MAY 2005 / VOLUME 57 / NUMBER 5

BY MIKE PRINCIPATO

An open letter to the boss

Dear Boss:

I've been seeing a lot of stories lately in the newspaper and on television about the declining state of manufacturing in America. The stories paint a pretty negative picture for a guy like me; frankly, they're depressing enough that my wife has started asking me whether I should think about another line of work. I can't blame her. We've got bills to pay like everyone else, and she's worried I might someday be one of those thousands of faceless, nameless workers we hear about who's just been laid off at the local steel mill, auto plant or aircraft factory.

But I'm not a quitter, and I figure you're not, either. I know this is a tough business and your life hasn't exactly been a bed of roses running the shop. Besides, I enjoy what I do for a living. Ever since I was a kid, I've loved making stuff and figuring out how things worked. For me, there's no feeling better than knowing I helped produce a complicated precision part out of what was once nothing more than a block of metal, and made it better and quicker than you estimated.

So, Chief, you know my heart's in the right place when I tell you what I'm about to tell you. Although I don't want my wife to know this, I'm worried, too. When I was a kid, there were shops like this one all over town. Now, we're down to your shop and only a handful of others within about 25 miles. I know about those other shops because their owners have called and asked me if I'd jump ship to work for them. Don't worry—I'm not going anywhere right now, because I think you've been fair to me. But it's still nice to hear once in a while that my skills and reputation are valuable.

My dad used to tell me, even before the dawn of CNC technology, that machinists were "the nobility of manufacturing workers," and would always make a good living with their trade skills. Now I'm not so sure.

So I don't think I'm risking much by telling you I've been losing confidence in the prospect of my future employment—and yours. More importantly, I want to give you advice on how to get that confidence back. I think the future of our shop, and maybe a lot of others, depends on taking a hard look at this business from the perspective of guys like me—the ones who program the controllers, crank the handles, take pride in their craft and make money for your company.

Whether you realize it or not, there's really just a core group of men and women here who have the necessary skills to produce the parts our customers order. That's not to say the other workers aren't important; they are. But finding a guy who can load a truck, polish a part or pack an order isn't nearly as tough as finding somebody who knows how to process-map a complex job, program a CNC or build a milling fixture. I don't meant to brag, but we're pretty smart people. You might be surprised what we know and the ideas we have that can improve your chances of surviving and prospering.

For example, did you know your best employees want to know your estimated time allowed for a job, rather than being kept in the dark? That way we know how we're doing compared to the goals you've set. We like you, Boss, and we trust you. We know all your estimates are not dead-on, but most are close enough to give us something to shoot for. So stop worrying about whether the labor-time information is something we'll use against you somehow. Instead, how about paying us a bonus if we beat the time, and remembering that when it's time for our annual reviews? Your better machinists and programmers will love that, and your weaker ones … well, wouldn't you rather know who they are than penalize your high achievers by lumping them in the same category?

My dad used to tell me … that machinists were 'the nobility of manufacturing workers,' and would always make a good living with their trade skills. Now I'm not so sure.

This brings up another point about communications. We're big boys and girls, and, like I said, we trust you. You need to trust us, too, and there's no better way to do that than by bringing us into the loop concerning good news and bad. Remember when we lost that big account last month? That hurt, especially because you were forced to lay off one of our team. When I heard we lost the account because the customer got a better price elsewhere, my first reaction was: "Why didn't you let us know there was a problem brewing and ask us for help? Three of us produced that particular part for the last 2 years. We could have suggested half a dozen ways to streamline its production and cut the price before the customer found someone else who would."

Same goes for good news. We deserve to know when our work earns us more orders or even a new customer. Believe me, a little bit of praise goes a long way. One of the guys here used to work at a shop whose owner bought pizza once a month and allowed an extra half hour at lunch to relay customer feedback from the outside world. That sounds like a pretty good idea to me, and a great way to boost our sagging morale.

Heck, if you wouldn't mind shuting down for a half day or so to let us really cleanup the shop and offices, you could invite customers to an open house. Some of us are pretty good with people, and we'd like nothing more than the chance to explain to our customers how we make their parts on our machinery. We think they'd be impressed—and it might lead to more business.

