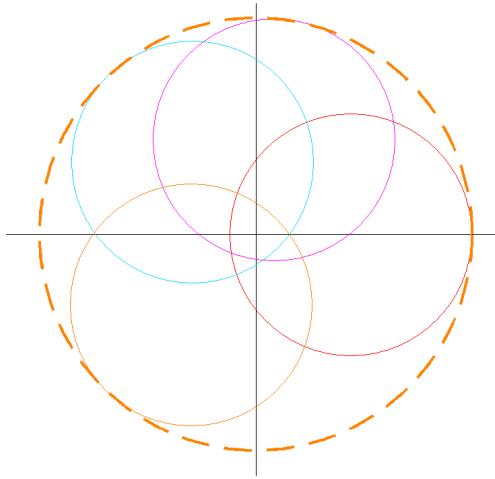
If the center of rotation is aligned with the longitudinal axis of the end mill, and end view looks like this: a circle centered at the origin. The tips of the flutes trace out the circle. The cutter will cut with the stamped diameter.



In this exaggerated view, the center of rotation is not aligned with its longitudinal axis.

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<sup>1</sup> You are free to distribute this article but not to change it.



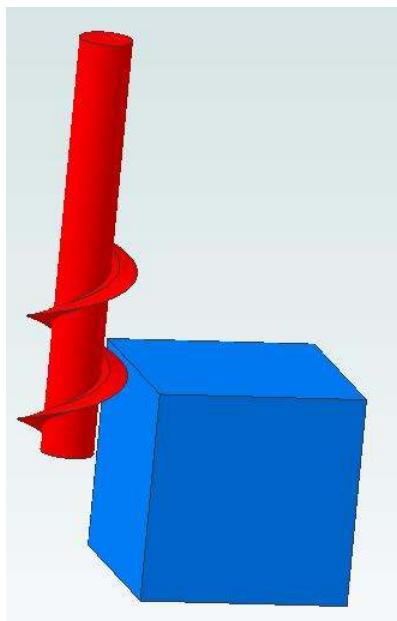
As the end mill rotates, it traces out a larger diameter than itself. The dashed line is this larger diameter and I will call it the "effective diameter". The smaller the misalignment, the closer the effective diameter is to the end mill's stamped diameter.

It is impossible for an end mill to be perfectly aligned with its center of rotation but it should be within a few thousandths of an inch. It mostly depends on the quality of the collet or end mill holder involved.

So what can we do about it? You will get predictable results with this end mill if you measure the effective diameter and use it rather than the end mill's diameter.

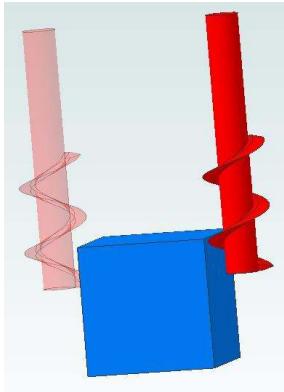
Note that if you remove the end mill and put it back into the collet in a different orientation, you will likely get a different effective diameter. One solution is to put a dot of nail polish on the end mill and on the collet. Line up the dots each time. If the holder is an R8, I line up the cutter with the locating pin in the spindle.

Measuring the effective diameter is rather simple and safe. Don't be trying to mic a spinning end mill!



Mount a block of scrap aluminum in your vise. The block should be at least  $\frac{1}{2}$ " along the Y axis and between  $\frac{1}{2}$ " and 1" along the X axis. The height should be around  $\frac{1}{2}$ ".

Install your end mill and start the spindle motor. Begin with the cutter on the left side of the block with the end of the end mill about  $\frac{1}{4}$ " below the surface of the block. Take a pass from back to front with a depth of cut of around 0.005". When done, zero the X axis on your DRO.



Now move the cutter to the right side of the block. Feed the cutter into the block to a depth of about 0.006". Then feed out until the cutter actually moves about 0.001". This is done to insure that both cuts are made with the cutter fed from the same direction. That avoids backlash error. With the same depth of cut, you will minimize differences in tool deflection.

After you complete the pass, turn off the motor, move the cutter a safe distance from the block along the Y axis, and clean all cut surfaces.

Using a micrometer, mic the distance between cut surfaces. Also note the DRO reading. Then subtract the mic reading from the DRO or dial reading. This is your effective diameter.

For example, I used a new 0.250" end mill. My DRO read 1.1732 and my mic read 0.9228.

$$1.1732 - 0.9228 = 0.2504"$$

So my new 0.250" end mill has an effective diameter of 0.2504". Not bad!

You may want to repeat the test a few more times to be sure the results are consistent. I started out with a dull end mill and the effective diameter kept changing.

## Acknowledgement

Thanks to Seb Fontana for pointing out that backlash is not a problem with manual machining if you use a DRO and lock all axes that are not going to move.

I welcome your comments and questions.

If you wish to be contacted each time I publish an article, email me with just "Article Alias" in the subject line.

Rick Sparber  
[Rgsparber.ha@gmail.com](mailto:Rgsparber.ha@gmail.com)  
Rick.Sparber.org