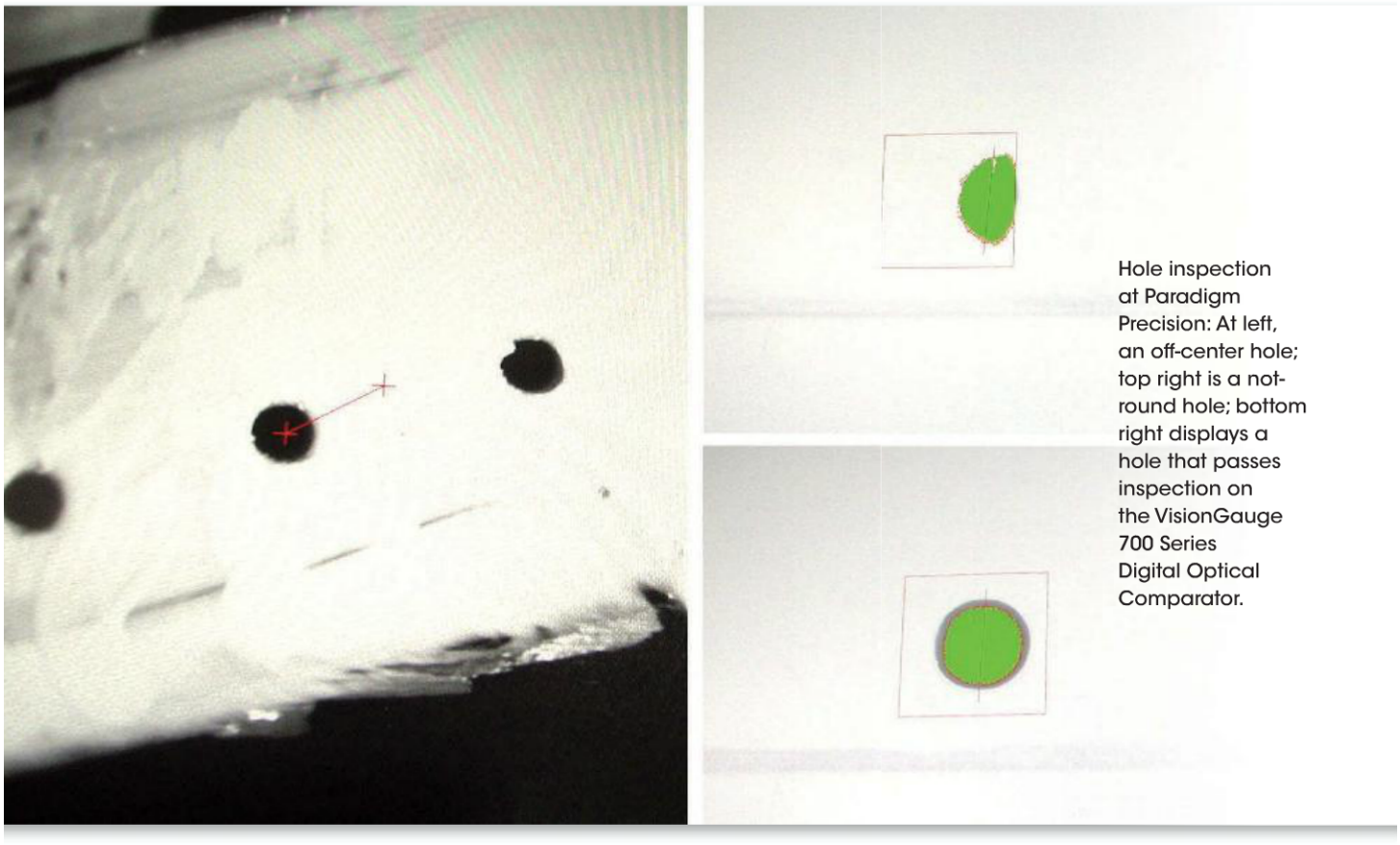
Paradigm Precision uses digital optical comparator for Aero Engine hole inspection



Hole inspection at Paradigm Precision: At left, an off-center hole; top right is a not-round hole; bottom right displays a hole that passes inspection on the VisionGauge 700 Series Digital Optical Comparator.

