➤BY ALAN RICHTER, MANAGING EDITOR

PEEL OUT

Switching from hard turning to peel grinding may allow large-volume producers of cylindrical parts to increase flexibility while reducing the cost per part.

Although more established in Europe, high-speed peel grinding is gaining popularity in the U.S. In addition to being an alternative to plunge grinding with a profiled grinding wheel, peel grinding can also replace hard turning. This is because the narrow wheel applied during peel grinding has a cutting edge similar to a turning tool so it contour-grinds a workpiece similar to how a part is produced on a lathe.

"Peel grinding is where you basically use the wheel as if it was a turning tool in which you concentrate all of the metal removal in one little section of the wheel, a narrow contact length of less than 1mm," said Mike Hitchiner, technology and vitrified CBN product manager for Saint-Gobain Abrasives Inc., Worchester, Mass. He added that peel grinding maximizes the metal-removal rate and minimizes the specific grinding energy.

Before covering why peel grinding can be a low-cost, high-productivity option, it's important first to understand how the process removes metal from the workpiece.

On a Roll

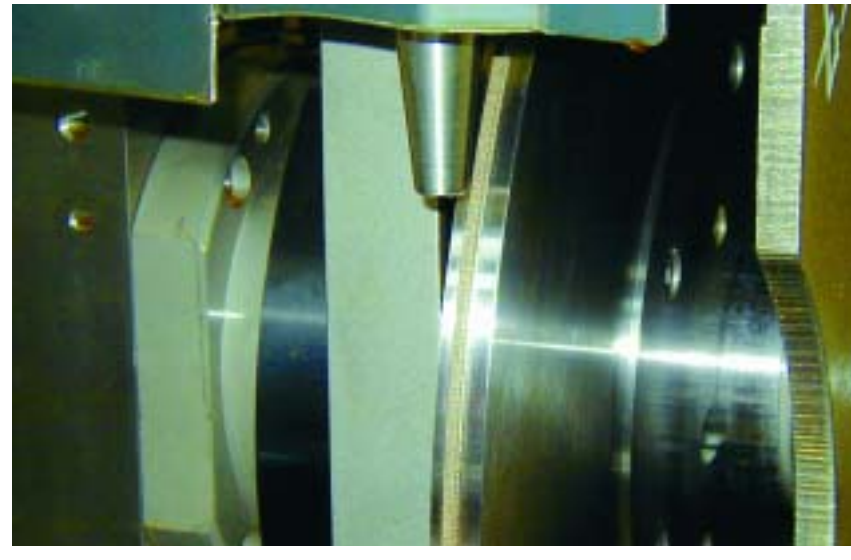
Two basic styles of peel-grinding wheels are available: One is flat along the entire surface and the other, which is more common, has an angled leading edge. Chris Cox, account manager for machining systems, Cinetic-Giustina Grinding, Livonia, Mich., explained that the company's peel grinders use a flat wheel. "We use a 5mm-wide wheel and, basically, all the stock is taken off with the leading edge or corner of the wheel and the rest of the wheel face provides the finish."

With an angled wheel, the grinding occurs in three cuts: rough, medium and finish. "The rough cut is on the angle," said Beat Maurer, head of cylindrical applications for United Grinding Technologies Inc., Miamisburg, Ohio. "The angle depends on the application and is usually around 10°." And as that angle wears, it's being resharpened.

He added that the corner of the wheel performs the medium cut, which creates the part size, and the flat portion imparts the finish.

Hitchiner noted that the wheel's finishing zone is critical. It must be wide enough, relative to the traverse feed per revolution, to provide a high overlap factor to generate a fine surface finish. However, a wheel that's too wide will induce higher grinding forces and increase the risk of chatter.

He added that when peel grinding a cylindrical workpiece, maximizing the work speed reduces thermal damage.



Cinetic-Giustina

A peel grinder's narrow wheel moves along a workpiece similar to a turning tool on a CNC lathe. Unlike the more common variety that has an angled leading edge, this wheel's entire 5mm surface is flat.

Peel grinders have work speeds up to 10,000 rpm, which allows a high overlap factor for a narrow wheel. Similar to flat wheels, most angled wheels are 5mm wide.

