

Welcome to *Revolutions*, the column that brings you the latest, most up-to-date and easy-to-read information about the people and technology of the gear industry. *Revolutions* welcomes your submissions. Please send them to Gear Technology, P.O. Box 1426, Elk Grove Village, IL 60009, fax (847) 437-6618 or e-mail people@geartechnology.com. If you'd like more information about any of the articles that appear, please use Rapid Reader Response at www.geartechnology.com/rrr.htm.

Gear Coating Raises Scuffing Resistance to Raise Torque Capacity

A gear manufacturer has an order for 1,000 spur pinions for use in small planetary reducers, but his customer means to use them with marginal lubrication and at a pitch-line velocity and torque that are so high they will cause scuffing and premature failure.

Also, the customer wants a single lubricant of one viscosity for this and other slower speed reducers in his machines, and he doesn't want the manufacturer to add antiscuffing agents to the oil because of concern about damaging other parts.

Faced with this problem, the manufacturer could do one of three things. He could curse his customer's unreasonable demands—privately, then try publicly to explain to him the physical limits of his imagined gears. He could redesign the pinions, planets and rings to make his customer's reducers perform at their specified speed and under their expected conditions.

Or, he could raise the gears' scuffing resistance—and consequently their torque capacity—by coating them with an amorphous hydrocarbon-based matrix



embedded with metal-containing nanocrystallites.

The third option is what The Timken Co. of Canton, OH, is offering to gear manufacturers. Applied by PVD, the coating is called ES200.

In lab tests, the coating increased a gear's scuffing torque. Scuffing torque is the torque at which scuffing appears at a particular pitch-line velocity with a particular lubricant. Consequently, ES200 significantly increased a gear's torque capacity, letting it operate at combinations of pitch-line velocities and torques that otherwise would cause scuffing.

The tests were conducted by Design Unit, a technical consulting business located at the University of Newcastle upon Tyne, in England. Design Unit tested 31 pairs of helical gears from Timken for scuffing resistance. The gears included ground gears; superfinished gears; and superfinished, coated gears.

According to the tests, a gear set consisting of a ground gear and a superfinished gear coated with ES200 had a scuffing torque 42% greater than a gear set consisting of two superfinished gears, and 70% greater than a gear set consisting of two ground gears.

The increase could be even greater than 70% among nonground gears, says Ken Krummrich, director of Timken's Engineered Surfaces Business.

Scuffing can limit the torque capacity of spur, helical, bevel, hypoid and worm gears. But, scuffing is most likely to occur in gears operating at very high pitch-line velocities with high sliding velocities, says Carl Ribaud, technical leader of gear-application development and testing in Timken's Engineered Surfaces Business.

ES200 is available for all gears,

including internal and external spurs, internal and external helicals, single- and double-enveloping worms, bevels and hypoids. The coating is meant for industrial applications, such as speed reducers and planetary gear sets.

Besides scuffing resistance, Timken tested ES200's effect on gears' pitting resistance. According to those initial tests, the coating increased pitting resistance so a gear's torque capacity could be increased 33% or its pitting life extended by about 10 times, given operation at a constant torque.

Assuming a standard gear steel, the coating is applied without affecting gear dimensions or microstructure and without causing gear distortion. The coating is about 2 μm (80 $\mu\text{in.}$) thick and is applied at temperatures less than 150°C (300°F).

The coating itself is applied by Timken as a service through its Engineered Surfaces Business. It receives customers' gears and coats them via batch processing with specialized physical-vapor-deposition equipment.

Also, Timken can increase a gear set's torque capacity with ES200 applied to only one gear per mesh. Thus, a customer with gear sets of two gears each has Timken apply its coating to only one gear from each set. In Design Unit's tests, the coating didn't cause increased abrasion on adjoining noncoated gears.

Besides prototypes for lab tests, Timken has created prototypes for customers to field test in applications and coated gears in low-volume production for customers as steps in proving ES200 to those people.

ES200's hardness can be difficult to compare with a gear's hardness because the thin coating can't be measured with

conventional hardness scales, like Rockwell and Brinell. Still, Ribaud says the coating is about 40% harder than a carburized steel based on nanohardness measurement.

