JANUARY 2003 / VOLUME 55 / NUMBER 1

The P/M Edge

▶ BY MICHAEL DEREN

Powder-metal endmills: the tougher roughers.

Think about the variety of endmills available. If you're like most metalworking professionals, you probably thought of the "big three": HSS, solid carbide and indexable carbide. But there's another type, one that you may not have considered using or knew existed: powder-metal endmills.

P/M endmills are one of the best-kept secrets in our industry. And they provide benefits that other types can't. Compared to M-42 HSS, for example, P/M endmills offer double the tool life. And, depending on the workpiece material, they can remove metal at twice the rate of HSS or carbide.

These performance advantages are due to recent improvements in the P/M process and to advanced coatings.

Helical Solutions

P/M endmills are effective for roughing all ferrous and nonferrous materials.

'No-Worry' Roughing

"P/M technology really addresses the brittleness of carbide," according to David McCulloch, president of endmill manufacturer Helical Solutions LLC, Saco, Maine. "P/M is not as brittle as carbide. It's more forgiving. It's tough with good wear resistance."

Carbide works well for finishing but not as well for roughing, added McCulloch, pointing out that a carbide tool can easily get nicked if it recuts chips. P/M cutters, on the other hand, are designed for roughing all types of ferrous and nonferrous materials.

"You can take this stuff (a P/M endmill) and start roughing with it and not worry about it," said McCulloch.

During the P/M manufacturing process, carbide is formed as a byproduct. This makes a P/M cutter more rigid than an M-42 HSS one while letting it "flex" more than a carbide tool. This minimizes the chance of P/M tools being damaged when run on large, low-horsepower machines, where they often are subjected to hard impacts and vibration.

Another benefit of P/M tools is that, like solid-carbide tools, they resist heat better than those made from M-42 HSS. And, compared to indexable-insert tools, there's no "hammering" while in the cut. Indexables are designed to shear away material, but they are less sharp and don't have as much of a helix as a solid endmill. This makes indexable tools tough on the machine, especially the spindle.

If you mill shallow pockets, though, you should not use a P/M cutter. It's designed for deep radial and axial cuts.

P/M endmills come in flat-bottom and ballnose styles. Three to eight

---

About the Author

Michael Deren is a CNC applications engineer and a regular CTE contributor. You can e-mail him at mderen@prexar.com.

flutes can be specified, with the number chosen dependent on cutter diameter and the type of material being machined. Lengths of cut range from 1 to 8 diameters, or longer.

Diameters are from ⅜" to over 2". (It's not cost-effective to manufacture P/M endmills smaller than ⅜". Carbide endmills are more economical to manufacture in these small sizes.)

As you might expect, P/M endmill prices fall between HSS and solid-carbide tools.

Coolant-fed endmills, which generally have a 35º helix, are designed for tough-to-machine materials such as stainless steel and titanium. Choose cutters with coolant holes in the gullets of the endmill. They are more effective when machining radially than those in which coolant exits from the bottom. Also, apply coolant at the highest pressure possible.

As for surface treatments, McCulloch said a multilayer coating consisting of titanium, carbonitride and aluminum is a good all-around coating. It has an oxidation resistance of 650º C. For extreme heat conditions, use tools coated with titanium aluminum nitride. It's the best choice for 13-8 and 17-4 PF stainless steel, titanium and other exotics.

Head to Head

In rough-milling, as in many metal-cutting operations, the more metal you remove per minute the more dollars you earn per hour. The metal-removal rate is the true standard by which to judge machine and tool performance.

It's important to recognize that by running at a deeper DOC and a slower feed rate, you can remove metal faster than you can with a shallower DOC and a higher feed. Consider an endmill run at 50,000 rpm and 2,000 ipm that removes 1 in.^{3}/min. Compare its mrr to an endmill running at 350 rpm and 8 ipm whose mrr is 5 in.^{3}/min. Which one is the "performance" mill?

My shop ran tests comparing the metal-removal rates of cobalt-HSS, solid-carbide, indexable-insert and P/M endmills in various materials. A sampling of the results follows. (All test tools were coated.)

TEST 1

Material: T-316 stainless steel
Tool: 1"-dia., 3-flute endmill with carbide inserts
DOC: 6 passes @ 0.200" radial, 0.200" axial
Speed, feed: 2,175 rpm @ 20 ipm
mrr: 0.80 in.^{3}/min.

Tool: 1"-dia., 4-flute P/M endmill
DOC: 1 pass @ 0.200" radial, 1.200" axial
Speed, feed: 325 rpm @ 7 ipm
mrr: 1.68 in.^{3}/min.

TEST 2

Material: 8640 steel
Tool: ½"-dia., 3-flute solid-carbide endmill
DOC: 4 passes @ 0.125" radial, 0.500" axial
Speed, feed: 1,337 rpm @ 12.1 ipm
mrr: 0.75 in.^{3}/min.

Tool: ½"-dia., 3-flute P/M endmill
DOC: 1 pass @ 0.500" radial, 0.500" axial
Speed, feed: 688 rpm @ 5.0 ipm
mrr: 1.3 in.^{3}/min.

TEST 3

Material: D-2 tool steel
Tool: ½"-dia., 3-flute solid-carbide endmill
DOC: 4 passes @ 0.125" radial, 0.500" axial
Speed, feed: 1,528 rpm @ 12.37 ipm
mrr: 0.78 in.^{3}/min.

Tool: ½" dia., 3-flute P/M endmill
DOC: 1 pass @ 0.500" radial, 0.500" axial
Speed, feed: 535 rpm @ 3.7 ipm
mrr: 0.92 in.^{3}/min.

TEST 4

Material: 8620 steel
Tool: 1"-dia., 4-flute cobalt-HSS endmill
DOC: 1 pass @ 1.0" radial, 1.0" axial
Speed, feed: 500 rpm @ 6.0 ipm
mrr: 6.0 in.^{3}/min.

Tool: 1"-dia., 4-flute P/M endmill
DOC: 1 pass @ 1.0" radial, 1.0" axial
Speed, feed: 500 rpm @ 15.0 ipm
mrr: 15.0 in.^{3}/min.

Making P/M parts

Powder-metal tool steels have been around for more than 30 years. The process for making them begins with the mixing of several metal powders. This mixture is compressed in a die under great pressure.

The resultant product, called a "green compact," is then sintered in a controlled-atmosphere furnace. It's heated to a temperature below the melting point of the primary element so that the particles bond together into a solid. Finally, the product is heat-treated to its final hardness.

—M. Deren

Supplier Selection

If you want to try P/M endmills, choose a supplier that offers a full range of cutter sizes.

A vendor that specializes in P/M products will likely provide the best support and be willing to furnish samples for testing. Then you can discover the benefits of P/M roughing endmills for yourself.

And, possibly, one day, you may find yourself testing P/M endmills that are designed for operations other than roughing. McCulloch said there's a new grade of P/M on the market that has a high-vanadium, high-cobalt content. Its hardness is in the 80 HRC range, which is near carbide's hardness. Do we have an alternative to carbide on the horizon for finishing?

Stay tuned.

To learn more about the products and services offered by Helical Solutions LLC, call (207) 282-3956, visit its Web site (www.helicalsolutionsllc.com) or circle ***Information Services #320****.*