MICRO manufacturing®
March/April 2011 Volume 4 Issue 2

WAR BIRDS

Military looks to draft small UAVs like the Nano Hummingbird

- μ Taking control of machine motion
- μ Micromachining frees users from macro constraints
- μ Micromolders face material challenges
- μ Cold forming: a fast, chipless way to produce parts

PLUS: Laser Points, About Tooling EDM Notes, Tech News, Down Sizing

micromanufacturing.com

By Bill Kennedy,
Contributing Editor

Difficult materials challenge micro-endmill users

Difficult-to-machine workpieces usually represent "an inconvenient truth." As material developers improve a metal's strength and resistance to heat and wear, while often reducing its weight, its machinability declines. Enhancements to alloys such as austenitic stainless steel, titanium and high-temperature superalloys generate an ever-increasing laundry list of machining problems, including built-up edge, chatter, workhardening and excessive tool wear. They make it difficult to impart acceptable surface finishes when micro-endmilling.

Performance Micro Tool

Performance Micro Tool recommends, if possible, applying a tool with an odd number of flutes for finishing operations, like these 3-flute, 0.005"-dia. (left) and 0.020"-dia. endmills.

Dave Burton, president of Performance Micro Tool Inc., a Janesville, Wis., producer of endmills, said his company outlines a basic set of conditions to maximize surface finish in any tough endmilling operation, namely minimal runout, a rigid setup, sufficient coolant, and appropriate speeds and feeds. He also advises against "babying" a microtool by applying too light of a chip load; rather, the chip load should be heavy enough to ensure that the tool actually cuts and doesn't simply rub the workpiece.

Burton recommends, if possible, applying a tool with an odd number of flutes. While many believe that four flutes are required for a strong microtool, Burton said, "You are always trying to compromise between strength and flute volume." The amount of carbide left on a 3-flute tool is similar to that on a 4-flute tool, yet the former provides more room for chip evacuation, he added.

Efficiently clearing chips and minimizing vibration preserves surface finish. "An even number of flutes, two or four, will always have one tooth becoming disengaged and another tooth engaging," Burton said. The repetitive beat of vibration can set up a "wobble" in the tool. "On a 3-flute tool you have 120° of separation between flutes. There will be a lot less vibration because one tooth will still be engaged while the second flute is engaging."

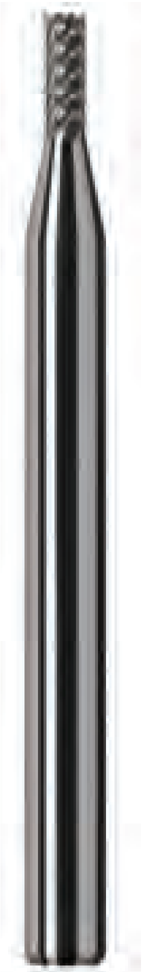
Many difficult-to-machine alloys are especially prone to BUE, said Jim Libby, owner of JLP Machine and Welding LLC, Kingston, Mass. Libby also does tool-development work for Microcut Inc., also of Kingston.

"Once you have shrunk down to the micro level, tool geometry changes drastically," he said. "A tiny bit of BUE on a microtool and it's pretty much over." The BUE essentially becomes the cutting edge. "In whatever way the BUE is adhering to the tool, you either are cutting with a more-negative rake or you have less relief. The BUE finally heats up and breaks off. When it does, it takes a piece of the coating and the tool with it, and changes that tool geometry." Libby said an AlTiN coating helps resist BUE in microtools.

Before finish milling, shops could use endmills with serrated chipbreakers that produce manageable chips. "If I have a ton of stuff to plow through, I am going to use a true rougher—a serrated tool," Libby said.

Most of the time, however, he uses two identical, nonserrated endmills to rough and finish. Libby buys two of the same tool, using one as a rougher and one as a finisher. When the finisher becomes worn, he exchanges it with the rougher and loads a new finisher.

Advances in tool grinders and manufacturing processes have led to better, stronger geometries in microtools, according to Libby. "Manufacturers can do more with the primary cutting edge and the relief," he said. "You might have a three-angle primary



Harvey Tool

Multiflute, high-helix finishing endmills from Harvey Tool feature as many flutes as the tool diameter allows; tools 0.062" in diameter and larger, like this one, have seven flutes.

edge and a greater relief behind it. Toolmakers are creating the needed clearances with as small an angle as possible, to maintain as much edge strength as possible." The rougher/finishers provide a good finish, Libby said, because they are made more like finishing tools, with more relief on the primary grind and more rake on the flute side.

Carbide strength also plays a role. "Years ago, you'd never consider touching a piece of stainless or any kind of high-nickel metal with a carbide tool," Libby said. "You'd always use a cobalt tool, because it wasn't as brittle as carbide." Current carbide materials are tougher, so sharp cutting edges on a carbide tool can endure roughing operations in high-nickel alloys.

Fine finishes in tough materials require tools that shear and resist wear. Excessively high rake angles, for example, can shorten tool life. Bob Srail, who handles production and custom tool orders for Melin Tool Co., Cleveland, said, "When you get into the small tool diameters, you can't have a lot of rake angle on a cutting face because it will grab as soon as you start cutting. That makes it difficult to machine tough materials. A 15° rake, or hook, on a tool will shear really well, but it might not last."

Efficiently clearing chips and minimizing vibration preserves surface finish.

As a tool wears, surface finish deteriorates, so most shops seek a balance between shearing action and tool life. To fine-tune the rake-face angle and other tool features, Melin Tool applies 1,200-grit wheels when grinding tools from 0.015" to 0.020" in diameter, and holds the wheels in a high-precision arbor to ensure cutting edge consistency.

Coatings can combat abrasive wear. Melin applies its nACo (nanocomposite) coating in a multilayer process in which an AlTiN layer is overlaid with a combination of AlTiN granules in a Si_3N_4 matrix.

Toolmakers mix, match and refine features to maximize workpiece surface quality. For example, Harvey Tool Co. LLC, Rowley, Mass., introduced multi-flute, high-helix finishing endmills. The tools combine flute helix angles that vary from 39° to 42°, a coating and edge prep, and as many flutes as the tool diameter allows. Tools with diameters less than 0.031" have four flutes, tools from 0.031" to 0.047" in diameter have six flutes, and diameters of 0.062" and larger have seven flutes.

The finishing endmills are designed to be preceded in an operation by a mill that hogs out main contours of a part, leaving 0.002" or less for a finishing pass.

In finishing operations, Harvey Tool recommends a full axial DOC, but a light radial DOC. Compared to hogging, which may engage half of the tool's circumference, finishing may engage 20 percent or less of the tool.

According to Jeff Davis, vice president of engineering for Harvey, maximizing the number of flutes on a tool allows the flutes to share the burden of cutting tough, abrasive materials. "Even in an ideal scenario, the life of a 4-flute tool is going to be approximately half what you might see with a 7-flute tool," he said.

Increasing the number of flutes increases the tool's core diameter and reduces the size of the chip gullets between the flutes. Because it's more rigid, a larger core diameter enhances tool performance at higher feed rates. In a roughing tool, Davis noted that the smaller gullets may restrict chip flow, but pairing the light DOC characteristic of finishing endmills with sufficient coolant flow should permit chips to exit easily. µ

About the author: Bill Kennedy is a contributing editor to MICROmanufacturing. Telephone: (724) 537-6182. E-mail: billk@jwr.com.