Gear Grinding 2003

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The benefits of ground gears are well known. They create less noise, transmit more power and have longer lives than non-ground gears. But grinding has always been thought of as an expensive process, one that was necessary only for aerospace or other high-tech gear manufacturing.

But over the past decade, much has changed in the world of gear grinding—the machines are more productive, the grinding wheels are better and the overall cost of grinding has gone down.

In the mid-1990s, gear grinding began to be incorporated on a wide scale into the operations of a wide variety of industries, including the makers of automobiles, trucks and motorcycles. That trend has continued to the point where, in many of those industries, grinding is ubiquitous.

"Virtually all Tier 1 automotive gear suppliers now have gear grinders or are being compelled to acquire gear grinders to stay competitive," says Brian Cluff, vice president of sales engineering for SU America Inc. and Star-SU Inc., both based in Hoffman Estates, Illinois.

Tom Lang, vice president/general manager of Kapp Technologies L.P. in Boulder, Colorado, agrees that gear grinding and honing are increasing in the U.S. automotive industry: "Today, all of the Big Three automotive companies have new generation automatic transmissions with hard finished transfer gears and final drive gears either in production or slated for production within the next 12–18 months."

Lang predicts the auto industry will continue to be hard finishing's largest growth market for the next 2–5 years.

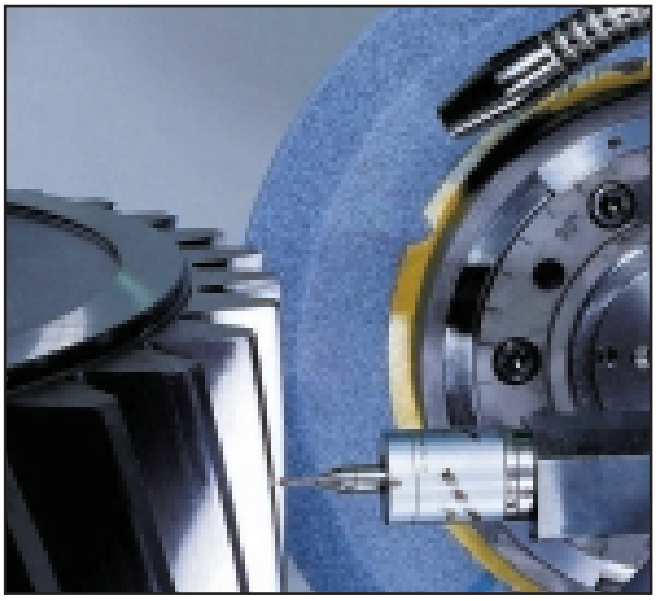
The auto industry is increasing its use of hard finishing so it can get rid of heat treat distortion, says Richard E. Scoda of Gleason Corp. Scoda, product manager for Gleason's gear grinding machines, says: "It's nothing to lose 2–3 gear classes [because of heat treat distortion]."

But automakers aren't the only ones grinding more today.

Photo courtesy of Gleason Corp.

"Gear tooth grinding has become more common in today's market," says Gary Rackley, president of Pro-Gear Co. Inc. Based in Depew, New York, Pro-Gear provides gear tooth grinding services.

Robert Barden of Niagara Gear Corp. adds that ground gears are now commonly used in the textile, printing, power transmission and motion control industries. Barden is vice president/general manager of Niagara Gear, which is based in Buffalo, New York, and specializes in manufacturing precision ground spur, helical and pump gears.



On-board inspection has become standard on many models of gear grinding machines. Photo courtesy of Kapp Technologies.

"Gear grinding has matured and proliferated throughout the gear industry," says Loyd Koch, owner of Bourn & Koch Machine Tool Co. in Rockford, IL. "Many standard gearboxes use ground gears to better control the backlash and noise. Because standard features and the cost of these operations has continued to come down, ground gears are making their way into lower cost products."

And what industries will next start to use or increase their use of ground gears?

Cluff's answer is simple: "All transmission manufacturers."

In Barden's opinion, a growth industry for ground gears is electric power co-generation.

"This has already become one of the fastest growing segments in the marketplace and presents great potential for future growth," he says, "not only here in the U.S., but abroad."

The wind energy industry is a growth industry in Europe and the United States. In '01 and '02, the European Union installed wind turbines totaling 10,364 megawatts of new capacity, while the U.S. installed 2,106.

Barden expects several factors to promote the use of such alternative energy sources: 1.) rising energy costs, 2.) strict environmental laws, 3.) geopolitical problems in critical, oil-producing regions, 4.) greater demand for energy due to economic development in Third World countries, and 5.) the total

demand for energy surpassing the supply of fossil fuels.

