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BY MIKE PRINCIPATO

Know thyself

Last month, I promised that I'd soon embark on my immodestly titled (and, perhaps, modestly anticipated) Great American Manufacturing Renaissance Plan. This month, I keep that promise with Step One: Know Thyself. In this step, we look at how to define who we really are … and aren't. Think of it as an introspective, manufacturing-guy-meets-Dr. Phil exercise, only much manlier.

I don't get paid to be a cheerleader for the metalcutting industry, much less all of manufacturing. And if you've read anything in this space over the last few years, you already know I'm nothing if not mercilessly, predictably and often infuriatingly capitalistic. So if you're reading this in expectation of the kind of rah-rah pep talk that you'd get from your average trade association, stop reading now. Still with me then? Great. Let's start today's class with some hard statistics about our place in the global economy:

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The U.S. is the world's No. 1 manufacturer, responsible for 25 percent of the world's manufactured output and $1.5 trillion of the annual U.S. gross domestic product (GDP). It's been that way for more than 20 years and hasn't changed significantly, even since 9/11.

The largest U.S. manufacturing industries are, in order, food, computers and electronics, and automobiles. No surprise there, right? But you might find it surprising that those three comprise only 30 percent of U.S. manufacturing; fabricated metal products and machinery—which includes dozens of individual sectors—account for 16 percent. Machine shops, one of those sectors, shipped products valued at $31.9 billion in 2005, up from $28.7 billion in 2004, according to the U.S. Census Bureau.

Manufacturing's contribution to U.S. GDP (the total value of goods and services produced by the U.S.) has declined dramatically—from 25 percent in post-World War II America to about 12 percent last year. But output from U.S. manufacturers has still increased over that same period. So why the skewed conventional wisdom among many citizens who think America "doesn't make anything anymore"? It's because during that same period, even as productivity surges in manufacturing have continued to push relative prices down, Americans are spending more money than ever on health care, business services and other products and services—the prices of which have been skyrocketing compared to manufactured goods. We produce more in GDP terms, but you'd never know it, would you?

Our economy is maturing right along with our self-indulgent population and the clueless politicians who enable that indulgence: Taxpayer-subsidized health care? You bet! More money for public school curricula that pale next to our global competitors? Sign us up! But realizing, much less appreciating, that manufacturing has continued to grow (especially in complex products including electronics and automobiles) despite being a smaller part of the overall economy … well, let's just say that we're a little like the late, great comedian Rodney Dangerfield. We get no respect.

Manufacturing has never been the largest employer in America. The vaunted "service economy" employs more workers per dollar of revenue—just look at the primitive, labor-intensive creation of a Subway sandwich. Do the math: One employee makes one Italian hoagie in 5 minutes to generate $5 in revenue and then repeats the process from scratch to make a second hoagie. Your shop, on the other hand, can produce perhaps 30 parts per hour at $5 per part on an unattended CNC milling center.

Manufacturers still employ 14.3 million workers in the U.S.; California, Texas, Ohio, Illinois and my home state, Pennsylvania, employ the largest number of that total. Do we employ fewer workers now than a decade ago? Yep. And yet manufacturing productivity has grown at a rate two and a half times faster than productivity growth in any other American business sector since 1987, according to the U.S. Bureau of Labor Statistics. Go figure.

Next month, I'll tell you why manufacturing drives our economy and that of any other powerful nation. Or did you think that China decided to start producing electronics and machinery in earnest because they couldn't find enough fast-food workers?

About the Author

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Taming warp

BY JAMES A. HARVEY

Don't be surprised when workpieces warp during machining. On the contrary, expect it when hogging and machining parts with thin features. However, there are straightforward methods of dealing with warp that eventually become second nature to most machinists.

Warping is less an issue on turned parts than milled ones. Because the material being removed on a lathe is symmetrical around the part's axis, the stress or release of stress from the machining operation is balanced, making the part less likely to warp.

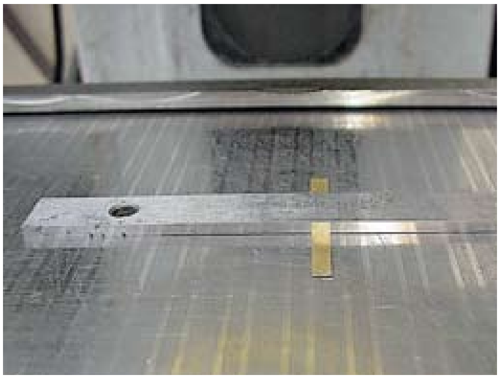
When milling, the amount of warpage is determined by internal stresses in the material. Cold-rolled raw stock tends to warp more during machining than hot-rolled and stress-relieved materials. Regardless of the material, assume it will warp to some degree and plan accordingly.

