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BY MIKE PRINCIPATO

Divide and conquer

When I was younger I cared deeply about appearances, despite the admonishments of everyone from my parents to older and wiser entrepreneurs. They counseled me to focus not on outwardly visible signs of business success, like plant size and employee head count, but on the measure that counted most: profits.

Being a legend in my own mind at the time, I followed youth's time-honored tradition and ignored my elders. In short order, I built successively larger buildings and scaled up on labor as fast as I could. As regular readers of this column know, I occasionally paid dearly for those decisions. In the late '90s, for example, my shop was chronically starved for cash and was forced to shrink to survive and fight another day.

While it was an expensive and near-ruinous lesson, in today's cutthroat manufacturing climate such impetuosity would be suicidal. For starters, excessive overhead spells death in the face of overseas competition. Whereas I was gunning for critical mass in growing my operation, figuring I would steamroll my competitors by offering bigger, faster and more accurate output, such a goal is simply unattainable now. No amount of critical mass in a U.S. shop will in and of itself offset the dramatically lower labor and regulatory costs of China, India and other manufacturing powerhouses.

Customers typically don't give a hoot about how large a plant is; they want world class-quality components shipped on time and at a competitive price.

Without a doubt, the market has shifted significantly during the last decade, leaving once-powerful megashops reeling in the wake of a sharp increase in outsourcing to lower-cost foreign producers. In short, it's a tough time to be a big shop—especially a big contract shop that relies on the success of other manufacturers for orders.

Consider a few realities of the contract manufacturing world, Sparky. Relatively few machined, fabricated or molded parts produced in quantity are immune to global competition. Outside of sensitive products made for U.S. national defense, components for emerging technologies (which, of course, eventually grow up to be mature commodity technologies) and products that are too heavy or lead-time sensitive to lend themselves to foreign manufacturing, just about anything can be produced in quantity less expensively overseas.

So who says you have to be big, at least "big" by the old-school definition, which meant in terms of plant size, head count and machines per location? Remember, the focus is on profits, not appearances.

Customers typically don't give a hoot about how large a plant is; they want world class-quality components shipped on time and at a competitive price.

I, therefore, propose a completely different approach to what has become, in just a few short years, a completely different market. Instead of planning for one increasingly larger shop in a single market, build your business by creating multiple smaller shops with distinct capabilities in distinct markets.

Let's say you have a 5,000-sq.-ft. machine shop in Detroit. You're plugging along on auto industry orders, but to run with the big dogs in the region you need a lot more capacity and broader expertise in any number of manufacturing technologies, from wire EDM to CNC turning. If you follow conventional wisdom, you'll buy bigger and faster versions of the sort of gear you already own, expand your building and start chasing bigger orders.

But, those bigger orders are what every other shop with the same aspirations will be chasing … during the most competitive and least profitable era in domestic automotive history. By following conventional wisdom, you will doom yourself to conventional results.

Don't do it. Instead, take that same capital and invest it in a different 5,000-sq.-ft. location at least 50 miles from Detroit, and in a shop built to serve any one of a dozen other nonautomotive industries in the Michigan area, ranging from medical to construction. Outfit this second location with machinery and labor reflective of the needs of the new customers you'll attract there, making it distinct from the equipment and skill sets housed in your first shop.

Repeat as necessary, and in 5 years, you might be the proud owner or manager not of one 20,000-sq.-ft. overhead-generating, cash-sucking, geographically landlocked, market-sensitive business, but of four or five lean, agile, profitable shops serving distinct markets with distinct gear and distinct expertise. That diversity will protect you from the cyclical nature of every industry. (What goes up must come down—this year, it's autos; next year, I predict housing.)

The centralization of administration, estimating and CNC programming will minimize your overhead. The comparatively small size of each operation will make each more manageable. You'll have all the meaningful benefits of a single large location, but with much greater intrinsic strength.

About the Author

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Parts marking essentials

More and more precision metal parts are being marked for traceability, identification, authenticity-documentation and process-progression requirements. The marking tools and systems available to do the job are as varied as the parts themselves. The marking methods range from a simple hammer-and-die approach to sophisticated laser etching.

Determining which marking system to apply depends on a variety of parameters. These include workpiece material, part volume, part features, type of mark, cycle time, the part's operating environment and costs. Three common ones are permanent electro-chemical, indent (dot-peen) and laser marking.

