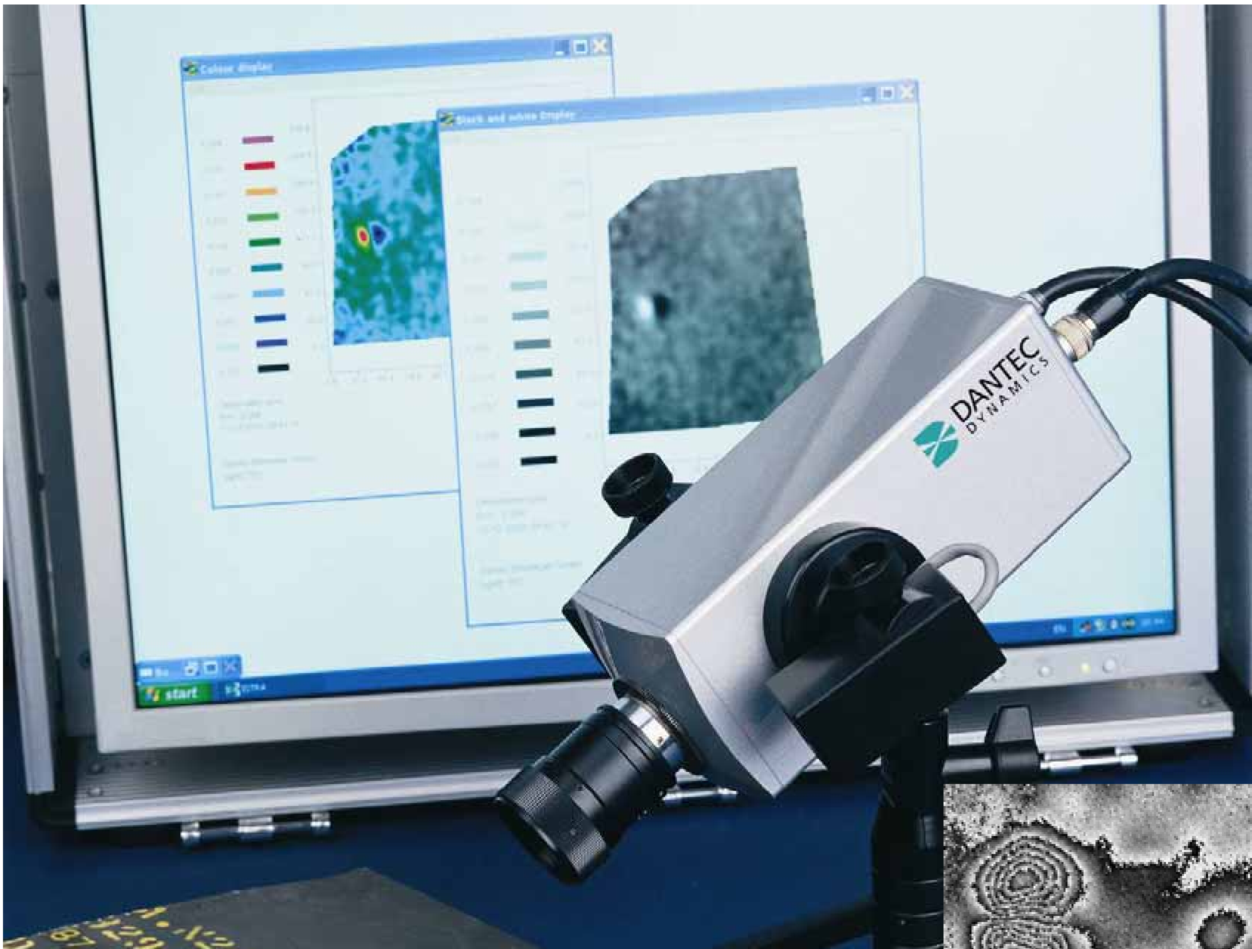
Nondestructive Large Area Testing using Shearography

General

The demand for greater product quality in industry has created a need for better and faster techniques for nondestructive testing. Because traditional techniques such as ultrasonic and radiography are rather time consuming, there is a need for alternatives, more rational methods. Shearography is one of those.
Due to recent development of advanced electronics and lasers, shearography is now a technique for in field nondestructive evaluations. The advantages with shearography are that it is a non-contact, full-field technique, which can perform fast inspections with high resolution.