The following are suggestions for producing straight, flat parts.

■ **Skin cut all surfaces of a workpiece material.** The first thing you should do is cut through the skin of the material on all surfaces. Ideally, no surface should be left unmachined.

■ **Let the material warp.** Allow material to "move" between vise clampings. Loosen and tighten the vise between roughing cuts so the material has a chance to seek its own shape. In other words, you want the material to "float" in the vise before clamping it for another cut. What you don't want to do is restrain thin and hogged out areas from roughing through finishing. If you do, the part will almost certainly bow when released.

■ **Use shims to prop up plates that must be clamped directly to a table.** This holds true for plates machined on a surface grinder and plates clamped directly to a milling machine table. If you start with a warped plate and pull it down with clamps or a magnetic chuck, the plate will return to its original bowed-shape when released. Before clamping the plate, measure the gap between the table and the plate in an unrestrained condition. To do that, the ends of the plate must be resting on the table with the bow facing up in the middle. Before clamping the plate, insert shims or pins on either side of the plate to fill the gap. Then clamp the plate on the shims and cut across the plate. That side will become flat in an unrestrained condition.



A warped workpiece is shimmed so it can't "suck down" on the magnet. The warp can then be ground away.

All images: J. Harvey

To remove the warp on a long bar clamped with a vise, each cut section must be indicated flat before proceeding with the next cut.

Toe clamps work well for clamping plates so the plate's entire surface is exposed for machining in one setup. Remember to cut through the material's skin on both sides before "fine tuning" the plates with the shims.

■ **Tap a plate down on parallels for the last cut only.** By letting material float in the vise between cuts or vise clampings, the material will have a chance to seek its own shape and relieve internal stresses. When you're close to a plate's final size, take a light finishing cut on one side without tapping it down on the parallels to produce one flat surface. Flip the plate over and, for the last cut only, tap the material down on the parallels so the plate comes out parallel. With thin plates, tighten the vise lightly on final cuts to avoid bending the plate. A plate machined in this manner will be flat and parallel in an unrestrained condition.

■ **Indicate previously machined surfaces to machine long bars.** The following are suggestions for machining long bars in a milling machine and maintaining straightness. First, cut through the skin of the bar on opposing surfaces. Do this skin roughing quickly while disregarding surface finish. Once you've made a quick cut through the skin over the bar's length, begin creating a finished flat surface. Do that by taking a long cut with a facemill and then moving the bar in the vise. After moving the bar, you must indicate the previously machined surface so it reads zero along the length of that surface. Then cut the next section while blending the Z heights.

What you can't do to create a flat over a bar's entire length is just slide the bar on parallels as you go.

About the Author

James A. Harvey is a machinist and plastic-injection-mold maker based in Garden Grove, Calif. Machining Tips is adapted from information in his book, "Machine Shop Trade Secrets: A Guide to Manufacturing Machine Shop Practices," published by Industrial Press Inc., New York. He can be e-mailed at HarvDog42@aol.com.

Exclusive housing

BY BILL KENNEDY, CONTRIBUTING EDITOR

After nearly 30 years of making tools and dies for other people, Jac Corless opened his own shop in Broomfield, Colo., in 2002. Jacstudio Precision specializes in automotive engine work, with about 70 percent of its business in rebuilds, head machining and high-performance upgrades. Customers include "everybody from drag racers to the members of the younger generation who want to go fast with their little four-cylinder sport compacts," Corless said. The rest of his business is job shop work, such as machining fixtures for an electronics company and creating tooling for a brewer. Corless also machines "onesie and twosie" prototypes and some "weird," often automobile-oriented, custom jobs.

One such odd job involved reverse engineering and then machining a pair of windshield-wiper transmissions for a 1936 Buick. The car's New Jersey owner saw Corless' Web site and sent a worn example of the assembly with a request to make two new ones. The transmission, approximately 1"×1½"×1½", consisted of a contoured aluminum casting (like a "bat wing," Corless said) housing a half gear that turned a full gear to cycle the wipers. Corless disassembled the worn unit and measured the components.

