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STAYING SHARP

manager's desk

By Keith Jennings

Up productivity by working less!

The dog days of summer are here, and those of us in the machining business have our hands full. We don't have much free time. For example, one employee recently explained how he has never completed a home project because his work projects eventually find their way home and take precedence. He wasn't complaining, just entrenched in the daily grind.

Most likely, you and your employees don't have much time for training and entertaining customers, much less a relaxing vacation. However, whatever the schedule or situation, nightly escapes from the machine shop's turmoil may increase employee productivity. How?

I'm no psychologist or scientist, but I've discovered a simple, yet effective way to become more productive at work: I don't work more, I work less. This way can't be learned in a productivity course for "three easy payments of $49.99." It's a matter of clearing one's mind of shop stress when not in the shop. It's become all too common for many employees to work on shop stuff at home or sit at the home computer like a zombie, checking and answering e-mails, constantly thinking about the current fire drill and not enjoying life.

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Technology has made it possible to connect to work computer systems from anywhere and subsequently our work goes with us everywhere. It's causing many problem solvers to become exhausted, draining them of the creativity and enthusiasm needed to think of effective ideas and solutions and to make their jobs interesting. Then, what used to be an exciting career has turned into a tired one that never stops. Instead of exceeding customer expectations, now they're satisfied just to ship an order and get it off the backlog. Instead of ending the stress, this obsession with catching up at home is only a temporary fix, requiring workers to take work to the kid's ball game, dinner with family or wherever they go.

What can someone do to fix this stagnation and get going again? We all deal with stress in different ways, and my solution may not be yours, but the key is to quit working 24-7. When the job is done for the day, don't carry that burden home and have it negatively impact your private life. Go home and listen to music or take a walk. Talk to a neighbor about fishing, your first car or how to remodel a bathroom. The possibilities are limitless.

Maybe you're like me and have evening activities with kids. If so, avoid work-related phone calls. Instead, put the phone on silent. When you return to the shop, perhaps your mind will be cleared because you spent time relaxing. With a mind cleared of stress and distractions, you'll be better able to focus during normal working hours, generating enthusiasm among co-workers, creating solutions for customers and ultimately getting more done.

Of course, there are times when working late or at home is necessary, but it shouldn't be a way of life. If it is, there are probably other problems in the shop that need to be addressed. Work during working hours, don't think about work after work and come in the next day with a rested body and mind. You may be amazed at the results. CTE

About the Author: *Keith Jennings is president of Crow Corp., Tomball, Texas, a family-owned company focusing on machining, laser cutting, metal fabrication and metal stamping. He can be e-mailed at kjennings@jwr.com.*

Transforming concepts into hardware

By Bill Kennedy, Contributing Editor

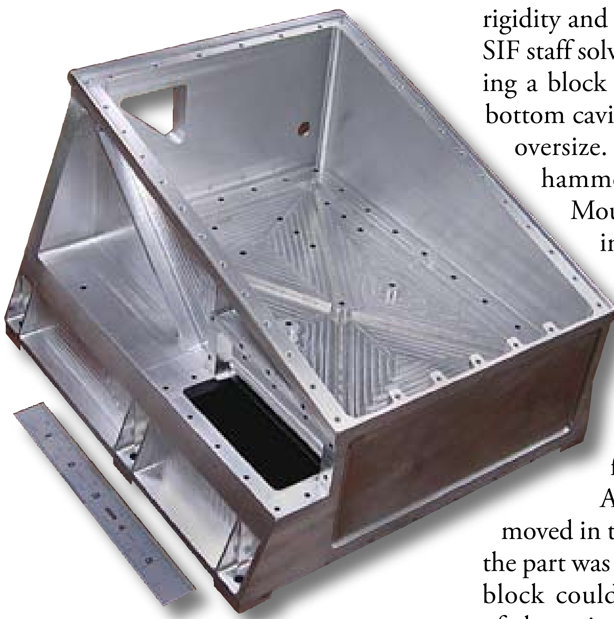
Transforming the academic concepts of physics into functioning hardware can take a good deal of effort and creativity. The Scientific Instrument Facility of Boston University's Physics Department does it every day. BU's SIF is a 10,500-sq.-ft. machine shop with CNC milling and turning machines, grinders, ultra-high-vacuum welding and fabricating capabilities, inspection equipment, and 2- and 10-ton capacity overhead cranes. "We support the professors, engineers and students of Boston University," said Heitor Mourato, SIF shop manager and one of six machinists on staff.

