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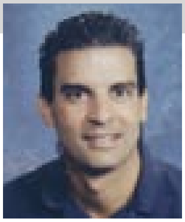
BY MIKE PRINCIPATO



Just one word

I'm declaring this month "everything old is new again" month, because, for whatever reason, I've recently heard from a slew of readers and colleagues about a topic that's been beaten into the ground as often as the Detroit Tigers: the lack of skilled workers.

Based on anecdotal evidence, it's a challenge every growing U.S. manufacturing operation faces, and, in the 2 years since I last covered the subject, the situation has gone from merely awful to clearly horrendous. At a time when specialized manufacturing in the U.S. is on the rebound and companies are finally in a hiring mood, the pool of craftsmen—or even rookies with potential—seems to be shallower than ever.

Granted, it's hard to believe that the tens of thousands of manufacturing employees who've lost their jobs at automobile and aircraft plants, steel mills and other mega-industries won't find their way to other, smaller contract manufacturers. But, if history is any indicator, they won't. For starters, many of these folks spend a big chunk of their working hours doing repetitive tasks, not reading drawings, setting up machines or building complex tooling; they're simply not qualified for your work. Then there's the thorny issue of compensation: Odds are they're expecting a higher hourly rate and more benefits than most small- to medium-sized shops can afford.

The machinery being produced today is more advanced and less expensive (in relative dollars) than at any time in history, and the downward price pressure the new stuff is exerting on used equipment means that quality, pre-owned gear is more affordable than ever.

Recently, I ran into one of my former employees, who opened his own successful machine shop. He and his partners have built a substantial customer list and order backlog after just a year in business. Their company produces industrial machinery components and prototypes and is ready to increase capacity. Naturally, they're looking for skilled machinists, and, mirroring the industry's plight, have found none.

What should they do? I have a one-word response: technology.

This is the same answer I, and many others, offered 10 years ago when confronted with the same labor conundrum. But 10 years ago, you still had a choice. If you didn't want to invest in advanced machinery, tools and controllers, there were still enough skilled craftsmen available to boost your manufacturing capacity. Now, you simply cannot add an appreciable amount of available labor hours by adding bodies. Trying to do so isn't only an exercise in futility, it's a perilously shortsighted strategy that ignores these new realities of our industry:

- An increasing quantity and diversity of assemblies and components will be manufactured outside of the U.S. That means fewer orders and declining revenues for downstream suppliers (that's you, Sparky). The outlook for high-production widgets is worse. Just ask a GM supplier.
- The low-productivity players who can't deliver on time are already history or are suffering lingering deaths. The name of the game now and in the future for manufactured goods is innovation (think iPod) and price (think a bazillion other portable audio players now chasing the same market Apple's Steve Jobs perfected). Trouble is, contract manufacturers don't innovate—that's our customers' job. That leaves price as our differentiator.
- The machinery being produced today is more advanced and less expensive (in relative dollars) than at any time in history, and the downward price pressure the new stuff is exerting on used equipment means that quality, pre-owned gear is more affordable than ever.

Considering the above, my advice to my old friend and to you is to invest in technology. I'd go so far as to say that before I'd hire more skilled labor (again, assuming that those new hires would simply increase existing capacity and not add a new expertise or service), I would bite the bullet and pay overtime rates to my existing workforce and put a down payment on another CNC machine.

Because, like never before, the race will not be won by the company with the biggest headcount, but by the one that is the most efficient.

About the Author

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Styles of workholding collets

The three basic styles of collets (left to right): push, draw and compression.

A workholding collet is a flexible-sided device that secures a workpiece. Collets are similar in function to chucks, but provide greater gripping force and precision over a narrower size range.

Collets are primarily used for holding a workpiece in the spindle of a machine, but have a range of other applications, including fixturing workpieces on vertical and horizontal machining tables. Collets are available in three basic styles: draw, push and compression.

The most common style is the draw collet. For this style, a thread is machined into the collet's end opposite the head angle. The collet is secured or drawn into a tapered socket by the thread. This applies pressure to the collet's angular design, causing the collet to grip the workpiece.

The most common draw collet is the C-type, which is generally for secondary operations when parts are loaded by hand.

The second most common style is the push collet, which relies on a locknut that resists pressure applied by a sliding tube or socket. The socket or tube has an ID pressure angle, which mates with the collet's angular design, and, pushing the socket forward, squeezes the collet. The most popular push collet is the B-type, which is typically for an automatic screw machine that consumes large quantities of stock.

