IDENTIFICATION OF DAMAGE TYPES IN CARBON FIBER REINFORCED PLASTIC LAMINATES BY A NOVEL OPTICAL FIBER ACOUSTIC EMISSION SENSOR

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ABSTRACT

In this research, phase-shifted FBG (PS-FBG) sensor was employed to practical AE detection for carbon fiber reinforced plastic (CFRP) composite laminate. Firstly, we evaluated the characteristics of AE signals detected by this kind of sensor. Secondly, through the experiment and simulation concerning AE source orientation, quantitative information about the standard for discriminating the AE signals due to transverse cracks and delaminations was obtained. Finally, according to the standard, we identified the occurrence of those two damage types successfully in the actual AE detection under three point bending and tensile test.

KEYWORDS : *Optical fiber sensors, Acoustic emission, Composite laminate, Modal analysis.*

1 INTRODUCTION

Acoustic emission (AE) monitoring is considered as a kind of SHM methods for carbon fiber reinforced plastic (CFRP) composite laminates. In this material, AEs generated by crack occurrence have low energy and a broad frequency range. Hence, sensor with high sensitivities and broad bandwidth is one of key points for the practical application of the AE technology. PZT sensors have been being used as AE sensors. However, because this kind of sensor has bulk size and is easily broken by large displacement, it is difficult to be embedded in the CFRP composite laminates.

One kind of optical fiber sensors, FBG sensor, with flexibilities and small size, is possible alternative AE sensor [1]. However, the trade-off between high sensitivities and broad bandwidth limits the application of the sensor.

In order to solve these problems, Wu and Okabe [2, 3] tried to apply one special kind of FBG sensor, called phase-shifted FBG (PS-FBG), to AE detection.

1.1 PS-FBG & Balanced PS-FBG sensing system

At the centre of refractivity of PS-FBG, a narrow peak with sharp slope (Figure 1(b)) was generated due to a π phase shift which was inserted into the core of periodic grating area (Figure 1(a)). This narrow peak makes PS-FBG sensor possess both high sensitivity and broad bandwidth [4]. And the usefulness of the sensor for detecting ultrasonic wave in the CFRP laminates was verified [2].

Moreover, with taking advantages of PS-FBG sensor, Wu and Okabe developed a novel high sensitive sensing system, called balanced PS-FBG sensing system [3]. The configuration of this system is shown at Figure 1(c). In this system, based on edge filtering demodulation method, external cavity tunable laser (TLS) (Agilent, 81682A) was used as light source. Then, PS-FBG was connected with TLS through a circulator. The Reflected and transmitted light powers from PS-FBG propagate to port 1 and port 2 of a balanced photo detector (BPD) (New Focus, 2117) respectively. At the BPD, the light power will be transformed into electrical power. At the BPD, only AC electrical component caused by change of axial strains with the propagation of AE wave is passed

