cover story

▶ BY ASSOCIATE EDITOR BRAD LEWIS
AND MANAGING EDITOR ALAN RICHTER

Iscar Metals

Precise Turns

A look at Swiss-style cutting tools and how they are applied.

By now, job shops are accustomed to the drumbeat of pessimistic news about the manufacturing sector: declining sales, layoffs, increased foreign competition—and the list goes on. Yet one area of precision manufacturing contradicts these gloomy tidings, where shops play to the strengths of emerging, and some say irrevocable, trends in metalcutting. These trends include small part runs, precise tooling and "mass-customization." That field is Swiss-style machining.

The operative word for this style of tooling and machining is "small." And to say tolerances are tight is an understatement of British proportions.

As Steve Baroni, foreman for Remco Swiss Ltd., Arlington Heights, Ill., said, "We can't go with tools that are imprecise. Here, a 0.005" tolerance isn't going to cut it."

Vince Robisch, Remco's president, added, "0.005" is a whole world of wrong."

To illustrate his point, Robisch held up his hand with thumb and index finger pinched together. "I just found one of these parts, so don't sneeze," he said as he laid down a tiny screw. "This beryllium-copper screw is turned out of a 0.062"-dia. stock," he said. "When you're turning this part, if you're more than 0.020" to 0.025" away from the guide bushing, the material is deflecting all over the place."

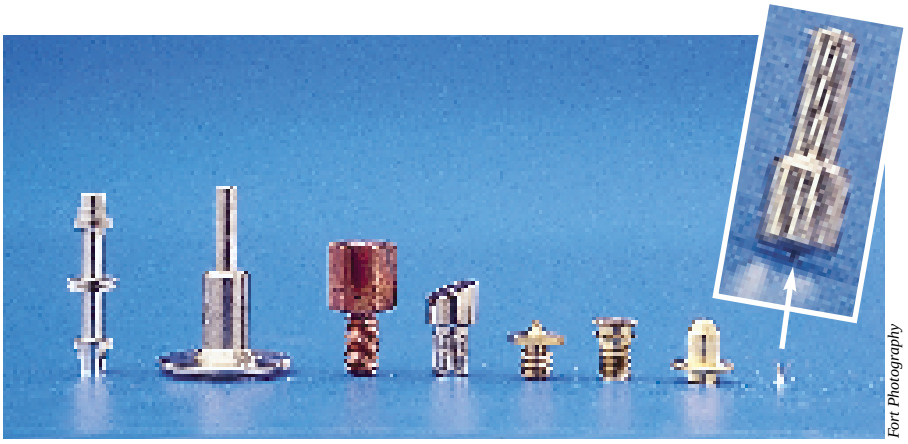
Still, if other types of machines can produce small parts, what makes Swiss-style turning unique? According to Robisch, there are two defining characteristics: the stationary guide bushing and the sliding headstock in the axial direction. Although significantly different from a conventional lathe, the operation of a Swiss-style lathe is fairly straightforward. Motion along the Z-axis comes from the workpiece itself, while the tool moves along the radial X-axis.

In addition to this tool/workpiece configuration, accuracy is maintained by keeping the tool/workpiece interface extremely close to the machine's guide bushing, typically from 0.025" to 0.040", Robisch said. He added that the distance primarily depends on the diameter of the bar stock, with a smaller diameter requiring a shorter distance than a larger diameter.

"You put those two things together and what you have is a stationary bushing with the tools right next to it. You never have a situation where the tool is farther away from the bushing. Therefore, you achieve a whole lot more ac-

curacy. The headstock moves forward and backward as necessary, to move the material past the tool," said Robisch.

While the need for a guide bushing is critical to Swiss machining, it can cause some problems, according to Bill Cox, president of Cox Manufacturing, San Antonio. "The guide bushing causes more problems than anything else because of the length-to-diameter ratio of the part," he said. "And it is especially true in running shaped stock, such as squares or hexagons. With any guide bushing, if you're running shaped stock, you have more irregularities in your turn diameter than you would off of a fixed-headstock machine."