To mark with an electro-chemical etching system, a resistor coating is transferred from the back of a stencil to the backing paper to create openings (the image) in the stencil. The stencil is then removed and placed on the part to be marked. When the marking applicator contacts the data-matrix pattern on the stencil, an electrical current passes through the openings in the stencil and generates a permanent mark.

The process, which removes metal similarly to how electrical discharge machining and electro-chemical deburring do, can mark any electrically conductive metal part. The marking depth range is from 0.0001" to 0.01", with the latter depth allowing part painting without obscuring the mark's visibility.

In addition to the stencil, electro-chemical marking requires an electrolyte solution to carry the electrical current. The part is positioned on a grounded plate, which completes the circuit.

A dot-peen system is another way to permanently mark parts with dot-matrix codes. The electrically controlled units apply a carbide stylus to cold-form dots (spherical recesses) with compressive force. The stylus generally has one of three tip angles: 60° for deeper and narrower indentations, 90° for midrange indentations or 120° for wider and shallower indentations.

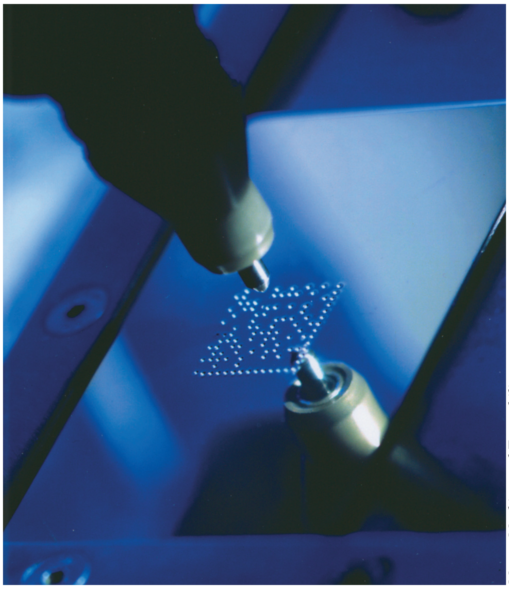
The dot-peen method creates easy-to-read straight, arced or radial indentations in soft or hard materials and on flat or uneven surfaces.

A host of dot-peen systems are available, ranging from hand-held to benchtop to integrated stations for production lines and severe industrial conditions.

To verify that each part receives its intended mark, a camera mechanism can be added to a parts marking system. The camera takes a picture of each part and analyzes the picture with software running in the background. A database stores the information about what is marked—not the image itself. For example, the software can record what serial numbers were marked on a given day.

For those companies with the daily volume of about 500 to 1,000 parts that need to be marked, the $50,000 to $150,000 or more price tag for a laser system is justified. The exception is aerospace tooling and fixtures, which are suitable applications for laser marking because their price tags are generally high even though they are low-volume parts. However, once a laser system is purchased, the cost for marking is close to free, excluding maintenance.

The CO_2, Nd:YAG (neodymium-doped: yttrium aluminum garnet) and ytterbium fiber lasers account for almost all laser marking performed and can process almost any material. Most industrial end users mark with Nd:YAG lasers. Of the Nd:YAG lasers, the majority are lamp-pumped as opposed to diode-pumped, which is a technology that's gaining market share.



Mecco Marking and Traceability

A marking head with a carbide stylus creates an information-rich, 2-D data-matrix code for product traceability.

One advantage of diode-pumped, solid-state lasers is they require less power. Typically, the diode systems go up to about 50w continuous power and the lamp systems go up to 100w.

In comparing dot-peen to laser marking, a laser is able to mark with significantly less workpiece damage and no surface deformation.

Conversely, a dot-peen machine is able to produce more readable results than a laser when marking a curved or irregular surface when the change in surface depth is significant. This is because the laser's focal depth needs to be maintained at almost the same distance throughout the marking process to achieve the best results, while the dot-peen system's pin-throw range can accommodate a greater surface variation.

This difficulty in laser marking such surfaces can be overcome by using a fiber laser attached to a robot that follows a curve, for example, and maintains the proper focal distance. Because all of the components are fused together through the fiber, the laser is immune to misalignment and optical contamination.

Get it right

BY JAMES A. HARVEY

A veteran toolmaker once said, "All I know is if I don't check it, it's wrong." It was said in response to my complaining about having wasted time working on a part that was already out of tolerance.

It seems you can double-check things all day long without finding an error and then the first time you don't check something, it'll be wrong.

