DAMAGE ASSESSMENT OF IMPACT DAMAGES ON CFRP WITH LASER SHEAROGRAPHY

Raphael Schoen, Steinbichler Optotechnik GmbH, Neubeuern, 83115 Germany

Simon G. Pickering, University of Bath, Bath, BA2 7AY, UK

ABSTRACT

CFRP material becomes widely used in Aviation industry for substituting or complementing conventional material compositions.

There are various advantages in comparison to conventional material that has been used so far, but also some disadvantages. Among those there is the difficulty to detect and estimate impact damages by visual inspection, as it has been carried out at e.g. aluminum material. CFRP material with its own particular behavior to impacts, caused by rough environments (e.g. stone, ice or bird impact, tool drop, etc.) makes visual inspection more difficult. Therefore investigation and defect estimation becomes more and more crucial in maintenance of composite material. The typical material behavior to an impact leaves only a small or even no visible indication on the material surface, but there is indeed a deeper damage extended in the material. Shearography full-field inspection method reveals the extension of the impact damages providing a base for decision of repair. This paper shows various impact damage examples on a CFRP stringer material with its extension into the material beyond the visible area. The metric impact determination allows obtaining data for comparison and/ or catalog of the defects.

KEYWORDS: Composite Material, Laser-Shearography, Impact damage evaluation, Composite repair, BVID

1. INTRODUCTION

Detection of impact damages is of general interest to the aerospace/maintenance industry in particular if impact damages are barely visible. For cases of impact damage and barely visible impact damage (BVID) Shearography provides a reliable and fast method for non-destructive-inspection of the material and further investigation and assessment. The detection procedure and results of three BVID’s using Shearography is described in this document.

1.1 Audience

The publication is targeted at material researchers and NDT researchers and personnel that deal in their orientation of work with damaged composite material structures and flaw evaluation.

2. SHEAROGRAPHY PRINCIPLE

Shearography method is an interferometric full-field out-of-plane deformation measurement method. Shearography is a derivate of ESPI method in order to enable its use in field. Interferometric methods have a laboratory measurement accuracy of 30nm. ESPI is best suited for use on optical tables that ensure vibration isolated environment. ESPI method delivers out-of-plane as well as in-plane deformation of objects. Shearography has been modified with a double object beam in order to cope with rough environments that exist in maintenance and production areas. Very small out-of-plane deformations can be determined by stressing the component with an approx. 30 Kelvin heat puls or applying small vacuum (Δ40mBar) to the component. The material with flaws that is exposed to this load shows an entire response, however the local flaws have a different out-of-plane deformation behavior to the global stress applied. Due to the double object beam the gathered data of a local out-of-plane deformation is measured as the first deviation of an out of plane curvature.

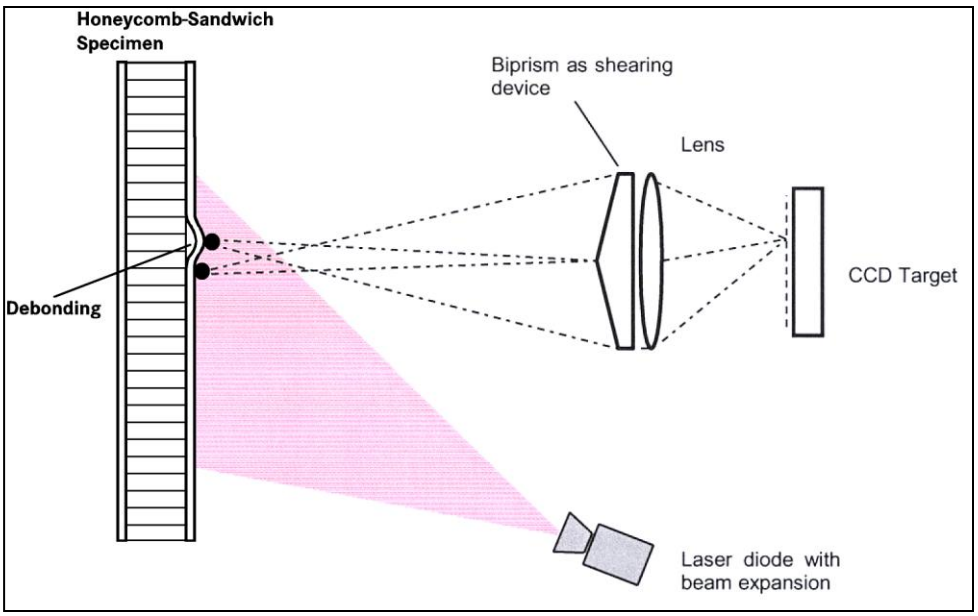


Figure 1. Shearographic principle

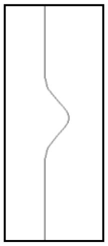


Figure 2. Theoretical drawing of curvatures caused by application of load to structures