Fort Photography

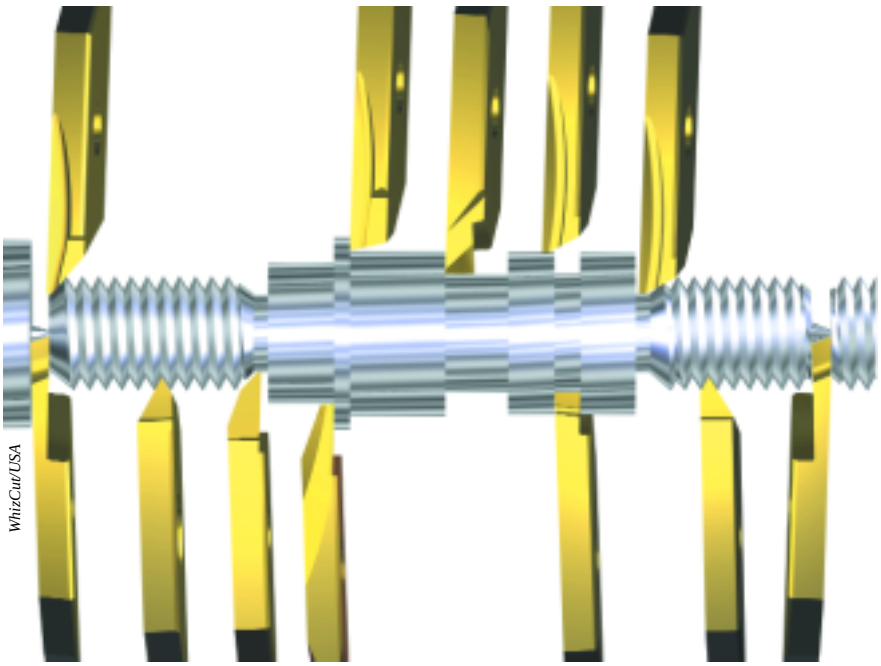
A selection of Swiss screw machine parts produced by Remco Swiss Ltd. The height of the parts measure from approximately 2mm (far right) to 17mm.

Mechanical or CNC

The types of Swiss-style machines are divided into cam-operated and CNC. The cam-operated variety is further subdivided into machines where the bar stock rotates, which are more common, and coil-fed lathes, where the cutting tools rotate around a nonrotating workpiece.

Cam-operated machines with rotating bar stock outnumber the more-expensive CNCs at Remco by roughly 4 to 1. And, like most Swiss-machining shops, Remco tends to use customized tooling and cams. "We don't pull generic tooling off the shelf," said Robisch. "When we get a new job, we engineer the tooling specifically for that job. The tooling is dedicated to that job only. When we finish the job, we pull the cams and the tooling off the machine and store it. So the next time the job comes along, the customer has already paid for the tooling, and it's all ready to go."

Cox also noted that cam technology is still alive and well. He added, "Twenty years ago, a set of cams were less accurate and cost more money than a set of cams that you can buy today that were produced on a CNC machine. The design work is done with a program, specialized for designing cams and cutting them on a CNC machine. So in many ways, our cam machines have been enhanced by CNC technology."



WhizCut/USA

Swiss-style indexable inserts are available for a variety of turning applications: On top (left to right): 35° copy turning, straight turning, grooving, finishing or 55° copy turning and copy turning. On bottom (left to right): straight or angular cut off, threading chuck ends, back turning with relief, grooving, threading and angular cut off close to the subspindle or support.

The main characteristic of Swiss-style tooling, besides being small, is the need for greater tool clearance to minimize pressure, according to Dave Branvold, foreman for Bay Swiss Manufacturing, Dayton, Nev. "The tool can't be subjected to a lot of friction," he said. "Otherwise, the bar stock will freeze up in the guide bushing."

A secondary characteristic Branvold cited was the need for cutting tools with positive angles. "Up until the last few years, we've stayed away from inserts because they could not meet our requirements. We would often grind our own tools from carbide blanks," he said. "Now we're using more inserts."

Branvold's experience is not exclusive to his shop. Many Swiss-machining shops found the simplest way to meet their tooling needs was to grind their own brazed carbide tools. In addition to Branvold and Robisch, Cox also emphasized his shop's need to custom-grind tools. "We use a tool that's ground especially for an application," he said.

But in response to a growing demand for stock tools, Swiss-style machinists have noticed more inserts are becoming available for their applications. "There's still a shortage of inserts for Swiss applications, although in the last 5 years it's improved a lot," said Cox.

David Wills, technical director for Stellram, LaVergne, Tenn., couldn't

agree more. “We’ve always been linked to this part of industry,” he said. “Having come from a niche-type of industry in Europe, one of our strongest niches in the U.S. is the small-turning program.”

Moreover, Stellram actively seeks out areas where it can help end users. Wills said: “Where we like to work with a customer is if he has problems with other cutting tool suppliers. We would obviously like to offer our services and our R&D department to improve his components and cycle time. Actually, we’ve gained a lot of respect from our customer base, and if we solve their problems, they stay with us.”

