Shearography Solution

for NDT Quality Control and Inspection of in-service Fighter Aircrafts

Shearography supports aircraft design and production phase

Fighter aircraft are designed to perform quick maneuvers to get into position to evade incoming threats (like enemy aircraft, missiles, etc.). Important factors that affect maneuverability are thrust to weight ratio, wing loading and control surfaces.

All these factors together drive the use of specifically designed lightweight composite components for major parts of the aircraft. Especially maneuver driving parts such as rudders, elevators and stabilizers. The parts must withstand extreme force and momentum changes; therefore, intensive tests on the developed parts are tremendously important. Shearography is a proven technology that helps material designers to validate their assumptions and avoid expensive design flaws in later development stages.

Aircraft maintenance: Find impacts, cracks and disbonds

Harsh flight mission conditions require frequent reliable and fast maintenance cycles for the fighter aircraft. For this reason, Shearography is a preferred solution. It allows component inspections in the range of 2m² to be performed in less than a minute. Typical, unavoidable defects caused during aircraft operations are impacts or BVID's, cracks and disbonds.

Shearography Measurement Principle

Shearography is an optical, NDT technique that provides fast and accurate indications about internal material discontinuities or anomalies in non-homogenous materials.

Using laser light, a shearing interferometer is able to detect extremely small (sub-µm) changes in surface out-of-plane deformation. When a test object is subjected to an appropriate load, a proportional strain is induced on the test surface. If underlying discontinuities are present, the surface will deform unevenly at these locations. This is then interpreted through the shearing interferometer as a change in the phase of the laser light.

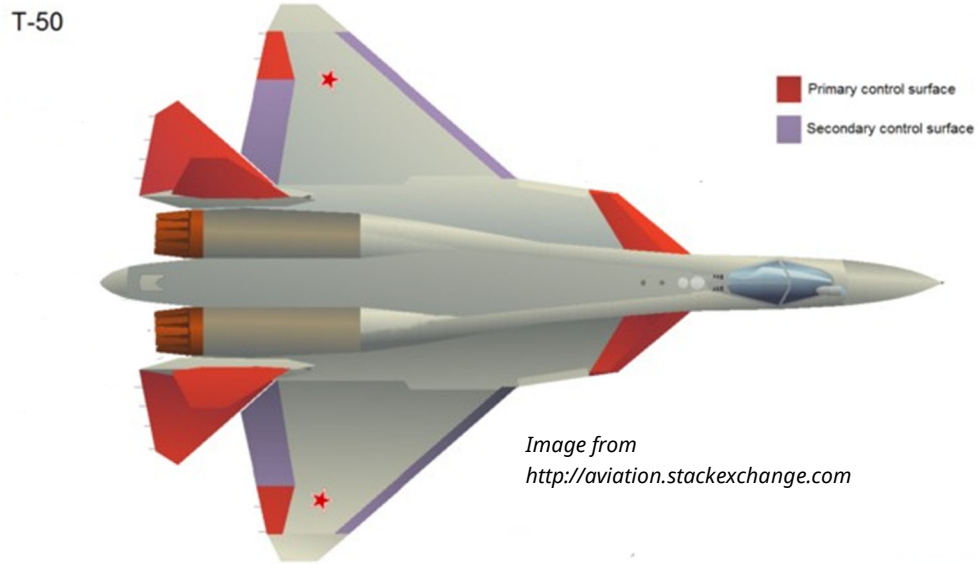
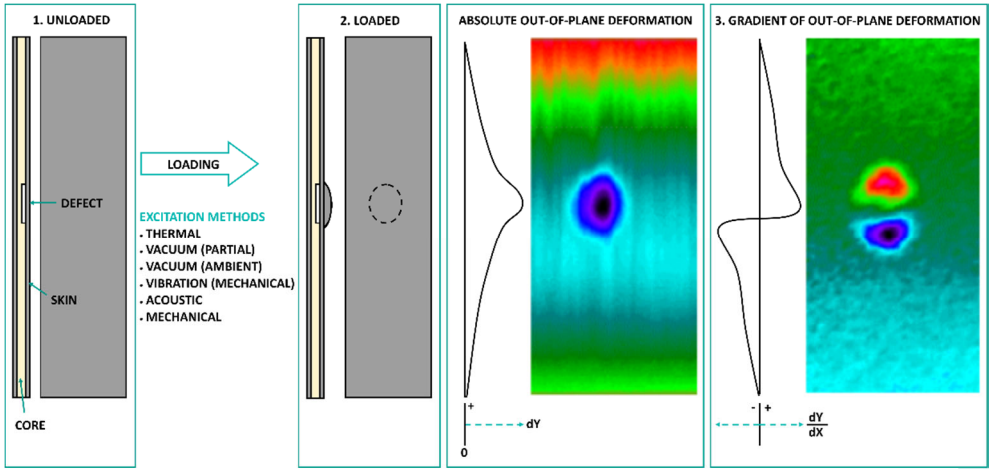


