MAY 2003 / VOLUME 55 / NUMBER 5

Special Focus: Medical Components

▶ BY BILL KENNEDY, CONTRIBUTING EDITOR

Small Cures

Swiss-type machines help shops meet the medical industry's needs.

The Hippocratic oath states that a doctor's first duty is to do the patient no harm. Today's minimally invasive diagnosis and treatment techniques help a physician keep that promise.

Arthroscopies and biopsies rely on small, light, complex probes and tools. Orthopedic and cosmetic operations employ tiny screws and long, thin rods for location and stabilization purposes. Oral surgeons anchor teeth with double-ended, miniature posts.

By most definitions, medical components are small. "Some of the large spinal parts may be ¾" in diameter, while the diameters of maxillofacial screws may be as small as 0.030"," said Mark Saalmuller, national sales manager for machine tool builder Tornos Technologies U.S. Corp., Brookfield, Conn.

And the operations performed on the parts are delicate. "Our latest challenge is drilling a 0.017"-dia. hole in a bone screw," said Tanya DiSalvo, operations manager at Criterion Tool & Die Inc., Brook Park, Ohio. "The drill looks like a pencil lead. It doesn't look like machining; it looks like [creating] fine artwork."

All images: B. Kennedy

Bone screws are some of the medical components Criterion Tool & Die produces on CNC Swiss-type machines.

The Swiss Advantage

Such small parts make it difficult—if not impossible—to maintain concentricity and location of crucial features if secondary operations require moving the part from one machine to another.

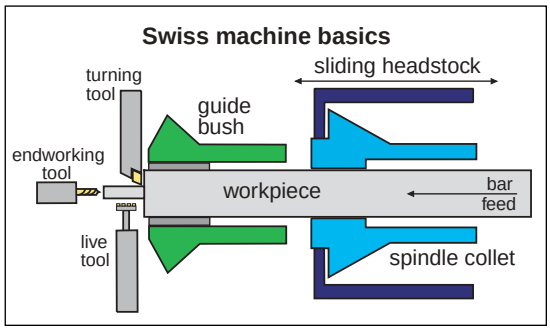
Swiss-style CNC machine tools allow the machining of small, complex and highly accurate parts in one chucking. Not surprisingly, a growing number of shops across the country are using the machines to manufacture these miniature medical marvels.

A CNC Swiss-type machine tool is distinguished from a traditional automatic by a sliding headstock that feeds a rotating bar (workpiece) through a guide bushing. Side- and end-mounted tools cut within millimeters of the guide bushing, effectively eliminating overhang and part deflection.

"Theoretically, you can accurately machine a ⅛"-dia. part that's 20" long," said Sohel Sareshwala, president of precision-parts maker Accu-Swiss Inc., Oakdale, Calif.

Early Swiss-style machines performed turning operations and had simple milling capabilities. A system of shafts and custom-made cams governed workpiece and tool movement; form tools were applied to produce complex shapes.

CNC technology is replacing cams and permitting the use of standard insert-style tools. And, today's machines have up to 12 axes of motion, live tooling and secondary subspindles that carry out work on the back of the part after is it "picked off" from the main



A sliding headstock feeds the rotating stock through a guide bushing, eliminating overhang and deflection.

spindle. Repeatable positioning is guaranteed because the subspindle takes hold of the part before it is cut off.

Bill Papp, Eastern regional sales manager for CNC Swiss machine builder Marubeni Citizen-Cincom Inc., Allendale, N.J., said CNC technology lets as many as three cutting tools be applied to a part simultaneously. Machining on the subspindle also multiplies machining efficiency.

Dennis Vaughn, manufacturing manager for Micro Med Machining, Miramar, Fla., pointed out that the work done in the subspindle's pickup collet is "free," in terms of machine utilization. Moreover, gang-tooling arrangements, driven tools and rotating tool turrets permit a Swiss-type machine to present an extremely wide selection of tools to the workpiece.

Criterion's toolmaker and screw machine department lead man, Dave Bohurjak, said he can mount as many as 48 different tools in each of the company's CNC Swiss machines.

The productivity-improvement potential this capability provides is impressive. For example, after a bone screw is turned to size and threaded in the machine's main spindle, it can be clamped in the subspindle, cut off and then be drilled, broached and milled while another screw is threaded.

