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Ultrasonic and IR Thermographic Detection of a Defect in a Multilayered Composite Plate

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Abstract

Multi-layered composites are frequently used in many applications as constructional materials. Such materials represent a difficult inspection task for some traditional techniques of non-destructive testing (NDT). Typical defects of composite materials are delaminations, lack of adhesion and crumpling, just to name a few. IR thermography and ultrasonics are typically considered as candidate techniques to detect different types of defects. In order to assess the potential usefulness of both methods, a composite laminate with a polytetrafluoroethylene disk inserted between two layers to simulate a delamination is investigated. Experimental evidences resulting from the two technologies are discussed.

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*Keywords:*Ultrasonic, Thermography, Composite;

1. Introduction

Carbon Fibre Reinforced Plastic (CFRP) materials are increasingly being used in modern civilian aircraft for structural applications, but the fear of delaminations and disbonds which can be introduced during the manufacturing process or later in the service life limits their use when these materials are employed to build composite laminated structures. In this perspective the detection and classification of delamination defects and the evaluation of

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component in-service integrity is necessary. Therefore, the ability to locate and define damaged regions within composite material structures by means of non-destructive testing (NDT) has greatly improved over the years. The NDT is of particular interest for the inspection of aerospace structures where the failure of a component may cause costs which exceed by many orders of magnitude the cost of the component that failed. Ultrasonic inspection, low frequency acoustic methods, X-ray imaging, optical and thermal methods are examples of possible investigation techniques [1]. However, these technologies possess clear advantages in some aspects but also limitations in others [2].

The ultrasonic sensing techniques have become more sophisticated over time. Today they are mature and widely used in the various fields of engineering and basic science. Advances in these are reflected in a number of papers [3][4][5]. Some advantages often cited include [6]: the sensitivity to both surface and subsurface discontinuities; the depth of penetration for flaw detection or measurement which is superior to other NDT methods; high accuracy in determining reflector position and estimating size and shape; minimal part preparation required; instantaneous results provided by electronic equipment and detailed images produced with automated systems; moreover, other uses are possible, such as thickness measurement of the part, in addition to flaw detection. However, the main advantage of ultrasonic sensing is its outstanding capability to probe inside objectives nondestructively because ultrasound can propagate through any kinds of media including solids, liquids and gases except vacuum. The overall increase of safety and quality guarantee is what makes this NDT method so crucial to organizations today.

Among the various ultrasonic sensing techniques, phased-array technology is very useful to inspect large structures quickly. In the past, the phased array technology was generally limited to the inspection of heavy wall components with complex geometries [7]; instead, today, due to improvements, it is being considered for use in different fields, mostly in aeronautic and in-line testing industries. Phased-array probes and holders, specifically designed for the inspection of composite flat panels, combined with composite specific software features, provide greater productivity while maintaining a high degree of reliability.

The main disadvantage of phased-array solution is the contact needed with the part to be inspected. This entails some problems since the surface must be smooth enough to assure good contact, a coupling medium (e.g. oil, ultrasound gel, water, glycerine) is necessary and time is needed to scan large surfaces. In addition, it poses the problem of the custom-built reference blocks which must be fabricated, used and stored following specific rules [8].

In the light of these problems, infrared thermography (IR) is attractive because it is non-contact and noninvasive inspection NDT method. The non-contact full-field measuring features of modern IR cameras, and their latest progresses in sampling rates, thermal and geometric resolution have all contributed to significantly foster interest towards thermal methods in general [9]. Infrared Thermography for NDT is mostly based on the active approach [10]; among many techniques available, lock in thermography (LT) offers a valid help to find defect signatures for qualitative and quantitative evaluation [11]. However, LT is affected by loss of contrast in presence of thick parts [9].

Given the drawbacks of thermographic and ultrasonic procedures, an integrated use may be advantageous to detect both shallow and deep defects saving time in the inspection of large surfaces. In this paper, a comparative study involving the two techniques is made.

2. Experimental investigation

The introduction of a delamination in test specimen is possible by embedment of a very thin teflon disk. This approach has the advantage of providing a well-defined location and geometry and has been used in many studies [13][14].

In this work, a composite laminate, 600x600 mm with a polytetrafluoroethylene (Teflon) disk of 15 mm in diameter, inserted deliberately between two layers, during hand lay-up of the specimen, and simulating an inter-ply subsurface damage (delamination), is investigated. The specimen has been manufactured using 8 plies of carbon/epoxy pre-preg material system. The average ply thickness obtained from specimen thickness measurement is 1.6 mm.