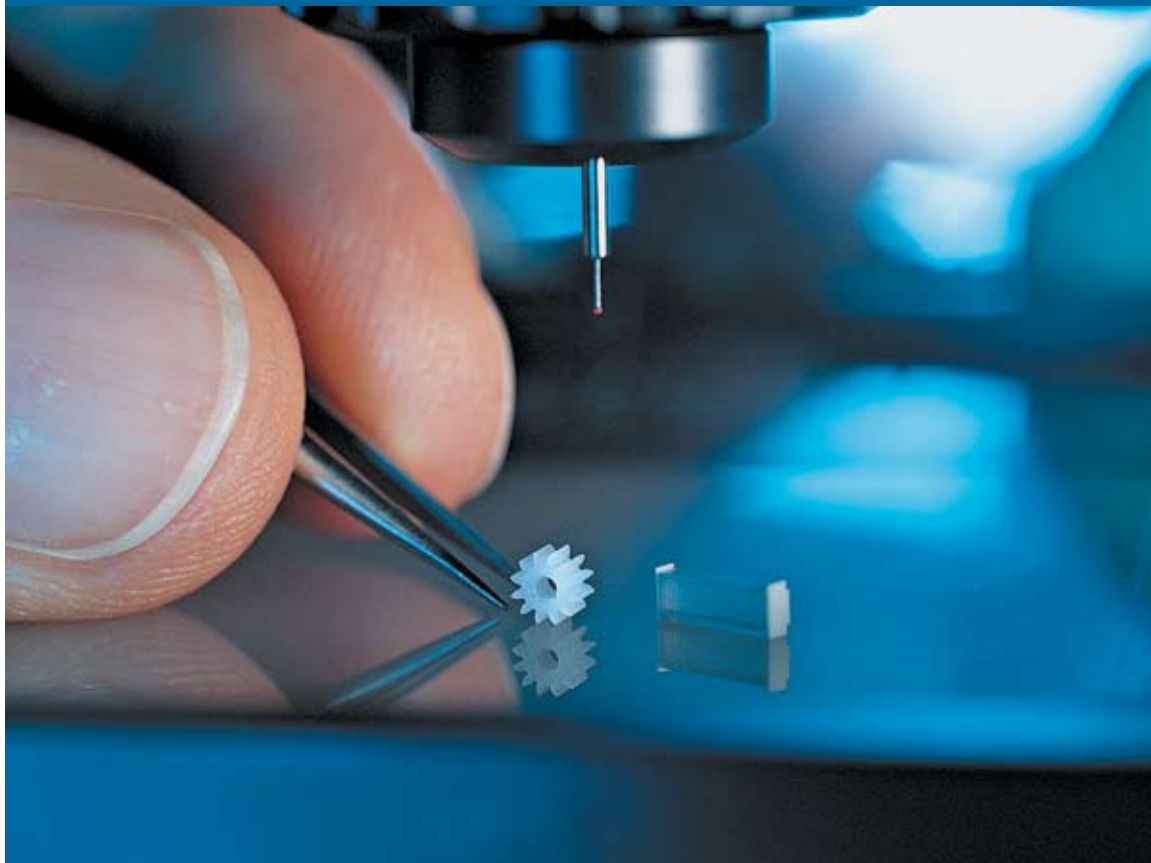


▶ BY ALAN RICHTER, EDITOR



Carl Zeiss

The F25 CMM from Carl Zeiss uses a light-touch contact sensor and an optical sensor for measuring micromechanical components with a measuring uncertainty of 250 nanometers at a resolution of 7.5 nanometers.

The SQUEEZE is on

As part tolerances continue to tighten across the board, accurately and consistently measuring them becomes more of a challenge.

Lev Landau, a famous Russian physicist, once said that you can calculate the properties of water, but it makes much more sense just to measure them. The same could be said about the dimensions of precision metal parts. But measuring those parts accurately with a high level of repeatability becomes more of a challenge as tolerances tighten—an ongoing trend.

"I have been working in the Industrial Metrology Group at Carl Zeiss for more than 20 years and have

seen our measuring machine accuracy increase by more than 300 percent during this time period," said Gerrit deGlee, new product manager of precision products, Carl Zeiss IMT Corp., Maple Grove, Minn. "At the same time, industry is continually challenging us to be more precise."

Dick Mierzejewski, vice president of sales, Edmunds Gages, Farmington, Conn., concurred that the movement towards closer and closer tolerance parts is pushing the metrology equipment envelope.

He said: "Because you're trying to measure tighter tolerance pieces, you need to be an order of magnitude better in terms of your ability to measure what the part tolerances are. So, if you're measuring 0.0001", you need to be good to 0.00001" and so on. It's definitely a challenge."

Environmental Issues

Of course, manufacturers have been producing parts for years with tolerances as tight as 1 or 2 microns, such as fuel injectors and hydraulic valve controls, but other manufacturers are finding tolerance requirements increasing as well. However, those manufacturers may not be familiar with the requirements for measuring parts to a higher level of precision, especially if measurement is performed on the shop floor. "The environment on the shop floor has to be under better control than what they had in the past," said Frank Powell, grinding products manager, Marposs Corp., Auburn Hills, Mich. He noted that the environment includes the quality of the material handling equipment moving the part from a machine tool to a gage and the quality of maintenance for the machine tools producing the parts. "If the machine isn't capable or maintained properly to produce the part for quality, all the gage is going to do is tell you that the part is not any good," Powell said. "People always blame the messenger."