SIF makes parts for devices ranging from a submillimeter telescope used in Antarctica to an apparatus applied in infant behavior research. While about half of the shop's clients submit jobs as 3-D solid models, "sometimes the [students] come over here with napkin drawings, and they have great ideas!" Mourato said. "They just need the mechanical part of it, and with our help, they can get their equipment."

One of the shop's more demanding projects was a 6"×9"×9" aluminum housing for CRaTER (Cosmic Ray Telescope for the Effects of Radiation) to be installed in a Lunar Reconnaissance Orbiter spacecraft being built and managed by the Goddard Space Flight Center. The telescope was a joint development of the engineering departments of BU and Massachusetts Institute of Technology. Mourato said the engineers gave SIF a solid model created in SolidWorks, and the shop programmed the part in Mastercam X2.

The stock material for the housing was a 6½"×9½"×9½" block of 6061-T651 aluminum. The material had to be certified by the vendor. True position for some part features was 0.001" to 0.002", a number of holes had to be reamed to 0.0005"/-0.0000", and a few areas required surface finishes of 16μin. R_a.

The first set of operations was performed on the shop's Hurco VM2 vertical machining center. They involved roughing and finishing a 2.2"-deep cavity on the bottom of the housing, including creating various features and drilling and tapping more than 60 holes. Most roughing was performed with a ⅝"-dia. extended-length HSS endmill. "I like using an HSS rougher endmill because it doesn't melt the material," Mourato said. "When aluminum gets too hot, it


BU SIF

Employing innovative toolholding and workholding techniques, the Scientific Instrument Facility of the Physics Department of Boston University machined this 6"x9"x9" thin-walled aluminum housing used to mount a telescope in a lunar orbiter spacecraft.

has a way of sticking to a carbide endmill. An HSS rougher endmill doesn't usually do that. For something like this, where you need to hog a lot of material out of the part, the coarse roughing endmill works unbelievably well."

The roughing endmill ran at 7,500 rpm and a 45-ipm feed. Setting cutting parameters depends on experience. Mourato said: "When I first programmed this job, I started at about 30 ipm. As the chips start flying, I can see if it can go higher or lower; you can actually feel it. If the chip comes out of it nice and clean, you keep cranking up the feed rate and the rpm. Once I think it is fine, I go back to the computer and change the program in Mastercam." The shop uses carbide endmills for finishing, with a ½"-dia. center-cutting endmill typically run at 7,500 rpm and 30 ipm.

Mourato estimated that total machining time required to make a part was about 30 hours, and the first set of operations consumed about a quarter of that time.

The housing has a floor and walls as thin as 1⁄16", compromising the part's rigidity and resistance to vibration. The SIF staff solved the problem by machining a block of nylon that matched the bottom cavity's features but was 0.005" oversize. "We had to use a rubber hammer to squeeze it in there," Mourato said. With the block in place, the housing could be flipped and clamped down. "You have support of the floor plus edge support all the way around," Mourato said. "Everything was nice and firm."

After more stock was removed in the second set of operations, the part was more flexible and the nylon block could be removed with a shot of shop air through one of the drilled holes. Removing it was important because the block was used for support and clamping throughout the rest of the process; between operations, it was removed, cleaned so it was free of chips and then replaced. "You don't want to start nicking the piece or denting the part," Mourato said.

The second set of operations also involved milling and drilling, producing a cavity on the part's top with thin walls up to 4⅛" tall. The height of the walls required a creative approach to drilling. To reach holes on the part's floor near the walls' tallest sections, a drill about 6" long was required.