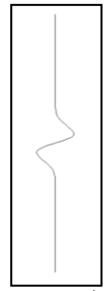


Figure 3. 1st deviation measured by Shearographic method that indicates the flaw

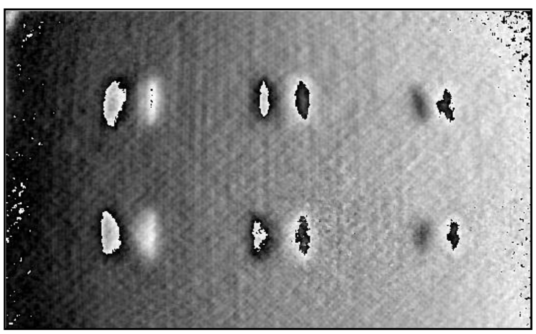


Figure 4. Exemplary image of six artificial defects in CFRP/ Honeycomb material with spatial 1st deviations of surface curvatures that indicate the flaws.

3. APPLICATION: CFRP STRINGER PANEL WITH IMPACT DAMAGES

The stringer panel poses the exemplary component to illustrate the determination and damage assessment of impact damages in CFRP composite material with Shearography-NDT method.

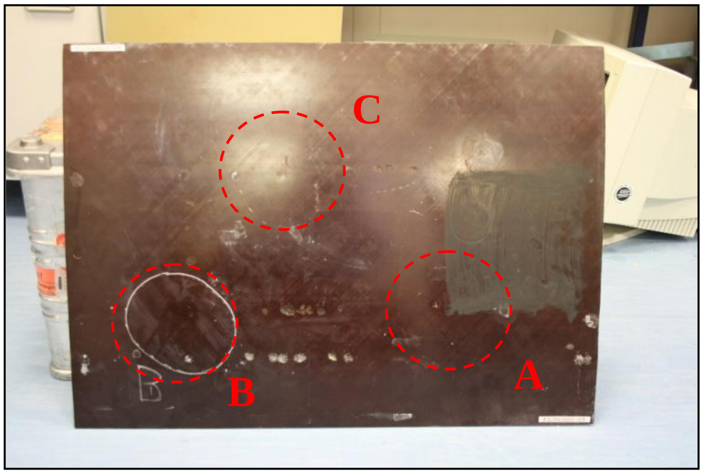


Figure 5. Stringer panel (front side view) with 3 impacted areas indicated with red circles

Figure 6. Stringer panel (back side view) with 3 impacted areas

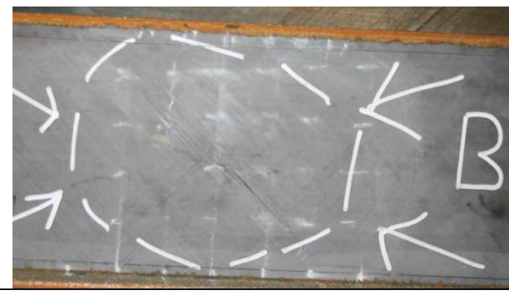
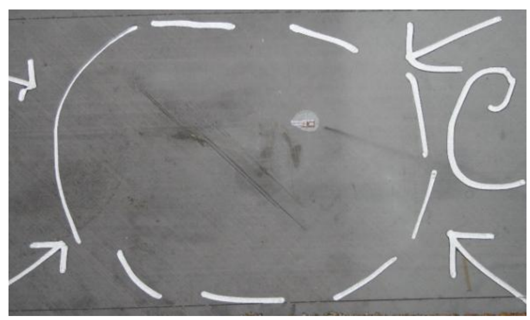
Impact damage	Front side view	Back side view
A		
B		
C		

Figure 7. Close up view table of the impacts on the front and back side

4. MEASUREMENT APPROACH

Three barely impact damages (BVID) at the areas marked A, B and C (see following images) were inspected by using the Laser-Shearography method. For the tests a Steinbichler ISIS3100 Shearography was used with a laser power of 4x70mW Laser Diodes. Thermal excitation of 1s was used to stress the stringer panel.

