



Fully automated setup of the GMM inspection systems at Milwaukee Gear allows for greater productivity and repeatability than older-model machines.

# Large Gears, Better Inspection

INVESTMENT IN GLEASON GMM SERIES INSPECTION EQUIPMENT HELPS DRIVE MILWAUKEE GEAR'S EXPANSION INTO PROFITABLE NEW MARKETS AROUND THE WORLD—ALL HUNGRY FOR LARGER, HIGH-PRECISION CUSTOM GEARS AND GEAR DRIVES.

Milwaukee Gear's diverse product portfolio includes gears for applications ranging from compressors to cooling towers, paper to plastics machines, wind turbines to coal mining equipment, offshore oil rigs to cranes and

hoists—wherever particularly high-quality, often completely custom gears are required.

But Milwaukee Gear president/CEO Richard Fullington says that customers today, regardless of the industry, are all buying essen-

tially the same product when they come to Milwaukee Gear: reliability.

Sales in *reliability* must be very good, judging from the robust level of activity on the production floors of Milwaukee Gear's 180,000-square-foot job shop, now running two shifts a day, five days a week. Milwaukee Gear's strategy in recent years of investing heavily in turnkey production capabilities for larger gears—including large-gear hobbing, grinding and heat treating equipment—is now paying off, as the company lands more and more work from "hot" sectors like wind power and mining and from markets as far away as China and India.

**Investment in inspection.** Now, Milwaukee Gear is "doubling down" on the big gears business again, this time with the installation of two new Gleason GMM Series Analytical Gear Inspection Systems, which Milwaukee Gear quality manager Joseph Leone says will enable the company to keep pace with both its expanding capacity and the increasingly challenging gear designs of its diverse customer base.

"Today's gear designers are stretching the limits of gear tooth geometries like never before," says Leone, who has spent the last 31 years helping put the "reliability" into Milwaukee Gear's products. "Extensively modified tooth forms, parabolic tip relief characteristics, finer micro finish tooth surface—whatever it takes to squeeze more horsepower, longer life, quieter operation out of the gear—it can and is being done. And all the while the quality bar continues to be raised, to where even AGMA 14 is typical rather than exceptional."

Leone says that, when push came to shove, the vintage 1980s 1.5-meter inspection system that was long the workhorse of his QC lab simply was not capable of meeting the accuracy and, most importantly, the repeatability requirements of many of these new-generation gears, despite the best efforts of inspectors with dozens of years of experience.

"Setting up the old system for a new part was a slow, tedious process, setting scales manually through a sight glass for lead inspection, then setting a scale for profile inspection, then pitch and so on," Leone says. "Measuring tooth thickness and tooth spacing was also painfully slow, with the probe being manually positioned for every tooth as the machine's rotary table was indexed. Ultimately, the process was not only extremely time-consuming, but also did not give us the ability to meet our repeatability requirements part to part. We needed an efficient, fully automated and high-

ly accurate and repeatable solution. And one that even a less experienced operator could quickly get up to speed on."

Today, Milwaukee Gear's climate-controlled QC lab looks very different than it did just 12 months ago, with the older inspection workhorse put out to pasture and two new Gleason GMM Analytical Inspection Systems now standing in its place.

Leone says it was apparent "right out of the box" that Milwaukee Gear had made the right decision to purchase the Gleason 1000GMM (1 meter workpiece diameter capacity), and then a second, larger 1500GMM (1.5 meter capacity), contingent on the first machine's performance. In just a few months of operation, the inspection systems are exceeding expectations in every critical category. For example:

**Repeatability.** Acceptance of the 1000GMM hinged on a runoff using a precision master gear, with an allowable pitch variation from nominal of no more than  $\pm 0.000030$ "—or 30 millionths of an inch. The average variation in pitch error during the month-long runoff period was 0.000016", and an average of 0.000013" from six readings taken every day, a fraction of what was required and well within the tolerances of even aircraft-quality gears.

Part of what allows such repeatability is the GMM's robust design, with a solid granite base, Meehanite cast-iron slide assemblies and

