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Borescope Technologies Fit Every Need

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Borescopes, the tools that are used to assess the health of everything from engines to airframes, are a mainstay of the aviation industry, from the original equipment manufacturers to the MROs, to the smaller repair stations and FBOs. The technology can yield an almost immediate return on investment if it allows a facility to avoid unnecessary downtime for valuable assets or prevents an accident. The market is mature and highly competitive. The technology moves quickly, tracking advances in areas such as optics and microelectronics.

Aviation is a prime consumer of these remote inspection products. But oil & gas, power production, pharmaceuticals – any industries that use machinery with piping and internal cavities – invest in the technology and drive its advances. There's also a wide range of capability. At the high end there are scopes that not only let technicians view

the turbines of pricey commercial jets but let them measure identified defects to thousandths of an inch.

Mid-tier scopes provide fewer bells and whistles but offer much the same basic remote visual inspection capability. They tend to be used in general aviation and business aviation by smaller aviation maintenance and repair facilities. The equipment is used for inspecting items such as engines – especially the PT6 – wing spars, and landing gear assemblies, says Frank Menza, owner and president of Titan Tool Supply, a distributor that has been in business since 1952.

At the low end are inexpensive and basically disposable products that might be used for very simple tasks but that are not really intended for aviation.

Mid-Market Dynamics

From the low end to the high-end prices range from less than $100 to more than $40,000. Customers sometimes employ a combination of high-end and mid-tier scopes to meet different needs. “A lot of aviation maintenance and repair facilities don’t need a $30,000 to $40,000 scope,” Menza says. Titan sells video scopes in the $3,995 to $10,000-$12,000 range, competing in quality, availability, and delivery times. The company offers a combination of video scopes, fiber scopes, and rigid scopes across all of the borescope markets.

Gradient Lens Corp. also competes on price as well as quality and believes in keeping its products simple. “We make a Ford or a Chevy, not a Mercedes,” says Doug Kindred, Gradient’s president and chief scientist. Ninety percent of customers don’t need all the bells and whistles of high-end scopes, he adds. Gradient’s prices start at about $9,000 and go up to about $14,000. In the aviation market the company targets smaller and medium-sized FBOs. Its equipment is used on “a lot of helicopters.” The company’s new Hawkeye V2 video scope includes features such as 5x to 10x magnification – depending on the tip – and 2x digital zoom, plus a 60-degree standard tip. There are two optional tips – a 90-degree tip and a close focus tip with a 60 degree field.

RF System Lab goes another step, offering a free demo program for its VJ-Advance video borescope, including free shipping to the user. Potential customers can try it out for two to four weeks, and if they like it they can buy the demo unit at a discount with the same warranty and customer service as a new unit, explains Duncan White, director of sales and marketing. The company also boasts a free loaner program for customers whose RF System Lab scopes are undergoing repair. This program is available for duration of ownership, he says.

White also asserts the “lowest repair cost for insertion tube replacement.” All told, RF System Lab’s relatively low initial pricing – from $9,000 to $15,000 – low repair pricing, and free loaners are advantages that add up over time, he says.

The 23-ounce borescope offers four-way, mechanical articulation. A sun visor also can be fit over the screen for outdoor use. The 3.9mm probe – it is also available 2.8mm and 6.9mm diameters – is popular in aviation, he says, especially for the PT6 engine. The VJ-Advance also has very short distal tips, White says, making it easier to get around bends. The 6.9mm tip is 15mm long, the 3.9mm tip is 13mm long, and the 2.8mm tip is 12mm long.

Borescopes R Us, both a designer and a distributor of borescopes, touts the PV4 as the top of the line among its own designs. (The company also distributes for KARL STORZ and IT Concepts.) The PV4 video scope starts at about $7,995 for the “base” unit with a 4mm probe. But the PV4 is versatile in its ability to accept and display inputs from 4mm, 6mm and 8mm probes on the same integrated 4.5-inch screen. This cost-saving interchangeable probe feature, for example, would be convenient for an FBO that works on several types of engines.

The LED-lighted PV4 offers four-way articulation, but the monitor also can rotate 360 degrees, a plus for user comfort. Borescopes R Us also says it repairs borescopes from Everest, Wise Digital, Olympus, and GE.

Move to Video

The aviation industry is moving to video scopes, the latest generation of borescopes, in part because they can provide higher resolution than older-generation fiber scopes. The integrated-display equipment has improved in quality and come down in price over the years, so that it is becoming more prevalent for engine inspection.

Another advantage of video scopes, which process signals digitally, is the ability to make and store images/video without additional accessories, explains Rich Crandall, director, group business development, for KARL STORZ Industrial Group America. Video scopes also can provide features such as annotation, time and date stamping, and labeling of the area being inspected. The video also can be enhanced when the digital signal is converted back into an image on the monitor, Crandall says.

Adjustments, such as brightness control, defect edge enhancement, noise reduction, and automatic white balance, can be made, he adds. High-end models from GE,

Olympus, and KARL STORZ also can provide remote measurement of defects (see sidebar).

Video camera chips also are getting smaller. Machida, for example, asserts that its VSC-2.4-100N video borescope – with two-way articulation – uses the “smallest high-resolution CCD [charge-coupled device] camera chip” on the market, according to Jitu Patel, vice president.

Video scopes are widely used in areas other than propulsion. KARL STORZ cites examples such as blind fastener inspection, rivet checks, guided assembly in blind areas, fuel tank corrosion inspection, hydraulic union leak check, hydraulic reservoir internal inspection, hydraulic pump internal inspection, and overall structural inspection. Moreover, the increasing use of composite materials in aircraft construction means that the inspection requirements for airframe and airframe components will only increase, Crandall predicts.

