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BY MIKE PRINCIPATO

Paradise found

A couple of years ago, I wrote a column—more a cautionary tale, really—about three buddies of mine who were thinking about bolting from their jobs as top-dog machinists to launch their own shop. Using their discernment process for context, I wrote about the importance of shop owners and managers stroking key employees, noting that in the absence of such care and feeding, great craftsmen would find greener pastures elsewhere.

Recently, I visited one particular "greener pasture" and had an enjoyable but all-too-brief visit to the machine shop launched a few months ago by that same group of buddies. One step into their modest headquarters, and I was as happy as a kid in a candy store.

What is it about the smell of metalcutting—the distinct aroma that wafts from the stew of hot chips and coolant—that is so irresistible? After just a few months in operation, this new shop reeked wonderfully. It made me want to do something dangerous, like run out and buy a new milling center.

Standing in formation on the floor like soldiers straining to do battle were the glorious machines that enable a small startup like this one to hurtle from nowhere to your best customer's doorstep faster than you can say "automation." A 4-axis machining center. A 10" CNC lathe. A CAD station. And a full complement of conventional gear. Some new, some used, but all bearing the telltale sparkle of well-maintained, precious assets. I've seen that same care given to grand pianos, racecars and artist's brushes. It's a literal reflection of the owner's pride in his special tools of the trade, simultaneously purposeful and personal.

These three guys have bet their respective ranches on their collective ability to profitably compete in one of the toughest businesses in America today, and every nook and cranny of their leased domain confirmed that they've got their priorities straight. No frills here. The emphasis of their startup business model suits the harsh landscape of U.S. contract manufacturing: Quality and on-time delivery gets you in the game. Price scores the runs.

I know these guys well enough to expect that—in a heartbeat—they'd swap a snazzy new Herman Miller desk chair for another lightly used bandsaw. The former looks cool and costs money; the latter is as attractive as Star Jones in spandex but makes money all day long. Who needs a fancy chair when you're busting your butt launching a new machine shop anyway?

Not surprisingly, customers are finding the new shop by word of mouth alone. A timely reminder for me, who faithful readers will recall is a marketing guy first and a manufacturing guy by default: Customers pay only for great parts and customer service; everything else is a nice convenience, period. Neither slick marketing nor any amount of skillful shmoozing can offset crappy components delivered late. That's a lesson the former employer of my three friends never learned, and something tells me that, given the geographic proximity of the new kids in town, he'll be regretting that soon enough.

Listening to these new entrepreneurs tell me about their recent conquests—selling new accounts, winning their first big order, securing a small line of credit—all while their single telephone handset continuously rang (a good omen if there ever was one for a new business) planted a big cheesy grin on my face that I was still wearing hours later. It took me back to my first days as an aspiring manufacturing titan, when the world was full of brass rings waiting to be grabbed.

What is it about the smell of metalcutting—the distinct aroma that wafts from the stew of hot chips and coolant—that is so irresistible?

That feeling, I suppose, is the point of this column. What better way for you to start the New Year than with the enthusiasm of a new owner or manager? After all, what's the difference, really, between my three friends and you? What's stopping you from feeling the excitement, the thrill, the *endless possibilities* of controlling your own capitalistic destiny?

If you are like me, it's because you're a grizzled, jaded veteran. We know all about the way it used to be in the metalcutting industry. When trade skills were plentiful. When American tool and die shops ruled the Earth. Before Mexico. Before Taiwan. Before China. We know how lousy cash flow can discourage the grandest dreams, how a stalled economy can decimate an industry and how losing a major customer can turn a balance sheet from friend to enemy and blood to ice overnight. After 5 years of getting the global economic stuffing knocked out of us, maybe we're just too damned old, cranky and tired to get excited about our business anymore.

If so, consider this: Tonight, my entrepreneurial friends are still at work, estimating jobs, programming machines, cutting metal, wondering when they'll be able to buy their next machine, thanking God they live in a country where they can shape their future with their own skill, guts and dough … and loving every minute of it. Are they nuts?

What do *you* think?

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Facing facts

One common type of milling cutter is the facemill. Facemills, like all milling cutters, are rotary tools with cutting edges that intermittently engage the workpiece.

