Helicopter rotor blade inspection

Using Laser Shearography solution with vibration excitation for NDT Quality Control & Inspection

Helicopter rotor blades

Rotor blades need to withstand high rotation speeds and dynamic bending forces to enable the high maneuverability of a helicopter. Simple maneuvers such as Forwards, Backwards, and Sideways are accomplished by altering the individual pitch angle of the rotor blade. Today composite materials are widely adopted as raw materials in the production of rotor blades due to their high strength-to-weight ratio.

Figure 1 – Airbus helicopter H120[1]

Composite is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure. However, unforeseen mechanical behaviors can occur under load or impact due to the high structural complexity of helicopter blades. Blade designers need a tool to validate or simulate their load cycling and fatigue behaviors. These test objects need to be tested and whichever testing method that engineers deploy should be simple in nature and the resulting data from the test should be easy to understand.

Once in production, manufacturing and in service repair facilities also require a reliable and repeatable solution. These facilities need to inspect blades for impact damages and any other type of service induced defect along with any other unidentifiable/undetectable anomaly that may be present.

Rotor blades maintenance: Find impacts and disbonds

Severe flight conditions require periodic as well as reliable inspections. These types of inspections are typically performed by maintenance personnel on all helicopters regardless of service. For this reason Shearography is a viable solution. This test method allows for component inspections in the area of a m² in less than a minute. This so important when time is of the essence when choosing an appropriate Non Destructive Testing technique.

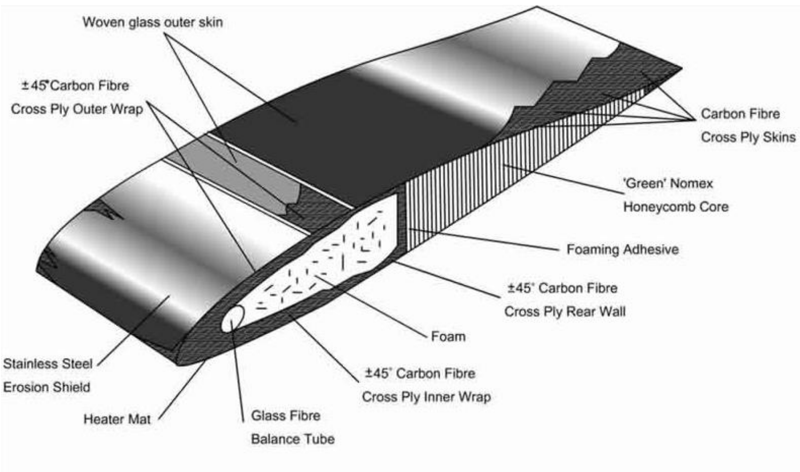


Figure 2 – Cross sectional view of a composite rotor blade[2]

Referring to Figure 2, a technician needs a to deploy the appropriate Non Destructive Evaluation technique which can accommodate any type of structure. One of the major benefits of deploying Shearography in this application is that Shearography has the ability to evaluate any specific shape of the rotor blades which by design in nature have a multi-structural and various materials incorporated in them. Shearography is so

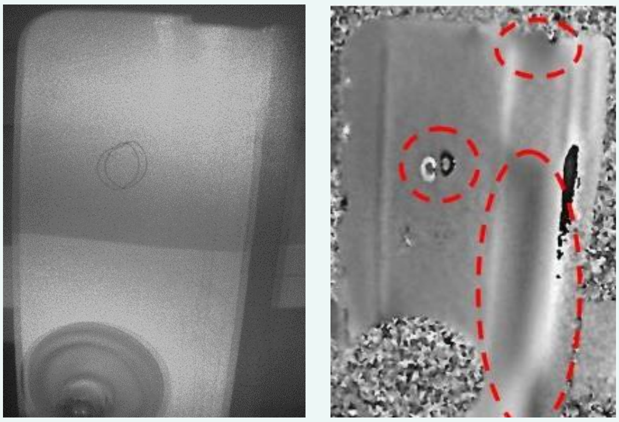
[1] Airbus Helicopters, http://www.airbushelicopters.com/website/en/ref/H120_26.html

[2] University of Liverpool, http://classroom.materials.ac.uk/images/heli-fig3.jpg

versatile that each rotor blade can be inspected with ease and requires no setup changes or sample preparation.

