▶ BY MICHAEL DEREN

Hole Choices

Hole finishing: boring vs. circular interpolation.

If you've ever done any hole finishing, you've probably asked yourself, "Should I bore this hole or use an endmill to circular-interpolate it?" The answer depends on a number of things.

"The No. 1 factor in determining whether to bore or circular-interpolate is the depth of the hole," said Matt Tegelman, manager of applications engineering at BIG Kaiser Precision Tooling Inc., Elk Grove Village, Ill.

The tool used, the workpiece material and the other particulars of the operation determine the actual depth that is achievable. But, generally, you can circular-interpolate to a depth-to-diameter ratio of 2:1 and bore to 4:1 with little problem. The rule of thumb is that the deeper the hole, the more likely it is you should bore.

Another factor is the hole-tolerance requirement. Tolerances of 0.0005" can be held consistently when circular interpolating. And, noted Anthony Bassett, president of Rigibore Inc., Mukwonago, Wis., "accuracies to 0.0003" [or] 0.0004" are not unheard of when circular interpolating."

If you need to hold tighter tolerances than 0.0005", it's probably better to choose boring.

Surface-finish requirement is another consideration. An endmill can't compete with a dedicated boring tool when it comes to surface finish.

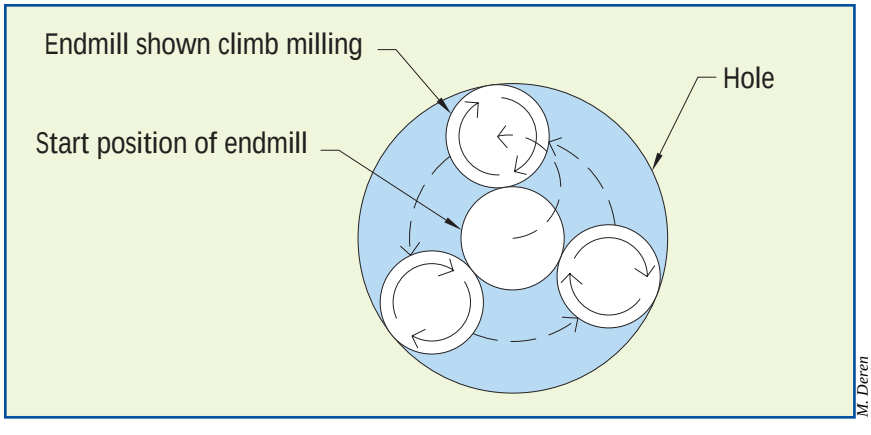
Tegelman said that a boring tool can achieve a 16-rms finish. An endmill can't deliver that fine a finish, let alone do so consistently. It reliably imparts a finish between 32 and 64 rms.

An issue specific to circular interpolation is the machine tool used to perform the operation. When new, a machine will circular-interpolate a hole within its published tolerances. Over time, though, as the ballscrews, spindle, ways and other components wear, the machine may not be able to meet these tolerances.

According to Randy Cloud, manufacturing process and design engineer at boring-tool maker Criterion Machine Works Inc., Costa Mesa, Calif., if a new machine crashes, it "will no longer make round holes. Or a year later, the machine—uncrashed but used and abused—will no longer make as round a hole as it used to.

"With boring tools, you can make as round a hole as the spindle will allow—today, tomorrow, next year or 5 years from now," said Cloud.

Armed with these general guidelines



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Motion of an endmill as it circular-interpolates.

The following companies contributed to this report:

BIG Kaiser Precision Tooling Inc.
(888) 866-5776
www.kptkaiser.com

Criterion Machine Works Inc.
(800) 854-7441
www.criterionmachineworks.com

Rigibore Inc.
(262) 363-3922
www.rigibore.com

and thoughts, let's review the fundamentals of each operation and look at examples of when to circular-interpolate and when to bore.

Circular Logic

Steps required to circular-interpolate a hole with an endmill:

1. Using the largest drill you can (one that doesn't exceed the desired hole diameter, of course!), remove as much material as possible. Drilling is the fastest way to remove metal on a mill.

2. Apply the largest-diameter roughing endmill you can to circular-interpolate the hole to within 0.060" of the final diameter. Surface finish is not critical at this point. You just want to remove metal quickly.

3. Apply the largest-diameter, solid-carbide endmill you can to circular-interpolate the hole to the size required. A carbide endmill leaves the best finish when circular interpolating.

Examples of when to circular-interpolate with an endmill:

Example A

Hole diameter	3.000", ±0.005"
Hole depth	2.000"
Location tolerance	±0.005"
Finish requirement	None

This is an excellent opportunity to circular-interpolate.

Reasons:

- because of the open hole tolerance;
- if a 1"-dia. or larger endmill is used, the depth-to-diameter ratio will be 2:1 or less; and
- no finish requirement.

Example B

Hole diameter	2.000", ±0.002"
Hole depth	2.000"
Location tolerance	±0.001"
Finish requirement	125 rms

This is also an excellent opportunity for circular interpolation.

Reasons:

- hole tolerance achievable by almost any machine tool running an endmill;
- if using a 1"-dia. or larger endmill, the depth-to-diameter ratio would be 2:1 or less; and
- finish achievable with a carbide endmill.

Example C

Hole diameter	2.000", ±0.0005"
Hole depth	2.000"
Location tolerance	±0.0005"
Finish requirement	125 rms

Circular interpolation may be a good choice for this job, although meeting tolerances will require a newer machine.

Reasons:

- hole diameter and location tolerance achievable by a newer machine tool;
- if a 1"-dia. or larger endmill were used, the depth-to-diameter ratio would be 2:1 or less; and
- finish achievable with a carbide endmill.

Boring In

Steps required to bore a hole (note that the first two steps are the same as for circular interpolation):

1. Using the largest drill you can, remove as much of the material as possible.

2. Apply the largest-diameter roughing endmill you can to circular-interpolate the hole to within 0.060" of the required diameter.

3. This is a critical step. Semifinish the hole with a twin-head roughing boring bar. You will be able to meet tighter tolerances and impart a better finish, because an equal amount of material is being removed from the periphery of the hole.

4. Finish the hole with a single-point boring bar.

Examples of when to bore:

Example D

Hole diameter	3.000", ±0.001"
Hole depth	6.000"
Location tolerance	±0.005"
Finish requirement	None

This hole requires boring.

Reason:

- with a 1½" to 2" boring bar, depth of bore exceeds 2:1.

Example E

Hole diameter	2.000", ±0.002"
Hole depth	2.000"
Location tolerance	±0.001"
Finish requirement	32 rms

This is another good boring opportunity.

Reason:

- finish requirement difficult to achieve with an endmill.

Example F

Hole diameter	2.000", ±0.0002"
Hole depth	4.000"
Location tolerance	±0.0002"
Finish requirement	32 rms

Boring would be the obvious choice.

Reasons:

- hole diameter and location tolerance unachievable with an endmill;
- if a 1"-dia. or larger tool were used, the depth-to-diameter ratio would be 4:1 or less; and
- finish requirement difficult to achieve with an endmill.

Finishing Pass

The decision about whether to bore or circular-interpolate depends on hole depth, as well as tolerance and surface-finish requirements. You also need to remember that the quality of a circular-interpolated hole is largely dependent on the machine tool, which degrades over time.

We all need to remember, too, that a "boring tool is only as good as the carbide you put in it," said Rigibore's Bassett. So make sure you use the correct grades and geometries.

About the Author

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