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Challenge on Tap

Shops and toolmakers discuss the challenges of tapping.

Precision Twist Drill Co.

When it comes to challenging operations, tapping ranks among the toughest. Unlike other metalworking operations, rapidly removing metal and imparting a fine surface finish are not the sole ends of the operation. When tapping, the point is to produce a thread that must mate with a fastener according to a given standard.

In addition, when other tools have finished cutting, tool removal is fairly simple. But for tapping, removing the tool can consume almost as much time as cutting the thread. All in all, this can make tapping a slow and tedious, but ultimately necessary, operation.

Beyond these everyday concerns, other factors add to the challenge of tapping. Primarily, they can be divided into two groups: material-related and operation-related. For both, the selection of the right tool can mean the difference between tapping many holes per tool, or one, or none. To that end, let's take a look at what some machinists and toolmakers have done when confronted by such challenges.

Workpiece Headaches

Tapping a difficult-to-machine material can be a costly proposition. A day spent watching a tool shatter in the cut can take the wind out of any shop owner's sails. Toolmakers are cognizant of this and strive to make their tools hard, but tough.

According to Dan Gajdosik, engineering manager for Besly Products Corp., South Beloit, Ill., the primary difficulties in tapping such materials

arise from the heat generated in the cut and the workpiece material shrinking around the tool. Titanium is particularly susceptible to this problem, he said.

When tapping these materials, he advised machinists to look for a tool that has a generous relief in the profile of the thread and the tap's back taper. These prevent the tool from seizing.

In addition, Gajdosik said that there are issues surrounding the strength of the tap's substrate.

"Many times, the tap's crests start to roll over, or become dull quickly, due to the workpiece's high hardness and strength," he said. In those cases, he recommends using premium high-speed-steel taps, as they have a higher toughness and red hardness and resist tool deformation and wear.

When designing a tap for hard materials, Paul Motzel, tapping applications specialist for Guhring Inc., Brookfield, Wis., said a low rake angle is critical. The angle lends more support when cutting.

One of the most difficult-to-machine materials is Stellite 31, a nickel-base superalloy. Mike Brown, owner of Computer Integrated Machining, Santee, Calif., won a contract to produce a fan blade for an aerospace motor. About 25 blades were needed for each motor. The job required producing a 10-32 UNF-2B thread in a through-hole for a jackscrew to release the blade from the motor.

From the start, the company was aware of the material's strong "memory," or tendency to contract once machined. In anticipation of the shape-memory problem, Brown first produced an oversized hole. "The print called for a hole 0.159" in diameter. So we drilled a 0.161"-dia. hole, going up by about 0.002"—not a lot. That way, the tap had less work to do," he said.

With the first taps tried, however, Brown said he could only tap one or two holes before the tool shattered. "The taps made a very high-pitched noise, like brakes were being put on, and we just knew something was wrong."

Finding the right tap, one that would last more than two holes, was a matter of trial and error. Brown said the taps he was experimenting with cost $18 each and lasted only one or two holes.

Eventually, Brown settled on the HSS Exotap tool from OSG Tool & Die Inc., Glendale Heights, Ill. With the Exotaps, Brown said the number of holes per tool increased to four.

"The taps cost around $12 to $15 apiece, which worked out to be about $3 or $4 per hole. This is kind of high, but in this kind of material, that was not excessive. But to be paying almost $20 per tap and have it last one hole, that was unacceptable."

Tapping with a carbide tool, furthermore, was simply not feasible. "On parts like these, you don't want to go with carbide, because it's too hard. For drilling the hole, it's OK, but there's a lot less forgiveness with carbide," Brown said.

This didn't mean carbide taps were out of the picture for this job, however. Though Exotaps taps are HSS, a secondary chasing operation was done by hand with a carbide tap. According to Brown, each part was removed from the fixture and given a quick thread chase with the $60 carbide tap.

Finding the right tool was not the entire solution to the problem, however. Brown said using the right lubricant was nearly as critical a factor. On the advice of a machinist friend, he changed from a tapping lube to a tapping wax from Castrol. The wax was applied by hand with a brush prior to each tapping run.

In another example of tapping difficult-to-machine materials, Dan Welter, foreman for Diamond Tool & Die Inc., Oakland, Calif., was given the job of tapping a "super-austenitic" stainless steel called AL-6XN. The material is popular for parts that convey liquid, such as pumps, and is particularly resistant to chloride corrosion.