Image from http://aviation.stackexchange.com

During the production process various NDT quality control techniques are used. Shearography is one of the most effective method for finding defects in composite materials with a very high probability of detection rates. This assures aerospace manufacturers of enhanced quality results, beyond the capabilities of conventional NDT methods.

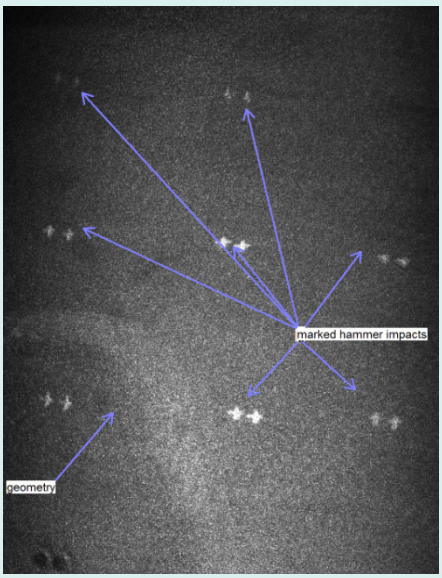


Shearography Measurement Principle

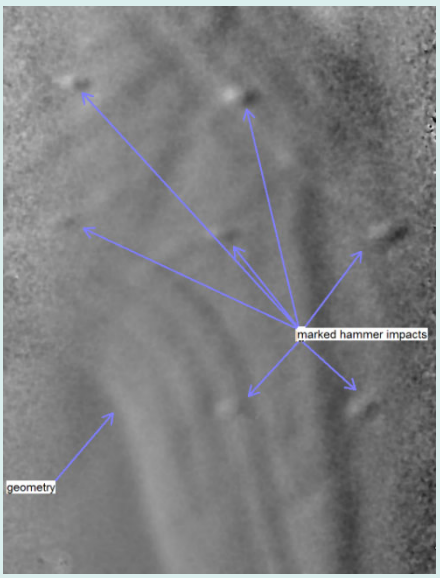
Shearography Maintenace Inspection Examples

Hammer impacted GFRP sample

Setup	• Setup consisted of a FlawExplorer Shearography sensor equipped with 8 laser diodes and four automatic heat lamps rated at 750W each. Heat excitation duration was 10sec. • The sensor is mounted on a Kuka robot. The rudder to sensor distance was fixed at 50cm.
Inspection Results	• No bare-eyes visible defects. Locations are indicated with a marker. • All impacts have crushed the inner core of the sample.