Programmed Changes

There's no denying that traditional cam-actuated machines are great for long runs. Once set up, they offer rock-solid reliability and cycle times in the seconds. But just-in-time supply initiatives are making truly long runs a thing of the past and frequent changeovers the norm.

In addition, many shops' normal workflow consists of small and varying quantities of parts. Criterion's DiSalvo said, "Our niche is prototype and pilot-production work. We have made five or 10 of a single part number, as well as 10,000."

Papp pointed out that setup is much faster on a CNC machine than on a cam machine. "CNC machines have the flexibility to change products in midstream with minimal downtime," he said. When running a new part on a cam machine, it can take weeks to design, machine and install the cams, not to mention engineer and fabricate custom form tools. CNC machines can handle some changes almost immediately.

"On very similar parts, where you may only have to change one or two dimensions, you're talking minutes," said Jack Graeber, president of Northwest Swiss-Matic Inc., a Minneapolis manufacturer of screw-machine parts for a wide range of industries.

Programming a large number of axes, however, isn't simple. Formerly, all Swiss CNC programming took place at the machine control. The operator specified codes for each step of the operation, programmed the subspindle separately and then entered "wait" or "pause" codes to coordinate simultaneous machining.

Recently, machine and software makers have introduced offline-programming systems. Until about a year ago, Criterion's programmers "were doing it pretty much sequentially, programming online," DiSalvo said. Now, Criterion uses PartMaker programming software from IMCS Inc., Fort Washington, Pa.

On an offline PC, the software displays the part in 3-D graphic form and breaks it down into a series of planar or rotational faces. The operator assigns a machining operation to each face and arranges the operations in a sequence. Then he or she runs a simulation and can adjust the program to coordinate the actions of the main spindle and subspindle and optimize cycle times. The operator then downloads the completed program to the machine control.

A tool database contains all the tooling available on the machine. And repetitive operations, such as drilling, can be stored and inserted into other machining processes, minimizing the amount of programming necessary.

Graeber said programming a CNC Swiss machine is one aspect of the machine shop business that appeals to young people today. However, he cautioned, "there is one catch. They have to know their machines, know their feeds and speeds and materials. You can teach them programming, but they also have to have some machining knowledge."

Setup-Time Reduction

Machining with more than one tool at a time while performing other operations simultaneously on the subspindle can shorten cycle times dramatically.

"A minute is a good cycle time for a complex part," Criterion toolmaker Bohurjak said. So setup time becomes a big cost factor when producing a batch of parts, especially for short runs.

The following companies contributed to this report:

IMCS Inc.
(888) 270-6878
www.partmaker.com

Marubeni Citizen-Cincom Inc.
(201) 818-0100
www.mctz.com

Tornos Technologies U.S. Corp.
(203) 775-4319
www.tornos.ch

Star CNC Machine Tool Corp.
(516) 484-0500
www.starcnc.com

Accu-Swiss Inc.
(800) 692-5774
www.accuswissinc.com

Criterion Tool & Die Inc.
(800) 616-0001
www.criteriontool.com

Micro Med Machining
(954) 447-8543
www.uticorporation.com

Northwest Swiss-Matic Inc.
(763) 544-4222
www.nwswissmatic.com

"It's not unusual to spend 8 hours setting up so we can run 25 pieces," DiSalvo said. "It may take 4 hours to get the tools in place, and 4 hours to finesse it. By the time we get the dance choreographed correctly, we're done."

Criterion continually seeks ways to reduce setup times. "In some cases, we can't," DiSalvo said.

However, opportunities to reduce setup times can arise in subsequent runs of a part. For example, DiSalvo continued: "We try to schedule like sizes together. Or, a customer may have a special thread made with a special form tool. If we have a couple different parts in a family with the thread, we do them all at the same time while [the required] cutter is in there."

The ability to use standard tools permits off-machine presetting, which is another timesaver. Turning a profit on a part means understanding the sum of setup and cycle times.

"A lot depends on the skill of your estimating," DiSalvo said. "You have to be able to see all the things happening simultaneously."

Criterion Tool's lead man, Dave Bohurjak, and operations manager, Tanya DiSalvo, discuss the machining of a medical part.

Precision, Materials, Tooling

Tolerances for some medical parts are in "tenths," and CNC Swiss machines are up to job. They can hold tolerances within 0.0001", and 0.0005" accuracy is common.

