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Feature

A Fresh Look at Borescopes

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From improved cameras to 'remote' repair capabilities, new advances in visual inspection capabilities are enabling technicians to see more and do more in their ongoing efforts to keep the engines on the wing and aircraft in the air.

It's hard to imagine, but it's been nearly 65-years since the first turbojet powered commercial aircraft entered service. What's even harder to believe are the tremendous technological advancements the various manufacturers' have made in those aircraft. The performance, economy and reliability found in today's jets were truly unimaginable in those early days.

Take the early Pratt & Whitney JT-series of engines for example: when the venerable JT8D was FAA certified in 1960, it had a TBO of a mere 800 hours. Compare that to today's engines that have 'on-condition' TBO numbers exceeding 3,000 hours and you'll see just how far technology has come.

Of course, along with technology, the tools technicians use to inspect and repair today's engines have come a long way too. One of those is the borescope: it has seen quite an evolution. In fact, today you actually have three varieties of borescopes to choose from: the standard rigid borescope, the flexible fiberscope and the newest member of the family, the multi-functional videoscope.

Rigid borescopes: this is the most traditional form of the technology. It's basically a rigid tube with a series of lenses inside that is used whenever you have straight-line access to a particular section of the airframe or engine. Typically rigid borescopes deliver exceptional optical clarity.

Fiberscopes: These are flexible instruments that can easily bend to travel deep inside the engine. Strands of fiber optic material transmit light to illuminate the area being inspected, while other strands are used to collect the images and carry them back to the viewing eyepiece.

Videoscopes: These are the latest advancement in remote visual inspection (RVI) technology. They are flexible like a fiberscope, but instead of using fiber optic strands to capture and relay the images, the videoscope has a small video camera at its end. The video camera gives the videoscope much better image quality, plus it provides the added benefit of digitally recording and storing the images.

A PVRS-2-4-1300-Articulating Flexible Videoscope from USA Borescope.

“While any scope can show you something inside an engine that you can’t see with a flashlight and mirror, each is better suited for a particular type of inspection,” explained Doug Kindred, president, Gradient Lens Corporation. “Today, fiberscopes are mostly used on the manufacturing side to inspect the insides of parts: especially if you have to get through really small openings.”

“On the aircraft inspection and maintenance side, videoscopes have taken over,” he said. “Why wouldn’t everybody want one? They deliver better image quality and you have the capability to capture images and video to document the inspection. Technicians can just do a better job.”

Kindred stated that thanks to their literal flexibility and the aforementioned video recording capabilities, the uses for videoscopes today has expanded beyond the engine and into airframe inspections.

“We have customers using our six-meter long scopes for looking at welds, rivets, and for inspecting wiring bundles, as well as looking for corrosion,”

he said. “While six-meters gets you well inside the airframe, the key benefit is still the ability to capture images and share them with other members of the maintenance team.”

“I was recently at a helicopter maintenance shop and we were looking inside a turbine engine,” Kindred added. “We saw something on the monitor that looked like the blade was cracked. After we reviewed the video again later on, we found that it wasn’t a crack at all. It was actually a tiny bit of debris.”

“By bing able to review the video again we went from having to tear down the engine, to having to do nothing at all,” he concluded. “That’s a huge difference to the operator. Don’t underestimate the value of being able to share and review the inspection video.”

Videoscopes: pushing forward picture quality

Obviously, when it comes to using any ‘scope’ the better the image the better the quality of the inspection. Borescope manufacturers across the board are constantly working to deliver the best overall image quality possible.

