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Automatic Five-Axis Inspection of Aerospace Components

Advances in digital optical comparators simplifies test and measurement

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There are several methods for inspecting laser-drilled and electrical discharge machined cooling holes on aircraft engine turbine blades, vanes, nozzles, heat shields, and other similar parts. These holes are essential features of the cooling systems that protect critical components against the high temperatures that would otherwise damage them and even cause them to fail.

The only way to ensure the formation of a proper boundary layer of cooler air to protect these parts from the high engine temperatures is to verify that all of the cooling holes are present and at their proper location. This has always been a challenge and there has never been a good way to check these holes.

Probably the most common approach has been to carry out a simple visual check. Everyone agrees that this is very inaccurate and prone to human error.

Another scheme involves using a coordinate measuring machine (CMM) to check pins inserted in a few holes on a small sampling of parts mounted on sine plates to obtain the proper rotation and tilt angles. This is slow, labor intensive, and falls far short of the objective of inspecting 100 percent of the holes on 100 percent of the parts.

Another frequent approach involves checking a few holes on a few parts—again, positioned using sine plates to obtain the proper rotary and tilt orientations—against Mylars on a traditional optical comparator. Again, this is slow, inaccurate, subjective, and only considers a small sampling.

None of these approaches has ever been satisfactory, especially when we consider the critical importance of these cooling holes.

A different approach

There is a technology that allows 100-percent inspection of these parts with none of the downsides: today's highly advanced digital comparators, for example the 700 Series VisionGauge Digital Optical Comparator. Five axes of motion is important when dealing with parts that have a complex geometry; another advantage of a vision-based system is that it doesn't need to come into contact with the part, as would be necessary for a touch probe.

Vision-based systems are typically much faster than touch-probe machines, not simply because of the noncontact nature of the probe, but also because it can position the part very accurately in all five axes. These systems are therefore very fast, typically much faster than the machine used to make the holes, so that—in practice—they can be used to inspect 100 percent of the holes on 100 percent of the parts, which is of course the most desirable scenario. Typical inspection time is a few seconds per hole.

Advanced optical subsystems produce very high-resolution image that are sharp and clear. These images are then handed over to software for analysis. These advanced software tools offer robust feature detection, specifically, extremely powerful "adaptive" feature-detection abilities which allow a user to accurately find and locate holes and slots on different surfaces, with different reflectivity, at different viewing angles, etc. The software does all of this automatically. Practically, this means that even if two holes have completely different appearances, you deal with them in exactly the same way when setting up a program. The software will adapt to the different conditions and figure things out on its own.

The software has specialized tools specifically designed to automatically deal with burrs and splatter in a reliable manner.

As a result of all of this, the system can automatically verify hole presence and also accurately measure hole location, typically achieving real-world repeatability of ±0.0001 in. It supports both round and shaped holes. Holes can be checked either one at a time, looking straight down each hole's nominal axis (ideal for coated parts, to minimize errors due to coating thickness variations) or multiple holes can be checked at once, viewing them at an angle (which is even faster and well suited for uncoated parts or parts with a uniform coating thickness).

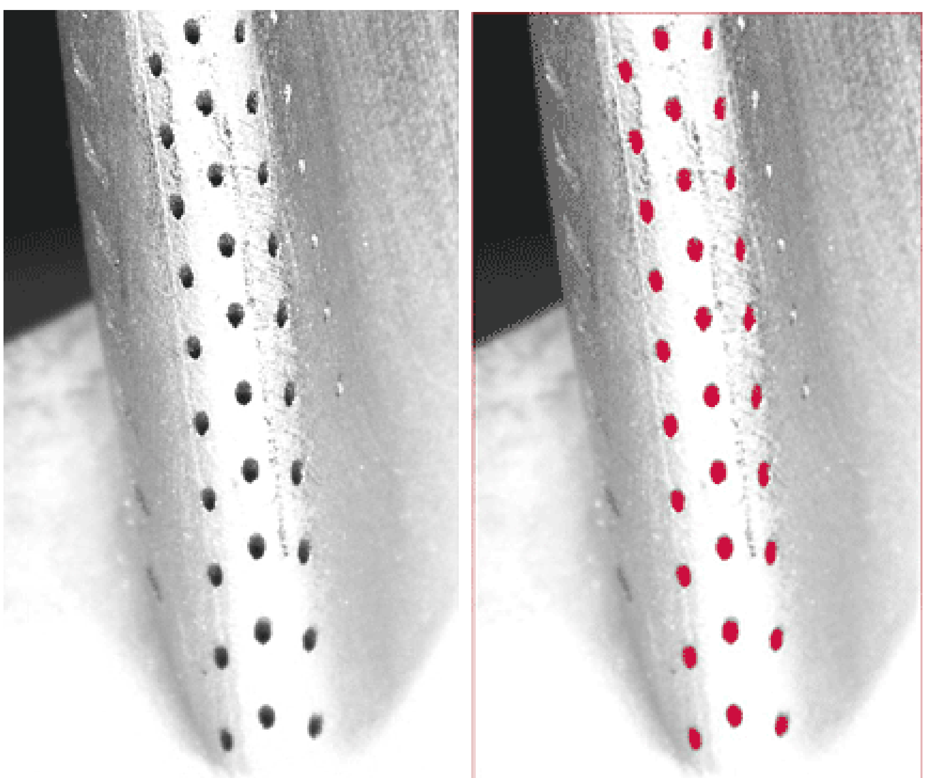
Programming the system is simple. The drill file—the same one used by the EDM drill, for example—can be used to program the system. The system is fitted with a chuck that allows parts to go directly from the EDM drilling machine to the inspection system without re-fixturing. Not only is this fast, but it also minimizes stack-up error. The system can be supplied with the same working envelope as most EDM drills, so, as the saying goes, "If you can drill it, we can check it!"

The system can output a wide range of results, including hole presence and hole offsets. It allows users to automatically create reports and collect measurements, statistics, images and other data for complete documentation. The system has built-in SPC as well as extensive data-exchange capabilities to send results to other applications. The hole offsets can also be used to modify EDM drilling program.

From the operator's point of view, the system is extremely easy to use: It has a straightforward interface and everything can be controlled via the barcode reader and joysticks. The system also has a fast and intuitive "operator review" mode to quickly revisit out-of-tolerance areas.

The software is intuitive and this provides the system with flexibility. It has an extensive set of measurement tools to carry out whatever dimension verifications might be required.

The 700 Series VisionGauge Digital Optical Comparator is a 5-axis inspection and measurement system that is ideal for parts with complex geometries such as aircraft engine turbine blade (shown in insert).


Left: Close-up of the cooling holes on the aircraft engine turbine blade.
Right: VisionGauge software reliably found and accurately measured and located the cooling holes.

About The Author

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Patrick Beauchemin is the president of VISIONx, a company that develops software and systems for visual inspection and high-accuracy measurement. There are more than 3,500 licenses of VISIONx's VisionGauge software in use worldwide. Beauchemin has published dozens of scientific and technical articles and is the holder of four patents.

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