Facemills are designed to machine surfaces parallel to the face of the cutter, effectively generating flat surfaces. A facemill is mounted on a spindle with an axis of rotation that is perpendicular to the workpiece surface. Each tooth of a facemill cuts on its circumferential surface and on one side. The teeth on the peripheral edge of the cutter practically do all of the cutting, while the bottom edge cleans up the workpiece surface and imparts the surface finish.

Facemills can be fed horizontally or vertically. Climb milling—cutter rotation in the direction of the table feed—is generally preferred. The forces in climb milling tend to push the workpiece into the fixture, and the chips form in a way that carries heat away from the workpiece.

Whenever possible, the edge of the workpiece should be in line with the center of the cutter. This position of the workpiece in relation to the cutter helps minimize workpiece movement.

Coarse-pitch cutters work well for roughing because they generally have larger chip gullets and provide more chip clearance for the heavier chip load.

The position of the cutter centerline relative to the workpiece also determines the cutter's angle of entry. A negative angle of entry is preferred because it ensures contact with the workpiece at the strongest area of the tooth—away from the cutting edge. A positive angle of entry causes the tooth to make contact with the workpiece at the cutting edge—the tooth's weakest point. Chipping of the cutting tool can result.

DOC in facemilling is measured both axially and radially. Axial DOC is the distance the facemill is set below the unmachined surface, and is determined by how deep the peripheral edges cut. An axial DOC is typically selected to minimize the number of passes required to remove a given amount of material. Radial DOC is the width, or distance, of workpiece surface engaged by the tool. The maximum WOC that a facemill can produce is determined by the effective cutting diameter, although full WOC is seldom recommended.

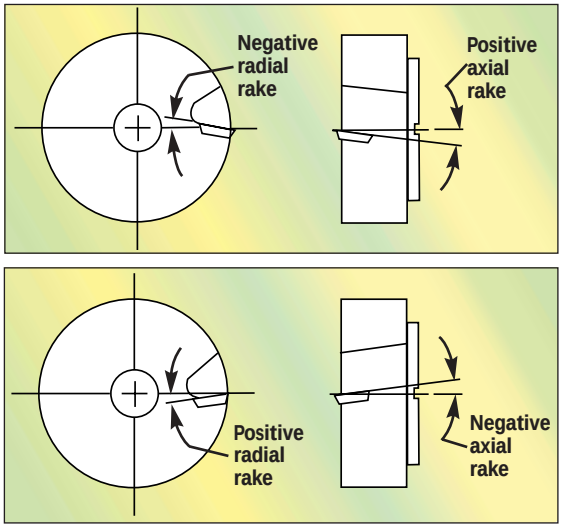
Modern facemills usually feature indexable inserts clamped in multiple pockets in the tool body. The number of inserts employed depends on the pitch of the cutter. A coarse-pitch cutter has fewer inserts than a fine-pitch cutter of the same diameter. Coarse-pitch cutters work well for roughing because they generally have larger chip gullets and provide more chip clearance for the heavier chip load. Conversely, fine-pitch cutters are well-suited for finishing. The greater number of inserts allows higher table feeds at lighter DOCs and lighter chip loads per tooth.

Three basic facemill geometries— double-negative, double-positive and positive-negative—help determine cutter characteristics.

A double-negative facemill positions the inserts at negative axial and radial rake angles. It is used to rough cast iron and hardened steels with machine tools that have adequate power and rigidity. High cutting forces are developed as the facemill is pushed into the workpiece.

While the double-negative design generally produces a poorer surface finish than the other geometries, it presents the strongest part of the cutting edge to the workpiece and, therefore, can withstand heavy chip loads. These attributes make a double-negative facemill a good choice for roughing.

A double-positive facemill positions the inserts at positive axial and radial rake angles and cuts with less machine horsepower because of its higher shear angle. The high shear angle reduces the shock load at the tool's entry point.



The various rake angles for a facemill.

A double-positive facemill is a good choice for less rigid setups or for machines with limited power. It also lends itself to the machining of fragile workpieces and materials that have a tendency to workharden. The high shear angle produces spiral chips that are directed out of the cutter, resulting in a finer surface finish than the double-negative facemill.

