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Structural Health Monitoring System of Composite Beams with Surface Bonded and Embedded Fibre Bragg Grating Sensors

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Abstract. Fibre Bragg Grating (FBG) sensors are frequently being used for Structural Health Monitoring (SHM) of aerospace structures. One of the most important advantages of using FBG sensors is that it is possible to embed them into composites. In this paper, manufacturing methods of composite specimens with embedded FBG sensors are given. To avoid stress concentrations at ingress/egress regions of fibre optic wires, PTFE (Teflon) tubes were used during manufacturing. Moreover, FBG connectors melt at high curing temperatures. Therefore, those connectors were cut and after manufacturing, these connectors were spliced back to the FBG sensors. Embedded FBG's were then checked and the correct wavelength data were taken. All the sensors were observed as intact and ready for bending tests. Procedure for bending tests is also explained including applied loads, boundary conditions, test setup and the peripheral equipment. Results of bending tests show that the system is an appropriate one for SHM purposes.

Introduction

Structural Health Monitoring (SHM) is a discipline of detecting adverse changes in a structure and interpreting these changes in order to improve reliability and to reduce life cycle costs [1]. Another definition of SHM is a continuous monitoring of the structures with embedded or mounted sensors with minimum human intervention to observe the structural integrity [2].

Being an alternative to Non-Destructive Testing (NDT), SHM with embedded FBG sensors provides in-situ and online monitoring opportunity [3]. This opportunity provides several advantages. Expensive routine maintenance activities, which cause aircraft to be out of service and require heavy labor force, are not needed anymore [4]. It is also possible to prevent damage through early detection. Through online monitoring, the life of the monitored structure could be estimated and maximized [4].

FBG sensors are used for SHM and damage detection applications and thanks to their advantages such as; durability, stability, chemical and physical compatibility, high strain range, lightweight, ability to withstand harsh environment, immunity to electromagnetic interference and ability to multiplexing (more than one sensor could be placed on one fibre optic cable.) [5-9].

Yet, the most important advantage of FBG sensors is the possibility of embedment into the composite structures. FBG sensors do not affect the strength of the host the structure since they are small and have lightweight [12].

Manufacturing of Composite Beams with Embedded and Surface Mounted FBG Sensors

Three identical composite beam specimens were manufactured using prepreg layers. One of the beams, named as the "1st Specimen", was manufactured without any sensor. One FBG sensor was mounted on one surface and one conventional strain gauge was mounted on the opposite surface. Other beams, the 2nd, and the 3rd specimens, each of which includes one embedded FBG sensor. The 2nd specimen has embedded FBG between unidirectional (UD) layers. The 3rd specimen has embedded FBG between woven (W) layers. After manufacturing, single FBG sensor was mounted on one of the surfaces of each specimen. All sensors are parallel to lengthwise beam axis.