Part of learning any trade is learning how to avoid trouble. Mistakes are no fun. The trick is to develop habits and ways of working that reduce your chances of making mistakes without wasting time.

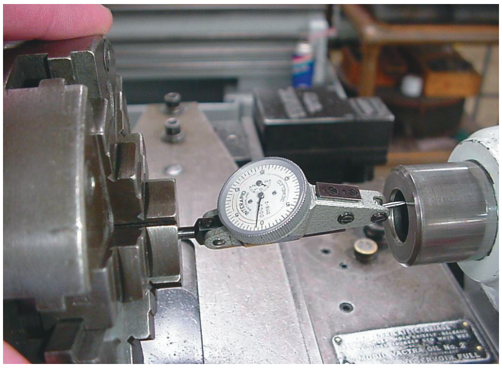
Everybody is different in how they approach jobs, and each of us has our own strengths and weaknesses. With that in mind, here are some suggestions that should give you some insight into avoiding errors.

■ Double-check measurements and calculations.

This is an important rule for making good parts. We all make mistakes during the course of a day; that's a given. Therefore, we have to try to catch our mistakes before we make a bad cut. The best way to do that is to double-check measurements and calculations, preferably with two or more different methods to ensure that you don't make the same mistake twice. When you double-check, you give yourself a huge mathematical advantage.

To illustrate my point, let's say you make one mistake for every 100 calculations or measurements you make. Making cuts based on that ratio would produce an excessive amount of errors. If you double-check yourself, in theory, you would reduce your chances of making an error to one in 10,000.

Double-checking eventually becomes second nature and is often rewarding. A mistake, after all, isn't really a mistake until you've made a bad cut.



J. Harvey

An indicator is rotated in the spindle to check if the tailstock is off-center.

■ Leave small amounts of material for reaming.

With reamers up to about ½" in diameter, try to leave no more than 0.005" on the ID for clean up. You can leave more but your reamed hole may go oversize, especially with reamers that are a bit dull. That's because as they resist cutting, they try to push sideways.

With tiny reamers, under ⅛" in diameter, you should leave 0.001" to 0.002" of material on the ID for clean up. With reamers over ½" in diameter, leaving 0.005" to 0.010" on the ID works well.

Because reamers are specialty tools, you should run them slowly to avoid premature tool wear.

■ Cut shafts precisely parallel by lining up the tailstock.

Shaft taper is an issue machinists always seem to be fighting. One reason a lathe will cut a taper on a long shaft when using a live center is because the tailstock is not centered.

Mount an indicator in the spindle and sweep the inside of the tailstock taper. This allows you to see how far off-center the tailstock is and make adjustments. Note that the tailstock would be off-center by half the amount of the total indicator reading.

■ Give your machine's digital readout a once over.

DROs are great tools—when they work. To make sure your DRO isn't skipping, compare the reading from your DRO to the reading on your handle dial. Even though lead screws and drive nuts wear, the thread pitch of those items remains constant so that handle dial reading remains relatively accurate in spite of wear.

Start by zeroing both the DRO and handle dial. Then crank the machine a few inches to see if your DRO reading and dial reading stay close together. Continue the process until you are satisfied that the DRO is not skipping.

If you find the DRO is skipping, let everyone in the shop know so that nobody ends up making junk.

■ Avoid clamping on a tool radius.

Many tools, such as endmills and fly cutters, have shanks that blend into the body of the tool with a fillet radius. In terms of strength and rigidity, that makes sense, but the radius can get you in trouble if you're not careful. If you inadvertently stick the tool too far into a holder, you may end up clamping on the radius, which can cause the tool to come loose when it is cutting. Clamp tools at least $\frac{1}{16}$" away from shoulder radii.

About the Author

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It's all in the preparation

BY BILL KENNEDY, CONTRIBUTING EDITOR

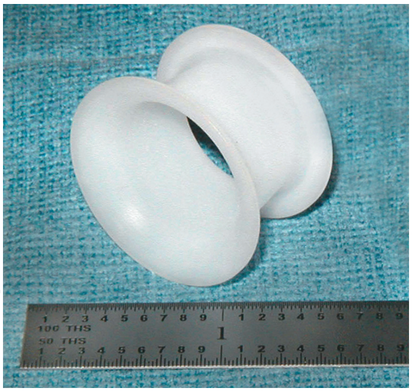
Any house painter will tell you that the time taken preparing for a job typically outweighs the time spent actually moving the brush. Custom machining is much the same. When Acinch Development, Susanville, Calif., reproduced a carburetor part for a 1930s Ford tractor, machining time was practically negligible compared to the time and thought invested in reverse engineering and process planning.

