▶ BY BILL KENNEDY, CONTRIBUTING EDITOR

# Complex and Complete

**A job shop's CNC Swiss-type machines produce hard-to-make parts from start to finish.**

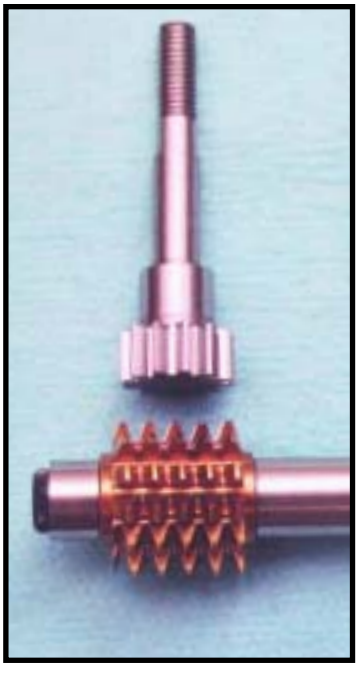
Despite flat-to-negative growth of machine tool sales in the U.S., purchases of CNC Swiss-type machine tools are climbing steadily. The reason is the machines' unique capabilities.

Originally developed to produce small, complex parts for watches, Swiss machines employ a sliding headstock that feeds a rotating workpiece through a collet and bushing. Static and rotating side- and end-working tools cut the part as it is fed. The workpiece can be transferred between main and back spindles, enabling machining of both ends of a part.

As a result, the machines are able to produce small, intricate parts complete in one chucking. This addresses two hot issues in manufacturing: The need to produce parts for increasingly miniaturized devices, and the quest to reduce costs by eliminating secondary operations and minimizing part-handling time.

One Midwest job shop tackles these issues head-on every day.

Northern Precision Inc., Fairfield, Ohio, combines Swiss CNC technology



*All photos: B. Kennedy*

**Northern Precision founders Harold Jarvis (left) and Dane Kerby check a part with a micrometer. Top right: Northern Precision used a small hob in a live cross-tool position to make the ⅜"-dia. gear on the end of this component. Bottom right: One of the shop's 0.015"-dia. drills.**

with creative machining strategies to stay busy and profitable—and fill a solid niche.

"We specialize in hard-to-make, complex parts," said the company's president, Harold Jarvis.

Northern Precision operates three Citizen L20 VII CNC Swiss machines. Because each one is essentially "two lathes and a mill in one," Jarvis said, the shop must focus on producing complex parts. "To be cost-effective, we can't just feed out and cut off. We have to make a part that would normally take several operations."

Swiss machining is all Northern Precision does; the shop has no equipment to perform secondary operations. "If you have to pick [the part] up and do something else with it, it's going to cost you money," Jarvis said. "We drop it right off the machine, ready to put in a box and ship."

## Getting Started

After spending a dozen years as a manufacturing engineer in the screw machine industry, Jarvis founded Northern Precision in 1999 with veteran mill operator Dane Kerby. The company began with one Swiss machine—and no customers.

"That's the interesting part," Jarvis laughed. "We bought a machine and did not have an order for any parts. It was scary. We started on a shoestring."

After Northern Precision found its first customer, word of mouth drew more. The shop now has 25 to 30 steady clients, including makers of fiber-optic, medical and automotive products. "As a matter of fact," Jarvis added, "a lot of our customers are regular screw machine houses, and some of them even have Swiss machines. They give us the tough stuff."

Northern Precision's customers may be steady, but the lot sizes are not. "One job I'll run 160,000 pieces," said Jarvis, "and one I'll run five." Most orders are for 1,000 to 10,000 parts.

Lead times currently are about 5 weeks. "Normally, we run about 3 weeks, but we've been absolutely swamped for the last 6 months," Jarvis said. He pointed out that his customers often need their orders quicker than 5 weeks, and even more work would be available if Northern Precision had more capacity.

The company plans to grow—and stick with Swiss machines. It would like to acquire machines capable of handling larger parts. "We could use two more machines right now," said Jarvis.