A positive-negative facemill positions the insert with an axial-positive and a radial-negative rake angle, combining strong cutting edges with a high shear angle. The combination of geometries causes the chips to flow away from the cutter and the workpiece.

These features make the positive-negative facemill a good choice for heavy roughing. The positive-negative facemill allows the cutting of free-machining steels, prehardened steels, cast iron, and some of the difficult-to-machine grades of aluminum and copper alloys.

The straight and narrow

BY BILL KENNEDY

The strict requirements for an aerospace application can make even a simple-looking part challenging to manufacture. Arrow Grinding Inc., Buffalo, N.Y., is a grinding shop that services aerospace customers as well as others.

Among the demanding aircraft parts the shop makes is a stainless steel, low-friction linear bearing called a slide rail. Although the part looks like a plain chrome-plated tube, it is a critical component of a hush kit for a large twin-jet business aircraft. A hush kit is a system of movable deflectors added to an engine to reduce noise in response to tightening environmental regulations. The deflectors move along the rails, which have to offer low friction and high wear resistance. Each engine features two slide rails per side, for a total of eight per aircraft. John Goller, Arrow president, said his company worked with the customer to develop a process to grind the rails, chrome-plate them, and then finish grind them to provide maximum precision, long life and rigidity.

The basis for a rail is a 43.96"-long, 0.748"-OD, 0.59"-ID, welded 17-7 stainless steel tube with a 30º chamfer on each end. The alloy is heat-treated to an H950 condition.

Workpiece straightness is crucial to accuracy. Klaus Koeller, Arrow plant manager said, "The tube has to be very, very straight, or the grinder will take more in some places than others."

As a result, Arrow straightens tubes upon receipt, and at a number of points throughout the manufacturing process. Straightening takes place on a manual arbor press. The goal is to maintain less than 0.005" runout over the length of the tube.

"It's quite an art to be able to straighten one of these," Koeller said. "Obviously, being a fairly thin-walled tube, if you put just a little too much pressure on while you are straightening it, it will kink."

Koeller said the first straightening may take from a half hour to an hour, depending on the condition of the tube when it arrives. The straightness of the tube affects all operations that follow. The tube is ground on a Cincinnati Viking CNC centerless grinder to an OD of 0.744" to 0.7445," removing about 0.001" per pass with a 70-grit aluminum-oxide wheel from Norton Abrasives. This takes about an hour.

Arrow then sends the tube out for chrome plating, which adds about 0.004" to 0.005" per side. "The more chrome we have, the more difficult it is to do a finish grind," Koeller said. "A tube this long, with a lot of chrome on it, tends to not grind evenly." In addition, too much plating can metallurgically damage the stainless steel.

When the tube returns from plating, Koeller said, "it generally has been bent again, because it sits in a tank and there is heat applied."

Back on the Viking grinder, Arrow changes the wheel over to a 70-grit silicon-carbide Norton wheel to grind the chrome. The DOC per pass is light: 0.0001" to 0.0002". This step can consume 2 hours. All grinding takes place with coolant, but the idea is to avoid generating any heat. "The expansion coefficients of the chrome and the base metal are different, and if there is any heat applied when you are grinding, the chrome can actually separate from the base metal," Koeller said. The finished tube has a uniform thickness of chrome of about 0.002" per side.

As the tube approaches its final OD of 0.749" to 0.7495" during the post-plating grind, it may bend again. Consequently, Arrow measures the tube and, if necessary, performs straightening between passes. "We run the tube through, check it, if it is still straight, take another cut," Koeller said. When the OD grind is completed, the tube is checked again and straightened as needed. Final surface finish is 16 R_a.

Arrow

This detail of a 44"-long slide rail shows a 0.300"-wide ground area that stops 2" from the end of the tube.

In use, the rails are joined in pairs with a flat, perforated aluminum plate that is welded between the rails along their lengths. To achieve a good weld, the chrome must be removed from each tube in a 0.300"-wide section that extends along the tube's entire length, except for 2" on one end. Using proprietary fixturing technology to clamp—but not bend!—the tube firmly and precisely on an Okamoto surface grinder, Arrow applies a Norton 60-grit ceramic wheel to remove the chrome. The wheel is formed to match the curvature of the tube. The grinding challenge in this case was picking the right wheel and parameters to grind through the chrome while not burning or warping the base material when the wheel breaks through the plating. Multiple light passes of about 0.0001" to 0.00015" were again the answer, consuming another 2 hours. After the longitudinal grind is done, the tube is straightened a final time.