I realize this is a lot to digest, Boss. How about after you've had some time to think about it, you get a few of us together for an informal meeting to discuss these ideas and a whole bunch more we've come up with? Because to tell you the truth, some of us are getting damned tired of hearing about how the Far East is going to surpass the U.S. as the world's manufacturing superpower. We think that we still deserve that title, and if you and other bosses listen a bit more to us, we'll keep it.

After all, we're all in this together, right? Thanks for reading.

About the Author

Mike Principato owns a machine shop in Pennsylvania. He can be e-mailed at ctemag1@netzero.net.

Grinding wheel fundamentals

BY DR. JEFFREY BADGER

The three components of a grinding wheel are the abrasive grits, the bond material and the porosity. The grits are the hard abrasive particles that do the cutting. The bond material is softer and acts to hold the grits in place. The porosity, or air holes, carries coolant to the grinding zone and provides space for chip formation.

The four basic grit types are aluminum oxide, silicon carbide, cubic boron nitride and diamond. Al_2O_3 and SiC are referred to as conventional abrasives, whereas CBN and diamond are called superabrasives. Their respective Knoop hardness values are 2,100 for Al_2O_3, 2,400 for SiC, 4,700 for CBN and 7,000 for diamond. A variety of abrasive types are in each group: blocky vs. angular, friable vs. tough and macrofracturing vs. microfracturing.

The basic bond types are vitrified, resin/rubber and metallic. Vitrified bonds are brittle, but tend to hold form well. Resin bonds tend to impart a finer surface finish and, because they are tougher, can achieve higher metal-removal rates. Metallic bonds, used in superabrasive wheels, tend to be free-cutting, or shelf-sharpening, and can also achieve higher metal-removal rates. Electroplated wheels are simply a single layer of superabrasive held in place by a metallic bond. Because they consist of only a single layer, they are not trued or dressed and spindle runout must be kept to a minimum.

In general, wheels with more bond material tend to act "harder." This has nothing to do with the hardness of the abrasive. Rather, it means that because of the additional bond material, the wheel is less likely to release grits once they become dull. Hard wheels tend to hold form better, but generate more heat. Soft wheels lose form more quickly, but generate less heat because they are self-sharpening.

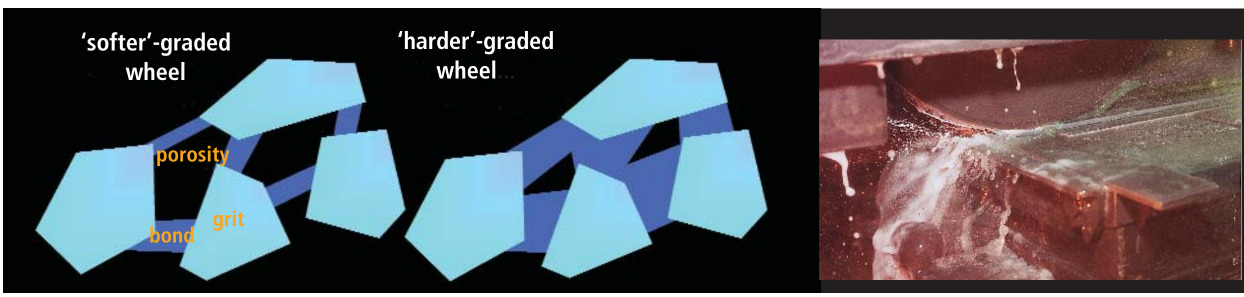
The correct choice of abrasive depends on numerous parameters. Typically, softer materials can be ground with conventional abrasives, whereas harder materials must be ground with superabrasives. Ferrous materials usually cannot be ground with diamond because of their affinity for carbon, i.e., at elevated temperatures the diamond simply dissolves into the steel.

Truing is the process of making the wheel round, so that it runs "true." Dressing is the process of imparting a desired surface topography on the wheel. In some processes, both are done in a single step, and it is referred to as dressing. Vitrified- and resin-bonded, conventional-abrasive wheels are usually trued and dressed in a single step with a single-point diamond, a diamond cluster or a diamond roll. CBN wheels are trued with a diamond roll or brake roll dresser. A single-point diamond or diamond cluster should not be used on CBN grinding wheels because the hard CBN grits cause the diamond to wear quickly.

