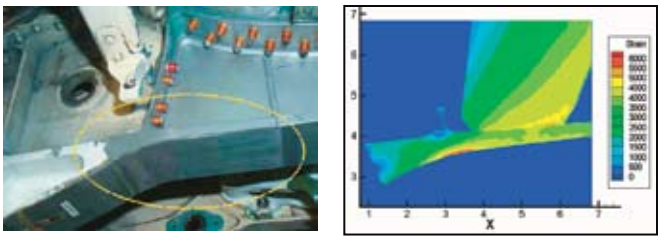
Experimental Stress Analysis

Experimental stress analysis is an important complement to the computational techniques used in structural testing at the NRC Institute for Aerospace Research (NRC Aerospace). Its researchers have access to a variety of techniques to directly measure deformation and strain in structures under load. These techniques include strain gauges, automated photoelasticity, digital image correlation, pressure sensitive film, shadow moire, and fringe projection. Strain measurement boundaries are also being pushed through improvements to techniques such as photoelasticity and pressure film.

Strain gauges
NRC Aerospace has extensive experience in applying these primary methods of local strain measurement, which are used in static as well as fatigue tests on metallic and composite materials. Hundreds of gauges as well as dedicated multi-channel data acquisition systems are used in current large-scale structures tests. NRC Aerospace researchers also have experience with high-temperature applications as well as non-standard strain gauge installations.

Automated photoelasticity
Photoelastic analysis is an extremely effective method for obtaining full-field strain measurements. The general procedure for photoelastic analysis involves bonding a thin plastic coating onto the structure, shining polarized light into the plastic, and then analyzing the resultant images. NRC Aerospace has developed custom hardware and software that uses a computer and a digital camera linked to rotationally motorized waveplates to calculate the principal strain differences and directions.



Photoelastic analysis on the bulkhead of a CF-18

Digital image correlation
Digital image correlation is a purely optical technique that can measure strain and out-of-plane displacements by tracking the movement of a random speckle pattern applied to a surface under test. The simple coating requirements for image correlation make it highly suitable for measuring strain on thin test specimens or on specimens subjected to extremely high strains that would debond or damage photoelastic coatings or strain gauges. NRC has experience applying this technique in unique situations ranging from full-scale test structures to miniaturized components.

Shadow moire/fringe projection
Shadow moiré is an optical technique that allows for measurement of out-of-plane displacements. A collimated light source is projected through a glass plate with lines etched on it. The shadows of these lines are projected onto the structure. When the structure is placed under load, any out-of-plane displacements cause interference fringes to form. These interference fringes can be calibrated to register the amount of out-of-plane displacement. NRC has custom hardware to produce the fringe patterns for subsequent analysis.

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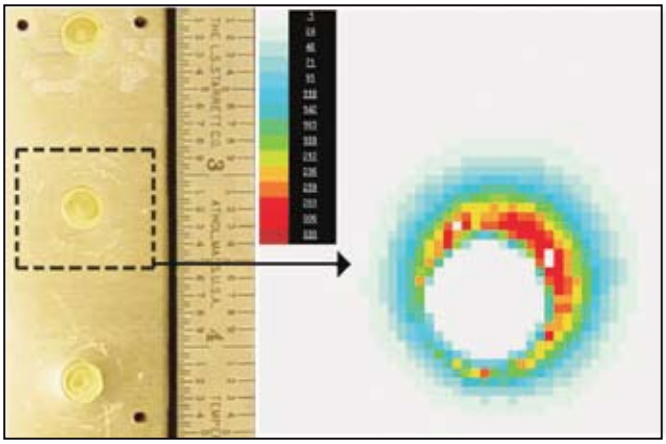
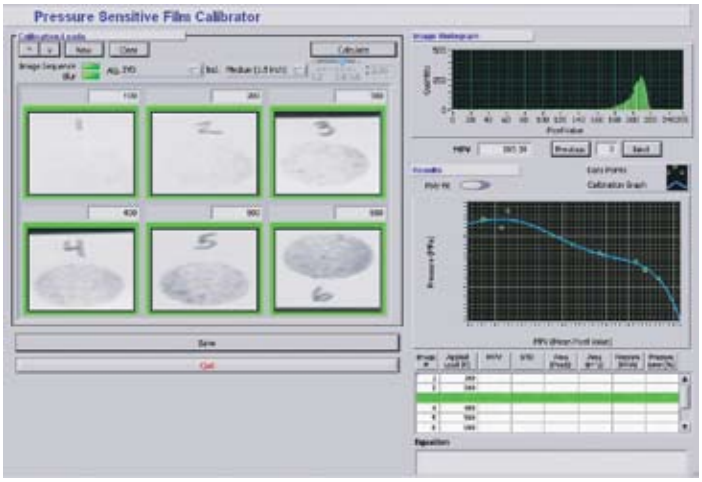
Pressure sensitive film

Researchers at NRC Aerospace have done a significant amount of work to increase the capabilities of pressure sensitive film, a commercially available product used to measure contact pressure. Pressure sensitive film is a thin polymer film coated with microscopic ink bubbles that are designed to burst at defined pressure ranges. The intensity of the red ink stain can then be directly correlated to the applied pressure.

In order to use this film in a more quantitative fashion, NRC Aerospace researchers have developed calibration hardware that allows stains at known pressures to be produced making it possible to generate calibration curves that correlate applied pressure to stain intensity.



Riveted lap joint (left) and composite pressure stain from the main rivet (right)



Pressure film software calibration module

NRC Aerospace researchers also developed software that allows several grades of pressure film to be stacked together then combined electronically to form a composite image spanning multiple pressure ranges. This pressure film analysis program can digitally combine and stack up to six film grades so that a full-range pressure analysis can be performed. Its multiple modules allow users to perform tasks such as:

- film calibration
- film analysis and alignment of multiple film stacks
- line profiles of analyzed film stains, and
- three-dimensional maps of contact pressure.

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