Fig. 2 shows the schematic of a shearography equipment. A laser beam illuminates the test object and a shearing sensor, with optics and a CCD-camera, registers the reflected light. The optics in the shearing sensor will double and laterally shear the image of the object producing a resulting image called a speckle interferogram, which is a unique space map of the surface. A speckle interferogram can only be made when coherent, divergent light is reflected on a diffuse surface. By comparing interferograms before and after loading a fringe pattern is produced, as can be seen in Fig. 1.



A non-contact, fast technique

Shearography is an optical method that gives information about surface deformation of a loaded structure. The load can be induced by heat, vacuum, pressure, sound or vibration. The surface area above a defect will deform differently than the surrounding surface area, which will be recorded with shearography, and presented as typical patterns (see Fig.1). Surface deformations of a few microns can be observed.

To improve image quality as well as defect visibility the "phase shifting technique" can be used. The image quality can also be improved with processes such as filtering.

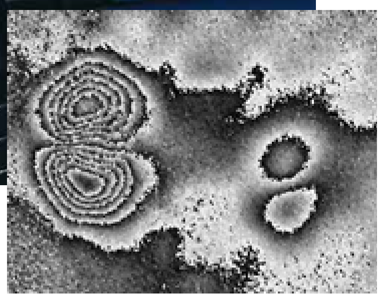


Fig. 1: Phasemap of two impact damages.

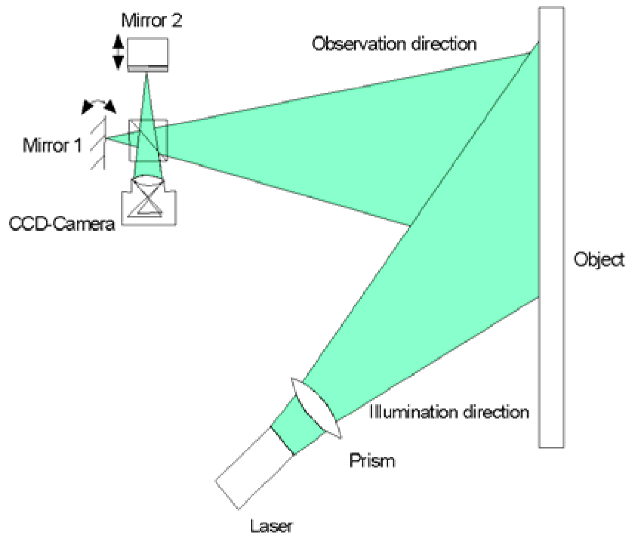


Fig.2: Schematic diagram of a shearography system.