A New Paradigm for Hole Inspection

Aerospace manufacturers know that quality control (QC) is mission critical when producing parts. OEMs rely on their suppliers for parts which are made to extremely tight tolerances and are delivered on time. So when a testing and verification process is cumbersome, prone to error and offers limited capabilities, suppliers are well served to examine alternative QC options.

Aerospace supplier Paradigm Precision (Orillia, Canada), a DPG Holding Company, recently faced such a challenge. Paradigm produces a wide range of complex, precision-machined aircraft engine components including heat shields, engine housings, vane actuator assemblies, shroud segments and more for customers such as UTC, Rolls Royce, Snecma, GE, AVIO and MTU. Their 8370-m² Orillia plant has 170 employees.

Holes by the Hundreds

"As an aerospace sector component supplier, we have extremely stringent quality requirements," said Mike Hellwig, Paradigm plant manager. Paradigm is required to manufacture parts per the AS9100 standard, which is based on ISO 9001 but specifically established by the aerospace industry in order to satisfy DOD, NASA and FAA quality conditions. In addition, they must meet customer-specific requirements including Production Part Approval Process (PPAP), SPC, Gage R&R Process Certification and Lean principles.

"We are required to validate every feature on the prod-

Display monitor shows holes to be inspected on Paradigm Precision's VisionGauge 700 Series Digital Optical Comparator.

uct until we obtain a large enough sample to introduce a sampling plan. And even with the plan, we must meet strict requirements including dimensional tolerances which can be as small as ±0.0063 mm," said Min Tong, quality control supervisor at Paradigm.

"Falling short of these exacting standards on one or two holes may not make an engine fail, but missing the mark even slightly has other consequences" said Hellwig. "Penalties can be assessed if 100% inspection criteria are not successfully met, which can affect us financially, not to mention our company's reputation in the industry."

One of Paradigm's families of precision-machined products are heat shields. Up to 160 different operations, including turning, milling and EDM drilling, are involved with manufacturing 16 different shield sizes. The heat shields are made of Single Crystal Superalloy materials that provide maximum strength and tolerance in the high-heat environment of turbine engines. Paradigm uses EDM drilling machines to drill the heat shield cooling holes, ranging in size from 0.4 to 1.9-mm diameter and in quantities from over 50 to nearly 400 holes, at different locations and angles into the assorted heat shields. The cooling holes must line-up precisely where the OEM specifies via CAD files and prints.

"We were using a CMM to perform part inspection to ensure the holes were in the right location per the OEM's requirements," said Tong. "However, because the holes are so small, we could not use the CMM to directly probe the holes. The CMM is unable to validate hole sizes below 0.76 mm. Instead, inspectors had to insert gage pins into the holes. Complicating the process, the pin size needed to be as close to the hole size as possible in order to make a tight fit. Then the probe needed to be rotated at a right angle to measure the pin and project the position of the hole."

Tong reported several limitations and challenges when using the CMM to inspect the small holes. For one, gage pins range in size from 0.28 to 6.35 mm, in 0.001" (0.0254 mm) increments, to accommodate the smaller holes. But if the pin is not perfectly positioned, the CMM probe can deflect off the pin, adding errors to the inspection process. Tong said, "Add to this the overall problem the varying hole locations and angles present for the probe to properly adjust. The heat shields have holes located with less than 2° of separation and with different angles. The angle of the CMM's probe only offers resolution every 7.5°, so it was very difficult to achieve the accuracy our customers required."

To minimize errors at that time, Tong said, their only option was to try to find the best probe possible for measuring at angles.

The CMM inspection process was taking Paradigm inspectors up to six hours to fully inspect 365 holes on one part. To reduce inspection time, they were measuring just two holes per side and then using Mylars to determine if the checked cooling holes fell in an acceptable range. Tong said, "This was not accurate enough to meet our customers' requirements, and if requested, we were not able to perform any SPC studies." Paradigm Precision determined that this inspection process was not acceptable, so they researched inspection options that didn't include contact probing.