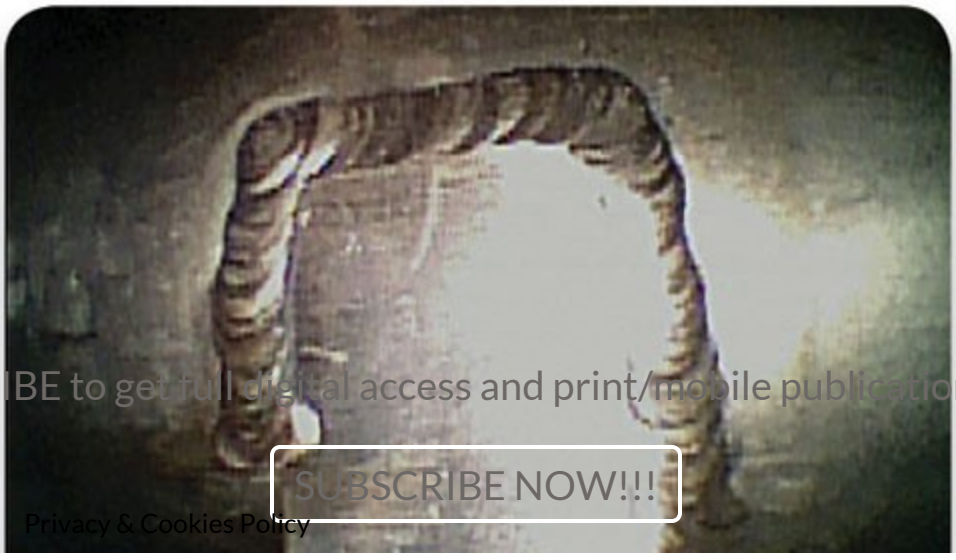
Olympus America recently took a big step forward with the introduction of their new IPLEX NX videoscope, what the company calls the ‘first HD quality’ industrial videoscope. As the company stated in the product’s announcement, introducing a new ultra-bright laser diode light system the IPLEX NX, “[will] help locate flaws that were previously undetectable and streamline inspections in even difficult to reach areas.”

“Since high-density CCD (charge-coupled device) camera chips are inherently light-hungry, we use Laser Diode (LD) technology to produce

unsurpassed brightness," stated Frank Lafleur, product manager, Remove Visual Inspection, Olympus America. "To do so, new diffusion methods with formed lenses are used to assure even distribution at the inspection site. Top it off with the new high-precision micro lens production and assembly methods, and it makes the basis of the HD RVI image."

"It (HD) is noticeable in every circumstance. The bare line resolution was increased by a grade or two on the USAF resolution chart [a resolution test pattern conforming to MIL-STD-150A standard, set by US Air Force in 1951]," he said. "What really makes it impressive is the range at which you can deliver the high-resolution image. The PulsarPic processor balances all settings and the result is an amazing image from up-close on highly-reflective surfaces to a couple of feet away from a dark surface."

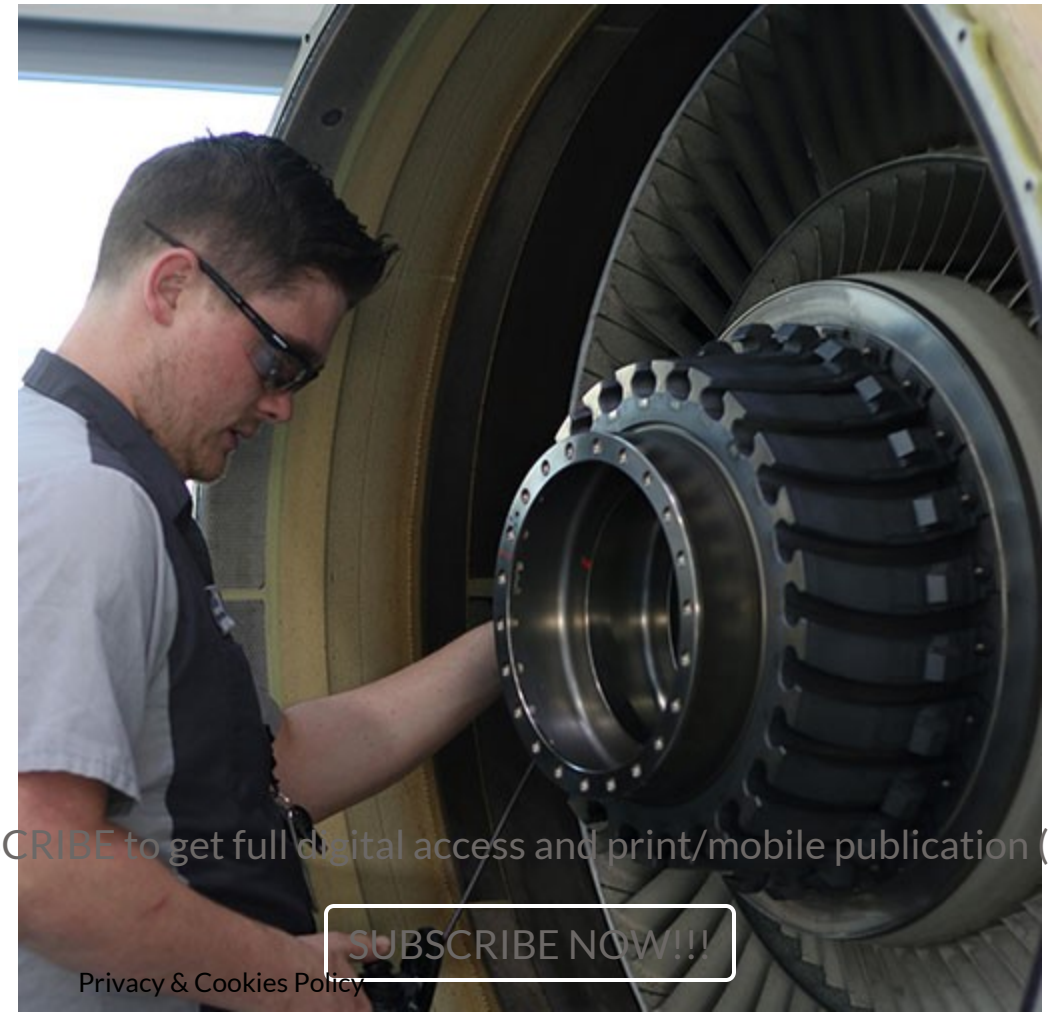
While CCD cameras have long been the standard for the videoscope industry, there is a bit of a shift going on. "The race is on to improve the lower-cost CMOS (complementary metal-oxide semiconductor) style image sensors," stated Shayne Gallo, Q.A. manager for USA Borescopes. "The major hurdles to overcome are providing enough illumination inside the inspection area, as well as getting proper color definition and clarity to perform suitable inspections."



