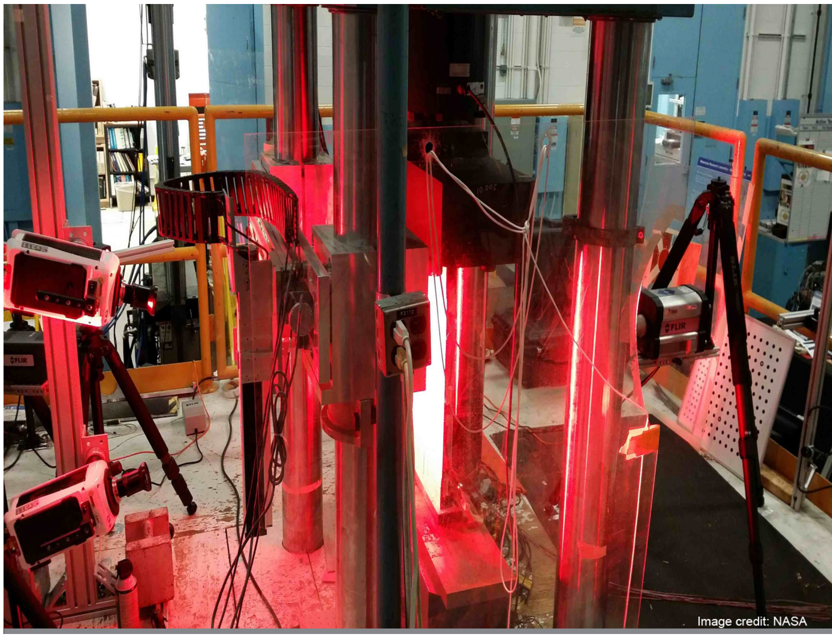


Image credit: NASA

National Aeronautics and
Space Administration

TECHNOLOGY SOLUTION

Sensors

Large Area Structural Damage Nondestructive Evaluation

System and method for wide Area in-situ measurement of progressive damage and determination of failure in a structure during loading

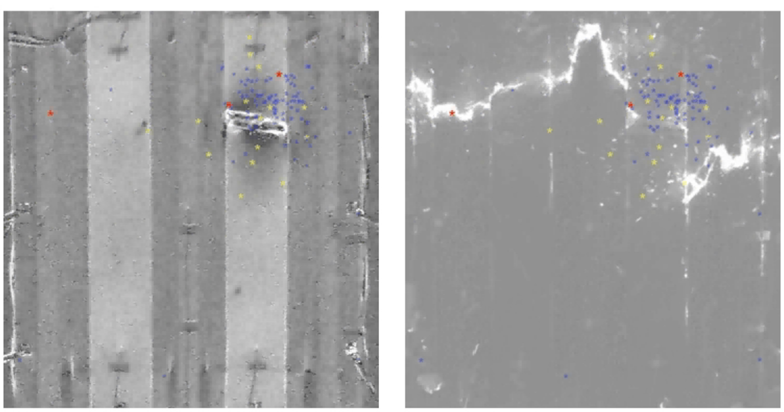
When testing composite structures, it is important to understand the response of the structure to the load. Of significance is the formation of damage and growth of that damage leading to ultimate failure. Understanding how a structure fails allows for optimal designs for improved safety and performance for the part during its life cycle. Inspection methods are required to determine damage initiation and growth in advanced composite structures during loading. Past methods for in-situ inspection of composite structures during loading have involved acoustic emission, passive thermography, digital image correlation, and fiber optics techniques. However, each of these has critical limitations. The combination of thermal and acoustic emission (AE) nondestructive evaluation (NDE) techniques, by mapping the acoustic emission events onto the thermal imagery, provides a very sensitive measurement system for detecting damage formation and growth.

BENEFITS

- A very sensitive measurement system for detecting damage formation and growth in real time
- Synchronizes both acoustic emission and thermal to loading to improve how to process and interpret AE and thermography indications
- Maps the AE over the thermography image to locate areas with heating with the clustered AE events that reveal where the structure will fail and ignore false indications
- Tracks multiple damage sites and correlate the AE event with the associated thermal signature

THE TECHNOLOGY

This technology provides a methodology to measure damage onset and grow at multiple locations in a composite structure during fatigue loading. The thermography inspection is non-contact and can cover very large areas. The acoustic emission sensors require contact at only the sensor attachment points and can cover large areas. The acoustic emission measurement is very sensitive to damage formation events such as matrix cracking, fiber breaks, and delamination, however the event location is approximate. An infrared camera is able to detect damage growth and location at areas of heating (due to fiber breaks, rubbing of disbond areas and matrix cracks) and thus confirm the acoustic emission measurements. If the loading is cyclic the infrared camera is also able to detect the relative depth of the damage. Combining both technologies helps to reduce false indications, confirm damage growth areas and where ultimate failure will occur. This provides a measurement capability to detect growing damage (location and size) for improved structures testing or during in-service applications. Multiple infrared (IR) cameras and multiple acoustic emission sensors can be employed internally or externally for full coverage of the structure. When significant damage growth is detected, the structure can be taken out of service for repair or for further inspections. This technology has been demonstrated for structures testing. In-situ NDE inspections are necessary to provide structural engineers a tool to incrementally control and document damage growth as a function of fatigue cycles before failure. This allows for the comparison of NDE results to develop and validate progressive damage analysis (PDA) models. The ultimate goal is to use the validated PDA models to decrease the time required to certify composite structures and therefore save development costs. Real time NDE can document the progression of damage and provide the documentation of ultimate failure mechanisms.



Mapping the acoustic emission onto the thermography imagery confirms damage growth areas and determines where ultimate failure will occur. Image credit: NASA

APPLICATIONS

The technology has several potential applications:

- Advances the state of the art in materials testing by providing a real time and large area inspection capability for determining damage onset and growth in a structure under load testing
- Tracks damage to determine the ultimate failure progression of complex structures such as advanced composites
- Helps the aerospace industry to design, build and test complex advanced composite structures

PUBLICATIONS

Patent No: 10,605,783

More Information

National Aeronautics and Space Administration

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