A customer involved with collectors of old tractors approached shop owner Bobby Wilson with the worn-out part, for which replacements or manufacturing data no longer existed. The approximately ¾"-long, $1\frac{3}{16}$"-dia. cylinder featured ID and OD tapers and radiused ends. Originally molded from Bakelite, or phenolic resin plastic, the part directs the flow of fuel and air between two carburetor chambers. The part press-fits into holes bored in the chambers, with its thin-walled construction enabling the part to flex and form a seal.

Wilson first had to determine the part's exact dimensions, which was difficult because it tapers inside and out and its ends are its only square and parallel features. He fabricated a locating jig by setting the part on its side in air-hardening modeling clay with the ends hanging free. When the clay hardened, Wilson clamped the part's ends in a vise. Then, on the shop's Birmingham B3VS CNC bed mill, he milled the base of the clay perpendicular to the ends, and milled the sides of the clay perpendicular to the base.

Now the part was rigidly mounted and truly horizontal in a clay block so that it could be clamped on the table of the bed mill. The mill's M400 Centroid control has a CNC digitizing feature, which employs a ruby touch probe to achieve a resolution as high as 0.0001". Wilson set the machine to probe the part's OD at 0.010" resolution. When that was done, he sawed the part—still in the clay block—in half, and put the half that stuck out of the clay back on the mill to probe the ID. Probing took 12 minutes.

To speed the handling of the digital files, Wilson exported them from the mill's control to his BobCAD-CAM software as partial wire-frame images rather than 3-D solids. He used the software to extrapolate the rest of the part dimensions from the wire frames and convert them into a solid model. He also blended the part's contours that were represented in steps instead of a smooth curve. "I smoothed any of the edges that may have picked up. Probing at 0.0001" resolution originally would smooth the image, but it takes time." The software also generated G-codes.



Acinch Development

Acinch Development reverse-engineered this thin-walled replacement carburetor part for a 1930s Ford tractor and machined it from plastic.

Wilson next had to decide how to hold the part during machining and plan the sequence of operations. "Having contours on both sides makes it really hard to hold," he said. "You could make a fixture and slide the part on it and tighten it down, but because the walls are so thin (0.036"), if you try to hold it, you flare it out."

Wilson decided to do the machining on his shop's bar-fed Top-Turn CNC-406 lathe, with the part essentially supporting itself. First, he tried roughing the inside, finishing the outside, then coming back and finishing the inside. However, the second pass caused the plastic to deviate, score and tear because the part was moving. The thin walls wanted to suck in and the dimensions were changing. As a result, Wilson said, "I did it all in one shot … one pass per side. When I parted it off, it was complete."

He used 1½"-dia. Delrin, or acetal copolymer plastic, bar stock. He chose porosity-free material because the part would be transporting gasoline and air vapors.

Wilson has been machining plastics for more than 30 years. He pointed out that chip control in plastic means having the chips roll smoothly off the part rather than break abruptly, as is desirable when machining metal. The chips also must leave the part at an angle calculated to avoid scarring the material.

In addition, machining this plastic requires coolant. "If you cut it dry it burns or melts and you get a haze across it," he said. Wilson uses True Blue coolant, a water-soluble, noncarcinogenic, biodegradable mixture.

The first operation was turning the bar to a straight 1.200" diameter. Wilson applied a TiAlN-coated carbide Sandvik Coromant TNMG triangular insert. Although the plastic is slightly abrasive, a coated insert isn't necessary, but to minimize tool inventory Wilson generally buys coated tools. He turned the bar at a 2,800-rpm spindle speed, a 0.017-ipr feed rate and a 0.30" DOC. He then formed the OD with a Sandvik Coromant VNMG 35° diamond insert, run at 2,800 rpm, 0.012 ipr and a DOC that varied from 0.158" to 0.173".

Wilson began forming the ID with an axial pass using a $\frac{11}{16}$"-dia., screw machine-length Chicago Latrobe cobalt-HSS drill. "The finished part is actually 0.720" long," he said, "and I drilled in about 1⅛". I drilled past the part, into the bar stock, so the chips would have somewhere to go." The drill ran at 1,800 rpm and 0.050 ipr.