Mourato said an extended-length No. 31 (0.120"-dia.) helical drill needed to make the holes would be expensive and difficult to find. In response, SIF staff fabricated an extension adapter from a piece of ½"-dia. round steel bar stock. In the bar's center, an axial hole was drilled to provide 0.002" of clearance for the drill diameter, and then the shop's welder silver-soldered the drill into the hole. The bar's shank end remained ½" in diameter to fit in the spindle collet, but the rest of it was turned to ⅜" to provide clearance from the part wall.

Mourato said it was more efficient and less expensive to make the custom holder than to buy an extended-length drill. "It took us 15 minutes to turn and drill the bar, about 5 minutes to solder it, and it was done." The drill ran at 3,000 rpm, a 5.76-ipm feed and pecked at 0.100" to make holes that were later tapped with a screw thread insert (STI) tap.

After the pockets on the housing's top and bottom were machined, it was moved to the shop's Milltronics VMD30 vertical machining center. That machine has 24" of Z-axis travel, which was needed to provide clearance when the part was supported with angle irons and a sine plate in later operations.

After CNC machining was complete, secondary operations performed on manual machines consumed about 16 hours. Mourato said many of the secondary processes could have been included in the CNC program if a large production run was anticipated. Initially, however, the job called for one engineering prototype of the housing. After design changes were made, two more units were ordered.

Secondary operations included countersinking holes to facilitate insertion of 18-8 stainless steel HeliCoils. Specifications for the countersinks included a 120° chamfer with a minimum and maximum diameter. Mourato said it was easy to make the countersinks on a manual mill.

The holes were tapped with STI taps using an air-driven Flexarm tapping machine. Other secondary operations included deburring, polishing and plating. After plating, the HeliCoils were screwed into the tapped holes, to be used later to secure the housing in the spacecraft. Considering the part's complexity and the creativity the shop staff put into making it, Mourato said, "This piece is one I'd take home and put over my mantel!" **CTE**

For more information about Boston University's Scientific Instrument Facility, visit physics.bu.edu/SIF or call (617) 353-5056.

Today's 5-axis and 'smart' machines

By George Weimer

How do you evaluate state-of-the-art milling technology? What are the differences between and proper uses of high-speed milling (HSM) and high-precision milling (HPM)? Also, what are smart machines?

If you go back before NC, the predicted new world of machining was more than astounding, and the answers were more than amazing.

Twenty-plus years ago, the above questions were pretty straightforward. You wanted speed for some cutting operations, and you wanted a precise finish for others. You selected a machine and tooling to achieve those results. Spindles, chucks and even tooling were pretty much the same. Factors like thermal deformation and the physics of high-speed vibration didn't enter into the decision.

Simply put, machining in general was simpler than today's options. Today, those questions must be asked. This doesn't mean your operators have to have doctorates in physics to run new milling machines. On the contrary, much of the advanced automation that handles the issues of thermal deformation, vibration and other critical parameters in advanced 5-axis machines is built into the machine, said Gisbert Ledvon, business development manager for machine tool builder GF AgieCharmilles, Lincolnshire, Ill.

This doesn't mean your operators have to have doctorates in physics to run new milling machines. On the contrary, much of the advanced automation that handles the issues of thermal deformation, vibration and other critical parameters in advanced 5-axis machines is built into the machine.

"Using integrated thermal controls and an operator support system for HSM on a 5-axis machine is important because relying solely on an operator's experience may lead to spindle damage since 5-axis technology is so complex. But this is also true for 3-axis HSM operations," he added.

Today's so-called "smart machines" support the operator automatically, optimizing cutting parameters and thus protecting the machine tool itself, including the spindle.

Looking at machine tools and high-torque spindles, the stiffness requirement is paramount. Polymer-granite bases are one design feature that Ledvon said enable the desired accuracies and provide significant support when performing HSM. "For high-speed cutting, it is most important to have good dampening at high dynamics," Ledvon said. "And, chip management is also important with these high-speed machines of today. The machine tools must be built so chips fall right onto the chip conveyor."

What then do you call high speed? Today, according to Ledvon, HSM means spindle speeds from 30,000 rpm to 60,000 rpm with 1 to 2 g of acceleration. The objective is to machine a large surface arc in a short time period and to achieve outstanding finishes and accuracy for primarily complex surfaces. HPM means less than 1 g of acceleration and high-volume chip-removal rates when roughing, primarily 2-D and 2½-D machining.

