By Patrick Beauchemin

Automatic 5-axis inspection of drilled components

New solutions increase accuracy and efficiency.

To ensure accuracy and optimize productivity, manufacturers of aerospace parts with complex geometries require an inspection and measurement solution that can properly view parts from all sides and angles. Until recently, this has been a challenge.

For example, cooling holes are essential features on many high-temperature components found on today's aircraft engines. Aircraft engine turbine blades, vanes, nozzles, and heat shields require holes to be electrical-discharge machined (EDM) or laser-drilled in order to keep the parts cool. These holes are critical in minimizing high temperatures that would otherwise damage the components and cause them to fail. To ensure the formation of a boundary layer of cooler air to protect these parts from high engine temperatures, producers must verify that all of the cooling holes are present and at their proper locations. This has always been particularly difficult during the measurement and inspection process.

Traditionally, the most common approach has been to carry out a simple visual check. However, this process is prone to human error and often inaccurate. Another process to obtain the proper hole location uses a coordinate measuring machine (CMM) to check pins inserted in a few holes on a small sampling of parts mounted on sine plates. This is slow, labor intensive, and falls far short of the objective of inspecting 100% of the holes on 100% of the parts. One often-seen approach involves checking a few holes on a few parts – positioned using sine plates to obtain the proper rotary and tilt orientations – against Mylars on a traditional optical comparator. This process is slow, subjective, and inaccurate because it only considers a small sampling. None of these approaches has ever been satisfactory, especially when considering the critical importance of these cooling holes.

Automated inspection

A 5-axis inspection and measurement system has recently been introduced to meet the inspection requirements for complex aerospace manufacture. The 700 Series VisionGauge digital optical comparator (developed by VISIONx Inc. and distributed throughout North America by Methods Machine Tools Inc.) uses five axes of motion (X, Y, Z, rotary, and tilt) to quickly and accurately inspect all sides and angles on the part. Powerful adaptive software locates features of interest on different surfaces with varying reflectivity and viewing angles. For both round and shaped holes, the VisionGauge 700 Series automatically verifies precise hole presence and accurately measures hole location.

In addition to increased accuracy, the 5-axis digital optical comparator offers faster inspection. Like most vision-based systems, it is much faster than a touch-probe machine. It positions the part accurately in all five axes simultaneously to further accelerate the inspection process. As a result, the system is typically faster than the machine used to make the holes. In practice, it is generally used to inspect 100% of the holes on 100% of the parts – the most desirable scenario. Typical inspection time is a few seconds per hole.

The 700 Series VisionGauge digital optical comparator is a 5-axis inspection and measurement system for the inspection of parts with complex geometry such as aircraft engine turbine blade (shown in inset).

Also, the vision-based system doesn't require contact with the part as a touch probe would, which is especially useful when a touch-probe is not small enough to inspect smaller holes. Also, when you do not touch the workpiece, you eliminate the risk of defacing or moving a lightly fixtured part.

Features for accuracy

When selecting an automatic 5-axis measurement solution, consider features that will result in high accuracy. For example, systems that offer all five axes with closed-loop encoder feedback achieve top positional accuracy. The 700 Series VisionGauge digital optical comparator has linear axes providing 0.25µm resolution and the rotary axes have a resolution of 0.005°.

Also, advanced optical sub-systems specifically designed to meet the demanding requirements of 5-axis inspection are important considerations. Optical sub-systems – with an extended depth-of-field, so that everything is perfectly in focus, even in areas of very high curvature regardless of the part's geometry – are extremely beneficial. It is also important to provide long working distances to ensure that there is ample clearance between the part and the entire optical system, to accommodate

Photo courtesy Airbus SAS/P. Masdet

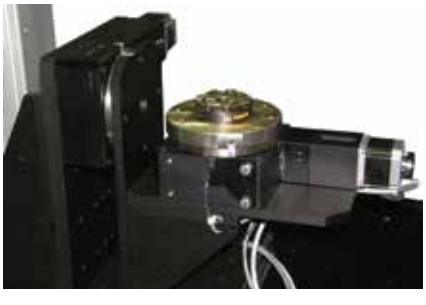
large and unusually-shaped parts. Combining extended optical depth-of-field and ample working distance provides the flexibility necessity for 5-axis inspection.

To produce distortion-free images that show very fine details with great clarity, the optical sub-system should use high-resolution precision optics and a high-resolution camera. Ultra-bright, all-LED, multi-angle, and multi-quadrant illumination that is computer-controlled and programmable is important for enabling the flexibility to easily inspect parts with complex geometric features.