"Demand for alternative energy sources should continue to grow," Barden says. "The development of newer technologies is inevitable."

Machine Tool Improvements

Today's gear grinding machines are much more productive than their counterparts of just a decade ago. This improvement doesn't stem from any one major change. However, a number of significant incremental improvements have made a big difference.

On-Machine Inspection. Many modern gear grinders come standard with on-machine inspection systems. With on-machine inspection, gears are no longer removed from a grinder and inspected elsewhere in a factory. The grinders use their inspection systems to analyze preliminary gear teeth. An operator can then compare actual parameters with specified parameters, make needed corrections and start the job.

"The gear can be checked on the machine and reground until the proper geometry is achieved," says Koch. "The controls can modify the program path using the inspection data taken as part of the grinding process."

Tom Lang agrees that on-machine inspection has been a major change in gear grinders since the mid-'90s. Such inspection speeds set-up, and faster set-ups lead to increased productivity. Lang also says integrated inspection and dressing systems have made modern gear grinders more flexible.

Some grinders also come with on-board dressing, allowing the manufacturer to redress vitrified grinding wheels without a separate device and without removing the grinding wheel from the machine.

In Buffalo, New York, Niagara Gear Corp. can use its grinders' on-board dressing for its vitrified wheels—including its CBN ones. Niagara tested vitrified CBN wheels and learned they could be used effectively, efficiently and economically in those grinders.

Direct Drives. Since the mid-'90s, there's been increased use of direct drive motors with grinding and workpiece spindles.

And the effect?

"Components used in today's machines now run at limits that were unthinkable just a decade ago," Barden says.

Barden and Lang agree the motors have contributed to increased productivity. Barden also credits direct drives with increasing gears' resulting quality.

Scoda says direct-driven spindles allow gear manufacturers to avoid transmission errors that can be present in gear trains because of tooth mesh inaccuracies.

Lang adds that the motors can combine with better vitrified abrasives and sophisticated multi-axis motion control in the dressing and grinding cycles to eliminate ghosting, biased forms, acoustic excitations and detrimental undulations.

Automatic Features. "Automatic" is more and more a word used with gear grinders, especially in serial production.

Automatic features now include parts loading, tool changers,

and stock division—the synchronizing of wheel to workpiece.

Lang says automation has eliminated idle time and contributed to a 50% reduction in floor-to-floor times compared with technology from the mid-'90s.

Richmond adds that the ability to easily automate and integrate gear grinders into a factory's material handling systems has been another major change in gear grinding since the mid-'90s.

Machine Software. Windows-based software is becoming as widespread on today's gear grinders as it is on personal computers. More manufacturers are using controllers based on Windows software, Barden says, so machines have become more "adaptive" to constantly changing technologies.

"As a result," Barden says, "tomorrow's ideas can be added to today's machines."

He adds that graphical interface and algorithmic software is more operator friendly, and dressing tools and techniques now allow tooth forms to be programmed and produced in a part that previously could only be drawn on paper.

Software plays a role in another advance since the mid-'90s: self-monitoring. According to Barden, drives and ball screw configurations, scales and sensors now allow for highly accurate, monitored motion in gear grinders.

According to Loyd Koch, many newer gear grinding machines come equipped with position systems that are removed from the driving members. This provides better precision and higher thermal stability, Koch says. He adds that the latest systems use absolute scale and encoder technology connected by serial digital data wiring. The absolute technology enables faster feed rates with higher position resolution and improves the reliability of the machine, Koch says.

Machine Footprint. In some cases, today's gear grinders have smaller footprints, too. Many gear grinding machine manufacturers have redesigned their models to take up less floor space.

The smaller footprints could allow gear manufacturers to better use their current floor space, with the possible effect of "creating" more space. That space might even allow manufacturers to avoid the time and expense of "brick and mortar" work to expand their factories. As Barden notes, the money not spent on brick and mortar could then be used on more equipment.

On the other hand, some gear grinders now come with larger footprints because of the extensive cooling systems often included on the machines' backside, says Cluff.

Grinding Wheels

Just as the machine tools have become more productive over the past decade, so too have the grinding wheels used on them. Most significantly, this is seen in improved vitrified grinding wheels.

Vitrified grinding wheels are much more durable today, Barden says, because of new materials used in blended-grain compositions and because of improvements in the bonding process. They have greater toughness and form holding capability, and they have higher stock removal rates, he says. Barden says those higher rates have resulted from improved grain struc-

tures, including increased porosity. He adds that the better structures have reduced the required grinding forces and lowered the grinding temperatures.

According to Cluff, today's vitrified bonded wheels can be as productive in terms of throughput as electroplated CBN wheels.