The third most common style is the compression collet. A compression collet relies on a special nut normally found on the end of a spindle. The nut, when turned, compresses the collet into the ID taper bore and causes the collet to collapse around the item being held. Compression collets primarily hold cutters, but, occasionally, they also hold workpieces. (Collets are used to hold cutting tools as well as workpieces.)

The influence of centrifugal force is less of a factor with collets than with chucks, because the collet is not contending with mass beyond the spindle, as is the case with chucks. The entire mass of the workpiece is collected within the collet, and the spindle socket serves as a backup, supporting and restricting outward movement.

Further advantages of collets are that they can hold the inside contour of a part, thereby exposing more of the part's surface to the cutting tool. And, collets can be customized to accommodate irregularly shaped parts. This involves digitizing the section of the workpiece to be held, transferring that information to a CNC and burning that pattern into the collet using a wire or sinker EDM.

Collets can last as long as 3 million grip-cycles with little or no deterioration if the proper material, heat-treatment and design criteria are used during their creation.

In some applications, the presence of chips in the collet's expansion slots is a cause for concern. Small chips lodged in the slots can reduce the collet's ability to flex. To prevent this, fillers can be inserted into the slots. Examples of fillers include caulk, rubber and cardboard. Flushing coolant through the fixture also keeps the slots clear.

The holding force of a collet can be adjusted from light to heavy. Collets can hold a practically limitless range of workpiece materials, including all types of metals, plastics, carbon, glass and fiberglass.

The holding force of a collet is dependent on its activating mechanism, a fixturing device that provides the power for the holding force. Fixtures are available with mechanical, pneumatic and hydraulic activating mechanisms. Pneumatic fixturing devices are somewhat limited in the amount of force they can exert, because they allow for only a certain amount of air pressure and will "max out" fairly quickly. For this reason, use of pneumatic devices is typically limited to more fragile parts.

Meanwhile, a hydraulic cylinder, depending on the diameter of its cylinder and its volume, is practically unlimited in the amount of force it can exert.

When increased gripping is required, serrated collets are used. Many different types of serrations are available. Some resist both left- and right-hand radial torque, while others reduce slippage caused by pushing or pulling of the workpiece. The basic principle behind serrations is to reduce the overall contact area, thus increasing the localized pressure in one area.

There are also several types of coatings that can augment gripping.

Depending on the application, they protect the finish of the workpiece being clamped, reduce slippage and increase surface hardness or lubricity.

Adapted from information provided by Hardinge Inc., Elmira, N.Y., and an article that appeared in CTE *that was written by Zagar Inc., Cleveland.*

From prototypes to production

BY BILL KENNEDY, CONTRIBUTING EDITOR

Padgett Machine Inc. does the majority of its machining and reverse-engineering work for the Department of Defense. The shop makes parts as critical as aluminum supports for aircraft wings and as exotic as components for deep-space radar arrays.

Some of Padgett's more detailed part programs take over 20 hours to run and would consume 900 pages of paper if printed out. Other parts, while simple in appearance, still require careful process management to minimize costs and maximize the shop's competitiveness in the tough governmental bidding environment. A good example, said Ed Padgett, co-owner of the Tulsa, Okla., shop with his brother Randy, is a ⅝"-long × ½"-wide × ¼"-thick Delrin polymer insulator for aircraft electronics equipment.

Padgett Machine

Padgett Machine uses a 4-axis lathe to efficiently machine this polymer insulator for aircraft electronics equipment.

Padgett used one set of operations to make 50 prototype insulators for customer tests and then upgraded its manufacturing methods to maximize efficiency in full production.

For the prototypes, Padgett began with a 2'×4'×⅜" sheet of Delrin. The sheet was held against a guide rail on a vertical bandsaw and cut into ⅝"-wide × ⅜"-thick × 48"-long strips and then into 6" lengths. Each strip was clamped by its ⅜" dimension in a vise set up on a Haas VF-2 vertical machining center. After a ¾"-dia. carbide endmill skim-cut 0.020" off the top of the strip, a ¼"-dia. carbide endmill machined the parallelogram forms of six insulators along the length of the strip. The cutters ran at about 6,000 rpm and a feed rate of 30 ipm. Then, after a HSS center drill spotted three hole locations on the top of each part, HSS drills, run at 7,000 rpm and 10 ipm, machined a 0.201" hole in the center of each and 0.093" holes at either side of the center hole.

