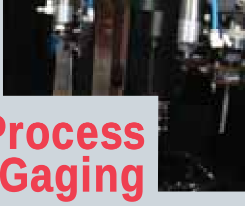
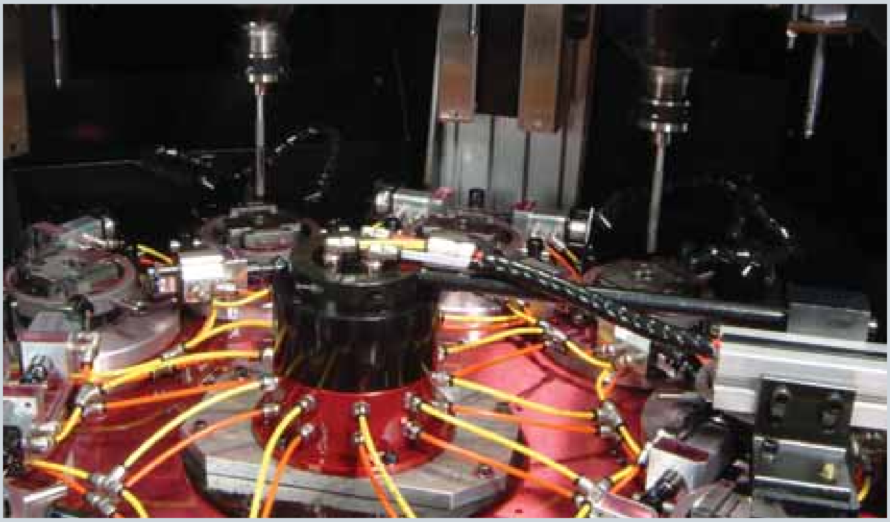


IN-PROCESS GAGING IS COST EFFECTIVE



Find the flaws before they cost you

Robert B. Aronson
Senior Editor

Sunnen's SV-1005 air-gage-equipped hone can automatically control hole size to accuracies of 0.25µm (0.000001") without operator intervention, working in a size range of 3–65-mm (0.120–2.56") diam. It is well-suited for automated, high-C_{pk} production of small engines, hydraulic valves/bodies, fuel injectors, gears, compressor parts, turbocharger housings and gun barrels, in medium and high volume.

In-process gaging has two potential benefits. It can tell you how well your machine tool is performing before you start cutting, or it can be used to determine if you are making parts to spec. It can also reduce trips to a test unit or a lab that not only takes time, but can mean an error-inducing re-setup.

While probes have long been used on machine tools to resolve setup problems, today there is a lot more probing going on as a means of validating the machine and checking its performance, according to Barry Rogers of Renishaw Inc. (Hoffman Estates, IL). The goal is to remove variation from the process whether It comes from the machine, its operator, the workpiece material, whatever.

Software advances are a big factor in aiding wider adoption of probing for process control. "We want to get probing routines into the cutting cycle," explains Rogers. "First a CAD model is imported, then the programmer can pick what features to measure — just click on a feature and drag and drop it into the inspection program."

Running an inspection program generates measurement data that can then be used to automatically update offsets for real-time feedback or be sent to an operator who will manually make the changes. For the automated feedback the company's AE Pro closed-loop software is used. For manual measurement, Renishaw's

OMV open software sends feature data to the operator for application of offsets, if needed.

Probes are also used to check the machine before cutting begins. You can use a master part or measurement artifact of known dimension to verify machine performance. A program touches off a series of points on the master. A deviation in machine measurement from control dimensions determines the need for offsets.

In-line probing for complex, high-value parts verifies precise dimensional relationships between various features at each step to avoid problems that can lead to rework or scrap. Renishaw MP700 machine tool probe offers submicron, CMM-like precision to in-line part inspection. Strain-gage design delivers low trigger force and uniform 3-D trigger pattern with 0.000010" (0.5µm) repeatability with a 2" (50-mm) stylus.

"You can also use machine comparison. First measure a feature with a machine tool probe, then check the data on a CMM and make necessary machine corrections," says Rogers.

"To meet the demand for working with the smaller parts found in the medical and aerospace industries, we now offer the OMP 400 which enables use of long, small-diameter styli without bending. It uses a strain gage which allows much lower, highly consistent trigger forces than possible from switch probes. This unit is a miniaturized version of our OMP 700 and is accurate to a quarter of a micron," says Rogers.

Another new system for automated pre-check is the OTS wireless twin probe system—a tool setter probe and a spindle-mounted touch probe sharing an optical transmission system that sends data through infrared signals. This provides a cable-free machining environment and gives users automated on-machine tool setting, broken tool detection, part setup and part verification capability.

A big seller for Renishaw is broken-tool laser detection. Low-cost units verify tool condition before starting an operation to prevent part damage. Detection particularly eliminates a common costly problem of tap breakage in drilling/tapping operations. If the broken or missing tool is not detected in an automated process, the tap, the tool that normally follows the drill, almost always is snapped.