What's driving these ever-higher speeds and feeds? One factor is the ability to do it—the engineering know-how to build such machines. But another factor is the job shop market itself. The driving forces there are cost reduction and higher speed to market of ever-more complex parts. Management has been betting on automation for generations and the technology is available. Using it properly is Ledvon's main issue.

When it comes to HSM, he said: "The most important thing is the programming. This is absolutely essential when it comes to 5-axis machinery. If you are going into 5-axis machines, be prepared for a new world of programming so you can simulate before you begin. Qualified programmers are required for 5-axis as well as just the right carbide and just the right coated tooling. Five-axis is a whole different world."

However, "people should not be afraid of 5-axis technology or smart machines in general. We have to go there," Ledvon said. Getting there, however, requires more preparation than machine setup and operations of a couple decades ago. "We developed our smart machines with spindle sensors that monitor tool life in terms of heat and vibration as well as balancing issues," he said. It's a serious problem when tools break at high speeds.

Today's high-speed, high-performance machine tools are equipped for this new reality. For example, GF AgieCharmilles' milling machines have Smart Machine Modules, which basically talk to the operator. They tell him if he's in the "green zone," the best zone in terms of speeds. They also tell him the thermal expansion and deformation situations for the high-speed machines. This all works with remarkable efficiency and high quality—if the operator speaks the new language of smart machines. CTE

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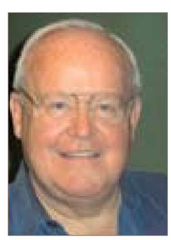


Efficient fixturing

By Edward F. Rossman, Ph.D.

Manufacturing efficiency can be improved by employing a rotisserie-type fixture arrangement to use fewer fixtures and making fixtures more rigid to reduce chatter and thereby allow more aggressive machining. Further efficiencies can be achieved using universal fixtures, which handle several part numbers, and tooling tabs, which can sometimes eliminate the need for special fixtures.

Using fewer fixtures means fewer nonrecurring fixture costs, improved part accuracy, reduced setup time, less work in process and lower storage cost. Changeover between multiple fixtures consumes valuable time and introduces more chances for part error through mislocation of the part or fixture.

A rotary fixture, for example, enables one milling fixture to take the place of several and still allow flip-flopping of a part to minimize warpage. Manually driven and program-driven rotisserie fixtures, along with making rotary fixtures adaptable to families of parts, can further reduce workholding costs and changeover times. Most milling machine controllers have the capacity to drive additional axes, such as an indexing fixture's motor and the slave motor driving a part's far end.

Picture the part mounted on a rotisserie, as in a home grill. The rotisserie-type fixture allows more of the part's surface to be presented to the cutting tool. One trick to minimize torque and twist in the part is to positively drive both ends of the fixture.

More than one rotisserie can be used on a multiple-spindle mill. In one case, three rotary fixtures replaced nine flat fixtures. This was done on a 3-spindle, 5-axis gantry machine—so there is one rotary fixture per spindle that replaced three flat fixtures—and reduced setup time by 67 percent.

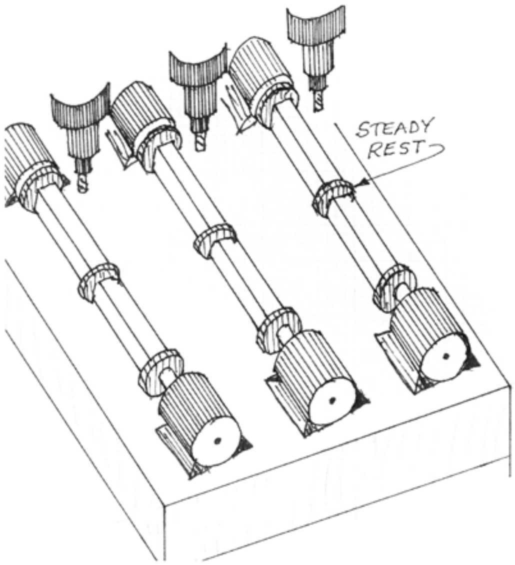
If rotisseries are long, a steady rest is added near a part's midsection. For a family of parts that vary only in length, a common rotisserie for several part numbers can be used and the rotisserie fixture's slave end is adjusted for part length.