On a Bridgeport Interact 4 mill fitted with a Heidenhain controller, Corless machined each new housing from a 1"×2"×2" block of 6061 T-6 aluminum. After clamping the block in a vise, he applied TiN-coated HSS tools to drill a 0.200"-dia. hole (countersunk 0.250") and a 0.250"-dia. hole (countersunk 0.312") for the transmission gear shafts, and to drill two 0.187"-dia. holes (countersunk 0.200") for screws to mount the housing on the car.


Jacstudio

Jac Corless machined these highly contoured aluminum housings and fabricated the windshield-wiper transmission components they contained for a 1936 Buick undergoing restoration.

To make the cavity that contains the gears, Corless first plunged a 4-flute, ¼"-dia. ball endmill, run at 750 rpm and a 50-ipm feed rate, to a maximum depth of 0.800". He performed the plunging operation to provide room for chips to escape during subsequent milling and applied flood coolant throughout for chip evacuation.

A series of radius cuts then formed the cavity. "I programmed the radii I needed and then kept dropping the Z level in 0.050" steps until I got down to the bottom," he said. Next, to fit the contour at the base of the car's windshield, a ⅜" ball endmill machined a double radius on the back of the housing and also cut an angle at the edge of the part to provide clearance for the wiper arm drive lever.

Machining the cavity and contours created a problem with the part, though. "It couldn't be clamped back into a vise; there was no square surface left. It took a long time to figure out how to hold it," Corless said. He solved the problem by milling a fixture out of wood—"just a bunch of clearances"—and screwing the housing to it through the mounting holes drilled earlier.

Corless then obtained the dimensions needed to program milling of the housing's complex outer contour. He put the worn part on the wood fixture and touched it off with the tools he intended to use to mill the new parts. After roughing the outer dimensions with a 4-flute, ½" square-shoulder endmill, he used a ⅜" HSS ball endmill to finish the contours on the lower part of the housing. For the top contours, he employed a 6-flute, 1"-dia., ⅜"-radius corner-rounding HSS endmill.

The next challenge was making the shafts on which the gears would turn. The large gear would be pressed on to a 1"-long shaft featuring three different diameters and a set of tiny splines. Corless made the shafts out of 01 tool steel drill rod. He first clamped the rod in his 14" Enco lathe and cut a 0.194" diameter for a length of 0.30", in preparation for a 10-32 thread.

Then he made 60 spline teeth, 0.015"-deep, on the next 0.5" length of the shaft. He applied an up-sharp HSS 60° threading tool turned sideways in the tool post, pushing it along the shaft towards the chuck via the longitudinal travel of the cross-slide. The lathe chuck was stationary while the tool cut each spline tooth. After every cut, Corless rotated the chuck 6° and cut another spline tooth until all were completed. Then he cut the shaft off and flipped it around to turn a 0.200" length of 0.199" diameter that would be the bearing surface in the housing's 0.200"-dia. hole. Corless said maintaining that ±0.001" tolerance, the tightest on the part, assured free movement of the gears. Finally, he flipped the shaft again and cut the 10-32 thread on its end.

Corless obtained steel gears from Stock Drive Products of New Hyde Park, N.Y., and modified them for use in the wiper transmissions. The original half gear was a casting that featured a backing plate with a lever-like extension. Corless milled the shape of the backing plate and lever from ⅛"-thick 1018 steel, silver-soldered the plate to a round gear of appropriate size, then machined off the unneeded half of the gear. The full round gear was simply milled to the desired thickness. Corless also machined a 7"-long × 0.312"-wide × ⅛"-thick lever from 1018 steel to attach the half gear to the wiper motor.

Finally, Corless machined rivets out of ¼"-dia. rod to attach the half gear assembly to the housing and to the wiper motor lever.

The car was being painstakingly restored with the intention of entering it in a *concours d'elegance* in Palm Beach, Fla. (a vehicle contest in which entries are judged on elegance of appearance). "That's why we kept these parts looking as close to the originals as we could," said Corless. He completed the job by polishing the housings to match the original's flash chrome plating.

Corless estimated that combined machining time for both transmissions was 14 hours. Job planning was equally as long, taking place while Corless ran other jobs. "I try to have things going while I'm doing other things, so I'm not just spinning my wheels," he said.

For more information about Jacstudio Precision, call (303) 469-6400 or visit www.jacstudio.com.