Other companies, such as Balzers Inc., make coatings for gears. Comparing those coatings' effects on gear performance with ES200's effects can be difficult, though. The effects may be

covered by confidentiality agreements between the companies and their gear customers. Or customers may be unwilling to reveal how their gears are affected by their coatings.

As with other coatings, ES200 can let gear manufacturers develop a higher-duty product line or increase life ratings.

That ability could be the best option to the gear manufacturer trying to create

1,000 spur pinions that meet his customers's needs.

As Krummrich says, the manufacturer could have Timken apply ES200 to the pinions for less than the cost to redesign the reducers. Also, coating could be done in less time than redesigning. Also, a coating that makes the reducers work has to be better for the manufacturer than private cursing of and attempted explanations to his customer.

CMM Gear Checking Software

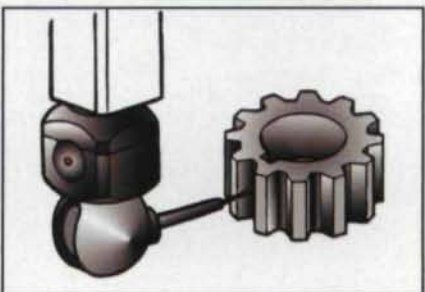
Anyone who ordered coordinate measuring machinery from Giddings & Lewis L.L.C. in the last few months found a free surprise in his package—an upgraded gear checker.


Sheffield CMM MeasureMax+ version 6.4 software can inspect spur and helical gears, both internal and external. Additionally, it can perform calibration, lead, profile, spacing/runout and topography checks, set reference frames and output plots on all Giddings & Lewis CMMs.

The gear checking capacity in MeasureMax+ is not as robust as a dedicated gear inspection system, such as those sold by Gleason Mahr, Klingelberg GmbH or M&M Precision Systems Corp. Those systems typically can also inspect worms, bevels, hobs and other parts.

However, it may be an inexpensive way for some shops to inspect gears—especially those whose gear manufacturing is only in small quantities or occasional.

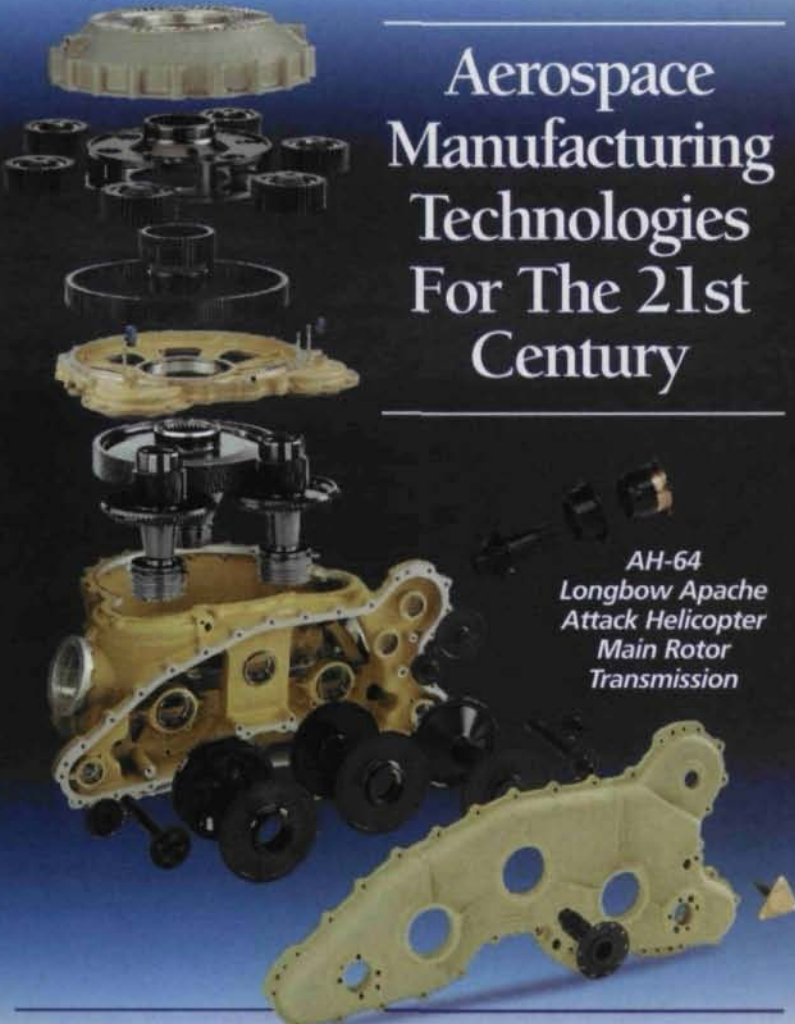
The package, which consists of a computer-controlled, articulating probe head and probe, the software and the





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CMM, costs \$53,000. This cost is for the basic and smallest machine package.

