Chapter 15

Non-Destructive Testing of Carbon Fibre Reinforced Polymer (CFRP) Composite Using Thermosonic Technique

Tanmoy Bose
National Institute of Technology, Meghalaya, India

N. S. V. N. Hanuman
National Institute of Technology, Meghalaya, India

Subhankar Roy
National Institute of Technology, Meghalaya, India

ABSTRACT

Composite materials are often subjected to low velocity impacts which leads to delamination in subsequent layers. Linear ultrasound-based approaches are not accurate enough to detect it properly. The local defect resonance (LDR) based thermosonic is proved to be an efficient candidate for detection of such defects. LDR frequency excitation leads to high amplitude vibration which raises defect temperature drastically, detectable by an infrared camera. In this chapter, a numerical investigation of LDR frequency excited ultrasound thermography is carried out on delaminated carbon fibre reinforced polymer (CFRP) plate. The location and size of the delamination can be easily understood from thermal signature. The temperature gradient variation is found to be high at first and then it decreases due to higher heat conduction rate. The delamination in CFRP plate is detected by standard phased array ultrasound testing (PAUT) using flat bottom hole in aluminium plate as a case study. Delamination detection by PAUT is found to be very time consuming process compared with thermosonic technique.

DOI: 10.4018/978-1-7998-1831-1.ch015
INTRODUCTION

The composite material is a combination of two or more materials which give a unique property. The classification of the composite materials is polymer matrix composites (PMC), metal matrix composites (MMC), ceramic matrix composites (CMC). Recent days PMC material utilization is more in the field of military, aerospace, automotive, architecture, marine and energy due to its good fatigue properties, corrosion resistance, and high strength to weight ratio. The large class of PMC material are carbon fiber reinforced plastic (CFRP) and Glass fiber reinforced plastic (GFRP) which are used based on their requirements (Satishkumar, Satheeshkumar, & Naveen, 2014; Chavan & Gaikwad, 2016; Vinay, Govindaraju, & Banakar, 2015). CFRP finds more usage in automobile and aeronautical industries due to increased rigidity compared to GFRP. These type of structures should be inspected by non-destructive testing procedures to avoid further damage or its complete failure. Some defects like voids, delamination and cut fibers exist during manufacturing. This type of light weight structures are prone impact damage due to less plastic deformation, which can be observed in case of metals. Impact severely decreases the lamina strength due to formation of micro-cracks and delamination in that portion. Impact damages are of two types viz, high velocity and low velocity impact. In case of high velocity impact, the composite structures are severely damages which can visualized also. But in case of low velocity impact, the damages can not be properly visualized and the damages are also known as barely visible impact damage (BVID). Ultrasonic non-destructive testing (NDT) is very popular to find defects in the composite materials. It uses linear wave spectroscopy in the form of either contact or non-contact method. The number of industries has implemented contact-based NDT method to identify flaws in mechanical components. In wave spectroscopy, wave is propagated in anticipated direction in the material with a specific velocity and get reflected from discontinuities within the material. Ultrasonic phased array technique is developed by microelectronic parts, which is processing the wave depends velocity of the wave, attenuation, and acoustic impedance. It has a multiple-element ultrasonic transducer which steering the beam means pulsing and receiving the signals with time corrected gain (TCG). It can show low-velocity impact damages non-visible inclusions by A-scan, S-scan, and C-scan (Caminero, García-Moreno, Rodríguez, & Chacónb, 2019). But detection of low velocity impact damage is still a challenging task using this method due to its occurrence within few layers from surface. Many kinds of literature prove that Thermography technique is very efficient for localizing the defect. Moreover contactless thermography technique is very suitable for the barely visible impact damages and micro flaws in a structure. But this is permissible to the finding the cracks near to the surface (Meola et al., 2015; Katunin, Dragan, & Dziendzikowski, 2015). Moreover ultrasonic testing (UT) gives very high precise images compare to the thermography technique (Ibrahim, Smith, Wang, 2017). The non-linear wave spectroscopy is the very efficient technique to describe the non-linear behavior of the defect which is specially applied on investigation rocks. One category of this is nonlinear ultrasound resonant spectroscopy (NRUS) which mainly detects the deviation structural resonance to predict fault within the structure. So, it is a volumetric method but unable to detect the location of flaws present in the structure. Ultrasound excited thermography or, thermosonic or sonic IR is a non-contact defect inspection technique to visualize three dimensional defect but its usage were severely restricted due to use of high power ultrasound welding horns and high non-repeatability of experiments. The concept of local defect resonance (LDR) has made this method highly repeatable and usage with low acoustic power which will not damage the investigating structure (Solodov, Bai, Bekgulyan, & Busse, 2011).