Maintenance Inspection of Composite Materials with Shearography

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Abstract. Modern hi-tech products today widely are made of composite materials, which are specifically designed for the purpose of their application. Other than a precise knowledge of the characteristics of these materials, which often are anisotropic, quality control is of the essence. As said components, e.g. in aerospace, aircraft, or also boat industry are safety relevant, and also of great value, defect monitoring has to be carried out in production as well as in maintenance.Shearography is a full field inspection technique, which is specifically suited to do defect monitoring, where of course different challenges are presented in production control and in maintenance. In this presentation emphasis is put on maintenance inspection in aircraft and boat industry.

1. Introduction

Composite materials have been well known for many years, but since the aerospace market is dramatically increasing, these materials are much more frequently used than in the past. Nowadays, different types of composite material find their way through Aerospace, Automotive, Marinis and has become significant importance for the strength and reliability of structural components. Having a major benefit of less weight and higher structural stiffness, composite materials are pretty sensitive to impact damage, foreign object damage (FOD), production failures (in-homogenous), repairs and/ or excessive loading. Therefore, durability and reliability become a very important issue. In the past, technologies like ultrasound, tapp testing and x-ray were typically applied to detect anomalies inside these materials, while optical technologies were not available as industrial products. With the availability of featuring state of the art computers, modern camera technology and Windows-based software tools, the optical measurement technologies already have reached the industrial level. The shearography technology has been well known for more than 25 years and is always the best choice to be introduced as fast, reliable and highly accurate measurement technique for detecting various kinds of defects inside composite materials. The following article describes this technology as well as its industrial application in the maintenance field.

2. Technology

Shearography is a pretty simple and easy to use optical measurement technology which provides full field results almost in real time during inspection. A typical system consists of a digital camera with an optical set-up(Fig 1), a laser source, an excitation device and a high-speed computer with evaluation software. In a simplified way, the object under test is

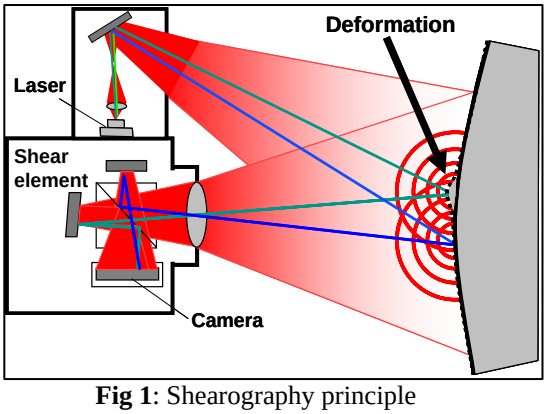

Fig 1: Shearography principle

illuminated with laser light and images from the object at different states of loading are taken. The loading of the surface is created by different excitation methods like vacuum, thermal, vibration or mechanical deformation and should induce a deformation of the outer surface, which is locally altered by the presence of sub-surface defects, e.g. disbonding or delaminations. A fast comparison of different images allows the calculations of the deformation gradient, being a sensitive measure for local defect. The excitation can always be kept to a minimum due to the high sensitivity of the system based on the used laser wavelength. The software used to evaluate and display the result is a key factor for the. Shearography technique which can detect anomalies like debondings, delaminations, voids, separation of structural components, wrinkles, kissing bondings, impact damage, internal corrosion, crushed core, changes in sections and core splices. Based on more than 17 years experience in the field of Non-Destructive Testing, the company Dantec Dynamics delivers turnkey systems to all major companies in the aerospace, automotive, electronic und heavy industry.