According to Barden, the choice between electroplated CBN and vitrified wheels has been blurred by newer, cooler-grinding vitrified abrasives in conjunction with high-pressure coolant systems.

"The choice may not be as readily defined today as it was five or 10 years ago," Barden says.

Lang, however, points out that setting up electroplated CBN wheels isn't as complicated as setting up vitrified wheels, saying the setup time is shorter and there are fewer operator qualification requirements.

Possibly blurring the choice even more are the latest aluminum oxide and ceramic vitrified wheels.

In Elgin, Illinois, Dennis Richmond, vice president of Reishauer Corp., says those wheels can offer a viable, less costly alternative to vitrified CBN wheels.

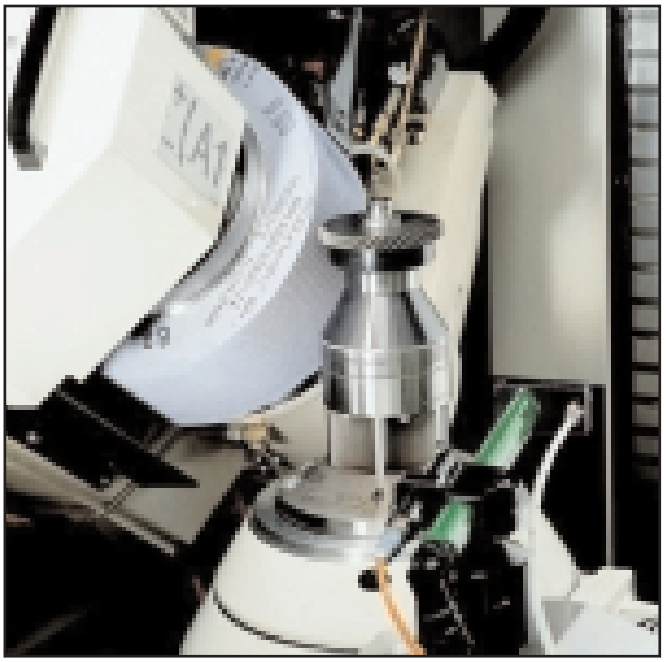
Richmond's company tested those wheels with its "cool cutting" process. Those tests led Richmond and Reishauer to several conclusions:

1) The latest aluminum oxide and ceramic wheels produce the same or less compressive stress as vitrified CBN wheels.

2.) Contrary to expectations, they were more productive than CBN wheels and had lower perishable costs.

3.) Unlike electroplated CBN wheels, they can be sharpened or refurbished by a gear manufacturer on the gear grinder. Electroplated CBN wheels have to be sent back to their manufacturer.

Richmond adds that the aluminum oxide and ceramic wheels can set new productivity standards.



Gear grinding machines and wheels are much more productive than they were a decade ago. Photo courtesy of Reishauer Corp.

Scoda echoes Richmond about ceramic's productivity. Scoda says ceramic wheels are used for maximum productivity applications, explaining ceramic wheels with multiple starts require higher surface speeds, such as 60 meters per second. He adds that the wheels have significantly longer lives than earlier wheels, such as vitrified aluminum oxide.

Scoda adds that the new wheel technology has greatly affected threaded wheel grinding of gears with diameters of 200 mm or less because gears of that size are made in high volume.

"That's where you get the biggest bang for the buck," he says.

Costs to Grind

Despite the significant gains in productivity and machine capabilities, the cost of gear grinding machines has remained constant—or in some cases even fallen—since the mid-'90s.

"The price of the equipment has remained relatively consistent since the mid-'90s," Richmond says, referring to gear grinding machines.

Lang, however, says today's gear grinders cost less—up to 30% less—through new, cost-efficient machine models based on modular design, such as common bases for grinding and honing machines and other identical parts. He also credits CNC systems and series production with helping reduce the gear grinders' cost.

Koch agrees that the cost of gear grinders has come down. "Even with all this sophistication, the machines sell for much less than the early machines," Koch says.

In addition to the cost of the machines, their greater productivity has made the cost of operating them fall as well. Richmond says the cost of grinding itself has decreased—in many cases, to less than 50 cents a gear. Richmond attributes the decrease to cycle times that can be 50–70% faster than in the past and to low costs for perishables, such as grinding wheels and diamond dressing tools.

And Barden agrees that grinding is cheaper today: "Costs have been drastically reduced."

The Future of Gear Grinding

Improvements in machine tools and cutting tools, the maturation of the technology, increased quality demands and lower overall costs point to a healthy future for gear grinding—at least that's what gear manufacturers involved in grinding seem to be saying.

"I think we are safe to go ahead and plan that next big purchase," Barden says. ⚙

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