Using a borescope to inspect the welds of the engine nacelle anti-ice system.
(Photo: Hawkeye videoscope.)

“Our latest articulating videoscope, the USAVS2-4-1500, introduces new features to provide improved color definition, clarity and brightness inside dark inspection areas,” he added. “This has proven to be especially popular among the engine shops performing inspections on PT6, Turbomecca and other smaller turbine engines.”

While the CCD vs CMOS debate continues, Gradient Lens is taking the “best tool for the job” approach and is now using both CCD and CMOS camera sensors on its flexible videoscope products.



“The CMOS camera sensors were originally developed for smartphones and because they are a mass consumer product, they cost a lot less than a CCD cameras,” Kindred explained. “Some operators may remember that years ago CMOS cameras were lower quality than CCD cameras, but the technology has made great strides. We use a 1.8mm camera in our 4mm and 6mm diameter borescopes today.”

“It’s really made these videoscopes cost-effective for smaller shops and FBOs to take advantage of the technology,” he said. “There are still a lot of these facilities using fiberscopes, which are okay, but don’t deliver near the image quality of a CMOS videoscope.”

“The better the image quality, the better job the technician can do during his inspection,” Kindred said.

“The damage they are looking for can often be quite small and very hard to see even for a technician who is very experienced.”

“If you play your cards right and do your homework you can get a videoscope with a CMOS camera that really approaches the quality of a scope with a CCD camera,” he said. “That will save you thousands of dollars.”

And speaking of shopping for a new "scope," Kindred cautioned that no matter what you're looking for you really do need to pay close attention to what you are buying, especially in the lower price points.

"The market has become very cluttered with a lot of new low-cost imports and it's hard for the typical maintenance guy to really know what's what," he said. "They all look similar in their marketing materials. My advice is to do your research and don't skimp on optical quality."

"Ask the manufacturer to give you a demonstration at your facility and do the inspections you routinely do," Kindred said. "We do this all the time. We sell very few scopes over the phone. Nothing beats a hands-on demonstration. If they won't give you one, move on to another brand."

Borescopes: The next generation

Borescopes, fiberscopes and videoscopes are really good at doing what each was intended to do. But, according to Jitu Patel, vice president of Machida, the new technological wave is to enable 'scopes' to do more than act as a passive observer.

"We work closely with engine manufacturers to develop tools to meet their specific needs," he said. "Since we make everything ourselves here in the United States, we can develop these specialized solutions to their needs. That's what we've been doing for 40-years."

Three new solutions that Patel described are Machida's working channel borescope, power blending borescope and its brand new videoscope that switches between ultraviolet and white light.

“Our working channel borescope has a separate hollow channel running the length of the shaft,” he said.

“You can run a variety of other tools including mechanical grabbers or even a vacuum line out through the channel to do a number of tasks inside the engine or airframe.”