Adding up the time consumed in grinding and straightening, but not including the time required for plating, completing a tube takes "a little less than a day, start to finish," Goller said. *For more information about Arrow Grinding Inc., call (800) 374-7463 or visit www.arrowgrinding.com.*

Virtual training

BY GREGORY FARNUM AND DAVID GEHMAN

Few jobs exist that are more hands-on and subject to change than a machinist's. No wonder most metalworking companies find themselves spending more on training. Can this sort of instruction be effectively—and economically—provided via computer?

The short answer: not completely. Information gained by tapping on a keyboard or wielding a mouse can never totally substitute for time in front of a machine. Still, computer-based training (CBT) has some pluses.

"The advantages are visual access and the ability to replay at will," said Ron Smith, manager of the Virtual Machine Shop, an online collection of training modules for the machine shop at www.jjjtrain.com/vms. He contrasts that with hands-on training, where "any time you have more than three people around an actual machine, somebody's going to have a hard time seeing and hearing."

VMS' modules were developed originally through Cerritos College and Gateway Cities Partnership Inc., a Paramount, Calif.-based economic development organization for some 27 cities in the greater Los Angeles area, under a U.S. Bureau of Labor grant.

According to Smith, aspects of machine tool and shop operation that fit well into the world of CBT include: overviews of machines, specifics of machine operation, methods and procedures, NC programming and housekeeping basics. Basically, anything that's repeated might make a good candidate.

While today's CBT makes use of almost every audio-visual medium available, most of it falls into one of two basic types: horizontal, for subjects of shopwide import, or vertical, specific to a single machine tool or process.

Examples of the horizontal type include the free manufacturing education pages from Michigan Technological University (www.mfg.mtu.edu/marc/primers/), as well as the postings on VMS. Between them, there is a lot of useful information about machine types and shop software and hardware. VMS has a discussion forum to air opinions and share experiences. Both are collections of online modules and are not intended as a full curriculum.

If a company is looking to access more rigorous training via the Internet, and is willing to pay for it, there's Tooling University (www.toolingu.com). Tooling U offers more than 180 courses in English and Spanish, complete with textbooks and computer technical support.

An expanding range of vertical training materials is available as well, most of it from machine and tooling manufacturers. Among the more noteworthy are those from Hydromat Inc., St. Louis; Makino Inc., Mason, Ohio; and Seco-Carboloy Inc., Warren, Mich.

Hydromat's CBT consists of an eight-disc CD-ROM offering. "It's quite extensive," said Kevin Shults, the machine tool builder's marketing manager. "The CDs cover every aspect of the operation and maintenance of our machines—an all-inclusive package for someone who needs to run a Hydromat machine and maintain it."

The interactive course employs video clips, photos and text. The user can begin at any level and, of course, repeat any segment at any time.

In developing its training materials, Makino sought to reduce the hassles of learning how to operate a new machine. "Companies are lean," pointed out Tim Jones, Makino's product line manager. "It's increasingly difficult for them to tie up people for a week or so by sending them to the machine tool builder when they need training."

For Makino, CBT seems more accessible, flexible and immediate than traditional training. When a customer buys a Makino machine covered in the training program, as soon as the order is placed but before the machine is delivered, the customer has immediate access to the online materials. "Because this course is for multiple users, customers can train as many of their employees as they want at a fraction of traditional costs," Jones said.

Seco-Carboloy has changed the focus of its traditional, off-site, lecture-based training program to emphasize CBT conducted at the customer's facility. Ron Davis, Seco-Carboloy's manager of technical marketing services, said: "Portable PCs with video playback enable our staff to demonstrate various real-world tooling applications. We're able to give customers educational engineering support and customers don't need a completely equipped lab to evaluate new options." The training program looks like a Web page, with navigation buttons to select and run different applications. "Computerized demonstrations really help students comprehend what's going on with cutting tools," Davis said.