Typical, unavoidable defects caused during helicopter operation are impacts and disbonds. Numerous, independent feasibility studies have shown that Shearography is one of the most effective solutions to find and characterize these types of defects.

The Vibration-Shearography test method takes advantage of the huge response a blade can have when facing vibrations. It also allows an NDT inspection which mimics real in-service loads, leading to the development of accurate pass/fail criteria for the operator. This unique testing methodology gives the end-user a fast and economic maintenance solution.

Shearography maintenance inspection example: **Aluminum-Honeycomb helicopter blade**	
Setup	• Setup consisted of a FlawEsplorer Shearography sensor at a distance of 1m from the blade • A local and self-hanging vibration actuator was fixed on the blade • Personnel performed a frequency sweep until a defining a vibration mode where only the defects were responding (3 kHz).
Inspection Results	• No defects were able to be identified by the human eye or touch. • A huge impact could and major disbonds were found and annotations were made utilizing the operating system software.  *Figure 3 – Shearography live and phase map, local vibro-excitation at 3 kHz*

<table>
<tr><th colspan="2">Shearography maintenance inspection example 2:
Nomex-Honeycomb helicopter blade</th></tr>
<tr><td>Setup</td><td>• Setup consisted of a FlawExplorer Shearography sensor at a distance of 50 cm from the blade
• A local and self-hanging vibration actuator was fixed on the blade
• A frequency sweep was conducted until a vibration mode where only the defects were responding (5 kHz) was achieved</td></tr>
<tr><td>Inspection Results</td><td>• No defects were able to be identified by the human eye or touch.
• A huge impact could be identified and once again the operator was able to record and annotate the results in real time within the operating software.

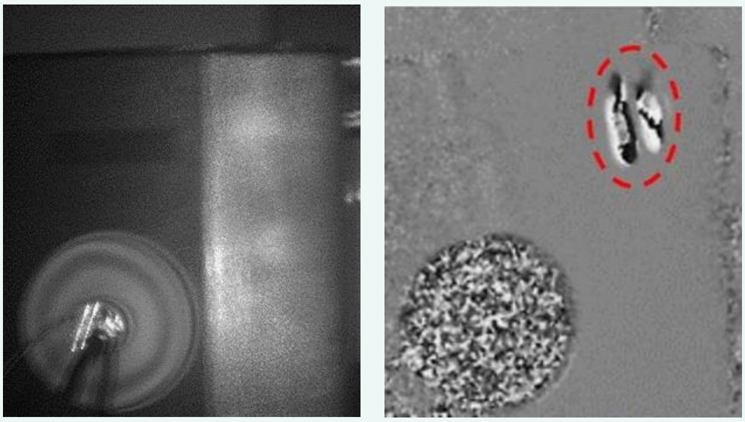



Figure 4 – Shearography live and phase map, local vibro-excitation at 5 kHz</td></tr>
</table>

The Laser Shearography measurement principle

Laser 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-micrometer) 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.