Although the machine tool and material handler are critical components, controlling temperature and humidity is also important. However, that doesn't mean the temperature needs to be at the measurement laboratory standard of 68° F or that humidity has to be kept to a minimum. Instead, the temperature and humidity need to remain constant. For example, Powell recalled a bearing manufacturer that was having trouble with a gage not holding size. He visited the plant and saw that the machine where the variation was occurring was about 20' from the heat-treatment furnace. "Every time they opened the furnace, the size went away. Imagine that!"

If environmental fluctuations can't be controlled by repositioning the equipment, another option—although rarely employed—is housing the metrology equipment in an environmental enclosure. "The operator just opens the door to access the measurement area of the machine, puts some parts in, closes the door and then initiates the measurement," said Timothy S. Fantauzzo, national sales manager, Optical



Carl Zeiss

Carl Zeiss' CenterMax CMM is designed to operate as accurately on a shop floor without an enclosure as a CMM in a metrology room.

Gaging Products Inc., Rochester, N.Y.

However, Powell feels equipment enclosures are generally not helpful as long as the measuring environment doesn't experience a significant rate of temperature change.

In addition, some manufacturers have designed their measuring equipment to operate as accurately on the shop floor as in the metrology room. For example, Carl Zeiss used materials technology borrowed from manufacturing machinery, such as symmetrically arranged gantry axes that provide vibration damping, in the design of its CenterMax coordinate measuring machine, enabling it to be integrated into a production environment. "You do not need to build a 'house' around the machine," deGlee said.

Keeping a consistent time when moving a part from a machine tool to a gage is also a requirement for measuring tight-tolerance parts. This enables process repeatability after a gage is already verified as being repeatable. "If it takes 1 minute to go from the machine to the gage, it should always take 1 minute," Powell said. "If I'm always measuring at the same point and the same time, I should get the same amount of cooling each time."

In addition to impacting workpieces, temperature also affects gaging systems. To remove a significant amount of thermal influences from gages, an end user should specify equipment with components that do not change with temperature fluctuations. For example, on its higher precision machines, Carl Zeiss uses thermally stable glass-ceramic scales. "This removes the uncertainty of the thermal expansion coefficients of the scales, as well as uncertainty of the sensors," deGlee said.

Enhanced Accuracy Tools

"As consumers push for more innovative products, parts

The following companies contributed to this report:

Carl Zeiss IMT Corp.
(763) 744-2400
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Edmunds Gages
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Marposs Corp.
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Optical Gaging Products Inc.
(800) OGP-GAGE
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Redoe Mold Co. Ltd.
(519) 734-6161
www.redoemold.com

When the Earth moves

Vibration is another factor impacting a manufacturer's ability to accurately measure precise parts. Windsor, Ontario-based Redoe Mold Co. Ltd. has a temperature-controlled CMM room located on the manufacturing floor with the moldmaker's vibration-generating machining centers and boring mills. The company's facility is also located near salt mines where blasting occurs regularly. Redoe needed to replace a 13-year-old CMM that wasn't able to achieve the level of accuracy and speed required for the complex automotive-lighting injection molds the company produces, so it chose a bridge-type LH 12.30.10 CMM from Wenzel GmbH of Germany, with a black granite table capable of supporting Redoe's heaviest molds and vibration damping capability. The CMM has a standard accuracy of TP200 U3 2.6 + (L/300) μm .

"The CMM structure has a self-stabilizing design with integrated pneumatic vibration dampeners, which eliminated the need for installing an isolated foundation on our shop floor," said Eric Leene, Redoe's plant foreman. "This in itself saved us a great deal of money and installation time."

Leene added that the level of sophistication in automotive lighting as a result of design, aesthetics and functionality has "exploded" in recent years, driving the need for tighter-tolerance molds. "With new discoveries in parabolic lenses that help drivers see the road ahead more clearly, coupled with



Eric Leene, Redoe Mold Co.'s plant foreman, left, and Chris Tessier, the moldmaker's chief CMM operator, observe as a Wenzel LH 12.30.10 CMM measures a parabolic lens mold.

aerodynamic body styling that has pushed once-obtrusive headlights deeper into the body and sharpening the angles required for directed beams, the challenges to moldmakers in terms of precision tooling have been intense," he explained. "Mold tolerances are now in tenths and microns, so the CMM is a critical part of the production process for inspecting the mold."

for those products often require a higher level of precision," according to Optical Gaging Products' Fantauzzo. He noted that the tools available for designing and producing parts are becoming more sophisticated. The latest CAD software and machine tools with 5-axis capabilities enable tighter toleranced and more complex parts to be specified and manufactured. "New measuring technology is an enabler," he said. "The ability to measure to tighter tolerances allows manufacturers to have the confidence to make parts with even tighter tolerances."