GFRP sample, Shearography life image

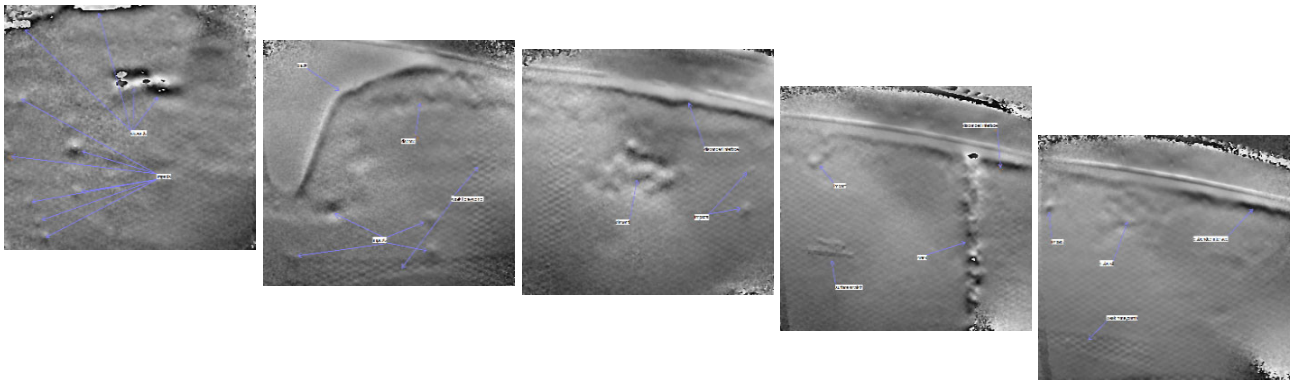


GFRP sample, Shearography filtered phase image

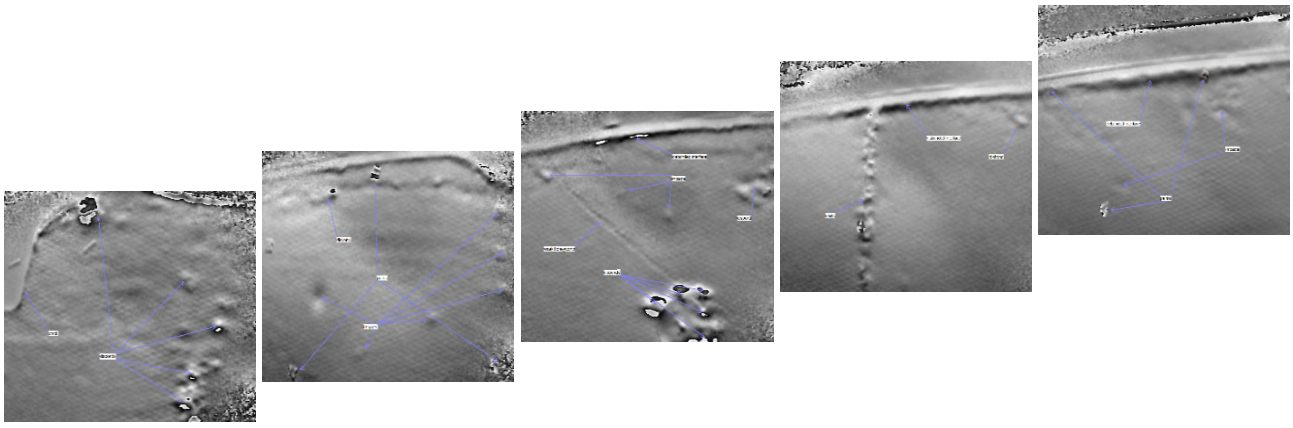
Port and starside rudder of a training fighter aircraft

Setup	• Setup consisted of a FLAWEXPLORER Shearography sensor equipped with 8 laser diodes and four automatic heat lamps rated at 750W each. Heat excitation duration was 10sec. • The sensor is mounted on a Kuka robot. The rudder to sensor distance was fixed at 50cm.
Inspection Results	• No bare-eyes visible defects. • Lots of hidden impacts were found in the inner core. • A few major cracks were also found. • Disbonds were also present. Some were located and others were spreading along material interfaces.