Wheel diameter is limited by the burst speed of the bonded layer. "Custom-designed, metal-cored, segmental vitrified CBN wheels can operate at wheel speeds as high as 200m/sec. at diameters greater than 350mm, but their maximum capability drops progressively as the diameter is reduced," Hitchiner stated. "Wheel size is, therefore, optimal at a diameter from 300mm to 400mm."

According to Maurer, peel grinding is an effective process for meeting high-volume-part runs because of its high mrr and wheel speed, which is usually from 100 to 180m/sec. As the wheel speed increases substantially, the grinding forces and corresponding heat are reduced exponentially.

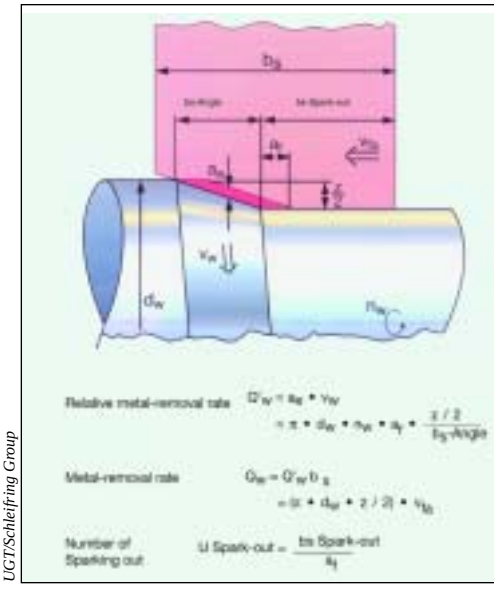
In other words, the wheel moves so quickly that it doesn't have time to generate much heat. And the chips carry away any heat that is generated. "Basically, you have cool cuts," Maurer said.

Therefore, the grinding fluid is more for lubricating and clearing chips and abrasive particles from the wheel's intergranular spaces than for cooling, which makes an oil-based fluid a better choice than a water-soluble one. "We have tried a 50/50 water- and oil-based emulsion," Maurer said, "but it doesn't work as well as oil only."

In addition, Maurer noted that because a water-based coolant doesn't lubricate as effectively as oil, CBN grits fracture during the grind. (Although CBN wheels are more common when peel grinding, diamond wheels are also applied.)

Hitchiner said one of the reasons peel grinding is more popular in Europe is because European manufacturers are more accustomed and willing to grind with oil. "In the U.S., they're far less into using oil as a coolant," he said.

To help entice the U.S. market to perform more peel grinding, Hitchiner said the Bensenville, Ill.-based Universal Superabrasives Inc. unit of Saint-Gobain Abrasives developed new CBN grits and a tougher vitreous-, or glass-, bond system that allows peel grinding with water-soluble coolants. The system, "T2 technology platform," is for ID and OD grinding of parts made of ferrous materials, including cast iron, steel and high-temperature, nickel-base superalloys. "Essentially, the new generation of glass-bond wheel is very good at holding the stronger abrasives that are now available on the market," he said.



UGT/Schleifring Group

The throughput rate that is customarily achieved when peel grinding 100Cr6 bearing steel. Key: b_S = wheel width; b_S-Angle = grinding angle; b_S-Spark-out = spark-out area; a_e = chip thickness; a_f = rate of advance (traverse feed)/revolution; V_{fa} = rate of advance; z/2 = stock removal/radius; n_W = work speed; v_W = surface speed; d_W = work diameter; Q_W = metal-removal rate; Q'_W = mrr/stress loading; U = spark-out overlap.

Nonetheless, "oil will still give you the best performance and the best wheel life," said Cox. "It will give you a better surface finish, too." However, to repeat a common metalcutting refrain, it's all application-dependent.

The Switch is On

Maurer said peel grinding has numerous advantages over hard turning. The biggest one probably is tooling costs—but not the initial expense.