“With the power blending borescope, if there is a nick or dent in a turbine blade, you can use the specialized tool to repair the damage per the engine manufacturer’s specifications,” Patel said. “Right now the blending borescope is approved for GE, Pratt & Whitney and Rolls-Royce engines.”

“To make the repairs easier for the technician, you can connect a portable viewer, which means the technician no longer has to look at the work directly through the scope’s ocular. The larger image allows him to better focus his efforts on the actual blending process,” he explained. “In addition, the blending process can be digitally recorded for sharing with other technicians or the engine manufacturer.”

Jennifer Kempsey, Machida’s marketing and operations manager added that the company is just now introducing a new borescope that will give technicians even more in-engine inspection capabilities.

“Our newest product is a 3mm video borescope that does both UV (ultraviolet) and white light inspections. It was developed specifically to enable more accurate dye penetrant inspections inside the engine,” she said. “You use the white light to navigate the tool inside the engine, then when you get to the area where the dye penetrant has been applied, you switch over to the UV light to do the inspection.”

Borescopes: critical inspections

Shawn Schmitz, an engine technical representative for Duncan Aviation said that borescopes have found a long list of uses throughout the MRO's various facilities.

"They allow us to perform inspections in areas in the engine and airframe where it is impossible to see with a flashlight and a mirror," he said. "For example, a lot of today's engines are 'on-condition,' which means at a given interval you can go in and do a borescope inspection to determine if the engine can stay on the aircraft or have to be removed for maintenance."

"The quality of the scopes today allow you to get crystal clear images, you can also shoot video of the internal components and take critical measurements to determine the severity of a problem," Schmitz stated. "The ability to take critical measurements is especially helpful."

Schmitz explained that engine manufacturers put specific limits on critical components including the rotating parts inside a jet engine. "Let's take a first-stage compressor for example: if we borescope it and find nicks or damage to the leading-edges of the blades, the engine's maintenance manual gives us criteria to base our maintenance decision on," he said. "If the manual says you can have a 15 thousandths deep nick on a first-stage blade, I now have a borescope with the technology to go in there and take a picture of that damage and measure the depth of that nick."

"I can then take that measurement and make a determination about the airworthiness of that blade," Schmitz said. "By enabling us to make a more informed decision, the borescope can save the operator a lot of time and money."

Schmitz said that while today's borescopes are very intuitive to use, Duncan Aviation's technicians all receive instruction from the engine's manufacturer when they attend the authorized factory training.

"We also buy borescopes from a variety of vendors and we always ask them to come in and show us how to correctly use and care for the equipment," he said. "That's critical. These tools can cost $30,000, so you want to make sure you're doing it correctly."

In addition, to help the technicians stay sharp, Schmitz said that they have made little wooden shadowboxes that house a scrap compressor blade. These imaginative 'simulators' were created to allow Duncan Aviation's technicians to practice on using the borescope in confined areas.

"They can go in and find the nick, take a picture and measure it," he said. "It's proven to be a great way to stay proficient with the tool. Then when you actually work inside the engine you know what you are doing."

Common borescope mistakes

Even with training, technicians still make mistakes when using a borescope. According to Patel one of the most common is simply not reading and understanding the instruction manual.

"The technician needs to do this with every borescope they use," he pointed out. "It just takes a few minutes and it tells them clearly what they can and cannot do with each piece of equipment."

"The next mistake is letting go of the borescope when it's inside the engine. It will just slide right out and hit the floor, which usually breaks the

camera," Patel said. "We say 'one-hand' operation and that means keeping one hand on the borescope at all times."

"Another problem is trying to use a borescope in an engine that's too hot," Kempsey said. "All of our borescopes work at 150°F and below. Anything above that temperature will damage the internal components of the borescope. They all have some kind of epoxy or glue around the lenses and those temperatures will melt that glue allowing the lenses to shift."

Lastly both Patel and Kindred stressed the need to "use the right tool for the right job." All too often technicians will try to force a 4mm borescope shaft through a 3.5mm opening. That can not only damage the borescope, but also quite possibly the inside of the engine.

No technician wants to be the one to go to their boss and say that the company has to remove and dismantle an engine because they damaged it with a borescope."

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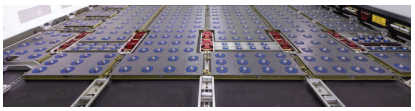

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