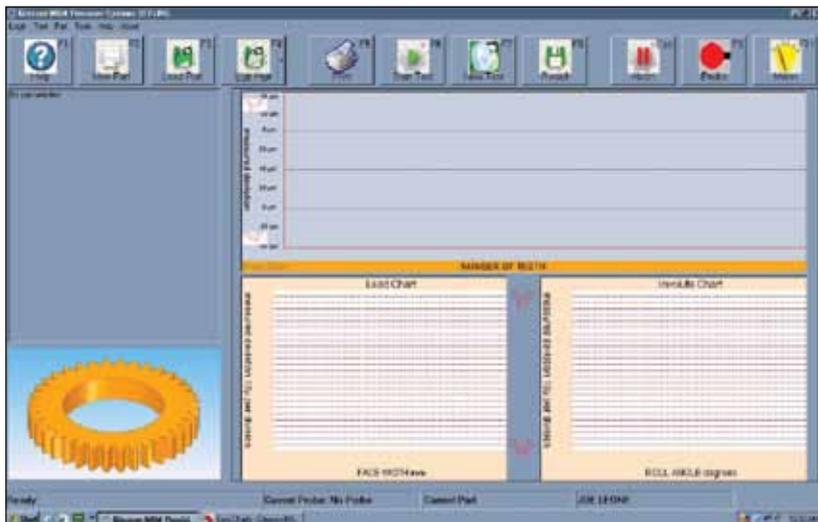
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**Part setup on the new machines is much faster and easier than on the 1980s-era predecessors.**



The QC lab at Milwaukee Gear was recently retooled with two large-diameter GMM inspection systems from Gleason.



The Gleason GAMA software allows new part programs to be created in just minutes.

heavy-duty rotary table giving them exceptional stiffness and rigidity to accommodate gears weighing as much as 2,200 kg for the 1000GMM and 4,500 kg for the 1500GMM.

**Productivity.** Where it might have taken an hour to set up and perform all the measurements required by a typical 1-meter, 60-tooth external gear on the older inspection system, Leone estimates that time has been cut in half by the new GMMs. “For our operation, this is particularly important—not so much on inspection of finished parts because volumes are low but in support of new part setups on our big hobber and in the form grinding cell. At Milwaukee Gear, it’s really the QC lab that

first determines whether a part is ready for processing, whether soft cutting or hard finishing. With the GMMs, the QC lab can keep pace with production.”

Where the older inspection system relied heavily on the expertise of the operator and considerable manual operation, Leone says that the GMMs instead use *GAMA* (Gleason Automated Measurement and Analysis) operating software to simplify programming and completely automate the inspection process. For both Milwaukee Gear’s most experienced inspectors and a new generation of less experienced operators, *GAMA* is designed to make life easier. Here’s how:

1) A typical screen has “quick buttons” across the top giving the operator immediate access to the most common system operations. All important gear and specific test information is shown down the left side of the screen, with tabs and forms making it easy for the operator to quickly and accurately establish gear parameters. The majority of the screen is used to chart the inspection results of, say, lead and involute tests, which appear in real time as the tests are performed. There is also a status bar at the bottom of the screen detailing the stage of the operation, who is operating the system, part number and so on.

2) Operators start the process either by loading and activating existing part programs with the click of a mouse, or by creating a completely new part program that can be done in just minutes with a few easy steps. The operator simply selects from a list of typical machine configurations, enters a part number and clicks a “create” button. A series of tabs then appears across the top of the screen. The operator clicks on these tabs one by one, filling out the necessary fields with pertinent gear data, special tests required for highly modified gear profiles and geometry, the type of analysis required (*GAMA* supports all global industrial standards such as DIN, AGMA, ISO, JIS, etc.), and so on. The operator also can select a variety of options for how a permanent record of the inspection is stored, whether in PDF format, SVG (scalable vector graphics), or even HTML for easy e-mailing.

*GAMA* is a true Windows VB.NET application, making it fully compatible with Milwaukee Gear’s LAN network, so that Milwaukee Gear can easily interface inspection results with its gear design and production resources for corrective actions downstream.

“In addition, GMM’s remote diagnostics capability has been very useful, particularly in the early stages of the installation, to get support from Gleason relative to program-

ming and operational questions,” adds Leone. “Gleason can actually take control of the GMMs from their location, help troubleshoot them...whatever we need.”

Significant productivity gains also result from the GMM’s use of a series of Renishaw SP80H 3-D scanning probes, with various stylus sizes and configurations—and all interchangeable from an automatic probe changer. As compared to the old inspection system and the process of painstakingly positioning the probe manually tooth by tooth, the Renishaw probe saves a lot of setup time. It acquires much more data faster by traveling along the surface of the part in all three dimensions—up, down, side to side and in and out—all fully automated.

...*And, of course, reliability.* Milwaukee Gear CEO Richard Fullington sells reliability—and he also believes in buying it. “Our relationship with both Gleason and M&M Precision Systems (a company purchased by Gleason in 2005) dates back several decades, and Gleason large gear hobbing and profile grinding equipment is at the heart of our expansion into new markets worldwide,” he says. “Our level of confidence and trust in

Gleason technology and [its] ability to service and support it, was of course instrumental in our decision to go forward with the GMMs. The results speak for themselves.” ⚙️

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