Davis provided an apt summary of the benefits of CBT: "A past pattern was for a customer to send a select group of employees to the class, expecting them to pass on the knowledge they gained. That's fine in theory, but it often didn't work. Not everyone is a good student, and even fewer are good teachers, so the results of this approach tend to be spotty at best. CBT [prepares] the best operators to demonstrate the best practices to anyone with a computer."

About the Authors

Gregory Farnum is a Detroit-based journalist specializing in industrial and scientific issues. David Gehman has been writing about manufacturing and software for more than 20 years as both a journalist and a marketing communications specialist.

BY MICHAEL DEREN

Don't get left holding the bag

The people I know in manufacturing who work as application engineers, programmers, mechanical engineers and so on are sort of a gypsy lot. They work at a company for a year or two and then move on. In many cases, they follow the work load. In other cases, they follow the money. Unfortunately, other engineers have no choice but to relocate to a new position due to local economies.

In many instances, you are asked to travel to an interview. In all instances, when you travel a long distance, you should be reimbursed for expenses. Airfare, mileage, tolls, hotel and meals are all items that are typically reimbursed.

The interviewing company usually prescreens potential candidates by phone, and then narrows the field to those they want to interview in person. I have had a company hold two phone interviews and then a video conference interview before bringing me to their facility. When I did go for the in-person interview, the potential employer put me up in a nice hotel and paid for my meals and mileage. When I left, I was told to send in the receipts for my expenses and was promptly reimbursed.

Back in mid-August, the lab administrator of a prominent research university in Baltimore contacted me about a position available as a machine shop coordinator in its engineering school. After we spoke for a while, he asked me how soon I could come in for an interview, as he was very interested. I told him it would be not until the following Friday. He suggested that if I could come in sooner, it would be better, as the school year was starting soon. I told him I would make arrangements to be there on Monday, which was in 4 days.

That day, I received an e-mail from an office assistant confirming my appointment on Monday and listing my interview schedule with several members of their organization. A couple of hours later, I received another e-mail from the administrative assistant. It stated: "I have made a reservation in your name at ____. Below is your hotel information and confirmation #. Also, you can send your airfare receipts to my address below for reimbursement. I will need your social security number and mailing address to process the refund." Great, this is a professional and efficient organization, I thought.

After trying to make airline reservations on short notice (airfare was well over $600) and finding out it would take more than 7 hours of in-transit time to fly there with no return flight on the same day, I decided to drive instead. The drive would only be 9 hours, with a lot less hassle. It would also save the university at least a couple of hundred dollars.

I left on Sunday, arrived that evening and had my interview on Monday morning. After several hours, the interview process was over. I then met with the administrative assistant, who gave me a partially filled out expense sheet to complete when I arrived home. She stated that I should wait to send the completed expense sheet until the administrative manager returned the following week from vacation. The manager would determine what budget(s) the funds would come from. No problem.

The following week I submitted the expense report for reimbursement. It amounted to less than $450. They covered the hotel, so I only asked for mileage and tolls.

After about 3 weeks without hearing from them, I contacted the administrative assistant. She stated that the manager had the expense sheet, but since only $300 was allocated for reimbursement, they would deduct the hotel from that amount and I would be receiving the difference, approximately $130.

What? When did they tell me this? Never. That is, until after the fact.

Although she was extremely slow in responding, I eventually talked to the manager and discussed the arrangements. On October 8, almost 2 months after their initial contact with me, I received an e-mail back from the manager. It stated, in part: "_____'s e-mail does not reference a specific amount that would be reimbursed to you for your expenses, nor does it state that we would reimburse all travel expenses. However, _____'s e-mail to you dated 8/17/04, which I will forward to you, states, 'With $300 being the given amount for travel ...,' supports the arrangements I mentioned to you in our conversation several days ago …"

Unfortunately, I never received this e-mail. Even if I had received it, it was composed and sent the day after my interview! Shortly after I received this e-mail, I sent a response, but have yet to hear from them.

This was the first time I ever ran into a pitiful organization like this. Had they told me that they had a fixed budget of $300 for the interview, I could have made a decision as to whether the position would be worth interviewing for.
The lesson to be learned: When you have to travel for an interview, get the reimbursement details up front, in writing. △

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