Enhancing fixture rigidity enables high-efficiency roughing and high-speed finish milling to further reduce costs and improve quality, which is needed when milling titanium alloys. When chatter is encountered, the chip-removal rate is limited to impart the required surface finish and achieve acceptable cutter life. Vibration within the part, fixture and tombstone is the main culprit of chatter when milling titanium. Use of rigid fixtures and damping of the fixture, part and tombstone is usually the solution to overcoming chatter.

A pogo tool (sometimes called a bed of nails) is a universal fixture for trimming thin, flexible 5-axis parts. The tool is used for sheet metal and composite parts. The center spacing of the pogo grid posts is about 5". Each post is set for height, and the top vacuum pad swivels to match part contour when a part is placed on it.

A small part works fine because only the pogos under the part are activated. Edge part locators position each part.

Some parts have a convenient flat surface to support and locate the part against a tooling plate during milling.



A rotisserie-type fixture allows more a part's surface to be presented to the cutting tool.

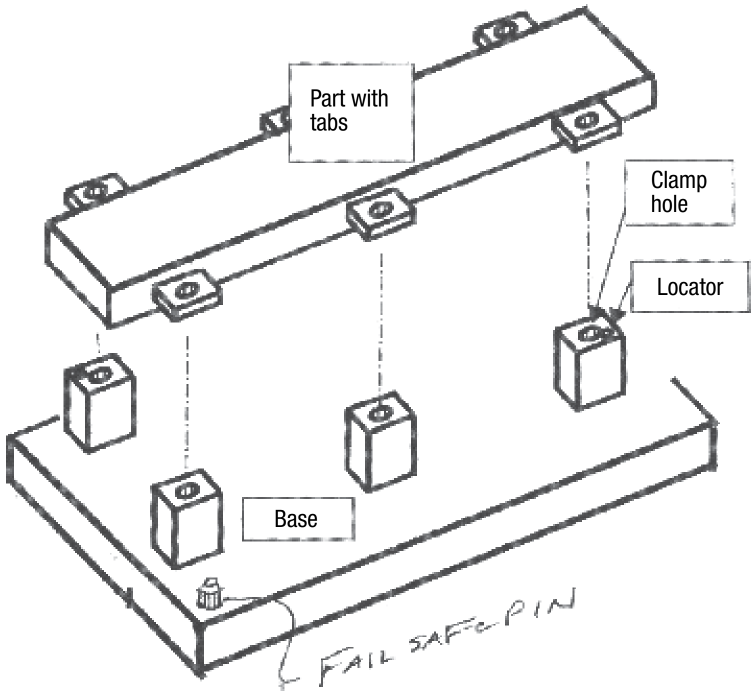
An option is to have built-in tooling tabs for supporting and precisely locating the part in fixtures.

These tabs are positioned around a part's periphery. In cases where the part is rather flat, without much Z-height variation, milling flats on the top and bottom of the tooling tabs establish the part's plane. The part then sets on standoffs from the tooling base. A hole is drilled in each tooling tab for clamping into the threaded hole in each standoff, and part location is established by using a round pin in one standoff and a diamond pin in a second standoff to mate with like holes in two of the tooling tabs. The same clamping through-holes in the tooling tabs are used when the part is flipped for milling on the other side.

If there are no built-in tooling tabs, then a clamping groove or slots can be machined along the part's periphery. These grooves are usually located about midway up the part's edge and allow standard clamps to hold the part. The part can rest on its flat surface, but if there is no flat side, support pad spots are machined into both sides of the nonflat surfaces.

To prevent part bowing, clamps are always near standoffs for the support pads. If the raw material does not have enough excess stock for tooling tabs, then pads are sometimes bonded or welded onto parts to locate and support the part during milling. After bonding or welding, the standoffs, which are usually long enough to establish a flat plane, are faced in planer fashion.