Figure 8. Application of a Shearography system with thermal excitation

5. RESULTS

In the chart below the visible indications of the BVID’s and their shearographic indications are shown. The shearographic images on the right hand side show that the damaged area extends beyond the visibly damaged area as seen on the left hand side. The use of Shearography allows an assessment of the non visible deeper damage.

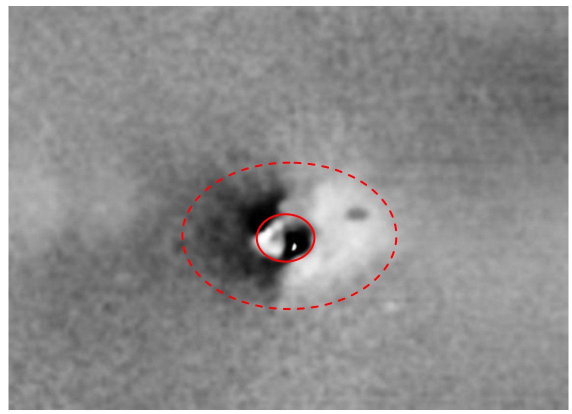
Impact damage	Visible damage	Shearographic Image
A		

Figure 9. View of the impact (left image) and the Shearographic result image (right image) with the defects extension into the material. (Visible area = red inner circle, non-visible area, but damaged area = outer red circle)

The Shearographic image shows that below the visible indication of the first impact the damaged area spread out deeper into the material.

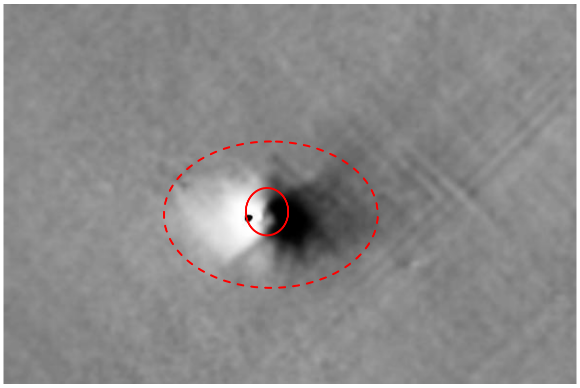
Impact damage	Visible damage	Shearographic Image
B		

Figure 10. View of the impact (left image) and the Shearographic result image (right image) with the defects extension into the material. (Visible area = red inner circle, non-visible area, but damaged area = outer red circle)

By eye barely any damage is seen, but Shearography reveals that there is a significant damaged area. Further investigation to size and evaluate the defect is enabled.

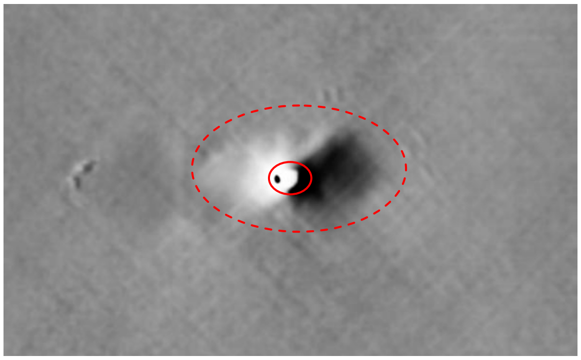
Impact damage	Visible damage	Shearographic Image
C		

Figure 11. View of the impact (left image) and the Shearographic result image (right image) with the defects extension into the material. (Visible area = red inner circle, non-visible area, but damaged area = outer red circle)

Some slight visible indication of damage is seen. Further investigation with Shearography shows that the damaged area extends beyond the area that could be discovered by visible inspection.

6. CONCLUSIONS

The results indicate that Shearography method is suited to inspect and detect impact damages in CFRP material. The results show that it is possible and feasible to determine and assess the extension of flaws in the material. Obtaining metric data is one base for a decision of possible material repair or component replacement.