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A 0.0004”-dia. endmill from Performance Micro Tool, which is dwarfed by the eye of a ladybug.

Jeff Davis, vice president of engineering for Harvey Tool Co., Rowley, Mass., said the most important factors in controlling micro-tool breakage are speeds and feeds. “If you don’t have the right rpm and feed rate and, therefore, the right chip load, you are going to pop that tool right off the bat.”

If the chip load is too small, the tool rubs instead of cuts, wears, heats up and breaks. With too large a chip load, the heavy cutting pressure will snap a microtool. The key is to find the combination of parameters where the tool remains intact and cuts effectively.

In terms of managing chip load, “most of the world is pretty good down to 0.005” in diameter,” said Dave Burton, president of Performance Micro Tool, Janesville, Wis. With tools smaller than that, however, “the radius on the cutting edge plays such a big role that it really kind of muddies up the rest of the variables if you don’t understand it,” he said.

“The rake geometry built into these tools is meant to be a shearing, positive rake, and if you take less than the suggested chip load, only a percentage of that tooth bites in and you are [effectively] using a negative angle. You start to wear a radius on the cutting edge and it ends up creating a lot of heat—a lot of rubbing and skipping.”

In addition to managing chip load, minimizing runout is crucial to keeping a microtool intact.

For example, the cutting edge of a 0.010”-dia. endmill may have a radius of 1μm. If it’s applied and the chip load is 0.000001”, the tool’s cutting edge will end up being honed, preventing it from shearing the workpiece material. “The cut might last 0.1” before the thing snaps,” Burton said. “At a suggested chip load of 0.0002”, you might get 100’ of cut. It has to do with whether the tool is cutting the material or the material is cutting the tool.”

In addition to managing chip load, minimizing runout is crucial to keeping a micro-tool intact. A negligible amount of runout for a large tool may represent a significant percentage of a small tool’s diameter. “You want to look at the runout of the cutter, the holder and the spindle as an entire system,” Davis said. “Even if you have your speeds and feeds dead nuts, if you are running a ⅛”- or ⅛”-dia. endmill and you’ve got 0.0003” or 0.0004” runout, you’re going to pop that tool.”

Davis said shops seeking to minimize runout increasingly employ shrink-fit and hydraulic toolholders and microtools with
shanks that meet metric h6 tolerances. While a standard English or ANSI cutting tool shank tolerance would be +0.00/-0.0005", an h6 tolerance for a tool with a 1/8"-dia. shank (the shank diameter for many microtools) would be +0.007/-0.00031", Davis explained, and the tighter tolerance maximizes grip and rigidity. (The metric h6 tolerance in this case is converted into inches.)

Runout can be checked statically, with an indicator. For very small tools, though, Burton recommends measuring machine runout dynamically, using noncontact instruments such as the Optec RI.

To protect a delicate microtool, tool-path programming should focus on gradual loading and unloading of cutting pressure. “Basically, with these small tools, you use a very high feed rate but you cut very little material; you don’t go very deep,” said Hans Liechti, manager of Mikron Corp. Monroe (Conn.)

This 0.046"-dia. endmill from Harvey Tool features a variable-helix design, which reduces chatter and harmonics that can break a microtool while also permitting use of higher metal-removal rates than standard micro-endmills.

The machine tool’s CNC must be capable of generating rapid back-and-forth tool motion, and the CAM program must anticipate moves into radii and corners to prevent the spindle from overshoing, applying too much pressure and breaking the tool, Liechti said. He added that the key is to maintain a constant feed as the tool moves linearly

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