Accu-Swiss' Sareshwala said precision is more important than cycle time for his company. "We don't talk about a million parts," he said. "We make short runs of very precise parts, 500 to 1,000 pieces only."

Medical components have specific material requirements, too. Instruments or disposable parts may be made from any of 300 or 400 stainless steel alloys, while implantable items usually are titanium, because it is light and impervious to corrosion caused by bodily fluids.

To prevent binding as the workpiece bar advances, the minimum OD of the Swiss machine's guide bushing is determined by the maximum OD of the workpiece material. This means, Sareshwala said, that the tolerances of the final part will be very close to the tolerances of the raw material. "When we are working at absolute plus or minus 0.0001", we use ground materials," he said. "A ground material is expensive. But when you buy expensive, you cry once; when you buy cheap, you cry forever."

A possible alternative to ground stock is the Rotary Magic guide bushing from Star CNC Machine Tool Corp., Roslyn Heights, N.Y. According to the company's general manager, George Bursac, the system pneumatically develops pressure that grips the stock and maintains constant zero clearance between it and the guide bushing. He said it lets users hold tolerances down to tenths without using ground stock, even when machining drawn materials with diameter variations as large as 0.0012".

Bursac also said that the materials for medical parts are not necessarily tough, but often they do not cut easily and they are prone to burrs. "Mainly what you need on titanium is a very sharp cutting edge. You can't have any kind of radius or negative geometry. It has to be a positive, sharp edge because it has to shear material, otherwise it heaps up and creates a problem," he said.

The inserts used in making medical parts typically have sharp corners or very small radii. Insert-indexing mechanisms feature side actuation, because of the limited space afforded by the gang tooling used on Swiss-type machines.

Toolholders have small shanks and short heads, again, due to limited space. The holders are designed to align the cutting edges of the inserts with the shank of the tools, both for space considerations and to make programming easier. If the programmer knows the dimension of the shank, he or she knows where the cutting edge will be.

Cutting Compromises

Because of the smallness of so many medical components, shops often have to make comprises in the way they machine them.

DiSalvo said that often "you're just grazing the material. You can't just go in with a heavy depth of cut and high speed and feed. It just doesn't work. The standard [cutting parameters] supplied by the tooling folks may not apply when you're working with these tiny parts."

Sareshwala said, "We have to compromise a little on the machining parameters, because the tools and machines are not meant to take a ⅛" depth of cut."

Criterion's Bohurjak pointed out that in turning operations on a Swiss machine, the workpiece is pushed past stationary tools. There is no way to withdraw the work to make a second pass, so the entire DOC must be taken in a single pass.

For example, turning ¼"-dia. stock down to 0.170" for a bone screw requires

a 0.08" DOC. The feed rate is light. “No more than 0.001" or 0.0015",” Bohurjak said. Although both roughing and finishing are combined in the single pass, finish isn’t compromised. “We don’t bat an eye at requirements for 16 rms, right off the machine.”

Growth Drives Technology

Manufacturing medical parts is a growth industry. It is the fastest-growing segment of Criterion’s business. And a Swiss machine builder said that while manufacturing overall is bumping along the bottom of a recession, “the medical-parts guys are complaining that they only grew 5 percent last year.”

To serve this pocket of growth, Swiss machine builders are continually developing new technology.

Miles Free, director of technology services for the Precision Machined Products Association, Brecksville, Ohio, said, “These guys keep imagining stuff and then they make it.”

For example, Tornos Technology’s Saalmuller said his company has combined the 12 axes of motion of its machines with its TB-Deco software to create macro programs that enable the machining of angular dental implants. Better than a straight post, these implants allow an oral surgeon to fix one end in the best bone available and still provide a perpendicular mount for a tooth.

Papp said Citizen’s new R04 machine offers increased accuracy though slides driven by linear motors that provide zero deflection and backlash, as well as rapid tool movement.

And Star Machine Tool’s new ECAS machines, reported Bursac, offer a new integrated control system that coordinates high-speed turning capabilities with numerically controlled secondary operations that speed the machining of complex geometries.

Smart shops are using Swiss CNC technology to carve a profitable niche in the manufacturing market, said Free. “The people who are adopting the Swiss-type machines are differentiating their businesses by holding very close tolerances and offering high value. Are the machines more expensive than standard technology? Well, yes. But if you take a look at how many machines would be needed to make parts of this complexity at the same quality, the answer is no.”