Next, Padgett flipped the strip in the vise, and the ¾" endmill machined off the bottom of the strip, separating the six insulators. The parts, located by the 0.201" hole, were then clamped individually on a Haas HRT210 rotary table. Acting as a 4th axis, the table was rotated to allow both ½"-wide ends of the part to be center-drilled. After a 0.132"-dia. HSS drill cut through to the center hole on each end, a 0.187"-dia. endmill circular-interpolated a 0.203"-dia. countersink on each end to a depth of 0.210". Padgett said circular interpolation facilitated creation of the odd-diameter countersink.

The milling operations left the top and bottom of the part with sharp edges, which were removed by hand with a file. Machining time per part was about 9 minutes, and deburring consumed about another minute and a half.

After receiving approval for production, Padgett changed the machining process to minimize parts handling. While making the prototypes, each was handled six times. "You can't build these parts that way and be cost-effective," he said.

Padgett moved the part to the shop's Daewoo Puma 2000 SY 4-axis lathe. The lathe has X-axis and Z-axis live tooling, and Y-axis control that permits milling and drilling of features that are not parallel or perpendicular to the spindle center. The machine enables the shop to "be innovative in how we build parts and saves throughput time," Padgett said.

In addition to accomplishing in one setup multiple operations that would otherwise require different setups or machines, Padgett said, "you are completing parts without losing the tolerance or worrying about positioning. Fixturing errors have been taken out of the loop."

On the 4-axis lathe, the workpiece is a 1"-dia. Delrin bar, fed into the machine at 0.300" increments by an SMW Space Saver 2000 servo bar feeder. In the first operation, a CCGW-332 carbide insert faces the bar's end at 800 sfm and 0.002 ipr, and turns down the OD to 0.020" larger than the part's maximum dimensions. Then the spindle stops, and a ½"-dia. carbide endmill, in a live-tool position operating in the Z-axis, mills the parallelogram shape. The endmill machines in three axes simultaneously, running at 5,000 rpm and 25 ipm.

Next, also in the Z-axis, a center drill moves in three axes to spot the three holes across the part face, followed by 0.201"-dia. and 0.093"-dia. drills to complete the holes. The drills run at 5,000 rpm, Padgett said, and "we peck to keep the plastic from wadding up around the drill."

X-axis live tooling is applied next. After a center drill locates a hole on one ½"-thick end of the part, the spindle flips the part so the drill can spot the other end. The sequence is repeated for a 0.132"-dia. drill to cut halfway through the part from either end. Similarly, a 0.187"-dia. carbide endmill then circular-interpolates the 0.210"-deep × 0.203"-dia. countersink on both ends.

A 0.120"-wide carbide part-off tool then plunges straight in from the X-axis at the back edge of the part. It doesn't actually cut the part off, but leaves about ⅜" of the bar diameter between the part and the stock. The groove provides room for a live ⅛"-dia., 45° chamfering tool, running at 5,000 rpm, to deburr the front and back edges of the part. "At a 25-ipm feed, deburring takes only 3 or 4 seconds a part," Padgett said.

The part-off tool then returns to complete its job, and the insulator falls into a parts catcher presented by a robotic arm, which deposits the part outside the machine.

He added that coolant is applied intermittently throughout the job, because Delrin is about as abrasive as aluminum and "a little bit of lubrication stabilizes tool life." Padgett is seeking maximum consistency because he plans to eventually run the job "lights out."

After the machining is completed, the machine operator spends about 10 seconds per part, hand-spinning a small chamfering tool in any holes that require deburring. Machining time for the part is 2 minutes, 55 seconds on the 4-axis lathe.

For more information about Padgett Machine Inc., call (918) 438-3444.

Femap 9.1: making a mesh of things

BY BILL FANE

UGS Corp. produces a package of midrange design, analysis and management software called the Velocity Series. The finite-element-analysis (FEA) component of this series is called Femap. It is a pre- and post-processor that links the model to the solver software.

Let's start with a brief look at the underlying principles of FEA and then go on to look at Femap.

First, consider the case of a simple triangular frame, supported at two corners and with a weight attached to the third corner. (These types of frames, which usually appear in week 1 of any strength-of-materials 101 engineering course, are constructed to calculate the stresses and deflections experienced by the frame members.)

