

characteristics, this type of film would be ideal; however, at the time of this reporting, no such film has been known. Machined components (with known fractional thicknesses) of a like material (similar density) to that of the material to be measured are necessary.

The machined components should have machined through-holes. For ease of use and better accuracy, the through-holes should be a size larger than 0.125 in. (≈ 3 mm). Standard components for this use are known as penetrameters or image quality indicators. Also needed is standard x-ray equipment, if film is used in place of digital equipment, or x-ray digitization equipment with proven conversion properties. Typical x-ray digitiza-

tion equipment is commonly used in the medical industry, and creates digital images of x-rays in DICOM format. It is recommended to scan the image in a 16-bit format. However, 12-bit and 8-bit resolutions are acceptable. Finally, x-ray analysis software that allows accurate digital image density calculations, such as Image-J freeware, is needed.

The actual procedure requires the test article to be placed on the raw x-ray, ensuring the region of interest is aligned for perpendicular x-ray exposure capture. One or multiple machined components of like material/density with known thicknesses are placed atop the part (preferably in a region of nominal and non-varying thick-

ness) such that exposure of the combined part and machined component lay-up is captured on the x-ray. Depending on the accuracy required, the machined component's thickness must be carefully chosen. Similarly, depending on the accuracy required, the lay-up must be exposed such that the regions of the x-ray to be analyzed have a density range between 1 and 4.5. After the exposure, the image is digitized, and the digital image can then be analyzed using the image analysis software.

This work was done by David Grau of Kennedy Space Center. Further information is contained in a TSP (see page 1). KSC-13206

Fuel Cell/Electrochemical Cell Voltage Monitor

Lyndon B. Johnson Space Center, Houston, Texas

A concept has been developed for a new fuel cell individual-cell-voltage monitor that can be directly connected to a multi-cell fuel cell stack for direct sub-stack power provisioning. It can also provide voltage isolation for applications in high-voltage fuel cell stacks. The technology consists of basic modules, each with an 8- to 16-cell input electrical measurement connection port. For each basic module, a power input connection would be provided for direct connection to a sub-stack of fuel cells in series within the larger stack. This power connection would allow for module power to be available in the range of 9-15 volts DC.

The relatively low voltage differences that the module would encounter from the input electrical measurement connection port, coupled with the fact that the module's operating power is supplied by the same substack voltage input (and so will be at similar voltage), provides for elimination of high-common-mode voltage issues within each module. Within each module, there would be options for analog-to-digital conversion and data transfer schemes.

Each module would also include a data-output/communication port. Each of these ports would be required to be either non-electrical (e.g., optically iso-

lated) or electrically isolated. This is necessary to account for the fact that the plurality of modules attached to the stack will normally be at a range of voltages approaching the full range of the fuel cell stack operating voltages. A communications/data bus could interface with the several basic modules. Options have been identified for command inputs from the spacecraft vehicle controller, and for output-status/data feeds to the vehicle.

This work was done by Arturo Vasquez of Johnson Space Center. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809. MSC-24592-1

Anomaly Detection Techniques With Real Test Data From a Spinning Turbine Engine-Like Rotor

These techniques are suitable for engine manufacturers and industries in aerospace and aviation.

John H. Glenn Research Center, Cleveland, Ohio

Online detection techniques to monitor the health of rotating engine components are becoming increasingly attractive to aircraft engine manufacturers in order to increase safety of operation and lower maintenance costs. Health monitoring remains a challenge to easily implement, especially in the presence of scattered loading conditions, crack size, component

geometry, and materials properties. The current trend, however, is to utilize non-invasive types of health monitoring or nondestructive techniques to detect hidden flaws and mini-cracks before any catastrophic event occurs. These techniques go further to evaluate material discontinuities and other anomalies that have grown to the level of critical defects that can lead to failure. Gener-

ally, health monitoring is highly dependent on sensor systems capable of performing in various engine environmental conditions and able to transmit a signal upon a predetermined crack length, while acting in a neutral form upon the overall performance of the engine system.

Spin simulation tests were conducted on a turbine engine-like rotor with and