The strongest growth area for suppliers of Swiss-style cutting tools appears to be in CNC machining. Unlike cam-operated machines, indexable, coated-carbide inserts are primarily applied when producing parts on CNCs. “On the Swiss-style CNCs, in most cases, we’re using an insert,” said Cox.

Dick Reiling, president and owner of Micro-Matics Corp., Minneapolis, said that he doesn’t think the time will come when Swiss-style machinists can totally stop making their own tools. “But,” he conceded, “we are trying to use indexable inserts as much as possible. They’re more expensive, but when the tool wears out, it’s a simple matter of changing out the insert. There’s little time or parts lost in the operation.”

Expanding Market

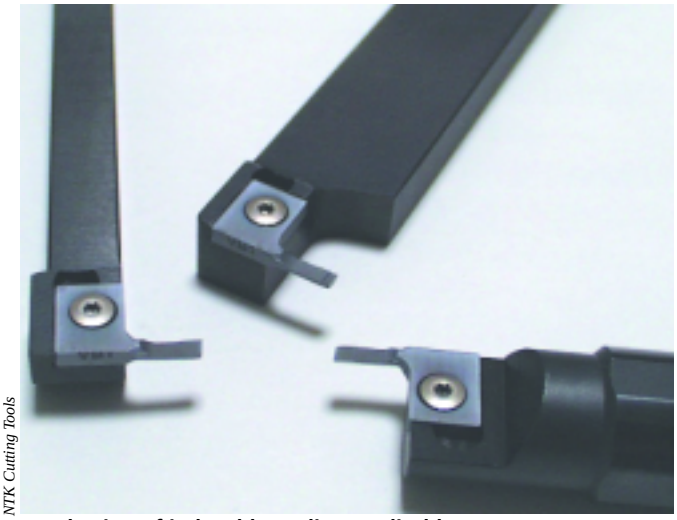
So what’s behind the growth of Swiss-style machining?

“I think the high-tech industry is driving the growth of Swiss machining,” said Wills. “The components are getting smaller and more lightweight, and the materials are getting more exotic. When I talk to the Swiss-machine OEMs, they say they’ve increased their business by 45 to 50 percent in the last two years. I don’t know of any other machine tool sales that grew 50 percent in two years.”

Wills added, “The other issue with these Swiss machines is that they are so accurate.”

Raymond Koontz, vice president and owner of Century Tool & Design Inc., Milldale, Conn., concurred that the demands of the high-tech sector, especially with its need for precision stainless steel computer parts, is one of the big reasons for the rise in Swiss machining. He added that this type of machining is applied to produce lower-tech products as well.

“Take the flint wheel on a Bic lighter,” said Koontz. “We produce the tooling for machining it. We also do the tooling that machines the valve for the lighter’s flame,” he said.



NTK Cutting Tools

A selection of indexable tooling applicable to most small, Swiss-type CNC lathes.

Primarily, job shops produce Swiss-style screw machine products by applying cutting tools composed of a piece of carbide brazed to the tip of a steel shank. These cutters also are called brazed carbide tools or “stick” tools. But the situation is changing as cutting tool manufacturers introduce more configurations of standard indexable inserts for Swiss machining.

Although the unit price of a brazed tool costs less and can be reground dozens—and possibly hundreds—of times while a worn insert is generally indexed or thrown away, the convenience and productivity enhancement motivates Swiss shops to increasingly try inserts, said Tommy Townsend, president of WhizCut/USA Inc., Little Rock, Ark.

According to Townsend, since a brazed carbide tool needs to be removed from the machine to be reground, its cutting edge is more difficult to relocate on the part after it’s placed back in the machine than an indexable insert. On the other hand, Townsend said the insert remains in the same location in relation to the workpiece after it has been indexed.

In addition, Townsend said it takes about 11 seconds to index an insert while 5 minutes of downtime is consumed to remove, regrind and replace a brazed tool.

He considers stick tools “ancient technology. And since a stick tool can cost $1,000 when you factor in machine downtime and labor, anyone who can find an appropriate indexable insert will use it. As we introduce new inserts, people are disregarding their stick tools.”

As a result of the increase in Swiss turning and Swiss shops consuming more indexable inserts, Townsend said the U.S. market for indexable Swiss tooling is rapidly expanding. “I have 150 customers and the number is growing every day. It’s beyond my expectations,” he said.