Fantauzzo added that one accessory used in advanced machining is also available for OGP video measuring systems—the rotary table. "A part mounted to a rotary table can be rotated during measurement, allowing more complete measurement of all sides of the part without the need to refixture it

between measurements," he said.

Rotary tables vary in load capacity and positioning accuracy. Single-axis and dual-axis rotaries can rotate a part during a measurement routine, allowing automatic, unattended measurement of even complex parts, such as turbine blades. "The system's metrology software controls the rotary table and the measurement process so all dimensional relationships are retained and quantified," Fantauzzo said.

Combining different sensors in a CMM is another way to increase accuracy, especially when measuring micro-mechanical components, according to deGlee. He noted that Carl Zeiss' new F25 uses both an optical sensor and a contact sensor to provide 3-D measurements. "Optical sensing is often useful for such small parts," he said. "However, it is limited in that it can only 'see' in two dimensions, so you will not be able to evaluate in the third dimension, and the visual edges are often rounded or coarse, which further limits the optical capabilities." By combining the optical sensor's measurement results with that of the touch sensor, which reportedly has a touch 100 times lighter than a typical CMM, this 2-D limitation is overcome. "Measurement uncertainties of less than 250 nanometers are possible with this machine," deGlee said.

Although the push toward tighter tolerances isn't limited to microcomponents, such parts typically have tight tolerances because as the part size scales down, so does the tolerance. Some of these components, such as fuel injectors and microbearings, are produced on smaller grinding machines where space is limited. To overcome this restriction, Marposs has developed the NanoUnimar compact gage



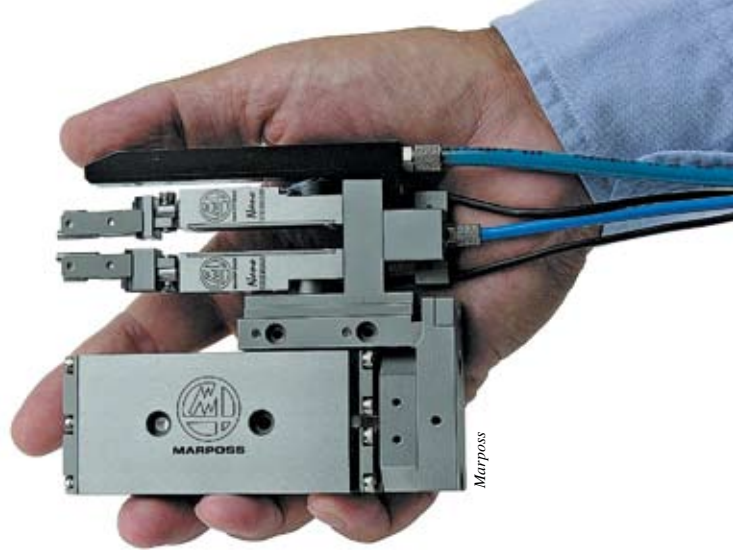
Marposs' M1 Wave electronic bore gage contains Bluetooth wireless technology and provides 0.5 μm repeatability over a 3mm- to 300mm-dia. range. According to the company, the gage is suitable for use in the harshest production environment.

for in-process grinder control. With a measurement range of $-100/+300\mu\text{m}$ and repeatability of $0.1\mu\text{m}$, the gage measures IDs, ODs, positioning and length for smooth and even interrupted surfaces. “Any kind of part that has an interruption in it is always a challenge,” Powell said. “For example, if you’re doing pneumatic gaging, you have to make sure you have the part oriented so you’re not measuring halfway across an interruption.”

Multisensor Approach

In addition to equipment using both contact and optical sensors, metrology tools are available with a host of other sensors that can deploy and retract automatically under program control. Multisensor-based machines increase productivity by doing more extensive measurements in a single setup. Each sensor has its own range of capabilities. “We have machines that can use as many as five sensors on the same machine,” said OGP’s Fantauzzo. “A measurement routine on a CNC machine could be moving along with optics, say, to look at edges on a large part, switch to a touch probe for bores and then deploy a laser to do surface scans. All that data is being accumulated in the software, and it is all being done without an operator at the machine,” he said.

In the end, though, there’s doubt for every type of measurement. “You can measure things, but you always have some degree of uncertainty associated with that,” said Edmunds Gages’ Mierzejewski. “When your degree of uncertainty exceeds or becomes a large percentage of the tolerance that you’re trying to measure, then you have difficulty



The NanoUnimar gage from Marposs is for smaller grinding machines and has a measurement range of $-100/+300\mu\text{m}$ for in-process measurement applications without mechanical refitting. Repeatability is $0.1\mu\text{m}$. The gage heads, each with a separate measuring finger, are applied for measuring a diameter, so the gage can be adapted for measuring 1mm- to 6mm-dia. parts.

saying, ‘Yes, I can measure that piece with confidence.’ ”

Of course, equipment is available to measure the tightest conceivable tolerances, but the cost may be prohibitive and the effort worthless, depending on the application. “I may be able to supply you with a gage that can repeat and measure down to an angstrom, but if you can’t produce it, what’s the point?” Powell asked. \triangle