After truing, resin- and metal-bonded CBN wheels require dressing to open up the glazed surface that was imparted by truing. This is done by "sticking" the wheel with a vitrified-bonded, Al_2O_3 or SiC conditioning stick. Vitrified-bonded, CBN wheels require no further preparation after truing. Resin- and metal-bonded diamond wheels also require sticking to open up the wheel.

Grinding wheels are a mature technology and significant advancements are infrequent. One relatively recent advancement in grit technology was seeded-gel abrasives, which were developed in the 1980s. Seeded-gel abrasives are simply a type of Al_2O_3 with a fine microstructure. This means the grits fracture into tiny pieces instead of large chunks, keeping the wheel sharp while maintaining form.

The correct combination of grit and bond types can yield the most significant developments. Finding the right combination for a specific application is often a matter of trial and error.



J. Badger

Inset: Bill Kennedy

A more-porous, softer-grade wheel wears faster but generates less heat and collapses later than a harder-grade wheel, which exhibits less wheel wear but generates more heat and collapses sooner. Inset: Surface grinding of an angled carbide splitter.

About the Authors

Dr. Jeffrey Badger is an independent grinding consultant. His Web site is www.TheGrindingDoc.com.

An innovative prototype

BY BILL KENNEDY, CONTRIBUTING EDITOR

A manufacturer developing a small electric motor with a cast aluminum housing wanted to work with a prototype before investing in tooling for producing the castings. Innovative Machining Inc., a job shop that handles engineering design and both production and prototype manufacturing, engineered a way to efficiently machine the prototype from aluminum bar stock.

Measuring 6" in diameter × 3" long, the complicated front half of the housing had a 1.85"-deep cavity on one end, a variety of holes and a contoured channel on the other, and an array of cooling fins around the OD. Using an IGES CAD file supplied by the manufacturer, Innovative created turning and milling toolpaths with Mastercam CAM software to machine the housing from a 6"-dia., 3¼"-long bar of 6061-T651 aluminum.

Initial roughing took place on a Mazak Quick Turn 20N CNC lathe. A 0.850"-dia. hole was drilled through the center of the part's axis, and the hole was counterbored at a diameter of 1.378" to a depth of 1.0". A grooving tool held in a boring bar cut a 0.056"-wide, 1.464"-dia. keyway 0.30" deep in the counterbore. Then the part was turned end-to-end in the lathe chuck and rough-bored to within 0.100" of final dimensions.

The rest of the process required three setups on a Haas VF-3 vertical machining center. Programmer Seth Cross said one of the main challenges in making the part was "timing," or aligning, the part in the three fixturings to ensure correct relationship among the housing's complex features.

For the first setup, the part was clamped on the VMC's table with custom-made aluminum soft jaws, and located using the center bore made previously on the lathe. First, a ½"-dia. SGS Ski-Carb endmill, run at a 7,500-rpm spindle speed and 50-ipm feed rate, roughed the inside of the part. One pass left 0.010" of excess stock in the cavity, and a second pass finished the casting bottom. Cross said maintaining the required 32 R_a surface finish was difficult, because the cavity's depth made it a long reach for the cutter. The solution was to "slow everything down."

Next, 18 flats, each 0.700" wide, were milled around the cavity wall with a 5⁄16"-dia., 2-flute Garr endmill run at 2,400 rpm and 10 ipm. A 45º chamfer mill, ground for use as a spotting tool, marked locations for two holes in the bottom of the cavity and for 14 other holes along its rim. Then a ¾" drill made two through-holes in the cavity bottom at 1,146 rpm and 4.58 ipm. In a cutout area in the cavity bottom, a ¼" drill run at 4,584 rpm and 22.92 ipm started a hole that was finished to a 0.150" depth with a ¼" flat-bottom drill applied at the same parameters.


Innovative Machining

This complex electric motor housing was machined from a 6"-dia., 3¼"-long bar of 6061-T651 aluminum.