Now, add several more triangular frames to create a bridge truss. Again, it is still relatively simple to calculate the stresses and deflections in each member.

Similarly, assume a simple solid beam with a weight hanging from its end is sticking out of a wall. Once again, it is relatively easy to calculate the stresses in the beam.

Now comes the hard part. Let's say you have a complex die-cast part, supported at several points and subject to multiple loads. How can you analyze it?

The solution is quite simple, just somewhat tedious to obtain. You do it by combining the first two examples. The solid beam could be replaced by a multiple-segment truss structure, and then the truss could be analyzed. The greater the number of truss elements, then the closer its solution will come to matching that of the solid beam.

This is known as FEA; a solid, homogeneous part is replaced by a mesh of small finite elements that is then analyzed.

The only problem is that to obtain reasonable accuracy, a complex 3-D part must be replaced by a mesh of perhaps tens or even hundreds of thousands of extremely small elements. The solution is not mathematically complex, but it could require several hundred years for one person do the calculations manually.

The principle of FEA became a viable tool with the advent of computers. Early mainframes were able to perform the required calculations within a reasonable time, but the machines themselves were expensive.

The good news is that modern PCs are capable of performing these calculations in a few seconds or, perhaps, a few minutes if the part is complex.

So why would a chipmaker be interested in FEA? For starters, one of the things affecting both part accuracy and cutting speed is the rigidity of the machining system from the machine tool frame through the toolholder to the tool tip itself. FEA software makes it viable to analyze these elements on a case-by case basis. It can even handle dynamic situations such as vibration analysis.

FEA is basically a four-step process: The 3-D model is built, it is meshed and the loads are applied, the mesh is solved and, finally, the results are displayed.

Femap normally covers steps two and four. The 3-D model is built in a suitable CAD system and then passed to Femap. Femap generates the mesh and the user applies the loads.

Next, Femap passes everything to a suitable solver, which does the number-crunching. Finally, the results are passed back to Femap, which then displays them in a variety of suitable output forms.

Femap was originally developed to run on engineering workstations, usually with UNIX as the operating system. As desktop PCs became faster and more powerful, it was ported over to run using Windows, but Femap still retained much of the look and feel of a UNIX application.

Version 9 of Femap significantly changed the user interface to make it look and operate like most Windows applications. Plano, Texas-based UGS also made it easier to use, even though it now contains more features and power.

Additionally, Version 9 also incorporates the Windows functionality of allowing users to open multiple models, as well as provide multiple views of a single model, at one time.

This brings us up to Version 9.1. Although a "point one" release usually indicates relatively minor changes, Femap Version 9.1 incorporates significant new features.

For example, Version 9.1 supports a fully associative interface with Solid Edge Version 18, UGS's parametric modeling product. This means changes made to the Solid Edge model will automatically reflect through and update the Femap data.

Enhancing this capability is the fact that Solid Edge 18 also has Femap Express built in for quick, first-hit analysis. This capability increases the user's confidence that his proposed design will pass the full-scale Femap analysis.

Femap can utilize about 17 different FEA solver packages. Not surprisingly, it integrates most tightly with UGS's NX version of the popular Nastran solver. This includes support for Nastran's spot-welding elements, which can make it much easier to analyze sheet-metal designs.

Femap Version 9.1 is able to import model files from a range of applications, including SolidWorks, Pro/Engineer, CATIA V5 and any program that can export a Parasolid, ACIS, STEP or IGES file.

An updated macro facility makes it easier for users to automate repetitive tasks. Macros can be recorded, edited and played back within their own access window.

A standard programming environment has been added. This allows programmers to set up Femap so it can talk to an Excel spreadsheet and vice versa, for example.

Although a 'point one' release usually indicates relatively minor changes, Femap Version 9.1 incorporates significant new features.

Femap 9.1 also improves its ability to share results and visualization through a new option that allows it to directly output .JT files. These are open-format 3-D files supported by many applications. (For more information, visit www.jtopen.com.)

Femap is a powerful, versatile program. Version 9.1 makes it even easier to access and control this power.

About the Author

Bill Fane is a former product engineering manager, a current instructor of mechanical design at the British Columbia Institute of Technology and an active member of the Vancouver AutoCAD Users Society. He can be e-mailed at Bill_Fane@bcit.ca.

