Cutting Tools Now

Carbides, Coatings & Other Hot Stuff

Nancy Bartels

The cutting tool is basic to gear manufacturing. Whether it's a hob, broach, shaper cutter or EDM wire, not much gets done without it. And the mission of the tool remains the same as always: removing material as quickly, accurately and cost-effectively as possible. Progress in the field tends to be evolutionary, coming gradually over time, but recently, a confluence of emerging technologies and new customer demands has caused significant changes in the machines, the materials and the coatings that make cutting tools.

What Customers Want Now

Like the Irish writer Oscar Wilde, cutting tool customers have simple needs: They want only the best. They also want it faster, cheaper, and with more technical and customer support.

They are under pressure to produce gears of higher and higher quality and, as a result, they are demanding the same thing of their cutting tool suppliers. They want tools that are more durable, can cut faster and more accurately, but are still cost-effective. Ken Brewer, Sales Manager for Fette Tool Systems, suggests that the general push is toward tools with grinding quality tolerances. He says, "People want aerospace quality cutting tools without having to pay aerospace prices."

And everyone wants more and better customer service and warranties. "Machine customers are demanding longer-than-standard warranties," says Bill McElroy of GMI, distributor of a range of gear manufacturing machines, tooling and cutting tools. "And they want machines that are idiot-proof." Harvey Yera of National Broach concurs. "Price is always a factor, but consistent high quality and good, extensive customer support is even more of an issue," he says.

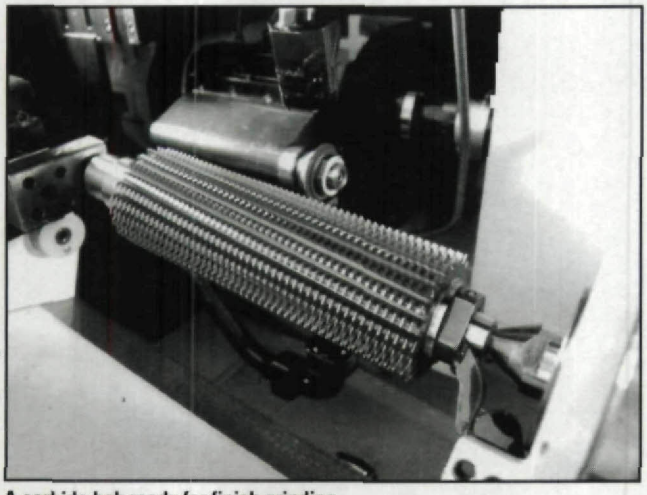
At Pfauter-Maag Cutting Tools, part of a nine-year-long redevelopment of the old Barber Colman facility in Loves Park, IL, has included installation of a new testing and analysis center. While the company uses it to check on its own work, its real purpose is to provide some of the latest equipment available to help customers solve their tool cutting problems. Says Bob Phillips, vice president of manufacturing and engineering "It's not a profit center. We do it for the customers. We have to be willing to do whatever it takes to have the customer satisfied with his cutting tool purchase."

Emerging Technologies

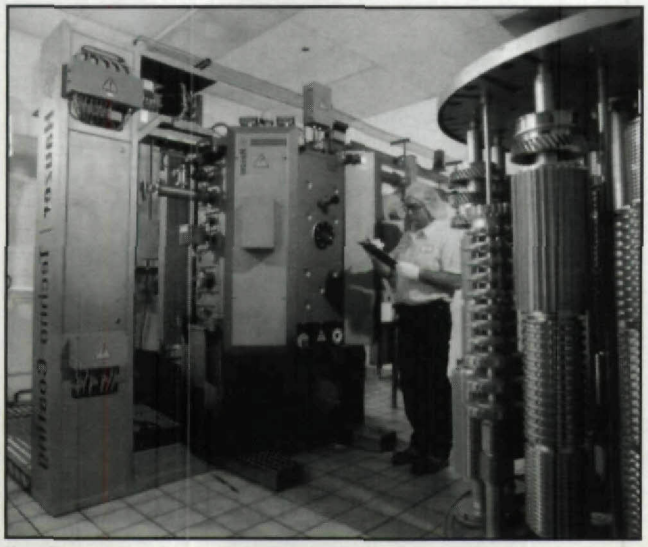
On the machine side, the latest development is dry hobbing. First introduced by Liebherr about two years ago, it has been greeted with a mixture of enthusiasm and skepticism, according to Ian Shearing, vice president of sales for Liebherr America.

For example, Carl Johnson, vice president, cutting tools, at Fellows Corp., cites the expense of manufacturing, handling and sharpening carbide tooling as a major concerns and calls dry hobbing an "emerging technology." Massimo Denipoti, managing director of SU America, echoes this skepticism, pointing out that it is the machine manufacturers who are pushing the technology and adding, "The tools are fragile, expensive, high-maintenance items. Many people are just trying it out now. It may be just a fad."

But while some manufacturers are waiting for more data before deciding about dry hobbing, the process is appearing in many high-production



A carbide hob ready for finish grinding.