Another key difference between this and dedicated gear checkers is that the new software can also measure a variety of non-gear features, according to Joe Zink, manager of software development for Giddings & Lewis of Fond du Lac, WI.

"With a dedicated gear checker, you can only measure dedicated gear parameters. With MeasureMax+, if a gear is on a shaft and you want to look at cylindricity, it is possible," Zink says. "You can look at all kinds of geometric features."

The MeasureMax+ gear checking procedure is relatively simple. To begin the process, the operator inputs the gear parameters from a selectable toolbar. The instrument measures lead, profile topography and tooth spacing in a gear by using a touch probe to collect data points. Points are collected along one face of the tooth, and the parameters are computerized. Studies can be started, interrupted, cancelled or resumed any number of times.

The software was designed to make life a little easier for machine shops as well. Bill Fetter, CMM marketing manager at Giddings & Lewis, noted that an advantage of the system is that it can make use of existing equipment at machine shops.

"For example, a shop will want to check different components of its inventory," he says, "they can use our equipment to check machine covers and housings as well as gears."

Although the MeasureMax+ software can be a good solution for some shops, it's not intended for everyone. There are still advantages to traditional gear inspection systems.

Gleason Mahr sells checkers to gear manufacturers, but doesn't deal so much with geometric measurement. Its inspection equipment generates an involute profile from the base circle, the same principle that's used in manufacturing. By contrast, says Bruce W. Cowley, Gleason product manager, CMM gear

inspection equipment must add rotary axes to correlate with a generative gear tester.

CMMs won't handle every job, Cowley says. "They're good for prismatic inspection. But for making measurements for a generative purpose, there are still correlation issues associated with that type of equipment."

Prismatic inspections involve checking factors like points, circles, lines and features that aren't contoured.

Knowing specifically what the software can check goes a long way in solving this very complicated purchasing decision for buyers of gear checkers. Gear checking software from M&M Precision Systems, for example, can check for things that the user doesn't have prints for and can generate parameters from which to manufacture new parts, according to M&M Precision's sales department.

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AGMA to Introduce New Quality Rating System

AGMA is preparing to release a new cylindrical gear accuracy tolerance rating standard, to replace AGMA 2000-A88. The new standard was discussed at the AGMA Gear Industry Regional Meeting, held in August in Rosemont, IL.

AGMA 2015-1-A01 is a complete revision of the old standard, according to Edward Lawson, chairman of the AGMA Inspection and Handbook Committee and director of metrology for M&M Precision Systems Corp. He gave a presentation on the new standard at the meeting.

Users of AGMA 2015-1-A01 will have to adjust to quality grades that are the

opposite of what they may be used to. The new standard's tolerancing system is based on ISO 1328-1. Like that standard and the world's other major gear standards, AGMA 2015-1-A01 will use lower-numbered grades to represent the smallest tolerances, while the higher-numbered grades will represent the largest tolerances. The highest quality gears will be grade 2 under the new standard.

To distinguish between gears rated according to the new standard and those rated according to the old standard, a new quality prefix has been introduced with AGMA 2015-1-A01. The new standard requires the letter "A," whereas the old standard required the letter "Q." So, a quality grade of 7 under the new system would be expressed as "A7" instead of "Q7."

In addition to the new numbering system, AGMA 2015-1-A01 will include new methods for analyzing profile and tooth alignment. Instead of the K-band system of charting profile deviations, the new standard incorporates a "line fit" method, which is similar to the methods included in other gear standards around the world. The new standard will also include information on instrument verification, master gears, composite testing and measurement process calibration.

Other major changes from AGMA 2000-A88 include tighter tooth alignment (lead) tolerances and the introduction of tolerances for total index (cumulative pitch) variation.

AGMA 2015-1-A01 is expected to be released toward the end of 2002. Additional information is available from AGMA by calling (703) 684-0211. ◉

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