To boost productivity, Northern Precision fitted its machines with bar loaders from LNS America that suspend the bar stock in oil. This helps control whipping when stock is rotating at up to 10,000 rpm. The machines also are equipped with CoolBlaster 2,000-psi coolant systems. They are particularly useful for clearing chips during deep-hole drilling, which eliminates pecking.

Both the loaders and coolant systems allow operations to be run at higher speeds, added Jarvis.

**Northern Precision operates three Citizen L20 VII Swiss-style machines.**

## Tool Considerations

Compared to large production lathes, Swiss machines have limited horsepower. The peak output of the main spindle drives of Northern Precision's Citizen machines is about 5 hp. This dictates special considerations regarding tool geometry.

"You're not able to push a tool as hard," Jarvis said. "We have a strategy of going with a positive rake, which cuts down on torque and horsepower requirements, and we get better finishes as well."

Toolmakers' feed and speed recommendations often don't apply to Swiss machining. "There is so much difference between what an insert is capable of and what these machines can handle," Jarvis said. "Just because a manufacturer says you can feed an insert at 0.006 ipr doesn't mean you can do it on these machines."

To cut fine features on small parts, obviously, the tools must be very small. One of Northern Precision's drills measures 0.015" in diameter.

Rigidity becomes an issue with tools that small. For example, "the length of cut of standard endmills is usually way too long for us," Kerby said. "The longer the flute length, the more it's going to have to stick out of the collet. We usually end up using stub-length endmills to keep the rigidity up."

## Optimizing the Job

Despite the availability of automated programming software for Swiss machines, Jarvis said he programs the machines at the control, "by hand." This requires the job shop to continually optimize its operations for maximum efficiency—and profitability.

"The CAM program might spit out code that is usable, but it's going to spit out the same code for the next job shop," Jarvis said. "I don't feel you can compete that way."

The time required for programming and setup at Northern Precision de-

pends on the order. A job that it has run before can take 15 minutes. "A new part with a lot of programming—when you are tweaking an operation to get it right—can take a day," Jarvis said.

How much time is spent optimizing a job depends on the part volume. Usually, a new part is programmed at conservative speeds and feeds. "I'm running a job right now that's 250 pieces, and it doesn't do any good to work to make cycle times very fast for that small a run," Jarvis said. However, over a longer run, optimization pays off.

Kerby recalled, "When we first entered the program for a run of 40,000 parts, it took 48 seconds to make a part. By tweaking speeds and feeds, we got it down to 36 seconds." The few hours devoted to tweaking proved worthwhile. Over the course of the run, machining-time savings totaled 133 hours.

Northern Precision prides itself on its ability to produce difficult parts, often in ways that defy normal Swiss-machine operating practices. One such part was a screw with a ⅝"-dia. gear on it. "We hobbed the gear right on the machine," Jarvis said. "The machine makers said it couldn't be done. We ran 160,000 of them."

The crucial step in machining the 12L14 steel part—a component for an automobile's power mirror—was matching the speed of the hob with the spindle speed. "One rpm off and you've got a mangled mess," Jarvis said.

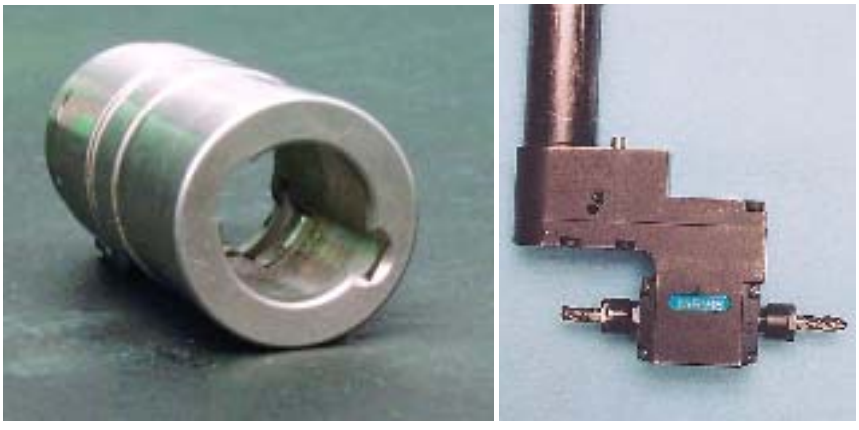
Northern Precision usually takes advantage of parametric programming to create complex contours with simplified programming language. The parametric programming language, also known as "custom macro," resides in many CNCs at the G-code level, and permits the use of variables, logic statements and looping. It enables machines to perform complex motions, such as interpolation.