Generating the part's ID contour "was kind of tricky," Wilson said. He used a GPCD-5 internal threading and profiling insert from Circle Machine Co. The tool ran at 2,800 rpm, 0.012 ipr and a DOC varying from 0.055" to

0.194". Wilson used the threading insert with a 7° leading edge to be able to follow the contour. The angle of the edge acts like a shear-angle cutter, reducing cutting pressures and minimizing breakout when the tool exits the part. "The side of the insert is doing the majority of your cutting, but the finishing is done with the point, like a taper cut."

Wilson held tolerances of ±0.0005" on the two sealing edges and within 0.001" on length.

Machining completed, the part remained attached to the bar by a thin strip. Wilson said: "I cut it off as close as I could with a surgical knife, then I put on my head loupe [or headband magnifier] and hand-broke that edge. I haven't found any tools yet able to deburr that delicate of a thing so I do it by hand. I deburred it maybe 0.005", chamfered around the edge, and she was done."

To date, Wilson has made the part in five different sizes, in diameters from 0.765" to 1.765". He can simply scale different sizes. "I check the new one, figure out what the percentage change is, and tell my CAD program to scale it to that," he said.

Total machining time for each part, inside and out, is only about 13 seconds. Wilson usually runs one part to fill the customer's order, then makes a couple more for stock. He observed that including time spent parting off and deburring the part, "we could run approximately 80 an hour. Now, if there were only more old tractors out there."

For more information about Acinch Development, visit www.acinchdev.com or call (530) 257-5694.

Process mapping

BY DAVID GEHMAN
AND GREGORY FARNUM

Every shop wants accuracy when it comes to costs and control of trends, things like machines drifting off tolerance. "More importantly, tracking processes gives you the ability to deliver at the times and in the amounts you promise," said George Seeley of Catalyst Connection, a provider of resources for Pittsburgh-area business development and productivity improvement. "Missed deliveries in an area like automotive is the kiss of death."

Time was, it was sufficient to identify and track batches of parts, but today, that's no longer good enough. In some situations, every part must be identified, as failure to do so could mean a costly recall or return. (Consider that without individual part identification, there is no way to determine whether a given problem affects just a few parts or an entire production run.)

This tracking requires continuous collection of current information on what employees and machines are doing, plus knowledge of where materials and products are at all times.

Manufacturing shops are among the most data-rich environments around. Speeds, feeds, quality data, dimensions, machine costs, people costs, downtime, uptime ... "shop activity" does not begin to describe it.

Getting this data is a tough job, and one all-too-common solution is to just let the data flow by, uncaptured and unchecked. "Unfortunately, some shops think that keeping real-time tabs on all the numbers takes more effort than it's worth," Seeley said.

Better solutions exist, chosen from a growing number of automatic ID technologies. The most common, seen in every U.S. store, is, of course, bar coding.

"Bar coding is a mature technology," said Roy Sutton, president of Data Net, Falls Church, Va., a shop floor data-collection systems integrator. "The technology's well understood and equipment is generally reliable and cost-effective."

Still, the type of conventional bar coding where codes are printed on labels that are then affixed to parts, totes or shelves has some drawbacks in metalworking. To say the least, heat, cleaning and pickling, cutting fluids, oil and grease, and rough handling are not friendly to paper.

"Bumpy bar coding is one solution," said Sutton. Bumpy bar coding involves stamping, laser etching or casting bar codes that gain their legibility not through ink on paper but by 3-D coding above or below the surface of the part. "Bumpy bar coding is more expensive than paper labels, which cost a fraction of a penny each, but they are effective in the worst of environments."

A second technology, radio frequency ID, encodes information on chips that travel with the parts. Most RFID systems are passive: When bombarded by radio energy from a reader, they use part of that incoming energy to beam back data. Physically, thanks to integrated circuit technologies, RFID chips can be made impervious to fluids and reasonable levels of heat cost-effectively. Plus, large amounts of information can be encoded into the chips, so a complete production history can be contained on each part. But operationally, the technology is in many ways at an early stage.

"Bar-code technology is cut and dried," said Seeley. "The equipment is standard, as are the machines that print labels. But RFID still requires heavy customization."

Sutton agreed. "Many RFID products have significant problems when in direct contact with metal," he said. "Each RFID installation has to be understood and tested thoroughly, and that usually means pilot projects, test samples and on-site development."