Heat Treating is a crucial step in manufacturing cutting tools.

facilities, particularly in the automotive sector, and major players in the gear hobbing machine market, Liebherr, Gleason and American Pfauter, all have machines that offer dry hobbing capability.

Dry hobbing machines share certain characteristics. They are rigid and very fast, have speedy chip removal and are capable of both wet and dry hobbing.

According to Jerry Knoy, vice president of sales for Pfauter-Maag, "Most new machines have dry hobbing capability. Even if customers don't want to use it right away, they want it there for the future."

Beyond Hobbing

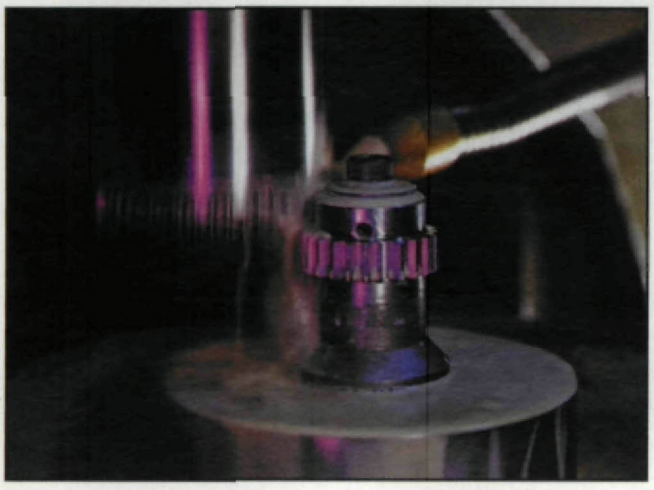
Improvements in shaper cutters will be following more or less the same trends as those in hobbing, according to Fellows' Carl Johnson. He sees continuing improvements in coatings and materials, including high speed steels, and more demand for disposable tools. Like hob manufacturers, shaper cutter suppliers will be confronted with a demand for longer tool life, better performance, higher speeds and more productivity.

Bill Maples of Star Cutter observes that improvements in powder metals will have an impact on cutting tools. "They are more homogeneous than other steels and provide a more even grain structure," he says, adding, "I think we're going to see less and less availability of wrought steel."

Makers of broaching tools have to meet the same demands from customers as hob manufacturers. In response to customer demands for longer tool life, quieter operation and longer times between sharpening, National Broach has introduced the SPIRALGLIDE broach bar, which offers continuous workpiece contact, virtually eliminating vibration and noise. The company says that the new tool increases broach life by 400%.

The other goal that broach manufacturers are aiming for, but have not yet reached, is the ability to broach parts after heat treating instead of before to increase accuracy.

EDM is another technology to watch. The jury is still out on how effective it is in cutting tool applications. Bill Maples says that his company used EDM to cut hobs for awhile, but was unhappy with the results. "We just couldn't get the accuracy or tool life we wanted," he says.



Shaper cutter manufacturing.

PFAUTER-MAAG GOES CELLULAR WITH CARBIDES

Carbide as the tool material of choice has undergone a renaissance in the last three years, and Pfauter-Maag Cutting Tools has primed itself to be in the forefront of this change. As part of an overall refurbishing and restructuring of the old Barber Colman operation it acquired in 1987, the company has installed a 9-machine (a tenth will be added by the time this article appears) carbide cutting tool cell at its renovated plant in Loves Park, IL.

Because carbide is a hard material already, and no heat treating is required, all the machines in the cell are grinders of one sort or another. Reineker form grinders are used for roughing and Reishauers for finishing. Huffman and ITM grinders do the gashing and threading from solid. Tropei grinders do face and bore grinding, and a Studer grinder is used for shank grinding. All the machines are less than three years old.

Lead times for production will depend, of course, on the application, but material removal time can run to roughly 50 hours with the new machines. (Actual lead times for carbide tools will run from 8–16 weeks, depending on design and availability of stock blanks.) The machines can all run unattended, and the cell operates seven days a week, 24 hours a day.

Flexibility and redundancy are important concepts on the Pfauter-Maag factory floor, and the carbide cell is no exception. While every effort is made to keep the equipment in the cell exclusively for carbide hob production, it does serve as back-up for the steel cutting equipment. "But the carbide always has first priority," says Bob Phillips, *vice president of manufacturing and engineering.*

The carbide cell was one of the most recent renovations at the Loves Park plant for a number of reasons. P-M had other, more urgent issues to address first. And until three years ago, there wasn't sufficient demand for carbide tools to make setting up a separate manufacturing cell worthwhile.

Then in 1994, improved carbide material and coatings, developments in machine technology, including dry hobbing, and the pressure of environmental concerns combined to reach critical mass, and the demand curve for carbide cutting tools began to look like a 90° angle. In 1994, P-M sold 17 carbide hobs. In 1995 it sold 350. Projections for 1996 run to 50 carbide hob sales a week.

At that point it made sense to have a separate cell. "There were a lot of good reasons to separate carbide manufacturing from the other processes," says Phillips. "The characteristics of carbide are very different from those of steel; there are only hard operations, and the filtration process is different. We also *wanted to develop* awareness on the part of operators that this was a completely different process." ⚙

A finish grinder in Pfauter-Maag's carbide cell.