Instead of needing many lines of code for a repetitive motion, with parametric programming, one line completes the entire task, Jarvis explained. "If you want to drill a hole [10 diameters deep], you have to program each individual drill movement—in, out, dwell. With parametric programming, you use logic statements to tell the machine to continue to a certain depth or dwell after so many pecks."

Northern Precision also uses parametric programming to produce long threads. Without a special attachment, the guide bushing limits the length of thread a Swiss machine can cut. The company found a way to use progressive turning to make a thread however long it wants. It turns a section, threads it, turns the next section and then matches up the previous thread with the incoming thread.

Jarvis pointed out that a CNC can basically repeat a thread, as in a deburring operation. "But most people don't understand how close the math has to be to match up an incoming thread with one cut previously. If you're out 0.0005", the thread is no good."

The key is matching the Z-axis movement precisely to the end of the previously completed length of thread. It is not simply a matter of telling the machine which Z-axis position to achieve; a mathematical function is necessary to determine the angle the tool travels to the desired end point. Jarvis said: "We have a formula that tells the control how far to move in the X-axis, and we name whatever infeed angle we want. I've shown it to the Citizen people who sold us the equipment. We're proud of it."



**Left: A vending machine component Northern Precision machined from ¾"-dia., 303 stainless steel bar stock. Note the chamfered broached feature on the facing end as well as the broached feature inside the part. A dual right-angle drill head (right), mounted in a live cross-tool position, enabled the shop to finish a slot on one end of a part in the main spindle and then chamfer a broached feature on the other end when the part was transferred to the back spindle.**

### A Prime Part

Another part that illustrates Northern Precision's approach to complexity and quality is a component for a vending machine's software-controlled lock. It was made from ¾"-dia., 303 stainless steel bar stock. Jarvis said producing the part on conventional machines would have required a minimum of five setups for turning, milling and broaching operations. Northern Precision made the part on one machine, in 15 operations, employing 13 different tools. Machining it completely took 3 minutes. Programming the most recent version of the part consumed 6 hours, and machine setup took 2 to 3 hours more.

The part had many challenging features, which Northern Precision handled in innovative ways. Three broaching operations, including an internal one performed 1" inside the part, were accomplished with specials. "The broaching operations were similar to shaping," Jarvis said. "The repetitive motions were accomplished through parametric programming."

To finish a large slot and produce a spherical chamfer on a broached feature, Northern Precision employed a dual right-angle drill head, mounted in a live cross-tool position. The head had a ballnose endmill on one side and a stub-length, square-shoulder endmill on the other. The arrangement provided the off-center end-working capability needed to square off the slot with the

part in the main spindle, and then, on the back spindle, produce the chamfer on the part's other end.

Cross-holes in the part had to meet a ±0.0005" tolerance, but the machine lacked enough live-tooling stations to mount a reamer. The solution was to program a small endmill, already used for another part feature, to circular-interpolate the hole to the required size.

### 'It Can Be Done'

Jarvis contrasted today's Swiss machines with the screw machines he worked with years ago. "These new machines are great. The accuracy is amazing," he said. "To change a dimension on a screw machine, you had to physically move a stop. On these [Swiss machines], you just punch in how much you want to move it and it moves."

What does apply from his screw machine days, however, is a can-do attitude. Jarvis said, "I worked with older fellows who really came up with some neat ideas. They had a philosophy of 'It can be done; you just have to find a way to do it.' It's what pushes us."

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