In all fixturing and clamping schemes, the question arises about the proper spacing between supports. Many of the peripheral tooling pads are about 16" apart. **CTE**



A sketch of how tooling tabs are used.

About the Author: *The late Edward F. Rossman, Ph.D., was an associate technical fellow in manufacturing R&D with Boeing Integrated Defense Systems, Seattle. Rossman's Shop Operations column is adapted from information in his book, "Creating and Maintaining a World-Class Machine Shop: A Guide to General and Titanium Machine Shop Practices," published by Industrial Press Inc., New York. The publisher can be reached by calling (212) 889-6330 or visiting www.industrialpress.com.*

Enhancing multiple-axis software

By David F. Schultz,
Numerical Control Computer Sciences

CAM software for multiple-axis machining is frequently used in the aerospace, automotive and turbo machinery industries to boost overall productivity. To provide end users with further time-saving techniques, Numerical Control Computer Sciences (NCCS) has released the latest version of its multiple-axis machining CAM software, NCL Version 9.6. The new version includes several enhancements to provide users with more advanced functionality and bring greater efficiency to their part programs.

■ Multiple-axis flow line milling allows the tool axis to be orientated normal to the surface being machined or a separate control surface. This feature is ideal for finish machining sculptured surfaces that are orientated at arbitrary angles from the machine's Z-axis.

■ Multiple-axis "waterline" rough machining is a new feature that extends "Z-level" style roughing to the multiple-axis realm. Rather than machining at multiple Z levels, the user can specify a revolved surface as the level control surface. The tool axis is orientated normal to the control surface, and the toolpath is generated at multiple offsets from the control surface. This feature is helpful for parts with a high degree of curvature, such as engraved tire molds.

■ Multiple-axis pocketing allows multiple-axis generation of lace-, non-lace- and collapse-style pocketing motions. The tool axis orientation can be normal to the surface being machined or an arbitrary control surface. This feature can be used for roughing and finishing curved pocket features, common on complex structural aerospace parts.

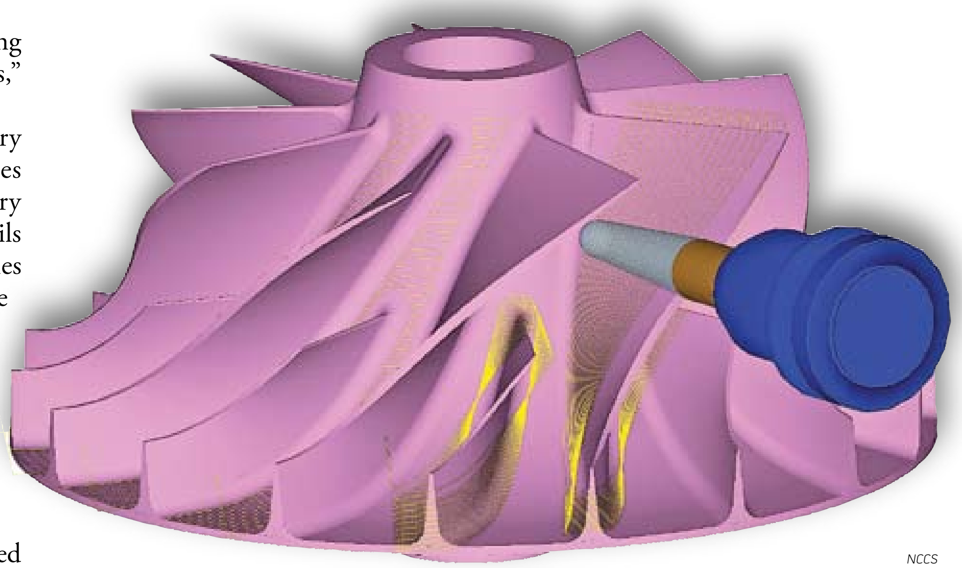
■ The software's enhanced ability to read G-code files allows a user to read, simulate and modify the files in what is now a fully integrated system feature. This capability allows the preservation of legacy G-code files and provides an accurate simulation of what will take place at the machine.

