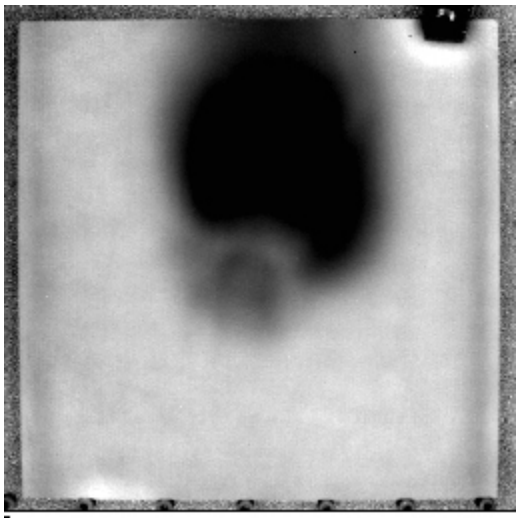
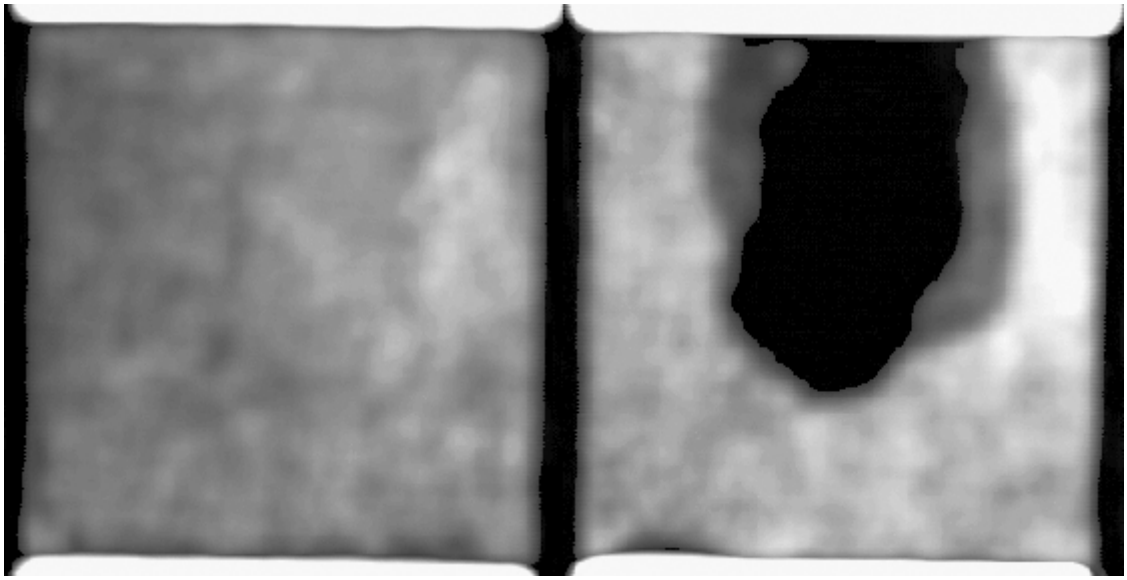
Nondestructive Evaluation Tests Performed on Space Shuttle Leading-Edge Materials Subjected to Impact

In support of the space shuttle Return To Flight efforts at the NASA Glenn Research Center, a series of nondestructive evaluation (NDE) tests were performed on reinforced carbon/carbon (RCC) composite panels subjected to ballistic foam impact. The impact tests were conducted to refine and verify analytical models of an external tank foam strike on the space shuttle leading edge. The NDE tests were conducted to quantify the size and location of the resulting damage zone as well as to identify hidden damage.



Thermography image of reinforced carbon-carbon panel after impact. Dark region indicates extent of subsurface damage.

Two primary NDE methods were employed in this effort, pulsed thermography and ultrasonic C-scan. In pulsed thermography, the material under inspection is excited with a short pulse of heat from high-intensity flash lamps. A series of thermal images is then captured over a period of time. Defect regions are seen as nonuniform surface temperatures, or hot spots, in the images (see the preceding figure). Advanced processing techniques are used to improve detection capability and image contrast. Ultrasonic C-scan uses a short ultrasonic pulse introduced into a material to identify defect regions. As the ultrasonic wave passes through the material, defects scatter and reflect the wave. This creates lower amplitude signals as measured by a receiving transducer, which are seen as a dark area in the resulting image (see the following figure).



Before (left) and after (right) ultrasonic C-scan images of impacted reinforced carbon-carbon panel. Darker region indicates reduction or loss of ultrasonic signal due to damage.

This approach was successful in identifying and characterizing damage from foam striking the RCC materials directly and at a 45° angle. The two complementary NDE methods were able to confirm the damage identification and location. Further tests are planned to address damage due to ice and other objects. The NDE research was performed by personnel from Glenn's Optical Instrumentation and NDE branch and Cleveland State University and is supported by the space shuttle Return To Flight program.

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