Test & Measurement Efficiency

Paradigm selected VisionGauge Digital Optical Comparator 700 Series, featuring five-axis inspection to efficiently view the heat shield holes from all sides and angles and solve their inspection challenges. VisionGauge Digital Optical Comparators are made by VISIONx Inc. (Pointe-Claire, Quebec Canada) and exclusively distributed in North America by Methods Machine Tools Inc. (Sudbury, MA).

The five axes of motion (*X, Y, Z*, Rotary, Tilt) enable quick, accurate inspection of all sides and angles on complex parts, such as in the aerospace and industrial gas turbine industries. Extremely powerful "adaptive" software locates features of interest on different surfaces with varying reflectiv-

ity and viewing angles. For both round and shaped holes, the VisionGauge 700 Series automatically verifies precise hole presence and accurately measures hole location—typically achieving repeatability of ±0.0001" (0.00254 mm).

> "We must meet strict requirements, including dimensional tolerances that can be as small as ± 0.0063 mm,"

Tong reports several benefits since using the 700 Series to check the hundreds of holes on the heat shield family of products. "The CMM can only rotate on the head whereas the VisionGauge five-axis solution can locate on the *X-Y* plane as well as *Z*," said Tong. "The 700 Series has linear axes with 0.25 µm resolution and a 0.005" [0.127-mm] resolution on the rotary axis, making it more accurate in angle inspection than with the CMM. Unlike the VisionGage, the CMM can only rotate at every 7.5°, which limited our ability to meet our customer's inspection requirements."

Tong also likes that the 700 Series requires no contact with the parts, which eliminates the possibility of marking or material deformation of the part. The digital optical comparator works directly with the part's CAD data and does not require any overlays, Mylars or templates, which can result in increased errors.

Paradigm inspectors have appreciated the high-resolution 20× optical magnification in a 38" (965-mm) diagonal image viewing area, which allows them to easily and accurately locate holes in all different angles. Tong points out that an ultra-bright all-LED illumination offers stable, repeatable multiangle and multiquadrant illumination conditions via a programmable, computer-controlled system. The system comes with very flexible and general-purpose reflected illumination.

The 700 Series features CAD Auto-Align and CAD Auto Pass/Fail tools. The Auto-Align tool automatically aligns CAD data to the part in less than two seconds, producing repeatable and accurate results that are completely operator-independent. The powerful Auto Pass/Fail tool automatically determines, very accurately and in real-time, if a part is within tolerance. The Auto Pass/Fail tool can be point-based or can consider complete geometric entities and perform both simultaneously, on the same part.

The comparator can be set up to automatically collect complete electronic documentation and device history for SPC and quality compliance purposes. "VisionGauge Digital Optical Comparators allow users to compare a part to its CAD data in real-time, fully automatically," said Tong. "This eliminates human error and significantly speeds up the process."

Proof in the Results

When evaluating the VisionGauge 700 Series, Paradigm found no other method was comparable to this five-axis digital optical comparator solution. By switching from the CMM to the VisionGauge 700 Series, results include increased accuracy, especially on parts—or holes—with complex geometry. Time saving is another huge benefit. Hellwig said that on one part with 50 holes, inspection used to take about one hour with the CMM. Now the same part takes about 10–15 minutes, a 75% time savings.

Tong continued, "An even greater time savings of 85% is realized when inspecting parts with 300 holes or more. And, VisionGauge makes 100% inspection more realistic in order to meet our customers' expectations."

VisionGauge 700 Series Digital Optical Comparator at Paradigm Precision.

Since Paradigm supplies components to many major aerospace engine manufacturers, requirements from each OEM vary. But the VisionGauge 700 Series is versatile for meeting whatever requirements the aerospace majors have, allowing them to customize inspection for each customer.

As a component supplier to aerospace OEMs, being accurate, efficient and flexible are key to remaining competitive, and the VisionGage solution has helped Paradigm's inspection fly.

This feature was edited by Senior Editor Michael Anderson from information provided by Method Machine Tools Inc.