An aircraft’s “soil pipe system” is another candidate for remote video inspection, Crandall notes, as this area tends to be a hot spot for corrosion. Rather than removing an entire soil pipe system from an airframe for inspection, several companies are using KARL STORZ pipe inspection solutions to check the integrity and condition of the system, avoiding unnecessary removal of this system and the associated costs, he adds.

Illumination

Illumination is key to the remote inspection of otherwise inaccessible areas. Borescopes that use LED lighting place the devices at the base or the tip. Larger, higher-power LEDs can be used in the base and the light can be passed through optical fiber to the tip. Gradient’s Hawkeye V2 video borescope places a detachable LED at the handle, which keeps the tip cool and allows for the use of other light sources, Kindred says.

RF System Lab, on the other hand, places LEDs in the tip of its VJ-Advance video scopes. The LEDs on the 2.8mm and 3.9mm scopes flash at the same refresh rate as the camera, White says. You never see the strobe effect on the screen, but it reduces the heat. The product is powered by AA batteries, which last “a couple hours” or rechargeable AA batteries, which are good for 4 hours, he says.

Olympus’s IPLEX NX uses a laser diode-based light source, which focuses the light very intensely, notes Frank Lafleur, product manager for Olympus. “In our case the

diode used could have a different set of substrates in order to help achieve its coherence, but also our angle of dispersion is much more narrow [than that of an LED] and thereby translates to a more efficient transmission to the target," he says.

Talking about light, Machida points to its 3mm UV video scope. "This newest addition to our product line," the VSC-3-100UV, "allows for the ability to switch from white light to UV from the handle to view small cracks in the blades," Patel says. When the product is paired with the company's 3mm VSC-3-100C "channel" scope, "you can apply the die penetrant without spraying, switch the probes out, return back to the area, switch to UV, and view any small cracks," he adds.

Connectivity

There is also a demand for networked borescope equipment. This may be driven in part by the aging inspector work force. But other factors are efficiency, cost savings, and convenience. If a remotely located OEM engineer can look over the shoulder of a maintenance technician and see exactly what the technician is seeing – video or stills of an engine inspection or defect — in real or near real time, they can compare notes and make a decision more quickly than if the engineer had to travel to the technician's location.

The possibilities for borescope connectivity extend to cloud data storage, Crandall says. This potentially could allow full, unhindered access to all historical and current data" associated with an engine.

"For example," he says, "the engineer could use the cloud to import the images from the last inspection, isolate the image of the defect and compare it side by side in real time to ascertain propagation." Cloud data storage also would "limit the risk of data loss (through non transfer) and could simply be done during the inspection in the background without the engineer even being aware of the process."

Some products offer the ability to share stills or videos from an inspection via the Internet either while the examination is proceeding or shortly afterward. This can be achieved either directly from the unit or by linking the unit to a computer and then sharing the information via conferencing software. Or the user can save the sensor data on a memory card via a built-in slot and then download the data to a computer for emailing.

GE Inspection Technologies, which offers video sharing direct from the borescope

device, cites the aging workforce as a driver behind this trend. The declining number of inspectors means that these experts might not have the time for a site visit. The company's Mentor Visual iQ borescope, for example, would let a less experienced inspector stream live video from the device via WiFi/Bluetooth and the Internet to a more experienced colleague in order to make the best decision. GE, to its knowledge, is unique in its ability to provide live streaming directly from the device, according to Tom Ward, senior product manager for visual inspection.

Olympus's IPLEX NX product, on the other hand, enables multiple experts to monitor remote procedures at the same time by using an SD card equipped with commercially available wireless LAN, enhancing analysis speed and inspection accuracy.

RF System Lab's VJ-Advance product can be tethered to a laptop via USB cable and provide live imaging like a Webcam, White explains. Colleagues logging into GoToMeeting software, for example, can see the inspection as it's taking place. Or the user can save video and stills to an SD card for viewing or emailing.

Ultimately, the addition of connectivity and metadata to the remote visual inspection sector can only serve to reduce the pressure on end users/operators, provide enhanced data acquisition methods, improve data analysis and decision-making, and open all industries to the possibility of big data, Crandall says. This is the key direction of development for the remote visual inspection sector, he predicts. But for connectivity to become mainstream, designers will have to miniaturize the technology for use in lightweight, battery-powered units while ensuring a stable, secure wireless connection in a wide variety of environments, a "difficult task," he says.

Articulation

Since probes have to navigate around curves inside an engine, the probe tip has to be maneuverable via mechanical or electronic control. The technician uses a joystick, lever, or other type of control to pull on wires that extend from the handheld unit to the tip in order to move it up or down, right or left. Clearly the control has to be precise and responsive with as little latency as possible. A great deal of thought goes into the design of the control system, from the vertebrae built into the tip, to the feedback provided to the operator.

Some manufacturers rely on direct, mechanical control of the distal tip, while others have introduced servo-based control, which may move the tip with greater force. Historically, servo-based control has been plagued by either lagging or overshooting, which requires continual operator adjustments and takes up valuable time, Lafleur says.

Olympus is confident enough in its new servo-driven control system that it permits potential customers to road test the product by tying the insertion probe in a knot to demonstrate how well its “low stress construction” and articulation system will hold up to the toughest curves. Lafleur says the IPLEX NX typically performs at 85 to 95 percent of its specification under these circumstances.

Titan’s TVT video scope, a 2.8mm, two-way-articulated unit, comes in a servo motor-driven model, with the ability to lock the articulation angle when you release pressure on the joystick. That’s also one of the smallest diameters available for a video scope, Menza says. The TVT series comes in five different models with three diameter sizes and three lengths. The 4.5mm and 6mm scopes are four-way articulated. All are illuminated via tip-mounted LEDs with five-step intensity control.