The material contains high levels of chromium, nickel and molybdenum (20, 24 and 6 percent, respectively). With its relatively high hardness at 88 HRB, the material tends to work-harden, said Welter.

The part was an ink pump for a printing press. In it, Welter tapped six 4-40 through-holes, three on each side of the part, with a 0.250" depth of thread.

The job first required him to drill the holes to depth in one operation, fol-

Diamond Tool & Die

Diamond Tool & Die uses Prototyp's Triple-S tap to thread holes 3 diameters deep in 304 stainless steel.

lowed by tapping. At first, he tried using standard, HSS, TiN-coated taps. However, the material's hardness was too great and the taps simply shattered.

After trying about six different HSS taps, he gave up on standard thread cutting as a solution to this problem and began exploring alternatives, such as roll-form tapping. Until recently, roll-form taps were considered appropriate only for soft materials. Welter found roll-form taps to be the answer.

He applied an OSG roll-form tap coated with ElektraLUBE. OSG says this 0.0001"-thick coating is a deposit of ductile, solid lubricant placed on the surface of the tap, which imparts a burnished surface. As a result, less torque is required to drive the tap, which helps prevent welding, loading and galling between the tap and the workpiece.

The following companies contributed to this article:

Besly Products Corp.
(800) 435-2965
www.besly.com

Computer Integrated Machining Inc.
(619) 596-9246
www.cimsd.com

Diamond Tool & Die Inc.
(510) 534-7050
dtdjobshop.com/diamond.htm

Firth Brown Tools Inc.
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www.firthbrown.com

Guhring Inc.
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www.guhring.com

Prototyp
(800) 877-3745
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Roberts Automatic Products Inc.
(800) 490-9875
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Deep Tapping While Blind

Workpiece material is not the only obstacle when tapping. Sometimes, the mechanics of the operation can be tricky, such as tapping blind holes. Dave Sibinski, process engineer for Roberts Automatic Products Inc., Chanhassen, Minn., said one of the biggest challenges in tapping blind holes is removing chips from the bottom of the hole so the tap doesn't compress them. And Sibinski knows whereof he speaks, because as a screw machinist, all the holes he taps in bar stock are blind.

"Even though the print may not call for bottoming, it is a bottoming condition," Sibinski said.

As he sees it, the problem with tapping blind is providing room for the tap to go deep enough for the print requirements. "If you're drilling beyond the cutoff and into the next piece or bar end, there'll be concentricity problems," he said.

And if you're drilling a deep hole blind, he added, there is the danger of ending up with a concentricity problem that gradually worsens.

At Diamond Tool & Die, Welter needed to tap one 5/16-18 blind hole with a 1"-deep thread per part in 304 stainless steel. Tapping 3 diameters deep, he said he needed a rigid tap that could do the job in one shot and provide effective chip removal. Roll forming the operation was quickly ruled out.

Prototyp, Crystal Lake, Ill., provided the needed tool: Its Paradur Triple-S, which is part of its ECO line of taps for difficult-to machine materials. According to Mathias Armbruster, manager of technical sales development for Prototyp, which is a part of Sandvik CTT's sales organization, the high helix of the tool allows the tap to reach those multiple diameters. "The high helix curls the chips tight and prevents them from 'birdnesting' around the shank," he said.

In addition to supplying the tools, sometimes toolmakers are closely involved with solving problems for machinists. Sai-Kin Eng, senior engineer for Firth Brown Tools Inc., Cambridge, Ontario, assisted on a job requiring an 18mm thread in a part with a 60mm-deep hole. He said several factors make deep-hole tapping particularly difficult. Coolant delivery is difficult in deep-hole environments, because chips become congested in the hole and prevent coolant from reaching the tool/workpiece interface.

However, because the material had good elongation properties, the customer was able to apply a roll-form tap. Since a roll form tap produces no chips, the hole size, typically near the pitch diameter of the thread, had to be held more closely than that of a thread cut with a conventional tap.

To help coolant delivery, a coolant-through tap was selected. In addition, multiple oil grooves and a special coating aided lubricity. This, in turn, lowered operating temperatures and kept the tool's edges from softening. Taken together, Firth Brown helped achieve a 50 percent reduction in tool life.

Though we have scarcely covered the range of potential challenges that await machinists, the tapping problems covered here offer insight into how day-to-day issues are resolved. Clearly, a strong measure of patience is required to meet the challenges of tapping.