BY DR. JEFFREY BADGER

Oil vs. water

Dear Doc,

Which is a better for grinding: oil or a water-based fluid?

The Doc Replies:

I'd like to say water-based, because it's better for the birds and the trees, easier to handle, nicer to inhale and doesn't explode—but I can't. In terms of grinding performance, oil outperforms water-based 99.5 percent of the time.

A common argument is that oil lubricates more effectively and water-based cools better, so the results are about the same. But that argument just doesn't fly.

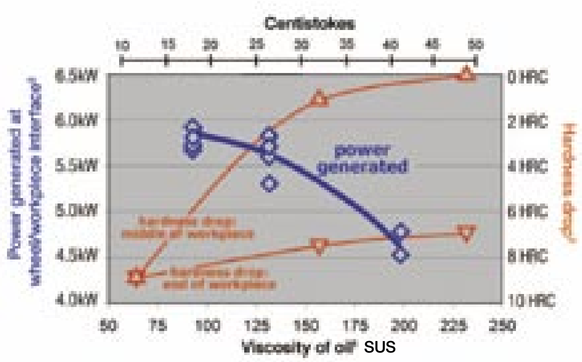
Because it minimizes friction and dulling of the grits, oil generates less heat. So even though oil doesn't remove as much heat, the net amount of heat entering the workpiece is lower.

Creep-feed operations benefit the most from effective cooling, because the long arc of cut for CF grinding enables a coolant to absorb more heat. But even when CF grinding, oil almost always performs better.

Let's say you're CF grinding with water-based coolant and generating 10kW of heat. If you have effective coolant delivery, the coolant may be able to remove 30 percent of that heat, leaving about 7kW. With oil, CF grinding generates only, say, 6kW to begin with. If oil only removes 5 percent of that heat, you're still better off at 5.7kW of heat instead of 7kW.

Dear Doc,

What viscosity do I want for my oil when grinding flutes in HSS?



1. Viscosities at 40° C (104° F) 2. M2, vitrified Al_2O_3, creep-feed grinding, 12 gpm at 30 psi. Hardness data from 8/95, *Lub Eng*, 51, 8, Lie et al. 3. M2, resin Al_2O_3, creep-feed grinding, 30 to 40 gpm at 60 to 80 psi. Power data courtesy of Normac.

J. Badger

Power generated and hardness drop vs. oil viscosity for two tests. At higher viscosities, power generation is lower due to less friction and less grit blunting, and the hardness drop is lower due to less heat entering the workpiece.

The Doc Replies:

A higher viscosity provides a thicker, better-lubricating layer of film between the grit and the workpiece. This means less heat generation and less wheel dulling.

Archives MNATP, Collection Meillassoux

Coolant companies often recommend around 24 to 27 centistokes. My experience has been the higher the viscosity, the better the results.

The blue curve in the graph shows results of a test done on a flute-grinding machine with a ceramic wheel. This test showed higher viscosities resulted in lower power generation. The red curve shows results from an academic study, where the researchers measured hardness drop at the middle and end of the workpiece (due to overtempering) at three different viscosity values. Again, the best results in terms of hardness drop were obtained using higher-viscosity oil.

However, nasty things can happen when the viscosity gets too high. High-viscosity oils are more difficult to pump and can cause a significant pressure drop in the system. This can cause the "peanut butter" problem to arise. High-viscosity oils also are more difficult to filter, requiring higher pressures and more idle time, and more coolant tends to stick to the parts.

Dear Doc,

I'm thinking of getting a chiller to lower the oil temperature when grinding. It used to be around 40° C, but now, with increased capacity, it is 50° to 55° C. Will a chiller reduce grinding burn?

The Doc Replies:

Yes, it will reduce burn, not because the oil is cooler, but because it has a higher viscosity at lower temperatures. Although not shown in the graph, the test referred to in the previous response saw power drop from 6.3kW to 5.8kW by dropping the coolant temperature to 37.7° from 43.3° C.

If your coolant salesman chose your oil based on 40° C and now you're at 55° C, you have a different oil. Check the viscosity at 55° C. It'll be drastically lower than at 40° C. A typical grinding oil will drop from 38 to 20 centistokes in that temperature range. That's a big enough drop to cause serious grinding burn.

A less expensive alternative is to choose a coolant that has the desired viscosity at the temperature at which you're running your grinding operation. △

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