In the locations spotted earlier on the housing rim, a 3⁄16" stub drill made six 0.750"-deep holes at 4,584 rpm and 16 ipm. Then, after a No. 31 (0.1200"-dia.) stub drill made two 0.05"-deep holes in the rim at 7,162 rpm and 13.5 ipm, a No. 30 (0.1285") reamer run at 3,357 rpm and 30 ipm brought them to final dimensions. Next, a long spotting drill, run at 2,292 rpm and 10 ipm, located three places where a No. 43 (0.89") drill run at 9,048 rpm and 12.6 ipm made three 0.270"-deep holes. Those three holes were threaded to a depth of 0.220" with a 4-40 tap at 800 rpm and 20 ipm.

Cross said one of the major challenges of this first setup was tapping these holes. They were so close to the cavity walls that there was insufficient clearance for tool extensions, so he was forced to apply an extended tap at reduced cutting parameters. To complete this setup's operations, which took about half an hour, a chamfer mill cleaned up the bottom of the cavity at 1,500 rpm and 45 ipm.

For the next setup, the housing was flipped 180º. Cross made a fixture plate with pins to fit the ¾" holes drilled earlier. "We slipped the part down on the pins and bolted it through the counterbore in the center," he said.

The ½" Ski-Carb endmill was applied first, at 9,168 rpm and 73 ipm, to facemill the end of the part, leaving 0.070"-wide × 0.093"-high rings of material around each of the three large through-holes. Then a 3⁄16", 2-flute endmill machined a twisting, 0.5"-wide × 0.75"-deep channel around the top of the part at 9,000 rpm and 30 ipm.

Cross said, "It took a while to machine the channel. I had to step down in light steps—0.100" or 0.125"—so I didn't break my tooling."

Next, a ½" chamfer mill, ground as a spotter and run at 6,000 rpm and 12 ipm, located six points on the rim where a 3⁄32" drill then made 1.5"-deep holes at 5,496 rpm and 13.8 ipm. Next to each of those holes, a No. 2 (0.221"), applied at 3,885 rpm and 15.6 ipm, drilled through the part. A ⅜" Ski-Carb endmill counterbored those six holes to a depth of 0.885". This set of operations took about 1 hour.

The third milling setup was on a vertical rotary table, which served as the Haas machine's 4th axis. The housing was clamped onto the table in a 3-jaw chuck. The fixture, featuring locating pins, was designed to hold the part about 4" away from the chuck to provide tool clearance.

The housing OD has seven flats along its axis. Six are 0.560" wide and one is 1.7" wide, and they were milled with a

½" Ski-Carb endmill at 9,000 rpm and 76 ipm. Then a chamfer mill spotting tool, run at 6,000 rpm and 10 ipm, marked one hole location in each narrow flat and nine locations in the wide flat.

A 0.261" G-drill run at 3,291 rpm and 15.6 ipm then drilled two holes in the wide flat, located 0.400" from the front of the part. A ¼-28 STI tap threaded those holes at 800 rpm and 28.57 ipm to prepare for later insertion of helicoils. Then, between the 0.261" holes and the front of the part, a ¼" Ski-Carb endmill made two 0.600"-dia., 0.375"-deep holes at 5,612 rpm and 42 ipm. The same endmill, run at 6,112 rpm and 42 ipm, also made a ¾"-dia. through-hole centered 0.700" from the housing's back edge.

Around the 0.600"-dia. hole, a No. 43 (0.089") drill run at 9,648 rpm and 12.6 ipm made four holes 0.375" deep, which were then threaded to a depth of 0.250" with a 4-40 tap at 800 rpm and 20 ipm. Holemaking concluded after a No. 17 (0.173") drill run at 4,965 rpm and 15.3 ipm made a 0.370"-deep hole in each of the 0.560" flats, 1.050" from the back edge of the housing. The holes were threaded with an 8-32 tap at 800 rpm and 25 ipm.

A final machining challenge—80 cooling fins, each 0.34" deep, arrayed axially around the housing—was overcome with two cutters designed by Shawn Gibbs, Innovative's general manager, and Dean Kerbs, shop floor manager. Each cutter was tooled with three carbide inserts. One cutter machined a 0.026" radius at the fin base and a 0.027" radius at the top, and the other, engineered to make the fins positioned next to the axial flats, produced only the base radius. The cutters ran at 1,900 rpm and 19 ipm. Run time for the operations in the third setup was 45 minutes.

