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Quality in Assembly: Fiber-Optic Profilometer Measures Surface Quality

by John Sprovieri

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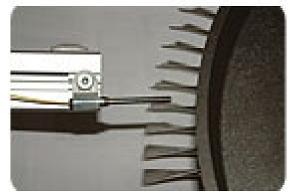
In the past, the compressor rotor for a jet engine was usually an assembly: Fan blades were attached to the disk with fasteners. Today, the rotor is apt to be a single part, the disk and blades machined from a solid piece of metal. Known as a "blisk," an integrally bladed rotor is lighter, stronger and more aerodynamic than an assembly.



A fiber-optic profilometer inspects the blades of a blisk. Photo courtesy Novacam Technologies Inc.

On the other hand, blisks are more expensive to repair. If a blade is damaged, the entire part must be replaced. As a result, blisks get an erosion-resistant coating so the blades last as long as possible. Though measured in microns, the thickness of this coating is critical to its effectiveness.

To measure the thickness of such coatings and perform other surface inspection tasks, Novacam Technologies Inc. (www.novacam.com, Pointe-Claire, Quebec) has introduced a unique, noncontact, fiber-optic profilometer. The instrument obtains high-resolution 3D images of a surface through a technique called low coherence interferometry.

According to Vuk Bartulovic, president of Novacam, the technology works like this: Broadband light from a superluminescent diode is split into two beams. One is focused on the part; the other is focused onto a flat reference surface. Light beams reflected from the part and the reference are then recombined and projected onto a sensor, where they create an interference pattern. Changes in the brightness or shape of this pattern correspond to differences in how far light travels from the part compared with the reference. If light from the part travels farther than light from the reference, there must be a depression on the part's surface. Since the distance from the reference is constant, algorithms can determine—with micron precision—how deep that depression is. By stitching together thousands of point measurements, the instrument can create a map of microscopic peaks and valleys on the part's surface.

Light from the diode is emitted and collected by a fiber-optic probe, which can be as thin as 1 millimeter in diameter. The probe can be positioned a few millimeters from the part or as far away as 1 meter. The instrument itself can be several meters away from the probe. The instrument has an axial resolution of less than 1 micron and lateral resolution of 8 to 75 microns, depending on the probe.

The probe can be mounted to a multiaxis scanning mechanism customized for the application. Alternatively, it can be mounted inside a machining center to measure grooves in a part as soon as they are made. The probe can also be mounted above a continuously moving web or adjacent to a rotating part, such as a commutator. With optical switching, multiple probes can measure several features of a part at once.

Because the instrument measures one point at a time, a complete inspection can take time. Even at a sample rate of 2,000 points per second, an inspection that requires 100,000 points will take 50 seconds, excluding time for acceleration and deceleration.

The profilometer can inspect parts that are difficult to examine with other techniques. For example, it can inspect long, narrow apertures, such as gun barrels, diesel fuel injectors and ink-jet nozzles.

For blisks, the profilometer can look at more than just coating thicknesses. It can inspect the leading and trailing edges of the blades, check their bow and contours, and measure tip clearance. The instrument can also obtain high-aspect ratio images of cooling holes in the blades. From these images, the size and incident angle of the holes can be determined. Other aerospace applications include measuring fiber layers in composite structures and inspecting rivet holes and heads.

In electronics, the profilometer can inspect packages for ball position, ball height, missing balls, warpage, lead coplanarity and the depth of laser etching. In the metals industry, it’s used to inspect the surfaces of high-integrity castings for defects that could promote corrosion or thermal failure. Plastics manufacturers use the device to determine the rheological properties of materials.

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