"We have found that there are less dedicated operations; instead the customers want gages that are quicker to change over a range of sizes," says David Hayes of Control Gaging (Ann Arbor, MI). "Our new product line addresses the quick-change issue. Gages that can handle smaller parts, chiefly in the aerospace and medical industries are in demand."

The company has also had to accommodate environmental issues in Europe. This includes the elimination of any lead in the equipment as well as any substance that might over time degenerate into a toxic material. "While currently there is an exemption for machine tool products, we feel that it's just a matter of time before this is eliminated and in the long term may be enforced in the US," says Hayes.

Remarkably, both the Japanese and Chinese are looking into these environmental issues. Another change is the need to integrate gage controls into the machine's control. Customers want an easier, simpler link for these controls.

Built-in gaging is more in demand. For example, the SV-1005 series vertical CNC honing system from Sunnen (St. Louis) now has an integrated air-gaging system to provide closed-loop control of tool size, along with downloadable SPC data. Matched with Sunnen's diamond-plated CGT Krossgrinding tools or MMT TurboHone multistone mandrel, the air-gage-equipped machine can automatically control hole size to accuracies of 0.25µm (0.000001") without operator intervention, working in a size range of 3–65 mm (0.120–2.56") diam. It is suitable for tasks such as automated, high-C_{pk} production of small engines, hydraulic valves/bodies, fuel injectors, gears, compressor parts, turbocharger housings, and gun barrels in medium and high volumes.

"There are always 'gotchas' *in a process."*

Measuring ever smaller parts is a challenge Marposs Corp. (Auburn Hills, MI) is resolving. The company's new NanoUnimar is a compact measuring tool that measures small devices in the machine tool with a precision not possible before, such as miniature bearings and tiny air motors.

"Another challenge area is measuring round parts," explains Frank Powell, product manager. "For example, it was common practice to make crankshafts with orbital grinders, then check form measurements such as roundness of the shafts on laboratory equipment. With our gage built into the machine we can make the form measurement directly."

This gage has the software to run in a PC off-line or on machine. The results correlate with lab equipment within half a micron. This system does not replace lab equipment but lets you take a snapshot of the process to see what may be going on.

Another new tool is a wireless gage plug system that checks parts while they are on the machine without a wire connection. Guided sequence routines available for use with the gage can tell the user what to measure and in what sequence.

"Generally, the gage is no longer an add-on," says Powell. "Requirements over long periods of time have forced a new emphasis on in-process gaging. Gages are directly integrated to the machine so that machine and gage are one," he concludes.

In our new NC version of PC-DMIS the idea was to bring most of the properties of the original PC-DMIS to in-process metrology," explains Steve Logee, director of business development, Wilcox Associates, Division of Hexagon Metrology (Elgin, IL). It can take measurement information from x number of machine tools and analyze them using the PC-DMIS evaluation engine.

Marposs gage fixture is mounted on a stand with recoil for protection of the gage in case the part is misloaded by the robot. This application features a Quick Set gage fixture for shaft-type parts.

There are now three distinct versions. PC-DMIS Lite is for those who use spindle probes, but don't need too much information, just some basics for tool setup, offset calculations, and simple geometry. It's an icon-driven package that shields the user from the complexity of entering M and G codes. It's offered as an option from OEMs.

Currently this version is used only for spindle probe measurements, but it may be expanded into serving other sensors and applications.

The second version, PC-DMIS NC Server, is more complex software running in a distributed process mode that can do complex metrology. It allows the user to bring a CAD model into the PC DMIS environment, develop a measurement program off-line, translate that into G and M codes and use it to validate the results of a NC program. For example, it would be possible to validate a critical cutting operation within minutes after its completion.

"After a machine does its cutting, you call up the probing sequence and make the necessary measurements," says Logee, "that data set goes to PC-DMIS for evaluation. The software then reports the result in the most meaningful format for the application at hand. This can range from a simple signal to the operator that something has gone wrong to a complex graphical report that manufacturing engineers can use to fine-tune process. The software can also send information back to the machine tool to correct for wear or geometry changes." PC-DMIS NC Server can manage the data coming from a number of machine tools simultaneously.

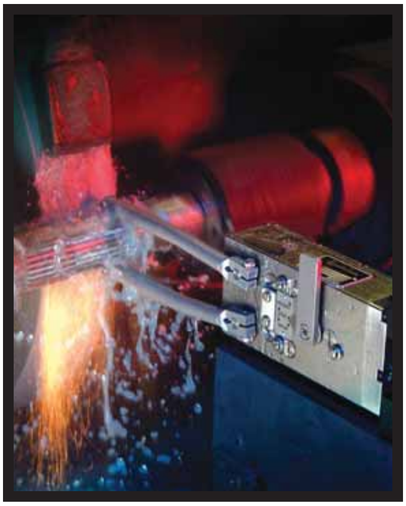
The top of the line is the PC-DMIS NCi (Interactive) program that takes control of a machine. This software runs on a machine tool in much the same way PC-DMIS runs on a CMM. It uses the probe to gather data about a feature or group of features, analyzes that data by comparing it to the CAD model and generates meaningful feedback in real time. It can be used for operations like iterative alignments or logical operations that require direct communications between the measurement software and the machine tool. It can also perform final inspection on parts that are either too large for a conventional CMM.