A 5-axis solution should offer advanced software; specifically, powerful, adaptive feature-detection software tools that accurately find and locate EDM-drilled holes on various surfaces that have different reflectivity and viewing angles. The software included with the system does all of this automatically, so that even when there are two holes with completely different appearances, inspection can proceed in exactly the same way when setting up a program. The software will adapt to the different conditions and can automatically and reliably detect and adjust for burrs and splatter.

Accuracy achieved

A full-featured automatic 5-axis measurement solution will automatically verify hole presence and also measure hole location very accurately – typically achieving real-world repeatability of ±0.0001" in both round and shaped holes. Holes can be checked either one at a time, looking straight down each hole's nominal axis, which is ideal for coated parts, to minimize errors due to coating thickness variations. Or multiple holes can be checked simultaneously and viewed at an angle, which is even faster and well-suited for uncoated parts or parts with a uniform coating thickness.



The 700 Series VisionGauge digital optical comparator features a chuck mounted on its double-rotary assembly.

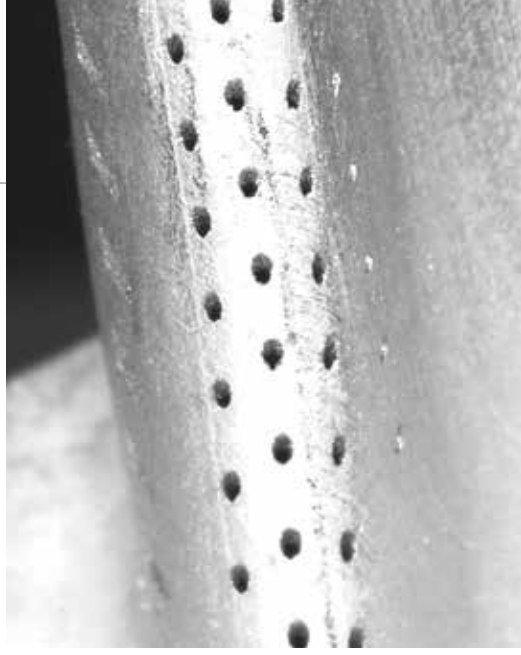
Easy programming preferred

With the system, the drill software parameters file can be used to program the 5-axis measurement system. A chuck that allows parts to go directly from the EDM drilling machine to the inspection system without re-fixturing not only speeds inspection, but also minimizes stack-up error. The system also can be supplied with the same working envelope as most EDM drills, so all holes are guaranteed to be fully inspectable.

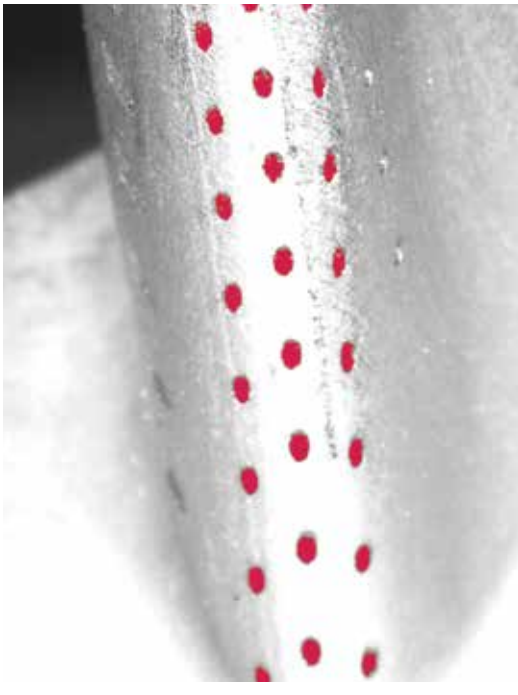
The measurement system should be able to output a wide range of results, including hole presence and hole offsets. This allows users to automatically create reports and collect measurements, statistics, images, and other data for complete documentation. The inspection system should have built-in SPC capabilities, including extensive data-exchange, to send results to other applications. With these software capabilities, hole offsets can also be used to modify the EDM drilling program.

For optimal efficiency, select a 5-axis measurement system that is easy-to-use, offering a straightforward interface with all functions being controlled via a bar-code-reader and joysticks. A fast and intuitive operator review mode to quickly revisit out-of-tolerance areas is also very helpful.

The 700 Series VisionGauge digital optical comparator 5-axis inspection and measurement system meets the demands of the aerospace industry. It has advanced, patented software tools and is easy to set up and use, producing highly accurate results. Aerospace manufacturers can now easily and reliably perform automated 5-axis inspections that were previously impossible to achieve. **A**



Close-up of the holes in the aircraft engine turbine blade, as seen by the 700 Series VisionGauge.



VisionGauge software found and located the holes in the aircraft engine turbine blades, as seen in this close-up post-analysis image.

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