■ The Enhanced Aerospace Application Library (AAL) is included because general-purpose CAM software packages may not always address the unique requirements of specific applications. The AAL includes processes, tools and routines that facilitate machining structural aerospace parts. Examples include automated machining of features such as flange tops, recessed pockets, closed-angled pockets and holes. Also included is automated modeling and machining of tooling geometry, such as “snap tabs,” counterbores and locating holes.

■ The Enhanced Turbo-machinery Application Library (TAL) addresses the manufacturing of complex rotary parts, such as impellers, blisks, airfoils and inducers. New toolpath strategies have been added to efficiently machine difficult-to-machine materials, such as stainless steel and titanium. The new strategies are designed to extend tool life and create optimal surface finishes.

NCL is a CAM system designed to provide enhanced flexibility in creating toolpaths to produce machined parts of any complexity. NCL provides parametric modeling, multiple-axis toolpath generation, post-processing, advanced material removal and machine simulation in a single integrated solution.

NCL offers a blend of automated and user-controlled toolpath generation techniques that result in reduced programming and machine time—and increased part quality. **CTE**



NCCS

NCCS’ NCL Version 9.6 CAM software introduces enhancements to enable more productive 5-axis machining.

About the Author: *David F. Schultz is manager of CAD/CAM applications and support for Numerical Control Computer Sciences, Newport Beach, Calif. For more information about the company’s machining software, call (949) 553-1077 or visit www.nccs.com.*

STAYING SHARP
machinist's corner

By Michael Deren

Find your shop's hidden talents

Times are tough for manufacturers, and I'm not talking about the bottom line. Many shops have more work than they can handle, but it's getting harder and harder to find competent employees—let alone attract new people into the business. This is not a local or regional problem, but a national one. Instead of looking outside your facility for employees, what about looking in-house? Do you know the core competencies of your own employees?

Chances are the more employees you have, the easier it will be to find ones with untapped potential. When was the last time you had one-on-one meetings with the employees you supervise or manage? Sure, you probably have plenty of group meetings, but one-on-one meetings are needed periodically. An opportune time for this is the employee's annual review. Most managers are rushed to complete the reviews and it's hard to spend much time with an employee, but by taking a few extra minutes, maybe you can learn about their untapped potential.

By brainstorming and doing some research on your employees using information already in their personnel files, you'll find solutions to your staffing problems.

Other than during an interview, when was the last time you looked at an employee's resume? Probably not since he was hired. Possibly, something you saw in that resume originally swayed your hiring decision. I'll bet you can't remember what it was. Maybe you should review all employees' resumes again. If you're looking for someone with a milling background, somewhere in that stack of resumes you may find that person. Possibly your company is expanding into robotics and you're looking for a knowledgeable engineer to help jump start this expansion. You might have just the person in-house and don't even know it.

Perhaps you need to fill a position that requires some special education or training. By looking at a person's educational background, you may be able to fill that vacancy with someone in-house. Many employees have attended outside training programs while employed elsewhere. It could be training on a specific machine tool or control system.

Do you know what your employees' hobbies and interests are? You're probably thinking, "Who cares about their hobbies?" But some hobbies could be beneficial to your company, such as one involving computers and programming. By tapping their interests and providing additional training, you could have a new IT person. Other workers might have an interest in repairing electronics and be perfectly suited to work in the maintenance department servicing or maintaining controls. Some employees may dabble with an inexpensive CAD package at home and are possible candidates for the CAD department.

Sometimes the most obvious way to learn about an employee's potential is the most overlooked. Just ask if anyone in your organization has the knowledge or expertise you're looking for. I can almost guarantee you will find someone who has what you're looking for. Sometimes, however, a different approach may be needed. I knew a manager who asked if anyone in my group had expertise in pneumatics. A couple of people admitted to knowing a little something. Afterwards, we found that one individual in the group had recently completed courses in pneumatics but didn't want to say anything in front of everyone else.

Some of these suggestions may be oversimplified. But by brainstorming and doing some research on your employees using information already in their personnel files, you'll find solutions to your staffing problems. And what better way to motivate employees than by showing that management cares enough to look for ways to advance their careers. CTE

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