Dave Strobelt, Swiss tooling product manager for Manchester Tool Co., Akron, Ohio, agreed that the growth of Swiss machining is expanding every year, but it still represents less than 10 percent of the overall U.S. metalcutting market. Nonetheless, cutting tool manufacturers are noticing the market potential.

“The trend is toward more manufacturers offering a cutting tool line dedicated to Swiss machining,” Strobelt said.

Coated Geometries

Besides being more convenient and enhancing productivity, Strobelt said indexable inserts for Swiss-style machines can also improve surface finishes, reduce built-up edge and improve chip control.

Strobelt said Manchester’s double-end inserts are ground up-sharp and PVD-coated with TiN or TiCN to help reduce BUE, especially in 300-series stainless steels. These stainless steels also are known for their propensity to generate long, stringy chips, which can be controlled by applying inserts with chipbreakers.

Small parts, great implications

BY TECHNICAL EDITOR CHARLES M. BOYLES, CPE

A bidirectional contact for a switch on a Harley-Davidson, a titanium implant for a root canal and a steel needle valve for a hydraulic system are just of few of the many parts produced on Swiss-style machines. These small, relatively long, precision parts often have tolerances of 0.0004" on the ID and 0.0003" on the OD.

Swiss-style screw machine shops produce parts like these in lots of 1,000 to 500,000, or more, with cycle times as low as 6.5 seconds. Swiss-style machining—done primarily in dedicated shops—often involves the removal of 90 percent of the material in the first pass, excels at maintaining concentricity over long turns and eliminates finishing operations like grinding.

However, to produce this level of quality, Swiss-style machining requires very round, consistent bar stock. If the stock varies, the variation shows up in the part. This consistency is met with Swiss-quality brass, steel and stainless steel produced to tight tolerances. Swiss-quality, cold-rolled stock is not available, but cold-rolled stock can be "skin-ground" to ensure roundness. This step adds 15 to 20 percent to the price of standard materials.

One Swiss-style shop is Lombard Swiss Screw, Addison, Ill. It turns brass, copper, phosphor-bronze, aluminum, leaded steel, free-machining steels, 300- and 400-series stainless steels and nickel-chrome-molybdenum alloys (8620s).

Lombard Swiss Screw President Bernie Seewald has found that tool life depends on the finishing requirements and varies substantially from material to material. For instance, when machining the same part in different materials, a cutting tool may produce 2,000 pieces in stainless, 3,000 to 4,000 pieces in free-machining copper, and 20,000 to 50,000 pieces in brass.

"The 303s and 416s are very difficult to machine, so we use Carpenter Project 70 stainless, since it's the best for machining," Seewald said. "Also, we use Micro 100 brazed carbide tools, which we grind on a diamond grinder, as well as TiN-coated inserts."

Tool life also depends on part design. Parts having square corners or shoulders, as opposed to radiused corners, can limit tool life to 1,000 pieces for some materials.

Since machine feeds on the shop's Swiss-style machines are left-handed, the tooling, including the drills and reamers, must be left-handed. This makes the cutters sort of unusual. And because left-handed reamers are not readily available, Lombard Swiss Screw makes its own.

In Swiss-style machining, one has to be concerned with how the tool reacts with the part and how the part reacts with the machine. Operating with a bushing inside the collet allows a shop to turn longer parts, but it has limitations. Since small parts have limited capacity to transfer heat from the cutting zone, any thermal expansion can be problematic.

For example, on 316 stainless steel parts measuring less than ⅛" in diameter and about 2" long, the cutting speed must be limited to 90 sfm; higher speeds generate too much heat and cause the part to weld to the bushing.

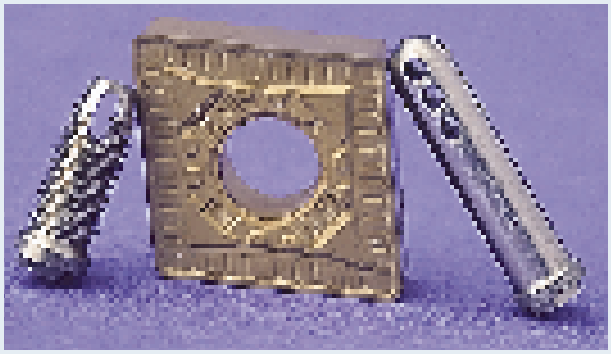
While newer Swiss-style machines are CNC-equipped, the majority of machines—60 to 70 percent, by some estimates—are cam-driven. However, even with a CNC, production is still limited to smaller parts. The size limitation—traditionally a maximum of 1¼"-dia. bar stock—has to do with the difficulties of handling larger stock.

