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DYNAMIC FIBRE BRAGG GRATING SYSTEM FOR THE DAMAGE DETECTION OF COMPOSITE REFLECTOR ANTENNA

Abstract

Structural Health Monitoring (SHM) is progressively considered by the aerospace industry as a promising method to improve safety and reliability and to maximize operational efficiency of structures. This paper discusses ongoing work to develop and verify a new structural health monitoring technique of composite aerospace structures based on real-time dynamic response measurements by using Fibre Bragg Grating (FBG) optical sensors. The experimental validation was performed on a lightweight antenna sub-reflector coming from SPAINSAT, manufactured and tested at EADS CASA ESPACIO. The system was designed and tested initially on a flat composite stiffened panel (manufactured and tested at University of Patras) and, as a second step, on a scaled up space oriented structure, which was a composite honeycomb plate (tested at ESA/ESTEC). Finally it was successfully validated on the antenna sub-reflector. Numerical simulation of all structures was used at all the steps of the work providing among others the location of the optical sensors used.

An integrated FBG sensor network was mounted on the antenna with optimum topology. An extensive instrumentation of the reflector was performed with more than 40 FBGs located in high strain locations. Because of the large number of FBGs, custom FBG arrays were produced on-line during fiber draw. The analysis of dynamic responses was employed to identify both the damage and its position. Initially, damage was simulated by slightly varying locally the mass of the structure at different zones. As a second step, real damage was introduced to the structure by means of interface's modifications (debonding, tightening torque) and of provoked delaminations. The structural dynamic behaviour has been numerically simulated and experimentally verified by means of vibration testing. Advanced digital signal processing techniques were used for the analysis of the dynamic response for feature extraction. Wavelet Transform's capability of separating the different frequency components in the time domain without loosing frequency information makes it a versatile tool for demanding signal processing applications. The classification step comprises of a feed-forward back propagation network, whose output determines the simulated damage size and location. Finally, dedicated training and validation activities were carried out by means of numerical simulations and experimental procedures.

Potential applications for the proposed system are during ground qualification extensive tests of space structures and during the mission, for the spacecraft monitoring. This approach will allow the correlation between the measured ground tests results of aerospace structural components and their actual performance, durability and health in space.