To get rid of burning, loading

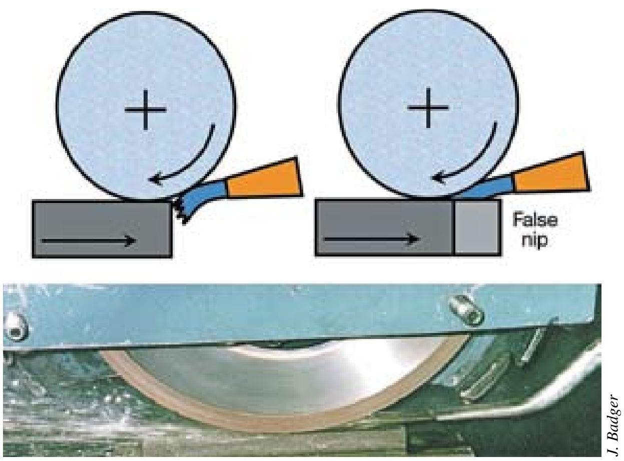
Dear Doc,

I get burning at the entry point of workpieces. I assume it's because there's no way for coolant to get into the grinding zone at the entry point. I use a ⅜"-ID copper tube as a coolant nozzle. What can I do?

The Doc Replies:

You have two options. First, you can put a "false nip" in front of the workpiece. This should have about the same geometry as your workpiece. You'll grind this nip away while grinding the workpiece. The nip helps drag coolant into the arc of cut to prevent burning at the entry point.

Or you can increase the coolant velocity so it approaches the wheel's surface velocity. That way, coolant will be carried into the arc of cut without using a false nip. You can increase coolant velocity by crimping the nozzle so the opening is wide and flat, not round. This decreases the orifice area, which maintains back pressure and ensures a higher exit velocity. A crimped nozzle not only prevents burn at the entrance point, it reduces loading, wheel wear and burn at other places.



A false nip (top right) helps coolant get into the grinding zone. Crimping the coolant nozzle (bottom) helps maintain back pressure, ensuring high exit velocities. Such velocities help coolant get into the arc of cut.

To prepare the ⅜" nozzle, which takes about 10 minutes, put a 1⁄32" shim at the entrance and crimp it slowly in a vice. As the opening widens, put in a wider shim and crimp it again. The opening should become somewhat rectangular, 1⁄32" high × ½" wide. This crimping reduces the orifice area from 0.11 sq. in. (area = $\pi D^2/4$, where D = ⅜") to 0.016 sq. in. (area = w × h, where w = ½" and h = 1⁄32"). That's a factor of seven, which should increase velocity so the coolant enters the arc of cut, even at the entry point.

Dear Doc,

I occasionally grind stainless steel with alumina wheels, but the grinding suffers from loading. I've dropped the table speed to decrease my metal-removal rate. This reduces the problem, but only for a little while. Why is stainless so difficult to grind, and what can I do without changing wheels or coolant types?

The Doc Replies:

Stainless steel is difficult to grind because it doesn't oxidize like other steels do. During grinding, most steels instantaneously form a layer of iron oxide at the surface. It's only a few molecules thick, but it provides a barrier between the aluminum oxide grits and the iron in the workpiece, preventing adhesion. Stainless, however, forms chromium oxide, or Cr_20_3, which is mutually soluble with Al_20_3. Therefore, the workpiece chemically bonds to the wheel grits.

First, make sure at least some coolant enters the arc of cut to act as a barrier between the grit and the workpiece. Therefore, use a small nozzle orifice, which gives a higher outlet velocity.

Second, if you're applying water-soluble coolant, make sure you have at least a 7 or 8 percent coolant concentration to act as a barrier between the grit and the workpiece.

Third, open up the wheel by dressing it aggressively with fast diamond traverses and deep cuts. It'll create a rougher surface finish, but we'll deal with that later.

Fourth, take smaller DOCs but with as fast a table speed as possible. This combination means less heat buildup on the workpiece and more wheel wear, so the self-sharpening wheel releases its dull, loaded grits.

Fifth, if possible, consider dropping your wheel speed, say from 6,000 to 5,000 sfm, to increase the wheel's self-sharpening ability.

Remove most of the stock under these conditions, leaving about 0.0006" of material. Dress the wheel several times with a slow diamond traverse and small DOC to remove all signs of loading and make the wheel closed and dull. Take the last passes with a 0.0002" DOC at medium to high table speeds. These conditions aren't ideal for long-term stock removal, but they'll create a fine surface finish in a reasonable cycle time with a clean, nonloaded wheel. △

About the Author

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