Postmachining operations included selective anodizing of parts of the housing service, and installation of helicoils. Three prototypes were produced.

Gibbs noted that the housing "had a lot of difficult challenges," but it's typical of Innovative's work. In many cases, he said, solving customer problems on specialized prototype parts leads to production-level contracts on other jobs.

For more information about Innovative Machining Inc., Wheat Ridge, Colo., visit www.innovativemachininginc.com or call (303) 421-1006.

Somebody call a doc

BY GREGORY FARNUM AND DAVID GEHMAN

First things first: What is a product data management (PDM) system and why would you want it? It's a software tool for storing and distributing essential product data. It does this by holding the master design data and other key product data, which is often called "product-definition data," in a single location—a secure "vault." There, its integrity can be assured and changes can be monitored, controlled and recorded.

Duplicate reference copies of this master data can then be distributed freely to various departments for analysis and approval. The changes, recommendations and queries that they make (the essential give and take of designing a product and bringing it into production) are then stored in the vault. Each modified copy of the data is signed, dated and filed in the vault alongside the original data, which remains as a permanent record.

PDM systems vary in their functionality, but some of their common capabilities are:

- Access control. Access to each piece of data in the product-definition database can be specified. For instance, read-only access can be given to personnel not directly involved in design or planning. This allows wide circulation of the data while maintaining its security.
- Classification. Components and materials can be organized in the database into classes to suit your business needs. In addition, each part can be given its own set of attributes. This enables designers and planners to locate a needed material or component with minimal effort, avoiding the time-wasting process of searching for and specifying a component or material whose equivalent may already exist in the database. Similarly, documents can be classified in terms of 2-D drawings, 3-D models, FEA (Finite Element Analysis) models, technical publications or whatever rubric is desired. Plus, the relationships between documents and parts can be established, making it easy to retrieve the documents related to a specific part.
- Product structure. PDM systems allow relationships to be specified by product structure. Thus, for any given product, the relationship among its components is recorded. Links between those physical objects and relevant documents are also recorded. Not only does this aid in the design process, it can serve as a manufacturing bill of materials for MRP II (Materials Requirement Planning II) or ERP (Enterprise Resource Planning) systems, and it makes it possible for personnel from other disciplines, such as manufacturing or finance, to quickly structure the data about that product in a way that's relevant and useful to them.
- Process management. Not only can PDM systems organize data, they can also organize the way people work with that data, thus helping to manage the process of bringing a design into production. The following is a fairly typical example of the sort of process management a PDM system can provide.

After a lot of give and take, and having evaluated various alternatives, the design team signs off on its CAD model of the design. The PDM system then alerts the designated analyst that the design is ready for FEA stress analysis. Once completed, the analyst signs off on the design, and the PDM system notifies manufacturing engineering to begin specifying the manufacturing process, which, in turn, alerts the tool designer to begin designing the needed tool(s). The system can send a red flag when the design has been held too long at any given stage so that minor delays don't turn into major logjams.

Put all these capabilities together and you have a system that can shorten design time, safeguard the integrity of your data, boost concurrent engineering and collaborative efforts generally, and, because of its automatic controls, checks and change-management processes, ease the path to ISO 9000 compliance. Furthermore, it's a great selling point for your company, particularly if you are going after contracts with global firms that are increasingly demanding higher levels of data integration and process accountability from their suppliers. So why not rush out and buy a PDM system today?

Well, there's cost for one thing. It could well be more than you are willing—or able—to spend on IT at the moment. Second, there's the complexity issue—you may not be ready to grapple with a system that will probably take weeks to install and learn.

So does that mean PDM is only for the big boys? Not exactly. The good news is that nearly every medium to large CAD developer, reacting to sluggish sales and to customer needs for more seamless internal communication, has added collaboration tools to its newer releases. In most cases, this includes some degree of PDM functionality.

For some time now, SolidWorks Corp., Concord, Mass., has provided built-in PDM software, called "PDMWorks," with its 3-D mechanical design package. It allows users to automatically bulk-load thousands of SolidWorks or AutoCAD files into a PDMWorks vault, complete with property and attribute mapping and configuration previews.

