Strategies, tactics and tools

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Machining a part—profitably—involves more than just arranging a sequence of cutting operations. World-class parts making also requires fine-tuning shop strategies and tactics to maximize the efficient use of available tools, time and equipment.

Puget Sound Precision Inc., Poulsbo, Wash., is a machine shop that does prototype and production work for a diverse selection of customers, including waterjet equipment manufacturers, toymakers and medical equipment producers.

The shop's strategic and tactical capabilities were put to the test when it machined an order of prototype orthopedic surgical tools. The job involved making three copies each of eight sizes of five basic tools—120 parts total.

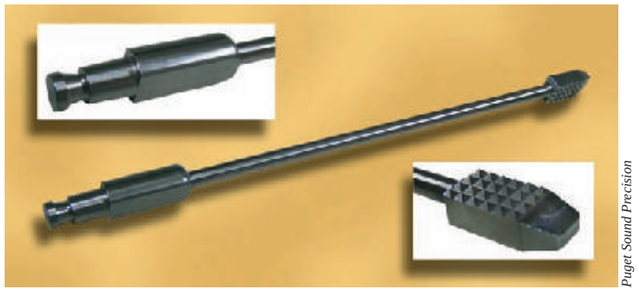
Puget Sound did much of the work on a 7-axis, 20mm-capacity Tsugami BS20C Mark III CNC Swiss-style lathe. The sliding-headstock machine is basically a CNC single-spindle screw machine that has a subspindle to grip the part as it comes out of the main spindle.

One 8¼"-long surgical tool was made from ¾"-dia. 17-4 stainless steel bar stock, heat-treated to H900 (41 to 43 HRC). The stock was ground to ±0.0005" to enhance machining consistency. Kevin Lahn, Puget Sound founder and president, said, "If you're trying to hold close tolerances, your bar has to be ground or it will move around in the machine."

In the first operation on the lathe, a Kennametal CNMG 321MN, coated carbide insert faced the bar end and then turned it to a diameter of 0.2888" (-0.0000"/0.0003") for a length of 0.640". The cutting speed was 350 sfm and the feed rate was 0.0015 ipr. Lahn said cutting speeds and feeds were similar for all the operations on the Tsugami.

Tools in an automatic lathe do not move laterally along the part, as in a traditional lathe; instead, the automatic machine's sliding headstock pushes the workpiece through the spindle and past the tool. Because the bar's OD is held in a collet, "once you've turned the bar down you can't pull it back more than about ¾"," Lahn said. "You basically rough and finish ¾" at a time, taking all the stock off in one cut, and then the main spindle feeds out more material. You have to plan out what you are doing. It's a strategy-intensive kind of approach." To balance the relatively heavy DOCs required, feed rates were not more than 0.002 ipr, according to Lahn.

The next part feature, a 0.165"-wide, 0.035"-deep tapered groove in the 0.2888" diameter, was machined with a 35° DNM coated carbide insert and a S10P back-turning tool from Kennametal. The DNM insert machined the portion of the groove on the side away from the headstock, then the back-turning tool finished the groove on the headstock side.



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Although this 8¼"-long orthopedic surgical tool could have been machined complete on a Swiss-style automatic lathe with milling capabilities, two additional machines were used to reduce programming time.

Next, the CNMG insert turned a 0.442" diameter for a distance of about 1½". The back-turning tool then cut a ⅛" radius on the headstock side of the 0.442" diameter. Next, it plunged into a 0.234" diameter, also creating a 0.035" radius at the junction of the shoulder and the smaller shaft. At this point, the subspindle rose to grip and support the free end of the part. "Give the command to synchronize the two spindles and they move together," Lahn said. "Then we 'dropped' that CNMG in there again and turned the rest of the part."

The CNMG insert turned the 0.234" diameter for a length of 5¾", formed another 0.035" radius, and then made a 0.01"-deep skim cut over the last 0.85" of the part.

For the long cut over the small diameter, Lahn said, "we used pretty much the same surface speed as before, but because we were taking a pretty substantial DOC [0.258"], we slowed the feed down a little bit. We were able to achieve a 16 R_a finish, right out of the machine."

After a Seco-Carboloy CVD-coated LCMF cutoff insert, run at 300 sfm and 0.002 ipr, cut the part off, the machine was stopped and the part was manually released from the subspindle.

Lahn said: "We don't let the part drop. Virtually all the time we are parting off, we have a hold of it with the subspindle. We do that as a routine because then we get a nice part off." The operations on the lathe consumed 6½ minutes.

For the next series of operations, Puget Sound moved the part to the shop's Fadal 4020 vertical machining center. The part was held in a vise with soft jaws machined to grip the 0.442" and 0.740" diameters. A ½"-dia., 4-flute carbide endmill, run at 1,500 rpm and 5 ipm, cut flats on both ends of the part, and then did the same on the other side after the part was flipped 180° in the vise. After a group of three identical parts was milled, the first set of vise jaws was replaced with a set machined to grip the part's new flats. The endmill then machined two more flats on the 0.740"-dia. end of the part to make it square.

The top and bottom of the finished surgical tool's square end feature a gripper pattern comprised of tiny 45°-angle pyramids. Puget Sound cut the pyramids with ⅛"-dia., half-round, 90°-included-angle carbide engraving tools from Harvey Tool. Run at 9,000 rpm and 2 ipm, one tool was applied in a 90° crisscross pattern to rough the pyramids 0.002" short of full depth, and then an identical tool, run at the same parameters, finished the pattern at full depth. The part was flipped in the vise to machine the gripper pattern on the other side.

In the last operation on the Fadal, the ½"-dia. endmill tapered the end of the part and wrapped radii around the corners, perpendicular to the gripper pattern. It took 21 minutes to mill the part's gripper patterns and nose.

For the final operation, cutting two slanted "duckbill" flats on the top and bottom of the part's nose next to the gripper pattern, the part was moved to a Bridgeport mill.

"We cut the flats on a Bridgeport because you can tip the head," Lahn said. "With the Fadal, you'd have to cut it with the side of the endmill, but we couldn't get the endmill up next to the pyramids because there's not enough room." Using a ½"-dia., 4-flute endmill, run at 2,000 rpm and 4 ipm, it took 2 minutes to machine the slanted flats.

Lahn acknowledged that the Tsugami's milling capabilities would have made it possible to machine the part complete on that machine. However, the nature of the job—short runs of slightly different parts—made it more time-efficient, in this case, to create a "sophisticated" blank on the lathe and then complete the variations on the Fadal and Bridgeport.

Lahn said, "If we were to do the gripper ends for all the different sizes on the Tsugami, we would have had to write a different program for each size. It wasn't worth the programming time."

The single program that programmer John Beh wrote to machine the gripper pattern on the Fadal enabled changing the pattern for different-size parts by simply specifying a different Z-depth for the cutter. Lahn also felt that waiting until after the long shaft was turned to mill the flats on the part's front end enhanced part accuracy. "We felt the subspindle would hang on better and support the rest of the turning if we did not mill that material away."

For more information about Puget Sound Precision Inc., visit www.pugetsoundprecision.com or call (360) 297-3939.