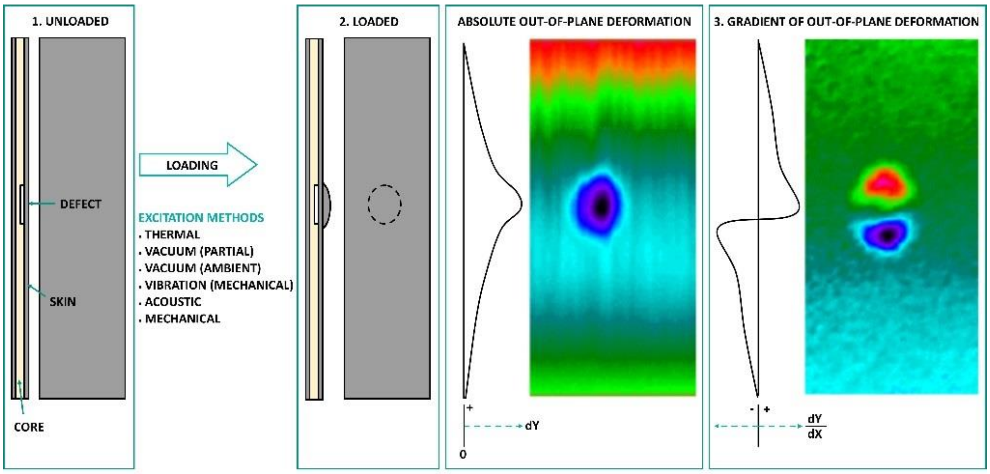


Figure 5 – The Laser Shearography principle

Local vibration excitation

Local vibration excitation is a loading technique where a piezo-electric shaker mechanically excites the object under test. The piezo-electric shaker is attached to the test object via the suction caused by a vacuum-seal frame. With a peak displacement of 15µm and push/pull force of +1000N/-50N, the vibration excitation system is a one-stop solution for most vibration applications. Using vibration excitation, various stiff and non-dampening materials can be excited with frequencies up to 20 kHz. The frequency sweep function allows the user to detect the defect semi-automatically.

The loading technique works with Laser Shearography as follows; when the resonance frequencies of a component are located, users can detect and visualize the components' various states via phase or time-average displays (see also application examples). The presence of defects will influence the components' frequencies and as such, cause the defects to respond locally at their own resonance frequencies.

Through vibration excitation, defects can be visualized in isolation and there may be different frequencies for different defect types, including shape, size and depth, for the same component.

Dantec Dynamics' local vibration excitation is a stand-alone and modular excitation solution which is designed to deliver optimal results with the FlawExplorer Laser Shearography sensor. Power and frequencies can easily be adapted by the user.

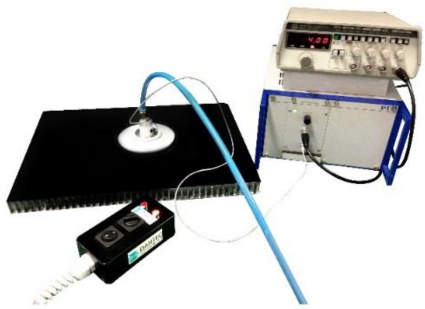


Figure 6 - Piezo-electric shaker and wave generator/amplifier

Dantec Dynamics' Laser Shearography solution

- Straightforward inspection method for Level I or Level II NDT personnel.
- Very well suited NDT method for detecting composite blade defects in inspection and quality control.
- Fast and easy inspection results can be collected throughout the whole NDT process.
- Recognized NDT technique in accordance with standards AIA NAS 410, CEN EN 4179 and ASNT SNT-TC-1A.
- Accepted NDT practice for Shearography of polymer matrix composites according to ASTM E2581.
- System has the ability to collect, record, measure and interpret data over large areas (~m2) with very short inspection times (~15 seconds).
- Real-time evaluation system that provides real time inspection results with the assessment tools inherent within the operating system.
- Compact system suitable for flexible in-field or laboratory use.
- Easy and safe usage with 3R classified laser diodes.

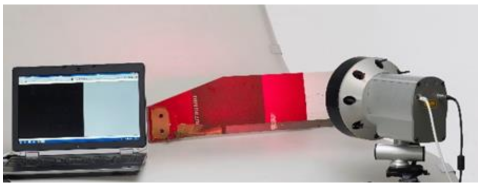


Figure 7 – FlawExplorer – portable, compact and rugged Shearography solution that takes NDT & Quality Control to a new level

FlawExplorer NDT inspection system

The FlawExplorer Portable Shearography System is a non-contact, optical NDT inspection solution used in the manufacturing and quality control areas. In addition, it can easily be deployed in the research and development area to evaluate advanced (non-homogenous) materials.

Shearography is an optimum Non Destructive Evaluation solution and maybe tailored specifically for integrated quality control process. Industries supported today are 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 to 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, delamina¬tions, 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.

For more information contact

Dantec Dynamics GmbH
Kaessbohrerstrasse 18
89077 Ulm, Germany
Tel.: +49-731-933-2200
Fax: +49-731-933-2299
Email: product.support@dantecdynamics.com

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