Larger diameter stock—2", for example—in 12' lengths is not only heavy but cumbersome to handle. Holding tight tolerances on large dimensions is expensive—a built-in constraint.

And, currently, there is a serious shortage of operators, setup personnel and programmers for Swiss-style machining. Compounding the labor-shortage problem, Swiss-style machines are a challenge to set up and program. Typically, it takes up to 8 hours to set up a CNC Swiss-style machine for turning a new part. The setup includes ensuring that up to 16 tools and the tool paths for up to 7 axes are properly arranged in sequence to machine a part correctly, as well as setting up and adjusting the bar feeder.

Steve Rose of Rose Training Systems Inc., Solon, Ohio, said, "In a typical training cycle, a machinist can be trained to operate a Swiss-style machine in about 2 to 3 months—Level 1. To increase operator skills to the point at which he can set up a machine—Level 2—it takes about 9 months. And to learn programming for a Swiss-style machine—Level 3—means about a year."

This training does not even address the skill and knowledge required to design and manufacture cams for the older machines.



Fort Photography

These threaded, titanium dental implants from Lombard Swiss Screw can be used as mounting posts for teeth and are representative of parts produced on Swiss-style machines.

Manchester Tool Co.

This tooling for cam-style and small, Swiss-type CNC machines targets the makers of precision parts that measure less than 5mm in diameter.

In addition, Strobelt said the company's inserts have a mirror-like finish—especially the highly polished CSV inserts for cam-style and small Swiss-style CNC machines—which allows them to impart finer surface finishes. This is particularly important for medical and dental hardware smaller than 5mm in diameter.

Because up-sharp cutting edges with minimal edge preparation are needed to produce the small-diameter, intricate parts typically Swiss-turned, Stellram's Wills noted that a single-layer, PVD coating works best. "When the coating is 5 or 6 microns thick, we're finding that that is too thick for Swiss applications," he said.

Coatings help to extend tool life, said Neal Buschmohle, assistant general manager for NTK Cutting Tools, Farmington Hills, Mich., and although 90 percent of the Swiss-style tooling NTK sells is coated, the company also offers uncoated inserts.

Buschmohle added that some end users regrind inserts, even though the company recommends against doing so. Regrinding may cause the tool to crack or break, or it can lead to poor finishes.

Century Tool's Koontz agreed that coatings are important for the life and performance of Swiss-style tooling, but also mentioned the need for chip control, especially in cutoff operations. He said Century grinds a groove, or notch, into the end of its inserts that "pulverizes" the chip.

"When you are cutting off with an insert without a groove in it, the chip peels off in the shape of a curly Q. As that insert is cutting and knocking out a chip, it's also keeping the oil from staying on the cutting edge. The oil is on the chip as it's coming out of the cut," Koontz explained. "The insert still works, but with the notching, as the insert is cutting off, it's pulverizing the chip immediately. Therefore, the oil is kept on the cutting edge all the time."

Substrate Considerations

The vast majority of inserts for Swiss-style machining have micrograin-carbide substrates.

To a lesser extent, cermet and ceramic inserts are applied as well, said Brent Lindsey, applications engineer for Kyocera Industrial Ceramics Corp., Mountain Home, N.C. He added that the choice of cutting tool material is determined by the machining operation and workpiece material.

Mike Gadzinski, manager of technical seminars and training for Iscar Metals Inc., Arlington, Texas, agreed that the substrate for Swiss tooling is primarily carbide. Cermets yield a better surface finish at higher speeds, because chips slide off the tool easier, Gadzinski said, adding that Swiss-style machines usually don't have fast enough spindles to make cermets as practical as carbide tools. "Below 700 sfm, cermets don't show that much advantage."

With carbide, how well the coating and substrate complement one another determines the speeds and feeds, said Strobelt.

Wills also emphasized the importance of micrograin-carbide substrates for Swiss turning, but said that 60 percent of an insert's performance is based on the coating preparation and adhesion. He divided the remaining 40 percent equally between the insert's substrate and its geometry.

All those interviewed agreed that as more Swiss-style cutting tools are consumed, more productivity-enhancing inserts will be introduced to replace conventional brazed tools.

"I believe end users will opt for indexable inserts when the needed configurations are available," Strobelt said.

For more information, go to "Article Search" and choose the "Turning" and/or "Screw Machining" categories.

Suppliers of Swiss-style tooling that contributed to this article:

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(800) 229-2368
www.centtool.com
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Iscar Metals Inc.
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www.iscarmetals.com
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