As important as tracking is, installing an automated data-collection system may not be economically justified. "You need to figure out the return on investment," Sutton pointed out. "Nobody is going to authorize a budget until the payoff is clear."

"You want to think through the value of automated data-collection equipment to your shop," said Seeley. "Managing mission-critical information is important for any company, and maybe even more important for smaller ones. The process of tracking parts through production is not much different than other forms of asset management."

"The key is to know exactly what you want to do," added Sutton. "Data collection by itself is not a panacea. Look at your business processes and judge whether accurate information about your processes has value."

Equally important is buy-in by both top management and the people who will be working with data-collection equipment. "You can't just walk in and announce that from this point on, everyone will be using bar codes," Sutton explained. "People need to be aware as early as possible about upcoming changes. Get them involved, get their feedback."

He added, "The number one cause of collection system failure is not involving the users early enough."

About the Authors

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

BY MICHAEL DEREN

A false economy

It seems everywhere, including trade magazines, I read about how the economy is picking up in the U.S. For instance, I read Publisher Don Nelson's "Lead Angle" editorial in CTE's March issue, which started off presenting the brighter news for manufacturing. It stated that durable goods orders have risen steadily, capacity utilization is at the highest percentage since 2000 and other key indicators are up. But the gist of the editorial was how manufacturing is losing jobs and what is being done to turn that around.

Being on the front lines, I see capacity utilization has increased—thankfully so. I also see how difficult it is to hire qualified personnel. However, I have other concerns. Specifically, I worry that the profitability of companies and the incomes of machinists aren't increasing along with the rising capacity utilization. Let's look at these two areas of concern.

I talk to a lot of vendors and people who work at other shops, here in New England and other parts of the country. The vendors all agree that purchases along with order sizes have increased, especially during the last few months. Are shops buying more because of new customer orders? Yes. Are shops buying more product to replenish their diminished tooling inventories? Yes. Does this mean shops are more profitable? Not necessarily.

All this means is shops are utilizing their capacities more. That is why the key indexes look brighter. More work is coming into their shops. At what price, though? Many shop owners are cutting their hourly shop rates to bring in work, not by a few percentage points, but by 20, 30 and even 40 percent. A shop that was charging, say, $75 per labor hour may now be charging $45 to $50 per hour.

Shops exist, ones that have good relations with their customers, that just take the job for what the customer will pay. This is so the customer won't send the job out for bid. Shops that don't have monthly payments for equipment and lower overhead costs, can, perhaps, afford to do this. What about shops that have thousands of dollars a month in equipment payments? What about rent, heat (heating oil costs in New England have gotten way out of hand), electricity, phone and other necessary expenses? How do these shops even get back to the shop rates they used to charge?

On the other side, I know of a few shops that would rather let a machine sit idle than drop their rates. How long will they be able to stay in business?

With some shops busy but making marginal profits while other shops have machines sitting idle because they refuse to do work for less than their standard shop rate, what happens to machinists' wages? They remain stagnant.

Yet gasoline prices have risen to record highs, with no sign of relief. So it costs more to drive my economy car 50 miles each way to work and back. I was paying about $13 per fill up at the beginning of the year. Now I'm giddy with excitement since the price dropped a few pennies a gallon and a fill up is under $20. Heating oil is up at least 50 cents a gallon from last year and electricity is up almost 40 percent from last year. Hell, even my trash removal service increased by 15 percent.

The backbreaker is, at our shop, pay decreased for the third straight year. This happens every July 1 when health insurance premiums increase. This year, the increase was 12 percent. Did the coverage improve? Nope. It didn't even stay the same. What we got was an increase in doctor co-pays and higher deductibles. This is not uncommon in the industry these days.

Many older machinists are taking early retirement and subsidizing their pensions with easier work until their Social Security benefits kick in. Others have taken part-time jobs to offset these increases.

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There used to be a time when companies would have a general rate increase to at least help offset this increase in employee-benefit costs. These rate increases, as well as merit increases, would offset the cost of living. Remember COLA? Not a soda, but Cost Of Living Adjustment? These days, how can companies even attempt to give the same level of benefits they used to? They can't. What can be done? I'm not sure. I do know that given the current manufacturing dilemma, the industry can't attract some of the best and brightest. The offering of stagnant wages, leaner benefits and harder work must be attractive to someone out there, but probably not the brightest. △

About the Author

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