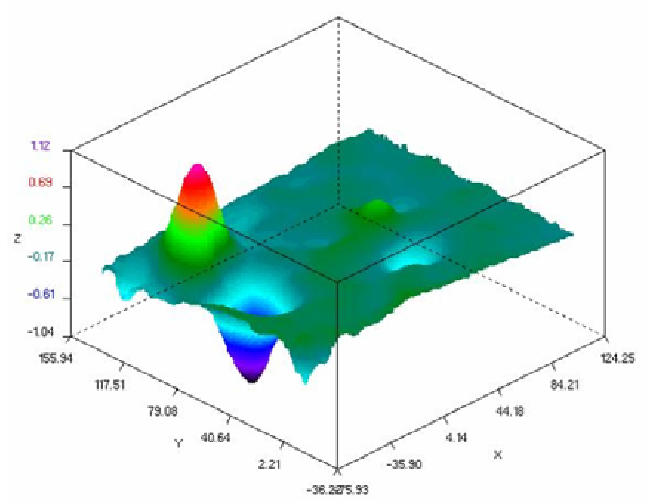


Fig 3a

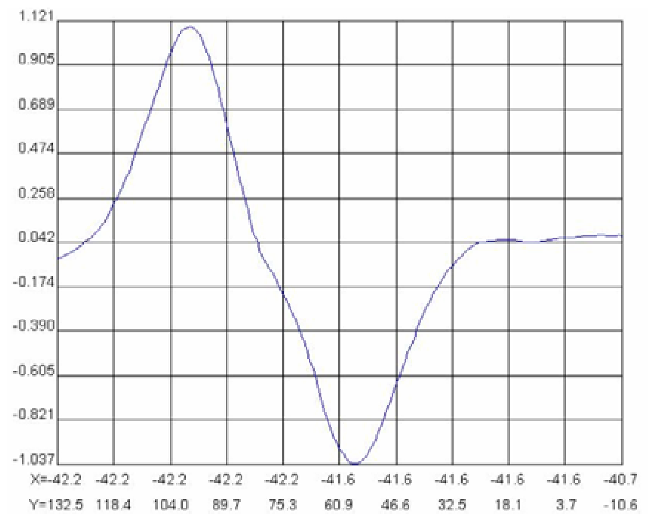


Fig. 3b: Impact damage seen in a) a three-dimensional image b) a cross section

Examples of applications with shearography

A portable shearography equipment, developed by Dantec Dynamics GmbH and owned by CSM Materialteknik, and a laser with green visible light output (532 nm) has been used for the following examples. The test objects were thermally loaded with a pair of 500 W halogen lamps.

Inspection of impact damages on metal structures

Fig. 3a) shows a three dimensional image of impact damages on a metal panel. Because shearography displays the 1st derivative of the displacement of the surface the defect is shown with positive and negative slopes. Fig. 3b) shows a cross section of the defect indication.

Inspection of impact damages on CFRP structures

Fig. 4 shows an image of a composite panel with aluminum core and 2 mm carbon fiber skins. The phase shifting technique and image processing has been used for evaluation of the speckle interferogram. The Inspection area was about 20 x 30 cm and the inspection took less than two minutes. The panel was also inspected with ultrasonic, with an inspection time of about forty minutes.

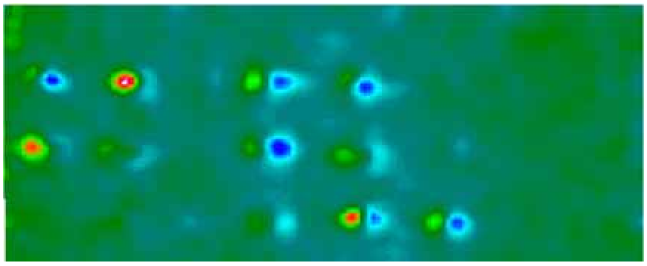


Fig. 4: Damages from impact energies of 3-12 J.

Inspection of aluminum honeycomb structure

A panel with 1 mm carbon fiber laminates and 10 mm aluminum core was inspected to search for delaminations caused by tension tests. Data from the circle in the middle of Fig. 5 has been removed because of the bolt that was situated there. Delaminations could be indicated near the bolt. The honeycomb structure could also be indicated which is a sign of the sensitivity and resolution of shearography.

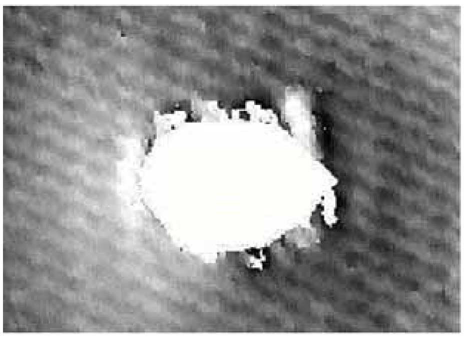


Fig. 5: Aluminum honeycomb structure

Conclusion and future technical developments

Shearography can be used both during initial manufacture and later for in-service inspection and offers rapid and unique inspections. By choosing the right inspection parameters, it can effectively detect delaminations, fatigue cracks, and debonds caused by impact damage or structural failure. The method does not necessitate the use of couplant or complex scanning mechanisms.

Inspection of composite repairs creates problems due to the non-homogenous construction and use of different materials. Shearography has shown potential to inspect repaired structures

The technique can also be used for strain mapping of structures.

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