On the other hand, both Fellows and Pfauter-Maag successfully use EDM in certain niche applications. Rack cutting tools to AA quality can be made with EDM, and National Broach uses EDM to make pot broach and blind spline rings. Pfauter-Maag has purchased two AGIE-CUT™ HSS 150 wire EDM machines to make special rack and shaper cutters.

The Carbide Connection

Carbide tools go hand in hand with the new dry hobbing machines. Tony Spinks of Parker Industries in Bohemia, NY, calls carbide tooling one of the "hot trends" of the moment.

It wasn't always this way. Time was when carbide was known for its expense, its brittleness and its general unsuitability as a cutting tool material. But recent developments in microcarbides and their processing have closed up the pores in the material and made it considerably stronger and harder. According to Primo Pappafava, president of General Carbide Corp., the addition of more cobalt to the carbide has increased its strength, and finer particle size (down to less than .6 microns in some cases) makes for a harder part. Now carbides are available with 400,000 psi strength, no visible porosity and 91 Rockwell A hardness.

Not A Panacea

While a lot of people are jumping on the carbide tool/dry hobbing bandwagon, many are careful to point out that it's not good for every application. Dr. Walter Eggert, Managing Director of the Pfauter Group, says: "Carbide hobbing is an

attractive approach in many applications, but it isn't always the best solution."

It seems to work best in high-production applications, such as automotive and hand tools, and in pitch ranges from 12 to 20 DP.

Dry hobbing, which in almost all cases uses carbide tooling, requires some means for disposing of hot chips quickly. In successful dry hobbing, 70–80% of the heat generated needs to be carried away in the chips.

The ability to do this, according to Ian Shearing, is a function of cutter diameter, number of cutter gashes, number of starts, the axial feed rate and the number of teeth in the workpiece. If the combination of these can be juggled to give the necessary chip thickness, dry hobbing will be successful. If not, it's not an option.

There are other drawbacks to carbide hobbing. In many cases, new machines, with their demand for huge capital outlays, are required. Cutting tools themselves are also very expensive—anywhere from 3–5 times the cost of high speed steel tools, and they require sharpening machines that use CBN/diamond wheels. For many applications, the selection of a good high speed steel with the proper coating may be a better choice than carbide.

Coatings

The third leg of the cutting tool triangle is coatings. The purpose of tool coating is to keep the heat generated in the cutting operation away from the material substrate. The right coating for the right application can be the difference between a good and a bad tool, and cutting tool manufacturers take their coating operations very seriously. Star Cutter is so particular about its tool coatings that it makes its own to ensure quality.

Introduced in the early 1980s, titanium nitride (TiN) is the workhorse of coatings. It is useful over a broad spectrum of applications and offers, conservatively speaking, an increased tool life of 200–300%.

But as with other parts of the cutting tool manufacturing process, research continues to improve TiN applications. Multi-Arc Inc. has been researching the interaction between surface preparation and the performance of coatings and has found a direct corollary between the amount of improvement provided and the quality of the preparation. A badly prepared surface (one with burrs, nicks, or one that is poorly ground) will not be improved by coating nearly as much as one that is properly prepared.

A result of this research is Multi-Arc's new Super TiN process for recoating hobs. It is a sequence of stripping the old coating, pre-coat polishing, an improved, smooth coating process and post-coat polishing, which results in doubling the tool life of hobs.

But newer materials and machines have also demanded newer, more efficient coatings; hence the appearance in the last 3–4 years of titanium carbonitride (TiCN) and titanium aluminum nitride (TiAlN). TiCN is a good coating choice for applications where moderate heat is generated. It is useful for machining abrasive or

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Hobs ready for coating.

adhesive materials, or those that are difficult to machine, such as aluminum alloy, tool steels and Inconel. TiAlN is the optimum coating for use with carbide tools. It offers much better oxidation resistance than TiN (up to 800°C). The heat generated during cutting creates a top layer of aluminum oxide, a thermal barrier coating with low heat transference, which is essential in dry cutting operations.

The other coating to keep an eye on is molybdenum disulfide (MoS_2). This is a coating for high speed steels which first appeared in aerospace applications. It is a solid film with a low coefficient of friction, and it is removed at a controlled rate. Work with this material in Europe suggests that applied by physical vapor deposition on top of a TiN or TiAlN surface, it has applications in hobbing. The material does not remain on the cutting edges of the tool, but flows into the flutes and spaces between the teeth, where it promotes chip flow away from the work.

Where To From Here?

The direction of cutting tool technology seems fairly clear: faster speeds, more exotic materials, and more hand-holding for customers as they learn to use the new technology. But some people suggest that the implications of these new developments are even more far reaching. Ian Shearing speculates that the faster speeds and feeds of dry-cutting-capable machines, which have dropped price-per-piece costs, may have effectively put the brakes on the development of chipless methods of gear production. He goes on to add, "The speeds in machines are now approaching direct motor speeds. If the trend continues, the days of kinematic drives may be numbered." ⚙

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