For example, he said a 16" CBN wheel costs about $1,500 and lasts at least 50,000 parts before it requires reconditioning. With hard turning, a $10 insert, for example, is changed every 150 parts, which equals $3,333 in tool costs for the same number of parts. In addition, indexing or swapping inserts takes time—i.e., money—and part inconsistency is a risk when a new cutting edge is applied. "Compared to hard turning, peel grinding is way more efficient," Maurer emphasized.

Hitchiner concurred that tooling costs are the main incentive to replace hard turning with peel grinding. "As wheel technology improved, wheels were able to overtake insert costs," he said. "I'm sure there's going to be a battle now as to which is better."

Cox, on the other hand, said flexibility, or the grinding machine's ability to rapidly changeover from one part to another, is the No. 1 reason for switching processes. He noted that Giustina's Evolution peel grinding machine does not require a special work driver to drive most of the components being ground. "We drive them only by center pressure, and, therefore, changeover is very rapid on this machine, sometimes within 1 minute from part to part," Cox said.

He added that a typical changeover involves changing the part program, because the same wheel is often used for different parts. A machine's features also can quicken changeovers. "We have a CNC tailstock on our machine that will automatically reposition itself for different part lengths," Cox said.

Ken Larson, sales and marketing for International Tool Machines of (Palm Coast) Florida Inc., also emphasized the importance of a machine that allows quick changeovers as part runs get smaller. "For the majority of our customers, they don't set up a machine and let it run for a week producing one part," he explained. "They might change it over many times during one shift, and the peel grinding process allows that. Our peel grinder changes over in about 15 minutes, and that includes changing over the CNC loader. If a customer is changing over a centerless grinder, it can take hours."

Higher part quality also motivates manufacturers to turn to peel grinding.

Maurer pointed out that, in general, a grinding machine is significantly more accurate than a lathe, which, in turn, produces higher quality parts with finer surface finishes. "There is no comparison between hard turning and grinding," he said. "Grinding is much more precise."

And because peel grinding usually allows parts to be completed in one setup, the risk of tolerance buildup is eliminated. "All of our machines are set up so they can cut the part without drivers," Maurer said, "so you can do a complete part."

Getting ROI

As lot sizes get smaller and smaller in many industries, the high level of flexibility peel grinding provides proves beneficial. But that doesn't necessarily mean peel grinding is appropriate for job shops, which are geared to machine whatever comes their way. A job shop would need to produce 200,000 to 1 million cylindrical parts a year to justify the expense of a peel grinder, Maurer explained. "You wouldn't normally see a peel grinder in a job shop," he said. "Peel grinding applies more in bigger companies, which have the production rate and financial backing for this type of equipment."

International Tool Machines

Two driven workheads support the workpiece in this ITM series 2005 OD peel grinder. An in-process gaging head ensures that a ±0.0001 tolerance is held.

In addition to the $500,000 to $1 million for the peel grinder, an end user would have to invest in high-pressure coolant pumps, a filtration system and the safety equipment required for high-speed grinding. "If you go higher than 63m/sec., you need special guarding on the machine," Maurer said. "That means you have much thicker wheel guards and you need glass sliding doors that can take the impact if the wheel blows up, for instance."

He added that because an oil-based fluid is used "99 percent of the time," a fire extinguisher on the machine and a flap to vent smoke to the roof rather than through the front of the machine are needed in case of a fire.

When it comes to filtration, a standard system is adequate, but costly high-pressure pumps, from 20 to 40 bar (290 to 580 psi), are required to direct fluid out of three nozzles: from the top, below and behind. "Because the wheel spins so fast, it generates a big air film around the wheel and you have to break through that air film to clean up the wheel," Maurer said. "Therefore, you need way more coolant pressure than you normally would."

Besides the upfront expense, peel grinding, like other grinding processes, is often viewed as a black art that requires skilled operators. "Any grinding process is quite different from hard turning," Maurer said. "Grinding is still a unique process, and, therefore, we put a big emphasis on customer training." He noted that training a machinist to peel grind can take 2 to 4 weeks.

The relative newness of peel grinding to the U.S. market is also a potential hurdle. "To some people it's actually scary because it is different," Cox said, "but it's nothing people should be afraid of. It's an application of age-old grinding principles and formulas. All we're doing is taking the next step."

The following companies contributed to this report:

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