Fighter aircraft rudder test sample



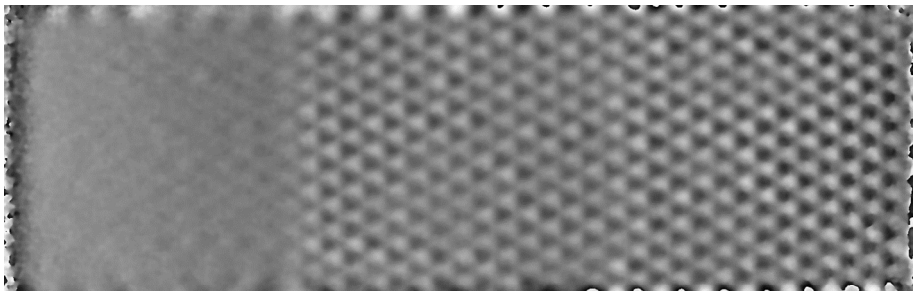
Fighter aircraft portside rudder, Shearography phase map results



Fighter aircraft starboard rudder, Shearography phase map results

Three types of honeycomb bondings

Robotic heat inspection	
Setup	• Setup consisted of a FlawExplorer Shearography sensor equipped with 8 laser diodes and four automatic heat lamps rated at 750W each. Heat excitation duration was 10sec. • The sensor is mounted on a Kuka robot. The rudder to sensor distance was fixed at 30cm.
Inspection Results	• No bare-eyes visible defects. • Rim defects can be seen for each bonding type. • Some cells are weaker than others in the same bonding type. • Honeycomb bonding types clearly differentiated by Shearography - 3 zones visible. • It appears that honeycomb bonding type 1 (left side) leads to the most sturdy material.



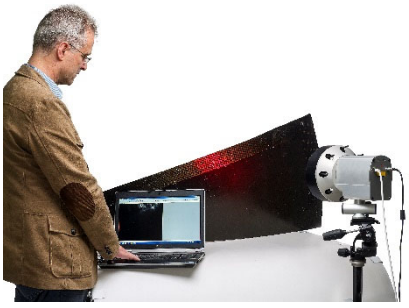
Honeycomb bondings sample, filtered Shearography phase image – three different bonding types, with some cell weakness visible.

Summary and Benefits

- Very well suited NDT method for detecting composite material defects in *inspection and quality control*.
- Certified NDT technique according to standards AIA NAS 410, CEN EN 4179 and ASNT SNT-TC-1A.
- Standard NDT practice for Shearography of polymer matrix composites according to ASTM E2581.
- Can measure, record and interpret data over large areas ($2m^2$) with very short inspection times (~15 seconds).
- Real-time measurement solution, providing same time inspection results.
- Non-contact optical technique, means the specimen under test is not contaminated and measurement of non-planar surfaces are easily possible.
- Robust and compact Shearography sensor suitable for flexible in-field or maintenance floor.
- Easy and safe usage with 3R classified laser diodes.

FlawExplorer Portable Shearography System

The FlawExplorer Portable Shearography System is a non-contact, optical NDT measurement solution used for quality control and material inspection of advanced (non-homogenous) materials.



FlawExplorer Portable Shearography System with 8 laser diodes.

Shearography is an optimum NDT solution, tailored specifically for integrated quality control processes, as used in the Aerospace,

Automotive, Wind Power, Marine, Aviation, Textile and other Composite related industries. The FlawExplorer actively supports the entire product life cycle from R&D, to componentry (manufacturing), assembly, end-test and in-service operation.

Applicable materials include, but are not limited to: composite honeycomb, rubber, composite overwrapped pressure vessels (COPV), ceramics, glass-fiber laminates, metal honeycombs, carbon-fiber (CFRP) laminates, fiber-metal laminates, bi-metals, foam-cores, cork, leather and metal-metal bonds.

Depending on the material strength and depth of defects within a sample, Laser Shearography can detect most defects and discontinuities that occur in composite structures, including: disbonds, delaminations, cracked cores, crushed cores, kissing bonds, wrinkling, fluid ingresses, porosity, cracks, repair defects and impact damage (BVIDs). Additional structural information such as ply drops, bulkheads, overlaps, splices, stringers and ribs, can also be detected.

FlawExplorer Shearography Systemc ombination with an automated robotic inspection.

More information

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