"Pneumatic gages are catching on and replacing manual systems," says Kevin Kaufenberg of Heidenhain (Schaumburg, IL). They use air pressure to actuate a gage. This increases the machine's capability and reduces time-consuming manual operations.

Another timesaver is that the Heidenhain gages don't need recalibration while many LVDT-based units have to be calibrated frequently. Heidenhain glass scales have an optical reference mark that is permanently etched and never drifts.

The newer units have longer strokes, up to 30 mm, which lets you use the same gage for a wide variety of parts.

Signature analysis is an important tool in process evaluation, both to check production machines and finished components. The concept is that manufacturing processes



WG2 Diameter Gage from Control Gaging provides real-time measurement feedback to a grinder for precise diameter control. Unit offers repeatability of less than 0.0005 mm and 30-sec setups.

can be evaluated through measurement of variables that are collected and digitized using sensors, yielding a process signature. These signatures are usually consistent and repeatable for a process and any aberrations indicate bad parts or tooling.

Nathan Sheaff, founder and CTO of Sciemetric (Ottawa, Canada), a supplier of signature analysis systems for assembly manufacturing, cites an early company success with Ford. Their engineers wanted a system that would check an engine as it was built as opposed to waiting until it was fully assembled.

In this system, a bank of stations checked the assembly process as each key part was added such as crankshaft and pistons. Each test was dynamically conducted at each station by mechanically rotating the shaft. The installation reportedly significantly reduced engine flaws.

Sheaff cautions, "Signature analysis will not tell you if a system will work but does warn of flaws such as cracks in material, improper assembly, and if the components are functioning properly. The crank angle is usually the best indicator of a defect in an engine, for example."

To establish a test procedure, signatures of ideal components are obtained, then the product is run with components with known defects. The difference in the signatures leads to the detection of a problem.

After a number of parts have gone through the system, there is a consistency check. This step is the key to learning how much out of spec should be allowed before a part is considered defective. There must also be an evaluation of naturally occurring features that might cause signal variations such as humidity, ambient temperature, vibration, and tool wear.

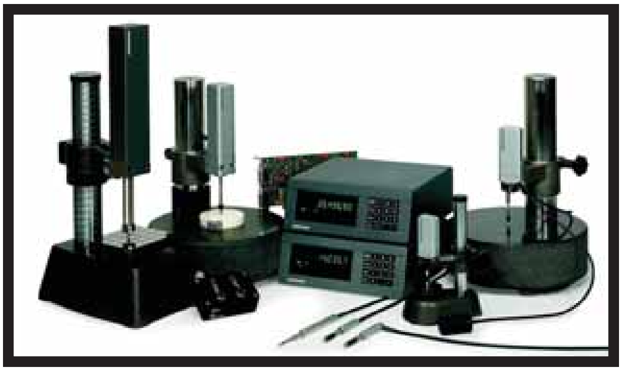
"With time you get to know what the serious problems are," says Sheaff. "Then you may be able to redesign the checking system to look only for one or two variables. We offer test units from two to 30 channels to address the number of variables.

"There are always 'gotchas' in a process," says Sheaff. "Sometimes we initially don't look for the right thing. A flaw gets through that was not detected. Then we have to rework the test and analysis. Having the signature data is crucial to being able to identify the root cause of the issue.

The signature analysis systems are not expensive, and some customers have found that one warranty claim will more than pay for an entire system," he concludes.

Software plays a big part in the improvement of in-process gaging. For example, the AutoComp system from Caron Engineering (Wells, MI) processes data on tool performance and corrects offsets automatically.

Each time a specific tool is compensated, the amount of compensation is recorded. This lets the operator monitor tool wear and set limits on how much adjustment should be allowed before the tool is replaced. A screen shows a red (time to replace), yellow (approaching replacement time) or green (tool OK) signal.



Heidenhain offers a wide family of gages for applications requiring extreme precision.

Another product from Caron Engineering is their Tool Monitoring Adaptive Control (TMAC). It monitors tool wear in real-time based on the amount of horsepower needed to cut a part. The power requirement increases as the tool's cutting edges deteriorate. TMAC constantly measures horsepower required by the spindle and feeds to determine when a tool is worn or broken, then signals the CNC to take corrective action.

Initially the system is programmed with the horsepower needed for a specific tool to make an optimum cut, along with the wear rates for that tool. The system then monitors these two limits. TMAC can also be set up to monitor coolant flow for each cutting situation.■