Recent versions of Palm Bay, Fla.-based VX Corp.'s CAD/CAM software come with integrated PDM software, which VX stresses is easy to use. Many of its features can be accessed via the standard menu bar. These include file and attribute sharing, document control with read-write permission control, versioning, and check-in/check-out. The history of actions taken in the course of a project is clearly documented.

"With a global economy, rapidly changing market conditions and real deadlines, manufacturers need advanced CAD/CAM designs that can meet the demands of compressed product cycles," noted VX CEO Mark Vorwaller. As a result, he said, "CAD/CAM systems will continue to become more intelligent and intuitive as new generations of software are developed and leveraged from current applications."

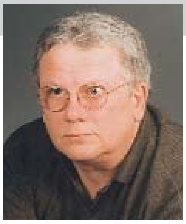
Clearly, CAD vendors en masse are seeking to add value to their offerings by integrating a variety of collaborative tools—including PDM—with their core products. So if you're interested in moving up to PDM and don't want to spend an arm and a leg on it, the solution is probably as close as your current CAD vendor. Sure, these integrated PDM modules won't do quite as much as a more comprehensive and more expensive system from a PDM vendor. But does that mean you won't be getting real and valuable functionality? Not at all, said Ken Amann, director of research for CIMdata Inc., Ann Arbor, Mich., an industrial software research and consulting firm.

"Certainly smaller organizations don't need all of the things in a full-scale PLM (Product Lifecycle Management) system (of which PDM is a subset)," said Amann. "They have fewer people and less data, but that doesn't mean these smaller-scale PDM systems aren't valuable. They make the data more shareable, and unleash the advantages that go with that." By themselves they won't provide enterprise-wide data integration, but, he said, "they can be a great place to start."

About the Authors

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

BY MICHAEL DEREN



Shift differential

For quite a few years, I have worked what is commonly known as the "normal," or day, shift. However, during my years of service in manufacturing, I worked both the second and third shifts as well. Thinking about the companies I have worked at, I often wonder why people work the shifts they do.

Reason No. 1: They have no choice. Most people want to work the first shift. Seniority usually determines who actually does. Many prospective employees are willing to start on the second or third shift to get their "foot in the door" at a desirable company.

Reason No. 2: They are night people. There are people who simply can't stand getting up early in the morning to go to work. Some label them as being lazy because they aren't early risers, but they just have to be out and about for a few hours. This helps them to get into the "groove" of their daily routine. Their body clocks can make them irritable if they get up early in the day. But let them get up later in the day, and they are veritable powerhouses.

Reason No. 3: They hate crowds. Some people simply don't like crowds—at the workplace or anywhere else. As most of you know, the day shift is when the bulk of employees work. Some feel just a little claustrophobic with all these people around, while others feel less stressed when there are only a few people around. Outside of work, many actually enjoy being able to go to the mall during the day when most people are at work. They don't have to fight the traffic or the crowds.

Reason No. 4: They have part-time jobs. When I was younger, I chose to work the third shift. At that company, third shift was from 10 p.m. to 6:30 a.m. I had a part-time job servicing those carpet shampooers you see at your local supermarket or grocery store. I would get to the first store by 7 a.m., work my route until about noon, then go home and get some sleep. I would get up around 8 p.m., play with the kids and go to work at my full-time job. For my family, this worked out great, and gave us a leg up on getting a house, a couple of cars and other goodies.

Reason No. 5: They have personal reasons. I have known quite a few individuals who work an off shift because their spouse works during the day. Typically, they have young children, especially preschoolers. Think about it. With the rising cost of daycare, this can add substantially to the bottom line. When I was a youngster, my mom worked during the day and my dad worked the second shift. My dad would pick me and my brother up from school and then pick up my mother from work. He would drop us off at home and continue on to work. In doing this, my parents were able to provide parental guidance throughout our formative years.

As far as I'm concerned, every shift is a normal shift. It just depends on who you ask.

Reason No. 6: They like the darker side. Some individuals prefer to have as little supervision as possible. Because there are fewer supervisors on second and third shifts, this allows certain individuals to do as little work as possible.

These are just some of the reasons why people work different shifts. As far as I'm concerned, every shift is a normal shift. It just depends on who you ask. △

About the Author

Michael Deren is a CNC applications engineer and a regular CTE contributor. He can be e-mailed at mderen @prexar.com.