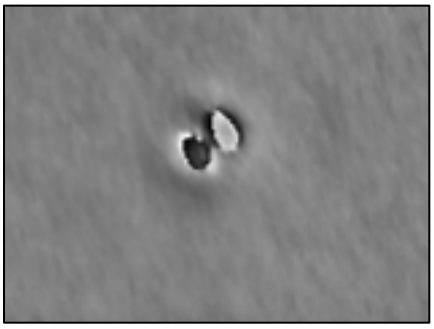

Fig 2: Shearography result image

3. Systems

Typically there are mobile and stationary systems available . Both of them feature the same software tool ISTRA which includes maximum automation combined with minimum user input. During the years we have developed various stationary and mobile systems which enable the operator to detect fast and reliable any potential damage inside composite materials. Special attention has been given to applications in the maintenance field where handling capabilities, easy operation and 100% repeatability is a key requirement. The mobile Q-800 Shearography sensor (Fig 3) provides with it's compact design, customized diode laser array and excitation maximum flexibility in regard to test set-up. It can be used in a vacuum chamber as well as in combination with thermal or vibration excitation systems and therefore it is an optimal solution for a wide range of objects in production as well as in maintenance. The Q-810 system (portable vacuum hood) (Fig 4) has a dedicated design for maintenance application which incorporates a touch screen display mounted on the hood for remote control of the measurement. The hood design provide repeatable measurement conditions in every environment and protects the optical setup against damage and contamination. The system consists of a vacuum and/or thermal excitation hood and a portable computer trolley and therefore can be easily handled by one single operator. This configuration offers a simple way to inspect parts outside the lab in nearly every environment without any surface preparation. The predefined test procedures are available with one mouse click and the test result is displayed seconds after. Several tools are available to improve image presentation afterwards. This gives the operator the possibility to scan very large areas in a very short time. This finally pays off day by day during operation and especially by the turnaround time of parts under inspection. Stationary systems are typically customized in regard to

Fig 3: Q-800 sensor

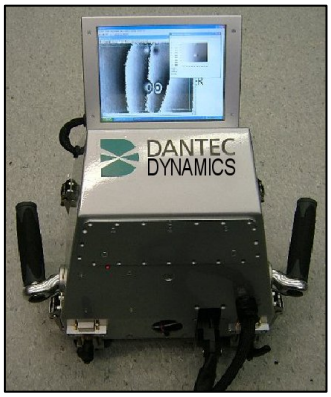

Fig 4: Q-810 sensor

hardware and automation while the evaluation software is still the same one like for the mobile units. This reduces training and operation time again because the operator can handle both systems without the usual adaption to different units.

4. Application

Dantec Dynamics experience with many installations in aerospace, automotive and shipyards has led into a wide field of applications. Starting with straight forward parts made of carbon composite many other materials like metal, rubber, Glare™, Honeycomb, laminates, foam and wood can be inspected with this technology. Special attention has been given to the aerospace and shipyard industry where very successful measurements have been performed. One of the early projects was a fully automated rotor blade inspection system for helicopters (Fig 5) and a robot-controlled inspection of Ariane V thermal protection parts (Fig 6). Many other systems were installed for inspection of various materials in different industries. In the aerospace maintenance field the requirement for in-field inspection as well as for the repair level is the inspection time. This is one of the Shearography advantages because each measurement covers an area of 170 x 250 mm in 15 seconds. Therefore, large areas can be inspected in a very short time which dramatically reduces the overall inspection time. Furthermore, Shearography provides straightforward results (Fig 7) on which the operator can identify defect free versus defect areas immediately. A lot of typical applications will be displayed during the presentation. In the shipyard industry mayor emphasis is put on the flexibility of the system and the ability to inspect complex structures and large areas. We have performed many successful tests on racing, sailing and America's Cup boats (Fig 8). The presentation will show several applications of the above.

Fig 5 Rotorblade Inspection

Fig 6 Ariane V part inspection

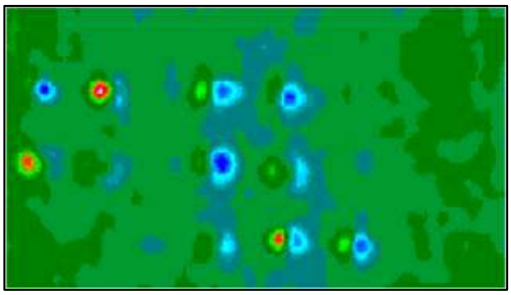

Fig 7 Aluminium Honeycomb with defects

Fig 8 America's Cup boat

5. Conclusion

Today NDT equipment based on shearography has reached a quality and performance level which opens many industrial applications in the inspection of composite materials in the production and maintenance area. Present systems combine easy handling with a significant reduction of inspection time. Based on the wavelength of light as a reference, shearography

systems achieve a high accuracy and very low detection level of different types of defects. It is quite obvious that the Shearography has reached a fully industrialized production level and provides very easy to understand results within a fraction of the current inspection time. The technology combines the accuracy of an optical measurement technology with the flexibility of a maintenance system. Several installations in the aerospace and marine industry demonstrate the reliability and the capabilities of shearography systems leaving high expectations for such a technology and therefore it will be an even more established technique in the future spread